FANUC

GE Fanuc Automation

Programmable Control Products

S2K Series
Standalone Motion Controller

User's Manual

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Warnings, Cautions, and Notes as Used in this Publication

Warning

Warning notices are used in this publication to emphasize that hazardous voltages, currents, temperatures, or other conditions that could cause personal injury exist in this equipment or may be associated with its use.

In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.

Caution

Caution notices are used where equipment might be damaged if care is not taken.

Note

Notes merely call attention to information that is especially significant to understanding and operating the equipment.

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CIMSTAR	Modelmaster	Series 90	VuMaster
Field Control	Motion Mate	Series Five	Workmaster
FrameworX	PACSystems	Series One	
GEnet	ProLoop	Series Six	

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Related Publications

GFK-1866 ***S2K Series Brushless Servo Amplifier User's Manual***

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Chapter 1 Before Operation

1.1 System Overview

The S2K Series is a family of high performance standalone brushless servo or stepper amplifiers with integrated motion controllers and user configurable I/O functions. Controllers are available in models configured for either resolver or serial encoder motor feedback. Encoder-based S2K servo models can be used only with GE Fanuc S-Series (SLM, SDM or SGM) servo motors. S2K resolver feedback servo controllers use GE Fanuc MTR-Series (3N, 3S or 3T) servo motors or third-party motors with appropriate ratings and resolver specifications. Please consult the factory for assistance in controlling non-GE Fanuc motors.

Servo models support continuous stall torque from 0.84–478 in-lb (0.095–54 Nm) while the stepper model supports holding torque from 144–3,074 oz-in (16.3–21.7 Nm). Servo controller models include four 230 VAC ratings of 4.3, 7.2, 16, and 28 amps continuous and two 460 VAC ratings of 7.2 and 20 amps continuous (460 VAC models are only available with resolver feedback). Peak currents of the 230 VAC servo models are two times the continuous ratings while the 460 VAC servo models are 1.5 times the continuous rating. The stepper controller has a rating of 5 amps.

Models supporting DeviceNet™ or PROFIBUS communications include 14 discrete I/O points. The 4.3 and 7.2 amp servo models and the stepper model are also available with 21 I/O points instead of the DeviceNet or PROFIBUS communications. All drives are capable of supporting the Modbus/RTU protocol. If the optional Modbus adapter is used (catalog number IC800MBUSADP) the standard RS-232 serial port can be used for multidrop applications. This adaptor is an externally mounted multi-drop RS-232 to RS-485 serial port converter.

The S2K Series controllers are optimized for use with the GE Fanuc S-Series or MTR-series servo and stepping motors. Overload and possible component damage may occur if the motor and amplifier are not properly matched. Tables 1-1 to 1-3 show the recommended pairing of the components.

The S2K Series stepper controller requires a single-phase 115 VAC supply. S2K Series servo controller models rated 230 VAC and 4.3 or 7.2 amp can operate on either 115 VAC single-phase or 230 VAC three-phase, while the all other models are rated for three-phase input. The 230 and 460 VAC models are intended to be operated from a three-phase supply but can be used with a single-phase power source.

The S-Series servo motors optimized for use with the S2K Series controllers range from 30 W to 5 kW and are rated for 230 VAC for full speed. Using a 115 VAC supply will result in a reduced operating speed of approximately one half of the rated speed.

The 30 to 1,000 Watt S-Series servo motors (SLM models only), MTR-3S and MTR-3N series and all stepping motor models are designed with standard NEMA shaft and flange mounting configurations for easy mounting to off-the-shelf gear reducers and couplings. The 750-Watt S-Series motor uses an oversized shaft diameter (0.625 inches) for the NEMA 34 mounting in order to handle the peak torque rating of this model. S-Series motor models from 1 to 5 kW (except the SLM100 1kW motor) and all MTR-3T Series motors have metric mounting configurations.

All servo motors are available with an optional 24 VDC holding brake. These brakes are spring-set, electrically released models designed for holding stationary loads. The user must supply a separate 24 VDC brake power supply. The 30-750 Watt S-Series motors have a pigtail cable with box style connectors for motor power, encoder and brake connections. The 1,000 to 5,000 Watt S-Series motors have MS style connectors and the brake power (when required) is integrated with the motor power connections in a common connector/cable. MTR-series servo motors include MS type connectors for brake power input. The MTR-3N and MTR-3T series brake motors integrate the brake power with the motor power in the same cable. MTR-3S brake motors require a separate brake power cable (CBL-30-BT).

S2K Series controllers are configured and programmed using the *Motion Developer* software for a personal computer. This software is a standalone application that works within the Machine Edition software environment and provides tools to simplify programming for the novice while providing direct code entry for the advanced user.

The following sections outline what should be accomplished before operating the S2K Series controller.

1.2 Unpacking and Inspecting Components

After opening the S2K Series package, please verify the following:

1. Did you receive the correct model components? The model number of each component is shown on the carton and product labels.
2. Did you receive all items shown on the packing list?
3. Was anything damaged during shipment?

> **Note**
>
> If you find any damage, please contact your local dealer/distributor or GE Fanuc directly.

1.3 Storage

Store S2K components in a clean, dry location that is not exposed to direct sunlight, rain, excessive temperatures (exceeding -40°C to 80°C), corrosive gasses or liquids.

For maximum protection, store all components in the original shipping container.

1.4 Part Numbers

The following figures show how to read the model number on the motors and S2K controllers.

1.4.1 Motor Part Numbers

IC800 SL M ttt M v B E rr

S-Series

SL = Low Inertia Series
SD = Med. Inertia Series
SG = High Inertia Series

Motor Power

003 = 30 Watt (SLM)
005 = 50 Watt (SLM)
010 = 100 Watt (SLM)
020 = 200 Watt (SLM)
040 = 400 Watt (SLM)
075 = 750 Watt (SLM)
100 = 1000 Watt (SDM, SLM)
250 = 2500 Watt (SDM, SLM)
350 = 3500 Watt (SLM)
450 = 4500 Watt (SGM)
500 = 5000 Watt (SDM, SLM)

Mounting

N = NEMA
M = Metric (SLM250, SLM350, SLM500, SDM100, SDM250, SDM500 & SGM450)

Encoder Resolution

25 = 2500 lines

Encoder Type

E = Serial Commutation, Incremental Quadrature Data

Brake

N = No Key and No Brake (Standard on 30 to 100 W models)
B = Brake and No Key (Optional on 30 to 100 W models)
K = Key and No Brake (Standard on 200 W and larger models)
X = Brake and Key (Optional on 200 W and larger models)

Voltage

1 = 115 VAC Motor (100 to 400 W models only)
2 = 230 VAC Motor (750 W to 5kW models)
3 = 115/230 VAC Motor (available only for 30 & 50 W models)

MTR- 3N - fs -w -R- B- M - S

Series

3N = Neodymium
3S = Samarium
3T = Metric

Frame/Stack

3N Series:
21, 22, 24, 31, 32, 33

3S Series:
22, 23, 32, 33, 34, 35, 43, 45, 46, 63, 65, 67, 84, 86, 88

3T Series:
11, 12, 13, 21, 22, 23, 24, 42, 43, 44, 45, 53, 54, 55, 57, 66, 67, 69

Winding

(See Specifications in Chapter 2)

Shaft Seal

0 = No seal (3T4x, 3T5x & 3T6x)
S = Shaft seal (standard on all models except 3T4x, 3T5x and 3T6x)

Mounting Flange

N = NEMA (NEMA23; 3N2x, 3S2x; NEMA34: 3N3x, 3S3x)
E = English (standard on 3S4x, 3S6x or 3S8x)
C = NEMA 56C (option on 3S4x only)
M = Metric (standard on 3T)

Brake

0 = No Brake
B = 24 Vdc Holding Brake (not available for 3S20 series)

Feedback

R = Resolver

1.4.2 S2K Controller Part Numbers

IC800 S S I 1 04 R S1

S2K

Type

S = Servo
T = Stepper

Power

I = Integrated Drive & Controller

Supply Voltage

1 = 90–250 VAC
(4.3 & 7.2 amp servo & 5 amp stepper models only)
2 = 180–250 VAC (16 & 28 amp models only)
4 = 324–528 VAC (7.2 or 20 amp models only)

Continuous Current

05 = 5 Amp Stepper Model (115/230 VAC only)
04 = 4.3 Amp Servo Model (115/230 VAC only)
07 = 7.2 Amp Servo Model (115/230 or 460 VAC)
16 = 16 Amp Servo Model (230 VAC only)
20 = 20 Amp Servo Model (460 VAC only)
28 = 28 Amp Servo Model (230 VAC only)

Motor Feedback Type

Blank = GE Fanuc serial encoder (S-Series motors only)
R = Resolver (MTR-Series or 3rd Party Resolver-based Motors)

Options

S1 = No Network Communication & 21 Discrete I/O
(Not available on 16, 20 or 28 amp models)
D2 = DeviceNet Communications & 14 Discrete I/O
P2 = PROFIBUS Communications & 14 Discrete I/O

1.4.3 S2K Cable Part Numbers (see Section 3.6.7)

1.5 Confirming System Components

The S2K Series system consists of a controller and a servo or stepping motor and various cables from GE Fanuc. Each controller is designed for use with specific GE Fanuc S-Series or MTR-Series motors. Please refer to the following table for the correct controller/motor combination.

Table 1-1 S-Series Motor Compatibility for Serial Encoder-based Controllers

Amplifier Model #	Applicable S-Series Servo Motor					
	Motor Model #	**Rated Output**	**Cont. Torque**	**Controller Voltage**	**Max. Speed**	**Encoder Resolution (Quad Counts)**
IC800SSI104S1 IC800SSI104D2 IC800SSI104P2 **115 / 230 VAC Input**	IC800SLM003N3NE25 IC800SLM003N3BE25*	30 W	0.84 in-lb	115/230VAC	5,000	10,000 Counts
	IC800SLM005N3NE25 IC800SLM005N3BE25*	50 W	1.42 in-lb	115/230VAC	5,000	10,000 Counts
	IC800SLM010N1NE25 IC800SLM010N1BE25*	100 W	2.83 in-lb	115VAC	5,000	10,000 Counts
	IC800SLM010N2NE25 IC800SLM010N2BE25*	100 W	2.83 in-lb	230VAC	5,000	10,000 Counts
	IC800SLM020N1KE25 IC800SLM020N1XE25*	200 W	5.7 in-lb	115VAC	5,000	10,000 Counts
	IC800SLM020N2KE25 IC800SLM020N2XE25*	200 W	5.7 in-lb	230VAC	5,000	10,000 Counts
	IC800SLM040N1KE25 IC800SLM040N1XE25*	400 W	11.5 in-lb	115VAC	5,000	10,000 Counts
	IC800SLM040N2KE25 IC800SLM040N2XE25*	400 W	11.5 in-lb	230VAC	5,000	10,000 Counts
	IC800SLM075N2KE25 IC800SLM075N2XE25*	750 W	21 in-lb	230VAC	5,000	10,000 Counts
IC800SSI107S1 IC800SSI107D2 IC800SSI107P2 **115 / 230 VAC Input**	IC800SLM100N2KE25 IC800SLM100N2XE25*	1000 W	28 in-lb	230VAC	5,000	10,000 Counts
	IC800SDM100M2KE25 IC800SDM100M2XE25*	1000 W	43 in-lb	230VAC	3,000	10,000 Counts
IC800SSI216D2 IC800SSI216P2 **230 VAC Input**	IC800SLM250M2KE25 IC800SLM250M2XE25*	2500 W	70 in-lb	230VAC	5,000	10,000 Counts
	IC800SDM250M2KE25 IC800SDM250M2XE25*	2500 W	104 in-lb	230VAC	3,000	10,000 Counts
IC800SSI228D2 IC800SSI228P2 **230 VAC Input**	IC800SLM350M2KE25 IC800SLM350M2XE25*	5000 W	140 in-lb	230VAC	5,000	10,000 Counts
	IC800SLM500M2KE25 IC800SLM500M2XE25*	5000 W	140 in-lb	230VAC	4,500	10,000 Counts
	IC800SDM500M2KE25 IC800SDM500M2XE25*	5000 W	210 in-lb	230VAC	3,000	10,000 Counts
	IC800SGM450M2KE25 IC800SGM450M2XE25*	4500 W	322 in-lb	230VAC	2,000	10,000 Counts

* Denotes motors that have the optional 24 VDC holding brake (requires customer supplied power supply)

Table 1-2. MTR-Series Motor Compatibility for Resolver-based Controllers

Amplifier Model #	Applicable MTR-Series Servo Motor				
	Motor Model #	**Cont. Stall Torque (in-lb)**	**Rated Speed (RPM)***	**CURC**	**CURP**
IC800SSI104RS1 IC800SSI104RD2 IC800SSI104RP2 **90—250 VAC Input** **1 or 3 phase**	MTR-3N21-H	4.5	6,250 / 12,500	69.7	100
	MTR-3N22-H	8.8	3,800 / 7,600	69.7	100
	MTR-3N24-G	14.2	1,700 / 3,400	60.5	90.7
	MTR-3N31-H	19.9	1,750 / 3,500	76.7	100
	MTR-3N32-G	35.4	750 / 1,500	69.7	100
	MTR-3N33-G	46.9	700 / 1,400	65.1	100
	MTR-3S22-G	5	2,650 / 5,300	34.8	48.8
	MTR-3S23-G	8	1,900 / 3,800	34.8	52.3
	MTR-3S32-G	14.6	2,000 / 4,000	67.4	100
	MTR-3S33-G	22	1,500 / 3,000	74.4	100
	MTR-3S34-G	28.2	1,150 / 2,300	69.8	100
	MTR-3S35-G	33.5	850 / 1,700	69.8	100
	MTR-3S43-G	34.6	750 / 1,500	79.1	100
	MTR-3T11-G	2.7	3,500 / 7,000	22.3	61.6
	MTR-3T12-G	5.3	4,250 / 8,500	43.7	100
	MTR-3T13-G	8	4,500 / 9,000	63.4	100
	MTR-3T21-G	5.3	3,025 / 6,050	40.0	80
	MTR-3T22-G	11.5	2,325 / 4,650	61.6	100
	MTR-3T23-G	17.7	1,800 / 3,600	62.8	100
	MTR-3T24-H	23	1,500 / 3,000	76.7	100
	MTR-3T43-H	50.4	925 / 1,850	100	100
IC800SSI107RS1 IC800SSI107RD2 IC800SSI107RP2 **90—250 VAC Input** **1 or 3 phase**	MTR-3N32-H	35.6	1,950 /3,900	84.7	100
	MTR-3N33-H	46.9	1,600 / 3,200	79.1	100
	MTR-3S43-H	14.4	1,850 / 3,700	77.8	100
	MTR-3S45-G	50.3	1,200 / 2,400	76.4	100
	MTR-3S46-G	67	850 / 1,700	76.4	100
	MTR-3T42-H	36.3	1,475 / 2,950	65.3	100
	MTR-3T43-J	54	1,500 / 3,000	100	100
	MTR-3T44-J	72.5	1,050 / 2,100	100	100
	MTR-3T45-H	90.2	825 / 1,650	98.6	100
IC800SSI216RD2 IC800SSI216RP2 **180—250 VAC Input** **3 phase**	MTR-3S45-H	32	5,300	68.1	100
	MTR-3S46-H	67	4,000	69.3	100
	MTR-3S63-G	73.2	3,400	69.3	100
	MTR-3S65-G	120.3	2,000	67.5	100
	MTR-3S67-G	175.5	1,400	70.6	100
	MTR-3T45-I	90.2	2,700	62.5	100
	MTR-3T54-H	119.3	2,100	66.3	100
	MTR-3T55-H	150.3	1,650	66.3	100

Amplifier Model #	Applicable MTR-Series Servo Motor				
	Motor Model #	**Cont. Stall Torque (in-lb)**	**Rated Speed (RPM)***	**CURC**	**CURP**
IC800SSI228RD2	MTR-3S65-H	120.3	4,300	76.4	100
	MTR-3S67-H	175.5	3,000	80.4	100
	MTR-3S84-G	198.6	3,300	96.1	100
	MTR-3S86-G	267.5	2,500	100	100
	MTR-3S88-G	356	1,900	100	100
	MTR-3T55-I	150.3	3,450	76.1	100
	MTR-3T57-H	194.5	2,450	69.6	100
	MTR-3T66-H	317.7	1,450	74	100
	MTR-3T67-G	371	1,250	74	100
	MTR-3T69-G	477	950	73.6	100
IC800SSI407RS1	MTR-3T42-H	36.3	7,900	65.3	100
IC800SSI407RD2	MTR-3T43-J	54	8,100	100	100
IC800SSI407RP2	MTR-3T44-J	72.5	5,100	100	100
324—528 VAC Input 3 phase	MTR-3T45-H	90.2	4,000	98.6	100
IC800SSI420RD2	MTR-3T54-H	119.3	4,300	53	100
IC800SSI420RP2	MTR-3T55-H	150.3	3,400	53	100
324—528 VAC Input	MTR-3T66-H	307	3,150	100	100
	MTR-3T67-G	358.5	2,700	100	100
3 phase	MTR-3T69-G	463	2,100	100	100

Dual speed values indicated rated speed at 120 VAC/240 VAC. Single speed ratings are at 240 or 480 VAC input power.

Table 1-3. MTR-Series Stepping Motor Compatibility

Amplifier Model #	Applicable MTR-Series Stepping Motor					
	Motor Model #	**Holding Torque**	**Controller Voltage**	**Max. Speed**	**CURC**	**KM**
	MTR-1221-*-D-E-0	144 oz-in	115 VAC	3,000 RPM	35.0	7
	MTR-1231-*-D-E-0	238 oz-in	115 VAC	3,000 RPM	31.0	10
IC800STI105S1	MTR-1324-*-D-E-*	335 oz-in	115 VAC	3,000 RPM	54.0	6
IC800STI105D2	MTR-1337-*-D-E-*	675 oz-in	115 VAC	3,000 RPM	82.0	3
IC800STI105P2	MTR-1350-*-A-E-*	630 oz-in	115 VAC	3,000 RPM	100	1
90—130 VAC	MTR-1350-*-D-E-*	995 oz-in	115 VAC	3,000 RPM	82.0	4
Input	MTR-1N31-I-*-D-S-0	650 oz-in	115 VAC	3,000 RPM	86.0	9
1 phase	MTR-1N32-I-*-D-S-0	1,200 oz-in	115 VAC	3,000 RPM	82.0	12
	MTR-1N41-G-*-A-E-0	1,905 oz-in	115 VAC	3,000 RPM	100	13
	MTR-1N42-H-*-A-E-0	3,074 oz-in	115 VAC	3,000 RPM	100	8

1.6 Agency Approvals

Product Series	UL/UR	CUL/CUR	CE
S2K Amplifiers	UL	CUL	EN50178
MTR-3N Series Motors	UR	No	EN60034-1
MTR-3S Series Motors	UR	No	EN60034-1
MTR-3T Series Motors	UR	CUR	EN60034-1

1.7 S2K Series Now Includes Resolver Feedback Models

GE Fanuc has incorporated the IMJ models, formerly manufactured by Whedco Incorporated, into the S2K series. As a result, GE Fanuc has replaced the old Whedco part numbers with equivalent S2K part numbers as shown in the following table. The 4.3 Amp S2K replaces the 3 Amp IMJ.

GE Fanuc Part Number	Replaces Whedco Model Number	Product Description
IC800SSI104RD2	IMJ-313D-X-D	Servo Motor Controller, 4 A Resolver Feedback with DeviceNet
IC800SSI104RP2	IMJ-313R-X-D	Servo Motor Controller, 4 A Resolver Feedback with PROFIBUS
IC800SSI104RS1	IMJ-313E-X-D	Servo Motor Controller, 4 A Resolver Feedback
IC800SSI107RD2	IMJ-317D-X-D	Servo Motor Controller, 7 A Resolver Feedback with DeviceNet
IC800SSI107RP2	IMJ-317R-X-D	Servo Motor Controller, 7 A Resolver Feedback with PROFIBUS
IC800SSI107RS1	IMJ-317E-X-D	Servo Motor Controller, 7 A Resolver Feedback
IC800SSI216RD2	IMJ-31GD-2-D	Servo Motor Controller, 16 A Resolver Feedback with DeviceNet
IC800SSI216RP2	IMJ-31GR-2-D	Servo Motor Controller, 16 A Resolver Feedback with PROFIBUS
IC800SSI228RD2	IMJ-31TD-2-D	Servo Motor Controller, 28 A Resolver Feedback with DeviceNet
IC800SSI228RP2	IMJ-31TR-2-D	Servo Motor Controller, 28 A Resolver Feedback with PROFIBUS
IC800SSI407RD2	IMJ-317D-4-D	Servo Motor Controller, 7 A Resolver Feedback 480V with DeviceNet
IC800SSI407RP2	IMJ-317R-4-D	Servo Motor Controller, 7 A Resolver Feedback 480V with PROFIBUS
IC800SSI407RS1	IMJ-317E-4-D	Servo Motor Controller, 7 A Resolver Feedback 480V
IC800SSI420RD2	IMJ-31LD-4-D	Servo Motor Controller, 20 A Resolver Feedback 480V with DeviceNet
IC800SSI420RP2	IMJ-31LR-4-D	Servo Motor Controller, 20 A Resolver Feedback 480V with PROFIBUS
IC800STI105D2	IMJ-105D-1-D	Stepping Motor Controller, 5 A with DeviceNet
IC800STI105P2	IMJ-105R-1-D	Stepping Motor Controller, 5 A with PROFIBUS
IC800STI105S1	IMJ-105E-1-D	Stepping Motor Controller, 5 A

Chapter 2

Hardware Overview

2.1 Specifications

The S2K series controllers are used with the S-Series or MTR-Series servo and stepping motors. This chapter contains the specifications for each of these components. Table 2-1 shows the hardware resources available on the S2K controllers.

Table 2-1. Hardware Resources

Hardware Resources	Max.
Master Axes	1
Auxiliary Encoder Input	1
Programmable Digital Inputs [1, 2]	14 or 21
Programmable Digital Outputs [1, 2]	6 or 10
High Speed Position Capture Input (30 µS)	1
Analog Inputs	2
Analog Outputs	1
Serial Ports	1
Network Connection	1

Notes

1. The S2K is available with additional I/O instead of a DeviceNet or PROFIBUS network communication port.
2. 14 total digital I/O lines are available. Up to 6 can be used as outputs. If 6 are used as outputs, then a maximum of 8 inputs are available. On units with additional I/O instead of a DeviceNet port, 21 total digital I/O lines are available. Up to 6 of these can be used as outputs. If 6 are used as outputs, then a maximum of 15 inputs are available.

2.1.1 Stepper Controller Electrical Specifications

The S2K Stepper Controller (IC800STI105xx) is suitable for use on a circuit capable of delivering not more than 5,000 rms symmetrical amperes and 130 volts maximum when protected by RK5 class 15A fuses. Table 2-2 summarizes the Stepper Controllers ***maximum continuous*** input power requirements. The actual input power and current is a function of the motor's operating point and the duty cycle.

Table 2-2. Stepper Controller Power Specifications

Specification	Units	Controller Rating
AC Input Voltage Range	VAC	90—130, 1 phase
AC Input Frequency Range	Hz	50—440
PWM Frequency to Motor	kHz	16.4
Output Current	A_{rms}	5 per phase
Max. Input Current	A_{rms}	10 A rms
Max. Input Power	KVA	1.3 @ 130 VAC
DC Power Outputs	VDC	+5 @ 0.5 A; +12 @ 0.5 A
Fuses		10 A time delay branch circuit fuse

2.1.2 Servo Controller Electrical Specifications

The Servo Controller models are suitable for use on a circuit capable of delivering not more than 5,000 rms symmetrical amperes, 250 volts maximum when protected by RK5 class fuses. Table 2-3 summarizes the ***maximum continuous*** input power requirements. The actual input power and current is a function of the motor's operating point and the duty cycle.

Table 2-3. Servo Controller Power Specifications

Specification	Units	Rating					
		SSI104[3]	SSI107[4]	SSI216[4]	SSI228[4]	SSI407[4]	SSI420[4]
AC Input Voltage Range	VAC	90–250, 1 or 3 phase		180–250, 3 phase		324–528, 3 phase	
AC Input Frequency Range	Hz	50–440					
PWM Frequency to Motor	kHz	16.4				8.2	
Motor Minimum Inductance	mH	1 (per phase)					
Cont. Output Current[1]	A_{rms}	4.3	7.2	16	28	7.2	20
Peak Output Current	A_{rms}	8.6	14.4	32	56	10.8	30
Max. Input Current 1-phase	A_{rms}	7	15	N/A	N/A	N/A	N/A
3-phase	A_{rms}	4	8	18	30	8	22
Max. Input Power	KVA @ Rated VAC	1.6	3.8	8.5	14.3	6.4	18
Logic Input Power	VAC	N/A	90-250 @ 0.5A	90–250 @ 0.5 A		+18–30 VDC@ 1.5 A	
DC Power Outputs[3]	VDC	+5 @ 0.25 A; +12 @ 0.5 A					
Logic Supply Fuses	**SSI104:** No internal fuses **SSI107, SSI216, and SSI228:** 2A, 250 volt fuse (Littelfuse #224002) on the 2L1 input only. The 2L2 input is not fused. This fuse is soldered in and is not considered field replaceable. **SSI407 and SSI420:** 5A, 125 volt fuse (Littelfuse #251005) on the +24 V input only. The COM input is not fused. This fuse is soldered in and is not considered field replaceable.						
Branch Circuit Fuse[2] 1-phase	A_{rms}	10	15	N/A	N/A	N/A	N/A
3-phase	A_{rms}	5	15	20	30	10	25

1) Outputs are provided with an internal overload protection. Controller performs rms current calculation and will not allow rms output to exceed the Cont. Output Current values listed in this table. For higher ambient temperatures, see section 2.3.
2) Use RK5 class time delay fuses for the supply line.
3) The 4.3 amp controller has no internal fuses.
4) These controllers have no internal motor power fuses. Their logic power supply input on 2L1 is fused internally with a 2A, 250 volt fuse (Littelfuse #224002). This fuse is soldered to the board and is not considered to be field-replaceable. This fuse is designed to protect against an internal logic power supply fault. The 2L2 input is not fused.

2.1.3 Isolation Transformer

An isolation transformer is not specifically required when using the S2K Series controllers. If the supply voltage is above the maximum of the range specified for each model, a transformer is required to drop the voltage to within the acceptable range. The transformer should be sized to provide adequate power under all operating conditions. Choose a transformer rated for a minimum of 125% of the drive maximum continuous input KVA.

2.1.4 Environmental Specifications

Table 2-4. Environmental Specifications

Operating Temperature[1, 2]	32 to 122 °F (0 to 50 °C)
Storage and Shipping Temperature	-40 to 176 °F (-40 to 80 °C)
Altitude [3]	3,300 Feet (1,000 m)
Relative Humidity (non-condensing)	5 to 95 %

1)For UL approved installation of the following controllers, maximum ambient temperature is 40°C (104°F): IC800SSI216P2, IC800SSI216RP2, IC800SSI216D2, IC800SSI216RD2, IC800SSI228P2, IC800SSI228RP2, IC800SSI228D2, IC800SSI228RD2, IC800SSI407RS1, IC800SSI407RP2, IC800SSI407RD2, IC800SSI420RP2, IC800SSI420RD2.

2) Assumes heat sink orientation is vertical.

3) Operation at higher altitudes requires controller derating. Please consult GE Fanuc.

2.1.5 S2K Communication Specifications

Table 2-5. S2K Serial Communication Specifications

Serial Communication*	
Available Ports	1
Functions Supported	Multi-purpose programming port
Format	RS-232
Maximum Addressable Units	1
Communication Rate	1200, 9600,19200 or 38400 baud
Protocol	ASCII or Modbus/RTU (optional Modbus RS-485 multi-drop port converter is available; part number IC800MBUSADP)

* See Section 3.6.7 and Chapter 9 for more information on serial communication

Table 2-6. S2K DeviceNet Specifications

<table>
<tr><th colspan="3">DeviceNet Communication Network*</th></tr>
<tr><td colspan="2">Number Available</td><td>1 port per unit</td></tr>
<tr><td colspan="2">Functions Supported</td><td>I/O slave messaging, position controller profile, and explicit peer-to-peer messaging</td></tr>
<tr><td colspan="2">Number of Nodes</td><td>64 maximum</td></tr>
<tr><td colspan="2">Input Power Requirements</td><td>11-25 VDC @ 40 mA maximum</td></tr>
<tr><td colspan="2">Communication Rate</td><td>125, 250, or 500 KBaud</td></tr>
<tr><td colspan="2">Length of Drop Line</td><td>20 feet maximum</td></tr>
<tr><td rowspan="4">Length of Trunk Line</td><td>Thin Cable</td><td>328 feet maximum</td></tr>
<tr><td rowspan="3">Thick Cable</td><td>328 feet maximum @ 500 KBaud</td></tr>
<tr><td>820 feet maximum @ 250 Kbaud</td></tr>
<tr><td>1,640 feet maximum @ 125 Kbaud</td></tr>
</table>

* See Chapter 8 for more information

Table 2-7. S2K PROFIBUS Specifications

PROFIBUS Communications Network*	
Number Available	1 port per unit
Functions Supported	PROFIBUS profile, multicast, broadcast
Maximum Addressable Units	100 maximum
Input Power Requirements	None
Communication Rate	9,600; 19,200; 45,450; 93,750; 187,500; 500,000; 1,500,000; 3,000,000; 6,000,000; or 12,000,000 Baud
Maximum length of Serial Data Link	3,936 feet @ 9.6 KBaud

* See Chapter 10 for more information

2.1.6 Input And Output Specifications

Table 2-8. Input and Output Specifications

Digital Inputs and Outputs		
Operating Range		12–24 VDC, 30 VDC maximum
Interface Format		optically isolated, source/sink user-configurable
Inputs	Maximum Off Voltage	4 VDC
	Minimum On Voltage	10 VDC
	Load	2 kΩ
Outputs	Maximum On Resistance	35 Ohms
	Maximum Load Current	100 mA
	Maximum Off Leakage Current	200 nA
Capture Input Response Time		30 µS
Analog Inputs		
Number Available		2
Operating Range		+/-10 VDC
Resolution		12 Bits
Input Impedance		50 kΩ
Analog Outputs		
Number Available		1
Functional Assignment		User programmable or configurable as velocity, current or following error
Operating Range		+/-10 VDC
Resolution		8 Bits
Output Current		5mA

2.1.7 Encoder Input And Output Specifications

Table 2-9. Encoder Input/Output Specifications

Auxiliary Encoder Input	
Number Available	1
Input Voltage	5, 12 or 15 VDC
Line Receiver	26LS33
Input Format	Single-ended or Differential Sine or Square Wave Quadrature, Pulse/Direction or CW/CCW Pulse
Max. Line Count Frequency	3 MHz (12 MHz Quadrature)
+5 or +12 VDC Power Output Capacity[1]	0.5 amps each
Encoder Output	
Number Available	1
Output Voltage	5.2 VDC +/-1%
Line Driver	26LS31
Output Format—See Section 3.6.6 (tracks format of source selected by the EOT parameter)	Differential Square Wave Quadrature, Pulse/Direction or CW/CCW Pulse
Marker Pulse Width	1/5000 of Encoder Revolution
Max. Line Count Frequency	3 MHz (12 MHz Quadrature)

Notes

1) The +5 Vdc output power supply available to power the auxiliary encoder (pin 19 of the Auxiliary I/O connector for models SSI104, SSI107 and SSI407 or the Pulse Input connector on models SSI216, SSI228 and SSI420) is also used to power the motor encoder. The motor encoder requires a maximum of 0.25 amps but typically draws 0.15 amp. Overloading the 5V supply will cause a loss of feedback and fault the amplifier.

2.1.8 Motor Feedback Input

Table 2-10. Motor Feedback Input

Motor Encoder Input (Encoder-based models only)	
Number Available	1
Resolution	2,500 lines per revolution
Line Receiver	26LS33
Data Input Format	Differential, Square Wave, Quadrature
Commutation Input Format	Serial (S-Series motors)
Max. Line Count Frequency	3 MHz (12 MHz Quadrature)
Motor Resolver Input (Resolver-based models only)	
Number Available	1
Resolution	4,096 pulses per revolution
Maximum Speed	15,000 RPM
Type	Control Transmitter
Phase Shift	± 5.0 degrees @ 5kHz
Null Voltage	< 20 mV @ 5 kHz
Transformation Ratio	0.5

2.1.9 S-Series Servo Motor Specifications

Table 2-11. S-Series Motor Specifications

Specification	Units	Motor Rating @ 20°C								
		SLM003	SLM005	SLM010		SLM020		SLM040		SLM075
		115/230V	115/230V	115V	230V	115V	230V	115V	230V	230V
Output Power	W	30	50	100		200		400		750
Continuous Stall Torque[1]	in-lb [Nm]	0.84 [0.095]	1.42 [0.16]	2.83 [0.32]		5.66 [0.64]		11.5 [1.3]		21.2 [2.4]
Peak Torque	in-lb [Nm]	2.48 [0.28]	4.25 A[0.48]	8.4 [0.95]		16.9 [1.91]		33.6 [3.8]		46.0 [5.2]
Rated Speed	RPM	3,000	3,000	3,000		3,000		3,000		3,000
Maximum Speed	RPM	5,000	5,000	5,000		5,000		5,000		4,500
Feedback		2,500 lines (10,000 counts/rev) Incremental Encoder (5 VDC±5% @ 0.3A; 250 kHz max.)								
Weight	lb [kg]	0.59 [0.27]	0.75 [0.34]	1.23 [0.56]		2.2 [1.0]		3.52 [1.6]		7.0 [3.2]
Rotor Inertia	in-lb-s2 x 10^{-4} [kg-m2 x 10^{-4}]	0.139 [0.016]	0.225 [0.025]	0.546 [0.062]		1.474 [0.17]		3.208 [0.36]		11.62 [1.31]
Shaft Thrust Load	lb [kg]	6.6 [3]	13.2 [6]	13.2 [6]		22 [10]		22 [10]		33 [15]
Shaft Radial Load[2]	lb [kg]	11 [5]	15.4 [7]	15.4 [7]		55 [25]		55 [25]		88 [40]
Mechanical Time Constant	ms	1.8	1.2	0.8	0.77	0.62	0.63	0.48	0.54	0.45
Torque Constant	in-lb/A(rms) [Nm/A(rms)]	0.91 [0.103]	1.42 [0.16]	1.86 [0.21]	3.28 [0.37]	2.39 [0.27]	3.72 [0.42]	2.66 [0.30]	4.78 [0.54]	5.4 [0.61]
Resistance (phase)	Ohms	4.0	4.2	1.9	5.7	0.91	2.3	0.41	1.46	0.43
Inductance (phase)	mH	2.4	2.8	1.7	5.0	3.2	7.8	1.9	5.1	3.2
Electrical Time Constant	ms	0.6	0.67	0.89	0.88	3.5	3.4	4.6	3.5	7.4
Continuous Current	A(rms)	1.0	1.0	1.6	1.0	2.5	1.6	4.3	2.5	4.3
Optional Brake Data @ 20°C (backlash = ±0.1°)										
Inertia Adder	In-lb-s^2 x 10^{-4} [kg-m^2 x10^{-4}]	0.026 [0.003]	0.026 [0.003]	0.026 [0.003]		0.26 [0.03]		0.26 [0.03]		0.78 [0.09]
Weight Adder	lb [kg]	0.44 [0.2]	0.42 [0.19]	0.44 [0.2]		0.88 [0.4]		0.88 [0.4]		1.54 [0.7]
Voltage	VDC± 10%	24	24	24		24		24		24
Current	A	0.26	0.26	0.26		0.36		0.36		0.43
Engage Time	ms	≤ 25	≤ 25	≤ 25		≤ 50		≤ 50		≤ 60
Release Time	ms	≤ 20	≤ 20	≤ 20		≤ 15		≤ 15		≤ 15
Torque	in-lb [Nm]	2.6 [0.29]	2.6 [0.29]	2.6 [0.29]		10.8 [1.3]		10.8 [1.3]		21.7 [2.5]
Environmental Data										
Humidity (non-condensing)	RH	85%								
Ambient Temperature (operating)	°C	0 to 40								
Storage Temperature	°C	-20 to 80								
Vibration[3]	G	5								
Shock	G	10								

1. Torque shown is available up to a certain ambient temperature. See Speed/Torque curve notes.
2. Radial shaft loads are specified at a position centered along the length of the shaft
3. Vibration tests are described in the section "Motor Vibration Testing" later in this chapter.

Specification	Units	Motor Rating @ 20°C							
		SDM100	SLM100	SLM250	SDM250	SLM350	SLM500	SDM500	SGM450
Output Power	W	1,000	1,000	2,500	2,500	3,500	5,000	5,000	5,000
Continuous Stall Torque[1]	in-lb [Nm]	43 [4.8]	28 [3.18]	70 [7.94]	104 [11.8]	97 [11]	140 [15.8]	210 [23.8]	322 [36.3]
Peak Torque	in-lb [Nm]	110 [12.4]	56 [6.3]	140 [15.8]	240 [27.1]	252 [28.5]	282 [31.9]	420 [47.5]	644 [72.8]
Rated Speed	RPM	2,000	3,000	3,000	2,000	3,000	3,000	2,000	2,000
Maximum Speed	RPM	3,000	5,000	5,000	3,000	5,000	4,500	3,000	3,000
Feedback		2,500 lines (10,000 counts/rev) Incremental Encoder (5 VDC ±5% @0.3 A; 250 kHz max.)							
Weight	lb [kg]	15 [6.8]	9.9 [4.5]	16.5 [7.5]	28.2 [12.8]	24 [10.9]	38 [17.3]	55 [25]	38 [17.3]
Rotor Inertia	in-lb-s^2 x 10^{-4} [kg-m^2 x 10^{-4}]	54.6 [6.17]	14.91 [1.69]	38.14 [4.31]	169.9 [19.2]	69.92 [7.90]	157.5 [17.8]	537.2 [60.7]	715.9 [80.9]
Shaft Thrust Load	lb [kg]	44 [20]	33 [15]	44 [20]	77 [35]	44 [20]	77 [35]	77 [35]	77 [35]
Shaft Radial Load[2]	lb [kg]	110 [50]	8 [40]	110 [50]	176 [80]	110 [50]	176 [80]	176 [80]	176 [80]
Mechanical Time Constant	Ms	0.70	0.78	0.52	0.72	0.45	0.46	0.9	0.46
Torque Constant	in-lb/A(rms [Nm/A(rms)]	7.61 [0.86]	3. [0.44]	4.3 [0.49]	7.5 [0.85]	4.51 [0.51]	5.04 [0.57]	7.52 [0.85]	11. [1.3]
Resistance (phase)	Ohms	0.56	0.27	0.1	0.18	0.05	0.028	0.068	0.028
Inductance (phase)	MH	10.0	1.8	1.1	3.8	1	1.12	2.2	0.56
Electrical Time Constant	Ms	18	6.7	11	21	20	20	32	20
Continuous Current	A(rms)	5.6	7.2	15.9	14	21.6	28	28	28.5
Optional Brake Data @ 20 °C (backlash = ± 0.1°)									
Inertia Adder	in-lb-s^2 x 10^{-4} [kg-m^2 x10^{-4}]	5.49 [0.62]	2.2 [0.26]	3.8 [0.43]	16.8 [1.9]	6.9 [0.79]	16.82 [1.9]	53.1 [6]	16.8 [1.9]
Weight Adder	lb [kg]	4.2 [1.9]	1.32 [0.6]	3.08 [1.4]	4.2 [1.9]	3.74 [1.7]	4.18 [1.9]	7.7 [3.5]	4.18 [1.9]
Voltage	VDC± 10%	24	24	24	24	24	24	24	24
Current	A	0.59	0.74	0.81	0.9	0.81	0.90	1.3	0.90
Engage Time	Ms	≤ 80	≤ 50	≤ 50	≤ 110	≤ 80	≤ 110	≤ 80	≤ 110
Release Time	Ms	≤ 70	≤ 15	≤ 15	≤ 50	≤ 15	≤ 50	≤ 25	≤ 50
Torque	in-lb [Nm]	43.3 [4.9]	43. [4.9]	69 [7.8]	143 [16.1]	104 [11.8]	143 [16.2]	217 [24.5]	143 [16.2]
Environmental Data									
Humidity (non-condensing)	RH	85%							
Ambient Temperature (operating)	°C	0 to 40							
Storage Temperature	°C	-20 to 80							

1. Torque shown is available up to a certain ambient temperature. See Speed/Torque curve notes.
2. Radial shaft loads are specified at a position centered along the length of the shaft
3. Vibration tests are described in the section "Motor Vibration Testing" later in this chapter.

Table 2-12. MTR-3N Series Motor Specifications

Specification	Units	3N21-H	3N22-H	3N24-G	3N31-H	3N32-G	3N32-H	3N33-G	3N33-H
Motor Stall Torque[1]	in-lb [Nm]	4.5 [0.5]	8.8 [1.0]	14.2 [1.6]	19.9 [2.25]	35.4 [4.0]	35.6 [4.0]	46.9 [5.3]	46.9 [5.3]
Motor Peak Torque[3]	in-lb [Nm]	11.5 [1.3]	23.1 [2.6]	44.7 [5.05]	48 [5.42]	94.1 [10.63]	79.1 [8.94]	138.5 [15.65]	116.5 [13.16]
Rated Speed: @120 VAC input @240 VAC input	RPM	6,250 12,500	3,800 7,600	1,700 3,400	1,750 3,500	750 1500	1,950 3,900	700 1,400	1,600 3,200
No-load Speed @240 VAC input	RPM	12,500	10,400	4,900	5,200	2,600	5,300	1,800	3,600
Feedback		4,096 pulse/rev resolver (control transmitter; 0.5 transformation ratio)							
Weight	lb [kg]	3.1 [1.4]	4.2 [1.9]	6.0 [2.7]	7.1 [3.2]	10.7 [4.9]	10.7 [4.9]	14.2 [6.5]	14.2 [6.5]
Rotor Inertia (with resolver)	in-lb-s^2 x 10^{-4} [kg-m^2 x 10^{-4}]	3.8 [0.42]	5.6 [0.64]	8.9 [1.0]	15.8 [1.78]	29.8 [3.4]	29.8 [3.4]	42.8 [4.8]	42.8 [4.8]
Shaft Thrust Load[2]	lb [kg]	20 [9.1]	20 [9.1]	20 [9.1]	35 [15.9]	35 [15.9]	35 [15.9]	35 [15.9]	35 [15.9]
Shaft Radial Load[2]	lb [kg]	50 [22.7]	50 [22.7]	50 [22.7]	85 [38.6]	85 [38.6]	85 [38.6]	85 [38.6]	85 [38.6]
Torque Constant	in-lb/A(rms) [Nm/A(rms)]	1.42 [0.16]	3.0 [0.34]	5.5 [0.62]	5.9 [0.67]	11.4 [1.3]	5.8 [0.66]	16.7 [1.89]	8.4 [0.95]
Resistance (line-line)	Ohms	3.0	4.2	6.8	4.1	6.2	1.6	8.4	2.1
Inductance (line-line)	MH	3.7	5.7	9.3	10.3	18	4.5	25.2	6.3
Electrical Time Constant	Ms	1.23	1.36	1.37	2.51	2.9	2.81	3.0	3.0
Continuous Stall Current	A(rms)	3.1	2.9	2.6	3.3	3.1	6.1	2.8	5.6
Optional Brake Data									
Inertia Adder	in-lb-s^2 x 10^{-4} [kg-m^2 x10^{-4}]	n/a	n/a	n/a	2.5 [0.282]	2.5 [0.282]	2.5 [0.282]	2.5 [0.282]	2.5 [0.282]
Weight Adder	lb [kg]	n/a	n/a	n/a	2.5 [1.14]	2.5 [1.14]	2.5 [1.14]	2.5 [1.14]	2.5 [1.14]
Voltage	VDC ±10%	n/a	n/a	n/a	24	24	24	24	24
Current	A	n/a	n/a	n/a	0.72	0.72	0.72	0.72	0.72
Engage Time	Ms	n/a	n/a	n/a	10	10	10	10	10
Release Time	Ms	n/a	n/a	n/a	30	30	30	30	30
Torque	in-lb [Nm]	n/a	n/a	n/a	32 [3.62]	32 [3.62]	32 [3.62]	32 [3.62]	32 [3.62]
Environmental Data									
Humidity (non-condensing)	RH	98%							
Ambient Temperature (operating)	°C	-20 to 40							
Storage Temperature	°C	-30 to 150							

1. Torque shown is available up to an ambient temperature of 25o C with motor mounted to a 10' x10' x 0.25' aluminum heat sink. For higher ambient temperatures, see section 2.3.
2. Shaft loads are based on L10 bearing life at 3,000 rpm and assume force is applied to center of shaft.
3. Peak torque ratings are limited by the specific amplifier used based on the amplifier's peak current limitations.

Table 2-13. MTR-3S Series Motor Specifications

Specification	Units	3S22-G	3S23-G	3S32-G	3S33-G	3S34-G	3S35-G	3S43-G	3S43-H	3S45-G	3S45-H
Continuous Stall Torque[1]	in-lb [Nm]	5 [0.56]	8 [0.90]	14.6 [1.65]	22 [2.5]	28.2 [3.2]	33.5 [3.8]	34.6 [3.9]	34.6 [3.9]	50.3 [5.7]	50.3 [5.7]
Peak Torque[3]	in-lb [Nm]	14.8 [1.67]	22.6 [2.55]	38.6 [4.36]	52.5 [5.93]	69.3 [7.83]	86.8 [9.81]	93.6 [10.58]	79.8 [9.02]	119.5 [13.50]	130.9 [14.79]
Rated Speed: @120 VAC input @240 VAC input	RPM	2,650 5,300	1,900 3,800	2,000 4,000	1,500 3,000	1,150 2,300	850 1,700	750 1,500	1,850 3,700	1,200 2,400	- 5,300
No-load Speed @240 VAC input	RPM	9,000	6,000	6,000	4,500	3,500	2,800	2,500	5,000	3,000	6,500
Feedback		4,096 counts/rev resolver (control transmitter; 0.5 transformation ratio)									
Weight	lb [kg]	2.1 [0.95]	2.8 [1.3]	5.5 [2.5]	7.1 [3.2]	8.7 [3.9]	10.2 [4.6]	15 [6.8]	15 [6.8]	20 [9.1]	20 [9.1]
Rotor Inertia	in-lb-s^2 x 10^{-4} [kg-m^2 x 10^{-4}]	1.2 [0.14]	1.6 [0.18]	6.3 [0.71]	8.2 [0.93]	10.0 [1.1]	11.9 [1.3]	19.8 [2.2]	19.8 [2.2]	27.8 [3.1]	27.8 [3.1]
Shaft Thrust Load[2]	lb [kg]	20 [9.1]	20 [9.1]	35 [15.9]	35 [15.9]	35 [15.9]	35 [15.9]	50 [22.7]	50 [22.7]	50 [22.7]	50 [22.7]
Shaft Radial Load[2]	lb [kg]	50 [22.7]	50 [22.7]	90 [40.9]	90 [40.9]	90 [40.9]	90 [40.9]	125 [56.8]	125 [56.8]	125 [56.8]	125 [56.8]
Torque Constant	in-lb/A(rms) [Nm/A(rms)]	3.8 [0.43]	5.3 [0.6]	5.2 [0.59]	6.9 [0.78]	9.47 [1.1]	11.5 [1.3]	11.86 [1.34]	6.2 [0.7]	9.2 [1.03]	4.6 [0.52]
Resistance (phase)	Ohms	22	20	7.3	6.9	8.1	9.2	10	2.5	3.2	0.81
Inductance (phase)	mH	21	26	23	22	30	42	53	13.3	20	4.9
Electrical Time Constant	ms	0.95	1.3	3.2	3.2	3.7	4.6	5.3	5.3	6.3	6.1
Continuous Current	A(rms)	1.4	1.5	2.9	3.2	3.0	2.9	2.9	5.6	5.5	10.9
Optional Brake Data											
Inertia Adder	in-lb-s^2 x 10^{-4} [kg-m^2 x10^{-4}]	N/A	N/A	0.34 [0.38]	0.34 [0.38]	0.34 [0.38]	0.34 [0.38]	5.0 [0.565]	5.0 [0.565]	5.0 [0.565]	5.0 [0.565]
Weight Adder	lb [kg]	N/A	N/A	2.5 [1.14]	2.5 [1.14]	2.5 [1.14]	2.5 [1.14]	4.0 [1.82]	4.0 [1.82]	4.0 [1.82]	4.0 [1.82]
Voltage	VDC± 10%	N/A	N/A	24	24	24	24	24	24	24	24
Current	A	N/A	N/A	0.72	0.72	0.72	0.72	0.71	0.71	0.71	0.71
Engage Time	ms	N/A	N/A	10	10	10	10	20	20	20	20
Release Time	ms	N/A	N/A	30	30	30	30	120	120	120	120
Torque	in-lb [Nm]	N/A	N/A	32 [3.62]	32 [3.62]	32 [3.62]	32 [3.62]	72 [8.14]	72 [8.14]	72 [8.14]	72 [8.14]
Environmental Data											
Humidity (non-condensing)	RH	98%									
Ambient Temperature (operating)	°C	-20 to 40									
Storage Temperature	°C	-30 to 150									

1. Torque shown is available up to an ambient temperature of 25°C with motor mounted to a 10' x10' x 0.25' aluminum heat sink. For higher ambient temperatures, see section 2.3.

2. Shaft loads are based on L10 bearing life at 3,000 rpm and assume force is applied to center of shaft.

3. Peak torque ratings are limited by the specific amplifier based on the amplifier's peak current limitations.

Specification	Units	3S46-G	3S46-H	3S63-G	3S65-G	3S65-H	3S67-G	3S67-H	3S84-G	3S86-G	3S88-G
Continuous Stall Torque[1]	in-lb [Nm]	67 [7.6]	67 [7.6]	73.2 [8.27]	120.3 [13.6]	120.3 [13.6]	175.5 [19.83]	175.5 [19.83]	198.6 [22.44]	267.5 [30.23]	356 [40.23]
Peak Torque[3]	in-lb [Nm]	159.4 [18.01]	174.7 [19.74]	177 [20]	293 [31.98]	269.5 [30.45]	418.4 [47.28]	379.3 [42.86]	331.1 [37.41]	451.4 [51.01]	594.4 [67.16]
Rated Speed: @120 VAC input @240 VAC input	RPM	850 1,700	- 4,000	- 3,400	- 2,000	- 4,300	- 1,400	- 3,000	- 3,300	- 2,500	- 1,900
No-load Speed @240 VAC input	RPM	2,500	5,000	4,500	2,800	5,500	1,900	3,800	4,000	3,000	2,300
Feedback		4,096 counts/rev resolver (control transmitter; 0.5 transformation ratio)									
Weight	lb [kg]	25 [11.3]	25 [11.3]	29 [13]	39 [18]	39 [18]	49 [22]	49 [22]	60 [27]	77 [35]	94 [43]
Rotor Inertia	in-lb-s^2 x 10^{-4} [kg-m^2 x 10^{-4}]	35.8 [4.0]	35.8 [4.0]	72 [8.1]	112 [12.6]	112 [12.6]	152 [17.2]	152 [17.2]	392 [44.3]	582 [65.7]	762 [86.1]
Shaft Thrust Load [2]	lb [kg]	50 [22.7]	50 [22.7]	70 [32]	70 [32]	70 [32]	70 [32]	70 [32]	100 [45]	100 [45]	100 [45]
Shaft Radial Load [2]	lb [kg]	125 [56.8]	125 [56.8]	185 [84]	185 [84]	185 [84]	185 [84]	185 [84]	250 [114]	250 [114]	250 [114]
Torque Constant	in-lb/A(rms) [Nm/A(rms)]	12.2 [1.4]	6.1 [0.7]	6.6 [0.75]	11.2 [1.30]	5.7 [0.64]	15.6 [1.8]	7.8 [0.88]	7.4 [0.84]	9.6 [1.1]	12.7 [1.4]
Resistance (phase)	Ohms	3.7	0.93	0.93	1.2	0.34	1.5	0.37	0.26	0.25	0.28
Inductance (phase)	mH	25	6.2	8.9	13.7	3.4	18.2	4.6	3.2	3.6	4.0
Electrical Time Constant	ms	6.8	6.7	9.6	11.4	10.0	12.1	12.4	12.3	14.4	14.2
Continuous Current	A(rms)	5.5	11	11	10.7	21.4	11.3	22.5	26.9	30.2	29.4
Optional Brake Data											
Inertia Adder	in-lb-s^2 x 10^{-4} [kg-m^2 x10^{-4}]	4.0 [0.452]	4.0 [0.452]	3.7 [0.418]	3.7 [0.418]	3.7 [0.418]	3.7 [0.418]	3.7 [0.418]	14.9 [1.68]	14.9 [1.68]	14.9 [1.68]
Weight Adder	lb [kg]	4.0 [1.82]	4.0 [1.82]	9 [4.1]	9 [4.1]	9 [4.1]	9 [4.1]	9 [4.1]	15 [6.82]	15 [6.82]	15 [6.82]
Voltage	VDC±10%	24	24	24	24	24	24	24	24	24	24
Current	A	0.71	0.71	1.14	1.14	1.14	1.14	1.14	1.51	1.51	1.51
Engage Time	ms	20	20	25	25	25	25	25	50	50	50
Release Time	ms	120	120	50	50	50	50	50	100	100	100
Torque	in-lb [Nm]	72 [8.14]	72 [8.14]	180 [20.3]	180 [20.3]	180 [20.3]	180 [20.3]	180 [20.3]	180 [20.3]	180 [20.3]	180 [20.3]
Environmental Data											
Humidity (non-condensing)	RH	98%									
Ambient Temperature (operating)	°C	-20 to 40									
Storage Temperature	°C	-30 to 150									

1. Torque shown is available up to an ambient temperature of 25° C with motor mounted to a 10' x10' x 0.25' aluminum heat sink. For higher ambient temperatures, see section 2.3.
2. Shaft loads are based on L10 bearing life at 3,000 rpm and assume force is applied to center of shaft.
3. Peak torque ratings are limited by the specific amplifier based on the amplifier's peak current limitations.

Table 2-14. MTR-3T Series Motor Specifications

Specification	Units	3T11-G	3T12-G	3T13-G	3T21-G	3T22-G	3T23-G	3T24-H	3T42-H	3T43-H	3T43-J	3T44-J
Continuous Stall Torque[1]	in-lb [Nm]	2.7 [0.30]	5.3 [0.60]	8.0 [0.90]	5.3 [0.60]	11.5 [1.30]	17.7 [2.00]	23.0 [2.60]	36.3 [4.10]	50.4 [5.70]	54.0 [6.1]	72.5 [8.19]
Peak Torque[3]	in-lb [Nm]	9.3 [1.05]	20.8 [2.35]	24.6 [2.78]	19.9 [2.25]	35.5 [4.01]	53.5 [6.05]	58.2 [6.58]	105.8 [11.9]	100.0 [11.3]	106.7 [12.06]	143.6 [16.23]
Rated Speed: @120 VAC input @240 VAC input @480 VAC input	RPM	3,500 7,000 -	4,250 8,500 -	4,500 9,000 -	3,025 6,050 -	2,325 4,650 -	1,800 3,600 -	1,500 3,000 -	1,475 2,950 5,900	925 1,850 -	1,500 3,000 6,800	1,050 2,100 5,100
No-load speed @240 VAC input @480 VAC input	RPM	12,900 -	10,800 -	10,600 -	9,250 -	7,100 -	4,700 -	4,350 -	4,000 7,900	2,600 -	4,050 8,100	3,000 6,000
Feedback		4,096 pulse/rev resolver (control transmitter; 0.5 transformation ratio)										
Weight	Lb [kg]	2.6 [1.2]	3.3 [1.5]	4.2 [1.9]	3.7 [1.7]	5.0 [2.3]	6.4 [2.9]	7.7 [3.5]	13.6 [6.2]	16.7 [7.6]	16.7 [7.6]	20 [9.0]
Rotor Inertia	in-lb-s^2 x 10^{-4} [kg-m^2 x 10^{-4}]	1.02 [0.12]	1.64 [0.19]	2.26 [0.29]	2.26 [0.29]	4.2 [0.47]	4.9 [0.55]	7.3 [0.82]	32 [3.6]	46 [5.2]	46 [5.2]	60 [6.8]
Shaft Thrust Load [2]	lb [kg]	N/A	N/A	N/A	17 [7.7]	17 [7.7]	17 [7.7]	17 [7.7]	41.5 [18.9]	41.5 [18.9]	41.5 [18.9]	41.5 [18.9]
Shaft Radial Load [2]	lb [kg]	N/A	N/A	N/A	62 [28.1]	62 [28.1]	62 [28.1]	62 [28.1]	157 [71.5]	157 [71.5]	157 [71.5]	157 [71.5]
Torque Constant	in-lb/A(rms) [Nm/A(rms)]	2.65 [0.3]	2.9 [0.32]	2.9 [0.32]	3.1 [0.35]	4.3 [0.49]	6.5 [0.74]	7.0 [0.79]	7.7 [0.87]	11.8 [1.33]	7.5 [0.85]	10.2 [1.15]
Resistance (phase)	Ohms	16.3	6.8	3.9	8.8	4.81	6.1	4.6	3.2	3.9	1.54	1.8
Inductance (phase)	mH	7.1	4.3	2.7	10.5	7.4	10.6	8.9	8.9	13.0	5.3	7.1
Electrical Time Constant	ms	0.43	0.63	0.69	1.19	1.54	1.73	1.93	2.78	3.33	3.44	3.94
Continuous Current	A(rms)	0.96	1.88	2.73	1.72	2.65	2.7	3.3	4.7	4.6	7.2	7.2
Optional Brake Data												
Inertia Adder	in-lb-s^2 x 10^{-4} [kg-m^2 x10^{-4}]	1.1 [0.12]	1.1 [0.12]	1.1 [0.12]	1.1 [0.12]	1.1 [0.12]	1.1 [0.12]	1.1 [0.12]	9.7 [1.1]	9.7 [1.1]	9.7 [1.1]	9.7 [1.1]
Weight Adder	lb [kg]	0.4 [0.2]	0.4 [0.2]	0.4 [0.2]	0.4 [0.2]	0.4 [0.2]	0.4 [0.2]	0.4 [0.2]	1.3 [0.6]	1.3 [0.6]	1.3 [0.6]	1.3 [0.6]
Voltage	VDC± 10%	24	24	24	24	24	24	24	24	24	24	24
Current	A	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.66	0.66	0.66	0.66
Engage Time	ms	25	25	25	25	25	25	25	20	20	20	20
Release Time	ms	25	25	25	25	25	25	25	30	30	30	30
Torque	in-lb [Nm]	10.6 [1.2]	10.6 [1.2]	10.6 [1.2]	10.6 [1.2]	10.6 [1.2]	10.6 [1.2]	10.6 [1.2]	88.5 [10]	88.5 [10]	88.5 [10]	88.5 [10]
Environmental Data												
Humidity (non-condensing)	RH	98%										
Ambient Temperature (operating)	°C	-20 to 40										
Storage Temperature	°C	-30 to 150										

1. Torque shown is available up to an ambient temperature of 25° C with motor mounted to a 10' x10' x 0.25' aluminum heat sink. For higher ambient temperatures, see section 2.3.
2. Shaft loads are based on L10 bearing life at 3,000 rpm and assume force is applied to center of shaft.
3. Peak torque ratings are limited by the specific amplifier based on the amplifier's peak current limitations.

Specification	Units	3T45-H	3T45-I	3T54-H	3T55-H	3T55-I	3T57-H	3T66-H	3T67-G	3T69-G
Continuous Stall Torque[1]	in-lb [Nm]	90.2 [10.2]	90.2 [10.2]	119.3 [13.48]	150.3 [16.98]	150.3 [16.98]	194.5 [21.98]	317.7 [35.9]	371 [41.9]	477 [53.9]
Continuous Torque w/ 480V, 20A drive	in-lb [Nm]	-	-	119.3 [13.48]	150.3 [16.98]	-	-	307 [34.69]	358.5 [40.5]	463 [52.3]
Peak Torque[3]	in-lb [Nm]	181 [20.45]	274.8 [31.05]	304.9 [34.45]	383.9 [43.38]	345.6 [39.05]	488.8 [55.23]	772.5 [87.29]	901.6 [101.9]	1165 [131.6]
Peak Torque w/ 480V, 20A drive	in-lb [Nm]	-	-	339 [38.3]	426 [48.1]	-	-	462 [52.2]	540 [61]	699 [78.9]
Rated Speed: @120v AC input @240v AC input @480v AC input	RPM	825 1,650 4,000	- 2,700 -	- 2,100 4,300	- 1,650 3,400	- 3,450 -	- 2,450 -	- 1,450 3,150	- 1,250 2,700	- 950 2,100
No-load speed @240v AC input @480v AC input	RPM	2,350 4,750	3,300 -	2,700 5,450	2,150 4,300	4,300 -	3,050 -	2,000 3,950	1,700 3,400	1,300 2,650
Feedback		4096 pulse/rev resolver (control transmitter; 0.5 transformation ratio)								
Weight	lb [kg]	22.9 [10.4]	22.9 [10.4]	28.6 [13]	33 [15]	33 [15]	41.9 [19]	79.3 [36]	92.5 [42]	119 [54]
Rotor Inertia	in-lb-s^2 x 10^{-4} [kg-m^2 x 10^{-4}]	74 [8.4]	74 [8.4]	220 [24.9]	271 [30.6]	271 [30.6]	373 [42.1]	833 [94]	965 [109]	1230 [139]
Shaft Thrust Load [2]	lb [kg]	41.5 [18.9]	41.5 [18.9]	31.5 [18.9]	31.5 [18.9]	31.5 [18.9]	31.5 [18.9]	48.3 [21.9]	48.3 [21.9]	48.3 [21.9]
Shaft Radial Load [2]	lb [kg]	157 [71.5]	157 [71.5]	115 [52.3]	115 [52.3]	115 [52.3]	115 [52.3]	200 [45]	200 [45]	200 [45]
Torque Constant	in-lb/A(rms) [Nm/A(rms)]	12.9 [1.46]	9.2 [1.04]	11.3 [1.27]	14.2 [1.6]	7.1 [0.8]	10 [1.13]	15.4 [1.74]	18 [2.04]	23.3 [2.63]
Resistance (phase)	Ohms	2.1	1.1	0.8	0.9	0.2	0.3	0.32	0.35	0.41
Inductance (phase)	mH	8.7	4.4	7.1	8.8	2.2	3.1	6.5	7.7	10
Electrical Time Constant	ms	4.1	4	8.9	9.8	11	10.3	20.3	22	24.4
Continuous Current	A(rms)	7.1	10	10.6	10.6	21.3	19.5	20.7	20.7	20.6
Optional Brake Data										
Inertia Adder	in-lb-s^2 x 10^{-4} [kg-m^2 x10^{-4}]	9.7 [1.1]	9.7 [1.1]	31.9 [3.6]	31.9 [3.6]	31.9 [3.6]	31.9 [3.6]	84.1 [9.5]	84.1 [9.5]	84.1 [9.5]
Weight Adder	lb [kg]	1.3 [0.6]	1.3 [0.6]	3.3 [1.5]	3.3 [1.5]	3.3 [1.5]	3.3 [1.5]	4.8 [2.2]	4.8 [2.2]	4.8 [2.2]
Voltage	VDC± 10%	24	24	24	24	24	24	24	24	24
Current	A	0.48	0.48	0.41	0.41	0.41	0.41	0.73	0.73	0.73
Engage Time	ms	20	20	25	25	25	25	25	25	25
Release Time	ms	30	30	50	50	50	50	75	75	75
Torque	in-lb [Nm]	88.5 [10]	88.5 [10]	159 [16]	159 [16]	159 [16]	159 [16]	354 [40]	354 [40]	354 [40]
Environmental Data										
Humidity (non-condensing)	RH	98%								
Ambient Temperature (operating)	°C	-20 to 40								
Storage Temperature	°C	-30 to 150								

1. Torque shown is available up to an ambient temperature of 25°C with motor mounted to a 10' x10' x 0.25' aluminum heat sink. For higher ambient temperatures, see section 2.3.
2. Shaft loads are based on L10 bearing life at 3000 rpm and assume force is applied to center of shaft.
3. Peak torque ratings are limited by the specific amplifier based on the amplifiers peak current limitations.

2.1.10 Stepping Motor Specifications

Table 2-15. Stepping Motor Specifications

Specification	Units	MTR-1221-D	MTR-1231-D	MTR-1324-D	MTR-1337-D	MTR-1350-A	MTR-1350-D	MTR-1N31-I-D	MTR-1N32-I-D	MTR-1N41-G-A	MTR-1N42-H-A
Holding Torque[2]	oz-in [Nm]	144 [1.02]	230 [1.62]	335 [2.37]	675 [4.77]	630 [4.45]	995 [7.02]	650 [4.59]	1,200 [8.47]	1,905 [13.45]	3,074 [21.71]
Inertia	oz-in-sec^2 [kg-m^2 x 10^{-3}]	0.0017 [0.012]	0.0036 [0.025]	0.0083 [0.059]	0.0170 [0.12]	0.0250 [0.176]	0.0250 [0.176]	0.0202 [0.14]	0.038 [0.27]	0.0783 [0.55]	0.1546 [1.09]
Rated Current/Phase	Amps	1.8	1.6	2.7	4.1	7.9	4.0	4.3	4.1	5.0	5.0
Phase Resistance[3]	Ohms	2.12	3.12	1.12	0.74	0.26	1.02	0.72	1.03	0.58	0.6
Phase Inductance	mH	8.0	12.4	10.0	8.9	3.1	12.6	5.8	10.3	7.8	9.8
Detent Torque	oz-in [Nm]	9.4 [0.066]	17 [0.12]	22 [0.16]	42 [0.3]	64 [0.45]	64 [0.45]	18 [0.13]	36 [0.25]	65 [0.46]	126 [0.89]
Number of Phases	N/A	2	2	2	2	2	2	2	2	2	2
Number of Poles	N/A	50	50	50	50	50	50	50	50	50	50
Full Steps per Revolution	Steps	200	200	200	200	200	200	200	200	200	200
Full Step Angle	Degrees	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Weight	Ib [kg]	1.5 [0.68]	2.5 [1.13]	3.2 [1.45]	5.3 [2.41]	7.6 [3.45]	7.6 [3.45]	5.0 [2.27]	8.4 [3.81]	11 [4.98]	18.4 [8.34]

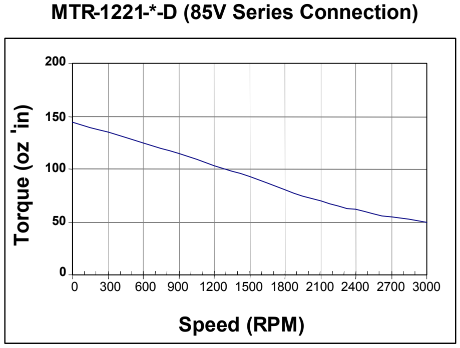
Notes:

1. All ratings typical at 25°C unless otherwise noted.
2. Holding torque specified for motor winding temperature at 130°C and motor unmounted in still air at 40°C.
3. Phase resistance with winding at 130°C and motor in still air at 40°C

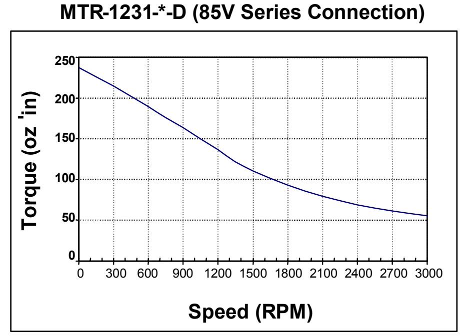
2.2 Motor Speed/Torque Curves

2.2.1 MTR-Series Stepping Motor/Controller Curves

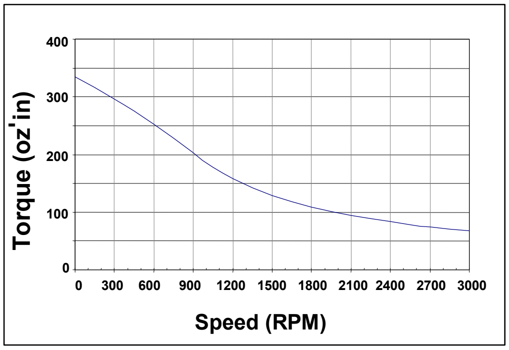
MTR-1221-*-D (85V Series Connection)



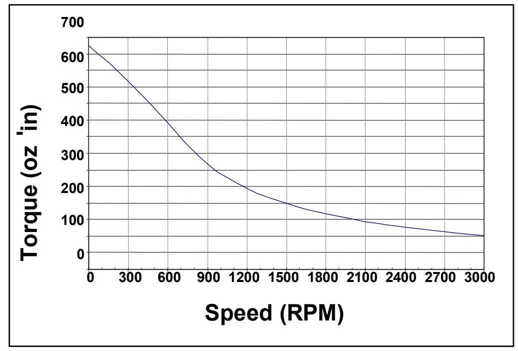
MTR-1231-*-D (85V Series Connection)



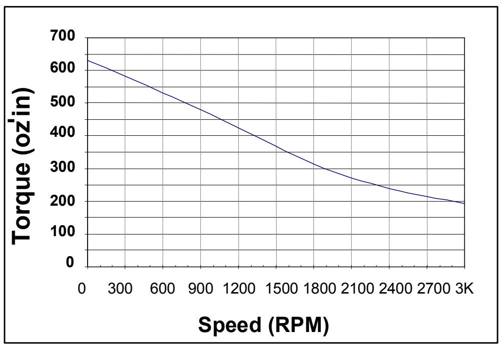
MTR-1324-*-D (85V Series Connection)



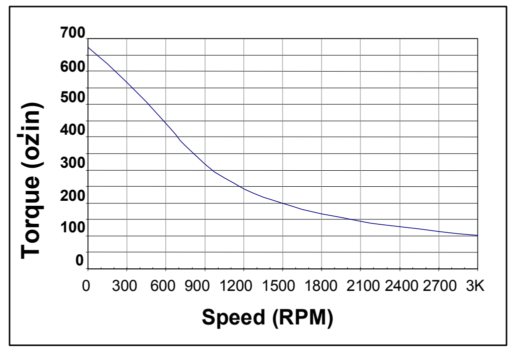
MTR-1337-*-D (85V Series Connection)



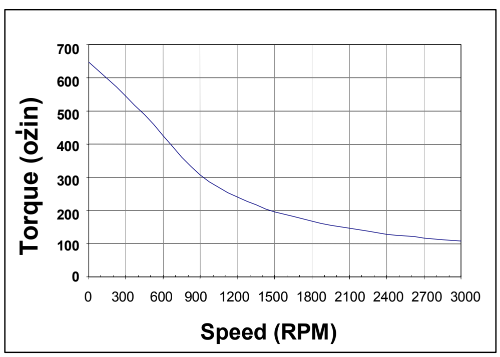
MTR-1350-*-A (85V Parallel Connection)



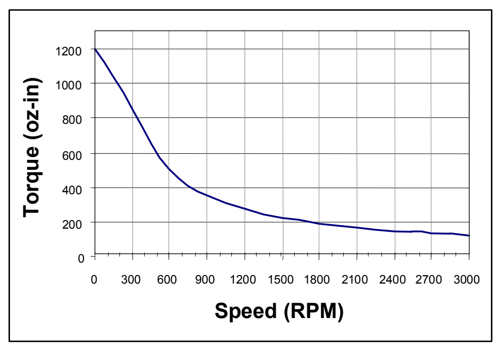
MTR-1350-*-D (85V Series Connection)



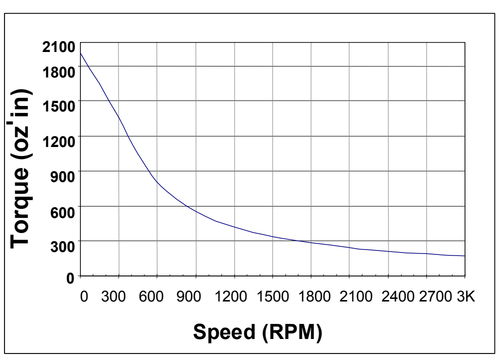
MTR-1N31-I-*-D (85V Series Connection)



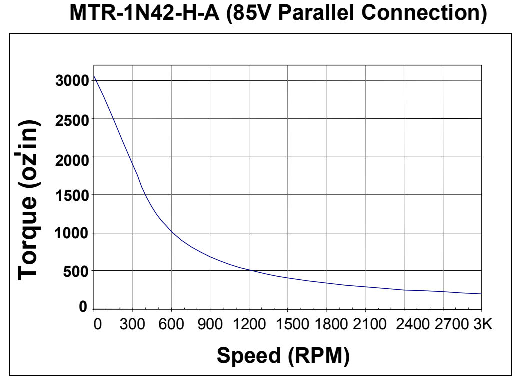
MTR-1N32-I-*-D (85V Series Connection)



MTR-1N41-G-A (85V Parallel Connection)



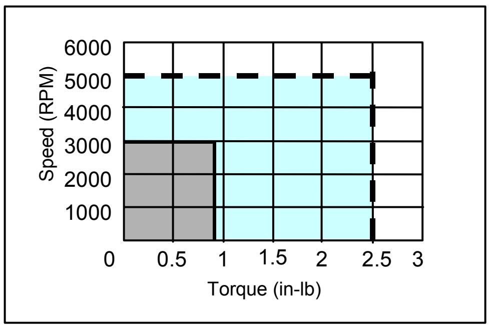
MTR-1N42-H-A (85V Parallel Connection)



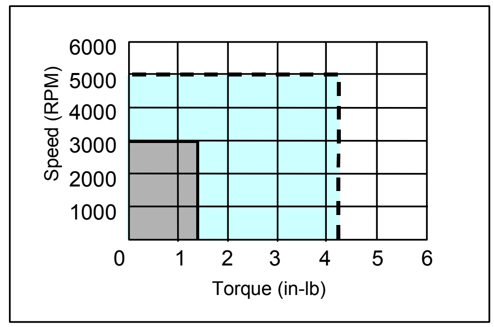
2.2.2 S-Series Servo Motor / Controller Curves

The curves below illustrate the relationship between motor speed and output torque when used with the specified S2K series model. The motor can operate continuously at any combination of speed and torque within the prescribed continuous operating zone. Curves are shown for a 230 VAC nominal supply.

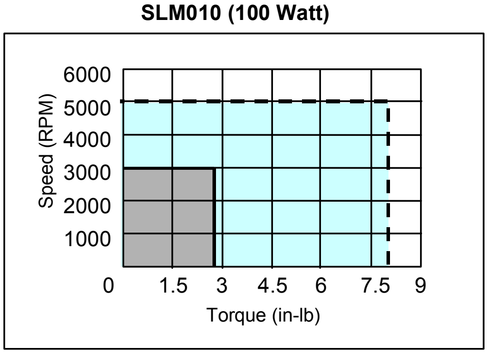
SLM003 (30 Watt)



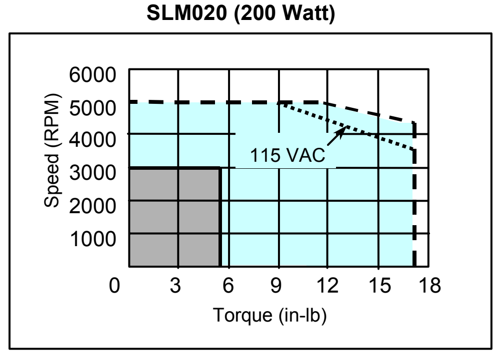
SLM005 (50 Watt)



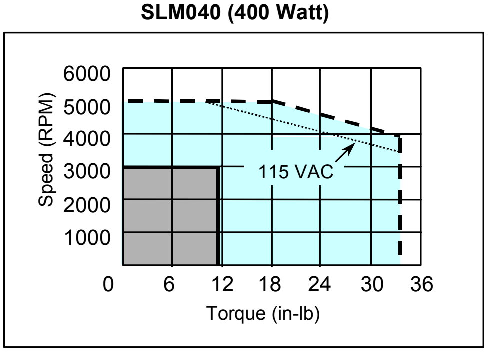
SLM010 (100 Watt)



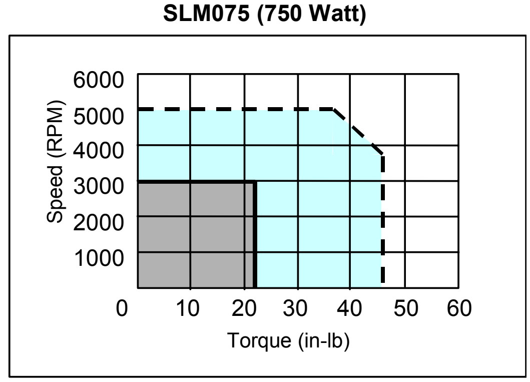
SLM020 (200 Watt)



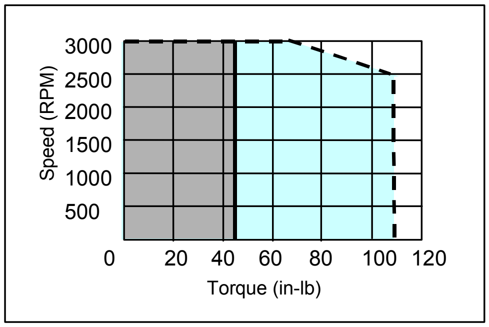
SLM040 (400 Watt)



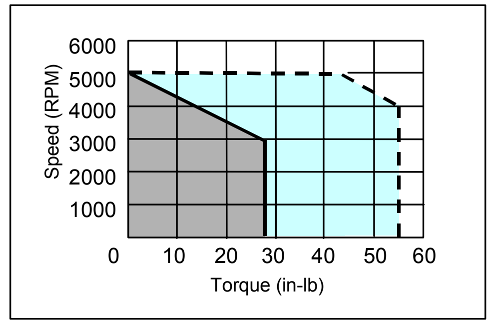
SLM075 (750 Watt)



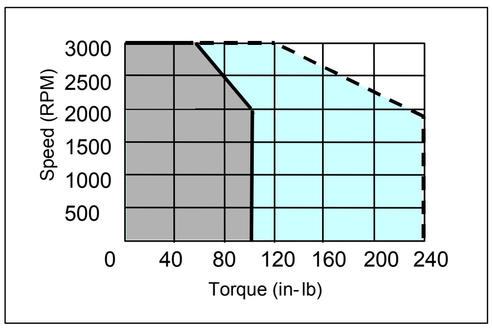
SDM100 (1000 Watt)



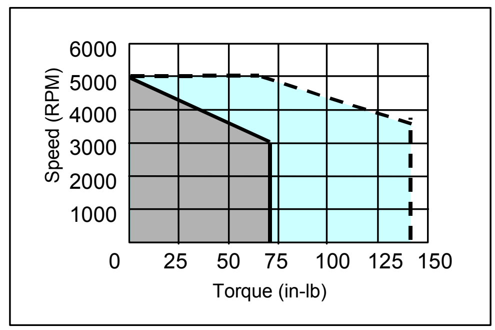
SLM100 (1000 Watt)



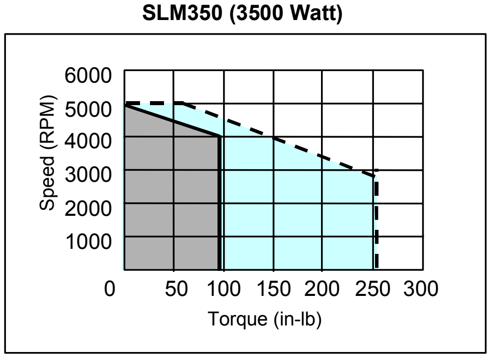
SDM250 (2500 Watt)



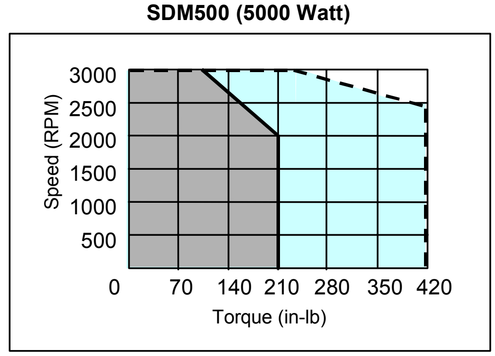
SLM250 (2500 Watt)



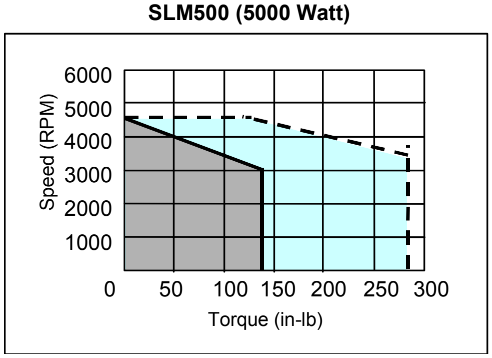
SLM350 (3500 Watt)



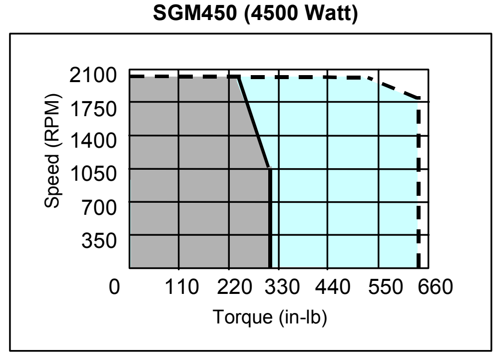
SDM500 (5000 Watt)



SLM500 (5000 Watt)



SGM450 (4500 Watt)



Note

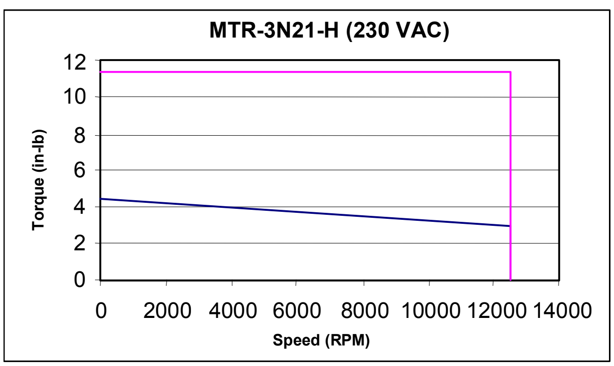
Continuous torque available for each motor model depends on the ambient temperature. These curves depict the maximum continuous torque available for each model up to the following ambient temperatures:

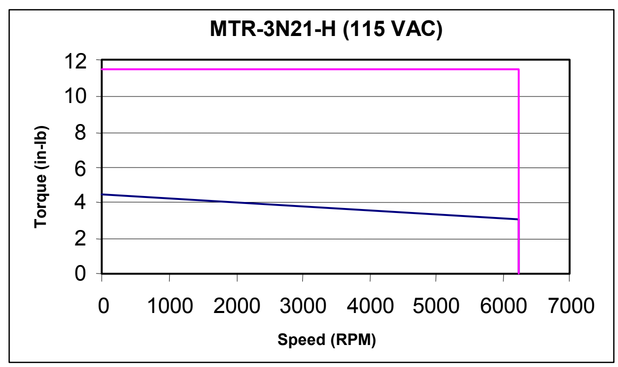
- SLM003, SLM100, SDM100, SDM250 & SGM450 = 40°C
- SLM005, SLM250, SLM500 = 20°C
- SLM350 = 25°C
- SDM500 = 35 C

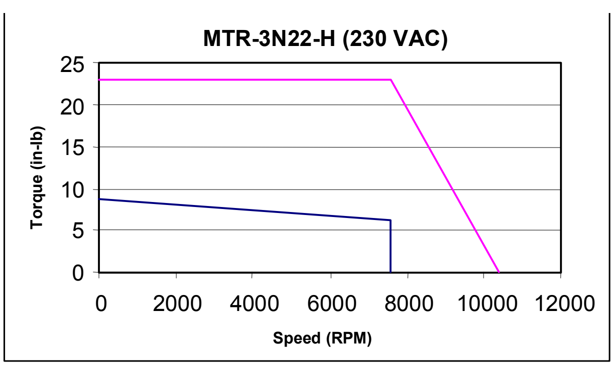
Higher ambient temperatures require motor derating as shown in the temperature derating curves in Section 2.3.

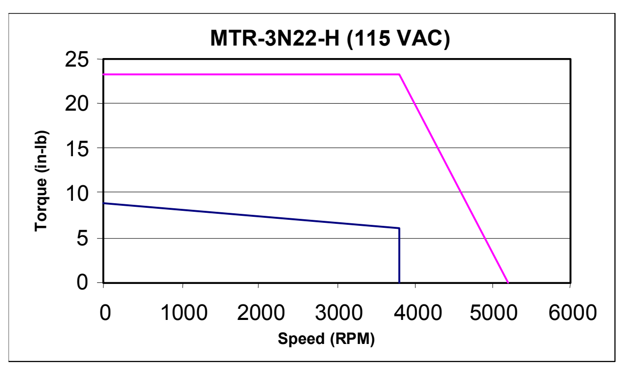
2.2.3 MTR-Series Servo Motor / Controller Curves

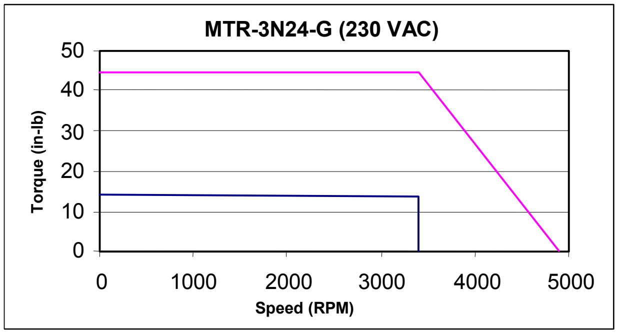
The curves below illustrate the relationship between motor speed and output torque when used with the specified S2K series model. The motor can operate continuously at any combination of speed and torque within the prescribed continuous operating zone. Curve titles indicate the VAC nominal supply.

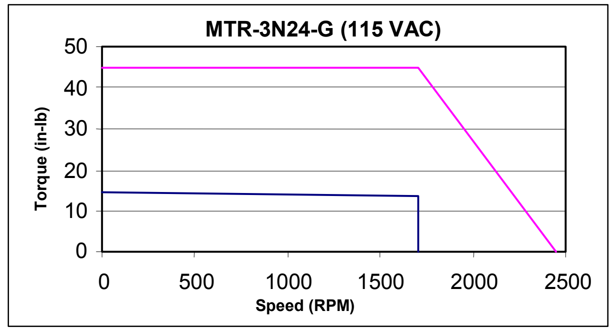


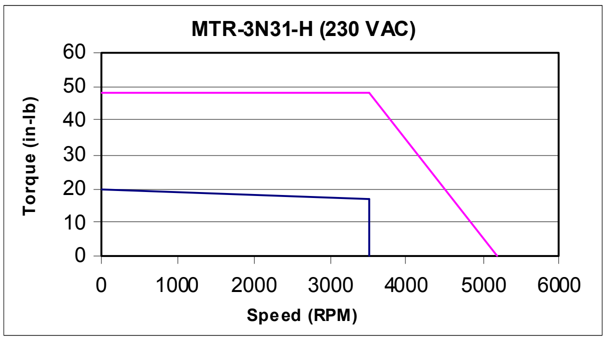


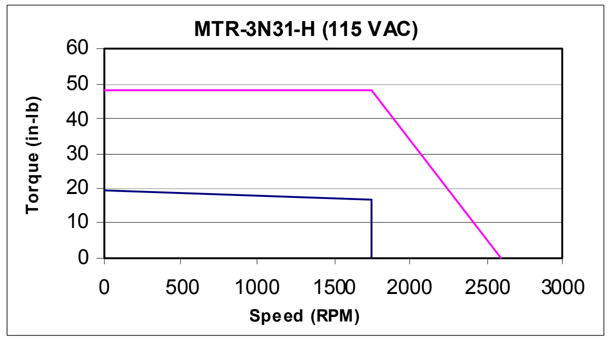


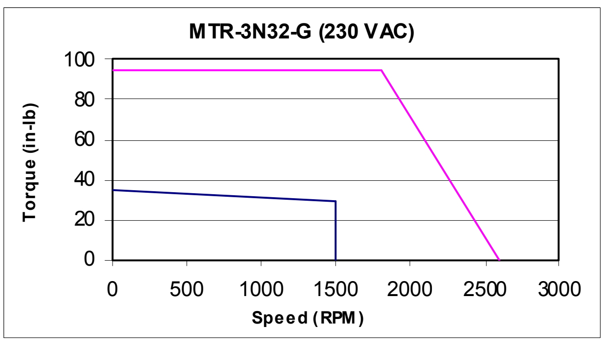


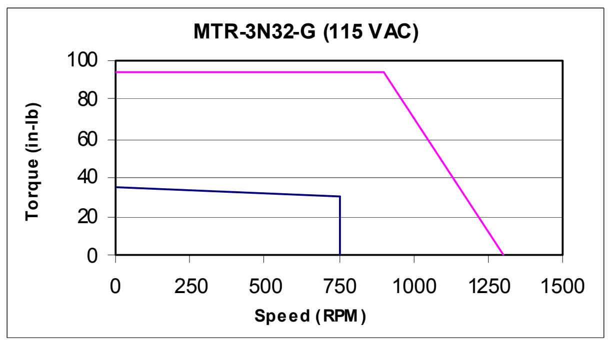

MTR-3N24-G (230 VAC)
Torque (in-lb)
Speed (RPM)

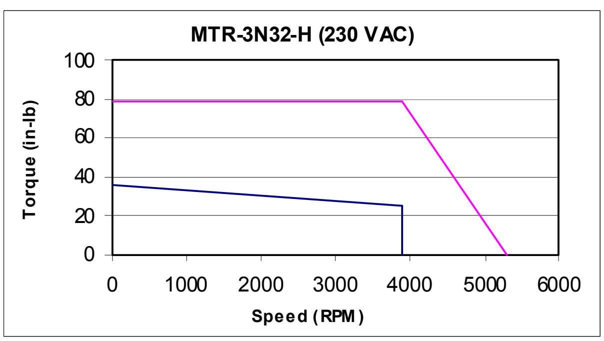

MTR-3N24-G (115 VAC)
Torque (in-lb)
Speed (RPM)

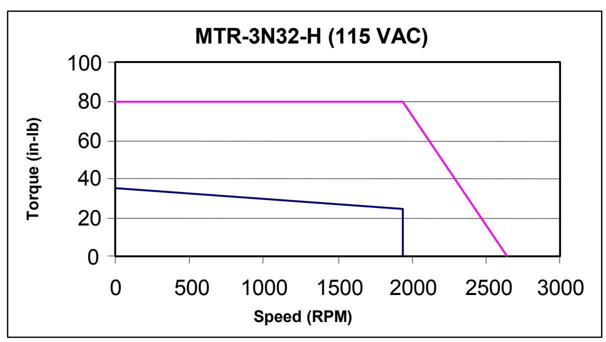

MTR-3N31-H (230 VAC)
Torque (in-lb)
Speed (RPM)

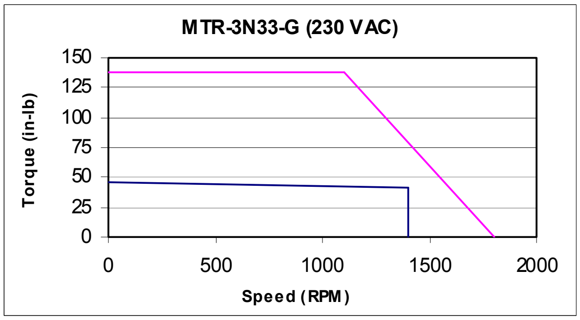

MTR-3N31-H (115 VAC)
Torque (in-lb)
Speed (RPM)

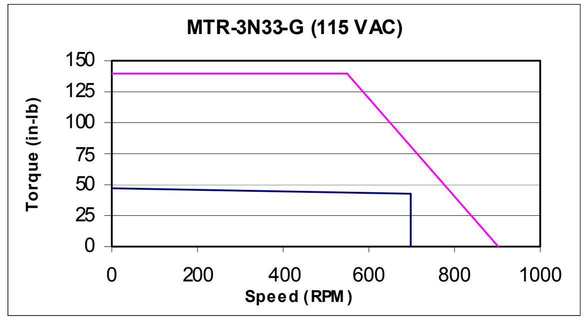

MTR-3N32-G (230 VAC)
Torque (in-lb)
Speed (RPM)

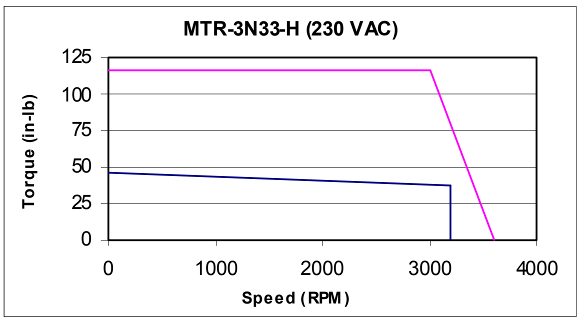

MTR-3N32-G (115 VAC)
Torque (in-lb)
Speed (RPM)

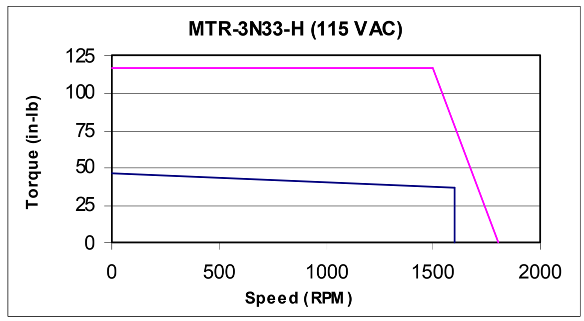

MTR-3N32-H (230 VAC)
Torque (in-lb)
Speed (RPM)

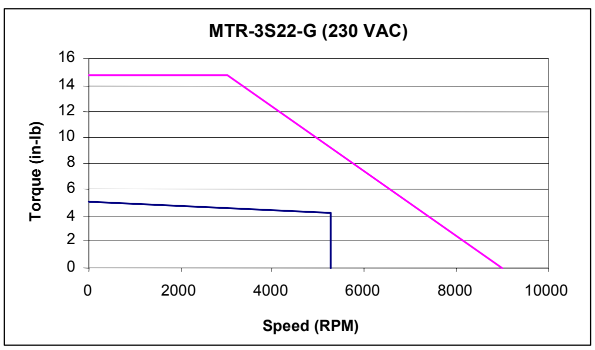

MTR-3N32-H (115 VAC)
Torque (in-lb)
Speed (RPM)

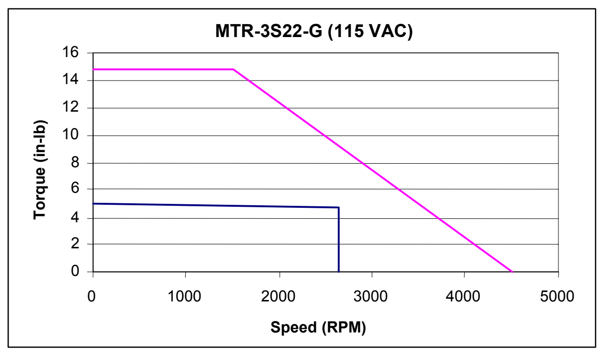

MTR-3N33-G (230 VAC)
Torque (in-lb)
150
125
100
75
50
25
0
0
500
1000
1500
2000
Speed (RPM)

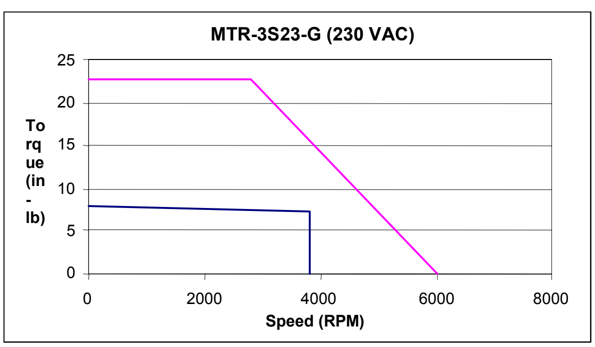

MTR-3N33-G (115 VAC)
Torque (in-lb)
150
125
100
75
50
25
0
0
200
400
600
800
1000
Speed (RPM)

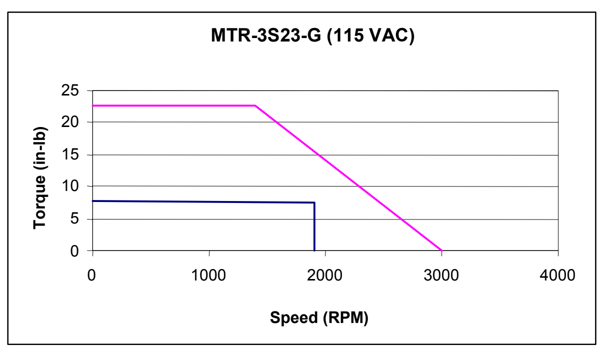

MTR-3N33-H (230 VAC)
Torque (in-lb)
125
100
75
50
25
0
0
1000
2000
3000
4000
Speed (RPM)

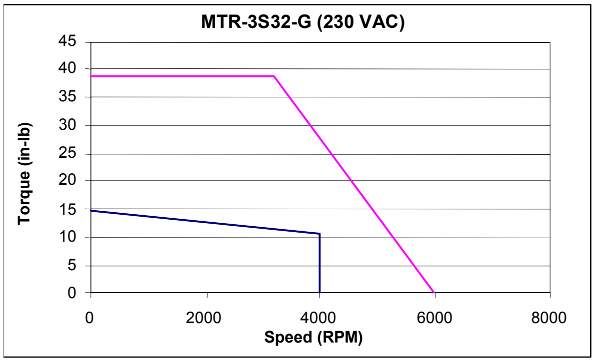

MTR-3N33-H (115 VAC)
Torque (in-lb)
125
100
75
50
25
0
0
500
1000
1500
2000
Speed (RPM)

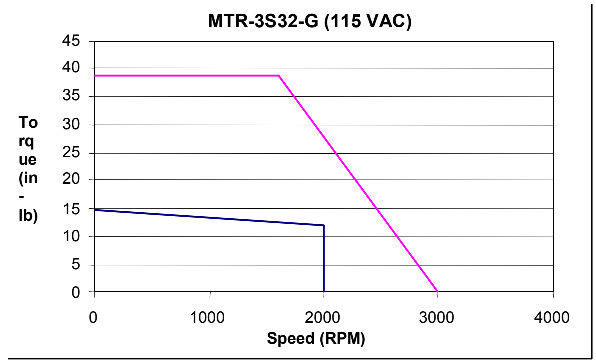

MTR-3S22-G (230 VAC)
Torque (in-lb)
16
14
12
10
8
6
4
2
0
0
2000
4000
6000
8000
10000
Speed (RPM)

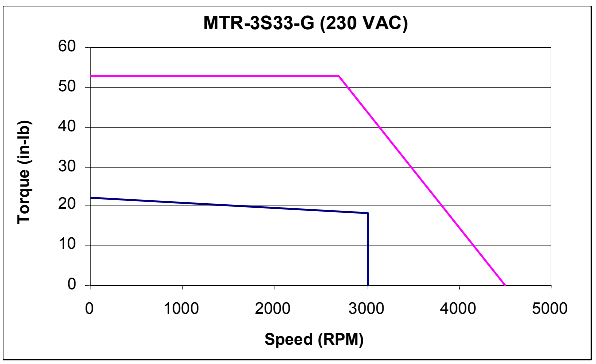

MTR-3S22-G (115 VAC)
Torque (in-lb)
16
14
12
10
8
6
4
2
0
0
1000
2000
3000
4000
5000
Speed (RPM)

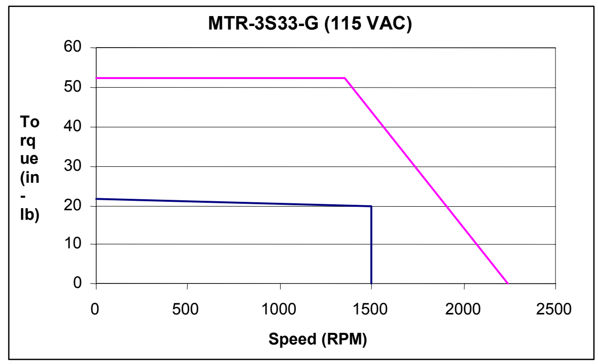

MTR-3S23-G (230 VAC)
Torque (in-lb)
25
20
15
10
5
0
0
2000
4000
6000
8000
Speed (RPM)

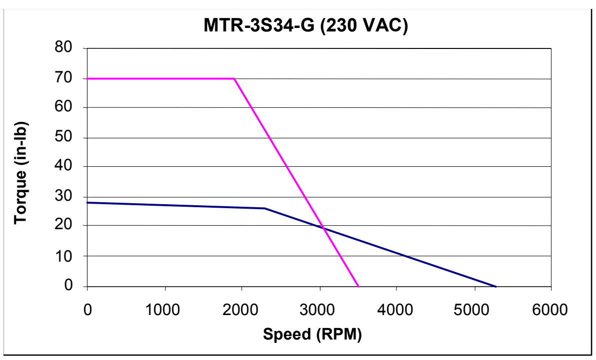

MTR-3S23-G (115 VAC)
Torque (in-lb)
25
20
15
10
5
0
0
1000
2000
3000
4000
Speed (RPM)

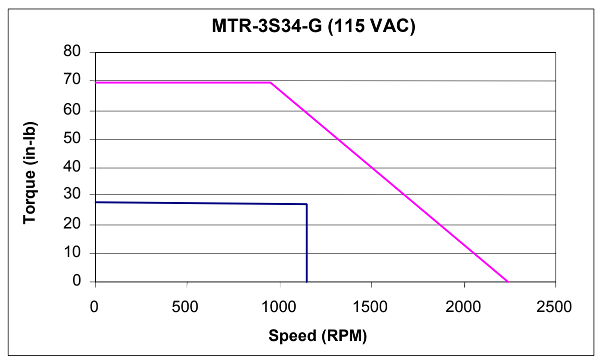

MTR-3S32-G (230 VAC)
Torque (in-lb)
Speed (RPM)
0 5 10 15 20 25 30 35 40 45
0 2000 4000 6000 8000

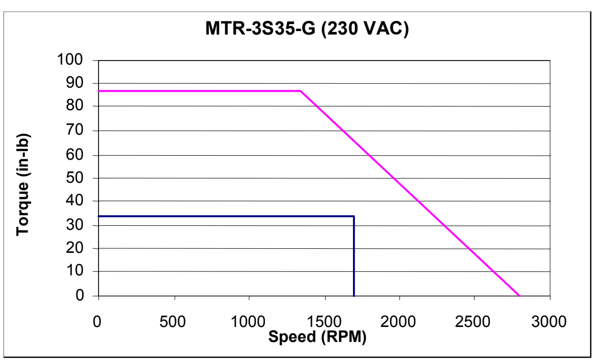

MTR-3S32-G (115 VAC)
To rq ue (in - lb)
Speed (RPM)
0 5 10 15 20 25 30 35 40 45
0 1000 2000 3000 4000

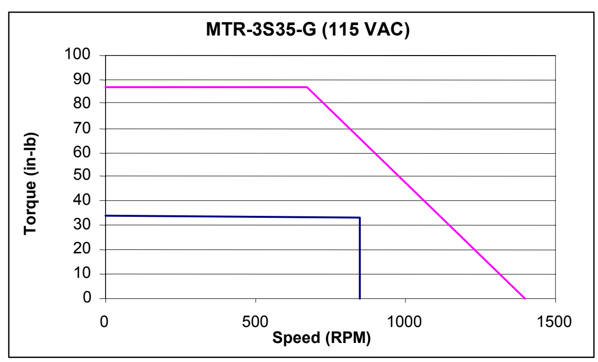

MTR-3S33-G (230 VAC)
Torque (in-lb)
Speed (RPM)
0 10 20 30 40 50 60
0 1000 2000 3000 4000 5000

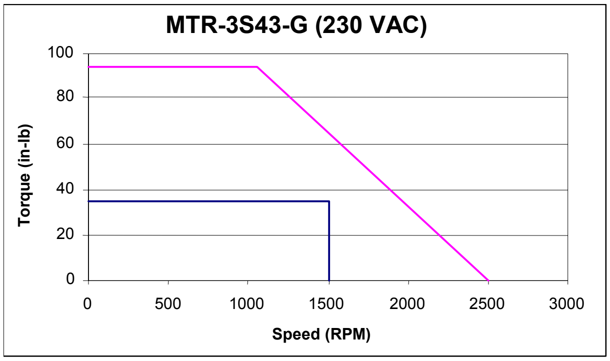

MTR-3S33-G (115 VAC)
To rq ue (in - lb)
Speed (RPM)
0 10 20 30 40 50 60
0 500 1000 1500 2000 2500

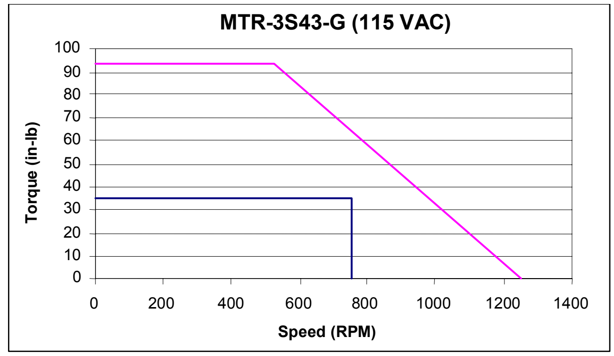

MTR-3S34-G (230 VAC)
Torque (in-lb)
Speed (RPM)
0 10 20 30 40 50 60 70 80
0 1000 2000 3000 4000 5000 6000

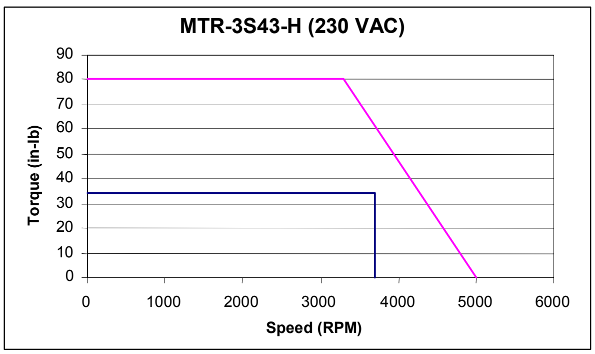

MTR-3S34-G (115 VAC)
Torque (in-lb)
Speed (RPM)
0 10 20 30 40 50 60 70 80
0 500 1000 1500 2000 2500

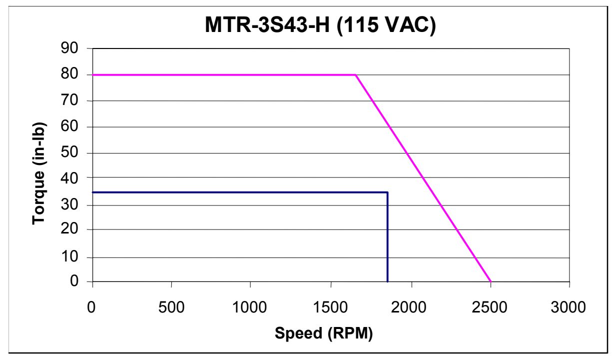

MTR-3S35-G (230 VAC)
Torque (in-lb)
Speed (RPM)
0 10 20 30 40 50 60 70 80 90 100
0 500 1000 1500 2000 2500 3000

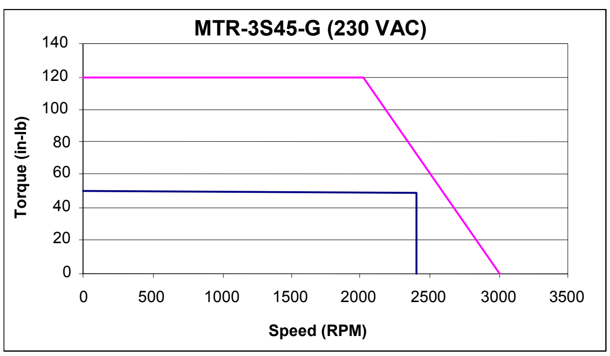

MTR-3S35-G (115 VAC)
Torque (in-lb)
Speed (RPM)
0 10 20 30 40 50 60 70 80 90 100
0 500 1000 1500

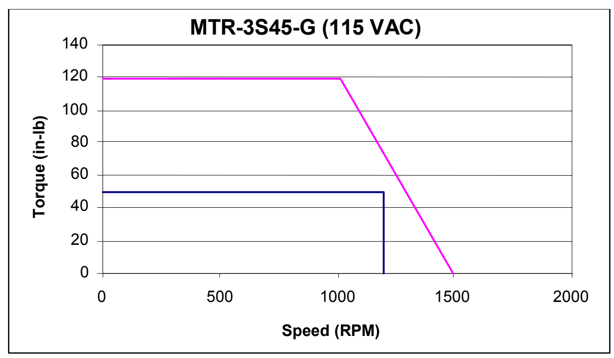

MTR-3S43-G (230 VAC)
Torque (in-lb)
Speed (RPM)

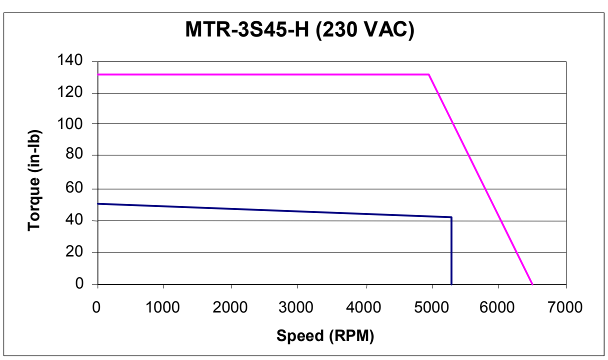

MTR-3S43-G (115 VAC)
Torque (in-lb)
Speed (RPM)

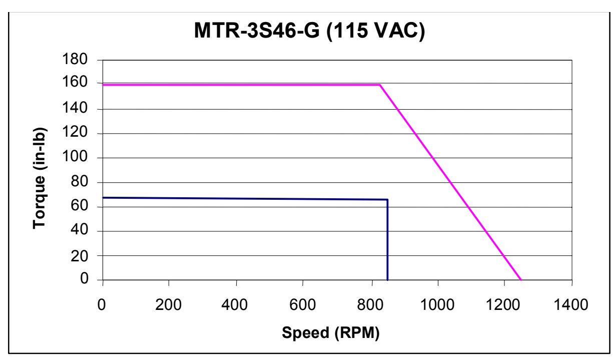

MTR-3S43-H (230 VAC)
Torque (in-lb)
Speed (RPM)

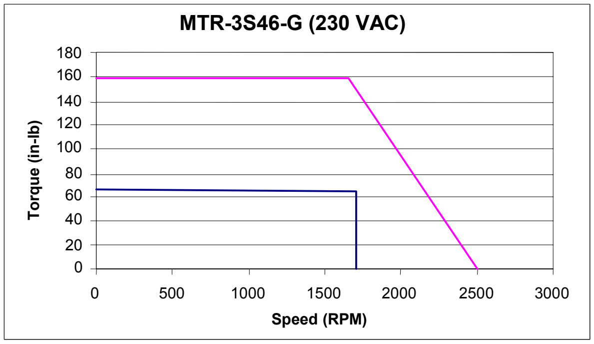

MTR-3S43-H (115 VAC)
Torque (in-lb)
Speed (RPM)

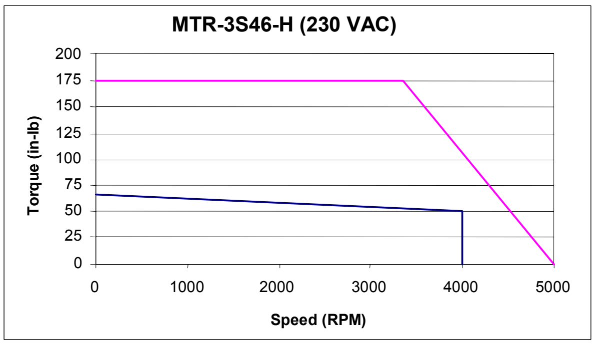

MTR-3S45-G (230 VAC)
Torque (in-lb)
Speed (RPM)

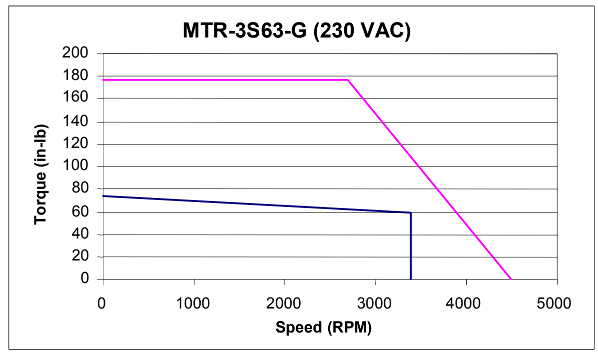

MTR-3S45-G (115 VAC)
Torque (in-lb)
Speed (RPM)

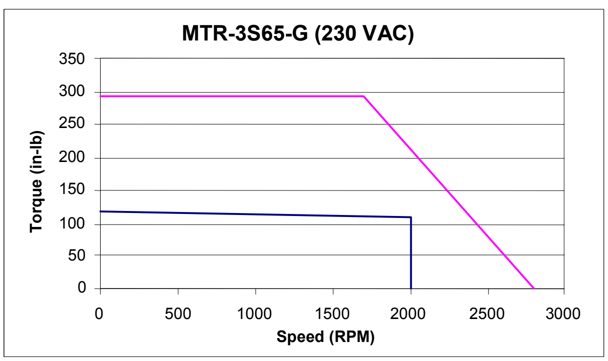

MTR-3S45-H (230 VAC)
Torque (in-lb)
Speed (RPM)

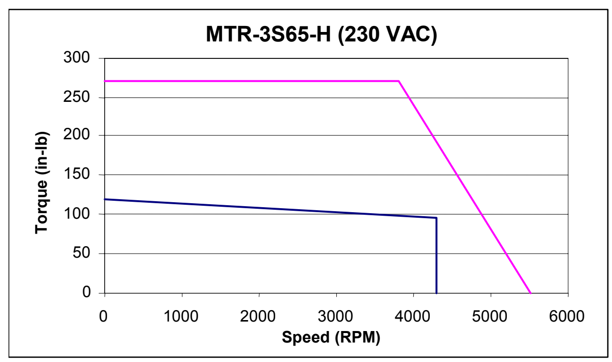

MTR-3S46-G (115 VAC)
Torque (in-lb)
Speed (RPM)

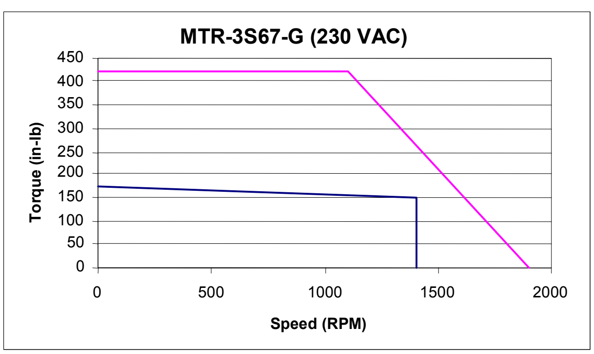

MTR-3S46-G (230 VAC)
Torque (in-lb)
180
160
140
120
100
80
60
40
20
0
0
500
1000
1500
2000
2500
3000
Speed (RPM)

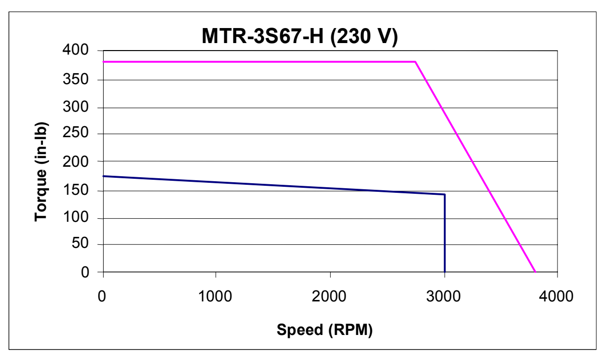

MTR-3S46-H (230 VAC)
Torque (in-lb)
200
175
150
125
100
75
50
25
0
0
1000
2000
3000
4000
5000
Speed (RPM)

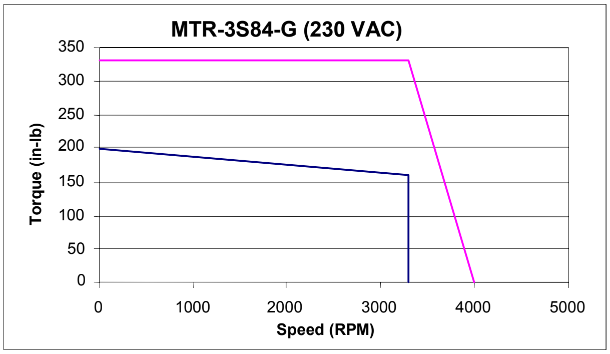

MTR-3S63-G (230 VAC)
Torque (in-lb)
200
180
160
140
120
100
80
60
40
20
0
0
1000
2000
3000
4000
5000
Speed (RPM)

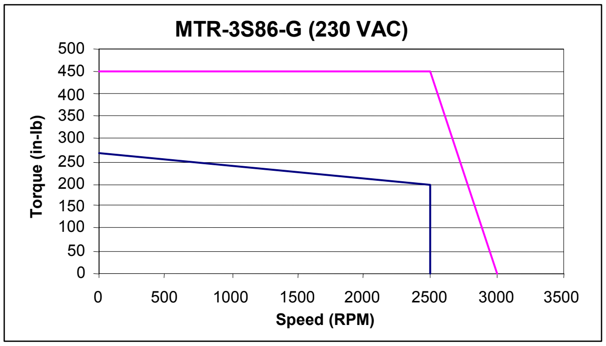

MTR-3S65-G (230 VAC)
Torque (in-lb)
350
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
Speed (RPM)

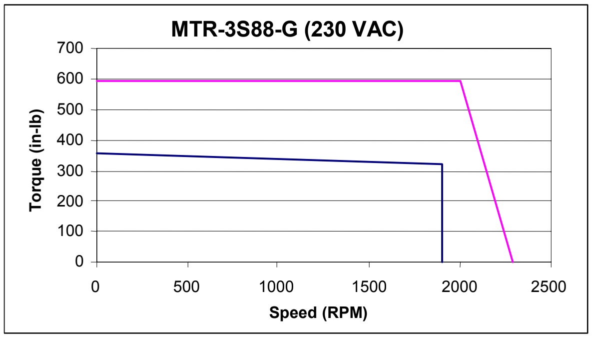

MTR-3S65-H (230 VAC)
Torque (in-lb)
300
250
200
150
100
50
0
0
1000
2000
3000
4000
5000
6000
Speed (RPM)

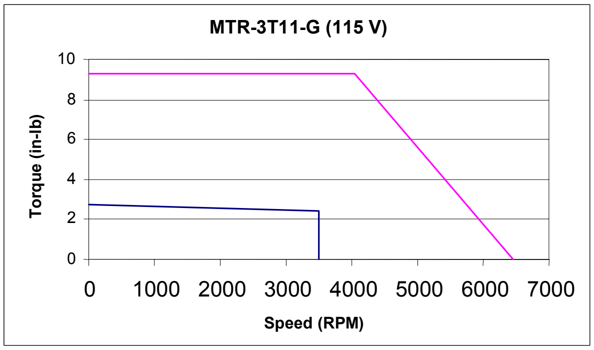

MTR-3S67-G (230 VAC)
Torque (in-lb)
450
400
350
300
250
200
150
100
50
0
0
500
1000
1500
2000
Speed (RPM)

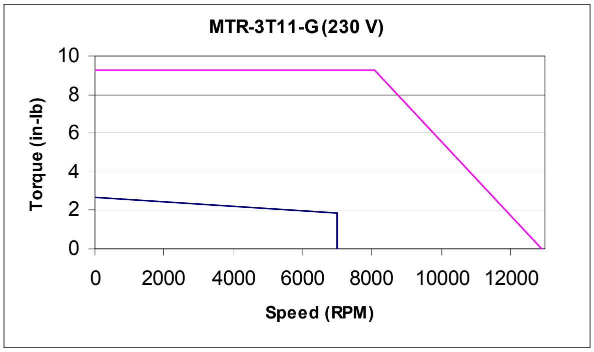

MTR-3S67-H (230 V)
Torque (in-lb)
400
350
300
250
200
150
100
50
0
0
1000
2000
3000
4000
Speed (RPM)

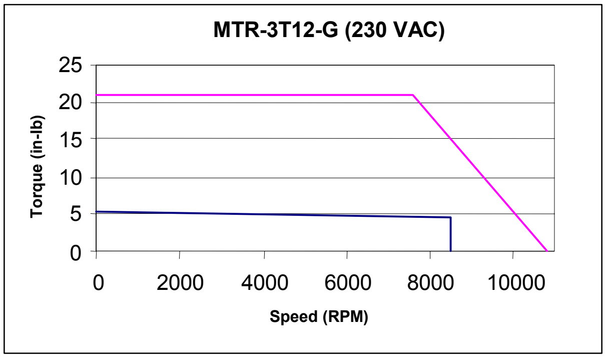

MTR-3S84-G (230 VAC)
Torque (in-lb)
Speed (RPM)
350
300
250
200
150
100
50
0
0
1000
2000
3000
4000
5000

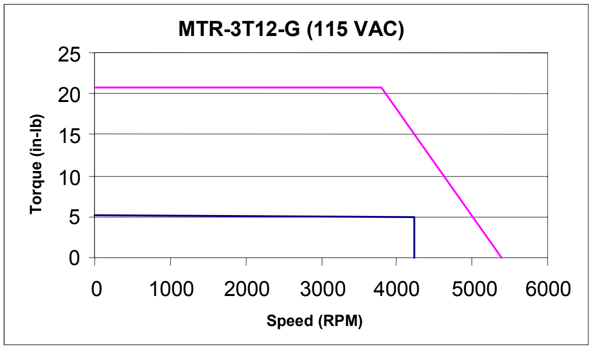

MTR-3S86-G (230 VAC)
Torque (in-lb)
Speed (RPM)
500
450
400
350
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
3500

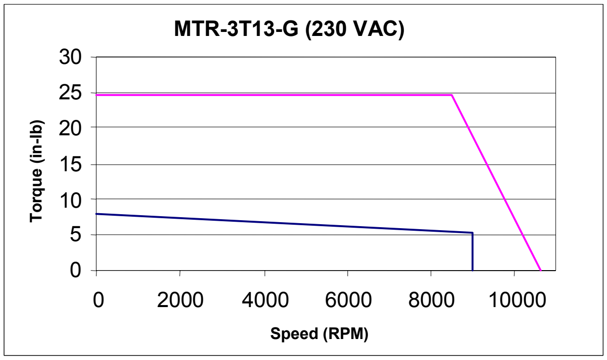

MTR-3S88-G (230 VAC)
Torque (in-lb)
Speed (RPM)
700
600
500
400
300
200
100
0
0
500
1000
1500
2000
2500

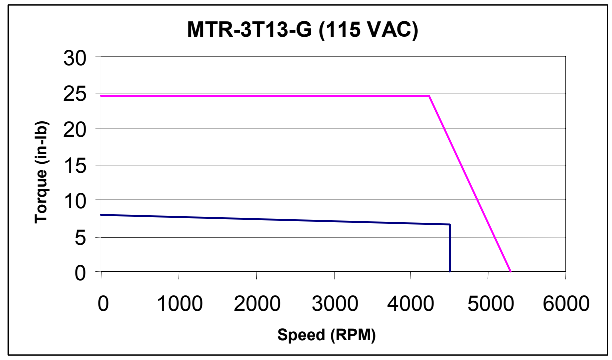

MTR-3T11-G (115 V)
Torque (in-lb)
Speed (RPM)
10
8
6
4
2
0
0
1000
2000
3000
4000
5000
6000
7000

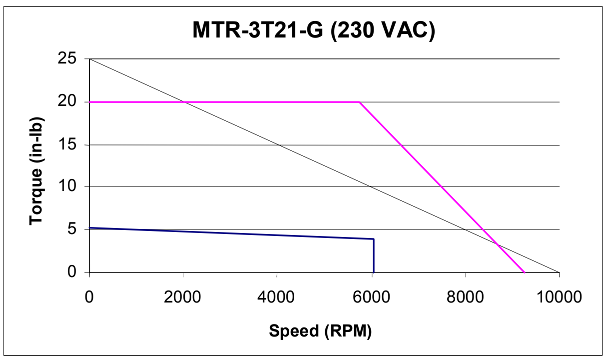

MTR-3T11-G (230 V)
Torque (in-lb)
Speed (RPM)
10
8
6
4
2
0
0
2000
4000
6000
8000
10000
12000

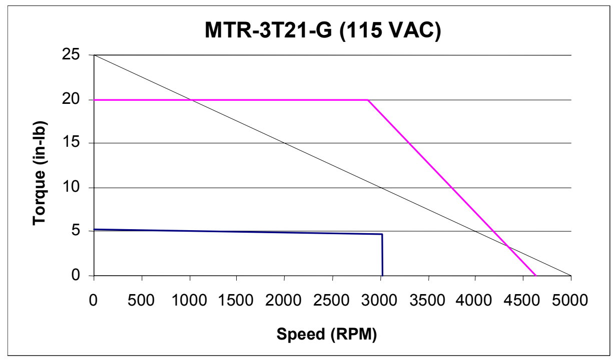

MTR-3T12-G (230 VAC)
Torque (in-lb)
Speed (RPM)
25
20
15
10
5
0
0
2000
4000
6000
8000
10000

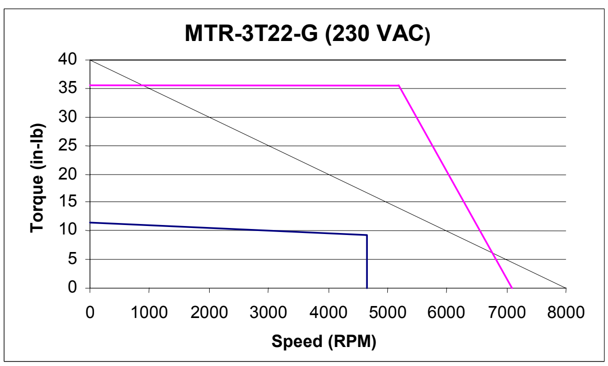

MTR-3T12-G (115 VAC)
Torque (in-lb)
Speed (RPM)
25
20
15
10
5
0
0
1000
2000
3000
4000
5000
6000

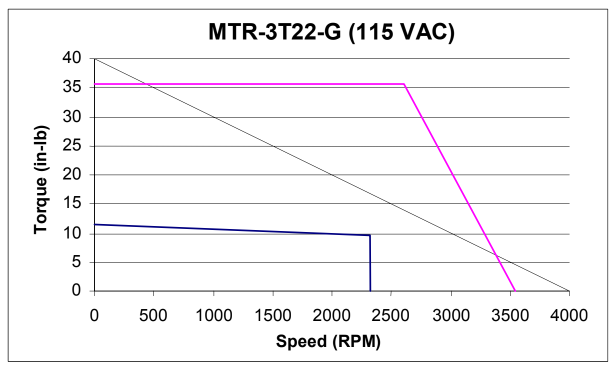

MTR-3T13-G (230 VAC)
Torque (in-lb)
30 25 20 15 10 5 0
0 2000 4000 6000 8000 10000
Speed (RPM)

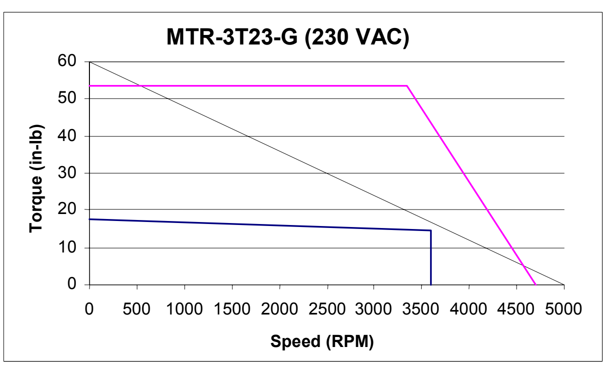

MTR-3T13-G (115 VAC)
Torque (in-lb)
30 25 20 15 10 5 0
0 1000 2000 3000 4000 5000 6000
Speed (RPM)

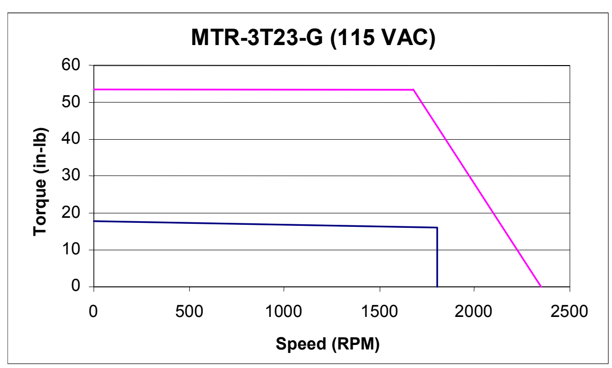

MTR-3T21-G (230 VAC)
Torque (in-lb)
25 20 15 10 5 0
0 2000 4000 6000 8000 10000
Speed (RPM)

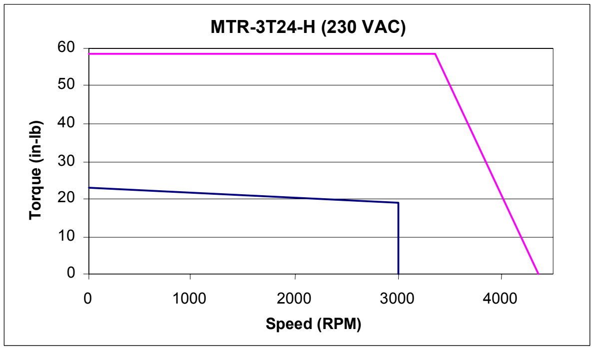

MTR-3T21-G (115 VAC)
Torque (in-lb)
25 20 15 10 5 0
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
Speed (RPM)

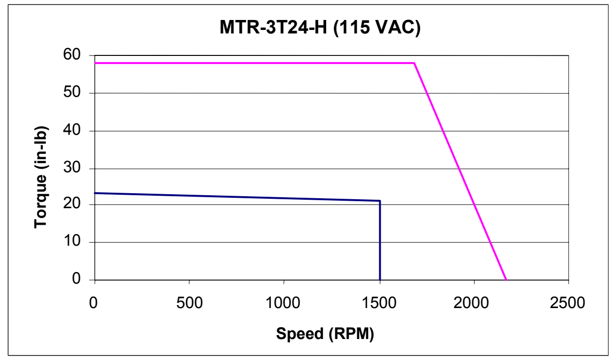

MTR-3T22-G (230 VAC)
Torque (in-lb)
40 35 30 25 20 15 10 5 0
0 1000 2000 3000 4000 5000 6000 7000 8000
Speed (RPM)

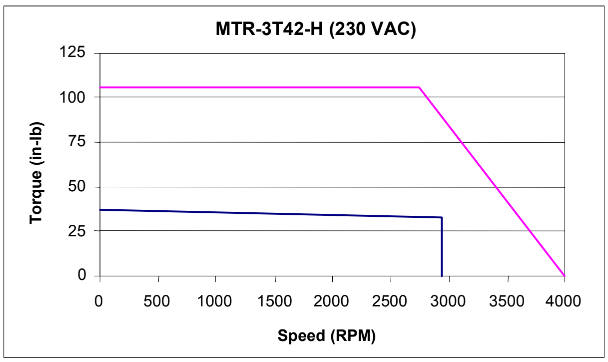

MTR-3T22-G (115 VAC)
Torque (in-lb)
40 35 30 25 20 15 10 5 0
0 500 1000 1500 2000 2500 3000 3500 4000
Speed (RPM)

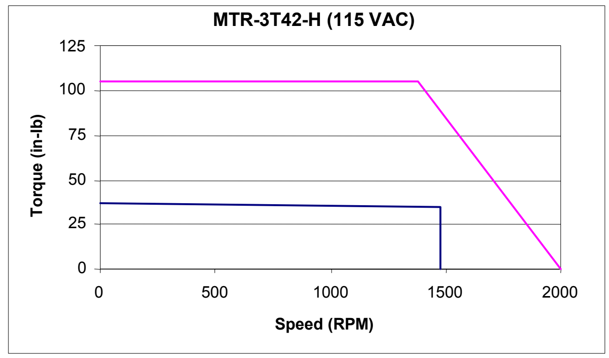

MTR-3T23-G (230 VAC)
Torque (in-lb)
60 50 40 30 20 10 0
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
Speed (RPM)

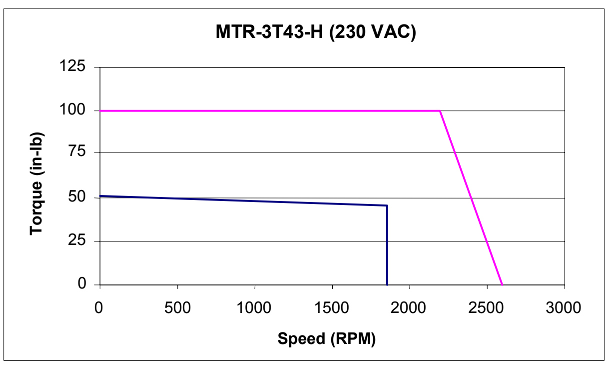

MTR-3T23-G (115 VAC)
Torque (in-lb)
60 50 40 30 20 10 0
0 500 1000 1500 2000 2500
Speed (RPM)

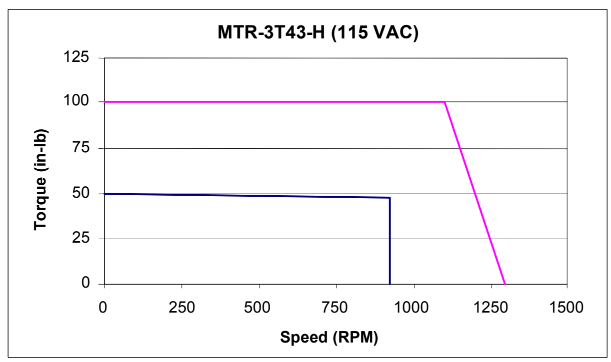

MTR-3T24-H (230 VAC)
Torque (in-lb)
Speed (RPM)
0 10 20 30 40 50 60
0 1000 2000 3000 4000

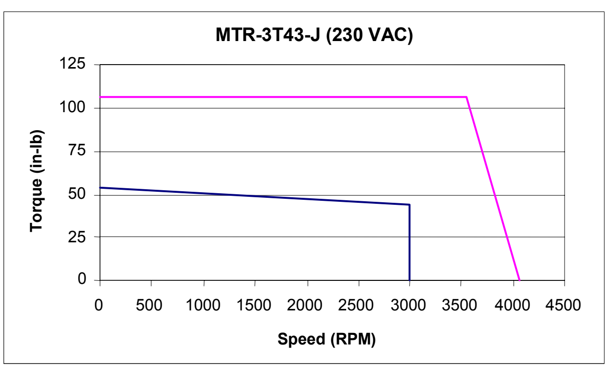

MTR-3T24-H (115 VAC)
Torque (in-lb)
Speed (RPM)
0 10 20 30 40 50 60
0 500 1000 1500 2000 2500

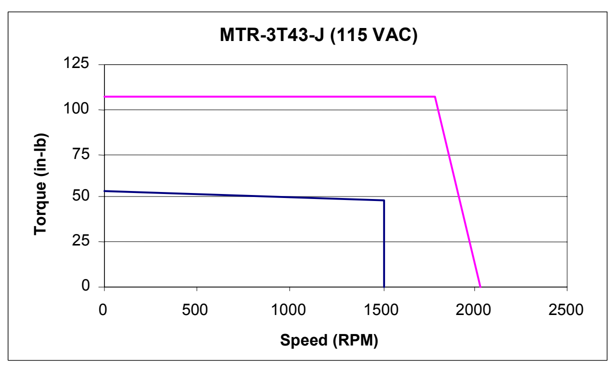

MTR-3T42-H (230 VAC)
Torque (in-lb)
Speed (RPM)
0 25 50 75 100 125
0 500 1000 1500 2000 2500 3000 3500 4000

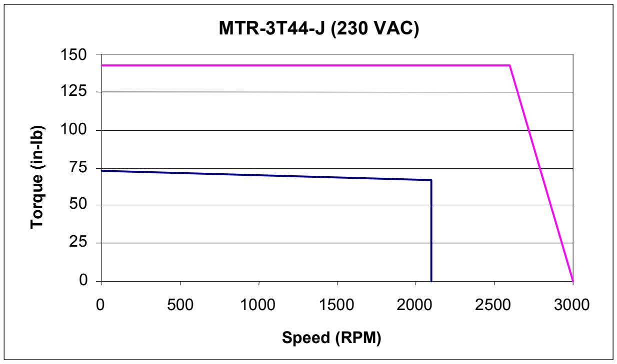

MTR-3T42-H (115 VAC)
Torque (in-lb)
Speed (RPM)
0 25 50 75 100 125
0 500 1000 1500 2000

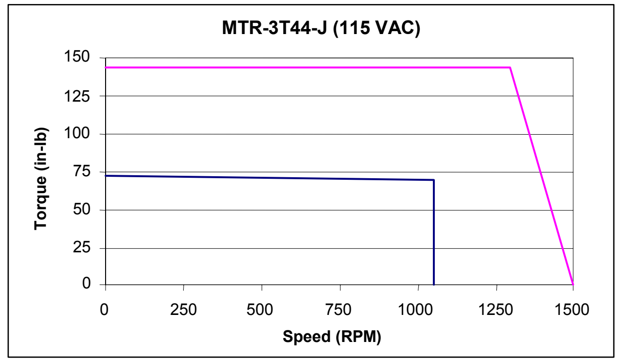

MTR-3T43-H (230 VAC)
Torque (in-lb)
Speed (RPM)
0 25 50 75 100 125
0 500 1000 1500 2000 2500 3000

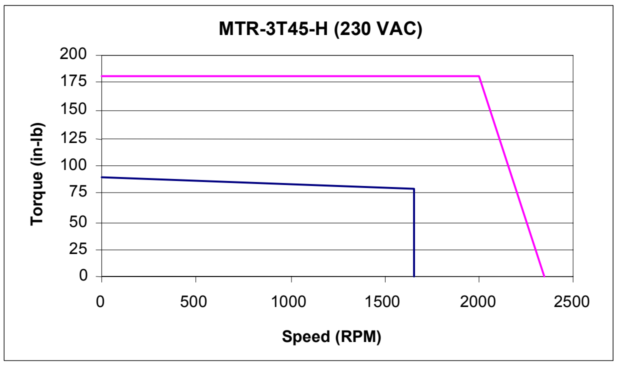

MTR-3T43-H (115 VAC)
Torque (in-lb)
Speed (RPM)
0 25 50 75 100 125
0 250 500 750 1000 1250 1500

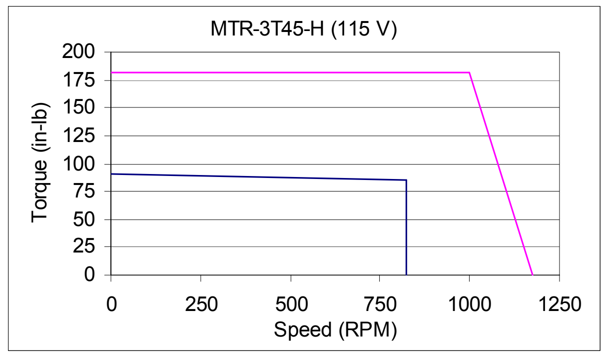

MTR-3T43-J (230 VAC)
Torque (in-lb)
Speed (RPM)
0 25 50 75 100 125
0 500 1000 1500 2000 2500 3000 3500 4000 4500

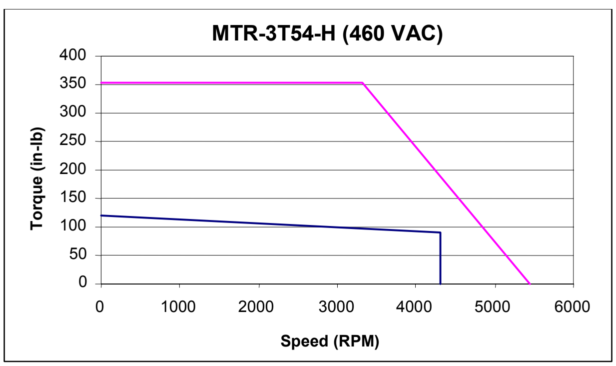

MTR-3T43-J (115 VAC)
Torque (in-lb)
Speed (RPM)
0 25 50 75 100 125
0 500 1000 1500 2000 2500

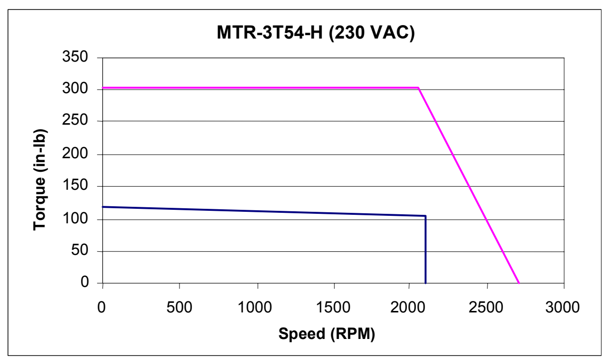

MTR-3T44-J (230 VAC)
Torque (in-lb)
Speed (RPM)

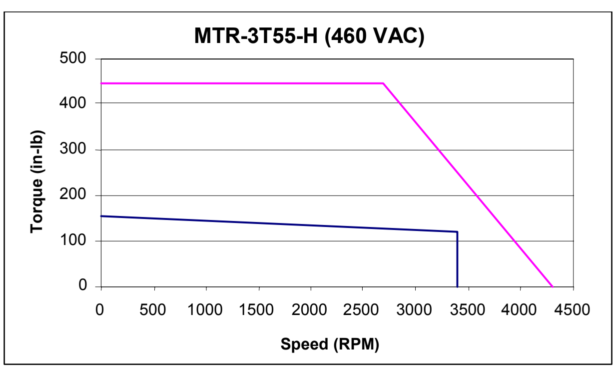

MTR-3T44-J (115 VAC)
Torque (in-lb)
Speed (RPM)

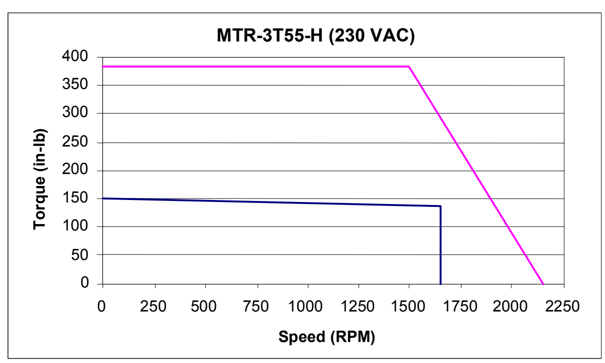

MTR-3T45-H (230 VAC)
Torque (in-lb)
Speed (RPM)

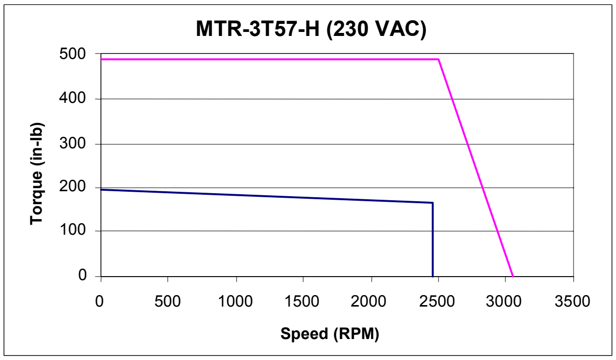

MTR-3T45-H (115 V)
Torque (in-lb)
Speed (RPM)

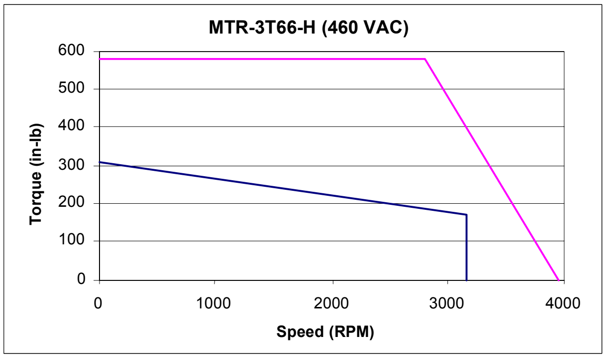

MTR-3T54-H (460 VAC)
Torque (in-lb)
Speed (RPM)

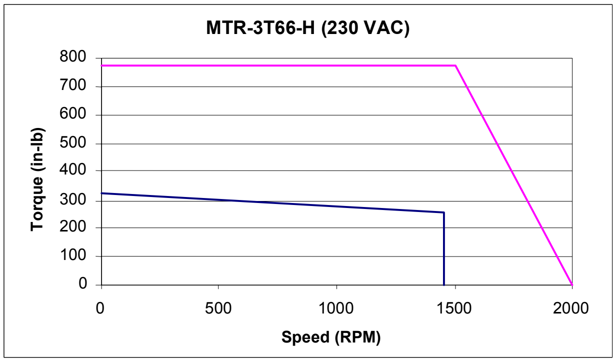

MTR-3T54-H (230 VAC)
Torque (in-lb)
Speed (RPM)

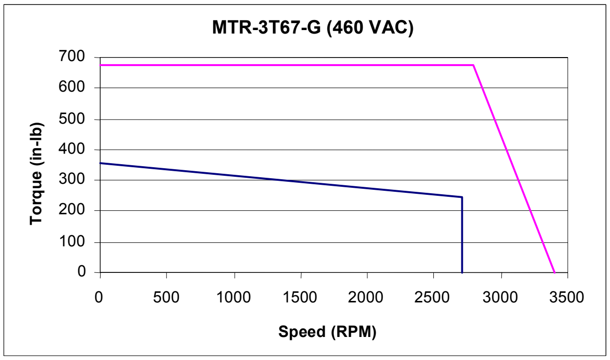

MTR-3T55-H (460 VAC)
Torque (in-lb)
Speed (RPM)

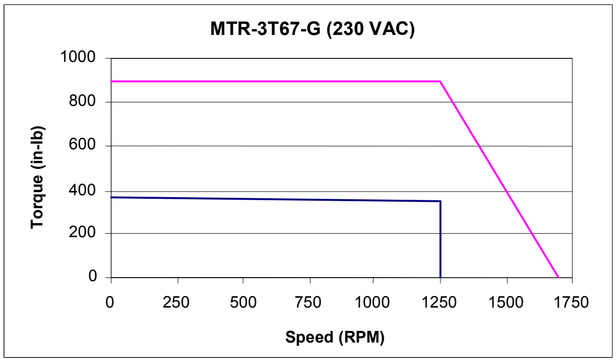

MTR-3T55-H (230 VAC)
Torque (in-lb)
Speed (RPM)

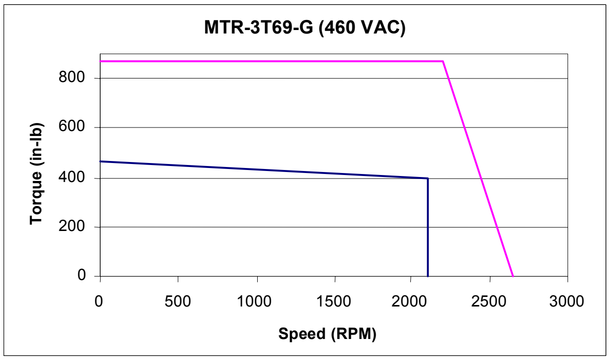

MTR-3T57-H (230 VAC)
Torque (in-lb)
Speed (RPM)

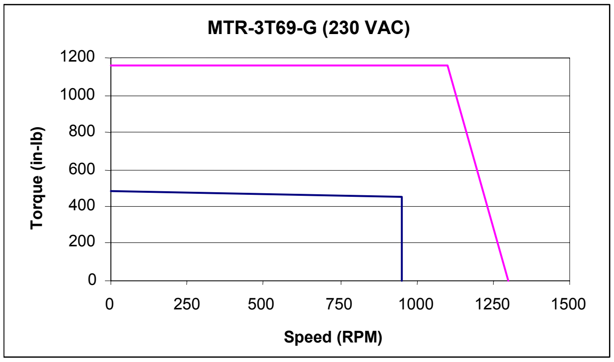

MTR-3T66-H (460 VAC)
Torque (in-lb)
Speed (RPM)


MTR-3T66-H (230 VAC)
Torque (in-lb)
Speed (RPM)


MTR-3T67-G (460 VAC)
Torque (in-lb)
Speed (RPM)


MTR-3T67-G (230 VAC)
Torque (in-lb)
Speed (RPM)


MTR-3T69-G (460 VAC)
Torque (in-lb)
Speed (RPM)

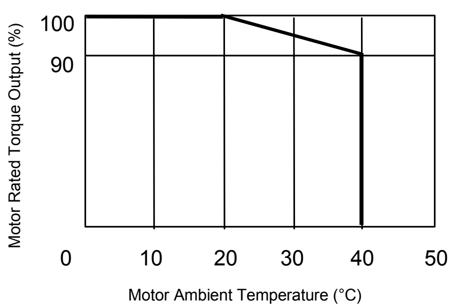

MTR-3T69-G (230 VAC)
Torque (in-lb)
Speed (RPM)

2.3 Servo Motor Derating Based on Ambient Temperature

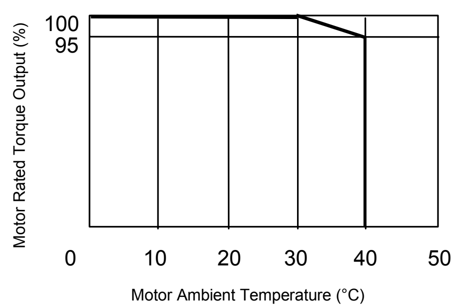
2.3.1 S-Series Motors

The S-Series servo motors produce the continuous torque shown in the speed/torque curves (Section 2.2.2), up to certain ambient temperature limits depending on the motor model. The following curves depict the continuous torque derating required for operation in ambient temperatures above this rating and up to the 40°C limit. The intermittent torque available from each motor does not need to be derated.

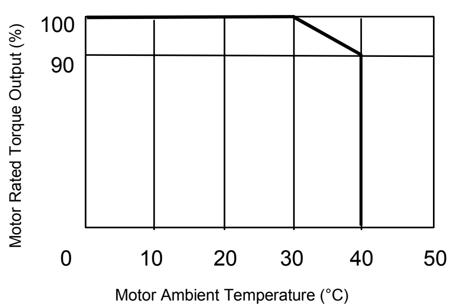
SLM005 / SLM040



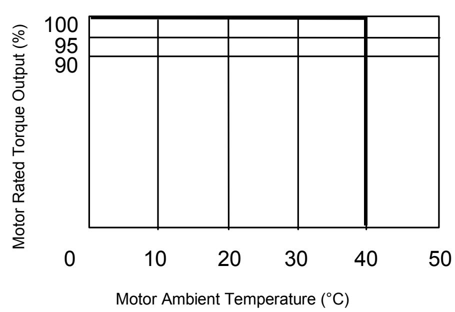
SLM010



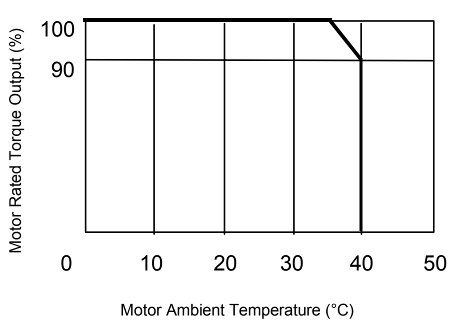
SLM020



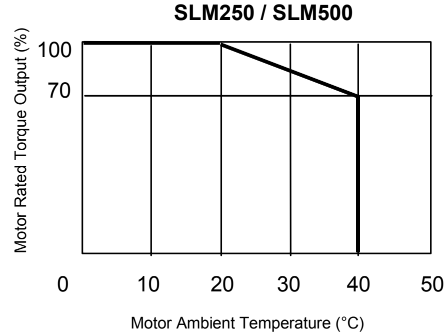
SLM003 / SLM075 / SLM100

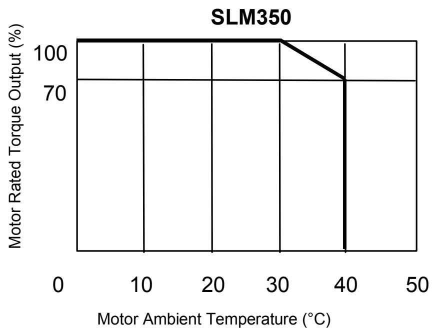


SDM500



SLM250 / SLM500





2.3.2 MTR Series Servo Motors

MTR Series Servo Motors are rated for 25°C ambient temperature with the motor mounted to a 10" x 10" x 0.25" aluminum heat sink. For operation of the motor in higher ambient temperatures, the continuous torque of the motor must be derated as follows:

```
Cont Torque @ amb. Temp, t°C=Rated Cont Torque x (155-t)/130.
```

2.4 Servo Motor Sealing

The S-Series and MTR-Series servo motors are designed to comply with an IP65 protection rating (excluding the cable connector on S-Series 30-750 Watt models). All MTR-3N, MTR-3S, MTR-3T1x, MTR-3T2x and S-Series motors rated 1-5 kW include a shaft oil seal as a standard feature, while the 30-750 Watt S-Series motors, MTR-3T4x, MTR-3T5x, MTR-3T6x and all stepping motors are not available with a shaft seal. Adequate precautions should be taken when mounting the motors to ensure proper protection against excessive exposure to fluids and spray.

