BL Brushless Servo Drives

User Guide

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IMPORTANT INFORMATION FOR USERS

Installation and Operation of Digiplan Equipment

It is important that Digiplan motion control equipment is installed and operated in such a way that all applicable safety requirements are met. It is your responsibility as a user to ensure that you identify the relevant safety standards and comply with them; failure to do so may result in damage to equipment and personal injury. In particular, you should study the contents of this user guide carefully before installing or operating the equipment.

Under no circumstances will the suppliers of the equipment be liable for any incidental, consequential or special damages of any kind whatsoever, including but not limited to lost profits arising from or in any way connected with the use of the equipment or this user guide.

SAFETY WARNING

High-performance motion control equipment is capable of producing rapid movement and very high forces. Unexpected motion may occur especially during the development of controller programs. ***KEEP WELL CLEAR*** of any machinery driven by stepper or servo motors. Never touch it while it is in operation.

This product is sold as a motion control component to be installed in a complete system using good engineering practice. Care must be taken to ensure that the product is installed and used in a safe manner according to local safety laws and regulations. In particular, the product must be enclosed such that no part is accessible while power may be applied.

User Guide Change Summary

The following is a summary of the primary changes to this user guide since the last version was released. This user guide, version 1600.135.08, supersedes version 1600.135.07.

When a user guide is updated, the new or changed text is differentiated with a change bar in the outside margin (this paragraph is an example). If an entire chapter is changed, the change bar is located on the outside margin of the chapter title.

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How To Use This Manual

This manual is designed to help you install, develop, and maintain your system. Each chapter begins with a list of specific objectives that should be met after you have read the chapter. This section is intended to help you find and use the information in this manual.

Assumptions

This user guide assumes that you have a fundamental understanding of the following:

- Basic electronics concepts (voltage, switches, current, resistors, etc.)
- Basic motion control concepts (torque, velocity, distance, etc.)

With this basic level of understanding, you will be able to effectively use this manual to install, develop, and maintain your system.

Contents of This Manual

The following information is included in this user guide:

Chapter 1: Introduction

This chapter provides a description of the product and a brief account of its specific features.

Chapter 2: Getting Started

This chapter contains a detailed list of items you should have received with your BL system shipment. It will help you become familiar with the system and ensure that each component functions properly. In this chapter, you will perform a preliminary configuration of the system.

Chapter 3: Installation

This chapter provides instructions to enable you to properly mount the system and make all electrical and non-electrical connections. Upon completion of this chapter, your system should be completely configured, installed, and ready to perform basic operations.

Chapter 4. BL Motor/Drive Packages

Information on the motor/drive packages available from Digiplan is provided in this chapter.

Chapter 5. Hardware Reference

This chapter contains drive specifications (dimensions and performance) and information on mains transformers available from Digiplan suitable for use with the drive. It may be used as a quick-reference tool for proper switch settings and I/O connections.

Chapter 6: Maintenance and Trouble-shooting

This chapter describes the recommended system maintenance and troubleshooting procedures. It also provides methods for isolating and resolving hardware and software problems.

Installation Process Overview

To ensure trouble-free operation, you should pay special attention to the following:

- The environment in which the system will operate
- The system layout and mounting
- The wiring and grounding practices used

These recommendations are intended to help you to easily and safely integrate the system into your equipment. Industrial environments often contain conditions that may adversely affect solid state equipment. Electrical noise or atmospheric contamination may also affect the system.

Installation Recommendations

Before you attempt to install this product, you should complete the following steps:

Step 1 Review this entire manual. Become familiar with the manual's contents so that you can quickly find the information you need.

Step 2 Develop a basic understanding of all system components, their functions, and interrelationships.

Step 3 Complete the basic system configuration and wiring instructions provided in Chapter 2, Getting Started. Note that this is a preliminary configuration, not a permanent installation, usually performed in a bench-top environment.

Step 4 Perform as many basic moves and functions as you can with the preliminary configuration. You can perform this task only if you have reviewed the entire manual. You should try to simulate the task(s) that you expect to perform when you permanently install your system. *However, do not attach a load at this time.* This will give you a realistic preview of what to expect from the complete configuration.

Step 5 After you have tested all of the system's functions and used or become familiar with all of the system's features, carefully read Chapter 3, Installation.

Step 6 After you have read Chapter 3 and clearly understand what must be done to properly install the system, you should begin the installation process. **Proceed In a linear manner**; do not deviate from the sequence or installation methods provided.

