

HUDSON BRUSHLESS DC SERVO MOTORS

COVERS HUDSON MODELS 23XX AND 34XX

VERSION 2.7 MARCH 13, 2020



THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

TABLE OF CONTENTS	3
INTRODUCTION	5
Inside This Document.....	5
Information on the Web	5
Notes on Motor Terminology	6
SAFETY AND SAFE HANDLING INFORMATION	7
General Precautionary Statement	7
Symbols Used in this Manual	7
Safe Handling Practices.....	8
Hudson Motor Pigtail	8
Attaching and Removing Shaft accessories.....	8
ESD-Safe Handling.....	8
FEATURES AND BENEFITS	9
INTERCONNECT AND WIRING	7
The Hudson Motor Pigtail.....	7
Motor Connector Options.....	8
Molex Mini-Fit Jr. Connector.....	8
Souriau Trim-Trio Connector.....	8
Connector Pinouts and Mating Parts	9
Molex Mini-Fit Jr. Pinout.....	9
Souriau Trim-Trio Pinout.....	10
ENCODER AND COMMUTATION SIGNALS	11
Encoder and Commutation Board Power Requirements	11
Encoder Signaling (Single-Ended Option).....	12
Encoder Signaling (Differential Option).....	12
Encoder Resolution	13
Commutation sensor signaling.....	13
Commutation - Phase Diagram	14
Wiring To Third-Party Drives.....	15
SERVO DRIVE SELECTION	16
Commutation.....	16
Six-Step (trapezoidal) Commutation	16
Sine wave Commutation.....	17
Sine wave commutation with Vector Torque Control.....	17
HUDSON MOTOR FAQ	18
Q: Are Hudson Motors UL or CE certified?	18
Q: How are Hudson Motors tested?	18
Q: What type of servo drives will Hudson Motors work with? ...	18
Q: How do I pick a motor and drive for my application?	18
Q: Which connector should I use?.....	19
Q: How do I choose the right encoder density?	19
Q: Which motor winding option should I pick?.....	20
Q: Do I need the optional motor shaft seal?.....	20
Q: How do I tune a Hudson motor?	21
Q: How can I change a motor's "sense of direction"?	21
Q: Why is the motor warm during operation?	22

Q: Where can I find 3-D drawings of Hudson motors?	22
APPENDIX A: HUDSON PART NUMBER KEY	23
APPENDIX B: NEMA 23 SPECIFICATIONS	24
APPENDIX C: NEMA 34 SPECIFICATIONS	25
APPENDIX D: PRODUCT DIMENSIONS	26
NEMA 23 Series Dimensions	26
NEMA 34 Series Dimensions	27
APPENDIX E: MOTOR CABLE NOTES.....	28
Golden Rules for Motor Cable Construction	28
Cable Making Guidelines.....	29

INTRODUCTION

Thank you for choosing Teknic's Hudson brushless DC servo motors for your automated machine project. Hudson servo motors provide the OEM machine builder with a powerful, responsive, reliable servo motor that is competitively priced and backed by the longest standard warranty (3 1/2 years!) on the market. And, each Hudson motor is built and tested in Teknic's New York assembly and test facility.

Hudson motors are highly configurable. With thousands of possible permutations, you purchase only the power, resolution and features you need. Hudson NEMA 23 and NEMA 34 motors are built to order with your choice of:

- Magnet stack length
- Shaft diameter
- Spring-tensioned shaft seal
- Winding configuration
- Encoder density
- Single-ended or differential encoder signaling
- Three rugged connector styles

Teknic direct OEM customers, please contact your Applications Engineer for motor selection assistance. Teknic distributor customers, please contact your distributor for motor selection assistance.

INSIDE THIS DOCUMENT

This document contains technical information on the Hudson family of brushless DC servo motors, including wiring information, drawings, application tips, and specifications. It is intended for the use of Teknic Direct OEM customers, Teknic distributors and their customers, and OEM motion control professionals evaluating servo motor solutions.

INFORMATION ON THE WEB

Please visit http://www.teknic.com/products/servo_motor.php for more information on the Hudson Family of BLDC servo motors including:

- Complete specifications
- Volume pricing information
- Interactive cut-away view of a Hudson motor
- CAD files
- Audio demonstration of a Hudson motor
- Warranty information
- Detailed photos and illustrations

NOTES ON MOTOR TERMINOLOGY

There is often confusion about brushless electric motor types because a number of motor technology terms are often used interchangeably. Hudson motors have been called (more or less correctly) all of the following:

- BLDC motors
- Three-phase, permanent magnet motors
- Synchronous, permanent magnet motors
- AC servomotors (AC because electronic commutation requires a sinusoidal current to produce constant torque, not to be confused with AC induction motors)
- DC servomotors (presumably to distinguish them from AC induction motors)
- 3-phase servomotors



Technically speaking, Hudson motors are classified as:
Three-phase, synchronous, permanent magnet, brushless servo motors.

The term “servo motor” refers to a motor that uses one or more feedback devices (encoder, Hall effect sensors, etc.) to control torque, velocity, and/or position in a closed loop manner. The term “brushless”, aside from the obvious, means the motor requires a drive (amplifier) that supports electronic, non-contact commutation. The term “permanent magnet” means that the motor has permanent magnets affixed to the rotor (brush motors typically have permanent magnets affixed to the stator). The term “synchronous” means that the rotational speed of the electromagnetic field is the same as (i.e. synchronous with) the speed of the rotor; there is virtually no “slip” between them. And finally, the term “3-phase” means the motor has three separate stator windings connected together in a delta or wye configuration.

Stepper motors are also brushless, permanent magnet motors, usually with 2 or 5 phases. Stepper motors are not typically servo controlled, although their position can be monitored with an add-on rotary encoder in cases where end-of-move corrections are required. Stepper motors are commutated by rotating the electromagnetic field in incremental steps (example: 200 full steps per revolution) and allowing the rotor to “catch up” with it.

SAFETY AND SAFE HANDLING INFORMATION

GENERAL PRECAUTIONARY STATEMENT

Always follow appropriate safety precautions when installing and operating motion control devices. Automated equipment should be designed to prevent personnel from coming into contact with moving parts and electrical contacts that could potentially cause injury or death. Read all cautions, warnings and notes before attempting to operate or service motion control devices. Follow all applicable codes and standards when using this equipment. Failure to use this equipment as described may impair or neutralize protections built into the product.

SYMBOLS USED IN THIS MANUAL

The following symbols and conventions are used on the equipment and in this manual. Please read all equipment labels and manuals before attempting to use motion control devices.



Caution, risk of danger

Identifies information about practices or circumstances that can lead to equipment damage, personal injury, or loss of life.



Shock hazard

Identifies presence of hazardous electrical voltages and currents.



Protective earth terminal

Indicates points that must be connected to a reliable earth system for safety compliance. Protective earth connections should never be omitted.



Earth ground terminal



Frame or chassis terminal (shield)



Direct current

Note



Identifies information that is critical for successful application and understanding of the product.

Tip



Identifies additional information that may be helpful in supporting certain applications.

SAFE HANDLING PRACTICES

HUDSON MOTOR PIGTAIL

- Never pick up, carry, or swing a Hudson motor by its pigtail.
Note: Maximum pigtail pull force is 7 lbs.
- The Hudson pigtail is not rated for continuous flexing. The pigtail should not move during machine operation.
- The Hudson motor should be installed such that there is no permanent tension on the pigtail (i.e. leave some slack when securing the pigtail to the machine).

ATTACHING AND REMOVING SHAFT ACCESSORIES

- Never hammer anything onto the motor shaft.
- When pushing an accessory onto the motor shaft, do not exceed the axial force limit pushing into the shaft (see table below).
- Never pry anything off the shaft (pulleys, pinions, etc.). When removing accessories use a gear puller that pushes on the center of the shaft. Do not exceed the axial force limit pulling out of the shaft (see table below).