2.5 Servo Motor Holding Brakes

Servo motors are available with an optional integral parking brake. The brakes are designed for failsafe operation and must be energized using a 24 Vdc power supply to release the brake.

Caution

The brake should be used only to hold motor position once the axis is stopped. Using the brake to stop a moving load may result in damage or premature failure of the brake mechanism. Use an external mechanical brake to stop moving loads during an emergency stop or loss of power.

The brakes require a finite time to engage and release the load as shown in the motor specification tables. These times must be considered in the brake sequencing logic when employing brake motors on vertical axes to prevent the load from falling. The controller must remain enabled until the brake is fully engaged or the load will not be adequately restrained.

The brake power supply is the user's responsibility and must comply with the brake specifications shown in the motor specification tables. GE Fanuc offers a 24 VDC, 5 Amp DIN-rail mounted power supply (IC690PWR024) that may be appropriate as a brake supply on multi-axis systems. A panel mounting conversion kit is also available (IC690PAC001). Brake power cables are available from GE Fanuc in several pre-finished lengths as shown in Table 3-13.

2.6 NEMA Motor Mounting

The MTR-Series and S-Series motors have mounting configurations as shown in the table below. For dimensional information on these motors (including mounting dimensions), please see the mechanical drawings in Chapter 3.

Table 2-16. Servo Motors Mounting Types

Motor Mounting	Motor Mounting					
	NEMA 23	NEMA 34	NEMA 42	NEMA 56C	Metric	English
SLM003	X					
SLM005	X					
SLM010	X					
SLM020		X				
SLM040		X				
SLM075*		X				
SLM100			X			
SDM100					X	
SLM250					X	
SDM250					X	
SLM350					X	
SLM500					X	
SDM500					X	
3N2x	X					
3N3x		X				
3S2x	X					
3S3x		X				
3S4x				X		X
3S6x						X
3S8x						X
3T1x					X	
3T2x					X	
3T4x					X	
3T5x					X	
3T6X					X	

* The SLM075 (750 Watt) model has an oversized shaft diameter for the NEMA 34 frame size. This is required because the torque rating of this motor exceeds the capacity of the standard NEMA 34 shaft size. This condition is typical of high performance brushless servo motors that produce high peak torque relative to their frame size. For details about motor installation and dimensions, see Chapter 3.

The MTR-Series stepping motors have standard NEMA shaft and flange mounting configurations as shown in Table 2-17 below. For dimensional information on these motors please refer to the mechanical drawings in Chapter 3.

Table 2-17. NEMA Mounting Sizes for MTR-Series Stepping Motors

Stepping Motor Model	Mounting		
	NEMA 23	NEMA 34	NEMA 42
MTR-1221	X		
MTR-1231	X		
MTR-1324		X	
MTR-1337		X	
MTR-1350		X	
MTR-1N31		X	
MTR-1N32		X	
MTR-1N41			X
MTR-1N42			X

2.7 S-Series Servo Motor Vibration Testing

There are two vibration tests for these motors, the Sweep Test and the Resonance Point Test.

- **Sweep Test**. The motor is subjected to a 5G variable frequency test for eight hours in each of three axes (X, Y, Z). For the purpose of these tests, X axis is parallel with the motor shaft, Y axis is parallel with the encoder connector, and Z axis is at a 90 degree angle to X and Y. In this test, the vibration frequency increases from 20 to 3,000 Hz. over a two-minute span, then decreases from 3,000 to 20 Hz. over a two-minute span. This pattern is repeated for a period of eight hours.
- **Resonance Point Test**. First, the resonant frequency having the highest vibration is identified while testing the motor with a 5 G variable frequency (20 to 3,000 Hz.) in three directions (X, Y, Z). Then, the motor is vibrated 10 million times in each direction (X, Y, Z) at the identified resonant frequency.

Chapter 3 Installation

3.1 Heat Load and Cooling

The heat load of the S2K Series controllers is dependent on the model as shown below:

Stepper Controller

Model SSI105: Heat Load = 20 Watts + (0.3 * current setting in percent) or 50 watts max.

Servo Controllers

Model SSI104: Heat Load = 25 watts + (35 * duty cycle) watts or 60 watts max.
Model SSI107: Heat Load = 35 watts + (65 * duty cycle) watts or 100 watts max.
Model SSI216: Heat Load = 50 watts + (150 * duty cycle) watts or 200 watts max.
Model SSI228: Heat Load = 60 watts + (280 * duty cycle) watts or 340 watts max
Model SSI407: Heat Load = 35 watts + (65 * duty cycle) watts or 100 watts max..
Model SSI420: Heat Load = 60 watts + (250 * duty cycle) watts or 310 watts max.

Duty cycle is defined as the percent of time the controller is at full rated output divided by the total cycle time. The SSI104 and SSI107 controllers are designed to operate at full rated current with only natural convection cooling at ambient temperatures up to 50°C. The SSI216, SSI228, SSI407 and SSI420 models have built-in fan cooling.

The controllers must be installed vertically for effective cooling. Allow a minimum clearance of 3 inches above and below the unit. A minimum of 2 to 3 inches clearance is also recommended on the right and left sides of the unit where possible.

Note

For UL approved installation of the following controllers, maximum ambient temperature is 40°C (104°F): IC800SSI216P2, IC800SSI216RP2, IC800SSI216D2, IC800SSI216RD2, IC800SSI228P2, IC800SSI228RP2, IC800SSI228D2, IC800SSI228RD2, IC800SSI407RS1, IC800SSI407RP2, IC800SSI407RD2, IC800SSI420RP2, IC800SSI420RD2.

3.2 Controller Mounting Guidelines and Environmental Conditions

It is the user's responsibility to install the components in a suitable location. The S2K controller must be installed in a location that satisfies the following environmental conditions:

1. **Atmosphere:** The circuitry must not be exposed to any corrosive or conductive contaminants.
2. **Ambient temperature:**

    0°C to +50°C (operating)
    -40°C to 80°C (storage)

    Note: For UL approved installation of the following controllers, maximum ambient temperature is 40°C (104°F): IC800SSI216P2, IC800SSI216RP2, IC800SSI216D2, IC800SSI216RD2, IC800SSI228P2, IC800SSI228RP2, IC800SSI228D2, IC800SSI228RD2, IC800SSI407RS1, IC800SSI407RP2, IC800SSI407RD2, IC800SSI420RP2, IC800SSI420RD2.

    Install the controller into ambient temperature conditions within the range of 0° C to +50° C. If the temperature exceeds this range, it may cause malfunction or damage to the controller. The controller heatsink and motor generate high temperatures. If the controller is housed in an enclosed control cabinet this heat load must be considered when evaluating the enclosure cooling requirements (see Section 3.1-*Heat Load and Cooling* for details on controller losses). Use heat exchangers or cooling devices to maintain an ambient temperature of 50° C or less.

3. **Humidity:** 95% relative humidity or less (non-condensing)
4. **Altitude:** No more than 1,000m (3,300 ft) above sea level for full rating. Contact GE Fanuc Applications Engineering for derating at higher elevations.
5. **Ventilation:** This controller is designed for vertical installation to ensure proper cooling. Install the controller with sufficient space for ventilation. Avoid mounting wireways and other adjacent components too close to the heatsink, top or bottom of the controller.
6. **Location:** Keep the following location guidelines in mind when selecting a site for the controller:
    - Do not install in places with high temperature, high humidity, dust, dirt, conductive powder or particulate, combustible gasses, or metal chips.
    - Avoid places exposed to direct sunlight.
    - Mount only to noncombustible materials such as metal.
    - Do not stand/step on or put heavy articles on the controller or motor.
    - The controller housing is not a waterproof enclosure. Do not use outdoors or in any unprotected environment. The controllers are designed with open construction and must be installed in a closed electrical operating area i.e. an enclosure that protects personnel from contact with wiring terminals and provides a pollution degree 2 environment.
    - Avoid locations where there is exposure to radiation such as microwave, ultraviolet, laser light or X-rays.
    - Do not apply excessive stress, put heavy articles on, or pinch the cables.

- Do not install the controller near heating elements such as cabinet heaters or large wire wound resistors. When such installation is unavoidable, provide a thermal shield between the servo controller and the heating elements.
- Mount controller and other heat producing components higher in the enclosure to avoid overheating other sensitive electronics installed in the same cabinet.

3.3 Installing the Controller

The S2K Series controllers are designed for panel mounting in electrical enclosures designed for industrial applications. Enclosure cooling or ventilation must be adequate to maintain the ambient temperature to within the component's specifications. Mount controllers vertically for proper cooling.

1. To ensure an adequate ground connection between the S2K and the panel to which it is mounted, install a star washer or equivalent under the mounting screws.
2. Firmly install the controller with screws and bolts without applying stress such as bending and twisting to the controller main unit.
3. Allow reasonable mounting clearance between adjacent units to ensure proper ventilation.

Caution

Since a misuse of the controller may lead to improper operation, or may damage the controller, carefully read the following cautions and warnings:

- Be sure to ground the controller properly using the ground terminals on the power input connector. Proper grounding includes conforming to applicable national and local electrical codes.
- Do not apply higher than rated voltage to the power input terminals (L1, L2 and L3)
- Do not apply the main input power to terminals other than terminals L1, L2 and L3 or damage will occur. Refer to Section 3.6 for wiring information.
- The power supply uses a capacitor filter. When you turn on power, a high charging current flows and you may see a large voltage drop. We recommend that you install line reactors to limit the charging current if this presents problems with other equipment on the machine.
- Do not perform a dielectric strength test or megger test on the controller or damage may occur. (When you perform a dielectric strength test or megger test to an external circuit, please disconnect all terminals to the controller so that no test voltage is applied to the controller.)
- If you use a ground fault breaker, use one rated for "Inverter," to withstand high frequency leakage current. See table 2-3 for fuse specifications.
- Use the motor and controllers only in the designated combinations (Table 1-1).
- When transporting, use caution to prevent damage to the S2K components. Do not move or carry the controller by holding the cables.

3.4 Installing the Motor

The S-Series and MTR-Series servo motors are designed for either vertical or horizontal mounting and have a protection rating of IP65 (not including the connectors and shaft). The motors should be mounted in a location where the environmental conditions are within the specifications stated in Chapter 2. Use the following guidelines when mounting the motors:

- Observe the shaft radial and thrust load limits. Loads exceeding these limits will cause premature failure of the motor. Excessive belt tension could cause bearing or shaft failure.
- Be sure to ground the motor using the ground wire in the motor power cable.
- Ensure that the motor cables are free from excessive stress, stretching, pinching or bending.
- To avoid damage, do not carry a motor by holding the cables or shaft.
- Do not apply excessive axial force or impact loads when installing the motor coupling or shaft pulley, or the encoder may be damaged. See axial load limit ratings in Chapter 2.
- Install the motor in a location free from corrosive contaminants, dust, excessive water spray, or combustible gas.
- The shaft of the S-series servo motor is treated with grease (Shell Oil Alvania No. 2) for corrosion protection during storage. Consider the effect of the grease on any plastic parts that are mated with the shaft.
- The optional servo motor brake should be used for holding stationary loads only. Do not use this brake to stop a moving load, or reduced life or damage to the brake may occur. Apply this brake only after the motor is stopped.

3.5 Mounting Dimensions

3.5.1 Controller Dimensions and Weight

Code in Diagram	Feature	Units	STI105, SSI10	SSI107, SSI407
N/A	Weight	lb. (kg)	4.0 (1.8)	6.0 (2.7)
A	Depth	inch (mm)	6.05 (153.7)	8.15 (207)
B	Total Width	inch (mm)	3.20 (81.3)	SSI107: 3.45 (87.6) SSI407: 4.350 (110.5)
C	Height	inch (mm)	8.50 (215.9)	8.50 (215.9)
D	Position Feedback Connector/Wire Loop Depth	inch (mm)	2.26 (57.4) (SSI104 only)	2.26 (57.4)
E	User I/O Connector Depth	inch (mm)	0.75 (19.1)	0.75 (19.1)

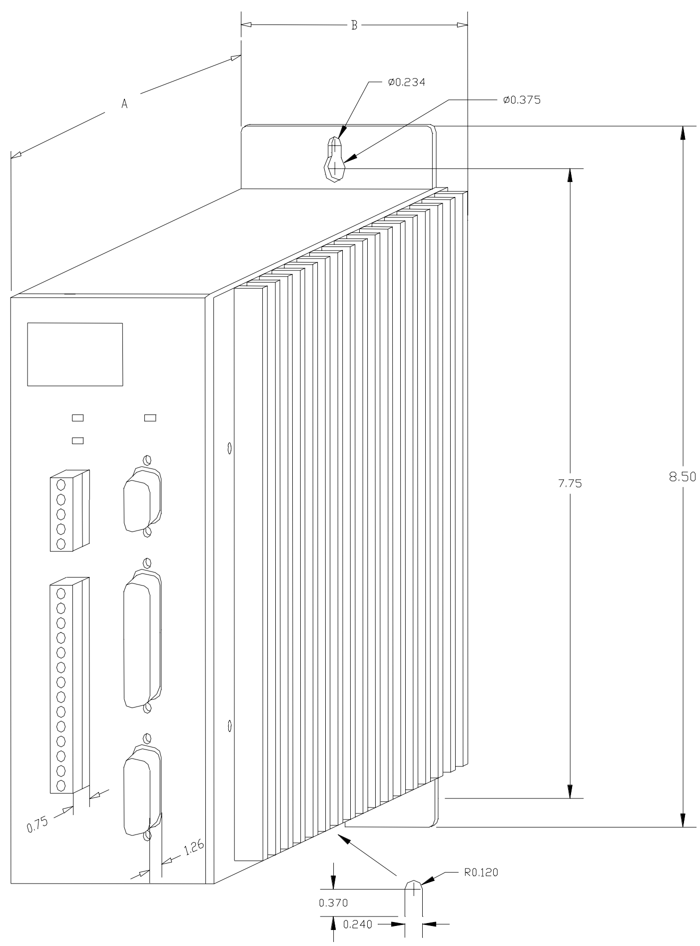


Figure 3-1. STI105, SSI104, SSI107, and SSI407 S2K Series Controller Dimensions

Code in Diagram	Feature	Units	SSI216 SSI228	SSI420
N/A	Weight	lb. (kg)	14 (6.4)	15 (6.9)
A	Depth	inch (mm)	10.15 (258)	
B	Total width	inch (mm)	5.25 (133.4)	
C	Height	inch (mm)	12.20 (309.9)	
D	Position Feedback Connector/Wire Loop Depth	inch (mm)	2.26 (57.4)	
E	User I/O Connector Depth	inch (mm)	0.75 (19.1)	

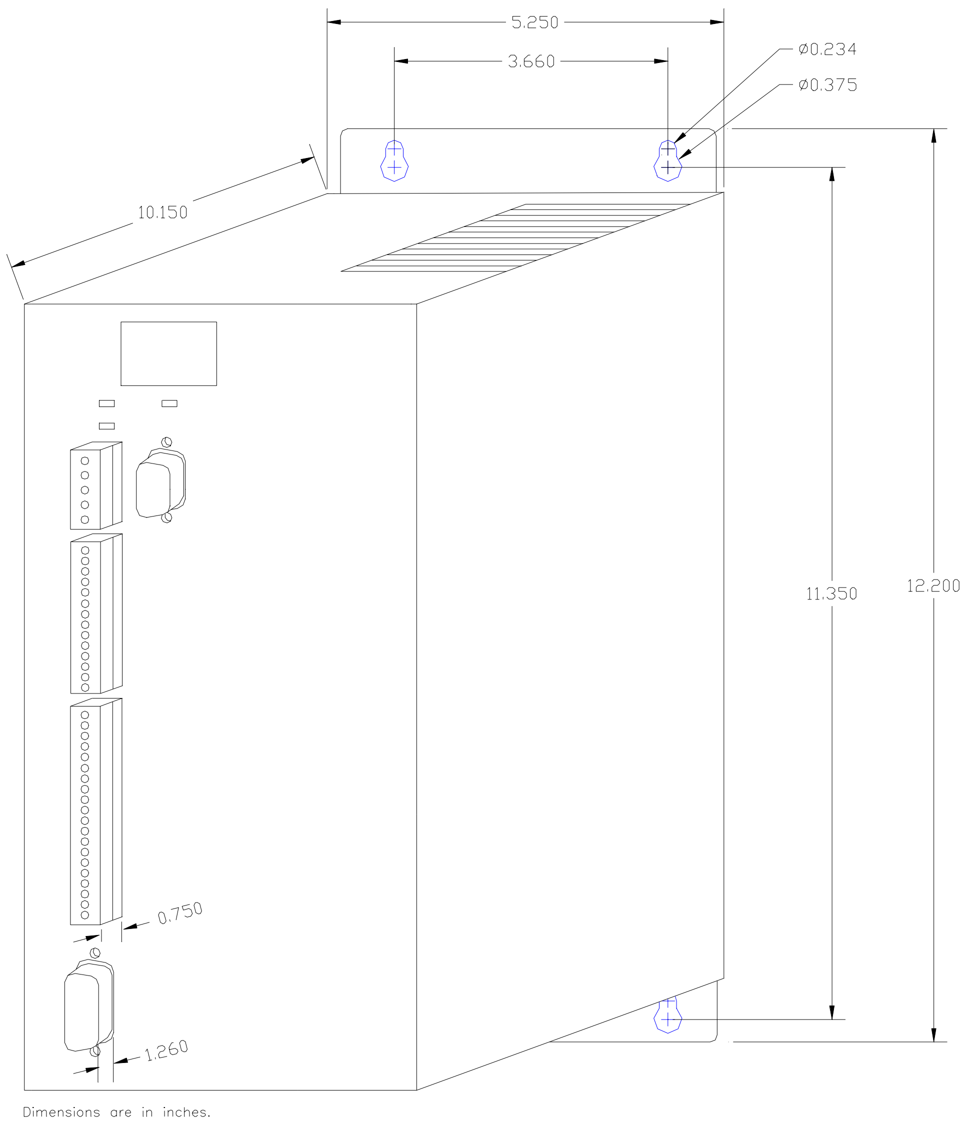
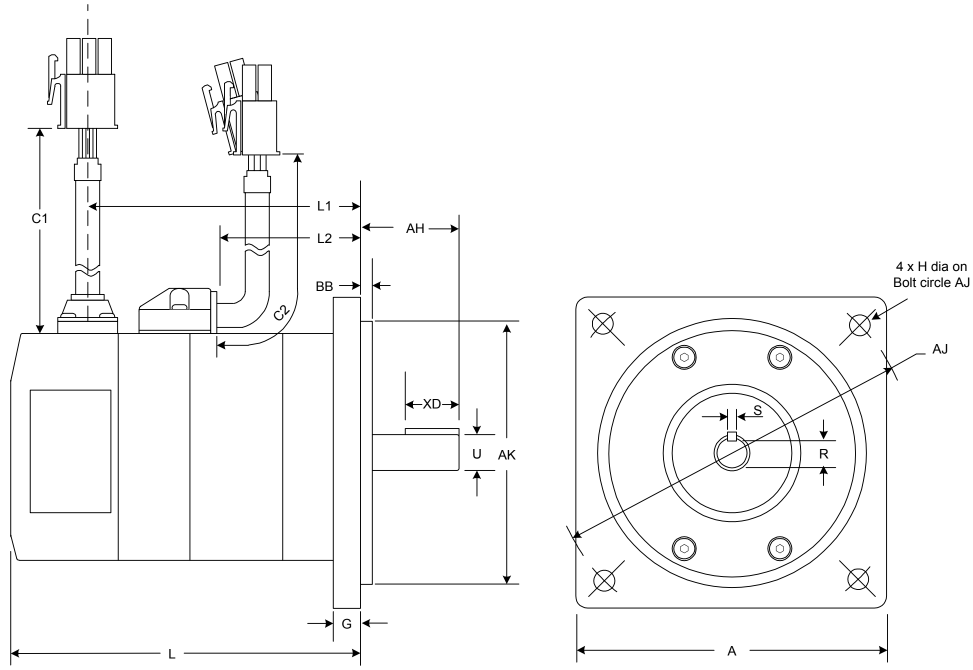


Figure 3-2. SSI216, SSI228, and SSI420 S2K Series Controller Dimensions`

3.5.2 S-Series Servo Motor Dimensions

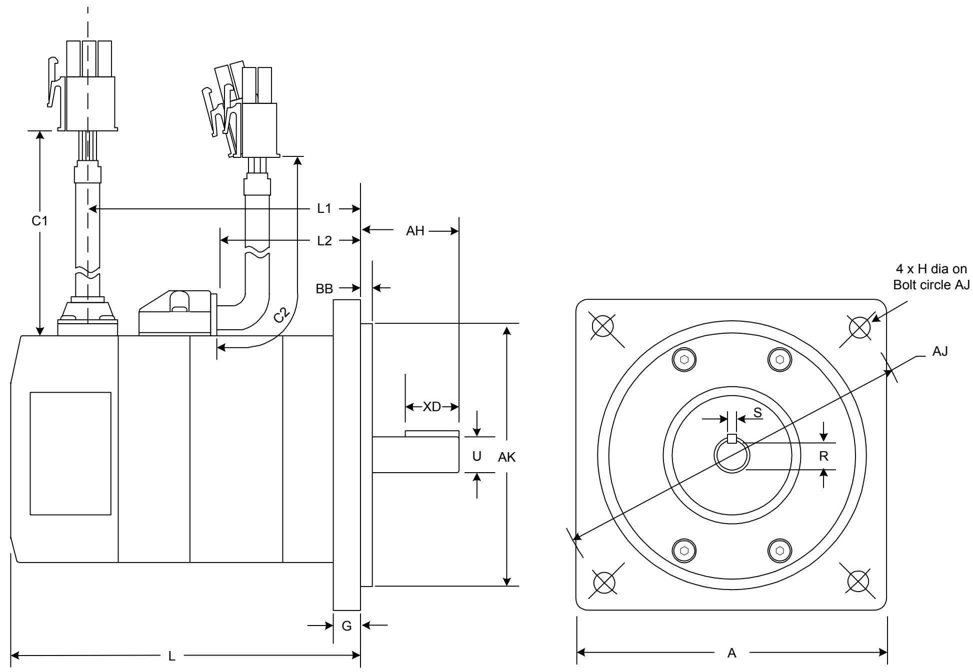


Model	Units	A	AH	AJ	AK	BB	G	H
SLM020 (200 Watt)	inch	3.42 ± 0.024	1.181 ± 0.028	3.875 ± 0.024	$2.877^{+0}_{-0.0012}$	0.118 ± 0.008	0.315 ± 0.012	0.2165 ± 0.010
	mm	86.868 ± 0.6	30 ± 0.7	98.425 ± 0.6	$73.0758^{+0}_{-0.030}$	3 ± 0.2	8 ± 0.3	5.5 ± 0.25

Model	Units	C1	C2	L1	L1 (With Brake)	L2 (With or Without Brake)
SLM020 (200 Watt)	inch	8.662	7.874	2.854	4.154	1.535
	mm	220	200	72.5	105.5	39

Model	Units	U	L	L (With Brake)	R	S	XD
SLM020 (200 Watt)	inch	$0.375^{+0}_{-0.0004}$	3.701	5.000	$0.3018^{+0}_{-0.015}$	$0.125^{+0}_{-0.002}$	$0.75^{+0}_{-0.016}$
	mm	$9.5250^{+0}_{-0.009}$	94	127	$7.666^{+0}_{-0.381}$	$3.175^{+0}_{-0.051}$	$19.050^{+0}_{-0.4}$

Figure 3-3. Dimensions for 200 Watt S-Series Servo Motor

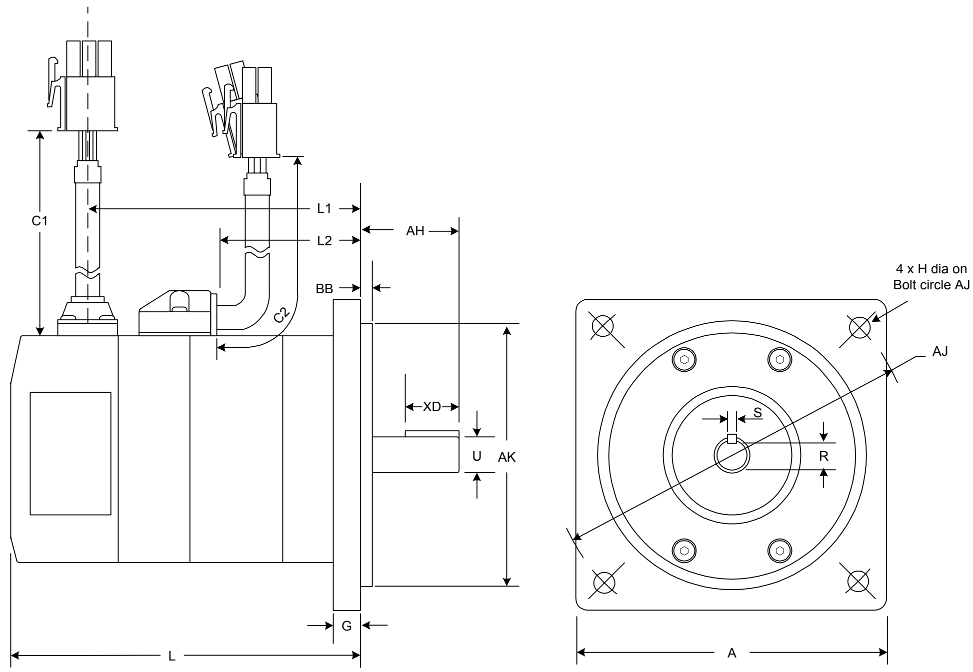


Model	Units	A	AH	AJ	AK	BB	G	H
SLM040 (400 Watt)	inch	3.42 ± 0.024	1.181 ± 0.028	3.875 ± 0.024	$2.877^{+0}_{-0.0012}$	0.118 ± 0.008	0.315 ± 0.012	0.2165 ± 0.010
	mm	86.868 ± 0.6	30 ± 0.7	98.425 ± 0.6	$73.0758^{+0}_{-0.030}$	3 ± 0.2	8 ± 0.3	5.5 ± 0.25

Model	Units	C1	C2	L1	L1 (With Brake)	L2 (With or Without Brake)
SLM040 (400 Watt)	inch	8.662	7.874	4.016	5.315	2.697
	mm	220	200	102	135	68.5

Model	Units	U	L (Without Brake)	L (With Brake)	R	S	XD
SLM040 (400 Watt)	inch	$0.375^{+0}_{-0.0004}$	4.862	6.161	$0.3018^{+0}_{-0.015}$	$0.125^{+0}_{-0.002}$	$0.75^{+0}_{-0.016}$
	mm	$9.5250^{+0}_{-0.009}$	123.5	156.5	$7.666^{+0}_{-0.381}$	$3.175^{+0}_{-0.051}$	$19.050^{+0}_{-0.4}$

Figure 3-4. Dimensions for 400 Watt S-Series Servo Motor

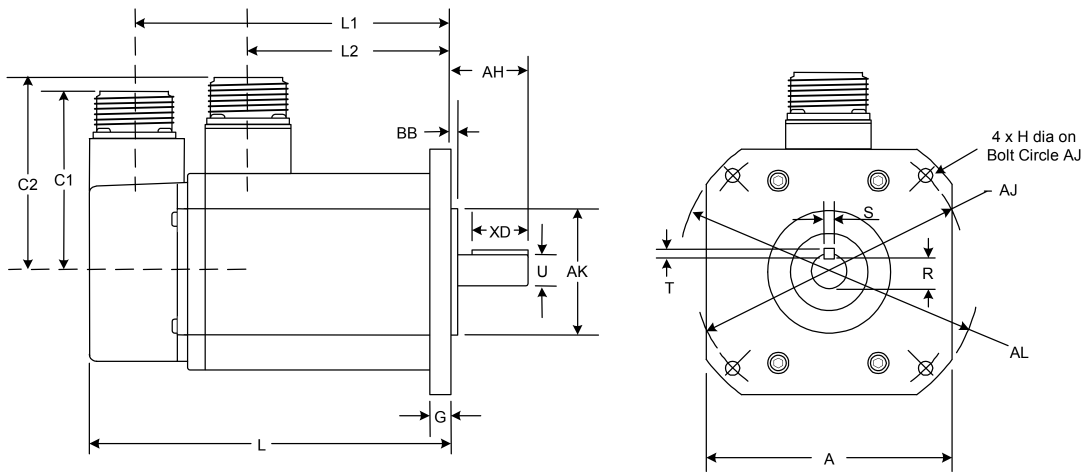


Model	Units	A	AH	AJ	AK	BB	G	H
SLM075 (750 Watt)	inch	3.42 ± 0.024	1.181 ± 0.028	3.875 ± 0.024	$2.877^{+0}_{-0.0012}$	0.118 ± 0.008	0.315 ± 0.012	0.2165 ± 0.010
	mm	86.868 ± 0.6	30 ± 0.7	98.425 ± 0.6	$73.0758^{+0}_{-0.030}$	3 ± 0.2	8 ± 0.3	5.5 ± 0.25

Model	Units	C1	C2	L1	L1 (With Brake)	L2 (With or Without Brake)
SLM075 (750 Watt)	inch	8.662	7.874	4.764	6.142	3.346
	mm	220	200	121	156	85

Model	Units	U	L (Without Brake)	L (With Brake)	R	S	XD
SLM075 (750 Watt)	inch	$0.625^{+0}_{-0.0004}$	5.610	6.988	$0.5165^{+0}_{-0.015}$	$0.1885^{+0}_{-0.002}$	$0.952^{+0}_{-0.016}$
	mm	$15.875^{+0}_{-0.011}$	142.5	177.5	$13.120^{+0}_{-0.383}$	$4.788^{+0}_{-0.051}$	$24.200^{+0}_{-0.4}$

Figure 3-5. Dimensions for 750 Watt S-Series Servo Motor



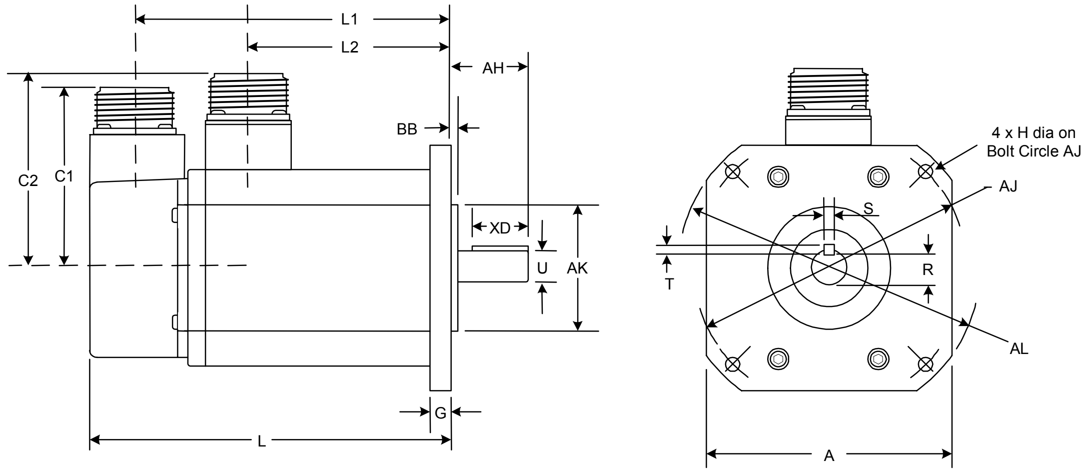
Note: Shaft end play (axial) = 0.0118” (0.3 mm) or less

Model	Units	A	AH	AJ	AK	AL	BB	G
SLM100	inch	4.38	1.378	4.95	$2.188^{+0}_{-0.004}$	5.512	0.118	0.394
	mm	111.25	35	125.73	$55.575^{+0}_{-0.1}$	140	3	10
SDM100	mm	130	55	145	$100^{+0}_{-0.035}$	165	6	12
SLM250	mm	100	55	115	$95^{+0}_{-0.035}$	135	3	10
SDM250	mm $^{+0}_{0.035}$	130	65	145	110	165	6	12

Model	Units	C1	C2	L1	L1 (W/Brake)	L2	L2 (W/Brake)
SLM100	inch	3.31	3.62	6.012	7.087	3.858	4.843
	mm	84	92	155	180	98	123
SDM100	mm	84	112	130	155	75	100
SLM250	mm	84	97	207	232	153	178
SDM250	mm	84	112	205	230	150	175

Model	Units	H	U	L	L (W/Brake)	R	S	T	XD
SLM100	inch	0.2600	$0.625^{+0}_{-0.0005}$	6.890	7.874	$0.5165^{+0}_{-0.015}$	$0.1885^{+0}_{-0.002}$	0.1885	1.000
	mm	6.6	$15.875^{+0}_{-0.013}$	175	200	$13.120^{+0}_{-0.383}$	$4.788^{+0}_{-0.051}$	4.788	25.4
SDM100	mm	9	$22^{+0}_{-0.013}$	150	175	18	$8^{+0}_{-0.036}$	7	41
SLM250	mm	9	$19^{+0}_{-0.013}$	227	252	15.5	$6^{+0}_{-0.036}$	6	42
SDM250	mm	9	$24^{+0}_{-0.013}$	225	250	20	$8^{+0}_{-0.036}$	7	41

Figure 3-6. Dimensions for 1000 Watt and 2500 W S-Series Servo Motors



Note: Shaft end play (axial) = 0.0118” (0.3 mm) or less

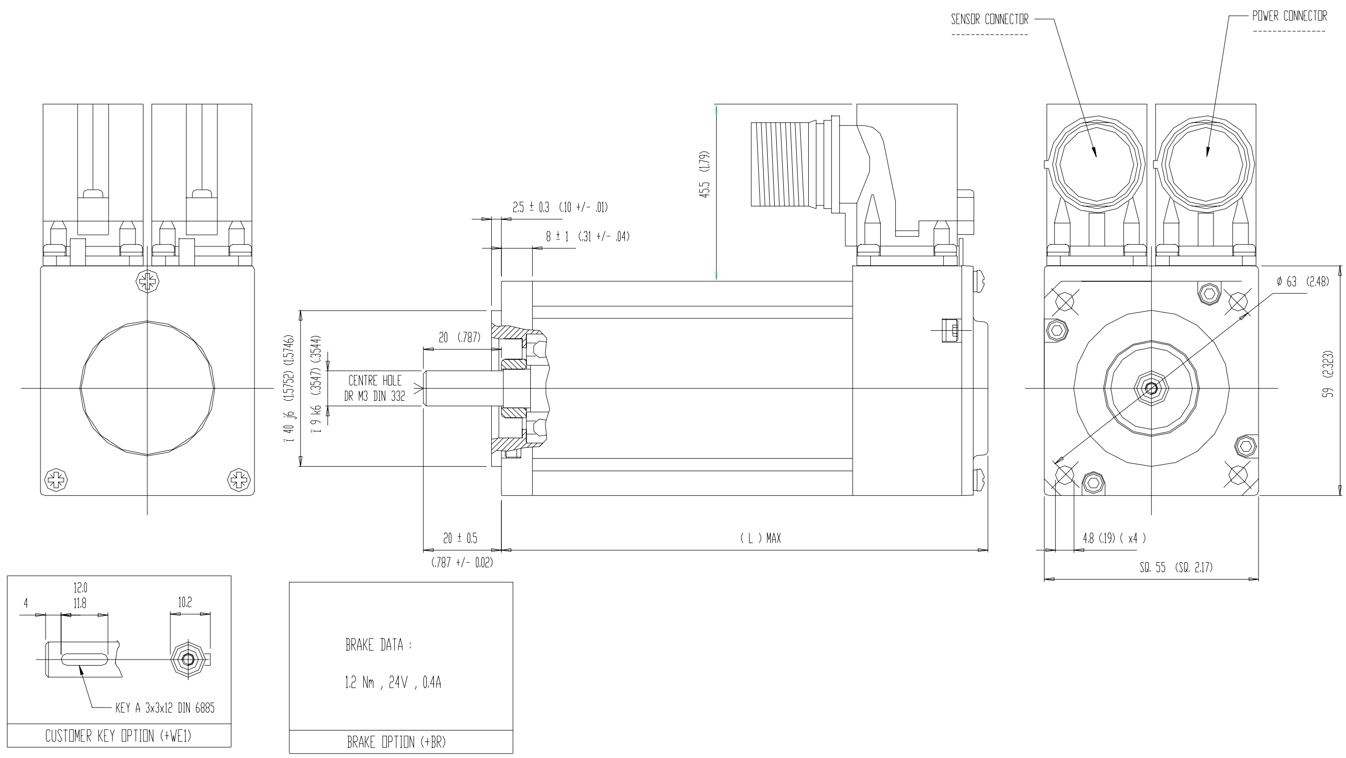
Model	Units	A	AH	AJ	AK	AL	BB	G
SLM350	mm	120	55	130/145*	$110^{+0}_{-0.035}$	162	3	12
SLM500	Mm	130	65	145	$110^{+0}_{-0.035}$	165	6	12
SDM500	Mm	176	70	200	$114.3^{+0}_{-0.035}$	233	3.2	18
SGM450	Mm	176	113	200	$114.3^{+0}_{-0.035}$	233	3.2	24

Model	Units	C1	C2	L1	L1 (W/Brake)	L2	L2 (W/Brake)
SLM350	mm	84	111	214	239	160	185
SLM500	Mm	84	119	257	282	202	227
SDM500	Mm	84	143	202	227	145	170
SGM450	Mm	84	143	269	317.5	212	260.5

Model	Units	H	U	L	L (W/Brake)	R	S	T	XD
SLM350	mm	9	$22^{+0}_{-0.013}$	234	259	18	$8^{+0}_{-0.036}$	7	41
SLM500	Mm	9	$24^{+0}_{-0.013}$	277	302	20	$8^{+0}_{-0.036}$	7	51
SDM500	Mm	13.5	$35^{+0}_{-0.016}$	222	247	30	$10^{+0}_{-0.036}$	7	50
SGM450	Mm	13.5	$42^{+0}_{-0.016}$	289	337.5	$37^{+0}_{-0.2}$	$12^{+0}_{-0.043}$	8	90

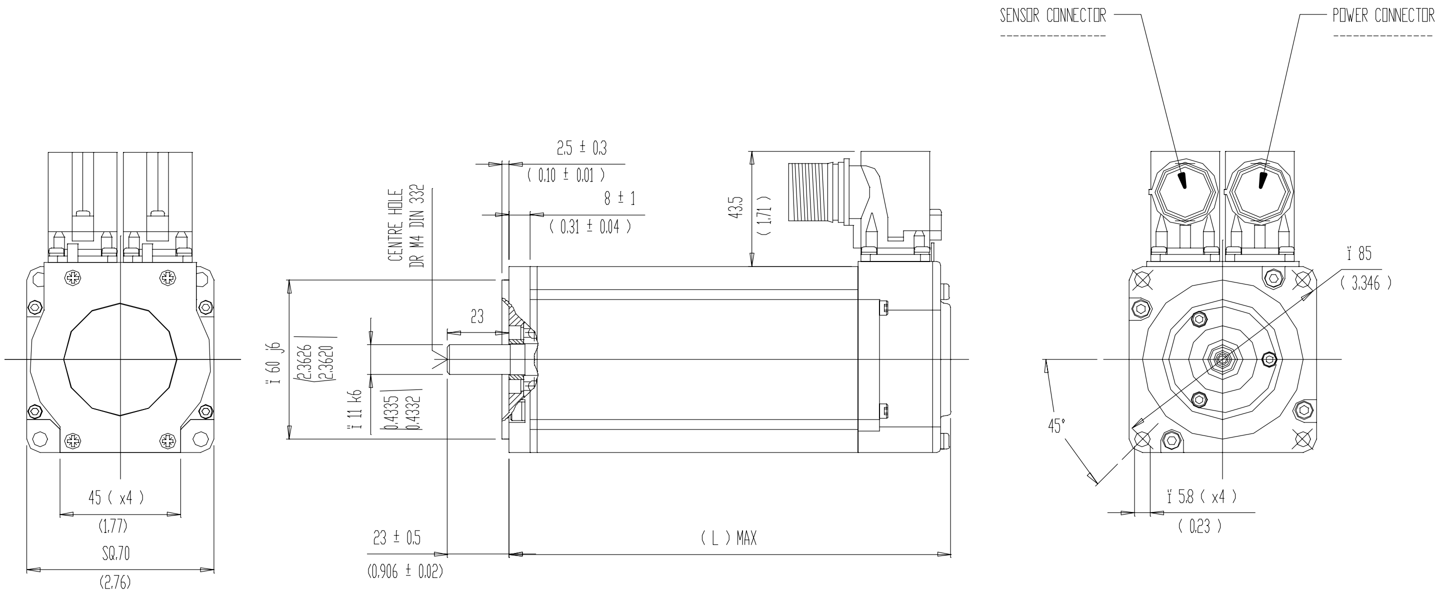
Figure 3-7. Dimensions for 4500 Watt and 5000 W S-Series Motors

3.5.3 MTR-Series Servo Motor Dimensions



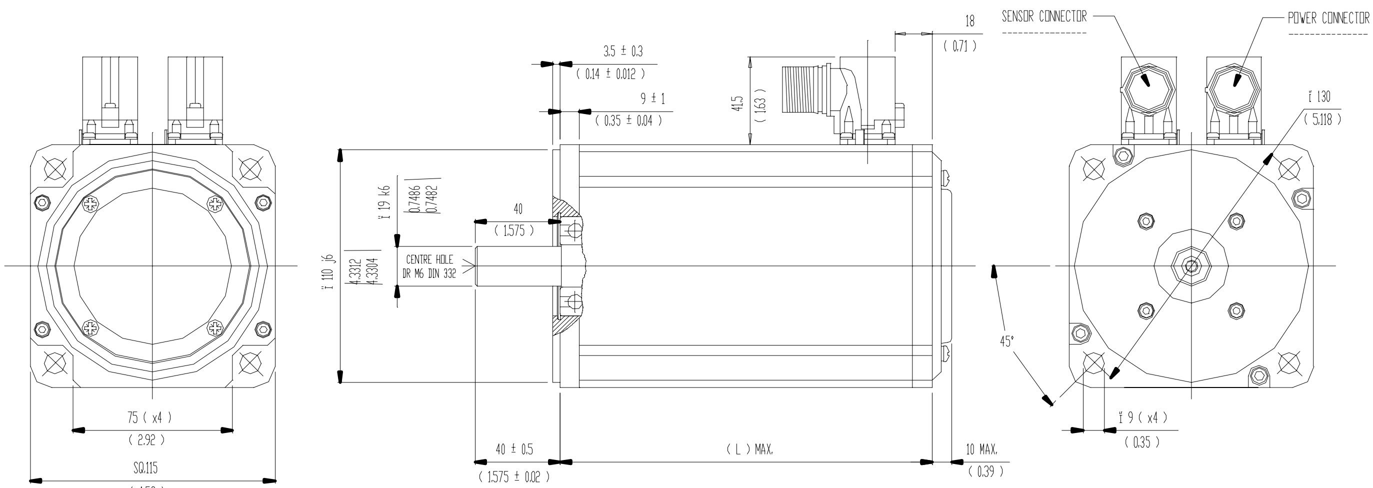
Motor	L Max	
	mm	Inches
3T11	125	4.921
3T12	150	5.906
3T13	175	6.890

Figure 3-8. Dimensions for MTR-3T1x-Series Servo Motors



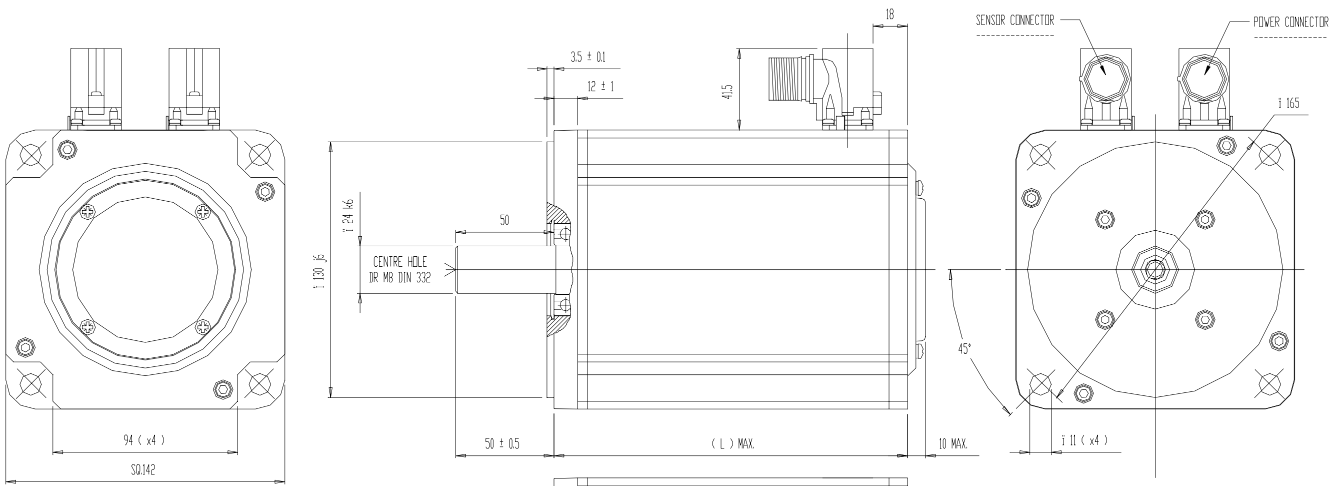
Motor	L Max	
	mm	Inches
3T21	143	5.6
3T22	168	6.6
3T23	193	7.6
3T24	218	8.6

Figure 3-9. Dimensions for MTR-3T2x-Series Servo Motors



Motor	L Max	
	mm	**Inches**
3T42	185	7.3
3T43	210	8.3
3T44	235	9.2
3T45	260	10.2

Figure 3-10. Dimensions for MTR-3T4x-Series Servo Motors



Motor	L Max	
	mm	Inches
3T54	230	9.0
3T55	255	10.0
3T57	305	12.0

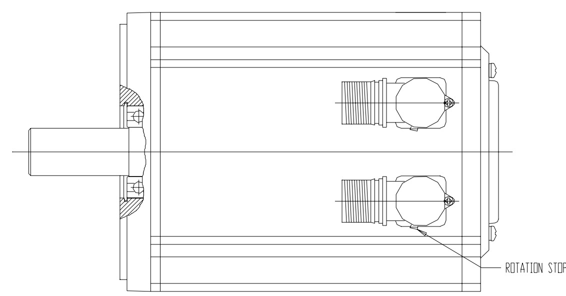
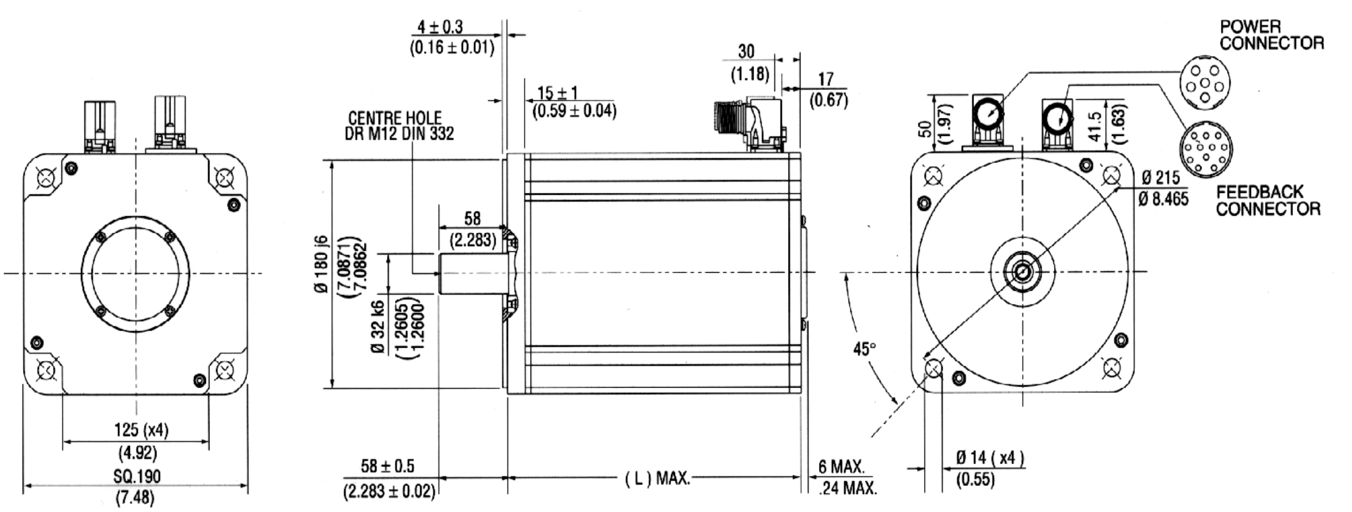
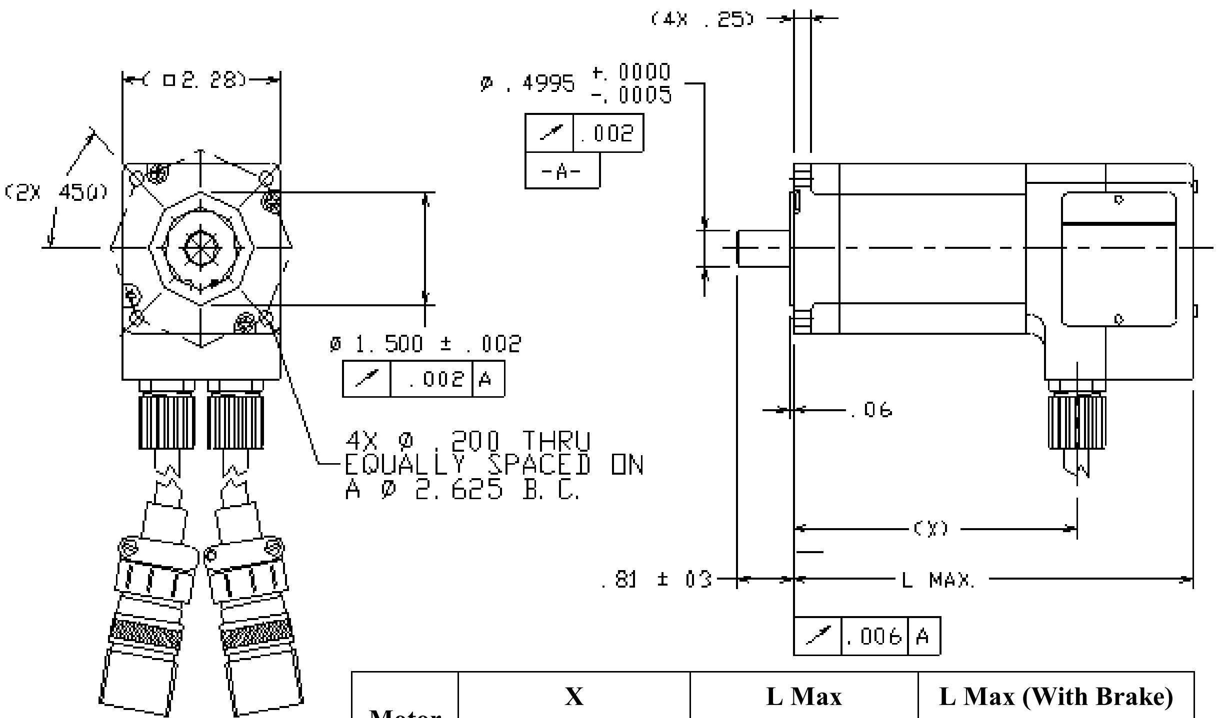


Figure 3-11. Dimensions for MTR-3T5x-Series Servo Motors



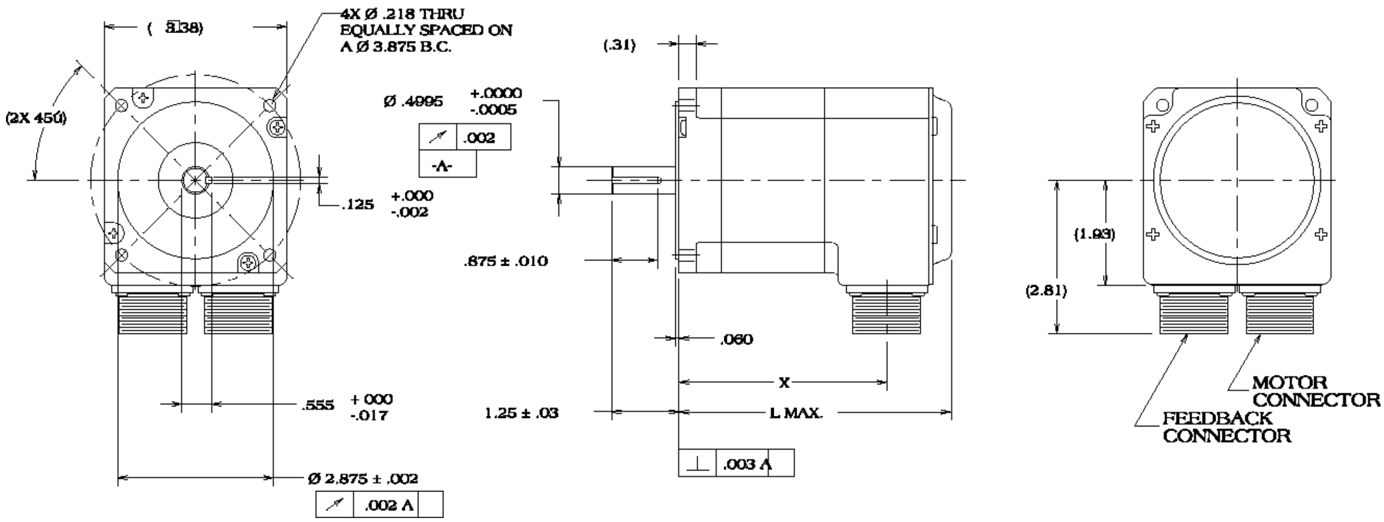
Motor	L Max	
	mm	Inches
3T66	320	12.6
3T67	345	13.6
3T69	395	15.6

Figure 3-12. Dimensions for MTR-3T6x-Series Servo Motors



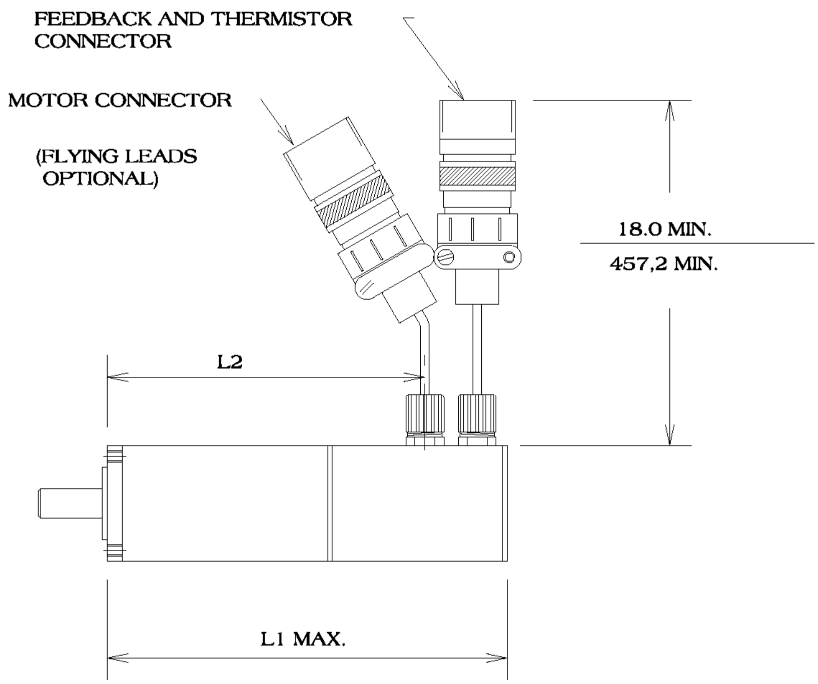
Motor	X		L Max		L Max (With Brake)	
	mm	Inches	mm	Inches	mm	Inches
3N21	78.7	3.1	124.5	4.9	185.7	7.31
3N22	104.1	4.1	149.9	5.9	211.1	8.31
3N24	154.9	6.1	200.7	7.9	261.9	10.31

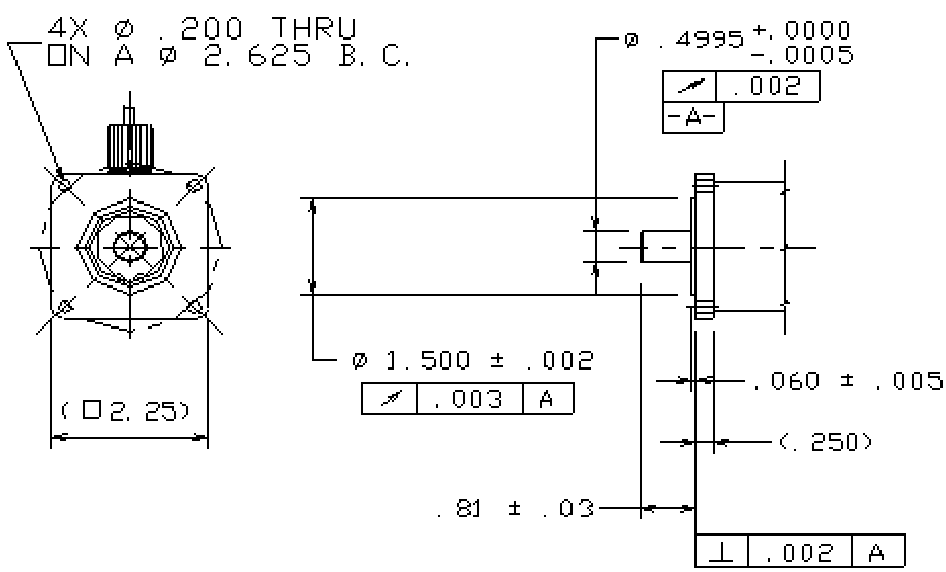
Figure 3-13. Dimensions for MTR-3N2x-Series Servo Motors



Motor	X		L Max		L Max (With Brake)	
	mm	Inches	mm	Inches	mm	Inches
3N31	97.5	3.84	130.3	5.13	197.9	7.79
3N32	135.6	5.34	168.4	6.63	235.9	9.29
3N33	173.7	6.84	206.5	8.13	274.1	10.79

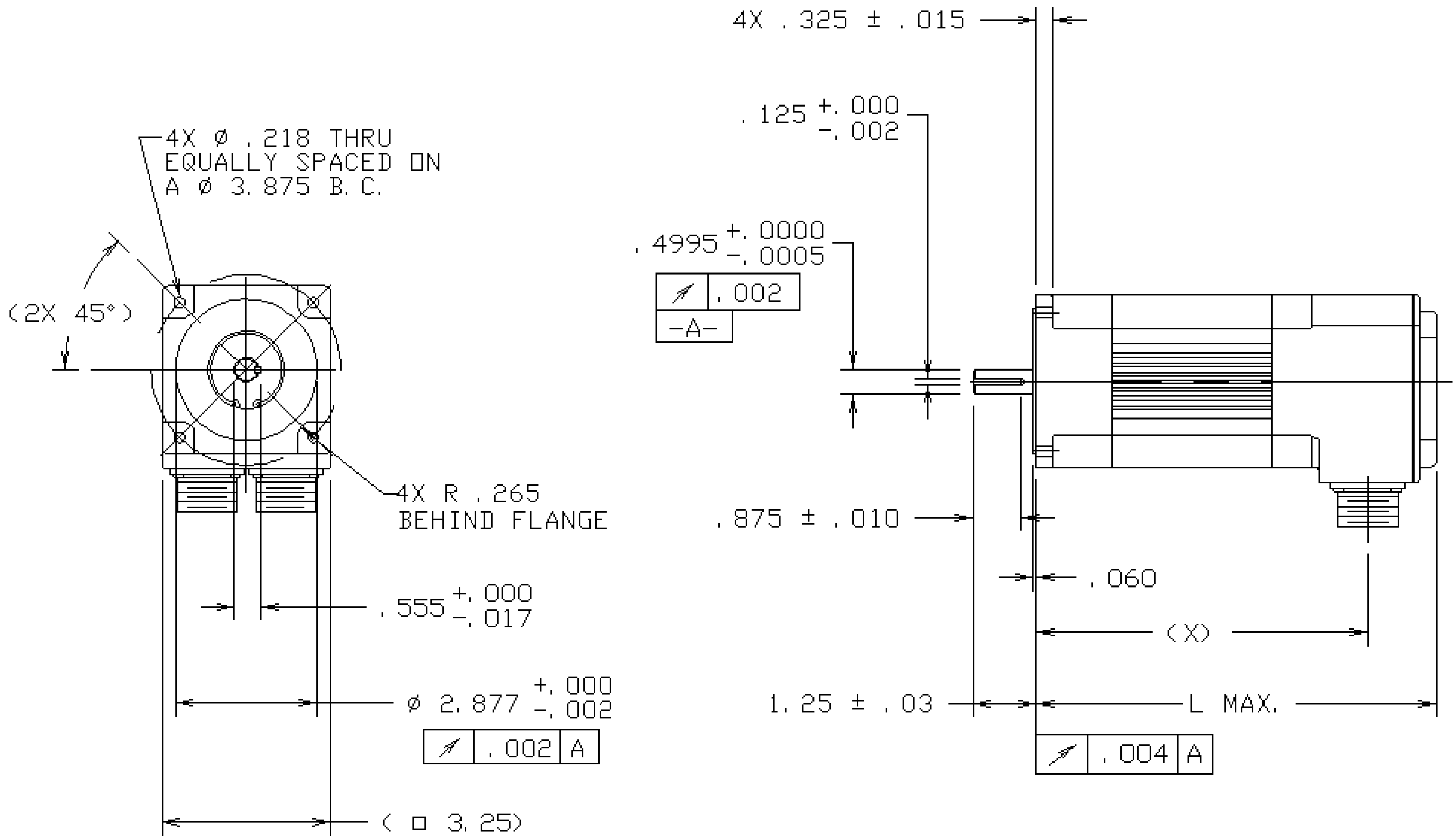
Figure 3-14. Dimensions for MTR-3N3x-Series Servo Motors





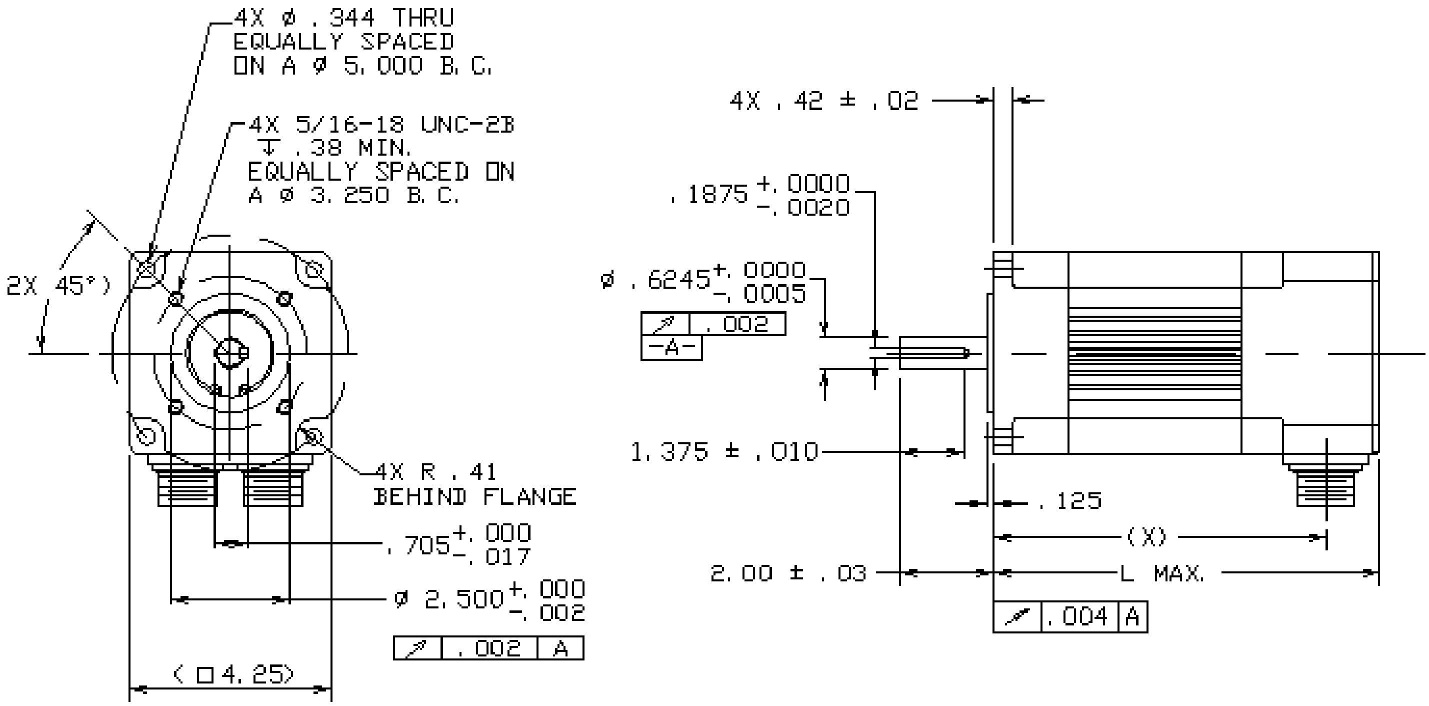
Motor	L1 Max		L2	
	mm	Inches	mm	Inches
3S22	187.9	7.4	149.9	5.9
3S23	212.9	8.38	176.0	6.93

Figure 3-15. Dimensions for MTR-3S2x-Series Servo Motors



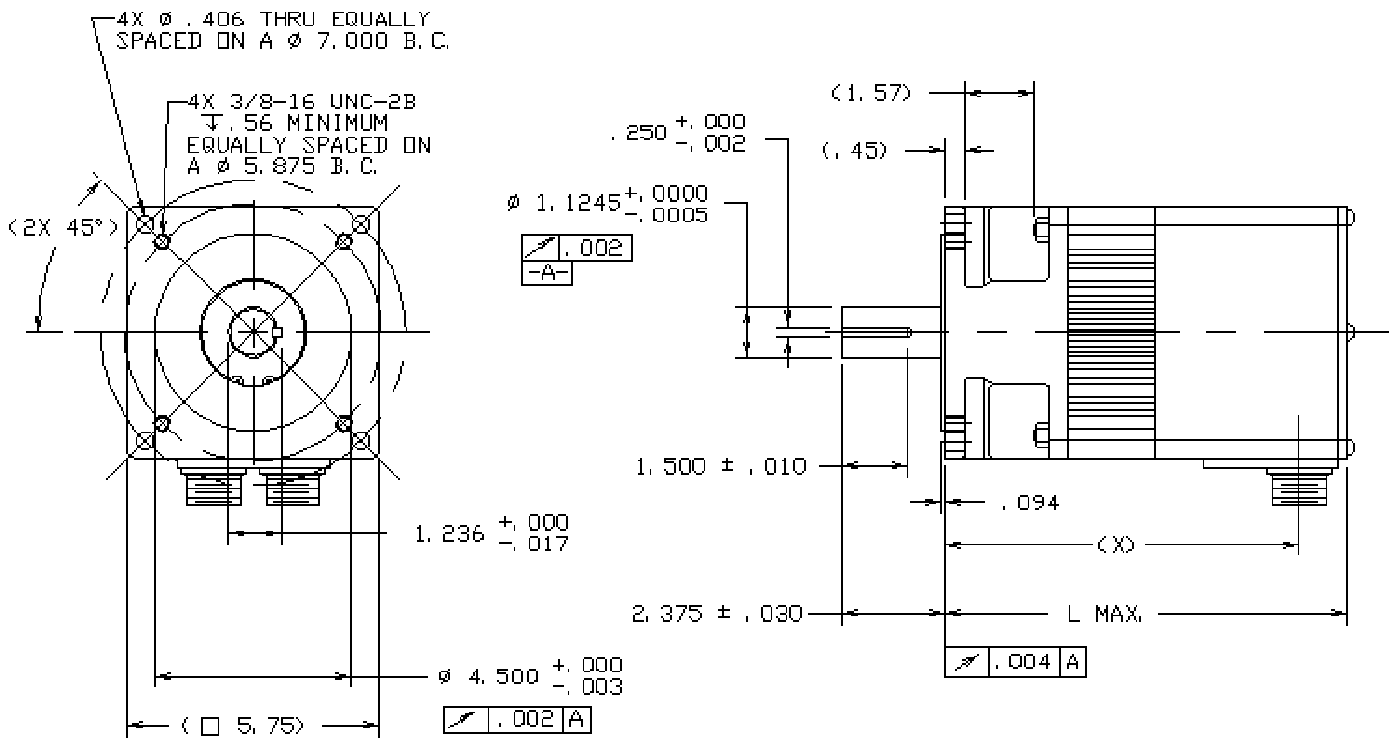
Motor	Brake	L Max		X	
		mm	Inches	mm	Inches
3S32	No	180.1	7.09	142.7	5.62
	Yes	236.5	9.31	142.7	5.62
3S33	No	205.5	8.09	168.1	6.62
	Yes	261.9	10.31	168.1	6.62
3S34	No	230.9	9.09	193.5	7.62
	Yes	287.3	11.31	193.5	7.62
3S35	No	256.3	10.09	218.9	8.62
	Yes	312.7	12.31	218.9	8.62

Figure 3-16. Dimensions for MTR-3S3x-Series Servo Motors



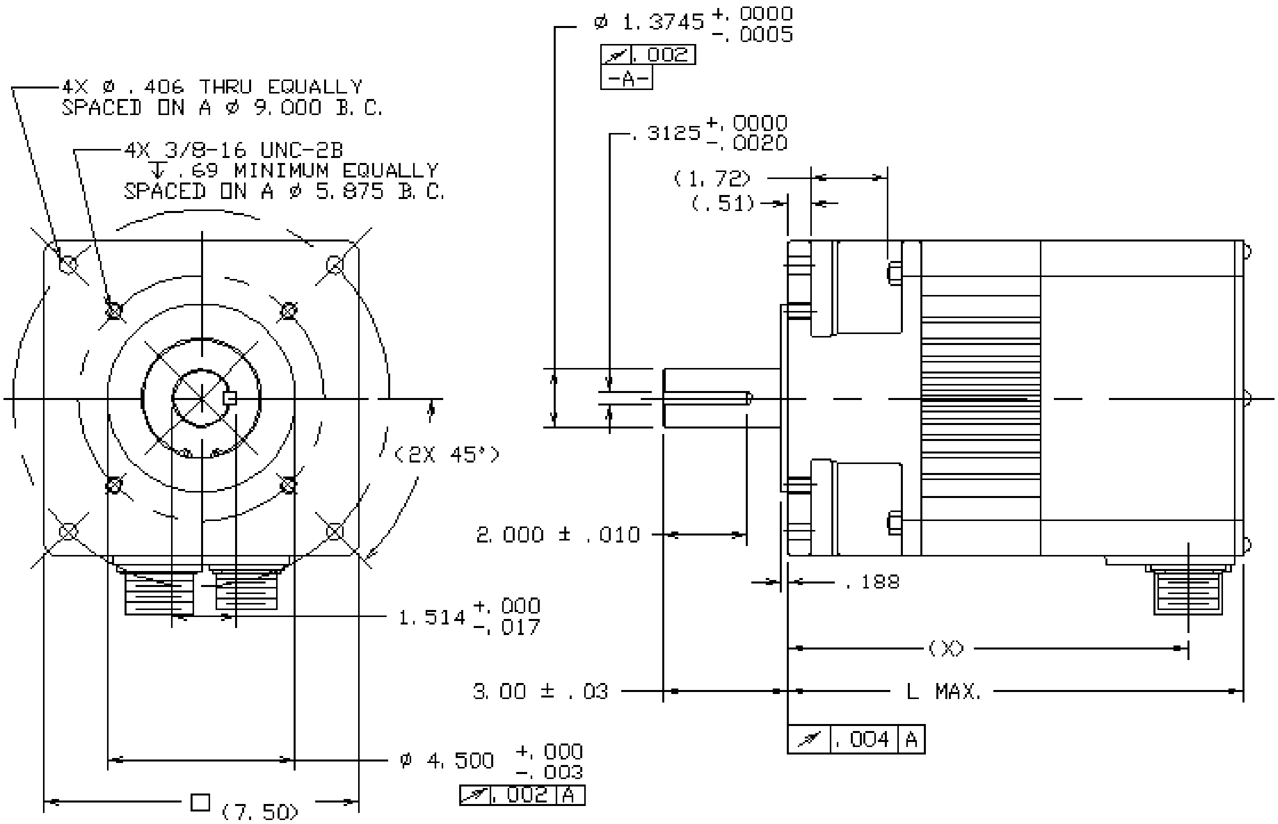
Motor	L Max		L Max (with Brake)		X	
	mm	Inches	mm	Inches	mm	Inches
3S43	213.4	8.4	275.3	10.84	178.1	7.01
3S45	251.5	9.9	313.4	12.34	216.2	8.51
3S46	289.6	11.4	351.5	13.84	254.3	10.01

Figure 3-17. Dimensions for MTR-3S4x-Series Servo Motors



Motor	L Max		L Max (with Brake)		X	
	mm	Inches	mm	Inches	mm	Inches
3S63	237.7	9.36	305.3	12.02	206.2	8.12
3S65	288.5	11.36	356.1	14.02	257.1	10.12
3S67	339.3	13.36	406.9	16.02	307.8	12.12

Figure 3-18. Dimensions for MTR-3S6x-Series Servo Motors



Motor	L Max		L Max (with Brake)		X	
	mm	Inches	mm	Inches	mm	Inches
3S84	277.6	10.93	350.8	13.81	242.8	9.56
3S86	328.4	12.93	401.6	15.81	293.6	11.56
3S88	379.2	14.93	452.4	17.81	344.4	13.56

Figure 3-19. Dimensions for MTR-3S8x-Series Servo Motors

3.5.4 Stepping Motor Dimensions

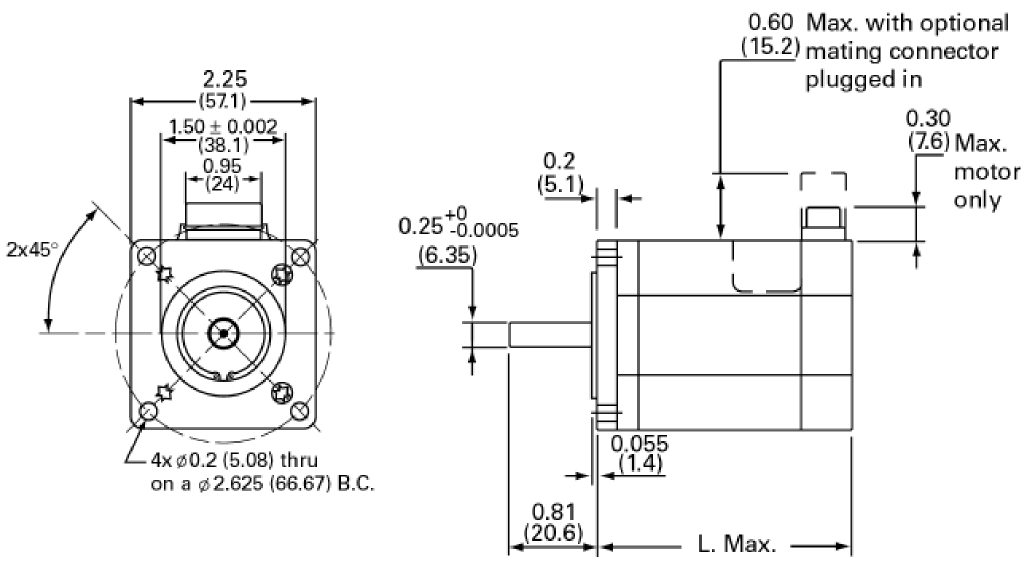


Figure 3-20. 1200 Series NEMA 23 Stepping Motor Dimensions

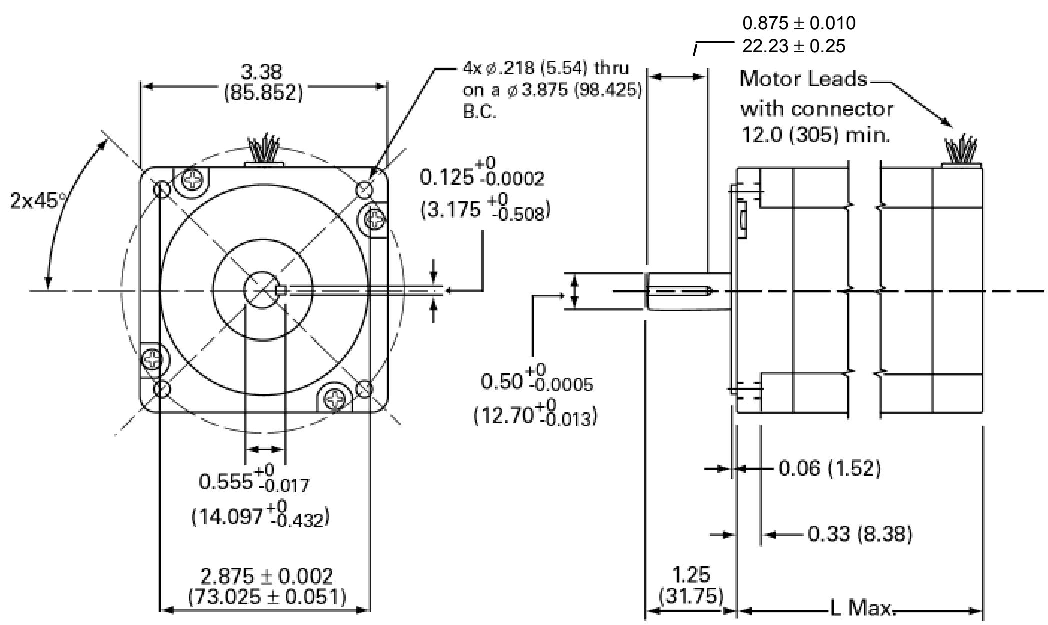


Figure 3-21. 1300 Series NEMA 34 Stepping Motor Dimensions

Motor Model	Units	L Max Dimension
STM1221	Inch (mm)	2.06 (52.3)
MTR-1221	Inch (mm)	2.06 (52.3)
MTR-1231	Inch (mm)	3.10 (78.7)
MTR-1324	Inch (mm)	2.58 (65.5)
MTR-1337	Inch (mm)	3.76 (95.5)
MTR-1350	Inch (mm)	5.06 (128.5)

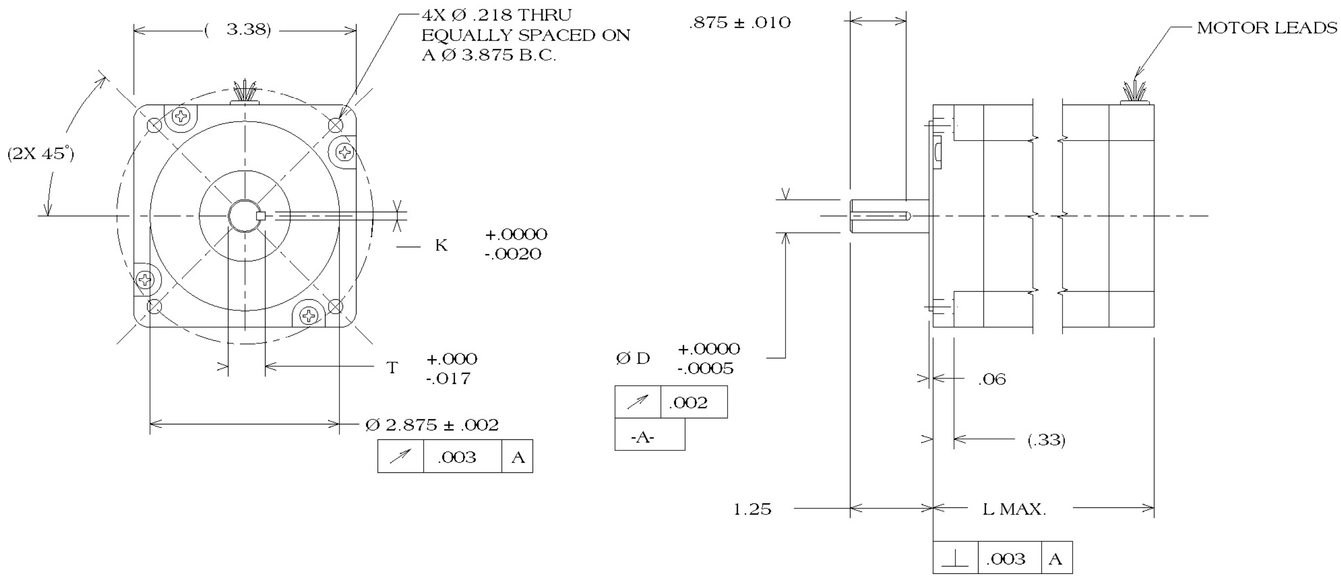


Figure 3-22. 1N30 Series NEMA 34 Stepping Motor Dimensions

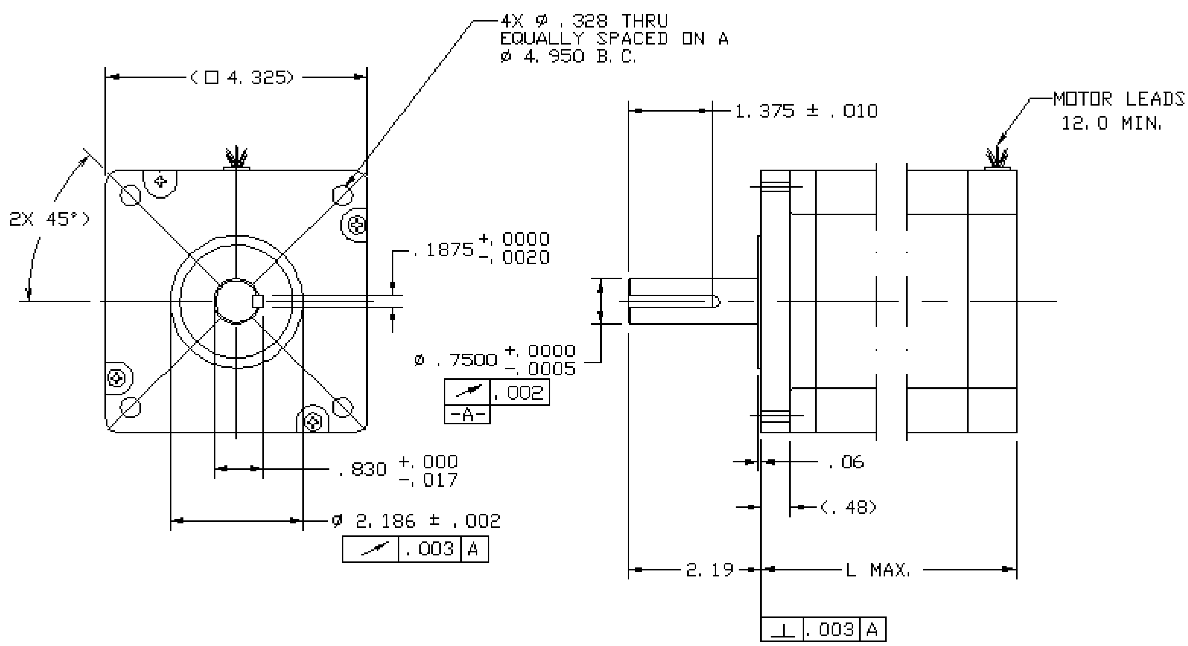


Figure 3-23. 1N40 Series NEMA 42 Stepping Motor Dimensions

Motor Model	Units	L Max Dimension
MTR-1N31	Inch (mm)	3.13 (79.5)
MTR-1N32	Inch (mm)	4.65 (118.1)
MTR-1N41	Inch (mm)	3.89 (98.81)
MTR-1N42	Inch (mm)	5.91 (150.11)

3.6 Wiring

3.6.1 General Wiring Considerations

See Chapter 2 for AC supply power requirements, fuse and isolation transformer ratings.

All power, input, and output must be in accordance with Class I, Division 2 wiring methods as defined in Article 501-4(b) of the National Electrical Code, NFPA 70 for installations within the United States, or as specified in Section 18-152 of the Canadian Electrical Code for installation within Canada.

Attach wiring connections for the main circuit according to Tables 3-2 through 3-4 while observing the following **cautions:**

Caution

Use vinyl-sheathed or equivalent wire rated at 250 VAC or greater for 230 VAC S2K models or 600VAC or greater for 460 VAC S2K models. Wire size should be determined considering ampacity and codes.

Never connect AC main power to output terminals.

Never allow wire leads to contact the enclosure.

Never operate the S2K controllers without an earth ground.

Warning

When using this equipment in a Hazardous (classified) location:

***Explosion hazard*--**substitution of components may impair suitability for Class I, Division 2;

***Explosion hazard*--**when in hazardous locations, turn off power before replacing or wiring modules;

***Explosion hazard*--**do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

3.6.2 AC Supply and Motor Wiring and Grounding

The S2K motion controllers are to be permanently connected in a closed electrical operating area. The mains input and motor output connections are made to the screw terminal connector located on the bottom of the S2K controller. The controllers are designed to operate with input voltages as shown in Chapter 2. No isolation transformer is required if the supply voltage is within the specified range. For the S2K servo controllers, the maximum achievable motor speed is directly related to the input voltage. For best performance connect these models to a three-phase 230 or 460 VAC power source depending on the controller's rated voltage.

All of the terminals marked with the symbol ⏚ are connected to the chassis ground. Connect the ⏚ terminal at the mains input end of the connector to the panel earth ground. Connect the ⏚ terminal near the motor output terminals to the motor frame ground wire in the motor power cable. DO NOT OPERATE THE S2K CONTROLLERS WITHOUT AN EARTH GROUND.

Design Notice. Where residual-current-operated protective device (RCD) is used for protection in case of direct or indirect contact, only RCD's of Type B is allowed on the supply side of this Electronic Equipment (EE). Otherwise another protective measure shall be applied such as separation of the EE from the environment by double or reinforced insulation or isolation of EE and supply system by a transformer. To meet the requirements of EN55011 and CE mark, EMI power line filters shall be employed between the motion controller and the supply mains. Table 3-1 lists suggested mains filters.

Table 3-1. Mains Power Filters for Reduction of Conducted EMI

Controller Model	Filter for 1 Phase Power	Filter for 3 Phase Power
STI105	Corcom 6FC10 Schaffner FN2070-10-06	Corcom 6FCD10
SSD, SSI 04	Corcom 6FC10 Schaffner FN2070-10-06	Corcom 6FCD10
SSD, SSI107	Corcom 12FC10	Corcom 16FCD10
SSD, SSI216	NA	Corcom 25FCD10
SSD, SSI228	NA	Corcom 36FCD10
SSI407, SSI420	NA	Corcom 25FCD10 Schaffner FN351H-25-33

Table 3-2. Power Terminal Connections and Wire Size for STI105 Stepper Controller

Terminal Symbol	Description	Connect to	Wire Size AWG[1]
⏚	Ground	Motor Ground	18-16
B+	Output Coil B+	Motor Coil B+	18-16
A/B-	Output Coil A-/B-	Motor Coil A-/B-	18-16
A+	Output Coil A+	Motor Coil A+	18-16
⏚	Ground	Power System Ground	18-16
NC	No Connection		
L2 & L2	Drive Input Power	90 – 130 VAC	18-16

Table 3-3. Power Terminal Connections and Wire Sizes for SSI104 4.3 A Servo Controller

Terminal Symbol	Description	Connect to	Wire Size AWG
⏚	Ground	Motor Ground	18-14
T	Output Phase T	Motor Phase T	18-14
S	Output Phase S	Motor Phase S	18-14
R	Output Phase R	Motor Phase R	18-14
⏚	Ground	Power System Ground	18-14
L3	Drive input power (do not connect for 1 phase input)	90 - 250 VAC	18-14
L2	Drive Input Power	90 - 250 VAC	18-14
L1	Drive Input Power	90 - 250 VAC	18-14

Table 3-4. Power Terminal Connections and Wire Sizes for SSI107 7.2 A Servo Controller

Terminal Symbol	Description	Connect to	Wire Size AWG[1]
⏚	Ground	Motor Ground	18-14
T	Output Phase T	Motor Phase T	18-14
S	Output Phase S	Motor Phase S	18-14
R	Output Phase R	Motor Phase R	18-14
⏚	Ground	Power System Ground	18-14
2L2	Logic Input Power	90 - 250 VAC	18-14
2L1			
1L3	Drive Input Power (do not connect for 1 phase input)	90 - 250 VAC	18-14
1L2	Drive Input Power	90 - 250 VAC	18-14
1L1			
EXT[2]	External Regen Resistor	INT	18-14
INT[2]	Internal Regen Resistor	EXT	18-14
DC+	High Voltage DC Bus	Ext. Regen Resistor	18-14

1) AWG size for stranded copper wire. Minimum wire size required will depend on motor and load. Consult *National Electrical Code Handbook* ampacities tables for proper wire size.
2) The S2K controllers dissipate regenerated energy in an internal regeneration resistor. If the application produces more regenerated power than the rating of the internal resistor, the controller will report an EC fault code (excessive clamp dissipation). Contact GE Fanuc to determine if an external clamp resistor is required.

Table 3-5. Power Terminal Connections and Wire Sizes for SSI216 16 A & SSI228 28A Servo Controller

Terminal Symbol	Description	Connect to	Wire Size AWG[1]
R	Output Phase R	Motor Phase R	16-10
S	Output Phase S	Motor Phase S	16-10
T	Output Phase T	Motor Phase T	16-10
⏚	Ground	Motor Ground Terminal	16-10
DC+	High Voltage DC bus	External Regen Resistor	16-10
INT[2]	Internal Regen Resistor	EXT	16-10
EXT[2]	External Regen Resistor	INT	16-10
DC-	High Voltage DC bus	No Connection	16-10
1L1	Drive Input Power	180 - 250 VAC	16-10
1L2			
1L3			
⏚	Ground	Power System Ground	16-10
2L1	Logic Input Power	180 - 250 VAC	18-14
2L2			

1) AWG size for stranded copper wire. Minimum wire size required will depend on motor and load. Consult *National Electrical Code Handbook* ampacities tables for proper wire size.
2) The S2K controllers dissipate regenerated energy in an internal regeneration resistor. If the application produces more regenerated power than the rating of the internal resistor, the controller will report an EC fault code (excessive clamp dissipation). Contact GE Fanuc to determine if an external clamp resistor is required.

Table 3-6. Power Terminal Connections and Wire Sizes for SSI407 7.2 A 460 VAC Servo Controller

Terminal Symbol	Description	Connect to	Wire Size AWG[1]
⏚	Ground	Motor ground terminal	16-10
T	Output phase T	Motor phase T	16-10
S	Output phase S	Motor phase S	16-10
R	Output phase R	Motor phase R	16-10
DC+	High voltage motor power bus	External clamp resistor	16-10
INT[2]	Internal clamp resistor	EXT	16-10
EXT[2]	External clamp resistor	INT	16-10
1L1 1L2 1L3	Drive input power	324 – 528 VAC	16-10
⏚	Ground	Power system ground	16-10
COM +24V	Logic input power	18 – 30 VDC	18-14

1) AWG size for stranded copper wire. Minimum wire size required will depend on motor and load.
Consult *National Electrical Code Handbook* ampacities tables for proper wire size.
2) The S2K controllers dissipate regenerated energy in an internal regeneration resistor. If the application produces more regenerated power than the rating of the internal resistor, the controller will report an EC fault code (excessive clamp dissipation). Contact GE Fanuc to determine if an external clamp resistor is required.

Table 3-7. Power Terminal Connections and Wire Sizes for SSI420 20A Servo Controller

Terminal Symbol	Description	Connect to	Wire Size AWG[1]
R	Output phase R	Motor phase R	16-10
S	Output phase S	Motor phase S	16-10
T	Output phase T	Motor phase T	16-10
⏚	Ground	Motor ground terminal	16-10
DC+	High voltage motor power bus	External clamp resistor	16-10
INT[2]	Internal clamp resistor	EXT	16-10
EXT[2]	External clamp resistor	INT	16-10
DC-	High voltage motor power bus	No connection	
1L1 1L2 1L3	Drive input power	324 – 528 VAC	16-10
⏚	Ground	Power system ground	16-10
COM +24V	Logic input power	18 – 30 VDC	18-14

1) AWG size for stranded copper wire. Minimum wire size required will depend on motor and load.
Consult *National Electrical Code Handbook* ampacities tables for proper wire size.
2) The S2K controllers dissipate regenerated energy in an internal regeneration resistor. If the application produces more regenerated power than the rating of the internal resistor, the controller will report an EC fault code (excessive clamp dissipation). Contact GE Fanuc to determine if an external clamp resistor is required.

3.6.3 S-Series Servo Motor Encoder Wiring

Position feedback cables as shown in Table 3-13 are available from GE Fanuc for the S2K Series controllers. Plug the motor end of the encoder cable into the connector on the motor and the DB-type connector end of the cable into the DB-15 socket labeled *Position Feedback* on the front of the controller. The best system reliability is achieved when the encoder cable is returned in a separate conduit from that housing the motor power cable. The feedback cable should use 24-28 AWG twisted pair wire and **must** be shielded. The shields must be terminated to the isolated ground pins on the *Position Feedback* (DB-15) connector on the S2K controller as shown in Table 3-8. Maximum serial encoder cable length is 15 meters using factory-supplied cables. If two parallel 24 AWG wires are connected to both the +5v and ground (GND), as shown in Table 3-8, longer cable runs require the wire gauge to be increased to reduce the signal voltage drop. The S-Series motors require a 5V ±5% (4.75 to 5.25 VDC) power source for proper operation. See Section 3.6.10, *Connection Diagrams*, for additional wiring detail.

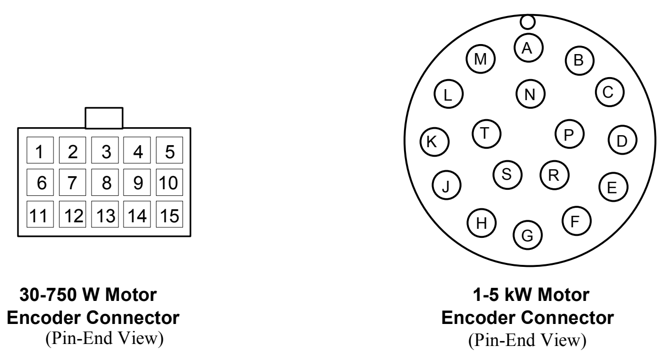


Figure 3-24. S-Series Servo Motor Serial Encoder Feedback Connectors

Table 3-8. Serial Encoder Position Feedback Connections on S2K Servo Controllers

Connect From DB15…		Connect To…	
S2K Position Feedback Connector Pin Number	**Signal Name**	**30-750 W S-Series Motor AMP Connector**	**1000-5000 W S-Series Motor MS-Style Connector**
1	A+	1	A
2	B+	3	C
3	Z+	5	E
4	RX	11	P
5	+5V	13	H
6	GND	14	G
7	NC	NC	NC
8	NC	NC	NC
9	A-	2	B
10	B-	4	D
11	Z-	6	F
12	TX	12	R
13	+5V	13	H
14	GND	14	G
15	Shield	15	J

3.6.4 S-Series Servo Motor Power and Brake Wiring and Grounding

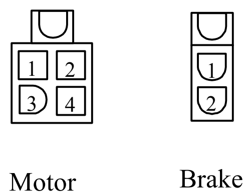
Motor power and brake cables as shown in Table 3-13 are available from GE Fanuc for the S2K Series Servo Controllers. Cables for S-Series motors with brakes include two 18 AWG leads for connection of a 24Vdc brake power supply (see section 2.1.9, Servo Motor Specifications, for brake power requirements) and brake control logic. The brakes are of a fail-safe design, engaged by internal springs and disengaged by the application of 24 Vdc power.

The motor cable must have a motor ground wire that connects one of the frame ground terminals on the controller to the frame ground pin on the motor connector. Tables to 3-13 show the proper wire size and Figure 3-25 shows the motor connector pin-out for each S-Series motor model. For noise sensitive applications, a shielded motor power cable may be necessary.

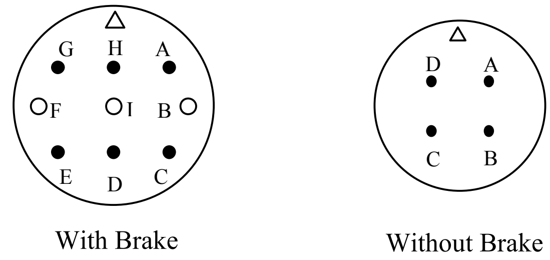
Note

A shielded motor power cable is required in CE marked systems. When used, the power cable shield should connect to the frame ground stud on the bottom of the controller and to the connector at the motor end. GE Fanuc’s standard motor power cables do **not** include a shield.

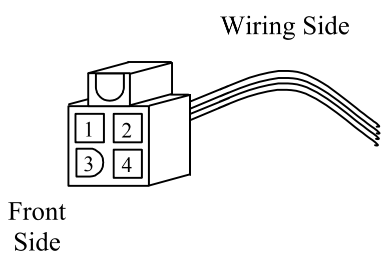
On the 30–750 Watt S-Series motors, the power connectors shown in the following figure are wired to the motors with short leads and include a separate connector (and require a separate brake cable) when the optional holding brake is included. On the 1.0–5.0 kW motors, the MS-style connectors shown are mounted directly on the motor’s frame and the brake connections are included in the same connector and cable.



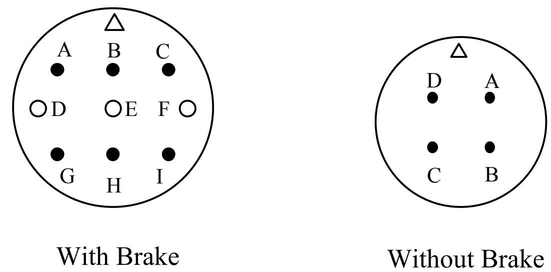
30-750 W (Front View)



SDM100, SLM100 SDM250, SLM250 & SGM450 (Front View)



Connector View Definition



SLM350, SDM500 & SLM500 (Front View)

30–750 W Motor Power	
Pin No.	**Signal**
1	T
2	R
3	S
4	GND

30–750 W Brake	
Pin No.	**Signal**
1	Brake
2	Brake

1–2.5 & 4.5 kW with Brake	
Pin No.	**Pin No.**
A & C	NC
E &D	GND
B	S
I	R
F	T
G & H	Brake

3.5–5 kW with Brake	
Signal	**Signal**
A & B	Brake
C & I	NC
D	T
E	R
F	S
G & H	GND

1-5 kW without Brake	
Pin No.	**Signal**
A	T
B	R
C	S
D	GND

Figure 3-25. S-Series Motor Power Connections

3.6.5 MTR-Series Servo Motor Power and Brake Wiring and Grounding

Motor power and brake cables as shown in Table 3-13 are available from GE Fanuc for the S2K Series Servo Controllers. MTR-3T series motors with brakes include two additional leads for connection of a 24Vdc brake power supply (see section 2.1.9, Servo Motor Specifications, for brake power requirements) and brake control logic into the motor power cable. MTR-3N and MTR-3S series motors with brakes use a physically separate brake power cable and connector. The brakes are of a fail-safe design, engaged by internal springs and disengaged by the application of 24 Vdc power.

The motor cable must have a motor ground wire that connects one of the frame ground terminals on the controller to the frame ground pin on the motor connector. Tables to 3-13 show the proper wire size and Figures 3-26 through 3-28 show the motor connector pin-out for each motor model. For noise sensitive applications a shielded motor power cable may be necessary.

Note

A shielded motor power cable is required in CE marked systems. When used, the power cable shield should connect to the frame ground stud on the bottom of the controller and to the connector at the motor end. GE Fanuc's standard motor power cables do **not** include a shield.

Connector Pin	Motor
1	Phase T
2	Phase S
Ground	Earth Case
4	Optional Brake -
5	Phase R
E	Optional Brake +

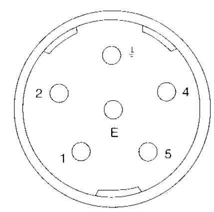


Figure 3-26. MTR-3T Series Motor/Brake Power Connections

Connector Pin	Motor
A	Phase T
B	Phase R
C	Phase S
D	Earth Case

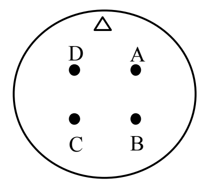


Figure3-27. MTR-3N and MTR-3S Series Motor Power Connections

Connector Pin	Motor
A	Brake +
B	Brake -

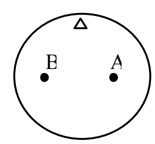


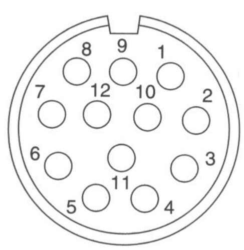
Figure 3-28. MTR-3N and MTR-3S Series Optional Brake Power Connections

3.6.6 MTR-Series Servo Motor Resolver Wiring

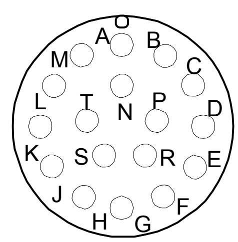
Resolver feedback cables as shown in Table 3-13 are available from GE Fanuc for the S2K Series resolver-based controllers used with MTR-Series motors. Plug the motor end of the resolver cable into the connector on the motor and the DB-type connector end of the cable into the DB-15 socket labeled *Position Feedback* on the front of the controller. The best system reliability is achieved when the encoder cable is returned in a separate conduit from that housing the motor power cable. The feedback cable should use 24-28 AWG twisted pair wire and **must** be shielded. The shields must be terminated to the isolated ground pins on the *Position Feedback* (DB-15) connector on the S2K controller as shown in Table 3-9. The maximum cable length for resolver feedback cables is 50 meters. See Section 3.6.10, *Connection Diagrams*, for additional wiring detail.

Table 3-9. Resolver Position Feedback Connections

Connect From S2K DB-15P…		Connect To…	
Position Feedback Connector Pin Number	**Signal Name**	**MTR-3T Series Motor Connector**	**MTR-3N or MTR-3S Series Motor Connector**
1	R1	5	E
2	R2	6	F
3	S1	1	D
4	S3	2	B
5	S2	4	C
6	S4	3	A
7	Therm	7	G
8	Therm	8	H
9	Shield	NC	NC
10	NC	NC	NC
11	Shield	NC	NC
12	NC	NC	NC
13	Shield	NC	NC
14	NC	NC	NC
15	Shield	NC	NC



MTR-3T Series Motors



MTR-3N and MTR-3S Series Motors

Figure 3-29. MTR-Series Resolver Feedback Connections

3.6.7 Serial Port Wiring

The S2K controller includes an RS-232 serial port that is used for programming and monitoring functions in addition to providing an interface for an Operator Interface Terminal. While the Motion Developer software uses normal ASCII communications, the S2K controllers also support an RTU protocol on this port allowing communication with any RTU-compliant OIT or device (see Chapter 9, "*Using Serial Communications"* for more details). The RTU register is used to enable/disable the RTU mode. A +12 VDC supply is available on pin 4 that can be used to power the display. This supply is also available on the I/O connector and can source a maximum of 0.5 amp combined load current.

Default settings for the serial port are 9,600 baud, 7 bits and odd parity. XON/XOFF flow control is used.

Prefabricated serial cables are available from GE Fanuc as part number IC800SKCS030 (3 meters) or you can build your own cable using the following S2K connection information. Cable should be Belden 8723 shielded cable or equivalent. To meet the requirements of EN61000-4-5 and CE mark, serial communication cables shall be shielded and shall not exceed 30 meters in length. Pin-out for the serial cable is shown in the following table.

Table 3-10. Serial Port Connections—Programming Interface Cable

S2K Connector Pin	PC Connector Pin	Label	Description
1, 6, 8, 9	1, 6 ,7 ,8, 9	N/C	No Connection
2	2	TX	Controller Transmit
3	3	RX	Controller Receive
4	4	+12VDC	DC Supply for OIT (0.5 A max.)
5	5	GND	Ground
7	N/C		Jumper pin 4 to pin 7 on controller connector
N/C	5	Shield	Cable Shield

3.6.8 Discrete I/O Wiring

The discrete inputs and outputs may be wired for either sinking or sourcing operation. The operational voltage range is 12 to 24 volts DC. The outputs can sink or source 100 mA maximum. The connection diagrams in Section 3.6.10 show proper connection for sourcing and sinking configurations. Points labeled as "IN_xx" are inputs only while points labeled "I/O_xx" can be used as either inputs or outputs.

The wiring to this connector should be of appropriate size and insulation quality for the application. To meet the requirements of EN61000-4-5 and CE mark, discrete I/O cables shall be shielded and shall not exceed 30 meters in length.

The discrete I/O are general purpose except for the Enable Input and the OK output. Three of the other general purpose inputs are used to connect a home switch and hardware overtravel switches when required by the application.

3.6.8.1 Connecting Homing and Overtravel Switch Inputs

Many applications require the use of a home position sensor to define the reference or "home" position of the axis. The S2K controllers have a number of home reference commands that can be used to home the axis to various reference points such as the encoder marker (RMF, RMR), a home switch (RHF, RHR) and the overtravel switches (ROF, ROR). When a home sensor is used, it must be wired to the Discrete Input 1 (DI1) terminal. When the controller executes one of the Run To Home Input commands (RHF, RHR), it will look for a state change on this physical input.

When the controller executes a Home To Overtravel Input command (ROF, ROR), it will look for a state change on the respective overtravel switch. The forward overtravel switch must be connected to Discrete Input 2 (DI2), and the reverse overtravel switch must be connected to Discrete Input 3 (DI3). To use these end-of-travel switches as a home sensor, it is **not** necessary to have the hardware overtravel inputs enabled (OTE=1). However, if the application requires end-of-travel protection, you must enable the hardware overtravel inputs by setting the Overtravel Enable register true (OTE=1).

3.6.8.2 Connecting Handwheel Encoder Inputs

The controller has a special function that enables the connection of a handwheel encoder, typically used to jog the axis at a low speed, to two of the discrete inputs. When the Handwheel Enable register is set to true (HWE=1), Discrete Input 5 (DI5) is used to connect the A-channel of the handwheel, and Discrete Input 6 (DI6) is used to connect the B-channel. The handwheel encoder inputs are limited to a maximum pulse rate of 500 pulses/second. The axis will follow the handwheel input based on the values of the Gearing Ratio Numerator (GRN) and Gearing Ratio Denominator (GRD) as shown below:

$$\text{Axis Pulses} = \frac{\text{GRN}}{\text{GRD}} * \text{Handwheel Pulses}$$

This additional encoder input can be used as a master source, within the maximum pulse rate limitation stated above, when the auxiliary encoder input is used for dual loop servo control.

3.6.9 Auxiliary I/O Wiring and Functional Descriptions

The Auxiliary I/O connector includes a number of diverse signals used to interface the S2K controller to your motion controller and machine. The functions available include:

- Analog Command Input (AI1)
- Torque Limit Analog Input (AI2)
- Analog Output (AO)
- +5 Vdc Output (for auxiliary encoder) (on the Pulse Input on SSI216, SSI228, & SSI420 models)
- +12 Vdc Output (for Enable input)
- Enable Input
- OK Output
- Encoder Output
- Auxiliary Encoder Input (on the Pulse Input on SSI216, SSI228, & SSI420 models)

The SSI216, SSI228, & SSI420 models have a different configuration for the Discrete I/O and Auxiliary I/O connections as shown on the connection diagrams in Section 3.6.10.

The Enable input and OK output may be wired for either sinking or sourcing operation. The operational voltage range is 12 to 24 volts DC. The OK output can sink or source 100 mA maximum. The wiring to the Auxiliary I/O connector should be of appropriate size and insulation quality for the application. To meet the requirements of EN61000-4-5 and CE mark, Auxiliary I/O cables shall be shielded and shall not exceed 30 meters in length.

SI105, SSI104, SSI107 and SSI407 Models

The Auxiliary I/O connector on these models is a standard 25-pin female D-shell connector and is wired according to the pin-out shown in Table 3-11 and in section 3.6.10, *Connection Diagrams*, for the 4.3 and 7.2 amp servo controller models and 5 amp stepper controller model.

GE Fanuc offers prefabricated connection options for the Auxiliary I/O signals:

- A breakout terminal board assembly (44A726268-001) and associated “plug-and-go” interface cables (IC800SKCIxxx) make all of the signals available on screw terminals from a compact terminal block that can be panel or DIN-rail mounted.
- Flying lead cables (IC800SKCFLYxxx) have a connector on one end and marked, stripped wires on the other end. The stripped ends can be wired to a user-supplied terminal strip or to the machine controller’s terminal strip. Each wire on the stripped end is marked with the pin number it connects to on the connector end.

See Table 3-13 for cable selection.

SSI216, SSI228, and SSI420 Models

The Auxiliary I/O connector on these models is a standard screw terminal connector and is wired according to the pin-out shown in Table 3-11 and in section 3.6.10, *Connection Diagrams* (note that these models are available with either DeviceNet or Profibus network connectivity). Because the connections are made to screw terminals, no prefabricated cable is offered for Auxiliary I/O connections for these models.

Detailed descriptions for each signal on the Auxiliary I/O connector are shown in the following table.

Table 3-11. Auxiliary I/O Connector Pin-out

SSI104 SSI107 SSI407 Pin #	SSI216 SSI228 SSI420 Pin #	Signal Name	Description
1	1	AI1+	Positive for differential analog input 1 used for the ± 10Vdc command interface
2	3	AI2+	Positive for differential analog input 2 used as a ± 10Vdc torque limit input
3	6	AO	Positive for the general purpose analog output
4	Pulse Input	IN_A+	Positive for the A channel of the auxiliary encoder input
5	Pulse Input	IN_B+	Positive for the B channel of the auxiliary encoder input
6	Pulse Input	Tie	Used to bias the auxiliary encoder inputs when used in single-ended mode
7	19	+12 Vdc	12 Vdc regulated power output for use with Enable and OK signals (0.5 A max.)
8	8	Out_A+	Positive for the A channel of the encoder output
9	10	Out_B+	Positive for the B channel of the encoder output
10	12	Index +	Positive for the index (marker) channel of the auxiliary encoder output
11	14	Common	Signal common for internal 5 and 12 Vdc supplies. Not referenced to frame.
12	N/A	Enable -	Negative for the power output enable discrete input
13	N/A	OK -	Negative for the controller OK discrete output
14	2	AI1 -	Negative for differential analog input 1 used for the ± 10Vdc command interface
15	4	AI2 -	Negative for differential analog input 2 used as a ± 10Vdc torque limit input
16	5 & 7	Analog Common	Common reference for analog inputs and outputs
17	Pulse Input	IN_A-	Negative for the A channel of the auxiliary encoder input
18	Pulse Input	IN_B-	Negative for the B channel of the auxiliary encoder input
19	Pulse Input	+ 5 Vdc	5 Vdc regulated power output (0.25 A max. current) for auxiliary encoder power
20	14 & 20	Common	Signal common for discrete inputs and outputs
21	9	Out_A -	Negative for the A channel of the encoder output
22	11	Out_B –	Negative for the B channel of the encoder output
23	13	Index -	Negative for the index (marker) channel of the auxiliary encoder output
24	15	Enable +	Positive for the power output enable discrete input
25	16	OK +	Positive for the controller OK discrete output
N/A	17	Input Common	Common side of the Enable discrete input optocoupler. Not referenced to any internal voltages or ground points.
N/A	18	Output Common	Common side of the OK SS relay output. Not referenced to any internal voltages or ground points.

Note: Auxiliary I/O Break Out Terminal board (part #44A726268-001) can be used to provide screw terminal interface for the connections. (Applies to 4A and 7A servo models and 5A stepper model only.)

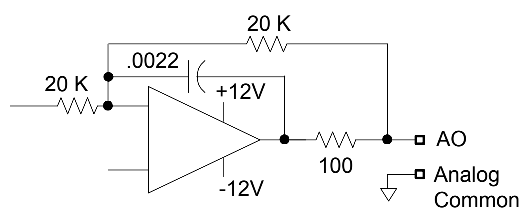
Analog Output (AO)

The hardware analog output is primarily used as a process input to the controller programs, but it can also be used a diagnostic output for various signals used in the tuning and debugging process. The *Analog Common* pin is used for the signal return. The Analog Output (AO) software parameter allows you to configure this output to represent one of the following signals:

- Actual velocity (AO = VLA)
- Actual output current (AO = CMD)
- Following error (AO = FE)

The output can also be forced to a specific voltage value by setting the AO parameter to the desired voltage from a program, PC terminal emulator, or Motion Developer terminal window. The analog Output value can be queried in the terminal window using the "?" command.

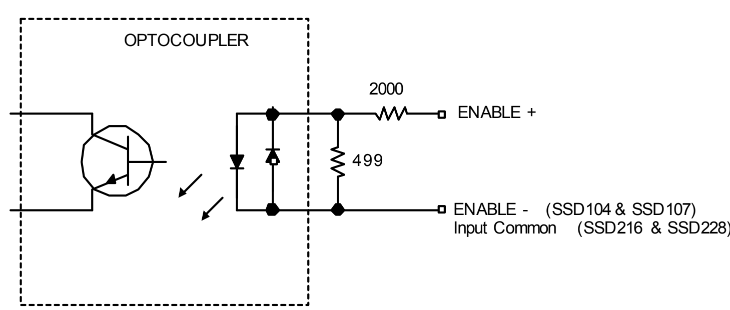
Use 20-28 AWG twisted-pair wire with an overall shield for this signal interface. For best noise immunity connect the shield to the *Analog Common* pin on the Auxiliary I/O connector. The internal schematic for the analog output circuit is shown below.



Enable Input

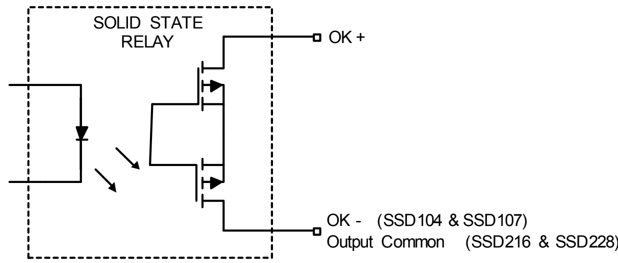
The Enable discrete input allows the host controller to enable or disable the power output stage of the controller and reset faults. The Enable input must be active to run the servo motor. This Enable hardware input works in tandem with a logical (software) enable register called the Power Output Stage Enable (POE) register. The POE register will allow current to flow into the motor only when set true and no faults are present on the controller. Since a Lost Enable (LE) fault is generated when this hardware enable input is false, ensure that POE=1, the hardware enable input is true, and all faults have been cleared (RSF register) to activate the power stage of the controller.

The current state of the Enable input can be queried using the Fault Code (FC) register in the terminal window. The Enable input should be connected as shown in the connection diagrams in Section 3.6.10. The internal schematic for the enable input circuit is shown below.



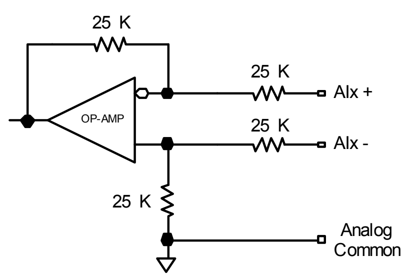
OK Output

The OK discrete output allows the S2K to communicate status information to the host controller. The OK output is active when the controller is enabled and no faults are present. The S2K LED status register will display OK when this output is active. The internal schematic for the OK output circuit is shown below.



Analog Inputs

There are two 12-bit differential analog inputs that support an operating voltage range of ± 10Vdc. These general-purpose inputs can be read as a voltage value in user programs using the AI command. The analog input values can also be queried in the terminal window using the "?" command. Wiring connections should use twisted shielded cable for best noise immunity. Connect the cable and shield as shown in Section 3.6.10, *Connection Diagrams*.



Auxiliary Encoder Input

The auxiliary encoder input is a flexible input that can be used as a master input for cam or electronic gearing applications, a secondary position monitor, a remote axis position feedback or as secondary position feedback for dual position loop control for the S2K servo controllers. The auxiliary encoder is selected as the master position source for camming by setting the Cam Shaft Position Type (CAT) equal to PSX. The auxiliary encoder is the default command source when gearing is enabled (GRE=1). If the Handwheel Input is enabled (HWE=1), digital inputs 5 and 6 are used for connecting an A/B type hand wheel for use as the gearing command source instead of the auxiliary encoder.

If the Position Feedback Enable is set (PFE=1), the axis position (PSA) is updated from the auxiliary encoder rather than the motor encoder. In addition, when the Position Feedback Numerator (PFN) is non-zero the S2K controller uses a dual position loop mode where the motor encoder is used for the primary position loop and the auxiliary encoder is used for secondary position loop. In this case the auxiliary encoder should be connected to the load to allow the S2K to accurately control the load position without the effects of lost motion from the mechanics. This dual loop arrangement is a very powerful feature that provides excellent servo stability while eliminating the inaccuracy caused by backlash and compliance in the system mechanics. The auxiliary encoder input is connected on the Auxiliary I/O connector for the STI105, SSI104, SSI107, and SSI407 models and to the Pulse Input connector for the SSI216, SSI228, and SSI420 models. Wiring connections should use twisted shielded cable for best noise immunity. Connect the cable and shield as shown in Section 3.6.10, *Connection Diagrams*. The auxiliary encoder inputs are labeled with "IN_" prefix on these diagrams.

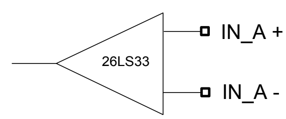
The S2K controller includes an electronic gearing mode that allows the motor to follow a master encoder (follower) or pulse command source (stepper emulator). The Auxiliary Encoder Type (QTX) register configures this input for one of the following signal types:

- Pulse/Direction input
- CCW/CW pulse input
- Quadrature (encoder) input

If an Auxiliary Encoder Input is being driven by a 26LS31 or equivalent differential line driver, it is recommended that a 120-ohm parallel termination resistor be used (please see specifications for RS422 communications for details). If being used in a singled-ended circuit, see the section called "Tie" below.

Note that the S2K Primary Encoder feedback receivers have internal termination resistors.

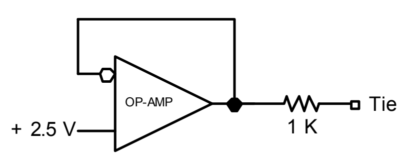
Note that on the SSI216, SSI228, and SSI420 models, the auxiliary encoder input and the +5Vdc output are located on the Pulse Input connector on the bottom of the controller. The internal schematic for the encoder input circuit is shown below.



NOTE: when the Auxiliary Encoder input is used with a single-ended signal source, see the next section titled "Tie" below.

Tie (for single ended encoder input)

The Tie point allows the auxiliary encoder inputs to be used as single-ended inputs. This terminal is internally connected to a 2.5 Vdc source through a 1 kΩ current limiting resistor. Typically, the Tie point is connected to the IN_A- and IN_B- input terminals to bias the line receiver. Note that on the SSI216, SSI228, and SSI420 models, this terminal is located on the Pulse Input connector on the bottom of the controller. For single-ended open collector encoder signals, a 470 Ω pull-up resistor is required. The internal schematic for the tie terminal is shown below.



Encoder Output (Out_A, Out_B, Index)

The S2K controller is typically used to control the position of the motor based on programmed commands. The encoder output buffers either the motor feedback or auxiliary encoder signals and makes them available as quadrature (A-Channel, B-Channel and Index) signals to another S2K controller for master/slave or cam following or to a host controller.

The S-Series motor encoder resolution is 2,500 pulses per revolution, so the feedback to the host controller supports 10,000 quadrature counts/revolution. For MTR-Series motors, the resolver-based S2K derives quadrature encoder signals from the resolver feedback with a maximum resolution of 1,024 pulses per revolution (4,096 quadrature counts per revolution). This maximum resolution can be scaled down to one of several predefined lower resolution values using the Encoder Output Type (EOT) register.

The encoder output is a differential output source (see Section 2.1.7 for specifications) with user selectable source via the Encoder Output Type (EOT) parameter. The EOT parameter determines whether this output tracks the auxiliary encoder input or the motor encoder input:

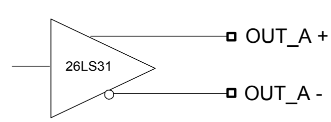
- **When EOT=0** (default), the encoder output buffers the **auxiliary encoder input** pulse-for-pulse. If the auxiliary input is a quadrature encoder the output will be quadrature. If the auxiliary input is CW/CCW pulses, the output will be in this same format.
- **When EOT is non-zero**, the output tracks the **motor encoder input** up to the full resolution of 2,500 lines/rev for encoder feedback controllers or 1,024 lines/rev for resolver feedback models; and the setting of the EOT register determines the output resolution. The allowed values for this resolution are:

  Encoder Feedback Controller: 0; 500; 625; 1,000; 1,250; 2,000, 2,500
  Resolver Feedback Controller: 0; 250; 256; 500; 512; 1,000; 1,024

The marker pulse width is fixed at 1/5,000th of the source encoder revolution (auxiliary or motor encoder based on setting of EOT). This implies that the marker pulse output width will vary with encoder speed and the smallest width will occur at the highest speed. For example, if the source encoder is rotating at 1000 RPM or 16.667 rev/sec then the encoder takes 0.06 seconds per revolution. Therefore, 1/5000th of this value, or 12 μS, represents the marker pulse width at that speed.

The encoder output is connected on the Auxiliary I/O connector. For best results, wiring connections should use 20-28 AWG twisted-pair wires with individual shields on each wire pair and an overall shield. For best noise immunity, connect the cable shield to one of the *common* inputs on the Auxiliary I/O connector. Connect the cable and shield as shown in Section 3.6.10, *Connection Diagrams*. The auxiliary encoder inputs are labeled with "Out_" prefix (such as Out_A+) and Index prefix (such as Index +) on these diagrams.

The typical internal schematic for each of the encoder output circuits is shown below.



It is possible to daisy chain a master encoder signal by connecting the master encoder signal to the auxiliary encoder input and then repeating this signal on the Encoder Output for use by downstream controllers. The propagation delay is approximately 50 ns for each daisy-chained S2K controller. For example, daisy-chaining eight controllers would result in approximately 400 ns (0.4 microseconds) encoder propagation delay on the final controller. For a 1,000 line (4,000 quadrature count) master encoder rotating at 6,000 RPM this represents an insignificant delay of 16% of the width of a single master encoder count.

High Speed Position Capture (Registration) Input

The S2K servo controllers support a high speed position capture input that can be used for registration applications to latch both the axis encoder and the auxiliary encoder positions with a 30 µS response time. The motor encoder position is stored in the Axis Position Capture (PCA) register while the auxiliary encoder position is stored to the Auxiliary Position Capture (PCX) register. The capture input is identified in the following table and depends on the controller model. This same input also functions as the auxiliary encoder index input. (See Section 3.6.10, *Connection Diagrams.)*

Table 3-12. High Speed Position Capture Input Identification

Controller Model	Inputs	Connector Name	Connection Diagrams	Input Rating
SSI104, SSI107, SSI407	IN_Index + and Common IN_Index – See Note 1	Auxiliary I/O	3-12, 3-13, 3-14, 3-15	15 VDC (Max.) See Note 2
SSI216, SSI228, SSI420	IN_I + and Common IN_I – See Note 1	Pulse Input	3-16	15 VDC (Max.) See Note 2

[1] Jumper this pin to the +5V pin for a 24V input device or to the Tie pin for any lower voltage input device. (This improves noise immunity.) See the following two figures for 24V examples.

[2] For 24V input devices, use the method shown in the following two figures.

The controller inputs are not rated for 24Volts, so for registration devices operating at 24VDC, use one of the circuits diagrammed below:

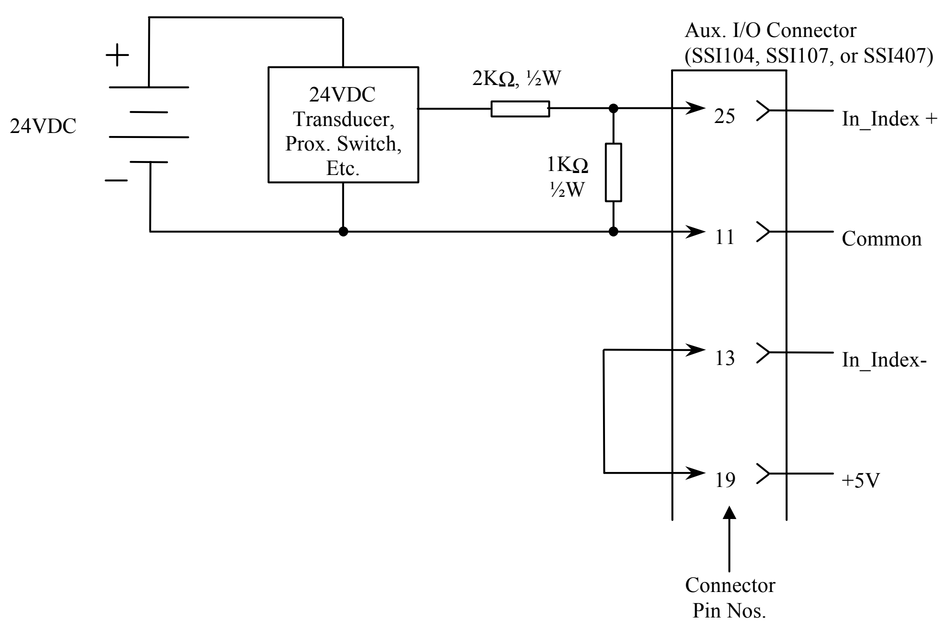


Figure 3-30. Connecting a 24VDC Input Device to an SSI104, SSI107, or SSI407 Controller

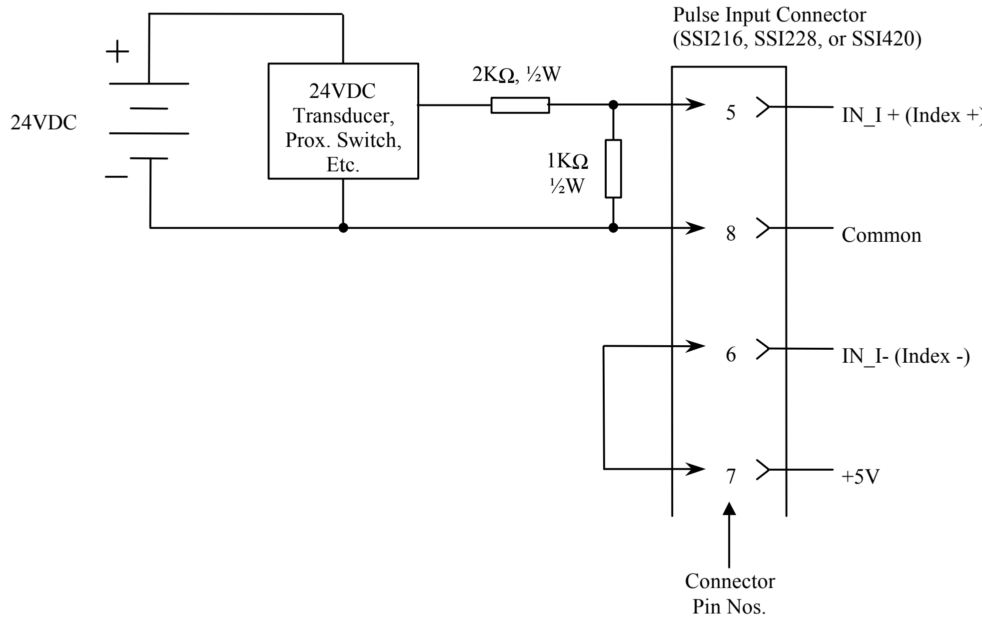


Figure 3-31. Connecting a 24VDC Input Device to an SSI216, SSI228, or SSI420 Controller

3.6.10 Connection Diagrams

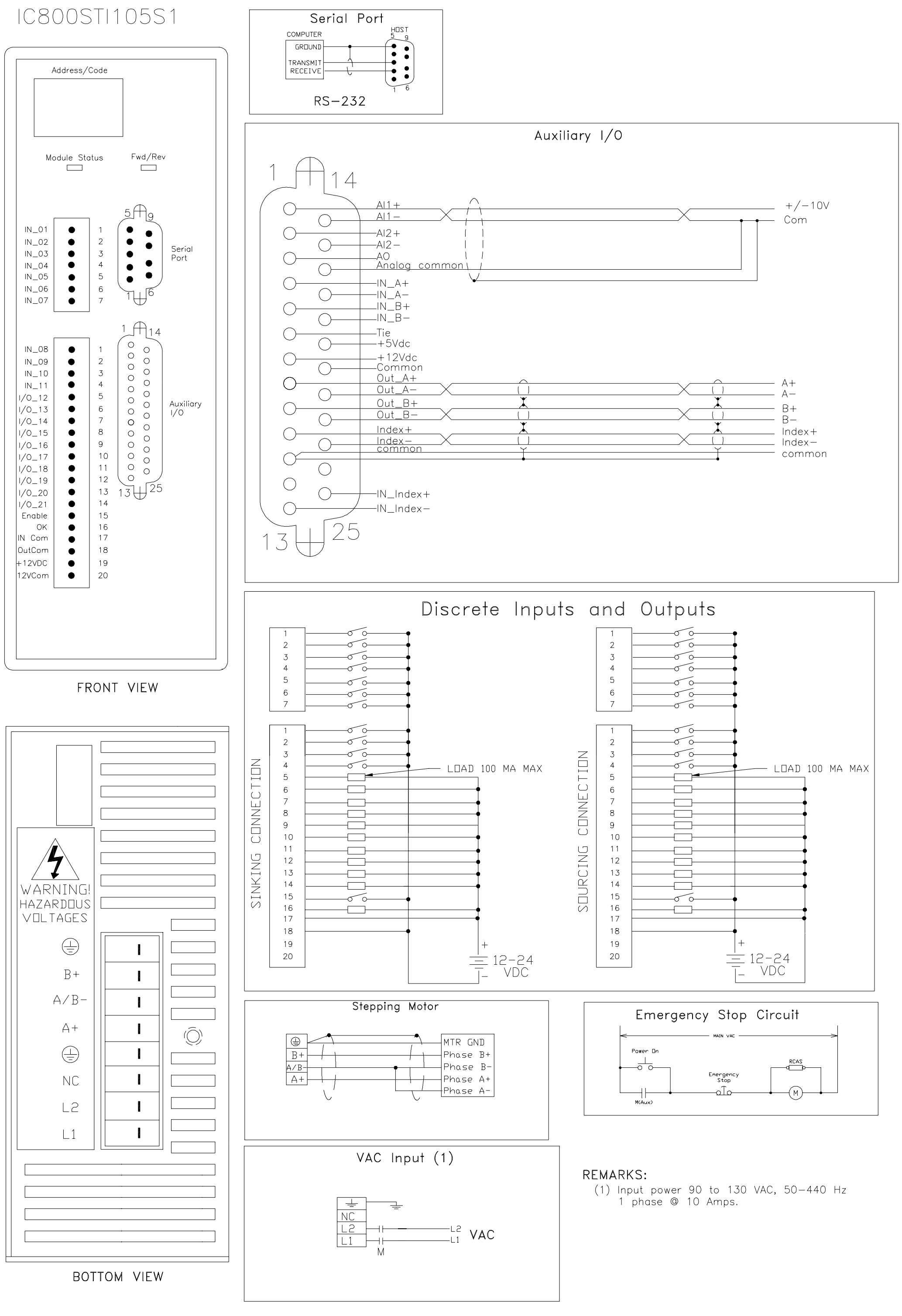


Figure 3-32. Connection Diagram for the Stepping Motor Controller (STI105S1)

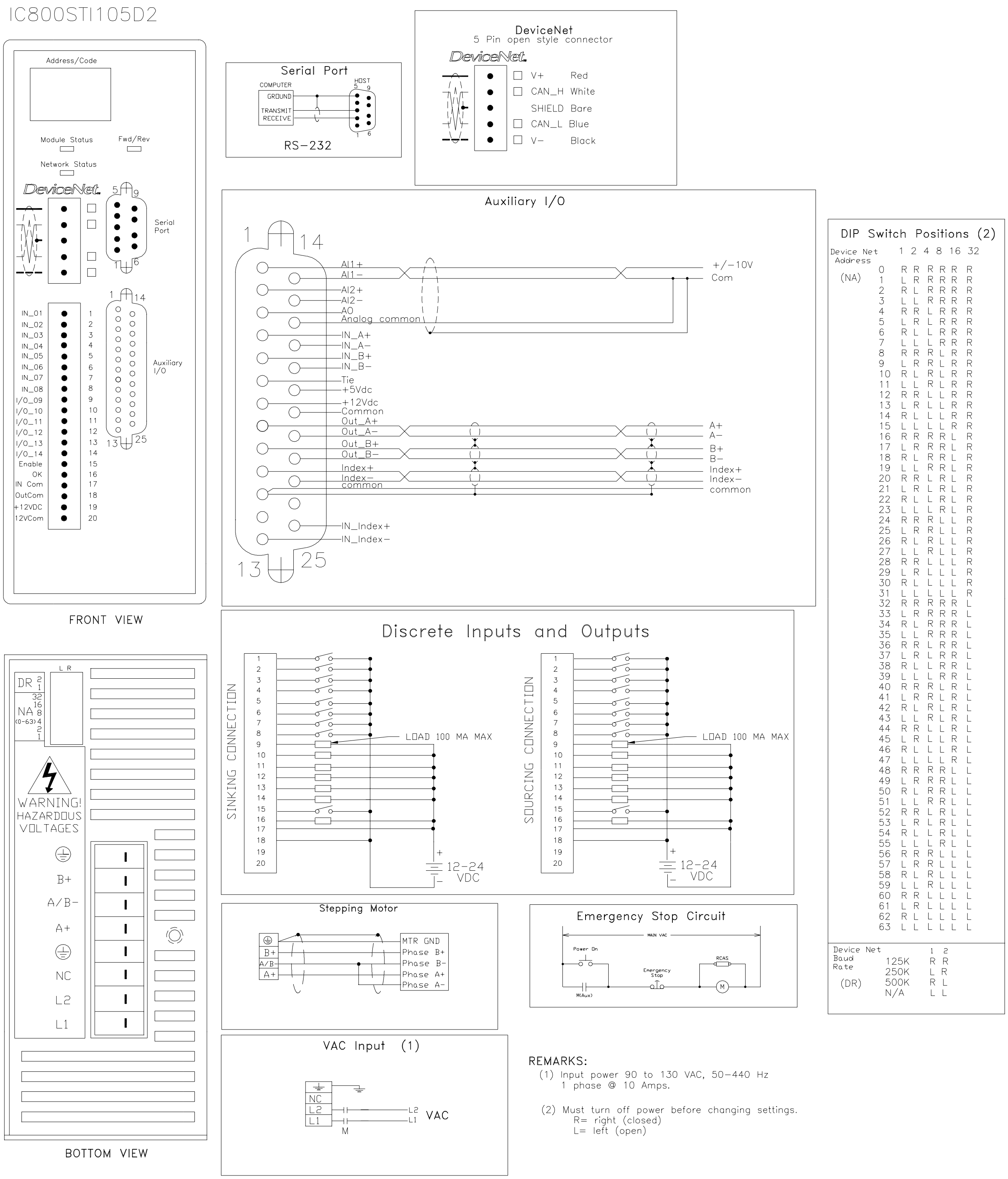


Figure 3-33. Connection Diagram for the Stepping Motor Controller with DeviceNet (STI105D2)

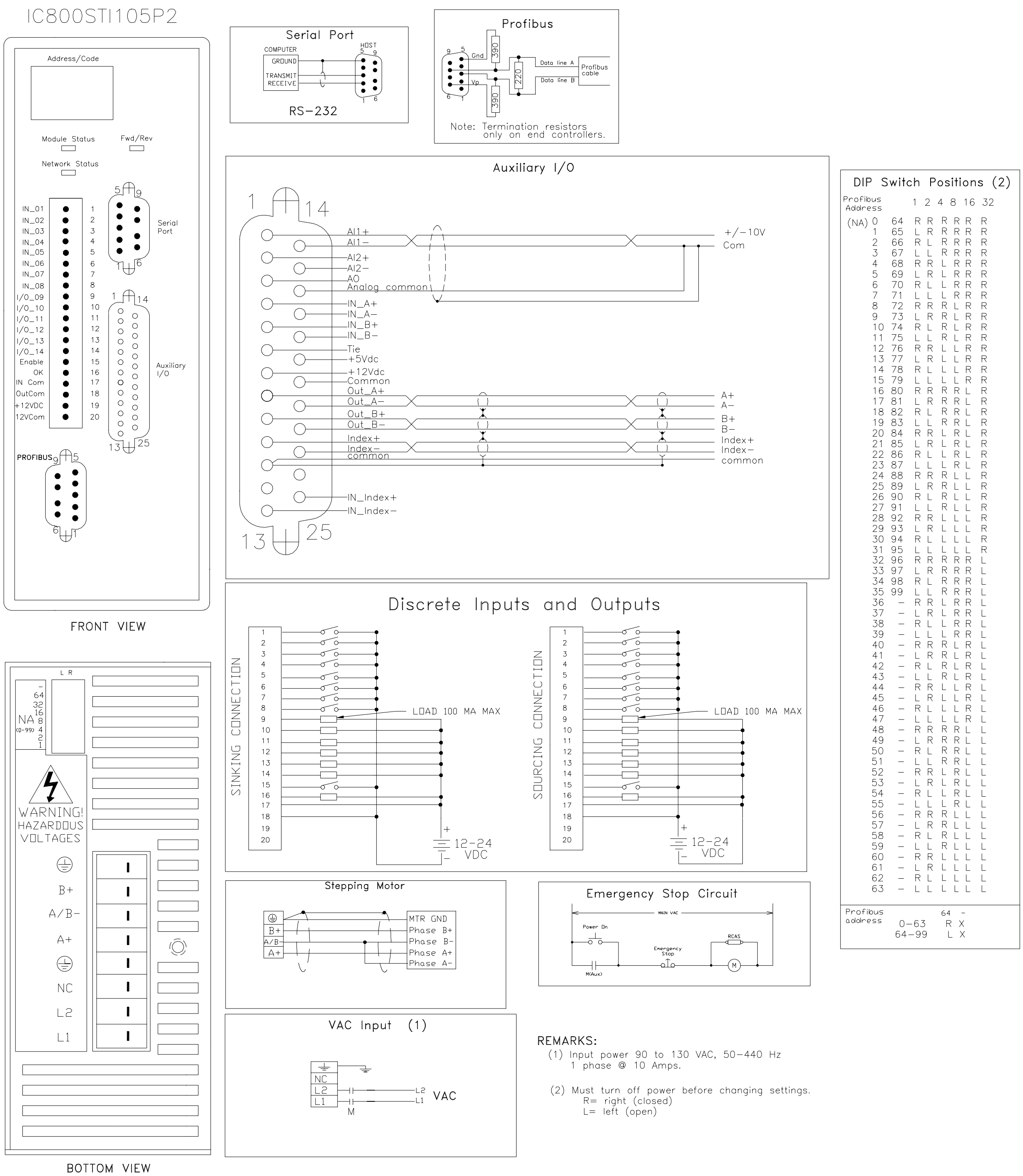


Figure 3-34. Connection Diagram for the Stepping Motor Controller with Profibus(STI105P2)

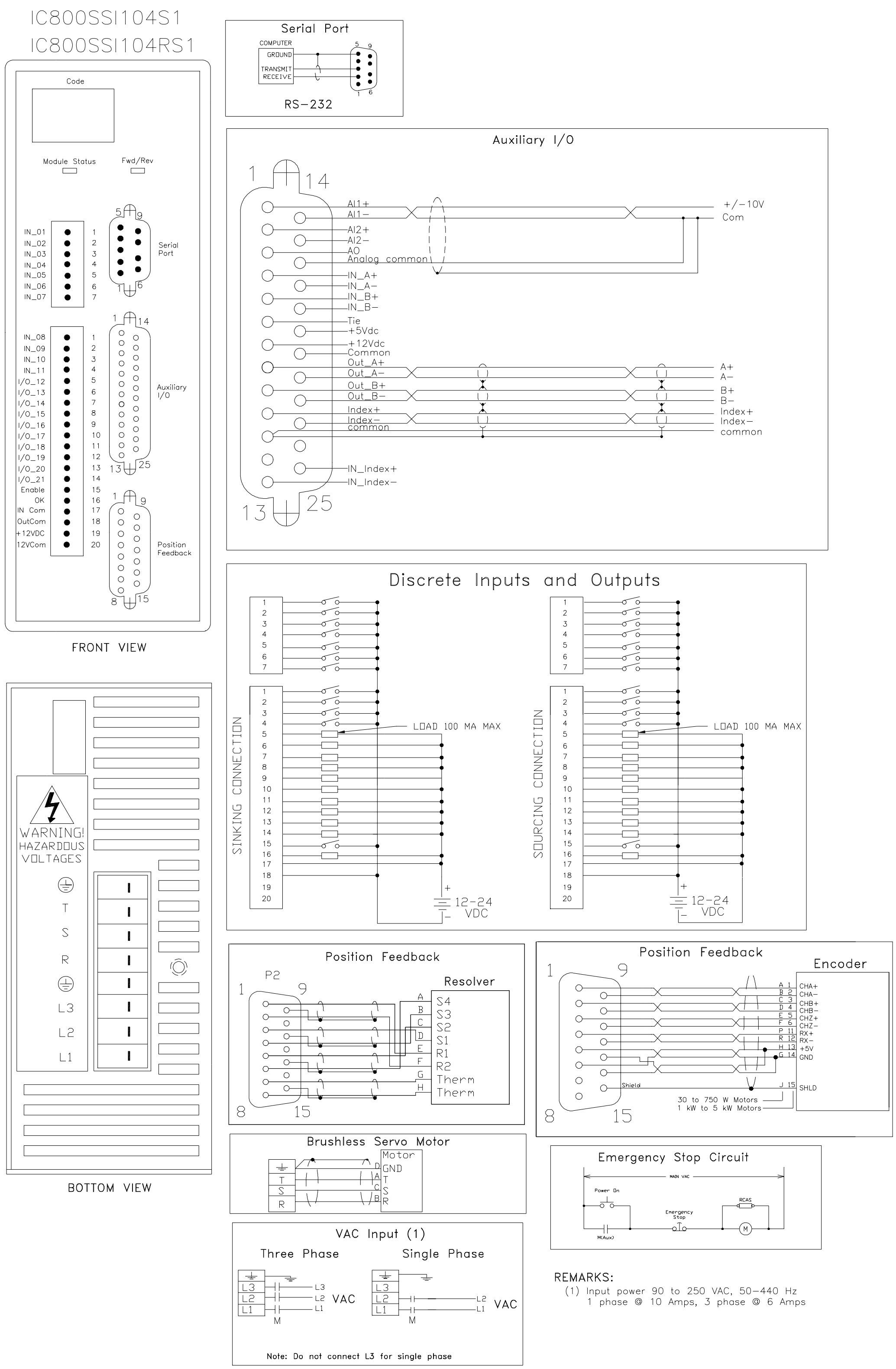


Figure 3-35. Connection Diagram for the 4.3 A Servo Controller (SSI104S1 with encoder feedback; SSI104RS1 with resolver feedback)

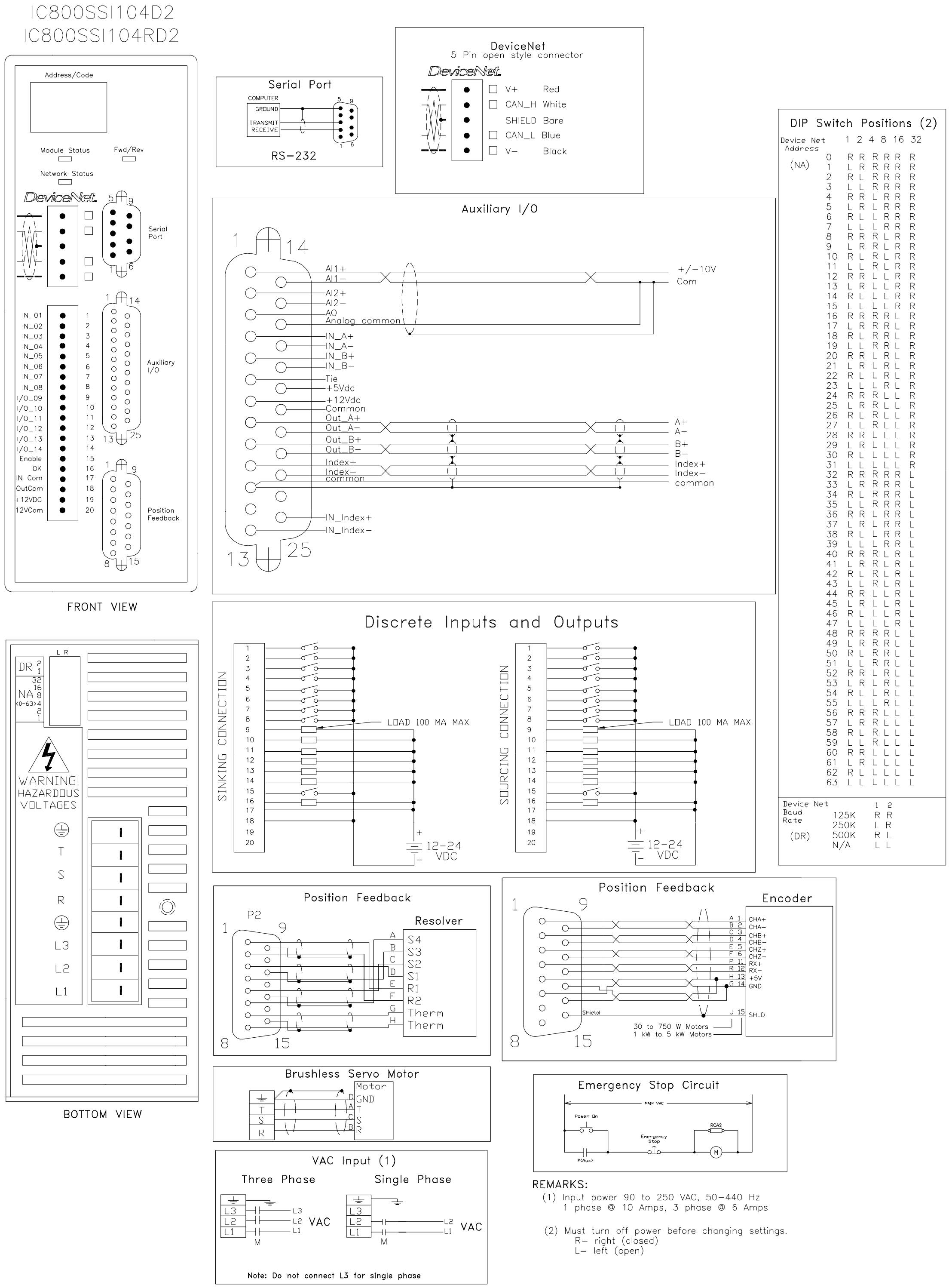


Figure 3-36. Connection Diagram for the 4.3 A Servo Controller with DeviceNet (SSI104D2 with encoder feedback; SSI104RD2 with resolver feedback)

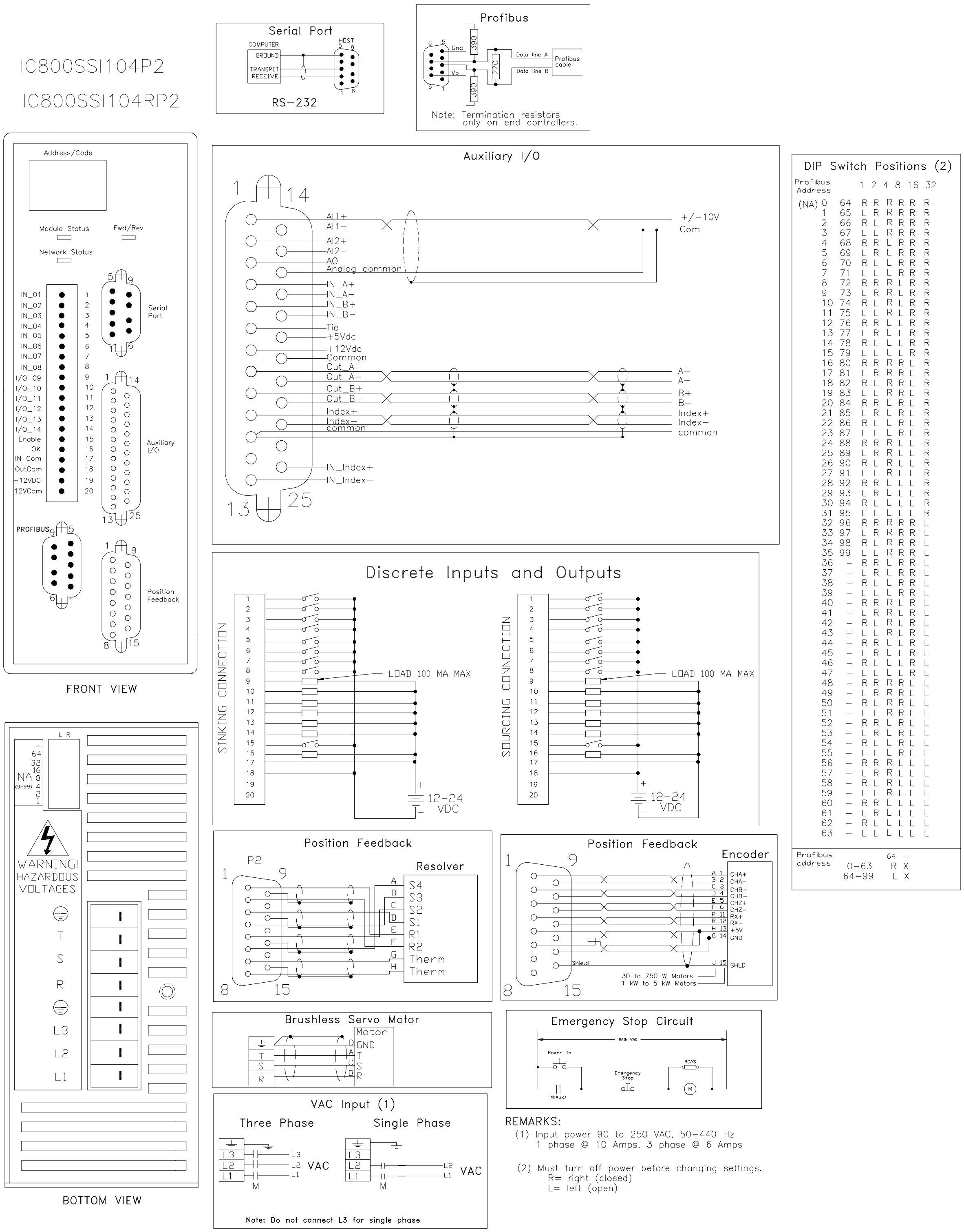


Figure 3-37. Connection Diagram for the 4.3 A Servo Controller with Profibus (SSI104P2 with encoder feedback; SSI104RP2 with resolver feedback)