Step 7 Before you begin to customize your system, check all of the system functions and features to ensure that you have completed the installation process correctly.

The successful completion of these steps will prevent subsequent performance problems and allow you to isolate and resolve any potential system difficulties before they affect your system's operation.

Developing Your Application

Before you attempt to develop and implement your application, you should consider the following:

- Recognize and clarify the requirements of your application. Clearly define what you expect the system to do.
- Follow the guidelines and instructions outlined in this user guide. **Do not skip any steps or procedures.** Proper installation and implementation can be ensured only if all procedures are completed in the proper sequence.

Chapter 1. INTRODUCTION

Chapter Objectives

The information in this chapter will enable you to understand the product's basic functions and features.

Product Description

The BL Series drives are high performance, low-loss pulse width modulated DC servo drives suitable for use with Digiplan brushless (ML range) servo motors. The drives can be supplied with an integral positioner which accepts motion control commands over an RS232C link. They are designed for rack or panel mounting and power-plate technology makes them capable of delivering a continuous output power of 100W to 2kW. Adjustable current limiting allows them to be matched to a wide range of motors.

The drives are fully protected against damage caused by overheating and by short-circuits across motor connections or to earth. Additional protection circuitry monitors the voltage rails within the drives and disables the power switches if these fall outside the specification.

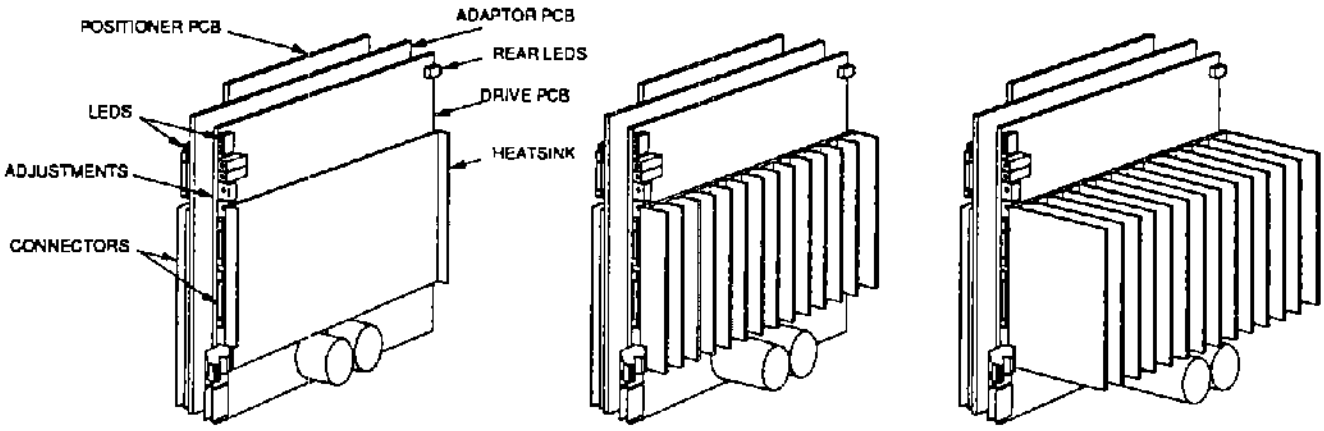


Figure 1-1. Basic BL Drives with Positioner

The built-in power supply operates from a single AC input voltage and uses a switching regulator to generate low voltage supplies, including power for the optional positioner. The supply has a built-in power dump circuit which protects its circuits by absorbing the power generated by the motor during deceleration.

Product Features

Protection Circuits

Adjustable Current Limit
Overcurrent
Overtemperature (Motor or drive)
Overvoltage
Output short circuit

Function Indicators

Current Limit
Drive Fault
Overtemperature
Logic Supply On

Adjustments

Tachometer gain
Balance
Time constant
Damping

Outputs and Inputs

Reset/Disable
Differential velocity/torque demand input
Fault output
Incremental encoder outputs

Other Features

Power dump
Euro rack system

Variant Information

Positioner	Fitted, not fitted
Mounting	Rack, L bracket or packaged

Table 1-1. BL Drive Type Variants

Theory of Operation

The drive contains all the necessary circuitry to control a brushless DC servo motor. It must be used in conjunction with a mains isolating transformer as this produces a suitable AC supply voltage from the AC mains supply.

The input to the drive is an analogue signal source, for example an analogue servo controller or simply a potentiometer. When the optional positioner is fitted, commands entered at an RS232C terminal or from a computer result in signals from the positioner to the drive which produce the commanded motion control function. The drive generates motor currents required to achieve the motion from the servo motor and an encoder provides feedback to complete the basic system shown in Figure 1-2.