Shaft Axial Force Limits, N (Lb.)					
		Pushing into shaft		Pulling out of shaft	
		NEMA 23	NEMA 34	NEMA 23	NEMA 34
Continuous, operating Static, short term Shock / Impact		90 (20.2)	115 (25.9)	22 (4.9)	32 (7.2)
		224 (50.4)	360 (80.9)	112 (25.2)	135 (30.3)
		45 (10.1)	68 (15.3)	45 (10.1)	68 (15.3)

ESD-SAFE HANDLING

- Never touch the bare pins on a Hudson motor connector unless you are working in a static-safe setting.

FEATURES AND BENEFITS

The cutaway view of a Hudson motor (model M-3431-LN-08K) highlights the anatomy, features, and benefits found inside (and outside) every Hudson brushless, 3-phase servo motor.



INSIDE (AND OUTSIDE) OF A HUDSON MOTOR

1. Generous length (16") pigtail eliminates costly motor cables in many applications
2. Single cable, single connector pigtail results in neater, lower cost installations
3. Three, highly reliable connector choices: low cost automotive-style, and sealed, bayonet-style
4. All Hudson motors come with connectors; you never have to deal with flying leads
5. Zero-clearance pigtail allows you to fit bigger motors into smaller spaces
6. Shatter-proof, stainless encoder disk eliminates shock-induced failures
7. Industry-standard position and commutation signals
8. Low-profile encoder allows you to fit motors into tighter spaces
9. Precision brass balancing tabs yield smoother motion with less vibration
10. Epoxy insulation layer allows the use of higher operating voltages
11. Compression-fit aluminum stator housing channels heat out of the motor
12. Sintered, nickel-plated, rare-earth magnets generate maximum power
13. Architectural-quality, anodized finish will look great for years
14. Oversized, permanently lubricated front bearing extends bearing life
15. Long-stroke, wave spring imparts consistent bearing preload
16. Optional high-performance shaft seal for more protection against dirt and dust
17. Smooth transition from external shaft diameter results in a stronger shaft
18. Feather keyway allows easy assembly, and the key can't work its way out
19. Helically skewed stator laminations improve motor smoothness
20. Tightly formed and laced end-turns heat more evenly for higher reliability
21. Overlapping coil design provides smoother torque and higher dynamic performance

INTERCONNECT AND WIRING

This section discusses Hudson motor interconnect topics, including the following:

- Motor connector options
- Mating connector parts and pinout information

THE HUDSON MOTOR PIGTAIL

Each Hudson motor comes with a 16" pigtail and one of three connector choices. This means you'll always receive a consistently wired, fully tested connector with no flying leads to deal with.



Hudson motor with DualShield pigtail and Trim Trio connector

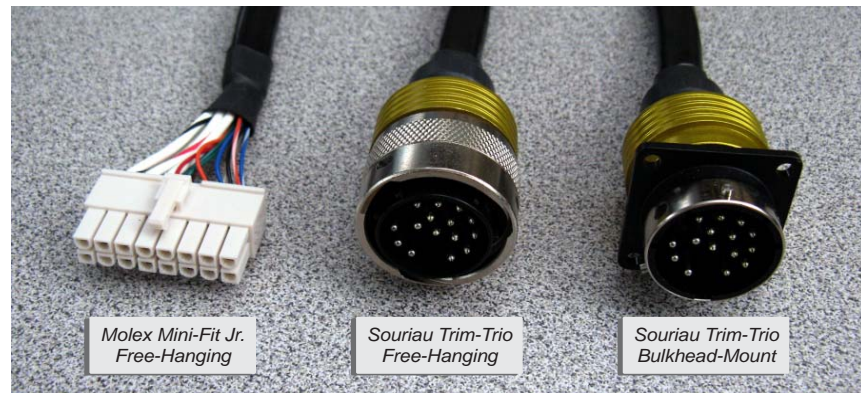
The recessed, tangential exit of the motor's DualShield™ pigtail allows for multiple mounting options and a smaller installed envelope, while the flexible 16-inch pigtail makes cable routing and maintenance convenient. The choice not to use on-body connectors means these motors can be slipped into locations previously deemed unusable due to accessibility and general space constraints.



On-body connectors (two motors at right, above) require more machine space than a Hudson (left) of the same NEMA frame size.

MOTOR CONNECTOR OPTIONS

Hudson motors are available in three connector options from well-established, widely available brands, Molex and Souriau. Each option delivers a strong, positively locked connection to the motor cable.



Hudson Motor Connector Options

MOLEX MINI-FIT JR. CONNECTOR

The Molex Mini-Fit Jr. connector provides a gas tight link with four points of contact. This low cost, rugged connector system has a current rating of up to 10A per circuit and a 600V rating. The housing features a positive lock, and fully isolated, low engagement-force terminals.

Use Molex Mini-Fit Jr. connectors when:



- Lower cost and high reliability is required
- Aesthetics are less critical
- The operating environment is relatively clean
- Less than 10A of continuous current per phase is required

SOURIAU TRIM-TRIO CONNECTOR

The Souriau Trim-Trio bayonet-style connector is a keyed, sealed, positively locking unit derived from the MIL-C 26482 specification.

Teknic's innovative use of this connector provides a termination system that is unique to the industry for having logic signals (commutation and encoder) *and* high current phase power (tested to over 20 amps) in the same connector. Use of only one connector can lower the cost of the motor and motor cable.

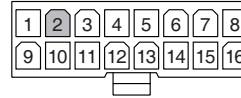
Use Souriau Trim-Trio connectors when:



- Aesthetics are more important
- The operating environment is clean to very dirty
- A water resistant seal is necessary
- Higher current-carrying capacity (> 10A continuous) is required

CONNECTOR PINOUTS AND MATING PARTS

MOLEX MINI-FIT JR. PINOUT



WIRE ENTRY VIEW

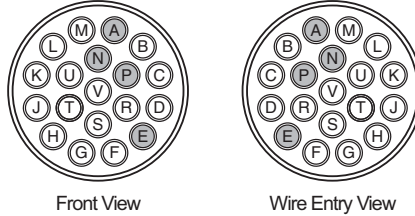
Pinout Table (Molex Minifit Jr.)

Pin#	AWG	Color	Signal Name	Notes
1	16	TIN	P DRAIN	Drain wire for Phase Cable shield
2	NO CONNECT			
3	26	GRN	COMM S-T	
4	26	GRN/WHT	COMM R-S	
5	26	GRY/WHT	COMM T-R	
6	26	TIN	E DRAIN	Drain wire for Logic Cable shield
7	26	BLK	GND	+5VDC return
8	26	BLU/WHT	ENC A~	Used only for differential encoder models
9	16	WHT/BLK <i>or</i> BLK	PHASE R	
10	16	WHT/RED <i>or</i> RED	PHASE S	
11	16	WHT	PHASE T	
12	26	RED	+5VDC IN	+5VDC input (encoder/hall power)
13	26	BRN	ENC I	
14	26	ORN	ENC B	
15	26	BLU	ENC A	
16	26	ORN/WHT	ENC B~	Used only for differential encoder models

Mating Parts

Part Description	Mfg. / Part Number
Connector Housing, panel mount	Molex / 39-01-2161
Terminal, male, 24 AWG (logic signals)	Molex / 39-00-0049
Terminal, male, 16 AWG (motor phases)	Molex / 39-00-0082
Crimp tool, 22-28AWG	Molex / 11-01-0198
Crimp tool, 16AWG	Molex / 2002182200
Extraction Tool	Molex / 11-03-0044

SOURIAU TRIM-TRIO PINOUT



Pinout Table (Souriau Connector)