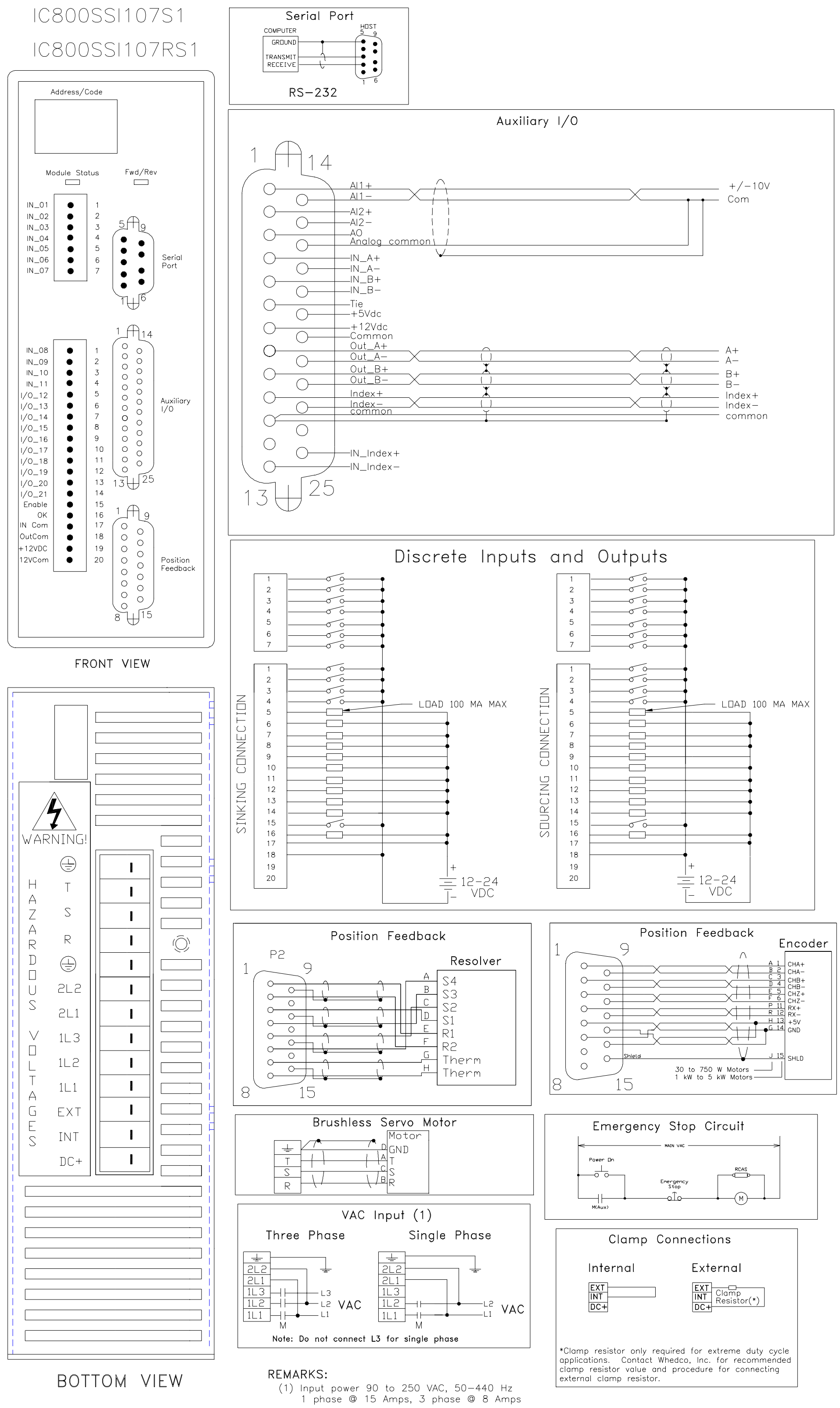


Figure 3-38. Connection Diagram for the 7.2A Servo Controller (SSI107S1 with encoder feedback; SSI107RS1 with resolver feedback)

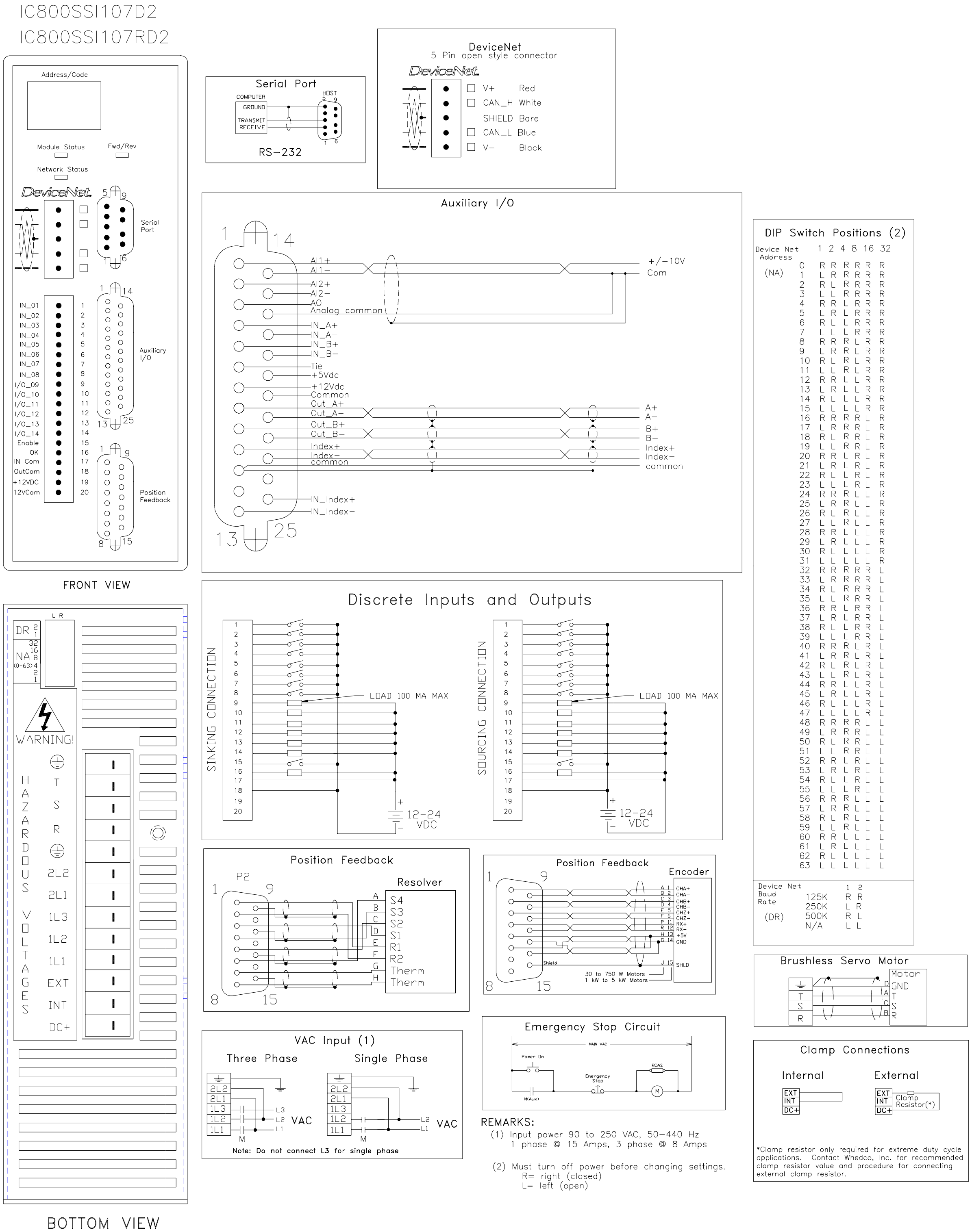


Figure 3-39. Connection Diagram for the 7.2A Servo Controller with DeviceNet (SSI107D2 with encoder feedback; SSI107RD2 with resolver feedback)

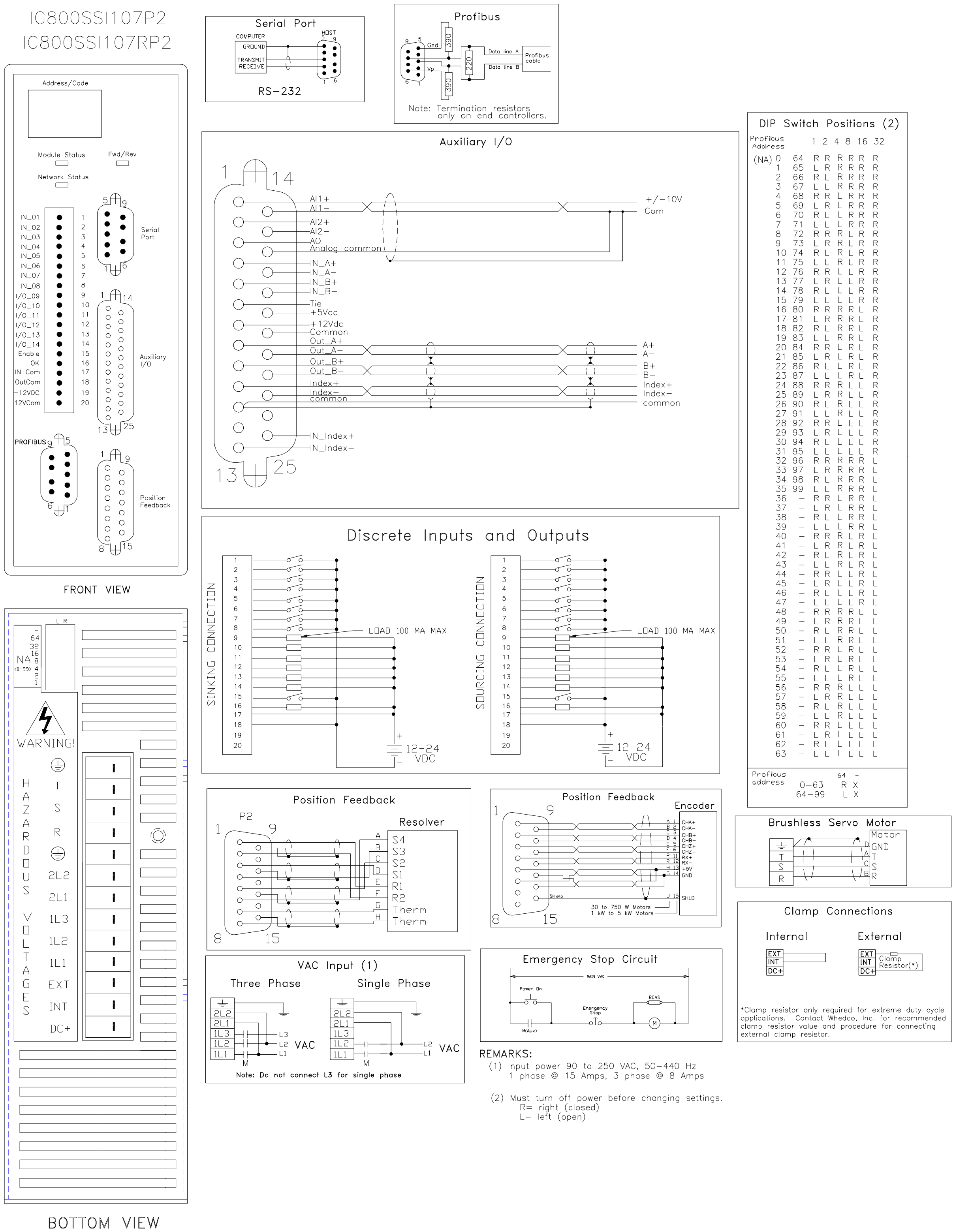


Figure 3-40. Connection Diagram for the 7.2A Servo Controller with Profibus (SSI107P2 with encoder feedback; SSI107RP2 with resolver feedback)

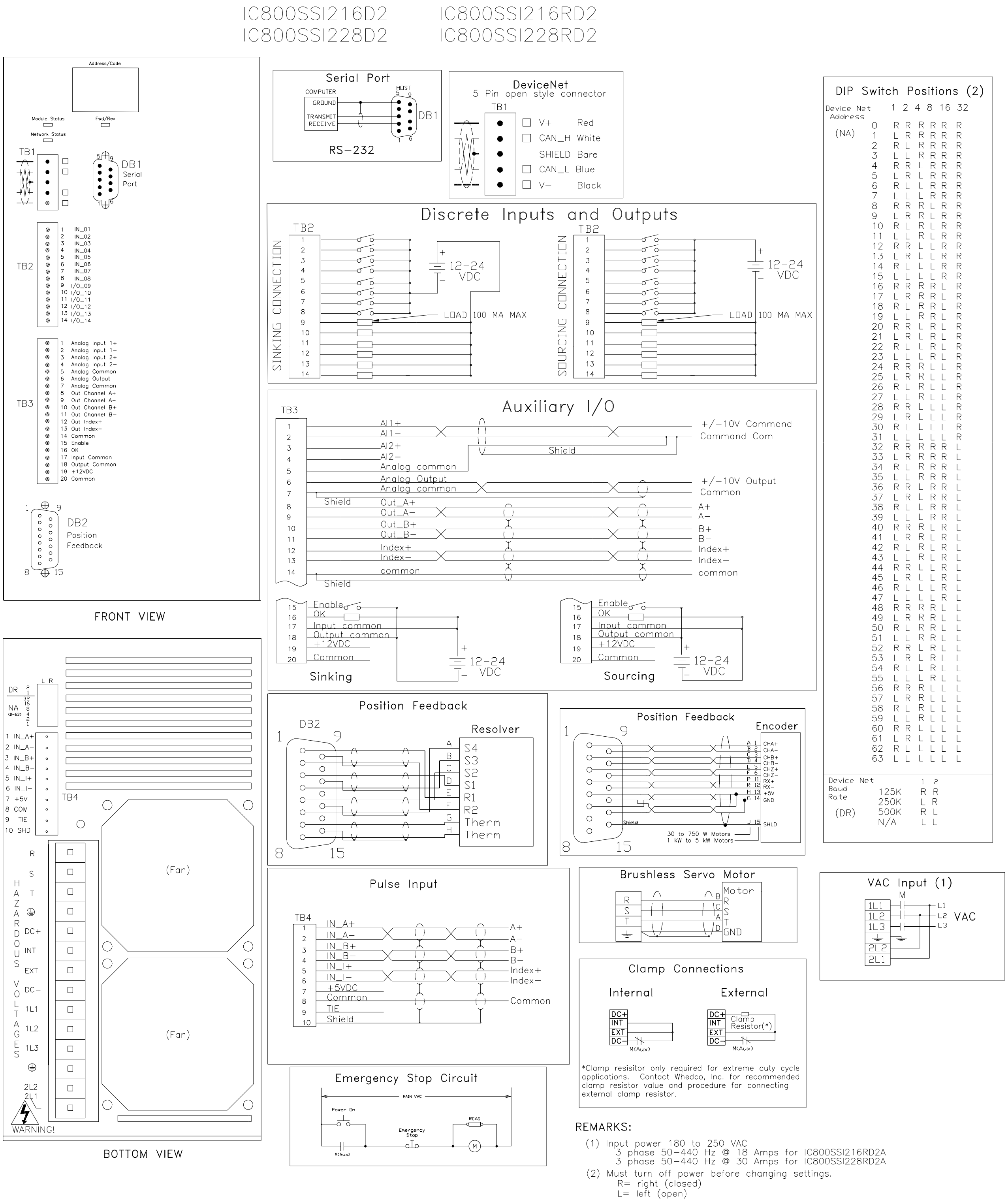


Figure 3-41. Connection Diagram for the 16 A & 28 A Servo Controllers with DeviceNet (SSI216D2 & SSI228D2 with encoder feedback; SSI216RD2 & SSI228RD2 with resolver feedback)

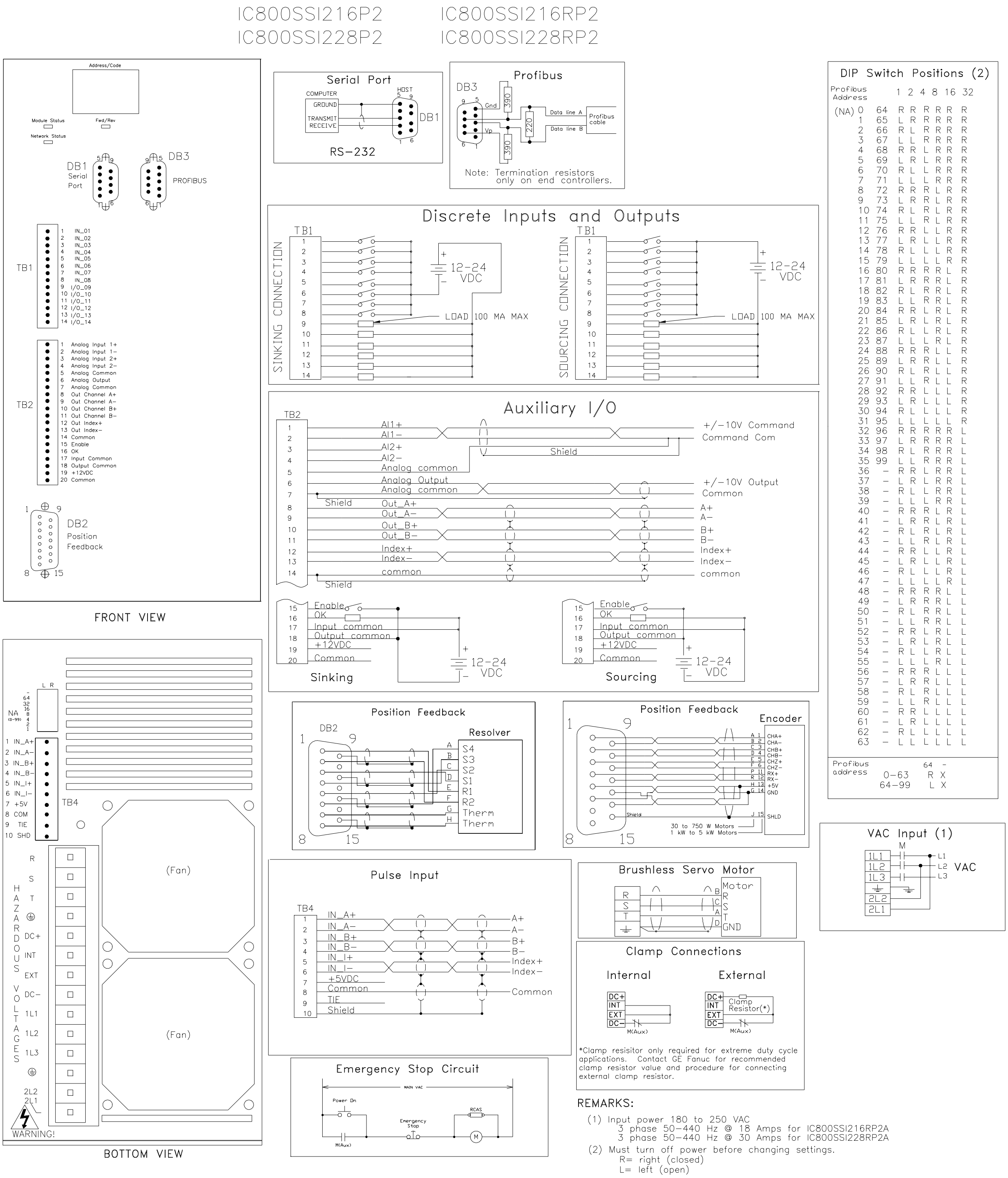


Figure 3-42. Connection Diagram for the 16 A & 28 A Encoder Feedback Servo Controllers with Profibus (SSI216P2 & SSI228P2 with encoder feedback; SSI216RP2 & SSI228RP2 with resolver feedback)

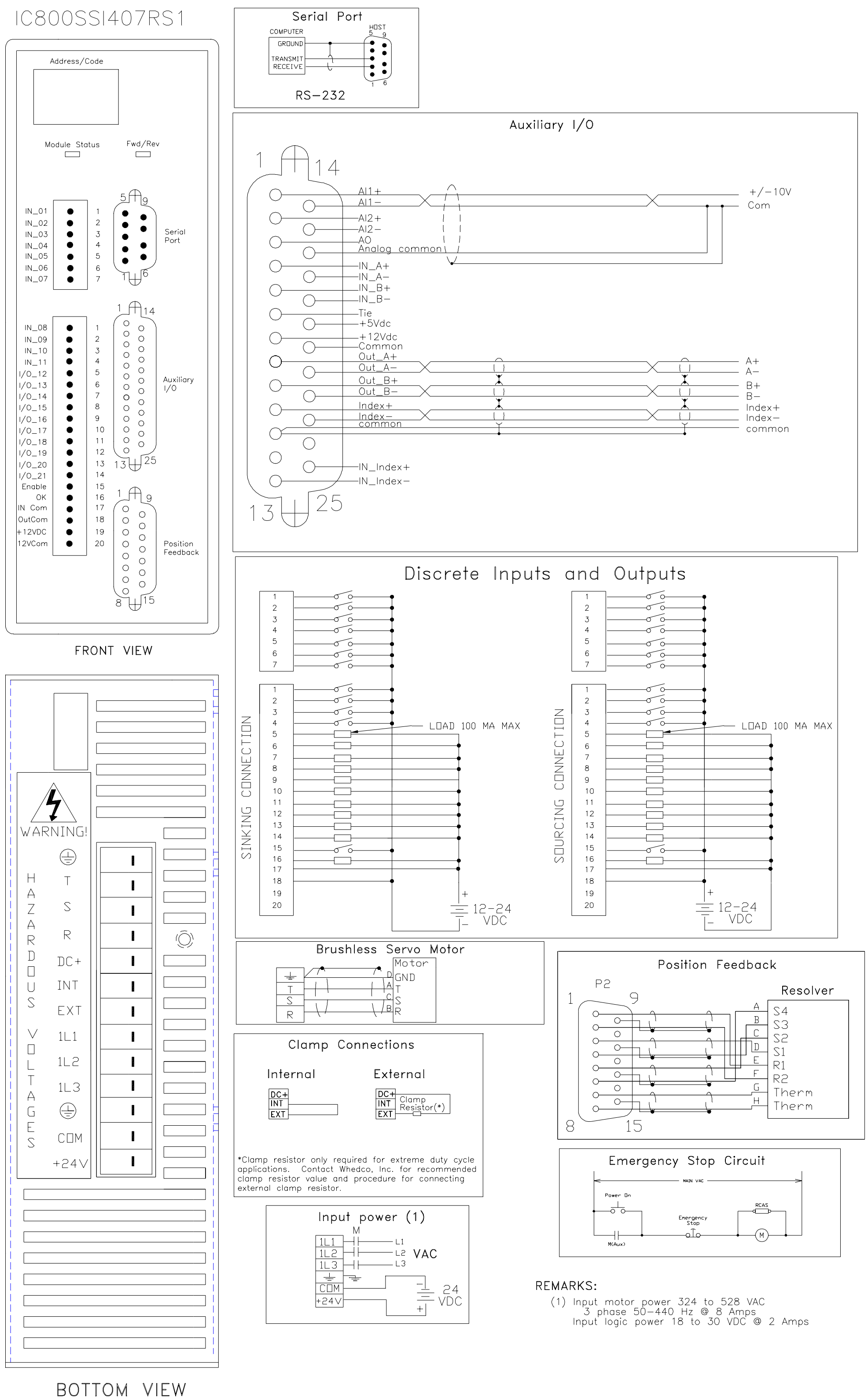


Figure 3-43. Connection Diagram for the 7.2 A 460 VAC Resolver Feedback Servo Controller (SSI407RS1)

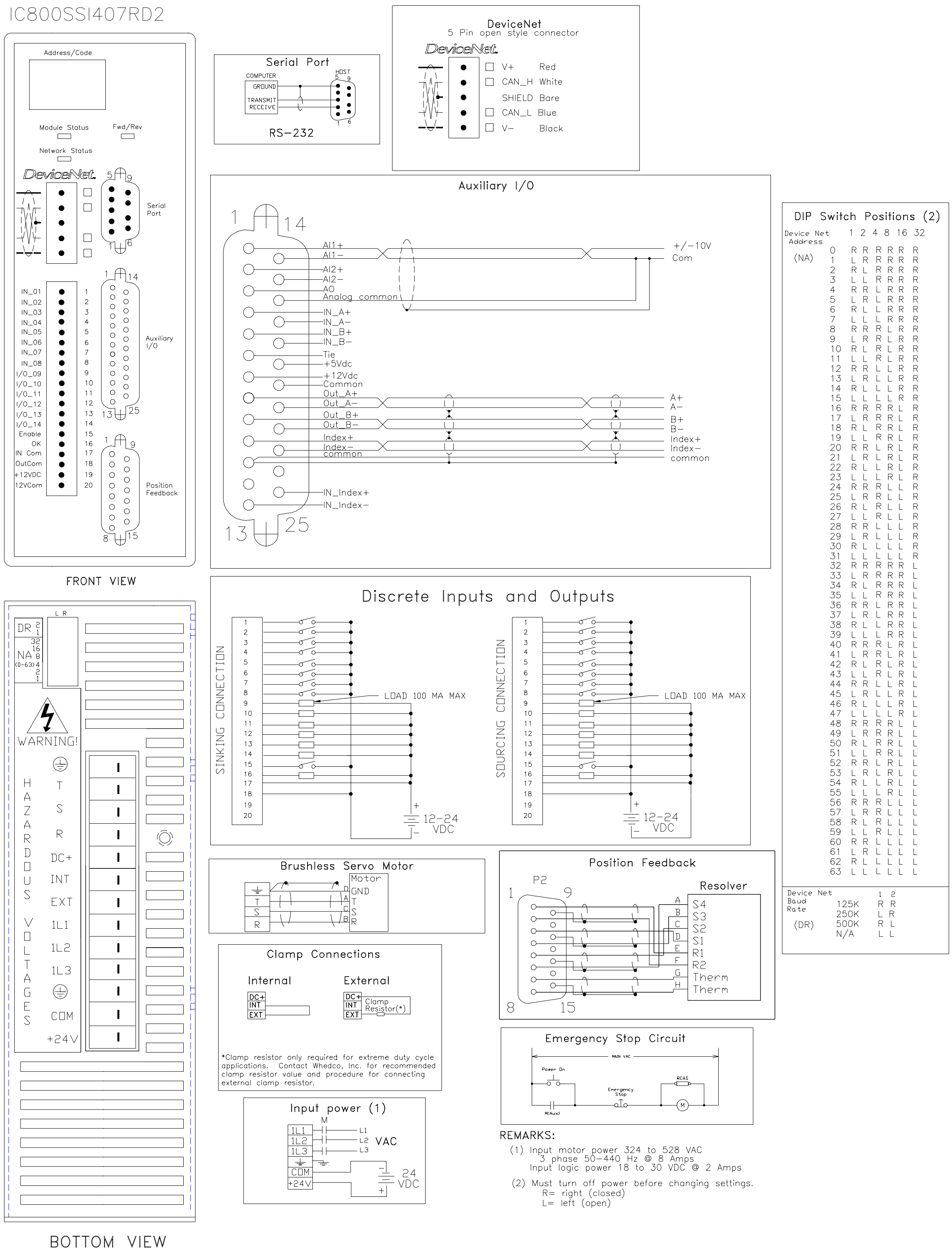


Figure 3-44. Connection Diagram for the 7.2 A 460 VAC Resolver Feedback Servo Controller with DeviceNet (SSI407RD2)

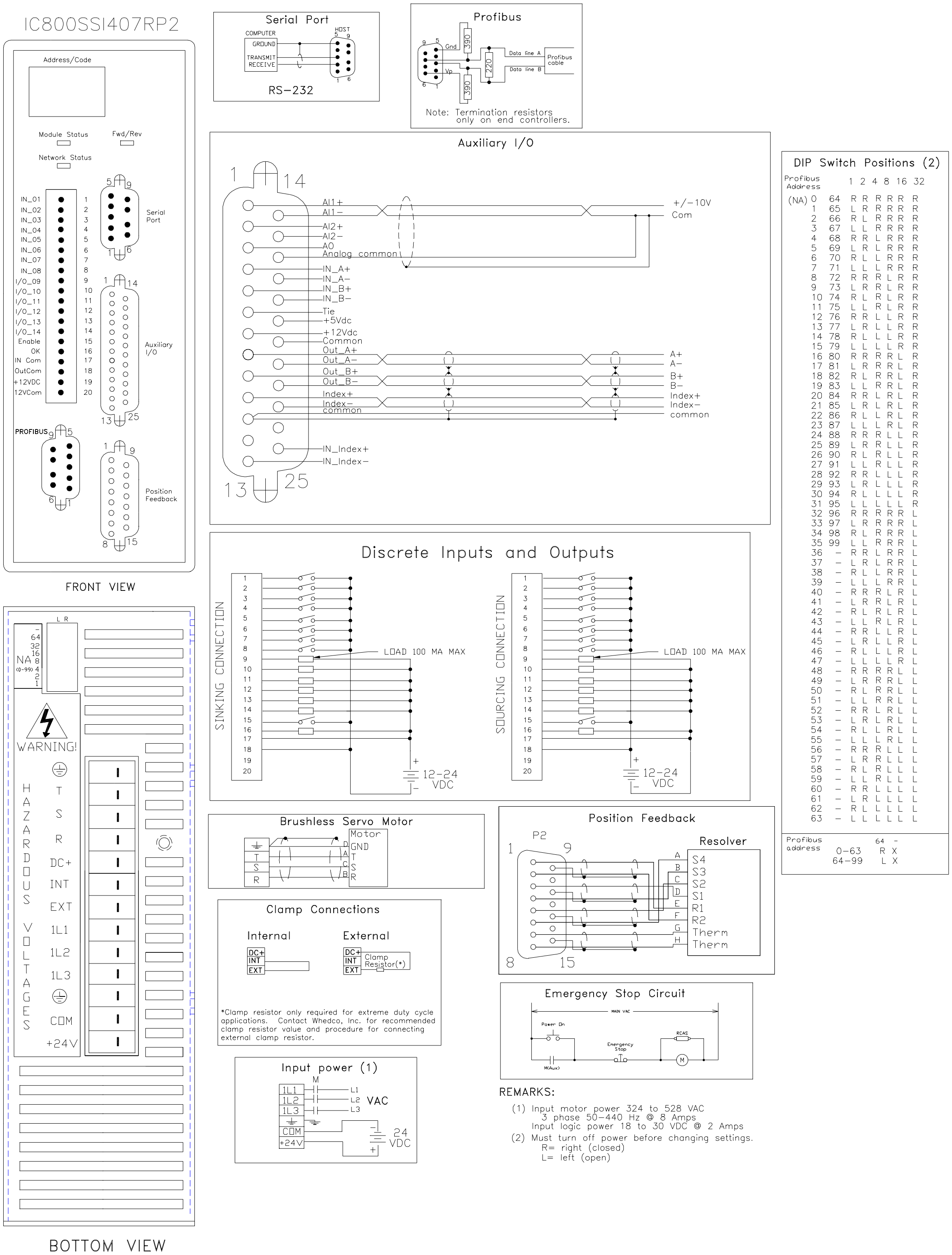


Figure 3-45. Connection Diagram for the 7.2 A 460 VAC Resolver Feedback Servo Controller with Profibus (SSI407RP2)

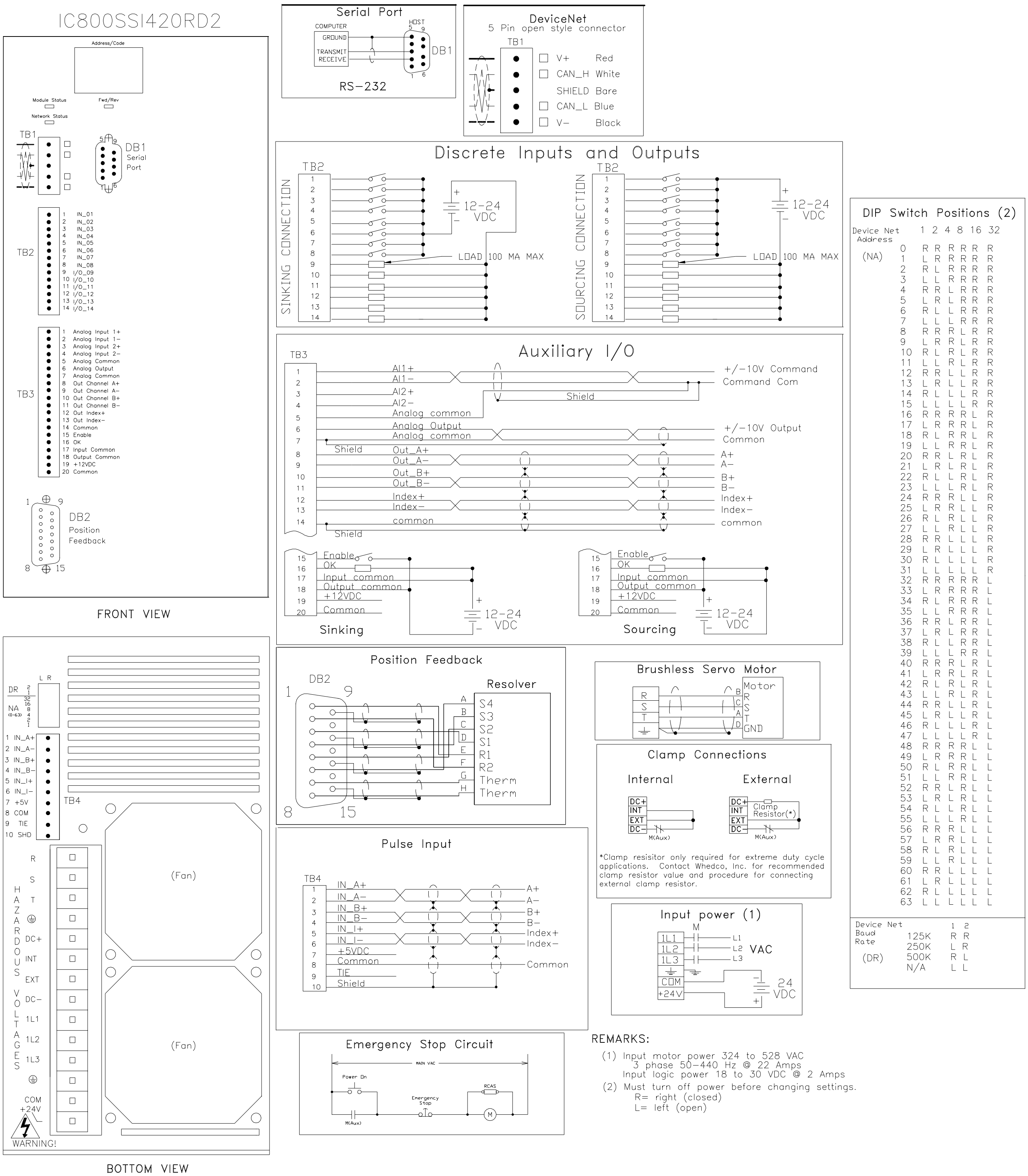


Figure 3-46. Connection Diagram for the 20 A 460 VAC Resolver Feedback Servo Controller with DeviceNet (SSI420RD2)

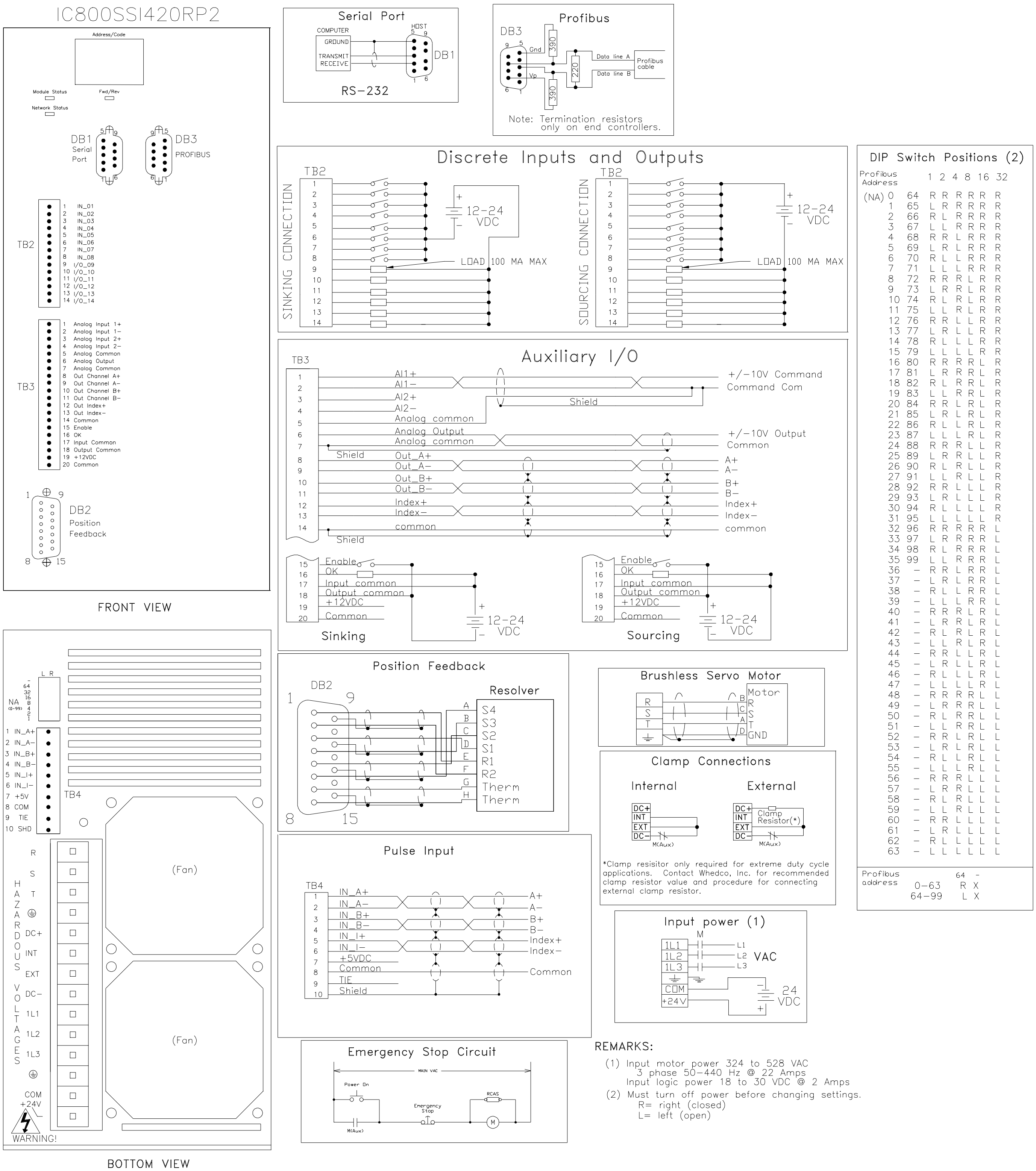


Figure 3-47. Connection Diagram for the 20 A 460 VAC Resolver Feedback Servo Controller with Profibus (SSI420RP2)

3.6.11 Cables and Connector Mates

Cables in several lengths are available from GE Fanuc for motor to controller connections and various other controller functions. It is strongly recommended that you use the cables available from GE Fanuc as shown in Table 3-13. GE Fanuc does not provide mating connectors for the MTR-Series motors or S-Series motors along with the motor; you can, however, purchase the S-Series and MTR-3T Series motor connector kits, shown in table 3-14, from GE Fanuc.

Note: GE Fanuc cables and connectors shown are not rated for IP67 environments, or washdown applications. GE Fanuc cables are not designed for high flex or cable track applications.

Table 3-13. Cables Available from GE Fanuc

S2K Series Cable	GE Fanuc Catalog Number	Description
Aux. I/O Interface	IC800SKCI010	Interface Cable, S2K Auxiliary I/O to 44A726268-001 Terminal Board Assembly, 1 m
	IC800SKCI030	Interface Cable, S2K Auxiliary I/O to 44A726268-001 Terminal Board Assembly, 3 m
	IC800SKCFLY010	Interface Cable, S2K Auxiliary I/O to flying leads, 1m (flying leads labeled with corresponding connector pin number)
	IC800SKCFLY030	Interface Cable, S2K Auxiliary I/O to flying leads, 3m (flying leads labeled with corresponding connector pin number)
Serial	IC800SKCS030	S2K Serial Communication Cable (DB1), 3 m
S-Series Servo Motor Encoder	IC800SKCEZ050	Encoder Cable, S2K to 200-750 W S-Series Motor, 5 m
	IC800SKCEZ100	Encoder Cable, S2K to 200-750 W S-Series Motor, 10 m
	IC800SKCEV050	Encoder Cable, S2K to 1 kW-5 kW S-Series Motor, 5 m
	IC800SKCEV100	Encoder Cable, S2K to 1 kW-5 kW S-Series Motor, 10 m
S-Series Servo Motor Power	IC800SKCPZ050	Power Cable, S2K to 200 - 750 W S-Series Motor, 5 m
	IC800SKCPZ100	Power Cable, S2K to 200 - 750 W S-Series Motor, 10 m
	IC800SKCPV050	Power Cable, S2K to 1 kW-2.5 kW S-Series Motor, 5 m
	IC800SKCPV100	Power Cable, S2K to 1 kW-2.5 kW S-Series Motor, 10 m
	IC800SKCPVL050	Power Cable, S2K to 4.5 kW-5 kW S-Series Motor, 5 m
	IC800SKCPVL100	Power Cable, S2K to 4.5 kW-5 kW S-Series Motor, 10 m
	IC800SKCBV050*	Power/Brake Cable, 1 kW-2.5 kW S-Series Motor with Brake, 5 m
	IC800SKCBV100*	Power/Brake Cable, 1 kW-2.5 kW S-Series Motor with Brake, 10 m
	IC800SKCBVL050*	Power/Brake Cable, 4.5 kW-5 kW S-Series Motor with Brake, 5 m
	IC800SKCBVL100*	Power/Brake Cable, 4.5 kW-5 kW S-Series Motor with Brake, 10 m
S-Series Servo Motor Brake Power **(200-750 W Motors)**	IC800SLCBZ050	Brake Cable, 200 - 750 W S-Series Motor with Brake, 5 m
	IC800SLCBZ100	Brake Cable, 200 - 750 W S-Series Motor with Brake, 10 m

S2K Series Cable	GE Fanuc Catalog Number	Description
MTR-Series Motor Resolver	CBL-3C-RD-xx	Resolver Cable, S2K to MTR-3N or MTR-3S Series Servo Motor, xx=10, 20 or 30 (feet)
	CBL-3T-RD-xx	Resolver Cable, S2K to MTR-3T Series Servo Motor, xx=10, 20 or 30 (feet)
MTR-Series Motor Power	CBL-34-MP-xx	Power Cable, S2K to MTR-3N Servo Motor, xx=10, 20 or 30 (feet)
	CBL-34-MP-xx	Power Cable, S2K to MTR-3S2x, 3S3x & MTR-3S43-H Servo Motor, xx=10, 20 or 30 (feet)
	CBL-38-MP-xx	Power Cable, S2K to MTR-3S8x Servo Motor, xx=10, 20 or 30 (feet)
	CBL-3C-MP-xx	Power Cable, S2K to MTR-3S43-G, 3S45, 3S46 & 3S6x-G Servo Motor, xx=10, 20 or 30 (feet)
	CBL-3P-MP-xx	Power Cable, S2K to MTR-3S6x-H Servo Motor, xx=10, 20 or 30 (feet)
	CBL-3T-MP-xx	Power Cable, S2K to MTR-3T4x, 3T5x & 3T6x Servo Motor, xx=10, 20 or 30 (feet)
	CBL-T7-MP-xx	Power Cable, S2K to MTR-3T1x & 3T2x Servo Motor, xx=10, 20 or 30 (feet)
MTR-Series Motor Brake	CBL-3T-MB-xx*	Power/Brake Cable, S2K to MTR-3T4x, 3T5x & 3T6x Servo Motor with Brake, xx=10, 20 or 30 (feet)
	CBL-T7-MB-xx*	Power/Brake Cable, S2K to MTR-3T1x & 3T2x Series Servo Motor with Brake, xx=10, 20 or 30 (feet)
	CBL-30-BT-xx	Brake Cable, S2K to MTR-3N & 3S Series Servo Motor with Brake, xx=10, 20 or 30 (feet)
Stepping Motor Power	CBL-12-MPS-xx	Power Cable, MTR-1216, 1221 & 1231 Stepping Motor to S2K, xx = 10, 20 or 30 feet
	CBL-13-MP-xx	Power Cable, MTR-1235, 1300, 1400 & 1N Series Stepping Motors, xx = 10, 20 or 30 feet
	CBL-14-MP-xx	Power Cable, MTR-1235, 1300, 1400 & 1N Series Splashproof Stepping Motors, xx = 10, 20 or 30 feet
Stepping Motor Encoder Cables	CBL-1C-ET-xx	Encoder Cable, MTR-1216, 1221 & 1231 Stepping Motors, xx = 10, 20 or 30 feet
	CBL-13-ET-xx**	Encoder Cable, MTR-1235, 1300, 1400 & 1N Series Stepping Motors to flying leads, xx = 10, 20 or 30 feet
	CBL-14-ET-xx**	Encoder Cable, MTR-1235, 1300, 1400 & 1N Series Splashproof Stepping Motors to flying leads, xx = 10, 20 or 30 feet

*The 1kW-5kW S-Series and MTR-3T Series servo motors incorporate the brake power and motor power into a single cable. When a brake is required, this cable (see Table 3-13) should be used in place of the standard motor power cable. The 30–750 W S-Series, MTR-3N, and MTR-3S Series servo motors require a separate brake cable as listed in Table 3-13 for motor brake power when the brake option is required.

** Stepping motor encoder feedback cables terminate in flying leads on the controller end. The S2K stepping motor controller encoder interface is included on the Auxiliary I/O connector. The TRM-JAUX-03 (3 ft. cable) or TRM-JAUX-10 (10 ft. cable) auxiliary I/O breakout terminal board can be used to provide a screw terminal interface for the encoder feedback signals.

Table 3-14. S-Series Servo Motor Connector Mates

Connector Kit	Connector Function	Qty	Connector Description	Manufacturer's Part Number	Manufacturer
IC800SLMCONKITZ 30 to 750 Watt S-Series Motors without Brake	Encoder	1	Socket	172163-1	AMP, Inc. or equivalent
		15	Contact	794058-3 or 770834-3	
	Power	1	Socket	172159-1	
		4	Contact	170366-1 or 170362-1	
	Brake	1	Socket	172157-1	
		2	Contact	170366-1 or 170362-1	
IC800SLMCONKITZB 30 to 750 Watt S-Series Motors with Brake	Encoder	1	Socket	172163-1	AMP, Inc. or equivalent
		15	Contact	794058-3 or 770834-3	
	Power	1	Socket	172159-1	
		4	Contact	170366-1 or 170362-1	
	Brake	1	Socket	172157-1	
		2	Contact	170366-1 or 170362-1	
IC800SLMCONKITV 1,000 to 2,500 Watt S-Series Motors without Brake	Encoder	1	MS-Shell*	MS3106B20-29S	Amphenol or equivalent
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
	Power (No Brake)	1	MS-Shell*	MS3106B20-4S	
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
IC800SLMCONKITVB 1,000 to 2,500 Watt S-Series Motors with Brake	Encoder	1	MS-Shell*	MS3106B20-29S	Amphenol or equivalent
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
	Power & Brake	1	MS-Shell*	MS3106B20-18S	
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
IC800SLMCONKITVL 3,500 to 5,000 Watt S-Series Motors without Brake	Encoder	1	MS-Shell*	MS3106B20-29S	Amphenol or equivalent
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
	Power (No Brake)	1	MS-Shell*	MS3106B22-22S	
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
IC800SLMCONKITVLB 3,500 to 5,000 Watt S-Series Motors with Brake	Encoder	1	MS-Shell*	MS3106B20-29S	Amphenol or equivalent
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
	Power & Brake	1	MS-Shell*	MS3106B24-11S	
		1	Cable Clamp	MS3057-16A (97-3057-1016)	
		1	Bushing	3420-16 (9779-513-16)	

* The connector shells shown for the 1-5 kW model servo motors are for straight mating connectors. For right angle connectors substitute MS3108 for MS3106 in the part number.

Table 3-15. T-Series Servo Motor Connector Mates

Motor Series	Connector Function	Qty	Connector Part Number	Manufacturer
MTR-3T Series	Motor Power	1	21000526	GE Fanuc
	Resolver	1	21000525	GE Fanuc

Table 3-16. Stepping Motor Connector Mates

Motor Series	Connector Function	Qty	Connector Part Number	Manufacturer
MTR-1200 Series Stepping Motors	Motor Power	1	640620-8	Amphenol or equivalent
		1	643075-8	
MTR-1300 Series Non-Splashproof Stepping Motors	Motor Power	1	21000244	GE Fanuc
	Encoder	1	21000246	GE Fanuc
MTR-1300 Series Splashproof Stepping Motors	Motor Power	1	21000399	GE Fanuc

Note

Equivalent parts from other vendors may be used for any of the connectors shown in Tables 3-14 through 3-16. Items in connector kits are not available separately.

3.6.12 GE Fanuc Motor Cables Specifications

The specifications for the motor power and encoder cables fabricated by GE Fanuc and shown in Table 3-13 are shown below. Although the motor power cables can tolerate moderate flexing they are not designed to withstand continuous flexing as in cable track applications. The encoder cables are not recommended for flexing applications.

Table 3-17. Specifications for IC800SKCPZxxx (30–750 Watt Motor Power Cable)

No. of conductors:	4 conductors, 18 AWG (16X30)
Jacket material:	Oil resistant gray PVC
Cable diameter:	0.31 inch, average
Color code:	3 conductors are black and numbered 4'th conductor is yellow/green
Max operating voltage:	600 V rms
Conductor DC resistance:	6.5 ohm / 1000 ft @ 20 C
Insulation resistance:	6.1 M ohm / 1000 ft
Operating temperature range:	-40 C to +90 C static; -5C to +90 C flexing
Duty:	Moderate flex; 1 million cycles
Minimum bend radius:	3.1 inches static; 4.6 inches flexing
Maximum pulling tension:	98 pounds
Nominal weight:	55 pounds
Flame resistance:	UL VW-1 CSA FT-1
Applicable specifications:	UL AWM-2587 CEC AWM I A/B II A/B

Table 3-18. Specifications for IC800SKCPVxxx (1–2.5 kW Motor Power Cable) and IC800SKCBVxxx (1–2.5 kW Motor Power & Brake Cable)*

No. of conductors:	4 conductors, 14 AWG (41X30)
Jacket material:	Oil resistant gray PVC
Cable diameter:	0.395 inch, average
Color code:	3 conductors are black and numbered 4'th conductor is yellow/green
Max operating voltage:	600 V rms
Conductor DC resistance:	2.5 ohm / 1000 ft @ 20 C
Insulation resistance:	6.1 M ohm / 1000 ft
Operating temperature range:	-40 C to +90 C static; -5C to +90 C flexing
Duty:	Moderate flex; 1 million cycles
Minimum bend radius:	4 inches static; 6 inches flexing
Maximum pulling tension:	201 lbs
Nominal weight:	122 lbs per 1000 ft.
Flame resistance:	UL VW-1 CSA FT-1
Applicable specifications:	UL AWM-2587 CEC AWM I A/B II A/B

* Brake conductors for this cable are carried in a separate cable but are terminated in the same motor power connector. See brake cable below for specification for this cable.

Table 3-19. Specifications for IC800SKCPVLxxx (3–5 kW Motor Power Cable) and IC800SKCBVLxxx (3–5 kW Motor Power & Brake Cable)*

No. of conductors:	4 conductors, 12 AWG (65X30)
Jacket material:	Oil resistant gray PVC
Cable diameter:	0.510 inch, average
Color code:	3 conductors are black and numbered 4'th conductor is yellow/green
Max operating voltage:	600 V rms
Conductor DC resistance:	1.6 ohm / 1000 ft @ 20 C
Insulation resistance:	6.1 M ohm / 1000 ft
Operating temperature range:	-40 C to +90 C static; -5C to +90 C flexing
Duty:	Moderate flex; 1 million cycles
Minimum bend radius:	5.1 inches static; 7.6 inches flexing
Maximum pulling tension:	338 lbs
Nominal weight:	238 lbs per 1000 ft.
Flame resistance:	UL VW-1 CSA FT-1
Applicable specifications:	UL AWM-2587 CEC AWM I A/B II A/B

* Brake conductors for this cable are carried in a separate cable but are terminated in the same motor power connector. See brake cable below for specification for this cable.

Table 3-20. Specifications for S2K S-Series Motor Brake Cable *

No. of conductors:	2 conductors, 18 AWG (16X30)
Jacket material:	Oil resistant gray PVC
Cable diameter:	0.26 inch, average
Color code:	2 conductors are black and numbered
Max operating voltage:	600 V rms
Conductor DC resistance:	6.5 ohm / 1000 ft @ 20 C
Insulation resistance:	6.1 M ohm / 1000 ft
Operating temperature range:	-40 C to +90 C static; -5C to +90 C flexing
Duty:	Moderate flex; 1 million cycles
Minimum bend radius:	2.6 inches static; 3.9 inches flexing
Flame resistance:	UL VW-1 CSA FT-1
Applicable specifications:	UL AWM-2587 CEC AWM I A/B II A/B

* For Z-series motors (30-750 Watt) this is a separate cable with a connector on the motor end. For all other motors this cable terminates in the motor power connector.

Table 3-21. Specifications IC800SKCEZxxx (30–750 Watt Motor Encoder Cable) and IC800SKCEVxxx (1–5kW Motor Encoder Cable)

No. of conductors:	6 pairs, 24 AWG (7X30)
Jacket material:	Oil resistant gray PVC
Cable diameter:	0.364 inch, average
Color code:	Blue/White paired with White/Blue Orange/White paired with White/Orange Green/White paired with White/Green Brown/White paired with White/Brown Slate/White paired with White/Slate Blue/Red paired with Red/Blue
Max operating voltage:	300 V rms
Conductor DC resistance:	2.5 ohm / 1000 ft @ 20 C
Insulation resistance:	6.1 M ohm / 1000 ft
Operating temperature range:	-20 C to +60 C
Duty:	Not recommended for flexing applications
Minimum bend radius:	4 inches
Flame resistance:	UL Type CL2, CM CSA PPC FT-1
Applicable specifications:	UL AWM Style 2690, 2919

Table 3-22. Specifications for CBL-Model Cables for Motor Power, Brake Power, and Feedback

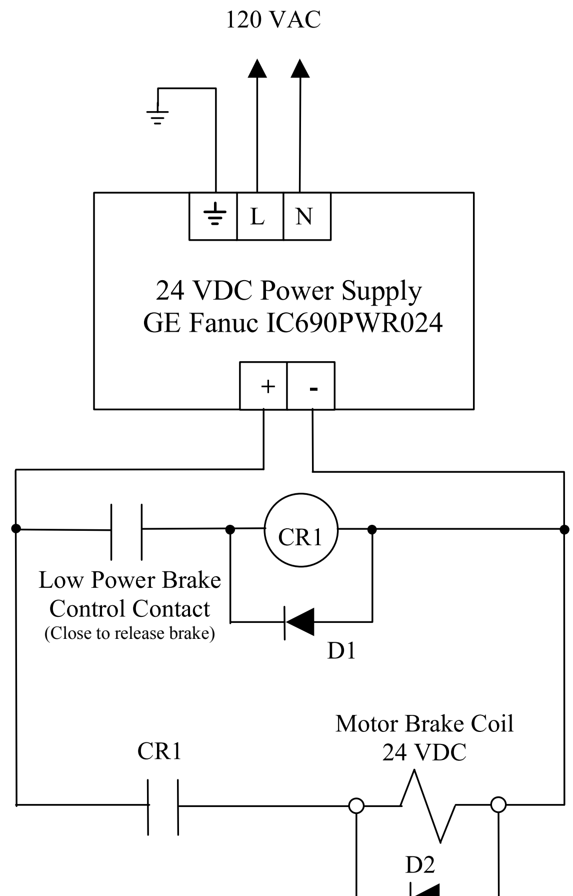
Cable Part Number*	No. of Conductors	Wire Gauge (AWG)	Jacket Material	Shielding	Cable Dia. Nom. OD (inches)	Max. Oper. Voltage	Operating Temp.	Cable Mfg.	Type
CBL-12-MP-xx	4 Twisted Pairs	#22	PVC	Foil Shield	0.265	300 Volt	80° C	Belden 9305	UL AWM 2464
CBL-12-MPS-xx	3 Twisted Pairs	#24	PVC	Foil Shield	0.232	300 Volt	80° C	Belden 9503	UL AWM 2464
CBL-13-MP-xx	3 Pairs	#18	PVC	Foil Shield	0.36	300 Volt	80° C	Alpha 2243	UL AWM 2464
CBL-14-MP-xx	3 Pairs	#18	PVC	Foil Shield	0.36	300 Volt	80° C	Alpha 2243	UL AWM 2464
CBL-1C-ET-xx	4 Twisted Pairs	#24	PVC	Foil Shield	0.265	300 Volt	80° C	Belden 9504	UL AWM 2464
CBL-13-ET-xx	4 Pairs	#22	PVC	Ind. Fold Shield	0.36	300 Volt	80° C	Alpha 6054C	UL AWM 2464
CBL-14-ET-xx	4 Pairs	#22	PVC	Ind. Fold Shield	0.36	300 Volt	80° C	Alpha 6054C	UL AWM 2464
CBL-3C-RD-xx	4 Twisted Pair	#22	PVC	Ind. Fold Shield	0.36	300 Volt	85° C	Alpha 6054C	UL AWM 2464
CBL-3T-RD-xx	4 Pairs	#22	PVC	Ind. Fold Shield	0.36	300 Volt	80° C	Alpha 6054C	UL AWM 2464
CBL-34-MP-xx	4	#16	PVC	90 % Braid	0.28	600 Volt	105° C	Alpha 3248	MIL-W-16878D
CBL-38-MP-xx	7	#16	PVC	Foil Shield	0.56	600 Volt	105° C	Alpha 5440/7	UL AWM 2501
CBL-3C-MP-xx	4	#14	PVC	Foil Shield	0.49	600 Volt	105° C	Alpha 5450/4	UL AWM 2501
CBL-3P-MP-xx	7	#16	PVC	Foil Shield	0.56	600 Volt	105° C	Alpha 5440/7	UL AWM 2501
CBL-3T-MP-xx	4	#14	Poly**	70% Braid	0.51	600 Volt	90° C	Alpha 25544	UL AWM 20952
CBL-T7-MP-xx	4	#16	PVC	90% Braid	0.28	600 Volt	105° C	Alpha 3248	MIL-W-16878D
CBL-3T-MB-xx	4	#12	PVC	None	0.505	600 Volt	90° C	Belden 7445A	UL AWM 2587
	2	#18			0.40			Belden 7409A	
CBL-T7-MB-xx	4	#16	PVC	90% Braid	0.28	600 Volt	90° C	Alpha 3248	MIL-W-16878D UL AWM
	2	#18		None	0.40			Belden 7409A	UL AWM 2587
CBL-30-BT-xx	1 Pair	#18	PVC	None	0.21	300 Volt	80° C	Belden 9740	UL AWM 2464

*See Table 3-13 for complete cable description and motor compatibility information.

** Polyurethane

3.7 Wiring The Optional Motor Brake

The following figure shows a typical wiring example for the optional S-Series and MTR-Series servo motor holding brake. The brake must be energized using a 24 VDC power supply to release its hold on the motor. Chapter 2 contains motor brake specifications showing the current requirements for each model motor. GE Fanuc offers a 24 VDC, 5 amp DIN-rail mounted power supply (Part Number IC690PWR024) that may be used. If the brake control contact is rated for switching the inductive load of the Motor Brake Coil, the control relay (CR1) may not be required.



Customer Supplied Components:

CR1 – Control relay, Coil: 24 VDC/50mA or less,
Contact: rated for 1Amp DC continuous and break

D1 – Diode, 1A, 100 VDC, 1N4002 or equivalent

D2 – Diode, 3A, 100 VDC, 1N5401 or equivalent

Figure 3-48. Typical Brake Wiring Diagram

3.8 Regenerative Discharge Resistor Selection and Wiring

Regenerative energy is normally created in applications with a high load inertia, high speed, vertical axes and/or frequent acceleration and deceleration. When decelerating a load, the stored kinetic energy of the load creates generator action in the motor causing energy to be returned to the servo controller. For light loads and low acceleration rates, the controller may be able to absorb and store this energy in the DC link filter capacitors or dissipate it in an internal regenerative resistor. Otherwise, an optional external regenerative discharge unit must be installed.

The S2K Series controllers include an internal regenerative discharge resistor that will control the regenerative energy in most applications. When an Over Voltage fault (LED Status Code OV) or an Excessive Clamp Duty Cycle fault (LED Status Code EC) occurs during motor deceleration, the cause is usually excessive regeneration and requires an optional external regenerative resistor kit. The SSI104 controller has no provisions for connecting an external resistor. As an alternative to adding an external resistor you can try a combination of the following actions:

- Reduce the deceleration rate and/or increase deceleration time
- Lower the top speed of the motor
- Reduce machine cycle rate
- Reduce load inertia connected to the motor
- Increase vertical axis counterbalance

GE Fanuc offers several different resistor kits (all kits include resistor mounting brackets) as shown in Table 3-23. Wiring between the resistor and the controller's power terminals is not included in the kit and is the user's responsibility. Connections to the resistor can be made by soldering, using a fast-on type terminal of appropriate size, or using a ring terminal bolted through the hole in the resistor terminal tab. See Figure 3-49.

Caution

Under normal operation the regenerative discharge resistor may become very hot. To prevent being burned, never touch the resistor. Mount the resistor well away from heat sensitive components or wiring to prevent damage. Also, the terminals of this resistor are at a high voltage potential. Either insulate the connections or provide adequate shielding to eliminate this shock hazard.

Table 3-23. Regenerative Discharge Resistor Kits

GE Fanuc Regenerative Discharge Resistor Kits	Resistor Kit Specifications			
	Resistance	Continuous Power[1]	Peak Power for 230 VAC Models[2]	Peak Power for 460 VAC Models[2]
IC800SLR001	50 Ω	100 W	3362 W	13612
IC800SLR002	100 Ω	225 W	1681 W	6806
IC800SLR003	20 Ω	300 W	8405 W	34031
IC800SLR004	15 Ω	1000 W	11207 W	45375

1) Resistor continuous power ratings are at 25ºC ambient temperature. Derate power linearly at 0.3% per ºC above 25ºC.
2) Peak power is based on an average discharge circuit turn-on voltage of 410 VDC for models rated 230 VAC and 825 VDC for models rated 460 VAC.

The resistor values included with the kits are average values for a variety of conditions. Smaller capacity (wattage) resistors may work in some applications and larger resistors may be required in others. The lower the resistance value, the faster the regenerative energy can be dissipated. Applications with large inertial loads, high speeds, and high deceleration rates regenerate more energy and may require a resistor with a lower resistance and/or larger capacity (wattage). As an alternative, when the capacity or resistance of the standard external regenerative resistor is insufficient for the application, reducing load inertia, maximum speed, deceleration rate, increasing vertical axis counterbalance or some combination of these measures can decrease the regenerative energy. See Section 3.8.1 for details on selecting the proper resistor based on application requirements.

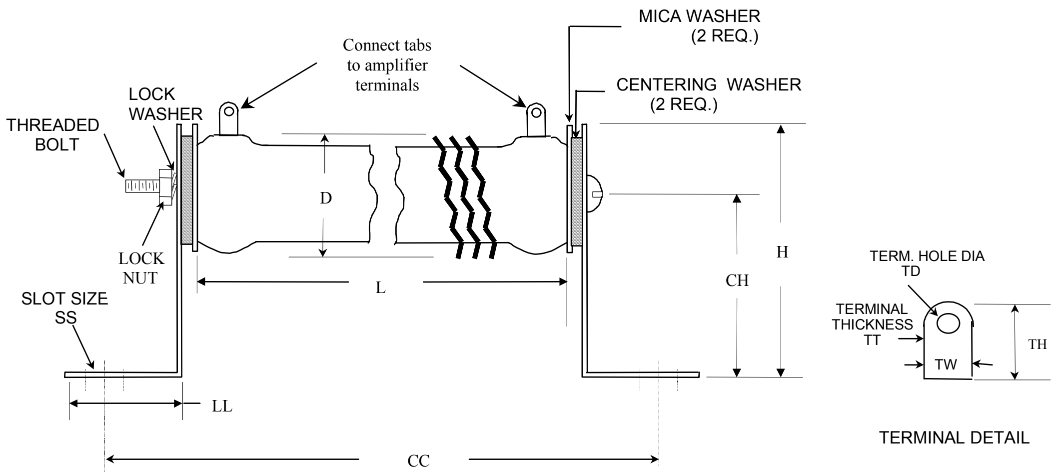
The wiring between the controller and the regenerative resistor should be kept as short as possible (less than 20 inches or 50cm) to prevent possible damage to the switching transistor from voltage transients due to cable inductance. The regenerative resistor may become very hot during normal operation. Therefore, route all wiring away from the resistor so that the wiring does not touch the resistor and has a minimum clearance of 3 inches (76mm).

Connect one terminal of the resistor to the controller's "EXT" power terminal and the other resistor terminal to the "DC+" controller power terminal. See 3.6.10 *Connection Diagrams*.

Note

> If you are not using an external resistor, a wire jumper must be connected between the power terminals "INT" and "EXT" as shown in the "Clamp Connections-External" sections of 3.6.10. If this jumper is not installed, the internal resistor is disabled and the controller may exhibit symptoms associated with excessive regeneration. This note does not apply to the SSI104 model controller.

When mounting the resistor, tighten the lock nut sufficiently to compress the lock washer. Although the lock nut should be tightened securely, avoid over-tightening so as not to strip the bolt threads.



Part Number	Dimensions (in inches)										
	Resistor		Bracket					Terminal			
	L +/-.062	D Max.	H	CH	CC	LL	SS	TH	TW	TT	TD
IC800SLR001	6.50	.910	1.75	1.25	7.562	.750	.218 X.437	.562	.250	.020	.166
IC800SLR002	10.5	1.312	2.13	1.5	11.562	.875	.281 X.562	.625	.375	.020	.173
IC800SLR003	8.5	1.125	1.75	1.25	9.562	.750	.218 X.437	.625	.375	.020	.173
IC800SLR004	15	2.50	4.25	3.0	17.0	1.25	.281 X.562	.625	.500	.025	.188

Figure 3-49. Regenerative Discharge Resistor Mounting and Wiring Dimensions

3.8.1 Calculating Regenerative Power and Selecting a Resistor

Use the following calculation to determine the average regenerative power that will be released in your application. These calculations ignore any losses due to resistance in the motor armature and lead wire. Based on the calculations, select the appropriate regeneration resistor kit from Table 3-23. The continuous power rating of the selected resistor must **exceed** the average calculated regenerative power from the equation below:

Average Regenerative Energy (Joules)	=	**Rotational Energy to be Released during Deceleration**	−	**Energy to be Consumed Through Axis Friction**	+	**(only in vertical axis operation)** **Vertical Axis Energy to be Released During Downward Motion**
		(STEP 1)		**(STEP 2)**		**(STEP 3)**

STEP 1: Rotational Energy to be Released During Deceleration (E_d)

$E_d = \left(6.19\times10^{-4}\right)\times\left(J_m + J_L\right)\times(\omega_i^2 - \omega_f^2)$ Joules

Where:

J_m	Motor rotor inertia (See Motor Specification table in Chapter 2)	(lb-in-s^2)
J_L	Load inertia reflected to motor shaft	(lb-in-s^2)
ω_i	Initial motor speed at the beginning of deceleration	(RPM)
ω_f	Final motor speed at the end of deceleration	(RPM)

This step must be calculated for each deceleration in the motion profile and then the values summed to arrive at a total regenerated energy for this step. For multi-speed (compound) moves, the starting and ending velocity must be used for ω_I and ω_f for each deceleration segment.

STEP 2: Energy to be Consumed Through Axis Friction (E_f)

$E_f = \left(5.91\times10^{-3}\right)\times t_a \times(\omega_i - \omega_f)\times T_f$ Joules

Where:

ω_i	Initial motor speed at the beginning of deceleration	(RPM)
ω_f	Final motor speed at the end of deceleration	(RPM)
t_a	Deceleration time	(Sec)
T_f	Axis friction torque (as seen by the motor)	(in-lb)

This step must be calculated for each deceleration in the motion profile and then the values summed to arrive at a total regenerated energy for this step. For multi-speed (compound) moves the starting and ending velocity must be used for ω_I and ω_f for each deceleration segment.

STEP 3: Vertical Axis Energy to be Released During Downward Motion (E_v)

(This term applies only in vertical axis operation)

$$E_v = \left(1.182 \times 10^{-2}\right) \times T_h \times \omega_m \times t_d \text{ Joules}$$

where:

T_h	Upward supporting torque applied by the motor during downward rapid traverse to hold the load against gravity	(in-lb)
t_d	Time of downward motion	(Sec)
ω_m	Motor speed during downward rapid traverse	(RPM)

STEP 4: Determine if an External Regenerative Discharge Resistor Is Required

Determine the *Average Regenerative Energy* using the equation in the beginning of this section. To compare this to the regenerative capacity of the controller, you must first perform the following calculations:

a) Account for the energy stored in the DC link filter capacitors:

Net Energy = Average Regenerative Energy – Capacitor Energy Storage (from Table 3-24)

b) Convert the Net Energy to Average Regenerative Power using the equation below:

$$\text{Average Regenerative Power (Watts)} = \text{Net Regenerative Energy (Joules)} \times \frac{1}{T}$$

where:

T = Total profile cycle time (seconds)

If the *Average Regenerative Power* exceeds the *Maximum Continuous Power* indicated in Table 3-23 for the controller you are using, an external regenerative discharge resistor is required:

Table 3-24. Controller Regenerative Discharge Ratings

Controller Model	Rating	Capacitor Energy Storage *	Min. External Resistance	Internal Resistor Ratings	
				Resistance	Max. Continuous Power
SSI104	4.3 Amp, 115/230 VAC	17.5 Joules	N/A	50 Ω	39 Watts
SSI107	7.2 Amp, 115/230 VAC	34.9 Joules	50 Ω	50 Ω	24 Watts
SSI216	16 Amp, 230 VAC	69.8 Joules	25 Ω	25 Ω	95 Watts
SSI228	28 Amp, 230 VAC	104.7 Joules	12 Ω	12.5 Ω	189 Watts
SSI407	7.2 Amp, 460 VAC	84.9 Joules	50 Ω	50 Ω	48 Watts
SSI420	20 Amp, 460 VAC	255 Joules	25 Ω	25 Ω	193 Watts

*Assumes nominal AC line voltage of 230 VAC or 460 VAC. High line voltage will dramatically reduce the amount of regenerated energy the controller capacitors can absorb (for example, a 10% high line voltage will reduce the maximum regenerated energy to 43% of the values shown).

If the calculated value exceeds the storage capability of the controller, then an external regenerative resistor is required (see Step 5).

STEP 5: Selecting a Regenerative Discharge Resistor Kit

If an external regenerative resistor kit is required it must meet the following criteria:

1. The resistance of the selected resistor must exceed the *Minimum External Resistance* value shown in Table 3-243-24 for your specific controller.
2. The value calculated for the *Average Regenerative Power* must be **less** than the *Continuous Power* rating shown in Table 3-23 for the selected resistor kit.

Contact GE Fanuc if you require assistance in selecting the appropriate value.

STEP 6: Determine the Peak Power Requirements for the Resistor

The peak power determines the maximum rate at which the regenerated energy must be dissipated to prevent overvoltage faults on the controller. The peak power must be calculated for each deceleration period of the profile by dividing the regenerated energy for that period by the time over which the energy is released.

Peak Power = Regenerated Energy/ Regeneration Time

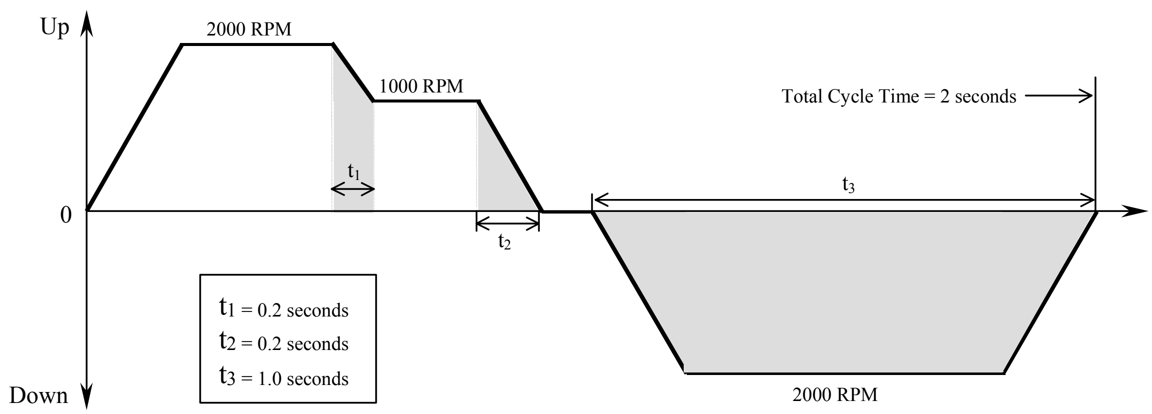
This value must be lower than the *Peak Power* rating for the resistor selected (see Table 3-23). If a non-standard resistor is substituted, its peak power can be calculated as follows:

230 VAC Models Peak Power = 410^2 / R Watts
460 VAC Models Peak Power = 825^2 / R Watts

where R is the resistance value in ohms for the selected resistor.

Regeneration Application Example:

Assume a vertical axis using an SLM100 motor (J_m = 0.001491 lb-in-s^2) with a load inertia (J_L) of 0.0139 lb-in-s^2. The SLM100 motor uses an SSI107 controller. The friction torque in the axis (T_f) is 10 in-lb and the torque that is required to support the load against gravity (T_h) is 15 in-lb. The axis requires the following compound velocity profile:



Since the example machine cycle involves a number of periods where regeneration occurs, the determination of the regenerated energy is more complicated. Regeneration occurs for each deceleration period when the axis is moving in the upward direction (against gravity) and during the period when the axis is moving in the downward direction. These areas are shaded in the profile shown above. The regeneration for each of these periods must be calculated as follows:

STEP 1a: Calculate the rotational energy during period t_1:

$E_{d1} = (6.19x10^{-4})$ x (0.001491+0.0139) x $(2000^2 – 1000^2)$= 28.58 Joules

STEP 1b: Calculate the rotational energy during period t_2:

$E_{d2} = (6.19x10^{-4})$ x (0.001491+0.0139) x $(1000^2 – 0^2)$ = 9.53 Joules

STEP 2a: Calculate the energy absorbed by friction during period t_1:

$E_{f1} = (5.91x10^{-3})$ x 0.2 sec x (2000 RPM-1000 RPM) x 10 in-lb = 11.82 Joules

STEP 2b: Calculate the energy absorbed by friction during period t_2:

$E_{f2} = (5.91x10^{-3})$ x 0.2 sec x 1000 RPM x 10 in-lb = 11.82 Joules

STEP 3: Calculate the regenerative energy for downward motion during period t_3:

$E_v = (1.182x10^{-2})$ x 15 in-lb x 2000 RPM x 1 Sec = 354.6 Joules

STEP 4: Calculate the *Average Regenerative Energy* for the entire cycle (E_{avg}):

E_{avg} = 28.58 + 9.53 – 11.28 – 11.82 + 354.6 = 369.1 Joules

To determine if the SSI107 controller can absorb this amount of energy, first determine the net energy the regeneration resistors must dissipate. To find this Net Energy value, subtract the energy stored in the controllers bus filter capacitors as shown under the *Capacitor Energy Storage* heading in Table 3-24.

Net Energy = 369.1 Joules – 41.1 Joules = 328 Joules

Next, we must convert this Net Energy to power so we can compare the result with the dissipation capability of the controller's internal regeneration resistor.

Average Power = Net Energy / Total Cycle Time = 328 / 2 Sec = 164 Watts

We now compare this result to the controller's Max. Continuous Power rating from Table 3-24. Since the 164 Watts required is more than the 25 watts allowed by the SSI107 controller, an external regenerative resistor **is** required.

STEP 5: Determine the proper external regeneration resistor size:

If we refer to the resistor selection criteria shown in Step 5 above, we must first select a resistor that has a resistance value larger than the *Min. External Resistance* for the SSI107 controller shown in Table 3-24. Therefore, our resistor must be at least 50 Ω. From the second criteria our calculated value of 164 Watts for the *Average Regenerative Power* must be **less** than the *Continuous Power* rating of the resistor we select.

From Table 3-23 we see that resistor kit IC800SLR002 has a resistance of 100Ω and a continuous power rating of 225 Watts which meets both of the selection criteria.

STEP 6: Check the peak power (P_{pk}) requirements for each regeneration period:

For period t_1: P_{pk1} = 28.58 Joules / 0.2 seconds = 142.9 Watts

For period t_2: P_{pk2} = 9.53 Joules / 0.2 seconds = 47.65 Watts

For period t_3: P_{pk3} = 369.1 Joules / 1 second = 369.1 Watts

The largest of these values, 369.1 Watts, is still less than the 2880 Watt *Peak Power* rating of the IC800SLR001 resistor kit so this standard resistor can be used.

3.9 Dynamic Braking Contact and Operation

For controller models SSI216, SSI228, SSI407 and SSI420 it is possible to configure a dynamic braking (DB) function that will use the internal regeneration resistor to dynamically brake the motor when power is removed from the controller. The DB function requires a normally closed auxiliary contact from the main AC line contact that feeds power to the controller. This contact (Maux) must be wired between the "EXT" and "INT" power terminals as shown in the section titled "Clamp Connections" within 3.6.10 *Connection Diagrams*.

For the other controller models it is necessary to use an external dynamic brake circuit as shown in the diagram below. The resistor value should be approximately equal to the motor armature resistance.

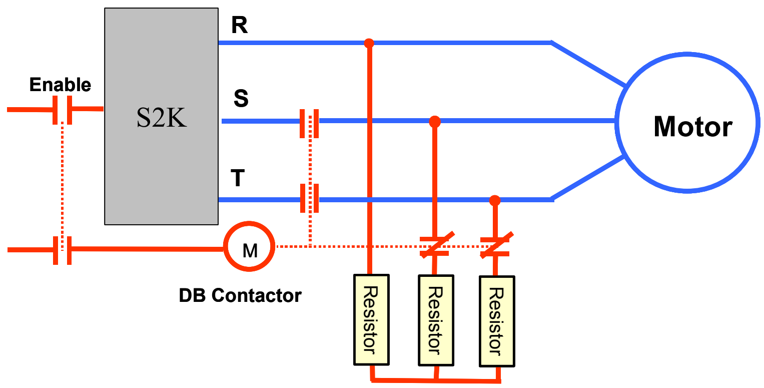


Figure 3-50. Typical External Dynamic Brake Circuit

Chapter 4 Getting Started

The flowchart in Figure 4-1 documents the process for completing a basic setup for an S2K motion controller. This chapter expands upon the pre-programming actions in this flowchart with step-by-step instructions for each part of the procedure. Once you have completed this basic set-up, you will be ready to start programming your motion control system.

Instructions for installing CIMPLICITY Motion Developer software to configure and program the controller are provided in Chapter 6, while Chapter 5 includes a detailed reference for all commands and registers supported by the S2K Series controllers. The Motion Developer software includes a *Motion Expert Wizard* that guides the novice user through the initial programming and parameter configuration of the S2K controller. The intent of this wizard is to provide a basic set-up that will allow you to run your motor. It does not attempt to cover all aspects of programming and configuring the controller since all applications have varied interface and program requirements.

The S2K configurations in this chapter illustrate how to set up S2K controllers I/O using the internal 12Vdc power supply for both servo and stepping models.

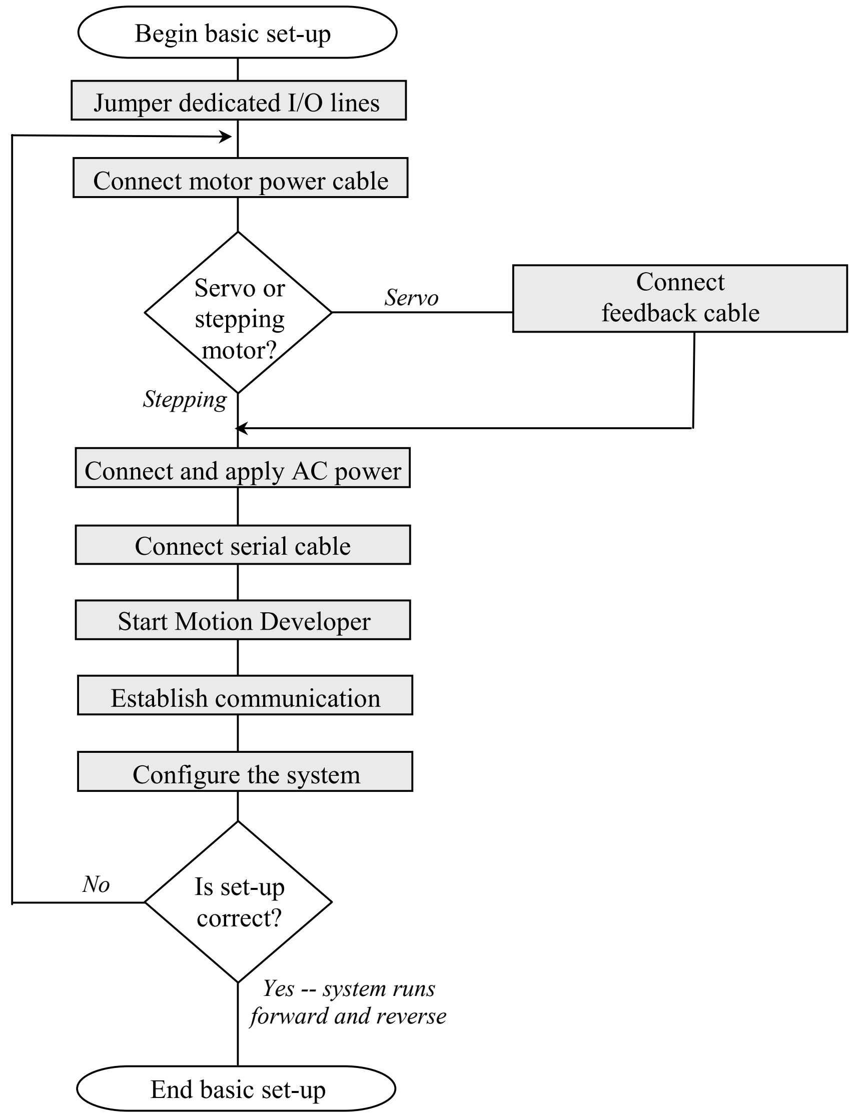


Figure 4-1. Basic Controller Set-up Flowchart

Step 1: Jumper Dedicated I/O Lines

The S2K controller has an enable discrete input that must be connected before the controller will run the motor. Use the guidelines provided below to wire your controller in either a sinking or sourcing configuration. These I/O configurations will allow you to use your controller in a most basic manner. Specific I/O configurations will vary depending on the requirements for your application.

For Sinking (Low-True) Connections

Jumper connections 15 and 18; 18 and 20; 17 and 19 (on the 20-pin Auxiliary I/O connector for controllers SSI216, SSI228, and SSI420; on the 20-pin Discrete I/O connector for controllers STI105, SSI104, SSI107, and SSI407).

For Sourcing (High-True) Connections

Jumper connections 15 and 18; 18 and 19; 17 and 20 (on the 20-pin Auxiliary I/O connector for controllers SSI216, SSI228, and SSI420; on 20-pin Discrete I/O connector for controllers STI105, SSI104, SSI107, and SSI407).

Note: If outputs are low true, or sinking, then inputs must also be low true. If outputs are high true, or sourcing, then inputs must also be high true.

Step 2: Connect Motor Power Cable

To minimize wiring errors we recommend using prefabricated cables available from GE Fanuc. Section 3.6.12–*Cables and Connector Mates* includes part number and length information for cables available from GE Fanuc and motor connector mates available from the manufacturer.

For S2K Series Servo Motor Controllers: Connect the flying leads labeled R, S, T, and ground to the appropriately labeled slots on the bottom of the controller. For S-Series servo motors rated 750 W and below, connect the box-style connector to the similar connector on the motor pigtail. S-Series servo motors rated 1kW and larger and all MTR-Series motors use MS-style connectors that mate to an equivalent connector on the opposite end of the power cable. All motor connectors are keyed to prevent improper installation. For details on the servo motor power connectors see Section 3.6.4—*S-Series Servo Motor Power and Brake Wiring and Grounding* and 3.6.5—*MTR-Series Servo Motor Power and Brake Wiring and Grounding*.

For S2K Series Stepping Motor Controllers: Connect the flying leads labeled Ground, B+, A/B-, and A+ to the appropriately labeled screw terminals on the bottom of the controller. Plug the motor side connector on to the in-line barrel style connector on the motor pigtail for NEMA 34 stepping motors or directly onto the motor mounted connector for NEMA 23 motors.

Step 3: Connect Position Feedback Cable (Servo only)

Connect the D-shell connector to its mate, labeled *Position Feedback* on the front of the S2K. Tighten the connector retaining screws to fasten the connector.

For S-Series servo motors rated 750 W and below, connect the box-style connector to the similar encoder connector on the motor pigtail. S-Series servo motors rated 1kW and above and MTR-Series motors use MS-style connectors that mate to an equivalent connector on the opposite end of the feedback cable. All motor connectors are keyed to prevent improper installation. For details on the servo motor connectors see Section 3.6.3–*Servo Motor Encoder Wiring* and Section 3.6.6–*MTR-Series Servo Motor Resolver Wiring*.

Step 4: Connect and Apply AC Power

Refer to Section 3.6.2 – AC Supply and Motor Wiring and Grounding for additional information.

Single-Phase AC Input

STI105 Stepper and SSI104 Servo Models: Connect power wires to the L1, L2, and ground connections to the screw terminals on the bottom of the controller.

SSI107, SSI216 and SSI228 Servo Models: Connect power wires to the 1L1, 1L2, and ground connections to the screw terminals on the bottom of the controller. To supply power to the controller logic circuit, jumper the 1L2 to the 2L2 connection; then jumper the 1L1 to the 2L1 connection.

CAUTION! For single-phase operation DO NOT *jumper the 1L3 connection.*

Three-Phase AC Input

SSI104 Servo Model: Connect power wires to the L1, L2, L3, and ground connections on the bottom of the controller.

SSI107, SSI216, SSI228, SSI407, and SSI420: Connect power wires to the 1L1, 1L2, 1L3, and ground connections on the bottom of the controller (see figure 2.4). To supply power to the logic circuit for models SSI107, SSI216, and SSI228, jumper the 1L2 to the 2L2 connection; then jumper the 1L1 to the 2L1 connection. The SSI407 and SSI420 models require a 24 Vdc logic supply on the COM and +24V terminals.

Apply Power to the S2K

Apply the proper AC voltage to the controller as shown below:

Model	Rating Output	Power Input	Input Frequency
SSI105	5 Amps Continuous	90-130 VAC, single-phase @ 10.0 Amps	50 - 440 Hz
SSI104	4.3 Amps Continuous	90-250 VAC single-phase @ 7 Amps three-phase @ 4 Amps	50 - 440 Hz
SSI107	7.2 Amps Continuous	90-250 VAC single-phase @ 17 Amps three-phase @ 9 Amps	50 - 440 Hz
SSI216	16 Amps Continuous	180-250 VAC three-phase @ 19 Amps	50 - 440 Hz
SSI228	28 Amps Continuous	180-250 VAC three-phase @ 34 Amps	50 - 440 Hz
SSI407	7.2 Amps Continuous	324-528 VAC three-phase @ 8 Amps	50 - 440 Hz
SSI420	20 Amps Continuous	324-528 VAC three-phase @ 22 Amps	50 - 440 Hz

Step 5: Establish Communication with Motion Developer

Install the Motion Developer software on Your PC

If you have not already installed Motion Developer on your PC, please do so at this time (see Chapter 6):

1. Close all Windows applications.
2. Insert the Motion Developer CD into your PC drive.
3. The CD has an autorun feature and should start automatically. If it does not then on the Windows task bar click **Start**/**Run**. Type `D:\Setup` ("D" should be replaced with the appropriate letter for your CD-ROM drive).

Connect Serial Communication Cable *(IC800SKCS030)*

1. Connect the end labeled "S2K" (9 pin female D-Shell connector) to the *Serial* port on the front of the S2K controller. Tighten the screws to fasten the connector.
2. Connect the end labeled "RS232 Port" (9 pin female D-Shell connector) to the RS-232 serial communication port on your computer. Tighten the screws to fasten the connector.

Run Motion Developer

From the **Start** menu, select **Programs**/**CIMPLICITY Machine Edition/CIMPLICITY Machine Edition**. The software will open to the Motion Developer home page in the InfoViewer window and the Manager tab in the Navigator window. (See the online help for details on using Motion Developer.)

Establish Communication

1. Create a new project in the Manager tab in Motion Developer. This will add a new Target (S2K controller) called *Target1* to the Projects tab, which will now be showing in the Navigator window.
2. From the Motion Developer toolbar click on the Terminal  Window button
3. Press the <Enter> key. If the controller is communicating the terminal window should respond with the following prompt:

   *GE Fanuc S2K Series

   Network Address - 0
4. If you do not see this prompt then refer to Chapter 6 for instructions on using the Motion Expert or Communication wizards to configure the controller for proper communication.

Using the Motion Developer Terminal Window

The terminal window in Motion Developer allows you to communicate directly with your S2K in an immediate execution mode over its serial port.

Note

> Changes made to registers, programs or motion blocks using the terminal window are **NOT** saved to your Motion Developer project or to non-volatile (Flash) memory. The terminal window communicates directly with the controllers working memory (volatile SRAM). To save these changes to your project you can manually change the appropriate values in your project using the script editors or import the controller's memory contents into your project target. **This import will overwrite ALL existing configuration, programs and motion blocks for that target controller.**

Here are a few tips for talking to your controller:

1. Motion controllers accept new commands and registers on a line-by-line basis. After you load a register or enter a command, press the <Enter> key on your computer keyboard.

2. The motion controller will tell you if it accepts the command or register with one of the following response in the terminal window:

   Input Accepted: An asterisk "*" followed by no response or by a requested answer means that your last entry was okay and the controller is waiting for the next entry.

   Input Not Accepted: A question mark "?" followed by a message (e.g. `INVALID COMMAND.` Additional messages are contained in Chapter 7.

3. Registers are loaded using the assignment command "=". For example, to load a velocity value of 100 axis units per second into an S2K, you would enter `MVL=100 <Enter>`.

4. You can interrogate the S2K to find the contents of registers using either the Q or ? command. For example, to learn the value of the velocity register, type `MVLQ` <Enter> or `MVL?` <Enter>. These are equivalent statements. The controller will return the contents of the velocity register on the next line of the terminal window (e.g. `*100`).

5. You can ask the controller its status by interrogating the status and fault registers. A complete listing of the status registers is shown in Chapter 7 – *Diagnostics*. For now, you can try this by typing `SRS?`<Enter> to query the system status register.

6. To preserve changes when controller power is cycled you must save the SRAM memory to non-volatile Flash memory using the SAVE command in the terminal window or the "Save to Flash" button on the Controller Functions wizard.

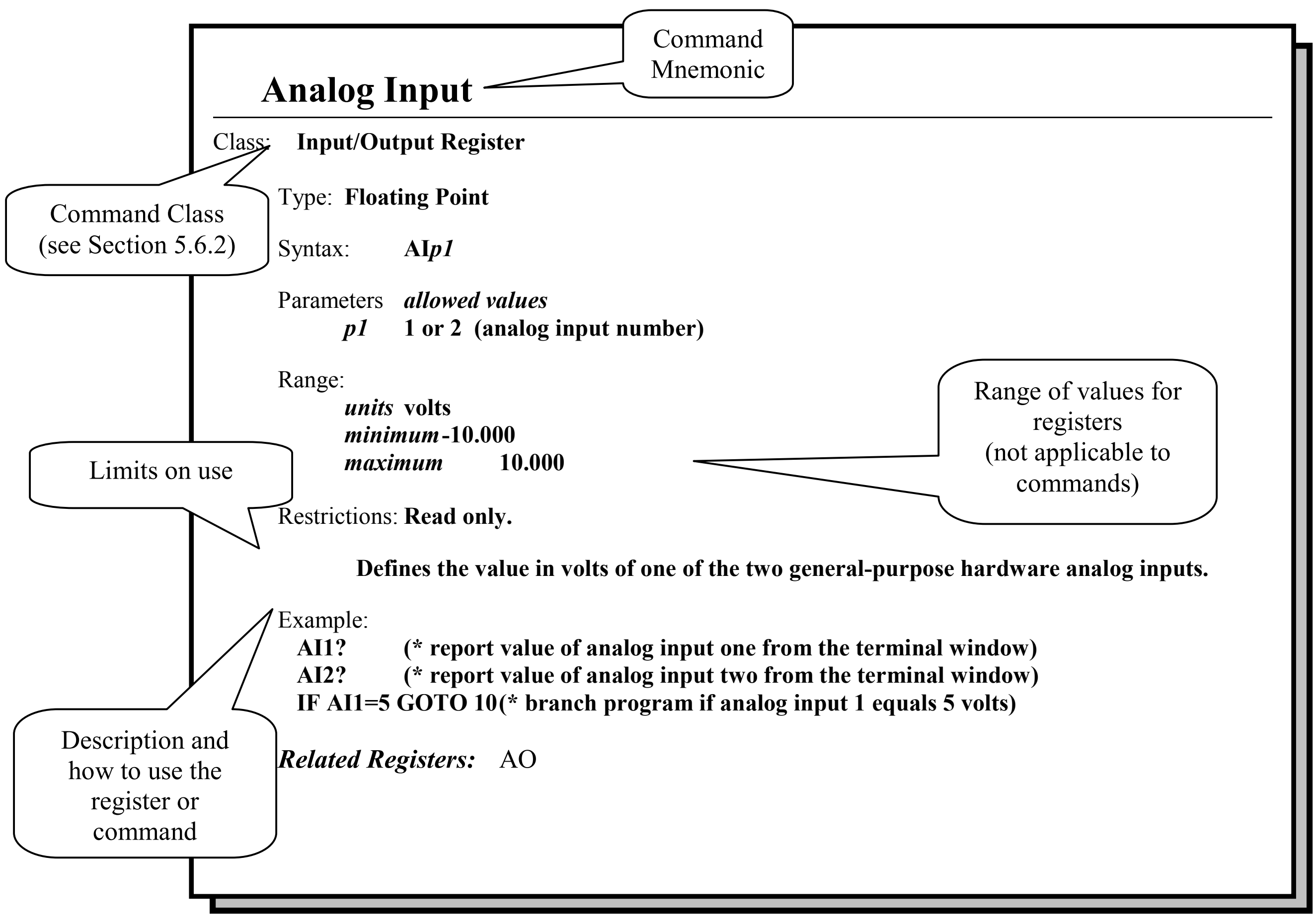
Step 6: Configure the System

Chapter 6 details the installation of the Motion Developer software to configure the S2K series controllers. Once installed, the Motion Expert wizard will guide you through the configuration of your controller. Please refer to the online help for additional details on configuration and programming.

Chapter 5 Software Reference

5.1 Software Overview

This chapter contains a comprehensive listing of all programming registers and commands for the S2K Series controllers. Commands are arranged in alphabetical order with symbolic commands listed first. The diagram below shows an example of the typical page layout for each command. There are also two quick reference summary guides to make locating a particular command even easier. Section 5.6.1 is an alphabetical listing and Section 5.6.2 list commands grouped by class.



5.2 S2K Programming Language Basics

The S2K Series has been designed specifically for motion and machine control. The programming language uses mnemonic constructs and supports a broad range of functionality and program flexibility.

Registers, commands, and operators/operands are the basic tools that you will need to create your motion control application programs. Detailed information on each is provided in “Commands and Registers” on page 5-59.

A typical command line would adhere to the following syntax structure, for example:

command line: Wait IP When Not DI3 Goto 310

action: wait until axis is in position or if digital input 3 is not true, then go to label 310.

Registers can be loaded directly with a data value or indirectly with the contents of a variable, for example:

register: MPI=1000

MPI=VF100

action: the Incremental Move Position (MPI) register can be loaded with either the value 1,000 or the contents of floating point variable 100.

The S2K Series supports full floating-point math and operators for complex mathematical and logical operations. Multifunction, single-line math operations use standard infix notation to simplify program readability and flow, for example:

mathematical equation: VF1=SQR(VF2**2.+VF3**2.)

calculation: result stored in floating point variable 1 equals the square root of the sum of the squares of floating point variables 2 and 3.

The S2K controllers support two modes of operation: ***preprogrammed task execution*** and ***immediate mode***.

Immediate Mode

In immediate mode the serial communications port functions as your control port, allowing you to send commands or load registers online and in real-time from an external source. Immediate mode is useful for applications in which motion register values and/or commands are not known in advance and may be a function of operations performed elsewhere on the machine. This mode is also a useful tool for debugging controller operation using the Motion Developer terminal window interface.

Immediate mode allows the following real-time operations:

1. Send/receive variables
2 Send immediate mode commands (e.g., AUTOTUNE, CLM)
3. Load/send new register values
4. Query system status and register values
5. Send motion commands

Note

Changes made to registers, programs or motion blocks using the terminal window are **NOT** saved to your Motion Developer project or to non-volatile (Flash) memory. The terminal window communicates directly with the controllers working memory (volatile SRAM). To save these changes to your project you can manually change the appropriate values in your project using the script editors or import the controller's memory contents into your project target. **This import will overwrite ALL existing configuration, programs and motion blocks for that target controller.** To save the changes to non-volatile memory, use the SAVE command in the terminal window or the "Save to Flash" button on the Controller Functions wizard.

Programmed Task Execution Mode

Programmed task mode allows the S2K controller to execute user application programs that are stored in memory. Up to four programs can be stored and run concurrently (see Section 5.3).

5.3 Programming Resources

The S2K controllers use a Real Time Operating System (RTOS) that allows you to create a control system for complex motion applications with real-time machine control and human-machine interface functions. The RTOS is multitasking and has global resources (shown in 5-1) that are shared by all tasks.

Multitasking provides a convenient and reliable technique for adding versatility and performance to real-time control systems. The S2K supports up to 6 concurrent tasks, including up to 4 programs, 1 motion block, and 1 communication port. Tasks run independently of each other except as designed by the programmer. Your communication port allows you to receive registers or commands while you are executing other tasks. Table 5-1 shows a listing of the programming resources available.

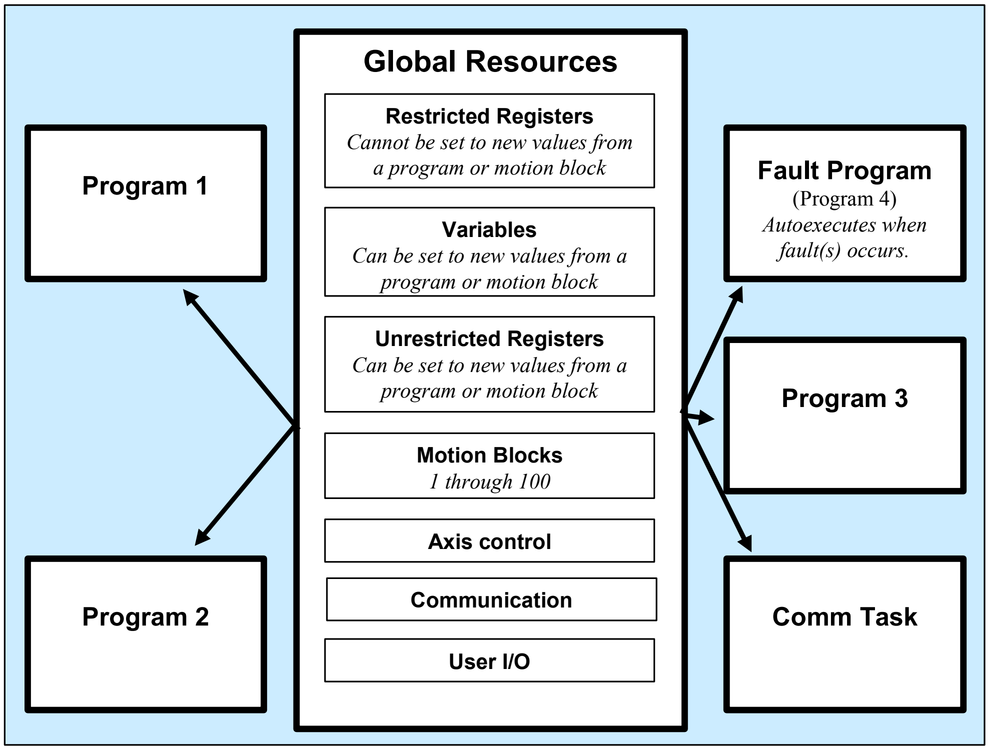


Figure 5-1. Structure of the S2K Real-Time Operating System

Table 5-1. Programming Resources

Flow Control Labels per program Nested GOSUBS per program	 999 32	**Countdown Timers**	8
		Maximum Concurrent tasks [3]	6
Programs General purpose Fault-handling	 3 1	**Master axes per program**	1
Motion Blocks	100	**Key Buffer Size**	256 bytes
Variables Boolean Floating point [1,2] Integer [1] String (127 characters each)	 256 2,048 4,096 144	**User RAM** [4, 5] User programs Variable	60 Kbytes 42 Kbytes

1. Integer and floating point variable memory space is shared; numbers shown are the maximum for each but not for both concurrently. Floating point variables require twice the memory of integer variables. Thus, for example, if 1,000 floating point variables are used, 2,096 integer variables are possible. **The default allocation is 1,024 floating point and 2,048 integer variables. The VFA register is used to reallocate the variable space.**
2. Floating point variables use a 32-bit mantissa and are precise to 9 decimal digits.
3. 4 program tasks, 1 motion block task, 1 communication port task.
4. **CAM memory is shared with program memory.** The S2K has 60K of RAM available for user program memory and the CAM table. Once a CAM point is entered or queried, or if the CAM compile start position (CCP) is entered or queried, 14K of RAM will be allocated for the CAM table, leaving 46K of RAM for the user program memory space.
5. User program RAM is saved to Flash EPROM by using the SAVE command (CAM memory is also saved to Flash in revision 2.5 and later). A portion of the variable memory is saved to Flash EEPROM using the SVV command (See SVV for more details).

5.3.1 Comment Statements

S2K controllers ignore and do not store any comments contained within an application program that are delimited using the “ (* ” symbol. When you execute a download from Motion Developer these comments are stripped away and are not stored in controller memory. To embed comments within a program and have them stored in controller memory, the REM command must be used.

5.3.2 Flow control

The S2K controllers provide a broad range of command that enable the user to control the structure and flow of program code providing a powerful tool to solve complex machine operations. Table 5-2 shows a brief listing of these commands.

Table 5-2. Flow Control Commands

EXP	Runs program *n*. If program *n* is currently running, then EXP*n* has no effect on program flow.
GOSUB	Goes to a label that functions as a subroutine.
GOTO	*Goes to* any labeled program statement in the currently executing program: `GOTO10        (*jump to the program line with label 10`
IF…GOSUB	If *condition* is true then GOSUB label.
IF…GOTO	If *condition* is true then GOTO label.
IF…THEN	If *condition* is true then execute the next line of the program; otherwise, skip the next line.
KLP	Kills program *n*. If program *n* is not running, then KLP*n* has no effect on program flow. For example: `IF DI4 THEN       (* if input 4 then` `EXP2              (* start program 2` `IF NOT DI5 THEN   (* if not input 5 then` `KLP3              (* kill program 3`
POP	The POP command retrieves and discards the top of the gosub stack. POP lets you leave a subroutine without executing a RETURN. For example: ` ...      (* subroutine entered with a GOSUB` `WAIT IP1 WHEN DI1 GOTO 700` `         (* wait for axis 1 in position. When not` `         (* emergency stop input, leave subroutine,` `         (* and execute E-stop code` `...` `RETURN   (* normal subroutine return` `700  POP (* retrieve and discard subroutine return address` `...      (* E-stop code`
REPEAT	Causes a motion block to repeat from the beginning.
RETURN	Returns to the statement in program immediately following the GOSUB, e.g., `GOSUB 100     (* save the program counter on the` `              (* gosub stack, then load the program` `              (* counter with the line at label 100` `...           (* another line of program` `100           (* subroutine code` `...` `RETURN        (* return to another line`
RSTSTK	Empties the GOSUB stack.
STVB*n* GOTO	Sets Boolean variable *n* and, if VB*n* was not already set, goes to the label specified.
WAIT	Causes the program or motion block to wait until the specified condition is true before advancing to the next line of code.
WAIT… WHEN… GOTO	**WAIT … WHEN … GOTO** *label* waits for the first expression (…) to become true, or when the second expression becomes true, it goes to the label: `WAIT IP1 WHEN DI1.1 GOTO 10` `         (* wait for axis 1 to be in` `         (* position, or when input 1, goto 10.`

A ***label*** is an integer number from 1 to 999 that immediately precedes a program statement and serves as a reference point. Assign labels to delineate program sections or to identify starting points for GOSUB and GOTO routines.

A ***subroutine*** is a section of a program containing an encapsulated routine that the GOSUB command can access multiple times from any point within the program. A program may contain up to 32 nested GOSUB calls (a nested GOSUB is simply a subroutine within a subroutine).

Use the commands GOTO, GOSUB, IF…GOTO, IF…GOSUB, RETURN, RSTSTK, and POP to get to and from the subroutines in your programs.

5.3.3 Programs, Multitasking and Security

The S2K controller can store and concurrently execute up to four separate programs in a round robin basis (i.e., one line of code is executed from a given task before the processor continues to the next task) as shown in Figure 5-2. The programs are titled Program1, 2, 3 and 4 and all have equal priority.

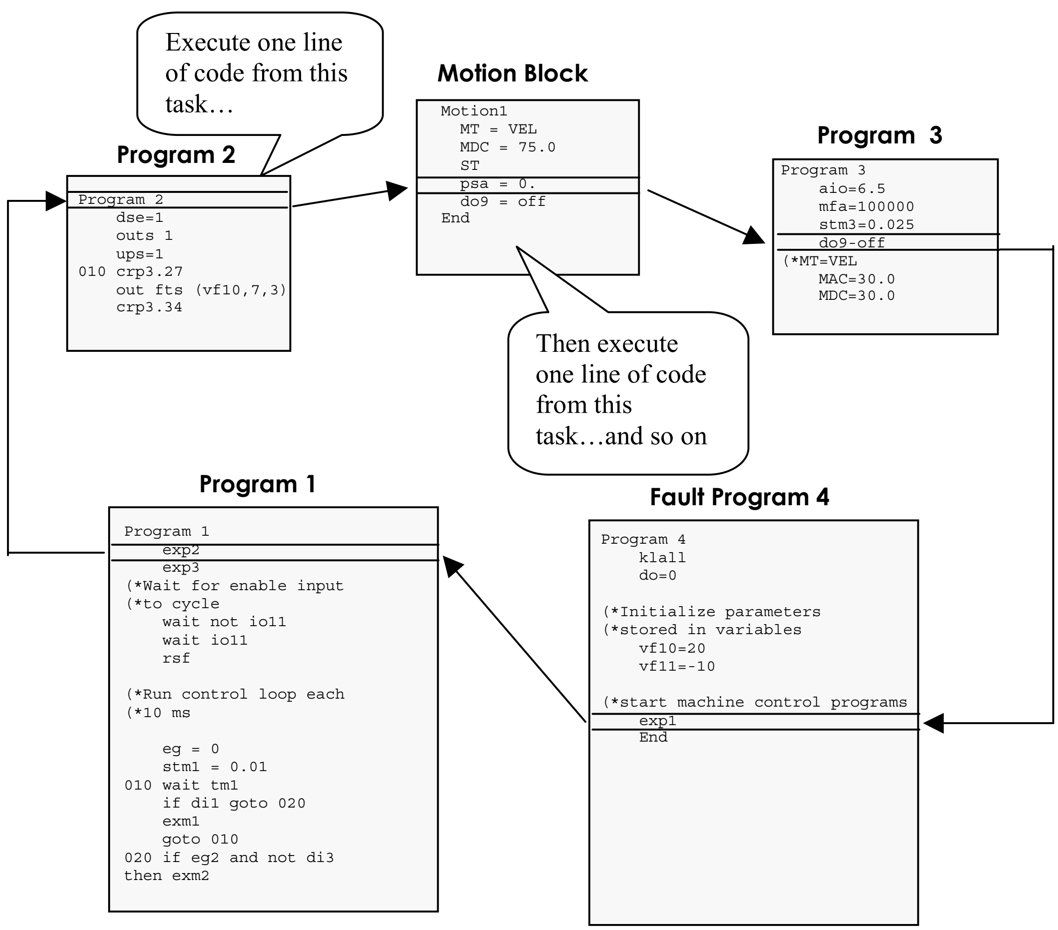


Figure 5-2. Multitasking Example Showing Round Robin Task Execution

Programs 1 through 3 are general-purpose programs while program 4 is a special purpose program designated for fault handling. When the controller detects one or more fault conditions, the S2K controller indicates that one or more fault conditions exist and Program 4 is automatically executed. Many events can cause a fault—the two most common causes are *power loss* and *enable loss*. One or both of these conditions occur in the course of normal machine operation, for example, on power cycles or in an e-stop condition. Your fault handling program must diagnose the cause of the fault and determine the appropriate system behavior. Chapter 7 provides details on diagnosing system faults.

The Motion Developer software automatically creates placeholders for programs 1-4 for each new target controller added to the project. The *Motion Expert* wizard facilitates the development of Program 1 for general machine control and provides several selections for creating basic fault handling code for Program 4.

Any program can start or stop any other program. Use **EXP***n* and **KLP***n* to start and stop individual programs; use **EXM***n* to start a motion block. The **KLALL** command will stop all programs. Table 5-3 tells you more about these multitasking commands:

Motion Developer allows you to substitute symbolic names in place of motion block or program numbers. For example, if motion block 1 represents a return to Home position move, it is more intuitive to call this move by the symbolic name “Home.” In this case you can start this motion by replacing the motion block number *n* with the symbolic name (EXM HOME) in the Execute Motion command.

Note

Symbolic names are stored as a part of your Machine Edition project but are not downloaded and stored to the controller. Programs imported from controller memory do not include the symbolic names.

EXM*n*	Kills any currently running motion block that includes the same MBA assignment and runs motion block n. If the motion block is currently running, then EXM*n* will restart the motion block at its beginning. For example: `IF DI4 THEN    (* if input 4 then` `EXM5           (* start motion block 5`
EXPn	Runs program n. If program n is currently running, then EXP*n* has no effect on program flow.
KLALL	Stop all programs but not motion blocks.
KLP*n*	Kills program *n*. If program n is not running, then KLP*n* has no effect on program flow. For example: `IF DI4 THEN       (* if input 4 then` `EXP2              (* start program 2` `IF NOT DI5 THEN   (* if not input 5 then` `KLP3              (* kill program 3`
LOCK/ UNLOCK	LOCK increases the execution rate for time-critical functions by allocating all of the controller's CPU resources to one task. It prevents any other programs and motion blocks from executing concurrently. If you use LOCK, be sure to UNLOCK before your program tries to execute a line of code that requires interaction with another program or motion block. ***Example of a locked program*** _____ _____ LOCK IF… UNLOCK Can't execute! All other tasks except the fault program and communication port are frozen!

Table 5-3. Multitasking Commands

Include either the RSF command in program 1 to clear fault conditions—these commands will work only when all of the conditions that caused the fault(s) have been corrected. If RSF does not clear the fault(s), further diagnostics are required.

Write your fault program so that the S2K controller will efficiently analyze the fault conditions and direct program flow appropriately. The flowchart shown in Figure 5-3 provides a recommended operation sequence for fault handling.

Incorporate the items included in Figure 5-3 into your fault handling program. Be sure to document your program for future reference using the comment delimiter (***.**

Use the REM command to embed critical program flow comments directly in programs or motion blocks. "REM" delimited comments are stored to the controller while (* delimited comments are not.

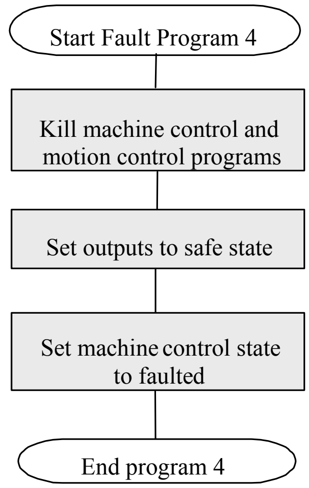


Figure 5-3. Structure For Fault Handling Program

Program Structure and Task Assignment

Begin with a thorough assessment of your system needs, keeping in mind that the S2K controller RTOS is a flexible operating system. Some good questions to ask include the following:

1. What tasks do I want to perform through programs?
2. What motions do I need to construct using motion blocks?
3. How can I divide my motion control tasks to get the maximum multitasking efficiency?

Document your answers to these questions and then use the following guidelines to determine how the tasks within your complete application program will interact:

- Use only as many tasks as are required to perform your application. Tasks include program 1 and any additional programs and motion blocks. Total execution efficiency is proportional to the number of total tasks executing.
- When using additional programs (program 2 and 3), allocate specific functions to separate programs. For example, one program can run the motor, a second program handles operator interface functions, and a third program outputs motor torque and sets position feedrate.
- Discipline yourself to use global resources (see Figure5-1) in blocks that are unique to individual programs or motion blocks. This practice avoids interactions between programs or motion blocks that could load a variable or register with a value that is nonconforming in another program. An example of this practice would be to use integer variables 1-49 in program 1, 50-99 in program 2, and so forth.
- Document your programs for future reference using the comment delimiters (*.
- Embed critical program flow comments directly in programs or motion blocks with the REM command.

Manage Your Program Security

Use the SECURE command to protect your intellectual property—it will prevent programs and motions blocks from being uploaded from the controller. This command also blocks use of the FAULT command. To enable the secure feature, first send the application program file to the controller, and then, from the terminal window in Motion Developer, type `SECURE <Enter>`. To disable the SECURE feature, type `CLM <Enter>` to clear the memory and start over.

The PASSWORD command is intended to prohibit program modification in the field. To password-protect your program:

- Type **`PASSWORD`** from the terminal window in Motion Developer
- At the *Enter Password* prompt, type the four- to ten-character password of your choice.

Caution

Do NOT forget your password. After you set the password, you will have to enter the password before accessing the program. If you do not enter the correct password, you will be able to use only diagnostic commands—you will NOT be able to clear the memory (i.e., use the CLM command) to start over. To start over, you must return the controller to the factory. THERE IS NO BACKDOOR!

If you lose or forget your password, call GE Fanuc to get a return merchandise authorization (RMA) number. Once you have an RMA number, ship the unit to GE Fanuc for service.

To change the password, type `CHANGEPW <Enter>` in the Motion Developer terminal window and follow the prompts.

5.3.4 Motion Blocks

Motion blocks allow you to define motions that can be called and used by any program or executed in *immediate mode* from the Motion Developer terminal window or an external control device (using the EXMx command). You can create and edit motion blocks using the Motion Developer wizard or manually using the script editor. The S2K Series controllers support up to 100 motion blocks.

Rules of Motion Block Execution				
1. Motion blocks complete executing one line of code before proceeding to the next line of code.	2. You can concurrently execute only one motion block with the executing program(s).	3. Once a motion block is executed, it overrides the currently executing motion block or motion.	4. No labels are allowed in motion block program code! Therefore, commands that use labels such as GOTO, IF…GOTO, GOSUB, etc. are not allowed in motion blocks.	5. REPEAT command causes motion block to be repeated continuously from the beginning.

Motion blocks include an implied "WAIT IP" line at the end of each move so this statement does not need to be included in a program after an EXM command in a program.

5.3.4.1 Blended Moves

Motion blocks allow the user to create complex motions such as multi-speed blended moves without a series of conditional and wait statements. For example, for a spindle infeed on a machine tool, you may want to define a move like the one shown in the following diagram:

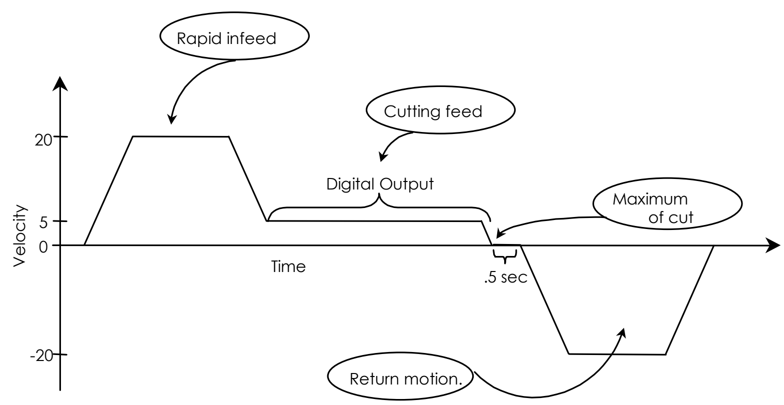
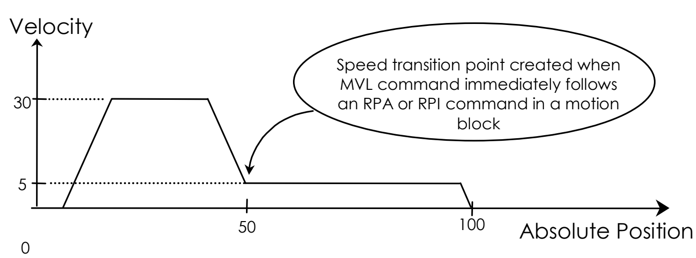


Figure 5-4. Complex Motion Profile Defined By a Motion Block

The motion block also utilizes another special condition to create blended or complex profiles as shown above. Blended motion is created when a motion block contains more than one move command (i.e., RPA or RPI command) and detects the MVL command immediately after the RPI or RPA command. In this case the profile generator will compute the initial move so that it reaches the speed transition point at the beginning speed of the next move at the position defined by the first move. For example the following motion block will generate the blended move shown below:

```
MAC = 50.0     (* set motion acceleration, units/sec^2 for initial move
MDC = 75.0     (* set motion deceleration, units/sec^2 for initial move
MJK = 0        (* set motion jerk percentage for initial move
MVL = 30.0     (* set motion velocity, units/sec for initial move
MPA = 50.0     (* set absolute move position for initial move
RPA            (* run to absolute move position
MVL = 5.0      (* set motion velocity, units/sec
MPA = 100.0    (* set absolute move position, units
RPA            (* run to absolute move position
```

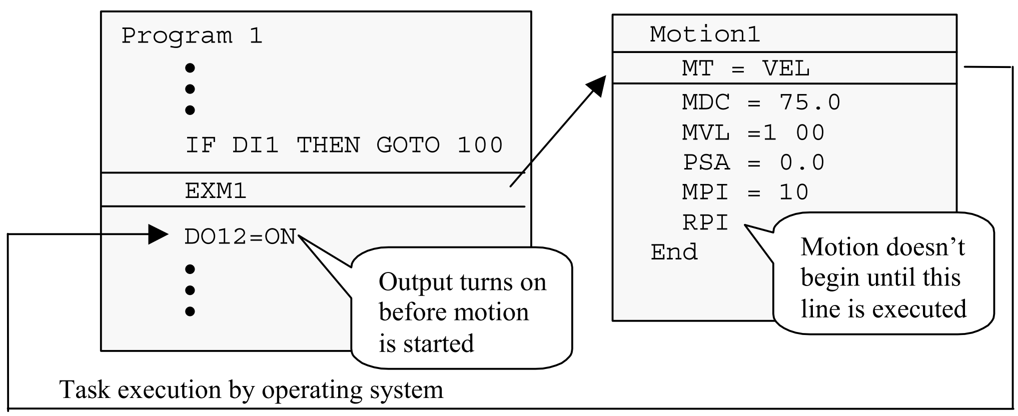


5.3.4.2 Achieving Expected Results

Because a motion block generally comprises several code lines before the actual motion is initiated by a command such as RVF, MPA, MPI, etc. the programmer must be careful how these are used in a program in order to achieve the expected results. For example, if the user wants to execute a motion block and then turn on an output at the end of the move the following program segment would not accomplish this:

```
EXM1     (*execute motion block 1
DO12=ON  (* turn on digital output 12
```

In this example the command to turn on the output will be executed before the motion even starts. Since the motion block is a separate task the operating system will execute the first line of code in the motion block (which will usually be something like MAC, MVL, etc.) and on the next processor sweep it will execute the “DO12=ON” of the main program as shown in the figure below:



A solution to this would be to include the DO12=ON line in the motion block or to set a binary variable (VB) to true at the end of the motion block and then include a “WAIT VBx” line in the main program.

5.3.5 Math Functions

The S2K controllers support full floating point math and operators for complex mathematical and logical operations:

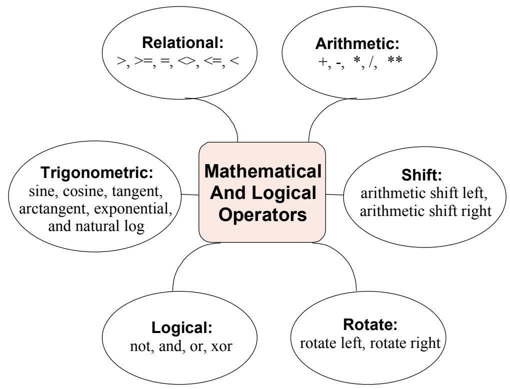


Figure 5-5. Math Functions

Multifunction, single-line math operations use standard infix notation to simplify program readability and flow. For example:

Mathematical equation:	VF1=SQR(VF2**2.+VF3**2.)
Calculation:	result stored in floating point variable 1 equals the square root of the sum of the squares of the floating point variables 2 and 3.

5.3.6 Variables

In some of the commands that you use, the parameter (*p1*, *p2*, etc.) that is part of the command's syntax can be a variable expression rather than a fixed constant. You can also set most of the registers to a variable expression.

Variables can also be used in mathematical operations. The S2K controllers support the variable types shown in Figure 5-6.

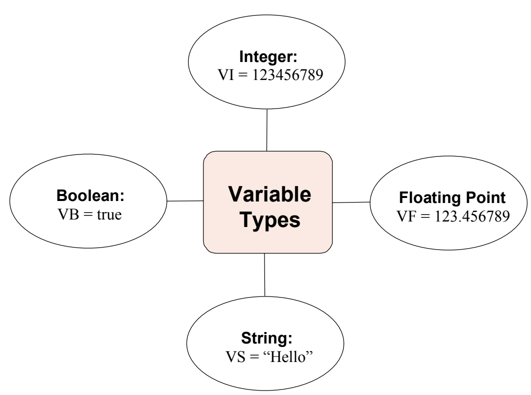


Figure 5-6. Variable Types Supported By S2K Controllers

Floating point and integer variables use a 32 bit mantissa to preserve precision when converting integer values to floating point.

Boolean variables (VB*n*) can have a value of 0 or 1 and are used mainly in conditional statements such as IF...GOTO and WAIT. They can also be used to change the value of Boolean registers (GRE, CIE, POE, etc.).

Floating point variables, VF*n*, can store any floating point value between 1.5 x 10^{-39} (absolute value) to 1.7 x 10^{38} (absolute value) with up to nine digits precision. Use floating point variables in expressions and to store parameters. Floating point arguments **must** include a decimal point.

Integer variables, VI*n*, can store any integer value between -2,147,483,648 and 2,147,483,647. They are used mainly in expressions and to store parameters. Integer variables are as precise as floating point variables and can represent fractional values with appropriate scaling factors.

String variables, VS*n*, can be loaded with a message up to 127 characters long. String variables are used in I/O commands (GET, IN and OUT).

For example, you could use the OUT command to send a message stored in string variable 1 to the serial port:

```
KLALL        (* kill any executing programs
VS1="This is a test.$N"
OUT VS1      (* output This is a test to serial port
```

You could also store commands within string variables and then use the EXVS command to execute them:

```
VS1= "MPA=10" (* set string variable 1
EXVS1              (* execute command stored in string var. 1
```

Pointer Variables (Indirect Referencing)

Integer variables can point to (reference) other variables, allowing you to construct many different kinds of data structures, including the following:

- Linear array
- Push down stack
- Circular buffer.

A pointer contains the number of the variable to which you want to point. If you want to have a pointer access floating point variable 53, you can set any integer variable (such as integer variable 10) to 53. For example:

```
VI10 = 53          (* load pointer
VF100 = VFVI10     (* load VF100 with value of floating point
                   (* variable pointed to by VI10 [VF53]
```

is equivalent to: `VF100 = 53.`

You can also use pointers to shorten programs. For example, you can send to the display a long list of characters whose ASCII values are stored in integer variables. Suppose you have ASCII codes stored in integer variables 100 through 200. You *could* send them to a display device using the PUT command one hundred times:

```
PUT CHR(VI100)
PUT CHR(VI101)
...
PUT CHR(VI200)
```

Or you could make the process quick and far less tedious with variable pointers:

```
VI1=100                 (* load the pointer 100
1  PUT CHR(VIVI1)       (* send ASCII characters stored in
                        (* VIVI1 to the display
VI1=VI1+1               (* increment VI1 by 1
IF VI1<=200 GOTO 1      (* continue to increment by 1 if VI1 <= 200
```

When VI1 is less than or equal to 200, the program loops, sending all ASCII codes stored in variables 100 through 200 in the process. When VI1 is greater than 200, it fails the check and goes on to the next program line.

Note

Motion Developer version 2.5 and earlier do not recognize indirect (pointer) variables that use a symbolic name (tag). For example, if you want to use VI200 as the pointer variable for a floating-point variable, you would construct the following:

VFVI200

However, if you rename VI200 to “Pointer_Variable,” Motion Developer will create the following construct:

VFPointer_Variable

The version 2.5 and earlier program parsers do not recognize the aliased construct and, therefore, do not replace the symbolic name VFPointer_Variable with VI200 when the program is downloaded to the controller; so VFPointer_Variable is sent to the controller. In turn, since the controller does not recognize the symbolic name VFPointer_Variable, a syntax error is generated. A workaround would be to create a new floating-point variable called VFPointer_Variable which is a tag for VFVI200.

5.3.7 Countdown Timers

The S2K controllers support 8 crystal-based timers with a resolution in milliseconds.. Use the STM*n* = xx.xxx (xx.xxx is a time in seconds) command to set these timers. Once set, a timer counts from the starting value down to zero. The timer automatically resets to the initial value and continues counting each time it reaches zero.

The timer flag, TM*n*, is set each time the timer reaches zero and reset each time the flag is read. You can use TM*n* in conjunction with the WAIT command for conditional program flow. For example:

```
STM8 = 0.333  (* start timer 8 with a period of 333 ms
WAIT TM8      (* wait until timer 8 reaches zero
```

5.3.8 Command Execution Time

The following table gives typical or average times for the example commands shown. Note that position and velocity data may be up to 488 µs “old’ regardless of execution time.

Table 5-4. Command Execution Time

Command Examples	Execution Time in µs
Null Loop	0
vf50 = psa	67
vf51 = vf50 + vf51	76
IF THEN	60
mvl = 100	22
vf51 = vf50/3	79
Sin(vf50)	557
vf50 = vla	63
GOTO, false	44
GOTO, true	50
vf50 = mvl	66
mvl = vf50	65
vfvi3 = fe	58
vfvi3 = cmd	76
vf50 = cmd	73
save variables to flash	280 ms
retrieve variables from flash	2050
vf50 = ai1	1335
rem	21
vf50 = pca, pcx	1335
mt = ‘new'	25

5.4 Saving and Restoring Parameters, Variables and Programs

The S2K controllers use nonvolatile FLASH memory. When changing register values using the terminal window the changes are stored in the S2K controller 's volatile SRAM memory. To preserve the controllers memory contents when power is cycled it is necessary to save the SRAM memory image to FLASH memory. There are several ways this can be accomplished using the Motion Developer software:

1. Executing the SAVE command from the Motion Developer terminal window or host serial device (i.e., type SAVE <Enter>)
2. Clicking the *Save To Flash* button on the Motion Developer Controller Functions wizard page

The reverse of this process allows the user to reload the contents of the FLASH memory into the active SRAM memory. This can be accomplished as follows:

1. Executing the RETRIEVE command from the Motion Developer terminal window or host serial device (i.e., type RETRIEVE <Enter>)
2. Clicking the *Get From Flash* button on the Motion Developer Controller Functions wizard page

Since the S2K controller does not, by default, automatically load the FLASH contents to SRAM it is necessary to execute the autoretrieve command (AUTORET) *before* the SAVE command in order for the register values and the user programs to be automatically retrieved after each power cycle.

Note

If AUTORET is not active (i.e., has not been set prior to the last SAVE command), all register values will be reset to the default values and the program memory space will be emptied after each power cycle. The AUTORET and SAVE commands are automatically included at the end of the application source code file each time Motion Developer performs a download operation.

The AUTORET, SAVE, and RETRIEVE commands **cannot** be included in programs.

AUTORET and SAVE do *not* save or restore variable values. Variables are all set to 0 at each power cycle. Variable values, however, can be saved to and restored from nonvolatile memory using the Save Variables (SVV) and Retrieve Variables (RTV) commands. The SVV command saves integer variables 1 through 1,024 and floating point variables 1 through 512 in FLASH memory. RTV restores the values of these variables to the controllers working memory (SRAM). The SVV and RTV commands are allowed only in programs and can only be executed when the motion generator is **not** active.

Caution

The controller flash memory can support a finite number of write cycles before the flash memory will fail. Although the typical limit for this type of flash is +100,000 write cycles, it is easy to exceed this limit by executing frequent SVV commands from within a program.

5.5 Advanced Programming

The S2K controllers support many powerful programming features that allow you to handle complex applications. Electronic gearing and camming, pulse-based motion control and registration control using high-speed position capture inputs. This section provides details on the registers and programming methods for using these functions.

5.5.1 Using Pulse-based Motion

The S2K controller supports various operating modes selected using the Motion Type register (MT). The pulse-based mode allows the user to program axis motion relative to a pulse input from a master encoder rather than time. Pulse-based mode simplifies the programming of cyclic applications where the axis motion is continuously repeated each time the master source traverses a specified distance.

Overview

Pulse-based motion requires the auxiliary axis (master pulse source) to be unidirectional and connected so that the auxiliary position (PSX) always counts up (value increases). There are two different pulse modes that can be configured:

- MT=PULSE: Standard pulse mode
- MT=PULVEL: Pulse-Velocity mode

Both modes use many of the same registers to specify the axis motion, however the function of some registers is different depending on the mode selected. Programs may change between these two modes while the axis is in motion.

Within each of the pulse modes the programmer can specify either incremental/absolute position-based motion or continuous motion where the axis will run at a specified velocity ratio until commanded to stop.

When using pulse-based motion you must specify the pulse input signal type connected to the auxiliary input that will be used as the command source. Using the Auxiliary Quadrature Type (QTX) register the following pulse signal types can be selected:

- **QTX=Q4**: Standard quadrature encoder signals. Controller will generate four counts (pulses) for each electrical cycle of the encoder input. (default)
- **QTX=PD**: Pulse and direction signals
- **QTX=CW**: Clockwise and counterclockwise pulse inputs

Since most applications will use an encoder this configuration has been set as the controller default.

The static (i.e., motor is not moving) accuracy of the servo axis to the auxiliary axis is +/- 1 pulse during the motion and zero pulses at the end of the motion. The dynamic accuracy is the instantaneous servo following error + .0017 * VLX where VLX is the velocity of the auxiliary axis in pulses per second. That is, during a motion, the servo position lags the auxiliary axis position by 1.7 ms. The error is zero pulses at the completion of the motion.

Using the In-Position Flag (IP) with Pulse-Based Motion

A run command "arms" the profile generator and sets the In-Position (IP) register to zero. For positioning-based motion, in which the move starts when the run command is executed, IP is set to zero very close to the time that actual motion begins. However, in pulse-based motion, the setting of IP to zero may not coincide with the start of motion in some cases. This would be true if, for example, a run command (such as RPA or RPI) were executed a significant amount of time before the encoder count triggered the start of motion. This scenario would be a problem if you wished to use IP as an indication of when motion begins. However, there is a programming technique you can use to ensure that IP goes to zero very close to the time that actual motion begins even when using pulse-based motion. This technique consists of including the following line of program code immediately before the line that contains the run command:

WAIT PSX => MPS - 0.005*VLX

This WAIT command causes the Program or Motion Block to wait until the auxiliary encoder position (PSX) is very close to the point (MPS) where motion will start. The 0.005*VLX is a term to anticipate the arrival of this position based on the velocity of the auxiliary encoder (VLX). The 0.005 value represents 5 ms. This "anticipation factor" allows for command line processing time and to ensure that the run command is executed at a point just BEFORE the Motion Pulse Start (MPS) position is reached. This precaution is necessary because if the run command is executed too far after the auxiliary encoder position passes the MPS position, a Following Error fault or Excessive Command Increment fault will occur.

5.5.1.1 Standard Pulse Mode (MT=PULSE) For A Position Based Move

The basic process for defining a pulse-based incremental or absolute move is shown in the steps below:

Step 1: Determine the Auxiliary Position register rollover modulus (PLX)

Since pulse-based motion is frequently used on unidirectional and/or rotary applications the register used to store the auxiliary position (PSX) will eventually rollover. Unlike the Axis Position (PSA) register where this rollover can be enabled/disabled using the PWE register, the PSX register rollover is always enabled. The default rollover limits are ±2,000,000,000 pulses. The auxiliary units can be scaled from pulses to any other desired engineering units using the Auxiliary Unit Ratio (URX) register. The Auxiliary Position Length (PLX) register defines these upper and lower rollover limits as follows:

Upper PSX Limit = PLX – 1/URX

Lower PSX Limit = - PSX

These limits are shown graphically in Figure 5-7.

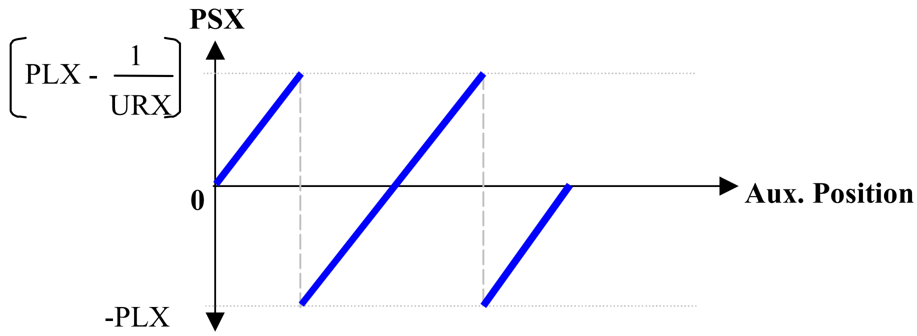


Figure 5-7. Auxiliary Position Register Wrapping

You generally want to define the rollover limits as the range of travel of the auxiliary axis that represents one machine or product cycle. For example, using a 1000 line auxiliary encoder as the pulse source, we want to scale the auxiliary units to revolutions and set the total range of travel for the auxiliary encoder to 100 revolutions. First scale the auxiliary units to revolutions by setting URX equal to 4000 (i.e., 4 x 1000 lines/revolution). Since PLX effectively defines half of the total range for the auxiliary position we set PLX equal to 50 (i.e., 100/2). Using the formulas from above we can calculate the upper and lower PSX limits as 49.99975 and –50 revolutions respectively.

Step 2: Determine the master encoder position where you want axis motion to start (MPS)

Next you need to specify in your program the auxiliary axis position where you want the pulse-based move to start. In the S2K controller the Motion Pulse Start Position (MPS) register is used to assign this position. When the move command (RPA or RPI) is executed the axis will wait until the auxiliary axis position (PSX) reaches the MPS position and then will begin the defined pulse-based move. If the auxiliary axis position is already beyond the move start point when the RPI or RPA command is executed the axis tries to jump instantly to make up the difference between the MPS starting point and the current auxiliary position. In this case the axis may fault on excessive command increment or following error. Since the MPS starting position must always be approached from a lower auxiliary position value you need to initialize the PSX register to prevent this type of discontinuity in the motion. Such problems can also arise if the auxiliary encoder (or alternate pulse source) moves in the reverse direction causing the auxiliary position to roll over from the lower (negative) limit to the upper limit before the MPS starting point is encountered. To prevent this you need to keep in mind that the auxiliary encoder must be connected so that its normal direction of travel will cause the Auxiliary Position (PSX) register to count up. The QTX register defines the directional conventions for connecting the different pulse command types.

Step 3: Determine how far the master encoder will travel in order to complete the axis motion (MPL)

Once the move start position has been set you need to specify either the incremental distance (MPI) or absolute position (MPA) for the axis motion. Like velocity-based motion, the direction of the axis is dictated by the sign of the MPI register for incremental moves or by the absolute position specified using the MPA register. If the MPA destination is less than the current axis position (PSA) when the move is initiated the axis will move in the reverse direction. If the MPA destination is greater than PSA the axis will move forward. Keep in mind that specifying large moves on the axis for small moves on the auxiliary axis (small values for MPL) will amplify any jitter or instability in the auxiliary encoder.

Step 4: Determine the portion of the move that will be allocated for acceleration and deceleration (MAP and MDP)

Now you need to specify how much of the move will be allocated for acceleration and deceleration. As with velocity-based motion the acceleration register also sets the deceleration register to the same value. If you require a different deceleration value you must specify it after the acceleration register. Since pulse-based motion is executed relative to the pulse input rather than time, acceleration (MAP) and deceleration (MDP) are specified as a percentage of the MPL distance. For example, if MPS=0, MPI=10 revolutions of the axis motor, MPL=100 revolutions of the auxiliary encoder and MAP=25. In this case the axis will accelerate over the first 25 encoder revolutions (MPL * MAP/100), slew for the next 50 revolutions and then decelerate over the final 25 revolutions (MPL * MDP/100) as shown in Figure 5-8.

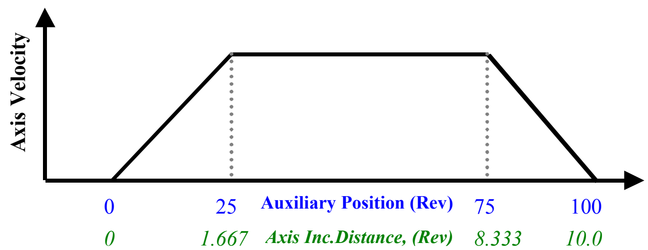


Figure 5-8. Acceleration/Deceleration as a Percentage of MPL

Note that the axis velocity is not specified for incremental or absolute pulse-based moves. The controller motion engine requires at least one degree of freedom in order to calculate a profile that can be executed under the other constraints you specified.

Step 5: Execute the move (RPI or RPA)

Once the steps above have been completed you need to include the appropriate run command in your program so that it will be executed prior to the auxiliary position reaching the starting point for the move (MPS). If you have configured an incremental move then the RPI command should be used. For absolute moves the RPA command must be used.

Now consider an example that puts it all together. The criteria are as follows:

- A 1000 line encoder will be used as the auxiliary pulse input
- Axis and auxiliary units are scaled for revolutions
- The axis must make an incremental move of 25 revolutions as the auxiliary encoder travels 3 revolutions
- The axis motion should start when the auxiliary encoder reaches 5 revolutions
- The acceleration should occur over 30% of the move and deceleration over 15%

Since no conditions were stipulated for the auxiliary encoder rollover position we will configure it for the maximum range which is 2,000,000,000/URX. Since our encoder has 4000 pulses/revolution and is scaled for revolutions we set URX=4000. Therefore, PLX=500,000 revolutions.

Next the starting point is defined at 5 revolutions of the auxiliary encoder. Therefore, MPS=5. Since we want the axis to move 25 incremental revolutions with an acceleration of 30% and deceleration of 15% we set MPI=25, MAP=30 and MDP=15 respectively. This axis profile is to be executed while the auxiliary encoder traverses 3 revolutions so we set MPL=3. The program segment would look like this:

```
MT=PULSE      (* set operating mode to pulse
QTX=Q4        (*set pulse source for quadrature encoder
PSX=0         (* initialize the auxiliary position
PSA=0         (* initialize the axis position
PLX=500000    (* set the auxiliary axis position rollover limits in revolutions
MPL=3.0       (* set the auxiliary move pulse length in revolutions
MPS=5.0       (* set the move to start at an aux. position of 5 revolutions
MAP=30        (* set axis acceleration to 30% of MPL or 0.9 encoder revolutions
MDP=15        (* set axis deceleration to 15% of MPL or 0.45 encoder revolutions
MPI=25.0      (* set the axis incremental move distance in revolutions
RPI            * execute the move when PSX=MPS
```

The profile is shown in Figure 5-9.

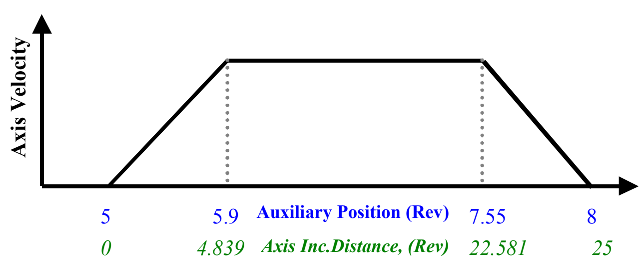


Figure 5-9. Pulse-based Incremental Move Example

To determine the incremental distance moved during the acceleration, slew and deceleration portions of the profile the following equations may be used:

$$\text{Distance During Accel} = \frac{\text{MAP * MPI}}{\text{200-MAP-MDP}} \quad \frac{30 * 25}{200-30-15} = 4.838709$$

$$\text{Distance During Decel} = \frac{\text{MDP * MPI}}{\text{200-MAP-MDP}} \quad \frac{15 * 25}{200-30-15} = 2.419354$$

$$\text{Distance During Slew} = \text{MPI}\left[1 - \frac{\text{MAP + MDP}}{\text{200-MAP-MDP}}\right] = 25\left[1 - \frac{30 + 15}{200-30-15}\right] = 17.741935$$

5.5.1.2 Using Standard Pulse Mode (MT=PULSE) For A Continuous Move

Continuous moves are similar to jogging the axis. In this case you want to run the axis at a predefined velocity rather than to a specified position or distance. Since pulse-based motion is made with respect to the pulse command source (auxiliary axis) rather than time, the velocity is specified as a ratio of the number of axis units for each auxiliary unit. This ratio is similar to a gearing ratio in the electronic gearing mode except that it cannot be changed once the continuous move is initiated.

The steps for defining a continuous move are similar to those stated above for a positional move:

Steps 1 and 2: Identical to the position-based move in Section 5.5.1.1.

Step 3: Determine the auxiliary axis distance that will be used for acceleration (MPL)

Because a continuous move has no predefined stopping point the MPL register assumes a different meaning. In this case MPL specifies the distance the auxiliary axis must travel to complete the axis acceleration or deceleration as shown in Figure 5-10 below. Note that for continuous moves the acceleration and deceleration must be programmed separately. If the MPL value to be used for the deceleration is the same as the acceleration then MPL doe not have to be repeated. If the deceleration must occur over a different auxiliary axis distance then the new value for MPL must be programmed. Since the MPL register effectively defines the acceleration and deceleration the MAP and MDP registers are not used for pulse-based continuous motion.

Step 4: Determine the axis velocity ratio (MVP)

The axis velocity is defined by the Motion Velocity of Pulse Move (MVP) register and is a ratio of the desired distance the axis should travel for each auxiliary axis unit of travel. Once the move is initiated (RVF or RVR command is executed) changing the ratio has no effect on the axis velocity.

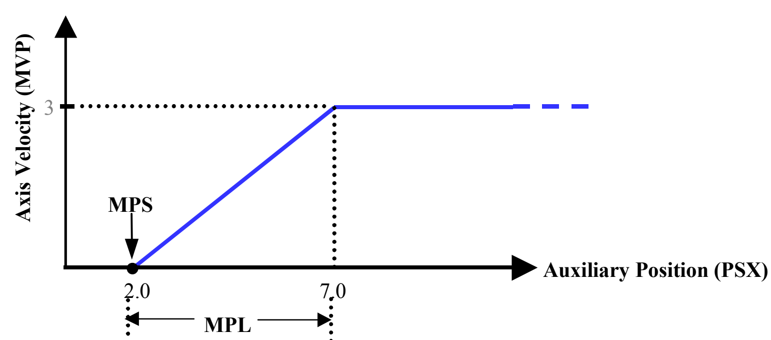


Figure 5-10. Pulse-based Continuous Motion

Caution

Once a continuous move is initiated axis behavior as the auxiliary position (PSX) increases in value is as defined above. If however, the auxiliary axis direction is reversed the axis motion becomes erratic and moves in large discrete steps that may cause damage to the machine or connected load. Only use this operating mode when the auxiliary axis is restricted to unidirectional operation.

Once the continuous move is initiated it will continue to track the pulse input until commands are issued to stop the motion. Although the HALT (HT) command will immediately stop the move with full system deceleration it is recommended that you stop the continuous move using the STOP (ST) command. This allows you to specify the deceleration. To execute a pulse-based stop you specify the auxiliary axis position where the deceleration will start (MPS), the auxiliary axis distance over which the deceleration should occur (MPL) and the STOP command (ST). Sample code for a pulse-based stop is shown below and the resulting profile is shown in Figure 5-11.

```
MPS=15      (* start deceleration at 15 auxiliary units
MPL=10      (* decelerate axis over 10 auxiliary units
ST          (* stop the axis motion
```

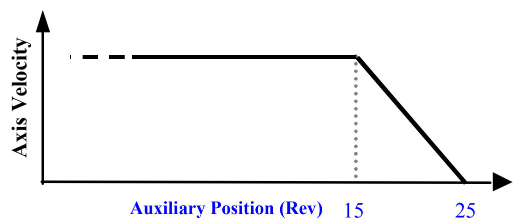


Figure 5-11. Stopping a Pulse-based Continuous Move

5.5.1.3 Using Pulse-Velocity Mode (MT=PULVEL) For A Position Based Move

The pulse-velocity mode behaves similarly to the standard pulse-based mode except that you can define an axis velocity ratio for the slew (constant velocity) portion of position-based moves. Since we are adding an additional constraint to the motion we must remove one in order to allow the S2K motion engine the freedom to calculate a solution. In this case the variable not specified is the total distance the auxiliary axis travels in order to complete the axis profile. Axis acceleration and deceleration are still specified over a certain range of auxiliary axis travel. The steps are as follows:

Step 1 and 2: Identical to the standard position-based move in Section 5.5.1.1 above

Step 3: Define the acceleration and deceleration for the move (MPL and MAP)

In this mode the MPL register defines the total distance the auxiliary axis will move as the axis traverses the acceleration and deceleration segments of the move. The MAP register is used to specify the percentage of this range that should be used for acceleration and the remainder is then used for deceleration. For example, if MPL=50 auxiliary units and MAP=25 then the acceleration will occur over the first 25% of MPL or 12.5 auxiliary units (MPL * MAP/100). The deceleration will then use the remaining 75% of MPL or 37.5 auxiliary units for our example [MPL*(1-MAP/100)]. The MDP register is not used for the pulse-velocity mode.

Step 4: Determine the axis velocity ratio (MVP)

The axis velocity ratio is defined as a ratio of the desired distance the axis should travel for each auxiliary axis unit of travel. This ratio is similar to the gearing ratio in the electronic gearing mode, however, once the move is initiated (RPI or RPA command is executed) changing the ratio has no effect on the axis velocity. This ratio is defined by the Motion Velocity of Pulse Move (MVP) register.

The following example shows how to use the pulse-velocity mode for an absolute move. The criteria are as follows:

- A 1,000 line (4,000 quadrature pulses per revolution) encoder will be used as the auxiliary pulse input
- Axis and auxiliary units are scaled for revolutions
- The axis must make an absolute move of 25 revolutions
- Axis velocity should be 2 times the auxiliary encoder velocity
- The axis motion should start when the auxiliary encoder reaches 5 revolutions
- The acceleration should occur over 3 revolutions of the auxiliary encoder and deceleration over 1 revolution

Since no conditions were stipulated for the auxiliary encoder rollover position we will configure it for the maximum range which is 2,000,000,000/URX. Since our encoder has 4,000 pulses/revolution and is scaled for revolutions we set URX=4000. Therefore, PLX=500,000 revolutions and QTX=Q4.

Next the starting point for the axis motion must occur when the auxiliary position equals 5 revolutions (PSX=5. Therefore, we must set MPS=5. Since the axis is to move to an absolute position of 25 revolutions we set MPA=25. The acceleration plus deceleration for the axis profile is to be executed while the auxiliary encoder traverses 4 revolutions (3 for accel and 1 for decel) so we set MPL=4. To partition the accel/decel as desired we need to allocate 3/4 of MPL for acceleration so MAP=75 percent. Deceleration will automatically be set to the 25 % of MPL or one revolution. Axis velocity must be twice the auxiliary encoder velocity so we set MVP=2 since both axis units and auxiliary units are already scaled for revolutions (if the encoder were scaled for pulses we would set MVP=2 axis rev/4000 aux. pulses = 0.0005). The program segment for our example looks like this:

```
MT=PULVEL     (* set operating mode to pulse-velocity
QTX=Q4        (* set pulse source for quadrature encoder
PSX=0         (* initialize the auxiliary position
PSA=0         (* initialize the axis position
PLX=500000    (* set the auxiliary axis position rollover limits in revolutions
MPL=4.0       (* set the auxiliary move pulse length for axis accel/decel in revs
MPS=5.0       (* set the move to start at an auxiliary position of 5 revolutions
MAP=75        (* set axis acceleration to 75% of MPL or 3 auxiliary encoder revs
MPA=25.0      (* set the axis absolute position in revolutions
MVP=2         (* set axis velocity to 2 times to auxiliary encoder velocity
RPA           (* execute the move when PSX=MPS
```

The profile is shown below:

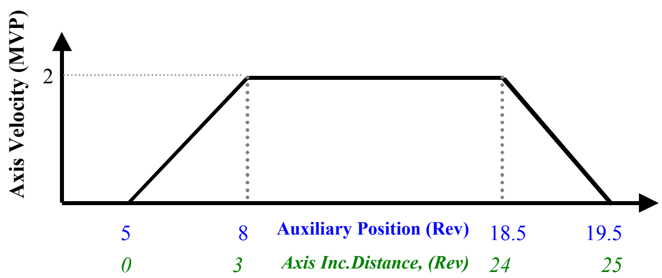


Figure 5-12. Pulse-velocity Absolute Move Example Profile

5.5.1.4 Using Standard Pulse Mode (MT=PULSE) For A Continuous Move

This mode is functionally identical to the standard pulse mode continuous move.

5.5.1.5 Pulse Mode Superimposed Over Electronic Gearing

The preceding sections discussed position-based and continuous axis motion that is relative to a non-moving frame of reference. There is one additional feature of the pulse-based operating modes that is very powerful capability for solving certain applications. Enabling electronic gearing while in pulse mode allows axis motion to be geared to follow a continuously moving master at a defined ratio while making correctional (superimposed) moves at defined master positions.

A rotary knife that does not require registration is an example of an application that can be simplified using this feature. Generally, this application involves a knife that follows a master encoder tracking a moving web of material. Once the knife is aligned to the cut location it will cut accurately while tracking any web speed variation. The base gear ratio is set so that the product cut length exactly equals the circumferential distance the tip of the knife blade traverses over one complete revolution. We call this the “synchronous cut length” since the knife blade rotates at a constant tangential velocity equal to the web speed. When the desired product length is shorter (super synchronous) or longer (subsynchronous) than this synchronous cut length the knife must respectively speed up or slow down when not in contact with the web as shown in Figure 5-13. Since the knife speed at the tip of the blade must be nearly equal to the web speed during the cut, there is a well-defined zone over which the knife can make these speed corrections. Typically the user defines a “cut angle” where the knife is in contact with the web. This cut angle will generally be larger for helical blades. Any required correction must be made over the remaining travel of knife rotation and must remain synchronized to the web position. Since axis motion during pulse mode is made relative to the position of the master (auxiliary encoder) it is ideal for this application.

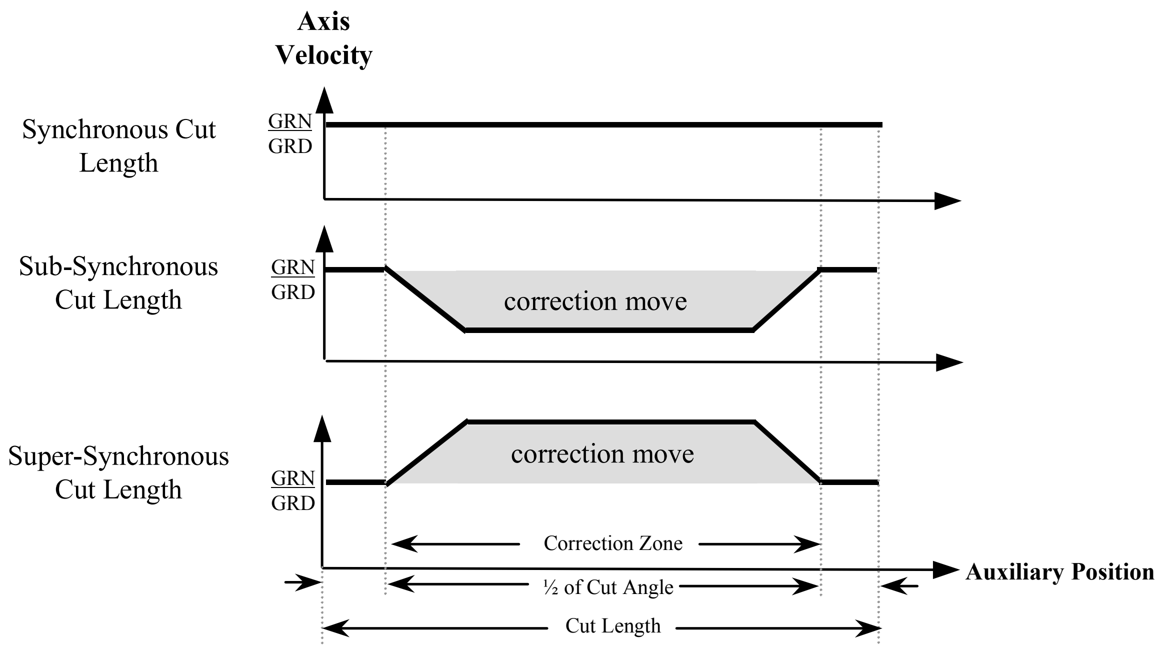


Figure 5-13. Types Of Correction Moves For Different Cut Lengths

By superimposing a pulse-based move on top of the normal synchronous gearing we can easily specify when the correction must start and stop relative to the cut position. The diagram in Figure 8 shows the basic mechanical configuration of this knife application.