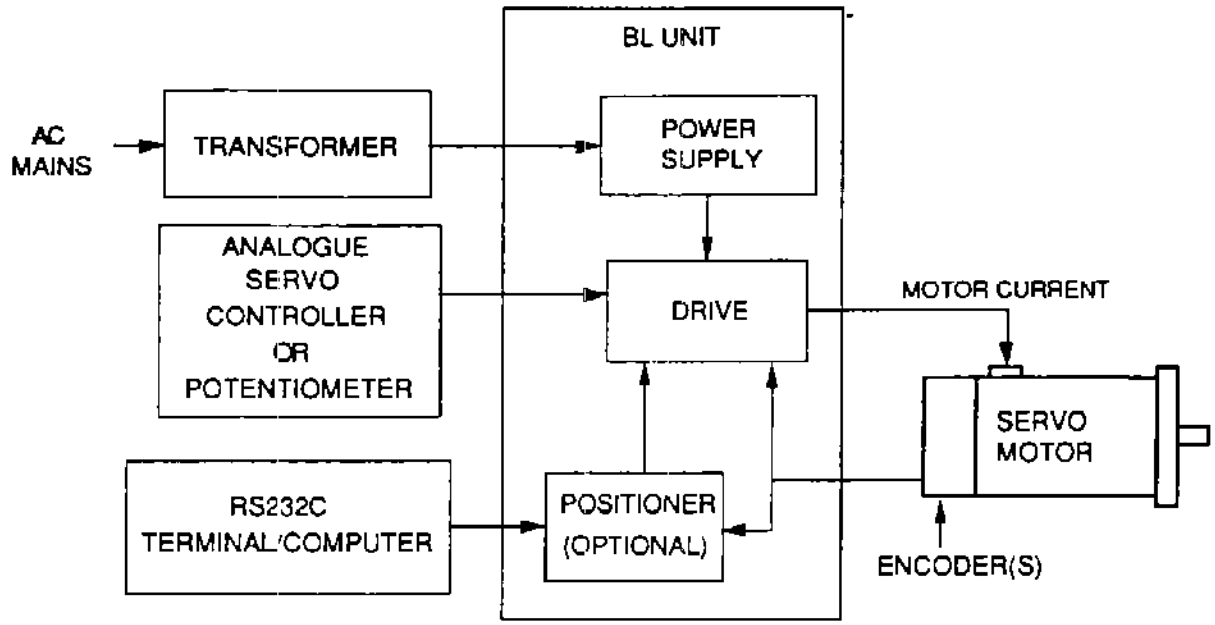


Figure 1-2. BL Drive System Schematic

Controls and Indicators

LED's

Current Limit LED (Yellow)

Illumination of this LED indicates that the axis is in current limit (does not disable the axis). This occurs if the rate of change of velocity demanded cannot be met by the drive or the torque request is greater than the set peak current.

Overtemperature LED (Red)

Illumination of this LED indicates overtemperature in the drive or the motor connected to it. The LED may also be illuminated if an excessive voltage drop occurs in the motor feedback cable.

Drive Fault LED (Red)

This LED, when illuminated, indicates that there has been an incremental encoder signal loss, overcurrent or overvoltage. It will also illuminate if the 24V DC is present but the AC input is absent.

Logic Supply On (Green) This LED indicates that the power to the logic circuits of the drive is present and correct.

Potentiometers

Balance This 20 turn potentiometer is used to adjust the balance of the amplifier to give zero motor current when there is no velocity input demand.

Tach Gain The level of the velocity feedback is adjusted by this 20 turn potentiometer.