Pin#	AWG	Color	Signal Name	Notes
A			NO CONNECT	
B	16	WHT/BLK <i>or</i> BLK	PHASE R	
C	16	WHT/RED <i>or</i> RED	PHASE S	
D	16	WHT	PHASE T	
E			NO CONNECT	
F	26	ORN/WHT	ENC B~	Used only for differential encoder models
G	26	GRN	COMM S-T	
H	26	GRN/WHT	COMM R-S	
J	26	BLU	ENC A	
K	26	BLU/WHT	ENC A~	Used only for differential encoder models
L	26	GRY/WHT	COMM T-R	
M	26	TIN	E DRAIN	Drain wire for Logic Cable shield
N			NO CONNECT	
P			NO CONNECT	
R	16	TIN	P DRAIN	Drain wire for Phase Cable shield
S	26	BLK	GND	+5VDC return
T	26	RED	+5VDC IN	+5VDC input (encoder/hall power)
U	26	BRN	ENC I	
V	26	ORN	ENC B	

Mating Parts

Part Description	Mfg. / Part Number
Connector Housing, for free-hanging pigtail	Souriau / UTG01619S
Connector Housing, for panel-mount pigtail	Souriau / UTG61619S
Terminal, female, 24 AWG (logic signals)	Souriau / SC24M1TK6
Terminal, female, 16 AWG (motor phases)	Souriau / RC16M23T
Backshell / Clamp	Souriau / UTG16AC

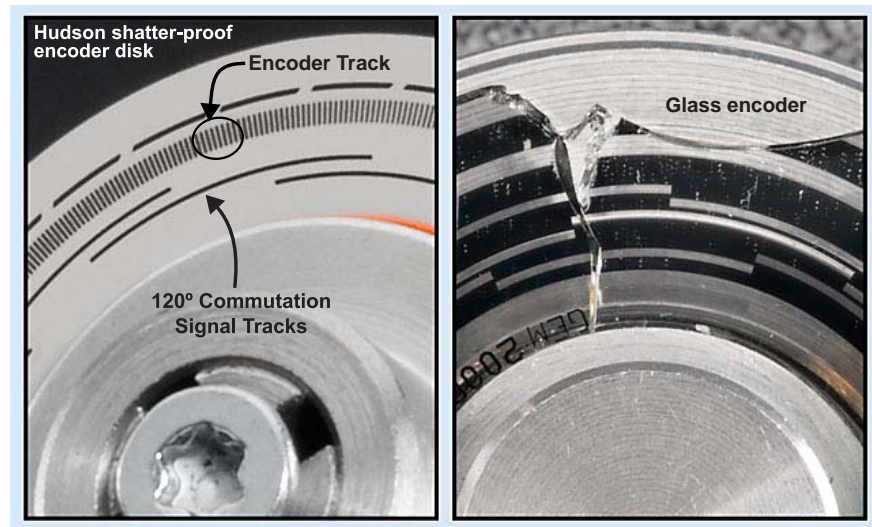
ENCODER AND COMMUTATION SIGNALS

Hudson Servo motors feature standard quadrature encoder outputs in single-ended or differential formats, as well as single-ended 120° commutation sensor signals (a.k.a. Hall effect signals). Because of this, Hudson motors are compatible with a wide variety of servo drives from major third-party manufacturers.

Encoder and commutation signals are read (optically) from the etched tracks on the precision shatter-proof encoder disk. These signals are then translated to driven output signals accessible at the motor connector.



Note: Hudson motors use optical commutation sensors (as opposed to traditional Hall effect sensors) because they are more robust and allow for superior torque accuracy and higher motor efficiency.



At left, a Hudson photo-lithographically etched encoder disk. At right, a glass encoder after a shipping accident.

ENCODER AND COMMUTATION BOARD POWER REQUIREMENTS

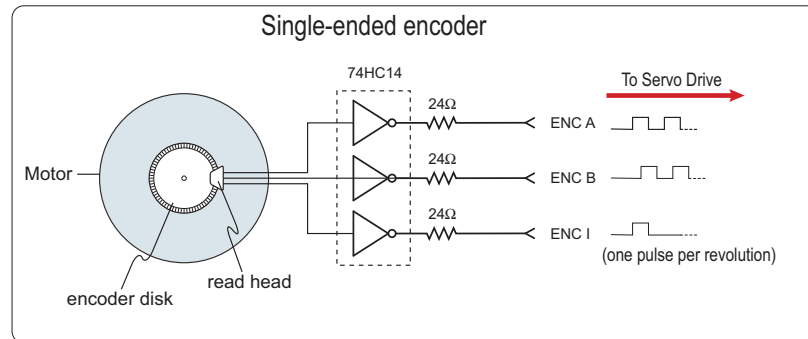
Hudson motors require a single 5VDC supply voltage to power the combined encoder / commutation sensor board. See the motor connection diagrams for complete pinout information.

Input voltage (at motor connector)	4.5-5.5VDC (6.0VDC absolute max.)
Current draw, loaded*	180mA @ 5VDC
Current draw, unloaded	125mA @ 5VDC

**All signals loaded with 200 ohm test load*

ENCODER SIGNALING (SINGLE-ENDED OPTION)

The single-ended encoder features 5 volt TTL, totem pole driven (i.e. “push/pull”) outputs at 10mA max.



Single-ended (TTL) encoder output

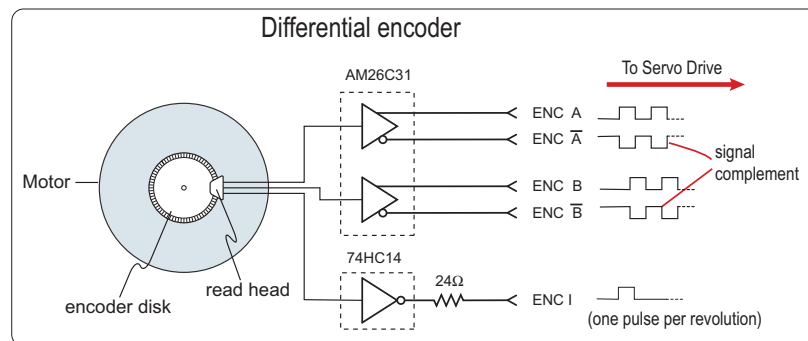


Single-ended encoders are appropriate in low to moderate electrical noise environments when lower cost and shorter cable runs are expected. The maximum cable length for single-ended encoders will vary based on cable quality, type of machine, and electrical environment. In general, lengths up to 30 feet perform very well, assuming good cabling practices. For lengths up to 50 feet, please consult your Applications Engineer for assistance.

ENCODER SIGNALING (DIFFERENTIAL OPTION)

Differential encoders have balanced (symmetrical, inverted) driven outputs intended to drive terminated, twisted pair transmission lines. This type of signaling method offers excellent common-mode noise immunity. They also support longer cable runs than single-ended signaling.

The differential encoder output is driven from an AM26C31 differential line driver optimized for 120Ω transmission lines. Refer to the AM26C31 data sheet for complete specifications.



Differential encoder output



Differential encoder signals provide greater noise immunity, especially over longer transmission ranges (up to 100 feet). In many applications, such as plasma cutting, differential encoder signaling is well worth the cost.

ENCODER RESOLUTION

NEMA 23

Hudson NEMA 23 motors support 2000, 4000, 8000, and 16000 counts per revolution, post-quadrature.

NEMA 34

Hudson NEMA 34 motors support 2000, 4000, 8000, and 16000 counts per revolution, post-quadrature.