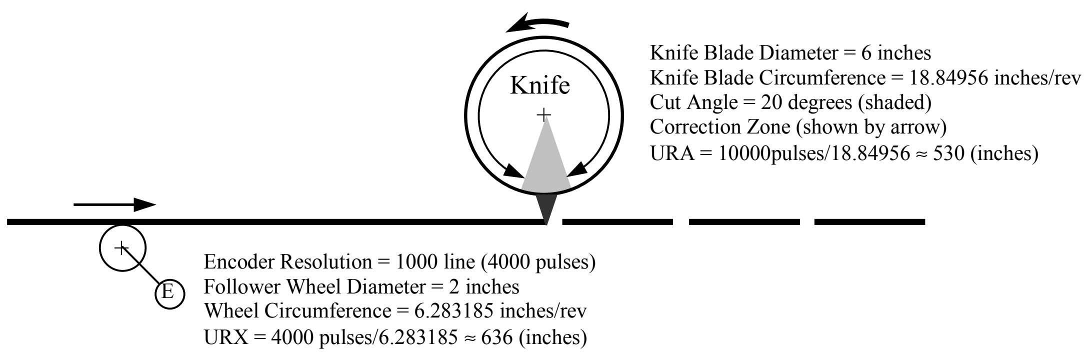


Figure 5-14. Rotary Knife Example

In this example we set the auxiliary and axis units to the same linear units of web travel that we'll call "web units". In our example we will use inches but any linear unit could be used by properly setting the (URA/URB) and URX scaling factors. From the information shown in Figure 5-14 we see that the synchronous cut length is about 18.85 inches and the cut angle will be set to 20 degrees centered on the cut. This parameter ensures that the knife is not in contact with the web when any required correction move is made. This leaves the balance of the knife's circumference to make the correction move. The program example below shows how this application can be solved. The cut length for this example was selected to be half the synchronous cut length so that 1.5 revolutions of the auxiliary encoder are required for each cut cycle (1 revolution of the knife).

Note

Since the encoder rollover position (PLX) must be set to a value that is greater than the cut length (VF101) and PLX can not be set from within a program, PLX should be set to the maximum value in the S2K configuration before program execution

```
    MT=PULSE            (* set controller to pulse mode
    VF100=18.84956      (* set circumference for 6 inch diameter knife, in inches
    VF103=9.424778      (* set desired product cut length, in inches
    VF102=20.0          (* set cut zone to 20 degrees centered on the cut position
    VF101=VF103         (* set cut length change variable equal to cut length
    VF104=VF100 * (VF102/360.0)  (* convert cut angle to web units
    PSA=0               (* initialize the axis position register
    PSX=0               (* initialize the auxiliary position
    VI1=URA/URB         (* initialize gear ratio variables
    VI2=URX

100 IF URA/URB>10000 OR URX>10000 GOTO 500    (* check range for GRN and GRD
    GRN=VI1             (* set synchronous gearing ratio
    GRD=VI2

200 IF VF101<>VF103 THEN(* if cut length has changed then set new length
    VF101=VF103
    MPI=VF100-VF101     (* set correction based on deviation from synch cut length
    MPS= VF104/2.0      (* set knife correction move start position to 1/2 cut angle
    MPL=VF101-VF104     (* set the allowed range for knife correction moves
    MAP=33              (* set accel and decel to 33% of knife correction move
    RPI                 (* arm the knife correction move
    GRE=1               (* enable electronic gearing
    WAIT PSX>=VF101     (* wait for beginning of next product cycle
    OFX= -VF101         (* reset auxiliary position for the next cycle
```

```
     GOTO 200          (* repeat the correction move
500  VI1=VI1/10        (* scale GRN & GRD to within allowed range of 1-10000
     VI2=VI2/10
     GOTO 100
```

5.5.2 Using Electronic Gearing

The S2K controllers support electronic gearing, also called master/slave or following, which can be used in a broad range of applications. Electronic gearing allows fast, on-the-fly gear ratio changes without the efficiency loss and maintenance of a mechanical gearbox. This section explains the programming details required to configure the electronic gearing application requirements.

Overview

In the S2K electronic gearing mode the axis motor is generally referred to as the slave and the auxiliary encoder/pulse input is the master. When gearing mode is enabled the slave axis follows the master input based on a user-defined ratio of slave pulses to master pulses.

Note

Electronic gearing does not use acceleration/deceleration limits and will change speed as quickly as system constraints will allow. If your application requires acceleration limits, consider using pulse-based motion or construct a program loop that will incrementally increase or decrease the gearing ratio (GRN/GRD) at the desired rate.

The S2K controller uses a position-lock type of electronic gearing to ensure that when gearing is enabled and the master source is already moving that the position error (pulses) that accumulates while the slave axis is accelerating will be corrected by allowing the axis to overspeed (run faster than the master pulse rate multiplied by the gearing ratio) as shown in Figure 5-15.

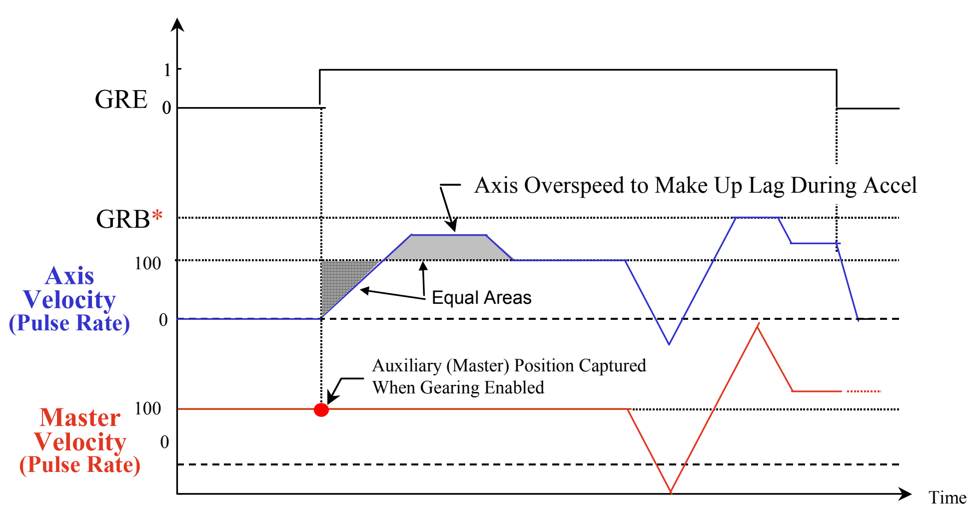


Figure 5-15. Electronic Gearing Timing Diagram

5.5.2.1 Gearing Master Source

The first consideration when using electronic gearing is to determine the master source and type. The master source selected will increment or decrement the Auxiliary Position (PSX) register. Most applications will use a quadrature encoder as the master source so it is set as the default source and type. The Auxiliary Quadrature Type (QTX) register is used to define this signal input type as follows:

QTX=Q4: Sets the auxiliary input for two pulse waveforms in quadrature. The controller will use x4 multiplication to derive the master pulses.

QTX=PD: Sets the auxiliary input for a Pulse/Direction input type. The Pulse input should be connected to the A- channel of the auxiliary input and the Direction input should be connected to the B-channel.

QTX=CW: Sets the auxiliary input for CW/CCW pulse input type. The clockwise pulse input should be connected to the A-channel of the auxiliary input and the counter-clockwise input should be connected to the B-channel

The QTX register configures the master input type for signals connected to the auxiliary encoder input. When the Hand Wheel Enable (HWE) register is set true the PSX register is updated from digital inputs 5 (A-channel) and 6 (B-channel). The handwheel mode is limited to a maximum pulse rate of 500 pulses/second but can be used in dual-loop applications where the auxiliary encoder input is already used for axis feedback from a load-mounted encoder.

The block diagram for electronic gearing is shown in Figure 5-16.

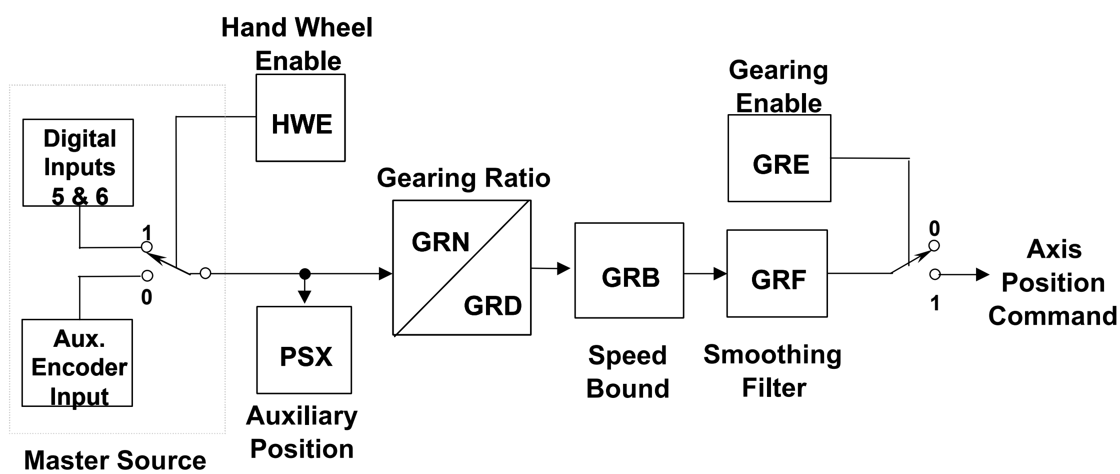


Figure 5-16. Electronic Gearing Block Diagram

5.5.2.2 Gearing Ratio

Once the gearing master source is selected the next consideration is the gearing ratio. This ratio is configured using the Gearing Numerator (GRN) and Gearing Denominator (GRD) registers according to the following formula:

$$\textbf{Axis Position} = \frac{\textbf{GRN}}{\textbf{GRD}} \times \textbf{Auxiliary Position}$$

This ratio is limited to a range of ± 1/10,000 to 10,000/1. The sign of the ratio determines the direction that the slave axis will move based on an increasing master command (See the QTX register in on page 5-232 for a definition of the directional conventions for each input type) and is assigned using the GRN register. Both the ratio and the direction can be changed on-the-fly.

Note

The electronic gearing ratio **always** is scaled in pulses regardless of the settings for the axis or auxiliary scaling registers (URA/URB or URX).

For example, consider a 500 line master encoder connected to a 2 inch diameter roll driving a web of material. The slave motor is driving a 2.5 inch diameter nip roll through a 2:1 gear reducer. The gearing ratio is determined as follows:

Step 1: For each revolution of the master encoder the web travels the circumference of the 2" roll or πD. This equals 2π inches per revolution.

Step 2: For each revolution of the master encoder the "auxiliary input generates 2000 pulses (4 x 500 lines). Therefore, from step 1 we determine the number of auxiliary pulses per inch of web travel as follows:

Auxiliary pulses/inch = (2000 pulses/encoder rev)(1 encoder rev/roll rev)(1 roll rev/2π inches)

= 1000/π

Step 3: For the S-Series motors the S2K uses 10,000 pulses/motor revolution. Since the motor is connected to a 2:1 reducer the motor makes 2 revolutions for each revolution of the drive roll. For each revolution of the drive roll the web travels 2.5π inches (πD). Therefore, we can calculate number of the slave axis pulses per inch of web travel as follows:

Axis pulses/inch = (10,000pulse/motor rev)(2 motor rev/roll rev)(1 roll rev/2.5π inches)

= 8000/π

Step 4: Since the gearing ratio is axis pulses/auxiliary pulses we can calculate the ratio as follows:

GRN/GRD = (axis pulses/inch) / (aux. pulses/inch) = (8000/π)/(1000/π) = 8000/1000

Therefore, GRN = 8000 and GRD = 1000.

5.5.2.3 Gearing Speed Limit

The Gearing Bound (GRB) register is used to limit the maximum axis pulses/second that the gearing function can command (See Figure 5-15). If the auxiliary pulse input rate multiplied by the gearing ratio exceeds the GRB limit, then the extra pulses are discarded. (i.e., the axis velocity is clamped at the bound limit). For example, if the gearing ratio is set to GRN/GRD = 8000/1000 and GRB=100,000 pulses/second then anytime the auxiliary input rate exceeded 12,500 pulses/second (GRB/gearing ratio) the limit would be imposed.

Keep in mind that since the excess pulses are discarded, there will be a positional error between the master and slave based on the number of discarded pulses. Setting GRB=0 disables the limit.

5.5.2.4 Gearing Filter

The Gearing Filter Constant (GRF) register configures the filtering for the electronic gearing output. The gearing filter sets the gearing output to a moving average value based on the number of samples specified by GRF. The amount of filtering increases as the GRF increases as follows:

GRF Value	Number Of Samples
0	Filter Disabled
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256

5.5.2.5 Gearing Enable/Disable

Electronic gearing can be enabled and disabled from within program and motion blocks by setting the Gearing Enable (GRE) register true. When a fault occurs, gearing is automatically disabled. Electronic gearing mode can be enabled for all settings on the Motion Type (MT) register and when gearing is enabled the controller sums the gearing output into the motion generator. This allows various motion types to be superimposed, providing a very powerful solution for complex applications. For example, an incremental move can be executed while electronic gearing is enabled in order to make a phase correction on a roll feed or to move the slave axis while the master is stationary.

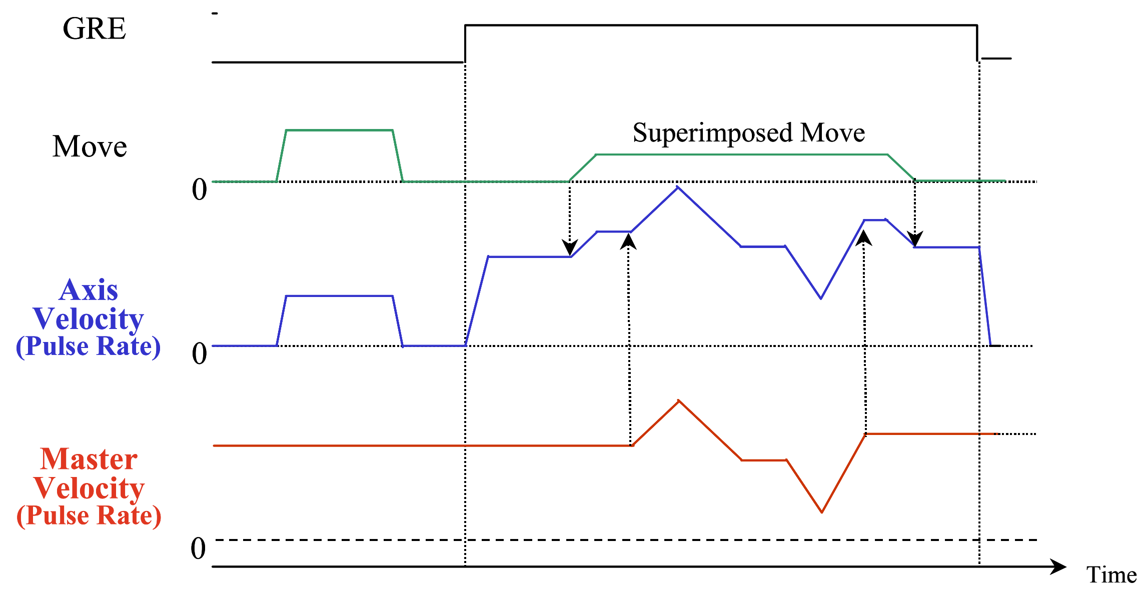


Figure 5-17. Superimposed Incremental Move with Gearing Enabled

5.5.3 Using Electronic Camming

The S2K controllers support electronic cam following which can be used to replace mechanical cams. This document explains the programming details required to configure the cam based on application requirements.

Overview

The S2K supports linear cyclic cams where the starting and ending position of the slave axis are at the same position as shown in Figure 5-18 below. The cam profile will wrap at the end points of the cam table and repeat the profile continuously until the cam is disabled. The S2K controller does not support non-cyclic or circular cyclic cams.

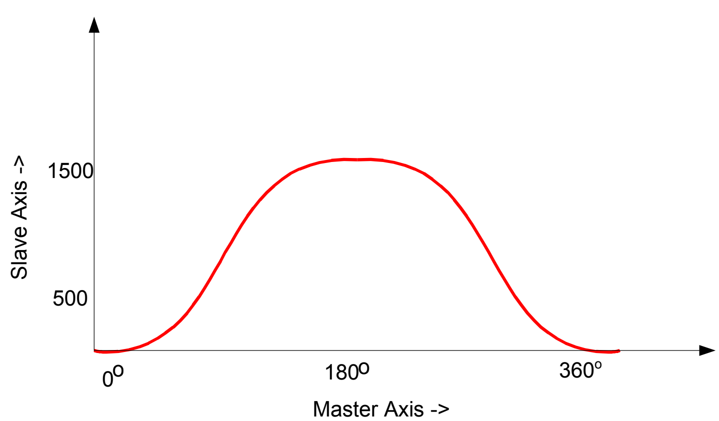


Figure 5-18. Example of a Linear Cyclic Cam Profile

Cam profiles are specified using a cam table. This table stores an array of position point pairs for the cam master and the slave (follower) axis controlled by the S2K. The S2K cam table is always constructed of 3600 equally spaced points representing a range of motion on the cam master from 0 to 359.9 degrees. Therefore, each data point represents 0.1 degrees of motion of the cam master. For each of the 3600 points the user must define a corresponding absolute position for the follower (slave) axis. The first (zero master degrees) and last (359.9 master degrees) slave axis positions must be the same value. The S2K controller uses a number of registers to define various aspects of the cam configuration and operation. The block diagram for the cam function is shown in Figure 5-19 below.

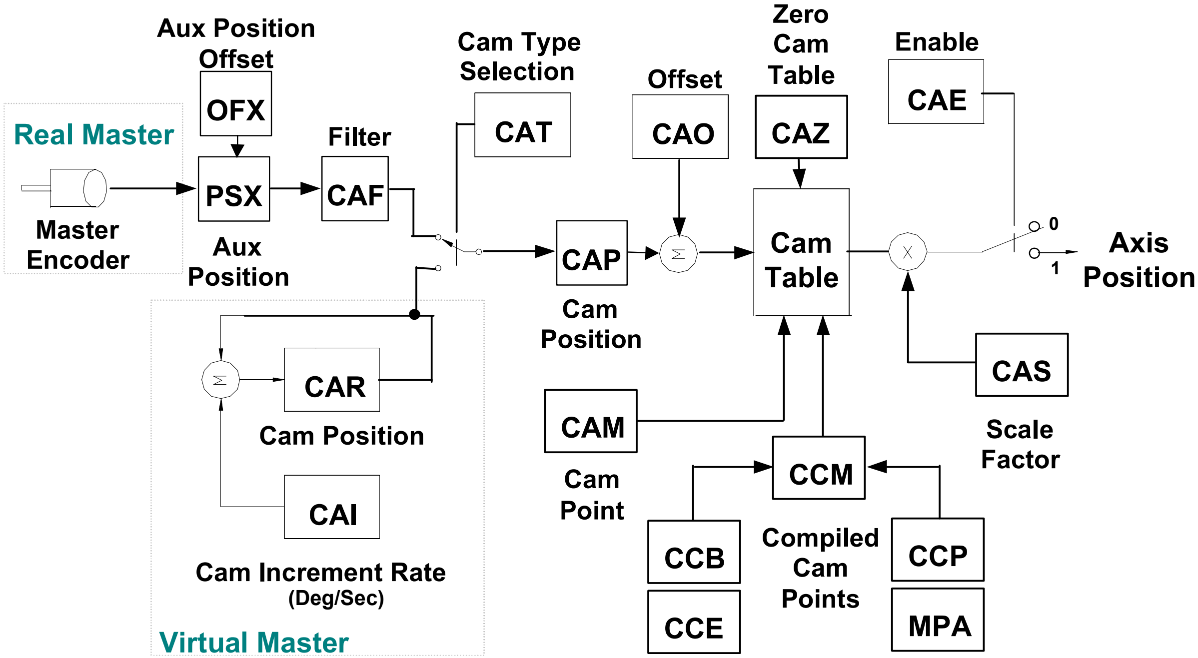


Figure 5-19. Cam Block Diagram

5.5.3.1 Cam Master Source

The S2K controller includes the Cam Type register (CAT) that allows the programmer to select between a real encoder master source (CAT=PSX) or a virtual time-based master source (CAT=CAR). Since most applications will use the auxiliary encoder as the master source, the CAT register defaults to this configuration. In this mode the Cam Position register (CAP) is referenced to the Auxiliary Encoder Position register (PSX) as shown in the block diagram above. The PSX register is modified by the Auxiliary Position Offset register (OFX). OFX is a write only register whose value is directly added to or subtracted from the PSX register value but since the CAM Offset register essentially performs the same function this register will generally not be used with cam programs. Since the S2K supports only cyclic cams the master and slave positions at the beginning and end of the cam table must gracefully rollover in either direction to allow continuous repetition of the cam profile in both directions. The S2K uses the Auxiliary Position Length register (PLX) to allow the programmer to specify the cam master position modulus (range of travel) for one complete cam cycle. Note that the PLX value represents the distance the master encoder must travel to produce 180 degrees of cam travel since the master axis is bounded by ± PLX as shown in Figure 5-20.

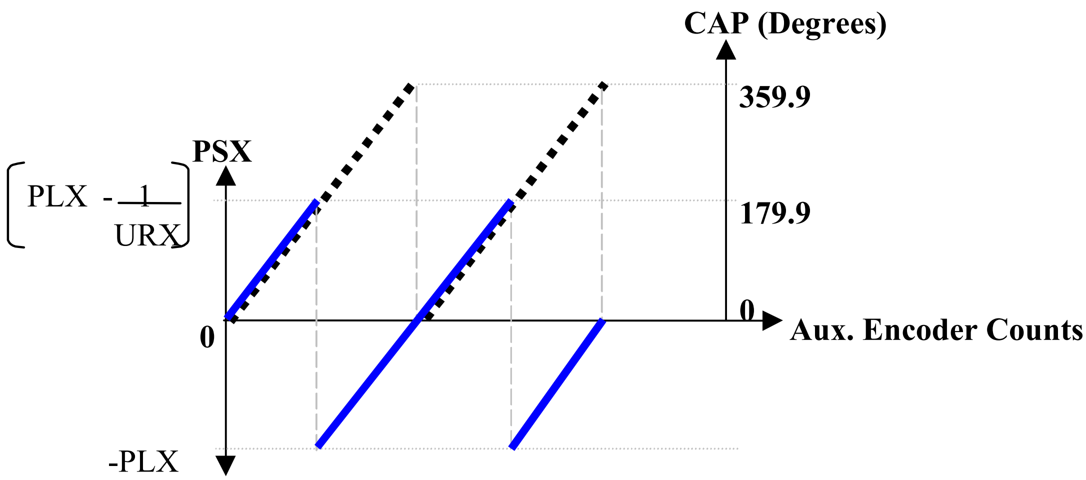


Figure 5-20. Auxiliary Position Register Wrapping

The Cam Position register (CAP) always ranges from absolute position 0 to 359.999 over one cam cycle. The rollover relationship between this register and the PSX register is shown in Figure 5-20. If you initialize the PSX and CAP registers to zero at the start of the profile and then run the master encoder in the forward direction the PSX register will increment up to the +PLX value and then roll over to the –PLX value on the next encoder count. As the master encoder continues to move forward the PSX register counts from –PLX to zero. Meanwhile, over the same span of master encoder travel the CAP register counts from 0 to 359.999 and then rolls over to zero at the same point as the PSX register as shown in Figure 5-20.

Alternatively, the S2K controller supports a virtual cam master source. If the CAT register is set to reference the CAR register the cam master source is an internal time-base generated by the controller. The CAR register represents an absolute position of the cam master over a range of 0 to 359.999 degrees and rolls over at the end points. The Cam Position Register Increment (CAI) sets the rate at which CAR is incremented/decremented in degrees/second. Negative values for CAI will decrement the value of the CAR register. The CAR register begins changing at the CAI rate when the cam is enabled (CAE=1) and stops changing when the cam is disabled (CAE=0). The values for CAR and CAI can be changed on the fly from the terminal window or from within a program. You can generate a virtual master profile by creating a program loop that gradually increments CAI from zero to some value and then back down to zero to generate accel/decel ramps.

5.5.3.2 Cam Filter

If the cam seems to run rough due to jitter or unstable motion of the auxiliary encoder then the Cam Filter Constant (CAF) can be used to smooth the cam shaft motion. Configurations that generate large moves on the axis for a small change of the master generally require more filtering. The filter constant sets the number of past cam positions that are used in the moving average filter algorithm. Using a higher number of samples increases the filtering and generates a smoother profile but also reduces the response of the axis. Use the smallest amount of filtering that yields acceptable results.

5.5.3.3 Cam Offset

The Cam Offset register (CAO) allows for on the fly phase corrections of the master axis position. CAO can be used to advance or retard the cam position by ± 180 degrees. As indicated by the block diagram in Figure 5-19 the CAO value is summed with the CAP register value and does not change the actual CAP value. Offset correction moves are executed with full system speed and torque in order to complete the move as quickly as possible (i.e., MAC, MDC and MVL limits do not apply).

5.5.3.4 Generating a Cam Table

The cam table is a two dimensional array that stores a set of 3600 master/slave position pairs used to define the shape of the cam profile. As the cam cycles from 0 to 360 degrees the axis motor will move according to the position values associated with each 0.1 degree of cam movement. Before loading data points into the cam table the table should always be cleared to ensure no previous data points corrupt the desired profile. The Zero Cam Table command (CAZ) is used to clear the table and should precede any program lines that load cam points into the table.

5.5.3.5 Using the Cam Point Register

The S2K controller provides two methods for generating cam table data points. The simplest method is to use the CAM Point (CAM) register to directly load the specific points of interest and allow the controller to populate the interim points using linear interpolation. This method works well when the cam profile is relatively simple and requires only segments that can be rendered with sufficient accuracy using linear segments. The CAM command can use direct or indirect referencing to load a specific point. An example of direct referencing would use CAM 180 = xx to load the axis position “xx” for cam master position of 180 degrees. The following example directly loads values using the cam command:

```
CAZ         (* clear cam table
CAM0=0      (* set axis position at 0 degrees to 0 axis units
CAM180=10   (* set axis position at 180 degrees to 10 axis units
CAM0=0      (* fill the rest of the cam table using linear interpolation
CAE=1       (* enable cam following
```

Indirect referencing uses variable pointers such as CAMVI20 = VF2 to load the axis position stored in floating point variable VF2 for the cam master position stored in integer variable VI20. Generally the easiest way to load cam points using the CAM register is to construct a program loop to increment the cam pointer value in 0.1-degree increments as shown below.

```
    CAZ                           (* clear cam table
    VI1 = 0                       (* initialize cam pointer to zero degrees
10  CAMVI1 = SIN(ITF(VI1)/10.0)   (* load cam table with a sine wave profile
    VI1 = VI1 + 1                 (* increment cam pointer by 0.1 degree
    IF VI1 < 3600 GOTO 10         (* continue until 359.9 degrees
```

Note in this example that when an integer variable pointer is used as the argument in the CAM register its value represents ten times the actual cam master position in degrees. This allows the controller to satisfy the 0.1-degree point resolution requirement while using integer variable pointers.

5.5.3.6 Using the Cam Compile Command

The second method builds the cam table in segments by compiling conventional absolute moves for each cam segment. This method can be used to create more complex cam profiles with defined acceleration and jerk values. The S2K controller provides several registers that are used to define each compiled profile segment.

The Cam Compile Begin (CCB) and Cam Compile End (CCE) registers state the starting and ending cam master positions for the segment in degrees (0.1 degree resolution). The Cam Compile Start Position (CCP) and Absolute Move Position (MPA) registers define the starting and ending axis positions for the segment in axis units. The normal MAP, MDP and MJK registers are used to define the acceleration, deceleration and jerk percentages just like a conventional velocity-based move in the S2K. The Compile Cam Motion (CCM) command completes the compile function for the segment and populates the appropriate section of the cam table as shown in the example in Figure 5-21.

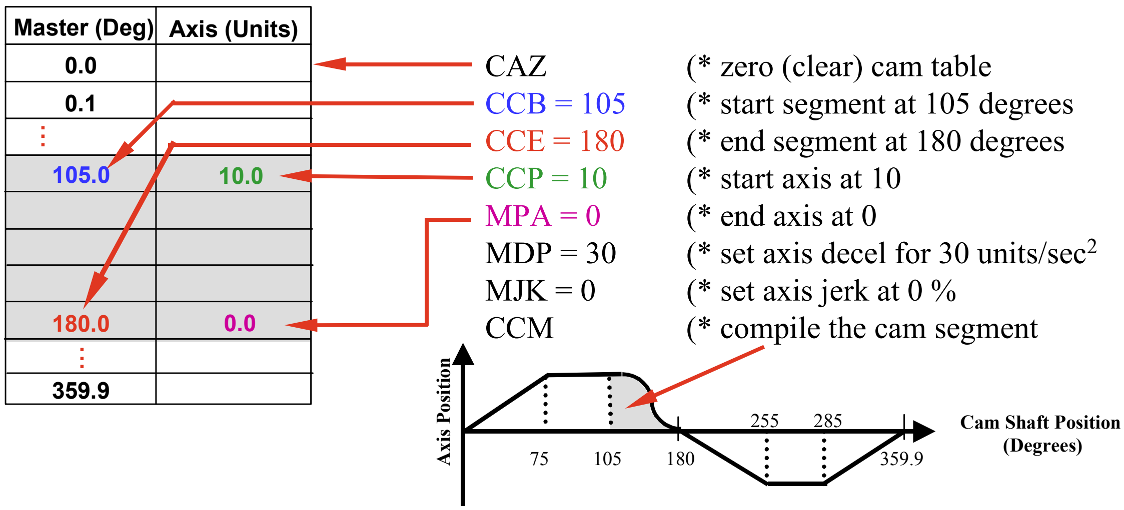


Figure 5-21. Example of a Compiled Cam Segment

In the example shown in Figure 5-21 the cam table is cleared and the segment of the profile for cam master positions from 105 to 180 degrees are compiled. The compiler calculates the required axis positions in 0.1 degree increments for this range of cam motion starting at the absolute axis position of 10 (CCP) and ending at axis position 0 (MPA). The segment will use 30% of the move distance to accelerate 40% at constant speed and 30% to decelerate. In order to complete the cam table similar program code would be required for each of the remaining five profile segments shown in this example.

5.5.3.7 Cam Scale Factor

Some applications require multiple cam profiles that are essentially the same shape but vary in amplitude of the axis motion. The S2K controller includes a Cam Scale Factor (CAS) that is used to adjust the magnitude of the axis position values stored in the cam table. Each axis position in the cam table is multiplied by the value in the CAS register as shown in the block diagram in Figure 5-19. Since the CAS default value is 1 no scaling adjustments are made unless the user programs a new value in the range of 0.01 to 100. Using the scale factor allows the programmer to create normalized cam tables and then use CAS to scale them for different parts.

5.5.3.8 Tips for Creating Cam Programs

Now that the basic framework for creating cam motion has been discussed its time to consider how to use these registers and commands in a program to create the desired motion. The following steps should be used as a guide to this process.

1. Determine if the cam will follow an encoder or the internal time-base and set CAT accordingly.

2. If an encoder master will be used establish the desired unit scaling for the Auxiliary Position register (PSX) by setting the URX register. Determine the range of master encoder travel for the cam cycle by setting the PLX register. Initialize the Auxiliary Position (PSX) register to zero (or other appropriate value).

3. If the time-based internal master will be used the Cam Position Register Increment (CAI) must be set to establish the execution speed of the cam.
4. Initialize the Axis Position register (PSA) to zero (or other appropriate value). Note: When the cam is enabled (CAE=1 is executed) the master position is read by the controller and the axis motor is moved to its corresponding absolute position stored in the cam table. This move to the starting position is governed by the normal absolute motion registers in the S2K. Therefore, the cam program should initialize acceleration (MAC), deceleration (MDC) and velocity (MVL) for this move.
5. Since the auxiliary axis position register automatically wraps it is not necessary to set Position Register Wrap Enable (PWE=1).
6. The programmer must ensure that the axis position (axis position values stored in the cam table multiplied by the scale factor, CAS) is always within the software overtravel limit settings (OTF & OTR).
7. Initialize the Cam Filter Constant (CAF) if profile filtering is desired. This may need to be determined empirically and added later so you may want to include the program line “CAF=0” as a place holder.
8. Initialize the Cam Offset (CAO) if a phase adjustment is desired. This may need to be determined empirically and added later so you may want to include the program line “CAO=0” as a place holder.
9. Clear the cam table using the CAZ command.
10. Create the cam table using either the CAM register or the compiled method. The specific program code to accomplish this will vary greatly depending on the application requirements. Using indirect referencing with variable pointers as discussed above allows new cam table data to be loaded over the network. If you are loading all 3600 points the order they are entered is irrelevant. If you are only entering a few points and allowing the interpolator to fill in the remaining points you must build the table from the top down starting at the cam angle of zero degrees and ending with a “CAM0=0” or CAM359.9=0” to force the interpolator to fill in the last points in the table.
11. Determine if a Cam Scale Factor will be used and initialize the CAS register.
12. Disable the hardware overtravel limits (OTE=0) if not already done in controller configuration.
13. Enable the cam (CAE=1).

An example of a typical cam initialization program is shown below:

```
PSA=0       (* reset axis position
PSX=0       (* initialize cam starting point
OTE=0       (* disable hardware overtravel limits
CAT=PSX     (* select the auxiliary encoder as the cam master source
CAO=0       (* set cam offset
CAS=2       (* set cam lift scale factor
```

CAF=0 (* set cam filter constant

MAC=200. (* set acceleration for initial axis move to position

MDC=100. (* set deceleration for axis move to position

MVL=50. (* set axis velocity for move to position

5.5.3.9 Additional Camming Information

1. If the axis move distance between two consecutive points is very large the controller may fault on following error.
2. The Cam Enable register (CAE) is reset to zero when a fault occurs or when the cam table is cleared (CAZ).
3. When the cam is disabled while the cam is running the axis motor decelerates to zero speed as quickly as the system constraints allow (similar to executing a HALT command).

5.5.4 Using High Speed Position Capture (Registration) Functions

The S2K controllers incorporate a software latch to capture both the axis and auxiliary positions when the capture input is set true. The capture input is the marker (Z-channel) input for the auxiliary encoder. Capture accuracy when the strobe input is activated is ± 30 µS and the captured axis position value is stored in the PCA register and the auxiliary position is stored in the PCX register. The IO register includes two bit flags that reflect the capture state as follows:

Bit 12 – Set true when the position capture input is active

Bit 13 – Set true when the capture input makes a low-to-high transition since the last time either of the capture registers (PCA or PCX) were read. Reset when either PCA or PCX is read.

Position capture can be used in a range of applications including measuring product length, product edge detection, determining product spacing and feeding to a registration mark.

5.5.5 Using Synchronized Axis and Auxiliary Position Readings

The S2K controllers include special versions of the Axis (PSA) and Auxiliary (PSX) Position registers for applications that require a snapshot in time for both positions in order to perform calculations or comparisons between the two values. The PZA and PZX registers allow such synchronized readings. Each time the program encounters the PZA command the value for axis position (PSA) is latched to the PZA register and a simultaneous reading (within 10 µs) of the auxiliary position (PSX) is latched to the PZX register. These values are overwritten each time the PZA command is executed.

5.6 Software Quick Reference Lists

5.6.1 Alphabetical Command and Register Listing

* Indicates registers that cannot be set in a program

Reg/Cmd	Class	Description
!	Program	exits terminal window line editor
?	Diagnostic	reports value of register to the terminal window
p1, p2	Operand	floating point operands
“p1”, $p2	Operand	string operands
+	Operator	concatenate strings p1 and p2
+, -, * , / , * *	Operator	arithmetic operators
>,>=, =, <>, <=, <	Operator	relational operators
16#p3	Operand	base 16 integer operand
2#p2	Operand	base 2 integer operand
ABS	Operator	absolute value of any floating point or integer operand
ADDN	System	address of network port
ADDR	System	RTU port address
AI	Input/Output	analog input
AIB	Input/Output	analog input deadband
AIN	Input/Output	network analog input
AIO	Input/Output	analog input offset
AND	Operator	logical AND of two operands of the same type
AO	Input/Output	analog output
AON	Input/Output	network analog output
AOP	Input/Output	power-up state of analog output
ASC	Operator	converts 1st character in string operand to ASCII code
ATN	Operator	arctangent trigonometric function
AUTORET	System	enables auto retrieving of user memory
AUTOTUNE	System	automatically sets up control constants
BAUD	System	baud rate of serial port
BAUDN	System	data rate of network port
BIT	System	data bits of serial port
BS	Input/Output	backspaces cursor
CAE	Motion	cam enable
CAF	Motion	cam filter constant
CAI	Motion	cam position register increment
CAM	Motion	cam point
CAO	Motion	cam offset
CAP	Motion	cam shaft position
CAR	Motion	cam position register
CAS	Motion	cam scale factor
CAT	Motion	cam shaft position type

Reg/Cmd	Class	Description
CAZ	Motion	zeros cam table
CCB	Motion	cam compile begin point
CCE	Motion	cam compile end point
CCM	Motion	compiles cam motion
CCP	Motion	cam compile start position
CE	System	conversion error
CHANGEPW	System	prompts for password change
CHR	Operator	converts ASCII character code to its associated character
CIE	System	computer interface format enable
CLL	Input/Output	clears line and positions cursor at beginning of line
CLM	System	clears user memory; resets registers to defaults
CLS	Input/Output	clears display and positions cursor at home
CMD	Axis	position controller command output
CMO	Axis	commutation angle offset
CMR	Axis	motor poles to resolver poles commutation ratio
CNC	System	close network connection
COS	Operator	cosine trigonometric function of a floating point operand
CR	Input/Output	positions cursor at beginning of next line down
CRH	Input/Output	positions cursor at home
CRM	Input/Output	remembers cursor position
CRP	Input/Output	positions cursor
CRR	Input/Output	positions cursor at remembered position
CURC	Axis	continuous current
CURCN	Axis	network continuous current
CURP	Axis	peak current
CURS	Axis	power save current
CURSN	Axis	network power save current
DEL	Operator	deletes characters from a string operand *(see* INS *for operator description)*
DEL	Program	deletes current statement in the terminal window line editor
DGC	Diagnostic	loads diagnostic condition for printing
DGE	Diagnostic	enables diagnostics
DGI	Diagnostic	load diagnostic item to print
DGL	Diagnostic	prints diagnostic line of items
DGO	Diagnostic	outputs diagnostic register value to serial port
DGP	Diagnostic	prints diagnostic message to serial port
DGS	Diagnostic	sets program to single step mode
DGT	Diagnostic	sets program to trace mode
DI	Input/Output	digital input
DIN	Input/Output	network digital input
DINA	Input/Output	network digital input register assignment
DIR*	Axis	direction of motor for forward moves
DIRN*	Axis	network direction of motor for forward moves
DIRX	Axis	direction of auxiliary position
DIRXN	Axis	network direction of auxiliary position

Reg/Cmd	Class	Description
DIT	Input/Output	digital input filter time
DO	Input/Output	digital output
DOE	Input/Output	fault on digital output fault enable
DON	Input/Output	network digital output
DONA	Input/Output	network digital output register assignment
DSE	System	display format enable
EG	Input/Output	positive-edge-sensitive digital input
EKB	Input/Output	empties key buffer
END	Program	ends program or motion block and exits editor
EOT	Axis	encoder output type
EXM	Program	executes motion block
EXP(*p1*)	Operator	takes exponential of a floating point operand
EXP	Program	executes program
EXVS	Program	executes command stored in string variable
FALSE	Operand	Boolean operator equivalent to OFF or a logical 0
FAULT	Program	enters editor at faulting statement
FC	System	fault code
FCN	System	network fault code
FCNN	System	network device fault code
FE	Axis	axis following error
FEB	Axis	following error bound
FI	System	fault input register
FIN	Operator	find string p1 in string operand p2
FIRMWARE	System	downloads firmware and saves in nonvolatile memory
FR	Axis	axis feedback resolution
FRC	Axis	axis feedback resolution for commutation
FTI	Operator	converts floating point operand to an integer by rounding
FTS	Operator	converts floating point operand to a string
FUNCTION	Input/Output	goes to label associated with key pressed
GET	Input/Output	gets one character from key buffer
GOSUB	Program	unconditionally branches to specified subroutine label
GOTO	Program	unconditionally branches to specified label
GRB	Motion	gearing bound
GRD	Motion	gearing denominator
GRE	Motion	gearing enable
GRF	Motion	gearing filter constant
GRN	Motion	gearing numerator
HSE	System	enables XON, XOFF handshake protocol for serial port
HT	Motion	halts motion
HTN	Motion	network halt
HWE	Motion	handwheel input enable
IF...GOSUB	Program	conditionally branches to specified subroutine label
IF...GOTO	Program	conditionally branches to specified label
IF...THEN	Program	conditionally executes next command in program
IN	Input/Output	inputs register value from key buffer

Reg/Cmd	Class	Description
INS	Operator	inserts characters into a string operand
IO	Input/Output	general I/O
IP	System	axis in position
IPB	Axis	in-position band
IPN	System	network in position
ITB	Operator	converts integer operand to a binary string
ITF	Operator	converts integer operand to a floating point number
ITH	Operator	converts integer operand to a hexadecimal string *(see* ITB *for operator description)*
ITS	Operator	converts integer operand to a string *(see* ITB *for operator description)*
KA	Axis	acceleration feedforward
KD	Axis	derivative control gain
KEY	System	character in key buffer
KI	Axis	integral control gain
KL	Axis	motor inductance
KLALL	Program	kills all programs
KLP	Program	kills program
KM	Axis	motor number
KP	Axis	proportional control gain
KSN	Axis	network stall velocity threshold
KSSN	Axis	network stall sensitivity
KT	Axis	filter time constant
KVN	Axis	network bus voltage
KY	Input/Output	puts character into key buffer
KYA*	Input/Output	key assignment
L	Program	makes last statement the current statement in line editor
LABEL	Program	makes statement at label the current statement in line editor
LED	Input/Output	state of display LED
LEN	Operator	computes the length of a string operand
LFT	Operator	selects leftmost characters of a string
LGN	Operator	takes natural log of any floating point operand
LOCK	Program	locks interpreter to program
LWR	Operator	converts string operand to lower case
MAC	Motion	motion acceleration/deceleration
MACN	Motion	network motion acceleration/deceleration
MAP	Motion	motion acceleration/deceleration percentage
MB	System	motion block executing
MDC	Motion	motion deceleration
MDCN	Motion	network motion deceleration
MDP	Motion	motion deceleration percentage
MEMORY	System	reports memory remaining
MFA	Motion	motion feedrate acceleration/deceleration
MFD	Motion	motion feedrate deceleration
MFP	Motion	motion feedrate percentage

Reg/Cmd	Class	Description
MID	Operator	selects middle characters of a string operand
MJK	Motion	motion jerk percentage
MOTION	Program	edits motion block
MOTORSET	System	automatically sets up motor constants
MPA	Motion	absolute move position
MPI	Motion	incremental move position
MPL	Motion	move pulses
MPN	Motion	network move position
MPO	Motion	offset move position
MPS	Motion	motion pulse start position
MT	Motion	motion type
MTM	Motion	move time
MVL	Motion	motion velocity
MVLN	Motion	network motion velocity
MVM	Motion	motion velocity for run to marker
MVP	Motion	motion velocity of pulse move
NCO	System	network connection open
NET	System	network connection available
NOT	Operator	logical NOT operation of any Boolean or integer operand
OFA	Axis	axis position offset
OFF	Operand	Boolean operator equivalent to FALSE or a logical 0 *(see* FALSE *for operand description)*
OFX	Axis	auxiliary position offset
ON	Operand	Boolean operator equivalent to TRUE or a logical 1 *(see* FALSE *for operand description)*
OR	Operator	logical OR operation of two operand of the same type
OTE	Axis	hardware overtravel enable
OTF	Axis	forward software overtravel
OTR	Axis	reverse software overtravel
OUSN	Input/Output	output command to network port with status
OUT	Input/Output	outputs string expression to serial port
OUTN	Input/Output	output command to network port
OUTS	Input/Output	outputs screen to display
PAR	System	parity of serial port
PASSWORD	System	prompts for password
PCA	Axis	axis position capture
PCX	Axis	auxiliary position capture
PFB	Axis	position feedback deadband
PFC	Axis	position feedback correction numerator
PFD	Axis	position feedback denominator
PFE*	Axis	position feedback enable
PFL	Axis	position feedback backlash
PFN	Axis	position feedback numerator
PFT	Axis	position feedback correction time
PHB	Motion	phase error bound

Reg/Cmd	Class	Description
PHE	Motion	phase-locked loop enable
PHG	Motion	phase gain
PHL	Motion	phase length
PHM	Motion	phase multiplier
PHO	Motion	phase offset
PHP	Motion	phase position
PHR	Motion	phase error
PHT	Motion	phase lockout time
PHZ	Motion	phase zero
PIPN	System	network profile in progress
PLA*	Axis	axis position length
PLX*	Axis	auxiliary position length
POE	Axis	power output stage enable
POP	Program	pops "gosub" address from top of "gosub" stack
PROG	System	program executing
PROGRAM	Program	edits program
PSA	Axis	axis actual position
PSAN	Axis	network axis actual position
PSC	Axis	command position
PSCN	Axis	network command position
PSO	Axis	offset position
PSR	Axis	resolver position
PSX	Axis	auxiliary position
PUT	Input/Output	puts one character to serial port
PWE*	Axis	position register wrap enable
PZA	Axis	axis position synchronized
PZX	Axis	auxiliary position synchronized
Q	Diagnostic	reports value of register
QTX*	Axis	auxiliary quadrature type
RDN	Motion	network run direction flag
REM	Program	remark
REPEAT	Program	repeats motion from start of motion block
RETRIEVE	System	retrieves user memory
RETURN	Program	returns from subroutine
REVISION	Diagnostic	reports firmware revision
REVN	Diagnostic	network device revision
RGT	Operator	selects rightmost characters of a string operand
RHF	Motion	runs forward to home input
RHR	Motion	runs reverse to home input
RIN	Motion	network run incremental flag
RMF	Motion	runs forward to marker
RMN	Motion	network run mode
RMR	Motion	runs reverse to marker
ROF	Motion	runs forward to overtravel input
ROL	Operator	rotates bits of an integer operand left by n number of places

Reg/Cmd	Class	Description
ROR	Motion	runs reverse to overtravel input
ROR	Operator	rotates bits of an integer operand right by n number of places *(see* ROL *for operator description)*
RPA	Motion	runs to absolute position
RPI	Motion	runs to incremental position
RPN	Motion	run profile of network device
RPO	Motion	runs to offset position
RSF	System	resets faults
RSFN	System	reset network faults
RSM	Program	resumes motion
RSTSTK	Program	resets "gosub" stack to empty
RTU	System	Remote terminal unit mode enable
RTUF	System	Remote terminal unit communication flag
RTV	System	retrieves variables from nonvolatile memory to RAM
RVF	Motion	runs to velocity forward
RVR	Motion	runs to velocity reverse
SAVE	System	saves user memory
SCAN	System	maximum scan time
SCRD	Input/Output	screen data
SCRL	Input/Output	screen line
SCRP	Input/Output	screen position of data
SECURE	System	secures user memory
SHL	Operator	arithmetic shift of integer operand of n places to the left
SHR	Operator	arithmetic shift of integer operand of n places to the right
SIN	Operator	sine trigonometric function of a floating point operand
SNI	Input/Output	scanned network input
SNIA	Input/Output	scanned network input address
SQR	Operator	takes square root of positive integer or floating point operand
SRA	System	axis status
SRP	System	program status
SRS	System	system status
ST	Motion	stops motion
STEP	Motion	step input
STF*(p1)*	Operator	converts a string operand to a floating point number
STF	System	sets fault
STFN	System	network sets fault
STI	Operator	converts a string operand to an integer
STM	System	start time of timer
STN	Motion	network stop
STVB...GOTO	Program	set Boolean variable and if variable wasn't set, GOTO label
SUP	Program	suspends motion
SVL	Input/Output	saves screen lines
SVV	System	saves variables from RAM to nonvolatile memory
TAN	Operator	tangent trigonometric function of a floating point operand
TL	System	axis at torque limit

Reg/Cmd	Class	Description
TLC	Axis	torque limit current
TLE	Axis	torque limit enable
TM	System	timer timed out flag
TMR	System	timer
TRC	Operator	convert a floating point operand to an integer by truncation
TRUE	Operand	Boolean operator equivalent to ON or a logical 1
UNLOCK	Program	unlocks interpreter from program
UPR	Operator	converts a string operand to upper case
UPS	Input/Output	update screen
URA*	Axis	axis unit ratio numerator
URB*	Axis	axis unit ratio denominator
URX*	Axis	auxiliary unit ratio
VB	Variable	Boolean variable
VBN	Variable	network Boolean variable
VF	Variable	floating point variable
VFA*	System	floating point variable allocation
VFN	Variable	network floating point variable
VI	Variable	integer variable
VIN	Variable	network integer variable
VLA	Axis	axis velocity
VLAN	Axis	network axis velocity
VLAT	Axis	axis velocity filter time constant
VLX	Axis	auxiliary velocity
VLXT	Axis	auxiliary velocity filter time constant
VS	Variable	string variable
VSN	Variable	network string variable
WAIT	Program	waits for expression to be true
WAIT...WHEN...GOTO	Program	waits for expression to be true or when expression becomes true goes to label
X	Program	steps through program/motion block
XOR	Operator	logical XOR function of two operands of the same type

5.6.2 Command and Register Listing By Class

* Indicates registers that cannot be set in a program

Axis Registers & Commands	Description
CMD	position controller command output
CMO	commutation angle offset
CMR	motor poles to resolver poles commutation ratio
CURC	continuous current
CURCN	network continuous current
CURP	peak current
CURS	power save current
CURSN	network power save current
DIR*	direction of motor for forward moves
DIRN*	network direction of motor for forward moves
DIRX	direction of auxiliary position
DIRXN	network direction of auxiliary position
EOT	encoder output type
FE	axis following error
FEB	following error bound
FR	axis feedback resolution
FRC	axis feedback resolution for commutation
IPB	in-position band
KA	acceleration feedforward
KD	derivative control gain
KI	integral control gain
KL	motor inductance
KM	motor number
KP	proportional control gain
KSN	network stall velocity threshold
KSSN	network stall sensitivity
KT	filter time constant
KVN	network bus voltage
OFA	axis position offset
OFX	auxiliary position offset
OTE	hardware overtravel enable
OTF	forward software overtravel
OTR	reverse software overtravel
PCA	axis position capture
PCX	auxiliary position capture
PFB	position feedback deadband
PFC	position feedback correction numerator
PFD	position feedback denominator
PFE*	position feedback enable

Axis Registers & Commands	Description
PFL	position feedback backlash
PFN	position feedback numerator
PFT	position feedback correction time
PLA*	axis position length
PLX*	auxiliary position length
POE	power output stage enable
PSA	axis actual position
PSAN	network axis actual position
PSC	command position
PSCN	network command position
PSO	offset position
PSR	resolver position
PSX	auxiliary position
PWE*	position register wrap enable
PZA	axis position synchronized
PZX	auxiliary position synchronized
QTX*	auxiliary quadrature type
TLC	torque limit current
TLE	torque limit enable
URA*	axis unit ratio numerator
URB*	axis unit ratio denominator
URX*	auxiliary unit ratio
VLA	axis velocity
VLAN	network axis velocity
VLAT	axis velocity filter time constant
VLX	auxiliary velocity
VLXT	auxiliary velocity filter time constant

Diagnostic Registers & Commands	Description
?	reports value of register to the terminal window
DGC	loads diagnostic condition for printing
DGE	enables diagnostics
DGI	load diagnostic item to print
DGL	prints diagnostic line of items
DGO	outputs diagnostic register value to serial port
DGP	prints diagnostic message to serial port
DGS	sets program to single step mode
DGT	sets program to trace mode
Q	reports value of register
AI	analog input
AIB	analog input deadband
AIF	analog input filter frequency
AIN	network analog input
AIO	analog input offset
AO	analog output
AON	network analog output
AOP	power-up state of analog output
BS	backspaces cursor
CR	positions cursor at beginning of next line down
DI	digital input
DIN	network digital input
DINA	network digital input register assignment
DIT	digital input filter time
DO	digital output
DOE	fault on digital output fault enable
DON	network digital output
DONA	network digital output register assignment
EG	positive-edge-sensitive digital input
EKB	empties key buffer
FUNCTION	goes to label associated with key pressed
GET	gets one character from key buffer
IN	inputs register value from key buffer
IO	general I/O
KY	puts character into key buffer
KYA*	key assignment
OUSN	output command to network port with status
PUT	puts one character to serial port
REVISION	reports firmware revision
REVN	network device revision

Input/Output Registers & Commands	Description
AI	analog input
AIB	analog input deadband
AIN	network analog input
AIO	analog input offset
AO	analog output
AON	network analog output
AOP	power-up state of analog output
BS	backspaces cursor
CLL	clears line and positions cursor at beginning of line
CLS	clears display and positions cursor at home
CRH	positions cursor at home
CRM	remembers cursor position
CRP	positions cursor
CRR	positions cursor at remembered position
FUNCTION	goes to label associated with key pressed
GET	gets one character from key buffer
KYA*	key assignment
LED	state of display LED
OUSN	output command to network port with status
OUT	outputs string expression to serial port
OUTN	output command to network port
OUTS	outputs screen to display
PUT	puts one character to serial port
SCRD	screen data
SCRL	screen line
SCRP	screen position of data
SNI	scanned network input
SNIA	scanned network input address
UPS	update screen

Motion Registers & Commands	Description
CAE	cam enable
CAF	cam filter constant
CAI	cam position register increment
CAM	cam point
CAO	cam offset
CAP	cam shaft position
CAR	cam position register
CAS	cam scale factor
CAT	cam shaft position type
CAZ	zeros cam table
CCB	cam compile begin point

Motion Registers & Commands	Description
CCE	cam compile end point
CCM	compiles cam motion
CCP	cam compile start position
GRB	gearing bound
GRD	gearing denominator
GRE	gearing enable
GRF	gearing filter constant
GRN	gearing numerator
HT	halts motion
HTN	halts motion network command
HWE	handwheel input enable
MAC	motion acceleration/deceleration
MACN	network motion acceleration/deceleration
MAP	motion acceleration/deceleration percentage
MDC	motion deceleration
MDCN	network motion deceleration
MDP	motion deceleration percentage
MFA	motion feedrate acceleration/deceleration
MFD	motion feedrate deceleration
MFP	motion feedrate percentage
MJK	motion jerk percentage
MPA	absolute move position
MPI	incremental move position
MPL	move pulses
MPN	network move position
MPO	offset move position
MPS	motion pulse start position
MT	motion type
MTM	move time
MVL	motion velocity
MVLN	network motion velocity
MVM	motion velocity for run to marker
MVP	motion velocity of pulse move
PHB	phase error bound
PHE	phase-locked loop enable
PHG	phase gain
PHL	phase length
PHM	phase multiplier
PHO	phase offset
PHP	phase position
PHR	phase error
PHT	phase lockout time
PHZ	phase zero
RDN	network run direction flag

Motion Registers & Commands	Description
RHF	runs forward to home input
RHR	runs reverse to home input
RIN	network run incremental flag
RMF	runs forward to marker
RMN	network run mode
RMR	runs reverse to marker
ROF	runs forward to overtravel input
ROR	runs reverse to overtravel input
RPA	runs to absolute position
RPI	runs to incremental position
RPN	run profile of network device
RPO	runs to offset position
RVF	runs to velocity forward
RVR	runs to velocity reverse
ST	stops motion
STEP	step input
STN	network stop

Operands	Description
“p1”, $p2	string operands
16#p3	base 16 integer operand
2#p2	base 2 integer operand
OFF	Boolean operator equivalent to FALSE or a logical 0 *(see* FALSE *operand description)*
ON	Boolean operator equivalent to TRUE or a logical 1 *(see* TRUE *operand description)*
p1, p2	floating point operands
FALSE	Boolean operator equivalent to OFF or a logical 0
TRUE	Boolean operator equivalent to ON or a logical 1

Operators	Description
+	concatenate strings p1 and p2
+, -, * , / , * *	arithmetic operators
>,>=, =, <>, <=, <	relational operators
ABS	absolute value of any floating point or integer operand
AND	logical AND of two operands of the same type
ASC	converts 1st character in string operand to ASCII code
ATN	arctangent trigonometric function
CHR	converts ASCII character code to its associated character
COS	cosine trigonometric function of a floating point operand
DEL	deletes characters from a string operand *(see* INS *operator description)*
EXP(*p1*)	takes exponential of a floating point operand
FIN	find string p1 in string operand p2

Operators	Description
FTI	converts floating point operand to an integer by rounding
FTS	converts floating point operand to a string
INS	inserts characters into a string operand
ITB	converts integer operand to a binary string
ITF	converts integer operand to a floating point number
ITH	converts integer operand to a hexadecimal string *(see* ITB *for operator description)*
ITS	converts integer operand to a string *(see* ITB *for operator description)*
LEN	computes the length of a string operand
LFT	selects leftmost characters of a string
LGN	takes natural log of any floating point operand
LWR	converts string operand to lower case
MID	selects middle characters of a string operand
NOT	logical NOT operation of any Boolean or integer operand
OR	logical OR operation of two operand of the same type
RGT	selects rightmost characters of a string operand
ROL	rotates bits of an integer operand left by n number of places
ROR	rotates bits of an integer operand right by n number of places *(see* ROL *operator description)*
SHL	arithmetic shift of integer operand of n places to the left
SHR	arithmetic shift of integer operand of n places to the right
SIN	sine trigonometric function of a floating point operand
SQR	takes square root of positive integer or floating point operand
STF*(p1)*	converts a string operand to a floating point number
STI	converts a string operand to an integer
TAN	tangent trigonometric function of a floating point operand
TRC	convert a floating point operand to an integer by truncation
UPR	converts a string operand to upper case
XOR	logical XOR function of two operands of the same type

Program Registers & Commands	Description
!	exits terminal window line editor
DEL	deletes current statement in the terminal window line editor
END	ends program or motion block and exits editor
EXM	executes motion block
EXP	executes program
EXVS	executes command stored in string variable
FAULT	enters editor at faulting statement
GOSUB	unconditionally branches to specified subroutine label
GOTO	unconditionally branches to specified label
IF...GOSUB	conditionally branches to specified subroutine label
IF...GOTO	conditionally branches to specified label
IF...THEN	conditionally executes next command in program

Program Registers & Commands	Description
KLALL	kills all programs
KLP	kills program
L	makes last statement the current statement in line editor
LABEL	makes statement at label the current statement in line editor
LOCK	locks interpreter to program
MOTION	edits motion block
POP	pops "gosub" address from top of "gosub" stack
PROGRAM	edits program
REM	remark
REPEAT	repeats motion from start of motion block
RETURN	returns from subroutine
RSM	resumes motion
RSTSTK	resets "gosub" stack to empty
STVB...GOTO	set Boolean variable, and if variable wasn't set, GOTO label
SUP	suspends motion
UNLOCK	unlocks interpreter from program
WAIT	waits for expression to be true
WAIT..WHEN..GOTO	waits for expression to be true or when expression becomes true goes to label
X	steps through program/motion block

System Registers & Commands	Description
ADDN	address of network port
ADDR	RTU port address
AUTORET	enables auto retrieving of user memory
AUTOTUNE	automatically sets up control constants
BAUD	baud rate of serial port
BAUDN	data rate of network port
BIT	data bits of serial port
CE	conversion error
CHANGEPW	prompts for password change
CIE	computer interface format enable
CLM	clears user memory; resets registers to defaults
CNC	close network connection
DSE	display format enable
FC	fault code
FCN	network fault code
FCNN	network device fault code
FI	fault input register
FIRMWARE	downloads firmware and saves in nonvolatile memory
HSE	enable XON, XOFF handshake protocol for serial port
IP	axis in position
IPN	network axis in position

System Registers & Commands	Description
KEY	character in key buffer
MB	motion block executing
MEMORY	reports memory remaining
MOTORSET	automatically sets up motor constants
NCO	network connection open
NET	network connection available
PAR	parity of serial port
PASSWORD	prompts for password
PIPN	network profile in progress
PROG	program executing
RETRIEVE	retrieves user memory
RSF	resets faults
RSFN	reset network faults
RTU	Remote terminal unit mode enable
RTUF	Remote terminal unit communication flag
RTV	retrieves variables from nonvolatile memory to RAM
SAVE	saves user memory
SCAN	maximum scan time
SECURE	secures user memory
SRA	axis status
SRP	program status
SRS	system status
STF	sets fault
STFN	network sets fault
STM	start time of timer
SVL	saves screen lines
SVV	saves variables from RAM to nonvolatile memory
TL	axis at torque limit
TM	timer timed out flag
TMR	timer
VFA*	floating point variable allocation

Variable Registers & Commands	Description
VB	Boolean variable
VBN	network Boolean variable
VF	floating point variable
VFN	network floating point variable
VI	integer variable
VIN	network integer variable
VS	string variable
VSN	network string variable

5.7 Commands and Registers

! Exits Terminal Window Line Editor

Class: Program Command

Syntax: !

Restrictions: Allowed only in programs or motion blocks being edited in the terminal window line editor.

Use: This command exits the terminal window line editor and restores immediate mode interactive communication with the controller.

Remarks: This command will not typically be used since Motion Developer provides a more full featured text editor for creating and editing programs and motion blocks. The terminal window can also be used for these functions and is entered using the PROGRAM and MOTION commands. While in the line editor mode

Example:

```
PROGRAM1      (* edit program 1)
*  PSA=0
X             (* step through program)
*  MAC=10
!             (* exit terminal window line editor)
*
```

Related Commands: PROGRAM, END, MOTION

? Reports Value of Register

Class: Diagnostic Command

Syntax: *p1*? (e.g., CURC? DI4? DOVI1?)

Parameters:

	allowed values	*description*
p1	any register	register

Restrictions: Not allowed in programs or motion blocks. Used only in the terminal window.

Use: This command is used in the terminal window to report the value of any register. It is identical to the Q command.

Related Commands: DGO, Q

p1, 2#*p2*, 16#*p3*, *p4* Integer Operands

Class: Operand

Type: Integer

Syntax: *p1*, 2#*p2*, 16#*p3*, *p4*

Parameters:

	allowed values	*range*
p1	any integer	-2,147,483,648 through 2,147,483,647
p2	any base 2 integer	0 through 11111111111111111111111111111111 (2^32 -1)
p3	any base 16 integer	00000000 through FFFFFFFF
p4	any integer register	

Use: These operands are used as integer numbers.

Example:

MAP1=45	(* set axis one motion acceleration percent to 45%)
VI1=2#10101111	(* set integer variable 1 to 10101111_2 [i.e., 175_{10}])
URA=4096	(* set axis one unit ratio numerator to 4,096 pulses/rev)
URB=1	(* set axis one unit ratio denominator to 1 pulses/rev)
VI2=423234	(* set integer variable 2 to 423,234)
VI3=16#40E8	(* set integer variable 3 to $40E8_{16}$ [i.e., 16616_{10}])

p1, *p2* Floating Point Operands

Class: Operand

Type: Floating point

Syntax: *p1*, *p2*

Parameters:

	allowed values	*range*
p1	any floating point	+/- 1.5E-39 through 1.7E38
p2	any floating point register	

Use: These operands are used as floating point numbers. Note that floating point numbers must always have a decimal point in them.

Example:

VF1=105.	(* set floating point variable 1 to 105.)
MPA1=20.2	(* set axis one absolute move position to 20.2)
VF2=FEB1	(* set floating point variable 2 to axis one following error bound)

"p1", p2, $p3 String Operands

Class:	Operand
Type:	String
Syntax:	"*p1*", *p2*, $*p3*

Parameters: *allowed values*

p1	any string, 0 through 127 characters long
p2	any string register
p3	any non-string register

Use: These operands are used as strings.

Remarks: 1. When a string contains a dollar sign, the character immediately after it is treated in a special manner. The possibilities are:

Character after $	*Interpretation when sent to serial port*
$	dollar sign
"	quote
0 through FF	ASCII code (in hexadecimal)
T	tab
L	line feed
R	carriage return
N	new line (carriage return and line feed)
Register or variable	output value of register or variable

2. Using the dollar sign followed by a register converts the value of the register into the appropriate string. Floating point, integer, and Boolean register values will be converted into strings containing the number value of the register. In the special case of bit-valued registers (e.g., SRS, SRP1, FCS), the register value will be converted into a string containing the hexadecimal (base 16) value of the registers. If the bit is specified (e.g., SRS1, SRP1.5, FCS2), the string will be "0" if the bit is zero; or it will be the assigned message of the bit if true.

Example:

```
VS1="Energy cost: $$50"     (* set string variable 1 to "Energy cost: $50")

VS2="$"Hello$""             (* set string variable 2 to ""Hello"")
OUT VS2                     (* output string expression to serial port)
*""Hello""

VS3=$SRA                    (* set string variable 3 to axis status register converted to hex string)
VS3?                        (* report value of string variable 3)
*"16#0100"

VS4=$PSA                    (* set string variable 4 to axis position converted to string)
VS4?                        (* report value of string variable 4)
*"2.563924"

VS5=$SRA8                   (* set string variable 5 to bit 8 of axis status register)
VS5?                        (* report value of string variable 5)
*"Axis in position"
```

>, >=, =, <>, <=, < Relational Operators

Class: Operator

Type: Boolean

Syntax: *p1 > p2*, *p1 >= p2*, *p1 = p2*, *p1 <> p2*, *p1 <= p2*, *p1 < p2*

Parameters: *allowed values*

p1 any integer, floating point, or string operand

p2 any integer, floating point, or string operand

Use: These operators are used to compare the two operands *p1* and *p2*. Note that *p1* and *p2* must be of the same type. If the relation is false, its value is 0; and if the relation is true, its value is 1. A *relation* is two operands with a relational operator between them. The operators are described below:

p1 > p2	*p1* greater than *p2*
p1 >= p2	*p1* greater than or equal to *p2*
p1 = p2	*p1* equal to *p2*
p1 <> p2	*p1* not equal to *p2*
p1 <= p2	*p1* less than or equal to *p2*
p1 < p2	*p1* less than *p2*

Remarks: Floating point operands must include a decimal point

Note that for string operands, the relational operators compare the two strings character by character. The ASCII values of each character are compared one by one from left to right.

Relational operators can not be used to compare Boolean registers or variables. (e.g., IF DI1=DI2 is an illegal operation while IF DI1 AND DI2 is legal)

Example:

VF1=12.5	(* set floating point variable 1 to 12.5)
VF2=12.0	(* set floating point variable 2 to 12.0)
VB1= VF1<=VF2	(* set Boolean variable 1 to VF1<=VF2)
VB1?	(* report value of Boolean variable 1)
* 0	
VS1="Hello"	(* set string variable 1 to "Hello")
VS2="AB"	(* set string variable 2 to "AB")
VS3="AC"	(* set string variable 3 to "AC")
VS4="ABC"	(* set string variable 4 to "ABC")
VB1= VS1<>VS2	(* set Boolean variable 1 to VS1<>VS2)
VB1?	(* report value of Boolean variable 1)
* 1	
VB1= VS2<VS3	(* set Boolean variable 1 to VS2<VS3)
VB1?	(* report value of Boolean variable 1)
* 1	
VB1=VS2>VS4	(* set Boolean variable 1 to VS2>VS4)
VB1?	(* report value of Boolean variable 1)
* 0	

+, -, *, /, ** Arithmetic Operators

Class: Operator

Type: Floating point, integer

Syntax: *p1 + p2, p1 - p2, - p1, p1 * p2, p1 / p2, p1 ** p2*

Parameters: *allowed values*
- *p1* any integer or floating point operand
- *p2* any integer or floating point operand

Use: These operators are used to perform arithmetic operations on *p1* and *p2*. Note that *p1* and *p2* must be of the same type. The operations are described below:

p1 + p2	add
p1 - p2	subtract
- p1	negate
*p1 * p2*	multiply
p1 / p2	divide
*p1 ** p2*	exponentiate (i.e., raise *p1* to the *p2* power)

+ Concatenation Operator

Class: Operator

Type: String

Syntax: *p1 + p2*

Parameters: *allowed values*
- *p1* any string operand
- *p2* any string operand

Use: This operator is used to concatenate strings *p1* and *p2*.

Example:

```
VS1="Hello"             (* set string variable 1 to "Hello")
VS2=VS1+ " There"       (* set string variable 2 to the concatenation of VS1 and " There")
VS2?                    (* report value of string variable 2)
*"Hello There"
```

ABS Absolute Value Operator

Class: Operator

Type: Floating point, integer

Syntax: ABS(*p1*)

Parameters: *allowed values*

p1 any integer or floating point operand

Use: This operator is used to take the absolute value of *p1*.

ADDN Address of Network Port

Class: System Register

Type: Integer

Syntax: ADDN

Range:
default 63
minimum 0
maximum 63

Restrictions: Read only

Use: Number used to identify the network address or for DeviceNet, the MAC ID (Media Access Control Identifier). Also works with PROFIBUS.

Remarks: DIP switches, located on the bottom of the S2K, set the default network address. Switch positions 1 through 6 set addresses from 0 through 63. When the controller is powered on, these default values are stored in the ADDN register. The table below indicates the DIP switch setting you must use for each address.

***Related Registers*:** BAUDN

Address	Switch					
	1	2	4	8	16	32
	1	**2**	**3**	**4**	**5**	**6**
0	R	R	R	R	R	R
1	L	R	R	R	R	R
2	R	L	R	R	R	R
3	L	L	R	R	R	R
4	R	R	L	R	R	R
5	L	R	L	R	R	R
6	R	L	L	R	R	R
7	L	L	L	R	R	R
8	R	R	R	L	R	R
9	L	R	R	L	R	R
10	R	L	R	L	R	R
11	L	L	R	L	R	R
12	R	R	L	L	R	R
13	L	R	L	L	R	R
14	R	L	L	L	R	R
15	L	L	L	L	R	R
16	R	R	R	R	L	R
17	L	R	R	R	L	R
18	R	L	R	R	L	R
19	L	L	R	R	L	R
20	R	R	L	R	L	R
21	L	R	L	R	L	R
22	R	L	L	R	L	R
23	L	L	L	R	L	R
24	R	R	R	L	L	R
25	L	R	R	L	L	R
26	R	L	R	L	L	R
27	L	L	R	L	L	R
28	R	R	L	L	L	R
29	L	R	L	L	L	R
30	R	L	L	L	L	R
31	L	L	L	L	L	R

Address	Switch					
	1	2	4	8	16	32
	1	**2**	**3**	**4**	**5**	**6**
32	R	R	R	R	R	L
33	L	R	R	R	R	L
34	R	L	R	R	R	L
35	L	L	R	R	R	L
36	R	R	L	R	R	L
37	L	R	L	R	R	L
38	R	L	L	R	R	L
39	L	L	L	R	R	L
40	R	R	R	L	R	L
41	L	R	R	L	R	L
42	R	L	R	L	R	L
43	L	L	R	L	R	L
44	R	R	L	L	R	L
45	L	R	L	L	R	L
46	R	L	L	L	R	L
47	L	L	L	L	R	L
48	R	R	R	R	L	L
49	L	R	R	R	L	L
50	R	L	R	R	L	L
51	L	L	R	R	L	L
52	R	R	L	R	L	L
53	L	R	L	R	L	L
54	R	L	L	R	L	L
55	L	L	L	R	L	L
56	R	R	R	L	L	L
57	L	R	R	L	L	L
58	R	L	R	L	L	L
59	L	L	R	L	L	L
60	R	R	L	L	L	L
61	L	R	L	L	L	L
62	R	L	L	L	L	L
63	L	L	L	L	L	L

ADDR Address of RTU Port

Class:	System Register
Type:	Integer
Syntax:	ADDR
Range:	
default	1
minimum	1
maximum	247
Restrictions:	Cannot be assigned in motion blocks. Available in firmware version 2.2 and higher.
Use:	The address of the RTU port is a number used to identify the RTU port.
Related Registers:	RTU

AI Analog Input

Class:	Input/Output Register	
Type:	Floating Point	
Syntax:	AI*p1*	
Parameters:	*allowed values*	
p1	1 or 2 (analog input number)	
Range:		
units	volts	
minimum	-10.000	
maximum	10.000	
Restrictions:	Read only.	
Use:	Defines the value in volts of one of the two general-purpose hardware analog inputs.	
Example:	AI1?	(* report value of analog input one from the terminal window)
	AI2?	(* report value of analog input two from the terminal window)
	IF AI1=5 GOTO 10	(* branch program if analog input 1 equals 5 volts)
Related Registers:	AO	

AIB Analog Input Deadband

Class: Input/Output Register

Type: Floating Point

Syntax: AIB*p1* (e.g., AIB1 AIB2)

Parameters: *allowed values*

p1 1 or 2 (analog input number)

Range:

units	volts
default	0
minimum	0
maximum	10.000

Restrictions: Cannot be assigned in motion blocks.

Use: Defines a range over which the analog input remains constant at zero volts. When the analog input AI1 is less than or equal to AIB1, the analog input is set to 0. When the analog input AI2 is less than or equal to AIB2, the analog input is set to 0.

Example:

```
AIB2=1.5    (* set analog input deadband equal to 1.5 V)
AIB2?       (* report value of analog input deadband from the terminal window)
```

***Related Registers**:* AI*p1*

AIN Network Analog Input

Class: I/O Register

Type: Integer

Syntax: AIN*p1.p2* (e.g., AIN28.2 AINVI5.6 AINVI2.VI7)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network address
p2	1 through 64 **or** VI*n*	analog input number

Range:

minimum	-32,768
maximum	32,767

Note that these minimum and maximum values are a function of your analog input device. Refer to the documentation for your analog input device to determine how to map its values to the motion controller.

Restrictions: Read only. Cannot be accessed in immediate mode over a DeviceNet connection.

Use: The network analog input is a general-purpose input used for process control.

***Related Registers**:* AON

AIO Analog Input Offset

Class:	Input/Output Register	
Type:	Floating point	
Syntax:	AIO*p1* (e.g., AIO1 AIO2)	
Parameters:	*allowed values*	*description*
p1	1 or 2	analog input number

Range:

units	volts
default	0
minimum	-10.000
maximum	10.000

Restrictions: Cannot be assigned in motion blocks.

Use: The analog input offset one, AIO1, is used to add a voltage offset to analog input one, AI1. Analog input offset two, AIO2, is used to add a voltage offset to analog input two, AI2.

Example:

AIO1=2.5	(* set analog input offset equal to 2.5 V)
AIO1?	(* report value of analog input offset from the terminal window)

Related Registers: AI*p1*

AND AND Logical Operator

Class: Operator

Type: Boolean, integer

Syntax: *p1* AND *p2*

Parameters:

	allowed values
p1	any Boolean or integer operand
p2	any Boolean or integer operand

Use: Used to perform a logical AND operations on *p1* and *p2*. Note that *p1* and *p2* must be of the same type. If *p1* and *p2* are Boolean operands, the logical operators perform bitwise logical operations.

Related Registers: NOT, OR, XOR

AO Analog Output

Class: Input/Output Register

Type: Floating point

Syntax: AO

Range:
units volts
default 0
allowed values -10.000 through 10.000
VLA (velocity of axis)
CMD (control output)
FE (following error)

Use: Defines the value in volts of the general purpose hardware analog output.

Remarks: Setting the analog output to VLA, CMD, or FE enables the analog output to assume a value based on the following:

- VLA (10 Volts = 20 Krpm)
- CMD (10 Volts = maximum peak rating of controller)
- FE (10 Volts = 128 pulses of following error)

Example:

AO=1.5	(* set analog output equal to 1.5 V)
AO=CMD	(* set analog output equal to control command output)
AO?	(* report value of analog output from the terminal window)

Related Registers: AI, AI*p1*, AOP

AON Network Analog Output

Class: I/O Register

Type: Integer

Syntax: AON*p1.p2* (e.g., AON15.7 AONVI2.4 AONVI5.VI2)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network address
p2	1 through 64 **or** VI*n*	analog output number

Range:

minimum -32,768
maximum 32,767

Note that these minimum and maximum values are a function of your analog output device. Refer to the documentation for your analog output device to determine how to map its values to the motion controller.

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: The network analog output is a general-purpose output used for process control.

Related Registers: AIN

AOP Power-up State of Analog Output

Class: Input/Output Register

Type: Floating point

Syntax: AOP

Range:

units volts
default 0
allowed values -10.000 through 10.000
VLA (velocity of axis, 10 V = 20 Krpm)
CMD (control output, 10 V = maximum peak rating of drive)
FE (following error, 10 V = 128 pulses of following error)

Restrictions: Not allowed in motion blocks.

Use: The power-up state of the analog output is the voltage that the analog output takes on upon system power-up.

Example:

```
AOP=5     (* set power-up state of analog output to 5 V)
AOP=FE    (* set AOP equal to following error)
AOP?      (* report value of power-up state of analog output from the terminal window)
```

Related Registers: AO

ASC — Convert from Character to ASCII Code Operator

Class: Operator

Type: Integer

Syntax: ASC(*p1*)

Parameters: *allowed values*
p1 — any string operand

Use: This operator is used to convert the first character in string operand *p1* to the ASCII code that represents this character.

Example:

VI1=ASC("Hello")	(* set integer variable 1 to the ASCII code of the first character of "Hello")
VI1?	(* report value of integer variable 1)
*72	(* note that 72 is the ASCII code for "H")

Related Operators: CHR

ATN — Arctangent Trigonometric Function Operator

Class: Operator

Type: Floating point

Syntax: ATN(*p1*)

Parameters: ***allowed values***
p1 — any floating point operand

Use: Used to perform the arctangent trigonometric function on *p1*. Result will be in degrees.

Related Commands: SIN, COS, TAN

AUTORET Enables Auto Retrieving of User Memory

Class: System Command

Syntax: AUTORET

Restrictions: Not allowed in programs or motion blocks.

Use: This command is used to enable auto retrieving of user memory from nonvolatile memory on power-up. This command must be included in the configuration data for the controller or the contents of the non-volatile memory will not be restored when controller power is cycled. The Motion Developer software automatically includes and saves this command when you develop and download a project.

Related Commands: RETRIEVE, SAVE

AUTOTUNE Automatically Sets Up Servo Tuning Constants

Class: System Command

Syntax: AUTOTUNE

Restrictions: Servo only; not allowed in programs or motion blocks.

Use: This command automatically sets up the control tuning constants, which are KA, KD, KI, KP, and KT.

Remarks: This command will execute only when the controller is faulted, the axis *Enable* input is true, and no programs or motion blocks are executing. The motor should be connected to the load when using this command. When executed, it causes the axis to move half a revolution in the forward direction. Be sure that the axis is free to move this far before executing this command. This command takes about two seconds to execute. When executed from the terminal window and the autotuning is finished, the controller will return either an asterisk (*) indicating successful completion or a question mark (?) followed by the appropriate error message. When executed from the Motion Developer *Controller Function* screen or main wizard page the status and/or error messages will be displayed in a pop-up dialog box. The possible error messages are as follows:

1. TORQUE TO INERTIA RATIO TOO LOW — the torque to inertia ratio of the axis is less than 125 radians/sec^2.
2. TORQUE TO INERTIA RATIO TOO HIGH — the torque to inertia ratio of the axis is greater than 125,000 radians/sec^2.
3. TORQUE RESPONSE NON-LINEAR — autotuning won't work**.**

If Autotune fails, the controller gains must be set manually using either the terminal window or the Motion Developer *Edit Axis Parameters* selection on the main wizard page.

Related Commands: MOTORSET

***Related Registers*:** KA, KD, KI, KP, KT, FR, CURC

BAUD Baud Rate of Serial Port

Class: System Register

Type: Integer

Syntax: BAUD

Range:
default 9,600
allowed values 1,200; 9,600; 19,200; 38,400

Restrictions: Cannot be assigned in motion blocks**.**

Use: The baud rate of the controller serial port is the bit rate at which data transfer takes place to and from the serial port.

Remarks: The controller sets the baud rate to a default setting of 9,600 on power up. To make the baud rate a different value, include the *BAUD = n* command in a program that is executed on power up. A higher baud rate is strongly recommended when using the Motion Developer monitoring functions.

Related Registers: BIT, PAR, HSE

BAUDN Baud Rate of Network Port

Class: System Register

Type: Integer

Syntax: BAUDN

Range:
default 125 kbit/s
allowed values 125, 250, 500

Restrictions: Read only

Use: Rate at which bit transfer takes place to and from the network port. Works with DeviceNet and PROFIBUS**.**

Remarks: DIP switches 1 and 2, located on the bottom of the S2K, set the default network baud rate. When powered on, these default values are stored in the BAUDN register. The table below indicates the DIP switch setting you must use for each baud rate.

Related Registers: ADDN

Network Baud Rate	Switch	
	1	2
125K	R	R
250K	L	R
500K	R	L
N/A	L	L

BIT Data bits of Serial Port

Class: System Register

Type: Integer

Syntax: BIT

Range:
default 7
allowed values 7, 8

Restrictions: Cannot be assigned in motion blocks.

Use: The number of data bits used to transfer characters to and from the serial port.

Remarks: Setting parity, PAR, to NONE and BIT to 7 at the same time is not allowed. This register defaults to 7 on power-up.

Related Registers: BAUD, PAR, HSE

BS Cursor Backspace

Class: Input/Output Command

Syntax: BS

Use: This command backspaces the cursor on the display**.**

Remarks: This command is used in conjunction with an ASCII operator display when the controller has display format enabled (DSE = 1). When executed this command writes ASCII character $08 to the controller serial port.

Related Commands: CR, CRH, CRP

Related Registers: DSE

***ASCII Code**:* $08

CAE Cam Enable

Class: Motion Register

Type: Boolean

Syntax: CAE

Range:
default 0
allowed values 0, 1

Use: Used to enable cam motion. If CAE is set to 1, then cam motion is enabled. If CAE is set to 0, cam motion is disabled.

Remarks: When the cam is initially enabled (CAE=1) the controller reads the current cam master position in register CAP and generates an absolute move on the axis to its position that corresponds to that master position in the cam table. Current accel (MAC/MAP), decel (MDC/MDP) and velocity (MVL) constraints are used for this move. CAE is reset to zero when a fault occurs or the cam table is zeroed using the CAZ command**.**

Related Registers: CAM, CAO, CAP, CAS, CAF, CAI, CAR, CAT, CAZ

Motion Templates: Electronic camming

CAF Cam Filter Constant

Class: Motion Register

Type: Integer

Syntax: CAF

Range:
default 0
minimum 0
maximum 3

Use: Used to smooth the motion of the axis when using cam following. A moving average filter of 1, 4, 8, or 16 past values of the cam master input is selected by the corresponding values of 0, 1, 2, or 3 for the cam filter constant.

Remarks: As the length of the moving average filter increases, the axis will increasingly lag the correct cam position. Use as little filtering as the application will allow.

The SAVE command does not save cam parameters to FLASH (nonvolatile) memory. Your program must set these registers before enabling cam operation. Only the points defined by the CAM register are saved to FLASH using the SAVE command (firmware version 2.5 or higher).

CAI Cam Position Register Increment

Class: Motion Register

Type: Integer

Syntax: CAI

Range:

units degrees/sec
default 0
minimum -10,000
maximum 10,000

Use: Defines the rate at which to increment the cam position register, CAR, when a virtual (time-based) cam master is required

Remarks: Use when Cam Shaft Position Type, CAT, is set to CAR which selects the virtual (time-based) cam master. This command is not used when CAT is set to PSX, which selects the auxiliary encoder as the cam master input source. CAI determines rate at which the Cam Position Register (CAR) is loaded with a new cam master position.

The SAVE command does not save cam parameters to FLASH (nonvolatile) memory. Your program must set these registers before enabling cam operation. Only the points defined by the CAM register are saved to FLASH using the SAVE command (firmware version 2.5 or higher).

Example:

```
CAT=CAR     (* use internal time-base as cam master source)
CAI=10      (* set cam master register, CAR, to increment at 10 degrees/second)
```

Related Registers: CAR, CAT

CAM Cam Point

Class: Motion Register

Type: Floating point

Syntax: CAM*p1* (e.g., CAM1 CAM32.4 CAMVI4)

Parameters:	***allowed values***	***description***
p1	0.0 through 359.9	cam position in degrees
	or VI*n*	cam position in degrees times ten

Range:

units	axis units
default	0 pulses
minimum	-2,000,000,000 pulses
maximum	2,000,000,000 pulses

Use: Used to define the axis **absolute** position at the specified cam master position for each point in a cam table.

Remarks:

1. The cam table comprises 3,600 cam points that are always equally spaced at 0.1 degree increments. The user may not need to enter every point in the table since the controller fills in any missing cam points by linearly interpolating between the points entered by the user.
2. The Zero Cam Table, CAZ, command should be executed before a new set of cam points are entered. This command clears the cam table of all previous data points and disables the cam function (CAE=0).
3. The controller can only store one cam table at a time. If multiple tables are required, subsequent tables must be loaded after the current table execution is completed. The controller variables can be used to store additional tables.
4. The numerical values for the minimum and maximum value of this register assume that the Axis Unit Ratio, (URA/URB), is set at its default value of 1. If (URA/URB) is set to a value other than 1, the default values will change according to:

Minimum = -2,000,000,000 pulses/(URA/URB)
Maximum = 2,000,000,000 pulses/(URA/URB)

5. The axis will make an absolute move to the axis position that corresponds to the current cam master position (CAP) at the instant the cam is enabled (CAE=1 is executed).
6. The Cam Scale Factor (CAS) command is used to scale the magnitude of every axis position value in the cam table. The programmer must ensure that all cam points multiplied by the Cam Scale Factor (CAS) are within the settings for the software overtravel limits (OTR and OTF) as follows:

$$OTR \leq CAM*CAS \leq OTF$$

7. The cam table positions wrap at either end of the table, and the cam profile executes continuously until camming is disabled.

Notes regarding CAM memory allocation:

8. If the axis move distance between two consecutive points is very large the controller may fault on following error.
9. The Cam Enable register (CAE) is reset to zero when a fault occurs or when the cam table is cleared (CAZ).
10. When the cam is disabled while the cam is running, the axis motor decelerates to zero speed as quickly as the system constraints allow (similar to executing a HALT command).
11. NOTE: Cam memory is shared with program memory. The S2K has 60K of RAM available for user program memory and the cam table. Once a cam point is entered or queried, 14K of RAM will be allocated for the cam table, leaving 46K of RAM for the user program memory space. Likewise, if the cam compile start position (CCP) is entered or queried, 14K of RAM will be dedicated for the CAM table.
12. As of S2K firmware revision 2.5, the cam table is saved from RAM to flash memory using the SAVE command. The cam table will be automatically retrieved on power up. The CLM command will clear the

cam table and the cam table memory allocation (reallocating all 60K of RAM to user program memory). If a cam point is queried (i.e., allocating 14K of RAM to the CAM table), and a SAVE is executed, the controller will then power-up with the CAM memory allocation. CLM (Clear User Memory) will reallocate RAM to program memory space only while the unit is still powered-up. To have the unit power-up in the “all program memory” mode after it has saved the CAM allocation flag, enter CLM followed by the SAVE command. See the CLM description *Remarks* for the precautions recommended when using the CLM command.

Example:

```
CAZ          (* zero cam table)
CAM0=0       (* set axis position at 0 degrees to 0 axis units)
CAM180=10    (* set axis position at 180 degrees to 10 axis units)
CAM0=0       (* fill rest of cam table)
CAP=0        (* initialize the cam master position to zero
CAE=1        (* enable cam following)
```

What Will Happen: The cam table is cleared and the three CAM data points construct an absolute move on the axis from zero to absolute position 10 and then back to zero. When the cam is enabled the controller reads the current master position (CAP which was initialized to zero) and moves the axis to its corresponding position from the cam table (in this case 0). The axis executes the 0-10-0 profile continuously until camming is disabled.

Related Commands: CAZ, CAE, CAO, CAS, CAT

CAO Cam Offset

Class: Motion Register

Type: Floating point

Syntax: CAO

Range:

units	degrees
default	0
minimum	-180.0
maximum	180.0

Use: Used to define an offset on the cam master position. This has the effect of shifting all points on the cam table by the offset value and is often used to set phasing or timing of the cam relative to other motion on the machine.

Remarks: The value of the CAO register does not change the value stored in the PSX, CAR or CAP position registers. The value of CAO is summed with the value in the CAP register to offset the position of the cam master.

The SAVE command does not save cam parameters to FLASH (nonvolatile) memory. Your program must set these registers before enabling cam operation. Only the points defined by the CAM register are saved to FLASH using the SAVE command (firmware version 2.5 or higher).

CAP Cam Shaft Position

Class: Motion Register

Type: Floating point

Syntax: CAP

Range:
units degrees
minimum 0.000
maximum 359.999

Restrictions: Read only

Use: This register is used to determine the cam shaft (master) position within the defined 0-359.999 degree master cycle.

Remarks: The defining input for this register is selected by the Cam Shaft Position Type, CAT, register. If CAT is set to CAR , then the CAP command will report the cam master position based on the value of the internal time-based Cam Position Register (CAR). If CAT is set to PSX, then the CAP command will report the cam master position based on the value of the Auxiliary (encoder) Position register (PSX). This register cannot be set directly. When CAT=PSX, the Auxiliary Position Length (PLX) register is used to set the range of auxiliary encoder travel required to generate one complete cam cycle. For example, if the auxiliary encoder is a 1000 line device (4000 pulses) and the desired scaling is one auxiliary encoder revolution for one cam cycle (0-360 degrees span on CAP register), the PLX register must be set to 2000 pulses (since PLX sets the aux. encoder position rollover to ± PLX, one half the number of pulses for an encoder revolution are used). This configuration will cause CAP to count from 0-180 degrees as PSX counts from 0-1999 pulses. PSX then rolls over to –2000 pulses and counts back to zero as CAP completes the cycle from 181-359.999 degrees.

Related Registers: CAT, CAR, PLX, PSX

CAR Cam Position Register

Class: Motion Register

Type: Floating point

Syntax: CAR

Range:
units degrees
default 0
minimum 0.000
maximum 359.999

Use: Used to define an internal time-base as a virtual master for cam following.

Remarks: The cam shaft position, CAP, is set to the value of this register when the Cam Shaft Position Type (CAT) is set to CAR. In this case the index rate for this register is defined by the Cam Position Register Increment (CAI) command in degrees/second. The CAR register increments at the rate defined by CAI while the cam function is enabled (CAE=1) and stops incrementing when camming is disabled (CAE=0). Camming can be enabled/disabled by a program and is automatically disabled when a controller fault occurs or the cam table is cleared (CAZ command is executed).

The SAVE command does not save cam parameters to FLASH (nonvolatile) memory. Your program must set these registers before enabling cam operation. Only the points defined by the CAM register are saved to FLASH using the SAVE command (firmware version 2.5 or higher).

Related Registers: CAT, CAI

CAS Cam Scale Factor

Class: Motion Register

Type: Floating point

Syntax: CAS

Range:
default 1
minimum .010000
maximum 100.000000

Use: Defines a scale factor to be applied to the magnitude of every axis position value entered in the cam point table**.**

Remarks: The Cam Scale Factor allows the user to create normalized cam tables that can then be rescaled for different parts.

The SAVE command does not save cam parameters to FLASH (nonvolatile) memory. Your program must set these registers before enabling cam operation. Only the points defined by the CAM register are saved to FLASH using the SAVE command (firmware version 2.5 or higher).

Related Registers: CAM

CAT Cam Shaft Position Type

Class: Motion Register

Syntax: CAT

Range:
allowed values PSX (auxiliary encoder position used as cam master source)
CAR (Internal time-base used as virtual cam master source)

Restrictions: Cannot be used in expressions.

Use: Selects the position register to use as the source for the cam master input. For normal cam following, CAT should be set to PSX. This makes the axis track the auxiliary encoder on the cam shaft. To make the axis move without the physical cam shaft turning, set CAT to CAR and set CAI to increment CAR at the desired rate**.**

Remarks: **The SAVE command does not save cam parameters to FLASH (nonvolatile) memory.** Your program must set these registers before enabling cam operation. Only the points defined by the CAM register are saved to FLASH using the SAVE command (firmware version 2.5 or higher).

Example:

```
CAT=CAR     (* use internal time-base as cam master input source)
CAT=PSX     (* use auxiliary encoder as cam master input source
CAI=100     (* set increment to 100 degrees/sec)
```

Related Registers: PSX, CAR, CAP, CAI, CAM

CAZ Zeros Cam Table

Class: Motion Command

Syntax: CAZ

Use: This command zeros the cam table. This must be done before a new set of cam points is entered**.**

Related Registers: CAM

Motion Templates: Electronic camming

CCB Cam Compile Begin Point

Class: Motion Register

Type: Floating point

Syntax: CCB

Range:

units	degrees
default	0
minimum	0.0
maximum	359.9

Use: This register is used to define the beginning master position for compiling the cam motion.

Related Registers: CCE

***Related Commands*:** CCM

CCE Cam Compile End Point

Class: Motion Register

Type: Floating point

Syntax: CCE

Range:

units	degrees
default	0
minimum	0.0
maximum	359.9

Use: Used to define the ending master position for compiling the cam motion**.**

Related Registers: CCB

***Related Commands*:** CCM

CCM Compiles Cam Motion

Class: Motion Command

Syntax: CCM

Use: This command compiles motion into the cam table. Axis motion starts at the Cam Compile Start Position (CCP) and ends at the value specified for the axis absolute move (MPA). The axis position data is put in the cam table starting at the cam master position specified by the Cam Compile Begin Point (CCB) and ending at the Cam Compile End Point (CCE). The axis motion is also defined by the usual parameters MAP, MDP, and MJK.

Remarks: The cam table can be populated with known master/slave position point pairs using simply the Cam Point (CAM) command. However, the Cam Compile (CCM) command allows the user to break the cam cycle into segments (specific range of cam master motion) and define an axis absolute motion profile for each segment. The compile command computes the cam points in the required 0.1 degree increments and populates the cam table accordingly. It is necessary to define segments that encompass the entire 360 degree cam cycle.

Example:

```
CCB=60      (* set cam compile beginning point to 60 degrees)
CCE=250     (* set cam compile ending point to 250 degrees)
CCP=0       (* set starting axis position to 0)
MPA=10      (* set ending axis position to absolute position 10)
MAP=30      (* set acceleration/deceleration percent to 30)
MJK=100     (* set jerk percent to 100)
CCM         (* compile axis motion into the cam table)
```

Related Registers: CCB, CCE, CCP, CCM, MPA, MAP, MDP, MJK

Motion Templates: Electronic camming

CCP Cam Compile Start Position

Class: Motion Register

Type: Floating point

Syntax: CCP

Range:
units axis units
default 0 pulses
minimum -2,000,000,000 pulses
maximum 2,000,000,000 pulses

Use: This register is used to define the starting position of the axis for compiling the cam motion.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, minimum, and maximum values will change appropriately (see URA and URB).

Related Registers: MPA

Related Commands: CCM

CE Conversion Error

Class: System Register

Type: Boolean

Syntax: CE*p1* (e.g., CE1 CEVI4)

Parameters:	*allowed values*	*description*
p1	1 through 4 **or** Vi*n*	program number

Range:
allowed values 0 **or** 1

Restrictions: Read only.

Use: The conversion error operand is used to determine whether a conversion operation in one of the programs worked correctly. A conversion error occurs when one data type (e.g., string) is converted to another type (e.g., floating point) and results in invalid data. If a conversion in program *p1* resulted in a conversion error, CE*p1* is set to 1; and if no error has occurred, CE*p1* is set to 0. Note that CE*p1* is updated after every conversion in program *p1*.

Example: CEVI1? (* report conversion error for program VI1)

Related Registers: SRP, ASC, CHR, ITF, STF, FTI, STI, FTS, ITB, ITH, ITS, ITD, ITT

CHANGEPW Prompts for Password Change

Class: System Command

Syntax: CHANGEPW

Restrictions: Not allowed in programs or motion blocks.

Use: This command is used to prompt the user for an initial password or a password change.

Remarks: If there is no existing password the CHANGEPW command will prompt for a new password. After the new password has been entered, the controller will prompt for the new password again for verification. If a password already exists the controller will prompt for the old password. After the old password has been entered, the controller will then prompt for the new password. The password can be from four to ten characters long. After the new password has been entered, the controller will prompt for the new password again for verification. Once this has been entered, the password will be changed to the new value. By entering no characters when prompted for the new password, the password function will be disabled.

WARNING: Once set there is no way to recover normal use of the controller without a valid password. Be sure to record the password and store in a safe location.

Related Commands: PASSWORD

CHR Convert from ASCII Code to Character Operator

Class: Operator

Type: String

Syntax: CHR(*p1*)

Parameters: *allowed values*
p1 any integer operand

Use: This operator is used to convert the ASCII code *p1* to the character represented by ASCII code *p1*.

Example:

```
VS1=CHR(65)     (* set string variable VS1 to the character represented by ASCII code 65)
VS1?            (* report value of string variable VS1 in the terminal window)
* “A”
```

Related Operators: ASC

CIE Computer Interface Format Enable

Class: System Register

Type: Boolean

Syntax: CIE

Range:
default 0
allowed values 0, 1

Restrictions: Cannot be assigned in motion blocks.

Use: The computer interface format enable register is used to define whether the computer interface format on the serial/program port is enabled. If CIE is set to 1, computer interface format is enabled, and if set to 0, computer interface format is disabled.

Remarks: When the computer interface format is enabled, queries to fault and status registers return numerical values instead of message strings. See Chapter 7 for fault and status register details.

Related Registers: HSE, FC, FI, IO, SRA, SRP, SRS

CLL Clears Line and Positions Cursor at Beginning of Line

Class: Input/Output Command

Syntax: CLL

Use: This command clears the current line and positions the cursor at the beginning of the line on the display.

Remarks: This command is used in conjunction with the display when DSE is set to 1.

Related Commands: CLS

Related Registers: DSE

ASCII Codes: $1B$49

CLM Clears User Memory; Resets Registers to Defaults

Class: System Command

Syntax: CLM

Restrictions: Not allowed in programs or motion blocks**.**

Use: This command removes all programs and motion blocks from the controller's SRAM memory and resets all registers to default values**.**

Remarks: 1. This command is irreversible; you cannot retrieve any programs, motion blocks, or registers that you have previously set after you execute this command.
2. This command is entered in the terminal window and will execute only when the controller is faulted and no programs or motion blocks are executing.
3. A Program 4 that is designed to unconditionally reset faults makes it impossible to place the controller in a faulted state, thereby preventing the use of the CLM command, which will prevent proper download to the target.

Notes regarding CAM memory allocation:

NOTE: Cam memory is shared with program memory. The S2K has 60K of RAM available for user program memory and the cam table. Once a cam point is entered or queried, 14K of RAM will be allocated for the cam table, leaving 46K of RAM for the user program memory space. Likewise, if the cam compile start position (CCP) is entered or queried, 14K of RAM will be dedicated for the CAM table.

As of S2K firmware revision 2.5, the cam table is saved from RAM to flash memory using the SAVE command. The cam table will be automatically retrieved on power up. The CLM command will clear the cam table and the cam table memory allocation (reallocating all 60K of RAM to user program memory). If a cam point is queried (i.e., allocating 14K of RAM to the CAM table), and a SAVE is executed, the controller will then power-up with the CAM memory allocation. CLM will reallocate RAM to program memory space only while the unit is still powered-up. To have the unit power-up in the "all program memory" mode after it has saved the CAM allocation flag, enter CLM followed by the SAVE command.

CLS Clears Display and Positions Cursor at Home

Class: Input/Output Command

Syntax: CLS

Use: This command clears the display and positions the cursor at home (i.e., the first column of the first line of the display).

Remarks: This command is used in conjunction with the display when DSE is set to 1.

Related Commands: CLL

Related Registers: DSE

ASCII Codes: $1B$4A

CMD Position Controller Commanded Output

Class: Axis Register

Type: Floating point

Syntax: CMD

Range:
units %
minimum -20,000.0
maximum 20,000.0

Restrictions: Read only.

Use: The position controller commanded output is used to control the position of the axis. It is a percentage of the controller continuous current setting, CURC.

For KI = KD =0, use the following formula:

$$CMD = \frac{FE * KP}{16,384} * CURC$$

Example: CMD? (* report position command output from the terminal window)

Related Registers: CURC

CMO Commutation Angle Offset (Servo Only)

Class: Axis Register

Type: Floating point

Syntax: CMO

Range:

units degrees
encoder feedback controllers default -90.0
resolver feedback controllers default 90.0
minimum -180.0
maximum 180.0

Restrictions: Brushless servo only.

Use: The commutation angle offset of the motor is determined by the motor selected for use with the controller. For GE Fanuc motors this value is set automatically by Motion Developer to the correct value for the motor model selected and typically will not require adjustment by the user. CMO values associated with GE Fanuc motor models are as follows:

Motor Model	CMO Value
S-Series	-90
MTR-3N Series	90
MTR-3S Series	-90
MTR-3T Series	90

If necessary, this value can be set automatically by the MOTORSET command. Only experienced users should make adjustments to this setting after consulting GE Fanuc for assistance.

Related Registers: None

Related Commands: MOTORSET

CMR Motor Poles to Resolver Poles Commutation Ratio

Class: Axis Register

Type: Integer

Syntax: CMR

Range:

default	Resolver feedback = 3; Encoder feedback = 1
minimum	1
maximum	16

Restrictions: Brushless servo only

Use:

Resolver Feedback
The motor poles to resolver poles commutation ratio is one of the motor constants needed to operate a servo motor with resolver feedback. This value, along with the value of CMO, can be set automatically by the MOTORSET command

Encoder Feedback
For encoder-based controllers using third-party encoder-based motors, this register must be set to the number of motor pole pairs (requires firmware revision 2.5 and later). NOTE: To run GE Fanuc S-Series servo motors, the CMR value must be set to 1, which is the controller default and the value set by the Motion Developer configuration wizard. Setting CMR=1 will automatically set FRC=10000 (firmware revision 2.5 and later). The CMR register can be set automatically with the MOTORSET command (see MOTORSET description for procedure).

Related Registers: CMO, FRC

Related Commands: MOTORSET

CNC Close Network Connection

Class: System Command

Syntax: CNC***p1***

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network address

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This command closes the network connection to the device addressed at *p1*.

Related Registers: NCO

COS Cosine Trigonometric Function Operator

Class: Operator

Type: Floating point

Syntax: COS(*p1*)

Parameters: *allowed values*
p1 any floating point operand

Use: Used to perform the cosine trigonometric function on *p1*. The operand *p1* must be in degrees.

Related Commands: SIN, TAN, ATN

CR Positions Cursor at Beginning of Next Line Down

Class: Input/Output Command

Syntax: CR

Use: This command positions the cursor at the beginning of the next line down on the display. It sends the ASCII codes for a carriage return ($0D) followed by a line feed ($0A) to the serial port. This command is typically used to positions the cursor at the beginning of the next line on an ASCII compliant operator display connected to the controller serial port.

Remarks: This command is used in conjunction with the display when DSE is set to 1.

Related Commands: BS, CRH, CRP

Related Registers: DSE

ASCII Codes: $0D$0A

CRH Positions Cursor at Home

Class: Input/Output Command

Syntax: CRH

Use: This command positions the cursor at home (i.e., the first column of the first line of the display).

Remarks: This command is used in conjunction with the display when DSE is set to 1.

Related Commands: BS, CR, CRP

Related Registers: DSE

ASCII Codes: $1B$48

CRM Remembers Cursor Position

Class: Input/Output Command

Syntax: CRM

Use: This command is used to remember the current position of the cursor.

Remarks: CRM is used in conjunction with the display when DSE is set to 1.

Related Commands: CRR

ASCII Codes: $1B$3F

CRP Positions Cursor

Class: Input/Output Command

Syntax: CRP*p1.p2* (e.g, CRP1.3 CRPVI2.3 CRP2.VI1 CRPVI1.VI2)

Parameters:

	allowed values	*description*
p1	1 to 4 or VI*n*	line position
p2	1 to 40 or VI*n*	column position

Use: This command positions the cursor on line *p1*, column *p2* of the display.

Remarks: This command is used in conjunction with the display when DSE is set to 1.

Example:

CRP1.2 (* position cursor at line 1, column 2 of the display)
CRP1.VI1 (* position cursor at line 1, column VI1 of the display)

Related Commands: BS, CR, CRH

Related Registers: DSE

ASCII Codes: $1B$46 $(p2+20h) $(p1+20h)

CRR Positions Cursor at Remembered Position

Class: Input/Output Command

Syntax: CRR

Use: This command is used to place the cursor at the position remembered by the CRM command.

Remarks: This command is used in conjunction with the display when DSE is set to 1.

Related Commands: CRM

Related Registers: DSE

ASCII Codes: $1B$40

CURC Continuous Current

Class: Axis Register

Type: Floating point

Syntax: CURC

Range:
units %
default 60.0 (stepper) and 100.0 (brushless servo)
minimum 1.0
maximum 100.0

Use: Limits the current that the drive will continuously supply to the motor. It is a percentage of the maximum continuous current rating of the drive.

Remarks: CURC is normally set by Motion Developer when a motor and controller are selected during axis configuration. The terminal window or the *Target Configuration/Controller & Motor Setup* option on the Motion Developer main wizard page can be used to manually set CURC. Use the following equation to calculate CURC:

100% x (motor continuous current rating / drive cont. current rating)

For example, when using a 5.6 Amp motor with a 7.2 Amp drive,

CURC = *100% x (5.6 Amps / 7.2 Amps) = 78%.*

For applications that require torque limiting to a value less than rated motor torque use the Torque Limit Current (TLC) command. Do not reduce the CURC value to limit motor torque for an application.

CURC Values For S2K Servo Models		
Motor	**Controller**	**CURC setting**
MTR-3N21-H	IC800SSI104R	69.7
MTR-3N22-H	IC800SSI104R	69.7
MTR-3N24-G	IC800SSI104R	60.5
MTR-3N31-H	IC800SSI104R	76.7
MTR-3N32-G	IC800SSI104R	69.7
MTR-3N32-H	IC800SSI107R	84.7
MTR-3N33-G	IC800SSI104R	65.1
MTR-3N33-H	IC800SSI107R	77.8
MTR-3S22-G	IC800SSI104R	34.8
MTR-3S23-G	IC800SSI104R	34.8
MTR-3S32-G	IC800SSI104R	67.4
MTR-3S33-G	IC800SSI104R	74.4
MTR-3S34-G	IC800SSI104R	69.8
MTR-3S35-G	IC800SSI104R	69.8
MTR-3S43-G	IC800SSI104R	67.4
MTR-3S43-H	IC800SSI107R	79.1
MTR-3S45-G	IC800SSI107R	76.4
MTR-3S45-H	IC800SSI216R	68.1
MTR-3S46-G	IC800SSI107R	76.4
MTR-3S46-H	IC800SSI216R	69.3
MTR-3S63-G	IC800SSI216R	69.3
MTR-3S65-G	IC800SSI216R	67.5
MTR-3S65-H	IC800SSI228R	76.4
MTR-3S67-G	IC800SSI216R	70.6
MTR-3S67-H	IC800SSI228R	80.4

CURC Values For S2K Servo Models		
Motor	**Controller**	**CURC setting**
MTR-3S84-G	IC800SSI228R	96.1
MTR-3S86-G	IC800SSI228R	100.0
MTR-3S88-G	IC800SSI228R	100.0
MTR-3T11-G	IC800SSI104R	22.3
MTR-3T12-G	IC800SSI104R	43.7
MTR-3T13-G	IC800SSI104R	63.4
MTR-3T21-G	IC800SSI104R	40.0
MTR-3T22-G	IC800SSI104R	61.6
MTR-3T23-G	IC800SSI104R	62.8
MTR-3T24-H	IC800SSI104R	76.7
MTR-3T42-H	IC800SSI107R	65.3
MTR-3T42-H	IC800SSI407R	65.3
MTR-3T43-H	IC800SSI104R	100.0
MTR-3T43-J	IC800SSI107R	100.0
MTR-3T43-J	IC800SSI407R	100.0
MTR-3T44-J	IC800SSI107R	100.0
MTR-3T44-J	IC800SSI407R	100.0
MTR-3T45-H	IC800SSI107R	98.6
MTR-3T45-H	IC800SSI407R	98.6
MTR-3T45-I	IC800SSI216R	62.5
MTR-3T54-H	IC800SSI216R	66.3
MTR-3T54-H	IC800SSI420R	53.0
MTR-3T55-H	IC800SSI216R	66.3
MTR-3T55-H	IC800SSI420R	53.0
MTR-3T55-I	IC800SSI228R	76.1
MTR-3T57-H	IC800SSI228R	69.6
MTR-3T66-H	IC800SSI228R	74.0
MTR-3T66-H	IC800SSI420R	100.0
MTR-3T67-G	IC800SSI228R	74.0
MTR-3T67-G	IC800SSI420R	100.0
MTR-3T69-G	IC800SSI228R	73.6
MTR-3T69-G	IC800SSI420R	100.0
SLM003	SSI104	23
SLM005	SSI104	23
SLM010-115V	SSI104	37
SLM010-230V	SSI104	23
SLM020-115V	SSI104	58
SLM020-230V	SSI104	36
SLM040-115V	SSI104	100
SLM040-230V	SSI104	55
SLM075	SSI104	100
SLM100	SSI107	100
SDM100	SSI107	77
SDM250	SSI216	87
SLM250	SSI216	100
SLM350	SSI228	77
SLM500	SSI228	99
SDM500	SSI228	100
SGM450	SSI228	100

CURC Values For S2K Stepper Models		
Motor	**Controller**	**CURC setting**
MTR-1221-_-D-E-0	STI105	35.0[a]
MTR-1231-_-D-E-0	STI105	31.0[a]
MTR-1324-_-D-E-_	STI105	54.0
MTR-1337-_-D-E-_	STI105	82.0
MTR-1350-_-A-E-_	STI105	100
MTR-1350-_-D-E-_	STI105	82.0
MTR-1N31-I-_-D-S-0	STI105	86.0
MTR-1N32-I-_-D-S-0	STI105	82.0
MTR-1N41-G-_-A-E-0	STI105	100
MTR-1N42-H-*-A-E-0	STI105	100
STM1221N0	STI105	70
STM1231N0	STI105	62
STM1324N0	STI105	100
STM1337N0	STI105	100

[a] CURC setting is determined by motor power cable wiring for MTR-1221 and MTR-1231. For model MTR-1221-_-D-E-0, CURC=35.0 when motor power cable is wired in *series*; CURC=70.0 for *parallel* wiring. For model MTR-1231-*-D-E-0, CURC=31.0 when motor power cable is wired in *series*; CURC=62.0 for *parallel* wiring.

Related Registers: CURCN, CURP, CURPN, CURS, CURSN, TLC

CURCN Network Continuous Current

Class: Axis Register

Type: Floating point

Syntax: CURCN*p1* (e.g., CURCN0 CURCN63 CURCNV12)

Parameters:

	allowed values	*description*
p1	1 through 63 **or** Vl*n*	network address

Range:

units	%
default	60.0 (stepper) and 100.0 (brushless servo)
minimum	1.0
maximum	100.0

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This command accesses attribute 101 of the DeviceNet position controller object to limit the current that the drive addressed at *p1* will continuously supply to the motor. It is a percentage of the maximum continuous current rating of the drive.

Remarks: The terminal window or the *Edit Controller/Motor Parameters* option on the Motion Developer main wizard page can be used to manually set CURCN. Use the following equation to calculate CURCN:
100% x (motor continuous current rating / drive cont. current rating)
For example, when using a 5.6 Amp motor with a 7.2 Amp drive,
CURCN = *100% x (5.6 Amps / 7.2 Amps) = 78%.*

CURCN Values For S2K Servo Models		
Motor	**Controller**	**CURCN setting**
MTR-3N21-H	IC800SSI104R	69.7
MTR-3N22-H	IC800SSI104R	69.7
MTR-3N24-G	IC800SSI104R	60.5
MTR-3N31-H	IC800SSI104R	76.7
MTR-3N32-G	IC800SSI104R	69.7
MTR-3N32-H	IC800SSI107R	84.7
MTR-3N33-G	IC800SSI104R	65.1
MTR-3N33-H	IC800SSI107R	77.8
MTR-3S22-G	IC800SSI104R	34.8
MTR-3S23-G	IC800SSI104R	34.8
MTR-3S32-G	IC800SSI104R	67.4
MTR-3S33-G	IC800SSI104R	74.4
MTR-3S34-G	IC800SSI104R	69.8
MTR-3S35-G	IC800SSI104R	69.8
MTR-3S43-G	IC800SSI104R	67.4
MTR-3S43-H	IC800SSI107R	79.1
MTR-3S45-G	IC800SSI107R	76.4
MTR-3S45-H	IC800SSI216R	68.1
MTR-3S46-G	IC800SSI107R	76.4
MTR-3S46-H	IC800SSI216R	69.3
MTR-3S63-G	IC800SSI216R	69.3
MTR-3S65-G	IC800SSI216R	67.5
MTR-3S65-H	IC800SSI228R	76.4

MTR-3S67-G	IC800SSI216R	70.6
MTR-3S67-H	IC800SSI228R	80.4
MTR-3S84-G	IC800SSI228R	96.1
MTR-3S86-G	IC800SSI228R	100.0
MTR-3S88-G	IC800SSI228R	100.0
MTR-3T11-G	IC800SSI104R	22.3
MTR-3T12-G	IC800SSI104R	43.7
MTR-3T13-G	IC800SSI104R	63.4
MTR-3T21-G	IC800SSI104R	40.0
MTR-3T22-G	IC800SSI104R	61.6
MTR-3T23-G	IC800SSI104R	62.8
MTR-3T24-H	IC800SSI104R	76.7
MTR-3T42-H	IC800SSI107R	65.3
MTR-3T42-H	IC800SSI407R	65.3
MTR-3T43-H	IC800SSI104R	100.0
MTR-3T43-J	IC800SSI107R	100.0
MTR-3T43-J	IC800SSI407R	100.0
MTR-3T44-J	IC800SSI107R	100.0
MTR-3T44-J	IC800SSI407R	100.0
MTR-3T45-H	IC800SSI107R	98.6
MTR-3T45-H	IC800SSI407R	98.6
MTR-3T45-I	IC800SSI216R	62.5
MTR-3T54-H	IC800SSI216R	66.3
MTR-3T54-H	IC800SSI420R	53.0
MTR-3T55-H	IC800SSI216R	66.3
MTR-3T55-H	IC800SSI420R	53.0
MTR-3T55-I	IC800SSI228R	76.1
MTR-3T57-H	IC800SSI228R	69.6
MTR-3T66-H	IC800SSI228R	74.0
MTR-3T66-H	IC800SSI420R	100.0
MTR-3T67-G	IC800SSI228R	74.0
MTR-3T67-G	IC800SSI420R	100.0
MTR-3T69-G	IC800SSI228R	73.6
MTR-3T69-G	IC800SSI420R	100.0
SLM003	SSI104	23
SLM005	SSI104	23
SLM010-115V	SSI104	37
SLM010-230V	SSI104	23
SLM020-115V	SSI104	58
SLM020-230V	SSI104	36
SLM040-115V	SSI104	100
SLM040-230V	SSI104	55
SLM075	SSI104	100
SLM100	SSI107	100
SDM100	SSI107	77
SDM250	SSI216	87
SLM250	SSI216	100
SLM350	SSI228	77
SLM500	SSI228	99
SDM500	SSI228	100
SGM450	SSI228	100

CURCN Values For S2K Stepper Models		
Motor	**Controller**	**CURCN setting**
MTR-1221-_-D-E-0	STI105	35.0[a]
MTR-1231-_-D-E-0	STI105	31.0[a]
MTR-1324-_-D-E-_	STI105	54.0
MTR-1337-_-D-E-_	STI105	82.0
MTR-1350-_-A-E-_	STI105	100
MTR-1350-_-D-E-_	STI105	82.0
MTR-1N31-I-_-D-S-0	STI105	86.0
MTR-1N32-I-_-D-S-0	STI105	82.0
MTR-1N41-G-_-A-E-0	STI105	100
MTR-1N42-H-*-A-E-0	STI105	100
STM1221N0	STI105	70
STM1231N0	STI105	62
STM1324N0	STI105	100
STM1337N0	STI105	100

[a] CURCN setting is determined by motor power cable wiring for MTR-1221 and MTR-1231. For model MTR-1221-_-D-E-0, CURCN=35.0 when motor power cable is wired in *series*; CURCN=70.0 for *parallel* wiring. For model MTR-1231-*-D-E-0, CURCN=31.0 when motor power cable is wired in *series*; CURCN=62.0 for *parallel* wiring.

***Related Registers**:* CURPN, CURSN, CURC, CURP, CURS, TLC

CURP Peak Current (Servo Only)

Class: Axis Register

Type: Floating point

Syntax: CURP

Range:
units %
default 100.0
minimum 1.0
maximum 100.0

Restrictions: Brushless servo only.

Use: The peak current setting limits the peak value of the current that the drive will supply to the motor. It is a percentage of the maximum peak current rating of the drive.

Remarks: CURP is normally set by Motion Developer when a motor and controller are selected during axis configuration. The terminal window or the *Edit Controller/Motor Parameters* option on the Motion Developer main wizard page can be used to manually set CURP. Use the following equation to calculate CURP:

100% x (motor peak current rating / drive peak current rating)

For example, when using a 5 Amp motor with a 4.3 Amp drive (8.6 Amp peak),

CURP = *100% x (5 Amps / 8.6 Amps) = 58%.*

Motor Model #	Controller	CURP Setting
MTR-3N21-H	IC800SSI104R	100
MTR-3N22-H	IC800SSI104R	100
MTR-3N24-G	IC800SSI104R	90.7
MTR-3N31-H	IC800SSI104R	100
MTR-3N32-G	IC800SSI104R	100
MTR-3N32-H	IC800SSI107R	100
MTR-3N33-G	IC800SSI104R	100
MTR-3N33-H	IC800SSI107R	100
MTR-3S22-G	IC800SSI104R	48.8
MTR-3S23-G	IC800SSI104R	52.3
MTR-3S32-G	IC800SSI104R	100
MTR-3S33-G	IC800SSI104R	100
MTR-3S34-G	IC800SSI104R	100
MTR-3S35-G	IC800SSI104R	100
MTR-3S43-G	IC800SSI104R	100
MTR-3S43-H	IC800SSI107R	100
MTR-3S45-G	IC800SSI107R	100
MTR-3S45-H	IC800SSI216R	100
MTR-3S46-G	IC800SSI107R	100
MTR-3S46-H	IC800SSI216R	100
MTR-3S63-G	IC800SSI216R	100

Motor Model #	Controller	CURP Setting
MTR-3S65-G	IC800SSI216R	100
MTR-3S65-H	IC800SSI228	100
MTR-3S67-G	IC800SSI216R	100
MTR-3S67-H	IC800SSI228	100
MTR-3S84-G	IC800SSI228	100
MTR-3S86-G	IC800SSI228	100
MTR-3S88-G	IC800SSI228	100
MTR-3T11-G	IC800SSI104R	61.6
MTR-3T12-G	IC800SSI104R	100
MTR-3T13-G	IC800SSI104R	100
MTR-3T21-G	IC800SSI104R	80
MTR-3T22-G	IC800SSI104R	100
MTR-3T23-G	IC800SSI104R	100
MTR-3T24-H	IC800SSI104R	100
MTR-3T42-H	IC800SSI107R	100
MTR-3T42-H	IC800SSI407	100
MTR-3T43-H	IC800SSI104R	100
MTR-3T43-J	IC800SSI107R	100
MTR-3T43-J	IC800SSI407	100
MTR-3T44-J	IC800SSI107R	100
MTR-3T44-J	IC800SSI407	100
MTR-3T45-H	IC800SSI107R	100
MTR-3T45-H	IC800SSI407	100
MTR-3T45-I	IC800SSI216R	100
MTR-3T54-H	IC800SSI216R	100
MTR-3T54-H	IC800SSI420	100
MTR-3T55-H	IC800SSI216R	100
MTR-3T55-H	IC800SSI420	100
MTR-3T55-I	IC800SSI228	100
MTR-3T57-H	IC800SSI228	100
MTR-3T66-H	IC800SSI228	100
MTR-3T66-H	IC800SSI420	100
MTR-3T67-G	IC800SSI228	100
MTR-3T67-G	IC800SSI420	100
MTR-3T69-G	IC800SSI228	100
MTR-3T69-G	IC800SSI420	100
SLM003	SSI104	32
SLM005	SSI104	35
SLM010-115V	SSI104	100
SLM010-230V	SSI104	100
SLM020-115V	SSI104	32
SLM020-230V	SSI104	58
SLM040-115V	SSI104	100
SLM040-230V	SSI104	90
SLM075	SSI104	100
SLM100	SSI107	100
SDM100	SSI107	100

Motor Model #	Controller	CURP Setting
SDM250	SSI216	100
SLM250	SSI216	100
SLM350	SSI228	100
SLM500	SSI228	100
SDM500	SSI228	100
SGM450	SSI228	100

Related Registers: CURC, CURCN, CURPN

CURS Power Save Current (Stepper Only)

Class: Axis Register

Type: Floating point

Syntax: CURS

Range:
units %
default 60.0
minimum 0.0
maximum 100.0

Restrictions: Stepper only.

Use: The power save current is used to reduce motor heating when the axis is stopped. While the axis is in position, the continuous current value, CURC, is reduced to the percentage set by CURS. For example, if CURC=50 and CURS=20, the value of CURC will be reduced to 10 percent (20% of 50) while the axis is in position.

Related Registers: CURC, CURCN, CURSN

CURSN Network Power Save Current (Stepper Only)

Class: Axis Register

Type: Floating point

Syntax: CURSNp1 (e.g., CURS0 CURSN63 CURSNVI5)

Range:
units %
default 60.0
minimum 0.0
maximum 100.0

Restrictions: Stepper only. Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This command accesses attribute 102 of the DeviceNet position controller object to reduce motor heating when the axis addressed at *p1*has stopped. While the axis is in position, the network continuous current value, CURCN, is reduced to the percentage set by CURSN. For example, if CURCN=50 and CURSN=20, the value of CURCN will be reduced to 10 percent (20% of 50) while the axis is in position.

Related Registers: CURCN, CURC, CURS

DEL Deletes Current Statement in Terminal Window Line Editor

Class: Program Command

Syntax: DEL

Restrictions: Allowed only in programs or motion blocks being edited in the terminal window line editor.

Use: This command is used to edit programs or motion blocks in the terminal window line editor. It deletes the current statement and makes the next statement the current statement.

Remarks: This command will not typically be used since Motion Developer provides a more full featured text editor for creating and editing programs and motion blocks. The terminal window can also be used for these functions and is invoked using the PROGRAM and MOTION commands. While in the line editor each line is prefixed by an asterisk (*). The exclamation point (!) command is used to exit the terminal window line editor.

Example:

```
PROGRAM1        (*edit existing program 1)
*  PSA=0
X               (* step through program)
*  MVL=10
X               (* step through program)
*  MAC=40
DEL             (* delete current statement MAC=40)
*  MPA=12
MAC=10          (* set motion acceleration)
*  MPA=12
!               (* exit terminal window line editor)
```

What will happen: This program example changes “MAC=40” to “MAC=10” in program 1.

Related Commands: PROGRAM, L, LABEL, X, !

DGC Loads Diagnostic Condition for Printing

Class: Diagnostic Command

Syntax: DGC*p1*=*p2* (e.g., DGC1=MB1, DGC2=TL1 or IP1)

Parameters:

	default	*allowed values*	*description*
p1		1 through 4	diagnostic condition number
p2	OFF	any Boolean expression **or** OFF	diagnostic condition

Restrictions: Not allowed in programs or motion blocks.

Use: This command assigns diagnostic condition *p1*. When one of the user defined diagnostic conditions is satisfied, and if diagnostics are enabled, a diagnostic line of items is sent to the terminal (see DGL, DGI).

Remarks: Upon clearing the memory with the CLM command, all diagnostic conditions and items are set to the value "OFF," which means that there are no diagnostic conditions/items assigned. If you wish to eliminate the assignment of diagnostic condition *p1*, use the DGC command and set parameter *p2* to "OFF." For example, DGC1=OFF will eliminate the assignment of diagnostic condition one.

Example:

```
STM2=0.5                (* set start time of timer two to 0.5 seconds)
DGC1=TM2 AND PROG1      (* assign diagnostic condition 1)
```

What will happen: Setting the start time of timer 2 and assigning diagnostic condition 1 will send a diagnostic line of items to the terminal every 0.5 seconds while program 1 is executing. Each diagnostic line will begin with the diagnostic condition satisfied, which in this case would be "TM2 AND PROG1," and then be followed by a colon and the diagnostic items loaded.

Related Commands: DGE, DGI, DGL, DGP

DGE Enables Diagnostics

Class: Diagnostic Command

Syntax: DGE=*p1* (e.g., DGE=0)

Parameters:

	default	*allowed values*	*description*
p1	0	0 and 1	diagnostic enable bit

Restrictions: Not allowed in programs or motion blocks. Diagnostics work only via serial communication.

Use: This command is used to enable the diagnostic mode of the system. When DGE is set to 1, diagnostics are enabled, and when set to 0, diagnostics are disabled.

Remarks: DGE is set to 0 upon power-up.

Related Commands: DGC, DGI, DGL, DGP, DGO, DGS, DGT

DGI Assigns Diagnostic Item to Print

Class: Diagnostic Command

Syntax: DGI*p1*=*p2* (e.g., DGI1=VLA DGI3=PHR1)

Parameters:

	default	*allowed values*	*description*
p1		1 through 8	diagnostic item number
p2	OFF	any register or OFF	diagnostic item

Restrictions: Not allowed in programs or motion blocks.

Use: This command assigns a diagnostic item to be printed whenever a DGL is executed or whenever one of the user-defined diagnostic conditions is met.

Remarks: Upon clearing the memory with the CLM command, all diagnostic conditions and items are set to the value “OFF,” which means that there are no diagnostic conditions/items assigned. If you wish to eliminate the assignment of diagnostic item *p1*, use the DGI command and set parameter *p2* to “OFF.” For example, DGI1=OFF will eliminate the assignment of diagnostic item one.

Example:

```
DGI1=PSA        (* assign diagnostic item one)
DGI2=VLA        (* assign diagnostic item two)
DGI3=FE         (* assign diagnostic item three)
DGI4=PSR        (* assign diagnostic item four)
```

What will happen: Assigning these diagnostic items when diagnostics are enabled will send the diagnostic items to the terminal when the DGL command is executed.

Related Commands*:* DGE, DGC, DGL, DGP

DGL Prints Diagnostic Line of Items

Class: Diagnostic Command

Syntax: DGL

Use: This command prints to the terminal a diagnostic line of items that have been assigned with the DGI command. This works only while diagnostics are enabled.

Remarks: Since this command is ignored when diagnostics are not enabled, it can be left in programs even when you are not using diagnostics.

Example:

```
DGI1=PSA              (* assign diagnostic item one)
DGI2=VLA              (* assign diagnostic item two)
DGI3=FE               (* assign diagnostic item three)
DGI4=PSR              (* assign diagnostic item four)
DGL                   (* print diagnostic line of items)
*DGL: PSA=0, VLA=0
 DGL: FE=0, PSR=3061
```

Related Commands: DGE, DGC, DGI, DGP

DGO Outputs Diagnostic Register Value to Serial Port

Class: Diagnostic Command

Syntax: DGO *p1* (e.g., DGO VLA, DGO IO)

Parameters:

	allowed values	*description*
p1	any register	register

Use: This command outputs a diagnostic register value to the serial or program port when diagnostics are enabled (DGE=1). DGO works the same as the "?" command, but it can also be used in programs and motion blocks.

Remarks: Since this command is ignored when diagnostics are not enabled, it can be left in programs even when you are not using diagnostics.

Example:

```
DGO PSA     (* outputs axis position to the serial port)
DGOVLA      (* outputs axis velocity to the serial port)
```

Related Commands: DGE, DGL, DGP

DGP Prints Diagnostic Message to Serial Port

Class:	Diagnostic Command	
Syntax:	DGP"*p1*" (e.g., DGP "Drill operating")	
Parameters:	*allowed values*	*description*
p1	any string, 0 through 127 characters long	diagnostic message

Use: This command prints the diagnostic message *p1* to the serial port. It works only when diagnostics are enabled.

Remarks: Since this command is ignored when diagnostics are not enabled, it can be left in programs even when you are not using diagnostics.

Example:

```
DGE=1                        (* enable diagnostics)
DGP "Diagnostics enabled"    (* send diagnostic message to serial port)
*Diagnostics enabled
```

Related Commands: DGE, DGC, DGI, DGL

DGS Sets Program to Single Step Mode

Class: Diagnostic Command

Syntax: DGS=*p1* (e.g., DGS=2)

Parameters:

	default	*allowed values*	*description*
p1	0	0 through 4 program number	(0 = no program in single step mode)

Restrictions: Not allowed in motion blocks.

Use: This command sets program *p1* to single step mode. If DGS is set to 0, single step mode is disabled. Single step mode can occur only when diagnostics are enabled.

Remarks: To execute a program while in single step mode, use the X-command in the terminal window editor to step through the program (i.e., execute the program one statement at a time). As each line of the program is executed, it is displayed in the terminal.

Example:

```
DGE=1          (* enable diagnostics)
DGS=3          (* set program three to single step mode)
EXP3           (* execute program three)
*  PSA=0
X              (* step through program)
*  MVL=25
X              (* step through program)
*  MAC=10
X
*  MPI=40
X
*  RPI
X
*  END
X
*
```

What will happen: Enabling diagnostics, setting program three to single step mode, and executing program three will cause only the first line of the program to execute. The X command causes the program to execute the next line, send that line to the terminal, and so on until it reaches the end of the program.

***Related Commands**:* DGE, DGT

DGT Sets Program to Trace Mode

Class: Diagnostic Command

Syntax: DGT=*p1* (e.g., DGT=2)

Parameters:

	default	*allowed values*	*description*
p1	0	0 through 4	program number (0 = no program in trace mode)

Restrictions: Not allowed in motion blocks.

Use: This command sets program *p1* to trace mode. If DGT is set to 0, trace mode is disabled. Trace mode can occur only when diagnostics are enabled.

Remarks:

1. When trace mode is enabled, each line of program *p1* is sent to the terminal as it is executing.
2. **CAUTION:** Trace mode can cause the program to run approximately 1,000 times slower than normal!

Example:

```
DGE=1          (* enable diagnostics)
DGT=3          (* set program three to trace mode)
EXP3           (* execute program three)
* PSA=0
  MVL=25
  MAC=10
  MPI=40
  RPI
  END
*
```

What will happen: Enabling diagnostics, setting program three to trace mode, and executing program three will cause each line of the program to be sent to the terminal while it is executing.

Related Commands: DGE, DGS

DI Digital Input

Class: Input/Output Register

Type: Integer, Boolean

Syntax: DI*p1* (e.g., DI DI4 DIVI1)

Parameters:

Model		*allowed values*	*description*
IC800S_IxxxD2 IC800S_IxxxP2 IC800S_IxxxRD2 IC800S_IxxxRP2	*p1* *p1* *p1* *p1*	none or 1 through 14 **or** VI*n*	digital input number
IC800S_IxxxS1 IC800S_IxxxRS1	*p1* *p1*	none or 1 through 21 **or** VI*n*	digital input number

Range:

Model		*allowed values*
IC800S_IxxxD2 IC800S_IxxxP2 IC800S_IxxxRD2 IC800S_IxxxRP2	*p1* *p1* *p1* *p1*	0 through $3FFF_{16}$ **or** 0 and 1
IC800S_IxxxS1 IC800S_IxxxRS1	*p1* *p1*	0 through $1FFFFF_{16}$ **or** 0 and 1

Restrictions: Read only.

Use: The digital input register contains the values of digital inputs, which are general purpose inputs used for process control.

Remarks:

1. When the DI*p1*? command is executed, the value of the digital input *p1* will be given as a Boolean number.
2. When DI? is executed, the digital inputs will be reported as binary numbers. The left-most bit represents digital input 14 or 21, depending on your controller model number (see ***Parameters*** above); and the right-most bit represents digital input 1.
3. DI1 = home; DI2 = forward overtravel (+OT) when OTE=1; DI3 = reverse overtravel (-OT) when OTE=1; DI 5 and DI 6 are used for the hand wheel inputs when HWE=1.
Set OTE = 1 to enable the hardware overtravel inputs. The hardware overtravel inputs require a normally closed contact.
4. Since the controller includes I/O points that may be used either as input or outputs the DI register bits for these shared points will change state when any digital output command (DO) forces the state of the bit. For example, if DO10=1 is executed then DI10 will also be TRUE.

Example:

```
DI?     (* report value of digital input register; example 2#00010010110001)
DI4?    (* report value of digital input four)
```

Related Registers: EG, DO, DID, IO, IOA, IOS

DIN Network Digital Input

Class:	I/O Register	
Type:	Integer, Boolean	
Syntax:	DIN*p1.p2* (e.g., DIN5 DINVI4 DIN3.28 DINVI3.16 DINVI6.VI9)	
Parameters:	*allowed values*	*description*
p1	0 through 63 **or** VI*n*	network address
p2	none **or** 1 through 1024 **or** VI*n*	digital input number

Range:

allowed values 0 through $FFFFFFFF_{16}$ **or** 0 and 1

Note that these minimum and maximum values are a function of your digital input device. Refer to the documentation for your digital input device to determine how to map its values to the motion controller.

Restrictions: Read only. Cannot be accessed in immediate mode over a DeviceNet connection.

Use: The network digital input register contains the values of the network digital inputs. The digital inputs are general-purpose inputs used for process control.

Remarks:

1. When the DIN*p1.p2*? command is executed, the value of the digital input *p2* of the network digital input device addressed at *p1* will be given as a Boolean number.
2. When DIN*p1*? is executed, up to four bytes of the digital inputs of the assigned assembly object instance of the network digital input device addressed at *p1* will be reported as a hexadecimal number.

Example:

```
DINA17=101,2     (* set assembly object instance 101 and 2 bytes)
DIN17?           (* report value of network digital inputs)
16#13AC
```

***Related Registers**:* DINA, DON

DINA Network Digital Input Register Assignment

Class: I/O Register

Syntax: DINA*p1* (e.g., DINA3 DINA63)

Parameters:

	allowed values	*description*
p1	0 through 63	network address

Range:

default	1,1	
allowed values	1 through 255	assembly object instance
	1 through 128	number of bytes

Restrictions: Not allowed in expressions.

Use: This register is used to assign the assembly object instance number and number of bytes to be used by the DIN register to read the network digital inputs from the device addressed at *p1*. The first number of the assignment is the assembly object instance and the second number is the quantity of bytes used by the assembly object instance data attribute.

Example: DINA11=101,2 (* set assembly object instance 101 and 2 bytes)

Related Registers: DIN

DIR Direction of Motor for Forward Moves

Class: Axis Register

Type: String

Syntax: DIR

Range:

default	CW
allowed values	CW, CCW

Restrictions: Not allowed in motion blocks.

Use: This register is used to define the direction of the motor assigned to the axis for forward moves. If DIR is set to CW, a forward move by the motor is clockwise, facing the motor shaft. If DIR is set to CCW, a forward move by the motor is counterclockwise, facing the motor shaft. The Fwd/Rev LED on the front of the controller illuminates green when the axis is moving in the forward direction and yellow when the axis is moving in the negative direction. In a program, this register can be set only when the controller is in the faulted state.

The axis actual position (PSA) is derived from the motor feedback (encoder or resolver) when PFE=0. When PFE=1, the axis position is derived from auxiliary encoder. See DIRX and PFE register descriptions for more details.

Related Registers: DIRN, DIRX , PFE

DIRN Network Direction of Motor

Class: Axis Register

Syntax: DIRN*p1* (e.g., DIRN0 DIRN63 DIRNVI5)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network address

Range:
allowed values CW, CCW

Restrictions: Not allowed in motion blocks. Cannot be accessed in immediate mode over a DeviceNet connection**.**

Use: This command accesses attribute 24 of the DeviceNet position controller object to define the direction of the motor assigned to the axis for forward moves. If DIR is set to CW, a forward move by the motor is clockwise, facing the motor shaft. If DIR is set to CCW, a forward move by the motor is counterclockwise, facing the motor shaft.

DIRX Direction of Auxiliary Position

Class: Axis Register

Type: String

Syntax: DIRX

Range:
default CW
allowed values CW, CCW

Restrictions: S2K servo only. Requires firmware revision 2.5 or later.

Use: The DIRX register defines the relative direction of the auxiliary position. It is important to make a distinction between the axis position and the auxiliary position. The axis position is defined by PSA, while the auxiliary position is defined by PSX. However, the feedback path for auxiliary position is not always from the auxiliary encoder (since the S2K has a flexible set of position modes). The S2K servo controller has three modes of position feedback.

Normal Mode (PFE = 0, PFN = don't care)
In this mode, the axis position is from the main encoder and the auxiliary position is from the auxiliary encoder. DIR controls the direction of forward moves from the main encoder feedback path. DIRX controls the relative direction of position from the auxiliary path (auxiliary encoder) routed to PSX. Therefore, switching DIRX from CW to CCW (or vice versa) will change the polarity of PSX.

Switched Mode (PFE = 1, PFN = 0)
In this mode, the axis position is from the *AUXILIARY* encoder and the auxiliary position is from the *MAIN* encoder. Switched Mode is the same as Normal Mode, except the auxiliary and main feedback paths have been switched. Thus, DIR controls the direction of forward moves from the auxiliary encoder feedback path. DIRX controls the relative direction of position from the main feedback path (main encoder) routed to PSX. In this case, switching DIRX from CW to CCW (or vice versa) will change still change the polarity of PSX, although the path will now be from the main encoder.

Dual Loop Mode (PFE = 1, PFN > 0)
The S2K offers the ability to have both main and auxiliary encoder paths close the axis position loop. This mode is similar to Switched Mode because the axis position is from the AUXILIARY encoder and the auxiliary position is from the MAIN encoder. Therefore, DIR controls the direction of forward moves from the auxiliary encoder feedback path. DIRX controls the relative direction of position from the main feedback path (main encoder) routed to PSX. For dual loop position mode to work correctly, the actual direction of the main and auxiliary encoders must be the same. That is, PSA and PSX must increment, as well as decrement, in the same motor direction. Otherwise, the system will be unstable resulting in a following error for any move.

***Related Commands*:** DIR, DIRXN, PFE, PFN, PSA, PSX

DIRXN Network Direction of Auxiliary Position

Class: Axis Register

Type: String

Syntax: DIRXN*p1* (e.g., DIRXN0, DIRXN63, DIRXNVI5)

Parameters:	*allowed values*	*description*
p1	0 through 63 or VI*n*	network address

Range:
allowed values CW, CCW

Restrictions: S2K DeviceNet servo only. Requires firmware revision 2.5 or later. Not allowed in motion blocks. Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This command accesses attribute 115 of the position controller object. DIRXN is a peer to peer network command that can access (read or write) the DIRX register of any S2K node on a DeviceNet network. The DIRX register defines the relative direction of the auxiliary position (PSX). Please see the description of DIRX for a complete understanding of its behavior.

Related Commands: DIR, DIRX, PFE, PFN, PSA, PSX

DIT Digital Input Filter Time

Class: Input/Output Register

Type: Floating point

Syntax: DIT*p1* (e.g., DIT2 DITVI3)

Parameters:	*allowed values*	*description*
p1	1 through 12 **or** VI*n*	digital input number

Range:

units	seconds
default	0.000
minimum	0.000
maximum	4.000

Restrictions: Cannot be assigned in motion blocks.

Use: This register allows up to three decimal places. The digital input filter time is used to represent the minimum duration of a pulse that the filter will allow to pass. This filter time is applied to the digital input specified.

Remarks: The primary use for this command is to de-bounce a contact connected to a digital input. Generally, contact bounce lasts for less than 30 milliseconds; so setting DIT=.03 should de-bounce the contact. Since filtering slows input response, use the smallest value for filter time that works for the application.

Example: DIT3=.03 (* set digital input filter time to 30 ms)

Related Registers: DI, DIA

DO Digital Output

Class: Input/Output Register

Type: Integer, Boolean

Syntax: DO*p1* (e.g., DO DO12 DOVI1)

Parameters:

Model		*allowed values*	*description*
IC800S_IxxxD2 IC800S_IxxxP2 IC800S_IxxxRD2 IC800S_IxxxRP2	*p1* *p1* *p1* *p1*	none **or** 9 through 14 **or** VI*n*	digital output number
IC800S_IxxxS1 IC800S_IxxxRS1	*p1* *p1*	none **or** 12 through 21 **or** VI*n*	digital output number

Range:

Model		*allowed values*
IC800S_IxxxD2 IC800S_IxxxP2 IC800S_IxxxRD2 IC800S_IxxxRP2	*p1* *p1* *p1* *p1*	0 through $3F00_{16}$ **or** 0 and 1
IC800S_IxxxS1 IC800S_IxxxRS1	*p1* *p1*	0 through $1FF800_{16}$ **or** 0 and 1

Use: The digital output register contains the values of digital outputs. The digital outputs are general-purpose outputs used for process control.

Remarks: 1. When the DO*p1*? command is executed in the terminal window, the value of the specific digital output *p1* will be given as a Boolean number.
2. When DO? is executed, **all** of the digital outputs will be reported as a binary number. The left-most bit represents digital output 14 **or** 21 and the right-most bit represents digital output 9 **or** 12 depending on your controller model number (see ***Parameters*** above).
3. Since DO*p1* is a Boolean value it cannot be used with relational operators (e.g., IF DO12=1 GOTO 100 is invalid; while IF DO12 GOTO 100 is a valid expression).
4. You can force the state of all or any combination of digital outputs using the form DO=xx. For example:

```
DO=0                 (* turn off all digital outputs
DO=256               (* turn on digital output 9
DO=512               (* turn on digital outputs 9 and 10
DO=16#300            (* turn on digital outputs 9 and 10
DO=2#00000100000000  (* turns on digital output 9
```

Example:

```
DO=16#3400           (* turns on digital output 11
DOVI1=1              (* turn digital output VI1 on
DO?                  (* report digital output register)
DO12?                (* report value of digital output 12)
```

Related Registers: DI

DOE Fault on Digital Output Fault Enable

Class: Input/Output Register

Type: Boolean

Syntax: DOE

Range:
default 0
allowed values 0, 1

Restrictions: Cannot be assigned in motion blocks.

Use: This register is used to enable the system to fault on a digital output fault. A digital output fault occurs when the state of the digital output is true but the state of the associated digital input is not (after a time of 4 ms). If DOE is set to 1, the fault on digital output fault is enabled; and if DOE is set to 0, it is disabled.

DON Network Digital Output

Class: I/O Register

Type: Integer, Boolean

Syntax: DON*p1.p2* (e.g., DON5 DONVI4 DON3.28 DONVI3.16 DONVI6.VI9)

Parameters:	*allowed values*	*description*
p1	0 through 63 **or** Vi*n*	network address
p2	none **or** 1 through 1024 **or** VI*n*	digital output number

Range:
allowed values 0 through $FFFFFFFF_{16}$ **or** 0 and 1

Note that these minimum and maximum values are a function of your digital output device. Refer to the documentation for your digital output device to determine how to map its values to the motion controller.

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: The network digital output register contains the values of the network digital outputs. The digital outputs are general-purpose outputs used for process control.

Remarks:
1. When the DON*p1.p2*? command is executed, the value of the digital output *p2* of the network digital output device at address *p1* will be given as a Boolean number.
2. When DON*p1*? is executed, **up to four bytes** of the digital outputs of the assigned assembly object instance of the network digital output device at address *p1* will be reported as a hexadecimal number.

Example:

```
DONA17=101,2     (* set assembly object instance 101 and 2 bytes)
DON17?           (* report value of all network digital outputs at node address17)
16#13AC
```

Related Registers: DONA, DIN

DONA Network Digital Output Register Assignment

Class:	I/O Register	
Syntax:	DONA*p1* (e.g., DONA3 DONA63)	
Parameters:	*allowed values*	*description*
p1	0 through 63	network address
Range:		
default	1,1	
allowed values	1 through 255	assembly object instance
	1 through 128	number of bytes
Restrictions:	Not allowed in expressions.	
Use:	This register is used to assign the assembly object instance number and number of bytes to be used by the DON register to get or set the network digital outputs of the device addressed at *p1*. The first number of the assignment is the assembly object instance and the second number is the quantity of bytes used by that assembly object instance's data attribute.	
Example:	DONA11=101,2 (* set assembly object instance 101 and 2 bytes)	
Related Registers:	DON	

DSE Display Format Enable

Class:	System Register
Type:	Boolean
Syntax:	DSE
Range:	
default	1
allowed values	0, 1
Restrictions:	Cannot be assigned in motion blocks.
Use:	This command is used to enable the display format on the serial port. If DSE is set to 1, the display format is enabled; and if set to 0, the display format is disabled.
Remarks:	When the display format is enabled, output strings from the PUT and OUT commands are prefixed by control code 11_{16} and suffixed by control code 12_{16}. The Whedco OIP display intercepts all strings delimited by the control codes and does not send those strings to its host port.
Related Commands:	PUT, OUT

EG Positive-Edge-Sensitive Digital Input

Class: Input/Output Register

Type: Integer, Boolean

Syntax: EG*p1* (e.g., EG EG4 EGVI3)

Parameters:

Model		*allowed values*	*description*
IC800S_IxxxD2 IC800S_IxxxP2 IC800S_IxxxRD2 IC800S_IxxxRP2	*p1* *p1* *p1* *p1*	none **or** 1 through 14 **or** VI*n*	positive-edge-sensitive digital input number
IC800S_IxxxS1 IC800S_IxxxRS1	*p1* *p1*	none **or** 1 through 21 **or** VI*n*	positive-edge-sensitive digital input number

Range:

Model		*allowed values*
IC800S_IxxxD2 IC800S_IxxxP2 IC800S_IxxxRD2 IC800S_IxxxRP2	*p1* *p1* *p1* *p1*	0 through $3FFF_{16}$ **or** 0 and 1
IC800S_IxxxS1 IC800S_IxxxRS1	*p1* *p1*	0 through $1FFFFF_{16}$ **or** 0 and 1

Use: EG contains the values of all digital inputs that have made a low to high transition since they were last cleared.

Remarks: 1. When the EG*p1*? command is executed from the terminal window, its value will be given as a Boolean number. A value of 1 means digital input *p1* made a low to high state change since its EG value was last read (i.e., cleared).
2. When EG? is executed, **all** positive-edge-sensitive digital inputs will be reported as a binary number. The left-most bit represents digital input 14 or 21, depending on your S2K model number (see ***Parameters*** above); the right-most bit represents digital input 1.
3. After the state of an input is read using the EG command, the EG value of that input is set to zero.
4. When setting the positive-edge-sensitive digital inputs, note that a zero will reset the input, and a 1 will not change the state of the input.

Example:

```
EG=16#1A      (* set EG to 1A16 [i.e., don't change inputs 2, 4, and 5, but reset all others])
EGVI1=0       (* set EG VI1 to 0 [i.e., reset the input represented by variable VI1])
EG?           (* report positive-edge-sensitive input register)
```

Related Registers: DI

EKB Empties Key Buffer

Class: Input/Output Command

Syntax: EKB

Restrictions: Not allowed in motion blocks.

Use: This command empties the key buffer**.**

Related Commands: KY, GET, IN

Related Registers: KEY

END Ends Program or Motion Block and Exits Editor

Class: Program Command

Syntax: END

Restrictions: Allowed only in programs or motion blocks.

Use: This command marks the end of a program or motion block **only** when using the terminal window line editor. If entered while in the terminal window line editor this command also exits the terminal window editor mode. This command should **not** be included in any program or motion block created using the Motion Developer script editors.

Remarks: **Caution:** When used in the terminal window line editor this command will delete all program/motion block statements that follow it. If you want only to exit the terminal window editor, use the "!" command.

Example:

```
PROGRAM1     (* define program 1 using the terminal window editor)
PSA=0        (* set axis position register)
MVL=10       (* set motion velocity)
MAC=40       (* set motion acceleration)
MPA=12       (* set absolute move position)
RPA          (* run to absolute position)
END          (* end program 1 and exit editor if using the terminal window editor)
```

Related Commands: !, PROGRAM, MOTION

EOT Encoder Output Type

Class: Axis Register

Type: Integer

Syntax: EOT

Range:
- *units* lines per revolution
- *default* 0
- *allowed values* Encoder Feedback Controller: 0; 500; 625; 1,000; 1,250; 2,000, 2,500
  Resolver Feedback Controller: 0; 250; 256; 500; 512; 1,000; 1,024

Restrictions: Brushless servo only; not allowed in motion blocks.

Use: This register sets the output type for the encoder output. When this register is set to zero, the encoder output buffers the auxiliary encoder input pulse for pulse. If the input is a quadrature encoder the output will be quadrature. If the input is CW/CCW pulses, the output will be the same format. When the EOT register is non-zero, the encoder output tracks the motor feedback encoder at the resolution set by the EOT value. For encoder-based models, the lines per revolution of the motor encoder is 2,500 (10,000 quadrature) and the encoder output can use the full 2,500 or divide down this resolution based on the allowed values shown above.

The encoder output marker pulse width is fixed at 1/5000th of a revolution of the source encoder. This implies that the marker pulse output width will vary with encoder speed and the smallest width will occur at the highest speed. For example, if the source encoder is rotating at 1,000 RPM or 16.667 rev/sec then the encoder takes 0.06 seconds per revolution. Therefore, 1/5000th of this value, or 12 µS, represents the marker pulse width at that speed.

There is a 40 nanosecond delay between the encoder input and encoder output signals when EOT=0.

Example:

```
EOT=0       (* encoder output uses the auxiliary encoder input)
EOT=1000    (* encoder output provides 1,000 lines per revolution of the motor)
```

EXM Executes Motion Block

Class: Program Command

Syntax: EXM*p1* (e.g., EXM50 EXMVI10)

Parameters:

	allowed values	*description*
p1	1 through 100 **or** VI	motion block number

Restrictions: Not allowed in motion blocks.

Use: This command executes motion block *p1*. If you rename a motion block in a Motion Developer project, the symbolic name replaces the block number (p1) when the EXM command is used in programs. For example, renaming motion block 1 to ***Home*** would then enable the use of either the EXM1 or EXMHome to start the execution of this motion block.

Remarks: If a motion block is already executing when the EXM command is encountered the controller will quit executing that motion block and then execute motion block *p1*. If motion block *p1* is already executing, EXM*p1* will restart it. One motion block cannot start another motion block.

Example:

```
MOTION1     (* edit motion block 1 in the terminal window editor)
MVL=10      (* set motion velocity)
MAC=40      (* set motion acceleration)
MPI=15      (* set incremental move position)
RPI         (* run to incremental move position)
END         (* end motion block 1 and the exit terminal window editor)

EXM1        (* execute motion block 1)
```

What will happen: Issuing the EXM1 command will cause the axis to move 15 axis units in the forward direction.

Related Commands: EXP

EXP — Executes Program

Class: Program Command

Syntax: EXP*p1* (e.g., EXP4 EXPVI9)

Parameters:

	allowed values	*description*
p1	1 through 4 **or** V*in*	program number

Restrictions: Not allowed in motion blocks.

Use: This command executes program *p1*. If you rename a program in a Motion Developer project, the symbolic name replaces the program number (p1) when the EXP command is used in programs. For example, renaming program 4 to ***Fault*** would then enable the use of either the EXP4 or EXPFault to start the execution of this program.

Remarks: If program *p1* is already executing, then this command does nothing.

Example:

```
PROGRAM1        (* edit program 1 in the terminal window editor)
PSA=0           (* set axis position register)
MVL=10          (* set motion velocity)
MAC=40          (* set motion acceleration)
MPA=12          (* set absolute move position)
RPA             (* run to absolute position)
END             (* end program 1 and exit editor)

EXP1            (* execute program 1)
```

What will happen: Issuing the EXP1 command will cause the axis to move to an absolute position of 12 units.

Related Commands: EXM

EXP(*p1*) — Exponential Operator

Type: Floating point

Syntax: EXP(*p1*)

Parameters:

	allowed values
p1	any floating point operand

Use: This operator is used to take the exponential of *p1* (i.e., raise the number e to the power *p1)*.

EXVS Execute Command Stored in String Variable

Class:	Program Command	
Syntax:	EXVS*p1* (e.g., EXVS12 EXVSVI6)	
Parameters:	*allowed values*	*description*
p1	1 through 144 **or** VI*n*	string variable number
Restrictions:	Not allowed in motion blocks.	
Use:	This command executes the command stored in string variable *p1*.	
Remarks:	Commands that are not allowed in programs cannot be executed using EXVS.	
Example:	VS1="MPA=10"	(* set string variable 1)
	EXVS1	(* execute command stored in string variable 1)
What will happen:	Loading string variable 1 and executing the command stored in string variable 1 will set the absolute move position, MPA, to 10 units.	