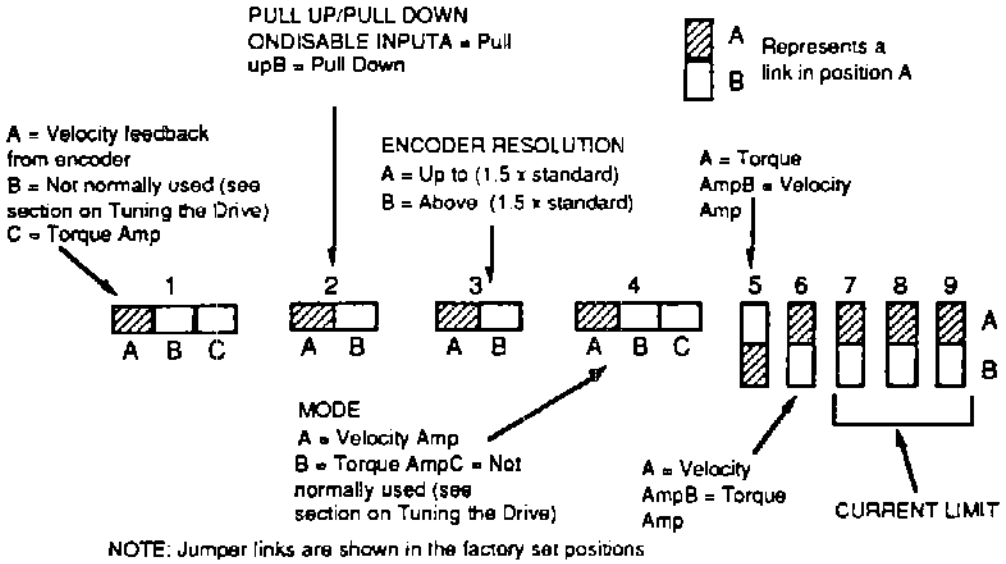
Time Constant The Time Constant single turn potentiometer and associated components determine the bandwidth of the amplifier.

Damping This single turn potentiometer adjusts the response characteristic of the amplifier so that the axis achieves the demanded velocity without overshoot.

Jumper Links BL drive options are selected by means of nine jumper links as shown in Figure 1-3. A full description of the jumper link functions will be found under "Setting Up the Drive". See Table 3-8 for Current Limit link settings and Figure 3-7 for Pull Up/Pull Down on disable input.

WARNING - Electric shock hazard

Remove power before changing jumper links.



NOTE: Jumper links are shown in the factory set positions

Figure 1-3. Jumper Link Setting Schematic

Chapter 2. GETTING STARTED

Chapter Objectives

The information in this chapter will help you to do the following:

- Verify that each component of your system has been delivered correctly.
- Become familiar with system components and their interrelationships.
- Establish the basic system configuration.
- Ensure that the drive functions correctly.

What You Should Have

Upon receipt, you should inspect your BL system delivery for obvious damage to its container. Report any damage as soon as possible. The items listed in Table 2-1 should be present and in good condition. To verify that you have the proper drive model, check the model number listed on the drive serial plate.

Ship Kit Table

Part Description	Part Number
BL Drive	**L bracket mount**: BL30L, BL75L, BL150L **Packaged**: BL30B, BL75B, BL150B **Front connectors**: BL30F, BL75F, BL150F **Rear connectors**: BL30R, BL75R, BL150R
Positioner (if ordered)	BLX30, BLX75, BLX150
Optional Transformers: Model TO92 Model TO170 Model TO171	 2050.036.04 2050.120.03 2050.121.03
BL User Guide	1600.135.XX
Positioner Option User Guide (if positioner is fitted)	1600.137.XX

Table 2-1. BL Drive Ship Kit

Systems may be shipped configured with drives and motors prewired or supplied as separate units.

Pre-installation Test

This section provides procedures to help you to connect up your BL drive system for a pre-installation test. *A temporary bench-top configuration is used for the pre-installation test.* Detailed permanent installation instructions are provided in Chapter 3, Installation.

The drive, motor and transformer must be separately connected to the machine protective earth connection. Terminals are provided for this purpose as shown in the following connection diagrams.

Figure 2-1 illustrates the pre-installation test configuration for systems without a positioner operating from a 240V mains supply.