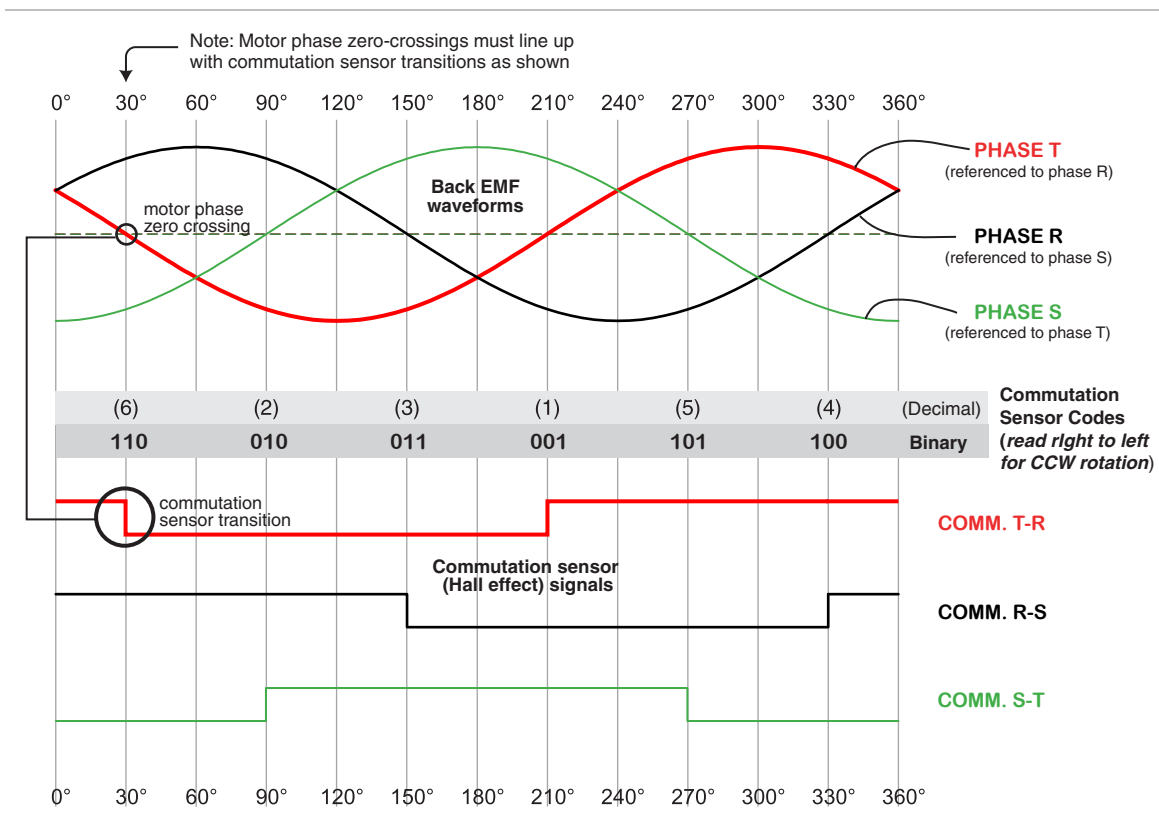
COMMUTATION SENSOR SIGNALING

The optical commutation sensors are 5V TTL, totem pole driven outputs with 10mA maximum current.

COMMUTATION - PHASE DIAGRAM

The diagram below illustrates the relationship between commutation sensor signals and motor phases for properly wired Hudson motors. Refer to this diagram when wiring third-party servo drives to Hudson motors. When using the diagram below, bear in mind the following:

- The waveforms below apply to sine wave drives that use 120° commutation sensors and perform encoder-based commutation. Six-step drives would produce a different back EMF signature.
- The drive must be wired to count *up* as the motor shaft is turned CCW (looking into the shaft).
- The commutation sequence shown in gray below **is read from right to left**. When spinning the shaft CCW, a properly wired motor should report commutation codes in the following sequence: 100, 101, 001, 011, 010, 110.



The above diagram shows the back-EMF waveforms you'd see if the motor shaft was spun counterclockwise (looking into the shaft) with an oscilloscope probe attached to the phase of interest and the ground clip attached to the reference phase. The lower part of the diagram shows how the commutation signals would appear on an oscilloscope (signal to ground).

The motor is phased correctly when the zero-crossings of motor phases line up with the transition points of the commutation sensor signals as shown in the illustration.

WIRING TO THIRD-PARTY DRIVES

When wiring a Hudson to a third-party drive, start with a motor that is wired to show positive encoder counts when spun CCW (viewed looking into the motor shaft). If this is not the case, swap encoder signals A and B (for single-ended encoders) or A and A~ (for differential encoders).

It's important to understand that each motor phase must align with its associated commutation signal as indicated in the diagram on the previous page. Phase T must align with Comm. T-R, Phase R with Comm. R-S, and Phase S with Comm. S-T. Consult the servo drive's documentation for pinout information and detailed coverage of motor/commutation phasing.



Note: Within the motion control industry, there is no standard naming convention for encoder signals, motor phases or commutation (Hall effect) signals. It may be necessary to determine the proper phase and commutation sensor wiring experimentally.

SERVO DRIVE SELECTION

Hudson motors will operate with most servo drives on the market that use one of the following methods of commutation:

- Six-Step (trapezoidal)
- Sine Wave
- Sine Wave with Vector Torque Control

COMMUTATION

Each Hudson motor comes with a precision optical encoder disk with 120° optical commutation sensors (analogous to traditional Hall effect sensors). During assembly the disk is positioned such that the commutation tracks line up with the permanent magnetic fields of the rotor.

SIX-STEP (TRAPEZOIDAL) COMMUTATION

Six-step commutation, called trapezoidal commutation due to its trapezoidal back EMF signature, is often used in cost-sensitive, lower precision applications.

During six-step commutation, the servo drive interprets the rotating commutation sensor codes from the motor to determine relative rotor to stator position and uses this information to sequence the application of current into the motor phases according to the example table below.

Step#	Commutation Sensor State 3 channels, 120° separation			Current Flow
1	1	0	1	From phase R to phase S
2	1	0	0	From phase R to phase T
3	1	1	0	From phase S to phase T
4	0	1	0	From phase S to phase R
5	0	1	1	From phase T to phase R
6	0	0	1	From phase T to phase S

During six-step commutation, current flows in only two phases at a time (the odd phase is always off). Example: In Step #1 above, when the commutation sensors read binary (1 0 1) the drive sends current through Phases R and S, while Phase T remains off. Six-step drives are less complicated in several ways. In fact, because there is only one current path at any time, only one loop is required to control current.

It is useful to understand that the commutation “code” changes state six times per electrical cycle¹, and thus provides a less precise fix on rotor position than a typical sine wave drive with encoder-based commutation. While this may be sufficient for less demanding motion applications, a high resolution feedback device—such as an encoder—is a better choice for high precision positioning tasks.

¹ Note: Hudson motors have 8-poles and therefore four electrical cycles per mechanical revolution. This means that Hudson commutation sensors transition (6 states x 4 electrical cycles) 24 times per motor revolution.

Pros and Cons:

Pro: Lower cost of implementation (relatively simple devices)

Con: High torque ripple

Con: No torque control loop, though does have a current loop

Con: Lower torque efficiency (at high speeds)

SINE WAVE COMMUTATION

Sine wave commutation is generally better suited to midrange applications where greater precision of control over position, velocity and/or current is required.

Most sine wave drives use the commutation sensors to initialize the commutation process. First, the commutation code is read from the motor to establish the initial rotor vs. stator position. Then the drive applies current to the motor windings to achieve the desired relationship between the permanent and electromagnetic fields. Once this relationship is established, the electromagnetic vector is “locked” to the encoder position, and commutation continues based on encoder feedback (and not on the Halls).

Though more efficient than six-step drives, sine wave drives run open loop with respect to torque control. While the current in each motor phase is individually servo controlled, the actual torque produced at the shaft is not. In most sine wave drives, torque errors are only corrected indirectly—after they have resulted in velocity and position errors. This generally means sine wave drives operate with a wider positioning error band than sine wave drives with true vector torque control (see next topic).