FALSE, OFF Boolean Operands

Class:	Operand	
Type:	Boolean	
Syntax:	FALSE, OFF, *p1*, *p2*	
Parameters:	*allowed values*	*range*
p1	any Boolean	0, 1
p2	any Boolean register	
Use:	These operands are used as Boolean numbers. TRUE and ON are equivalent to the Boolean number 1, and FALSE and OFF are equivalent to the Boolean number 0.	
Example:	VB1=FALSE	(* set Boolean variable 1 to FALSE [i.e., zero])
	POE1=OFF	(* set power output stage enable of axis one to OFF [i.e., zero])
	DO8=OFF	(* set digital output 8 to zero)
	VB2=0	(* set Boolean variable 2 to zero)
***Related Registers**:*	TRUE, ON	

FAULT Enters Terminal Window Editor at Faulting Statement

Class: Program Command

Syntax: FAULT

Restrictions: Not allowed in programs or motion blocks. Use only in the Motion Developer terminal window while not in line editor mode.

Use: This command enters the terminal window editor and makes the statement that faulted the system the current statement.

Remarks: This command will execute only when the axis has stopped and no programs or motion blocks are executing.

Example:

```
PROGRAM1        (* edit program 1)
PSA=0           (* set axis position register)
STF             (* set fault)
END             (* end program 1)

EXP1            (* execute program 1 from terminal window)
FAULT           (* enter terminal window editor and make statement that faulted system the
                (* current statement)
*STF
```

FC Fault Code

Class: System Register

Type: Integer, Boolean

Syntax: FC*p1* (e.g., FC FC5 FCVI3)

Parameters:

	allowed values	*description*
p1	none **or** 0 through 31 **or** VI*n*	fault code register bit number

Range: *allowed values*
0 through $FFFFFFFF_{16}$ **or** 0 and 1

Restrictions: Read only.

Use: The fault code register is used to identify what type of fault has taken place.

Remarks:

1. When the FC? command is executed from the terminal window, the fault code register value will be given as an English statement as shown in the message column it the table below. If no fault has occurred, the message given is *Controller functional*.
2. The Fault Code register is latched. Once a bit is set true it will not be cleared until faults are reset (RSF command executed).
3. If the computer interface format is enabled (CIE=1), and the FC? command is executed, the fault code register value will be given as an integer number equal to the decimal equivalent of the registers binary value. If no fault has occurred, the fault code register is set to 0. The possibilities are listed in the table below.
4. When FCx is executed the Boolean status of bit 'x' will be given.

bit	message	bit	message
0	Power Failure	18	Reserved
1	Reserved	19	Network Power Failure
2	Software Fault	20	Duplicate Network Address
3	Lost Enable	21	Excessive Following Error
4	Digital Output Fault	22	Excessive Command Increment
5	Invalid Command in String	23	Position Register Overflow
6	Transmit Buffer Overflow	24	Position Feedback Lost (Resolver Feedback Models Only)
7	Resource Not Available	25	Motor Power Over-Voltage
8	Invalid Variable Pointer	26	(4.3 Amp) Motor Power Clamp Excessive Duty Cycle
9	Mathematical Overflow		(7.2 Amp) Motor Power Clamp Excessive Duty Cycle—Under-Voltage
10	Mathematical Data Error		(16–28 Amp) Motor Power Under-Voltage
11	Value Out of Range	27	(4.3 Amp) Reserved
12	String Too Long		(7.2 Amp) Motor Power Clamp Over-Current Fault
13	Nonexistent Label		(16–28 Amp) Motor Power Clamp Excessive Duty
14	Gosub Stack Underflow	28	Motor Over-Current Fault
15	Gosub Stack Overflow	29	Motor Over-Temperature Fault (Resolver Feedback Models Only)
16	Invalid Motion	30	Controller Over-Temperature
17	Reserved	31	Network Communication Error

FCN Network Fault Code

Class: System Register

Type: Integer, Boolean

Syntax: FCN*p1* (e.g., FCN FCN4 FCNVI6)

Parameters:

	allowed values	*description*
p1	none **or** 0 through 15 **or** VI*n*	network fault code register bit number

Range:
allowed values 0 through $FFFF_{16}$ or 0 and 1

Restrictions: Read only.

Use: The network fault code register is used to identify what type of network fault has taken place. Applies to DeviceNet and PROFIBUS networks.

Remarks: 1. When the FCN? command is executed in the terminal window, the network fault code register value will be given as an English statement as shown in the message column in the table below. If no fault has occurred, the message given is *Network Functional*.
2. If the computer interface format is enabled (CIE=1), and the FCN? command is executed, the network fault code register value will be given as an integer number equal to the decimal equivalent of the registers binary value. If no fault has occurred, the network fault code register is set to 0. The possibilities are listed below.
3. When FCNx is executed the Boolean status of bit 'x' will be given.

Bit	message	bit	message
0	Network Off-line	8	Not Enough Data
1	Addressed Device Not Present	9	Too Much Data
2	Addressed Device Out of Connections	10	Device State Conflict
3	Connection Deleted Unexpectedly	11	I/O Scan Time-Out
4	TIME-OUT ON RESPONSE	12	Invalid Attribute Value
5	Not Requested Response	13	Attribute Not Supported
6	Error Response	14	Object Does Not Exist
7	Resource Unavailable	15	Reserved

FCNN Network Device Fault Code

Class: System Register

Type: Integer, Boolean

Syntax: FCNNp1.p2 (e.g., FCNN0 FCNN63.31 FCNN2.VI3 FCNNVI5.VI3)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network node address
p2	none or 0 through 31 **or** VI*n*	network device fault code register bit number

Range:
allowed values 0 through FFFFFFFF$_{16}$ **or** 0 and 1

Restrictions: Read only. Cannot be accessed in immediate mode over a DeviceNet connection. When used with the Motor Cube device, only bits 3, 16, 21, 26, 28, 29, and 30 are supported; the remaining bits are reserved for future use.

Use: The network device fault code register accesses attribute 100 of the DeviceNet position controller object to identify what type of fault has taken place in the device addressed at *p1*.

Remarks: 1. When the FCNN? command is executed, the fault code register value will be given as an English statement. If no fault has occurred, the message given is *Controller functional*.
2. If the computer interface format is enabled (CIE=1), and the FCNN? command is executed, the fault code register value will be given as an integer number. If no fault has occurred, the fault code register is set to 0. The possibilities are listed below:

bit	message	bit	message
0	Power Failure	18	Reserved
1	Reserved	19	Network Power Failure
2	Software Fault	20	Duplicate Network Address
3	Lost Enable	21	Excessive Following Error
4	Digital Output Fault	22	Excessive Command Increment
5	Invalid Command in	23	Position Register Overflow
6	Transmit Buffer	24	Resolver Feedback Lost
7	Resource Not Available	25	Motor Power Over-Voltage
8	Invalid Variable Pointer	26	(4.3–7.2 Amp) Motor Power Clamp Excessive Duty Cycle—Under-Voltage
9	Mathematical Overflow		(16–28 Amp) Motor Power Under-Voltage
10	Mathematical Data	27	(4.3 Amp) Reserved
11	Value Out of Range		(7.2 Amp) Motor Power Clamp Over-Current Fault
12	String Too Long		(12–28 Amp) Motor Power Clamp Excessive Duty Cycle
13	Nonexistent Label	28	Motor Over-Current Fault
14	Gosub Stack Underflow	29	Motor Over-Temperature
15	Gosub Stack Overflow	30	Controller Over-Temperature
16	Invalid Motion	31	Network Communication
17	Reserved		

FE Axis Following Error

Class: Axis Register

Type: Floating point

Syntax: FE

Range:
- *units* axis units
- *minimum* 0 pulses
- *maximum* 16,000 pulses

Restrictions: Read only.

Use: The axis following error is the difference between the axis position, PSA, and the command position, PSC.

Remarks: The numerical values for the minimum and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the minimum and maximum values must be divided by the value of (URA/URB) (see URA and URB).

Related Registers: PSA, PSC, FEB, URA, URB

FEB Following Error Bound

Class: Axis Register

Type: Floating point

Syntax: FEB

Range:
- *units* axis units
- *defaults* 5,000 pulses (stepper)
  1,000 pulses (encoder feedback servo)
  400 pulses (resolver feedback servo)
- *minimum* 0 pulses
- *maximum* 16,000 pulses

Use: The following error bound is a limit set on the following error (FE). If this limit is exceeded, the system will fault and the motor will free-wheel to a stop.

Remarks: **This value must always be set to a non-zero value. If FEB is set to zero the controller will fault when initiating any motion command or block.** The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, minimum, and maximum must be divided by the value of (URA/URB) (see URA and URB).

Example:
```
FEB=0.5     (* set following error bound)
FEB?        (* report value of following error bound)
```

Related Registers: FE, URA, URB

FI Fault Input

Class: System Register

Type: Integer, Boolean

Syntax: FI*p1* (e.g., FI FI8 FIVI7)

Parameters:

	allowed values	*description*
p1	none **or** 0 through 15 **or** VI*n*	fault input register bit number

Range:

allowed values 0 through $FFFF_{16}$ **or** 0 and 1

Restrictions: Read only.

Use: The fault input register is used to identify what type of faults are currently active.

Remarks:

1. When the FI? command is executed from the terminal window, the fault input register value will be given as an English statement as shown in the message column in the table below. If no faults are active, the message given is *No fault input is active*.
2. If the computer interface format is enabled, and the FI? command is executed, the fault input register value will be given as an integer number equal to the decimal equivalent of the registers binary value. If no faults are active, the fault input register is set to 0. The possibilities are listed below.
3. When FIx is executed the Boolean status of bit 'x' will be given.

bit	message
0	(Encoder-feedback controllers) Reserved
	(Resolver-feedback controllers) Position feedback lost input active
1	Motor power over-voltage input active
2	(4.3 Amp) Motor power clamp input active
	(7.2 Amp) Motor power clamp or under-voltage input active
	(16–28 Amp) Motor power under-voltage input active
3	(4.3 Amp) Reserved
	(7.2 Amp) Motor power clamp over-current input active
	(16–28 Amp) Motor power clamp input active
4	Motor over-current input active
5	(Encoder-feedback controllers) Reserved
	(Resolver-feedback controllers) Motor over-temperature input active
6	Controller over-temperature input active
7	Network power failure input active
8–15	Reserved

FIN Find String in String Operator

Class: Operator

Type: Integer

Syntax: FIN(*p1*,*p2*)

Parameters: *allowed values*
p1 any string operand
p2 any string operand

Use: This operator is used to find string *p2* in string *p1*. If *p2* is found in *p1*, the value returned is the location of the first character of *p2* in the string *p1* where a value of 1 represents the first (leftmost) character of string *p1*. If *p2* is not in *p1*, the value returned is 0.

Example:

VS1="Jogging"	(* set string variable 1 to "Jogging")
VI1=FIN(VS1,"Jog")	(* set integer variable 1 to location of first character of "Jog" in string variable (* VS1)
VI1?	(* report value of integer variable 1)
*1	
VI2=FIN(VS1,"in")	(* set integer variable 2 to location of first character of "in" in VS1)
VI2?	(* report value of integer variable 2)
5	('in' starts at the 5^{th} character in the string "jogging")
VI3=FIN(VS1,"Hello")	(* set integer variable 3 to location of first character of "Hello" in string (* variableVS1)
VI3?	(* report value of integer variable 3)
0	(* zero indicates "hello" was not found in the string "jogging")

FIRMWARE Downloads and Saves Firmware

Class: System Command

Syntax: FIRMWARE

Restrictions: Not allowed in programs or motion blocks.

Use: This command, when executed from the terminal window, sets the controller in a mode to receive an updated firmware file and save it in nonvolatile memory. **Note: Firmware downloads are supported by Motion Developer version 1.4 and later.**

Remarks: This command will execute only when the controller is faulted and no programs or motion blocks are executing.

FR Axis Feedback Resolution

Class: Axis Register

Type: Integer

Syntax: FR

Range:

units	pulses/revolution
defaults	10,000 (encoder feedback servo; S-Series motors) 4,096 (resolver feedback brushless servo)
minimum	500
maximum	1,000,000

Restrictions: Servo only.

Use: The axis feedback resolution is defined as the number of position feedback pulses per revolution of the axis motor. The actual source, and, therefore, the resolution for the axis position feedback depends on the setting of the Position Feedback Enable (PFE) register and the Position Feedback Numerator (PFN) register:

PFE=0 & PFN=n/a (Use motor encoder for axis position feedback):
In PFE is set to 0, then FR must be set to the feedback resolution of the motor connected to the main feedback (encoder or resolver) path.

For S2Ks with encoder feedback, in this mode FRC must be set to the same value as FR (Firmware revision 2.5 and later).

PFE=1 & PFN=0 (Single Loop—Use the auxiliary encoder for axis position feedback):
If the PFE register is TRUE and the PFN register is zero, then the controller closes the axis position loop using the auxiliary encoder feedback. The auxiliary encoder is used to update the axis position register (PSA) and is used as position feedback for the axis, while the motor feedback (encoder or resolver) is still used for commutation of the motor. In this mode, the FR register must be set to the number of auxiliary encoder quadrature pulses that are equivalent to one revolution of the **motor**. This determination must include all gearing and mechanical translation in both the auxiliary encoder and motor connection to the load. For example, consider an application where a 1,000 line auxiliary encoder is belted to the load end of a ball screw using a 5:1 ratio with the motor mounted to the opposite end of the screw through a 2:1 gearbox. For each screw revolution the auxiliary encoder makes 5 revolutions and generates 20,000 quadrature pulses to the controller (5 rev * 4000 pulses/rev) while the motor makes 2 revolutions. Therefore, for each revolution of the motor the auxiliary encoder generates 10,000 pulses and FR=10,000.

PFE=1 & PFN=non-zero value (Dual Loop—Use auxiliary encoder AND motor feedback for primary feedback & also use motor feedback as secondary feedback):
In this dual-loop mode, FR must be set to the resolution of the motor feedback (encoder or resolver). Also, PFN and PFD must be set to scale the auxiliary encoder resolution to match the resolution of the motor feedback (encoder or resolver). For example, if the motor feedback has a resolution of 10,000 pulses/rev and the auxiliary feedback has a line count of 1,000 (4,000 pulses/rev), then the ratio of PFN/PFD must be equal to 10,000/4,000. PFN and PFD do not have to be reduced to their lowest common denominator form (although they can be). For instance, setting PFN=10,000 and PFD=4,000 is the same as setting PFN=5 and PFD=2.

Related Commands: AUTOTUNE

Related Registers: FRC, PFE, PFN, PFD

FRC Axis Feedback Resolution for Commutation

Class: Axis Register

Type: Integer

Syntax: FRC

Range:

units	pulses/revolution
default	10,000
minimum	100
maximum	64,000

Restrictions: S2K servo encoder feedback only. Requires firmware revision 2.5 or later.

Use: Similar to FR, FRC is the feedback resolution equal to the number of pulses per revolution for the axis. The distinguishing factor is that FRC is used for the position feedback path that is commutating the motor. The S2K servo controller with encoder feedback has two position feedback paths. The first path is called the main (or motor) feedback, which is located on the DB15 Position Feedback connector. The second path is called the auxiliary feedback, which is located on a separate connector. The S2K always commutates the motor from the main feedback path, regardless of position mode (See PFE). Therefore, FRC must *ALWAYS* be set to the feedback resolution of the encoder that is connected to the main feedback input.

Axis Position from Main Encoder (PFE=0):
In this mode FRC must be equal to FR, since the motor commutation and axis position feedback are both derived from the motor encoder.

Axis Position from Auxiliary Encoder (PFE=1):
In this mode FRC must be set to the resolution of the main (motor) encoder feedback, and FR must be set to the resolution of the auxiliary encoder feedback.

Firmware Revisions 2.4 and 2.5 Backward Compatibility:
There is backward compatibility for users going from S2K firmware revision 2.4 to revision 2.5. If the user application program sets CMR=1, FRC will automatically default to 10,000. Thus, setting CMR=1 will still commutate GE Fanuc S-Series motors with standard 10,000 pulse/rev encoders. Programs designed for revision 2.4 or earlier, which use S-Series motors (CMR=1), will not require program code modifications to include FRC once the controller is upgraded to firmware revision 2.5 or later.

Related Commands: FR, PFE, CMR

FTI Convert Floating Point to Integer Operators

Class: Operator

Type: Integer

Syntax: FTI(*p1*)

Parameters: *allowed values*

p1 any floating point operand

Use: Used to convert floating point operand *p1* to an integer by rounding to the nearest integer. If a truncation conversion is required use the TRC operator.

Remarks: If the floating point number is too large to be represented by an integer, then the FTI operator will return a result of zero and set the *Floating Point Value Out of Range* bit (bit 6) of the Program Status Register (SRP) to true (1). See Chapter 7 for information on status registers.

Example:

```
VF1=12.9505      (* set floating point variable 1 to 12.9505)
VI1=FTI(VF1)     (* set integer variable 1 to VF1 converted to integer by rounding)
VI1?             (* report value of integer variable VI1 in terminal window)
*13
```

Related Registers: TRC

FTS Convert Floating Point to String Operator

Class: Operator

Type: String

Syntax: FTS (*p1,p2,p3*)

Parameters:

	allowed values	*description*
p1	any floating point operand	floating point operand
p2	any integer operand in range 0 through 40	field width
p3	any integer operand in range 0 through 10	number of decimal places

Use: This operator is used to convert floating point operand *p1* to a string with field width *p2* and *p3* decimal places.

Remarks: 1. If the floating point number cannot be contained in the field width specified, then the result is a string of asterisks of length equal to the field width.
2. The field width (*p2*) must include a character for the decimal point and sign of the number. For example, to display 123.456 a field width of eight must be used.
3. If the field width (*p2*) is set to 0, then the result is the string representation of the floating point number, which has the minimum field width. When *p2*=0 the number of decimal places (*p3*) field is ignored.

Example:

```
VF1=12.9505          (* set floating point variable 1 to 12.9505)
VS1=FTS(VF1,6,2)     (* set string variable 1 to VF1 converted to string with field width 6 and 2
                     (* decimal places)
VS1?                 (* report value of string variable 1)
*"  12.95"
```

FUNCTION Goes to Label Associated with Key Pressed

Class: Input/Output Command

Syntax: FUNCTION *p1, p2, p3, p4, p5, p6, p7, p8, p9, p10, p11, p12*

Parameters:

	allowed values	*description*
p1	0, 1 through 999	label associated with function key A
...	... ...	
p12	0, 1 through 999	label associated with function key L

Restrictions: Allowed only in programs.

Use: This command, when executed in a program, first fetches the key code from the key buffer. If there is no key in the key buffer, it will wait for a key to be pressed. If a function key has been pressed, program execution is then transferred to the statement at the label associated with the function key pressed. If any other key has been pressed, the key code goes back into the key buffer and execution continues at the next program statement.

Remarks: If one or more of the function keys have been disabled by setting KYA*p1* to OFF, where *p1* is the number of the function key, it is appropriate to set the associated label(s) in the FUNCTION statement equal to 0.

Examples:

```
PROGRAM1 (* edit program 1)
PSA=0        (* set axis position)
MVL=5        (* set motion velocity)
MAC=40       (* set motion acceleration)
5 FUNCTION 10,20,30,5,5,5,5,5,5,5,5,5     (* go to label associated with key pressed)
GET VS1      (* get character from key buffer)
GOTO 5       (* go back and wait for another key press)
10 RVF       (* run forward)
GOTO 5       (* go back and wait for another key press)
20 RVR       (* run reverse)
GOTO 5       (* go back and wait for another key press)
30 ST30 ST1 (* stop axis)
WAIT IP      (* wait for axis to be in position)
GOTO 5       (* go back and wait for another key press)
END          (* end program 1 and exit editor)
```

What will happen: This program, once executed, will set the axis position, motion velocity, and acceleration. It will then wait for a key to be pressed, and then the program execution will go to label 10, 20, 30, or 5, depending on which function key was pressed. If some other key was pressed, then the key code is taken out of the key buffer (GET VS1) and execution goes back to label 5.

Related Commands: GOTO

GET Gets One Character from Key Buffer

Class: Input/Output Command

Syntax: GET *p1* (e.g., GET VI5 GET VS10)

Parameters:

	allowed values	description
p1	any variable register	variable register

Restrictions: Allowed only in programs.

Use: This command gets one character from the key buffer (256 bytes max.)and loads it into the variable *p1*. If no character is available in the key buffer, then this command waits until a character is put into the key buffer.

Remarks:
1. If *p1* is a Boolean variable, VB*n* or VBVI*n*, the resulting value will be 0 if the character is ASCII 0; otherwise the resulting value is 1.
2. If *p1* is a floating point or integer variable, VF*n*, VFVI*n*, VI*n*, VIVI*n*, the resulting value will be the ASCII value of the character. (see Appendix A)
3. If *p1* is a string variable, VS*n* or VSVI*n*, the resulting value is the actual character.

Example:

```
PROGRAM1      (* edit program 1 in the terminal window)
GET VI1       (* get one character from the key buffer)
GET VS1       (* get one character from the key buffer)
END           (* end program 1 and exit editor)

EXP1          (* execute program 1)
KYE           (* put character 'E' into key buffer)
KYE           (* put character 'E' into key buffer)
VI1?          (* report value of integer variable register)
* 69          (* capital letter 'E' has an ASCII value of 69)
VS1?          (* report value of string variable register)
* E
```

Related Commands: PUT, IN, OUT, EKB

GOSUB Unconditional Branch to Subroutine Label

Class: Program Command

Syntax: GOSUB*p1* (e.g., GOSUB349 GOSUBVI10)

Parameters:

	allowed values	*description*
p1	1 through 999 **or** VI*n*	label number

Restrictions: Allowed only in programs.

Use: This command causes the program execution to go unconditionally to the subroutine at label *p1*. The program will return to the line immediately following the GOSUB command when it encounters the RETURN command.

Remarks: There can be up to 32 nested GOSUB statements in a program.

Example:

```
PROGRAM1            (* program 1)
PSA=0               (* set axis position register)
MVL=1               (* set motion velocity)
MAC=10              (* set motion acceleration)
RVF                 (* run to velocity forward)
GOSUB5              (* unconditional jump to subroutine at label 5)
VI1=6               (* load integer variable)
GOSUBVI1            (* unconditional jump to subroutine at label 6)
GOTO10              (* unconditional jump to label 10)
5  OUT "Press any key to stop axis $N             (* output string expression to display)
GET VI2             (* get one character from key buffer)
ST                  (* stop axis)
RETURN              (* return from subroutine at label 5)
6 OUT "Axis  position is "+ FTS(PSA,5,2) + " units.$N"     (* output string expression to display)
RETURN              (* return from subroutine at label 6)
10 END              (* end program 1)
```

What will happen: This program, once executed, runs the axis in the forward direction. Then the execution goes to the subroutine at label 5, which waits for a character from the key buffer and returns upon receiving the character. Next, the execution goes to the subroutine at label 6, which prints the axis position on the display and returns. It then goes to the statement at label 10, which ends the program.

***Related Commands**:* GOTO, RETURN, POP, RSTSTK

GOTO Unconditional Jump to Program Label

Class: Program Command

Syntax: GOTO*p1* (e.g., GOTO50 GOTOVI43)

Parameters:

	allowed values	*description*
p1	1 through 999 **or** VI*n*	label number

Restrictions: Allowed only in programs.

Use: This command causes the program execution to go unconditionally to the statement at label *p1*.

Example:

```
PROGRAM1                (* program 1)
PSA=0                   (* set axis position register)
MVL=1                   (* set motion velocity)
MAC=10                  (* set motion acceleration)
RVF                     (* run to velocity forward)
GOSUB5                  (* unconditional jump to subroutine at label 5)
VI1=6                   (* load integer variable)
GOSUBVI1                (* unconditional jump to subroutine at label 6)
GOTO10                  (* unconditional jump to label 10)
5 OUT "Press any key to stop axis $N"             (* output string expression to display)
GET VI2                 (* get one character from key buffer)
ST                      (* stop axis)
RETURN                  (* return from subroutine at label 5)
6 OUT "Axis position is " + FTS(PSA,5,2) + " units.$N"    (* output string expression to display)
RETURN                  (* return from subroutine at label 6)
10 END                  (* end program 1)
```

What will happen: This program, once executed, runs the axis in the forward direction. Then the execution goes to the subroutine at label 5, which waits for a character from the key buffer and returns upon receiving the character. Next, the execution goes to the subroutine at label 6, which prints the axis position on the display and returns. It then goes to the statement at label 10, which ends the program.

***Related Commands**:* GOSUB

GRB Gearing Bound

Class: Motion Register

Type: Floating point

Syntax: GRB

Range:
units axis units/sec
default 0 pulses/sec
minimum 0 pulses/sec
maximum 16,000,000 pulses/sec

Use: This register sets a bound on the maximum axis pulses per second that the electronic gearing function can command. If the pulse input rate times the gearing ratio (GRN/GRD)results in a value outside of the bound, then the extra pulses are discarded (i.e., the rate is clamped at the bound limit). When the value of GRB is zero, there is no bound on electronic gearing. See Section 5.5.2, *Using Electronic Gearing*, for more details.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, minimum, and maximum values must be divided by the value of (URA/URB) (see URA and URB).

***Related Registers*:** GRN, GRD

GRD Gearing Denominator

Class: Motion Register

Type: Integer

Syntax: GRD

Range:
default 1
minimum 1
maximum 10,000

Use: The gearing denominator is a parameter used in electronic gearing. It is defined as the denominator of the gearing ratio between the axis and the gearing input. The gearing input source is typically the auxiliary encoder input unless the handwheel input is enabled (HWE=1). Change the sign on the GRN parameter to change motor direction while gearing is enabled (GRE=1).

Axis Pulses = Gearing Input Pulses * GRN/GRD.

If either GRN or GRD is outside the allowed range try dividing both register values by a prime number (2, 3, 5, 7, 11, etc.) until both values are integers within the allowable range.

See Section 5.5.2, *Using Electronic Gearing*, for more details.

Related Registers: GRN, GRE, HWE, QTX

GRE Gearing Enable

Class: Motion Register

Type: Boolean

Syntax: GRE

Range:
default 0
allowed values 0, 1

Use: The gearing enable is used to enable electronic gearing. If GRE is set to 1, then electronic gearing is enabled and the axis will follow the gearing input based on the gearing ratio (GRN/GRD); and if GRE is set to 0, it is disabled.

Remarks: Electronic gearing does not use acceleration/deceleration limits and will accelerate/decelerate as quickly as system constraints will allow when the GRE bit is set true/false. Use pulse-based motion when acceleration limits are required. When the gearing enable bit is set true the controller will begin to accumulate master encoder pulses. If gearing is enabled while the master is moving the axis will overspeed within system constraints in an attempt to decrement any master pulses that accumulate while the axis is accelerating. Gearing is automatically disabled when a controller fault occurs. See Section 5.5.2 – *Using Electronic Gearing* for more details.

Related Registers: GRD, GRN, GRB, GRF, QTX

Motion Templates: Electronic gearing

GRF Gearing Filter Constant

Class: Motion Register

Type: Integer

Syntax: GRF

Range:
default 0
minimum 0
maximum 8

Use: The gearing filter constant is used to filter the output of electronic gearing. The amount of filtering increases by the value as a power of two from 0 (no filter) to 8 (a filter of 256 samples). Note that higher values slow system response so use the smallest acceptable value. See Section 5.5.2, *Using Electronic Gearing*, for more details.

Related Registers: GRB, GRN, GRD

GRN Gearing Numerator

Class: Motion Register

Type: Integer

Syntax: GRN

Range:
default 1
minimum -10,000
maximum 10,000

Use: The gearing numerator is a parameter used in electronic gearing. It is defined as the numerator of the gearing ratio between the axis and the gearing input. The gearing input source is typically the auxiliary encoder input unless the handwheel input is enabled (HWE=1). Changing the sign of the GRN value will change the direction of the motor while gearing is enabled (GRE=1).

Axis Pulses = Gearing Input Pulses * GRN/GRD.

If either GRN or GRD is outside the allowed range try dividing both register values by a prime number (2, 3, 5, 7, 11, etc.) until both values are integers within the allowable range.

See Section 5.5.2, *Using Electronic Gearing*, for more details.

Related Registers: GRD, GRE, HWE, QTX

HSE XON, XOFF Handshake Protocol Enable

Class: System Register

Type: Boolean

Syntax: HSE

Range:
default 0
allowed values 0, 1

Restrictions: Cannot be assigned in motion blocks.

Use: This register is used to enable the XON, XOFF handshake protocol on the serial/program port. If HSE is set to 1, then handshake protocol is enabled; and if HSE is set to 0, then it is disabled.

Related Registers: CIE

HT Halts Motion

Class: Motion Command

Syntax: HT

Use: This command immediately halts all axis motion.

Remarks: This command should be used only at low velocities or in extreme situations as the sudden stop may damage mechanical components in the system. This command sets SRA register bits 0, 1, 2, and 14 to Logic 0.

Example:

```
MVL=10    (* set motion velocity)
MAC=10    (* set motion acceleration)
RVF       (* run to velocity forward)
HT        (* halt motion)
```

What will happen: Setting the velocity and acceleration and issuing the RVF command will cause the axis to run in the forward direction. Issuing the HT command will cause the axis to halt immediately.

***Related Commands**:* ST

HTN Network Halt

Class: Motion Command

Syntax: HTN*p1* (e.g., HTN0 HTN63 HTNVI5)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network node address

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: The network halt command accesses attribute 21 of the DeviceNet position controller object to immediately halt all motion for the axis addressed at *p1*.

Remarks: This command should be used only at low velocities or in extreme situations because the sudden stop may damage mechanical components in the system. For normal stops use the STN command.

***Related Commands*:** HT, ST, STN

HWE Handwheel Input Enable

Class: Motion Register

Type: Boolean

Syntax: HWE

Range:
default 0
allowed values 0, 1

Use: The handwheel input enable is used to enable handwheel quadrature input on digital inputs 5 (handwheel channel A) and 6 (handwheel channel B) to be used in place of the auxiliary encoder input for electronic gearing. If HWE is set to 1, then handwheel input is enabled; and if HWE is set to 0, it is disabled and the auxiliary encoder is used as the electronic gearing input source. The axis will follow the auxiliary input based on the values of GRN and GRD as shown below:

Axis pulses = Handwheel Input Pulses * GRN/GRD

Remarks: The maximum pulse rate is 500 pulses/second.

Utility Template: Jog using electronic handwheel

IF...GOSUB Conditional Jumps to Subroutine Label

Class: Program Command

Syntax: IF *p1* GOSUB*p2* (e.g., IF VB5 GOSUB35)

Parameters:

	allowed values	*description*
p1	any Boolean expression	Boolean expression
p2	1 through 999 **or** VI*n*	label number

Restrictions: Allowed only in programs.

Use: This command causes the program execution to go conditionally to the subroutine at label *p2* if condition *p1* is true (i.e., evaluates to 1). The program will return when it encounters the RETURN command.

Remarks: There can be up to 32 nested gosub statements in a program.

Example:

```
PROGRAM1                 (* program 1)
PSA=0                    (* set axis position register)
MVL=1                    (* set motion velocity)
MAC=10                   (* set motion acceleration)
RVF                      (* run to velocity forward)
OUT “Press any key to stop axis  $N”                (* output string expression to display)
1 IF KEY GOSUB5          (* conditional jump to subroutine at label 5)
IF IP GOTO10             (* conditional jump to label 10)
GOTO1                    (* unconditional jump to label 1)
5 OUT “Axis position is “ + FTS(PSA,5,2) + “ units.$N”    (* output string expression to display)
EKB                      (* empty key buffer)
ST                       (* stop axis)
RETURN                   (* return from subroutine at label 5)
10 END                   (* end program 1)
```

What will happen: This program runs the axis in the forward direction. It then waits for a character from the key buffer and goes to the subroutine at label 5 upon receiving the character. This subroutine prints the axis position on the display, empties the key buffer, stops the axis, and returns. Once the axis is in position (IP), the execution goes to the statement at label 10, which ends the program.

Related Commands: GOSUB, IF...GOTO, RETURN, POP, RSTSTK

IF...GOTO Conditional Jump To Program Label

Class: Program Command

Syntax: IF *p1* GOTO*p2* (e.g., IF VB3 GOTO11)

Parameters:

	allowed values	*description*
p1	any Boolean expression	Boolean expression
p2	1 through 999 **or** VI*n*	label number

Restrictions: Allowed only in programs.

Use: This command causes the program execution to go conditionally to label *p2* if *p1* is true (i.e., evaluates to 1).

Example:

```
PROGRAM1              (* edit program 1)
PSA=0                 (* set axis position register)
MVL=1                 (* set motion velocity)
MAC=10                (* set motion acceleration)
RVF                   (* run to velocity forward)
OUT "Press any key to stop axis$N"  (* output string expression to display)
1 IF KEY GOSUB5       (* conditionally gosub 5)
IF IP GOTO10          (* conditionally goto 10)
GOTO1                 (* unconditionally goto 1)
5 OUT "Axis position is " + FTS(PSA,5,2) + " units.$N"     (* output string expression to display)
EKB                   (* empty key buffer)
ST                    (* stop axis)
RETURN                (* return from gosub)
10 END                (* end program 1 and exit editor)
```

What will happen: This program, once executed, runs the axis in the forward direction. It then waits for a character from the key buffer and goes to the subroutine at label 5 upon receiving the character. This subroutine prints the axis position on the display, empties the key buffer, stops the axis, and returns. Once the axis is in position (IP), the execution goes to the statement at label 10, which ends the program.

Related Commands: GOTO, IF...GOSUB, IF...THEN

IF...THEN Conditionally Executes Next Command

Class: Program Command

Syntax: IF *p1* THEN (e.g., IF VF3>1.1 THEN)

Parameters:

	allowed values	*description*
p1	any Boolean expression	Boolean expression

Restrictions: Allowed only in programs and motion blocks.

Use: This command conditionally executes the next command in the program. If condition *p1* is true the next program line is executed. Otherwise, the next line is skipped.

Example:

```
PROGRAM1        (* edit program 1)
VB1=0           (* set Boolean variable)
IF VB1 THEN     (* conditionally execute next command)
VF5=30          (* set floating point variable)
END             (* end program 1 and exit editor)
```

What will happen: This program, once executed, sets Boolean variable one to zero and does not set floating point variable to 30 because the condition of the IF...THEN command was false.

***Related Commands**:* IF...GOTO

IN — Inputs Register Value from Key Buffer

Class: Input/Output Command

Syntax: IN p1 (e.g., IN VI5   IN VS10)

Parameters:

	allowed values	*description*
p1	any variable register	variable register

Restrictions: Allowed only in programs.

Use: This command inputs a register value from the key buffer. The characters entered are echoed back to the display device until an invalid character or a carriage return is entered. If an invalid character is entered, then the command aborts and the offending character is left in the key buffer.

Remarks:
1. If *p1* is a Boolean, floating point, or integer variable, VB*n*, VBVI*n*, VF*n*, VFVI*n*, VI*n*, VIVI*n*:
   a.) if the number is greater than 40 characters long, or if it is out of the numerical range of the variable, then bit 5 in the program status register will be set to 1, which means "String value out of range." A zero will be loaded into the variable.
   b.) if one or more of the characters is not valid, then bit 4 in the program status register will be set to 1, which means "Invalid digit in string." A zero will be loaded into the variable.

2 If *p1* is a string variable, VS*n,* or VSVI*n*, and the string entered is greater than 127 characters, only the first 127 characters will be loaded. The rest will stay in the key buffer.

Example:

```
     PROGRAM1                           (* edit program 1)
     OUT "Enter an integer:$N"          (* output string expression to display)
1    IN VI1                             (* input register value from key buffer)
     IF NOT CE1 GOTO2                   (* conditionally goto 2)
     OUT "Invalid number -Enter again$N"   (* output string expression to display)
     EKB                                (* empty key buffer)
     GOTO1                              (* unconditionally goto 1)
2    OUT "Enter a string:$N"            (* output string expression to display)
     IN VS1                             (* input register value from key buffer)
     END                                (* end program 1 and exit editor)
```

What will happen: This program, once executed, will prompt the user to enter an integer. After the user enters the number, the program checks to see if both program status register bits 4 and 5 (CE1) are not set. If either one is set, the program prints an error message and asks the user to enter it again. If neither one is set, the program goes to 2, where the user will be prompted to enter a string. Once it is entered, the program ends.

***Related Commands*:** GET, OUT

Related Registers: CE

INS, DEL Edit String Operators

Class: Operator

Type: String

Syntax: INS(*p1*,*p2*,*p4*) DEL(*p1*,*p3*,*p4*)

Parameters:

	allowed values	*description*
p1	any string operand	string to be edited
p2	any string operand	string to be inserted
p3	any integer operand >= 0	number of characters to delete
p4	any integer operand >= 1	location in *p1* to insert/delete

Use: These operators are used to edit string operand *p1*. The operations are described below:

INS insert characters into string—inserts string operand *p2* into string operand *p1* at location *p4*.
DEL delete characters from string—deletes *p3* characters starting at location *p4* of string operand *p1*.

Example:

```
VS1="Drill operation"        (* set string variable 1 to "Drill operation")
VS2=INS(VS1,"in ",7)         (* set string variable 2 to SV1 with "in " inserted at location 7)
VS2?                         (* report value of string variable 2)
*"Drill in operation"
VS3=DEL(VS2,3,7)             (* set string variable 3 to SV2 with 3 characters deleted starting at location 7)
VS3?                         (* report value of string variable 3)
*"Drill operation"
```

IO General I/O

Class: Input/Output Register

Type: Integer, Boolean

Syntax: IO*p1* (e.g., IO IO4 IOVI8)

Parameters:

	allowed values	*description*
p1	none **or** 0 through 15 **or** VI*n*	I/O register bit number

Range:
allowed values 0 through $FFFF_{16}$ **or** 0 and 1

Restrictions: Read only.

Use: The general I/O register is used to identify what inputs and outputs are active.

Remarks:
1. When the IO? command is executed, the general I/O register will be given as an English statement that says what inputs or outputs, if any, are active. If none of the inputs or outputs are active, the message given is *No I/O is active*.
2. If the computer interface format is enabled (CIE=1), and the IO? command is executed, the general I/O register will be given as an integer number equal to the decimal equivalent of the register's binary value. If none of the inputs or outputs are active, the I/O register is set to 0. The possibilities are listed below.
3. When IOx is executed the Boolean status of bit 'x' is given.

bit	message
0	Reserved
1	Reserved
2	Axis channel A input active
3	Axis channel B input active
4	Auxiliary channel A input active
5	Auxiliary channel B input active
6	Auxiliary index input active
7	Marker input active
8	Home input active
9	Forward overtravel input active
10	Reverse overtravel input active
11	Enable input active
12	Capture input active (i.e., capture input level is high)
13	Capture input edge (capture input made a low/high transition since last PCA reset)
14	Reserved
15	OK output active

Related Registers*:* DI, DO, CIE

IP Axis in Position

Class: System Register

Type: Boolean

Syntax: IP

Range:
allowed values 0, 1

Restrictions: Read only.

Use: The *Axis In Position* register is used to determine whether the axis is in position. If the axis is in position, then IP will be 1; and if the axis is not in position, then IP will be 0. The axis is in position when the position error (PSC-PSA) is less than the value set by the In Position Band (IPB) register. **For continuous moves initiated by the RVF or RVR commands, IP is set true at the end of the acceleration segment.**

Related Registers: IPB, SRA

IPB In-Position Band

Class: Axis Register

Type: Floating point

Syntax: IPB

Range:
units axis units
default 0 pulses
minimum 0 pulses
maximum 16,000 pulses

Use: The in-position band register defines the maximum amount of position error (PSC-PSA) that the axis can have and still be in position.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, minimum, and maximum values must be divided by the value of (URA/URB) (see URA and URB).

Related Registers: URA, URB, IP

IPN Network In Position

Class:	System Register
Type:	Boolean
Syntax:	IPN*p1* (e.g., IPN0 IPN63 IPNVI5)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI *n*	network node address

Range:

allowed values	0, 1

Restrictions: Read only. Cannot be accessed in immediate mode over a DeviceNet connection.

Use: The network in position register accesses attribute 12 of the DeviceNet position controller object to determine whether the axis addressed at *p1* is in position. If the axis is in position, then IPN will be 1; and if the axis is not in position, then IPN will be 0.

Related Registers: IP, IPB, SRA

ITB, ITH, ITS Convert Integer to String Operators

Class: Operator

Type: String

Syntax: ITS(*p1*,*p2*) ITB(*p1*,*p2*) ITH(*p1*,*p2*)

Parameters:

	allowed values	*description*
p1	any integer operand	integer
p2	any integer operand in range 0 through 40	field width

Use: These operators are used to convert the integer operand *p1* to a string. The operations are described below:

ITB convert integer to binary string—converts *p1* to a binary string.
ITH convert integer to hex string—converts *p1* to a hexadecimal string.
ITS convert integer to string—converts *p1* to a string.

Remarks: 1. If the integer cannot be contained in the field width specified, then the result is a string of asterisks of length equal to the field width.
2. If the field width is set to 0, then the result is the string representation of the integer, which has the minimum field width.

Example:

```
VI1=2282             (* set integer variable 1 to 2282)
VS1=ITS(VI1,6)       (* set string variable 1 to VI1 converted to string with field width of 6)
VS1?                 (* report value of string variable 1)
*"  2282"
VS2=ITB(V11,4)       (* set string variable 2 to VI1 converted to binary string with field width of 14)
VS2?                 (* report value of string variable 2)
*"2#100011101010"
VS3=ITH(VI1,4)       (* set string variable 3 to VI1 converted to hex string with field width of 4)
VS3?                 (* report value of string variable 3)
*"****"
VS3=ITH(VI1,0)       (* set string variable 3 to VI1 converted to hex string with minimum field width)
VS3?                 (* report value of string variable 3)
*"16#8EA"
```

ITF Convert Integer to Floating Point Operator

Class: Operator

Type: Floating point

Syntax: ITF(*p1*)

Parameters: *allowed values*

p1 any integer operand

Use: This operator is used to convert integer operand *p1* to a floating point number. Both integer and floating point data types use a 32 bit mantissa to prevent loss of precision when converting from integer to floating point.

Example:

```
VI1=12          (* set integer variable 1 to 12)
VF1=ITF(VI1)    (* set floating point variable 1 to VI1 converted to floating point)
VF1?            (* report value of floating point variable 1)
*12.
```

KA Acceleration Feedforward

Class: Axis Register

Type: Integer

Syntax: KA

Range:
default 0
minimum 0
maximum 64,000

Restrictions: Servo only.

Use: The acceleration feedforward constant is used to reduce following error during acceleration or deceleration. The equation for setting KA based on the torque to inertia ratio and the axis feedback resolution, FR, is:

$$KA = \frac{2^{32}\pi}{FR} \times \frac{1}{\left(\frac{torque}{inertia}\right)}$$

Where torque is the continuous torque of the motor in in-lbs and inertia is the system inertia in in-lb-sec^2. The KA value along with the values of all the other control constants can be set automatically by the AUTOTUNE command.

Related Registers: FR

Related Commands*:* AUTOTUNE

KD Derivative Control Gain

Class: Axis Register

Type: Integer

Syntax: KD

Range:
defaults 200 (2,500 line count encoder servo)
500 (resolver feedback servo)
minimum 0
maximum 8,000

Restrictions: Servo only.

Use: The derivative control gain is used to multiply the time derivative of the following error to control the position of the axis. The equation for setting KD based on the torque to inertia ratio and the axis feedback resolution is:

$$KD = \frac{316{,}022{,}860}{FR} \times \frac{1}{\sqrt{\frac{torque}{inertia}}}$$

Where torque is the continuous torque of the motor in in-lbs and inertia is the system inertia in in-lb-sec^2. The KD value along with the values of all the other control constants can be set automatically by the AUTOTUNE command.

Related Registers: FR

Related Commands: AUTOTUNE

KEY Character in Key Buffer

Class: System Register

Type: Boolean

Syntax: KEY

Range:
allowed values 0, 1

Restrictions: Read only.

Use: This register is used to determine whether a character is in the key buffer. KEY is equal to 1 when there is a character in the key buffer, and it is equal to 0 when there is none. The Key buffer can hold up to 256 bytes.

Related Registers: SRS

Related Commands: KY, EKB, GET, IN

KI Integral Control Gain

Class: Axis Register

Type: Integer

Syntax: KI

Range:
default 0
minimum 0
maximum 64,000

Restrictions: Servo only.

Use: The integral control gain is used to multiply the time integral of the following error to control the position of the axis. The equation for setting KI based on the torque to inertia ratio and the axis feedback resolution, FR, is:

$$KI = \frac{686{,}310}{FR} \times \sqrt{\frac{torque}{inertia}}$$

Where torque is the continuous torque of the motor in in-lbs and inertia is the system inertia in in-lb-sec^2. The KI value along with the values of all the other control constants can be set automatically by the AUTOTUNE command.

Related Registers: FR

Related Commands: AUTOTUNE

KL Motor Inductance

Class: Axis Register

Type: Integer

Syntax: KL

Range:
- *units* mH
- *default* 4 mH for encoder feedback controllers
  10 mH for resolver feedback controllers
- *minimum* 1 mH
- *maximum* 100 mH

Restrictions: Servo only.

Use: The motor inductance is used to tune the digital current controller to the attached motor. This register should be set to the motor's **line-line** inductance in mH—use the following table for your KL values:

S-Series Motor	KL Value (mH)	S-Series Motor	KL Value (mH)	S-Series Motor	KL Value (mH)
SLM003	5	SLM040-115V	4	SLM250	2
SLM005	6	SLM040-230V	10	SLM350	2
SLM010-115V	3	SLM070	6	SLM500	1
SLM010-230V	10	SLM100	4	SDM500	2
SLM020-115V	6	SDM100	10	SGM450	4
SLM020-230V	16	SDM250	4		

MTR-Series Motor	KL Value (mH)	MTR-Series Motor	KL Value (mH)	MTR-Series Motor	KL Value (mH)
MTR-3N21-H	4	MTR-3S45-G	20	MTR-3T22-G	7
MTR-3N22-H	6	MTR-3S45-H	5	MTR-3T23-G	11
MTR-3N24-G	9	MTR-3S46-G	25	MTR-3T24-H	9
MTR-3N31-H	10	MTR-3S46-H	6	MTR-3T42-H	9
MTR-3N32-G	18	MTR-3S63-G	9	MTR-3T43-H	13
MTR-3N32-H	5	MTR-3S65-G	14	MTR-3T43-J	5
MTR-3N33-G	25	MTR-3S65-H	3	MTR-3T44-J	7
MTR-3N33-H	6.3	MTR-3S67-G	18	MTR-3T45-H	9
MTR-3S22-G	21	MTR-3S67-H	5	MTR-3T45-I	4
MTR-3S23-G	26	MTR-3S84-G	3	MTR-3T54-H	7
MTR-3S32-G	23	MTR-3S86-G	4	MTR-3T55-H	9
MTR-3S33-G	22	MTR-3S88-G	4	MTR-3T57-H	3
MTR-3S34-G	30	MTR-3T11-G	7	MTR-3T66-H	7
MTR-3S35-G	42	MTR-3T12-G	4	MTR-3T67-G	8
MTR-3S43-G	53	MTR-3T13-G	3	MTR-3T69-G	10
MTR-3S43-H	13	MTR-3T21-G	11		

KLALL Kills All Programs

Class: Program Command

Syntax: KLALL

Restrictions: Not allowed in motion blocks.

Use: This command kills all programs (i.e., it stops their execution).

Remarks:
1. This command will not stop any motion caused by any previously executed programs. The motion will run to completion.
2. If this command is executed in a program, then the program that executes the command will **NOT** be killed.
3. If this command is executed from the terminal window it will kill all four programs.

***Related Commands**:* KLP

KLP Kills Program

Class: Program Command

Syntax: KLP*p1* (e.g., KLP3 KLPVI30)

Parameters:

	allowed values	*description*
p1	1 through 4 **or** VI*n*	program number

Restrictions: Not allowed in motion blocks.

Use: This command kills program *p1* (i.e., it stops its execution).

Remarks: This command will not stop any motion caused by program *p1*. The STOP (ST) or HALT (HT) commands must be used to stop motion.

***Related Commands**:* KLALL

KM Motor Number

Class: Axis Register

Type: Integer

Syntax: KM

Range:
Units none
Default 1
Minimum 1
Maximum 20

Restrictions: Stepper only.

Use: The motor number parameter is used to tune the stepper controller current loop to provide optimum performance for the attached stepper motor. This register must be set to the KM number found on the GE Fanuc stepper motor label or selected from the following table. The KM value is used as a pointer by the controller to look-up a number of tuning constants for a given motor. If the value for KM is not recognized by the controller a set of default tuning constants are used and may not be optimum for the connected motor. The Motion Developer Axis Configuration wizard automatically configures the KM value based on the selected motor.

Stepping Motor Model	Motor Cube	KM Value
STM1221N0	MCUB1221	7
MTR-1231-N-D-E-0	MCUB1231	10
MTR-1N31-I-N-A-S-0	MCUB1324	9
MTR-1N32-I-N-D-S-0	MCUB1337	12

Stepping Motor Model	KM	Wiring*	Max Current
MTR-1221-*-D-E-0	7	Series	1.8 Amps
MTR-1231-*-D-E-0	10	Series	1.6 Amps
MTR-1324-*-D-E-*	6	Series	2.7 Amps
MTR-1337-*-D-E-*	3	Series	4.1 Amps
MTR-1350-*-A-E-*	1	Parallel	7.9 Amps
MTR-1350-*-D-E-*	4	Series	4.0 Amps
MTR-1N31-I-*-D-S-0	9	Series	6.6 Amps
MTR-1N32-I-*-D-S-0	12	Series	4.1 Amps
MTR-1N41-G-*-A-E-0	13	Parallel	5.5 Amps
MTR-1N42-H-*-A-E-0	8	Parallel	6.4 Amps
—	2, 5, 11, and 14–20	—	—

The S2K controller is 5 Amps maximum

KP Proportional Control Gain

Class: Axis Register

Type: Integer

Syntax: KP

Range:

default	10
minimum	0
maximum	8,000

Restrictions: Servo only.

Use: The proportional control gain is used to multiply the following error to control the position of the axis. The equation for setting KP based on the axis feedback resolution, FR, is:

$$KP = \frac{327{,}680}{FR}$$

This value along with the values of all the other control constants can be set automatically by the AUTOTUNE command.

For example, the FR value for GE Fanuc S-Series servo motors is 10,000 so KP should be set to 197.

Related Registers: FR

Related Commands: AUTOTUNE

KSN Network Stall Velocity Threshold

Class: Axis Register

Type: Integer

Syntax: KSN*p1* (e.g., KSN0 KSN63 KSNVI5)

Parameters:	*allowed values*	*description*
p1	0 through 63 **or** VI*n*	network node address

Range:

units	pulses
minimum	200,000 pulses
maximum	16,000,000 pulses

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: The network stall velocity register accesses attribute 111 of the DeviceNet position controller object to set the minimum velocity at which stall detection will start to work.

Remarks: The Position Controller attribute that this register accesses exists in GE Fanuc Motor Cubes™ but not in the S2K controllers.

Related Registers: KVN

KSSN Network Stall Sensitivity

Class: Axis Register

Type: Floating Point

Syntax: KSSN*p1* (e.g., KSSN0 KSSN63 KSSNVI5)

Parameters:	*allowed values*	*description*
p1	1 through 63 **or** VI*n*	network address

Range:

units	seconds
default	0.2
minimum	0.001
maximum	2.000

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection. This command is applicable only to MotorCube products that are equipped with a DeviceNet interface.

Use: Before a DeviceNet MotorCube will fault due to stall (i.e., following error), the internal stall detection algorithm must detect a stall condition for a time greater than the MotorCube's Network Stall Sensitivity time.

Remarks: Firmware revision 2.3 and later; use with DeviceNet MotorCube Network nodes only, revision 1.1 and later.

Related Registers: KSN, KVN

KT Filter Time Constant

Class: Axis Register

Type: Integer

Syntax: KT

Range:

default	3
minimum	0
maximum	5

Restrictions: Servo only.

Use: The filter time constant is used to eliminate dither. Generally, the lower the bandwidth of a servo system, the higher the filter time constant should be. The equation for setting KT based on the torque to inertia ratio is:

$$KT = \left\lfloor \frac{280}{\sqrt{\dfrac{torque}{inertia}}} + 0.5 \right\rfloor$$

where the brackets mean to take the integer part of the number only, torque is the continuous torque of the motor in in-lbs and inertia is the system inertia in in-lb-sec^2. The KT value along with the values of all the other control constants can be set automatically by the AUTOTUNE command.

Related Commands: AUTOTUNE

KVN Network Bus Voltage

Class:	Axis Register	
Type:	Integer	
Syntax:	KVN*p1* (e.g., KVN0 KVN63 KVNVI5)	
Parameters:	*allowed values*	*description*
p1	0 through 63 **or** VI*n*	network node address

Range:

units	volts
minimum	0
maximum	50

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: The network bus voltage register accesses attribute 112 of the position controller object to set the bus voltage for the device addressed at *p1*.

Remarks: The Position Controller attribute that this register accesses exists in GE Fanuc's Motor Cubes™ but not in the S2K controllers.

***Related Registers**:* KSN

KY Puts One Character into Key Buffer

Class:	Input/Output Command	
Syntax:	KY*p1* (e.g., KY1 KYB)	
Parameters:	*allowed values*	*description*
p1	any ASCII character	ASCII character

Restrictions: Not allowed in motion blocks.

Use: This command puts one character into the key buffer.

Example: KYE (* put "E" into key buffer)

***Related Commands**:* GET, IN

KYA Key Assignment

Class: Input/Output Register

Syntax: KYA*p1* (e.g., KYA2)

Parameters: *allowed values* *description*
p1 1 through 12 function key A-L (see table below)

Range:
default SINGLE
allowed values OFF (no key codes are put in the key buffer)
SINGLE (only key-pressed code is put into key buffer)
DOUBLE (key-pressed/key-released codes are put into key buffer)

Restrictions: Not allowed in programs, motion blocks, or expressions.

Use: This register is used to determine what function key codes are put into the key buffer after pressing and releasing function key *p1*.

Related Registers: KEY, KEYW

Function Key	Value
A	1
B	2
C	3
D	4
E	5
F	6
G	7
H	8
I	9
J	10
K	11
L	12

L Last Statement to Current Statement in Terminal Window Line Editor

Class: Program Command

Syntax: L

Restrictions: Allowed only in programs or motion blocks being edited in the terminal window line editor.

Use: While editing a program or motion block using the terminal window line editor this command makes the last statement the current statement in the line editor.

Remarks: This command will not typically be used since Motion Developer provides a more full featured text editor for creating and editing programs and motion blocks. The terminal window can also be used for these functions and is invoked using the PROGRAM and MOTION commands. While in the line editor each line is prefixed by an asterisk (*). Use the exclamation point (!) command to exit the terminal window line editor.

Example:

```
PROGRAM1      (* edit program 1 from the terminal window)
*  PSA=0
X             (* step through one line of the program)
*  MVL=10
X             (* step through one line of the program)
*  MAC=40
L             (* make last statement the current statement)
*  MVL=10
!             (* exit terminal window line editor)
*
```

Related Commands: PROGRAM, MOTION, X, !

LABEL Makes Statement at Label the Current Statement

Class: Program Command

Syntax: LABEL*p1* (e.g., LABEL53)

Parameters: *allowed values* *description*
p1 1 through 999 label number

Restrictions: Allowed only in programs being edited in the terminal window line editor.

Use: This command makes the statement at label *p1* the current statement in the terminal window line editor.

Example:

```
PROGRAM1        (* edit program 1 from the terminal window)
* PSA=0
LABEL5          (* make statement at label 5 current statement)
*005OUT “Press any key to stop axis$N”
!               (* exit line editor)
*
```

Related Commands: PROGRAM, L, X, !

LED State of Display Led

Class: Input/Output Register

Type: Boolean

Syntax: LED*p1* (e.g., LED2 LEDVI5)

Parameters: *allowed values* *description*
p1 1 through 3 **or** VI*n* LED number

Range:
default 0 on power-up
allowed values 0, 1

Restrictions: Write only.

Use: This register contains the state of one of the display LEDs.

Remarks: Write only. This register cannot be read.

Example: LED1=1 (* set state of display LED one)

ASCII Codes: See the following table.

Code (Hex)	Description	Command
31	Turn Led1 on	LED1=1, OUT “$1B$31”
32	Turn Led2 on	LED2=1, OUT “$1B$32”
33	Turn Led3 on	LED3=1, OUT “$1B$33”
34	Turn Led 1 off	LED1=0, OUT “$1B$34”
35	Turn Led 2 off	LED2=0, OUT “$1B$35”
36	Turn Led 3 off	LED3=0, OUT “$1B$36”

LEN Length of String Operator

Class: Operator

Type: Integer

Syntax: LEN(*p1*)

Parameters: *allowed values*
p1 any string operand

Use: This operator is used to compute the length of the string in *p1*.

Example:

VI1=LEN("Hello")	(* set integer variable 1 to length of string "Hello")
VI1?	(* report value of integer variable 1)
*5	

LFT Select Leftmost Characters of String Operator

Class: Operator

Type: String

Syntax: LFT(*p1*,*p2*)

Parameters:

	allowed values	*description*
p1	any string operand	string
p2	any integer operand >= 0	number of characters

Use: Used to select leftmost *p2* characters of string *p1*.

Example:

VS1="Jogging axis forward"	(* set string variable 1 to "Jogging axis forward")
VS2=LFT(VS1,7)	(* set string variable 2 to leftmost 7 characters of VS1)
VS2?	(* report the value of string variable VS2 in terminal window)
*"Jogging"	

***Related Commands**:* MID, RGT

LGN Natural Log Operator

Class: Operator

Type: Floating point

Syntax: LGN(*p1*)

Parameters: *allowed values*
p1 any positive floating point operand

Use: This operator is used to take the natural log of *p1* (i.e., the logarithm base e of *p1*).

LOCK Locks Interpreter to Program

Class: Program Command

Syntax: LOCK

Restrictions: Allowed only in programs.

Use: This command locks the command interpreter to the program, which causes other currently executing programs or motion blocks to be to suspended.

Remarks: Once a program containing the LOCK command is done executing, the interpreter will automatically be unlocked from that program. LOCK will not prevent program 4 from executing when a fault occurs.

Example:

```
PROGRAM1        (* edit program 1)
STM1=0.01       (* load start time of timer 1 and start timer 1)
1 WAIT TM1      (* wait for expression to be true)
LOCK            (* lock interpreter to program)
IF KEY GOTO2    (* conditionally goto 2)
UNLOCK          (* unlock interpreter from program)
GOTO1           (* unconditionally goto 1)
2 END           (* end program and exit editor)
```

What will happen: This program, once executed, will first wait for 10 ms. Then, it locks the interpreter and checks for KEY to be true (i.e., for a character to be entered into the key buffer). If KEY is true, then the program goes to the statement at label 2, which ends the program. If it is not, then it unlocks the interpreter and goes to the statement at label 1, which waits for 10 ms, etc.

Related Commands: UNLOCK

LWR Case Conversion Operators

Class: Operator

Type: String

Syntax: LWR(*p1*)

Parameters: *allowed values*
p1 any string operand

Use: Used to convert string operand *p1* to lower case.

Remarks: Use UPR to convert to upper case.

Example:

```
VS1="Hello"      (* set string variable 1 to "Hello")
VS2=UPR(VS1)     (* set string variable 2 to upper case of VS1)
VS2?             (* report value of string variable 2)
*"HELLO"
VS3=LWR(VS1)     (* set string variable 3 to lower case of VS1)
VS3?             (* report value of string variable 3)
*"hello"
```

Related Commands: UPR

MAC Motion Acceleration/Deceleration

Class: Motion Register

Type: Floating point

Syntax: MAC

Range:

units	axis units/sec^2
default	100 pulses/sec^2
minimum	100 pulses/sec^2
maximum	1,000,000,000 pulses/sec^2

Use: This register is used to define both an acceleration and a deceleration rate for the axis. Define the deceleration rate separately with MDC. In cases where the acceleration rate differs from the deceleration rate, you must set MAC first and MDC second. MAC is used **only** when the motion type is set to velocity (MT=VEL).

Acceleration/deceleration for pulse-based and time-based moves is set using MAP.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, minimum, and maximum values must be divided by the value of (URA/URB) (see URA and URB).

Restrictions: This register is not allowed to have a value of zero. If this register is loaded with a value of zero by use of an indirect reference, the error will not be detected until the program is run, causing a run time error. For example, if VF100 = 0.0 and MAC = VF100, this indirect reference of MAC to a value of zero will produce a run time error.

Example:

```
PSA=0     (* set axis position)
MVL=10    (* set motion velocity)
MAC=40    (* set motion acceleration)
MPI=12    (* set incremental move distance)
RPI       (* run to position)
```

What will happen: Setting the axis position, velocity, acceleration, and incremental move distance and issuing the RPI command will cause the axis to move 12 units in the forward direction. It will accelerate at 40 units/sec^2 to a velocity of 10 units/sec, and then decelerate at 40 units/sec^2 to zero velocity.

Related Registers: MDC, MAP, MT, URA, URB

MACN Network Motion Acceleration

Class: Motion Register

Type: Integer

Syntax: MACN*p1* (e.g., MACN0 MACN63 MACNVI5)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network node address

Range:

units	pulses/sec^2
minimum	100 pulses/sec^2
maximum	1,000,000,000 pulses/sec^2

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

This register is not allowed to have a value of zero. If this register is loaded with a value of zero by use of an indirect reference, the error will not be detected until the program is run, causing a run time error. For example, if VF100 = 0.0 and MACN = VF100, this indirect reference of MACN to a value of zero will produce a run time error.

Use: The MACN register accesses attribute 8 of the DeviceNet position controller object to define an acceleration rate for the axis addressed at *p1*. You can define the deceleration rate separately using MDCN.

Related Registers: MAC, MDC, MDCN

MAP Motion Acceleration/Deceleration Percentage

Class: Motion Register

Type: Integer

Syntax: MAP

Range:

units	%
default	50
minimum	1
maximum	99

Use:

Time based moves (MT=TIME):
This register defines both acceleration and a deceleration percentage for the axis. The deceleration percentage can be defined separately with the MDP command. In cases where the acceleration percentage differs from the deceleration percentage, you must set MAP first and MDP second. The acceleration percentage is the percentage of axis move time that the axis will accelerate. The deceleration percentage is similarly defined (see MDP).

For Compiled Cam Profile Segments (MT=VEL):
For compiled cam motion the MAP register defines the percentage of the total segment length over which acceleration/deceleration will take place. MAP also sets the Motion Deceleration Percentage register (MDP) to the same value. When using MDP to specify a deceleration value that is different from the acceleration value you must first set MAP and then set MDP.

Pulse-based moves (MT=PULSE or PULVEL):
This register defines the percentage of total auxiliary units (defined by the MPL) over which axis acceleration or deceleration will occur during an incremental or absolute pulse-based move. For example if MAP=20 the acceleration will take 20% of the total move pulses, deceleration will take 20% and the constant velocity segment will take the remaining 60%. MAP is **not** required for continuous pulse-based moves initiated by the RVF and RVR commands. For applications requiring different acceleration and deceleration values the MDP register must be set **after** the MAP register.

Remarks:

1. If MAP is set to a value greater than 50, then MDP is automatically set to the value of MAP subtracted from 100. Otherwise, MDP=MAP.
2. If MAP and MDP are assigned separately, their values cannot be set so that MAP+MDP>100.

Example:

```
MPI=5      (* set incremental move position)
MT=TIME    (* set motion type to time)
MTM=10     (* set move time)
MAP=40     (* set acceleration percentage)
RPI        (* run to incremental move position)
```

What will happen: The example used above will cause the axis to move 5 units in the forward direction in 10 seconds. It will accelerate 40% of the move time (i.e., 4 seconds), then stay at a constant speed for 20% of move time, then decelerate for the last 40% of move time (i.e., 4 seconds).

Related Registers: MDP, MAC, MT, MTM

MB Motion Block Executing

Class: System Register

Type: Boolean

Syntax: MB

Range:
allowed values 0, 1

Restrictions: Read only.

Use: This register is used to determine whether a motion block is executing. If the motion block is executing, then MB is equal to 1; and when it is not executing, then MB is equal to 0.

Related Registers: SRA

MDC Motion Deceleration

Class: Motion Register

Type: Floating point

Syntax: MDC

Range:
units axis units/sec^2
default 100 pulses/sec^2
minimum 100 pulses/sec^2
maximum 1,000,000,000 pulses/sec^2

Use: This register is used to define a deceleration rate for the axis when the deceleration rate must be different from the acceleration rate. In these cases you must set MAC first and MDC second. MDC is used **only** when the motion type is set to velocity (MT=VEL). Deceleration for pulse-based and time-based moves is set using MDP.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, minimum, and maximum values must be divided by the value of (URA/URB) (see URA & URB).

Restrictions: This register is not allowed to have a value of zero. If this register is loaded with a value of zero by use of an indirect reference, the error will not be detected until the program is run, causing a run time error. For example, if VF100 = 0.0 and MDC = VF100, this indirect reference of MDC to a value of zero will produce a run time error.

Example:

```
PSA=0        (* set axis position)
MVL=10       (* set motion velocity)
MAC=40       (* set motion acceleration)
MDC=10       (* set motion deceleration)
MPA=12       (* set absolute move position)
RPA          (* run to absolute position)
```

What will happen: The RPA command will cause the axis to move to absolute position of 12 axis units. It will accelerate at 40 units/sec^2 to a velocity of 10 units/sec, and then decelerate at 10 units/sec^2 to zero velocity.

Related Registers: MAC, MDP, MT, URA, URB

MDCN Network Motion Deceleration

Class: Motion Register

Type: Integer

Syntax: MDCN*p1* (e.g., MDCN0 MDCN63 MDCNVI5)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network node address

Range:

units	pulses/sec^2
default	100 pulses/sec^2
minimum	100 pulses/sec^2
maximum	1,000,000,000 pulses/sec^2

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

This register is not allowed to have a value of zero. If this register is loaded with a value of zero by use of an indirect reference, the error will not be detected until the program is run, causing a run time error. For example, if VF100 = 0.0 and MDCN = VF100, this indirect reference of MDCN to a value of zero will produce a run time error.

Use: The MDCN register accesses attribute 9 of the DeviceNet position controller object to define a deceleration rate for the axis addressed at *p1*.

***Related Registers**:* MAC, MACN, MDC

MDP Motion Deceleration Percentage

Class: Motion Register

Type: Integer

Syntax: MDP

Range:
units %
default 50
minimum 1
maximum 99

Use:

Time based moves (MT=TIME):
This register defines a deceleration percentage for the axis. The deceleration percentage is the percentage of axis move time that the axis will decelerate. In cases where the deceleration percentage differs from the acceleration percentage, you must set MAP first and MDP second.

For Compiled Cam Profile Segments (MT=VEL):
For compiled cam motion the MDP register defines the percentage of the total segment length over which deceleration will take place. When using MDP to specify a deceleration value that is different from the acceleration value you must first set MAP and then set MDP.

Pulse-based moves (MT=PULSE or PULVEL):
This register defines the percentage of total auxiliary units (defined by the MPL register) over which axis deceleration will occur during an incremental or absolute pulse-based move. For example if MDP=20 the deceleration will take 20% of the total MPL units. For applications requiring different acceleration and deceleration values the MDP register must be set **after** the MAP register. MDP is **not** required for continuous pulse-based moves initiated by the RVF and RVR commands.

Remarks:

1. If the deceleration percentage is the same as the acceleration percentage the MDP command is not necessary (MDP=MAP). In this case if MAP is set to a value greater than 50, then MDP is automatically set to the value of MAP subtracted from 100.
2. If MAP and MDP are assigned separately, their values cannot be set so that MAP+MDP>100.

Example:

```
MT=PULSE        (* set motion type pulse mode)
MPS=10.0        (* set motion start position, aux units)
MPL=1000        (* set number of aux units for the move}
MAP=25          (* set acceleration to 25% of MPL)
MDP=40          (* set deceleration to 40% of MPL)
MPI=5           (* set the axis move distance)
RPI             (* run the incremental move)
```

What will happen: The RPI command will cause the axis to move 5 units in the forward direction as the auxiliary axis input counts from 10 to 1010 (MPS to MPS + MPL). It will accelerate over 25% of the move (250 aux. units), then stay at a constant speed for 35% of the move (350 aux. units), then decelerate for the last 40% of the move (400 aux. units).

Related Registers: MAP, MDC, MT, MVT

MEMORY Reports Memory Remaining

Class: System Command

Syntax: MEMORY

Restrictions: Not allowed in programs or motion blocks.

Use: This command reports the remaining memory in bytes.

MFA Motion Feedrate Acceleration/Deceleration

Class: Motion Register

Type: Integer

Syntax: MFA

Range:

units	percent/second
default	1,000
minimum	1
maximum	200,000

Use: This register is used to define both an acceleration and a deceleration rate for the motion feedrate percentage. Define the deceleration rate separately with MFD. In cases where the acceleration rate differs from the deceleration rate, you must set MFA first and MFD second.

Example:

```
MFP=40     (* set motion feedrate percentage)
MFA=500    (* set motion feedrate acceleration)
MFP=80     (* set motion feedrate percentage)
```

What will happen: Setting motion feedrate acceleration to 500 and motion feedrate percentage to 80 will cause the controller to accelerate the motion feedrate from 40 percent to 80 percent at 500 percent/second.

***Related Registers**:* MFD, MFP

MFD Motion Feedrate Deceleration

Class: Motion Register

Type: Integer

Syntax: MFD

Range:

units	percent/second
default	1,000
minimum	1
maximum	200,000

Use: This register is used to define a deceleration rate for the motion feedrate percentage. In cases where the acceleration rate differs from the deceleration rate, you must set MFA first and MFD second.

Example:

```
MFP=80    (* set motion feedrate percentage)
MFD=500   (* set motion feedrate deceleration)
MFP=40    (* set motion feedrate percentage)
```

What will happen: Setting motion feedrate deceleration to 500 and the motion feedrate percentage to 40 will cause the controller to decelerate the motion feedrate from 80 percent to 40 percent at 500 percent/second.

Related Registers: MFA, MFP

MFP Motion Feedrate Percentage

Class: Motion Register

Type: Floating point

Syntax: MFP

Range:

units	percent
default	100.00
minimum	0.00
maximum	100.00

Use: This register is used to define a feedrate percentage for the axis motion. The feedrate percentage causes the motion to run at a velocity that is a percentage of the motion velocity specified when the motion command was executed.

Remarks: This register is set to its default value on power-up.

Example:

```
MVL=20     (* set motion velocity)
MAC=50     (* set motion acceleration)
RVF        (* run forward at velocity)
MFD=500    (* set feedrate deceleration)
MFP=63     (* set feedrate percentage)
```

What will happen: Setting motion velocity, acceleration, feedrate deceleration, and feedrate percentage and issuing the run forward at velocity (RVF) command will cause the axis to run forward at 63% of the MVL value of 20 units/second, or 12.6 units/second.

Related Registers: MFA, MFD

Motion Templates: Absolute move with feedrate override; time based, absolute move with feedrate override

MID Select Middle Characters of String Operator

Class: Operator

Type: String

Syntax: MID(*p1*,*p2*,*p3*)

Parameters:

	allowed values	*description*
p1	any string operand	string
p2	any integer operand >= 0	number of characters
p3	any integer operand >= 1	location of characters

Use: Used to select middle *p2* characters of string *p1*.

Example:

VS1="Jogging axis forward"	(* set string variable 1 to "Jogging axis forward")
VS2=MID(VS1,4,9)	(* set string variable VS2 to the middle 4 characters of VS1 starting from (* character 9)
VS2?	(* report value of string variable VS2 in terminal window)
* "axis"	

Related Commands: LFT, RGT

MJK Motion Jerk Percentage

Class: Motion Register

Type: Integer

Syntax: MJK

Range:
units %
default 0
minimum 0
maximum 100

Restrictions: MJK has no effect when MT is set to PULSE or PULVEL.

Use: This register is used to define a jerk percentage for the axis. The jerk percentage is the percentage of acceleration/deceleration time that the axis will jerk.

Remarks: If MJK is set to 0, there is no jerk limit (i.e., the jerk is infinite).

Example:

```
PSA=0        (* set axis position)
MVL=5        (* set motion velocity)
MAC=10       (* set motion acceleration)
MPI=40       (* set incremental move position)
MJK=100      (* set motion jerk percentage)
RPI          (* run to incremental move position)
MJK=0        (* set motion jerk percentage)
RPI          (* run to incremental move position)
```

What will happen: This program will cause the axis to move 40 units in the forward direction. The axis will smoothly ramp the acceleration and deceleration up to 10 units/sec^2 and back down to zero for the whole time it is accelerating and decelerating. Then, setting the jerk percentage to 0 and issuing the RPI command will enable the axis to achieve instantaneously the acceleration rate and deceleration rate during the move.

MOTION Edits Motion Block in the Terminal Window Line Editor

Class: Program Command

Syntax: MOTION*p1* (e.g., MOTION60)

Parameters:

	allowed values	description
p1	1 through 100	motion block number

Restrictions: Allowed only in programs being edited in the terminal window line editor.

Use: Used to enter the terminal window line editor at the first statement of motion block *p1*. It can be used to view or edit motion blocks but typically will not be used since the Motion Developer provides a more convenient and full featured editor.

Example:

```
MOTION1   (* edit motion block 1 from the terminal window)
MVL=10    (* set motion velocity)
MAC=40    (* set motion acceleration)
MPI=15    (* set incremental move position)
!         (* exit terminal window line editor)
*
```

***Related Commands**:* PROGRAM, DEL, L, X, !, FAULT

MOTORSET Automatically Sets Up Motor Constants

Class: System Command

Syntax: MOTORSET

Restrictions: Brushless servo only; not allowed in programs or motion blocks.

Use: This command automatically sets up the motor constants CMO and CMR required for proper commutation of a brushless servo motor. **For all GE Fanuc motors, the Motion Developer wizards automatically set the values for CMO and CMR when a specific motor is selected.**

Remarks: This command will execute only when the controller is faulted, the axis *Enable* input is true, and no programs or motion blocks are executing. The motor must **not** be connected to a load when you use this command. Executing MOTORSET with a load attached to the motor will yield improper values. When executed, MOTORSET causes the motor rotor to line up with two locations of the stator vector. This command must be executed from the terminal window and takes from 2 to 30 seconds to execute; when finished, the controller or system will return either an asterisk (*) indicating successful completion or a question mark and one of the following error messages:

1. SWITCH MOTOR LEADS—two motor leads should be switched.
2. BAD POLES RATIO—the motor poles to resolver poles ratio was less than 1 or greater than 16

It is important to set CURC and KL correctly for MOTORSET to work properly. For best results, set CURC and KL before executing the MOTORSET command.

<u>**Encoder Feedback Procedures**</u>
If using a motor with an encoder, the following steps are required to correctly determine the CMO and CMR of a motor.

1. *Initialize Registers*
   Set KL and CURC accordingly
   Set FR and FRC to the feedback resolution of the encoder
   Set CMR to a value other than 1 (from 2 to 16)
   Execute a SAVE command

2. *Determine CMR*
   Cycle the power
   Turn the motor shaft at least a ¼ of a revolution
   Execute a MOTORSET command
   Now CMR is computed, but CMO may be incorrect
   Execute a SAVE command to save CMR

3. *Determine The Correct CMO*
   Cycle the power
   Turn the motor shaft at least a ¼ of a revolution
   Execute a MOTORSET command
   CMO is now computed correctly
   Execute a SAVE command to save CMO

Related Commands: AUTOTUNE

Related Registers: CMO, CMR, CURC, FR, FRC, KL

MPA Absolute Move Position

Class: Motion Register

Type: Floating point

Syntax: MPA

Range:

units	axis units
default	0 pulses
minimum	-2,000,000,000 pulses
maximum	2,000,000,000 pulses

Use: For velocity-based, time-based and pulse-based moves this register is used to define the absolute position to which the axis will move. For compiled cam profile segments the MPA register defines the axis absolute position at the end of the profile segment.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, minimum, and maximum values must be divided by the value of (URA/URB) (see URA and URB).

Example:

```
PSA=0       (* set axis position)
MVL=10      (* set motion velocity)
MAC=40      (* set motion acceleration)
MPA=8       (* set absolute move position)
RPA         (* run to absolute position)
```

What will happen: Setting the axis position, velocity, acceleration, and absolute move position and issuing the RPA command will cause the axis to move to absolute position of 8 axis units.

```
CAZ         (* clear the cam table)
CCB=0       (* start profile segment at zero degrees)
CCE=90      (* end segment at 90 degrees on cam master)
CCP=0       (* start axis motion at absolute position zero)
MPA=10      (* end axis motion at absolute position 10)
CCM         (* compile cam segment and load cam table)
```

What will happen: The CCM command will compile the cam profile segment defined from 0 to 90 degrees (CCB to CCE) on the cam master. Over this segment the axis will move from an absolute position of zero to an absolute position of 10 (CCP to MPA).

Related Registers: MPI, MPO, URA, URB

Related Commands: RPA, CCM

MPI Incremental Move Position

Class: Motion Register

Type: Floating point

Syntax: MPI

Range:
units axis units
default 0 pulses
minimum -2,000,000,000 pulses
maximum 2,000,000,000 pulses

Use: This register is used to define the incremental move position of the axis.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, minimum, and maximum values must be divided by the value of (URA/URB) (see URA and URB).

Example:

```
MVL=10    (* set motion velocity)
MAC=40    (* set motion acceleration)
MPI=12    (* set incremental move position)
RPI       (* run to incremental move position)
```

What will happen: Setting the velocity, acceleration, and incremental move position and issuing the RPI command will cause the axis to move 12 units in the forward direction.

Related Registers: MPA, MPO, URA, URB

Related Commands: RPI

MPL Move Pulses

Class: Motion Register

Type: Floating point

Syntax: MPL

Range:

units	auxiliary units
default	20,000,000 pulses
minimum	1 pulse
maximum	20,000,000 pulses

Use: Used only for pulse-based motion (MT=PULSE or PULVEL). This register is **not** used for time-based or velocity-based motion.

For Incremental or Absolute Moves:

When MT=PULSE: this register defines the number of input pulses (or auxiliary position units if URX is not equal to 1) over which the axis makes its motion.

When MT=PULVEL: this register defines the total auxiliary units over which the acceleration **and** deceleration for the axis motion will occur. The percentage of MPL used for acceleration is defined by MAP (i.e., axis acceleration will occur over MPL*MAP/100 aux. units). The remainder of MPL is then used for deceleration. MVP in this case defines the axis velocity as a ratio of axis units/aux. unit.

For Continuous Moves:

The MPL register defines the number of auxiliary position units over which the acceleration or deceleration will occur.

Remarks: The numerical values for the default, minimum, and maximum of this register assume that the pulse unit ratio is set at 1. If the unit ratio is set to a value other than 1, the default, minimum, and maximum must be divided by the value of URX. (see URX)

Example:

```
MT=PULSE     (* set motion type to pulse)
PSA=0        (* set axis position to zero)
PSX=0        (* set auxiliary position to zero)
MPS=2        (* set motion start position to 2 aux. units)
MPL=5        (* set move to occur over 5 aux. units)
MAP=20       (* set motion acceleration/deceleration percent to 20)
MPA=10       (* set absolute move position to 10 axis units)
RPA          (* run to absolute position)
```

What will happen: After you issue the RPA command, the axis will wait until the auxiliary position reaches 2 units. Then, while the auxiliary position moves to 7 units, the axis will move to absolute position of 10 axis units, using 1 auxiliary unit of motion to accelerate, 3 aux. units to run at a constant velocity, and 1 aux. unit to decelerate to a stop.

```
MT=PULSE     (* set motion type to pulse)
PSA=0        (* set axis position to zero)
PSX=0        (* set auxiliary position to zero)
MPS=2        (* set motion start position to 2 aux. units)
MPL=5        (* set move to occur over 5 aux. units)
MVP=5.0      (* set axis velocity to 5 axis units/sec for each aux unit/sec)
RVF          (* run to velocity in the forward direction)
```

What will happen: After you issue the RVF command, the axis will wait until the auxiliary position reaches 2 aux. units. Then, accelerate the axis to a velocity of 5 axis units/sec for each aux. unit/sec as the auxiliary axis moves from 2 to 7 aux. units (MPS to MPS+MPL).

Related Registers: MT, MPS, MVP, URX

MPN Network Move Position

Class: Motion Register

Type: Integer

Syntax: MPN*p1* (e.g., MPN0 MPN63 MPNVI5)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network node address

Range:

units	pulses
minimum	-2,000,000,000 pulses
maximum	2,000,000,000 pulses

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: The MPN register accesses attribute 6 of the DeviceNet position controller object to define the move position of the axis addressed at *p1*.

***Related Registers**:* MPI, MPA, MACN, MDCN, MVLN

MPO Offset Move Position

Class: Motion Register

Type: Floating point

Syntax: MPO

Range:

units	axis units
default	0 pulses
minimum	-2,000,000,000 pulses
maximum	2,000,000,000 pulses

Use: This register is used to define the destination position for an offset move initiated by the Run to Offset Position (RPO) command. MPO is similar to MPA except that positions are with respect to the PSO register instead of the PSA register.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, maximum, and minimum values must be divided by the value of (URA/URB) (see URA and URB).

Example:

```
PSO=0      (* set offset position register)
MVL=10     (* set motion velocity)
MAC=40     (* set motion acceleration)
MPO=8      (* set offset move position)
RPO        (* run to offset move position)
```

What will happen: Setting the offset position register, velocity, acceleration, and offset move position and issuing the RPO command will cause the axis to move 8 units in the forward direction.

***Related Registers**:* MPA, MPI, URA, URB

***Related Commands**:* PSO, RPO

MPS Motion Pulse Start Position

Class: Motion Register

Type: Floating point

Syntax: MPS

Range:

units auxiliary units
default 0 pulses
minimum -2,000,000,000 pulses
maximum 2,000,000,000 pulses

Use: This register is used to define the auxiliary position (PSX) at which the pulse-based axis motion should start. To use the MPS register MT must be set to PULSE or PULVEL. It is not used for velocity-based or time-based motion.

Remarks: The meaning of the MPS register differs slightly for pulse-based incremental or absolute moves and pulse-based continuous moves.

For incremental (RPI) and absolute (RPA) moves: MPS defines the auxiliary position (PSX) where the axis motion will start.

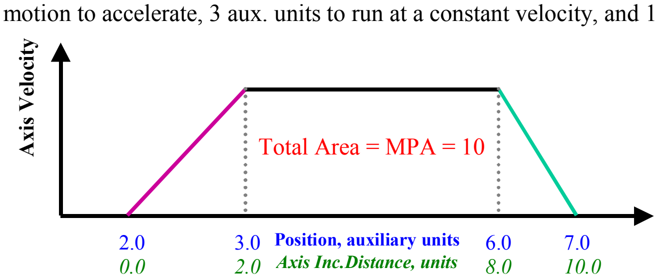
For continuous moves (RVF or RVR): The MPS register is used to define the auxiliary position where either axis acceleration or deceleration will start. Therefore, program segments for continuous moves must use MPS twice. Once to specify where to start the acceleration segment and again to specify where to start the deceleration segment.

The numerical values shown for the default, minimum, and maximum of this register assume that the Auxiliary Unit Ratio (URX) is set to its default value of 1. If URX is set to a value other than 1, the default, maximum, and minimum values must be divided by the value of URX.

Example:

```
MT=PULSE      (* set motion type to pulse)
PSA=0         (* set axis position to zero)
PSX=0         (* set auxiliary position to zero)
MPS=2         (* set motion start position to 2 aux. units)
MPL=5         (* set move pulses to 5 auxiliary units)
MAP=20        (* set motion acceleration/deceleration percent to 20)
MPA=10        (* set absolute move position to 10 axis units)
RPA           (* run to absolute position)
```

What will happen: After you issue the RPA command, the axis will wait until the auxiliary position reaches 2 units. Then, while the auxiliary position moves to 7 units, the axis will move to 10 units, using 1 auxiliary unit of motion to accelerate, 3 aux. units to run at a constant velocity, and 1 aux. unit to decelerate to a stop.



Related Registers: MT, MPL, MVP, URX

MT Motion Type

Class: Motion Register

Syntax: MT

Range:
default VEL
allowed values VEL (velocity)
PULSE (pulse input)
TIME (time)
PULVEL (pulse/velocity)

Restrictions: Not allowed in expressions; cannot be changed when motion generator is active.

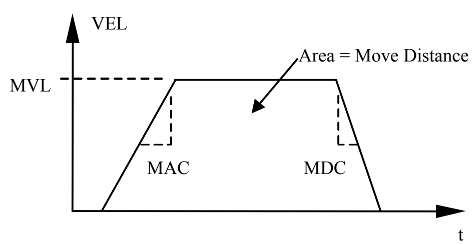
Use: The motion type register is used to define the type of commands that will be used to define a motion profile. The motion registers that are used for each of the allowed motion types are:

MT Setting	Registers that Define Motion Profile
MT=VEL	MAC, MDC, MJK, and MVL
MT=PULSE	MAP, MDP, MPL, MPS, and MVP
MT=PULVEL	MAP, MPL, MPS, and MVP
MT=TIME	MAP, MDP, MJK, and MTM

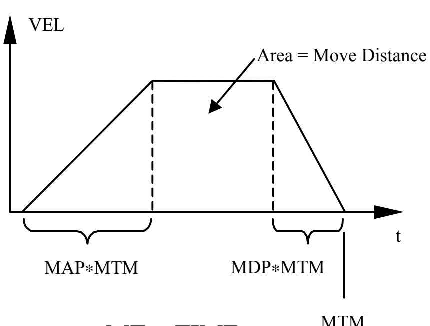
Remarks: MT can be changed between PULSE and PULVEL while the axis is in motion. The change will take effect when the next motion command is executed. The PULVEL mode function is the same as the PULSE mode except for incremental or absolute moves the axis velocity is specified by the MVP register as the ratio of axis units/aux. units.

Example:

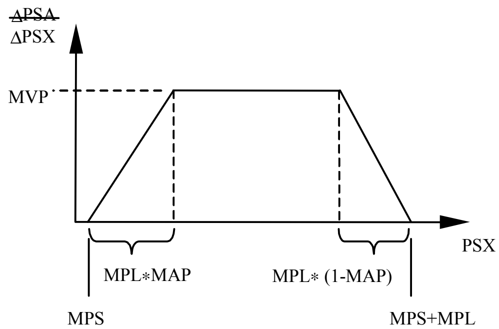
MT=VEL	(* set motion type to velocity)
MT?	(* report motion type of axis)



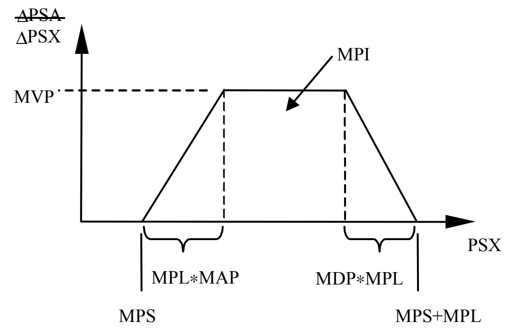
MT = VEL



MT = TIME



MT = PULVEL



MT = PULSE

MTM Move Time

Class: Motion Register

Type: Floating point

Syntax: MTM

Range:

units	seconds
default	10,000.000
minimum	.005
maximum	10,000.000

Use: The move time register defines the time in which the axis will move. MTM is used when the motion type, MT, is assigned to time.

Example:

```
MPI=5       (* set incremental move position)
MT=TIME     (* set motion type to time)
MTM=10      (* set move time)
MAP=40      (* set motion acceleration percentage)
RPI         (* run to incremental move position)
```

What will happen: Setting the incremental move position, move time, and acceleration percentage and issuing the RPI command will cause the axis to move 5 units in the forward direction in 10 seconds.

Related Registers: MT

MVL Motion Velocity

Class: Motion Register

Type: Floating point

Syntax: MVL

Range:

units	axis units/sec
default	1 pulse/sec
minimum	1 pulse/sec
maximum	16,000,000 pulses/sec

Use: This register is used to define the motion velocity of the axis. MVL is used when the motion type, MT, is assigned to velocity.

Remarks: The numerical values for the default, minimum, and maximum of this register assume that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, maximum, and minimum values will change appropriately (see URA and URB).

Restrictions: This register is not allowed to have a value of zero. If this register is loaded with a value of zero by use of an indirect reference, the error will not be detected until the program is run, causing a run time error. For example, if VF100 = 0.0 and MVL = VF100, this indirect reference of MVL to a value of zero will produce a run time error.

Example:

```
PSA=0       (* set axis position)
MVL=10      (* set motion velocity)
MAC=40      (* set motion acceleration)
MPA=12      (* set absolute move position)
RPA         (* run to absolute position)
```

What will happen: Setting the axis position, velocity, acceleration, and absolute move position and issuing the RPA command will cause the axis to move 12 units in the forward direction. It will accelerate at 40 units/sec^2 to a velocity of 10 units/sec, and then decelerate at 40 units/sec^2 to zero velocity.

Related Registers: MT, MAC, URA, URB

MVLN Network Motion Velocity

Class: Motion Register

Type: Integer

Syntax: MVLN*p1* (e.g., MVLN0 MVLN63)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** V*in*	network node address

Range:

units	pulses/sec
minimum	1 pulse/sec
maximum	16,000,000 pulses/sec

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

This register is not allowed to have a value of zero. If this register is loaded with a value of zero by use of an indirect reference, the error will not be detected until the program is run, causing a run time error. For example, if VF100 = 0.0 and MVLN = VF100, this indirect reference of MVLN to a value of zero will produce a run time error.

Use: This register accesses attribute 7 of the DeviceNet position controller object to define the motion velocity of the axis.

Related Registers: MAC, MACN, MVL

MVM Motion Velocity for Run to Marker

Class: Motion Register

Type: Floating point

Syntax: MVM

Range:

units	axis units/sec
default	4,096 pulses/sec
minimum	1 pulse/sec
maximum	4,096 pulses/sec

Use: This register is used to define the motion velocity of the axis when one of the run to marker commands, RMF or RMR, is used.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, maximum, and minimum values must be divided by the value of (URA/URB) (see URA and URB).

Example:

```
PROGRAM1        (* edit program one)
MVM=0.5         (* set motion velocity for run to marker)
MAC=40          (* set motion acceleration)
RMF             (* run forward to marker)
WAIT IP         (* wait for axis one to be in position)
PSA=0           (* set axis position)
END             (* end program one and exit program editor)
```

What will happen: This program, once executed, will set the velocity for run to marker and acceleration and then run the axis forward until the marker is encountered. It will then wait for the axis to be in position and set the axis position to 0.

***Related Registers**:* MT, MVL, URA, URB

***Related Commands**:* RMF, RMR

MVP Motion Velocity of Pulse Move

Class: Motion Register

Type: Floating point

Syntax: MVP

Range:

units	axis units/auxiliary units
default	0.000001
minimum	0.000001
maximum	1,000

Use: This register defines the motion velocity only for pulse-based moves.
When MT=PULSE: The MVP register is used only for continuous moves (initiated using the RVF or RVR commands) and is expressed as a ratio of axis units to auxiliary units. For example, if both the axis and the auxiliary encoder are scaled for revolutions then MVP defines the number of revolutions the axis motor will move for each revolution of the auxiliary encoder.

When MT=PULVEL: In this mode the MVP register is used to define the axis velocity for incremental, absolute and continuous moves and is expressed as a ratio of axis units to auxiliary units.
The MVP register is not used for velocity-based moves or time-based moves.

MVP cannot be changed for any move already armed (by executing the respective RPI, RPA, RVF or RVR command) or in process.

Example:

```
MT=PULSE      (* set motion type to pulse)
PSX=0         (* set auxiliary position register to zero)
MPS=1         (* set motion start position to 1 aux. unit)
MPL=3         (* set move length for acceleration to 3 aux. units)
MVP=2.5       (* set axis velocity to 2.5 axis units/auxiliary unit)
RVF           (* run at velocity in the forward direction)
MPS=10        (* set motion start position to 10 aux. units)
MPL=2         (* set move length for deceleration to 2 aux. units)
ST            (* stop motion)
```

What will happen: When the RVF command is executed, the axis will wait until the auxiliary position reaches 1 unit (MPS). Then, while the auxiliary position moves to 4 units (MPS+MPL), the axis will accelerate to a velocity of 2.5 axis units/auxiliary units. The axis will then wait until the auxiliary position reaches 10 units; then, while the auxiliary position moves to 12 units, the axis will decelerate to a stop.

***Related Registers**:* MT, MPS, MPL

NCO Network Connection Open

Class: System Register

Type: Boolean

Syntax: NCO*p1*

Parameters:	*allowed values*	*description*
p1	0 through 63 **or** VI*n*	network address

Range:
allowed values 0, 1

Restrictions: Read only. Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This register returns a one when network connection is established with the device addressed at *p1*. If a connection cannot be established, then this register returns a zero.

***Related Registers**:* NET

Related Commands: CNC

NET Network Connection Available

Class: System Register

Type: Boolean

Syntax: NET

Range:
allowed values 0,1

Restrictions: Read only.

Use: This register is used to determine when a network access can be made. Works with DeviceNet and PROFIBUS.

***Related Registers**:* NCO, SRS

NOT Not Logical Operator

Class: Operator

Type: Boolean, integer

Syntax: NOT *p1*

Parameters: *allowed values*
p1 any Boolean or integer operand

Use: Used to perform a logical NOT operation on *p1*.

Related Registers: AND, OR, XOR

OFA Axis Position Offset

Class: Axis Register

Type: Floating point

Syntax: OFA

Range:
units axis units
minimum -2,000,000,000 pulses
maximum 2,000,000,000 pulses

Restrictions: Write only.

Use: This register defines an offset to be applied to the axis position register, PSA. The offset is not stored; rather, the value of the PSA register is changed by the offset.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, maximum, and minimum values must be divided by (URA/URB). (see URA and URB).

Example:

```
PSA?            (* query value of axis position register)
*5.326          (* current position)
OFA=4.674       (* offset position register)
PSA?            (* query value of axis position register)
*10             (* current position)
```

Related Registers: PSA, URA, URB

OFX Auxiliary Position Offset

Class: Axis Register

Type: Floating point

Syntax: OFX

Range:

units	auxiliary units
minimum	-2,000,000,000 pulses
maximum	2,000,000,000 pulses

Restrictions: Write only.

Use: This register defines an offset to be applied to the auxiliary position register, PSX. The offset is not stored. Rather, the value of the PSX register is changed by the offset.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the auxiliary unit ratio, URX, is set at its default value of 1. If the auxiliary unit ratio is set to a value other than 1, the default, maximum, and minimum values must be divided by the value of URX (see URX).

Example:

```
PSX?           (* query value of auxiliary position register)
*5.326         (* current position)
OFX=4.674      (* offset position register)
PSX?           (* query value of auxiliary position register)
*10            (* current position)
```

Related Registers: PSX, URX

OR OR Logical Operator

Class: Operator

Type: Boolean, integer

Syntax: *p1* OR *p2*

Parameters: *allowed values*

p1	any Boolean or integer operand
p2	any Boolean or integer operand

Use: Used to perform a logical OR operation on *p1* and *p2*. Note that *p1* and *p2* must be of the same type. If *p1* and *p2* are integer operands, the logical operators perform bitwise logical operations.

***Related Commands*:** AND, NOT, XOR

OTE Hardware Overtravel Enable

Class: Axis Register

Type: Boolean

Syntax: OTE

Range:
default 0
allowed values 0, 1

Restrictions: Cannot be assigned in motion blocks.

Use: The OTE register is used to enable hardware overtravel inputs using discrete inputs 2 and 3 (IN_01 and IN_02). Input 2 is the forward overtravel input, and input 3 is the reverse overtravel input. Directional conventions are set by the DIR command.

Remarks: If the hardware overtravel inputs are disabled (OTE=0), they can be used as general purpose inputs. Use bits 9 and 10 of the IO register to read the state of the hardware overtravel inputs when enabled. Bit 10 of the Axis Status Register (SRA) also reports if either overtravel limit is active but cannot specify which specific limit is active. The controller also supports software travel limits set using the OTF and OTR commands. Generally when travel limits are used in an application the Position Wrap Enable function should be disabled (PWE=0).

***Related Registers**:* IO

OTF Forward Software Overtravel

Class: Axis Register

Type: Floating point

Syntax: OTF

Range:

units axis units
default 2,100,000,000 pulses
minimum -2,100,000,000 pulses
maximum 2,100,000,000 pulses

Use: This register is used to define the forward software overtravel limit for the axis.

Remarks: The software overtravel limits are ignored during any of the homing functions (RHF, RHR, RMF, RMR, ROF, ROR). The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, maximum, and minimum values must be divided by the value of (URA/URB) (see URA and URB).

Example:

```
PSA=0      (* set axis position)
MVL=10     (* set motion velocity)
MAC=40     (* set motion acceleration)
MPA=12     (* set absolute move position)
OTF=10     (* set forward software overtravel limit)
RPA        (* run to absolute move position)
```

What will happen: By setting the axis position, velocity, acceleration, absolute move position, and forward software overtravel and issuing the RPA command, the axis will move 10 units in the forward direction and immediately halt all motion.

Related Registers: OTR, URA, URB

OTR Reverse Software Overtravel

Class: Axis Register

Type: Floating point

Syntax: OTR

Range:

units	axis units
default	-2,100,000,000 pulses
minimum	-2,100,000,000 pulses
maximum	2,100,000,000 pulses

Use: This register is used to define the reverse software overtravel limit for the axis.

Remarks: The software overtravel limits are ignored during any of the homing functions (RHF, RHR, RMF, RMR, ROF, ROR). The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, maximum, and minimum values must be divided by the value of (URA/URB) (see URA and URB).

Example:

```
PSA=0        (* set axis position)
MVL=10       (* set motion velocity)
MAC=40       (* set motion acceleration)
MPA=-15      (* set absolute move position)
OTR=-12      (* set reverse software overtravel limit)
RPA          (* run to absolute move position)
```

What will happen: Setting the axis position, velocity, acceleration, absolute move position, and reverse software overtravel and issuing the RPA command causes the axis to move 12 units in the reverse direction and immediately halts all motion.

Related Registers*:* OTF, URA, URB

OUSN Output a Command to Network Port with Status

Class: I/O Command

Syntax: OUSN*p1"p2"* (e.g., OUSN5"MPA=3")

Parameters:	*allowed values*	*description*
p1	0 through 63 **or** VI*n*	network address
p2	any valid program command	

Restrictions: Allowed only in programs. Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This command outputs a command over the network to be executed by the addressed controller.

Remarks: If the command sent to the addressed controller is not accepted, then bit 8 in the program status register (SRP, see Chapter 7) will be set to 1, indicating an *Invalid Command Acknowledgment*.

Related Commands: OUTN

OUT Outputs String Expression to Serial Port

Class: Input/Output Command

Syntax: OUT*p1* (e.g., OUT VS1, OUT "Hello")

Parameters:

	allowed values	*description*
p1	any string expression	string expression

Use: This command outputs a string expression to the serial port. The string operand "$" can be used to convert register and variable values to strings for use by the OUT command.

Remarks: The operand *p1* can be from 1 to 127 characters long. If the display format is disabled (i.e., DSE=0), the string expression will be sent to the terminal.

Example:

```
VS1="This is a "        (* load string variable 1)
VS2="TEST"              (* load string variable 2)
OUT VS1+VS2             (* output string expression to the serial port)
*This is a TEST
OUT $PSA                (* output value of axis position register)
*2.563924
OUT $SRA8               (* output value of in position register)
*Axis in position
```

***Related Commands**:* IN, PUT, $

Related Registers: DSE

***ASCII Codes**:* See the table below and the *Standard ASCII Codes* table in Appendix A.

Code (Hex)	Description	Use	Command
08	backspace	Moves the cursor back one space and prints a space.	BS, OUT "$08"
0A	line feed	Moves the cursor down one line.	OUT "$0A"
0D	carriage return	Moves the cursor to the leftmost space.	OUT "$0D"
31	LED1 on	Turns LED1 on.	LED1=1, OUT "$1B$31"
32	LED2 on	Turns LED2 on.	LED2=1, OUT "$1B$32"
33	LED3 on	Turns LED3 on.	LED3=1, OUT "$1B$33"
34	LED1 off	Turns LED1 off.	LED1=0, OUT "$1B$34"
35	LED2 off	Turns LED2 off.	LED2=0, OUT "$1B$35"
36	LED3 off	Turns LED3 off.	LED3=0, OUT "$1B$36"
3C	alpha off	Disables the function key keypad.	OUT "$1B$3C"
3E	alpha on	Enables the function key keypad.	OUT "$1B$3E"
3F	cursor remember	Remembers the current cursor position.	CRM, OUT "$1B$3F"
40	cursor return	Returns the cursor to the remembered position.	CRR, OUT "$1B$40"
41	cursor up	Moves the cursor up one line.	OUT "$1B$41"
42	cursor down	Moves the cursor down one line.	OUT "$1B$42"
43	cursor right	Moves the cursor right one space.	OUT "$1B$43"
44	cursor left	Moves the cursor left one space.	OUT "$1B$44"
46	cursor position	Places the cursor in a specific position defined by the next two ASCII codes sent. The first is the horizontal position with an offset of 32 (33-62) and the second is the vertical position with an offset of 32 (33-36).	CRP*p1.p2*, OUT "$1B$46$*p3*$*p4*" *p3* - 33 through 62 (21 through 3E hex) *p4* - 33 through 36 (21 through 24 hex)
48	cursor home	Homes the cursor, i.e., moves it to the upper left-hand corner of the screen.	CRH, OUT "$1B$48"
49	clear line	Clears the current line and places the cursor at the beginning of the line.	CLL, OUT "$1B$49"
4A	clear display	Clears the display and homes the cursor.	CLS, OUT "$1B$4A"

OUTN Output Command to Network Port

Class: I/O Command

Syntax: OUTN*p1"p2"* (e.g., OUTN5"MPA=3")

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	recipient's network address
p2	any valid program command	

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This command outputs a command over the network to be executed by the addressed controller.

***Related Commands**:* OUSN

OUTS Outputs Screen to Display

Class: Input/Output Command

Syntax: OUTS*p1* (e.g., OUTS2 OUTSVI1)

Parameters:

	allowed values	*description*
p1	1 through 50 or Vi*n*	screen number

Use: This command is used to output screen *p1* to the display(OIP).

Remarks: This command is used in conjunction with the display when DSE is set to 1.

Related Registers: SCRL, DSE

PAR Parity of Serial Port

Class: System Register

Syntax: PAR

Range:

default ODD

allowed values NONE, EVEN, ODD

Restrictions: Not allowed in motion blocks or expressions.

Use: This register is used to define the parity of the serial port.

Remarks: Setting PAR to NONE and BIT to 7 at the same time is not allowed. This register defaults to ODD on power-up.

***Related Registers**:* BAUD, BIT, HSE

PASSWORD Prompts for Password

Class: System Command

Syntax: PASSWORD

Restrictions: Not allowed in programs or motion blocks.

Use: This command prompts the user to enter a password that was previously defined using the CHANGEPW command.

Remarks: Enter the 4 to 10 character password at the *Enter password:* prompt to gain full access to the controller programming and configuration. If the correct password is not entered at the prompt, only diagnostic commands can be entered. To assign an initial password or to change an existing password use the CHANGEPW command.

Warning

Do NOT forget your password. Clearing memory will not reset the password. You must return the unit to the factory for repair. THERE IS NO BACKDOOR! Consider using the SECURE command instead.

Related Commands: CHANGEPW, SECURE

PCA Axis Position Capture

Class: Axis Register

Type: Floating point

Syntax: PCA

Range:
units axis units
minimum -2,000,000,000 pulses
maximum 2,000,000,000 pulses

Restrictions: Read only.

Use: This register is used to store the value of the position captured by the position capture input when this input is used to capture the axis position. The position capture input is located on the Auxiliary I/O connector (IN-Index) for the SSI104 and SSI107 models or on the Pulse Input connector (IN_I) for the SSI216 and SSI228 model controllers.

Remarks: 1. If a position has not been captured, then the axis position capture register will be 0. Bit 12 of the I/O register (IO) reflects the level of the capture input and is true when the capture input is active. Bit 13 of the IO register (IO) will be set to 1 when the capture input makes a low to high logical transition since PCA was last reset (read). After a position has been captured, the position can be reported using the PCA? command. Once the PCA register is read it will be reset to 0, and IO register bit 13 will be cleared (set to zero) until a position is captured again.
2. The numerical values for the minimum and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the maximum and minimum must be divided by the value of (URA/URB) (see URA and URB).

***Related Registers**:* URA, URB, PCX, IO

PCX Auxiliary Position Capture

Class: Axis Register

Type: Floating point

Syntax: PCX

Range:
units auxiliary units
minimum -2,000,000,000 pulses
maximum 2,000,000,000 pulses

Restrictions: Read only.

Use: This register is used to store the value of the position captured when the position capture is used to capture the auxiliary encoder input of the axis. The position capture input is located on the Auxiliary I/O connector (IN-Index) for the SSI104 and SSI107 models or on the Pulse Input connector (IN_I) for the SSI216 and SSI228 model controllers.

Remarks:
1. If a position has not been captured, then the auxiliary position capture register will be 0. Bit 12 of the I/O register (IO) reflects the level of the capture input and is true when the capture input is active. Bit 13 of the IO register (IO) will be set to 1 when the capture input makes a low to high logical transition since PCA was last reset (read). After a position has been captured, the position can be reported using the PCX? command. Once the PCX register is read it will be reset to 0, and IO register bit 13 will be cleared (set to zero) until a position is captured again.
2. To ensure proper operation of the edge trigger, always read PCA as well as PCX when using PCX.
3. The numerical values for the minimum and maximum of this register are assuming that the auxiliary unit ratio, URX, is set at its default value of 1. If the auxiliary unit ratio is set to a value other than 1, the maximum and minimum values must be divided by the value of URX (see URX).

***Related Registers**:* URX, PCA, IO

PFB Position Feedback Deadband

Class: Axis Register

Type: Floating point

Syntax: PFB

Range:

units	axis units
default	0 pulses
minimum	0 pulses
maximum	16,000 pulses

Restrictions: Dual-loop servo only.

Use: The Position Feedback Deadband is the amount of static position error allowed before the controller attempts to correct the position error when the controller is configured for dual-loop mode.

To enable dual-loop mode in the controller, set PFE equal to 1 and PFN equal to a non-zero value (Note: PFD must also be set properly in this mode). In this mode the motor position feedback is the primary position feedback device and the auxiliary encoder is the secondary feedback device. The motor position feedback is used for position feedback while normal programmed motion is being executed, and the secondary feedback is used to ensure accurate static position based on the auxiliary encoder feedback. This dual-loop mode offers the best servo stability when using a separate (load mounted) position feedback device in application with lost motion in the motor drive train.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, maximum, and minimum values must be divided by the value of (URA/URB) (see URA and URB).

Related Registers: PFC, PFD, PFE, PFL, PFN, PFT, URA, URB

PFC Position Feedback Correction Numerator

Class: Axis Register

Type: Integer

Syntax: PFC

Range:
default PFN
minimum 0
maximum 10,000

Restrictions: Closed loop stepper or dual loop servo only.

Use: The position feedback correction numerator is a parameter used when auxiliary encoder position feedback is used to control the position of a stepper servo (i.e., closed loop stepper) or when a servo controller is configured for dual-loop mode. PFC replaces the numerator of the feedback ratio PFN/PFD and is used to fine tune this feedback ratio to eliminate hunting as the controller attempts to correct of the final position error.

To enable dual-loop mode in a servo controller, set PFE equal to 1 and PFN equal to a non-zero value (Note: PFD must also be set properly in this mode). In this mode the motor position feedback is the primary position feedback device and the auxiliary encoder is the secondary feedback device. The motor position feedback is used for position feedback while normal programmed motion is being executed, and the secondary feedback is used to ensure accurate static position based on the auxiliary encoder feedback. This dual-loop mode offers the best servo stability when using a separate (load mounted) position feedback device in application with lost motion in the motor drive train.

Remarks: Normally this parameter is left at the default of PFN, which means it has the same value as PFN. If there are problems with hunting for the final position, use this parameter to reduce the axis position error correction by setting it to a value slightly less than PFN.

***Related Registers**:* PFD, PFE, PFN

PFD Position Feedback Denominator

Class: Axis Register

Type: Integer

Syntax: PFD

Range:
default 1 for servo; 4 for stepper controllers
minimum 1
maximum 10,000

Restrictions: Closed loop stepper or dual-loop servo only.

Use: The position feedback denominator is a parameter used when auxiliary encoder position feedback is used to control the position of a stepper servo (i.e., closed loop stepper) or when a servo controller is configured for dual-loop mode. PFD is defined as the denominator of the position feedback ratio (PFN/PFD) between the motor position feedback and the auxiliary encoder inputs. This ratio must equate the number of motor position feedback pulses to auxiliary encoder pulses per unit of load movement. This determination must include all gearing and mechanical translation in **both** the auxiliary encoder **and** motor connection to the load. For example, consider a servo application where a 1000 line auxiliary encoder is belted to the load end of a ball screw using a 2:1 ratio with the motor mounted to the opposite end of the screw through a 2:1 gearbox. For each screw revolution, the auxiliary encoder makes 2 revolutions and generates 8,000 quadrature pulses to the controller (2 rev * 4000 pulses/rev). For the same 1 revolution of the screw the motor makes 2 revolutions and generates 20,000 quadrature pulses (2 rev * 10,000 pulses/rev). Therefore, the PFN/PFD ratio must be equivalent to 20000/8000 and be within the allowable range. In this case PFN=20000 exceeds the 10,000 range limit for this register so if we divide both PFN and PFD by 2 we get a ratio of 10000/4000 or PFN=10000 and PFD=4000. (For a stepper use 50,000 pulses/rev instead of 10,000/rev)

To enable dual-loop mode in a servo controller, set PFE equal to 1 and PFN equal to a non-zero value (Note: PFD must also be set properly in this mode). In this mode the motor position feedback is the primary position feedback device and the auxiliary encoder is the secondary feedback device. The motor position feedback is used for position feedback while normal programmed motion is being executed and while the secondary feedback is used to ensure accurate static position based on the auxiliary encoder feedback. This dual-loop mode offers the best servo stability when using a separate (load mounted) position feedback device in applications with lost motion in the motor drive train.

Stepper Controller (PFN= non-zero & PFE=1):
For a stepper controller using encoder feedback the Position Feedback Ratio (PFN/PFD) is used to map the auxiliary encoder feedback to the 50,000 steps/revolution of the motor. This is done by setting the ratio equal to the number of motor pulses/rev (50,000) divided by the number of auxiliary encoder pulses generated during 1 motor revolution. In the simplest case, where the encoder is mounted to the stepper motor, the denominator would be the quadrature resolution of the auxiliary encoder. For example using a 1000 line encoder (4000 quad pulses) the ratio is 50000/4000. Since the PFN and PFD registers are limited to a range of 10,000 we can reduce this ratio to 50/4 or PFN=50 and PFD=4 which are the default register values. If the feedback encoder is mounted at the load, this ratio must include all gearing and mechanical translation in **both** the auxiliary encoder **and** motor connection to the load (see example for dual-loop servo above except use 50,000 pulses/rev for the motor instead of 10,000/rev).

Related Registers: PFN, PFE

PFE Position Feedback Enable

Class: Axis Register

Type: Boolean

Syntax: PFE

Range:
default 0
allowed values 0, 1

Restrictions: Closed loop stepper or dual-loop servo only; not allowed in motion blocks. In a program, this register can be set only when the controller is faulted.

Use: The position feedback enable register is used to determine whether the axis receives position feedback from the motor position feedback or the auxiliary encoder.

Servo Controller (PFE=0):
If PFE is set to 0, then the axis uses the motor position feedback. This is the controller's normal operating mode.

Servo Controller (PFE = 1 and PFN=0):
In this single-loop mode the auxiliary encoder is used for position feedback and directly updates the axis position register (PSA). The motor position feedback is still used for commutation.

Servo Controller (PFE = 1 and PFN=non-zero):
In this dual-loop mode the motor position feedback is the primary position feedback device and the auxiliary encoder is the secondary feedback device. The motor position feedback is used for position feedback while normal programmed motion is being executed and while the secondary feedback is used to ensure accurate static position based on the auxiliary encoder feedback. This dual-loop mode offers the best servo stability when using a separate (load mounted) position feedback device in application where there is lost motion in the motor drive train. The Position Feedback ratio (PFN/PFD) must be properly set when using this mode. Also the PFB, PFC, PFL and PFT registers are enabled in this mode.

Open Loop Stepper (PFE=0):
If PFE is set to 0, then the stepper controller runs open loop. This is the controller's default operating mode.

Closed Loop Stepper (PFE=1):
If PFE is set to 1, then the stepper controller uses the auxiliary encoder feedback to close the position loop. The Position Feedback Ratio (PFN/PFD) must be properly configured to map the auxiliary encoder feedback to the 50,000 steps/revolution of the stepper motor.

Related Registers: PFN, PFD, PFL, PFT, PFB, PFC

PFL Position Feedback Backlash

Class: Axis Register

Type: Integer

Syntax: PFL

Range:

units	pulses
default	0
minimum	0
maximum	16,000

Restrictions: Dual-loop servo only.

Use: The position feedback backlash register is used to compensate for mechanical backlash when the servo controller is configured for dual-loop mode (PFE=1 and PFN=non-zero value). In this mode the PFL value is used to offset an equivalent number of pulses lost due to mechanical backlash or other sources of lost motion in the motor drive train when axis direction is reversed.

Related Registers: PFT, PFB, PFE

PFN Position Feedback Numerator

Class: Axis Register

Type: Integer

Syntax: PFN

Range:
default 0 for servo; 50 for stepper controllers
minimum 0
maximum 10,000

Restrictions: Closed loop stepper or dual loop servo only.

Use: The position feedback numerator is a parameter used when auxiliary encoder position feedback is used to control the position of a stepper servo (i.e., closed loop stepper) or is used to configure a servo controller for either single-loop or dual-loop position feedback mode.

Single-Loop Servo Controller (PFN=0 & PFE=1):
When the controller is configured for single-loop position feedback, the auxiliary encoder is the primary position feedback for the axis. In this case the auxiliary encoder directly changes the axis position register (PSA).

Dual-Loop Servo Controller (PFN= non-zero & PFE=1):
When the controller is configured for dual-loop position feedback the motor position feedback is the primary position feedback device and the auxiliary encoder is the secondary feedback device. The motor position feedback is used for position feedback while normal programmed motion is being executed and while the secondary feedback is used to ensure accurate static position based on the auxiliary encoder feedback. This dual-loop mode offers the best servo stability when using a separate (load mounted) position feedback device in application with lost motion in the motor drive train.

In this mode PFN is defined as the numerator of the position feedback ratio (PFN/PFD) between the axis (motor position feedback) and the auxiliary encoder inputs. This ratio must equate the number of motor encoder pulses to auxiliary encoder pulses per unit of load movement. This determination must include all gearing and mechanical translation in **both** the auxiliary encoder **and** motor connection to the load.

For example, consider an application where a 1000 line auxiliary encoder is belted to the load end of a ball screw using a 2:1 ratio with the motor mounted to the opposite end of the screw through a 2:1 gearbox. For each screw revolution the encoder makes 2 revolutions and generates 8,000 quadrature pulses to the controller (2 rev * 4000 pulses/rev). For the same 1 revolution of the screw the motor makes 2 revolutions and generates 20,000 quadrature pulses (2 rev * 10,000 pulses/rev). Therefore, the PFN/PFD ratio must be equivalent to 20000/8000 and be within the allowable range. In this case PFN=20000 exceeds the 10,000 range limit for this register so if we divide both PFN and PFD by 2 we get a ratio of 10000/4000 or PFN=10000 and PFD=4000.

Stepper Controller (PFN= non-zero & PFE=1):
For a stepper controller using encoder feedback the PFE register must be set to 1. The Position Feedback Ratio (PFN/PFD) is then used to map the auxiliary encoder feedback to the 50,000 steps/revolution of the motor. This is done by setting the ratio equal to the number of motor pulses/rev (50,000) divided by the number of auxiliary encoder pulses generated during 1 motor revolution. In the simplest case where the encoder is mounted to the stepper motor the denominator would be the quadrature resolution of the auxiliary encoder. For example using a 1000 line encoder (4000 quad pulses) the ratio is 50000/4000. Since the PFN and PFD registers are limited to a range of 10,000 we can reduce this ratio to 50/4 or PFN=50 and PFD=4 which are the default register values. If the feedback encoder is mounted at the load this ratio must include all gearing and mechanical translation in **both** the auxiliary encoder **and** motor connection to the load (see example for dual-loop servo above except use 50,000 pulses/rev for the motor instead of 10,000/rev).

Related Registers: PFD, PFE, PFC

PFT Position Feedback Correction Time

Class: Axis Register

Type: Floating point

Syntax: PFT

Range:

units	seconds
default	.010
minimum	.001
maximum	4.000

Restrictions: Stepper or dual-loop servo only.

Use: The position feedback correction time is the time that the servo controller waits between position corrections when using dual-loop position feedback (PFE=1 and PFN=non-zero value). The PFT, PFC and PFB registers, when properly adjusted, prevent limit cycling (hunting) around the final position.

Related Registers: PFL, PFB, PFE

PHB Phase Error Bound

Class: Motion Register

Type: Integer

Syntax: PHB

Range:

units	pulses
default	32,000
minimum	0
maximum	32,000

Use: The phase error bound register is used to define a bound on the phase error of the phase-locked loop. If this limit is exceeded, the phase error is set to half of the phase error bound, and bit five of the axis status register, SRA, is set to 1. This corresponds to the axis status message *Phase error past bound*.

Related Registers: PHR, PHE

PHE Phase-Locked Loop Enable

Class: Motion Register

Type: Boolean

Syntax: PHE

Range:
default 0
allowed values 0, 1

Use: This register is used to determine whether the phase-locked loop is enabled. If PHE is set to 1, then the phase-locked loop is enabled; and if PHE is set to 0, it is disabled.

Phase-Locked Loop operation allows the controller to maintain the phase (in this case the value of the auxiliary encoder) constant with respect to a cyclic event (in this case a pulse on the “Z” channel auxiliary encoder input). Phase locked operation is achieved by varying the ratio between the axis and the auxiliary encoder input as a function of the phase performance. Applications include packaging and labeling. The relationship between the axis to auxiliary ratio and the phase error, gain, and zero settings during phase locked operation is given by:

PHM(n) = PHM(n-1) + [PHR(n) - PHR(n-1) * PHZ / 256] * [PHG / 64]

Related Registers: PHB, PHG, PHL, PHM, PHO, PHP, PHR, PHT, PHZ

Motion Templates: Phase-locked loop

PHG Phase Gain

Class: Motion Register

Type: Integer

Syntax: PHG

Range:
default 0
minimum 0
maximum 255

Use: The phase gain is used to multiply the phase error, PHR, to adjust the value of the phase multiplier, PHM.

Related Registers: PHR, PHM, PHE

PHL Phase Length

Class: Motion Register

Type: Integer

Syntax: PHL

Range:

units	pulses
default	1,000
minimum	500
maximum	64,000

Use: The phase length register is used to define the number of pulses during one cycle of the reference input.

***Related Registers*:** PHP

PHM Phase Multiplier

Class: Motion Register

Type: Floating point

Syntax: PHM

Range:

minimum	0.0001
maximum	10,000.0000

Restrictions: Read only.

Use: The phase multiplier is the ratio between the axis and the reference input when using the phase-locked loop.

Related Registers: PHE

PHO Phase Offset

Class: Motion Register

Type: Integer

Syntax: PHO

Range:
units pulses
default 0
minimum -32,000
maximum 32,000

Use: The phase offset register is used to define an offset on the reference position, PHP, of the phase-locked loop.

Related Registers: PHP

PHP Phase Position

Class: Motion Register

Type: Integer

Syntax: PHP

Range:
units pulses
default 0
minimum -PHL/2
maximum PHL/2 - 1

Use: The phase position register is used to define the reference position of the phase-locked loop.

Related Registers: PHL, PHO, PHE

PHR Phase Error

Class: Motion Register

Type: Integer

Syntax: PHR

Range:
units pulses
minimum -32,000
maximum 32,000

Restrictions: Read only.

Use: The phase error is the difference between the desired reference position and the reference position that was captured when the position capture input became active. It can be used, along with PHG and PHZ, to make corrections in the phase position.

PHR = (PHP – PHO)

Related Registers: PHG, PHZ, PHE

PHT Phase Lockout Time

Class: Motion Register

Type: Floating point

Syntax: PHT

Range:
units seconds
default 0.05
minimum .001
maximum 4.000

Use: The phase lockout time is the time interval, after the position capture, in which the position capture input is disabled. This time interval is used to account for any undesired position capture inputs.

Related Registers: PHE

PHZ Phase Zero

Class: Motion Register

Type: Integer

Syntax: PHZ

Range:
default 245
minimum 0
maximum 255

Use: The phase zero register is used to define the zero of the compensator of the phase-locked loop. This, in conjunction with PHG, defines a method of correction of the phase in the phase-locked loop.

Related Registers: PHG, PHE

PIPN Network Profile in Progress

Class: System Register

Type: Boolean

Syntax: PIPN*p1* (PIPN0 PIPN63 PIPNVI5)

Parameters:

	allowed values	*description*
p1	0 through 63 or VI*n*	network address

Range:
default 0
allowed values 0, 1

Restrictions: Read only. Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This register returns a one when a network profile is in progress for the device addressed at *p1*. If a network profile is not in progress, then this register returns a zero.

Related Registers: IPN

PLA Axis Position Length

Class: Axis Register

Type: Floating point

Syntax: PLA

Range:

units	axis units
default	2,000,000,000 pulses
minimum	500 pulses
maximum	2,000,000,000 pulses

Restrictions: The PLA register value cannot be changed from within the programs or motion blocks (e.g., PLA=25.1). However, this register can be copied to a floating-point variable in a program or motion block (e.g., VF20=PLA).

Use: This register is used to define the axis position length. This is actually half the axis position register length. The axis position register, PSA, will count from -PLA units to PLA-(1/ [URA/URB]) units if position register wrap, PWE, is enabled. PLA has no effect on the axis position register if PWE is disabled.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, maximum, and minimum values must be divided by the value of (URA/URB) (see URA and URB).

Related Registers: PWE, URA, URB

PLX Auxiliary Position Length

Class: Axis Register

Type: Floating point

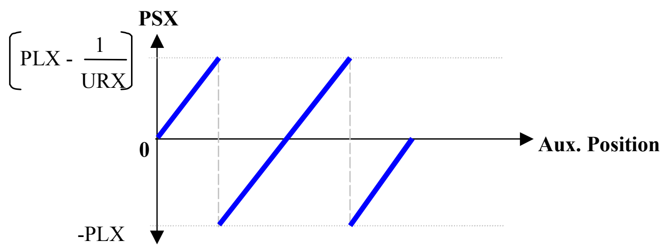
Syntax: PLX

Range:

units	auxiliary units
default	2,000,000,000 pulses
minimum	500 pulses
maximum	2,000,000,000 pulses

Restrictions: The PLX register value cannot be changed from within the programs or motion blocks (e.g., PLX=25.1). However, this register can be copied to a floating-point variable in a program or motion block (e.g., VF20=PLX).

Use: This register is used to define the auxiliary encoder position range. This is actually half the auxiliary position register length. The auxiliary position register, PSX, counts from -PLX auxiliary units to PLX-(1/URX) auxiliary units as shown below:



When Electronic Cam is Enabled:
When the electronic cam function is enabled (CAE=1) the auxiliary position register range defined above represents the cam master position range required to complete one cycle of the cam table. For example, assuming we have a 1000 line (4000 pulse/rev) auxiliary encoder, the axis and auxiliary units are both in revolutions ([URA/URB]=10000; URX=4000) and PLX=0.5, then the PSX register will count from -0.5 to 0.49975 encoder revolutions to complete one cam cycle.

Remarks: The Position Wrap Enable register (PWE) has no effect on the auxiliary position register rollover. The PSX register automatically rolls over at the limits defined above for PLX. Make sure the PSX register is initialized to a value that falls with this range.

The numerical values for the default, minimum, and maximum of this register are assuming that the Auxiliary Unit Ratio, URX, is set at its default value of 1. If the auxiliary unit ratio is set to a value other than 1, the default, maximum, and minimum values must be divided by the value for URX (see URX).

Related Registers: URX, PSX

POE Power Output Stage Enable

Class: Axis Register

Type: Boolean

Syntax: POE

Range:
default 1
allowed values 0, 1

Use: This register is used to determine whether the power output stage of the amplifier of the axis is enabled. If POE is set to 1, then the power output stage is enabled; and if POE is set to 0, it is disabled. **The POE register is a logical enable that will allow current to flow into the motor only when set true and no faults are present on the controller.**

POP Pops "Gosub" Address from Top of "Gosub" Stack

Class: Program Command

Syntax: POP

Restrictions: Allowed only in programs

Use: This command pops the last gosub address from the top of the gosub stack. It causes the program to exit a subroutine without returning.

Example:

```
PROGRAM1                          (* edit program 1)
MVL=5                             (* set motion velocity)
MAC=40                            (* set motion acceleration)
MPA=10                            (* set absolute move position)
GOSUB10                           (* unconditionally gosub 10)
GOTO20                            (* unconditionally goto 20)
10 RPA                            (* run to absolute position)
11 IF IP GOTO12                   (* conditionally goto 12)
IF FC <> 0 GOTO15                 (* conditionally goto 15)
GOTO11                            (* unconditionally goto 11)
12 RETURN                         (* return from gosub)
15 POP                            (* pop gosub address from top of gosub stack)
OUT "CONTROLLER  FAULT$N"         (* output string expression to the display)
OUT "TYPE 'FC?' FOR MESSAGE$N"    (* output string expression to the display)
20 END                            (* end program 1 and exit editor)
```

What will happen: This program, when executed, will set the velocity, acceleration rate, and absolute move position. Execution will then go to the subroutine at label 10, which will run the axis in the forward direction for 10 units. While the axis is running, the program checks two things: 1) to see if the axis is in position (IP); and 2) to see if a fault has occurred (FC<>0). If a fault has occurred, the program execution will go to label 15. Then, the program will pop the address of label 10 off of the stack, print an error message, and end. If a fault does not occur, the program will return to the statement after "GOSUB10," which goes to the statement at label 20, which ends the program.

***Related Commands**:* GOSUB, RETURN, RSTSTK

PROG Program Executing

Class: System Register

Type: Boolean

Syntax: PROG*p1* (e.g., PROG3 PROGVI4)

Parameters:

	allowed values	*description*
p1	1 through 4 or Vi*n*	program number

Range:
allowed values 0, 1

Restrictions: Read only.

Use: The program executing register is used to determine whether a program is executing. If program *p1* is executing, then PROG*p1* will be 1; and if program *p1* is not executing, then PROG*p1* will be 0.

***Related Registers**:* SRP

PROGRAM Edit Program in Terminal Window Line Editor

Class: Program Command

Syntax: PROGRAM*p1* (e.g., PROGRAM2)

Parameters:

	allowed values	*description*
p1	1 through 4	program number

Restrictions: Not allowed in programs or motion blocks. Allowed only in Motion Developer terminal window.

Use: This command starts the terminal window line editor at the first statement of PROGRAM *p1*. It is used either to view or edit programs.

Remarks: This command will not typically be used since Motion Developer provides a more full featured text editor for creating and editing programs and motion blocks. The terminal window can also be used for these functions and is invoked using the PROGRAM and MOTION commands. While in the terminal window line editor each line is prefixed by an asterisk (*). Use the exclamation point (!) command to exit the terminal window line editor.

This command will execute only when the axis has stopped and no programs or motion blocks are executing.

Example:

```
PROGRAM1      (* edit program 1)
PSA=0         (* set axis position register)
MVL=10        (* set motion velocity)
MAC=40        (* set motion acceleration)
MPA=12        (* load absolute move position)
RPA           (* run to absolute move position)
END           (* end program 1 and exit editor)
```

***Related Commands**:* MOTION, END, X, !, DEL, L, LABEL, FAULT

PSA Axis Position

Class: Axis Register

Type: Floating point

Syntax PSA

Range:

units	axis units
default	0 pulses
minimum	-2,000,000,000 pulses
maximum	2,000,000,000 pulses

Use: This register is used to define the position of the axis.

Remarks: This register supports up to six decimal places. The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, maximum, and minimum values must be divided by the value for (URA/URB) (see URA and URB).

Example:

```
PSA=0          (* set axis position)
MVL=10         (* set motion velocity)
MAC=40         (* set motion acceleration)
MPA=8          (* set absolute move position)
RPA            (* run to absolute position)
```

What will happen: Setting the axis position, velocity, acceleration, and absolute move position and issuing the RPA command will cause the axis to move 8 units in the forward direction.

Related Registers: URA, URB, PLA, PWE, OFA

PSAN Network Axis Position

Class: Axis Register

Type: Integer

Syntax: PSAN*p1* (e.g., PSAN0 PSAN63 PSANVI5)

Parameters:

	allowed values	*description*
p1	0 through 63 or VI*n*	network node address

Range:

units	pulses
minimum	-2,000,000,000 pulses
maximum	2,000,000,000 pulses

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This register accesses attribute 13 of the DeviceNet position controller object to define the actual position of the axis.

PSC Commanded Position

Class: Axis Register

Type: Floating point

Syntax: PSC

Range:
units axis units
default 0 pulses
minimum -2,000,000,000 pulses
maximum 2,000,000,000 pulses

Restrictions: Read only.

Use: This register supports up to six decimal places. This register is used to determine the commanded position of the axis. The commanded position is the controller's required position for the axis. The difference between this and the axis position, PSA, is called the following error, FE.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, minimum, and maximum values must be divided by the value for (URA/URB) (see URA and URB).

Related Registers: PSA, FE, URA, URB

PSCN Network Command Position

Class: Axis Register

Type: Integer

Syntax: PSCN*p1* (e.g., PSCN0 PSCN63 PSCNVI5)

Parameters:

	allowed values	*description*
p1	0 through 63 or Vi*n*	network address

Range:
units pulses
minimum -2,000,000,000 pulses
maximum 2,000,000,000 pulses

Restrictions: Read only. Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This register accesses attribute 15 of the DeviceNet position controller object to determine the command position of the axis. The command position is the controller's required position for the axis. The difference between this and the network axis position, PSAN, is called the following error, FE.

Related Registers: PSA, PSAN, FE

PSO Offset Move Reference Position

Class: Axis Register

Type: Floating point

Syntax: PSO

Range:

units	axis units
default	0 pulses
minimum	-2,000,000,000 pulses
maximum	2,000,000,000 pulses

Use: This register supports up to six decimal places. This register is used to define the reference position for offset moves initiated using the MPO command.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, maximum, and minimum values must be divided by the value for (URA/URB) (see URA and URB).

Example:

```
PSO=0       (* set offset position)
MVL=10      (* set motion velocity)
MAC=40      (* set motion acceleration)
MPO=10      (* set offset move position)
RPO         (* run to offset move position)
```

What will happen: Setting the offset position, velocity, acceleration, and offset move position and issuing the RPO command will cause axis one to move 10 units in the forward direction.

Related Registers: MPO, RPO, URA, URB

PSR Resolver Position

Class: Axis Register

Type: Integer

Syntax: PSR

Range:

minimum	0
maximum	4,095 (resolver feedback brushless servo) or 65,535 (encoder feedback brushless servo)

Restrictions: Brushless servo only; read only.

Use: This register is used to determine the resolver position.

PSX Auxiliary Position

Class: Axis Register

Type: Floating point

Syntax: PSX

Range:

units	auxiliary units
default	0 pulses
minimum	-2,000,000,000 pulses
maximum	2,000,000,000 pulses

Use: Defines the position of the auxiliary encoder of the axis.

Remarks: This register supports up to six decimal places. The numerical values for the default, minimum, and maximum of this register are assuming that the auxiliary unit ratio, URX, is set at its default value of 1. If the auxiliary unit ratio is set to a value other than 1, the default, minimum, and maximum values must be divided by the value for URX (see URX).

Example:

```
PSX=20    (* set auxiliary position to 20 auxiliary units)
PSX?      (* report auxiliary position)
```

Related Registers: URX, PLX, OFX

PUT Puts One Character to Serial Port

Class: Input/Output Command

Syntax: PUT *p1* (e.g., PUT VS1 PUT“A”)

Parameters:

	allowed values	*description*
p1	any string expression	string expression

Use: This command puts one character to the serial port. It takes the string expression and outputs only the first character to the serial port.

Example:

```
PUT VS1        (* put one character of string variable 1 to serial port)
PUT“Hello”     (* put one character of the string “Hello” to serial port [i.e., H])
```

Related Commands: GET, IN, OUT

Related Registers: DSE

PWE Position Register Wrap Enable

Class: Axis Register

Type: Boolean

Syntax: PWE

Range:
default 0
allowed values 0, 1

Restrictions: Cannot be assigned in programs or motion blocks.

Use: This register is used to determine whether the axis position register wrap is enabled. If PWE is set to 1, axis position register wrap is enabled; and if PWE is set to 0, it is disabled.

Remarks: When position register wrap is enabled, the controller will use the axis position length, PLA, to define the upper and lower roll over limits for the Axis Position register (PSA) as -PLA axis units to PLA-(1/[URA/URB]) axis units. Wrapping is required in unidirectional applications to prevent position register overflow or in applications where it makes sense to define a position modulus. PWE has no effect on the Auxiliary Position register (PSX) which always wraps. The setting of PWE has no effect on electronic cam mode.

Related Registers: PLA, PSA

PZA Axis Position Synchronize

Class: Axis Register

Type: Floating point

Syntax: PZA

Range:

units axis units
default 0 pulses
minimum -2,000,000,000 pulses
maximum 2,000,000,000 pulses

Restrictions: Read only.

Use: This register is used to synchronize the reading of the axis position and the auxiliary position. This register is read first, then the PZX register is read. **By using these registers instead of the standard position registers (PSA and PSX), there will be no more than 10 microseconds between the two readings.**

Remarks: Each time the PZA command is executed the value in the axis position register (PSA) is latched into the PZA register and within 10 µs the value in the auxiliary position register (PSX) is latched into the PZX register. These values remain until the PZA command is executed again.

The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1. If the axis unit ratio is set to a value other than 1, the default, minimum, and maximum must be divided by the value for (URA/URB) (see URA and URB).

Example: VF1=PZA-PZX (* calculate difference between axis and auxiliary positions)

Related Registers: PZX, URA, URB, PSA, PSX

PZX Auxiliary Position Synchronized

Class: Axis Register

Type: Floating point

Syntax: PZX

Range:

units	auxiliary units
default	0 pulses
minimum	-2,000,000,000 pulses
maximum	2,000,000,000 pulses

Restrictions: Read only.

Use: This register is used to synchronize the readings of the auxiliary position and the axis position. The PZA register is read first, then this register is read. **By using these registers instead of the standard position registers (PSA and PSX), there will be no more than 10 microseconds between the two readings.**

Remarks: Each time the PZA command is executed the value in the axis position register (PSA) is latched into the PZA register and within 10 µs the value in the auxiliary position register (PSX) is latched into the PZX register. These values remain until the PZA command is executed again.

The numerical values for the default, minimum, and maximum of this register are assuming that the auxiliary unit ratio, URX, is set at its default value of 1. If the auxiliary unit ratio is set to a value other than 1, the default, minimum, and maximum values must be divided by the value for URX (see URX).

Example: VF1=PZA-PZX (* calculate difference between axis and auxiliary positions)

Related Registers: PZA, URX, PSA, PSX

Q Reports Value of Register

Class: Diagnostic Command

Syntax: *p1*Q (e.g., SRSQ PSAQ MPAQ)

Parameters:

	allowed values	*description*
p1	any register	register

Restrictions: Not allowed in programs or motion blocks.

Use: This command is used to report the value of any register. It is exactly the same as the ? command.

Related Commands: DGO, ?

QTX Auxiliary Quadrature Type

Class: Axis Register

Syntax: QTX

Range:

default Q4

allowed values Q4 (quadrature x4)
PD (pulse/direction)
CW (clockwise/counterclockwise)

Restrictions: Not allowed in expressions.

Use: This register is used to define the signal input type for the auxiliary encoder input. The auxiliary encoder input is discussed in Section 3.6.6. The signal types supported are listed below:

Q4 (quadrature x4) Sets the input for two pulse waveforms in quadrature with a pulse multiplier of 4. (e.g., a 1,000 line encoder will generate 4,000 pulses)
PD (pulse/direction) Sets the input for a pulse input on channel A (IN_A) and a direction input on channel B (IN_B).
CW (CW/CCW) Sets the input for a pulse input on channel A (IN_A) for CW motion and a pulse input on channel B (IN_B) for CCW motion.

Remarks: The auxiliary encoder input will cause the Auxiliary Position register (PSX) to **increase** when:

1) QTX=Q4 and channel A leads channel B;
2) QTX=PD and channel B+ > channel B-;
3) QTX=CW and channel A has a pulse waveform and channel B does not.

Related Registers: PSX

RDN Network Run Direction Flag

Class: Motion Register

Type: Boolean

Syntax: RDN*p1* (RDN0 RDN63 RDNVI5)

Parameters:

	allowed values	description
p1	0 through 63 or VI*n*	network node address

Range:
allowed values 0, 1

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This command accesses attribute 23 of the DeviceNet position controller object to set the direction of motion of the axis addressed at *p1* when the RMN*p1* register is set to 1 (velocity mode). 1 = forward motion; 0 = reverse motion.

Related Registers: RMN

Related Commands: RPN, RVR, RVF

REM Remark

Class: Program Command

Syntax: REM*p1* (e.g., REM Program starts here)

Parameters:

	allowed values	description
p1	any string, 0 through 127 characters	text comment

Restrictions: Allowed only in programs or motion blocks.

Use: This command is used to add textual comments to a program or motion block.

Remarks: Comments are stored as part of a program or motion block, but they are ignored while the program or motion block is executing.

Example:

```
PROGRAM1                     (* edit program 1)
REM Set update screen to 5   (* comment)
UPS=5                        (* set update screen register)
```

REPEAT Repeats Motion from Start of Motion Block

Class: Program Command

Syntax: REPEAT

Restrictions: Allowed only in motion blocks.

Use: This command causes the motion block to repeat motion from the beginning of the motion block.

Example:

```
MOTION1     (* edit motion block 1)
            (* assign axis one to motion block)
MVL=10      (* set motion velocity)
MAC=40      (* set motion acceleration)
MPI=15      (* set incremental move position)
MPA=0       (* set absolute move position)
RPI         (* run to incremental position)
RPA         (* run to absolute position)
REPEAT      (* repeat motion from beginning of motion block)
END         (* end motion block 1 and exit editor)
```

What will happen: This motion block, when executed, will load the velocity, acceleration rate, incremental move position, and absolute move position. Next, the axis will move 15 units in the forward direction. Once the motion is completed, the axis will then move 15 units in the reverse direction. It will repeat this motion until a motion command or another motion block is executed.

RETRIEVE Retrieves User Memory

Class: System Command

Syntax: RETRIEVE

Restrictions: Not allowed in programs or motion blocks.

Use: This command is used to retrieve user memory from nonvolatile memory.

Remarks: This command will execute only when the controller or the system is faulted, the UPS register is set to its default value of zero (i.e., UPS=0) and no programs or motion blocks are executing.

Related Commands: SAVE, AUTORET

RETURN Returns from "Gosub"

Class: Program Command

Syntax: RETURN

Restrictions: Allowed only in programs.

Use: This command causes the program to return from a subroutine to the statement after the gosub statement.

Example:

```
PROGRAM1                  (* edit program 1)
MVL=5                     (* set motion velocity)
MAC=40                    (* set motion acceleration)
MPA=10                    (* set absolute move position)
GOSUB10                   (* unconditionally gosub 10)
GOTO20                    (* unconditionally goto 20)
10 RPA                    (* run to absolute position)
WAIT IP                   (* wait for expression to be true)
OUT "Axis in position$N"  (* output string expression to display)
RETURN                    (* return from gosub)
20 END                    (* end program 1 and exit editor)
```

What will happen: This program, when executed, will load the velocity, acceleration rate, and absolute move position. It will then go to the subroutine at label 10, which will run the axis in the forward direction for 10 units. Once the axis is in position, the program will print a string. The program will return to the statement after "GOSUB10," which goes to the statement at label 20, which ends the program.

***Related Commands**:* GOSUB, POP, RSTSTK

REVISION Reports Firmware Revision

Class: Diagnostic Command

Syntax: REVISION

Restrictions: Not allowed in programs or motion blocks.

Use: This command reports the revision of the system firmware.

REVN Network Device Revision

Class: Diagnostic Command

Syntax: REVN*p1* (REVN0 REVN63)

Parameters:

	allowed values	*description*
p1	0 through 63	network node address

Restrictions: Not allowed in programs or motion blocks. Cannot be accessed in immediate mode over a DeviceNet connection. This is a diagnostic command and is not allowed in programs or motion blocks.

Use: This command accesses attributes 4 and 7 of the DeviceNet identity object to report the model number and firmware revision of the device addressed at *p1*.

Related Commands: REVISION

RGT Select Rightmost Characters of String Operator

Class: Operator

Type: String

Syntax: RGT(*p1*,*p2*)

Parameters:

	allowed values	*description*
p1	any string operand	string
p2	any integer operand >= 0	number of characters

Use: Used to select the rightmost *p2* characters of string *p1*.

Example:

VS1="Jogging axis forward"	(* set string variable 1 to "Jogging axis forward")
VS2=RGT(VS1,7)	(* set string variable VS2 to rightmost 7 characters of VS1)
VS2?	(* report the value of string variable VS2 in terminal window)
* "forward"	

Related Commands: LFT, MID

RHF Runs Forward to Home Input

Class: Motion Command

Syntax: RHF

Use: This command runs forward to the home input.

Remarks: When this command is executed, the axis will run forward until the home input is encountered. It will then stop and run back to the position where the home input (digital input DI1) was detected. The software overtravel limits, OTF and OTR, are ignored while the axis is homing.

Example:

```
PROGRAM1     (* edit program 1)
MVL=1        (* set motion velocity)
MAC=50       (* set motion acceleration)
RHF          (* run forward to home input)
WAIT IP      (* wait for axis to be in position)
PSA=0        (* set axis position register)
END          (* end program 1 and exit editor)
```

What will happen: This program, once executed, will first set the motion velocity and acceleration. It will then run the axis in the forward direction until the home input is encountered, wait for the axis to be in position, and then set the axis position register to 0.

Related Commands: RHR, RMF, ROF

Related Registers:

When MT=VEL	MVL, MAC, MDC, MJK, MFP, MFA, MFD
When MT=TIME	Command cannot be used
When MT=PULSE	Command cannot be used

***Motion Templates*:** Run reverse until home input; run reverse until home and marker inputs

RHR Runs Reverse to Home Input

Class: Motion Command

Syntax: RHR

Use: This command runs reverse to the home input.

Remarks: When this command is executed, the axis will run reverse until the home input is encountered. It will then stop and run back to the position where the home input was detected. The software overtravel limits, OTF and OTR, are ignored while the axis is homing.

Example:

```
PROGRAM1      (* edit program 1)
MVL=1         (* set motion velocity)
MAC=50        (* set motion acceleration)
RHR           (* run reverse to home input)
WAIT IP       (* wait for axis to be in position)
PSA=0         (* set axis position register)
END           (* end program 1 and exit editor)
```

What will happen: This program, once executed, will first set the motion velocity and acceleration. It will then run the axis in the reverse direction until the home input is encountered, wait for the axis to be in position, and then set the axis position register to 0.

***Related Commands**:* RHF, RMR, ROR

Related Registers:

When MT=VEL	MVL, MAC, MDC, MJK, MFP, MFA, MFD
When MT=TIME	Command cannot be used
When MT=PULSE	Command cannot be used

Motion Templates: Run reverse until home input; run reverse until home and marker inputs

RIN Network Run Incremental Flag

Class: Motion Register

Type: Boolean

Syntax: RIN*p1* (RIN0 RIN63)

Parameters:

	allowed values	*description*
p1	0 through 63 or VI*n*	network node address

Range:

allowed values 0, 1

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This command accesses attribute 10 of the DeviceNet position controller object to set the absolute or incremental position mode of the axis addressed at *p1*. 0 = absolute position mode; 1 = incremental position mode.

Related Registers: RMN

Related Commands: RPA, RPI, RPN

RMF Runs Forward to Marker

Class: Motion Command

Syntax: RMF

Use: This command runs forward to the marker. The marker is defined as the encoder channel index input when using encoder feedback controllers or as the zero position on the resolver when using resolver feedback controllers.

Remarks: When this command is executed, the axis will run forward at the velocity specified in the MVM register until the marker is encountered. It will then stop and run back to the position where the marker was detected. The software overtravel limits, OTF and OTR, are ignored while homing the axis.

Example:

```
PROGRAM1     (* edit program 1)
MVM=1        (* set motion velocity for run to marker)
MAC=50       (* set motion acceleration)
RMF          (* run forward to marker)
WAIT IP      (* wait for axis to be in position)
PSA=0        (* set axis position register)
END          (* end program 1 and exit editor)
```

What will happen: This program, once executed, will first set the motion velocity for run to marker and acceleration. It will then run the axis in the forward direction until the marker is encountered, wait for the axis to be in position, and then set the axis position register to 0.

Related Commands: RMR, RHF, ROF

Related Registers:

When MT=VEL	MVM, MAC, MDC, MJK, MFP, MFA, MFD
When MT=TIME	Command cannot be used
When MT=PULSE	Command cannot be used

Motion Templates: Run reverse until marker input; run reverse until home and marker inputs; run reverse until overtravel and marker inputs

RMN Network Run Mode

Class: Motion Register

Type: Integer

Syntax: RMN*p1* (RMN0 RMN63 RMNVI5)

Parameters:

	allowed values	description
p1	0 through 63 **or** VI*n*	network node address

Range:

allowed values 0, 1

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This command accesses attribute 3 of the DeviceNet position controller object to set the motion mode of the axis addressed at *p1*. 0 = position mode; 1 = velocity mode; and 2 = torque mode.

Related Registers: RDN, RIN

Related Commands: RPA, RPI, RPN, RVF, RVR

RMR Runs Reverse to Marker

Class: Motion Command

Syntax: RMR

Use: This command runs reverse to the marker. The marker is defined as encoder channel index input on encoder feedback controllers or as the zero position on the resolver of resolver feedback controllers.

Remarks: When this command is executed, the axis will run reverse at the velocity specified in the MVM register until the marker is encountered. It will then stop and run back to the position where the marker was detected. The software overtravel limits, OTF and OTR, are ignored while the axis is homing.

Example:

```
PROGRAM1     (* edit program 1)
MVM=1        (* set motion velocity for run to marker)
MAC=50       (* set motion acceleration)
RMR          (* run reverse to marker)
WAIT IP      (* wait for axis to be in position)
PSA=0        (* set axis position register)
END          (* end program 1 and exit editor)
```

What will happen: This program, once executed, will first set the motion velocity for run to marker and acceleration. It will then run the axis in the reverse direction until the marker is encountered, wait for the axis to be in position, and then set the axis position register to 0.

Related Commands: RMF, RHR, ROR

Related Registers:

When MT=VEL	MVM, MAC, MDC, MJK, MFP, MFA, MFD
When MT=TIME	Command cannot be used
When MT=PULSE	Command cannot be used

Motion Templates: Run reverse until marker input; run reverse until home and marker inputs; run reverse until overtravel and marker inputs

ROF Runs Forward to Overtravel Input

Class: Motion Command

Syntax: ROF

Use: This command runs forward to the forward overtravel input.

Remarks: When this command is executed, the axis will run until the forward overtravel input is encountered. It will then stop and run back to the position where the forward overtravel input was detected. The software overtravel limits, OTF and OTR, are ignored while the axis is homing. The hardware overtravel inputs do **not** need to be enabled (OTE=1) to use this command.

Example:

```
PROGRAM1      (* edit program 1)
MVL=1         (* set motion velocity)
MAC=50        (* set motion acceleration)
ROF           (* run forward to overtravel input)
WAIT IP       (* wait for axis to be in position)
PSA=0         (* set axis position register)
END           (* end program 1 and exit editor)
```

What will happen: This program, once executed, will first set the motion velocity and acceleration. It will then run the axis in the forward direction until the forward overtravel input is encountered, wait for the axis to be in position, and then set the axis position register to 0.

Related Commands: ROR, RHF, RMF

Related Registers:

When MT=VEL	MVL, MAC, MDC, MJK, MFP, MFA, MFD
When MT=TIME or MT=PULSE	Command cannot be used

Motion Templates: Run reverse until overtravel inputs; run reverse until overtravel and marker inputs

ROL, ROR Rotate Operators

Class: Operator

Type: Integer

Syntax: *p1* ROL *p2*   *p1* ROR *p2*

Parameters: *allowed values*

p1 any integer operand

p2 any integer operand

Use: These operators are used to rotate the bits of *p1* by the number of places specified by *p2*.

Example:

```
VI1=2#11101001        (* set integer variable 1 to 2#11101001)
VI2=VI1 ROL 2         (* set integer variable 2 to VI1 rotated left by 2 places)
VS1=ITB(VI2,12)       (* set string variable 1 to VI2 converted to binary string)
VS1?                  (* report value of string variable 1)
*"2#1110100100"
VI3=VI1 ROR 3         (* set integer variable 3 to VI1 rotated right by 3 places)
VS2=ITB(VI3,32)       (* set string variable 2 to VI3 converted to binary string)
VS2?                  (* report value of string variable 2)
*"2#10000000000000000000000000011101"
```

Related Operators: SHL, SHR

ROR Runs Reverse to Overtravel Input

Class: Motion Command

Syntax: ROR

Use: This command runs reverse to the reverse overtravel input.

Remarks: When this command is executed, the axis will run until the reverse overtravel input is encountered. It will then stop and run back to the position where the reverse overtravel input was detected. The software overtravel limits, OTF and OTR, are ignored while the axis is homing. The hardware overtravel inputs do **not** need to be enabled (OTE=1) to use this command.

Example:

```
PROGRAM1     (* edit program 1)
MVL=1        (* set motion velocity)
MAC=50       (* set motion acceleration)
ROR          (* run reverse to overtravel input)
WAIT IP      (* wait for axis to be in position)
PSA=0        (* set axis position register)
END          (* end program 1 and exit editor)
```

What will happen: This program, once executed, will first set the motion velocity and acceleration. It will then run the axis in the reverse direction until the reverse overtravel input is encountered, wait for the axis to be in position, and then set the axis position register to 0.

Related Commands: ROF, RHR, RMR

Related Registers:

When MT=VEL	MVL, MAC, MDC, MJK, MFP, MFA, MFD
When MT=TIME	Command cannot be used
When MT=PULSE	Command cannot be used

***Motion Templates*:** Run reverse until overtravel inputs; run reverse until overtravel and marker inputs

RPA Runs to Absolute Position

Class: Motion Command

Syntax: RPA

Use: This command runs the axis to the absolute move position.

Remarks: The run commands override each other unless they are used in a motion block.

Example:

```
PSA=0     (* set axis position register)
MVL=10    (* set motion velocity)
MAC=40    (* set motion acceleration)
MPA=8     (* set absolute move position)
RPA       (* run to absolute move position)
```

What will happen: Setting the axis position register, velocity, acceleration, and absolute move position and issuing the RPA command will cause the axis to move 8 units in the forward direction.

Related Commands: RPI, RPO, RVF, RVR

Related Registers:

When MT=VEL	MPA, MVL, MAC, MDC, MJK, MFP, MFA, MFD
When MT=TIME	MPA, MTM, MAP, MDP, MJK, MFP, MFA, MFD
When MT=PULSE	MPA, MPS, MPL, MAP, MDP, MVP

Motion Templates: Absolute move; blended move; absolute move with feedrate override; time-based absolute move; time-based absolute move with feedrate override; pulse-based absolute move; pulse-based blended move

RPI Runs to Incremental Position

Class: Motion Command

Syntax: RPI

Use: This command runs the axis to the incremental move position, MPI (i.e., it runs from the current position of the axis to the current position incremented by the value of MPI).

Remarks: The run commands override each other unless they are used in a motion block.

Example:

```
MVL=10    (* set motion velocity)
MAC=40    (* set motion acceleration rate)
MPI=12    (* set incremental move position)
RPI       (* run to incremental move position)
```

What will happen: Setting the velocity, acceleration, and incremental move position and issuing the RPI command will cause the axis to move 12 units in the forward direction.

Related Commands: RPA, RPO, RVF, RVR

Related Registers:

When MT=VEL	MPI, MVL, MAC, MDC, MJK, MFP, MFA, MFD
When MT=TIME	MPI, MTM, MAP, MDP, MJK, MFP, MFA, MFD
When MT=PULSE	MPI, MPS, MPL, MAP, MDP, MVP

Motion Templates: Incremental move; time-based incremental move; pulse-based incremental move; index move after input; index move at predefined auxiliary position reference

RPN Run Profile of Network Device

Class: Motion Command

Syntax: RPN*p1* (RPN0 RPN63)

Parameters:

	allowed values	*description*
p1	0 through 63 or VI*n*	network node address

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This command accesses attribute 11 of the DeviceNet position controller object to cause the axis addressed at *p1* to perform one of the following functions:

Run to absolute position when RMN=0 and RIN=0
Run to incremental position when RMN=0 and RIN=1
Run to velocity forward when RMN=1 and RDN=1
Run to velocity reverse when RMN=1 and RDN=0
Run to torque when RMN = 2

Related Registers: RIN, RDN, RMN

Related Commands: RPA, RPI, RVF, RVR

RPO Runs to Offset Position

Class: Motion Command

Syntax: RPO

Use: This command runs the axis to the Offset Move Position (MPO).