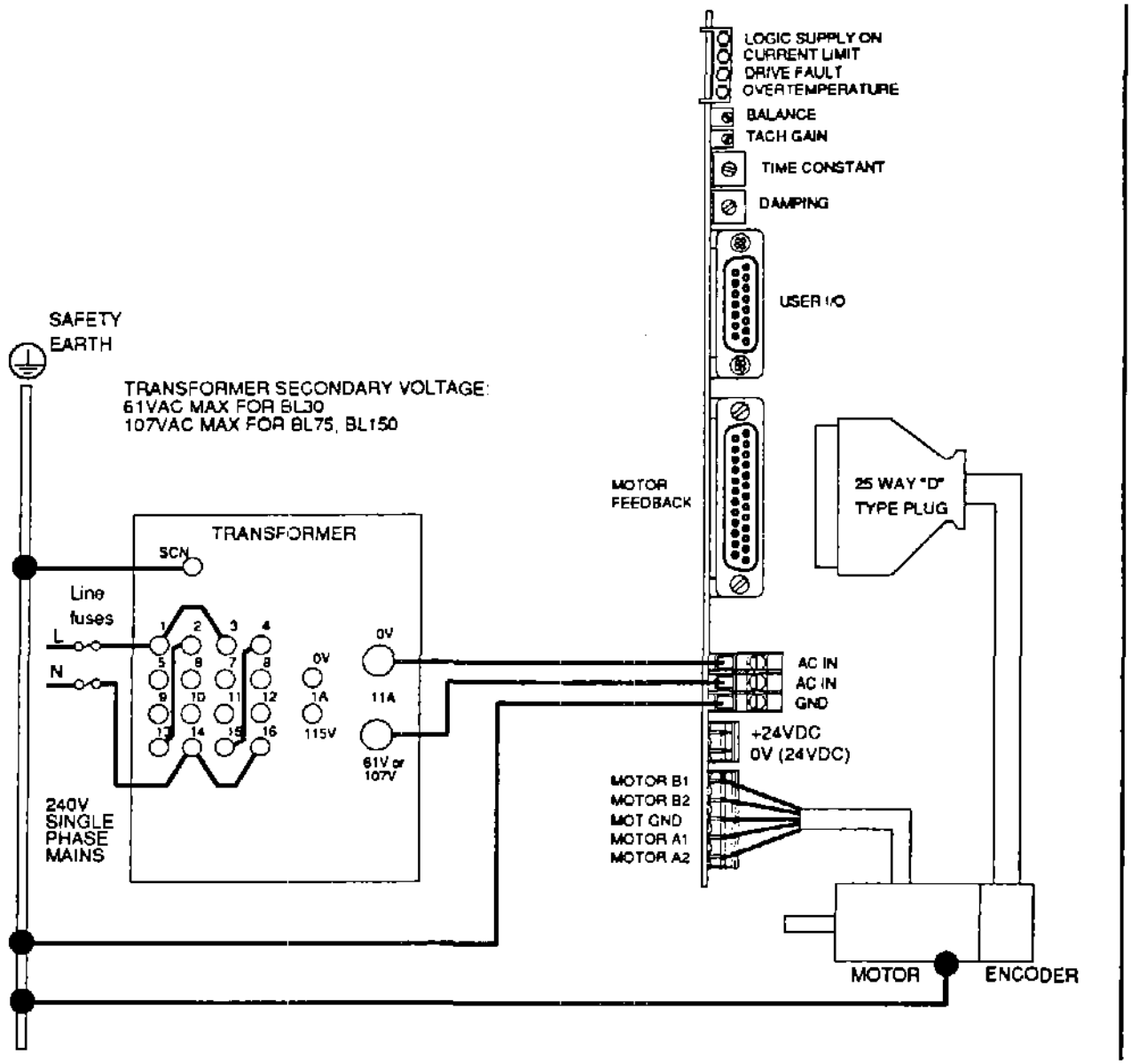


Figure 2-1. Pre-installation Test Configuration (240V AC Mains Supply)

Figure 2-2 shows the pre-installation test configuration for systems without a positioner operating from 120V AC mains supplies.