SINE WAVE COMMUTATION WITH VECTOR TORQUE CONTROL

Sine wave drives with Vector Torque Control (VTC) are often the drive of choice for high precision, high throughput positioning and contouring applications. A sine wave VTC drive is wired, and operates, in basically the same way as a sine wave drive without VTC. The key difference is how torque is controlled. While most sine wave drives servo control only the individual motor phase currents, VTC drives servo control the actual torque produced at the motor shaft.

The drive simultaneously takes calibrated current measurements from all motor phases, combines this data with information about rotor position, phase resistance, inductance and back-EMF, and then applies advanced vector mathematics to calculate the exact torque being produced at the shaft. This tight torque feedback loop allows for very rapid corrections in torque error, resulting in superior dynamic tracking performance.

HUDSON MOTOR FAQ

Q: ARE HUDSON MOTORS UL OR CE CERTIFIED?

A: Yes. The entire Hudson family has been successfully tested for compliance with UL and CE certification standards. This means that Hudson motors have earned the stamp of approval from independent agencies certifying that they meet rigorous standards for electrical safety and electromagnetic emissions. Field audits every quarter by UL inspectors ensure ongoing conformance with these standards.

Q: HOW ARE HUDSON MOTORS TESTED?

A: To ensure out-of-the-box reliability, each motor is thoroughly tested before shipment. The tests include:

- 100% HASS tested (Highly Accelerated Stress Screening)
- Mechanical compliance tests
- Encoder integrity test
- Commutation sensor accuracy test
- Full electrical compliance test
- Extended functional test on a vector torque fixture

Q: WHAT TYPE OF SERVO DRIVES WILL HUDSON MOTORS WORK WITH?

A: Hudson servo motors are 3-phase, synchronous, permanent magnet, brushless, servo motors. They have incremental encoders that output standard quadrature signals and have standard, 120° optical commutation sensors. Hudson BLDC motors will work with the following drive types:

- Six-step (trapezoidal)
- Sine wave
- Sine wave with vector torque control

See the section “Servo Drive Technology” earlier in this document for more information on supported servo drive types.

Q: HOW DO I PICK A MOTOR AND DRIVE FOR MY APPLICATION?

A: Complete coverage of this topic is beyond the scope of this document; however, the main steps in selecting a servo motor and drive include:

1. Understand the motion system including axis mechanics, weights, effect of friction, gearing, and motion performance requirements such as move distances, accelerations, velocities, and duty cycles.
2. Determine what you need from the motor in terms of peak torque, continuous torque, and RPM.

3. Select a motor with sufficient torque and speed capability to meet the requirements determined in step 2. Add a reasonable amount of engineering margin.
4. Identify a drive that can deliver sufficient power (current and voltage plus margin) to the motor to meet the identified torque and speed requirements.



Note: Selecting the right servo drive is not always a straightforward task. It is easy to inadvertently select under-powered servo drives because published drive specs and power requirements are often unclear. Regardless of a motor's torque and speed *capabilities*, if it is fed insufficient voltage and/or current from the drive, torque and speed will be limited.

Q: WHICH CONNECTOR SHOULD I USE?

A: Use the Molex MiniFit Jr. connector in relatively clean, dry environments (general dust is OK), and when 10 amps or less motor phase current will be applied.

A: Use Souriau Trim-Trio connectors in dirty environments, where water mist or fumes may be present, or when more than 10 amps per phase will be applied.

Q: HOW DO I CHOOSE THE RIGHT ENCODER DENSITY?

A: The best encoder for a given job varies based on axis gearing, positioning resolution requirement, and maximum velocity. Some designers automatically select the highest resolution encoder available “just to be safe”; but, buying the highest resolution encoder isn't necessarily the best choice for all situations. Consider the following:

- The higher the encoder density, the greater the cost.
- The higher the encoder density the higher the encoder output frequency. Not all drives and controllers can process higher frequency encoder signals. See tip below.
- As encoder output frequency increases, the ability to filter out the effect of high frequency noise can diminish in some drive types.

Tip: Verify that any servo drive selected to run a Hudson motor is able to process high speed encoder signals. The encoder density (encoder counts per revolution) directly affects encoder output frequency. For example, when a 2,000 count encoder reaches 2000 RPM, the encoder output frequency is 66.7 kHz. A higher density encoder (16,000 counts per rev.) at 2000 RPM will output encoder signals at 533 kHz, and at 5000 RPM this encoder will have an output frequency of 1.33 MHz.

Q: WHICH MOTOR WINDING OPTION SHOULD I PICK?

A: Your Applications Engineer has software tools to help analyze the application and determine the best winding configuration for a given drive.

Why the winding matters. There are three available winding options for your Hudson motor. Each type of winding yields a different torque vs. speed curve for a given servo drive, so it's important to select a motor winding that optimizes the drive's voltage and current capabilities.

In general, the Hudson winding configurations fall into three loosely defined categories based on drive voltage.

- 24-75 VDC (lower voltage, higher current)
- 60-160VDC (medium voltage, medium current)
- 150-400VDC (higher voltage, lower current)

In short, the choice of winding selection depends on several factors including servo drive power and application requirements. Your Applications Engineer will help you select the best motor winding.

Q: DO I NEED THE OPTIONAL MOTOR SHAFT SEAL?

A: For extra protection beyond the standard double-sealed ball bearings, an optional dynamic shaft seal is available. The seal is appropriate when the motor face will be exposed to potentially damaging particulate matter generated during machine operations.

The high quality shaft seal is spring tensioned, has a Viton® lip for minimal compression set and excellent high temperature properties, and a PTFE coating for low friction and wear. It also has a metal outer case for greater structural rigidity, and a Viton® outer coating for a better OD seal and greater tolerance to thermal expansion differentials.



Optional Hudson motor shaft seal

Note: The shaft seal option is not available for Hudson NEMA 23 motors with non-standard (.25") shaft diameter.

Q: HOW DO I TUNE A HUDSON MOTOR?

A: Each servo drive manufacturer has its own software and procedures for wiring and tuning motors. Consult your servo drive manufacturer for wiring and tuning procedures.

Hint: Hudson servo motors have relatively fast electrical time constants, and therefore respond very rapidly to changes in winding current. This allows the motor to follow dynamic commands very quickly and faithfully. If less aggressive servo response is required for an application, it is usually easy to reduce current or torque loop gains in the drive.

Q: HOW CAN I CHANGE A MOTOR'S "SENSE OF DIRECTION"?

A: Some drives may include firmware or software that allows you to reverse direction by changing a setting. Consult the servo drive manufacturer for more information.

In some scenarios, however, you may need to reverse the motor's sense of positive and negative motion by modifying the motor cable. Assuming you have a properly operating motor, *except* direction of rotation is reversed; swap the following signals to change the direction of rotation:

Motors with Differential Encoders

- Swap Phase S with Phase T
- Swap Comm R-S with Comm T-R
- Swap Enc A with Enc A~

Motors with Single-Ended Encoders

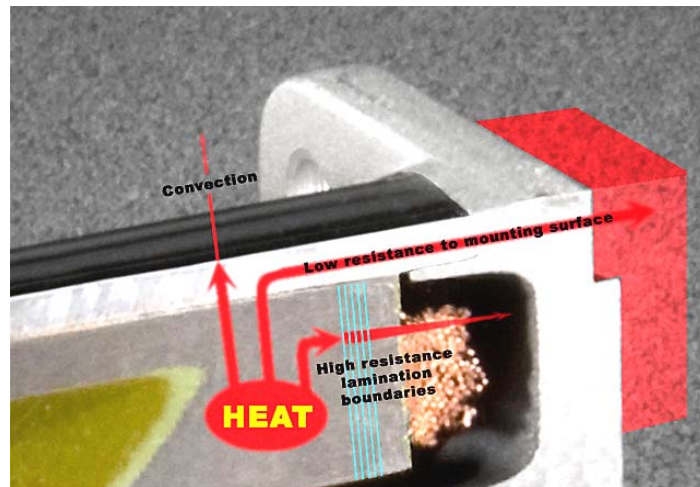
- Swap Phase S with Phase T
- Swap Comm R-S with Comm T-R
- Swap Enc A with Enc B



Note: Make any necessary wiring changes at the motor extension cable and not at the motor's pigtail connector. This generally saves time, money, and preserves the motor warranty.