Remarks: The run commands override each other unless they are used in a motion block.

Example:

```
PSO=0     (* set offset position register)
MVL=10    (* set motion velocity)
MAC=40    (* set motion acceleration rate)
MPO=8     (* set offset move position)
RPO       (* run to offset move position)
```

What will happen: Setting the offset position register, velocity, acceleration, and offset move position and issuing the RPO command will cause the axis to move 8 units in the forward direction.

Related Commands: MPO, PSO, RPA, RPI, RVF, RVR

Related Registers:

When MT=VEL	MPO, MVL, MAC, MDC, MJK, MFP, MFA, MFD
When MT=TIME	MPO, MTM, MAP, MDP, MJK, MFP, MFA, MFD
When MT=PULSE	MPO, MPS, MPL, MAP, MDP, MVP

Motion Templates: Offset move; time-based offset move; pulse-based offset move

RSF — Resets Faults

Class: System Command

Syntax: RSF

Restrictions: Not allowed in motion blocks.

Use: This command resets all controller faults.

Remarks: The RSF command sets the axis commanded position equal to the actual position, thus making axis following error and motor torque output equal to zero. Faults should be automatically reset by a program only after allowing appropriate inspection into the source of the fault.

***Related Commands*:** STF

Related Registers: FC

RSFN — Reset Network Faults

Class: System Command

Syntax: RSFN*p1* (RSFN RSFN() RSFN63 RSFNV15)

Parameters:

	allowed values	*description*
p1	none **or** 0 through 63 **or** VI*n*	network node address

Restrictions: Not allowed in motion blocks. Cannot be accessed in immediate mode over a DeviceNet connection.

Use: When *p1* is not specified, this command resets the network faults of the controller. When *p1* is specified, this command accesses attribute 17 of the position controller object to reset faults of the controller addressed at *p1*.

***Related Commands*:** RSF, RSFS, RSFALL

Related Registers: FCN

RSM — Resumes Motion

Class: Program Command

Syntax: RSM

Restrictions: Not allowed in motion blocks.

Use: This command resumes axis motion suspended using the SUP command.

***Related Commands*:** SUP

RSTSTK Resets "Gosub" Stack to Empty

Class: Program Command

Syntax: RSTSTK

Restrictions: Allowed only in programs.

Use: This command resets the gosub stack to empty.

Remarks: This command will eliminate all gosubs that have been executed.

Example:

```
     PROGRAM1                        (* edit program 1)
     IN VI1                          (* input variable value from key buffer)
     IF VI1>=0 GOTO5                 (* conditionally goto 5)
     OUT"-"                          (* output string expression to serial port)
     VI1=-VI1                        (* set integer variable 1)
5    VI2=10                          (* set integer variable 2 with pointer)
     GOSUB10                         (* unconditionally gosub 10)
     GOTO30                          (* unconditionally goto 30)
10   VIVI2=VI1 - VI1/10*10 + 48      (* set integer variable VI2)
     VI1=VI1/10                      (* set integer variable 1)
     VI2=VI2+1                       (* set integer variable 2 with next pointer)
     IF VI2>16 GOTO20                (* conditionally goto 20)
     IF VI1<>0 GOSUB10               (* conditionally gosub 10)
     VI2=VI2-1                       (* set integer variable 2 with pointer)
     OUT CHR(VIVI2)                  (* output string expression to serial port)
     RETURN                          (* return from gosub)
20   RSTSTK                          (* reset gosub stack to empty)
     OUT"ERROR:$N"                   (* output string expression to serial port)
     OUT"Number more than 6 digits$N" (* output string expression to serial port)
30   END                             (* end program 1 and exit editor)
```

What will happen: This program inputs an integer variable value from the key buffer. If the value is negative, the program sends a negative sign to the display, sets the integer value positive, and continues to label 5, which sets the variable pointer to 10. The program then goes to the subroutine at label 10, which stores the ASCII code of the ones digit in VI10, the ASCII code of the tens digit in VI11, etc. If the number of digits is greater than 6, the program goes to label 20, which resets the gosub stack and prints an error message; otherwise, each character of integer number VI1 will be sent to the serial port and the program ends at label 30.

Related Commands: POP, GOSUB

RTU Remote Terminal Unit Mode Enable

Class: System Command

Syntax: RTU

Type: Boolean

Range:
default 0
allowed values 0, 1

Restrictions: Cannot be assigned in motion blocks. Available in firmware version 2.1 and higher.

Use: The RTU enables the controller to communicate with a remote terminal unit (RTU). If RTU is set to 1, RTU mode is enabled; if RTU is set to 0, RTU mode is disabled.

Remarks: Allows user to toggle back and forth between RTU mode and serial communication mode. When the controller is in RTU mode, receipt of 10 consecutive non-RTU messages (such as pressing the <Enter> key 10 consecutive times from the Terminal Window) will revert the controller back to serial communication mode with the currently set baud rate, odd parity, and 7 data bits. **Once in this mode it is not possible to set RTU=1 and it is necessary to cycle power on the controller to re-enable RTU communications.**

Related Registers: ADDR, BAUD, BIT, RTUF

RTUF Remote Terminal Unit Communication Flag

Class: System Command

Syntax: RTUF

Type: Boolean

Range:
allowed values 0, 1

Restrictions: Read only. Available in firmware version 2.1 and higher.

Use: This register is used to tell whether Remote Terminal Unit (RTU) communication is occurring. This flag is set to one when a RTU communication occurs correctly and is cleared to zero when its value is tested. A program can monitor for successful RTU communication by testing RTUF at a rate slower than the RTU communication rate. As long as RTUF continues to return a value of 1, RTU communication is correctly taking place.

Related Registers: ADDR, RTU

RTV Retrieve Variable from Nonvolatile Memory to RAM

Class:	System Command
Syntax:	RTV
Restrictions:	Allowed only in programs.
Use:	The RTV command retrieves integer variables 1 through 1,024 and floating point variables 1 through 512 from nonvolatile memory (flash) to RAM. If the RTV command is executed before a Save Variables (SVV) command has been executed the affected variables will be set to zero.
Related Registers:	VI, VF
Related Commands:	SVV, SAVE, RETRIEVE

RVF Runs to Velocity Forward

Class: Motion Command

Syntax: RVF

Use: This command runs the axis in the forward direction.

Remarks: The run commands override each other unless they are used in a motion block.

Example:

```
MVL=10    (* set motion velocity)
MAC=50    (* set motion acceleration)
RVF       (* run forward)
```

What will happen: Loading the velocity and acceleration and issuing the RVF command will cause the axis to run in the forward direction until another motion command is issued.

Related Commands: RVR, RPA, RPI, RPO

Related Registers:

When MT=VEL	MVL, MAC, MDC, MJK, MFP, MFA, MFD
When MT=TIME	Command cannot be used
When MT=PULSE	MPS, MPL, MVP

Motion Templates: Run reverse until torque limit; velocity-based continuous move; run forward until torque limit; run reverse at torque limit; single-axis run forward until input

Utility Templates: Jog using single-pole, double-throw switch

RVR Runs to Velocity Reverse

Class: Motion Command

Syntax: RVR

Use: This command runs the axis in the reverse direction.

Remarks: The run commands override each other unless they are used in a motion block.

Example:

```
MVL=10    (* set motion velocity)
MAC=50    (* set motion acceleration)
RVR       (* run forward)
```

What will happen: Setting the velocity and acceleration and issuing the RVR command will cause the axis to run in the reverse direction until another motion command is issued.

***Related Commands**:* RVF, RPA, RPI, RPO

Related Registers:

When MT=VEL	MVL, MAC, MDC, MJK, MFP, MFA, MFD
When MT=TIME	Command cannot be used
When MT=PULSE	MPS, MPL, MVP

Motion Templates: Run reverse until torque limit; velocity-based continuous move; run forward until torque limit; run reverse at torque limit; single-axis run forward until input

***Utility Templates**:* Jog using single-pole, double-throw switch

SAVE Saves User Memory

Class: System Command

Syntax: SAVE

Restrictions: Not allowed in programs or motion blocks.

Use: This command is used to save user memory from RAM to nonvolatile memory. Starting with firmware version 2.1 and later the Save command also executes the AUTORET command.

Remarks: This command will execute only when the controller or system is faulted and no programs or motion blocks are executing.

***Related Commands**:* AUTORET, RETRIEVE, SVV

SCAN Maximum Scan Time

Class: System Register

Syntax: SCAN

Range:

units	seconds
default	0
minimum	0.00
maximum	1.00

Restrictions: Not allowed in programs, motion blocks or expressions.

Use: Defines the maximum time allowed between updates of the I/O connection of the network. If the I/O connection is not updated in time, then the system will fault due to *Network Communication Error* and the FCN register will indicate an *I/O Scan Time-Out* (bit 11 set to 1). If SCAN is set to zero, then no check of the update time is performed. Applies to DeviceNet and PROFIBUS networks.

Example: SCAN=0.05 (* set maximum scan time to 50 milliseconds)

SCRD Screen Data

Class: Input/Output Register

Syntax: SCRD*p1.p2* (e.g., SCRD1.1 SCRDVI1.2 SCRDVI5.VI7)

Parameters:

	allowed values	*description*
p1	1 through 50 or VI*n*	screen number
p2	1 through 4 or VI*n*	line number

Restrictions: Not allowed in expressions.

Use: This register is used to define screen data for line *p2* of screen number *p1*.

Example:

SCRD1.1=FTS(VLA,5,2)	(* set screen data for screen 1, line 1 to axis velocity, field width of (* 5 and 2 decimal places)
SCRDVI1.2="Jogging"	(* set screen data for screen VI1, line 2 to "Jogging")

Related Registers: SCRP, SCRL, UPS

SCRL Screen Line

Class: Input/Output Register

Type: String

Syntax: SCRL*p1.p2* (e.g., SCRL1.1 SCRLVI2.3 SCRLVI4.VI9)

Parameters:

	allowed values	*description*
p1	1 through 50 **or** VI*n*	screen number
p2	1 through 4 **or** VI*n*	line number

Range:

default “”
allowed values any string, 0 through 40 characters long

Use: This register is used to define a line of characters for line number *p2* of screen *p1*.

Example:

SCRL1.1=“Axis velocity:” (* set screen line 1 of screen 1 to “Axis velocity:”)
SCRLVI2.3=“Motion Parameters” (* set screen line 3 of screen VI2 to “Motion Parameters”)

Related Registers: SCRD, SCRL, UPS

SCRP Screen Position of Data

Class: Input/Output Register

Type: Integer

Syntax: SCRP*p1.p2* (e.g., SCRP1.1 SCRPVI2.3 SCRPVI3.VI6)

Parameters:

	allowed values	*description*
p1	1 through 50 **or** Vi*n*	screen number
p2	1 through 4 **or** VI*n*	line number

Range:

default 1
minimum 1
maximum 40

Use: This register is used to define the column position where the screen data, SCRD, is placed on the screen line.

Example:

SCRP1.1=15 (* set screen position of data for screen 1, line 1 to column 15)
SCRPVI2.3=20 (* set screen position of data for screen VI2, line 3 to column 20)

Related Registers: SCRD, SCRL, UPS

SECURE Secures User Memory

Class: System Command

Syntax: SECURE

Restrictions: Not allowed in programs or motion blocks.

Use: This command secures user memory space and protects user's intellectual property. It disables the PROGRAM, FAULT, and MOTION commands and prohibits programs or motion blocks from being uploaded to the controller. To re-enable these commands, you must execute the CLM command to clear the memory.

Related Commands: PASSWORD, CHANGEPW

SHL, SHR Arithmetic Shift Operators

Class: Operator

Type: Integer

Syntax: *p1* SHL *p2*   *p1* SHR *p2*

Parameters: *allowed values*
p1 any integer operand
p2 any integer operand

Use: These operators are used to perform an arithmetic shift of *p1* by the number of places specified by *p2*.

Example:

```
VI1=2#11101001        (* set integer variable 1 to 2#01101001)
VI2=VI1 SHL 3         (* set integer variable 2 to VI1 shifted left by 3 places)
VS1=ITB(VI2,13)       (* set string variable 1 to VI2 converted to binary string)
VS1?                  (* report value of string variable 1)
*"2#11101001000"
VI3=VI1 SHR 2         (* set integer variable 3 to VI1 shifted right by 2 places)
VS2=ITB(VI3,8)        (* set string variable 2 to VI3 converted to binary string)
VS2?                  (* report value of string variable 2)
*"2#111010"
```

Related Operators: ROL, ROR

SIN Sine Trigonometric Function Operator

Class: Operator

Type: Floating point

Syntax: SIN(*p1*)

Parameters: *allowed values*
p1 any floating point operand

Use: Used to perform trigonometric functions on *p1*. The operand *p1* must be in degrees.

SNI Scanned Network Input

Class: I/O Register

Type: Integer, Boolean

Syntax: SNI*p1.p2*

Parameters:	*allowed values*	*description*
p1	1 through 4 **or** Vi*n*	scanned register number
p2	none **or** 1 through 32 **or** Vi*n*	digital input number

Range:
allowed values 0 through $FFFFFFFF_{16}$ **or** 0 and 1

Restrictions: Read only.

Use: The scanned network input register contains the values of the network digital inputs of the node at the address assigned by SNIA. The digital inputs are general-purpose inputs used for process control.

Remarks: The controller cannot read the network inputs using this register unless the node is in a scan list of a scanner installed on the same network.

Example:

```
SNIA1=24        (* set node address for scanned input one to 24)
SNI1?           (* report value of scanned inputs)
*16#135B60F7
```

SNIA Scanned Network Input Address

Class: I/O Register

Type: Integer

Syntax: SNIA*p1*

Parameters:	*allowed values*	*description*
p1	1 through 4 **or** Vi*n*	scanned register number

Range:
default 0
allowed values 0 through 63

Use: This register is used to assign the address of the node whose inputs are scanned for the scanned register *p1*.

Example:

```
SNIA1=24     (* set node address for scanned input one to 24)
```

SQR Square Root Operator

Class: Operator

Type: Floating point, integer

Syntax: SQR(*p1*)

Parameters: *allowed values*
p1 any positive integer or floating point operand

Use: This operator is used to take the square root of *p1*.

SRA Axis Status

Class: System Register

Type: Integer, Boolean

Syntax: SRA*p1* (e.g., SRA SRA4 SRAVI3)

Parameters:

	allowed values	*description*
p1	none **or** 0 through 15 **or** VI*n*	axis status register bit number

Range:
allowed values 0 through $FFFF_{16}$ **or** 0 and 1

Restrictions: Read only.

Use: The axis status register is used to determine the status of the axis.

Remarks:
1. When the SRA? command is executed, the axis status register value will be given as an English statement.
2. If the computer interface format is enabled, and the SRA? command is executed, the axis status register value will be given as an integer number equal to the decimal equivalent of the registers binary value. Note that if the axis direction is reverse, bit 7 will be set to 0, and the associated message is *Axis direction reverse*. The possibilities are listed below:

bit	message	bit	message
0	Motion generator enabled	8	Axis in position*
1	Gearing enabled	9	Axis at torque limit
2	Phase locked loop enabled	10	Axis at overtravel*
3	Motion block executing	11	Axis at software overtravel*
4	Phase error captured	12	Motion suspended
5	Phase error past bound	13	AXIS FAULT
6	Axis accel/decel	14	Cam enabled
7	Axis direction forward	15	Reserved

* These bits are latched when Bit 0 goes False, and are reset when Bit 0 goes True again.

SRP Program Status

Class: System Register

Type: Integer, Boolean

Syntax: SRP*p1.p2* (e.g., SRP1 SRPVI1.3 SRP2.VI3 SRPVI1.VI2)

Parameters:

	allowed values	*description*
p1	1 through 4 **or** VI*n*	program number
p2	none **or** 0 through 15 **or** VI*n*	program status register bit number

Range:
allowed values 0 through $FFFF_{16}$ **or** 0 and 1

Restrictions: Read only.

Use: The program status register is used to determine the status of a program.

Remarks: 1. When the SRP*p1*? command is executed, the program status will be given as an English statement. If the program is not executing, the message given is *Program not executing.*
2. If the computer interface format is enabled and the SRP*p1*? command is executed, the program status will be given as an integer number equal to the decimal equivalent of the registers binary value. Note that if the program is not executing, bit 0 will be set to 0, and the associated message is *Program not executing*. The possibilities are listed below:

bit	message	bit	message
0	Program executing	8	Invalid command acknowledgment
1	Program locked out	9	Variable save failure
2	Reserved	10	Reserved
3	Reserved	11	Reserved
4	Invalid digit in string	12	Reserved
5	String value out of range	13	Reserved
6	Floating point value out of range	14	Reserved
7	Reserved	15	PROGRAM FAULT

SRS System Status

Class: System Register

Type: Integer, Boolean

Syntax: SRS*p1* (e.g., SRS SRS8 SRSVI2)

Parameters:

	allowed values	*description*
p1	none **or** 0 through 15 **or** VI*n*	system status register bit number

Range:
allowed values 0 through $FFFF_{16}$ **or** 0 and 1

Restrictions: Read only.

Use: The system status register is used to determine the status of the system.

Remarks:
1. When the SRS? command is executed, the system status register value will be given as an English statement.
2. If the computer interface format is enabled and the SRS? command is executed, the system status register value will be given as an integer number equal to the decimal equivalent of the registers binary value. Note that if no program is executing, bit 0 will be set to 0, and the associated message is *No program executing*. The possibilities are listed below:

bit	message	bit	message
0	Program executing	8	Reserved
1	Program locked out	9	Reserved
2	Reserved	10	Reserved
3	Motion block executing	11	Reserved
4	Key buffer empty	12	I/O FAULT
5	Transmit buffer empty	13	AXIS FAULT
6	Network connection available	14	SYSTEM FAULT
7	Network on-line	15	MEMORY FAULT

ST Stops Motion

Class: Motion Command

Syntax: ST

Use: This command stops all motion.

Remarks: This command, once executed, will immediately decelerate the axis at the deceleration loaded. This command sets SRA register bits 0, 1, 2, and 14 False (to Logic 0).

Restrictions: Do not use ST in Program 4. Its use in program 4 is unnecessary since the profile generator is halted any time a fault occurs. If ST (or any other motion command) is present in Program 4 when the controller is faulted, it will result in generation of an “Invalid Motion” message that masks the actual fault cause by overwriting the message for the actual fault. As an alternative, you may use the HT (Halt) command instead since it will not produce the “Invalid Motion” message.

Example:

```
MVL=10     (* set motion velocity)
MAC=20     (* set motion acceleration)
MDC=40     (* set motion deceleration)
RVF        (* run forward)
ST         (* stop all motion)
```

What will happen: Setting the velocity, acceleration, and deceleration and issuing the RVF command will cause the axis to run forward. Issuing the ST command will decelerate the axis at 40 units/sec^2 and stop all motion.

***Related Commands**:* HT

Related Register:

When MT=VEL	MDC, MJK
When MT=TIME	No registers used
When MT=PULSE	MPS, MPL

Motion Template: Run forward until input

Utility Templates: Jog using single-pole, double-throw switch

STEP Step Input

Class: Motion Command

Syntax: STEP*p1* (e.g., STEP100 STEPVI1)

Parameters:

	allowed values	*description*
p1	-16,000 through 16,000 or VI*n*	number of pulses

Restrictions: Servo only; not allowed in motion blocks.

Use: This command applies a step input to the axis.

Remarks: The step input cannot be larger than the following error bound, FEB.

Related Registers: FEB

STF Sets Fault

Class: System Command

Syntax: STF

Restrictions: Not allowed in motion blocks.

Use: This command faults the controller.

Remarks: If this command is in a program, executing STF will fault the program, which will stop program execution.

Related Commands: RSF

Related Registers: FC

STFN Network Set Fault

Class: System Command

Syntax: STFN*p1* (STFN0 STFN63 STFNVI5)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network node address

Restrictions: Not allowed in motion blocks. Cannot be accessed in immediate mode over a DeviceNet connection.

Use: This command accesses attribute 17 of the DeviceNet position controller object to fault the controller addressed at *p1*.

Related Commands: RSF, RSFN, STF

Related Registers: FC, FCNN

STF(*p1*) Convert String to Floating Point Operator

Class: Operator

Type: Floating point

Syntax: STF(*p1*)

Parameters: *allowed values*
p1 any string operand

Use: This operator is used to convert the string operand *p1* to a floating point number.

Remarks:
1. If the string operand contains an invalid digit for a floating point number, then this operator will return a result of zero and set the "Invalid digit in string" bit (i.e., bit 4) of the program status register.
2. If the converted value is too large to be represented by a floating point number, then this operator will return a result of zero and set the "String value out of range" bit (i.e., bit 5) of the program status register.

Example:

```
VS1="12.95"       (* set string variable 1 to "12.95")
VF1=STF(VS1)      (* set floating point variable 1 to VS1 converted to floating point)
VF1?              (* report value of floating point variable 1)
*12.95
```

STI Convert String to Integer Operator

Class: Operator

Type: Integer

Syntax: STI(*p1*)

Parameters: *allowed values*
p1 any string operand

Use: This operator is used to convert the string operand *p1* to an integer.

Remarks:
1. If the string operand contains an invalid digit for an integer, then this operator will return a result of zero and set the "Invalid digit in string" bit (i.e., bit 4) of the program status register.
2. If the converted value is too large to be represented by an integer, then this operator will return a result of zero and set the "String value out of range" bit (i.e., bit 5) of the program status register.

Example:

```
VS1="1204"      (* set string variable 1 to "1204")
VI1=STI(VS1)    (* set integer variable 1 to VS1 converted to integer)
VI1?            (* report value of integer variable 1)
*1024
```

STM Start Time of Timer

Class: System Register

Type: Floating point

Syntax: STM*p1* (e.g., STM2 STMVI3)

Parameters:

	allowed values	*description*
p1	1 through 8 **or** Vi*n*	timer number

Range:

units	seconds
default	2,000,000.000
minimum	.001
maximum	2,000,000.000

Use: This register is used to define the starting time from which a timer will count down continuously to zero seconds. Once a timer is set, it will immediately start counting. For example, after you enter **STM1=7**, timer one would be set to seven seconds and would immediately start to count down to zero seconds. Once it has reached zero seconds, it would start again at seven seconds, count down to zero seconds, and so on.

Remarks: Timer resolution is in milliseconds.

Example:

```
STMVI2=5    (* set start time of timer VI2 to five seconds)
STM3?       (* report start time of timer three)
```

***Related Registers*:** TMR, TM

STN Network Stop

Class: Motion Command

Syntax: STN*p1* (e.g., STN0 STN63 STNVI5)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network node address

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: The network stop command accesses attribute 20 of the DeviceNet position controller object to stop all motion for the axis addressed at *p1*.

Remarks: This command, once executed, will immediately decelerate the axis at the deceleration loaded.

Related Commands: HT, HTN, ST

STVB..GOTO Sets Boolean Variable; "Gotos" Label

Class: Program Command

Syntax: STVB*p1* GOTO*p2* (e.g., STVB1 GOTO30 STVBVI1 GOTOVI2)

Parameters:

	allowed values	*description*
p1	1 through 256 **or** VI*n*	Boolean variable number
p2	1 through 999 **or** VI*n*	label number

Restrictions: Allowed only in programs.

Use: This command sets Boolean variable *p1* and then checks to see if it was previously set. If Boolean variable *p1* was not set, this command will cause the program to go to label *p2*.

Example:

```
     PROGRAM1                  PROGRAM2               (* edit program)
10   VI1=VI1+1            10   VI2=VI2+1              (* set integer variable)
     IF VI1<1000 GOTO10        IF VI2<996 GOTO10      (* conditionally goto 10)
     STVB1 GOTO20              STVB1 GOTO20           (* set Boolean variable 1 and if Boolean
                                                      (* variable 1 wasn't set, goto 20)
     GOTO10                    GOTO10                 (* unconditionally goto 10)
20   OUT"VI1="            20   OUT"VI2="              (* output string expression to the
                                                      (* serial port)
     OUT ITS(VI1,5)+"$N"       OUT ITS(VI2,5)+"$N"    (* output string expression to the
                                                      (* serial port)
     VI1=0                     VI2=0                  (* load integer variable)
     VB1=0                     VB1=0                  (* reset Boolean variable 1)
     GOTO10                    GOTO10                 (* unconditionally goto 10)
     END                       END                    (* end program and exit editor)
```

What will happen: These two programs, when executed, will increment integer variables 1 and 2 until they reach 1,000 and 996 respectively. The first program to finish this task will set *p1* equal to 1; and, since it was not previously set, it will go to the statement at label 20, which outputs the value to the display, loads 0 into the integer variable, and resets Boolean variable 1. If one program finishes this task while the other is outputting the value to the display, the program will go back to label 10, increment the integer variable, and check again for Boolean variable 1 to be reset.

***Related Commands**:* IF...GOTO

SUP Suspends Motion

Class: Program Command

Syntax: SUP

Restrictions: Not allowed in motion blocks.

Use: This command suspends axis motion.

Remarks: Motion will continue to be suspended until the RSM command is executed, which resumes the motion. If, however, a motion command is issued while motion is suspended, the suspended motion will be eliminated and the new motion will be executed.

***Related Commands**:* RSM

SVL Saves Screen Lines

Class: System Command

Syntax: SVL

Restrictions: Not allowed in motion blocks.

Use: This command is used to save the screen lines from RAM to nonvolatile memory.

Remarks: If the screen lines are not saved correctly, then bit 9 in the program status register will be set to 1, which means *Screen Lines Save Failure*.

Related Commands: RETRIEVE, SAVE

SVV Save Variables from RAM to Nonvolatile Memory

Class: System Command

Syntax: SVV

Restrictions: Allowed only in programs. The Motion Generator cannot be running when the SVV command is executed (SRA bits 0,1,2 and 14 must be false). The ST or HT command can be used to set these bits False (to Logic 0).

Use: The SVV command saves integer variables 1 through 1,024 and floating point variables 1 through 512 from RAM to nonvolatile memory.

Remark: If the variables are not saved correctly, then bit 9 in the Program Status Register (SRP) will be set to 1, which means *Variable Save Failure*. It is good programming practice to test the status of the Variable Save Failure flag each time the SVV command is executed to ensure that the save was successful.

It takes approximately 300 ms to write to flash memory and approximately 3 ms to read flash variables. To ensure reliable execution of the SUV command, the program task should use the LOCK command to secure full access to the CPU. Communication through the serial port and network ports is suspended until the save is complete.

Caution: The controller flash memory can support a finite number of write cycles before the flash memory will fail. Although the typical limit for this type of flash is +100,000 write cycles, it is easy to exceed this limit by executing frequent SVV commands from within a program.

When using multiple programs with multiple SVV commands, it is possible to get two SVV commands executed at the same time, causing the controller to write -0.5s into the variables. To prevent this from occurring on your system, place a flag in your program and wait for it to be cleared before executing SVV, for example:

```
(* VB100 SVV in use flag
PROGRAM1
 . . .
WAIT NOT VB100
VB100 = 1
SVV
VB100 = 0
. . . .
END
```

Related Registers: VI, VF

Related Commands*:* SAVE, RETRIEVE, RTV

TAN Tangent Trigonometric Function Operator

Class: Operator

Type: Floating point

Syntax: TAN(*p1*)

Parameters: *allowed values*
p1 any floating point operand

Use: Used to perform the tangent trigonometric function on *p1*. The operand *p1* must be in degrees

Related Commands: SIN, ATN, COS

TL Axis at Torque Limit

Class: System Register

Type: Boolean

Syntax: TL

Range:
allowed values 0, 1

Restrictions: Servo only; read only.

Use: This register is used to determine whether the axis is at its torque limit. If the axis is at its torque limit, then TL is equal to 1; and when it is not at its torque limit, then TL is equal to 0.

***Related Registers*:** TLC, TLE, SRA

TLC Torque Limit Current

Class: Axis Register

Type: Floating point

Syntax: TLC

Range:
units %
default 100.0
minimum 0.1
maximum 100.0

Restrictions: Servo only.

Use: This command loads the torque limit current as a percentage of the continuous current, CURC.

Remarks: The torque limit is enabled by the TLE command.

Related Registers: TL, TLE, CURC

TLE Torque Limit Enable

Class: Axis Register

Type: Boolean

Syntax: TLE

Range:
default 0
allowed values 0, 1

Restrictions: Servo only.

Use: This command is used to enable the torque limit. If TLE is set to 1, then torque limit is enabled; and if TLE is set to 0, it is disabled.

Related Registers: TL, TLC

Motion Templates: Run reverse until torque limit; run forward until torque limit; run reverse at torque limit.

TM Timer Timed Out Flag

Class: System Register

Type: Boolean

Syntax: TM*p1* (e.g., TM1 TMVI3)

Parameters:

	allowed values	*description*
p1	1 through 8 **or** Vi*n*	timer number

Range:
allowed values 0, 1

Restrictions: Read only.

Use: This register is used to tell whether one of the timers timed out (i.e., was equal to 0). If TM*p1* is set to 1, then the timer timed out; if TM*p1* is set to 0, it did not time out. After the state of the timed out flag is read, the flag is set to zero until the timer times out again. It is then set to 1 and will stay at 1 until it is read again.

Related Registers: TMR, STM

TMR Timer

Class: System Register

Type: Floating point

Syntax: TMR*p1* (e.g., TMR2 TMRVI3)

Parameters:

	allowed values	*description*
p1	1 through 8 **or** Vi*n*	timer number

Range:

units	seconds
minimum	0.000
maximum	2,000,000.000

Restrictions: Read only.

Use: The timer register is used to determine the current value of timer *p1*.

Example: TMRVI2? (* report timer VI2)

Related Registers: STM, TM

TRC Convert Floating Point to Integer Operators

Class: Operator

Type: Integer

Syntax: TRC(*p1*)

Parameters: *allowed values*
p1 any floating point operand

Use: Used to convert floating point operand *p1* to an integer by truncation of the decimal values. If rounding is required use the FTI operator.

Remarks: If the floating point number is too large to be represented by an integer, then the TRC operator will return a result of zero and set the *Floating Point Value Out of Range* bit (bit 6) of the Program Status Register (SRP). For information on status registers see Chapter 7.

Example:

```
VF1=12.9505      (* set floating point variable 1 to 12.9505)
VI2=TRC(VF1)     (* set integer variable 2 to VF1 converted to integer by truncation)
VI2?             (* show value of VI2 in the terminal window)
*12
```

***Related Registers**:* FTI

TRUE, ON Boolean Operands

Class: Operator

Type: Boolean

Syntax: TRUE, ON, *p1*, *p2*

Parameters:

	allowed values	*range*
p1	any Boolean	0, 1
p2	any Boolean register	

Use: These operands are used as Boolean numbers. TRUE and ON are equivalent to the Boolean number 1, and FALSE and OFF are equivalent to the Boolean number 0.

Example:

```
VB1=TRUE         (* set Boolean variable 1 to TRUE [i.e., one])
POE1=ON          (* set power output stage enable of axis one to ON [i.e., one])
DO1.8=ON         (* set digital output 8 of module 1 to one)
VB2=0            (* set Boolean variable 2 to zero)
```

Related Registers: FALSE, OFF

UNLOCK Unlocks Interpreter from Program

Class: Program Command

Syntax: UNLOCK

Restrictions: Allowed only in programs.

Use: This command unlocks the interpreter from the program, which lets other currently suspended programs execute concurrently.

Example:

```
        PROGRAM1        (* edit program 1)
        STM1=0.01       (* load start time of timer 1 and start timer 1)
1       WAIT TM1        (* wait for expression to be true)
        LOCK            (* lock interpreter to program)
        IF KEY GOTO2    (* conditionally goto 2)
        UNLOCK          (* unlock interpreter from program)
        GOTO1           (* unconditionally goto 1)
2       END             (* end program and exit editor)
```

What will happen: This program, once executed, will first wait for 10 ms. Then it locks the interpreter and checks for KEY to be true (i.e., for a character to be entered into the key buffer). If KEY is true, then the program goes to the statement at label 2, which ends the program. If KEY is not true, it unlocks the interpreter and goes to the statement at label 1, which waits for 10 ms, etc.

Related Commands: LOCK

UPR Case Conversion Operators

Class: Operator

Type: String

Syntax: UPR(*p1*)

Parameters: *allowed values*
p1 any string operand

Use: Used to convert string operand *p1* to upper case.

Remarks: Use LWR to convert to lower case

Example:

```
VS1="Hello"       (* set string variable 1 to "Hello")
VS2=UPR(VS1)      (* set string variable 2 to upper case of VS1)
VS2?              (* report value of string variable VS2 in the terminal window)
*"HELLO"
VS3=LWR           (VS1)(* set string variable 3 to lower case of VS1)
VS3?              (* report value of string variable VS3 in the terminal window)
*"hello"
```

Related Commands: LWR

UPS Update Screen

Class: Input/Output Register

Type: Integer

Syntax: UPS

Range:
default 0
minimum 0
maximum 50

Use: This register is used to determine which screen is updated. The screen data, SCRD, for the screen specified in UPS is updated every 1/4 second.

Remarks: This register is set to 0 upon power-up.

Related Registers: SCRD, SCRP

URA Axis Unit Ratio Numerator

Class: Axis Register

Type: Integer

Syntax: URA

Parameters:	*allowed values*	*description*
p1	0 through 63 or VI*n*	network address

Range:

units	the ratio of URA/URB is in pulses/axis unit
default	1
minimum	1
maximum	1,000,000

Restrictions: Requires firmware revision 2.5 or later. Not allowed in programs or motion blocks.

Use: The axis unit ratio scales the axis programming units. The S2K controller uses various registers to represent axis position, velocity, acceleration, deceleration and jerk (MPA, MPI, MVL, MAC, MDC, etc.). Internal to the S2K, these registers are computed using pulse units, which are fundamentally the same as the pulse units of the axis feedback. The axis unit ratio lets you simplify programming tasks by scaling the axis programming units, where:

Axis Units = (Pulses)/(URA/URB)

For example, if the motor encoder has 10,000 pulses per revolutions and you want to program position increments in revolutions, then the ratio of URA/URB would be set to 10,000 (URA=10,000, URB=1). Thus, setting MPI = 1 would be equivalent to 10,000 pulses or 1 revolution. Similarly, the unit ratio axis can be set to scale pulse units to any engineering units, such as inches or millimeters. The axis unit ratio (URA/URB) is simply the number of pulses per axis programming unit.

Remarks:

1. This register can be set only after the memory has been cleared using the CLM command and before any programs or motion blocks are defined.
2. The numerical values for the default, minimum, and maximum of all registers with axis units are assuming that the axis unit ratio (URA/URB) is set at the default of 1 (URA=1, URB=1). If the axis unit ratio is set to a value other than 1, then the maximum and minimum values will be scaled appropriately by the axis unit ratio. For example, the maximum value of the MAC register is 1,000,000,000. If the unit ratio axis is set to 4096 (URA=4096, URB=1), then the new maximum for MAC would be (1,000,000,000 pulses)/(4,096 pulses/axis unit) = 244140.625 axis units.

Related Commands: URA, URX, PLA, PSA, PZA, OFA, VLA

URB Axis Unit Ratio Denominator

Class: Axis Register

Type: Integer

Syntax: URB

Parameters:

	allowed values	*description*
p1	0 through 63 or VI*n*	network address

Range:

units	the ratio of URA/URB is in pulses/axis unit
default	1
minimum	1
maximum	1,000,000

Restrictions: Requires firmware revision 2.5 or later. Not allowed in programs or motion blocks.

Use: The axis unit ratio scales the axis programming units. The S2K controller uses various registers to represent axis position, velocity, acceleration, deceleration and jerk (MPA, MPI, MVL, MAC, MDC, etc.). Internal to the S2K, these registers are computed using pulse units, which are fundamentally the same as the pulse units of the axis feedback. The axis unit ratio allows the user to simplify programming tasks by scaling the axis programming units, where:

Axis Units = (Pulses)/(URA/URB)

For example, if the motor encoder has 10,000 pulses per revolutions and the user desires to program position increments in revolutions, then the ratio of URA/URB would be set to 10,000 (URA=10,000, URB=1). Thus, setting MPI = 1 would be equivalent to 10,000 pulses or 1 revolution. Similarly, the unit ratio axis can be set to scale pulse units to any engineering units, such as inches or millimeters. The axis unit ratio (URA/URB) is simply the number of pulses per axis programming unit.

Remarks: 1. This register can be set only after the memory has been cleared using the CLM command and before any programs or motion blocks are defined.
2. The numerical values for the default, minimum, and maximum of all registers with axis units are assuming that the axis unit ratio (URA/URB) is set at the default of 1 (URA=1, URB=1). If the axis unit ratio is set to a value other than 1, then the maximum and minimum values will be scaled appropriately by the axis unit ratio. For example, the maximum value of the MAC register is 1,000,000,000. If the unit ratio axis is set to 4096 (URA=4096, URB=1), then the new maximum for MAC would be (1,000,000,000 pulses)/(4,096 pulses/axis unit) = 244140.625 axis units.

Related Commands: URA, URX, PLA, PSA, PZA, OFA, VLA

URX Auxiliary Unit Ratio

Class: Axis Register

Type: Integer

Syntax: URX

Range:

units	Aux. encoder pulses/auxiliary unit
default	1
minimum	1
maximum	1,000,000

Restrictions: This register cannot be changed from within programs or motion blocks. See Note below.

Use: The auxiliary unit ratio is used to define auxiliary units (engineering units for the auxiliary encoder input) for the PLX, PSX, PZX, OFX and VLX registers. The Motion Developer Axis Configuration wizards assist in properly configuring URX for the desired auxiliary units and controller configuration.

Remarks: 1. This register can be set only after the memory has been cleared using the CLM command and before any programs, configuration parameters or motion blocks are defined.
2. The numerical values for the default, minimum, and maximum of all registers with auxiliary units are assuming that the auxiliary unit ratio, URX, is set at its default value of 1. If the auxiliary unit ratio is set to a value other than 1, the maximum and minimum values will be divided by the auxiliary unit ratio (URX). For example, if the maximum value of a register is 2,000,000,000 pulses and the auxiliary unit ratio is set to 10,000 (i.e., auxiliary units in revolutions for a 4000 line encoder), the new maximum of that parameter will be (2,000,000,000 pulses)/(4,000 pulses/auxiliary unit) = 500,000 auxiliary units. In resolver-based controllers,

Related Registers: PLX, PSX, PZX, OFX, VLX, URA

Note: URX is an integer register. Rounding of the calculated URX value to the nearest integer will result in cumulative position error. The impact of this error is application dependent. Rotary unidirectional applications will continuously accumulate error in one direction, while for a linear application with limited travel the error may be acceptable. If this error is unacceptable changing mechanical gear ratios or selecting a different (larger) axis unit may reduce or eliminate this error. Selecting “counts” as your axis unit (URX=1) will always eliminate this error.

VB Boolean Variable

Class: Variable Register

Type: Boolean

Syntax: VBp1 (e.g., VB1 VBVI2)

Parameters:	allowed values	description
p1	1 through 256 **or** VIn	Boolean variable number

Range:
- default: 0
- allowed values: 0, 1

Use: Boolean variables are used mainly in conditional statements of programs, such as IF...GOTO (conditional goto) and WAIT (wait for expression to be true). They can also be used to load register values.

Example:

```
VB1=VI1>0         (* set Boolean variable one to 1 if integer variable one is greater than zero)
VB3=VB1 AND VB2   (* set Boolean variable three to 1 if both Boolean variable one and Boolean
                  (*  variable two are set)
VBVI2=VI1<5       (* set Boolean variable VI2 to 1 if integer variable one is less than five)
VBVI2?            (* report Boolean variable VI2)
```

VBN Network Boolean Variable

Class: Variable Register

Type: Boolean

Syntax: VBN*p1.p2* (e.g., VBN1.1 VBNVI2.VI5)

Parameters:	*allowed values*	*description*
*p*1	1 through 63 **or** Vi*n*	network address
p2	1 through 256 **or** VI*n*	Boolean variable number

Range:
- *default*: 0
- *allowed values*: 0, 1

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: Network Boolean variables are used mainly in conditional statements of programs, such as IF...GOTO (conditional goto) and WAIT (wait for expression to be true). They can also be used to load register values. Cannot be accessed in immediate mode over a DeviceNet connection.

Example:

```
VBN5.1=VI1>0      (* set network Boolean variable one of controller addressed at five to 1 if integer
                  (* variable one is greater than zero)
VBNVI20.3=VB1     (* set network Boolean variable three of controller addressed at VI20 to 1)
VBN3.VI2=VI1<5    (* set network Boolean variable VI2 of controller addressed at three to 1 if
                  (* integer variable one is less than five)
VBN3.VI2?         (* report network Boolean variable VI2 of controller addressed at three)
```

VF Floating Point Variable

Class: Variable Register

Type: Floating point

Syntax: VF*p1* (e.g., VF1 VFVI2)

Parameters:

	allowed values	*description*
p1	1 through 2,048 **or** VI*n*	floating point variable number

Range:

default	0.0
minimum	1.5×10^{-39} (absolute value)
maximum	1.7×10^{38} (absolute value)

Use: Floating point variables are used in variable expressions and to load register values.

Remarks: The numerical value for the maximum of parameter *p1* shown above is assuming that the floating point variable allocation, VFA, is set to 2,048. If VFA is set to a value other than 2,048, the maximum of *p1* will change (see Table 5-1). Floating point variables use a 32 bit mantissa and must include a decimal point when used in programs or motion blocks.

Example:

```
VF1=5.776             (* set floating point variable one to 5.776)
VI1=2000              (* set integer variable to 2,000)
VFVI1=SQR(2.*VF1)     (* set floating point variable VI1 [i.e., 2,000] to square root of 2 times 5.776)
VF2=PSA/5.            (* set floating point variable two to axis position divided by 5)
VFVI1?                (* report floating point variable VI1)
```

Related Registers: VFA

VFA Floating Point Variable Allocation

Class: System Register

Type: Integer

Syntax: VFA

Range:

default	1,024
minimum	0
maximum	2,048

Restrictions: Cannot be assigned in programs or motion blocks.

Use: The floating point variable allocation register is used to define how many floating point variables can reside in memory.

Remarks:
1. This register can be set only after the memory has been cleared using the CLM command and before any programs or motion blocks are defined.
2. Setting the register will overwrite part of the memory space normally allocated for integer variables. One floating point variable will take over the space that two integer variables previously occupied. For example, if VFA is set to 200, the integer variables will range from 1 to 3,696 [4,096 - (2*200)].

Related Registers: VF, VI

VFN Network Floating Point Variable

Class: Variable Register

Type: Floating point

Syntax: VFN*p1.p2* (e.g., VFN1.1 VFNVI2.VI5)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** Vi*n*	network address
p2	1 through 2,048 **or** Vi*n*	floating point variable number

Range:

default	0.0
minimum	1.5×10^{-39} (absolute value)
maximum	1.7×10^{38} (absolute value)

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: Network floating point variables are used in variable expressions and to **indirectly** load register values. The argument of the VFN command cannot directly refer to a named register such as PSA or VLA. The register must first be loaded to a floating point variable (VF) and then the VFN command must use this variable as an indirect pointer to the register value (example; VF100=PSA, VFN5.1=VF100).

Remarks:

1. The numerical value for the maximum of parameter *p2* shown above is assuming that the floating point variable allocation, VFA, of the addressed controller is set to 2,048. If VFA is set to a value other than 2,048, the maximum of *p2* will change.
2. In order to access the extended floating point variables, the indirect addressing scheme (i.e., VFN*n*.VI*n*) must be used.
3. Floating point variables use a 32 bit mantissa and must include a decimal point when used in programs or motion blocks.

Example:

```
VFN5.1=5.776            (* set network floating point variable one of controller addressed at five to 5.776)
VI1=3500                (* set integer variable to 3,500)
VFVI1=SQR(2.*VFN5.1)    (* set floating point variable VI1 [i.e., 3,500] to square root of 2 times 5.776)

VF100=PSA/5.0           (* set pointer to the axis position register)
VFNVI20.2=VF100         (* set network floating point variable two of controller addressed at VI20 to
                        (* axis position divided by 5 using indirect reference to pointer variable VF100)

VFN3.VI1?               (* report network floating point variable VI1 of controller addressed at three)
```

Related Registers: VFA, VFEA, VI

VI Integer Variable

Class: Variable Register

Type: Integer, Boolean

Syntax: VI*p1*.*p2* (e.g., VI1 VIVI2 VI1.5 VI1.VI3 VIVI2.VI6)

Parameters:

	allowed values	*description*
p1	1 through 4,096 **or** Vi*n*	integer variable number
p2	none or 0 through 31 **or** VI*n*	integer variable bit number

Range:

default	0
minimum	-2,147,483,648
maximum	2,147,483,647

Use: Integer variables are used in variable expressions and to load register values.

Remarks: The numerical value for the maximum of parameter *p1* shown above is assuming that the floating point variable allocation, VFA, is set to 0. If VFA is set to a value other than 0, the maximum of *p1* will change. Integer variables use a 32 bit mantissa to preserve precision when converting to floating point.

Example:

```
VI1=3000            (* set integer variable one to 3,000)
VI2=-330            (* set integer variable two to -330)
VIVI1=VI1+VI2       (* set integer variable VI1 [i.e., integer variable 3,000] to 3,000 plus -330)
VI3=PSR*2           (* set integer variable three to PSR times 2 [i.e., position times 2])
VI2?                (* report integer variable two)
VI1.4=1             (* set bit four of integer variable one)
VI5.17=0            (* clear bit 17 of integer variable five)
VI2.3=VI4.2 OR VI5.7   (* set bit three of VI2 if bit two of VI4 or bit seven of VI5 is set)
```

Related Registers: VFA

VIN Network Integer Variable

Class: Variable Register

Type: Integer

Syntax: VIN*p1*.*p2* (e.g., VIN1.1, VINVI2.VI5)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network address
p2	1 through 4,096 **or** VI*n*	integer variable number

Range:

default	0
minimum	-2,147,483,648
maximum	2,147,483,647

Restrictions: Cannot be accessed in immediate mode over a DeviceNet connection.

Use: Network integer variables are used in variable expressions and to load register values.

Remarks: 1. The numerical value for the maximum of parameter *p2* shown above is assuming that the floating point variable allocation, VFA, of the address controller is set to 0. If VFA is set to a value other than 0, the maximum of *p2* will change.
2. In order to access the extended integer variables, the indirect addressing scheme (i.e., VIN*n*.VI*n*) must be used.

Example:

```
VI1=5000              (* set integer variable one to 5,000)
VIN5.2=-330           (* set network integer variable two of controller addressed at five to -330)
VIN2.VI1=VI1+VIN5.2   (* set network integer variable VI1 [i.e., integer variable 5,000)
                      (* of controller addressed at two to 5,000 plus -330]
VINVI20.3=PSR*2       (* set network integer variable three to PSR times 2, [i.e., position times 2])
VINVI20.3?            (* report network integer variable three of controller addressed at VI20)
```

Related Registers: VFA, VFEA, VI

VLA Axis Velocity

Class: Axis Register

Type: Floating point

Syntax: VLA

Range:
units axis units/sec
minimum -16,000,000 pulses/sec
maximum 16,000,000 pulses/sec

Restrictions: Read only.

Use: This register is used to determine the current velocity of the axis.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the axis unit ratio, (URA/URB), is set at its default value of 1.If the axis unit ratio is set to a value other than 1, the default, maximum, and minimum values must be divided by the value of (URA/URB) (see URA and URB).

Related Registers: URA, URB, VLAT

VLAN Network Axis Velocity

Class: Axis Register

Type: Integer

Syntax: VLAN*p1* (e.g., VLAN0 VLAN63 VLANVI5)

Parameters:

	allowed values	*description*
p1	0 through 63 **or** VI*n*	network address

Range:
units pulses/sec
minimum -16,000,000 pulses/sec
maximum 16,000,000 pulses/sec

Restrictions: Read only. Cannot be accessed in immediate mode over a DeviceNet connection**.**

Use: This command accesses attribute 14 of the DeviceNet position controller object to determine the actual velocity of the axis.

Related Registers: VLA

VLAT Axis Velocity Filter Time Constant

Class: Axis Register

Type: Floating point

Syntax: VLAT

Range:

units	seconds
default	0.01
minimum	0.002
maximum	0.1

Use: The axis velocity filter time constant represents the length of the time window that is used to filter the axis velocity, VLA. This time window is applied to previous values of VLA in order to calculate the current filtered value of VLA. This happens every 2 msec.

Remarks: VLAT can be set only in 2 msec increments (i.e., 0.002, 0.004, 0.006, ...). This corresponds to the number of previous values of VLA that are being filtered. For example, setting VLAT = 0.01 means that the previous 5 values of VLA will be filtered, since 0.002*5 = 0.01.

Example:

```
VLAT=0.008      (* set axis velocity filter time constant to 0.008 sec)
VLAT?           (* report value of axis velocity filter time constant)
```

Related Registers: VLA, VLXT

VLX Auxiliary Velocity

Class: Axis Register

Type: Floating point

Syntax: VLX

Range:
units auxiliary units/sec
minimum -16,000,000 pulses/sec
maximum 16,000,000 pulses/sec

Restrictions: Read only.

Use: This register is used to determine the current auxiliary velocity of the axis.

Remarks: The numerical values for the default, minimum, and maximum of this register are assuming that the auxiliary unit ratio, URX, is set at its default value of 1. If the auxiliary unit ratio is set to a value other than 1, the default, minimum, and maximum values must be divided by the value of URX (see URX).

Related Registers: URX, VLXT

VLXT Auxiliary Velocity Filter Time Constant

Class: Axis Register

Type: Floating point

Syntax: VLXT

Range:
units seconds
default 0.01
minimum 0.002
maximum 0.1

Use: The auxiliary velocity filter time constant is used to represent the length of the time window that is used to filter the auxiliary velocity, VLX. This time window is applied to previous values of VLX in order to calculate the current filtered value of VLX. This happens every 2 msec.

Remarks: VLXT can be set only in 2 msec increments (i.e., 0.002, 0.004, 0.006, ...) This corresponds to the number of previous values of VLX that are being filtered. For example, setting VLXT = 0.01 means that the previous 5 values of VLX will be filtered, since 0.002*5 = 0.01.

Example:

```
VLXT=0.008      (* set auxiliary velocity filter)
VLXT?           (* report value of auxiliary velocity filter time constant)
```

Related Registers: VLX, VLAT

VS String Variable

Class:	Variable Register
Type:	String
Syntax:	VS*p1* (e.g., VS1 VSVI2)

Parameters:

	allowed values	*description*
p1	1 through 144 **or** VI*n*	string variable number

Range:

default	“”
allowed values	any string, 0 through 127 characters long, enclosed in quotes

Use: String variables are used mainly to load strings and in input/output commands such as GET, PUT, IN, and OUT as a means of user interface.

Example:

VS1=“$20”+“$R”	(* set string variable one to a space followed by a carriage return)
VI1=2	(* set integer variable one to 2)
VSVI1=“Done”+VS1	(* set string variable VI1 [i.e., string variable two] to “Done” followed by a (*space and a carriage return)
VSVI2?	(* report string variable VI2)

Related Commands: EXVS, GET, PUT, IN, OUT

VSN Network String Variable

Class:	Variable Register	
Type:	String	
Syntax:	VSN*p1.p2* (e.g., VSN1.1, VSNVI2.VI5)	
Parameters:	*allowed values*	*description*
p1	0 through 63 **or** VI*n*	network address
p2	1 through 144 **or** VI*n*	string variable number
Range:		
default	“”	
allowed values	any string, 0 through 127 characters long, enclosed in quotes	
Restrictions:	Cannot be accessed in immediate mode over a DeviceNet connection.	
Use:	Network string variables are used mainly to load strings and in input/output commands such as GET, PUT, IN, and OUT as a means of user interface.	
Example:	VSN5.1=“$20”+“$R”	(* set network string variable one of controller addressed at five to a space (* followed by a carriage return)
	VI1=2	(* set integer variable one to 2)
	VSN3.VI1=“Done”	(* set network string variable VI1 [i.e., string variable two] of controller (* +VSN5.1 addressed at three to “Done” followed by a space and a carriage (* return)
	VSNVI20.2?	(* report network string variable two of controller addressed at VI20)
Related Commands:	GET, PUT, IN, OUT, VS	

WAIT Waits for Expression to be True

Class: Program Command

Syntax: WAIT*p1* (e.g., WAIT VB1 WAIT KEY)

Parameters:

	allowed values	*description*
p1	any Boolean expression	Boolean expression

Restrictions: Allowed only in programs or motion blocks**.**

Use: This command causes the program or motion block to wait for Boolean expression *p1* to be true (i.e., evaluate to 1). Once *p1* is true, the next program or motion block statement will be executed.

Example:

```
PROGRAM1        (* edit program 1)
PSA=0           (* set axis position register)
MVL=10          (* set motion velocity)
MAC=40          (* set motion acceleration)
MPA=0           (* set absolute move position)
MPI=10          (* set incremental move position)
RPI             (* run to incremental move position)
WAIT IP         (* wait for expression to be true)
STM1=1          (* set start time of timer 1)
WAIT TM1        (* wait for expression to be true)
RPA             (* run to absolute move position)
WAIT IP         (* wait for expression to be true)
OUT “Motion completed”    (* output string expression to display)
END             (* end program 1 and exit editor)
```

What will happen: This program sets the axis position register, velocity, acceleration, absolute move position, and incremental move position. Then it issues the RPI command, which runs the axis 10 units in the forward direction. It then waits until the axis is in position. Next, it loads timer 1 with a start time of 1 second. The timer will then count down from 1 second to 0. Once it reaches 0, the RPA command is issued, which runs the axis 10 units in the reverse direction. It waits until the axis is in position, and then it prints *Motion completed* to the display.

Related Commands: WAIT...WHEN...GOTO

WAIT...WHEN...GOTO

Class: Program Command

Syntax: WAIT *p1* WHEN *p2* GOTO*p3*

Parameters:

	allowed values	*description*
p1	any Boolean expression	Boolean expression
p2	any Boolean expression	Boolean expression
p3	1 through 999 **or** VI*n*	label number

Restrictions: Allowed only in programs.

Use: This statement causes the program either to wait for *p1* to become true (i.e., evaluate to 1) or to go conditionally to label *p3* if *p2* is true (i.e., evaluates to 1).

Example:

```
PROGRAM1                    (* edit program 1)
MVL=5                       (* set motion velocity)
MAC=40                      (* set motion acceleration)
MPI=25                      (* set incremental move position)
RPI                         (* run to incremental move position)
WAIT IP WHEN KEY GOTO5      (* wait for expression to be true or when condition becomes true
                            (* goto 5)
OUT "Motion complete$N"     (* output string expression to display)
GOTO10                      (* unconditionally goto 10)
5 ST                        (* stop axis)
WAIT IP                     (* wait for expression to be true)
OUT "Motion interrupted$N"  (* output string expression to display)
10 END                      (* end program 1 and exit editor)
```

What will happen: This program, once executed, sets the velocity, acceleration, and incremental move position. It then issues the RPI command, which runs the axis 25 units in the forward direction. If a character goes into the key buffer (KEY) before the axis is in position (IP), the program execution will go to the statement at label 5, which stops the axis. It then prints *Motion interrupted* to the display and ends. If a character does not go into the key buffer before the axis is in position, the program will continue to the next statement, which prints *Motion complete*. It then goes to the statement at label 10, which ends the program.

Related Commands: WAIT

X Steps Through Program/Motion Block in Terminal Window Line Editor

Class: Program Command

Syntax: X*p1* (e.g., X X3 X10)

Parameters:

	allowed values	*description*
p1	1 through 65,000	step size

Use: While in the Motion Developer terminal window this command:

1. Steps *p1* lines through a program or motion block while in the terminal window line editor.
2. Steps through the execution of a program if **not** in the line editor, diagnostic mode is enabled (DGE=1) and single-step mode is enabled (DGS is set to the program you wish to step through).

Note that *p1* is optional. If *p1* is not specified, a value of 1 will be assumed.

Remarks: This command will most often be used for single step program execution while debugging program execution and will not typically be used for creating and editing programs and motion blocks since Motion Developer provides a more full featured text editor. While in the terminal window line editor each returned line is prefixed by an asterisk (*). Use the Exit Line Editor (!) command to exit the terminal window line editor.

Example:

```
PROGRAM1      (* edit program 1 from terminal window)
*  MVL=5
X             (* step through one line of the program)
*  MAC=40
X2            (* step through two lines of the program)
*  MPI=25
!             (* exit terminal window line editor)
*
```

Related Commands: DGE, DGS, PROGRAM, MOTION, L, LABEL, !

XOR Exclusive OR Logical Operator

Class: Operator

Type: Boolean, integer

Syntax: *p1* XOR *p2*

Parameters: *allowed values*
p1 any Boolean or integer operand
p2 any Boolean or integer operand

Use: Used to perform a logical exclusive OR operation on *p1* and *p2*. Note that *p1* and *p2* must be of the same type. If *p1* and *p2* are integer operands, the logical operators perform bitwise logical operations.

Related Commands: AND, NOT, OR

Chapter 6 Using Motion Developer

6.1 Installing Motion Developer

The material in this chapter was developed using Motion Developer software.

6.1.1 Computer System Requirements

The following describes the minimum requirements to install and run Motion Developer software (catalog number SA648MODEV).

Minimum Hardware Requirements

200 MHz Pentium-based workstation

- 64 MB RAM
- 200 MB free hard disk space
- CD ROM drive or access to one via parallel port or network
- 800 by 600 resolution, 256 color display and video adapter

Software Compatibility

- Windows® NT™ operating system version 4.0 with service pack 4 or later
- Windows 98, Windows ME, Windows 2000, or Windows XP operating system

6.1.2 Installation

To Install Motion Developer from a CD:

1. Shut down all other application programs.
2. Insert the CD into your CD-ROM drive. Windows will automatically start the setup program. If the setup program does not automatically start, use the Windows Start/Run utility. Run the **setup.exe** file in the root directory of the CD.
3. Click Install Motion Developer to start the install process.
4. Follow the instructions as they appear on the screen.

® Windows is a registered trademark and NT is a trademark of Microsoft, Inc.

6.1.3 Product Authorization

Before you start developing projects, we strongly recommend that you authorize the software using the built-in Product Authorization utility. If you don't authorize the software, you will be able to use it only for a four-day trial period. After the trial period, you cannot download or save target information. The authorization procedure will take only a few minutes and will also allow you to take advantage of any product support for which you qualify. You will need to contact us by telephone, fax, or Internet as part of the authorization process.

To Authorize Motion Developer:

Have your serial number(s) ready. The serial numbers can be found on the License Key sheet that came with your product.

1. Run the Product Authorization utility from the Start menu/Programs/CIMPLICITY Machine Edition/Product Authorization. The Product Authorization dialog box appears.
2. Click Software, and then click Add.
3. You can authorize the software by means of the Internet, email, phone, fax, or disk (disk is used if transferring authorization from another computer). Make your selection, then click Next.
4. Under Mandatory, fill in the fields. If you are authorizing by fax, fill in the fields under Optional. Click Next.
5. You will be prompted for a key code. You can request your key code through the following means:
   - **Phone**. Our phone number is listed on the screen.
   - **Fax**. Click Print FAX and fax the Product Authorization Request to us (our fax number will be on the print out). We will then fax you back with your new key code(s).
   - **Internet.** Go to www.gefanuc.com, select the Support link, then choose the Software Registration link on the Support page.

Product Authorization is complete once you type in the new key code and it has been accepted. Depending on the product you've purchased, you may need to run the Product Authorization program a number of times.

To Move the Authorization to Another Computer

You can run the software only on the computer on which the Product Authorization was installed. If you want to develop your projects on a different computer, you will need to complete the following steps to move the authorization from one computer to another.

1. Install CIMPLICITY Motion Developer on the computer to which the authorization will be moved.
2. Run the Product Authorization program from the Start menu/Programs/CIMPLICITY Machine Edition/Product Authorization. The Product Authorization dialog box appears.
3. Click Software. There is a site code on the top right hand side of the screen. Write down this site code carefully. This has to be accurate in order for the move to work. You will need it (Target Site Code) when you move the authorized software from the source computer.
4. Click Add. The Product Authorization wizard appears.
5. Click Authorize by disk. At this point, you need to go to the source computer that has the authorized software, and move the authorization to a disk.
6. From the source computer, run the Product Authorization program and click Software.

7. Click Move, and then click OK. Enter the target site code that you wrote down from Step 3 and click Next. Verify that the site code is correct and click OK.
8. Insert a blank formatted floppy disk into the floppy drive and click Next. The authorization code will be moved to the disk and a dialog box should appear telling you it was successful. Click OK.
9. Go back to the computer to which you are moving the authorization and insert the floppy disk. (The screen that is asking for an authorization disk should be displayed.) Click Next.
10. Click Finish. A screen should appear telling you the move was successful. Click OK. The authorization has now been moved to the new computer.

6.1.4 Technical Support

Contact Choices

You have several contact choices if you need help with your GE Fanuc products:

- **Fax**. Send a message via the Technical Support Fax number at (780) 420-2049
- **Internet.** Use the address www.gefanuc.com to reach the GE Fanuc home page, then click the Support link to reach the main Support page. The Support pages allow you to look up technical information, download useful files, register software, or send a question to our support experts.
- **Telephone.** Call 1-800 GEFANUC (1-800 433-2682)
- **e-mail**. Address your message to support@gefanuc.com

For Most Efficient Service

Motion Developer Software Help. When contacting us about a Motion Developer software problem, include the information listed below in your fax or message. If telephoning, call from a telephone near your computer and have your Motion Developer software running, if practical, and have the following information available to help us assist you as quickly as possible:

- ☐ The GE Fanuc software product name, serial number, and version number.
- ☐ The brand and model of computer system hardware (computer, monitor, etc).
- ☐ Computer operating system and version number.
- ☐ The steps you performed prior to the problem occurrence.

S2K Motor and Controller Help. When contacting us about an S2K hardware problem, include the information listed below in your fax or message. If telephoning, call from a telephone near your installation, if practical, and have the following information available to help us assist you as quickly as possible:

- ☐ The S2K model and serial number for controller and motor
- ☐ The circumstances leading up to the problem occurrence.

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Chapter 7 Diagnostics

7.1 LED Display Status Codes

The S2K Series controllers are equipped with a two-digit LED status display on the front panel of the controller. The controller will display all current codes in a round robin fashion. The status register will display OK when there are no faults and the controller is in an operational mode.

Table 7-1. LED Display Status Codes

Display Code	Status	Description	Fault Code Register Bit (See Section 7.3.1)
OK	okay	Drive enabled, CPUs and operating system functional	N/A
CC	faulted	Motor regen circuit over current	27
DT	faulted	Controller over temperature	30
EC	faulted	Motor regen circuit excessive duty cycle	26
EI	faulted	Excessive command increment	22
FE	faulted	Excess following error	21
FL	faulted	Position feedback lost (resolver feedback servo only)	24
LE	faulted	Lost enable	3
MT	faulted	Motor over temperature (servo only)	29
OC	faulted	Motor over current (resolver feedback servo only)	28
OV	faulted	Motor over voltage	25
PF	faulted	Power failure	0
PO	faulted	Position register overflow	23
SF	faulted	Software fault	2
UV	faulted	Motor under voltage	26
0-63	ok/faulted	DeviceNet node address/fault code (alternate)	N/A
•	ok/faulted	Flashing decimal indicates serial communication traffic	N/A

Note that the display reports the DeviceNet™ node address of units equipped with a DeviceNet™ communication port. If the unit is *OK* and the node address is set to *5*, then the display alternates between OK and 05. If the S2K controller is faulted due to FE and LE, the unit will alternately display FE, LE, 05 … FE, LE, 05 … etc.

7.2 Status Messages

Table 7-2 shows a list of command messages that will display either in the terminal window or the Feedback Zone of the Motion Developer software. The table attempts to state possible causes and solutions to each error message. When the Computer Interface Format Enable (CIE) parameter is set to 1 the CIE code numbers shown in the table below will be returned over the serial interface rather than the command text message. See Chapter 5 for a description of the CIE parameter.

Table 7-2. Status Messages

CIE Code Number	Status Message	Possible Cause(s)	Possible Solution(s)
6	RECEIVE ERROR	A character that was entered was not received correctly by the controller.	Check to make sure that the serial/program port settings such as baud (BAUD), parity (PAR) and data bits (BIT) are correct. The *Edit Communication Parameters* selection on the Motion Developer wizards screen has a *Test Communications* button and access to the communication parameter setting. Also, check the connection to the serial/program port and integrity on the serial cable.
7	NETWORK ADDRESS OUT OF RANGE	The DeviceNet address entered is less than 0 or greater than 63, or the PROFIBUS address is greater than 99.	Re-enter the network address making sure that it is a number 0 through 63 for DeviceNet or 0 through 99 for PROFIBUS. The *Edit Communication Parameters* selection on the Motion Developer wizards screen access to the network address setting when the *Use Network Address* selection is set to true.
8	LABEL OUT OF RANGE	The program label entered as part of a program statement is less than 1 or greater than 999.	Correct the label reference in your program making sure that it is a number 1 through 999.
9	INVALID COMMAND	The system or controller did not recognize the command entered.	The command was misspelled or the wrong syntax was used. Re-enter the command corrections in your program and download to the controller.
10	INVALID DIGIT	The number entered as a parameter for the command contained an invalid digit.	Re-enter the command making sure that the parameter does not contain an invalid digit.
11	INVALID ASSIGNMENT	The assignment entered was not valid for the associated command.	The assignment was misspelled. Re-enter correctly spelled command. The assignment was invalid. Re-enter the command with valid assignment.
12	TOO MANY DECIMAL PLACES	Value entered as a parameter had more decimal places than allowed for the command entered.	Re-enter the command making sure that the parameter does not have too many decimal places. For example, an integer number can not be entered with any decimal places.

CIE Code Number	Status Message	Possible Cause(s)	Possible Solution(s)
13	SYNTAX ERROR - POSSIBLY MISMATCHED OPERAND AND OPERATOR TYPE	The operands in an expression are not of the correct type for the operator.	Make sure to use the appropriate conversion operators to achieve the correct types of operands for the operator.
14	SYNTAX ERROR - POSSIBLY TOO MANY OPERANDS	There are more operands in an expression than the operators require.	Review the syntax of the operators used. For nested expressions check that the parentheses are properly placed.
15	SYNTAX ERROR - POSSIBLY TOO FEW OPERANDS	There are fewer operands in an expression than the operators require.	Review the syntax of the operators used. For nested expressions check that the parentheses are properly placed.
16	SYNTAX ERROR - POSSIBLY UNBALANCED PARENTHESES	There is a difference in the number of left parentheses and right parentheses.	Be sure to use the same number of left and right parentheses when creating nested expressions.
17	EXPRESSION TOO LONG	The expression entered is longer than the register or command will accept.	Simplify the expression. Break the expression into two or more parts.
18	EXPRESSION NOT BOOLEAN	The command expects an expression with a Boolean result and the expression as entered evaluated to an integer, floating point, or string.	Review the expression for correct form. Consider using one of the comparison operators.
19	EXPRESSION NOT INTEGER	The command expects an expression with an integer result and the expression as entered evaluated to a Boolean, floating point, or string.	Review the expression for correct form. Consider using one of the conversion operators.
20	EXPRESSION NOT FLOATING POINT	The command expects an expression with a floating point result and the expression as entered evaluated to a Boolean, integer, or string.	Review the expression for correct form. Consider using one of the conversion operators.
21	EXPRESSION NOT STRING	The command expects an expression with a string result and the expression as entered evaluated to a Boolean, integer, or floating point.	Review the expression for correct form. Consider using one of the conversion operators.
22	COMMAND NOT ALLOWED	The command entered in the program/motion block editor is not allowed in a program/motion block, or the command entered in immediate mode (using the terminal window) is allowed only in a program and/or motion block.	For specific information about the command you are using, see the ***Restrictions*** information for the command in Chapter 5
23	NOT READY FOR COMMAND	While entering commands in the immediate mode using the terminal window the system was not ready to accept the command entered because it was executing an operation that cannot be interrupted by that command.	Wait until the operation (program or motion) is finished or stop it by using the kill program commands (KLP or KLALL) or the stop motion commands (ST or HT). See the ***Remarks*** information for these commands in Chapter 5.
24	OUT OF PROGRAM MEMORY	The system has run out of memory available for programs and motion blocks.	Delete any programs or motion blocks that are not currently being used.

CIE Code Number	Status Message	Possible Cause(s)	Possible Solution(s)
25	NO PROGRAM FAULT	The FAULT command was entered using the terminal window when there was no active program fault	If the controller is faulted, the FC? command can be used in the terminal window to show what fault has occurred.
26	INVALID COMMAND IN STRING	An attempt was made to execute the EXVS command, but the command stored in the string variable was not recognized by the system.	The command is misspelled. Check spelling and re-enter the command. The command is invalid. Re-enter valid command.
27	TRANSMIT BUFFER OVERFLOW	The program has sent more characters to the transmit buffer than the communications port can handle.	The PUT or OUT commands have been executed multiple times — they are in a loop. Change the program accordingly.
28	RESOURCE NOT AVAILABLE	The addressed network controller is not online.	Check network connections. Check network address and baud rate. Check the Network Fault Code register (FCN) for more information.
29	INVALID VARIABLE POINTER	When creating an indirect reference to a variable location using another variable as a pointer, the pointer was out of the range of registers available for that variable type.	Re-enter the pointer reference making sure that it is in the range of the type of register accessed.
30	MATHEMATICAL OVERFLOW	The result of the expression entered was outside the allowed bounds of the type of expression.	Re-enter the expression making sure that the operation will never go outside the allowed bounds for the type of expression. If using an integer expression, consider using a floating point expression instead.
31	MATHEMATICAL DATA ERROR	The result of the expression entered cannot be represented as a number.	Make sure that the SQR and LGN operators never have negative operands. Make sure that a divide-by-zero operation will never occur.
32	VALUE OUT OF RANGE	The value entered as a parameter was out of the range specified for the command entered.	Re-enter the command making sure that the parameter is within the range specified for the command. See the ***Parameters*** information in Chapter 5 for the allowed range.
33	STRING TOO LONG	The string entered was longer than 127 characters.	Re-enter the command/string using 127 or fewer characters.
34	NONEXISTENT LABEL	The LABEL command was entered in the terminal window program editor with a nonexistent label.	Re-enter the LABEL command making sure that the label reference exists in the program. See Label command in Chapter 5.
35	DUPLICATE LABEL	The program label entered as part of a program statement was already in the current program.	Re-enter the program statement making sure that the label does not already exist in the program. Remove the duplicate label from the existing program statement first.
36	MISSING QUOTATION MARK	A string was entered as part of a command without being enclosed in quotes.	Re-enter the command with the string enclosed in quotation marks.

CIE Code Number	Status Message	Possible Cause(s)	Possible Solution(s)
37	INVALID MOTION	The combination of motion parameters defines a motion that cannot be executed or a motion command or motion block was executed when the system was faulted. Tried to enable gearing while PFE=1.	Make sure that the motion parameters define a motion that can be executed. For specific information about the parameters you are using, see Chapter 5. Make sure the system is not faulted when executing a motion command or motion block. Set PFE=0 before enabling gearing.
38	Reserved		
39	SWITCH MOTOR LEADS	The MOTORSET command was entered, and the system decided from its calculations that two motor leads should be switched.	Switch two of the motor leads.
40	BAD POLES RATIO	The MOTORSET command was entered, and the system calculated the motor poles to resolver poles ratio to be less than 1 or greater than 16.	Use a different resolver.
41	Reserved		
42	TORQUE TO INERTIA RATIO TOO LOW	The AUTOTUNE command was entered and the system calculated the torque to inertia ratio of the axis to be less than 125 radians/sec^2.	Autotuning with the AUTOTUNE command will not work. Use the tuning parameters KA, KD, KI, KP, and KT manually adjust servo controller response. See Chapter 5
43	TORQUE TO INERTIA RATIO TOO HIGH	The AUTOTUNE command was entered and the system calculated the torque to inertia ratio of the axis to be greater than 125,000 radians/sec^2.	Autotuning with the AUTOTUNE command will not work. Use the tuning parameters KA, KD, KI, KP, and KT manually adjust servo controller response. See Chapter 5
44	TORQUE RESPONSE NON-LINEAR	The AUTOTUNE command was entered, and the system could not calculate the control constants because the motor did not respond linearly.	Autotuning with the AUTOTUNE command will not work. Use the tuning parameters KA, KD, KI, KP, and KT manually adjust servo controller response. See Chapter 5
45	Enter password:	The password has been activated using the PASSWORD command and the system is waiting for the valid password to be entered.	Enter the correct password.
46	Password accepted	The PASSWORD command and the correct password have been entered, or the CHANGEPW command and the new password have been entered correctly.	Continue with normal operation.
47	Invalid password - access denied	The PASSWORD or CHANGEPW command has been entered, and the password entered is incorrect.	Continue with normal operation.
48	Enter old password:	The CHANGEPW command has been entered, and the system is waiting for the old password to be entered.	Enter the old password.
49	Enter new password:	The CHANGEPW command has been entered, and the system is waiting for the new password to be entered.	Enter the new password.
50	Enter new password again to verify:	The CHANGEPW command has been entered, and the system is waiting for the new password to be entered and verified.	Enter the new password again.

CIE Code Number	Status Message	Possible Cause(s)	Possible Solution(s)
51	Invalid password - Password unchanged	Invalid password - Password unchanged	Enter the CHANGEPW command again to start over. Make sure that the new password is at least 4 characters and no longer than 10 characters.
52	Retrieving user memory...	The RETRIEVE command has been entered, and the system is in the process of retrieving user memory.	Wait for user memory to be retrieved.
53	User memory retrieved	The RETRIEVE command has been entered, and the system has retrieved user memory.	Continue with normal operation.
54	Saving user memory...	The SAVE command has been entered; the system is in the process of saving user memory.	Wait for user memory to be saved.
55	User memory saved	The SAVE command has been entered, and the system has saved user memory.	Continue with normal operation.
56	FLASH MEMORY ERASE FAILURE	The SAVE command was entered, and the flash memory could not be erased.	Controller is defective. Try a different controller.
57	FLASH MEMORY PROGRAM FAILURE	The SAVE command was entered, and the program could not be written to the flash memory card.	Controller is defective. Try a different controller.
58	STORED PROGRAM DOES NOT CHECKSUM	The RETRIEVE command was entered in the terminal window and the program stored in the flash (non-volatile) memory has an invalid checksum.	Download the program and save the program again using the SAVE command. Replace the controller.
59	Are you sure you want to clear all the user memory and reset the registers to their default values?	The CLM command has been entered in the terminal window and the system is waiting for the user to respond.	If you are sure that you want to clear the controller memory, type **Y** or **y**. The system will clear all memory and reset the registers to their default values. If you are not sure, type **N** or **n**. The system will continue with normal operation.
60	User memory cleared	The user memory has been cleared using the CLM command.	Continue with normal operation.
61	Are you sure you want to erase the current firmware and load a new firmware version?	The FIRMWARE command has been entered in the terminal window and the system is waiting for the user to respond.	If you are sure that you want to erase the firmware, type **Y** or **y**. The system will erase the current firmware and load the new firmware. If you are not sure, type **N** or **n**. The system will continue with normal operation.

7.3 Status Register Messages

The S2K controllers have the following status registers that can provide valuable information on the current state of system resources:

- System Fault Code (FC) Register
- Input Fault Code Register (FI)
- General I/O Register (IO)
- Axis Status Register (SRA)
- Program Status Register (SRP)
- System Status Register (SRS)

The contents of any status register can be queried using either the terminal window or the Controller Function screen in the Motion Developer software. The bits for each registers can also be queried in programs in order to facilitate program flow decisions. The following tables show the contents of each status register. Also, see Chapter 5 for descriptions of the register commands.

7.3.1 System Fault Code Register (FC)

The Fault Code (FC) register is latched. Once a bit is set true it will not be cleared until faults are reset (RSF command executed).

Bit	System Fault Code Message	Possible Cause(s)	Possible Solution(s)
All Bits Set To Zero	Controller Functional	The controller is not faulted.	Continue with normal operation
0	Power Failure	A power failure has occurred. This fault always occurs when the system is powered-up.	Use the RSF command in the Motion Developer terminal window or the reset button on the Controller Functions page to reset the fault condition.
1	Reserved		
2	Software Fault	The Set Faults (STF) command was executed.	Use the RSF command in the Motion Developer terminal window or the reset button on the Controller Functions page to reset the fault condition.
3	Lost Enable	The enable discrete input was deactivated. For units with DeviceNet this bit will be true when a controller receives a group 2 message from a DeviceNet master without the enable bit set true.	Reactivate the enable input. Use the RSF command in the Motion Developer terminal window or the reset button on the Controller Functions page to reset the fault condition.
4	Digital Output Fault	A digital output fault occurs when the state of the hardware digital output is true but the state of the associated digital output register (DO) is not (after a time of 4 ms) and the Digital Output Fault Enable (DOE) is enabled.	Check that the output common is connected to power return and the input common is connected to +v +V of the I/O power supply or vice versa, depending on whether you are using a sinking or sourcing configuration. Check that the output is not shorted.

Bit	System Fault Code Message	Possible Cause(s)	Possible Solution(s)
5	Invalid Command in String	The program attempted to execute the Execute Command Stored In String Variable (EXVS) command, but the command stored in the string variable was not recognized by the system. The program attempted to execute the OUTN command, but the recipient did not recognize the command sent over the network.	The command is misspelled. Re-enter the correctly spelled command in the program editor. The command is invalid. Re-enter the valid command in the program editor.
6	Transmit Buffer Overflow	The program has sent more characters to the transmit buffer than the serial port can handle.	The PUT or OUT commands have been executed multiple times—they are in a loop. Change the program accordingly.
7	Resource Not Available	The addressed network controller is not online.	Check network connections. Check network address and baud rate DIP switches for correct settings. Check Network Fault Code register (FCN) for more information.
8	Invalid Variable Pointer	When creating an indirect reference to a variable location using another variable as a pointer, the pointer was out of the range of registers available for that variable type.	Re-enter the pointer reference making sure that it is in the range of the type of register accessed.
9	Mathematical Overflow	The result of an expression in the program or motion block was outside the allowed bounds of the type of expression.	Re-enter the expression in the program/motion block editor making sure that the operation will never go outside the allowed bounds of the type of expression. If using an integer expression, consider using a floating point expression instead.
10	Mathematical Data Error	The result of an expression in the program or motion block cannot be represented as a number.	Make sure that the Square Root (SQR) and Natural Log (LGN) operators in the program/motion block never have negative operands. Make sure that a divide by zero operation will never occur in the program/motion block.
11	Value Out of Range	The value of a parameter obtained from a variable or expression was out of the range specified for the register or command in the program or motion block.	Make sure that the variable or expression stays within the range of the register or parameter of the command. See the ***Parameter*** and ***Range*** information in Chapter 5.
12	String Too Long	The result of a string variable operation in the program/ motion block was longer than 127 characters.	Re-enter the string variable operation in the program/motion block editor making sure that the result is not more than 127 characters.
13	Nonexistent Label	One of the following commands was in the program with a label that does not exist in the program: GOTO, GOSUB, IF...GOTO, IF...GOSUB, WAIT...ON...GOTO, STVB...GOTO, FUNCTION.	Re-enter the command in the program editor making sure that the label exists in the program. Add the label number to the appropriate statement in the program.

Bit	System Fault Code Message	Possible Cause(s)	Possible Solution(s)
14	GOSUB Stack Underflow	The RETURN command was executed without a corresponding GOSUB.	Make sure the program will execute a GOSUB command the same number of times it will execute the RETURN command. Check for program flow through a subroutine without a GOSUB call.
15	GOSUB Stack Overflow	There were more than 32 nested GOSUB commands in the program.	Make sure the program will execute a GOSUB command the same number of times it will execute the RETURN command. If a program leaves a subroutine without using a RETURN command, use the POP gosub stack command to remove the return address from the gosub stack.
16	Invalid Motion	The combination of motion parameters defines a profile that cannot be executed or a motion command or motion block was executed while the system was faulted.	Make sure that the motion parameters define a motion that can be executed. For specific information about the parameters you are using, see the command information in Chapter 5. Make sure the system is not faulted when executing a motion command or motion block.
17	Reserved		
18	Reserved		
19	Network Power Failure	The network connector is disconnected, or the network power is below the minimum voltage.	Reconnect the network connector. Inspect the network power source and replace if required.
20	Duplicate Network Address	More than one device on the network is using the same network address (MAC ID).	Assign each device a unique network address. Network address for the S2K controllers are set using the DIP switches on the bottom of the controller.
21	Excessive Following Error	The axis Following Error (FE) was greater than the Following Error Bound (FEB) limit.	Make sure that the control constants are set up properly. Make sure that the motor position feedback wiring is correct. Make sure that the motor has sufficient torque for the required motion profiles.
22	Excessive Command Increment	The program simultaneously executed too many motions or the motion generator calculated a position command of more than 8000 pulses for one 488 µS loop update. This corresponds to a velocity command of 16,384,000 pulses/sec which exceeds the 16,000,000 pulses/sec limit for MVL.	Make sure that the program does not execute too many motions simultaneously.

Bit	System Fault Code Message	Possible Cause(s)	Possible Solution(s)
23	Position Register Overflow	The axis has moved past +/-2,000,000,000 pulses and Position Register Wrap Enable (PWE) is disabled.	If the axis is to move constantly in one direction for long periods of time, PWE should be enabled. Make sure that the motion parameters define a motion that does not cause position register overflow. For specific information about the parameters you are using, see Chapter 5
24	Position Feedback Lost	Motor position feedback disconnected or miswired.	Correct motor position feedback wiring problem.
25	Motor Power Over-Voltage	The controller DC bus voltage was greater than 475 Vdc.	The regeneration circuit did not function correctly. Make sure that the wiring is correct.
26 *(4.3 amp)*	Motor Power Clamp Excessive Duty Cycle	The internal regeneration clamp was operated past its 25 Watt continuous rating.	Reduce deceleration rate or reduce maximum velocity.
26 *(7.2 amp)*	Motor Power Clamp Excessive Duty Cycle—Under-Voltage	The internal regeneration clamp circuit was operated past its 25 Watt continuous rating or the motor power is off.	Try using an external regeneration resistor instead. Turn motor power on. Replace blown fuse(s).
26 *(16 - 28 amp)*	Motor Power Under-Voltage	The motor power is off.	Turn motor power on. Replace blown fuse(s).
27 *(4.3 amp)*	Reserved		
27 *(7.2 amp)*	Motor Power Clamp Over-Current Fault	The external regeneration resistance is less than 50 ohms.	Make sure that the resistor value is at least 50 ohms. Make sure that the resistor is correctly wired.
27 *(12 - 28 amp)*	Motor Power Clamp Excessive Duty Cycle	The internal regeneration clamp was operated past 50 Watt continuous rating.	Try using an external regeneration resistor.
28 *(4.3 & 7.2 amp)*	Motor Over-Current Fault	This fault occurs when the controller is not able to control the motor current, such as when a short occurs in the motor or motor wiring.	Check the wiring of the motor leads for correct phasing. Make sure that the motor leads are not shorted between phases or phase to ground. Check tuning gains and KL register for proper setting.
28 *(16 - 28 amp)*	Motor Over-Current Fault	This fault occurs when the controller is not able to control the motor current, such as when a short occurs in the motor, motor wiring, or external regeneration clamp resistor circuit.	Make sure the regen resistor leads are not shorted. Check the wiring of the motor leads for correct phasing. Make sure that the motor leads are not shorted between phases or phase to ground. Check tuning gains and KL register for proper setting.
29	Motor Over-Temperature	The temperature sensor in the motor sensed the motor going over its maximum allowed temperature.	Check for a broken wire in the motor feedback cable. If motor is hot, it is improperly sized.

Bit	System Fault Code Message	Possible Cause(s)	Possible Solution(s)
30	Controller Over-Temperature	The temperature of the controller heat sink was greater than 80^{o}C.	Check the controller for adequate air flow. A fan may be needed, or through-wall heat sink mounting can be used to allow adequate air flow.
31	Network Communication Error	Network is not properly configured.	Check network configuration.

7.3.2 Network Fault Code Register (FCN)

Bit	Network Fault Code Message	Possible Cause(s)	Possible Solution(s)
All bits set to 0	Network functional	The network is not faulted.	Continue with normal operation.
0	Network Off-line	Network cable is disconnected or there is no power to the network. No network card. No other node on network.	Connect network cable. Examine network for proper power distribution.
1	Addressed Device Not Present	Device not present on network or address not correct for intended device.	Connect device to network. Change address to match device address.
2	Addressed Device Out of Connections	Maximum number of server connections are presently open.	One or more client devices must delete connection to this server.
3	Connection Deleted Unexpectedly	Connection deleted by transmission error or timeout.	Examine network cable for proper connections and terminations. Examine device for proper connection and operation.
4	Time-out On Response	Server connection deleted or server timed out (250 ms).	Examine transmission media and server. Examine network cable for proper connections and terminations.
5	Not Requested Response	Server transmission error.	Examine transmission media and server. Examine network cable for proper connections and terminations.
6	Error Response	Server error response.	Examine transmission media and server. Examine network cable for proper connections and terminations. Verify network object or service exists for the device addressed.
7	Resource Unavailable	Server device doesn't have required resource. May be caused by getting or setting a variable not allocated in server.	Make certain that server has resources available.
8	Not Enough Data	Mismatched data type between client and server.	Ensure client and server data types match.
9	Too Much Data	Mismatched data type between client and server.	Ensure client and server data types match.
10	Device State Conflict	Controller is in program mode.	Exit the line editor.
11	I/O Scan Timeout	Controller or digital inputs not scanned within specified interval.	Increase allotted scan time in SCAN register. Update scan time in scanner.
12	Invalid Attribute Value	Attribute value entered is out of range	Enter a value within the allowed range. Check attribute values supported by the addressed device
13	Attribute Not Supported	Attribute is not supported by this object	Check attribute values supported by the addressed device
14	Object Does Not Exist	Object is not supported by this node	Check attribute values supported by the addressed device
15	Reserved		

7.3.3 System Fault Input Register (FI)

Bit	Fault Input Message	Possible Solution(s)
All Bits Set To Zero	No fault input active	There are no currently active fault inputs.
0	Reserved	
1	Motor power over-voltage input active	The controller DC bus voltage is greater than 475 Vdc.
2 *(4.3 amp)*	Motor power clamp input active	The internal regeneration circuit is on.
2 *(7.2 AMP)*	Motor power clamp or under-voltage input active	The internal regeneration circuit is on or the motor power is off.
2 *(16 - 28 amp)*	Motor power under-voltage input active	The motor power is off.
3 *(4.3 AMP)*	Reserved	
3 *(7.2 AMP)*	Motor power clamp over-current input active	The external regeneration resistance is less than 50 ohms.
3 *(16 - 28 AMP)*	Motor power clamp input active	The internal regeneration circuit is on.
4	Motor over-current input is active	The controller was putting out excessive current to the motor.
5	Motor over-temperature inactive	The temperature sensor in the motor is sensing the motor temperature is over its allowed maximum, or the motor feedback cable is not connected correctly.
6	Controller over-temperature input is active	The temperature of the controller heat sink is greater than 80^o C.
7	Network power failure input is active	The DeviceNet network is disconnected or the network power source is below the minimum voltage.

7.3.4 General I/O Register (IO)

Bit	General I/O Message	Description
All Bits Set To Zero	No I/O is active	None of the above I/O is active.
0	Reserved	
1	Reserved	
2	Axis channel A input active	Channel A of the motor encoder is active.
3	Axis channel B input active	Channel B of the motor encoder is active.
4	Auxiliary channel A input active	Channel A of the auxiliary encoder is active.
5	Auxiliary channel B input active	Channel B of the auxiliary encoder is active.
6	Auxiliary index input active	The index input of the auxiliary encoder is active.
7	Marker input active	The index input of the motor encoder is active.
8	Home input active	The home input is active.
9	Forward overtravel input active	The forward overtravel input is active.
10	Reverse overtravel input active	The reverse overtravel input is active.
11	Enable input active	The enable input is active.
12	Capture input active	The position capture input is active.
13	Capture input edge	A positive edge was sensed on the position capture input.
14	Reserved	
15	OK output active	The OK output is active.

7.3.5 Axis Status Register (SRA)

Bit	Axis Status Message	Description
Bit 7 Set to Zero	Axis direction reverse	The axis is moving or has last moved in the reverse direction.
0	Motion generator enabled	The motion generator is enabled. This bit is true while a run command is being executed. This bit is independent for gearing, camming and phase locked loop operation.
1	Gearing enabled	Electronic gearing is enabled (GRE=1).
2	Phase-locked loop enabled	The phase-locked loop is enabled (PHE=1).
3	Motion block executing	A motion block is executing.
4	Phase error captured	The phase error (PHR) has been captured by the position capture input.
5	Phase error past bound	The phase error is outside the phase error bound (PHB) limit.
6	Axis accel/decel	The axis is either accelerating or decelerating. For pulse-based moves this bit is set true as soon as a pulse-based move is armed (RPI, RPA, RVF or RVR command is executed) and remains true until accel/decel is complete.
7	Axis direction forward	The axis is moving or has last moved in the forward direction.
8	Axis in position	The axis is stopped and the Axis Position (PSA) is within the In Position Band (IPB) of the Command Position (PSC).
9	Axis at torque limit	The Torque Limit Enable (TLE) parameter is enabled and the axis is at the torque limit set by the Torque Limit Current (TLC) parameter.
10	Axis at overtravel	The axis is either at a hardware overtravel input or a software overtravel limit.
11	Axis at software overtravel	The axis is at a software overtravel limit.
12	Motion suspended	The motion of the axis has been suspended.
13	AXIS FAULT	A fault specific to the axis has occurred.
14	Cam enabled	Cam following is enabled (CAE=1)
15	Reserved	

7.3.6 Program Status Register (SRP)

Bit	Program Status Message	Description
Bit 7 Set to Zero	Program not executing	The program specified is not executing.
0	Program executing	A program is executing.
1	Program locked out	The program is being locked out by another program.
2	Reserved	
3	Reserved	
4	Invalid digit in string	The program specified a string variable to floating point or integer variable conversion, and the string variable contained an invalid digit; or the floating point or integer variable input by the IN command contained an invalid digit.
5	String value out of range	The program specified a string variable to floating point or integer variable conversion, and the string variable contained a number out of the range of the variable; or the floating point or integer variable input by the IN command was out of the range of the variable.
6	Floating point value out of range	The program specified a floating point to integer variable conversion and the floating point variable contained a number out of the range of the integer variable.
7	Reserved	
8	Invalid command acknowledgment	The OUSN command was executed, and the responding device didn’t accept the command as valid.
9	Variable save failure	The Save Variables To Flash (SVV) command was executed and variables could not be saved in flash memory.
10-14	Reserved	
15	PROGRAM FAULT	The program specified caused the system to fault.

7.3.7 System Status Register (SRS)

Bit	Program Status Message	Description
0	Program executing	One of the programs is executing.
1	Program locked out	One of the executing programs is being locked out by another program.
2	Reserved	
3	Motion block executing	One of the motion blocks is executing.
4	Key buffer empty	The key buffer contains no characters to be input by the GET or IN commands.
5	Transmit buffer empty	The transmit buffer of the controller is empty.
6	Network connection available	There is a connection available for communication.
7	Network on-line	The network is ready to communicate.
8	Reserved	
9	Reserved	
10	Reserved	
11	Reserved	
12	I/O FAULT	A digital output fault has occurred. This fault occurs when the state of the hardware digital output is true but the state of the associated digital output register (DO) is not (after a time of 4 ms) and the Digital Output Fault Enable (DOE) is enabled.
13	AXIS FAULT	A fault specific to the axis has occurred.
14	SYSTEM FAULT	A fault has occurred. This could be any fault possible in the system.
15	MEMORY FAULT	A memory fault has occurred due to the user program memory not having a valid checksum.
Bit 0 set to zero	No program executing	None of the programs is executing.
Bit 4 set to zero	Character in key buffer	A character is available to be input by the GET or IN commands.

7.4 Application Program Diagnostics

The S2K Series controllers support a host of diagnostic tools to help you identify and correct programming problems. Most of these tools are used in the Motion Developer terminal window and/or make use of a basic line editor available within the terminal window.

7.4.1 Embed and Enable Diagnostics in an Application Program

The S2K controllers include several diagnostic commands that you can use with the Motion Developer terminal window to debug your application programs. You can integrate the Print Diagnostic Message (DGP) and Output Diagnostic Register (DGO) commands into an application program to check register values or report other conditions during program execution without affecting program performance. The Enable Diagnostics (DGE) command allows the user to enables diagnostics when appropriate. The controller ignores any diagnostic commands in an application program until you set DGE=1 using the Motion Developer terminal window.

In the following example, we have downloaded the following program 1, including some diagnostics, to the controller:

RSF	(* reset faults
PSA = 0	(* set axis position register to zero
DGP "Motion Beginning: "	(* diagnostic print command
DGO PSA	(* output diagnostic register – axis position
MVL = 10	(* set motion velocity to 10 units/second
MAC = 40	(* set acceleration rate to 40 units/second
MPA = 12	(* set absolute move destination to 12 units
RPA	(* execute absolute move
WAIT IP	(* wait for motion to complete
DGP "Motion Complete: "	(* diagnostic print command
DGO PSA	(* output diagnostic register – axis position-
END	(* end program

From the terminal window when we then enable diagnostics (type `DGE=1 <Enter>)` and execute Program 1 (type EXP1 <Enter>) we receive the following diagnostic information in the terminal window:

* dge =1

* exp1

* Motion beginning: PSA = 0

Motion complete: PSA = 12

This example demonstrated how to write diagnostics into your application program. Other diagnostics, such as the Load Diagnostic Condition (DGC) and Assign Diagnostic Item (DGI) commands, are not allowed *within* programs but are useful to assign diagnostic conditions or items to your system.

In the following example, we have created an application program that uses the Print Diagnostic Line (DGL) command:

RSF	(* reset faults
PSA = 0	(* set axis position register to zero
DGL	(* print diagnostic items
DGO PSA	(* output diagnostic register – axis position
MVL = 10	(* set motion velocity to 10 units/second
MAC = 40	(* set acceleration rate to 40 units/second
MPA = 12	(* set absolute move destination to 12 units
RPA	(* execute absolute move
WAIT IP	(* wait for motion to complete
VB1 = 1	(* set Boolean variable 1 to a value of 1
DGP "Motion Complete: "	(* diagnostic print command
DGO PSA	(* output diagnostic register – axis position-
END	(* end program

From the terminal window we now assign diagnostic items 1 and 2 and established a diagnostic condition. We then enable diagnostics (type `DGE=1 <Enter>`) and execute Program 1 (type EXP1 <Enter>) and receive the following diagnostic information in the terminal window:

* DGI1 = PSA	(assign diagnostic item 1 to axis position)
* DGI2 = VLA	(assign diagnostic item 2 to axis velocity)
* DGC1 = PROG1 AND VB1	(set diagnostic condition 1 to Prog 1 executing AND Boolean variable 1 true)
* dge =1	(enable diagnostics)
* exp1	(execute program 1)
* DGL: PSA = 0, VLA = 0	(diagnostic output to the terminal window)
PROG1 AND VB1: PSA = 12, VLA = 0	(diagnostic output based on condition 1)

You can use the **DGC** command to assign up to 8 diagnostic conditions that tell the system to print a line of diagnostic items to the terminal window any time the condition is satisfied. Diagnostic conditions can be any Boolean expression, for example, program *n* is executing (PROG*n*), timer *n* has timed out (TM*n*) or motion generator is enabled (SRA0).

You can define up to eight diagnostic items using the **DGI** command. A diagnostic item is any system register that can be queried using the "?" or "Q" terminal window commands, such as axis position (PSA), axis velocity (VLA), or variable values (VB*n*, VI*n*, VF*n*, VS*n*). See Chapter 5 for detailed descriptions of these commands.

To *unassign* a diagnostic item or condition, set it to OFF (e.g. **DGC1 = OFF** or **DGI6 = OFF**).

Note

Remember to set `DGE=1` in the terminal window to enable your diagnostics—otherwise, your controller will ignore them!

7.4.2 Runtime Debugging Tools

It's probably no surprise—sometimes you will send a program to the controller without an error, and then it won't run. For demonstration purposes, a bug was included into the following program 1, and then it was sent to the controller:

```
VF10 = 0              (* initialize floating point variable 1 to zero
PSA = 0               (* set axis position register to zero
MPA = 12              (* set absolute move destination to 12 units
MVL = 10              (* set motion velocity to 10 units/second
MAC = 40              (* set acceleration rate to 40 units/second
MPA = 100.0/VF10      (* set absolute move destination to 100/VF10 units
RPA                   (* execute absolute move
END                   (* end program
```

We then execute program 1 from the terminal window (type `EXP1 <Enter>)`. The terminal window displays the following:

```
* exp1                    (execute program 1)
*
```

The motor does nothing so we suspect a run time problem in the program code. The S2K includes a number of system status registers that provide extensive feedback on a broad range of controller conditions. In this case we will check the System Fault Code Register (FC). To query the System FC register you can either:

1. Type "FC?" in the terminal window
2. Select the System Fault Code Register from the pull-down list under the System Status Registers area of the Controller Functions wizard page

We will type **`FC?`** In the terminal window to query the fault code register. As expected, the controller reports "Mathematical Data Error" because of the divide-by-zero operation included in our program. The following section explains how to use the FAULT command to help pinpoint the exact location of the problem within the program structure.

7.4.3 About the Terminal Window Line Editor

Each S2K controller has a resident line editor that gives the user the means, using the Motion Developer terminal window feature, to scroll through the programs and motion blocks that reside in the controller's memory. The *terminal window* ***line editor*** is a tool for finding bugs on-the-fly, while connected in real-time with the controller. The *terminal window* ***line editor*** scrolls through only one line of code at a time. Any changes that you make in the line editor will not affect your master application program stored in your Motion Developer project; but they will change the controller's resident program (stored in volatile SRAM memory) and affect the behavior of the controller.

To use the *terminal window* ***line editor*** to identify specific lines of defective code:

- Type `FAULT` when your program does not execute properly due to a bug.
- Type `PROGRAMn`, where *n* is the number of the program through which you wish to scroll.
- Type `MOTIONn`, where n is the number of the motion block through which you wish to scroll.

Once the program or motion block is active in the terminal window, the commands shown in Table 7-3 can be used to navigate through the lines of code and to make changes. See Chapter 5 for detailed descriptions for these commands.

Table 7-3. Terminal Window Line Editor Command Summary

Editor Command	Function
X	Step Forward to the Next Line of Code
L	Step Backward to the Previous Line of Code
DEL	Delete Entire Line of Code
!	Exit the Terminal Window Editor (resumes immediate mode of operation)

Note

The Motion Developer software provides more full-featured script editors that are recommended for making changes to programs or motion blocks. Changes made using the terminal window editor are NOT saved in your Motion Developer project and will not be archived unless you perform an *Import From Controller* operation from the main wizard screen Import/Export Functions selection. Also, these changes will not be saved to FLASH (non-volatile memory) unless a SAVE command is executed from the terminal window or the Controller Functions page.

7.4.4 Finding Program Errors Using the FAULT Command

The Motion Developer software automatically checks for many syntax errors when a download operation is executed but cannot check for many runtime error conditions. The FAULT command is an additional diagnostic tool to help you locate programming errors.

The FAULT command is used in the Motion Developer terminal window. If a program operation causes a fault, the FAULT command gives an online connection to the *terminal window* ***line editor***. Use the following procedure to diagnose a fault in an application program:

1. Type `KLALL <Enter>`
2. Type `FAULT` <Enter> (this opens the line editor at the faulty program line)
3. Type `!` <Enter> to exit the terminal window line editor

Using this tool on the faulty example program above, the terminal window displays the following:

1 klall

*1 fault

* MPA = 100.0/VF10

1 !

Most application programs will not be as short as our example. If your program has many lines, it is possible that you will issue the FAULT command, view the faulty program line displayed in the terminal window, and not know exactly where to find that program line in order to fix the error.

The *terminal window* ***line editor*** lets you step backward and forward through your program, displaying one line at a time, until you pinpoint the location of the fault. The “L” and “X” commands are used within the *terminal window editor* to step backward and forward respectively through the program lines.

Scroll until you have found a familiar reference point—when you know exactly where that fault exists in your application program, it’s time to exit the *terminal window* ***line editor*** and fix the error using the Motion Developer *program script* ***editor***.

7.4.5 Query Registers for Current Data (Q, ?)

The Motion Developer software Data Watch window allows many system variables and registers to be monitored continuously in real-time. In addition to this powerful tool Motion Developer provides the commands (Q or ?) for the terminal window to display the current state of almost any parameter while the system is executing an application program. This value is a one-time snap shot for that instant in time. To view the value again the command must executed again. For example:

*1 PSA?	(query the axis position register)
* 0	(terminal window displays current position

7.4.6 Run an Application Program in Single-Step Mode

Single-step mode is another terminal window tool for diagnosing program conditions. With single-step mode enabled, one line of a program is executed at a time using the **X*n*** command, where the number *n* indicates the number of program line used for the step. The Set Program to Single-Step Mode command (DGS) defines which program will use the single-step mode.

Note: You can place only one program at a time in single-step mode.

To enable single-step mode from the Motion Developer terminal window:

1. Type KLALL <Enter>
2. Type DGE=1 <Enter>
3. Type DGS= *p1* <*Enter*> where *p1* is the program number
4. Type EXP*n* <Enter> to execute the program *n*

Single-step through the program until you execute line END.

7.4.7 Run an Application Program in Trace Mode

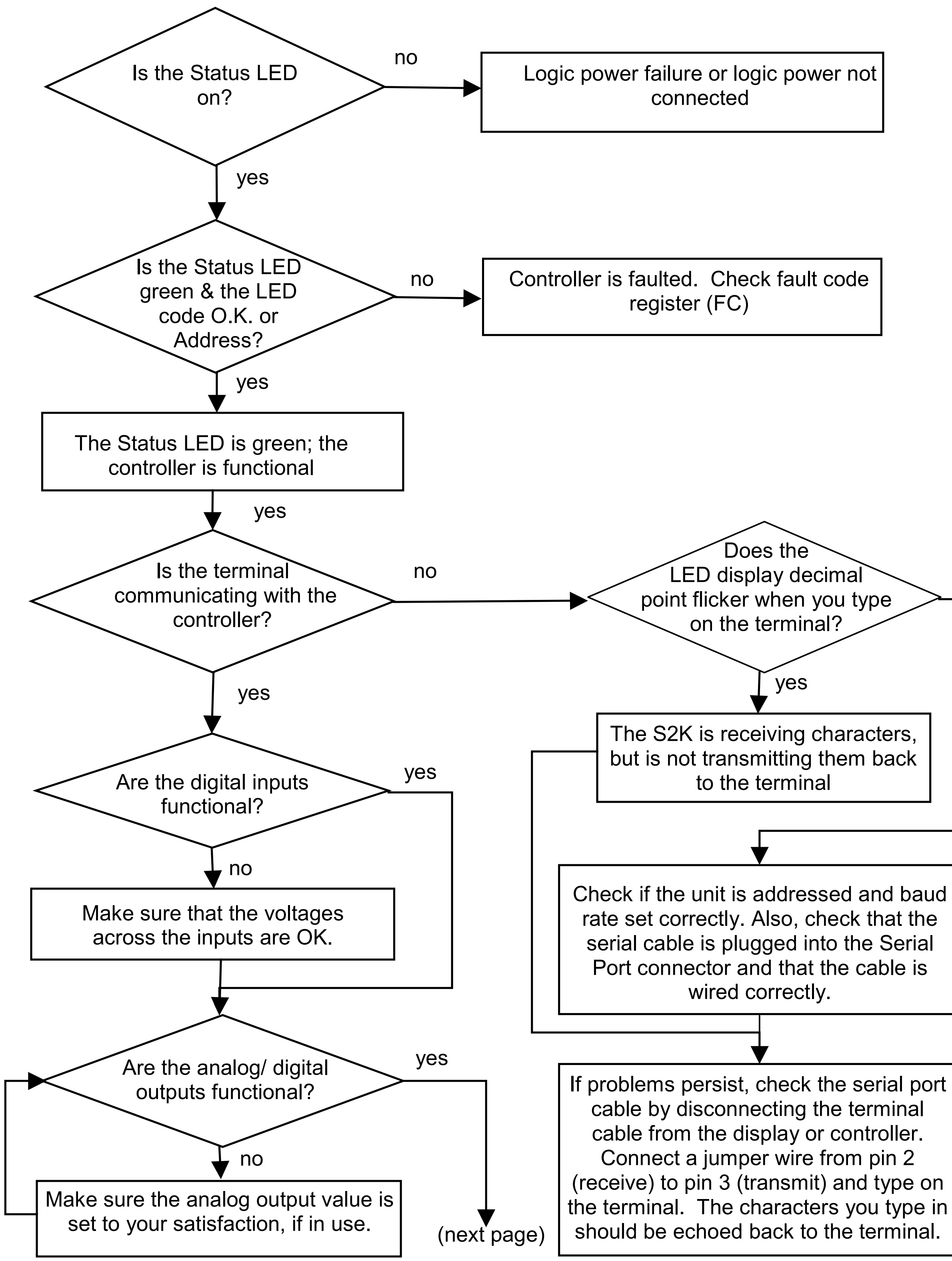
Trace mode outputs each program line to the Motion Developer terminal window as the program executes that line. No "X" command input is required as with single-step mode.

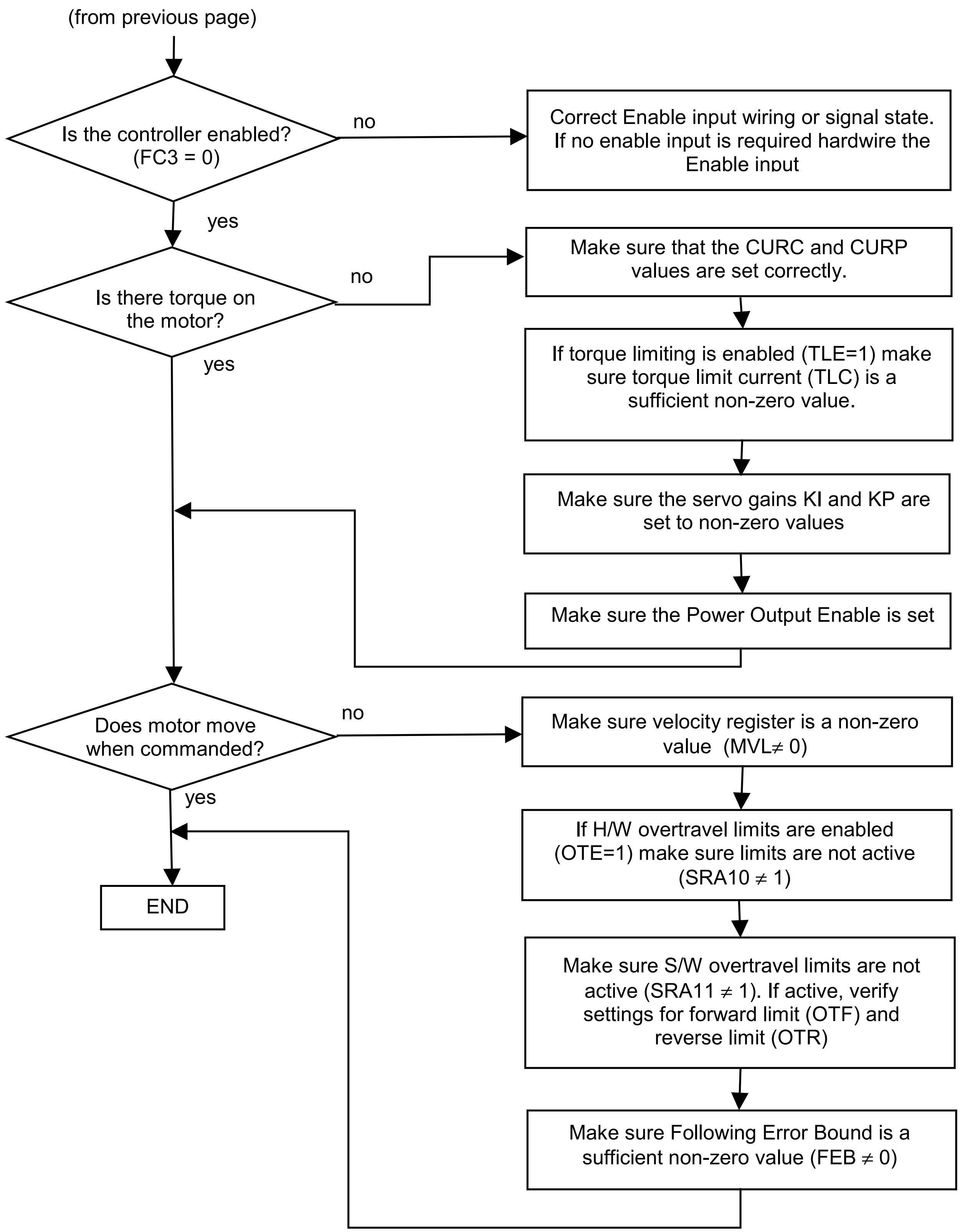
Note: Only one program at a time can be in trace mode.

To enable trace mode execute the following steps from the terminal window:

1.	Type KLALL <Enter>	(kills all programs)
2.	Type DGE=OFF <Enter>	(disable diagnostics)
3.	Type DGS=0 <Enter>	(disable single-step mode)
4.	Type DGT=*p1* <Enter>	(enable trace mode, *p1* is the desired program number)
5.	Type DGE=1 <Enter>	(enable diagnostics)
6.	Type EXP*p1* <Enter>	(*p1* is the desired program number)

7.5 Troubleshooting Flow Chart




(from previous page)
Is the controller enabled? (FC3 = 0)
no
Correct Enable input wiring or signal state. If no enable input is required hardwire the Enable input
yes
Is there torque on the motor?
no
Make sure that the CURC and CURP values are set correctly.
If torque limiting is enabled (TLE=1) make sure torque limit current (TLC) is a sufficient non-zero value.
Make sure the servo gains KI and KP are set to non-zero values
Make sure the Power Output Enable is set
yes
Does motor move when commanded?
no
Make sure velocity register is a non-zero value (MVL≠ 0)
If H/W overtravel limits are enabled (OTE=1) make sure limits are not active (SRA10 ≠ 1)
Make sure S/W overtravel limits are not active (SRA11 ≠ 1). If active, verify settings for forward limit (OTF) and reverse limit (OTR)
Make sure Following Error Bound is a sufficient non-zero value (FEB ≠ 0)
yes
END

Chapter 8 Using DeviceNet Communications

8.1 DeviceNet™ - What it is and How it Works

DeviceNet is a digital, serial, multi-drop network that connects and serves as a communication path for GE Fanuc's S2K controllers and other industrial controls and I/O devices. Using DeviceNet allows one network to connect both simple and high-level devices from many manufacturers. Those devices may each contain one or more nodes, or connection points, to the network. Each node gets a unique Node Address that serves as its network address.

DeviceNet is a producer-consumer network that supports multiple communication hierarchies and message prioritization. Therefore, when used on DeviceNet, S2K products can act as slaves to a DeviceNet master and/or communicate with other DeviceNet products in a peer-to-peer fashion, including other S2K controllers. Those two network architectures can also coexist on a single DeviceNet network, using both *master/slave* and *peer-to-peer* communication to create the *distributed control architecture*.

- DeviceNet specifications are managed and controlled by the Open DeviceNet Vendors Association (ODVA)
- ODVA members are users and designers who promote growth, use, and technology.
- Based on Controller Area Network (CAN) technology
- International standard
- Well-suited to networking intelligent I/O devices
- Uses low-cost serial bus system
- Has real-time capabilities

™ DeviceNet is a trademark of the Open DeviceNet Vendors Association (ODVA)

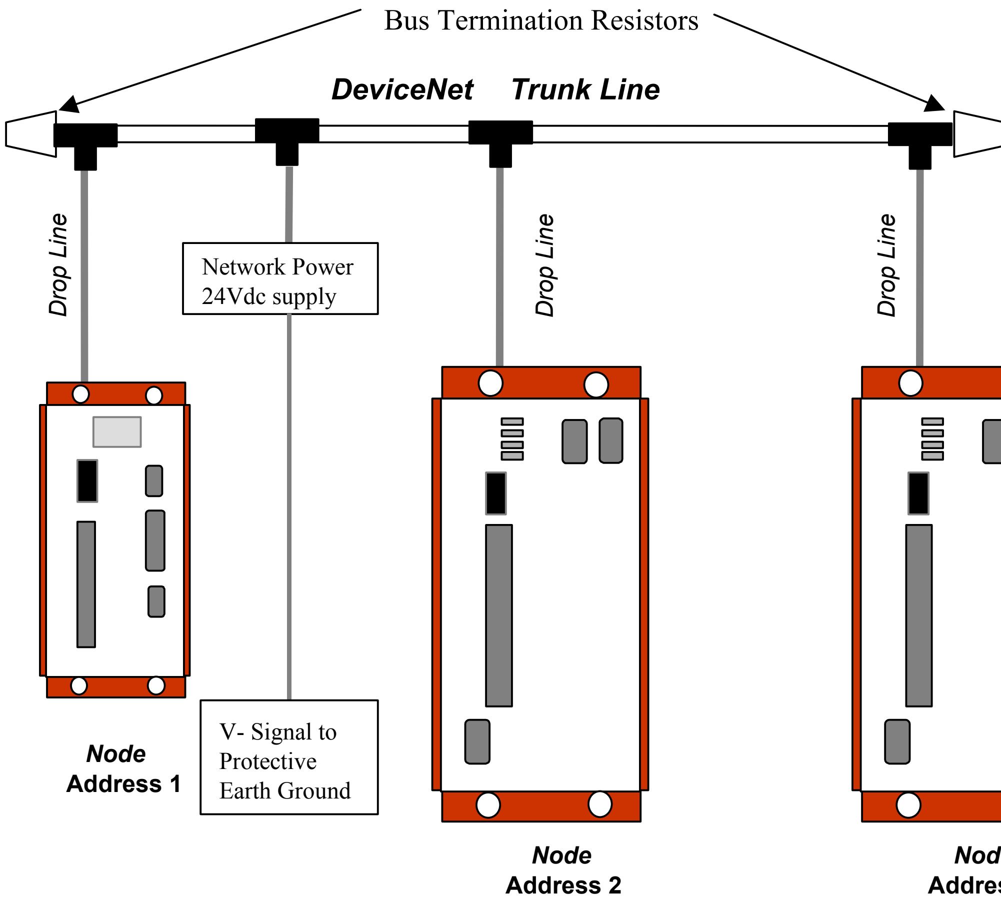


Figure 8-1. DeviceNet Thick Wire trunk with Thin Wire Drop Connections

8.1.1 DeviceNet Cable and Installation

A DeviceNet network uses 5-wire, multi-conductor cable. Two wires form a twisted pair transmission line for network communications. A second pair transmits network power. The fifth conductor forms an electromagnetic shield. Cable is available in a variety of current-carrying capacities. On a DeviceNet field bus, every device must power its network transceiver from the network power source. Some devices draw all their power from the network supply. The S2K controller powers only its transceiver and requires 40ma maximum per node from the network power supply.

A network can include both high-capacity trunk cable and lower capacity cable for individual branch circuits. DeviceNet installations typically include the two main types of network cable, DeviceNet Thick and DeviceNet Thin cable. Thick cable provides for longer distances and more power. Generally, Thick cable is used for the trunk cable. Thin cable is used for shorter distances and is generally used for drop cables or where cable flexibility is necessary. A newer cable type, DeviceNet Flat cable, is gaining acceptance in low noise environments and provides for easy connectivity of nodes to the LAN. A cable should be selected to provide sufficient current carrying capacity in the network power pair to provide power to the sum of all network power consumption. It is important to carefully select a quality network cable and install it with attention to cable routing and grounding.

Table 8-1. DeviceNet Cable Specifications

Thick Cable General Specifications	Two shielded pairs—Common axis with drain wire in the center Overall braid shield—65% coverage; 36 AWG or 0.12mm tinned copper Drain wire - #18 Copper min.; 19 strands minimum (individually tinned) Outside diameter—0.410 inches (min.) to 0.490 inches (max.) roundness, radius delta to be within 15% of 0.5 O.D.
Thin Cable General Specifications	Two shielded pairs—Common axis with drain wire in the center Overall braid shield—65% coverage; 36 AWG or 0.12mm tinned copper Drain wire—#22 Copper min.; 19 strands minimum (individually tinned) Outside diameter—0.240 inches (min.) to 0.280 inches (max.) roundness, radius delta to be within 20% of 0.5 O.D.
Network Topology	Bus with limited branching (trunkline/dropline)
Redundancy	Not supported
Network Power for Node devices	Nominal 24 volt DC +/- 4%
Allowed Nodes (Bridging excluded)	64 Nodes
Data Packet Size	0-8 bytes with allowance for message fragmentation
Duplicate Address Detection	Address verified at power-up
Error Detection / Correction	CRC—retransmission of message if validity not acknowledged by recipient

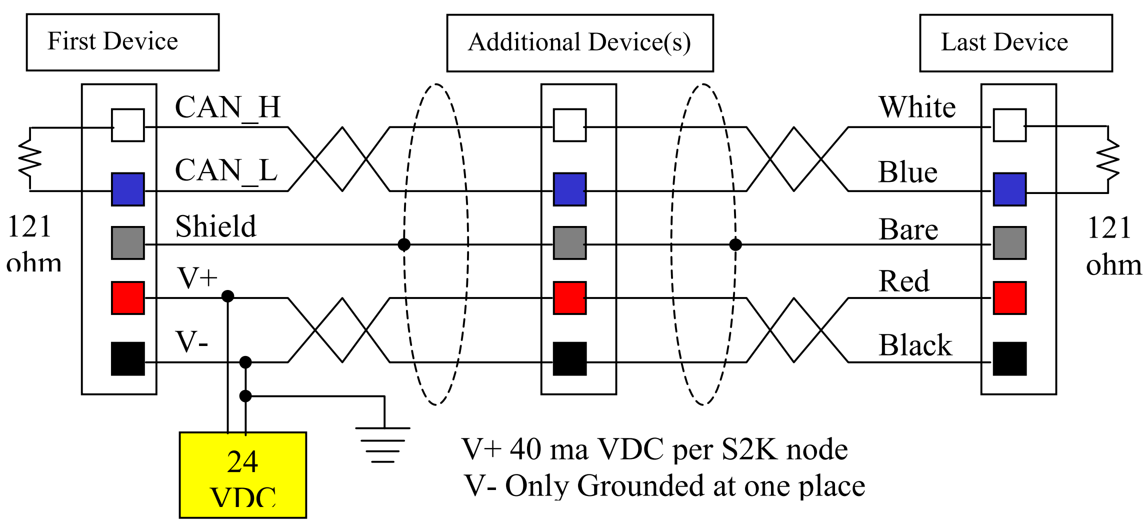


Figure 8-2. DeviceNet Thin Wire Multi-drop Wiring Connections

8.1.2 DeviceNet Response Times

The time needed to send a DeviceNet message with 8 data bytes over the network at various baud rates is summarized in the table below. **The response time of the S2K to register read/load command is approximately 0.2 milliseconds. All devices on a DeviceNet network segment must be operating at the same baud rate and each device must have a unique Node Address.**

Table 8-2. DeviceNet Response time

Data Rate	Message Time [1]	8 node Scan Cycle Time [2]
125K	0.888 ms	14.21 ms
250K	0.444 ms	7.10 ms
500K	0.222 ms	3.55 ms

Notes:
1. 8 data byte message including 3-bit inter-frame space
2. Transmission time for 16 messages of eight data bytes

8.1.3 DeviceNet Bus Length

The maximum length of the bus is limited by the cable type, transfer rate, and number and accumulated length of drop lines. Individual branch lengths (drops) may not exceed 6 meters and are limited to one network node per drop. However, the node may be a device offering multiple ports, i.e., a multi-port tap.

With DeviceNet Thin cable, the maximum bus length, regardless of data rate, is 100 meters.

With DeviceNet Thick cable used as the trunk line, the maximum bus length is shown in the following table.

Table 8-3. Thick Cable Maximum bus length

Data Rate	Bus length and drop length restrictions
500 Kbps	100m bus length and branches totaling < 39m
250 Kbps	250m bus length and branches totaling < 78m
125 Kbps	500m bus length and branches totaling < 156m

8.1.4 DeviceNet Bus Connectors

A DeviceNet cable plant (installed network cable) has two basic connection types. An open connector is available with inline terminal block wiring terminations. This type of connection is suitable for environments without excessive humidity or vibration levels. Typically, Thin wire connections are made to this connector. The S2K products use this type of connector. It is possible using Thin wire cable to connect several S2K nodes together by inserting two conductors into each terminal pin, similar to a multi-drop wiring scheme. Terminating resistors may additionally be added to the appropriate terminal pins. This arrangement provides an economical cable plant, typically within the same cabinet.

The second type uses a five-pole, circularly arranged connector. This type provides a robust connection and is more resistant to moisture and vibration. Trunk line cables lengths, network T connectors, network power supply taps, Thin wire drop cables and terminators are readily available in this form factor and in IP67 sealant ratings. The trunk line and drop line cable plant arrangement, providing the greatest potential network length, is often used to connect wiring cabinets or a cabinet to an external I/O device.

8.1.5 DeviceNet Bus Connector Pin Assignments

All S2K Controllers that include DeviceNet have the same 5-pin standard open-style plug connectors. Each bus connector may accommodate either a single drop line cable or two DeviceNet Thin wire cables for a multi-drop configuration. The pins to signal to wire color assignments are shown in the following table.

Table 8-4. S2K DeviceNet Connector Pin Assignments

Pin	Signal Name	Wire Color
1	V-	Black
2	CAN_L (Data low)	Blue
3	Shield	Bare
4	CAN_H (Data High)	White
5	V+	Red

8.1.6 DeviceNet Bus Termination

Termination of a DeviceNet network is passive and includes one resistor at each end of the network, i.e., exactly two resistors per DeviceNet network. A terminating resistor is placed across the data communications at pin 2 (CAN_L) and pin 4 (CAN_H). The correct terminating resistor is a 121-ohm, 1%, 0.25-watt resistor.

<u>DeviceNet networks must always be terminated to operate properly regardless of cable length.</u>

8.1.7 DeviceNet Bus Power Supply and Grounding

DeviceNet networks require a power supply of 24 volts DC (+/- 4%) at a 16A maximum. However, with the use of DeviceNet Thick cable, a maximum of 8A is permitted on a single network segment. The 16A maximum current is possible only if the power supply is placed between two DeviceNet Thick cable network segments, thus supplying 8A to each segment. The data lines would not connect at this junction of two segments.

With the use of DeviceNet Thin cable, a maximum network power of 3A current per network segment is permitted.

With a DeviceNet network, grounding the network and its devices is very important. In DeviceNet, all cable shields must be tied to ground at each device connection. The connection is made by tying the bare wire of the network cable to pin 3 (Shield) of the network connector. In a Thin wire multi-drop configuration, both shield wires landing at a node should be connected to pin 3.

The DeviceNet network power supply must also be grounded, but only at one point. The V- signal must be connected to a protective earth ground at the power supply only. If multiple power supplies are used, only one power supply must have V- connected to earth ground.

8.2 Certification and Testing

The Open DeviceNet Vendors Association (ODVA) governs the DeviceNet specification. Products bearing the *DeviceNet Conformance Tested* logo have been DeviceNet-certified by an ODVA certified independent conformance testing lab. S2K products have been certified at the University of Michigan testing facility. DeviceNet connectivity is an option on all S2K Series motion controllers. Over 200 other suppliers offer DeviceNet-compatible products.

8.3 Network Size and Device Types

A single DeviceNet network can have 64 *nodes*, or device types. The S2K controllers conform to the **Type 10_{16} Position Controller** ODVA-specified device profile.

I/O messaging protocols are defined in the DeviceNet specification by *Device Profiles*. For DeviceNet users, this conformance promotes interchangeability with other devices that qualify for the same profile.

8.4 S2K Series Real-Time Operating System (RTOS)

In addition to the DeviceNet conventions described herein, the S2K Series controllers use a Real-time Operating System (RTOS), which has been designed specifically for motion and machine control. Chapter 5 describes the operating system and the commands and registers specific to DeviceNet in more detail. Chapter 7 details the diagnostics associated with DeviceNet.

8.5 Getting Started

8.5.1 DeviceNet Connection Checklist

GE Fanuc-supplied Components:

- An S2K Series controller with DeviceNet per axis
- An S-Series motor per axis
- Cables
- DC power to digital I/O
- CIMPLICITY Machine Edition Motion Developer software

User-supplied Components:

- DC power
- 16-gauge wire to jumper I/O connectors
- DeviceNet trunk line
- A trunk line connector (T) per device
- DeviceNet drop line cable and 230 VAC power supply for each controller
- Quantity 2 terminating resistors for beginning and end of the trunk line
- PC or PLC with DeviceNet scanner (for master/slave architecture only)
  Note: **scanner module must be compatible with UCMM-capable devices**.

8.5.2 Complete Basic Set-up Procedure

Before you connect and use your S2K controller on DeviceNet, take a few minutes to complete the controller Basic Set-up described in Chapter 4, *Getting Started*.

The set-up process takes you systematically through each of the following items:

- Installing the Motion Developer software
- Connecting cables
- Jumper dedicated I/O (if applicable)
- Establishing communication with the controller
- Completing basic equipment configuration

If you are using multiple S2K controllers, repeat the set-up for each component. When you have completed the set-up, leave your connections and jumpers in place—you're ready to build your DeviceNet system!

8.5.3 Configure S2K Controllers for DeviceNet

Each S2K controller requires some simple configuration before being used on DeviceNet. You have already established communication between your PC and controller through the Motion Developer software. Now it's time for some DeviceNet-specific configuration.

The flowchart in Figure 8-3 documents the process for configuring S2K controllers for DeviceNet. The remainder of this section expands upon each action in Figure 8-3 with systematic instructions for each part of the process.

The first step is to set the Node Address, which provides a unique network address, from 0 through 63, for each DeviceNet node. S2K Series controllers ship from the factory with the Node Address set to 63 and the network data rate set to 125K.

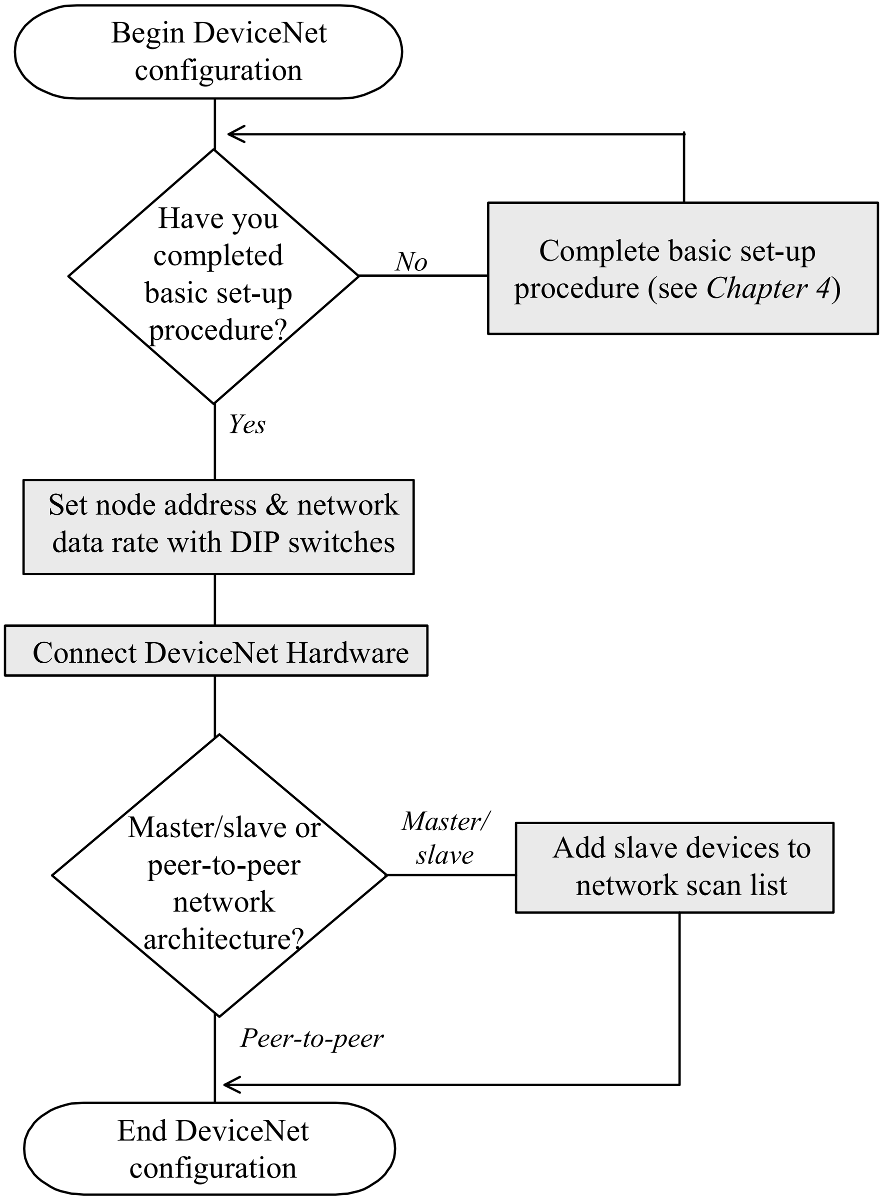


Figure 8-3. DeviceNet Configuration Process

Step 1: Set the Node Address

To change the Node Address, ensure that the S2K controller power is off. Use the Network Address (*NA)* DIP-switches located on the bottom of the S2K controller to set a Node Address from 0-63 for each S2K. Figure 8-4 shows the DIP switch settings associated with each Node Address and Figure 8-5 shows the location of the DIP switches and the proper orientation for left (L) and right (R) switch settings.

Each device operating on a DeviceNet network segment must have a unique address.

Address	Switch					
	1	2	4	8	16	32
0	R	R	R	R	R	R
1	L	R	R	R	R	R
2	R	L	R	R	R	R
3	L	L	R	R	R	R
4	R	R	L	R	R	R
5	L	R	L	R	R	R
6	R	L	L	R	R	R
7	L	L	L	R	R	R
8	R	R	R	L	R	R
9	L	R	R	L	R	R
10	R	L	R	L	R	R
11	L	L	R	L	R	R
12	R	R	L	L	R	R
13	L	R	L	L	R	R
14	R	L	L	L	R	R
15	L	L	L	L	R	R
16	R	R	R	R	L	R
17	L	R	R	R	L	R
18	R	L	R	R	L	R
19	L	L	R	R	L	R
20	R	R	L	R	L	R
21	L	R	L	R	L	R
22	R	L	L	R	L	R
23	L	L	L	R	L	R
24	R	R	R	L	L	R
25	L	R	R	L	L	R
26	R	L	R	L	L	R
27	L	L	R	L	L	R
28	R	R	L	L	L	R
29	L	R	L	L	L	R
30	R	L	L	L	L	R
31	L	L	L	L	L	R

Address	Switch					
	1	2	4	8	16	32
32	R	R	R	R	R	L
33	L	R	R	R	R	L
34	R	L	R	R	R	L
35	L	L	R	R	R	L
36	R	R	L	R	R	L
37	L	R	L	R	R	L
38	R	L	L	R	R	L
39	L	L	L	R	R	L
40	R	R	R	L	R	L
41	L	R	R	L	R	L
42	R	L	R	L	R	L
43	L	L	R	L	R	L
44	R	R	L	L	R	L
45	L	R	L	L	R	L
46	R	L	L	L	R	L
47	L	L	L	L	R	L
48	R	R	R	R	L	L
49	L	R	R	R	L	L
50	R	L	R	R	L	L
51	L	L	R	R	L	L
52	R	R	L	R	L	L
53	L	R	L	R	L	L
54	R	L	L	R	L	L
55	L	L	L	R	L	L
56	R	R	R	L	L	L
57	L	R	R	L	L	L
58	R	L	R	L	L	L
59	L	L	R	L	L	L
60	R	R	L	L	L	L
61	L	R	L	L	L	L
62	R	L	L	L	L	L
63	L	L	L	L	L	L

Figure 8-4. S2K Controller DIP Switch Settings for Node Address

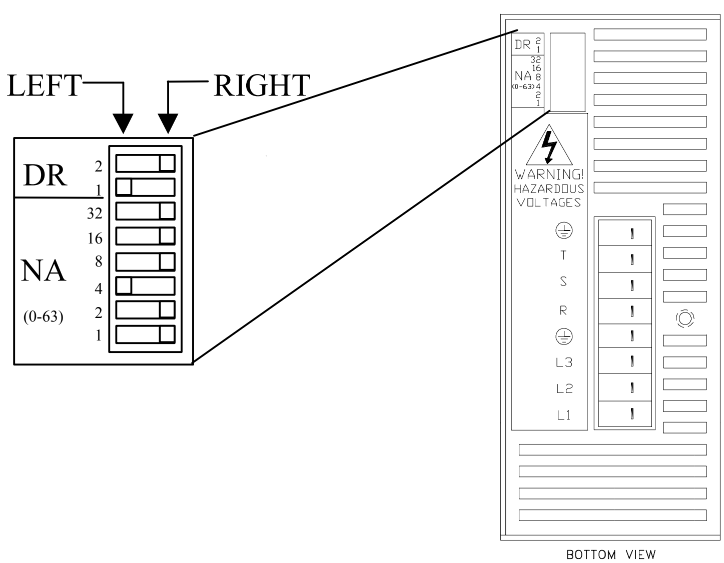


Figure 8-5. Location of DIP Switches

Step 2: Set the Network Data Rate

To change the network data rate, ensure the S2K controller power is off. Then flip the Data Rate (*DR)* DIP-switches 1 and 2 to a setting provided in the Table 8-5 below.

Table 8-5. S2K DIP Switch Settings for Network Data Rate

Network data rate	Switch Locations	
	Switch #1	Switch #2
125k	Right	Right
250k	Left	Right
500k	Right	Left
N/A	Left	Left

When you have configured all of your S2K controllers, proceed to the next step to complete your DeviceNet set-up and connection**.**

All devices operating on a DeviceNet network segment must be set to the same baud rate.

8.5.4 Add Slave Devices to Scan List

(*Not required for peer-to-peer communication)*

About DeviceNet Scanners

DeviceNet systems using master/slave architecture need a scanner (DeviceNet master device) installed in the host PC or PLC. The scanner buffers all communication between the PC or PLC and any devices on the network in the order in which they have been added to a scan list. Your scanner ***must*** be able to communicate with slave devices that support the Unconnected Message Manager (UCMM) protocol. The S2K Controller is not a scanner and cannot act on the network as a master device. The S2K controller may operate as a slave (server) to a DeviceNet compliant or certified master (client).

To determine whether you have a UCMM-compatible scanner, verify with the manufacturer that their scanner uses the complete *Predefined Master/Slave Connection Set Allocation Procedure*, detailed in section 7.9.1, volume I of the DeviceNet Specification. If your scanner is UCMM-compatible, follow the manufacturer's instructions for proper installation and connection. If your scanner is not UCMM-compatible, you will need to purchase one that is.

Add S2K Slave Devices to Scan List

Some DeviceNet scanner configuration tools can use an Electronic Data Sheet (EDS) file for each S2K controller model. The EDS file is an ASCII format file that tells the master device what types of devices are connected to the network and how those devices send and receive messages.

S2K controller EDS files are included with your Motion Developer CD-ROM in the path MotionDeveloper/EDS/S2K. Look for a file name that matches the controller model (e.g., x_x-SSI104 would be the EDS file for the 4.3 amp controller model). You may also request EDS files from GE Fanuc's customer support center. Then follow the instructions provided with your DeviceNet commissioning software to load the EDS files and add your S2K controllers to the scan list.

The S2K motion controller supports the polled connection. Bytes produced are eight and bytes consumed are eight. You may optionally configure the scanner for an explicit connection of maximum 128 bytes transmitted and 128 bytes received.

Apply DC Voltage to the DeviceNet Trunk Line. You must have DC voltage on the DeviceNet LAN cable before you can communicate to the S2K controllers.

8.5.4.1 Communicating With DeviceNet Nodes Overview

Serial Port Communication

S2K controllers allow you to communicate serially while they are connected to a DeviceNet system. This means that at any time, you can bypass the network communication protocols and talk directly to your controllers to perform any task that the operating system permits, including application program development, diagnostics...even setting tuning constants or other registers.

Non-serial controller-to-controller communication over DeviceNet

The Motion Developer software makes it possible to communicate from a PC to any S2K controller on the same DeviceNet network after connecting to any single node on the network. The initial connection to the PC may be made serially or via a PC-installed DeviceNet card. No serial connection to the additional S2K controllers or knowledge of DeviceNet communication protocol is required. Program editing and diagnostics are as easy as typing simple mnemonic commands in the Motion Developer terminal window.

Running Resident Application Programs

S2K controllers allow you to run a complete program *and* communicate over DeviceNet. S2K Series controllers include DeviceNet extensions to read and write to variables within your controller, making the interface between your motion program and your master program straightforward, simple, and powerful.

Peer-to-Peer Systems

S2K controllers allow multiple controllers and some I/O devices from other vendors to communicate peer-to-peer over DeviceNet with no master. Each controller can share information with all other peer controllers on the network, so it’s easy to create a high-performance, multi-axis system.

Distributed Control Systems

S2K controllers can simultaneously function as slaves to a master device and as peers to each other. With distributed control, you can manage system behavior through peer-to-peer communication or DeviceNet communication from the master device. You also get the power to optimize network traffic to further boost system performance.

8.5.5 DeviceNet Communication Methods

DeviceNet systems provide several ways to communicate with S2K controllers and other network nodes. In fact, S2K controllers make it easy to use the DeviceNet I/O channel for system control. You can manipulate bits and bytes in the I/O message simply by turning them on and off as you would discrete inputs and outputs. S2K controllers also contain DeviceNet objects that allow users to read and write registers and send commands via the explicit messaging connection. These communication methods are defined in a following section of this chapter.

The communication method that you use will depend upon the network architecture of the system. Table 8.6, for example, lists the available DeviceNet message types.

Table 8-6. DeviceNet System Communication Methods

Message Type	Medium	Used in…
Explicit Message Priority One[1]	UCMM	Peer-to-peer network
I/O Priority Two[2]	Master-slave connection set	Master-slave network
Explicit Message Priority Three[1]	Master-slave connection set	Master-slave network
I/O and Explicit Messages	Master-slave connection set UCMM	Distributed control (combination of master-slave and peer-to-peer network architecture)

Notes
1. Explicit messages allow users to send commands and get/set registers of the controller. Explicit messages sent peer-to-peer have a higher priority and, therefore, are faster than explicit messages sent within master/slave network architecture.
2. I/O messages have priority over *priority three* explicit messages.

8.5.6 Master/Slave Network Architecture

DeviceNet has specified a *Predefined Master/Slave Connection Set* for motion controllers. This consolidates the steps required to create and configure an application-to-application connection, letting you establish a communication environment that uses fewer network and device resources than other connection hierarchies do. A master can have up to 63 slaves. A slave can have only one master. Multiple masters may reside on the same network segment, however, they do not share slave nodes.

8.5.6.1 Allocating the Master/Slave Connection Set

Before an S2K device can use the *Predefined Master/Slave Connection Set*, it must become a slave to the master device, which allocates the *Predefined Master/Slave Connection Set*. Most manufacturers of DeviceNet scanners and commissioning software packages have given their products the power to simplify the master/slave allocation process. This is the process that uses the UCMM protocol the S2K requires in a master device.

8.5.6.2 Master/Slave Message Types

When used on DeviceNet, GE Fanuc S2K controllers support two message types (objects) within the *Predefined Master/Slave Connection Set*:

- I/O command/response (implicit) messages
- Explicit messages

Implicit messages have a predefined data content that eliminates the need to transmit identifiers along with the data. Explicit messages have no predefined data content and require headers to identify the type and meaning of the data.

Compared with explicit messages, implicit messages require less programming and network overhead. Explicit messages, however, are valuable because they allow the exchange of data not supported in the predefined data field of the I/O message. In master/slave architectures, explicit messages are typically used for configuration-type activities; and I/O messages are used for control (although it is possible to use explicit messages for control).

All data values used in implicit messaging are scaled to encoder counts. The registers affected in the S2K are scaled in user units (counts/URA). Conversely, to scale the S2K register values to counts multiply by URA (S2K Value * URA).

8.5.6.3 Implicit I/O Command/Response Messages

The Position Controller Profile in the DeviceNet specification defines and governs the format and content of the I/O command and response messages. Tables 8-7 through 8-10 show the **general** format for these messages for the S2K controllers or any position controller device (*Device Type* 10 hex). Later sections will define the **specific** format for each action allowed for implicit messages as defined by the DeviceNet specification. The Command message is initiated by the master device sequence and results in a response message from the slave device.

Implicit Command Message

Implicit command messages are issued (produced) by the DeviceNet <u>master</u> device and take the general form shown below. Table 8-8 defines the function of each of the pre-defined bits and bytes within this message.

Table 8-7. Implicit Command Message General Format

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Reg Arm	Hard Stop	Smooth Stop	Direction (V. Mode)	Incremental	N/A	Load Data/ Start Profile
1	Command Data 1							
2	Command Axis Number = 001_2			Command Message Type				
3	Command Data 2							
4	Command Data 3							
5	Command Data 4							
6	Command Data 5							
7	Command Data 6							

Table 8-8. Descriptions of Implicit Command Message Bits

Byte	Bit	Name	Action	S2K Equivalent Action
0	0	Load Data/ Start Profile	Set from zero to one to load command data. The transition of this bit from zero to one will also start a profile move when the Command Message Type is set to 01hex (position, default) or 02hex (velocity, optional). This bit is used in a "leading edge" fashion such that the S2K responds only to the command message when this bit transitions from a zero to a one state.	None
0	2	Incremental	This bit is used to define the position value (command message 01 only) as either absolute or incremental: 0 = absolute position value 1 = incremental position value.	None
0	3	Direction (Velocity Mode Only)	This bit is used to control the direction of the motor in velocity mode (command type 02 only). Velocity mode must be configured first. 1 = forward or positive 0 = reverse or negative	None
0	4	Smooth Stop	This bit is used to bring the motor to a controlled stop at the currently implemented deceleration rate.	Setting this bit from zero to one will command the controller to execute the STOP (ST) command.
0	5	Hard Stop	This bit is used to bring the motor to an immediate stop	Setting this bit from zero to one will command the controller to execute the HALT (HT) command.
0	6	Reg Arm	Setting this bit will clear the capture edge bit of the I/O register, allowing a new position to be captured.	Clear the "capture input edge" bit (bit 13) of the IO register.
0	7	Enable	This bit is used in the same manner as the hardware "enable" input. Clearing this bit will fault the controller due to *enable lost*, and the currently executing motion profile will be aborted.	Set this bit from zero to one to command the controller to execute the Reset Faults (RSF) command and enable the axis.
2	0-4	Command Message Type	This field defines the Command Message Type	None
2	5-7	Command Axis Number	These three bits will always be set to 001_2 to indicate axis 1 or in the case of type 1A or 1B messages the Instance number 1.	None

Implicit Response Message

The Implicit response message is issued (produced) by the DeviceNet slave (S2K) in response to the implicit command message consumed from the DeviceNet master and has the general form shown below. Table 8-10 defines the function of each of the pre-defined bits within this message.

Table 8-9. Implicit Response Message General Format

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Registration Level	Home Level	Current Direction	General Fault	On Target Position	N/A	Profile in Progress
1	Response Data 1							
2	Load Complete	N/A	FE Fault	Negative Limit	Positive Limit	Rev Limit	Fwd Limit	N/A
3	Response Axis Number = 001_2			Response Message Type				
4	Response Data 2							
5	Response Data 3							
6	Response Data 4							
7	Response Data 5							

Table 8-10. Description of Implicit Response Message Bits

Byte	Bit	Name	Action	S2K Equivalent Action
0	0	Profile in Progress	This bit indicates that a profile move is in progress	Same as the "motion generator enabled" bit (bit 0) of the SRA register.
0	2	On Target Position	This bit indicates whether the axis is on the last targeted position. (*1 = Current position* equals the last target position.) Target position is the position commanded by an implicit message.	When the target position minus the axis actual position (PSA) is less than the current In-Position-Band (IPB) this bit is returned as true. This does not necessarily reflect the status of the "axis in position" (SRA8) bit. If PSA rolls over (PLA setting) during an incremental target position move this response message bit will be false while SRA8 will be true.
0	3	General Fault	This bit indicates the logical "OR" of all fault conditions.	Same as the "system fault" bit (bit 14) of the SRS register.
0	4	Current Direction	This bit shows the current direction of the motor. If the motor is not moving the bit will indicate the direction of the last commanded move. 0 = reverse or negative direction and 1 = forward or positive direction.	Same as the "axis direction forward" bit (bit 7) of the SRA register.
0	5	Home Level	This bit reflects the level of the home input.	Same as the "home input active" bit (bit 8) of the IO register.
0	6	Registration Level	This bit reflects the level of the capture input.	Same as "capture input active" bit (bit 12) of the IO register.
0	7	Enable	This bit indicates the state of the OK output. A 1 indicates the OK output is active.	Same as "OK output active" bit (bit 15) of the IO register.
2	1	Fwd Limit	This bit indicates that the forward over travel input is active.	Same as "forward over travel input active" bit (bit 9) of the IO register.
2	2	Rev Limit	This bit indicates that the reverse over travel input is active.	Same as "reverse over travel input active" bit (bit 10) of the IO register
2	3	Positive Limit	This bit indicates that the motor has attempted to travel past the programmed positive limit position. This bit remains valid until the motor is moved within the limits or the programmed limit value is set greater than the current position.	Same as ["Axis at software over travel" AND "Axis direction forward"] (bit 11 AND bit 7) of the SRA register.
2	4	Negative Limit	This bit indicates that the motor has attempted to travel past the programmed negative limit position. This bit remains valid until the motor is moved within the limits or the programmed limit value is set less than the current position.	Same as ["Axis at software over travel" AND NOT "Axis direction forward"] (bit 11 AND NOT bit 7) of the SRA register.
2	5	FE Fault	This bit indicates that a following error fault has occurred. This fault occurs when the following error, or difference between the commanded position and actual position, exceeds the programmed allowable following error.	Same as "excessive following error" bit (bit 21) of the FC register. Commanded Position = PSO Actual Position = PSA Allowable following error = FEB
2	7	Load Complete	This bit indicates that the command data contained in the implicit command message has been successfully loaded into the device.	None
3	0-4	Response Message Type	This byte defines the Response Message Type.	None
3	5-7	Response Axis Number	These three bits will always be set to 001_2 to indicate axis 1.	None

Starting a Profile Move

A profile move is a move that uses Acceleration, Target Velocity and Deceleration to run **at** a Target Velocity or **to** a Target Position. The S2K operating mode determines the type of move and is set via a separate implicit message (see Command Type 1B Position Controller message, attribute 3). The default mode setting is position and will execute a move **to** a target position. Multiple messages may be required to set Acceleration, Target Velocity and Deceleration prior to executing the target move.

Issuing a single or multiple messages to the S2K device should be done sequentially, using the handshake sequence, with the target move instruction occurring last in the sequence.

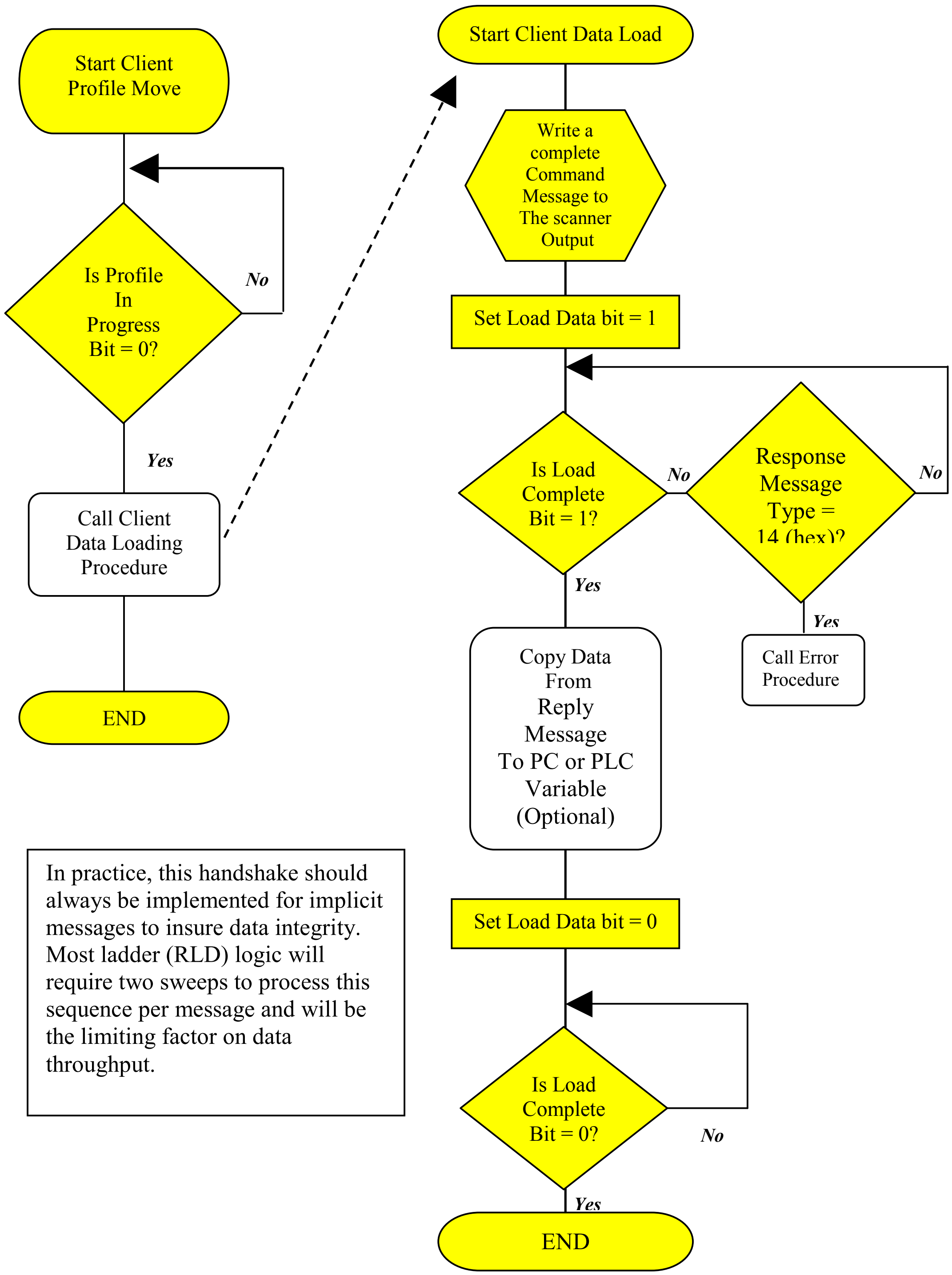
Master-Slave I/O Handshake Sequences

The Load Data/Start Profile bit (command message byte 0, bit 0) and the Load Complete bit (response message byte 2, bit 7) is used to synchronize data transfers between the DeviceNet master and the S2K controller (slave). The S2K acts on the data contained in a command message **only** when the Load Data/Start Profile bit goes true (rising edge). In each data transaction, you **must** reset the Load Data/Start Profile bit to zero **before** writing new command data into the scanner output table since action is taken only when this bit makes a 0 to 1 transition. Write a complete data set into the scanner output table (8 bytes of output data mapped to the node) before setting the Load Data/Start Profile bit to true. The Figure 8-6 below flowcharts the master/slave messaging handshake sequence.

To execute a profile move via implicit messaging, (to Target Position) or with configuration change (at Target Velocity) start at the beginning of the handshake sequence “start Client profile move.” For all other implicit commands, begin at “start client data load” in the handshake sequence.

The functionality of the “Load Complete” (response message byte 2 bit 7) bit insures that no messages will be lost in a communications sequence. This new DeviceNet specification functional bit has been included in S2K firmware version 2.1 and later.

The format of these messages and the handshake sequence complies with ODVA regulated specifications for the device type 10 hex (position controller) that the S2K belongs.



In practice, this handshake should always be implemented for implicit messages to insure data integrity. Most ladder (RLD) logic will require two sweeps to process this sequence per message and will be the limiting factor on data throughput.

Figure 8-6. Master/Slave Messaging Handshake Sequence

8.5.6.4 Summary of Defined I/O Command / Response Message Types

The specific Command Message Type is defined by byte 2 of the command message issued by the DeviceNet master. The allowed types are pre-defined by the DeviceNet position controller specification and currently are limited to the options shown in Table 8-11.

Command message types 01 to 05 support the ability to request specific data in the response message. The Valid response message types are indicated in Table 8-12.