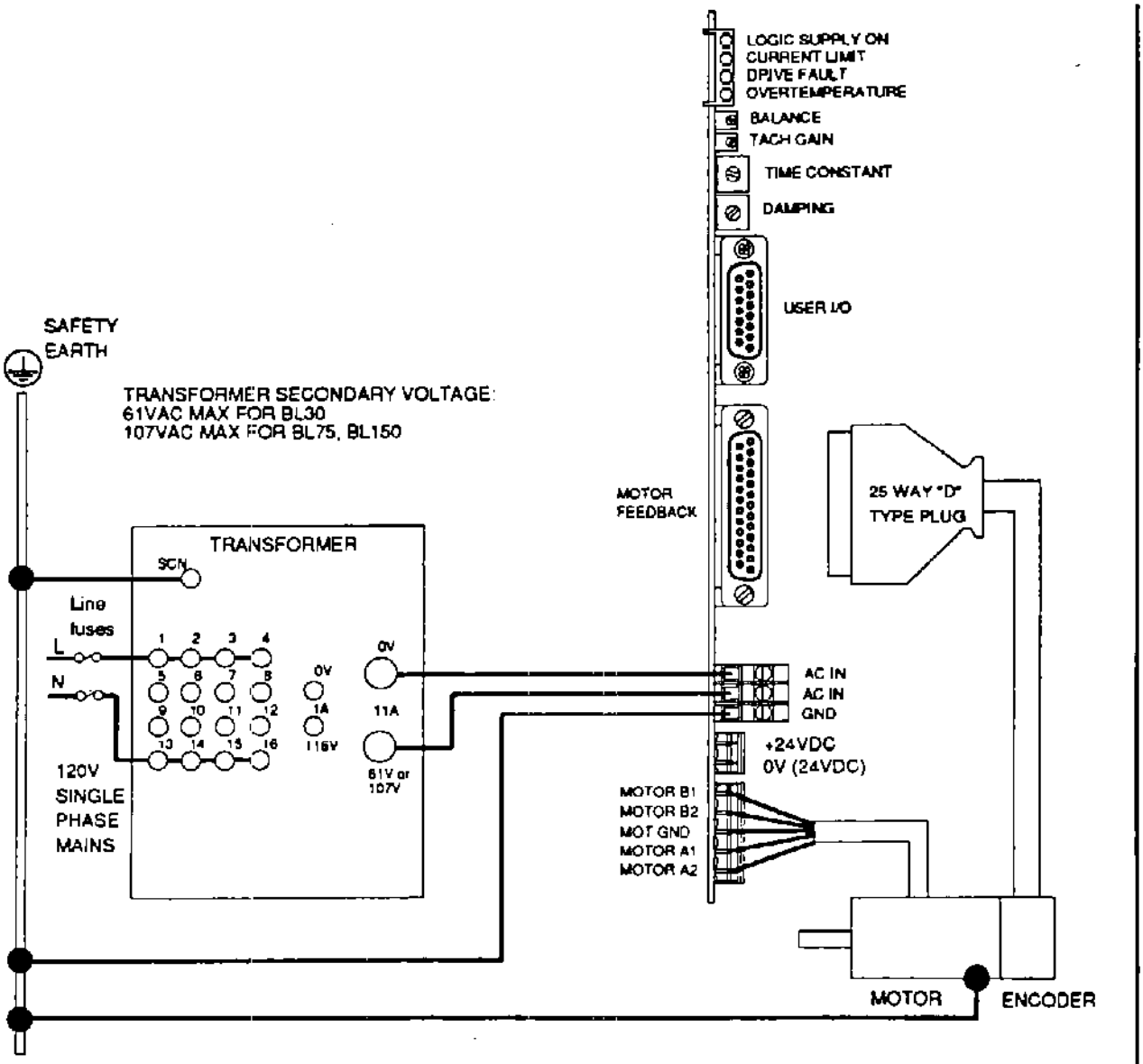


Figure 2-2. Pre-installation Test Configuration (120V AC Mains Supply)

Figure 2-3 illustrates the pre-installation test configuration for systems supplied with a positioner.