Q: WHY IS THE MOTOR WARM DURING OPERATION?

A: A Hudson motor may feel warm to the touch despite running cooler internally because heat is more effectively transferred out of the motor core. Hudsons use a tight fitting, cylindrical aluminum housing surrounding the stator to provide a low-resistance path for heat to flow out of the motor. Improved heat flow out of the motor increases continuous power output and improves long term reliability.



In exposed-lamination motors (i.e., motors with no true housing) axial heat flow from motor to mounting surface is impeded by the many oxide-coated interfaces between the steel laminations. To make matters worse, silicon steel [laminations] have about 6 times the thermal resistance of aluminum, which makes exposed-lamination motors good insulators (good at holding in heat) but poor radiators.

Q: WHERE CAN I FIND 3-D DRAWINGS OF HUDSON MOTORS?

A: 3D files for Hudson motors can be found at:
<http://www.teknic.com/downloads/>

APPENDIX A: HUDSON PART NUMBER KEY

Example

3 4 1 1 P - L N - 0 8 K
M-□□□□□-□□-□□□□

NEMA Frame Size: 23, 34

Stack Length: 1-4

Indicates the number of magnet sets (stacks) on the rotor.

Winding/Magnetic Structure: 1-9

Indicates the winding design. Different designs offer unique torque, speed and power characteristics.

Electrical Interface¹:

Indicates the pigtail connector and winding type.

P: MiniFit-16 pigtail, free-hanging, winding A

G: MiniFit-16 pigtail, free-hanging, winding B

S: MiniFit-16 pigtail, free-hanging, winding C

C: Sealed Trim-Trio pigtail, free-hanging, winding A

V: Sealed Trim-Trio pigtail, free-hanging, winding B

E: Sealed Trim-Trio pigtail, free-hanging, winding C

Y: Sealed Trim-Trio pigtail, bulkhead mount, winding A

R: Sealed Trim-Trio pigtail, bulkhead mount, winding B

W: Sealed Trim-Trio pigtail, bulkhead mount, winding C

Shaft/End Bell:

L: Standard, with parallel keyway (NEMA 23: 0.375", NEMA 34: 0.500")²

Q: 0.250" round shaft, no keyway (available on M-231x and M-232x motors only)

Sealing³:

N: Dust (standard)

S: Shaft Seal (in addition to dust sealing)⁴

Encoder Density:

Counts per revolution (post-quadrature)

02: 2,000 counts/revolution

04: 4,000 counts/revolution

08: 8,000 counts/revolution

16: 16,000 counts/revolution

Encoder Type:

All encoders use precision-etched, stainless steel disks.

K: Line-driven, single-ended TTL⁵

D: Differential

1: Contact Teknic for technical information on the different windings

2: Dimensions of keyway are 12x3mm (NEMA 23) and 20x5mm (NEMA 34), key not included

3: IPC rating depends upon electrical interface option and sealing option together

4: Not available with 0.250" shaft

5: 667kHz maximum output frequency limit, post quadrature

APPENDIX B: NEMA 23 SPECIFICATIONS

SPECIFICATIONS		
GENERAL	Insulation Rating:	Class H, 180°C
	Motor Poles:	8
	Standard Shaft Diameter:	0.375 in., 9.5 mm
	Motor Pigtail Type:	Space saving, single-exit, DualShield™
	Motor Pigtail Length:	16 in ± 1 in., 406.4 mm ± 25.4 mm.
	RoHS:	RoHS Compliant
ENVIRONMENTAL	Shock:	2.0 G
	Vibration:	0.5 G
	Max External Deceleration:	250,000 rad/s ²
	Max Case Temperature:	85°C
	Max Winding Temperature:	155°C
	Storage Temperature:	-20 to 85°C
	Humidity, non-condensing:	0-95%
Operating Conditions:	No direct fluid wash-down or submerged use	
ENCODER	Type:	Floating optical disk; single-ended or differential signals
	Resolution(s):	2000, 4000, 8000, 16000 counts/rev (post-quad)
	Current Draw, Loaded:	180mA @ 5VDC, all signals loaded with 200Ω load
	Current Draw, Unloaded:	125mA @ 5VDC
	Max Quadrature Error:	60°
COMMUTATION	Commutation Type:	120° spaced, optical commutation sensors
MECHANICAL LOADING	Bearing Type:	Oversized, single-row, deep groove, radial with non-contacting lubrication seals.
	Bearing Life vs. Load:	Depending on the specific motor model, typical bearing life is approximately 3.2 x10 ⁹ to 5.0 x10 ⁹ revolutions (based on 5 lb axial and 25 lb radial loads, centered 1.0 inch from front bearing surface). For more detailed loading information, contact Teknic.
	Shaft Axial Force Limits:	See chart on page 8
WARRANTY	36 months + 6 months. Warranty covers 36 months of field duty, and OEMs are allowed up to 6 additional months (FOB Teknic) for machine installation time.	

INDIVIDUAL SPECIFICATIONS

Modd	2310	2310	2311	2311	2321	2321	2331	2331	2341	2341
Electrical Interface Option	S/E/W	P/C/Y	S/E/W	P/C/Y	S/E/W	P/C/Y	S/E/W	P/C/Y	S/E/W	P/C/Y
Resistance, phase to phase, [ohms]	2.87	0.72	2.76	0.69	2.46	0.62	2.42	0.61	2.98	0.75
Inductance, phase to phase, [mH]	1.61	0.4	2.93	0.733	3.66	0.92	3.55	0.89	4.59	1.15
Electrical Time Constant, [mS]	0.56	0.56	1.06	1.06	1.49	1.49	1.47	1.47	1.54	1.54
Back EMF (Ke), [Vpeak/kRPM]	9.28	4.64	13.27	6.64	23.29	11.65	27.31	13.65	36.4	18.2
Continuous Torque [oz-in] ^{1,2}	39	39	60	60	116	116	145	145	186	186
Weight [oz, g]	22.1, 626				32.8, 929		44.2, 1253		54.1, 1533	

1: Typical, varies by application – contact your sales engineer for application specific rating.

2: The G, P or S electrical interface option (Mini-Fit Jr. connectors) limits the continuous current capacity to 10 amps RMS, which in turn limits continuous torque capacity.

For more continuous torque use the Y, C or E electrical interface option (Trim-Trio connectors).