Table 8-11. Command Message Type Definitions

Command Message Type (hex)	**Function**	**Valid Response Message Type(s)** (hex)	**Required Mode Setting(s)**
01	Set Target Position and Move to Target Position	01, 02, 03, 05, 08	Position (default)
02	Set Target Velocity	01, 02, 03, 05, 08	Position (default)
	Move at Target Velocity	01, 02, 03, 05, 08	Velocity
03	Set Acceleration	01, 02, 03, 05, 08	Position (default)
		01, 02, 03, 05, 08	Velocity
04	Set Deceleration	01, 02, 03, 05, 08	Position (default)
		01, 02, 03, 05, 08	Velocity
05	Set Target Torque	01, 02, 03, 05, 08	Torque
1A	Position Controller Supervisor	1A	All
1B	Position Controller	1B	All
1F	Get/Set a Parameter Value	1F	All

The command message function is executed when the Load Data/Start Profile bit transitions from zero (low) to one (high).

An Error Response message (14h) may be automatically generated as a valid response to any command message. An error response message will have precedence over any requested response data.

Table 8-12. Response Message Type Definitions

Response Message Type (hex)	**Function**	**Units**	**S2K Equivalent** (See Note)
01	Actual Position	Counts	PSA
02	Commanded Position	Counts	PSC
03	Actual Velocity	Counts/sec	VLA
05	Actual Torque	1000 = 100%	TLC
08	Captured Registration Position	Counts	PCA
14	Command/Response Error	General Error Code and Additional Code in hex	
1A	Position Controller Supervisor Attribute	Various	
1B	Position Controller Attribute	Various	
1F	Parameter Instance	DINT	VI001–VI128
		Floating Point	VF001–VF128

Note: The S2K variables are in user units to convert to counts multiply the variable by the value of URA.

8.5.6.5 Specific Defined Master I/O Command Message Types

Target Position Command Message

When the Command Message Type is set to 01, the command message is used to define the target position for an axis. This command additionally initiates a move to the target position.

The target position value is set using a double word (DINT) in bytes 4–7. Target position is not the same as the S2K commanded position. This Target Position is in **pulses** (encoder counts) and executes when the Load Data/Start Profile bit transitions from zero to one. The axis will immediately move to the incremental or absolute position set by the *Incremental* bit (byte 0, bit 2) if not faulted and the Enable bit (bit 7, byte 0) is true. The current programmed values of acceleration, deceleration and velocity active in the S2K will be used for the move to target position. This is a single point-to-point move.

The target position command message format is shown in Table 8-13 below.

Table 8-13. Implicit Command Message Type 01 - Set Target Position

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Reg Arm	Hard Stop	Smooth Stop	Direction (Velocity Mode)	Incremental	N/A	Load Data/ Start Profile
1	N/A							
2	Command Axis Number=001_2			Command Message Type = 01				
3	Response Axis Number=001_2			Response Message Type				
4	Target Position Low Byte							
5	Target Position Low Middle Byte							
6	Target Position High Middle Byte							
7	Target Position High Byte							

Target Velocity Command Message

When the Command Message Type is set to 02, the command message is used to define the target velocity for an axis.

When the S2K is set to position mode (default) then this action will load the MVL register in the S2K with a new value. This Target Velocity is in **pulses/second** (encoder counts/second) and executes when the Load Data/Start Profile bit transitions from zero to one. The value in the MVL register will be encoder counts/second converted to the active user unit scaling (URA).

When the S2K is set to velocity mode (Position Controller Object Attribute 3 = 1) then this command will initiate a *run-at-velocity* move (similar to executing the RVF or RVR command). The direction of the *run-at-velocity* move is determined by the state of the *Direction* bit (byte 0, bit 3) of the command word when the Load Data/Start Profile bit is activated. The Direction bit set to logic ON level will cause forward movement, OFF indicates reverse movement is desired. The target velocity value is set using a double word (DINT) in bytes 4–7. In Velocity mode the axis will begin moving and accelerate, with the programmed acceleration, to the target velocity when the Load Data/Start Profile bit is activated. This format is used to jog the axis.

The target velocity command message format is shown in Table 8-14.

Table 8-14. Implicit Command Message Type 02—Set Target Velocity

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Reg Arm	Hard Stop	Smooth Stop	Direction (Velocity Mode)	Incremental	N/A	Load Data/ Start Profile
1	N/A							
2	Command Axis Number=001_2			Command Message Type =02				
3	Response Axis Number=001_2			Response Message Type				
4	Target Velocity Low Byte							
5	Target Velocity Low Middle Byte							
6	Target Velocity High Middle Byte							
7	Target Velocity High Byte							

Acceleration Command Message

When the Command Message Type is set to 03, the command message is used to define the acceleration for a move to target position or a move at target velocity. The acceleration value is set using a double word (DINT) in bytes 4–7. This acceleration value is in **pulses/second^2** (encoder counts/second^2) and executes when the Load Data/Start Profile bit transitions from zero to one.

This command loads the acceleration (MAC) register in the S2K, however does not automatically load the deceleration (MDC) register. The value in the MAC register will be encoder counts/second^2 converted to the active user unit scaling (URA).

The acceleration command message format is shown in Table 8-15 below.

Table 8-15. Implicit Command Message Type 03—Set Acceleration

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Reg Arm	Hard Stop	Smooth Stop	Direction (Velocity Mode)	Incremental	N/A	Load Data/ Start Profile
1	N/A							
2	Command Axis Number=001_2			Command Message Type = 03				
3	Response Axis Number=001_2			Response Message Type				
4	Acceleration Low Byte							
5	Acceleration Low Middle Byte							
6	Acceleration High Middle Byte							
7	Acceleration High Byte							

Deceleration Command Message

When the Command Message Type is set to 04, the command message is used to define the deceleration for a move to target position or a move at target velocity. The deceleration value is set using a double word (DINT) in bytes 4–7. This deceleration value is in **pulses/second^2** (encoder counts/second^2) and executes when the Load Data/Start Profile bit transitions from zero to one.

Unlike the S2K operating system the DeviceNet Position Controller, specification requires that deceleration is set independently of acceleration settings. Setting the Acceleration (MAC) via an implicit message will NOT automatically change the Deceleration (MDC) variable in the S2K.

This command loads the deceleration (MDC) register in the S2K. The value in the MDC register will be encoder counts/second^2 converted to the active user unit scaling (URA).

The deceleration command message format is shown in Table 8-16 below.

Table 8-16. Implicit Command Message Type 04—Set Deceleration

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Reg Arm	Hard Stop	Smooth Stop	Direction (Velocity Mode)	Incremental	N/A	Load Data/ Start Profile
1	N/A							
2	Command Axis Number=001_2			Command Message Type = 04				
3	Response Axis Number=001_2			Response Message Type				
4	Deceleration Low Byte							
5	Deceleration Low Middle Byte							
6	Deceleration High Middle Byte							
7	Deceleration High Byte							

Torque Command Message

When the Command Message Type is set to 05, the command message is used to set the output continuous torque. A data value of 1000 (DINT) in bytes 4-7 represents 100% of the full continuous current setting. The S2K register CURC establishes the maximum continuous rating for the motor. The 1000 data value of this message is 100% of the active CURC setting and in S2K terms is equivalent to setting the TLC register.

This command is valid only when the controller configuration has been changed from the default position mode to torque mode (Position Controller Object Attribute 3 = 2).

Table 8-17. Implicit Command Message Type 05—Set Torque

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Reg Arm	Hard Stop	Smooth Stop	Direction (Velocity Mode)	Incremental	N/A	Load Data/ Start Profile
1	N/A							
2	Command Axis Number=001_2			Command Message Type = 05				
3	Response Axis Number=001_2			Response Message Type				
4	Torque Low Byte							
5	Torque Low Middle Byte							
6	Torque High Middle Byte							
7	Torque High Byte							

Position Controller Supervisor and Position Controller Command Message(s)

The Position Controller Supervisor Command Message Type 1A hex allows you to read and write variables into the S2K controller Position Controller Supervisor Attributes via implicit (I/O) messaging.

The Position Controller Command Message Type 1B hex allows you to read and write variables into the S2K controller Position Controller Attributes via implicit (I/O) messaging.

Using either command, it is possible to write a single attribute to the S2K and read a single attribute from the S2K within the single command/reply sequence.

NOTE: When using this message, you must specify both Get and Set commands for each message. Take care to specify valid attributes that will not adversely affect the current operation.

Table 8-18. Implicit Command Message Type 1A or 1B hex—Get / Set Position Controller Supervisor or Position Controller Attribute(s).

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Reg Arm	Hard Stop	Smooth Stop	Direction (Velocity Mode)	Incremental	N/A	Load Data/ Start Profile
1	Position Controller/Supervisor Attribute to Get							
2	Instance (always 001_2)			Command Message Type = 1A or 1B				
3	Position Controller/Supervisor Attribute to Set							
4	Attribute Value Low Byte							
5	Attribute Value Low Middle Byte							
6	Attribute Value High Middle Byte							
7	Attribute Value High Byte							

The Position Controller/Supervisor Command message bytes are defined as follows:

Position Controller/ Supervisor Attribute to Get (Byte 1)
This byte defines the variable the master wants to get (read). The attribute value is returned in the slave's (S2K controller) 1A or 1B hex response message.

Position Controller/ Supervisor Command Message Type and Instance (Byte 2)
This byte defines the command type (1A or 1B hex) in the least significant five bits (bits 0 - 4). A value of 1A hex selects the Position Controller Supervisor Object. A value of 1B hex selects the Position Controller Object.

The most significant three bits (bits 5–7) are used to select the desired *Instance* of a particular *Attribute*. The instance zero is not a valid selection for this type of implicit messaging. While *Instance* values in the range of 1- 7 are available, the S2K only supports *Attribute Instances* 0 and 1 for the Position Controller/Supervisor Objects. Since *Instance* 0 is invalid in this format always set the value of these three bits to a binary one (001_2).

Position Controller/ Supervisor Attribute to Set (Byte 3)
This byte defines the variable the master wants to set (write) to the new value defined by the Attribute *Value* (bytes 4-7) field. The new value will be set when the Load Data/Start Profile bit transitions from zero to one.

Position Controller/ Supervisor Attribute Value (Bytes 4–7)
This double word defines the new value for the attribute specified in the *Position Controller Supervisor Attribute to Set* byte and executes when the Load Data/Start Profile bit transitions from zero to one. The data in this field must match the type associated with the selected attribute (byte 3) and fit within the range of the selected attribute.

The supported services are Get (Get Attribute Single Service), which is a read command, and Set (Set Attribute Single Service), which is a write command. Certain S2K data registers are read only and do not support the Set service as indicated in the tables below. Data types DINT and UDINT are four bytes in length. Data types INT and USINT are two bytes in length. Attributes starting at number 100 and higher are vendor specific extensions and are not specified in the DeviceNet document.

Table 8-19. Position Controller Supervisor Object Attributes—Implicit Command Message Type 1A

Attribute	Service	Description	S2K Register	Data Type	Data Values
1	**Get**	**Number of Attributes** -The total number of attributes supported by this object in this device. Some attributes are not valid for implicit messaging.		USINT	12
3	**Get**	**Axis Number**—Always one for S2K.		USINT	1
5	**Get**	**General Fault**—The logical OR of all fault condition flags in the device. Set when some fault is active. Reset when the fault condition is removed. Automatically returned as (byte 0, bit 3) in all implicit response messages.	FC (All bits)	BOOL	0 = Reset 1 = Set
12	**Get/Set**	**Home Arm**—Used to arm the home input. Part of the Implicit home cycle "home to switch" sequence.	RHF, RHR	BOOL	0 = trigger has occurred 1 = armed
15	**Get/Set**	**Index Arm**—Used to arm the index input. Part of the Implicit home cycle "home to marker" sequence.	RMF, RMR	BOOL	0 = trigger has occurred 1 = armed

Attribute	Service	Description	S2K Register	Data Type	Data Values
16	**Get**	**Home Input Level**—Actual level of the home switch input. Automatically returned as (byte 0, bit 5) in all implicit response messages.	DI (Bit 1)	BOOL	0 = low 1 = high
21	**Get/Set**	**Registration Arm**—Used to arm the registration input. Automatically set as (byte 0, bit 6) of the implicit command message.	IO (Bit 13)	BOOL	0 = trigger has occurred 1 = armed
22	**Get**	**Registration Input Level**—Actual level of the registration input. Automatically returned as (byte 0, bit 6) in all implicit response messages.	IO (Bit 12)	BOOL	0 = low 1 = high
24	**Get**	**Registration Position**—Returns the captured position value in counts of the axis when the registration input was set. Same as implicit response message 08.	PCA	DINT	+/- 2,000,000,000

Table 8-20. Position Controller Object Attributes—Implicit Command Message Type 1B

Attribute	Service	Description	S2K Register	Data Type	Data Values
1	**Get**	**Number of Attributes**—The total number of attributes supported by this object in this device. Some attributes are not valid for implicit messaging.		USINT	47
3	**Get/Set**	**Mode**—Operating mode.		USINT	0 = Position (default) 1 = Velocity 2 = Torque
6	**Get/Set**	**Target Position**—Profile move position defined in counts. The *Set* function is equivalent to executing implicit command message 01.	MPI, MPA	DINT	+/- 2,000,000,000
7	**Get/Set**	**Target Velocity—**Profile velocity defined in counts/second. The *Set* function is equivalent to executing implicit command message 02.	MVL	DINT	1 to 16,000,000
8	**Get/Set**	**Acceleration**—Profile acceleration defined in counts/second/second. The *Set* function is equivalent to executing implicit command message 03.	MAC	DINT	100 to 1,000,000,000
9	**Get/Set**	**Deceleration**—Profile deceleration defined in counts/second/second. The *Set* function is equivalent to executing implicit command message 04.	MDC	DINT	100 to 1,000,000,000
10	**Get/Set**	**Incremental Position Flag—** Determines how target position (Attribute 6) is interpreted. Automatically *Set* as (byte 0, bit 2) of the implicit command message.		BOOL	0 = Absolute Position 1 = Incremental Position

Attribute	Service	Description	S2K Register	Data Type	Data Values
11	**Get/Set**	**Load Data / Profile In Progress—** The *Set* function is used to start a profile move and/or load command data. Automatically *Set* as (byte 0, bit 0) of the implicit command message. The *Get* function returns the status of the profile command generator and indicates "Profile In Progress". Automatically returned as (byte 0, bit 0) in all implicit response messages.		BOOL	0 = Reset, 1 = Set A "Set Service" activates the load/start function only on rising edge. A "Get Service" returns a 1 value if the command generator is active.
12	**Get**	**On Target Position**—Indicates that the device actual position is within the in-position band (Attribute 106) distance to the target position (Attribute 6). Automatically returned (byte 0 bit 2) in all implicit response messages.		BOOL	0 = False 1 = True
13	**Get/Set**	**Actual Position**—The device actual position in counts. The *Set* function may be used to home (zero) the axis. The *Get* function is the Same as implicit response message 01.	PSA	DINT	+/- 2,000,000,000
14	**Get**	**Actual Velocity—**The device actual velocity in counts/second. Same as implicit response message 03.	VLA	DINT	+/- 16,000,000
15	**Get**	**Commanded Position—**The device instantaneous calculated commanded position in counts. Same as implicit response message 02.	PSC	DINT	+/- 2,000,000,000
17	**Get/Set**	**Enable Controller/Clear Faults**—Set the state of the device. Enabling the device resets controller status errors and enables torque to the servomotor. Automatically *Set* as (byte 0, bit 7) of the implicit command message.	Enable, RSF	BOOL	0 = Disable 1 = Enable
18	**Get/Set**	**Profile Type**—Defines the type of move profile to use.		USINT	0 = Trapezoidal (linear) 1 = S-Curve (jerk limited)
19	**Get/Set**	**Profile Gain**—Set a gain value for non-trapezoidal profiles (If Attribute 18 = 1) ***Note**: This Profile Gain value is written to the MJK register when a move to target position is commanded.	MJK* *See Note ←	DINT	0 to 100 (per cent)
20	**Get/Set**	**Smooth Stop**—Force immediate deceleration to zero velocity at programmed deceleration rate. Automatically *Set* as (byte 0, bit 4) of the implicit command message.	ST	BOOL	0 = Operate Normal 1 = Stop Immediately
21	**Get/Set**	**Hard Stop**—Force immediate deceleration to zero velocity. Automatically *Set* as (byte 0, bit 5) of the implicit command message.	HT	BOOL	0 = Operate Normal 1 = Stop Immediately

Attribute	Service	Description	S2K Register	Data Type	Data Values
23	**Get/Set**	**Instantaneous Direction**—Used in Velocity mode (Attribute 3 = 1) to set direction of profile move. Automatically *Set* as (byte 0, bit 3) of the implicit command "set target velocity" message.		BOOL	0 = Negative, reverse 1 = Positive, forward
24	**Get/Set**	**Reference Direction**—Direction of motor rotation for a positive move as viewed from the load end of the motor shaft.	DIR	BOOL	0 = Clockwise 1 = Counter Clockwise
25	**Get/Set**	**Torque**—Used only in torque mode (Attribute 3 = 2) to S*et* a percent value of the maximum continuous current setting. Used in all modes to *Get* the current torque value, the same as implicit response message 05.	TLC	DINT	+/- 1,000 = +/- 100.0% 0 = no torque output
30	**Get/Set**	**Proportional Gain**—Tuning variable to adjust the position loop proportional gain. Automatically *Set* by the AUTOTUNE command.	KP	INT	0 to 8,000
31	**Get/Set**	**Integral Gain**—Tuning variable used to adjust the time integral of the position loop. Automatically *Set* by the AUTOTUNE command.	KI	UINT	0 to 64,000
32	**Get/Set**	**Derivative Gain**—Tuning variable used to adjust the time derivative of the position loop. Automatically *Set* by the AUTOTUNE command.	KD	INT	0 to 8,000
36	**Get/Set**	**Acceleration Feed Forward**—Tuning variable used to adjust the acceleration feed forward of the position loop.	KA	UINT	0 to 64,000
40	**Get/Set**	**Feedback Resolution**—The actual number of position feedback counts per revolution of the servomotor.	FR	DINT	500 to 1,000,000
45	**Get/Set**	**Maximum Following Error**—If the difference between the actual (Attribute 13) and commanded (Attribute 15) position exceeds this value the "Following Error Fault" flag is set and the axis stops in fault mode.	FEB	DINT	0 to 16,000
47	**Get**	**Following Error Fault**—Status flag for excessive following error condition established in (Attribute 45). Automatically returned (byte 2 bit 5) in all implicit response messages.	FC (Bit 21)	BOOL	0 = Not Faulted 1 = Faulted
48	**Get**	**Actual Following Error**—The actual amount of following error (difference between commanded and actual position) in feedback counts.	FE	DINT	0 to 16,000
50	**Get**	**Forward Limit**—When the hardware forward over travel input is active, no forward motion is allowed. Automatically returned (byte 2 bit 1) in all implicit response messages.	DI (Bit 2)	BOOL	0 = Normal 1 = Active

Attribute	Service	Description	S2K Register	Data Type	Data Values
51	**Get**	**Reverse Limit**—When the hardware reverse over travel input is active, no reverse motion is allowed. Automatically returned (byte 2 bit 2) in all implicit response messages.	DI (Bit 3)	BOOL	0 = Normal 1 = Active
54	**Get/Set**	**Positive Software Over Travel Limit**—Positive direction limit on axis motion set in feedback counts.	OTF	DINT	+/- 2,100,000,000
55	**Get/Set**	**Negative Software Over Travel Limit**—Negative direction limit on axis motion set in feedback counts.	OTR	DINT	+/- 2,100,000,000
56	**Get**	**Positive Limit Triggered**—Active when axis motion is stopped due to positive software over travel limit. Automatically returned (byte 2 bit 3) in all implicit response messages.	SRA 11 AND SRA 07	BOOL	0 = Normal 1 = Active
57	**Get**	**Negative Limit Triggered**—Active when axis motion is stopped due to negative software over travel limit. Automatically returned (byte 2 bit 4) in all implicit response messages.	SRA 11 AND NOT SRA 07	BOOL	0 = Normal 1 = Active
58	**Get**	**Load Data Complete**—Indicates that valid data for a valid implicit message command type has been loaded into the position controller device. Automatically returned (byte 2 bit 7) in all implicit response messages.		BOOL	0 = Normal 1 = Active
		Begin Vendor Specific Extensions To DeviceNet Specifications			
100	**Get**	**Fault Code**—Identifies what type of system fault has occurred. A fault (non-zero value) in the FC register will stop motion and must be reset with the "Enable" (Attribute 17) command.	FC	UDINT	0 to FFFF FFFF (hex) 32 bits with each bit representing a different fault.
101	**Get/Set**	**Continuous Current**—Limits the continuous current the controller will supply to the servomotor. This value is a percentage of the "Maximum Continuous Current" setting.	CURC	INT	1 to 1,000 1,000 = 100.0%
102	**Get/Set**	**Power Save Current**—Stepper Motor Controllers only. While the axis is "in position", the continuous current output to the stepper motor is reduced to the percentage set.	CURS	INT	1 to 1,000 1,000 = 100.0%
103	**Get/Set**	**Peak Current**—Limits the peak value of current the controller will supply to the servomotor. This value is a percentage of the "Maximum Peak Current" setting.	CURP	INT	1 to 1,000 1,000 = 100.0%
104	**Get/Set**	**Commutation Ratio**—Do not change S2K Controller defaults without factory supervision.	CMR	INT	1 to 16

Attribute	Service	Description	S2K Register	Data Type	Data Values
105	**Get/Set**	**Commutation Offset—**Do not change S2K Controller defaults without factory supervision.	CMO	INT	+/- 1,800
106	**Get/Set**	**In-position Band**—Defines the maximum amount of position error that the axis can have and still be in position. A move is not considered complete unless in position (IP) is true. [IPB > (PSC - PSA)]	IPB	INT	0 to 16,000
107	**Get/Set**	**Position Wrap Enable**—Determines if the position register (PSA) wrap is enabled. The position length register (PLA) determines the wraparound point.	PWE	BOOL	0 = Disabled 1 = Enabled
108	**Get/Set**	**Filter Time Constant**—Tuning variable used to eliminate dither. Automatically set by the AUTOTUNE command.	KT	INT	0 to 5
109	**Get/Set**	**Motor Inductance**—Tuning variable used to match controller to servomotor. Value from motor inductance specifications.	KL	INT	1 to 100
110	**Get/Set**	**Motor Number**—Stepper controller only. Used to match motor to controller.	KM	INT	0 to 20
111-113	**N/A**	**--**	--	--	--
*** 114**	**Get/Set**	Axis Feedback Resolution for Commutation – The feedback resolution of the main encoder used to commutate the motor.	FRC	DINT	100 to 64,000
*** 115**	**Get/Set**	Direction of Auxiliary Position – This register controls the relative direction of the auxiliary position as routed through the PSX register.	DIRX	BOOL	0 = Clockwise 1 = Counter Clockwise

* - Requires firmware revision 2.5 or later

Parameter Command Message

The Parameter Command Message Type 1F hex allows you to read and write variables into the S2K controller via implicit (I/O) messaging. Instances are divided between integer (DINT) and floating-point variables as indicated in Table 8-18. Using this command it is possible to write a single variable to the S2K and read a single variable from the S2K within the single command/reply sequence.

The other parameter message bytes are defined as follows:

Parameter Instance to Get
This byte defines the integer or floating point variable the master wants to get. The value is returned in the slave's (S2K controller) 1F hex response message.

Parameter Instance to Set
This byte defines the integer or floating point variable the master wants to set to the new value defined by the *Parameter Value* (bytes 4-7). The new value will be set when the Load Data/Start Profile bit transitions from zero to one.

Parameter Value
This double word defines the new value for the variable specified in the *Parameter Instance to Set* byte and executes when the Load Data/Start Profile bit transitions from zero to one.

Table 8-20. Command Message Type 1F hex—Get/Set Parameter Instance

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Reg Arm	Hard Stop	Smooth Stop	Direction (Velocity Mode)	Incremental	N/A	Load Data/ Start Profile
1	Parameter Instance to Get							
2	Command Axis Number=001_2			Command Message Type = 1F				
3	Parameter Instance to Set							
4	Parameter Value Low Byte							
5	Parameter Value Low Middle Byte							
6	Parameter Value High Middle Byte							
7	Parameter Value High Byte							

Table 8-21. Parameter Instances for Command Message Type 1F

Instance	S2K Variable Equivalent
0	None
1–128	Integer Variables: VI1–VI128
129–255	Floating Point Variables: VF1–VF127

8.5.6.6 Specific Defined I/O Slave Response Message Types

The S2K controller will issue a response message when the master in the form of a command message accesses the node. Bytes 0, 2 and 3 are the same for all response message types. The Response Message Type field specified in byte 3 of the message defines the content of bytes 1 and 4 through 7.

Actual Position Response Message

When the Response Message Type is set to 01 hex the response message is used to return the **actual** position of the S2K controller to the DeviceNet master. The actual position response message format is shown in Table 8-22 below.

The actual position value is in **pulses** (encoder counts) and is defined using a double word in bytes 4–7.

Table 8-22. Response Message Type 01 hex—Actual Position

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Registration Level	Home Level	Current Direction	General Fault	On Target Position	N/A	Profile in Progress
1	N/A							
2	Load Complete	N/A	FE Fault	Negative Limit	Positive Limit	Rev Limit	Fwd Limit	N/A
3	Response Axis Number=001_2			Response Message Type = 01				
4	Actual Position Low Byte							
5	Actual Position Low Middle Byte							
6	Actual Position High Middle Byte							
7	Actual Position High Byte							

Commanded Position Response Message

When the Response Message Type is set to 02, the response message is used to return the **commanded** position of the S2K controller to the DeviceNet master. The commanded position value is in pulses and is defined using a double word (DINT) in bytes 4–7.

Table 8-23. Response Message Type 02 hex—Commanded Position

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Registration Level	Home Level	Current Direction	General Fault	On Target Position	N/A	Profile in Progress
1	N/A							
2	Load Complete	N/A	FE Fault	Negative Limit	Positive Limit	Rev Limit	Fwd Limit	N/A
3	Response Axis Number=001_2			Response Message Type = 02				
4	Commanded Position Low Byte							
5	Commanded Position Low Middle Byte							
6	Commanded Position High Middle Byte							
7	Commanded Position High Byte							

Actual Velocity Response Message

When the Response Message Type is set to 03, the response message is used to return the actual velocity of the S2K controller axis to the DeviceNet master. The actual velocity value is in pulses/second and is defined using a double word (DINT) in bytes 4–7.

Table 8-24. Response Message Type 03 hex—Actual Velocity

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Registration Level	Home Level	Current Direction	General Fault	On Target Position	N/A	Profile in Progress
1	N/A							
2	Load Complete	N/A	FE Fault	Negative Limit	Positive Limit	Rev Limit	Fwd Limit	N/A
3	Response Axis Number=001_2			Response Message Type = 03				
4	Actual Velocity Low Byte							
5	Actual Velocity Low Middle Byte							
6	Actual Velocity High Middle Byte							
7	Actual Velocity Position High Byte							

Torque Response Message

When the Response Message Type is set to 05, the response message is used to return the actual torque of the S2K controller axis to the DeviceNet master. The actual torque value is returned where 1000 = 100% of the continuous current setting and is defined using a double word (DINT) in bytes 4–7.

Table 8-25. Response Message Type 05 hex—Actual Torque

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Registration Level	Home Level	Current Direction	General Fault	On Target Position	N/A	Profile in Progress
1	N/A							
2	Load Complete	N/A	FE Fault	Negative Limit	Positive Limit	Rev Limit	Fwd Limit	N/A
3	Response Axis Number=001_2			Response Message Type = 05				
4	Torque Low Byte							
5	Torque Low Middle Byte							
6	Torque High Middle Byte							
7	Torque Position High Byte							

Captured Registration Position Response Message

When the Response Message Type is set to 08, the response message is used to return the position value in pulses of the PCA register. This value is stored to PCA when the registration input is triggered is defined using a double word (DINT) in bytes 4–7.

Table 8-26. Response Message Type 08 hex—Captured Registration Position

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Registration Level	Home Level	Current Direction	General Fault	On Target Position	N/A	Profile in Progress
1	N/A							
2	Load Complete	N/A	FE Fault	Negative Limit	Positive Limit	Rev Limit	Fwd Limit	N/A
3	Response Axis Number=001_2			Response Message Type = 08				
4	Captured Registration Position Low Byte							
5	Captured Registration Position Low Middle Byte							
6	Captured Registration Position High Middle Byte							
7	Captured Registration Position High Byte							

Command/Response Error Response Message

When the Response Message Type is 14 hex the response message is used to return the error codes associated with a failed or invalid implicit command message. This message will overwrite any requested response data if an error condition is present.

Table 8-27. Response Message Type 14 hex—Command Response Error

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Registration Level	Home Level	Current Direction	General Fault	On Target Position	N/A	Profile in Progress
1	Reserved = 0							
2	Load Complete	N/A	FE Fault	Negative Limit	Positive Limit	Rev Limit	Fwd Limit	N/A
3	Response Axis Number=001_2			Response Message Type = 14				
4	General Error Code							
5	Additional Error Code							
6	Copy of Command Message byte 2							
7	Copy of Command Message byte 3							

Table 8-28. Response Message Type 14 hex—Command Response Error Codes

General Error Code (hex)	Additional Error Code (hex)	Response	Semantics
05	01	Path Destination Unknown	A consumed axis number was requested that does not exist in the device.
	02	Path Destination Unknown	A produced axis number was requested that does not exist in the device.
08	01	Service Not Supported	The requested Command Message Type is not supported.
	02	Service Not Supported	The requested Response Message Type is not supported.
09	FF	Invalid Attribute Value	Load value is out of range
0E	FF	Attribute Not Settable	A request to modify a non-modifiable attribute was received.
11	FF	Reply Data Too Large	The Data requested is more than 4 bytes.
13	FF	Not Enough Data	The Implicit Command contains fewer than 8 bytes.
14	01	Attribute Not Supported	Attribute to SET specified in the command is not supported.
	02	Attribute Not Supported	Attribute to GET specified in the command is not supported.

Position Controller/Supervisor Attribute Response Message

The Position Controller Supervisor Response Message Type 1A hex returns the attribute data requested in the type 1A command message.

The Position Controller Response Message Type 1B hex returns the attribute data requested in the type 1B command message.

Table 8-29. Response Message Types 1A and 1B hex—Command Response Error

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Registration Level	Home Level	Current Direction	General Fault	On Target Position	N/A	Profile in Progress
1	Attribute to Get							
2	Load Complete	N/A	FE Fault	Negative Limit	Positive Limit	Rev Limit	Fwd Limit	N/A
3	Instance Number=001_2			Response Message Type = 1A or 1B hex				
4	Attribute Value Low Byte							
5	Attribute Value Low Middle Byte							
6	Attribute Value High Middle Byte							
7	Attribute Value High Byte							

Parameter Response Message

When the Response Message Type is set to 1F hex, the response message is used to define the parameter response message. This message allows the S2K controller to send parameter data to the DeviceNet master in response to a parameter command message. The parameter response message format is shown in Table 8-30 below.

The parameter value is defined using a double word in bytes 4–7.

Table 8-30. Response Message Type 1F hex Parameter

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Enable	Registration Level	Home Level	Current Direction	General Fault	On Target Position	N/A	Profile in Progress
1	Parameter Instance to Get							
2	Load Complete	N/A	FE Fault	Negative Limit	Positive Limit	Rev Limit	Fwd Limit	N/A
3	Response Axis Number=001_2			Response Message Type = 1F				
4	Parameter Value Low Byte							
5	Parameter Value Low Middle Byte							
6	Parameter Value High Middle Byte							
7	Parameter Value High Byte							

8.5.6.7 Homing the S2K via the Implicit Connection

A sample procedure for homing the S2K position controller via the I/O channel is described below. You will want to set up a sequencer in the master and using the message handshaking, sequence through the following messages assuming there are no faults on the controller and the controller is enabled.

An enhancement would be to *Get* the values for Acceleration, Deceleration and Velocity and save them to variables in the Master prior to executing the home cycle. After the home cycle is complete, *Set* the values back into the S2K.

1. **Change the Mode to Velocity**—Use the Position Controller Command Message 1B hex, Attribute 3, and data value 1.
2. **Set Acceleration—**Use Command Message 03 to set Acceleration to a rate appropriate for the home move. Equivalent to setting MAC in the S2K.
3. **Set Deceleration—**Use Command Message 04 to set Deceleration to a rate appropriate for the home move. Equivalent to setting MDC in the S2K, unlike the S2K operating system setting Acceleration does NOT automatically set the Deceleration.
4. **Arm the Home function—**Use one of the following methods depending on desired home mode:
    a. Home Switch—*Set* the Home Arm function via the Position Controller Supervisor Command Message 1A hex. Attribute 12. Equivalent to the RHF or RHR command in the S2K. The Home switch input is digital input “IN_01” on the S2K I/O terminal.
    b. Marker**—***Set* the Index Arm function via the Position Controller Supervisor Command Message 1A hex. Attribute 15. Equivalent to the RMF or RMR function in the S2K, maximum velocity of 4,096 is enforced.
5. **Initiate the Home Move**—Set the target Velocity and Direction with the Command Message 02. Direction is established by the state of the Direction (byte 0, bit 3) bit of this command. This command will initiate the home move and the axis will move in the specified direction.
6. **Wait for the Home move to complete**—The Profile in Progress bit (byte 0, bit 0) of the response message will go to zero when the home move completes. Use the appropriate message below after the move completes to check that the home function completed:
    a. Home Switch—*Get* the Home Arm status via the Position Controller Supervisor Command Message 1A hex. Attribute 12.
    b. Marker**—***Get* the Index Arm status via the Position Controller Supervisor Command Message 1A hex. Attribute 15.

When the Profile in Progress bit is zero AND the appropriate Arm status is zero the home move cycle is complete.

7. **Homing to Switch and Marker**—If you want to create a home cycle to the home switch and marker, perform steps 1-6 for the Home Switch and then repeat steps 4-6 for the Marker.

8. **Set the Home Position**—Use the Position Controller Command Message 1B hex, attribute 13 to *Set* the Actual Position register to the desired home position value i.e., zero.
9. **Reset the Controller to Position Mode** - Use the Position Controller Command Message 1B hex, Attribute 3, and data value 0.

8.5.6.8 Jogging the S2K via the Implicit Connection

Jogging the S2K controller axis using the implicit connection may be accomplished in a way similar to the home cycle routine. A sample procedure for jogging the S2K position controller via the I/O channel is described below.

1. **Change the Mode to Velocity**—Use the Position Controller Command Message 1B hex, Attribute 3, and data value 1.
2. **Set Acceleration—**Use Command Message 03 to set Acceleration to a rate appropriate for the jog move. Equivalent to setting MAC in the S2K.
3. **Set Deceleration—**Use Command Message 04 to set Deceleration to a rate appropriate for the jog move. Equivalent to setting MDC in the S2K, unlike the S2K operating system setting Acceleration does NOT automatically set the Deceleration.
4. **Initiate the Jog Move**—Set the target Velocity and Direction with the Command Message 02. Direction is established by the state of the Direction (byte 0, bit 3) bit of this command. This command will initiate the jog move and the axis will move in the specified direction at the programmed acceleration.
5. **Terminate the Jog Move—**Set the smooth stop bit (Byte 0, Bit 4) True. The smooth stop will terminate the jog move at the programmed deceleration. For a faster stop, use the hard stop bit (Byte 0, Bit 5).
6. **Reset the Controller to Position Mode—**Use the Position Controller Command Message 1B hex, Attribute 3, and data value 0.

8.6 Using Explicit Messages

The *Explicit Messaging Connection* is a generic, multipurpose communication path between two DeviceNet *nodes*. Explicit messages travel from client to server. The *client* originates a message, or request; the *server* reacts to the message with a response. The client’s DeviceNet services usually generate message identifiers and headers automatically.

8.6.1 Peer-to-peer Network Architecture
(For S2K controller client to S2K controller server communication)

Using the available DeviceNet message types, S2K controllers can communicate to each other over DeviceNet in a peer-to-peer fashion. This is useful in multi-axis systems because two controllers can share information to improve system performance. Peer-to-peer communication allows S2K controllers to perform the following functions:

- Send commands to other controllers
- Receive commands from other controllers
- Load registers and variables from one controller into another controller
- Read registers and variables contained in another controller
- Exchange status information between controllers

In a peer-to-peer architecture, system designers can allow their S2K controllers to communicate to each other over the network using standard S2K command mnemonics. **No knowledge of DeviceNet communication protocol is required!** This will allow a simple program controlled exchange between any two S2K systems on the network segment. Connections are opened and closed automatically by the S2K.

This built in service can also be used for diagnostic and troubleshooting remote S2K nodes. First, connect to any S2K controller serial port that is a node in the network. Using the Motion Developer terminal window, you can talk directly to any S2K controller on the network just as if you were connected directly to its serial port. The S2K commands are used to send/receive commands or load/read registers from one controller to another. In the active Target (S2K controller) properties in Motion Developer set the *Use Network* field to true and enter the appropriate Node Address (network address). This function enables an automatic connection to a remote node as if you were connected to the remote node's serial port.

In addition, it is possible to send a command to an S2K controller on DeviceNet without changing the network address as we did in the previous example. Using the **OUTN** command, you can address any valid command to the Node Address (network address) of the desired controller.

Running a peer-to-peer application is easy. Look at the figure below for an example.

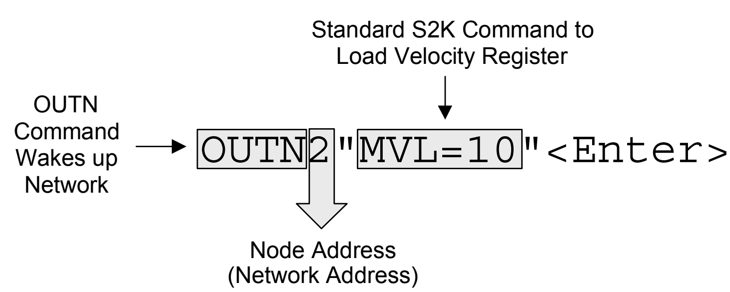


Figure 8-7. Syntax to Output a Command to a Node Address

Valid S2K commands that may be used in the peer-to-peer mode with another S2K controller are listed below. Consult other sections of this manual for more information about these commands.

Table 8-31. S2K Commands for peer-to-peer Operation

Command	Description
CNC	Close Network connection
NCO	Open Network Connection
NET	Network connection available
VBNx.Y	get/set Boolean variable y in S2K at node x
VINx.Y	get/set integer variable y in S2K at node x
VFNx.Y	get/set floating point variable y in S2K at node x
VSNx.Y	get/set string variable y in S2K at node x
OUTNx	Send command string to S2K at node x (fault controller if network error)
OUSNx	Send command string to S2K at node x (update status but do not fault controller if network error)

In the following excerpts from a DeviceNet application program, motion sequences are controlled between S2K controllers over DeviceNet. The operator interface on the network can display position information from both axes at the same time.

```
(*Program1

10  STM1=1                    (*sets timer 1=1 second
    WAIT TM1                  (*waits for 1 second
    PSA=0                     (*sets axis 1 absolute position=0
    STM1=2                    (*sets timer 1=2 seconds
    WAIT TM1                  (*waits for 2 seconds
    EXM1                      (*executes motion block 1
    WAIT NOT MB               (*waits for motion block 1 to end
    STM1=1                    (*sets timer 1 to1 second
    WAIT TM1                  (*waits for timer 1 to time out
    OUTN63"PSA=0"             (*over DeviceNet set axis 2 absolute position=0
    STM1=2                    (*sets timer 1=2 seconds
    WAIT TM1                  (*waits for timer 1 to time out
    OUTN63"MAC=2500000"       (*sets axis 2 acceleration=2,500,000 pulses/sec²
    OUTN63"MVL=250000"        (*sets axis 2 velocity=250,000 pulses/sec
    OUTN63"MPI=250000"        (*sets axis 2 incremental move distance
    OUTN63"RPI"               (*commands axis 2 to run incremental move distance=250,000
15  OUTN63"VB1=IP"            (*sets Boolean variable 1 in axis 2 true when axis 2 is In Position
    IF NOT VBN63.1 GOTO15     (*go to label 15 until axis 2 is In Position i.e.,, Boolean variable 1 is true
20  GOTO10                    (*repeat program continuously
    END

(*Program 2 - runs concurrently with Program 1 and updates the Operator Interface
(*display with the current position of axis 2

    STM2=0.2                  (*sets timer 2=200 milliseconds
10  WAIT TM2                  (*waits for 200 milliseconds
    OUTN63"VF1=PSA"           (*set floating point variable 1 in axis 2=absolute
                              (*Position of axis 2
    GOTO10                    (*repeat program continuously
END
```

8.6.2 Distributed Control Network Architecture

Using Peer-to-peer and Master/Slave Communication in the Same System

DeviceNet supports concurrent communication hierarchies. Peer-to-peer and master-slave messaging can coexist on the same network; and so can multiple message types. This means that GE Fanuc S2K controllers on a peer-to-peer network are ideal for distributed control applications with self-contained automation tools.

Being already DeviceNet-enabled, these self-contained tools support a plug-and-play automation architecture in which the operation of the tool is not dependent on the plant network, but connectivity to that network allows dynamic interaction between the tool and the plant network. Tool behavior (e.g.,, target position) can be changed based on inputs from the network. In addition, status information can be shared among the tool, supervisory controls, and human-machine interfaces on the network.

Using Remote I/O in a DeviceNet Peer-to-Peer System (S2K client to server I/O)

In some systems, it may be desirable to use remote I/O modules for additional I/O data controlled by the S2K. This allows for expansion I/O in the S2K application. S2K controllers use explicit messages to communicate with UCMM-capable remote I/O Modules. The DeviceNet messages and connections are handled automatically by the S2K and do not require building explicit messages in the application program. Figure 8-8 illustrates this procedure.

The S2K version 2.1 and later firmware supports the digital and analog point objects mentioned below and may access digital and analog I/O in each other. This messaging is limited only by the number of available connections that each S2K can support. A maximum of three client and three server connections are available in the S2K.

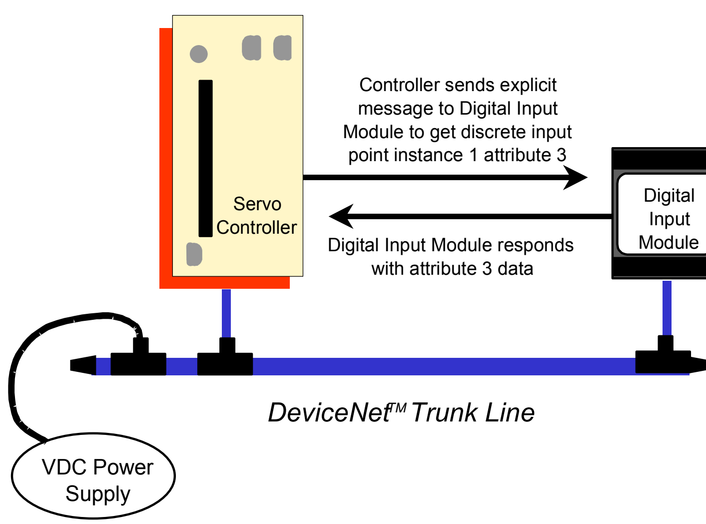


Figure 8-8. Communication Between S2K Controller and Remote I/O Module

S2K products have several general-purpose registers (inputs and outputs) that can be used directly in the S2K control program for process control. The registers for those inputs and outputs, and their maximum I/O counts, are listed in the table in Table 8-32.

Table 8-32. S2K I/O Registers—Maximum Counts

Type	S2K Register	Maximum # of Nodes *	Data Type	Maximum # per Node
Analog Input	AIN	63	2-byte INT	64
Analog Output	AON	63	2-byte INT	64
Digital Input	DIN	63	BOOL	1,024
Digital Output	DON	63	BOOL	1,024

* The S2K will use one of the 64 available node addresses.

8.6.2.1 Expansion I/O with the S2K

The S2K series motion controllers include automatic access in its native programming language to support DeviceNet, peer mode, explicit messaging to UCMM capable I/O device without the necessity of a DeviceNet master device on the network. The I/O Device must support UCMM and have the appropriate objects and/or attributes. Refer to the command and register documentation in Chapter 5 for more detailed information about the commands mentioned below. The intent of this section is to demonstrate the operating concepts of UCMM capable I/O as distributed I/O controlled by the S2K controller.

There are two methods available to access remote I/O; using point data objects and using assembly objects. The two methods serve different purposes, however may be used together in the same S2K program as needed. For example, many UCMM I/O devices provide status and control data that you may wish to access as integers. The actual I/O point data you may wish to access as Boolean bits or single analog points. Keep in mind that one 32-bit message transfer is more efficient than 32 one-bit messages. If the digital data is accessed infrequently in the S2K program, the single bit point data access becomes very effective and is simple to use.

The maximum amount of input (S2K consumed) data allowed per node is 128 bytes (status + digital + analog). Output data (S2K produced) is also limited to 128 bytes per node (command + digital + analog). The S2K has capacity to monitor and control up to the full 63 nodes on the network segment. S2K products have several general-purpose registers (inputs and outputs) that can be used directly in the S2K control program for process control. The registers for those inputs and outputs, and their maximum I/O counts, are listed in the table in Table 8-32.

Table 8-33. S2K I/O Registers—Maximum Counts

Type	S2K Register	Maximum # of Nodes *	Maximum # per Node
Analog Input	AIN	63	64 (2-byte INT)
Analog Output	AON	63	64 (2-byte INT)
Digital Input	DIN	63	1,024 bits
Digital Output	DON	63	1,024 bits

* The S2K will use one of the 64 maximum available node addresses

Using Point Data Objects

This form of access is ideal for ease of use and guarantees connection and synchronization. The S2K, when encountering this form of command in the application program, will suspend program execution, open a connection and perform the requested get or set of data. This may cause a delay in the executing motion program of up to two milliseconds.

The GE Fanuc VersaPoint Distributed I/O supports the point data objects.

One programming technique that avoids a delay in the executing motion program is to set up a polling routine in a different program. For example if Program 1 is the main executable, use Program 2 as an I/O handler. Create a loop structure that copies I/O data to/from compatible S2K variable types. Use the S2K variables in your main program. <u>There is, however, no guarantee of data synchronization with this method.</u>

Example:

```
Program 2
10      VB1 = DIN22.1
        VB2 = DIN22.2
        VI1.3 = DIN22.3
        DON22.1 = VB11
        DON22.2 = VB12
        DON22.3 = VI2.3
GOTO 10
```

Discrete Point data—Allows access of digital inputs 1 to 1,024 (128 input bytes) and digital outputs 1 to 1,024 (128 output bytes) per DeviceNet address. The I/O device must support the DeviceNet discrete input and/or discrete output objects for this method to function. Using the command forms *DINp1.p2* (Digital Input Network) and *DONp1.p2* (Digital Output Network) will get from or set to the addressed node a single Boolean value. No configuration is required. Note that the *DINp1.p2* command is read only and may not be assigned a value in the program.

Example:

```
DON4.22 = 0               (* Set DeviceNet node 4, Digital Output 22 = OFF
DON4.22 = 1               (* Set DeviceNet node 4, Digital Output 22 = ON
VB1 = DIN22.1             (* Assign the value of node 22, Digital Input 1 to VB1
IF DIN22.1 GOTO 10        (* If node 22, digital input 1 = ON, GOTO label 10
```

Analog Point data—Allows access of analog inputs 1 to 64 (128 input bytes) and analog outputs 1 to 64 (128 output bytes) per DeviceNet node address. The I/O device must support the analog input and/or analog output point data objects for this method to function. Using the command forms *AINp1.p2* (Analog Input Network) and *AONp1.p2* (Analog Output Network) will get from or set to the addressed node a single 2-byte INT value. No configuration is required. Note that the *AINp1.p2* command is read only and may not be assigned a value in the program.

Example:

```
    AON4.22 = 1234            (* Set DeviceNet node 4, Analog Output 22 = 1234
    IF AIN7.32 > 3200 THEN    (* Is DeviceNet node 7, Analog Input 32 > 3200?
    AON4.22 = -3200           (* Set DeviceNet node 4, Analog Output 22 = -3200
10: REM "complete the function here"
```

Using Assembly Objects

Assembly objects allow access to I/O data arrays as a four-byte integer. The full 128 bytes of input and/or digital output data are accessible in four-byte segments. This form of the command is *DINp1* or *DONp1*. This mode does require configuration in the S2K and some knowledge of the DeviceNet specifications of the I/O device however, there are benefits for certain applications. Accesses to status and command data in the I/O device or more efficiently accessing I/O nodes with many discrete bits are a few reasons this method may be used.

Step 1—Configuration: Configuration is required in the S2K control to map the I/O data associated with the UCMM capable I/O device. This configuration is accomplished with the *DINA* and *DONA* command in the S2K controller as part of its configuration program.

The configuration command takes the form:

DINA (Network Digital Input Register Assignment)

DINA(p1)= assembly object instance number, number of attribute bytes

i.e., DINA22 = 100,4

DONA (Network Digital Output Register Assignment).

DONA(p1)= assembly object instance number, number of attribute bytes

i.e., DONA22 = 101,16

Where (p1) = network Node Address (0-63) of the I/O device.

The range of attribute bytes is 1–128. A suitable assembly object instance should be selected to present desired data, within the maximum 128-byte limit. You will have to contact the vendor of the UCMM capable I/O device to get attribute information about the product.

Step 2—Selecting the 4-byte data segment: When the data length of the *DINA* configuration is set to a value greater than four bytes (number of attribute bytes) use a *DINO* (Digital Input Network Offset) command to select which 4 byte segment of data to map to the 32-bit integer represented by *DINp1*. Similarly, if the data length of the *DONA* configuration is set to a value greater than four bytes use a *DONO* (Digital Output Network Offset) command to select which 4 byte segment of data to map to the 32-bit integer represented by *DONp1*. These “pointers” may be changed at any time in the program prior to executing the program line containing the *DINp1* or *DONp1* command.

Step 3—Access the data: The *DINp1* command when executed in the program performs a “get” of the data defined by the *DINA* configuration and selected by the *DINO* command. *DINp1* data is read only. The *DONp1* command when executed in the program performs a “set” of the data defined by the *DONA* configuration and selected by the *DONO* command. The data latencies, connection management and error handling is the same as for the point data objects.

The integer form of the command (*DINp1* or *DONp1*) is not strictly limited to digital input or output data.

Example:

An I/O device with 16 DO and 8 DI and 1 AO and 2 AI, the assembly object data will have 2 bytes for the DO and 2 bytes for the AO on output and 1 byte for the DI and 4 bytes for the AI on input. The mapping of the data is vendor defined in most cases. You will need the assembly object instance documentation from the vendor for the selected devices.

There will also be status bytes in the assembly data, often the first few input and output bytes but, for this example, we will ignore them. The *DINp1* register will get four bytes at a time of the five bytes of the assembly object input data. The particular 4-byte segment is determined by the *DINO* command. As you can see only one of the four bytes is really DI, the rest is AI data (it could be status data as well). The *DINp1* form of the register isn't just DI, it is a window on the I/O data that the I/O device is producing just as the I/O device would send to a PLC or PC based controller.

Using GE Fanuc VersaPoint Distributed I/O Assembly Objects:

The assembly object instance number to use for VersaPoint I/O input data is 100. The byte length will vary depending on the number and type of input modules connected to the VersaPoint DeviceNet NIU. This data includes in LSB-MSB order; NIU status (2bytes) + discrete input data (number of input points rounded up to the nearest byte boundary) + analog input data (2 bytes per point). Some VersaPoint analog input modules include additional bytes of data other than the input value.

The assembly object instance number to use for VersaPoint I/O output data is 101. The byte length will vary depending on the number and type of output modules connected to the DeviceNet NIU. This data includes in LSB-MSB order; discrete output data (number of outputs rounded up to the nearest byte boundary) + analog output data (2 bytes per point).

VersaPoint I/O does not support separate assembly object instances for discrete and analog data and will combine all input data or output data into a single input or output block of data. Consult the VersaPoint documentation for configuration, installation and mapping of status and I/O data.

Connection Management

The S2K manages DeviceNet client communications by using the UCMM (Unconnected Message Manager) protocol to establish a logical “connection” to the addressed server node (I/O device). This is the reason the I/O device must support UCMM. These connections are dynamic and usually are managed automatically by the S2K however; there are cases where the application program should use manual connection management. The S2K application programmer should be alert if more than three client connections are potentially active in the S2K. Master/Slave connection does not affect this since the S2K uses two server connections for the master scanner connection. Each S2K provides three client and three server connections each of which may be opened and closed independently.

Initial connection to the server (I/O) node requires opening the connection path and may cause a delay in the executing motion program of up to two milliseconds. A client connection is to the server node address and multiple Get/Set service messages may be performed to the same node without closing an open connection. Successive uses of a Get/Set command if called frequently in the motion program do not need to re-open the connection and are more efficient (approximately a one millisecond delay) in use. If the connection remains idle for 2.5 seconds it will time out and close automatically and the connection message will be required on the next access to the device node.

In the event that all the client connections in the S2K are in service when the command is executed in the motion program, the S2K will attempt to close one of the open existing idle client connections and attempt to open a connection to the specified node. Any network communication error will set FC31 and automatically execute program 4. The network fault code register (FCN) will indicate network faults in the connection and should be examined to determine network status after a fault.

Use the NCO read only register to check for valid connections if attempting to access a busy node address. The NCO will attempt to open a connection without faulting the S2K if the connection fails. Be certain that the lines of program code following the NCO line decide what to do about the connection.

Example:

```
      REM Start of connection test
      VI101 = 0              (* Clear variable used as error counter
  10  IF NCO5 GOTO 20        (* IF a connection is available to node 5 GOTO 20
      VI101 = VI101 + 1      (* Increment error counter
      IF VI101 > 50 THEN     (* Waited 5 sec for a connection?
          STF                (* Stop Fault the control
      STM1 = 0.100           (* Set Delay Timer
      WAIT TM1               (* Wait for 100ms
      GOTO 10                (* Loop for connect retries
  20  DON5.9 = ON            (* Set output on node 5
      (* add all node 5 I/O commands here *)
```

8.6.3 DeviceNet Objects for Explicit Messaging (Used with non-S2K peer client)

It is useful to understand CAN messaging and DeviceNet objects in some detail in order to generate the client explicit message to the S2K server. The client interface will determine how the data exchange is implemented. The interface may vary from a very user-friendly interface to low-level message encoding. Follow instructions in the client DeviceNet driver to implement the message properly.

For an in-depth DeviceNet resource, consult the current *DeviceNet Specification* published by the ODVA (www.odva.org).

About CAN and DeviceNet

CAN (Controller Area Network) specifications define both a hardware specification (CAN controller chips) and description of the network stack up to the Data Link Layer. This includes several message frame types of which the “data frame” is the most commonly used DeviceNet message frame. DeviceNet is an application protocol linked to the CAN specification at the Data Link Layer.

Higher priority data gets the right of way. The one with the lowest Node Address having bus priority resolves simultaneous transmission of data with the same service priority. Similar to Ethernet, any node can attempt to transmit if the bus is quiet (recessive). This provides inherent peer-to-peer capability. If two or more nodes try to access the network simultaneously, a bit-wise non-destructive arbitration mechanism resolves the conflict with no loss of data or bandwidth. By comparison, Ethernet uses collision detectors, which result in loss of data and bandwidth, as both nodes have to back off and resend their data.

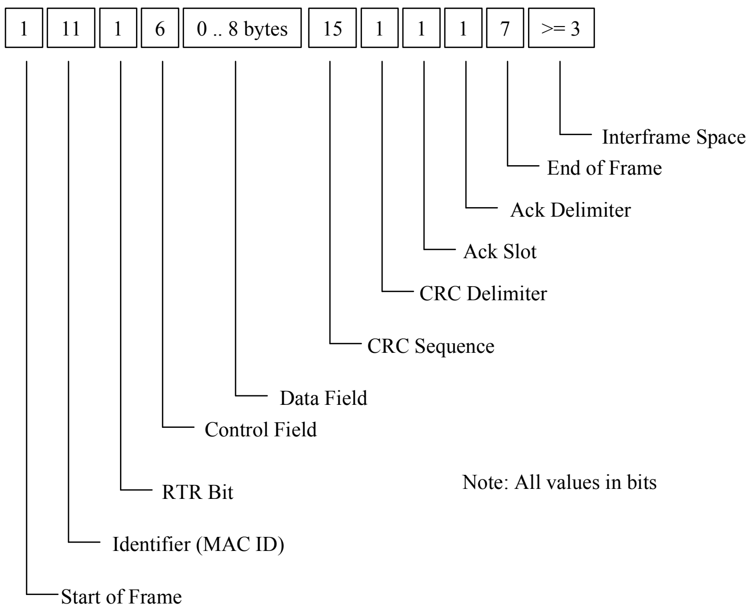


Figure 8-9. CAN Message - Data Frame format

The 8-byte data field of the CAN data frame is where the specific DeviceNet explicit message information is implemented. For DeviceNet, this field is populated for the Object Model. The Object Model provides a template for organizing and implementing the *Attributes* (data), *Services* (methods or procedures) and *Behaviors* of the components of a Device Net product (server). Think of the Object Model as providing an addressing scheme for each vendor supported *Attribute*. The *Attribute* is a specific command or grouping of data that the vendor has built into a device. The address for a given *Attribute* consists of four numbers. The table below indicates the range of values available. The DeviceNet specification reserves some objects (Object Class Identifier numbers) for specific purposes and allows others to be vendor specific. When building the message, you will additionally need to specify the priority (service code) of this message.

Table 8-34. Object Model Field Value Ranges

Address	Lowest Value	Highest Value
Node Address (Node Address)	0	63
Object Class Identifier	1	65535
Instance Number	0	65535
Attribute Number	1	255

8.7 Introduction to DeviceNet Object Modeling

DeviceNet is an object-oriented network protocol that uses some specialized terms to describe node behavior and the ways in which devices exchange information. For example, nodes communicate with each other via messaging connections. Each *node* consists of a collection of objects, or *object classes*. In turn, a node may contain more than one *instance* of an object class. An object has *attributes* and may provide *services*. To give these terms an everyday-use perspective, the figure below illustrates how the DeviceNet model allows access to an attribute via an addressing scheme similar to the path used to access a particular file on a PC. The numbers in parentheses indicate the range of identifying numbers allowed for each grouping.

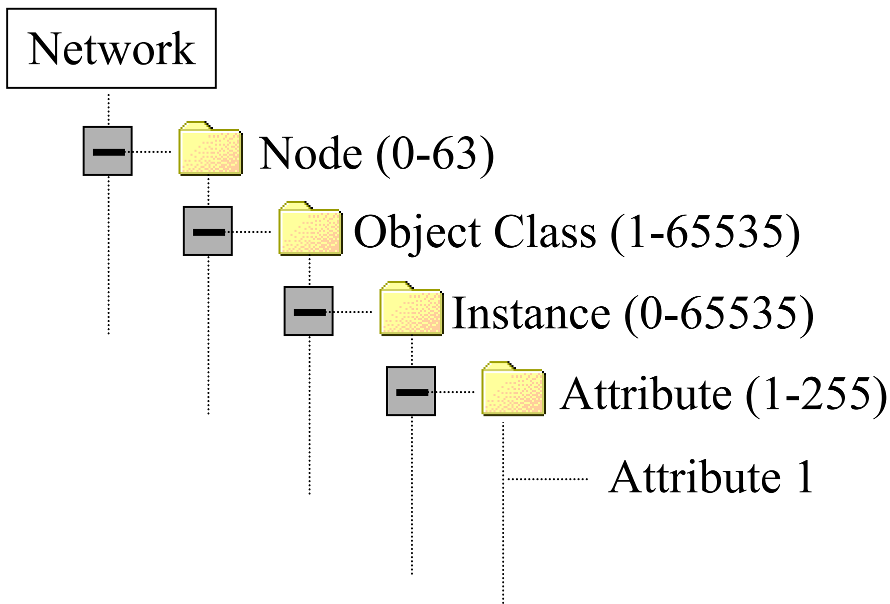


Figure 8-10. DeviceNet Terms Applied to a file tree structure

Translating the terms in Figure 8-10 to a DeviceNet scenario is simple. Look at Figure 8-3. The DeviceNet trunk line is the network, the S2K controllers are the nodes, and each oval represents an object class. Each of these objects performs services. The *Connection Object* for example has two instances:

- The I/O Connection
- The Explicit Messaging Connection

There is a complete table of all the objects supported in the S2K Controller later on in this chapter. For now consider the Object Model simply as an addressing scheme that allows access to a given type of data or service. You do not need to delve into more detail than this unless you are establishing an explicit connection from a non-S2K client.

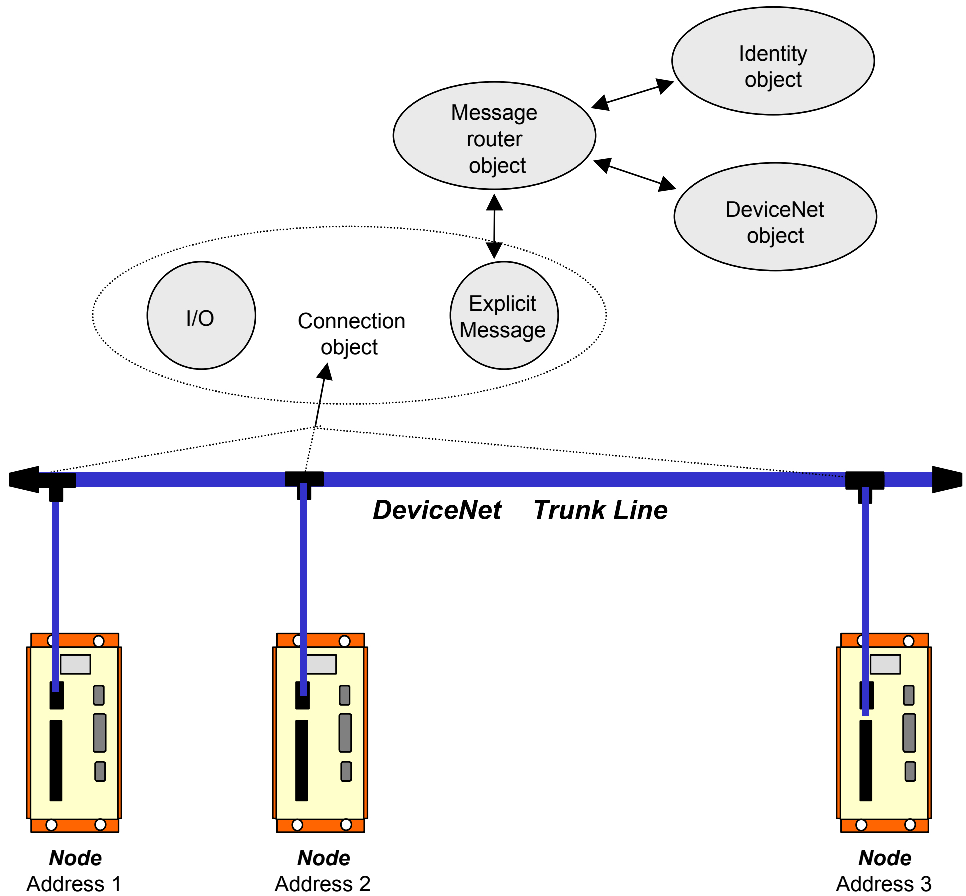


Figure 8-11. DeviceNet Object Model for S2K Controllers

For an in-depth DeviceNet resource, please consult the current *DeviceNet Specification* published by the ODVA (www.odva.org).

Objects in DeviceNet

Object classes (sometimes just called class or object) are categories that describe subdivisions of the functionality of a device. For instance, a device has the ability to move information on the wire. It has an identity. It performs some sort of operation on the data it receives. These are all examples of different classes of objects in a device (communications, identity and application objects, respectively).

It is quite common to have different "copies" of the same class in a given device that perform essentially the same set of functions, but for different reasons or in different ways. For example, a controller might want to exchange I/O data with a device while at the same time a diagnostic tool examines some other piece of data inside the device to make sure that it is operating properly. This is accomplished by having multiple instances of the class of object that handles communications.

Each instance shares a common data structure for the characteristics, but each instance has its own set of this data, and the individual values in the data structure can be, and in this case are, different between the instances. This is how each instance can have different operating characteristics. We call this data structure the list of "instance attributes" for this object. The attribute list is defined by the Object Model in Volume 2 of the DeviceNet Specifications and is common to all instances of the particular object class.

The attributes of each instance control all the behavioral characteristics of an instance, thus each instance has its own unique set of the same attributes. A good example of this can be found in the DeviceNet Specifications Volume 1, Chapter 7 tables 7.2, 7.2a, 7.3, 7.4 & 7.5. These different instances of the connection class are predefined to have certain characteristics. Notice that each table contains the same list of attributes, but each instance has different values for many of these attributes. These different values determine the behavior of each instance. Thus, each can have different behavior.

Explicit messages (client requests) use the DeviceNet *objects* that reside within the S2K controller (server). These objects support *services* that allow you (the client) to send commands and get/set attributes to your S2K controller (the server) over DeviceNet. The services perform as described below: See Table 8-37 for the field parameters for each service type.

Table 8-35. S2K Supported Explicit message Services

Send Command Service	Sends a command to the S2K controller. If an error is detected, an error response is returned. Otherwise, a successful *Send Command Response* is returned with the requested data.
Set Attribute Single Service	Modifies an attribute value within the S2K controller. The service validates any attribute data before it accepts the modification. If an error is detected, an error response is returned; otherwise, a successful *Set Attribute Single* R*esponse* is returned.
Get Attribute Single Service	Causes the object to return the contents of the specified attribute to the requester. If an error is detected, an error response is returned; otherwise, a successful *Get Attribute Single Response* is returned along with the requested attribute data.

The remainder of this section shows how to use the available *objects* in the S2K controller and provides examples of how to use them with explicit messaging over DeviceNet. Table 8-38 identifies those objects and the services and attributes that they provide.

Table 8-37 includes *System* and *Variable* (i.e.,, Boolean, Integer, Floating Point, and String) *Objects* that allow you to send commands to the controller and get/set controller variables via explicit messaging. Those objects are unique to S2K products and have been designed to let you get the most of your S2K DeviceNet controllers. This is especially important because unlike most other DeviceNet motion controllers, GE Fanuc S2K motion controllers can run complete application programs in conjunction with DeviceNet communication. Use Table 8-38 and the examples that follow as your guide, and try the examples with your own equipment—you'll see just how easy it is to send explicit messages to the S2K controllers. Table 8-37 lists the parameters that are specified within the service data field of service requests and successful service responses.

The most commonly used explicit objects for a PLC or PC host is the Assembly Object (code 4) and the System Object (code 64). Many of the other objects will be used frequently however are normally handled automatically by the S2K.

Additional Explanation for the Assembly Object (code 4)

The Assembly object is potentially one of the most useful objects in the S2K. Using the Get or Set attribute single service with the assembly object allows the explicit connection to access (read or write) a group of thirty-two integers or floating point variables with one message. This is especially useful when the host is initializing a large number of variables i.e., sending a new recipe for product changeover to the S2K.

The S2K controller has 192 separate assembly object instances defined to access variable data. The following table indicates these instances. Each instance embodies thirty-two variables and is byte aligned on 128 byte boundaries. Each S2K variable is four bytes in length.

Table 8-36. Variable Instances for the S2K Assembly Object

Type	Instance (x)	Variable Instance to Get or Set [1]
Integer Variables	768–895	n = 32(x -768) +1
Floating Point Variables	896–959	n = 32(x - 896) + 1

1. n represents the least significant variable within a 32 variable group.

The array of data (32 variables) associated with the assembly object will be 128 bytes in length. Byte zero will map to the least significant byte of variable n, byte 4 will be the LSB of n +1 and so on. The variable data is organized in the LSB–MSB format i.e., for variable n at byte zero, byte zero is the LSB, byte 1 is the Low middle byte, byte 2 is the High middle byte and byte 3 is the MSB.

As an example to access integer variable VI33–VI64 the appropriate instance (x) would be 769.

Table 8-37. Service Data Field Parameters

Service	Service Code	Service Type	Name	Data Type	Description of Parameter
Send Command Service	32h	Data for Request	Immediate Mode Choice	BOOL	Immediate mode commands are to be executed when non-zero.
			Command	SHORT_STRING	Controller command of 0-240 characters. Does not include unit address or carriage return
		Service Data for Success Response	Command Response	SHORT_STRING	Response to the controller command. String contains the same response you would get had the same command been sent over the S2K serial port.
Set Attribute Single Service	10h	Data for Request	Attribute ID	USINT	Identifies the attribute to be read/returned.
			Attribute Data	Attribute-specific	Contains the value to which the specified attribute is to be modified
Get Attribute Single Service	0Eh	Data for Request	Attribute ID	USINT	Identifies the attribute to be read/returned.
		Service Data for Success Response	Attribute Data	Object/class Attribute-specific Structure	Contains the requested attribute data.

Table 8-38. S2K Position Controller DeviceNet Objects—Comprehensive list

Object & Class ID (Hex)	Instance (S2K - Register)	Service	Service Code (Hex)	Attribute ID	Attribute Description	Attribute Type	Attribute Values
Identity 01	1	Reset	05	—	Type of Reset	USINT	0, 1
	1	Get	0E	1	Vendor ID	UINT	38
	1	Get	0E	2	Device type	UINT	16 (S2K)
	1	Get	0E	3	Product code	UINT	0-65,535
	1	Get	0E	4	Revision	UINT, UINT	1-4, 10-99
	1	Get	0E	5	Status	WORD	0-65,535
	1	Get	0E	6	Serial number	UDINT	0 - (2^{32}-1)
	1	Get	0E	7	Product name	SHORT STRING	Model number
DeviceNet 03	0	Get	0E	1	Revision	UINT	2
	1	Get	0E	5	Allocation info.	BYTE, USINT	0-255, 0-63, 255
	1	Allocate M/S Connection Set	4B	—	—	BYTE, USINT	0-255, 0-63
	1	Release M/S Connection Set	4C	—	—	BYTE	0-255
Assembly 04	768 - 959	Get/Set	0E/10	3	Data	ARRAY (BYTE)	(See explanation above)
Connection 05	0	Create	8	—	—	—	—
	0	Delete	9	—	—	—	—
	1-6	Reset	5	—	—	—	—
	1-6	Delete	9	—	—	—	—
	1-6	Apply Attributes	0D	—	—	—	—
	1-6	Get	0E	1	State	USINT	0-5
	1-6	Get	0E	2	Instance type	USINT	0, 1
	1-6	Get	0E	3	Transport class trigger	BYTE	23_{16} or 83_{16}
	1-6	Get	0E	4	Produced connection ID	UINT	$0\text{-}7F0_{16}$ or $FFFF_{16}$
	1-6	Get/Set	0E/10	5	Consumed connection ID	UINT	$0\text{-}7F0_{16}$ or $FFFF_{16}$
	1-6	Get	0E	6	Initial comm. Characteristics	BYTE	0, 1, 21_{16}, 33_{16}
	1-6	Get	0E	7	Produced connection size	UINT	256, 8, 34
	1-6	Get	0E	8	Consumed connection size	UINT	256, 8, 34
	1-6	Get/Set	0E/10	9	Expected packet rate	UINT	0-65,535

Object & Class ID (Hex)	Instance (S2K - Register)	Service	Service Code (Hex)	Attribute ID	Attribute Description	Attribute Type	Attribute Values
Object & Class ID (Hex)	**Instance** (S2K - Register)	**Service**	**Service Code (Hex)**	**Attribute ID**	**Attribute Description**	**Attribute Type**	**Attribute Values**
Connection 05 (Continued)	1-6	Get/Set	0E/10	12	Watchdog timeout action	UINT	0, 1, 3
	1-6	Get	0E	13	Produced connection path length	UINT	0, 6
	1-6	Get	0E	14	Produced connection path	EPATH	Empty, 202424003021_{16}
	1-6	Get	0E	15	Consumed connection path length	UINT	0, 6
	1-6	Get	0E	16	Consumed connection path	EPATH	Empty, 202424003020_{16}
Discrete Input Point 08	1-14 (DIn)	Get	0E	3	Input point value	BOOL	0, 1
Discrete Output Point 09	9-14 (DOn)	Get/Set	0E/10	3	Output point value	BOOL	0, 1
Analog Input Point 0A	1, 2 (AI1, AI2)	Get	0E	3	Analog Input Value	INT	-10,000 = - 10 volts to +10,000 = +10 volts

Object & Class ID (Hex)	Instance (S2K - Register)	Service	Service Code (Hex)	Attribute ID	Attribute Description	Attribute Type	Attribute Values
Analog Output Point 0B	1 (AO)	Get/Set	0E/10	3	Analog Output Value	INT	-10,000 = - 10 volts to +10,000 = +10 volts
	1	Get	0E	7	Output Range	USINT	3 = +/- 10 volt
Parameter 0F	0	Get	0E	2	Maximum Instance	UINT	255
	0	Get	0E	8	Parameter class descriptor	WORD	1
	0	Get	0E	9	Configuration assembly instance	UINT	0
	1-128	Get/Set	0E/10	1	Parameter Value	DINT	-2,147,483,648 to 2,147,483,647
	129-255	Get	0E	1	Parameter Value	REAL	1.5 EE-39 to 1.7 EE38 (absolute value)
	1-255	Get	0E	2	Link Path Size	USINT	0
	1-255	Get	0E	3	Link Path	ARRAY	Empty
	1-255	Get	0E	4	Descriptor	WORD	0
	1-128	Get	0E	5	Data Type	EPATH	C4 (hex) = DINT
	129-255	Get	0E	5	Data Type	EPATH	CA (hex) = REAL
	1-255	Get	0E	6	Data Size	USINT	4
Position Controller Supervisor 24	0	Get	0E	1	Revision	UINT	2
	0	Get/Set	0E/10	32	Consumed command message	ARRAY (BYTE)	8 byte Implicit Command message
	0	Get	0E	33	Produced response message	ARRAY (BYTE)	8 byte Implicit Response message
	1	Get	0E	1	Number of Attributes	USINT	12
	1	Get	0E	2	Attribute List	ARRAY (USINT)	1-3, 5-7, 12, 15, 16, 21, 22, 24
	1	Get	0E	3	Axis number	USINT	1
	1	Get	0E	5	General fault	BOOL	0, 1 = fault present
	1	Get	0E	6	Command Message Type	USINT	1-5, 26, 27, 31
	1	Get	0E	7	Response Message Type	USINT	1-3, 5, 8, 20, 26, 27, 31
	1	Get/Set	0E/10	12	Home Arm	BOOL	0 = trigger has occurred 1 = armed
	1	Get/Set	0E/10	15	Index Arm	BOOL	0 = trigger has occurred 1 = armed
	1	Get	0E	16	Home Input Level	BOOL	0 = low 1 = high
	1	Get/Set	0E/10	21	Registration Arm	BOOL	0 = trigger has occurred 1 = armed
	1	Get	0E	22	Registration Input Level	BOOL	0 = low 1 = high

Object & Class ID (Hex)	Instance (S2K - Register)	Service	Service Code (Hex)	Attribute ID	Attribute Description	Attribute Type	Attribute Values
Position Controller Supervisor 24 Continued	1 (PCA)	Get	0E	24	Registration Position	DINT	+/- 2,000,000,000
Position Controller 25	0	Get	0E	1	Revision	UINT	2
	1	Get	0E	1	Number of Attributes	USINT	47
	1	Get	0E	2	Attribute list	ARRAY (USINT)	1-3, 6-15, 17-21, 23-25, 30-32,36, 40, 45, 47, 48, 50, 51, 54-58, 100-110
	1	Get/Set	0E/10	3	Mode	USINT	0 = Position 1 = Velocity 2 = Torque
	1 (MPI, MPA)	Get/Set	0E/10	6	Target position	DINT	+/-2,000,000,000
	1 (MVL)	Get/Set	0E/10	7	Target velocity	DINT	1-16,000,000
	1 (MAC)	Get/Set	0E/10	8	Acceleration	DINT	100-1,000,000,000
	1 (MDC)	Get/Set	0E/10	9	Deceleration	DINT	100-1,000,000,000
	1	Get/Set	0E/10	10	Incremental position flag	BOOL	0 = Absolute 1 = Incremental
	1	Get/Set	0E/10	11	Load Data / Start Profile	BOOL	0, 1
	1	Get	0E	12	On target position	BOOL	0, 1
	1 (PSA)	Get/Set	0E/10	13	Actual position	DINT	+/-2,000,000,000
	1 (VLA)	Get	0E	14	Actual Velocity	DINT	+/- 16,000,000
	1 (PSC)	Get	0E	15	Commanded position	DINT	+/-2,000,000,000
	1	Get/Set	0E/10	17	Enable	BOOL	0 = disable drive 1 = enable drive
	1	Get/Set	0E/10	18	Profile type	USINT	0 = trapezoidal 1 = s-curve
	1 (MJK)	Get/Set	0E/10	19	Profile gain	DINT	0-100
	1 (ST)	Get/Set	0E/10	20	Smooth stop	BOOL	0, 1 = stop
	1 (HT)	Get/Set	0E/10	21	Hard stop	BOOL	0, 1 = halt

Object & Class ID (Hex)	Instance (S2K - Register)	Service	Service Code (Hex)	Attribute ID	Attribute Description	Attribute Type	Attribute Values
Position Controller 25 (Continued)	1	Get/Set	0E/10	23	Instantaneous Direction	BOOL	0 = reverse, negative 1 = forward, positive
	1 (DIR)	Get/Set	0E/10	24	Reference Direction	BOOL	0 = Forward-CW 1 = Forward- CCW
	1 (TLC)	Get/Set	0E/10	25	Torque	DINT	+/- 1,000
	1 (KP)	Get/Set	0E/10	30	Proportional Gain	INT	0–8,000
	1 (KI)	Get/Set	0E/10	31	Integral Gain	UINT	0–64,000
	1 (KD)	Get/Set	0E/10	32	Derivative Gain	INT	0–8,000
	1 (KA)	Get/Set	0E/10	36	Acceleration Feed Forward	UINT	0–64,000
	1 (FR)	Get/Set	0E/10	40	Feedback Resolution	DINT	500–1,000,000
	1 (FEB)	Get/Set	0E/10	45	Max. Following Error	DINT	0–16,000
	1	Get	0E	47	Following Error Fault	BOOL	0, 1
	1	Get	0E	48	Actual Following Error	DINT	0–16,000
	1	Get	0E	50	Forward Limit	BOOL	0, 1
	1	Get	0E	51	Reverse Limit	BOOL	0, 1
	1 (OTF)	Get/Set	0E/10	54	Positive Soft Limit Position	DINT	+/- 2,100,000,000
	1 (OTR)	Get/Set	0E/10	55	Negative Soft Limit Position	DINT	+/- 2,100,000,000
	1	Get	0E	56	Positive Limit Triggered	BOOL	0, 1
	1	Get	0E	57	Negative Limit Triggered	BOOL	0, 1
	1	Get	0E	58	Load Data Complete	BOOL	0, 1
	Begin Vendor Specific Attributes						
	1 (FC)	Get	0E	100	Fault Code	UDINT	0–FFFF FFFF (hex)
	1 (CURC)	Get/Set	0E/10	101	Continuous Current	INT	1–1,000
	1 (CURS)	Get/Set	0E/10	102	Power Save Current	INT	0–1,000
	1 (CURP)	Get/Set	0E/10	103	Peak Current	INT	1–1,000
	1 (CMR)	Get/Set	0E/10	104	Commutation Ratio	INT	1–16
	1 (CMO)	Get/Set	0E/10	105	Commutation Offset	INT	+/- 1,800

Object & Class ID (Hex)	Instance (S2K - Register)	Service	Service Code (Hex)	Attribute ID	Attribute Description	Attribute Type	Attribute Values
Position Controller 25 (Continued)	1 (IPB)	Get/Set	0E/10	106	In-position Band	INT	0–16,000
	1 (PWE)	Get/Set	0E/10	107	Position Wrap	BOOL	0, 1=enabled
	1 (KT)	Get/Set	0E/10	108	Filter Time Constant	INT	0-5
	1 (KL)	Get/Set	0E/10	109	Motor Inductance	INT	1-100
	1 (KM)	Get/Set	0E/10	110	Motor Number	INT	0-20
	1 (FRC)	Get/Set	0E/10	* 114	Feedback Resolution For Commutation	DINT	100-64,000
	1 (DIRX)	Get/Set	0E/10	* 115	Direction of Auxiliary Position	BOOL	0 = Forward-CW 1 = Forward- CCW
System 64	1	Send Command	32	FF (hex)	S2K Command	SHORT_ STRING	S2K acceptable command
Boolean Variable 65	n (VBn)	Get/Set	0E/10	1	Value	BOOL	0, 1
Integer Variable 66	n (VIn)	Get/Set	0E/10	1	Value	DINT	-2,147,483,648 to +2,147,483,647
Floating Point Variable 67	n (VFn)	Get/Set	0E/10	1	Value	REAL	1.5 EE-39 to 1.7 EE38 (absolute value)
String Variable 68	n (VSn)	Get/Set	0E/10	1	Value	SHORT STRING	Character string, 0-127 characters long

n = variable instance

Notes: The *Get/Set Attribute Single* services parse faster and are more efficient than the *Send Command* service because they take fewer bytes to send and receive.

* - Requires Firmware revision 2.5 or later

8.7.1 Explicit message examples

The explicit message examples that follow were generated from a typical DeviceNet commissioning software program for a third party device. Other DeviceNet commissioning software products have a screen similar to the Basic Configuration operator interface screen shown in Figure 8-12. Use this screen to generate your explicit messages.

Get Attribute Single Service

The *Get Attribute Single* service lets an explicit message retrieve the values of any of the DeviceNet object instances (refer to Table 8-38) that support the *Get Attribute Single* service. This example uses the Get Attribute Single service to get the string ***Hello*** stored in string variable 3 from the controller.

The device requesting service (by sending the command) is the client, with a Node Address=00. The device responding to the command is the server, with a Node Address=01. Figure 8-12 shows the data that you must enter. The *Service Code*, *Class*, *Instance*, and *Attribute* all come from the table of S2K Controller DeviceNet Objects in Table 8-38.

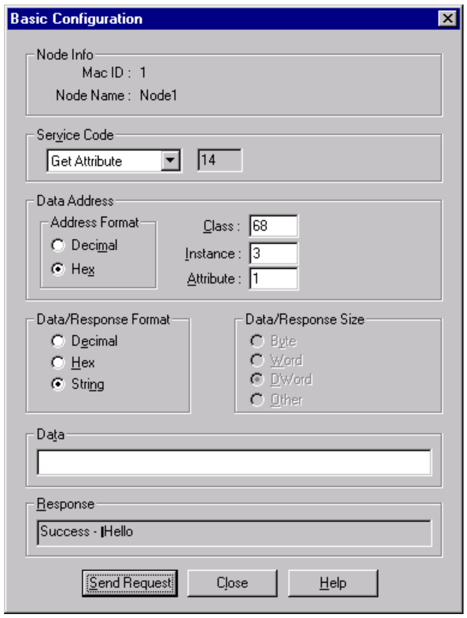
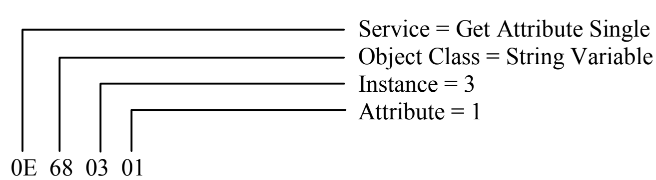


Figure 8-12. Using the Explicit Messaging Connection to Get Attribute

Click the *Send Request* button to send the command over DeviceNet to the controller. The successful response reveals the value of string variable 3 to be ***Hello***.

The *Basic Configuration* screen shows the simplified view of what occurs when you send a command. When you click that *Send Request* button, the client and server are actually exchanging data behind-the-scenes.

The data (hex) passed by the client application to DeviceNet are:



Set Attribute Single Service

The *Set Attribute Single* service allows an explicit message to set the value of any of the DeviceNet object instances (refer to Table 8-38) that support the *Set Attribute Single* service.

This example uses the *Set Attribute Single* service to set integer variable 20 (14 hex) to 2,000,000,000 (77359400 hex). The device requesting service (by sending the command) is the client, with a Node Address=00. The device responding to the command is the server, with a Node Address=01. Figure 8-13 shows the data the user must enter. The *Service Code*, *Class*, *Instance*, and *Attribute* all come from the table of S2K Controller DeviceNet Objects in Table 8-38. Click the *Send Request* button to send the command over DeviceNet to the controller. The response tells us that the explicit message was successful.

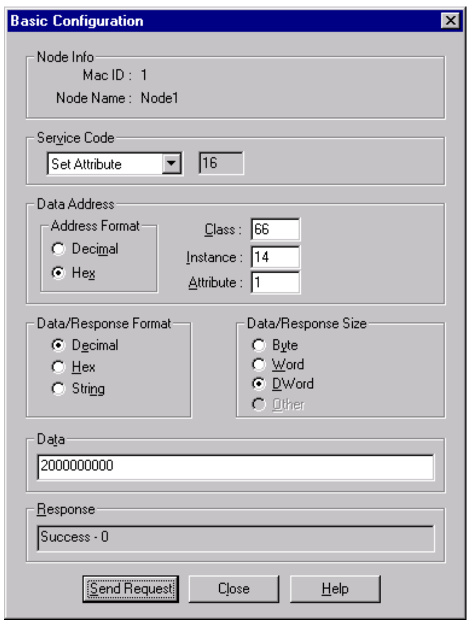
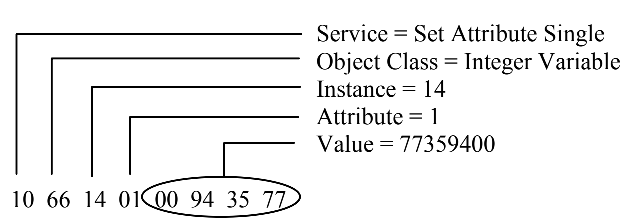


Figure 8-13. Using the Explicit Messaging Connection to Set Attribute

The *Basic Configuration* screen shows the simplified view of what occurs when you send a command. When you click that *Send Request* button, the client and server are actually exchanging a series of fragmented requests and responses.

The data (hex) passed by the client application to DeviceNet are:



Send Command Service

The *Send Command* service allows you to send the registers and commands as explicit messages in immediate mode to your S2K controller. DeviceNet places no limits on the controller's capabilities in a network environment—you can still create, store, and execute programs within your S2K controller, just as if you were communicating to the controller via its serial port.

This example uses the *Send Command Service* to set the CURC (continuous current limit) register value to 50% by sending the string CURC=50.0 as an explicit message. The string can be from 0–240 characters. It should not include a unit address or carriage return.

The device requesting service (by sending the command) is the client, with a Node Address=00. The device responding to the command is the server, with a Node Address=01. Figure 8-14 shows the data the user must enter. Click the *Send Request* button to send the command over DeviceNet to the controller. The response tells us that the explicit message was successful—the CURC register is set to 50.0 percent.

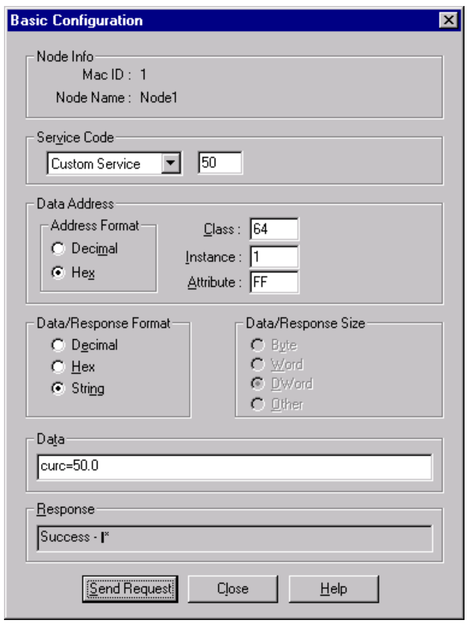
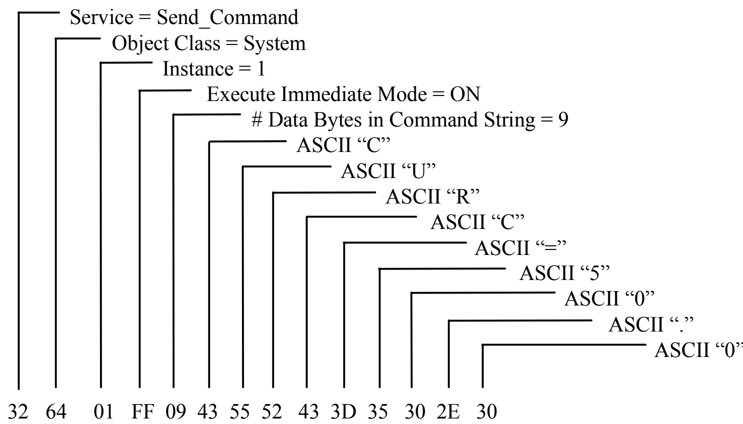


Figure 8-14. Basic Configuration Screen Used to Send Explicit Messages

The *Basic Configuration* screen shows the simplified view of what occurs when you send a command. When you click that *Send Request* button, the client and server are actually exchanging a series of fragmented requests and responses. If the request includes any error, you will receive an error response. The data (hex) passed by the client application to DeviceNet are:



8.8 Frequently Asked Questions about S2K DeviceNet

Why can’t I communicate with my S2K node?

You must have DC voltage on the DeviceNet LAN cable to power the CAN transceivers.

More than 80% of all communication difficulties are based on the LAN cable installation. There is a very good DeviceNet LAN troubleshooting guide available on the ODVA web site (www.odva.org).

Make sure your master scanner supports UCMM protocol and the S2K is configured in the scanner for polling mode (8 bytes produced, 8 bytes consumed).

The controller is in a faulted state. How can I attempt to reset the fault?

Using the I/O (implicit) messaging: Set the Enable bit (bit 7 of byte 0) in the Command message off then back on. This will cause the controller to act as if you had typed the RSF command into the terminal. The dedicated hardware input must also be true.

Using the explicit message, Send Command Service: For reset from a non-S2K client (PC or PLC), use the System object (64 hex) to send the RSF command string to the S2K controller. The dedicated hardware input must also be true.

Peer-to-peer (i.e., S2K to S2K): Use the OUTN command to send the RSF command string to the S2K controller. The dedicated hardware input must also be true.

How do I poll the S2K for response data without changing data or making the axis move?

Set the Load Data bit false in the command message. The reply message will still contain the requested data.

What does the message “Resource Not Available” means for a DeviceNet system?

The DeviceNet communication did not occur for some reason. Query the FCN register for more specific network fault code messages.

How does the S2K manage the UCMM connection?

Each S2K can open three client connections and respond to three server connections without any problems. The S2K automatically handles the network connection management. If all three connections of a given type are open and another connection is attempted the S2K will check for an available connection. If a connection is open but unused, the S2K will reassign it to the new connection. If all the message connections of the desired type (client or server) are used, the S2K will issue an “out of connection” fault. If you are using many devices on a network with a particular S2K node, the NCO register should be used.

What does NCO do?

NCO is a read only register that lets you attempt to make a connection without faulting the S2K if the connection is unavailable. When using NCO make sure that the next line of program code makes a decision about what to do if the connection is not available i.e., increment an error counter and try again x number of times.

How many server connections does the master/slave connection consume?

Typically, two server connections are consumed. One server connection is used for the I/O messaging and one for the explicit connection. If explicit messaging is not available or not being used, then only one server connection is used. The three client connections remain available for peer-to-peer or expansion I/O communication.

What is the meaning of the various states of the “Network Status” LED on the S2K?

The network status LED conforms to the DeviceNet specification and has the following conditions:

Table 8-39. Network Status LED States

For this state:	LED is:	To indicate:
Not powered/Not On-line	Off	*Device is not online.* • The S2K has not completed the duplicate node address test yet. • The S2K may not be powered.
On-line, Not Connected	Flashing Green	*Device is online but has no connections in the established state.* • Has passed duplicate device test. • S2K has no established connections.
Link OK On-line, connected	Green	*The device is online and has connections in the established state.* • The S2K has one or more established connections
Connection Time-Out	Flashing Red	*One or more I/O connections are in the Timed-Out state.*
Critical Link Failure	Red	*Failed communication device. The device has detected an error that has rendered it incapable of communication on the network.* • Duplicate node address • Bus-off command
Communication Faulted and Received an Identify Comm Fault Request-Long Protocol	Flashing Red & Green	*The device has detected a Network Access error and is in the Communication Faulted state. The device has subsequently received and accepted an Identify Communications Faulted Request-Long Protocol message.*

Why is the value in the PSA register different than the actual position read in the implicit reply message?

The PSA is scaled to user units by the URA register. The implicit reply position is always in feedback (encoder) counts. To convert PSA to encoder counts multiply PSA by the current URA setting.

The system response times to the PC or PLC are too slow, what can I do?

In the master-slave polling configuration the S2K must wait its turn to be polled by the master scanner. The best throughput gains are achieved by decreasing the sweep time of the master scanner host (PC or PLC). I/O messaging via the handshake sequence will require two host sweeps per message. Generally, the scanner is running on a 10 ms network polling cycle (may be adjustable) and stays well ahead of the host ladder.

The advantage to the I/O (implicit) messaging is that the scanner maps implicit command/response data buffers for each networked node. Rather than sending all the messages to one node, send messages to multiple nodes and allow the S2Ks to communicate to each other in the much faster peer-to-peer mode. This is a distributed control approach.

Many scanners have the ability to use explicit messaging along with the I/O messaging. While there is typically only one explicit messaging transmit and receive buffer per network it is possible to use the Assembly Object (code 4) to get/set up to thirty two variables per two host sweeps to a single S2K.

What is the format of the floating-point numbers used in the DeviceNet interface?

DeviceNet uses the Single Precision Binary Real Format ANSI-IEEE 754-1985 specification as required for ODVA conformance. This is a 32-bit representation that allows values of 3.4×10^{38} to 1.2×10^{-38} to be used. Bits 0–22 are the fraction, bits 22–30 are the biased exponent and bit 31 is the sign bit. This format is compatible with many PLC floating-point formats as well. Internal to the S2K these values are automatically converted to the native S2K 8-byte format.

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Chapter 9

Using Serial Communications

9.1 Getting Started

The S2K Motion Controller includes a multi-purpose RS232 serial port. The S2K serial port may operate at 1,200; 9,600; 19,200 or 38,400 baud and has configurable settings for data bits (7,8) and parity (odd, even). Software flow control is supported and the S2K provides a variety of commands associated with the serial port and string manipulation. Usage of the port is alternately available as an ASCII serial port or as an RTU Slave protocol port. Using the port in one mode prohibits usage in the other however, program control is provided to switch between serial port modes.

This chapter assumes that you have completed the basic setup for your S2K controller. Basic setup entails connecting and configuring all motion control system components, applying power, and running the motor from the controller.

9.2 ASCII Protocol

ASCII is the default mode of the serial port and may be used for many functions:

- Configuration and programming
- Downloading new S2K firmware
- Loading and storing programs and motion blocks
- Monitoring variable and register data via ASCII terminal
- Interfacing to serial devices such as RF tag readers, digital scales, bar code readers or serial printers.

When the serial port is in ASCII mode, the factory default is to operate at 9,600 baud, 7-bit, odd-parity. Chapter 5 provides detailed information about the instructions related to reading and writing ASCII data with the serial port as well as the extensive string manipulation commands available within the S2K.

Primarily the ASCII serial port is designed to be a programming and debugging interface. This is defined as "terminal" mode. Alternately it may be used in a "data" mode.

9.2.1 ASCII Terminal Mode

In the default, terminal mode operation is very simple. You may use any “dumb” terminal that has the same serial configuration. You are automatically online to the S2K and valid commands are immediately processed. When using the CIMPLICITY Machine Edition Motion Developer terminal, the addressing is automatically done based on the active target properties. You do not have to type the address field on each line. If using a dumb terminal you will require the address field for each line sent.

The S2K expects the following command line format:

<Address> <command string> [query character] <terminator>

Address is a required field and in the S2K has two forms:

- Local–Any valid serial address 1-9 or A-V is permitted. The S2K does not require address setting via configuration and will accept any of the previous address settings.
- Local Connect-Remote/Redirected–DeviceNet networked S2Ks are accessible via the re-direct addressing format. This is accomplished by using the redirect character “>”. The following address field format should be used to access a remote S2K.

<Local Serial address> <redirect character> <Remote DeviceNet address>

For example, the serial connection is to a S2K controller networked and at address 1. Using the remote/redirect, the terminal connection to this node is able to operate as the terminal connection to a different networked node i.e., node 6. The address field would be “1>6”.

Command String is a required field and may be any valid S2K command. A command will be rejected if the S2K is not in the appropriate operating mode to accept it. In a query only the variable or register address is used in the command field. An example is to set a value to an S2K variable: “1 VF1=123.456 <cr>”.

Query Character or “?” is an optional field and is used to instruct the S2K to return the data of the variable or register in the command string. An example would be to query the Axis Position register for networked node 6: “1>6 PSA? <cr>”.

Terminator is a required field and is the ASCII carriage return character <cr>.

As each ASCII character of the command line is entered, the S2K will echo that character back to the terminal. A dumb terminal should be configured in full-duplex mode to avoid double characters on the terminal screen. When the S2K receives the terminator character <cr> an ASCII carriage return/line feed <cr/lf> is sent to the terminal.

After each full command line, the S2K will return additional ASCII data in response to the command entered and the current executing circumstances. Typical responses are:

Null Response is returned if the command field is blank or null. This is an ASCII string containing model identification and station address information. For example:

```
* GE Fanuc S2K Series <cr/lf>
  Network Address – 1 <cr/lf>
```

Status Message is returned if the S2K rejects the command line. The status string is prefixed with the ASCII "?" character and provides either a numeric or text status message based on the setting of the S2K CIE register. The return data is completed with an ASCII <cr/lf>. A complete list of the status messages may be found in Table 7-2. A sample status message would appear as: "? INVALID COMMAND <cr/lf>"

Query Response Message is returned if the query command accessed a valid variable or register in the S2K. The data string is prefixed by the ASCII "*" character and includes the variable value. The return data is completed with an ASCII <cr/lf>. A sample query message would appear as: "1 PSA? <cr>' and the response message is "*123.456 <cr/lf>"

Special Operating Mode Messages are returned when the command message places the S2K control into special operating modes. These modes include: firmware loading, online program edit, single-step program, trace program, clear memory, auto tune (servo only) and diagnostic messaging.

9.2.2 ASCII Data Mode

The ASCII data mode is really a specialized command sent via the normal terminal mode interface. This command allows the terminal equipment to write a string to the S2K, character by character that will not be interpreted as a command or generate a status response message. The KY command may be used to load any single ASCII character into a special S2K memory location, the KEY buffer. S2K internal commands are available to test for presence of data in the key buffer (KEY, SRS), clear the key buffer (EKB) and read the key buffer to a variable (GET, IN).

For example to send the word "HELLO" to the key buffer you need to format one command per character:

```
1 KYH <cr>
1 KYE <cr>
1 KYL <cr>
1 KYL <cr>
1 KYO <cr>
```

You can have the S2K generate a string output to the terminal in any format in an S2K program (as long as its 7 bits odd parity) with the OUT command. For example:

```
OUT "Position is "+$PSA+"$N"
```

Send the string "Position is 123.456<cr,lf>" to the serial port . The "+" is the string concatenation operator. Special operators "$", are listed in Chapter 5. You can control the number of digits, etc. if you use the FTS or ITS commands to convert register or variable values to strings, i.e.,

```
VS10 = FTS(VF100,7,2).
```

Alternately the PUT command allows a single character to be output to the terminal (serial port). Various program examples are shown in the PUT command documentation in Chapter 5.

9.3 RTU Protocol

This chapter documents the basic setup procedure required to connect an S2K motion controller to a Remote Terminal Unit (RTU) master, such as a QuickPanel, Datapanel or CIMPLICITY Machine Edition - View software target (CE and NT ViewStation) and configure the controller for communication with the S2K. RTU **slave** mode is available in all S2K controllers with firmware version 2.1 or higher.

The RTU Slave functionality of the S2K allows the RTU Master to:

- Read/Write single bits (Boolean) VB1-VB256.
- Read/Write signed words (Integer) VI1-VI4096.
- Read/Write signed double words (DINT) VI1-VI4096.
- Read/Write floating-point variables VF1-VF2047.
- Read Text (String variables 128 characters each) VS1-VS144.

The S2K serial communications is point-to-point only (no multi-drop), therefore, the S2K controller is always node address one unless the multi-drop port adaptor is used. Contact your GE Fanuc sales representative for more information about the S2K multi-drop adapter.

Refer to your RTU master device documentation for instructions on creating touch screen objects that are tagged to controller variables and for the proper use of any RTU function keys.

Note

When RTU communication is enabled, the controller cannot communicate with the CIMPLICITY Machine Edition Motion Developer software. The controller will automatically disable RTU mode (RTU=0) if ten consecutive non-RTU messages are received (e.g., ten carriage returns from the Motion Developer Terminal Window). See the RTU command documentation in Chapter 5 for more details.

9.3.1 Connect S2K Controller to RTU master device

The serial communications cable is limited to 50 feet maximum. There is however, an option to add the Modbus Adapter port converter, which supports multi-drop, longer distances and node addressing.

9.3.1.1 Modbus Adapter

GE Fanuc’s Modbus adapter model ADP-COMJ-MBUS allows multidrop communication with S2K motion controllers via Modbus. The ADP-COMJ-MBUS fits into the RS-232 Serial Port on S2K motion controllers to convert the RS-232 signal to a RS-422/485 signal.

The RS-422/485 port has a 6-position terminal block connector with the Transmit Data outputs and Receive Data inputs labeled accordingly. Keep the Echo jumper in the “OFF” position.

Table 9-1. Modbus Adapter RS-422/485 Connections

Connection	Description
TD(A)	Transmit +
TD(B)	Transmit -
RD(A)	Receive +
RD(B)	Receive -
GND	Ground
+12VDC	+12 VDC Supply for RS-485*

* Note: users should keep the RS-422/485 supply isolated from the RS-232 side.

Modbus Adapter Power

The RS-232 side derives power from the DTR line (pin 4) and requires no user intervention.

The RS-422/485 side requires 12 Vdc at 60 mA supplied by user.

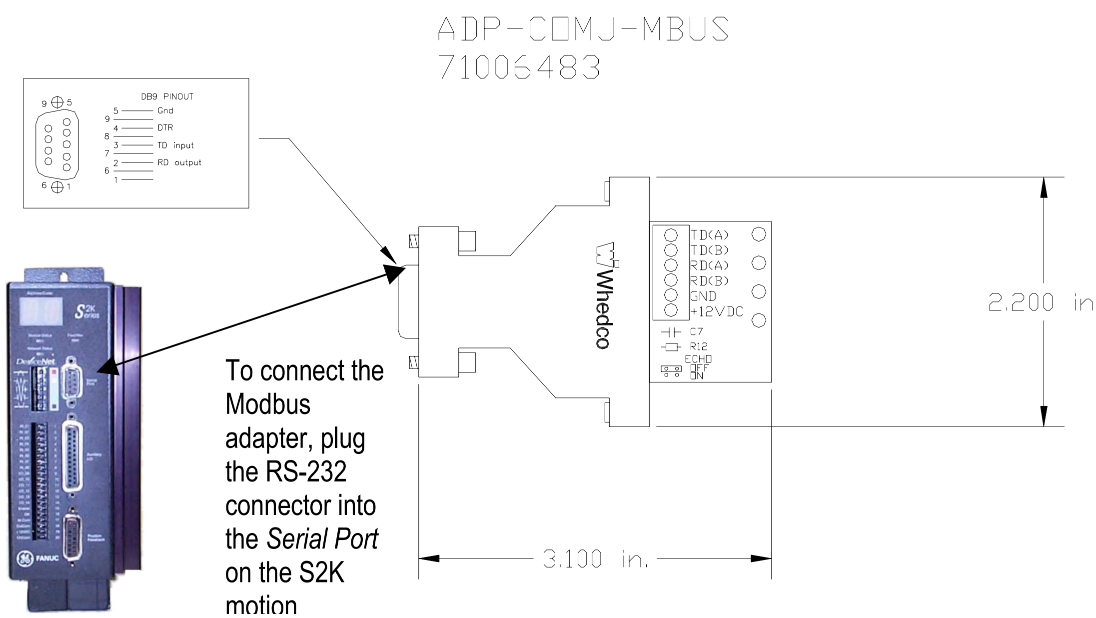

Figure 9-1. Modbus Adapter-to-S2K Connection

Note

Both QuickPanel and DataPanel support RS-485 without a converter.

9.3.1.2 QuickPanel Serial Wiring

Connect the DB-9 serial cable connector to the serial port on the front of the S2K controller. Connect the DB-25 pin connector to its mate on the QuickPanel. The following figures detail the proper serial cable wiring.

Follow manufacturer's instructions to connect and apply power to the QuickPanel.

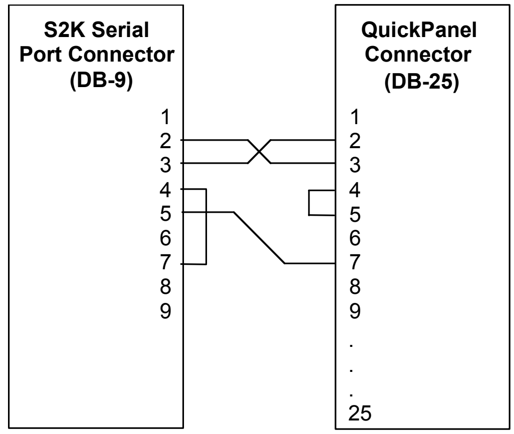

Figure 9-2. RS-232 Serial Cable Wiring for QuickPanel

9.3.1.3 Datapanel Serial Wiring

Connect the DB-9 serial cable connector to the Serial Port on the front of the S2K controller. Connect the DB-9 pin connector to its mate on the Datapanel (labeled *Serial Port*). The following figure details the proper orientation of the DB-9 connectors and serial cable wiring.

Follow manufacturer's instructions to connect and apply power to the Datapanel.

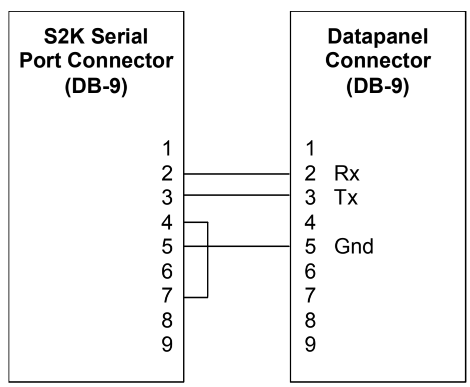

Figure 9-3. RS-232 Serial Cable Wiring for Datapanel with DB-9 COM2 Connector

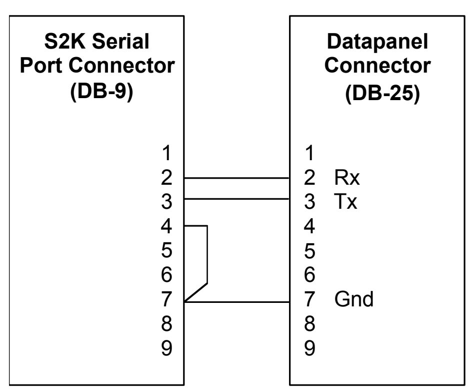

Figure 9-4. RS-232 Serial Cable Wiring for Datapanel with DB-25 COM2 Connector

9.3.1.4 ViewStation Serial Wiring

Connect the DB-9 connector to the serial ports. The figure below outlines cable pin outs. The same three-meter cable (IC800SKCS030) used to download a motion program using CIMPLICITY Machine Edition-Motion Developer can be used to communicate to a ViewStation. The DB-9 connector with the jumper is labeled IMC or OIP and must be connected to the S2K.

Follow manufacturer's instructions to connect and apply power to the ViewStation.

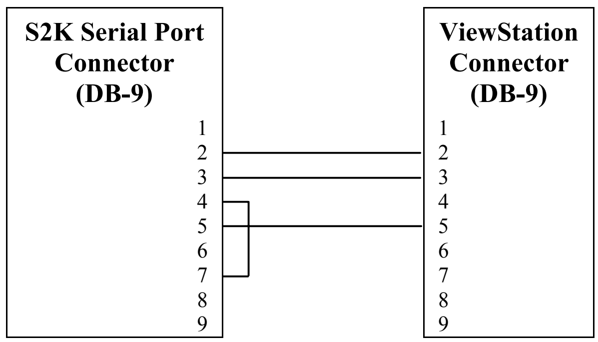

Figure 9-5. Serial Cable Wiring for ViewStation

9.3.2 Configure S2K Remote Terminal Unit (RTU) Communication

Place the following register settings into a program that executes automatically each time power is cycled to the controller, such as Program 4, the fault handling program, or another program that is executed from within Program 4 (see Section 9.3.6 – *Functionality Cautions*).

Note

If you set the following registers using the Motion Developer Terminal Window, your settings will be lost with each power cycle.

Table 9-2. Serial Port Configuration

Register	Setting	Description
BIT	N/A	Data bits. Setting RTU= ON forces BIT=8 while setting RTU=OFF forces BIT=7
PAR	ODD	Parity of serial port; odd is default value for all controllers
BAUD	19200	Serial port baud rate to manufacturer-recommended setting for RTU communication
RTU	ON	Enables RTU communication (see Chapter 5 for more details)

9.3.3 QuickPanel, Datapanel and ViewStation Configuration

This section includes separate procedures for configuring QuickPanel, Datapanel and ViewStation products from GE Fanuc. Please turn to the procedure that is appropriate for your application.

9.3.3.1 Procedure for QuickPanel Users

Install and run the *QuickDesigner* software. Then configure the QuickPanel using the procedure outlined below. QuickPanel RTU commands (tags) used in the QuickDesigner tool include: ID-Input Discrete, OD-Output Discrete, IR-Input Register, OR-Output Register, ILS-Input Register long signed, LS-Output Register long signed, IFR-Input Register float, FR-Output Register float and MS-text register.

Configure the New Project Screen

1. Click **New** to start a new project.
2. Enter a name for your project.
3. Select the QuickPanel model from the display device menu.
4. Click **OK**.

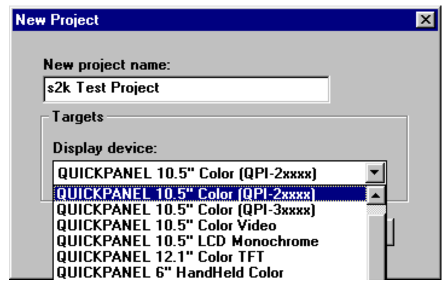

Figure 9-6. QuickDesigner New Project Screen

Configure the Project Setup Screen

1. Set PLC to Modicon Modbus.
2. Click ***Port…*** to open Serial Parameters Screen.

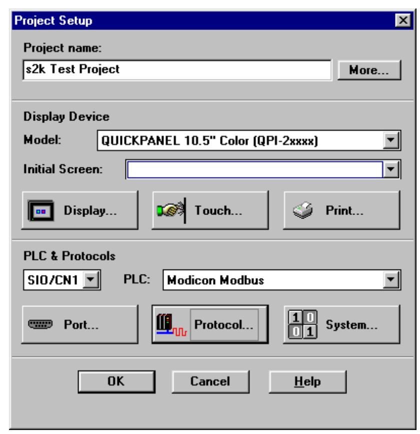

Figure 9-7. QuickDesigner Project Setup Screen

Configure the Serial Parameters Screen

1. Set Electrical format to **RS232C**
2. Set Baud rate to **19200**.
3. Set Data bits to **8**.
4. Set Parity to **Odd**.
5. Set Stop bits to **1**.
6. Click **OK** to return to Project Setup screen.
7. From Project Setup screen, click **Protocol…** to open Modicon Modbus (Serial) screen.

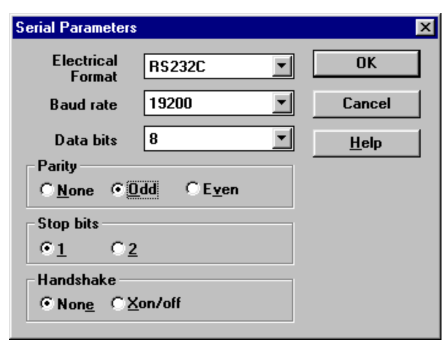

Figure 9-8. QuickDesigner Serial Parameters Screen

Configure the Modicon Modbus (Serial) Screen

1. Set PLC ID to **1**.
2. Set Float Storage Format and DWord Storage Format to **LSW-MSW**.
3. Click **OK**.
4. Click **OK** again to return to the Panel Manager screen.

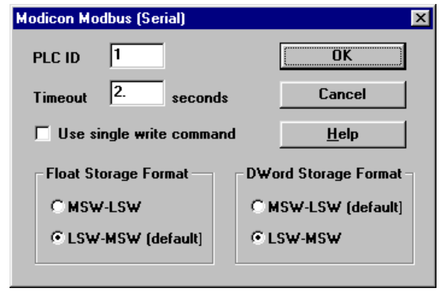

Figure 9-9. QuickDesigner Modicon Modbus Screen

The QuickPanel device driver is now configured and ready to communicate with the S2K controller. Turn to your QuickPanel documentation for instructions on creating read-only and editable panel objects that allow you to send commands, report data, and edit controller variables from the RTU touch screen. *Mapping Variables with Tag Numbers* in Section 9.3.4 details how the QuickPanel data types correspond with controller variables and tags.

9.3.3.2 Procedure for Datapanel Users

Install and run the DataDesigner software. Then configure the Datapanel using the procedure outlined below.

Configure the New Project Screen

1. Click *New* to start a new project.
2. Select the appropriate model from the Datapanel Type menu.
3. Enter a name for your project.
4. Click **OK**.

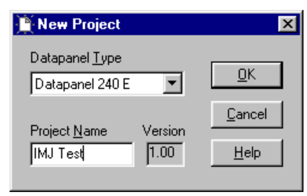

Figure 9-10. DataDesigner New Project Screen

Configure the Protocol and Port Settings Screen

1. Select Project/Project Type menu
2. Under the Protocol/Print tab, set the Channel A Protocol to **15: Modicon (RTU mode)**.
3. Click **Apply**.
4. Click the **Datapanel COM1** tab.
5. Set the Baud Rate to **19200**.
6. Set Data Bits to **8**.
7. Set Stop Bits to **1**.
8. Set Parity to **Odd**.
9. Click **OK**.

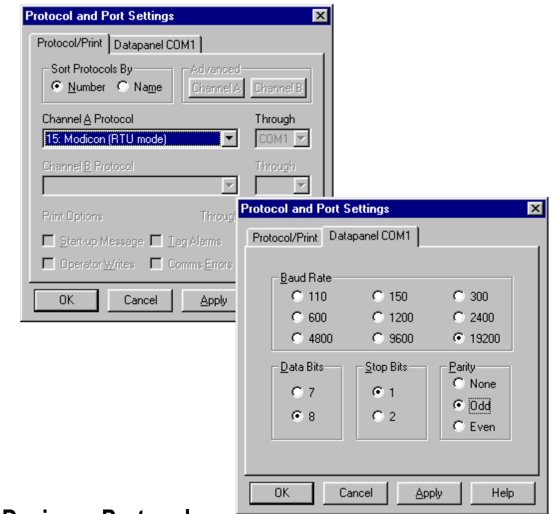

Figure 9-11. DataDesigner Protocol and Port Settings Screens

The Datapanel device driver is now configured and ready to communicate with the S2K controller. Turn to your Datapanel documentation for instructions on creating read-only and editable panel objects that allow you to send commands, report data, and edit controller variables from the RTU touch screen. *Mapping Variables with Tag Numbers* in Section 9.3.4 details how the Datapanel data types correspond with controller variables and tags.

9.3.3.3 Procedure for ViewStation Users

1. Create a ViewStation target on your machine using the CIMPLICITY Machine Edition – VIEW software. This may be various CE or NT target types.
2. Enter the name of your project.

Once the project is open, you can configure the Modbus driver.

3. Under the PLC Access tab, right click and choose "New Driver"
4. Choose Modbus
5. Configure the Modbus setting to the following:

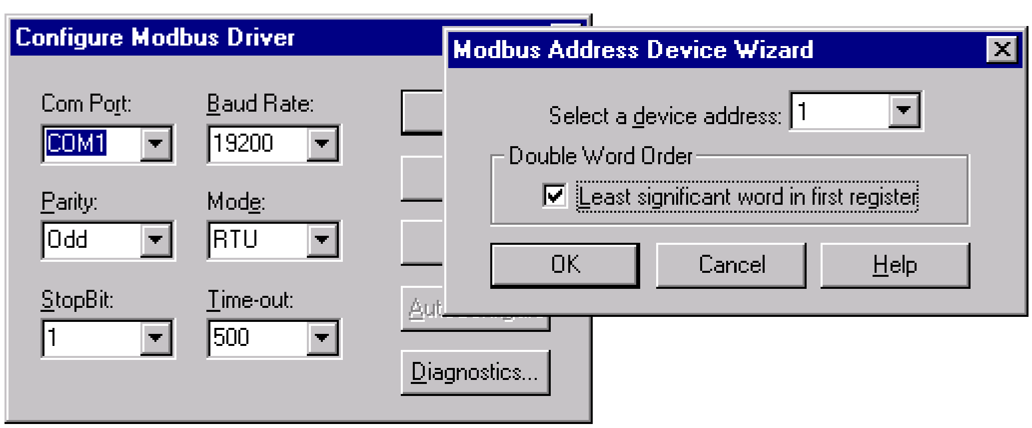

Figure 9-12. ViewStation Modbus Driver Configuration Screen

6. Ensure the device address is set to “1”. The Modbus slave address is hard coded to 1 on the motion controller. Select the “Least significant word in first register” checkbox as well.

The ViewStation is now ready to communicate to the S2K. You now have to create variables within the ViewStation target that will communicate to the motion controller.

To make the RTU addressing work appropriately, always use the complete S2K RTU data address and the View address type specified in Table 9-3. An example: To create a View variable that will access a floating point variable [VF2] in the S2K controller, create a PLC Access variable that references the device you set up with the Modbus driver and address type 8 (R/W) Float and S2K data address 40002 (for controller address floating point value VF2). Once configured this will allow the ViewStation to read and write data to this [VF2] address.

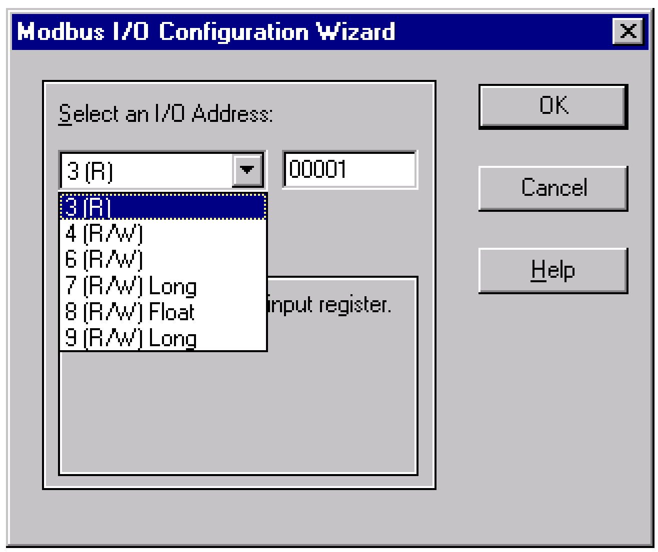

Figure 9-13. ViewStation Modbus Address Setting Screen

9.3.4 Mapping S2K Variables with Tag Numbers

The ViewStation, QuickPanel and Datapanel support commands for single bits, 16-bit words, 32-bit double words, floating point numbers, and text data. The S2K controllers support those same commands in the form of Boolean, integer, floating point, and string variables. The following table has been created to map the RTU data types and addresses to the appropriate variables in the motion controller.

Table 9-3., RTU Data Types, OI Tags and Map of S2K Variables

Generic RTU Function Codes	GE Fanuc QuickPanel RTU Command	GE Fanuc DataPanel Table	GE Fanuc View Data Types	S2K RTU Data Address	S2K Controller Variables	Comments
01 – Read 05 – Write BOOL	ID, OD	CL	0 (R/W)	00001 to 00256	VB1 to VB256	Read may access multiple bits. Write is always single bit.
03 – Read 06 – Write 16-bit INT	IR, OR	HR	4 (R/W)	00001 to 04096	VI1 to VI4096	Read may access multiple registers. Write is always a single register.
03 – Read 16 – Write 32-bit DINT	ILS, LS	HR	9 (R/W) Long	10001 to 14095	VI1 to VI4095	Command for Odd-numbered S2K Controller Variables
03 – Read 16 – Write 32-bit DINT	ILS, LS	HR	9 (R/W) Long	20002 to 24096	VI2 to VI4096	Command for Even-numbered S2K Controller Variables
03 – Read 16 – Write 32-bit REAL	IFR, FR	HR	8 (R/W) Float	30001 to 32047	VF1 to VF2047	Command for Odd-numbered S2K Controller Variables
03 – Read 16 – Write 32-bit REAL	IFR, FR	HR	8 (R/W) Float	40002 to 42048	VF2 to VF2048	Command for Even-numbered S2K Controller Variables
03 – Read STRING	MS (read only)	HR (read only)	4 (R/W)	50100 to 64400	VS1 to VS144	128 byte string maximum. (See Note)

Note

When accessing strings, the S2K data address must increment by 100 i.e., 50100 (VS1), 50200 (VS2), 50300 (VS3) … 64300 (VS143), 64400 (VS144). The S2K string variables are read only via RTU protocol.

9.3.5 Cautions for Shared Variable Space

The 16-bit INT commands read and write to the same S2K variable space as the 32-bit DINT commands, making it possible to overwrite data. For example, if the QuickPanel OR1 tag writes to VI1 and the LS10001 tag subsequently writes to VI1, the data written via the OR1 tag will be lost.

9.3.6 Functional Considerations

The S2K programmable RTUF flag can be used by your program to monitor for successful RTU communications. See details for this register in Chapter 5.

Motor noise in the serial cable can interfere with the transfer, or download, of the controller file to the Datapanel or QuickPanel. To avoid this problem, consider disabling your motor before attempting to transfer a file to the Datapanel or QuickPanel, or try different grounding schemes for the serial cable to minimize noise.

Always design your S2K programs to include the hardware permissive, such as the Enable input, which must be set true before the Program 4 fault-handling code will reset faults and restart the main program. Failure to observe this recommendation could result in the controller being stuck in an endless loop if a runtime error occurs in the main program. This error will cause Program 4 to execute, which would then reset faults and restart the main program, which would fault again on the same runtime error. When not in RTU mode the normal procedure to break out of a repeating loop is to repeatedly type KLALL <Enter> in the Motion Developer Terminal Window. However, with RTU mode enabled the Motion Developer Terminal Window can no longer communicate with the controller since it requires standard ASCII serial communications. If you find yourself in this dilemma, try configuring Windows Hyper Terminal for the bit, parity and baud rate shown in Table 9-3 above and set Emulation to Auto Detect. Then try quickly and repeatedly typing KLALL <Enter> to interrupt the program loop. If this fails you will have to return the S2K unit to the factory to have the flash memory replaced.

A sample method of dealing with the RTU to ASCII mode selection is to have Program 1 enable the RTU protocol and have Program 4 (the fault handler) disable RTU and set serial port settings for the Motion Developer interface.

Note

For the S2K firmware version 2.2 and later. Once ten illegal RTU characters are received in a row, the RTU flag is automatically set to zero. Receiving a valid RTU character or cycling the power resets the error counter. Once in this state, the RTU=1 command will not change RTU i.e., it will be maintained at 0 until the power is cycled. The indication that the controller is in this state is that the value of RTU will always be 0 regardless of any attempt to set it to 1. To break the loop, connect a terminal to the S2K, send 10 (or more) characters to disable RTU then type KLALL to stop the program execution. (KLALL does successfully interrupt the program in the example.) It is no hardship to connect a terminal: the user will have to repair the program anyway.

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Chapter 10 PROFIBUS Communications

10.1 PROFIBUS Network Overview

- PROFIBUS is an open, vendor-independent fieldbus standard for a wide range of applications in industrial automation, including motion control.
- PROFIBUS is a dynamic technology that grows functionally while complying with the European Fieldbus Standard EN 50 170.
- PROFIBUS Guidelines and Profiles provide the means for further technical development based on the ever-changing communication requirements of the networks, systems, and devices used in today's industrial automation applications.

PROFIBUS specifications reference three different protocols to cover a range of industrial requirements:

PROFIBUS – DP	High speed data communication. DP stands for *Decentralized Periphery*. In practice, the majority of slave applications are DP applications. The GE Fanuc S2K Motion Controller is a PROFIBUS-DP Slave device.
PROFIBUS – FMS	Object oriented general-purpose data communication. FMS stands for *Fieldbus Message Specification*. FMS protocol devices may exchange data on the same bus used for DP devices.
PROFIBUS – PA	Meets requirements for intrinsic safety and non-intrinsic safety areas and includes bus-powered field devices.

The PROFIBUS logo is a trademark of the PROFIBUS International Organization. Membership in the organization is open to all individuals, companies and organizations. More information about the organization and the protocol is available at http://www.profibus.com

10.1.1 Bus Communication

The PROFIBUS specification defines the technical characteristics of a serial field bus system that links distributed digital controllers on the network, from field level to cell level. PROFIBUS is a multi-master system that allows the joint operation of several automation, engineering or visualization systems with their distributed peripherals on one bus. PROFIBUS distinguishes between the following types of devices:

- **Master devices** determine the data communication on the bus. A master can send messages without an external request when it holds the bus access rights (the token). Masters are also called active stations.
- **Slave devices** include motion controllers, drives, I/O devices, valves, and transducers. Slaves do not have bus access rights and can only acknowledge received messages or send messages to the master when requested to do so. Slave devices are passive stations and require only small portions of the bus protocol.

The majority of PROFIBUS-DP applications are located at the field level. The field level typically includes slave devices (i.e., the S2K motion controller station) and host devices such as PLC or PC control systems for the PROFIBUS-DP master station. Operator interfaces and DCS type systems usually operate at the cell level.

Table 10-1. Data Bandwidth Demands on PROFIBUS Communications Systems

Level	Amount of Data	Transmission Duration	Transmission Frequency
Management level	Mbytes	Hours/Minutes	Day/Shift
Cell level	Kbytes	Seconds	Hours/Minutes
Field Level	Bytes	Several 100 µseconds to 100 milliseconds	10 to 100 milliseconds
Actuator sensor level	Bits	µsec to milliseconds	Milliseconds

10.1.2 Network Topology

A PROFIBUS-DP network may have up to 127 stations (address 0–126), however, address 126 is reserved for commissioning purposes. The bus system must be sub-divided into individual segments to handle this many participants. These segments are linked by repeaters. The function of a repeater is to condition the serial signal to allow connection of segments. In practice, both regenerating and non-regenerating repeaters may be used. Regenerating repeaters actually condition the signal to allow increased range of the bus. *Up to 32 stations are allowed per segment and the repeater counts as a station address.*

A specialized "link" segment consisting only of optical fiber modem repeaters may be used to span long distances. Plastic fiber optic segments are typically 50 meters or less while glass fiber optic segments may extend several kilometers.

The user assigns a unique PROFIBUS station address to identify each master, slave, or repeater in the entire network. Each participant on the bus must have a unique station address.

Network addresses for the GE Fanuc S2K products are established using the DIP switches located on the bottom of the controller. *The GE Fanuc S2K controllers accommodate addresses 0 – 99.*

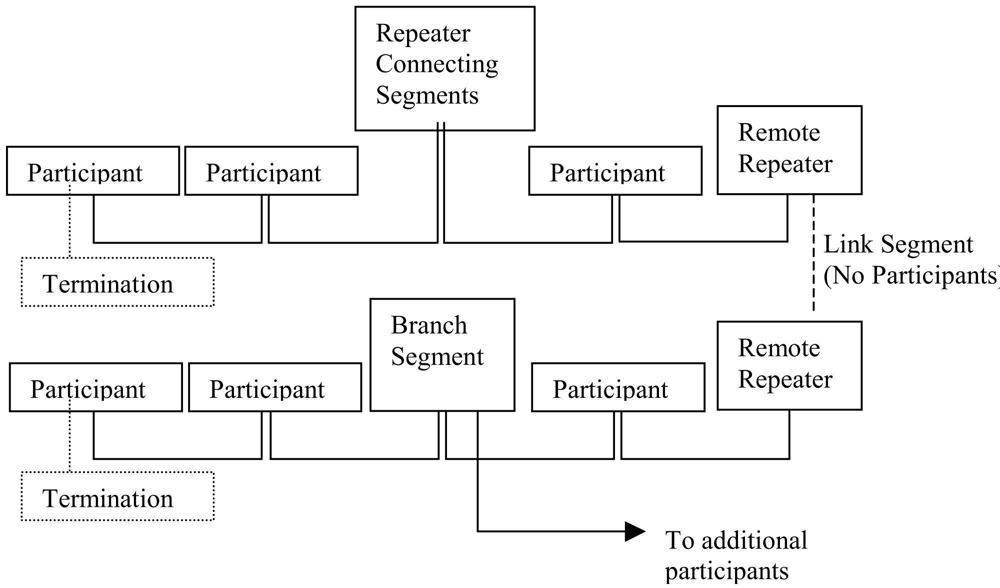


Figure 10-1. Repeaters and bus termination

10.1.3 Network Segment Length

PROFIBUS uses either fiber optic or RS-485 copper media. The copper bus line specified in EN 50 170 is “Line Type A” and is the recommended cable type. A more economical copper cable “Line Type B” is commonly used for smaller installations, however, is not specified in EN 50 170. It is extremely important to use cable rated to PROFIBUS specifications. The higher the baud rate selected and the longer the distances involved the more critical cable selection becomes. You will recognize the distinctive purple color of PROFIBUS cable.

Stub or “T” type branch connections are supported if the total stub (branch) lengths do not exceed 6.6 meters. Do not use stubs at all on 12 Mbaud networks.

The data rates for network communication with maximum segment trunk length per cable type are provided below. Multiple segments may be connected via repeater stations to extend the total bus length.

Table 10-2. Network Data Rates and Segment Distance Limitations

Data Rates	9600 baud 19.2 Kbaud 93.75 Kbaud	187.5 Kbaud	500 Kbaud	1,500 Kbaud	3,000 Kbaud 6,000 Kbaud 12 Mbaud
Trunk distance: Line Type A RS-485 Copper	1.2 km (~3,937 ft)	1,000 m (~3,280 ft)	400 m (~1,312 ft)	200 m (~656 ft)	100 m (~328 ft)
Trunk distance: Line Type B RS-485 Copper	1.2 km (~3,937 ft)	600 m (~1,968 ft)	200 m (~656 ft)	N/A	N/A
Trunk Distance: (glass) Fiber	@ 6 km (~19,685 ft)				

10.1.4 Network connectors

PROFIBUS connections are created with a 9 pin sub-D connector. A minimum connection is to use a shielded pair of wires (Pins 1, 3 and 8) with terminating connections in the appropriate bus plugs. The pin to signal conventions are described below.

Table 10-3. Plug Connector Pin Allocation of the PROFIBUS Bus Plug Connector

Pin No.	Signal	Designation
1	Shield	Shield / Protective Ground
2	M24	Ground / Common of the 24 V output voltage
3	RxD/TxD-P	Receive data / transmission data plus
4	CNTR-P	Control signal for repeaters (direction control)
5	DGND	Data transmission potential (ground to 5V)
6	VP	Supply voltage of the terminating resistance (+ 5 V)
7	P24	Output voltage (+ 24 V)
8	RxD/TxD-N	Receive data / transmission data negative
9	CNTR-N	Control signal for repeaters (direction control)

10.1.5 Network Termination

The bus must be terminated at both ends of the trunk line. Commercially available plug connectors may have built in terminating resistors or you may build your own.

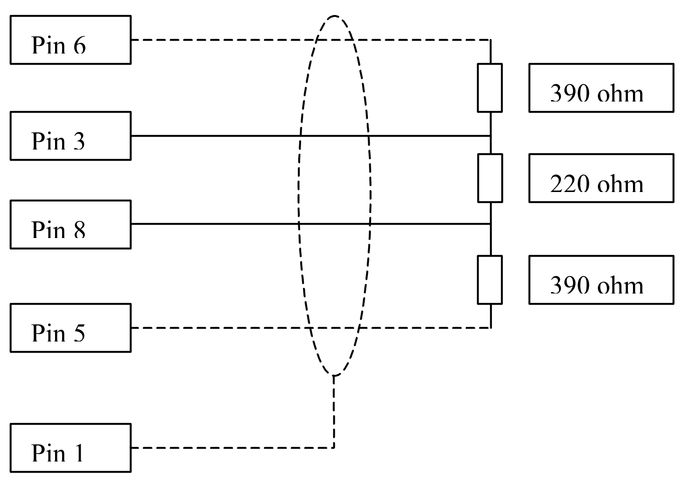


Figure 10-2. Bus Termination for Type A cable in accordance to PROFIBUS specifications

10.1.6 Network Baud Rate

The master configures the appropriate network baud for each station on the network. Allowed values for S2K network baud rates are: 9,600; 19,200; 45,450; 93,750; 187,500; 500,000; 1,500,000; 3,000,000; 6,000,000; or 12,000,000.

10.2 Getting Started

The following information is intended to outline the steps required to commission a S2K and incorporate it into a PROFIBUS network segment.

10.2.1 Connection Checklist

GE Fanuc-Supplied Components

- ☐ 1 S2K controller with PROFIBUS per axis
- ☐ 1 motor per axis
- ☐ Cables
- ☐ CIMPLICITY Motion Developer software

User-Supplied Components

- ☐ DC power to digital I/O
- ☐ 16-gauge wire to jumper I/O connectors
- ☐ PROFIBUS network hardware

10.2.2 Complete Basic Set-up Procedure

Before you connect and use your S2K controller on PROFIBUS, take a few minutes to complete the Process for Basic Set-up located in Chapter 4.

The set-up process takes you systematically through each of the following items:

- Install software
- Connect cables
- Jumper dedicated I/O (if applicable)
- Establish communication with the controller
- Complete basic equipment configuration
- Run the motor to verify correct set-up.

If you are using multiple S2K controllers, repeat the set-up for each controller. When you have completed the set-up, leave your connections and jumpers in place—you're ready to configure your PROFIBUS system.

To operate S2K Controllers for PROFIBUS, the S2K controller requires some simple network configuration before being used.

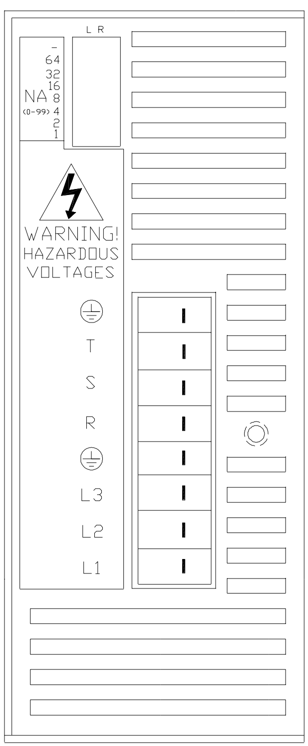
Step 1: Set the PROFIBUS Address

The PROFIBUS address provides a unique network address, from 0 through 99, for each S2K node. S2K controllers ship from the factory with the PROFIBUS address set to one.

Caution: Ensure that controller power is off before you handle DIP switches.

Use the DIP switches located on the bottom of the controller to set the PROFIBUS address to a network address indicated in figure 10-4.

Figure 10-3 shows the location of the controller switches and the proper orientation for left and right switch settings.



BOTTOM VIEW

Figure 10-4. Location of DIP Switches on Bottom of S2K Controller

DIP Switch Positions (2)

Profibus Address		1	2	4	8	16	32
(NA) 0	64	R	R	R	R	R	R
1	65	L	R	R	R	R	R
2	66	R	L	R	R	R	R
3	67	L	L	R	R	R	R
4	68	R	R	L	R	R	R
5	69	L	R	L	R	R	R
6	70	R	L	L	R	R	R
7	71	L	L	L	R	R	R
8	72	R	R	R	L	R	R
9	73	L	R	R	L	R	R
10	74	R	L	R	L	R	R
11	75	L	L	R	L	R	R
12	76	R	R	L	L	R	R
13	77	L	R	L	L	R	R
14	78	R	L	L	L	R	R
15	79	L	L	L	L	R	R
16	80	R	R	R	R	L	R
17	81	L	R	R	R	L	R
18	82	R	L	R	R	L	R
19	83	L	L	R	R	L	R
20	84	R	R	L	R	L	R
21	85	L	R	L	R	L	R
22	86	R	L	L	R	L	R
23	87	L	L	L	R	L	R
24	88	R	R	R	L	L	R
25	89	L	R	R	L	L	R
26	90	R	L	R	L	L	R
27	91	L	L	R	L	L	R
28	92	R	R	L	L	L	R
29	93	L	R	L	L	L	R
30	94	R	L	L	L	L	R
31	95	L	L	L	L	L	R
32	96	R	R	R	R	R	L
33	97	L	R	R	R	R	L
34	98	R	L	R	R	R	L
35	99	L	L	R	R	R	L
36	–	R	R	L	R	R	L
37	–	L	R	L	R	R	L
38	–	R	L	L	R	R	L
39	–	L	L	L	R	R	L
40	–	R	R	R	L	R	L
41	–	L	R	R	L	R	L
42	–	R	L	R	L	R	L
43	–	L	L	R	L	R	L
44	–	R	R	L	L	R	L
45	–	L	R	L	L	R	L
46	–	R	L	L	L	R	L
47	–	L	L	L	L	R	L
48	–	R	R	R	R	L	L
49	–	L	R	R	R	L	L
50	–	R	L	R	R	L	L
51	–	L	L	R	R	L	L
52	–	R	R	L	R	L	L
53	–	L	R	L	R	L	L
54	–	R	L	L	R	L	L
55	–	L	L	L	R	L	L
56	–	R	R	R	L	L	L
57	–	L	R	R	L	L	L
58	–	R	L	R	L	L	L
59	–	L	L	R	L	L	L
60	–	R	R	L	L	L	L
61	–	L	R	L	L	L	L
62	–	R	L	L	L	L	L
63	–	L	L	L	L	L	L

Profibus address	64	–
0–63	R	X
64–99	L	X

Figure 10-3. S2K DIP Switch PROFIBUS Address Settings

Step 2: Configure Master to Add Slave to the Network

PROFIBUS-DP systems accept S2K controllers as slaves to a network master. The network master automatically sets the network data rate for the S2K controllers that have been properly configured and connected to the network.

A device electronic data sheet or GSD file for the S2K Motion Controller is available from GE Fanuc to expedite the master configuration. A GSD file contains information to specify methods of communication and types of messaging available. Most PROFIBUS master configuration tools require the GSD file in order to operate.

10.2.3 The GSD File Data for the S2K Motion Controller

```
;=======================================================
; GSD File Standalone Motion Controller
;
; Version:  V1.0
;=======================================================
#PROFIBUS_DP
GSD_Revision        = 1

;General parameters
Vendor_Name         = "GE Fanuc"
Model_Name          = "Standalone Motion Controller"
Revision            = "V1.0"
Ident_Number        = 0x05E9
Protocol_Ident      = 0
Station_Type        = 0
FMS_supp            = 0
Hardware_Release    = "D"
Software_Release    = "V1.0"
9.6_supp            = 1
19.2_supp           = 1
45.45_supp          = 1
93.75_supp          = 1
187.5_supp          = 1
500_supp            = 1
1.5M_supp           = 1
3M_supp             = 1
6M_supp             = 1
12M_supp            = 1
MaxTsdr_9.6         = 60
MaxTsdr_19.2        = 60
MaxTsdr_45.45       = 250
MaxTsdr_93.75       = 60
MaxTsdr_187.5       = 60
MaxTsdr_500         = 100
MaxTsdr_1.5M        = 150
MaxTsdr_3M          = 250
MaxTsdr_6M          = 450
```

```
MaxTsdr_12M         = 800
Redundancy          = 0
Repeater_Ctrl_Sig    = 2
24V_Pins            = 0
Implementation_Type  = "DPC31"

; Slave-Specification:
Freeze_Mode_supp     = 1
Sync_Mode_supp       = 1
Auto_Baud_supp       = 1
Set_Slave_Add_Supp   = 0
User_Prm_Data_Len    = 3              ; 3 bytes for DPV1
User_Prm_Data        = 0x00,0x00,0x00
Fail_Safe            = 1
Min_Slave_Interval  = 1
Max_Diag_Data_Len    = 6
Modul_Offset         = 0
Slave_Family         = 1       ; Drive Family
Modular_Station      = 1
Max_Module           = 1     ; Only one module at a time
Max_Input_Len        = 20  ; 20 bytes input data
Max_Output_Len       = 20; + 20 bytes output data
Max_Data_Len         = 40  ; = 40 bytes I/O data

; Module Definition List
;
; PPO Type 1 (PKW 4 words, PZD 2 words)
;
Module = "PPO-Type 1" 0xF3, 0xF1
EndModule
;
; PPO Type 2 (PKW 4 words, PZD 6 words)
;
Module = "PPO-Type 2" 0xF3, 0xF5
EndModule
;
; PPO Type 3 (PZD 2 words)
;
Module = "PPO-Type 3" 0xF1
EndModule
;
; PPO Type 4 (PZD 6 words)
;
Module = "PPO-Type 4" 0xF5
EndModule
```

10.3 Overview of Master/Slave Station Types

The PROFIBUS-DP protocol defines two station types: Masters and Slaves. Masters form the logical token ring and may access the medium while holding the token. Masters initiate message cycles to other stations. There are two classes of master devices. The class 1 master handles the data exchange with slaves assigned to it. The class 2 master is provided for configuration purposes and may briefly take over control of a given slave device. Commonly only a class 1 master (mono master) is used for configuration and data messaging.

During startup, the master sets up the communication connections to the configured slave list and begins the cyclic polling process. A monitoring time is established and if communication is not possible, an error in communications is reported. This monitoring time is reset on each successful message transfer. Slave stations are configured and added to the messaging sequence from lowest address to highest address.

Slaves act neutrally with respect to medium access and respond to requests from master stations only within a message cycle. All slaves have the same priority for bus access. When a slave detects a loss of communication, it sets outputs to a known state and waits for a configuration message from a master station.

S2K motion controllers serve as slaves on a PROFIBUS-DP network.

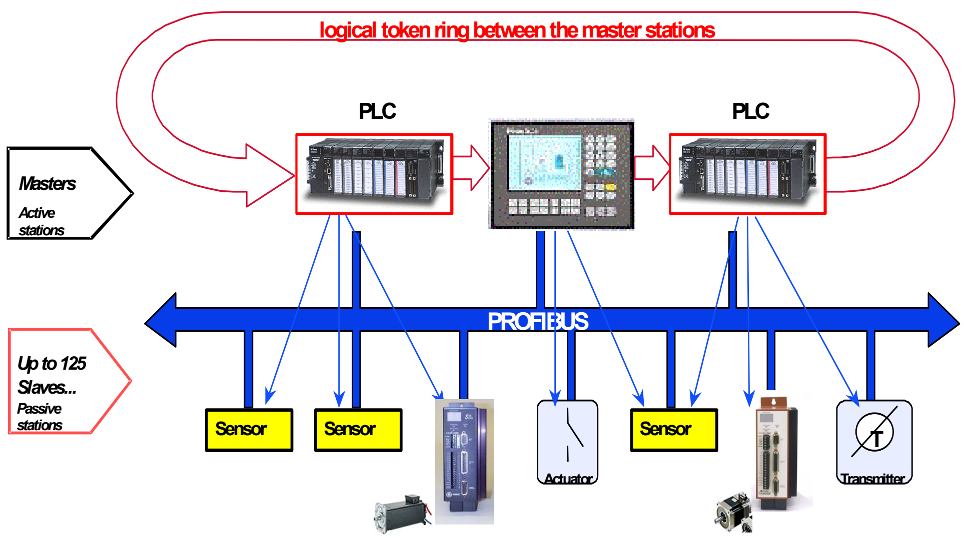


Figure 10-5. PROFIBUS Master/Slave Network Architecture

10.3.1 PROFIBUS Communication

S2K's communicate via cyclic data transfer, the process by which process data (PZD) and parameters (PKW) are transferred from master to slave and from slave to master. GE Fanuc S2K motion controllers use the PROFIBUS profile's Type 2 Octet-String 20—the 20-byte data string.

When writing data, the master transfers process data (control word and setpoints) and tasks for parameter processing to the slave. When the data are read, the master retrieves process data (status word and actual values) and responses from parameter processing.

10.3.2 Global Control for PROFIBUS-DP

The PROFIBUS-DP "global control" mechanism can be used when slave coordination requirements are high. For example, when setpoints must be switched or specified simultaneously.

In addition to the node-related user data communication, the masters can send control commands simultaneously to one slave, a group of slaves (Multicast) or all slaves (Broadcast). These global control commands can be used for event-controlled synchronization of the slaves. The master establishes the global commands to use and assigns the global group number to the slaves during the configuration message.

Typical global commands are “clear data” to establish a known output state on fault, the “freeze” message to coordinate the reading of the inputs and the “sync” message to coordinate switching of outputs. There is additionally an unfreeze and unsync command to restore the station to normal messaging.

The S2K Motion Controller supports global messages: *clear data, auto baud, freeze/unfreeze* and *sync/unsync*. The global message *change address* is not supported. The S2K station address is set via DIP switches.

10.3.3 Output Data Words

The format for the 20 bytes of data the PROFIBUS-DP master will write to the S2K motion controller is described in the following table. This format conforms to the user profile group PROFIDrive 0302hex (indicates Version 2, Application Class 3). User profile groups promote operability between products created by different vendors and allow users to interchange products.

The *Parameter Channel* (PKW), composed of the first four data words (eight bytes), is used with the appropriate *Task ID* and *Parameter Number* (PNU) to access variable and register data in the S2K on an as needed basis.

The *Process Data Channel* (PZD), composed of two to six words, is used to operate the axis and is always active.

The message (telegram) actually transmitted to the S2K will take one of the following supported message forms depending on the settings in the Task ID and Control Word (STW):

- PPO-Type 1 message consisting of 4 PKW words and 2 PZD words (PZD – words 5 and 6).
- PPO-Type 2 message consisting of 4 PKW words and 6 PZD words.
- PPO-Type 3 message consisting of 0 PKW words and 2 PZD words (PZD – words 5 and 6).
- PPO-Type 4 message consisting of 0 PKW words and 6 PZD words.

Table 10-4. PROFIBUS-DP Output Data Words for S2K Motion Controllers

<table>
<tr><th></th><th>Output Word</th><th>Bit 15</th><th>Bit 14</th><th>Bit 13</th><th>Bit 12</th><th>Bit 11</th><th>Bit 10</th><th>Bit 9</th><th>Bit 8</th><th>Bit 7</th><th>Bit 6</th><th>Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th></tr>
<tr><td rowspan="4">PKW</td><td>1</td><td colspan="4">Task ID</td><td>Res</td><td colspan="11">Parameter Number (PNU)</td></tr>
<tr><td>2</td><td colspan="8">Index</td><td colspan="8">Reserved</td></tr>
<tr><td>3</td><td colspan="16">Parameter Value MSW</td></tr>
<tr><td>4</td><td colspan="16">Parameter Value LSW</td></tr>
<tr><td rowspan="7">PZD</td><td>5</td><td colspan="16">Control Word (STW)</td></tr>
<tr><td rowspan="2">6</td><td colspan="8">Digital Outputs</td><td colspan="8" rowspan="2">Motion Block to Execute</td></tr>
<tr><td>Res</td><td>Res</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td></tr>
<tr><td>7</td><td colspan="16">Velocity Setpoint MSW</td></tr>
<tr><td>8</td><td colspan="16">Velocity Setpoint LSW</td></tr>
<tr><td>9</td><td colspan="16">Position Setpoint MSW</td></tr>
<tr><td>10</td><td colspan="16">Position Setpoint LSW</td></tr>
</table>

Res = Reserved

10.3.3.1 Parameter Channel Task ID

The Task ID defines the functions available in the parameter channel (PKW) and sets behavior for the PKW messaging. Setting Task ID equal to zero effectively shuts down the parameter channel and causes the remainder of the channel to be void.

Table 10-5. Available Output Word Task IDs

Task ID	Function
0	No task
1	Request parameter value
2	Change parameter value (word)
3	Change parameter value (double word)
4	Reserved
5	Reserved
6	Request parameter value (array)
7	Change parameter value (array word)
8	Change parameter value (array double word)
9	Request number of array elements
10–15	Reserved

10.3.3.2 Parameter Number (PNU)

The Parameter Number (PNU) allows you to read and write specific registers and variables of the S2K controller. PROFIBUS-DP parameters fit into two data classes: cyclic and acyclic.

Cyclic data communicate set points and actual values for parameters that frequently change, such as speed, and position. Cyclic data is contained in the process data channel (PZD). Cyclic parameters use low quantities of data (from 16 to 32 bits) and require a short cycle time of a few milliseconds. Cyclic data exchange is efficient and has the following characteristics:

- Devices produce data at a user-configured rate
- Devices that need more bandwidth can get it
- Data are sampled at precise intervals for better determinism

Acyclic data are those parameters that seldom change, like minimum and maximum speed limits. Acyclic data is transferred over the parameter channel (PKW). Parameters that require higher quantities of data use *acyclic* data exchange.

Table 10-6. PROFIBUS Parameter Number (PNU) List for S2K

PNU	Parameter	S2K Equivalent Register	Valid Access Modes	Data Type	Description
1	Command Position	PSC	RO	integer32	Command position of the axis.
2	Actual Position	PSA	RW	integer32	Real position in pulses. Set to redefine actual position.
3	Actual Velocity	VLA	RO	integer32	Actual velocity in pulses/sec.
4	Following Error	FE	RO	integer16	Axis following error is the difference between the axis position (PSA) and the command position (PSC).
5	Current Command	CMD	RO	integer16	Position controller command output, used to control the position of the axis (where 1000 = full continuous current setting).
6–19	Reserved				
20	Position Setpoint	MPA/MPI	RW	integer32	Profile move position defined in pulses.
21	Velocity Setpoint	MVL	RW	integer32	Defines motion velocity of the axis. Signed quantity in speed control mode automatically determines the direction of the move.
22	Acceleration	MAC	RW	unsigned32	Profile acceleration rate defined in pulses/second^2.
23	Deceleration	MDC	RW	unsigned32	Profile deceleration rate defined in pulses/second^2.
24	Jerk	MJK	RW	unsigned16	Percentage of acceleration/deceleration time that the axis will jerk limit.
25	Jog Velocity One	MVL	RW	integer32	Defines motion velocity of the axis while jogging one. Signed quantity automatically determines the direction of the jog.
26	Jog Acceleration/Deceleration One	MAC, MDC	RW	unsigned32	Defines acceleration/deceleration rate in pulses/second^2 while jogging one.
27	Jog Velocity Two	MVL	RW	integer32	Defines motion velocity of the axis while jogging two. Signed quantity automatically determines the direction of the jog.
28	Jog Acceleration/Deceleration Two	MAC, MDC	RW	unsigned32	Defines acceleration/deceleration rate in pulses/second^2 while jogging two.
29	Reference Position		RW	integer32	Set actual position (PSA) to this value when Referencing finishes.
30	Reference Velocity		RW	integer32	Set velocity (MVL) to this value during Referencing while in position control mode. Signed quantity automatically determines the direction of the move.
31	Marker Velocity		RW	integer16	Defines the motion velocity (MVM) of the axis when running to a marker input (RMF or RMR). Signed quantity automatically determines the direction of the move. Maximum value 4096 pulses/sec.

PNU	Parameter	S2K Equivalent Register	Valid Access Modes	Data Type	Description
32	Reference Acceleration/Deceleration		RW	unsigned32	Defines acceleration/deceleration rate in pulses/sec^2 while referencing.
33	Reference Position Type	*RMF, RMR, RHF, RHR, ROF, ROR*	RW	unsigned16	Establishes the type of homing move to execute. Home to: 0=Home input, 1=Marker input, 2=OT input
34	Torque Limit	TLC	RW	unsigned16	Output torque limit; set value to limit torque when torque limit is enabled. 1000 = 100% full continuous current setting.
35	Torque Limit Enable	TLE	RW	Boolean	Set to FFhex to enable torque limit; set to 0 to disable torque limit.
36–49	Reserved				
50	Motor Direction for Forward moves	DIR	RW	unsigned16	Defines direction: 0=CW forward direction, 1=CCW forward direction, as viewed from the load end of the motor shaft.
51	Position Length	PLA	RW	unsigned32	Defines axis position length (value is half the axis position register length).
52	Position Wrap Enable	PWE	RW	Boolean	Determines whether position register wrap is enabled: FFhex = enabled; 0 = disabled.
53	Overtravel Input Enable	OTE	RW	Boolean	Determines whether hardware overtravel inputs are enabled: FFhex = enabled; 0 = disable.
54	Forward Software Overtravel	OTF	RW	integer32	Defines forward software overtravel limit for the axis in pulses.
55	Reverse Software Overtravel	OTR	RW	integer32	Defines reverse software overtravel limit for the axis in pulses.
56	Following Error Bound	FEB	RW	unsigned16	Limit set on the following error in pulses. System faults when limit is exceeded.
57	In-position Band	IPB	RW	unsigned16	Defines maximum amount of position error in pulses that the axis can have and still be in position.
58	Motor Feedback Resolution	FR	RW	unsigned32	Number of actual position feedback pulses in one revolution of the motor. Set value to a positive number only.
59	Commutation Ratio	CMR	RW	unsigned16	Motor poles to resolver poles commutation ratio. One of the motor constants needed to operate a resolver feedback servo motor. This value, along with the value of CMO, can be set automatically by the MOTORSET command.
60	Commutation Offset	CMO	RW	integer16	Commutation angle offset. Set by the motor manufacturer. This value, along with the value of CMR, can be set automatically by the MOTORSET command.
61	Continuous Current	CURC	RW	unsigned16	Continuous current limits the current that the drive will continuously supply to the motor. It is a percentage of the maximum continuous current rating of the drive times ten.
62	Peak Current	CURP	RW	unsigned16	Limits the peak value of the current that the drive will supply to the motor. It is a percentage of the maximum peak current rating of the drive times ten. Servo motor controllers only.
63	Power Save Current	CURS	RW	unsigned16	The power save current is used to reduce motor heating when the axis is stopped. While the axis is in position, the continuous current value, CURC, is reduced to the percentage loaded into CURS. The percentage is times ten. Stepping motor controllers only.