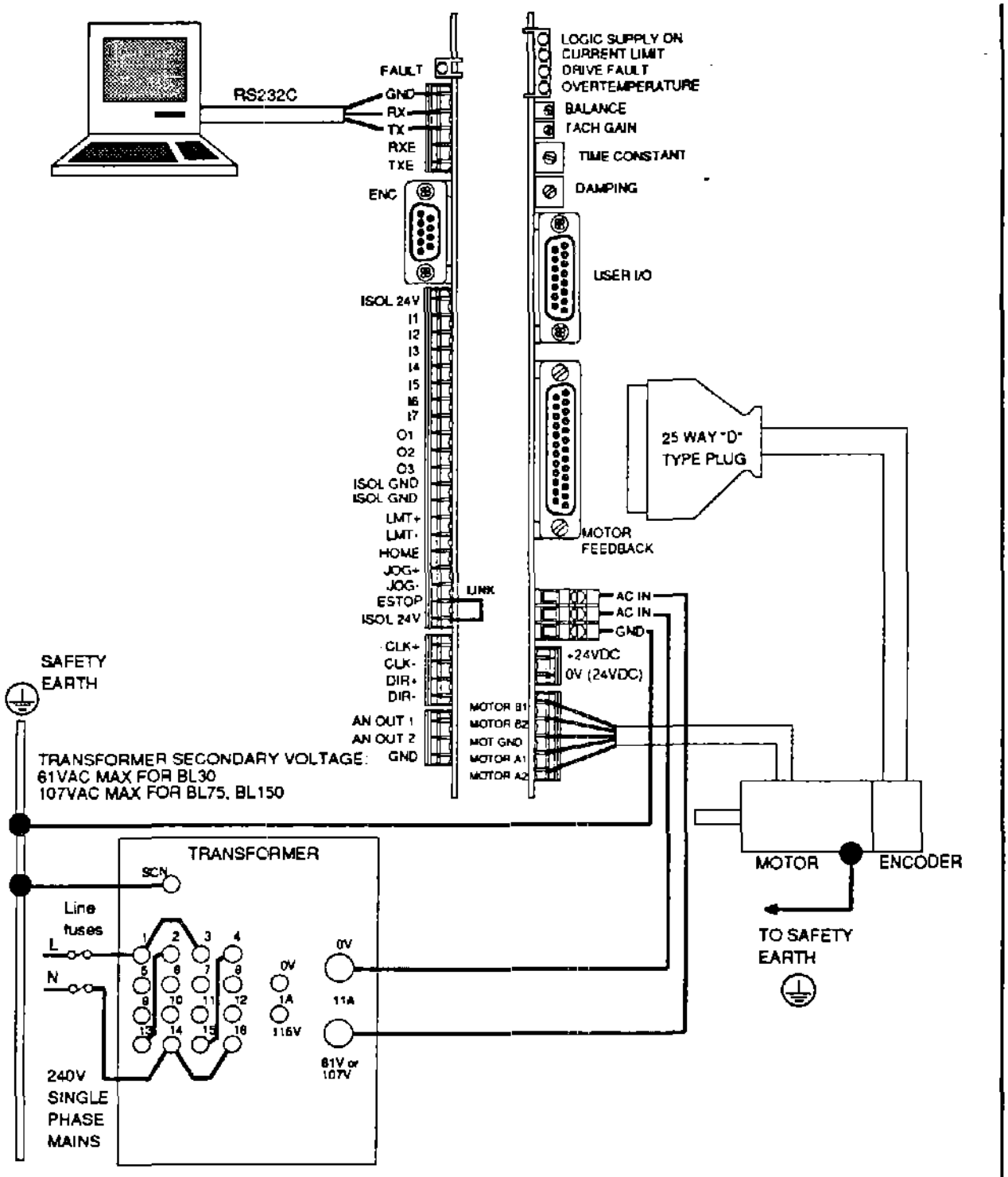


Figure 2-3. Pre-installation Test Configuration (Positioner-equipped Systems)

RS232C Controller

If a positioner is fitted, the RS232C connections from the controller to the positioner are as shown in Figure 2-4. Note that the Tx and Rx lines are cross-connected so that the transmit output is connected to the receive input in each case.

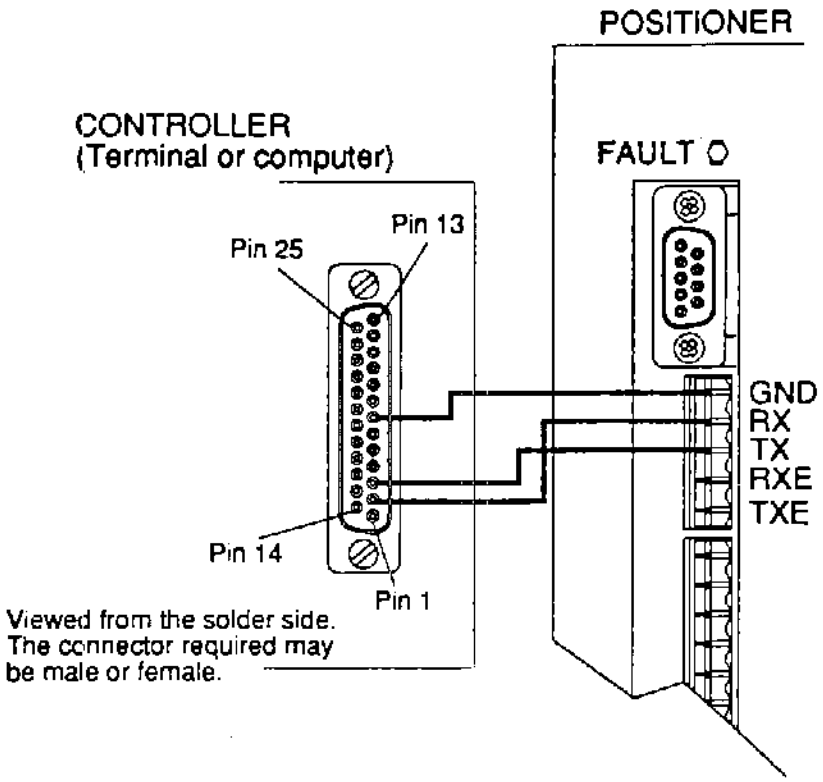


Figure 2-4. Controller to Positioner RS232C Connections

A cable suitable for this connection is available from Digiplan. Its part number is 7967.100. The connections RXE and TXE are not used for the test.