APPENDIX C: NEMA 34 SPECIFICATIONS

SPECIFICATIONS		
GENERAL	Insulation Rating:	Class H, 180°C
	Motor Poles:	8
	Standard Shaft Diameter:	0.500 in., 12.7 mm
	Motor Pigtail Type:	Space saving, single-exit, DualShield™
	Motor Pigtail Length:	16 in ± 1 in., 406.4 mm ± 25.4 mm.
	RoHS:	RoHS Compliant
ENVIRONMENTAL	Shock:	2.0 G
	Vibration:	0.5 G
	Max External Deceleration:	250,000 rad/s²
	Max Case Temperature:	85°C
	Max Winding Temperature:	155°C
	Storage Temperature:	-20 to 85°C
	Humidity, non-condensing:	0-95%
	Operating Conditions:	No direct fluid wash-down or submerged use
ENCODER	Type:	Floating optical disk; single-ended or differential signals
	Resolution(s):	2000, 4000, 8000, 16000 counts/rev (post-quad)
	Current Draw, Loaded:	180mA @ 5VDC, all signals loaded with 200Ω load
	Current Draw, Unloaded:	125mA @ 5VDC
	Max Quadrature Error:	60°
COMMUTATION	Commutation Type:	120° spaced, optical commutation sensors
MECHANICAL LOADING	Bearing Type:	Oversized, single-row, deep groove, radial with non-contacting lubrication seals.
	Bearing Life vs. Load:	Depending on the specific motor model, typical bearing life is approximately 3.2 x 10 ⁹ to 5.0 x 10 ⁹ revolutions (based on 5 lb axial and 25 lb radial loads, centered 1.0 inch from front bearing surface). For more detailed loading information, contact Teknic.
	Shaft Axial Force Limits:	See chart on page 8
WARRANTY	36 months + 6 months. Warranty covers 36 months of field duty, and OEMs are allowed up to 6 additional months (FOB Teknic) for machine installation time.	

INDIVIDUAL SPECIFICATIONS

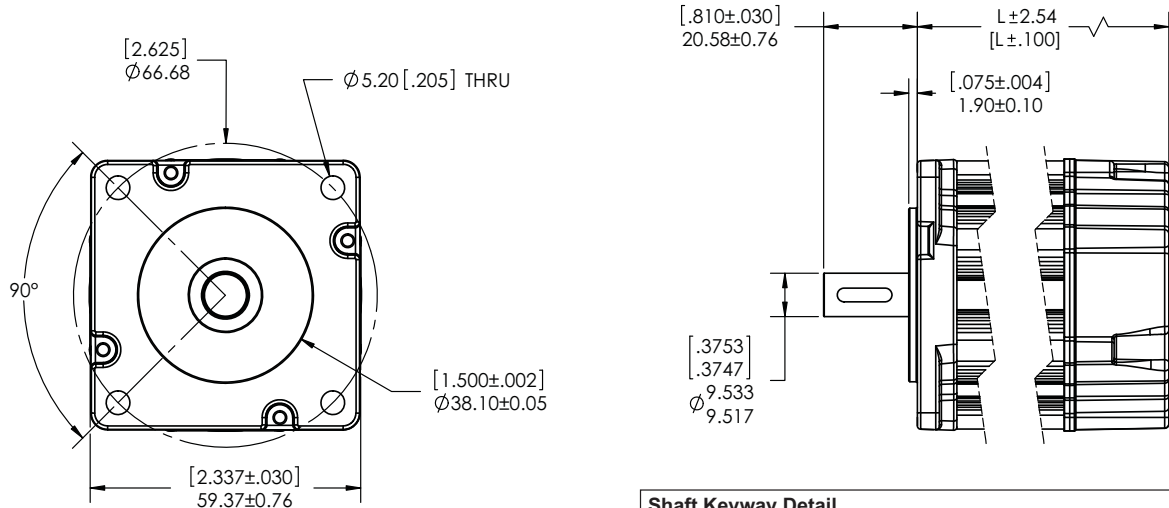
Model	3411	3411	3421	3421	3422	3422	3422	3431	3431	3431	3432	3432	3432	3441	3441	3441
Electrical Interface Option	S/E/W	P/C/Y	S/E/W	P/C/Y	S/E/W	P	C/Y	S/E/W	P	C/Y	S/E/W	P	C/Y	S/E/W	P	C/Y
Resistance, phase to phase, [ohms]	3	0.75	2.500	0.624	1.65	0.413	0.413	1.42	0.355	0.355	2.183	0.546	0.546	2.637	0.659	0.659
Inductance, phase to phase, [mH]	3.9	0.975	4.791	1.198	3.18	0.795	0.795	3.452	0.863	0.863	5.058	1.265	1.265	6.64	1.66	1.66
Electrical Time Constant, [mS]	1.3	1.3	1.92	1.92	1.9	1.92	1.92	2.43	2.43	2.43	2.32	2.32	2.32	2.52	2.52	2.52
Back EMF (Ke), [Vpeak/kRPM]	29.36	14.69	46.99	23.49	38.91	19.46	19.46	48.27	24.13	24.13	58.43	29.22	29.22	77.9	38.95	38.95
Continuous Torque [oz-in] ^{1,2}	150	150	289	289	289	223	289	400	287	400	377	349	392	479	461	479
Weight [oz, g]	49.6, 1406		73.6, 2087					99.2, 2812					121.6, 3447			

1: Typical, varies by application – contact your sales engineer for application specific rating.
 2: The G, P or S electrical interface option (Mini-Fit Jr. connectors) limits the continuous current capacity to 10 amps RMS, which in turn limits continuous torque capacity.
 For more continuous torque use the Y, C or E electrical interface option (Trim-Trio connectors).

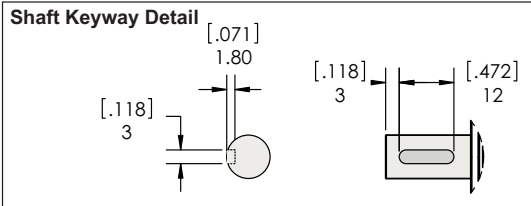
APPENDIX D: PRODUCT DIMENSIONS

NEMA 23 SERIES DIMENSIONS

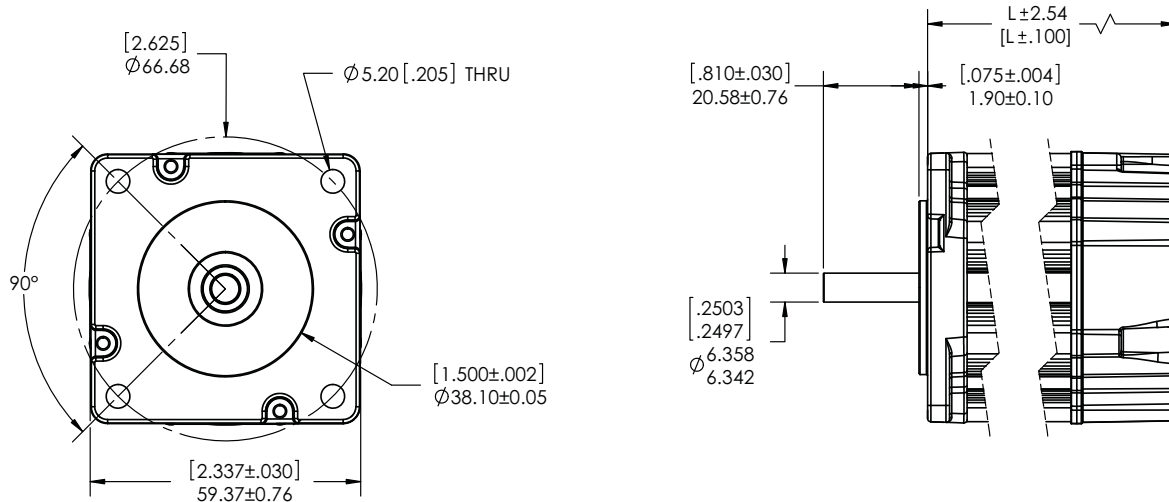
3/8" shaft option



Note: Shaft key not included
 (Available through McMaster-Carr)
 Part Number: 96717A086
 Description: Metric shaft key
 Dimensions: 3mm x 3mm x 10mm