PNU	Parameter	S2K Equivalent Register	Valid Access Modes	Data Type	Description
64	Proportional Gain	KP	RW	unsigned16	The position loop proportional control gain is used to multiply the following error to control the position of the axis. Set automatically by the AUTOTUNE command.
65	Integral Gain	KI	RW	unsigned16	The position loop integral control gain is used to multiply the time integral of the following error to control the position of the axis. Set automatically by the AUTOTUNE command.
66	Derivative Gain	KD	RW	unsigned16	The position loop derivative control gain is used to multiply the time derivative of the following error to control the position of the axis. Set automatically by the AUTOTUNE command.
67	Acceleration Feed Forward	KA	RW	unsigned16	The acceleration feedforward constant is used to reduce following error during acceleration or deceleration. Set automatically by the AUTOTUNE command.
68	Filter Time Constant	KT	RW	unsigned16	Filter time constant is used to eliminate dither. Set automatically by the AUTOTUNE command.
69	Motor Inductance	KL	RW	unsigned16	Tunes the digital current controller to the attached motor.
70	Stepping Motor Number	KM	RW	unsigned16	Tunes the controller to provide optimum performance for the attached stepper motor.
71	Output Control		RW	v2	0 = output is not under PROFIBUS control; 1 = output is under PROFIBUS control. Bit-wise control for each of outputs 9 – 14.
*** 72**	Feedback Resolution For Commutation	FRC	RW	unsigned32	The feedback resolution of the main encoder used to commutate the motor. Equal to the number of encoder pulses per revolution of the motor (100–64,000).
*** 73**	Direction of Auxiliary Position	DIRX	RW	unsigned16	This register controls the relative direction of the auxiliary position as routed through the PSX register (0=Clockwise, 1 = Counter Clockwise).
74–89	Reserved				
90	Integer variables (1–100)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 1 through 100.
91	Integer variables (101–200)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 101 through 200.
92	Integer variables (201–300)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 201 through 300.
93	Integer variables (301–400)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 301 through 400.
94	Integer variables (401–500)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 401 through 500.
95	Integer variables (501–600)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 501 through 600.
96	Integer variables (601–700)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 601 through 700.
97	Integer variables (701–800)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 701 through 800.
98	Integer variables (801–900)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 801 through 900.
99	Integer variables (901–1000)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 901 through 1000.
100	Integer variables (1001–1100)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 1001 through 1100.
101	Integer variables (1101–1200)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 1101 through 1200.

PNU	Parameter	S2K Equivalent Register	Valid Access Modes	Data Type	Description
102	Integer variables (1201–1300)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 1200 through 1300.
103	Integer variables (1301–1400)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 1301 through 1400.
104	Integer variables (1401–1500)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 1401 through 1500.
105	Integer variables (1501–1600)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 1601 through 1700.
106	Integer variables (1601–1700)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 1601 through 1700.
107	Integer variables (1701–1800)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 1701 through 1800.
108	Integer variables (1801–1900)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 1801 through 1900.
109	Integer variables (1901–2000)	VI	RW	array [100] integer32	Value from –2,147,483,648 to +2,147,483,647 for integer variables 1901 through 200.
110	Floating point variables (1–100)	VF	RW	array [100] floating point	Absolute value from 1.5 x 10^{-39} to 1.7 x 10^{38} for floating point variables 1 through 100.
111	Floating point variables (101–200)	VF	RW	array [100] floating point	Absolute value from 1.5 x 10^{-39} to 1.7 x 10^{38} for floating point variables 101 through 200.
112	Floating point variables (201–300)	VF	RW	array [100] floating point	Absolute value from 1.5 x 10^{-39} to 1.7 x 10^{38} for floating point variables 201 through 300.
113	Floating point variables (301–400)	VF	RW	array [100] floating point	Absolute value from 1.5 x 10^{-39} to 1.7 x 10^{38} for floating point variables 301 through 400.
114	Floating point variables (401–500)	VF	RW	array [100] floating point	Absolute value from 1.5 x 10^{-39} to 1.7 x 10^{38} for floating point variables 401 through 500.
115	Floating point variables (501–600)	VF	RW	array [100] floating point	Absolute value from 1.5 x 10^{-39} to 1.7 x 10^{38} for floating point variables 501 through 600.
116	Floating point variables (601–700)	VF	RW	array [100] floating point	Absolute value from 1.5 x 10^{-39} to 1.7 x 10^{38} for floating point variables 601 through 700.
117	Floating point variables (701–800)	VF	RW	array [100] floating point	Absolute value from 1.5 x 10^{-39} to 1.7 x 10^{38} for floating point variables 701 through 800.
118	Floating point variables (801–900)	VF	RW	array [100] floating point	Absolute value from 1.5 x 10^{-39} to 1.7 x 10^{38} for floating point variables 801 through 900.
119	Floating point variables (901–1000)	VF	RW	array [100] floating point	Absolute value from 1.5 x 10^{-39} to 1.7 x 10^{38} for floating point variables 901 through 1000.
120	Boolean variables (1–100)	VB	RW	array [100] Boolean	Value 0 or FFhex for Boolean variables 1 through 100
904	Current PPO-Write		RO	unsigned16	PPO data word type 1 through 4.
911	Current PPO-Read		RO	unsigned16	PPO data word type 1 through 4.
918	Node address		RO	unsigned16	Network address for the motion controller.
930	Operating mode		RW	unsigned16	1=Speed control, 2=Position control
947	Fault Number	FC	RO	array[64] unsigned16	Identifies up to 64 types of system faults that have taken place. Stores the numerical equivalent of each FC register bit that would be set + 1.

PNU	Parameter	S2K Equivalent Register	Valid Access Modes	Data Type	Description
952	Number of Faults		RW	unsigned16	Identifies the number of faults (up to 65,535) that have occurred since the last power cycle. Set to zero to clear.
953	Alarm Parameter		RO	v2	Bit 0 = forward hardware overtravel; bit 1 = reverse hardware overtravel; bit 2 = forward software overtravel (OTF); bit 3 = reverse software overtravel (OTR).
963	Current baud rate	BAUDN	RO	unsigned16	Rate at which bit transfer takes place to and from the PROFIBUS port.
965	Profile Number		RO	octet-string2	0302hex indicates Application Class 3, version 2.
967	Control word		RO	v2	Bits 0 through 15 control the drive. See figure 3.8.
968	Status word		RO	v2	Displays information about the status and signals of the motion controller. See figure 3.9.

Notes: RW= Read/Write, RO=Read Only
* - Requires firmware revision 2.5 or later

10.3.3.4 Index

Index into the data array for PNU 90 through 120 (variables) and PNU 947 (fault array).

10.3.3.5 Parameter Value

The data to be sent to the slave station.

***MSW**:* Parameter value, most significant word.

***LSW**:* Parameter value, least significant word.

10.3.3.6 Process Data Channel Control Word (STW)

The bits set in this word control the axis operation. The Control Word (STW) is always active to the motion controller and the status of the bits must be constantly maintained in the host PLC or PC control application logic.

Speed Control Mode or *Position Control Mode* is selected via the parameter channel PNU 930. The default is for Position mode. See PNU 967 in a previous table for an alternate way to acquire this data.

Table 10-7. Allocation of Control Word Bits (STW)

Bit	Meaning	
	Speed Control Mode	**Position Control Mode**
0	ON/OFF 1	
1	Operating condition/OFF 2	
2	Operating condition/OFF 3	
3	Enable operation/Inhibit operation	
4	Operating condition/Inhibit ramp	Operating condition /Reject traversing
5	Enable ramp/Stop ramp	Operating condition/Intermediate stop
6	Enable setpoint/Inhibit setpoint	Activate traversing task (edge)
7	Acknowledge/No meaning	
8	Jogging 1 ON/Jogging 1 OFF	
9	Jogging 2 ON/Jogging 2 OFF	
10	Control by automation/No control	
11	Reserved	Start Referencing/Terminate Referencing
12	Reserved	Relative/Absolute
13	Reserved	
14	Reserved	
15	Reserved	

10.3.3.6.1 Speed Control Mode – Descriptions of Control Word (STW) Bits

The following table describes the operation of the STW Control Word when the mode selected is Speed. PNU 930 in the parameter channel sets the mode of operation.

Table 10-8. Detailed Allocation of Control Word (STW) Bits for Speed Control Mode.

Bit	Value	Meaning	Remarks
0	1	ON	Drive ready. Must be set for operation.
	0	OFF 1	Drive disabled. Returns to status “ready to switch-on.”
1	1	Operating Condition	All “OFF2” commands are withdrawn. Must be set for operation.
	0	OFF2	Drive disabled. Drive at “switch-on inhibit” status.
2	1	Operating Condition	All “OFF3” commands are withdrawn. Must be set for operation.
	0	OFF3	Drive disabled. Drive at “switch-on inhibit” status (Fast Stop).
3	1	Enable Operation	Enable drive. Then acceleration to the entered setpoint.
	0	Inhibit Operation	Drive disabled. Motor coasts down and into the “ready” status (refer to control word, bit 0).
4	1	Operating Condition	--
	0	Inhibit Ramp	Speed set to zero. Drive remains enabled. Same functionality as the S2K “HT” command.
5	1	Enable Ramp	--
	0	Stop Ramp	Speed ramps down to zero. Same functionality as the S2K “ST” command.
6	1	Enable Setpoint	Velocity setpoint input is switched on
	0	Inhibit Setpoint	Speed ramps to zero. Velocity setpoint set to zero. Same functionality as the S2K “ST” command.
7	1	Acknowledge	Group signal is acknowledged at a positive edge; converter is in the “fault’ status until the fault has been removed and then goes into “switch-on inhibit”.
	0	No Meaning	--
8	1	Jogging 1 ON	Prerequisite: Operation is enabled and setpoint inhibited. Drive accelerates to jogging 1 velocity (See PNU’s 25 and 26).
	0	Jogging 1 OFF	Drive stops if jogging 1 was previously on.
9	1	Jogging 2 ON	Prerequisite: Operation is enabled and setpoint inhibited. Drive accelerates to jogging 2 velocity (See PNU’s 27 and 28).
	0	Jogging 2 OFF	Drive stops if jogging 2 was previously on.
10	1	Control by Automation	Control via interface, process data valid.
	0	No Control	Process data invalid.
11–15	--	Reserved	--

10.3.3.6.2 Position Control Mode -- Descriptions of Control Word (STW) Bits

The following table describes the operation of the STW (Control Word) bits when the operating mode selected is position. PNU 930 in the parameter channel sets the mode of operation.

Table 10-9. Detailed Allocation of Control Word (STW) Bits for Position Control Mode

Bit	Value	Meaning	Remarks
0	1	ON	Drive ready. Must be set to operate.
	0	OFF1	Drive disabled. Returns to status “ready to switch-on.”
1	1	Operating Condition	All “OFF2” commands are withdrawn. Must be set to operate.
	0	OFF2	Drive disabled. Drive at “switch-on inhibit” status.
2	1	Operating Condition	All “OFF3” commands are withdrawn. Must be set to operate.
	0	OFF3	Drive disabled. Drive at “switch-on inhibit” status (Fast Stop).
3	1	Enable Operation	Enable drive. Then acceleration to the entered set point.
	0	Inhibit Operation	Drive disabled. Motor coasts down and into the “ready” status (refer to control word, bit 0).
4	1	Operating Condition	--
	0	Reject Traversing	Speed set to zero. Drive remains enabled. Same functionality as the S2K “HT” command.
5	1	Operating Condition	Must be continuously available for execution of a drive task.
	0	Intermediate Stop	Speed ramps down to zero. Same functionality as the S2K “ST” command. The drive task is not cancelled. The drive task continues when a change to bit 5=1 occurs.
6	edge	Activate Traversing Task	Each edge transition enables a drive task (toggle bit). A change in edge may occur only when the following conditions exist: 1) Drive must be enabled. 2) Reference point has been set by status bit 11. 3) Bit 12 has acknowledged the previous change in edge.
7	1	Acknowledge	Group signal is acknowledged at a positive edge; converter is in the “fault’ status until the fault has been removed and then goes into “switch-on inhibit”.
	0	No Meaning	--
8	1	Jogging1 ON	Prerequisite: Operation is enabled and setpoint inhibited. Drive accelerates to jogging 1 velocity (See PNU’s 25 and 26).
	0	Jogging1 OFF	Drive stops if “Jogging1” was previously on.
9	1	Jogging2 ON	Prerequisite: Operation is enabled and set point inhibited. Drive accelerates to “Jogging2” velocity (See PNU’s 27 and 28).
	0	Jogging2 OFF	Drive stops if “Jogging2” was previously on.
10	1	Control by Automation	Control via interface, process data valid.

Bit	Value	Meaning	Remarks
	0	No Control	Process data invalid.
11	1	Start Referencing	Referencing is started with a change from 0 to 1. Bit 11 of the status word is set to 0. Prerequisite: Operation is enabled and no positioning procedure is active.
	0	Terminate Referencing	A running reference procedure is terminated. Drive ramps to a stop.
12	1	Relative	Position set point is relative to drives current position.
	0	Absolute	Position set point is absolute to drives reference position.
13–15	--	Reserved	

10.3.3.7 Digital Outputs 9 through 14:

Digital outputs 9 through 14 (DO09–DO14) are available on the S2Kcontroller. These 24V DC outputs may be operated by the motion program operating in the S2K or may be controlled by the PROFIBUS master station. Use PNU 71, output control, to determine which digital outputs are under PROFIBUS control (0=not under PROFIBUS control; 1=under PROFIBUS control). Bit-wise control for each of outputs 9 – 14.

10.3.3.8 Velocity Setpoint

MSW: Velocity setpoint value, most significant word. See PNU 21.

LSW: Velocity setpoint value, least significant word. See PNU 21.

10.3.3.9 Position Setpoint

MSW: Position setpoint value, most significant word. See PNU 20.

LSW: Position setpoint value, least significant word. See PNU 20.

10.3.3.10 Motion Block to Execute

The “Motion Block to Execute” portion of the command words allow the master device to initiate operation of any of the stored motion blocks in the S2K. Stored S2K motion blocks 0–99 are available to be executed, however, they must be created and stored in the S2K memory. The commanded value of the “Motion Block to Execute” references the S2K internal motion blocks with block numbers 1–100. For example to execute S2K, motion block 0 set “Motion Block to Execute” equal to one. Setting “Motion Block to Execute” = 0 is a command to execute no internal S2K motion blocks. Other portions of this manual detail operation of S2K motion blocks and provide example programs. Commanding a motion block to execute will immediately terminate any previously operating motion block.

10.3.4 Input Data Words

The PROFIBUS master reads this reply data from the S2K slave each time the slave is accessed.

The parameter channel (PKW) returns data because of the active command words Task ID and specified PNU. This data will vary as the command word task changes.

The Process Data channel (PZD) reflects cyclic status information. The actual position and velocity values are always represented in feedback pulses (encoder counts) and feedback pulses per second respectively.

Table 10-10. PROFIBUS-DP Input Data Words for S2K Motion Controllers

<table>
<tr><th></th><th>Input Word</th><th>Bit 15</th><th>Bit 14</th><th>Bit 13</th><th>Bit 12</th><th>Bit 11</th><th>Bit 10</th><th>Bit 9</th><th>Bit 8</th><th>Bit 7</th><th>Bit 6</th><th>Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th></tr>
<tr><td rowspan="4">PKW</td><td>1</td><td colspan="4">Response ID</td><td>Res</td><td colspan="11">Parameter Number (PNU)</td></tr>
<tr><td>2</td><td colspan="8">Index</td><td colspan="8">Reserved</td></tr>
<tr><td>3</td><td colspan="16">Parameter Value MSW</td></tr>
<tr><td>4</td><td colspan="16">Parameter Value LSW</td></tr>
<tr><td rowspan="7">PZD</td><td>5</td><td colspan="16">Status Word (ZSW)</td></tr>
<tr><td rowspan="2">6</td><td colspan="8">Digital Inputs</td><td colspan="8" rowspan="2">Motion Block Executing</td></tr>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>7</td><td colspan="16">Actual Velocity MSW</td></tr>
<tr><td>8</td><td colspan="16">Actual Velocity LSW</td></tr>
<tr><td>9</td><td colspan="16">Actual Position MSW</td></tr>
<tr><td>10</td><td colspan="16">Actual Position LSW</td></tr>
</table>

Res = Reserved

10.3.4.1 Response ID

Defines the responses available.

Table 10-11. Available Input Word Response IDs

Response ID	Function
0	No response
1	Transfer parameter value (word)
2	Transfer parameter value (double word)
3	Reserved
4	Transfer parameter value (array word)
5	Transfer parameter value (array double word)
6	Transfer number of array elements
7	Task cannot be executed (with error number in PKW4 see table below)
8–15	Reserved

10.3.4.1.1 PKW4 Word Error Numbers

Possible error numbers reported in the PKW4 word are listed below when the task response ID =7.

Displays information about the status and signals of the position controller. See PNU 968 in a previous table.

Table 10-12. Reply message ID 7, Error Numbers (PKW4)

Error	Explanation
0	Illegal parameter number (PNU)
1	Parameter value cannot be changed
2	Lower or upper limit violated
3	Erroneous array index
4	No array
5	Incorrect data type
6	Reserved
7	Descriptive element cannot be changed
8	Reserved
9	Descriptive data not available
10–16	Reserved
17	Task cannot be executed due to operating status
18	Reserved
19	Data cannot be read in cyclic data transfer

10.3.4.2 Process Data Channel Status Word (ZSW)

The bits in this word report status of the drive. Speed Control mode or Position Control Mode is selected via command word PNU 930. See PNU 967 in a previous table for alternate ways to acquire this data.

Table 10-13. Allocation of Status Word Bits (ZSW)

Bit	Meaning	
	Speed Control Mode	Position Control Mode
0	Ready for switch-on/Not ready for switch-on	
1	Ready for operation/Not ready for operation	
2	Operation enabled/Operation inhibited	
3	Fault/No fault	
4	No OFF 2/Off 2	
5	No OFF 3/Off 3	
6	Switch-on inhibit/No switch-on inhibit	
7	Alarm/No alarm	
8	Setpoint in range/Setpoint out of range	No contouring error/Contouring error
9	Control requested/Operation on site	
10	Setpoint reached/Setpoint not reached	Setpoint in range/Setpoint out of range
11	Reserved	Reference point set/No reference point set
12	Reserved	Setpoint acknowledge (edge)
13	Reserved	Drive stationary/Drive moving
14	Torque limit/No torque limit	
15	Heartbeat (edge) (100ms)	

10.3.4.2.1 Speed Control Mode -- Descriptions of Status Word (ZSW) Bits

Table10-14. Detailed Allocation of Status Word (ZSW) Bits for Speed Control Mode

Bit	Value	Meaning	Remarks
0	1	Ready for switch-on	Drive ready to be enabled
	0	Not ready for switch-on	Drive disabled.
1	1	Ready for operation	Refer to control word, bit 0.
	0	Not ready for operation	Drive disabled
2	1	Operation enabled	Refer to control word, bit 3.
	0	Operation inhibited	Drive disabled
3	1	Fault	Drive faulted, and thus not operational. Goes into the switch-on inhibit status after acknowledgement if the fault has been removed. Fault numbers are returned in the fault parameters.
	0	No-Fault	No unacknowledged faults exist.
4	1	No OFF 2	See control word, bit 1.
	0	OFF 2	“OFF 2” command present.
5	1	No OFF 3	See control word, bit 2
	0	OFF 3	“OFF 3” command present.
6	1	Switch-on Inhibit	Re-close only with “OFF 1” and then “ON”
	0	No switch-on Inhibit	Drive ready to be enabled
7	1	Alarm	Drive still operational. Alarm in service parameter: No acknowledge. See PNU 953.
	0	No Alarm	Alarm not present or alarm has disappeared again. See PNU 953.
8	1	Setpoint in range	Drive running at velocity setpoint.
	0	Setpoint out of range	Drive not running at velocity setpoint. Equivalent to S2K “FE” fault.
9	1	Control requested	The automation system is requested to accept control (always true).
	0	Operation on site	Control only possible on the device itself.
10	1	Setpoint reached	Actual value = comparison value (velocity setpoint), set via PNU 21.
	0	Setpoint not reached	Drive has not yet reached the setpoint.
11–13	--	Reserved	--

Bit	Value	Meaning	Remarks
14	1	Torque Limit	Drive at torque limit specified by PNU 34. Torque limit must be enabled via PNU 35.
	0	No torque limit	Drive not at torque limit specified by PNU 34.
15		Heartbeat edge	Bit turns on and off every 100 milliseconds to validate that the drive remains functional

10.3.4.2.2 Position Control Mode -- Descriptions of Status Word Bits

Table10-15. Detailed Allocation of Status Word (ZSW) Bits for Position Control Mode

Bit	Value	Meaning	Remarks
0	1	Ready for switch-on	Drive ready to be enabled
	0	Not ready for switch-on	Drive disabled.
1	1	Ready for operation	Refer to control word, bit 0.
	0	Not ready for operation	Drive disabled
2	1	Operation enabled	Refer to control word, bit 3.
	0	Operation inhibited	Drive disabled
3	1	Fault	Drive faulted, and thus not operational. Goes into the switch-on inhibit status after acknowledgement if the fault has been removed. Fault numbers are returned in the fault parameters.
	0	No-Fault	No unacknowledged faults exist.
4	1	No OFF2	See control word, bit 1.
	0	OFF2	“OFF2” command present.
5	1	No OFF3	See control word, bit 2
	0	OFF3	“OFF3” command present.
6	1	Switch-on Inhibit	Re-close only with “OFF1” and then “ON”
	0	No switch-on Inhibit	Drive ready to be enabled
7	1	Alarm	Drive still operational. Alarm in service parameter: No acknowledge. See PNU 953.
	0	No Alarm	Alarm not present or alarm has disappeared again. See PNU 953.
8	1	No Contouring error	No following error faults.
	0	Contouring error	Following error faults exist.
9	1	Control requested	The automation system is requested to accept control (always true).

Bit	Value	Meaning	Remarks
	0	Operation on site	Control only possible on the device itself.
10	1	Set point in range	The actual position value is located at the end of a drive task in the positioning window.
	0	Set point out of range	Drive task active or actual position outside positioning window.
11	1	Reference Point Set	Referencing was preformed and is valid.
	0	No reference point set	No valid reference present.
12	edge	Set point acknowledge	An edge was used to acknowledge that a new drive task was accepted. Same level as bit 6 of the control word.
13	1	Drive stationary	Signals the conclusion of a drive task or stand still during intermediate stop and stop.
	0	Drive moving	Drive task is being executed.
14	1	Torque Limit	Drive at torque limit specified by PNU 34. Torque limit must be enabled via PNU 35.
	0	No torque limit	Drive not at torque limit specified by PNU 34. Torque limit must be enabled via PNU 35.
15	edge	Heartbeat	Bit turns on and off every 100 milliseconds to validate that the drive remains functional

10.3.4.3 Digital Inputs 1 through 8

Status (level) of the S2K digital inputs (DI01– DI08) available on the controller.

10.3.4.4 Actual Velocity

MSW: Actual velocity value, most significant word. See PNU 3.

LSW: Actual velocity value, least significant word. See PNU 3.

10.3.4.5 Actual Position

MSW: Actual position value, most significant word. See PNU 2.

LSW: Actual position value, least significant word. See PNU 2.

10.3.5 Fault History and Fault Cause Codes

Parameter (PNU) 952, *number of faults*, stores fault conditions (a maximum of 65,535) that have occurred since the last power cycle or since the last time the *number of faults* parameter (PNU 952) was reset by writing a zero.

The *fault number* parameter (PNU 947) can return up to eight fault causes for each of the eight fault conditions the S2K can store.

> *Fault condition*—Any of the various severe faults that may occur to cause the S2K Motion Controller to immediately stop motion and internally execute motion program four. The S2K maintains a specific 32-bit register “FC” of which the transition to “on” state of one or multiple bits is considered a fault condition.
>
> *Fault cause*—In S2K terms this is any one of the possible thirty-two fatal errors constantly monitored and listed in the “FC” register. This is represented by a specific bit in the “FC” register.

Parameter (PNU) 947, *fault number*, identifies a single fault cause of a fault condition by returning a PROFIBUS fault number code. The PROFIBUS fault number codes are derived from the Fault Code (FC) register in the S2K controller and are represented by the FC register bit position plus one. For example, the S2K fault code register bit FC03 (bit 3) “lost enable” fault would be represented as PROFIBUS fault number code 04. FC21 (bit21) “excessive following error” would be PROFIBUS fault number code 22.

The S2K PROFIBUS controller internally maintains a 64-place data table (1–64) to store a series of PROFIBUS fault number codes. The S2K fault code data is organized in an 8x8 array table where each of the possible eight fault conditions (each time the S2K sensed a fault) may contain up to eight fault causes (fault code descriptions). This data is volatile and will be lost or reset to zero if the S2K is power cycled. Each element of the fault history array will contain one of the fault number codes in the following table or the value zero. A maximum of eight fault codes are stored when a fault condition occurs. A maximum of eight fault conditions, representing the most recent faults, are saved.

The PROFIBUS acknowledge/reset fault sequence described in the next section or other methods may be used to place the S2K back into operation. This does not clear the fault history data in the S2K. Only a power cycle clears the table.

When a new fault condition occurs, the number of faults (PNU 952) parameter is increased by one. The previous fault condition data (if present) is relocated eight places lower in the S2K fault history table. The new fault number data is placed in the first eight locations

The PNU 947 command will use the *Index* field of the PKW command (parameter channel) to select which element (1–64) of the fault data history to read. The command field *Task ID* should be set to one when the message is executed. This will return the value of the index selected PROFIBUS fault code parameter. Subsequent messages may increment the Index value to get the next fault code value stored in the S2K. A returned value of zero indicates the end of the fault code list for that fault condition. The fault codes for the most recent fault condition will always be in index one through eight.

Table 10-16. PROFIBUS S2K Fault Number Codes

Fault Code	Message	Fault Code	Message
1	Power Failure	20	Network Power Failure
2	Reserved	21	Duplicate Network Address
3	Software Fault	22	Excessive Following Error
4	Lost Enable	23	Excessive Command Increment
5	Digital Output Fault	24	Position Register Overflow
6	Invalid Command in String	25	Position Feedback Lost *(Resolver S2Ks)*
7	Transmit Buffer Overflow		
8	Resource Not Available	26	Motor Power Over-Voltage
9	Invalid Variable Pointer	27	*(3–4.3 Amp)* Motor Power Clamp Excessive Duty Cycle
10	Mathematical Overflow		*(7.2 Amp)* Motor Power Clamp Excessive Duty Cycle—Under-Voltage
11	Mathematical Data Error		*(12–28 Amp)* Motor Power Under-Voltage
12	Value Out of Range	28	*(3–4.3 Amp)* Reserved
13	String Too Long		*(7.2 Amp)* Motor Power Clamp Over-Current Fault
14	Nonexistent Label		*(12–28 Amp)* Motor Power Clamp Excessive Duty Cycle
15	Gosub Stack Underflow	29	Motor Over-Current Fault
16	Gosub Stack Overflow	30	Motor Over-Temperature
17	Invalid Motion	31	Controller Over-Temperature
18	Reserved	32	Network Communication Error
19	Reserved		

Table 10-17. Example Fault Number Parameters

Number of faults (n = PNU 952)	Index	Fault Number (cause) (PNU 947)	Fault Code Register Message
n (The is the most recent fault condition)	1	22	Excessive following error
	2	29	Motor Over-current Fault
	3	0	Indicates no more fault causes exist for this fault condition. Query until you reach zero to ensure you have reviewed all faults.
	. . .	. . .	. . .
n - 1	9 . . . 16	Up to 8 fault causes	…
. . .	. . .	. . .	…
n - 7	57 . . . 64	Up to 8 fault causes	…

10.3.5.1 Acknowledging and Resetting Faults

Faults disable the drive. When a fault condition occurs, examine the fault numbers (see the previous section) and determine the fault cause. Once the condition that triggered the fault is removed, you are ready to reset the fault. The fault must be acknowledged and cleared before the drive can be enabled. Use the following procedure to reset faults and re-enable the axis. The bits referenced are in the PKZ channel, within the ZSW input and STW output words.

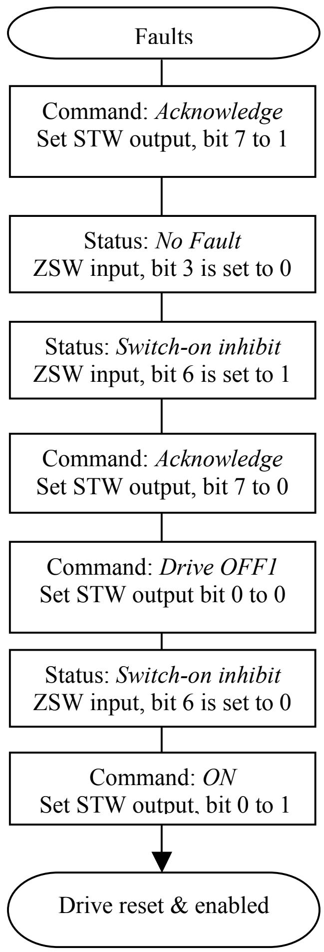


Figure 10-6. Acknowledging and Resetting Faults

10.3.6 Enabling

To drop the enable on the drive, set bit 3 of the control word to zero. Disabling the drive does not set the fault bit (bit 3) of the status word. When bit 3 is set to 1, the drive goes to the enable state.

Bit 2 of the status word indicates the state of the drive enable: 1 = enabled; 0 = inhibited (i.e., disabled)

Note that control word bits 0 through 3 must be true in order to keep the controller in the enabled state.

10.3.7 Referencing

Prior to activating a drive task in position mode, the drive must have a reference point set. The PNU's 29–33 are used for the reference task. The signed value in the *reference velocity* parameter, PNU 30, determines the direction of referencing for reference position types 0 (home input), and 2 (OT input). The signed value in the *marker velocity* parameter, PNU 31, determines the direction of referencing for reference position type 1 (marker input).

The value in the *reference position type* parameter, PNU 33, determines the reference type:

0 = Home input = DI1
1 = Marker input = Resolver position zero or encoder index
2 = OT input (DI2 = forward; DI3 = reverse)

Table 10-18. Excerpt from Data Word Parameters (PNU) Table

PNU	Parameter *(Generation D RTOS Equivalent)*	Data Type	Description
29	Reference position	integer32	Set actual position (PSA) to this value when Referencing finishes.
30	Reference velocity	integer32	Set velocity (MVL) to this value during Referencing while in position control mode. Signed quantity automatically determines the direction of the move.
31	Marker velocity	integer16	Defines the motion velocity (MVL) of the axis when running to a marker input (RMF or RMR). Signed quantity automatically determines the direction of the move.
32	Reference acceleration/deceleration	unsigned32	Defines acceleration/deceleration rate in pulses/sec^2 while referencing.
33	Reference position type *(RMF, RMR, RHF, RHR, ROF, ROR)*	unsigned16	0=Home input, 1=Marker input, 2=OT input

10.3.8 Performing a Drive Task

The user may perform a drive task by either running at a velocity setpoint, to a position setpoint or by executing a motion block. To run to a position setpoint, set the byte *Motion Block to Execute* to zero. To execute a motion block, set the byte *Motion Block to Execute* to the number of the motion block, from 1 to 100. The status byte *Motion Block Executing* indicates whether a motion block is executing.

10.3.9 Relative Positioning in Motion Blocks

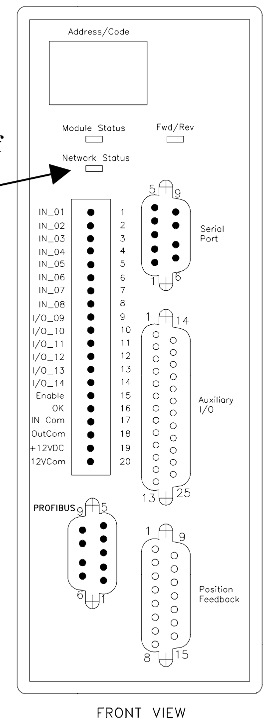
Do not use incremental commands such as MPI for relative positioning within a motion block executed via a PROFIBUS drive task. Instead, use offset commands (e.g., MPO) for relative positioning. To allow the offset commands to be used for relative positioning, set PSO=0 at the beginning of a motion block.

10.4 Diagnostics

S2K controllers provide a Network Status LED on the front of the unit to indicate three possible network states:

- OFF = no connection
- RED = baud rate found—not in data exchange
- GREEN = Data exchange.

Figure 10-7. Location of Network Status LED on the S2K



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Appendix A Tables and Formulas

Standard ASCII (American Standard Code for Information Interchange) Codes

Char.	Dec.	Hex.	Char.	Dec.	Hex.	Char.	Dec.	Hex.
NUL	0	00	+	43	2B	V	86	56
SOH	1	01	,	44	2C	W	87	57
STX	2	02	-	45	2D	X	88	58
ETX	3	03	.	46	2E	Y	89	59
EOT	4	04	/	47	2F	Z	90	5A
ENQ	5	05	0	48	30	[	91	5B
ACK	6	06	1	49	31	\	92	5C
BEL	7	07	2	50	32	]	93	5D
BS	8	08	3	51	33	^	94	5E
HT	9	09	4	52	34	_	95	5F
LF	10	0A	5	53	35	`	96	60
VT	11	0B	6	54	36	a	97	61
FF	12	0C	7	55	37	b	98	62
CR	13	0D	8	56	38	c	99	63
SO	14	0E	9	57	39	d	100	64
SI	15	0F	:	58	3A	e	101	65
DLE	16	10	;	59	3B	f	012	66
DC1	17	11	<	60	3C	g	103	67
DC2	18	12	=	61	3D	h	104	68
DC3	19	13	>	62	3E	i	105	69
DC4	20	14	?	63	3F	j	106	6A
NAK	21	15	@	64	40	k	107	6B
SYN	22	16	A	65	41	l	108	6C
ETB	23	17	B	66	42	m	109	6D
CAN	24	18	C	67	43	n	110	6E
EM	25	19	D	68	44	o	111	6F
SUB	26	1A	E	69	45	p	112	70
ESC	27	1B	F	70	46	q	113	71
FS	28	1C	G	71	47	r	114	72
GS	29	1D	H	72	48	s	115	73
RS	30	1E	I	73	49	t	116	74
US	31	1F	J	74	4A	u	117	75
SP	32	20	K	75	4B	v	118	76
!	33	21	L	76	4C	w	119	77
”	34	22	M	77	4D	x	120	78
#	35	23	N	78	4E	y	121	79
$	36	24	O	79	4F	z	122	7A
%	37	25	P	80	50	{	123	7B
&	38	26	Q	81	51	|	124	7C
′	39	27	R	82	52	}	125	7D
(	40	28	S	83	53	~	126	7E
)	41	29	T	84	54	“	127	7F
*	42	2A	U	85	55			

AWG to Metric Wire Size Conversion

Since there is not an exact correspondence between American AWG wire sizes and metric sizes, the metric values in the following table are close approximations. If you need greater precision, contact your wire supplier.

AWG to Metric Wire Size Conversion	
AWG Size	**Metric Cross Section in square millimeters (mm^2)**
1	42.4
2	33.6
4	21.2
6	13.2
8	8.37
10	5.26
12	3.31
14	2.08
16	1.31
18	0.82
20	0.52
22	0.32
24	0.21
26	0.13
28	0.081
30	0.051

Temperature Conversion

Formulas

°C = 5/9(°F – 32)

°F = (9/5 x °C) + 32

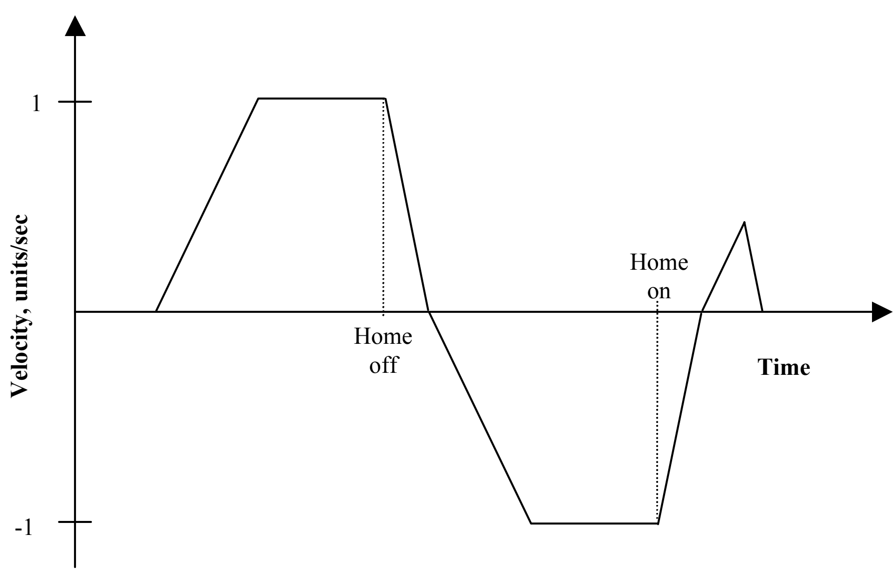
Appendix B
S2K Motion Templates

The S2K program templates shown in this appendix are intended to provide the user with guidelines for creating a variety of program elements that may comprise a complete machine control program. Many of the templates are available as standard selections within the Motion Developer software or the text from the templates can be combined and entered into the program editor. The templates are divided into the following functional categories:

- Homing Routines
- Velocity Based Motion
- Time Based Motion
- Pulse Based Motion
- Torque Limited Motion
- Synchronized Motion
- Utility Templates

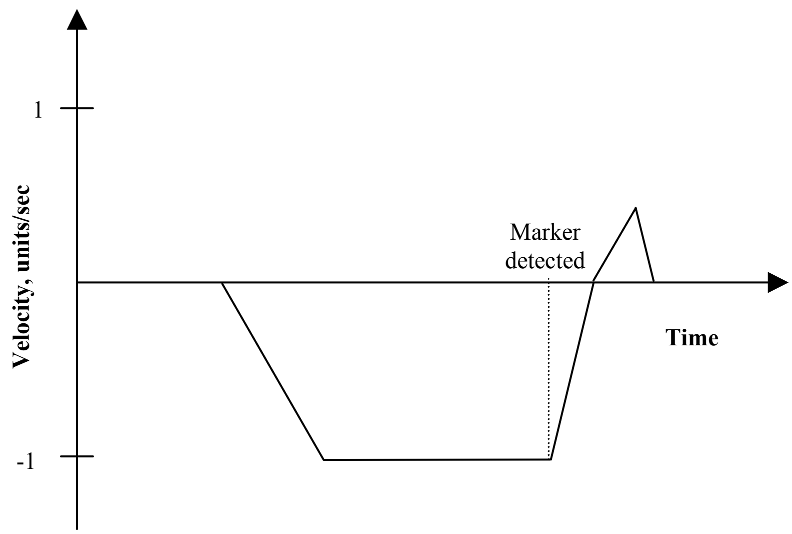
B.1 Homing Routines

B.1.1 Run Reverse until Home Input



```
(* Notes:
(* 1-    Registers that have been previously loaded with appropriate values do not have to be reloaded   (*
for this motion
(* 2-    Loading the MAC register also loads the MDC register with the same value.  To set MDC to a
(*       value different from MAC, load MDC after loading the MAC register.
(* 3-    This example assumes the Motion Feedrate Percentage(MFP) is set to its default value of 100.


(* Move Type:               Run reverse until home input
(* Engineering Units:       Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                  Run forward until the home input is off.  Run reverse until home
(*                          input, then stop and run back to the position where the home input
(*                          was detected.  Set position to zero.
(* MT = VEL                 This register cannot be loaded if motion is in progress.
(*                          MT does not need to be set unless it is set to an MT setting other than
(*                          VEL. The default value for MT is VEL.

      MAC = 50.0            (* set motion acceleration, units/sec^2
      MDC = 75.0            (* set motion deceleration, units/sec^2
      MJK = 0               (* set motion jerk percentage, % of accel & decel interval
      MVL = 1.0             (* set motion velocity, units/sec
      RVF                   (* run forward
      WAIT NOT IO8          (* wait for home input to be off
      RHR                   (* run reverse until home input
      WAIT IP               (* wait for axis to be in position
      PSA = 0.0             (* set axis position, units
```

B.1.2 Run Reverse until Marker Input



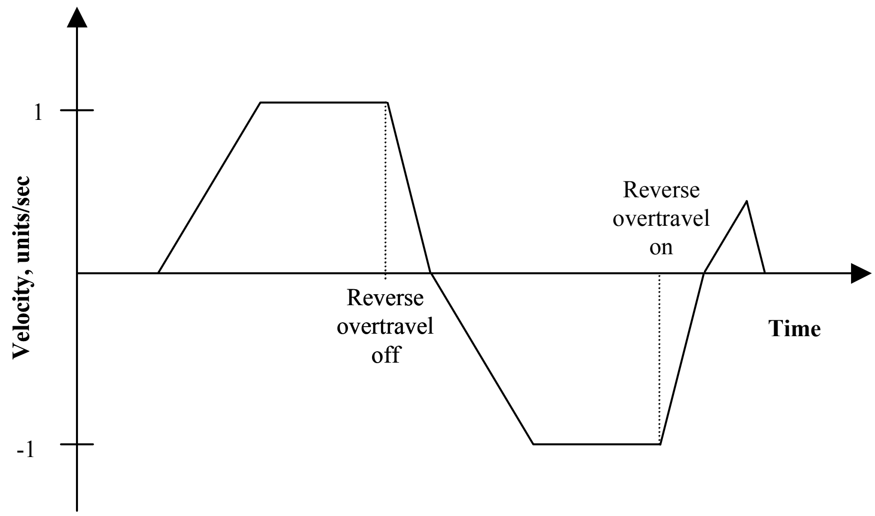
(* Notes:
(* 1- Registers that have been previously loaded with appropriate values do not have to be reloaded
(* for this motion.
(* 2- Loading the Motion Acceleration (MAC) register also loads the Motion Deceleration (MDC)
(* register with the same value. To set MDC to a value different from MAC, load MDC after
(* loading the MAC register.
(* 3- This example assumes Motion Feedrate Percentage (MFP) is set to its default value of 100.

(* Move Type:	Run reverse until marker input
(* Engineering Units:	Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:	Run reverse until marker input, then stop and run back to the
(*	position where the marker input was detected. Set position to zero.
(* MT = VEL	This register cannot be loaded if motion is in progress.
(*	MT does not need to be set unless it is set to a MT setting other than VEL. The default value for MT is VEL.

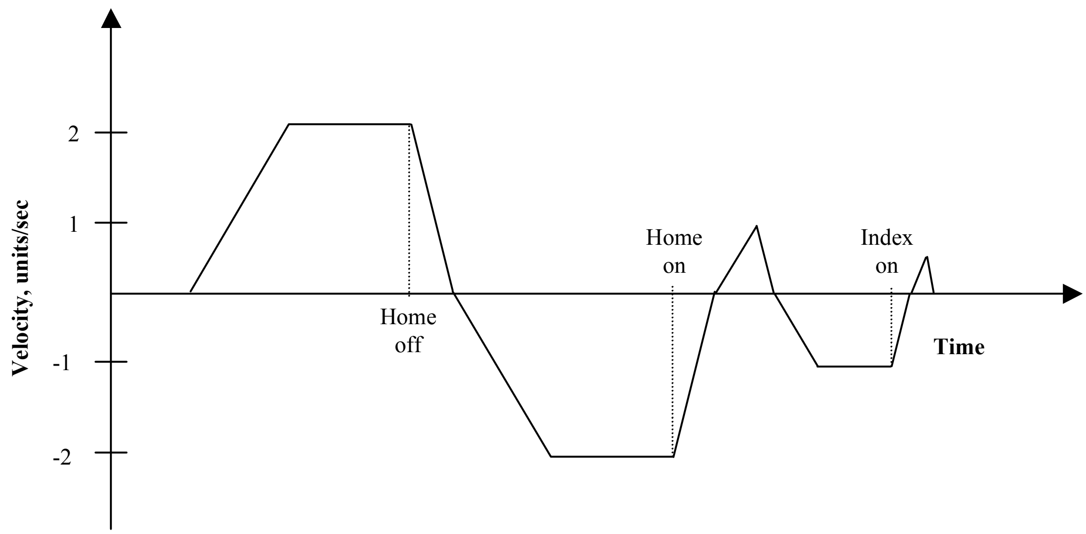
MAC = 50.0	(* set motion acceleration, units/sec^2
MDC = 75.0	(* set motion deceleration, units/sec^2
MJK = 0	(* set motion jerk percentage, % of accel & decel interval
MVM = 1.0	(* set motion velocity for run to marker, units/sec
RMR	(* run reverse until marker input
WAIT IP	(* wait for axis to be in position
PSA = 0.0	(* set axis position, units

B.1.3 Run Reverse until Overtravel Input



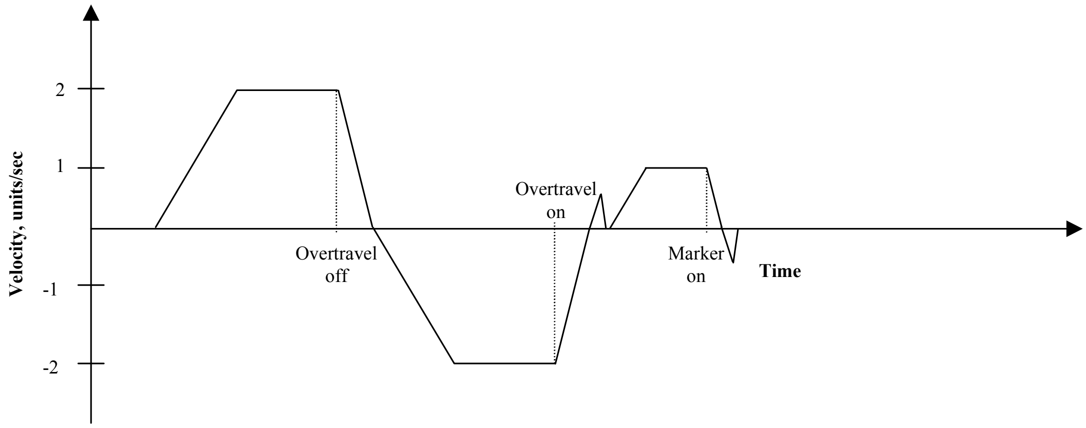

```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values do not have to be reloaded
(*      for this motion.
(* 2-   Loading the MAC register also loads the MDC register with the same value.  To set MDC to a
(*      value different from MAC, load MDC after loading the MAC register.
(* 3-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.

(* Move Type:              Run reverse until overtravel input
(* Engineering Units:      Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                 Run forward until reverse overtravel input is off.  Run reverse until
(*                         overtravel input, then stop and run back to the position where the
(*                         overtravel input was detected.  Set position to zero.
(* MT = VEL                This register cannot be loaded if motion is in progress.
(*                         MT does not need to be set unless it is set to a MT setting other than VEL.
(*                         The default value for MT is VEL.

      MAC = 50.0           (* set motion acceleration, units/sec^2
      MDC = 75.0           (* set motion deceleration, units/sec^2
      MJK = 0              (* set motion jerk percentage, % of accel & decel interval
      MVL = 1.0            (* set motion velocity, units/sec
      RVF                  (* run forward
      WAIT NOT IO10        (* wait for reverse overtravel input to be off
      ROR                  (* run reverse until overtravel input
      WAIT IP              (* wait for axis to be in position
      PSA = 0.0            (* set axis position, units
```

B.1.4 Run Reverse until Home and Marker Inputs



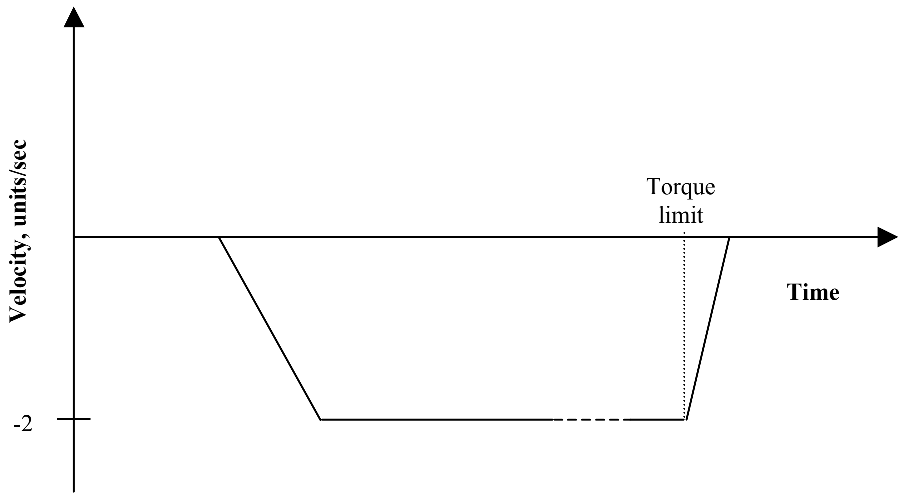

```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*      do not have to be reloaded for this motion.
(* 2-   Loading the MAC register also loads the MDC register with the same value.  To set MDC to a
(*      value different from MAC, load MDC after loading the MAC register.
(* 3-   This example assumes the Motion Feedrate Percentage(MFP) is set to its default value of 100.

(* Move Type:               Run reverse until home and marker inputs
(* Engineering Units:       Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                  Run forward until home input is off.  Run reverse until home input is
(*                          on. Run reverse until the marker input, then stop and run back to that
(*                          position. Wait until axis is in position and set position to zero.
(* MT = VEL                 This register cannot be loaded if motion is in progress.
(*                          MT does not need to be set unless it is set to a MT setting other than
                            VEL. The default value for MT is VEL.

     MAC = 50.0             (* set motion acceleration, units/sec^2
     MDC = 75.0             (* set motion deceleration, units/sec^2
     MJK = 0                (* set motion jerk percentage, % of accel & decel interval
     MVL = 2.0              (* set motion velocity, units/sec
     MVM = 1.0              (* set motion velocity for move to marker,  units/sec
     RVF                    (* run forward
     WAIT NOT IO8           (* wait for home input to be off
     RHR                    (* run reverse until home input
     WAIT IP                (* wait for axis to be in position
     RMR                    (* run reverse until index input
     WAIT IP                (* wait for axis to be in position
     PSA = 0.0              (* set axis position, units
```

B.1.5 Run Reverse until Overtravel and Marker Inputs




```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*      do not have to be reloaded for this motion.
(* 2-   Loading the MAC register also loads the MDC register with the same value.  To set MDC to a
(*      value different from MAC, load MDC after loading the MAC register.
(* 3-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.

(* Move Type:               Run reverse until overtravel and marker inputs
(* Engineering Units:       Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                  Run forward until reverse overtravel input is off.  Run reverse until
(*                          overtravel input.  Run forward until marker input, then stop and run
(*                          back to the position where the marker input was detected.  Set position
(*                          to zero.
(* MT = VEL                 This register cannot be loaded if motion is in progress.  MT does not
(*                          need to be set unless it is set to a MT setting other than VEL.
(*                          The default value for MT is VEL.


     MAC = 50.0             (* set motion acceleration, units/sec^2
     MDC = 75.0             (* set motion deceleration, units/sec^2
     MJK = 0                (* set motion jerk percentage,  % of accel & decel interval
     MVL = 2.0              (* set motion velocity, units/sec
     MVM = 1.0              (* set motion velocity for run to marker, units/sec
     RVF                    (* run forward
     WAIT NOT IO10          (* wait for reverse overtravel input to be off
     ROR                    (* run reverse until overtravel input
     WAIT IP                (* wait for axis to be in position
     RMF                    (* run forward until index input
     WAIT IP                (* wait for axis to be in position
     PSA = 0.0              (* set axis position, units
```

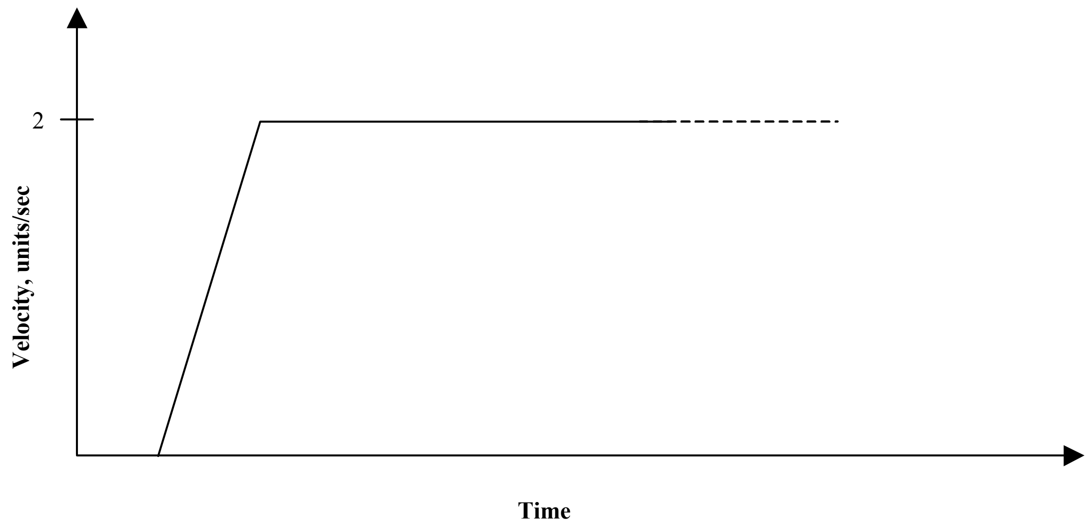
B.1.6 Run Reverse until Torque Limit




```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*      do not have to be reloaded for this motion.
(* 2-   Loading the MAC register also loads the MDC register with the same value.  To set MDC to a
(*      value different from MAC, load MDC after loading the MAC register.
(* 3-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.

(* Move Type:             Run reverse until torque limit
(* Engineering Units:     Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                Run reverse until torque limit reached.  Disable torque limit and set
(*                        position to zero once axis is in position.
(* MT = VEL               This register cannot be loaded if motion is in progress.
(*                        MT does not need to be set unless it is set to a MT setting other than
                          VEL. The default value for MT is VEL.

        MAC = 50.0        (* set motion acceleration, units/sec^2
        MDC = 75.0        (* set motion deceleration, units/sec^2
        MJK = 0           (* set motion jerk percentage, % of accel & decel interval
        MVL = 2.0         (* set motion velocity, units/sec
        TLC = 10.0        (* set torque limit current, % of continuous current
        TLE = ON          (* enable torque limit
        RVR               (* run reverse
        WAIT TL           (* wait axis to be at torque limit
        HT                (* halt all motion
        TLE = OFF         (* disable torque limit
        PSA = 0.0         (* set axis position, units
```

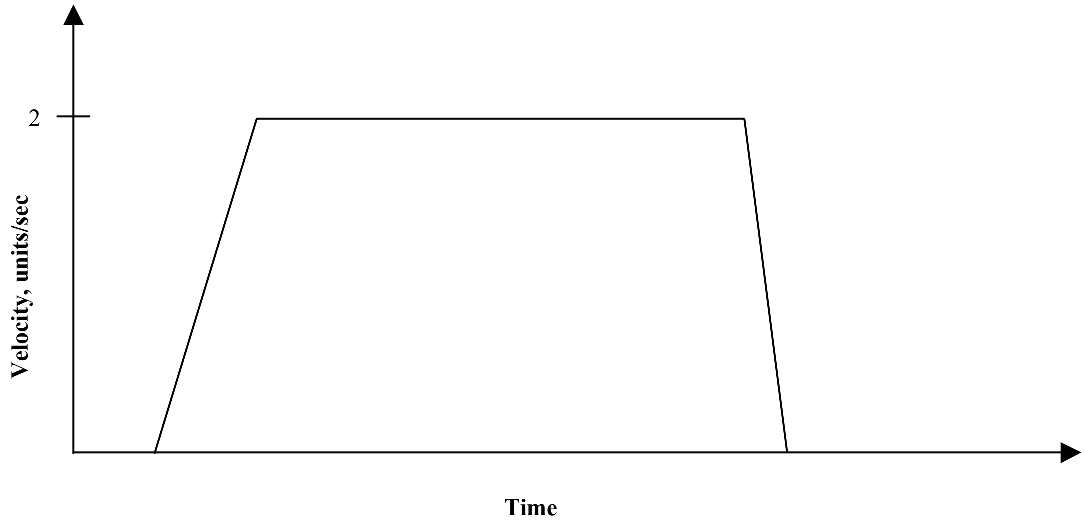
B.2 Velocity Based Motion

B.2.1 Continuous Move




```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*      do not have to be reloaded for this motion.
(* 2-   Loading the MAC register also loads the MDC register with the same value.  To set MDC to a
(*      value different from MAC, load MDC after loading the MAC register.
(* 3-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.

(* Move Type:               Continuous move
(* Engineering Units:       Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                  move forward with a velocity of 2 units/second.
(*                          position to zero once axis is in position.
(* MT = VEL                 This register cannot be loaded if motion is in progress.
(*                          MT does not need to be set unless it is set to a MT setting other than
(*                          VEL. The default value for MT is VEL.

        MAC = 50.0          (* set motion acceleration, units/sec^2
        MDC = 75.0          (* set motion deceleration, units/sec^2
        MJK = 0             (* set motion jerk percentage, % of accel & decel interval
        MVL = 2.0           (* set motion velocity, units/sec
        RVF                 (* run forward
```

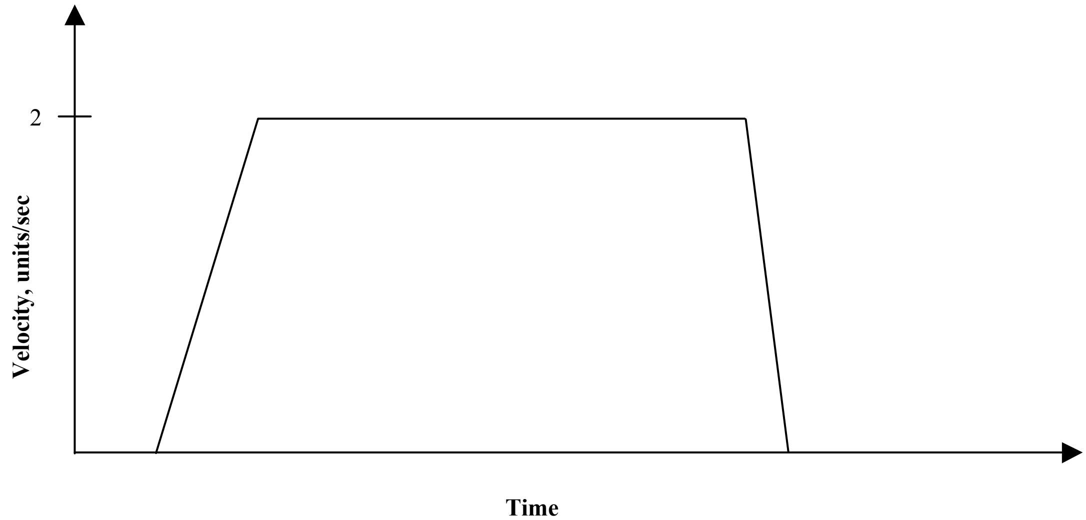
B.2.2 Incremental Move



(* Notes:
(* 1- Registers that have been previously loaded with appropriate values
(* do not have to be reloaded for this motion.
(* 2- Loading the MAC register also loads the MDC register with the same value. To set MDC to a
(* value different from MAC, load MDC after loading the MAC register.
(* 3- This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.

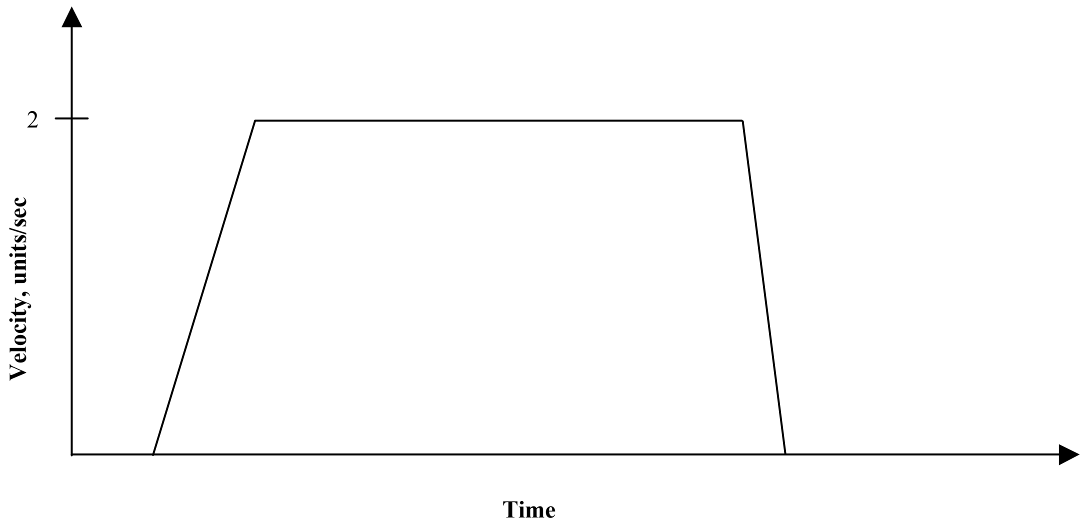
```
(* Move Type:           Incremental move
(* Engineering Units:   Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:              move forward 10 units
(*                      position to zero once axis is in position.
(* MT = VEL             This register cannot be loaded if motion is in progress.
(*                      MT does not need to be set unless it is set to a MT setting other than
(*                      VEL. The default value for MT is VEL.

    MAC = 50.0          (* set motion acceleration, units/sec^2
    MDC = 75.0          (* set motion deceleration, units/sec^2
    MJK = 0             (* set motion jerk percentage, % of accel & decel interval
    MVL = 2.0           (* set motion velocity, units/sec
    MPI = 10.0          (* set incremental move position, units
    RPI                 (* run to incremental move position
```

B.2.3 Absolute Move




```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*      do not have to be reloaded for this motion.
(* 2-   Loading the MAC register also loads the MDC register with the same value.  To set MDC to a
(*      value different from MAC, load MDC after loading the MAC register.
(* 3-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 4-   RPA moves the axis from its present position to the absolute position specified in the MPA
(*       register. This example begins by loading the absolute position register, PSA, with 0 for the
(*       purpose of accurately graphing the subsequent motion.  In general, applications will only load
(*       PSA at the end of a homing  motion.

(* Move Type:               Absolute move
(* Engineering Units:       Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                  move to an absolute position of 10 units
 (* MT = VEL                This register cannot be loaded if motion is in progress.
(*                          MT does not need to be set unless it is set to a MT setting other than
(*                          VEL. The default value for MT is VEL.

 (* Initialize absolute position register to 0
        PSA = 0.0           (* set absolute position, units

(* Move axis to absolute position 10 with the accelerations and velocities shown.
        MAC = 50.0          (* set motion acceleration, units/sec^2
        MDC = 75.0          (* set motion deceleration, units/sec^2
        MJK = 0             (* set motion jerk percentage, % of accel & decel interval
        MVL = 2.0           (* set motion velocity, units/sec
        MPA = 10.0          (* set absolute move position, units
        RPA                 (* run to absolute move position
```

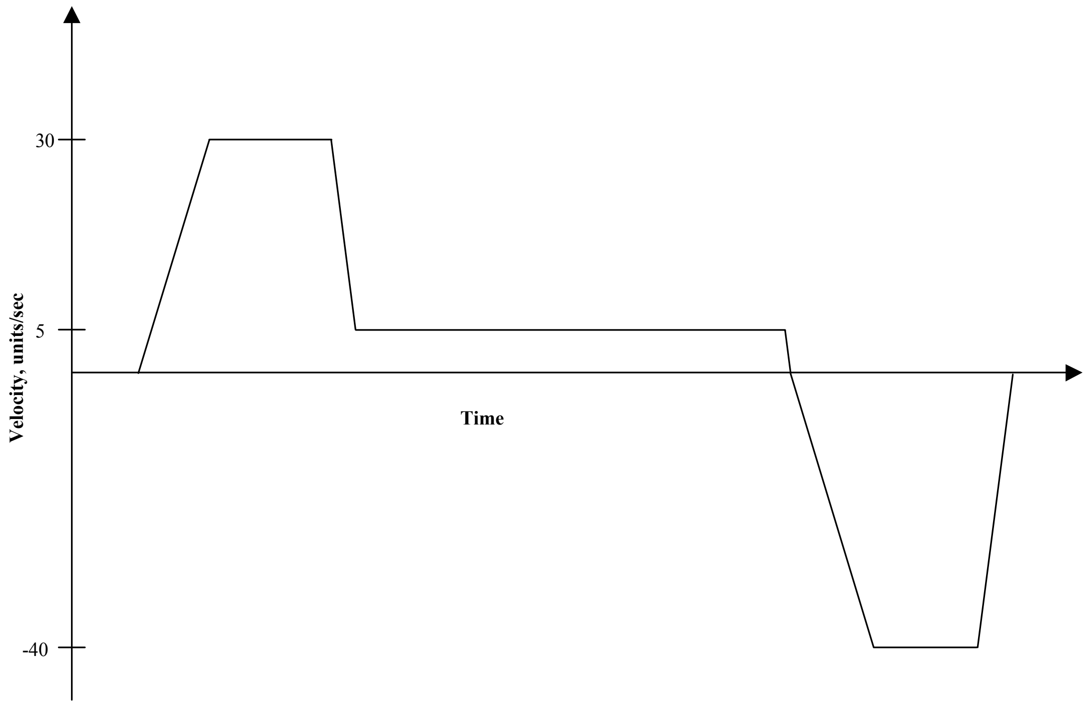
B.2.4 Offset Move



(* Notes:
(* 1- Registers that have been previously loaded with appropriate values do not have to be reloaded
(* for this motion.
(* 2- Loading the MAC register also loads the MDC register with the same value. To set MDC to a
(* value different from MAC, load MDC after loading the MAC register.
(* 3- This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 4- RPO moves the axis from its present position to the offset position specified in the MPO
(* register. This example begins by loading the offset position register, PSO, with 0 for the purpose
(* of accurately graphing the subsequent motion. Applications may require other offset position
(* register values.

```
(* Move Type:              Offset move
(* Engineering Units:      Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                 Move to offset position of 10 units.
(* MT = VEL                This register cannot be loaded if motion is in progress.
(*                         MT does not need to be set unless it is set to a MT setting other than
(*                         VEL. The default value for MT is VEL.

(* Initialize offset position register to 0
        PSO = 0.0          (* set offset position, units

(* Move axis to offset position 10 with the accelerations and velocities shown.
        MAC = 50.0         (* set motion acceleration, units/sec^2
        MDC = 75.0         (* set motion deceleration, units/sec^2
        MJK = 0            (* set motion jerk percentage, % of accel & decel interval
        MVL = 2.0          (* set motion velocity, units/sec
        MPO = 10.0         (* set offset move position, units
        RPO                (* run to offset move position
```

B.2.5 Blended Move



(* Notes:
(* 1- Registers that have been previously loaded with appropriate values
(* do not have to be reloaded for this motion.
(* 2- Loading the MAC register also loads the MDC register with the same value. To set MDC to a
(* value different from MAC, load MDC after loading the MAC register.
(* 3- This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 4- RPA moves the axis from its present position to the absolute position specified in the MPA
(* register. This example begins by loading the absolute position register, PSA, with 0 for the
(* purpose of accurately graphing the subsequent motion. In general, applications will only load
(* PSA at the end of a homing motion.
(* 5- Blended moves are specified by setting a new velocity in the instruction immediately following a
(* run command AND CAN BE DONE ONLY IN MOTION BLOCKS!

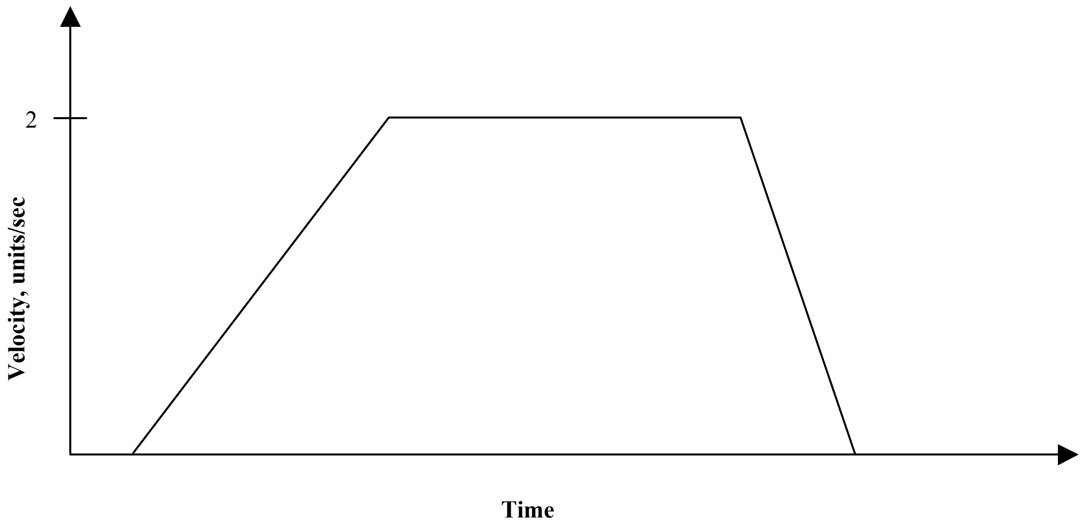
(* Move Type: Velocity-based, blended move
(* Engineering Units: Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion: Move to 100 units at 30 units/sec, then decelerate to 5 units/sec and
(* move to 110 units. Finally, move back to position 0 at 40 units/sec.
(* MT = VEL This register cannot be loaded if motion is in progress.
(* MT does not need to be set unless it is set to a MT setting other than
(* VEL. The default value for MT is VEL.

(* Initialize absolute position register to 0
PSA = 0.0 (* set absolute position, units

```
(* Execute blended move with the accelerations and velocities shown.
    MAC = 50.0          (* set motion acceleration, units/sec^2
    MDC = 75.0          (* set motion deceleration, units/sec^2
    MJK = 0             (* set motion jerk percentage, % of accel & decel interval
    MVL = 30.0          (* set motion velocity, units/sec
    MPA = 100.0         (* set absolute move position, units
    RPA                 (* run to absolute move position
    MVL = 5.0           (* set motion velocity, units/sec
    MPA = 110.0         (* set absolute move position, units
    RPA                 (* run to absolute move position
    MPA = 0.0           (* set absolute move position, units
    MVL = 40.0          (* set motion velocity, units/sec
    RPA                 (* run to absolute move position
```

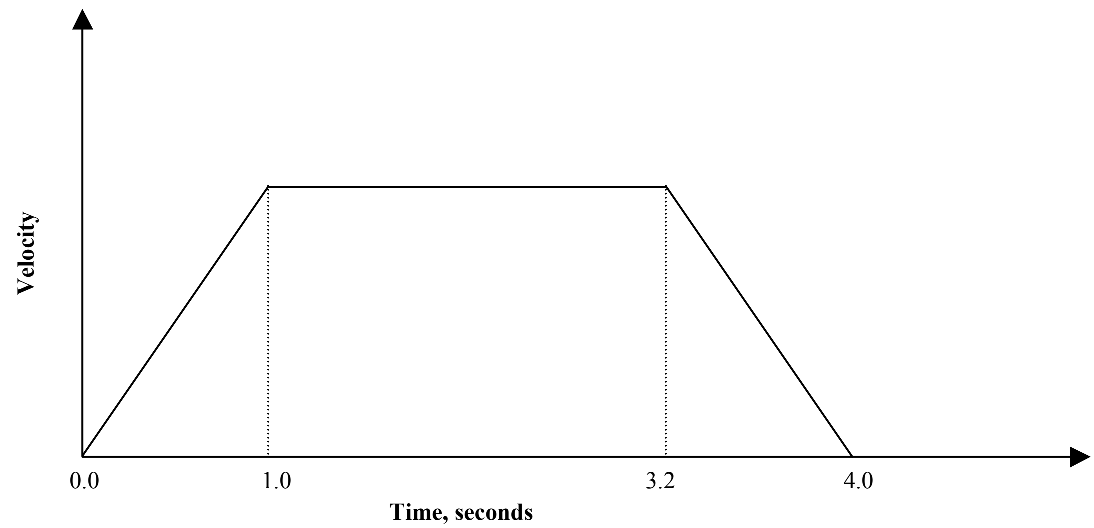
B.2.6 Absolute Move with Feedrate Override




```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values do not have to be reloaded
(*       for this motion.
(* 2-   Loading the MAC register also loads the MDC register with the same value.  To set MDC to a
(*       value different from MAC, load MDC after loading the MAC register.
(* 3-   Loading the MFA register also loads the MFD register with the same value.  To set MFD to a
(*       value different from MFA, load MFD after loading the MFA register.
(* 4-   The Motion Feedrate Percentage register, MFP, slows time by the % specified.  Thus the
(*       velocity is scaled by MFP.  Since acceleration is proportional to 1/(t^2), the acceleration is
(*       scaled by (MFP)^2.
(* 5-   RPA moves the axis from its present position to the absolute position specified in the MPA
(*       register.  This example begins by loading the absolute position register, PSA, with 0 for the
(*       purpose of accurately graphing the subsequent motion.  In general, applications will only load
(*      PSA at the end of a homing motion.


(* Move Type:                 Absolute move with feedrate override
(* Engineering Units:         Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                    Move to 10 units at 20% of 10 units/sec, i.e., 2 units/sec.
(* MT = VEL                   This register cannot be loaded if motion is in progress.
(*                            MT does not need to be set unless it is set to a MT setting other than
(*                            VEL. The default value for MT is VEL.

(* Initialize absolute position register to 0
      PSA = 0.0               (* set absolute position, units

(* Move axis to absolute position 10 with the accelerations and velocities shown.
      MAC = 50.0              (* set motion acceleration, units/sec^2
      MDC = 75.0              (* set motion deceleration, units/sec^2
      MJK = 0                 (* set motion jerk percentage, % of accel & decel interval
      MVL = 10.0              (* set motion velocity, units/sec
      MFA = 500               (* set motion feedrate acceleration, feedrate % / sec
      MFD = 650               (* set motion feedrate deceleration, feedrate % / sec
      MFP = 20.0              (* set motion feedrate percentage, % of velocity
      MPA = 10.0              (* set absolute move position, units
      WAIT MFP <= 20.0        (* wait for feedrate to decrease to 20.0
      RPA                     (* run to absolute move position
```

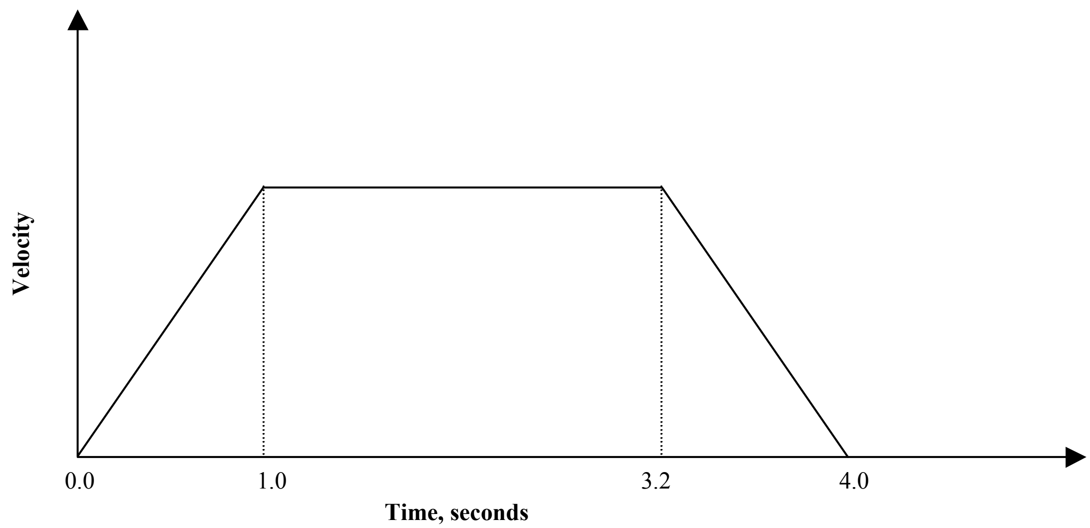
B.3 Time-Based Motion

B.3.1 Time Based Incremental Move



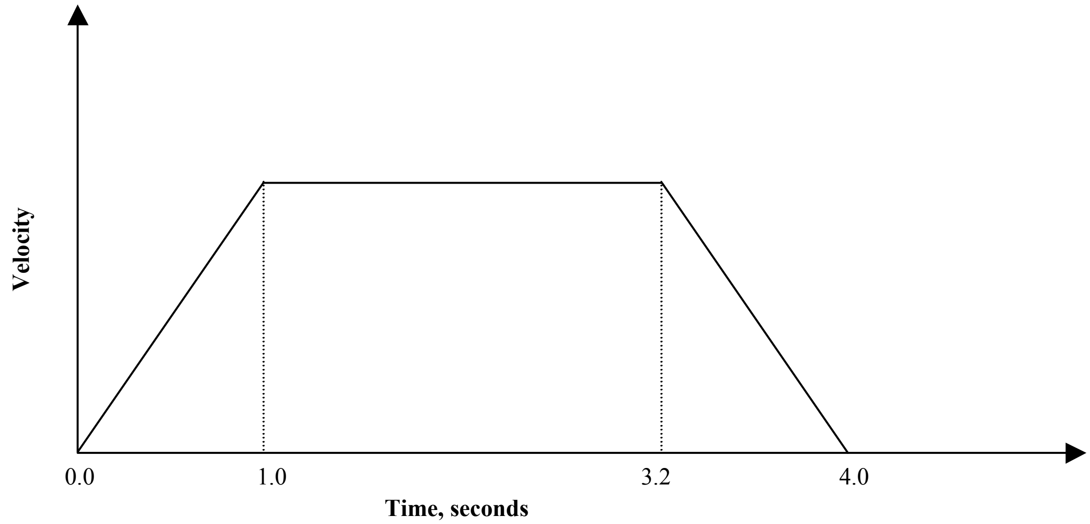

```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*      do not have to be reloaded for this motion.
(* 2-   Loading the MAP register also loads the MDP register with the same value.  To set MDP to a
(*      value different from MAP, load MDP after loading the MAP register.
(* 3-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.

(* Move Type:               Time-based incremental move
(* Engineering Units:       Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                  Move 5 units forward in 4.0 seconds.
(* MT = TIME                This register cannot be loaded if motion is in progress.
(*                          MT does not need to be set unless it is set to a MT setting other than
(*                          TIME. The default value for MT is VEL.

        MAP = 25            (* set motion acceleration percentage, % of move time
        MDP = 20            (* set motion deceleration percentage, % of move time
        MJK = 0             (* set motion jerk percentage, % of accel & decel interval
        MTM = 4.0           (* set move time, seconds
        MPI = 5.0           (* set incremental move position, units
        RPI                 (* run to incremental move position
```

B.3.2 Time Based Absolute Move



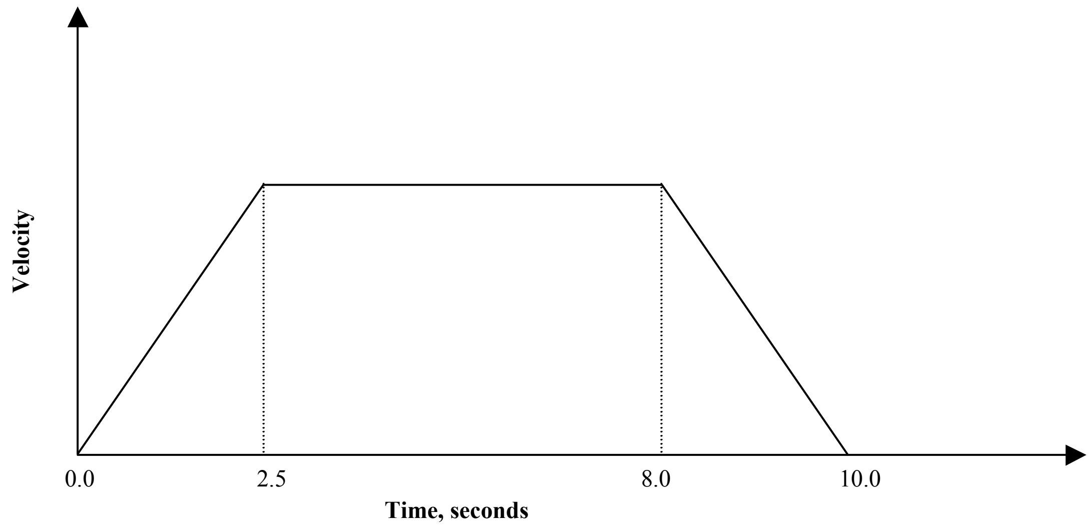

```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values do not have to be reloaded
(*      for this motion.
(* 2-   Loading the MAP register also loads the MDP register with the same value.  To set MDP to a
(*      value different from MAP, load MDP after loading the MAP register.
(* 3-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 4-   RPA moves the axis from its present position to the absolute position specified in the MPA
(*      register. This example begins by loading the absolute position register, PSA, with 0 for the
(*      purpose of accurately graphing the subsequent motion.  In general, applications will only load
(*      PSA at the end of a homing motion.

(* Move Type:              Time-based absolute move
(* Engineering Units:      Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                 Move to absolute position of 5 units in 4.0 seconds.
(* MT = TIME               This register cannot be loaded if motion is in progress.
(*                         MT does not need to be set unless it is set to a MT setting other than
(*                         TIME.  The default value for MT is VEL.

(* Initialize absolute position register to 0
        PSA = 0.0          (* set absolute position, units

(* Move axis to absolute position 5 with the accelerations and move times shown.
        MAP = 25           (* set motion acceleration percentage, % of move time
        MDP = 20           (* set motion deceleration percentage, % of move time
        MJK = 0            (* set motion jerk percentage, % of accel & decel interval
        MTM = 4.0          (* set move time, seconds
        MPA = 5.0          (* set absolute move position, units
        RPA                (* run to absolute move position
```

B.3.3 Time Based Offset Move




```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values do not have to be reloaded
(*      for this motion.
(* 2-   Loading the MAP register also loads the MDP register with the same value.  To set MDP to a
(*       value different from MAP, load MDP after loading the MAP register.
(* 3-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 4-   RPO moves the axis from its present position to the offset position specified in the MPO
(*      register.  This example begins by loading the offset position register, PSO, with 0 for the
(*      purpose of accurately graphing the subsequent motion.  Applications may require other offset
(*       position register values.

(* Move Type:               Time-based offset move
(* Engineering Units:       Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                  Move to offset position of 5 units in 4.0 seconds.

(* MT = TIME                This register cannot be loaded if motion is in progress.
(*                          MT does not need to be set unless it is set to a MT setting other than
(*                          TIME.  The default value for MT is VEL.

(* Initialize offset position register to 0
        PSO = 0.0           (* set offset position, units

(* Move axis to offset position 5 with the accelerations and move times shown.
        MAP = 25            (* set motion acceleration percentage, % of move time
        MDP = 20            (* set motion deceleration percentage, % of move time
        MJK = 0             (* set motion jerk percentage, % of accel & decel interval
        MTM = 4.0           (* set move time, seconds
        MPO = 5.0           (* set offset move position, units
        RPO                 (* run to offset move position
```

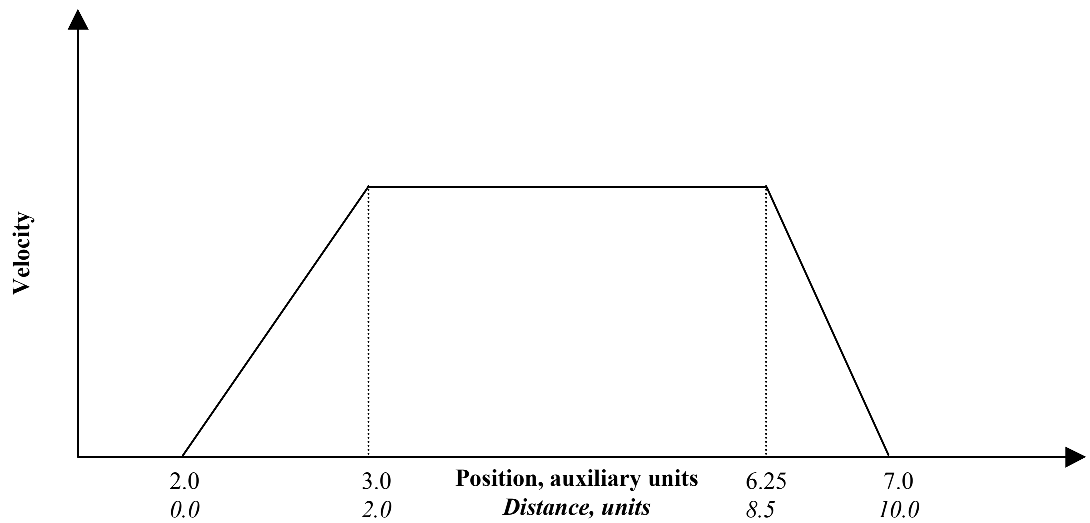
B.3.4 Time Based Absolute Move with Feedrate Override




```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*      do not have to be reloaded for this motion.
(* 2-   Loading the MAP register also loads the MDP register with the same value.  To set MDP to a
(*       value different from MAP, load MDP after loading the MAP register.
(* 3-   Loading the MFA register also loads the MFD register with the same value.  To set MFD to a
(*       value different from MFA, load MFD after loading the MFA register.
(* 4-   The Motion Feedrate Percentage register, MFP, slows time by the % specified.  Thus the move
(*       time and the accel and decel times are increased by the reciprocal of the % specified in MFP.
(* 5-   RPA moves the axis from its present position to the absolute position specified in the MPA
(*       register. This example begins by loading the absolute position register, PSA, with 0 for the
(*       purpose of accurately graphing the subsequent motion.  In general, applications will only load
(*      PSA at the end of a homing motion.

(* Move Type:                Time-based absolute move with feedrate override
(* Engineering Units:        Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                   Move to 5 units in 10 seconds.(40% of 10 seconds = 4 seconds)
(* MT = TIME                 This register cannot be loaded if motion is in progress.
(*                           MT does not need to be set unless it is set to a MT setting other than
(*                           TIME.  The default value for MT is VEL.

(* Initialize absolute position register to 0
      PSA = 0.0              (* set absolute position, units

(* Move axis to absolute position 5 with the accelerations and move times shown.
      MAP = 25               (* set motion acceleration percentage, % of move time
      MDP = 20               (* set motion deceleration percentage, % of move time
      MJK = 0                (* set motion jerk percentage, % of accel & decel interval
      MTM = 4.0              (* set move time, seconds
      MPA = 5.0              (* set absolute move position, units
      MFA = 500              (* set motion feedrate acceleration, feedrate % / sec
      MFD = 650              (* set motion feedrate deceleration, feedrate % / sec
      MFP = 40.0             (* set motion feedrate percentage, % of velocity
      WAIT MFP <= 40.0       (* wait for feedrate to decrease to 40.0
      RPA                    (* run to absolute move position
```

B.4 Pulse-Based Motion

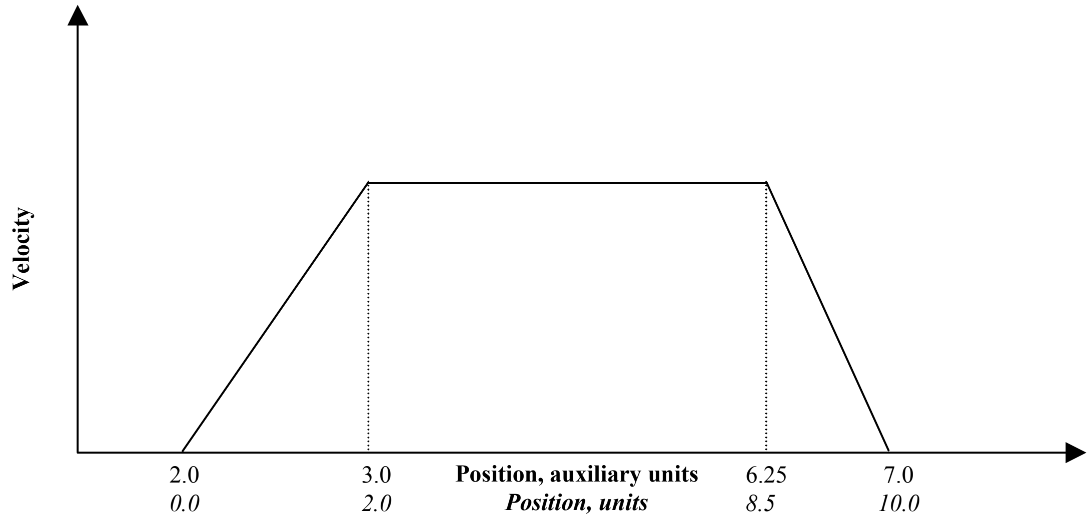
B.4.1 Pulse-Based Incremental Move



(* Notes:
(* 1- Registers that have been previously loaded with appropriate values do not have to be reloaded
(* for this motion.
(* 2- Loading the MAP register also loads the MDP register with the same value. To set MDP to a
(* value different from MAP, load MDP after loading the MAP register.
(* 3- This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 4- This example begins by loading the auxiliary position register (PSX) with 0 for the purpose of
(* accurately depicting the motion. In general, applications will load MPS with the appropriate
(* starting position.

```
(* Move Type:              Pulse-based incremental move
(* Engineering Units:      Motor revolutions: i.e., URA/URB = position feedback resolution
(*                         URX = auxiliary feedback resolution

(* Motion:                 The axis will remain in position until the auxiliary position increases
(*                          to 2 aux. units. Then, as the aux. position increases from 2 to 7 aux.
(*                          units, the axis will run forward 10 axis units.
(* MT = PULSE              This register cannot be loaded if motion is in progress.
(*                         MT does not need to be set unless it is set to a MT setting other than
(*                         PULSE. The default value for MT is VEL.

(* Initialize auxiliary position register to 0
        PSX = 0            (* set auxiliary position, aux. units

(* Move axis 10 units as the auxiliary position goes from 2 to 7 units
        MAP = 20           (* set motion acceleration percentage, % of move pulses
        MDP = 15           (* set motion deceleration percentage, % of move pulses
        MPS = 2.0          (* set motion start position, aux. units
        MPL = 5.0          (* set move pulses, aux. units
        MPI = 10.0         (* set incremental move position, units
        RPI                (* run to incremental move position
```

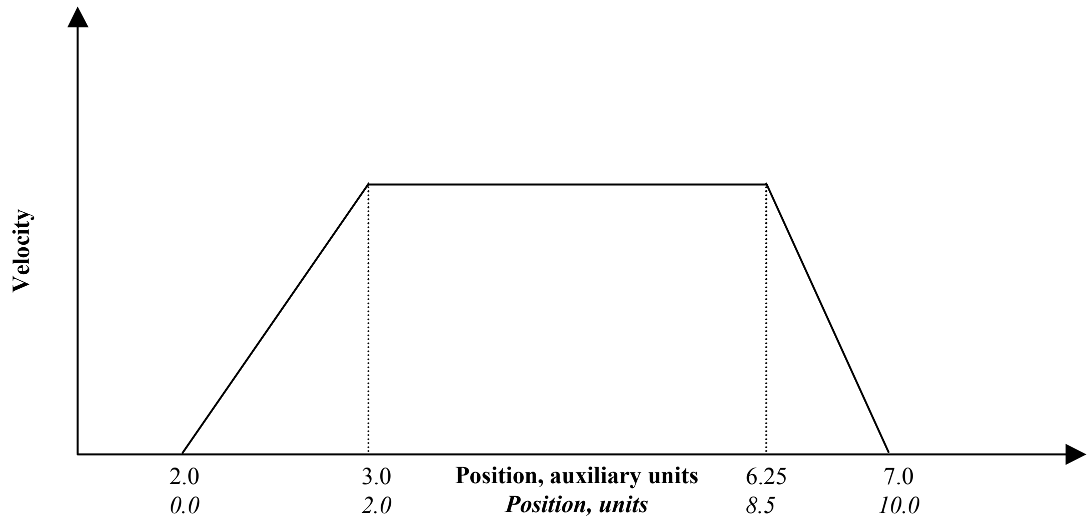
B.4.2 Pulse-Based Absolute Move



(* Notes:
(* 1- Registers that have been previously loaded with appropriate values do not have to be reloaded
(* for this motion.
(* 2- Loading the MAP register also loads the MDP register with the same value. To set MDP to a
(* value different from MAP, load MDP after loading the MAP register.
(* 3- This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100
(* 4- RPA moves the axis from its present position to the absolute position specified in the MPA
(* register. This example begins by loading the absolute position register, PSA, with 0 for the
(* purpose of accurately graphing the subsequent motion. In general, applications will only load
(* PSA at the end of a homing motion.
(*5- This example loads the auxiliary position register (PSX) with 0 for the purpose of accurately
(* depicting the motion. In general, applications will load MPS with the appropriate starting
(* position.

```
(* Move Type:               Pulse-based absolute move
(* Engineering Units:       Motor revolutions: i.e., URA/URB = position feedback resolution
(*                          URX = auxiliary feedback resolution

(* Motion:                  The axis will remain in position until the auxiliary position increases
(*                           to 2 aux. units. Then, as the aux. position increases from 2 to 7 aux.
(*                           units, the axis will run to an absolute position of 10 units.
(* MT = PULSE               This register cannot be loaded if motion is in progress.
(*                          MT does not need to be set unless it is set to a MT setting other than
(*                           PULSE. The default value for MT is VEL.

(* Initialize absolute position register to 0
        PSA = 0.0           (* set absolute position, units

(* Initialize auxiliary position register to 0
        PSX = 0             (* set auxiliary position, aux. units

(* Move axis to absolute position 10 with the accelerations and move pulses shown.
        MAP = 20            (* set motion acceleration percentage, % of move pulses
        MDP = 15            (* set motion deceleration percentage, % of move pulses
        MPS = 2.0           (* set motion start position, aux. units
        MPL = 5.0           (* set move pulses, aux. units
        MPA = 10.0          (* set absolute move position, units
        RPA                 (* run to absolute move position
```

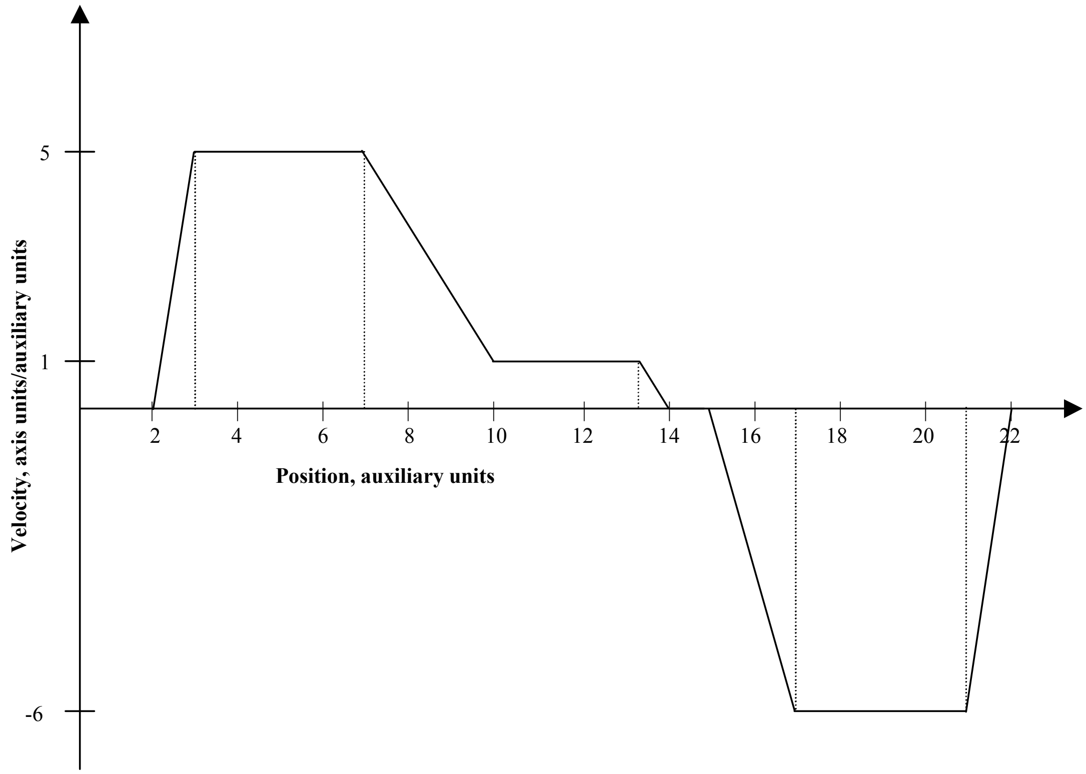
B.4.3 Pulse-Based Offset Move



(* Notes:
(* 1- Registers that have been previously loaded with appropriate values
(* do not have to be reloaded for this motion.
(* 2- Loading the MAP register also loads the MDP register with the same value. To set MDP to a
(* value different from MAP, load MDP after loading the MAP register.
(* 3- This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 4- RPO moves the axis from its present position to the offset position specified in the MPO
(* register. This example begins by loading the offset position register, PSO, with 0 for the
(* purpose of accurately graphing the subsequent motion. Applications may require other offset
(* position register values.
(*5- This example begins by loading the auxiliary position register (PSX) with 0 for the purpose of accurately depicting the motion. In general, applications will load MPS with the appropriate starting position.

```
(* Move Type:              Pulse-based offset move
(* Engineering Units:      Motor revolutions: i.e., URA/URB = position feedback resolution
(*                         URX = auxiliary feedback resolution

(* Motion:                 The axis will remain in position until the auxiliary position increases
(*                          to 2 aux. units. Then, as the aux. position increases from 2 to 7 aux.
(*                          units, the axis will run to an offset position of 10 units.
(* MT = PULSE              This register cannot be loaded if motion is in progress.
(*                         MT does not need to be set unless it is set to a MT setting other than
(*                         PULSE. The default value for MT is VEL.

(* Initialize offset position register to 0
        PSO = 0.0          (* set offset position, units

(* Initialize auxiliary position register to 0
        PSX = 0            (* set auxiliary position, aux. units

(* Move axis to offset position 10 with the accelerations and move pulses shown.
        MAP = 20           (* set motion acceleration percentage, % of move pulses
        MDP = 15           (* set motion deceleration percentage, % of move pulses
        MPS = 2.0          (* set motion start position, aux. units
        MPL = 5.0          (* set move pulses, aux. units
        MPO = 10.0         (* set offset move position, units
        RPO                (* run to offset move position
```

B.4.4 Pulse-Based Blended Move



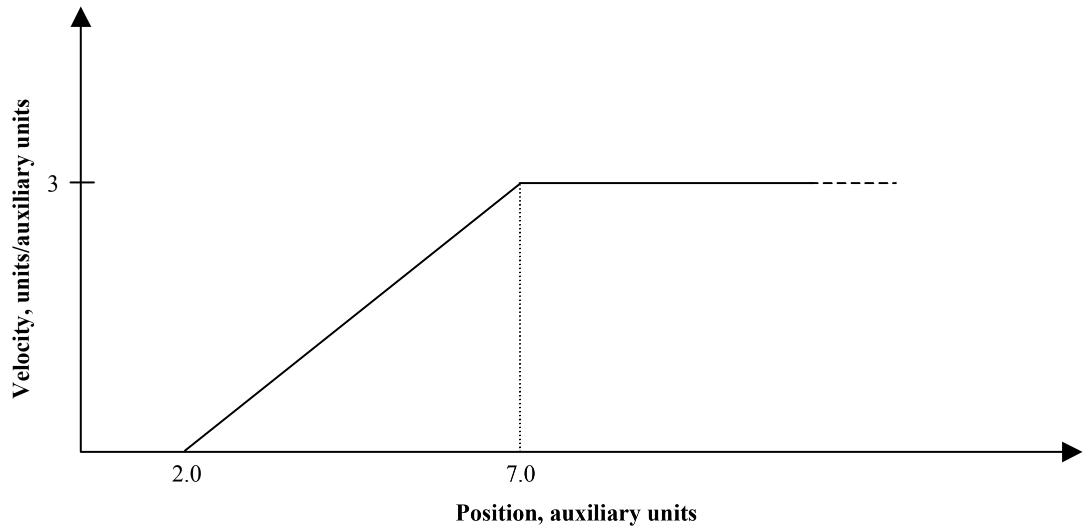
(* Notes:
(* 1- Registers that have been previously loaded with appropriate values need not be reloaded for this
(* motion.
(* 2- This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 3- This example begins by loading the auxiliary position register with 0 for the purpose of
(* accurately depicting the motion. In general, applications will load MPS with the appropriate
(* starting position.
(* 4- RPA moves the axis from its present position to the absolute position specified in the MPA
(* register. This example begins by loading the absolute position register, PSA, with 0 for the
(* purpose of accurately graphing the subsequent motion. In general, applications will load PSA
(* only at the end of a homing motion.
(* 5- Blended moves are specified by setting a new velocity in the instruction immediately following a
(* run command AND CAN BE DONE ONLY IN MOTION BLOCKS!

(* Move Type: Pulse based blended move
(* Engineering Units: Motor revolutions: i.e., URA/URB = position feedback resolution
(* URX = auxiliary feedback resolution

(* Motion: The axis (axis 1 for Target®) will remain in position until the auxiliary
(* position increases to 2 aux. units. Then, as the aux. position increases
(* from 2 to 10 aux. units, the axis will run forward to 30 axis units. As
(* the aux. position further increases to 14 aux. units, the axis will finish
(* running forward to 34 axis units. Finally, as the aux. position increases
(* from 15 to 22 aux. units, the axis will move back to position 0 axis
(* units.

```
(* MT = PULSE                 This register cannot be loaded if motion is in progress.
(*                            MT does not need to be set unless it is set to a MT setting other than
(*                             PULSE.  The default value for MT is VEL.

(* Initialize auxiliary position register to 0.
        PSX = 0               (* set auxiliary position, aux. units

(* Initialize absolute position register to 0
        PSA = 0.0             (* set absolute position, units

(* Execute blended move with the accelerations and velocities shown.
        MAP = 20              (* set motion acceleration percentage, % of move pulses
        MDP = 15              (* set motion deceleration percentage, % of move pulses
        MPS = 2.0             (* set motion start position, aux. units
        MPL = 8.0             (* set move pulses, aux. units
        MPA = 30.0            (* set absolute move position, units
        RPA                   (* run to absolute move position
        MVP = 1.0             (* set motion velocity of pulse move, axis units/aux. units
        MPS = MPS + 8.0       (* set motion start position, aux. units
        MPL = 4.0             (* set move pulses, aux. units
        MPA = 34.0            (* set absolute move position, units
        RPA                   (* run to absolute move position
        MPS = MPS + 5.0       (* set motion start position, aux. units
        MPL = 7.0             (* set move pulses, aux. units
        MPA = 0.0             (* set absolute move position, units
        RPA                   (* run to absolute move position
```

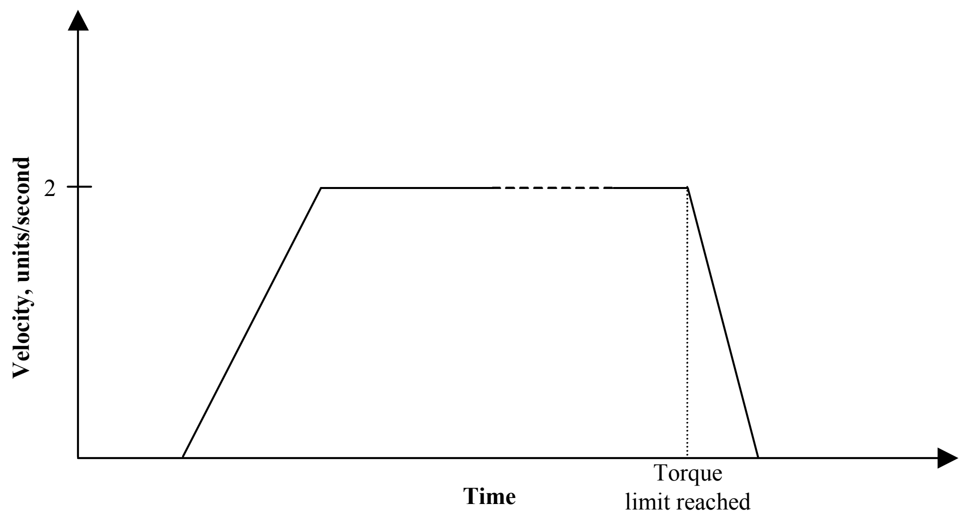
B.4.5 Pulse-Based Continuous Move




```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values do not have to be reloaded for
(*      this motion.
(* 2-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 3-   This example begins by loading the auxiliary position register (PSX) with 0 for the purpose of
(*      accurately depicting the motion.  In general, applications will load MPS with the appropriate
(*      starting position.

(* Move Type:               Pulse-based continuous move
(* Engineering Units:       Motor revolutions: i.e., URA/URB = position feedback resolution
(*                          URX = auxiliary feedback resolution

(* Motion:                  The axis will remain in position until the auxiliary position increases to
(*                           2 aux. units.  Then, as the aux. position increases from 2 to 7 aux. units,
(*                          the axis will accelerate to 3 units/aux. units.
(* MT = PULSE               This register cannot be loaded if motion is in progress.
(*                          MT does not need to be set unless it is set to a MT setting other than
(*                          PULSE.  The default value for MT is VEL.

(* Initialize auxiliary position register to 0
        PSX = 0             (* set auxiliary position, aux. units

(* Execute single-axis continuous move with the accelerations and move pulses shown
        MPS = 2.0           (* set motion start position, aux. units
        MPL = 5.0           (* set move pulses, aux. units
        MVP = 3.0           (* set pulse move velocity, units/aux. units
        RVF                 (* run forward
```

B.5 Torque Limited Motion

B.5.1 Run Forward until Torque Limit



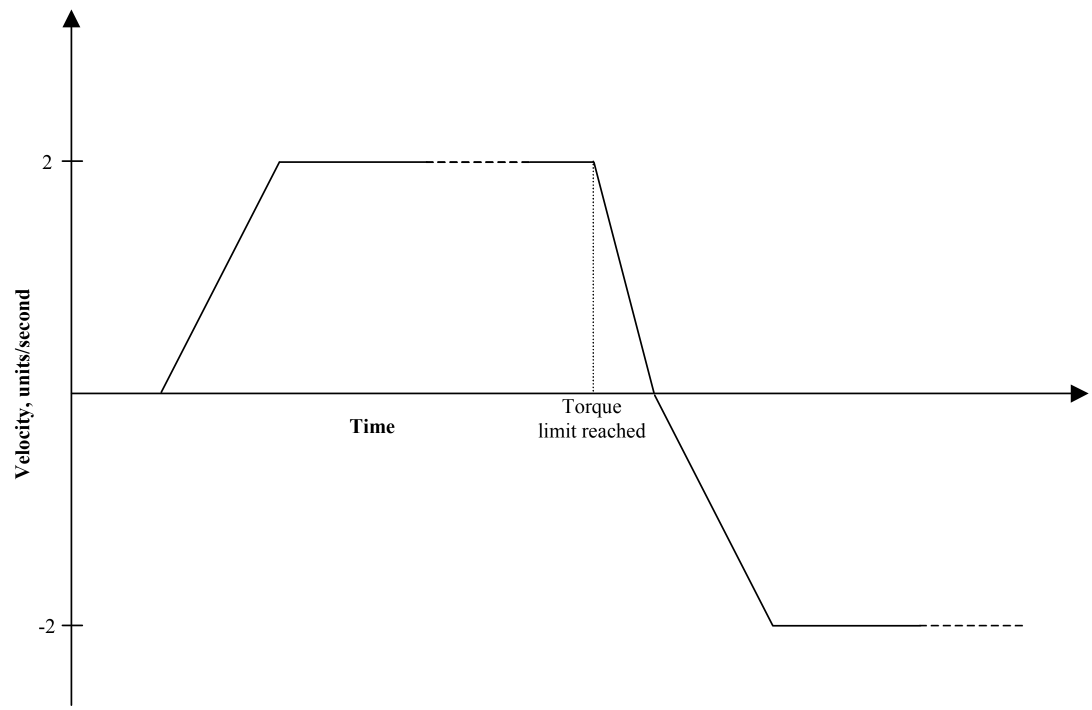
(* Notes:
(* 1- Registers that have been previously loaded with appropriate values
(* do not have to be reloaded for this motion.
(* 2- Loading the MAC register also loads the MDC register with the same value. To set MDC to a
(* value different from MAC, load MDC after loading the MAC register.
(* 3- This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 4- If this template is executed within a motion block, the WAIT TL command is not executed until
(* the acceleration portion of the RVF command is complete.

(* Move Type: Run forward until torque limit
(* Engineering Units: Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion: Run forward until torque limit.
(* MT = VEL This register cannot be loaded if motion is in progress.
(* MT does not need to be set unless it is set to a MT setting other than
(* VEL. The default value for MT is VEL.

```
MAC = 50.0        (* set motion acceleration, units/sec^2
MDC = 75.0        (* set motion deceleration, units/sec^2
MJK = 0           (* set motion jerk percentage, % of accel & decel interval
MVL = 2.0         (* set motion velocity, units/sec
TLC = 10.0        (* set torque limit current, % of continuous current
TLE = ON          (* enable torque limit
RVF               (* run forward
WAIT TL           (* wait for axis to be at torque limit
ST                (* stop all motion
TLE = OFF         (* disable torque limit
```

B.5.2 Run Reverse at Torque Limit




```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*      do not have to be reloaded for this motion.
(* 2-   Loading the MAC register also loads the MDC register with the same value.  To set MDC to a
(*       value different from MAC, load MDC after loading the MAC register.
(* 3-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 4-   If this template is executed within a motion block, the WAIT TL1 and TLE1 = OFF commands
(*      are executed only after the acceleration portions of the preceding motion commands are complete.

(* Move Type:                   Run reverse at torque limit
(* Engineering Units:           Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                      Run forward until torque limit, then run reverse.
(* MT = VEL                     This register cannot be loaded if motion is in progress.
(*                              MT does not need to be set unless it is set to a MT setting other than
(*                              VEL. The default value for MT is VEL.

        MAC = 50.0              (* set motion acceleration, units/sec^2
        MDC = 75.0              (* set motion deceleration, units/sec^2
        MJK = 0                 (* set motion jerk percentage,  % of accel & decel interval
        MVL = 2.0               (* set motion velocity, units/sec
        TLC = 10.0              (* set torque limit current, % of continuous current
        TLE = ON                (* enable torque limit
        RVF                     (* run forward
        WAIT TL                 (* wait for axis to be at torque limit
        RVR                     (* run reverse
        TLE = OFF               (* disable torque limit
```

B.6 Synchronized Motion

B.6.1 Electronic Gearing (Follower)

```
(* Notes:
(* 1 -  Registers that have been previously loaded with appropriate values do not have to be
(*      reloaded for this motion.
(* Move Type:            Electronic gearing
(* Engineering Units:    Motor revolutions: i.e., URA/URB = position feedback resolution
(*                       URX = auxiliary feedback resolution
(* Motion:               Move axis in relation to the auxiliary encoder input.  Axis will follow
(*                        the auxiliary encoder input based on the gearing ratio set by the values
(*                        for the Gearing Numerator (GRN) and Gearing denominator (GRD)
(*                        parameters. (i.e. axis pulses = GRN/GRD* auxiliary pulses)

        GRN = 1          (* set gearing numerator
        GRD = 1          (* set gearing denominator
        GRB = 0          (* set gearing bound
        GRF = 0          (* set gearing filter constant
        GRE = ON         (* enable electronic gearing
```

B.6.2 Phase-Locked Loop

```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values do not have to be
(*      reloaded for this motion.
(* 2-   The phase-locked loop becomes active whenever a position is captured.  The output of the phase-
(*      locked loop is calculated based on the phase error, PHR, which is the difference between the
(*      desired reference position, PHP, and the captured position.  The output of the PLL replaces the
(*      gearing numerator each time the position is captured, thereby changing the value of PHM.

(* Move Type:            Phase-locked loop
(* Engineering Units:    Motor revolutions: i.e., URA/URB = position feedback resolution
(*                       URX = auxiliary feedback resolution

(* Motion:               Move axis in relation to the auxiliary input.  The axis will follow the
(*                       auxiliary input based on the output of the phase-locked loop
(*                       (i.e. axis pulses = PHM * auxiliary pulses) where PHM is the phase
(*                       multiplier, which is equal to the output of the phase-locked loop
(*                       divided by the gearing denominator, GRD.

        PHP = 0          (* set phase position, pulses
        PHL = 4000       (* set phase length, pulses
        PHO = 0          (* set phase offset, pulses
        PHB = 2000       (* set phase error bound, pulses
        PHG = 10         (* set phase gain
        PHZ = 245        (* set phase zero
        PHT = 0.05       (* set phase lockout time, seconds

        GRN = 1000       (* set gearing numerator
        GRD = 1000       (* set gearing denominator
        GRB = 0          (* set gearing bound
        GRF = 0          (* set gearing filter constant

        GRE = ON         (* enable electronic gearing
        PHE = ON         (* enable phase-locked loop
```

B.6.3 Electronic Camming 1

```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*      do not have to be reloaded for this motion.
(* 2-   Loading the MAP register also loads the MDP register with the same value.  To set MDP to a
(*       value different from MAP, load MDP after loading the MAP register.
(* 3-   Loading the MAC register also loads the MDC register with the same value.  To set MDC to a
(*      value different from MAC, load MDC after loading the MAC register.
(* 4-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 5-   Since this template incorporates labels and commands that are not allowed in motion blocks
(*      (GOSUB, RETURN) it can only be used in a program.

(* Move Type:               Electronic camming
(* Engineering Units:       Motor revolutions: i.e., URA/URB = position feedback resolution
(*                          URX = auxiliary feedback resolution

(* Motion:                  Move axis in relation to the auxiliary input.  The axis will follow the
(*                          auxiliary input based on the cam table which contains the points for the
(*                          cam motion.

(* Variables used:          VI10     initial cam location
(*                          VF10     calculated cam shaft offset, degrees

(*  CAM TABLE SETUP

  100  CAZ                  (* zero cam table
(* compile 285 - 75 degree motion segment
       CCP = -1.0           (* set cam compile start position, axis units
       MPA = 1.0            (* set absolute move position, axis units
       CCB = 285.0          (* set cam compile beginning point, degrees
       CCE = 75.0           (* set cam compile ending point, degrees
       MAP = 25             (* set motion accel percentage, % of motion
       MDP = 20             (* set motion decel percentage, % of motion
       MJK = 100            (* set motion jerk percentage, % of accel/decel interval
       CCM                  (* compile axis motion segment
(* compile 75 - 105 degree dwell
       CCP = MPA            (* set cam compile start position, axis units
       CCB = CCE            (* set cam compile beginning point, degrees
       CCE = 105.0          (* set cam compile ending point, degrees
       CCM                  (* compile axis motion segment
(* compile 105 - 255 degree motion segment
       CCP = MPA            (* set cam compile start position, axis units
       MPA = -1.0           (* set absolute move position, axis units
       CCB = CCE            (* set cam compile beginning point, degrees
       CCE = 255.0          (* set cam compile ending point, degrees
       CCM                  (* compile axis motion segment
(* compile 255 - 285 degree dwell
       CCP = MPA            (* set cam compile start position, axis units
       CCB = CCE            (* set cam compile beginning point, degrees
       CCE = 285.0          (* set cam compile ending point, degrees
       CCM                  (* compile axis motion segment
       RETURN               (* return from subroutine

 (*  RUN CAM MOTION

(* MT = VEL                 This register cannot be loaded if motion is in progress.
(*                          MT does not need to be set unless it is set to a MT setting other than
```

(*VEL. The default value for MT is VEL.

```
CAT = PSX                       (* set cam type to auxiliary input
CAS = 2.5                       (* set cam scale factor
VI10 = 2700                     (* define initial cam location
VF10 = -CAP + ITF(VI10) / 10.   (* calculate the cam shaft offset
IF VF10 > 180. THEN             (* bound offset to +/- 180 degrees
VF10 = VF10 - 360.
IF VF10 <= -180. THEN VF10 = VF10 + 360.
CAO = VF10                      (* set cam offset, degrees
GOSUB 100                       (* generate cam table
MVL = 1.0                       (* set motion velocity, units/sec
MAC = 50.0                      (* set motion acceleration, units/sec^2
MDC = 75.0                      (* set motion deceleration, units/sec^2
MPA = CAS * CAMVI10             (* set absolute move position, units
RPA                             (* run to initial cam follower position
WAIT IP                         (* wait for axis to be in position
CAF = 2                         (* set cam filter constant
STM1 = 0.1                      (* set start time of timer 1, seconds
WAIT TM1                        (* wait for filter to settle
CAE = ON                        (* enable electronic camming
```

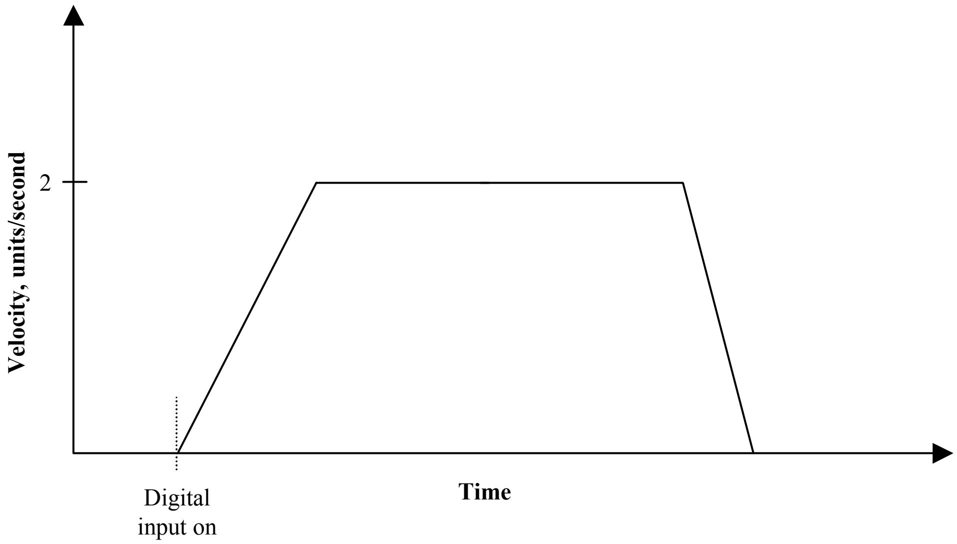
B.6.4 Electronic Camming 2

```
(* Program:     S2K_CAM1.txt
(* Part number: 2050xxxx
(* Product:  S2Kwith encoder feedback motor
(* Application:  Simple Sine CAM demo
(* Revision 1.0                          07/05/2000  wbh
(* Original revision

(*======================================================================

(* This example compiles a sinusoidal shape cam.  Axis position = 0 for
(* -90 <= x <90; 1+sine(2x-270) for 90 <= x < 270.
(* The example is coded as a subroutine for ease of use.  Gosub 100 in program 1
(* for an external CAM input, gosub 200 to use the controller internal time base.
(* The controller initialization parameters are included.

(************************)
(* Controller Parameters *)
(************************)

  ura = 10000                        (* axis unit ratio numerator
  urb = 1                            (* axis unit ratio denominator
  pwe = off                          (* disable position register wrap
  ipb = 0.01                         (* in-position band, units
  feb = 0.25                         (* following error bound, units
  dse = 0                            (* no OIP
  ote = off                          (* disable hardware overtravels
  dir = cw                           (* forward motor direction

  qtx = q4                           (* counts per encoder line
  urx = 1                            (* auxiliary encoder pulses per unit
  plx = 2000                         (* 2*plx counts per 360 degrees of CAM input

(****************************************************)
(* MOTOR AND AXIS PARAMETER ASSIGNMENTS FOR          *)
(* SLM100N2KE25A MOTOR AND 7.2 AMP S2K CONTROLLER    *)
(****************************************************)
```

```
        cmr = 1                                     (* motor poles/resolver poles
        cmo = -90                                   (* commutation offset
        curc = 100.                                 (* continuous current, % drive rated
        curp = 100.                                 (* peak current, % drive rated
        kp = 32                                     (* proportional gain
        ki = 9300                                   (* integral gain
        kd = 230                                    (* derivative gain
        ka = 73                                     (* accel feedforward
        kt = 2                                      (* filter time constant
        kl = 3                                      (* SLM100 motor line-line inductance

      (*=========================================================================

      (************************************************)
      (* Program 1: dummy program to call CAM function *)
      (************************************************)

        Program1                                    (* begin program 1
        rsf                                         (* reset faults
        psa = 0.                                    (* reset axis position
        gosub 200                                   (* initialize CAM
        goto 999                                    (* goto end of program


      (************************************************************)
      (* Subroutine 100: CAM example using auxiliary encoder input *)
      (************************************************************)

      (* Subroutine identification
100     REM CAM example with computed CAM table
        REM Axis position = 0 for -90<=x<90; 1+sin(2x-270)for 90<=x<270;
        REM CAM input = auxiliary encoder position register, PSX

      (* Load 3600 point CAM table
        caz                                         (* empty cam table
        vi100 = 900                                 (* initialize x
101     camvi100=1.+sin((itf(2*vi100)/10.)-270.)    (* load cam table with sin(2x-270))
        vi100 = vi100 + 1                           (* increment x
        if vi100 < 2700 goto 101                    (* continue for 1800 points
        dgp "Cam Load Complete $N"                  (* print cam loaded message

        psx = 0.                                    (* initialize starting CAM angle
        cat = psx                                   (* cam shaft position type = aux encoder register
        cao = 0.                                    (* set cam shaft angle offset
        cas = 2.5                                   (* set cam lift scale factor
        caf = 3                                     (* set cam input filter to max
        mac = 10.0                                  (* set acceleration
        mvl = 2.0                                   (* set velocity
        cae = 1                                     (* enable camming
        return                                      (* return from subroutine


      (************************************************************)
      (* Subroutine 200: CAM example using CAM position register   *)
      (************************************************************)

      (* Subroutine identification
200     REM CAM example with computed CAM table
        REM Axis position = 0 for -90<=x<90; 1+sin(2x-270)for 90<=x<270;
        REM CAM input = cam position register
```

```
      (* Load 3600 point CAM table
        caz                                         (* empty cam table
        vi100 = 900                                 (* initialize x to 90 degrees
201     camvi100=1.+sin((itf(2*vi100)/10.)-270.)    (* load cam table with sin(2x-270))
        vi100 = vi100 + 1                           (* increment x
        if vi100 < 2700 goto 201                    (* continue until x = 270 degrees

        dgp "Cam Load Complete $N"                  (* print cam loaded message

        cai = 0.                                    (* set cam increment, degrees/sec
        car = 0.                                    (* set cam position register to 0 degrees
        cat = car                                   (* cam shaft position type = cam position register
        cao = 0.                                    (* set cam shaft angle offset
        cas = 2.5                                   (* set cam lift scale factor
        mac = 10.0                                  (* set acceleration
        mvl = 2.0                                   (* set velocity
        cae = 1                                     (* enable camming
        wait ip                                     (* wait for axis at first cam point
        cai = 90.                                   (* set cam increment = 90 degrees/second
        return                                      (* return from subroutine


        999  End                                    (* end program 1
```

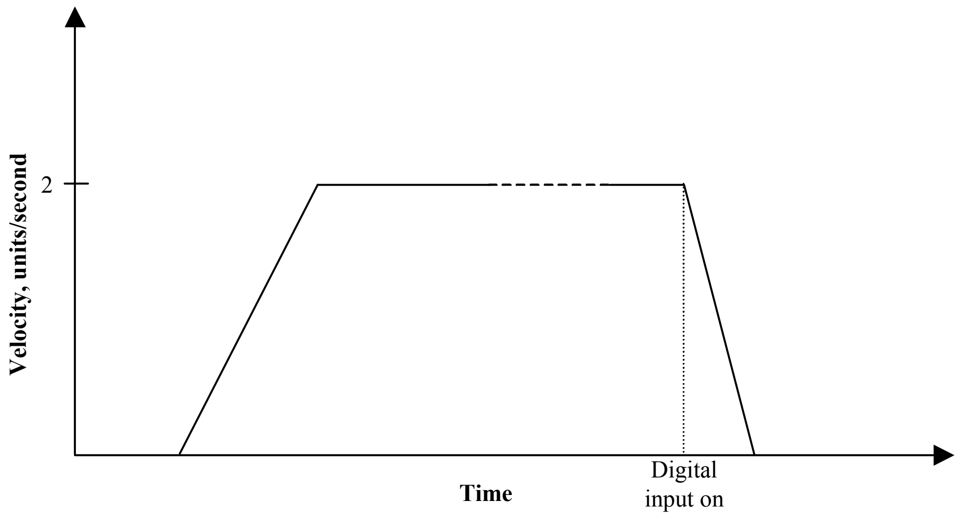
B.6.5 Index Move After Digital Input



(* Notes:
(* 1- Registers that have been previously loaded with appropriate values
(* do not have to be reloaded for this motion.
(* 2- Loading the MAC register also loads the MDC register with the same value. To set MDC to a
(* value different from MAC, load MDC after loading the MAC register.
(* 3- This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.

```
(* Move Type:               Index move after digital input
(* Engineering Units:       Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                  Run forward by 3 units after digital input 1 turns on.
(* MT = VEL                 This register cannot be loaded if motion is in progress.
(*                          MT does not need to be set unless it is set to a MT setting other than
(*                          VEL. The default value for MT is VEL.

      MAC = 50.0            (* set motion acceleration, units/sec^2
      MDC = 75.0            (* set motion deceleration, units/sec^2
      MJK = 0               (* set motion jerk percentage, % of accel & decel interval
      MVL = 2.0             (* set motion velocity, units/sec
      MPI = 3.0             (* set incremental move position, units
      WAIT DI1              (* wait for digital input 1 to be turned on
      RPI                   (* run to incremental move position
```

B.6.6 Run Forward until Digital Input



(* Notes:
(* 1- Registers that have been previously loaded with appropriate values
(* do not have to be reloaded for this motion.
(* 2- Loading the MAC register also loads the MDC register with the same value. To set MDC to a
(* value different from MAC, load MDC after loading the MAC register.
(* 3- This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* Move Type: Run forward until digital input
(* Engineering Units: Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion: Run forward until input turned on.
(* MT = VEL This register cannot be loaded if motion is in progress.
(* MT does not need to be set unless it is set to a MT setting other than
(* VEL. The default value for MT is VEL.

```
MAC = 50.0      (* set motion acceleration, units/sec^2
MDC = 75.0      (* set motion deceleration, units/sec^2
MJK = 0         (* set motion jerk percentage, % of accel & decel interval
MVL = 2.0       (* set motion velocity, units/sec
RVF             (* run forward
WAIT DI1        (* wait for digital input 1 to be turned on
ST              (* stop all motion
```

B.6.7 Index Move at Predefined Auxiliary Position Reference

```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*      do not have to be reloaded for this motion.
(* 2-   Loading the MAP register also loads the MDP register with the same value.  To set MDP to a
(*      value different from MAP, load MDP after loading the MAP register.
(* 3-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 4-   In order for this example to work properly, the position register wrap must be enabled ( PWE =1)
(* 5-   Since this template incorporates labels and commands that are not allowed in motion blocks
(*      (GOTO), it can be used only in a program.

(* Move Type:               Index move at predefined auxiliary position reference
(* Engineering Units:       Motor revolutions: i.e., URA/URB = position feedback resolution
(*                          URX = auxiliary feedback resolution

(* Motion:                  The axis will remain in position until the position capture input edge is
(*                          detected.  Then, as the aux. position increases by 3 aux. units, the axis
(*                          will run  forward 6 axis units.
(* MT = PULSE               This register cannot be loaded if motion is in progress.
(*                          MT does not need to be set unless it is set to a MT setting other than
(8                          PULSE. The default value for MT is VEL.

     MAP = 20               (* set motion acceleration percentage, % of move pulses
     MDP = 15               (* set motion deceleration percentage, % of move pulses
     MPL = 3.0              (* set move pulses, aux. units
     MPI = 6.0              (* set incremental move position, units
     VF10 = 0.2             (* load distance between sensor and motion start
001  VF20 = PCA             (* reset position capture
     VF21 = PCX             (* reset aux. position capture
     WAIT IO13              (* wait for position capture input edge
     VF11 = PCX + VF10      (* calculate motion start position
     IF VF11 < (PLX - (MPL + VF10)) - (1.0 / ITF(URX)) GOTO 10
                            (* if start position < max positive goto 10
     OFX = -(MPL + VF10)    (* offset aux. position by move pulses  + distance between sensor and
                            (* motion start
     MPS = VF11 - (MPL + VF10)
                            (* set motion start position, aux. units
     RPI                    (* run to incremental move position
     WAIT IP                (* wait until motion ends
     OFX = MPL + VF10       (* offset aux. position back to original
     GOTO 1                 (* go back and wait for position capture
010  MPS = VF11             (* set motion start position, aux. units
     RPI                    (* run to incremental move position
     WAIT IP                (* wait until motion ends
     GOTO 1                 (* go back and wait for position capture
```

B.6.8 Index with Registration Mark

```
      (* Program:     Index1.txt
      (* Part number: 2050xxxx
      (* Product:  S2K
      (* Application: Index with registration mark

      (* Revision 1.0                      07/05/2000  wbh
      (* Original revision

      (* This program example illustrates an indexing application where the final
      (* position is determined by the location of a registration mark on the indexed
      (* material.  Provision is also included for a registration window to reject
      (* extraneous registration signals.  Not included in this example are procedures
      (* for homing and setting the initial position of the registration mark.

      (*************)
      (* Index I/O *)
      (*************)

      (*    di4                                    (* start index input
      (*    do12                                   (* index complete output

      (***************************)
      (* Index motion parameters *)
      (***************************)

        vf10 = 13.55                      (* nominal index length
        vf11 = 10.00                      (* location of beginning of registration window
        vf12 = 12.5                       (* location of end of registration window
        vf13 = 2.00                       (* distance to feed after registration mark

        vf100 = 0.                        (* scratchpad register

      (******************************)
      (* Index to registration mark *)
      (******************************)
        psa = 0.0                         (* initialize axis position
        mac = 200.                        (* load index acceleration
        mdc = 300.                        (* load index deceleration
        mvl = 20.                         (* load index velocity
050     wait not di4                      (* wait for no start input
        do12 = off                        (* turn off index complete output
        mpa = vf10                        (* load nominal label length
        wait di4                          (* wait for start input
        rpa                               (* start index motion
        wait psa >= vf11                  (* wait for start of registration
                                          (*  window
        vf100 = pca                       (* reset position capt flag
        wait io13 when psa >= vf12 goto 55 (* wait for capture edge

                                          (*  when beyond window, go wait for motion to stop
        mpa = pca + vf13                  (* compute updated index position
        rpa                               (* run to new index position
055     wait ip                           (* wait for motion complete
        do12 = on                         (* turn on index complete output
        ofa = -mpa                        (* subt the last move from the axis position
        goto 50                           (* repeat index cycle
```

B.7 Utility Templates

B.7.1 First-In First-Out Buffer

```
(* Function:                    First in first out buffer

(* Operation:
(*      Subroutine 300:         Increment stack input pointer and depth.
(*                                      Depth limited to value in VI21.
(*                                      Set VB20 if depth = VI21.
(*
(*      Subroutine 310:         If depth > 0, increment stack output pointer and
(*                                      decrement stack depth.  VB21 set if depth = 0.
(*
(*      Subroutine 320:         Initialize FIFO stack input and output pointers to
(*                                      value in VI20.  Initialize depth to 0.

(*  Global resources:
(*      VB20                    FIFO full flag
(*      VB21                    FIFO empty flag

(*  Module specific resources:
(*      Labels 300 through 320
(*      VFVI20 - VF(VI20+VI21)          FIFO stack variables
(*      VI20                    FIFO start
(*      VI21                    maximum FIFO length
(*      VI22                    FIFO input pointer
(*      VI23                    FIFO output pointer
(*      VI24                    FIFO depth

(* Example of FIFO use:
(*
(*      VFVI22 = AIp1           (* load analog input into fifo, IMJ uses AIp1 register
(*      GOSUB 300               (* increment input pointer
(*      ...
(*      IF VI24 = 0 GOTO 20     (* check for data available
(*      AO = VFVI23             (* load analog output from fifo
(*      GOSUB 310               (* increment output pointer
(*  20  ...

(*  begin FIFO

(*  Subroutine: Increment FIFO stack input pointer. Call after loading
(*  variable pointed to by VI22 with new input value.

300     VI22 = VI22 + 1                 (*  increment input pointer
        IF VI22 >= (VI20+VI21) THEN     (*  reset input pointer if
        VI22 = VI20                     (*    past top of buffer
        VI24 = VI24 + (NOT VB20)        (*  increment stack depth
        VB21 = FALSE                    (*  reset FIFO empty flag
        VB20 = (VI24 >= VI21)           (*  set state of FIFO full flag
        RETURN                          (*  return from subroutine

(*  Subroutine: Increment FIFO stack output pointer.  Call after
```

```
(*  retrieving value from variable pointed to by VI23.

310   IF VI24 = 0 GOTO 315            (*  If empty, return from subroutine
      VI23 = VI23 + 1                 (*  increment output pointer
      IF VI23 >= (VI20+VI21) THEN     (*  reset output pointer if
      VI23 = VI20                     (*    end of buffer
      VI24 = VI24 - 1                 (*  decrement stack depth
      VB21 = (VI24 = 0)               (*  set state of FIFO empty flag
315   RETURN                          (*  return from subroutine

(*  Subroutine: Initialize FIFO

320   VI22 = VI20                     (*  initialize input pointer
      VI23 = VI20                     (*  initialize output pointer
      VI24 = 0                        (*  initialize stack depth
      VB20 = FALSE                    (*  reset FIFO full flag
      VB21 = TRUE                     (*  set FIFO empty flag
      RETURN                          (*  return from subroutine
```

B.7.2 Jog Using Analog Input

```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*      do not have to be reloaded for this motion.
(* 2-   Loading the MAC register also loads the MDC register with the same value.  To set MDC to a
(*      value different from MAC, load MDC after loading the MAC register.
(* 3-   Loading the MFA register also loads the MFD register with the same value.  To set MFD to a
(*       value different from MFA, load MFD after loading the MFA register.
(* 4-   The Motion Feedrate Percentage Register, MFP, slows time by the % specified.  Thus the velocity
(*       is scaled by MFP.  Since acceleration is proportional to 1/(t^2), the acceleration is scaled by
(*      (MFP)^2.
(* 5-   Since this template incorporates labels and commands that are not allowed in motion blocks
(*       (GOTO), it can be used only in a program.


(* Move Type:                 Jog using analog input
(* Engineering Units:         Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                    Jog axis in response to the analog input.  The axis will move at a
(*                            velocity that  is proportional to the analog input.

(* Variables used:            VF10     velocity scale factor, (units/sec)/volt
(*                            VF11     computed feedrate percentage
(*                            VF12     maximum velocity, units/sec
(* MT = VEL                   This register cannot be loaded if motion is in progress.
(*                            MT does not need to be set unless it is set to a MT setting other than
(*                            VEL.  The default value for MT is VEL.

      AIBp1 = 0.0             (* set analog input deadband, volts.  IMJ requires AIBp1=0.0
      AIOp1 = 0.0             (* set analog input offset, volts.  IMJ requires AIOp1
      VF10 = 4.0              (* set velocity scale factor, (units/sec)/volt
      VF12 = 40.0             (* set maximum velocity, units/sec
      MFA = 500               (* set motion feedrate acceleration, feedrate % / sec
      MFD = 650               (* set motion feedrate deceleration, feedrate % / sec
      MFP = 0.0               (* set motion feedrate percentage, % of velocity
      MAC = 200000.0          (* set motion acceleration, units/sec^2
      MDC = 200000.0          (* set motion deceleration, units/sec^2
      MJK = 0                 (* set motion jerk percentage, % of accel & decel interval
      MVL = 40.0              (* set motion velocity, units/sec
      WAIT MFP = 0.0          (* wait for feedrate to decrease to 0.0
      RVF                     (* run forward
001   VF11 = ((AI p1* VF10) / VF12) * 100.
                              (* compute feedrate percentage.  IMJ requires AIp1 register
      IF VF11 < 0.5 THEN      (* if feedrate < minimum allowed then
      VF11 = 0.0              (*  set feedrate to 0
      IF VF11 > 100.0 THEN    (* if feedrate > maximum allowed then
      VF11 = 100.0            (*  set feedrate to maximum
      MFP = VF11              (* set motion feedrate percentage
      GOTO 1                  (* go back and compute new feedrate
```

B.7.3 Jog Using Electronic Handwheel

```
(* Move Type:              Jog using electronic handwheel
(* Engineering Units:      Motor revolutions: i.e., URA/URB = position feedback resolution
(*                         URX = auxiliary feedback resolution
(*
(* Motion:                 Move axis in relation to the electronic handwheel.  The electronic
(*                          handwheel is used in place of the auxiliary input as a means of
(*                         positioning for electronic gearing.  The axis will follow the auxiliary
(*                         input based on the values of GRN and GRD, i.e.,
(*
(*                                           GRN
(*                           axis pulses = ——— * handwheel pulses
(*                                           GRD

(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*      do not have to be reloaded for this motion.
(* 2-   The electronic handwheel input can be connected to the auxiliary input or to digital inputs 5 and 6.
(*      Setting HWE = ON enables digital inputs 5 and 6 as the handwheel inputs.

(* MT = VEL                This register cannot be loaded if motion is in progress.
(*                         MT does not need to be set unless it is set to a MT setting other than
(*                         VEL.  The default value for MT is VEL.

     GRN = 1               (* set gearing numerator
     GRD = 1               (* set gearing denominator
     GRB = 0               (* set gearing bound
     GRF = 0               (* set gearing filter constant
     GRE = ON              (* enable electronic gearing
     HWE = ON              (* enable digital inputs 5 and 6 electronic handwheel
```

B.7.4 Jog Using Single-Pole, Double-Throw Switch

```
(* Notes:
(* 1-   Registers that have been previously loaded with appropriate values
(*       do not have to be reloaded for this motion.
(* 2-   Loading the MAC register also loads the MDC register with the same value.  To set MDC to a
(*      value different from MAC, load MDC after loading the MAC register.
(* 3-   This example assumes the MFP (Motion Feedrate Percentage) is set to its default value of 100.
(* 4-   Since this template incorporates labels and commands that are not allowed in motion blocks
(*       (GOTO), it can only be used in a program.

(* Move Type:                Jog using single-pole, double-throw switch
(* Engineering Units:        Motor revolutions: i.e., URA/URB = position feedback resolution

(* Motion:                   Jog axis in response to a single-pole, double-throw switch.  Jog axis
(*                            forward while digital input 1 is true.  Jog axis reverse while digital input
(*                           2 is true.
(* MT = VEL                  This register cannot be loaded if motion is in progress.
(*                           MT does not need to be set unless it is set to a MT setting other than
(*                           VEL. The default value for MT is VEL.

        MAC = 50.0           (* set motion acceleration, units/sec^2
        MDC = 75.0           (* set motion deceleration, units/sec^2
        MJK = 0              (* set motion jerk percentage,  % of accel & decel interval
        MVL = 1.0            (* set motion velocity, units/sec
001     WAIT DI1 OR DI2      (* wait for digital input 1 or 2 to turn on
        IF DI2 GOTO 20       (* goto label 20 if digital input 2 on
        RVF                  (* run forward
        WAIT NOT DI1         (* wait for digital input 1 to turn off
        ST                   (* stop all motion
        GOTO 1               (* go back and wait for digital input
020     RVR                  (* run reverse
        WAIT NOT DI2         (* wait for digital input 2 to turn off
        ST                   (* stop all motion
        GOTO 1               (* go back and wait for digital input
```

B.7.5 Retriggerable One-Shot

```
(* Function:                Retriggerable One Shot

(* Operation:               Implement one-shot output on DO7 and DO8 with
(*                          programmable on-delay and programmable off-delay.
(*                          One-shots are triggered by VB27 and VB28.

(* NOTE: to maintain accurate timing, call this module every 10 ms.
(*
(* Global resources:
(*      vb27                DO7 one shot input
(*      vb28                DO8 one shot input
(*      vf40                DO7 on-delay time, sec
(*      vf41                DO7 off-delay time, sec
(*      vf42                DO8 on-delay time, sec
(*      vf43                DO8 off-delay time, sec

(* Module specific resources:
(*      Labels 500 through 549
(*      tm7 and tm8         One shot timers
(*      vb120               DO7 output on_delay timer flag
(*      vb121               tm7 timer state
(*      vb122               DO8 output on_delay timer flag
(*      vb123               tm8 timer state
(*      do7                 one shot output
(*      do8                 one shot output

(* Example of One-Shot use:
(*      do7 = off           (* initialize outputs to off
(*      do8 = off
(*      vb120 = off         (* initialize states to off
(*      vb121 = off
(*      vb122 = off
(*      vb123 = off
(*      stm1 = 0.01         (* initialize i/o scan timer
(* 005    wait tm1          (* wait for scan tick
(*      ...                 (* body of i/o scan
(*        gosub 500         (* execute ONE_SHOT
(*      goto 05             (* repeat scan

(* Begin One_shot
(* Start DO7 One-Shot if vb27
500     if not vb27 goto 505        (* if no input go check timers
        vb27 = false                (* reset input trigger
        if vf40 < 0.005 goto 510    (* no delay if time < 5 ms
        stm7 = vf40                 (* start on-delay timer
        vb120 = true                (* set on-delay timer flag
505     vb121 = tm7                 (* capture timer state
        if (not vb120) or (not vb121) goto 515
                                    (* if timing, continue else start off-delay
510     if vf41 < 0.005 goto 516    (* no delay for short times
        stm7 = vf41                 (* start off-delay timer
        vb120 = false               (* cancel on-delay flag
        do7 = on                    (* turn on output
        goto 520                    (* go check next input
```

```
515   if vb120 or (not vb121) or (not do7) goto 520
                                  (* if timing continue
516   do7 = off                   (* else turn off output

(* Start DO8 One-Shot if vb28
520   if not vb28 goto 525        (* if no input go check timers
      vb28 = false                (* reset input trigger
      if vf42 < 0.005 goto 530    (* no delay if time < 5 ms
      stm8 = vf42                 (* start on-delay timer
      vb122 = true                (* set on-delay timer flag
525   vb123 = tm8                 (* capture timer state
      if (not vb122) or (not vb123) goto 535
                                  (* if timing, continue else start off-delay
530   if vf43 < 0.005 goto 536    (* no delay for short times
      stm8 = vf43                 (* start off-delay timer
      vb122 = false               (* cancel on-delay flag
      do8 = on                    (* turn on output
      goto 540                    (* go check next input
535   if vb122 or (not vb123) or (not do8) goto 540
                                  (* if timing continue
536   do8 = off                   (* else turn off output

540   return
(*  End One_shot
```

B.7.6 PID Algorithm

```
(* Function:                      Proportional, Integral, Derivative Controller with bounded integrator

(* Operation:                     Solve PID algorithm:
(*                                output(n) = KA*command(n) + KP*error(n) + KI*sum(error(N))
(*                                 + KD*{0.2083646*[error(n-1) - error(n-2)]
(*                                           - .0285944*[error(n) - error(n-3)]}

(* Global resources:
(*  PID parameters
(*      VF20                      KP, proportional gain
(*      VF21                      KI, integral gain
(*      VF22                      KD, derivative gain
(*      VF23                      KF, feed forward gain
(*      VF24                      integrator bound
(*  Inputs
(*      VF100                     command(n)
(*      VF101                     error(n)
(*  Output
(*      VF102                     PID output(n)

(*  Module specific registers:
(*      VF103                     error(n-1)
(*      VF104                     error(n-2)
(*      VF105                     error(n-3)
(*      VF106                     integrator accumulator
(*      VF107                     derivative result

(* Example PID initialization:
(*      VF20 = 1.0                (* set proportional gain
```

```
(*      VF21 = .01              (* set integral gain
(*      VF22 = 10.0             (* set derivative gain
(*      VF23 = 0.0              (* set feed forward gain
(*      VF24 = 7.5              (* set integrator bound
(*      VF103 = 0.0             (* reset PID state to zero
(*      VF104 = 0.0
(*      VF105 = 0.0
(*      VF106 = 5.0             (* preset integrator with command

(* Example PID use: input is analog input, output is analog output
(*      STM2 = 0.01             (* initialize control loop timer
(* 005    WAIT TM2              (* wait for timer
(*      VF100 = 5.0             (* load command
(*      VF101 = VF100 - AIp1    (* compute error.  IMJ requires AIp1 register
(*      CALL 100                (* execute PID
(*      IF VF102 > 10. THEN     (* bound output
(*      VF102 = 10.
(*      IF VF102 < -10. THEN
(*      VF102 = -10.
(*      AO = VF102              (* set output
(*      ...                     (* other control loop functions
(*      GOTO 05                 (* repeat

(* Begin PID
(* Compute integral term: accum = accum + (error * KI)
100     vf106 = vf106 + vf101 * vf21        (* add error to accumulator
        if vf106 < -vf24 then               (* lower integrator bound
        vf106 = -vf24
        if vf106 > vf24 then                (* upper integrator bound
        vf106 = vf24
(* Compute derivative term using 4th order FIR filter
        vf107 = (vf101 - vf105) * -0.0285944 + (vf103 - vf104) * 0.2083646
        vf105 = vf104                       (* update history registers
        vf104 = vf103
        vf103 = vf101
(* Compute PID output
        vf102 = vf101*vf20 + vf106 + vf107*vf22 + vf100*vf23
        return
(* End PID
```

B.7.7 Torque-Limited Pressing/Capping

```
 (* Function:                   Torque limited pressing/capping

(* Operation:                   Run motor to press workpiece.  Pressing operation ends when specified
(*                              torque limit or maximum press travel is reached.  Set cycle complete and
(*                              workpiece accept outputs.

(*  Global resources:
(*      DI1                     Input of start cycle
(*      DI2                     Input of stop cycle
(*      DO7                     Output of part accepted
(*      DO8                     Output of cycle complete

(*      VB01                    At cycle start flag
(*      VB02                    Motion has stopped flag
(*      VB03                    Press reached torque limit flag

(*      VF01                    Press acceleration, units/sec^2
(*      VF02                    Press deceleration, units/sec^2
(*      VF03                    Press jerk, % of accel and decel interval
(*      VF04                    Press velocity, units/sec
(*      VF05                    Cycle start position, units
(*      VF06                    Maximum press travel, units
(*      VF07                    Press torque limit current, % maximum  continuous current
(*      VF08                    Minimum acceptable part location, units
(*      VF09                    Maximum acceptable part location, units
(*      VF10                    Retract acceleration, units/sec^2
(*      VF11                    Retract deceleration, units/sec^2
(*      VF12                    Retract jerk, % of accel and decel interval
(*      VF13                    Retract velocity, units/sec
(*      VF14                    Press location at torque limit, units

(* Module specific resources:
(* Example of torque limited pressing invocation:
(*      do7 = off               (* cancel part accepted output
(*      do8 = off               (* cancel cycle done output
(*      goto 001

(* Begin torque limited pressing:
001   WAIT EG1 AND NOT DI2             (* wait for cycle start input
      DO8 = OFF                        (* turn off cycle complete output
      IF VB01 GOTO 005                 (* if not at start position
      VB01 = FALSE                     (* then reset at cycle start flag
      EXM1                             (*  run to cycle start position
      WAIT VB01 WHEN EG2 GOTO 010            (* wait until at start position if cycle stop, go stop
005   IF EG2 GOTO 010          (*  when cycle stop, go stop
      VB03 = FALSE             (* reset reached torque limit flag
      MAC = VF01               (* set run acceleration, units/sec^2
      MDC = VF02               (* set deceleration, units/sce^2
      MJK = FTI(VF03)          (* set motion jerk percentage,  % of accel & decel interval
      MVL = VF04               (* set run velocity
      MPA = VF06               (* set maximum distance to run
      TLC = VF07               (* set torque limit current, % continuous current
      TLE = ON                 (* enable torque limit
      RPA                      (* run to position with torque limit
      WAIT (IP OR TL OR EG2)           (* wait until in position or torque limit
```

```
        VB03 = TL               (* save torque limit state
        VF14 = PSA              (* save axis position
        DO7 = VB03 AND PSA>=VF08 AND PSA<= VF09     (* set accept output
        ST                      (* stop axis motion
        STM2 = 1                (* pause at torque limit
        WAIT TM2
        TLE = OFF               (* disable torque limit

        VB01 = FALSE            (* reset at cycle start flag
        EXM1                    (* retract to home
        WAIT VB01 WHEN EG2 GOTO 010     (* wait for move complete
                                (*  when cycle stop, go stop
        DO8 = ON                (* turn on cycle complete output
        GOTO 001                (* go to start of program

010     VB02 = FALSE            (* reset stopped flag
        EXM2                    (* stop motion
        WAIT VB02               (* wait for motion stopped
        GOTO 001                (* go to start of program

(* Motion Blocks
        Motion1                 (* Run reverse to cycle start position
        MAC = VF10              (* set acceleration, units/sec^2
        MDC = VF11              (* set deceleration, units/sce^2
        MJK = FTI(VF12)         (* set motion jerk percentage,  % of accel & decel interval
        MVL = VF13              (* set run velocity
        MPA = VF05              (* set position
        RPA                     (* run to position
        WAIT IP                 (* wait for axis to be in position
        VB01 = TRUE             (* set at cycle start flag
        End                     (* End motion block

Motion2                         (* Stop motion
        MDC = VF11              (* set deceleration, units/sce^2
        MJK = FTI(VF12)         (* set motion jerk percentage, % of accel & decel interval
        ST                      (* stop
        VB01 = FALSE            (* reset at start position
        VB02 = TRUE             (* set motion stopped flag
        End
```

B.7.8 Two-Hand Anti-Tiedown

```
 (* Function:                 Two hand anti_tiedown

(* Operation:                 Implement anti_tiedown on inputs DI1 and DI2.
(*                            VI110 = 30 while (DI1 AND DI2) if DI1 and DI2
(*                            occur within 0.5 seconds of one another.

(*  Global resources:
(*      DI1                   anti_tiedown input
(*      DI2                   anti_tiedown input
(*      VI110                 anti_tiedown state of
(*                                  idle of 10        waiting for input
(*                                  armed of 20       waiting for 2nd input
(*                                  active of 30      both inputs active
(*                                  relax of 40       waiting for no inputs

(* Module specific resources:
(*      TM03                  anti_tiedown timer

(* Example of anti_tiedown use:
(*      vi110 = 040           (* initialize state to relax
(*      do7 = off             (* "active" output
(*      stm1 = .025           (* initialize i/o scan timer
(* 005    wait tm1            (* wait for i/o scan timer
(*      gosub vi110           (* scan: goto state
(*      do7 = (vi110 = 30)    (* set/reset output
(*      ...                   (* rest of i/o scan
(*      goto 005              (* repeat

(* Begin anti_tiedown
(* state is idle - wait for either input
010     if not (di1 or di2) goto 015      (* if no input return to scan
        stm3 = .5             (* start timer
        vi110 = 20            (* state is armed
015     return                (* return to scan

(* state is armed - wait for time-out or both inputs
020     if not tm3 goto 22    (* if timed out
        vi110 = 40            (*  state is relax
        goto 025              (*  return to scan
022     if not (di1 and di2) goto 025     (* if both inputs are true
        vi110 = 30            (*  state is active
025     return                (*  return to scan

(* state is active - wait for either input relaxed
030     if di1 and di2 goto 035   (* if either input is false
        vi110 = 40            (*  state is relax
035     return                (*  return to scan

(* state is relax - wait for both inputs relaxed
040     if (di1 or di2) goto 045  (* if both inputs false
        vi110 = 10            (*  state is idle
045     return                (*  return to scan

(* End of anti_tiedown
```

D

M

Q

R

S

T

X