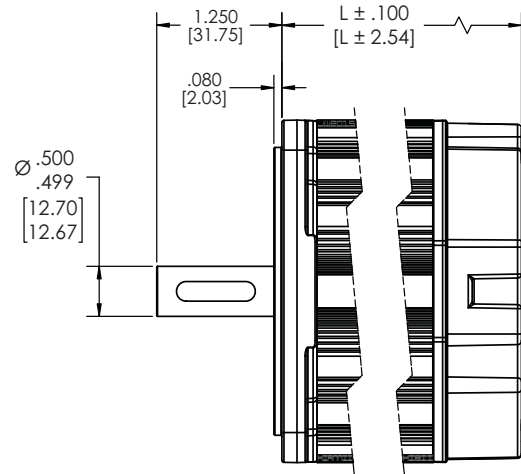
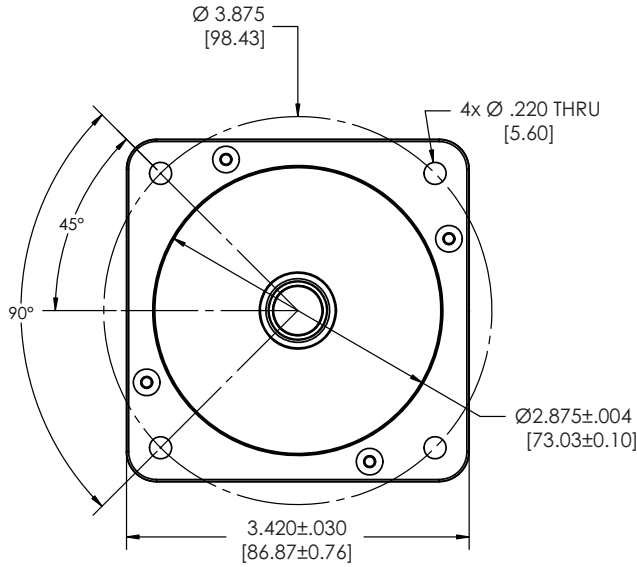


1/4" shaft option

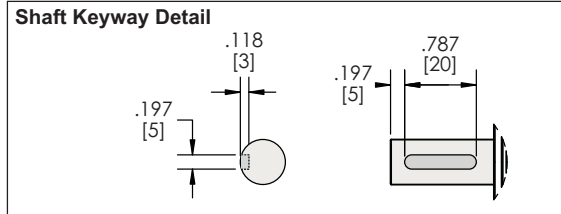


Model	Motor Body Length (L)	
M-231x	70.94 mm	2.79 in.
M-232x	89.92 mm	3.54 in.
M-233x	108.97 mm	4.29 in.
M-234x	128.02 mm	5.04 in.

NEMA 34 SERIES DIMENSIONS



Note: Shaft key not included
 (Available through McMaster-Carr)
 Part Number: 96717A181
 Description: Metric shaft key
 Dimensions: 5mm x 5mm x 20mm



Model	Motor Body Length (L)	
M-341x	70.37 mm	2.77 in.
M-342x	89.19 mm	3.51 in.
M-343x	108.19 mm	4.29 in.
M-344x	127.37 mm	5.01 in.

APPENDIX E: MOTOR CABLE NOTES

Please read and follow the recommendations and guidelines outlined in this section if you plan on designing and building motor extension cables. Always use two separate, shielded cables – one for motor phases, and one for low voltage signals (encoder, commutation sensors, etc.).

GOLDEN RULES FOR MOTOR CABLE CONSTRUCTION



1. Use low capacitance, shielded twisted pair cable for the encoder and commutation sensor signals.
2. Don't ground the encoder cable shield to the motor case or allow it to touch the motor phase shield at any point.
3. Don't run the motor's commutation (Hall) signals through the motor phase cable at any point. Use two cables, one for low voltage signals and one for motor phases.
4. Use 16AWG or larger shielded cable for motor phases.
5. Motor phase leads should be kept as short as possible where they exit the cable shield, preferably under 2".
6. The motor phase cable shield termination should be kept short at both ends, preferably under 2".
7. **The shield on the motor phase cable must not come in contact with the shield of the encoder cable at any point.** Cover exposed shield and drain wires with heat shrink tubing at termination points to prevent the shields from touching. Failure to isolate these shields can result in loss of logic signal integrity.

CABLE MAKING GUIDELINES

The following guidelines will help minimize cable design, fabrication, and application issues.



Note: Each type of crimp terminal requires a specific handset and die. Failure to use the proper tool, die, terminal, or wire for the job will likely result in poor quality terminations and premature cable harness failures.

GENERAL RECOMMENDATIONS

1. Avoid cables made with hand tools.

Hand crimping tools, when properly selected and used by a skilled operator, make good crimp connections. However, since these tools are expensive, typically \$200 - \$400 each, technicians rarely have the wide variety required to make proper crimps on all of the terminal types and wire sizes they encounter. Unfortunately, it's easy to use the wrong tool and not realize it, or even more likely, to use the wrong tool and think it's "probably OK". These hand tools are awkward, cumbersome to use and often require the operator to master a certain "feel" to achieve consistent, high quality results. Unfortunately, these hand tools don't have any built-in quality assurance features.

In certain instances, you may need to make a hand crimped cable, for example, when you're in a hurry for a custom length cable. If you do, be sure that you have the exact hand tool and die that the terminal manufacturer recommends, perform a visual inspection to ensure that the insulation is captured in the terminal's strain relief and do a pull test on each connection before inserting it into the connector.

2. Verify that your cable shop has all of the proper tools and equipment.

Use a cable shop that has automated presses for wire termination and make sure they have the proper applicator "heads" (dies) for the exact terminals used. (If they don't, consider buying applicator heads for them). It's strongly preferred that they have presses with automatic "crimp height" checking as this in-process check is the main measure of termination quality. Making this 100% check without requiring human intervention is a key advantage. If they don't have these automatic crimp-height-checking presses, make sure their general procedures include checking the crimp height on first articles and periodically during a run of cables. Under no circumstances should you accept a shop using hand tools.

3. Specify 100% electrical testing of all cables.

Specify that cables and harnesses be 100% electrically tested, preferably with resistance tests. The cable shop should have automated equipment by CableScan, DynaLab, CheckSum, or other vendors for this purpose. The initial fixturing cost for 100% electrical testing is typically low, ranging from \$0-\$200 per different cable assembly.

4. Be certain that all terminals are properly specified

Check all your terminal specifications carefully. Research all of your drawings and make certain that the terminals specified can accept the necessary wire gauges. Also, look carefully at the insulation diameter range supported by each terminal. If the insulation diameter range on the terminal is incorrect for the wire used, the individual wire strain relief will be compromised and this can lead to premature terminal failure. Make certain that the plating between mating terminals is the same. Using gold is great, but not if you are mating with tin. Always mate gold plated terminals with gold plated terminals, and tin with tin to avoid galvanic corrosion.

5. Prepare complete, pictorial drawings.

Create drawings that are pictorial in nature (i.e. visually representative of the subject). Include fabrication details such as jacket strip lengths, shield termination details, cable tie locations, marking details, etc. The more call-outs, detail views, and exploded views, the better. Visual communication is critical here. Don't leave the details to the cable shop as "best practices" vary widely from shop to shop. Include the complete BOM (Bill of Materials) right on the drawing. Finally, make the end-to-end cable length easy to modify. This may help reduce future drawing effort if you need similar cables of varying length at some point down the road.

A note on hand crimp tools



When necessary, quality cables *can* be made with hand tools, provided that crimp terminal manufacturer's guidelines are followed. An excellent web-based resource on this subject is the Molex document "*Good Crimps and How to Recognize them*" which is located at this URL:

<http://www.molex.com/tnotes/crimp.html>

This document shows how to identify good and bad crimps as well as best practices and specifications for crimp techniques and tooling.

Teknic Incorporated
115 Victor Heights Pkwy
Victor, NY 14564

Copyright © 2020 Teknic Inc. All rights reserved