1. Connect the Motor

WARNING - Electric shock hazard

Ensure that AC power is disconnected before attempting to connect or disconnect the motor. Lethal voltages are present on the motor connectors.

Motor and feedback connectors are pre-wired. Plug the 5-way screw terminal connector into the Motor socket and the 25-way D connector into the Motor Feedback socket. During final installation it may be necessary to extend the leads or re-wire the connectors - information on lead colours etc. will be found in Chapter 3 "Installation".

2. Connect the Transformer

The motor and logic supplies are derived from a single-phase isolating transformer, which should be rated for the total loading. This clearly depends on the duty cycle, but would be typically 2.5A @ 61V for the BL30, 6A @ 107V for the BL75 and 11A @ 107V for the BL150. .

Normally, the BL system is shipped with one of the Digiplan transformers: TO170, TO171 or TO92.

Primary Fuses

Primary in-line fuses protect the transformer and secondary conductors in the event of a secondary short circuit fault condition. Suitable fuse values can be calculated using the formulae given in Chapter 3.

***Before* connecting the AC supply leads, measure the secondary voltage(s) from the isolating transformer. These should not exceed 61V AC for the BL30 or 107V AC for the BL75 or BL150 at the nominal AC input voltage.**

Connection Examples

Figures 2-1 and 2-2 illustrate connections for the standard Digiplan transformers. Note separate wires should be used for the drive and transformer screen connections to safety earth.
Transformer covers must be replaced before power is applied to any pre-installation test configuration circuit arrangement.

Testing the BL System without a Positioner

1. Set the drive potentiometers as follows:

TIME CONSTANT	Fully CCW
DAMPING	Fully CCW
TACH GAIN	Fully CW

2. For the pre-installation test set the drive up as a velocity amp by putting the jumper links in the following position:

1	A
2	A
3	A
4	A
5	B
6	A
7, 8 and 9	A (to give minimum motor current)

For more information on jumper link settings see Figure 1-3 and Table 3-8.

3. Refer to Figure 1-3 and Table 3-8 and set the drive jumper links accordingly. Information on setting the jumper links will be found in the same section.

4. Make sure that the motor is held securely and that the shaft is free to rotate.

5. Turn the Time Constant and Damping controls fully CCW and the Tach Gain control fully CW.

6. Turn on the 24V supply (if used) and the main AC supply.

7. Rotate the Balance control until the motor shaft remains stationary. Rotating the Balance control CW should cause the motor to rotate CW and therefore, rotating CCW should cause the motor to rotate CCW.

Testing the BL System with a Positioner

1. Set the drive potentiometers as follows:

TIME CONSTANT	Fully CW
DAMPING	Fully CCW
TACH GAIN	Fully CW

2. For the pre-installation test set the drive up as a torque amp by putting the jumper links in the following position:

1	C
2	A
3	A
4	B
5	A
6	B
7, 8 and 9	A (to give minimum motor current)

For more information on jumper link settings see Figure 1-3 and Table 3-8.

3. Make sure that the motor is held securely and the shaft is free to rotate.

4. Turn on the 24V supply (if used) and the main AC supply.

5. Check that the controller is communicating with the positioner by typing 1R<CR> (assuming the device address is 1). Note that all commands should be followed either by a space or carriage return <CR>. The positioner should respond with *R if it is ready to accept commands. If there is no response, or a different character is returned, refer to the Troubleshooting section before going any further.

   Type OFF to ensure the drive is disabled.

6. Put a wire jumper link or normally closed push-button switch, between emergency stop and isolated 24V.

7. Type the following:

   CPG5 CVG2 CFG0 CTG0 COFF0

8. Type the following:

   MC V1 A500 ON G

9. Motor should rotate slowly. This confirms that the drive is working.

10. Type S OFF

Chapter 3. INSTALLATION

Chapter Objectives

The information in this chapter will enable you to do the following:

- Mount all system components
- Connect all system inputs and outputs
- Ensure that the system is installed properly
- Perform basic system tests

You must complete all steps in Chapter 2, "Getting Started" before proceeding with the steps in this chapter.

This chapter also covers mains transformer information.

Environment

The drive system should be installed in an area where there is adequate ventilation above and below the racks. In some applications involving high duty cycles, ventilation fans and/or additional dump resistors may be required.

BL Power Dissipations

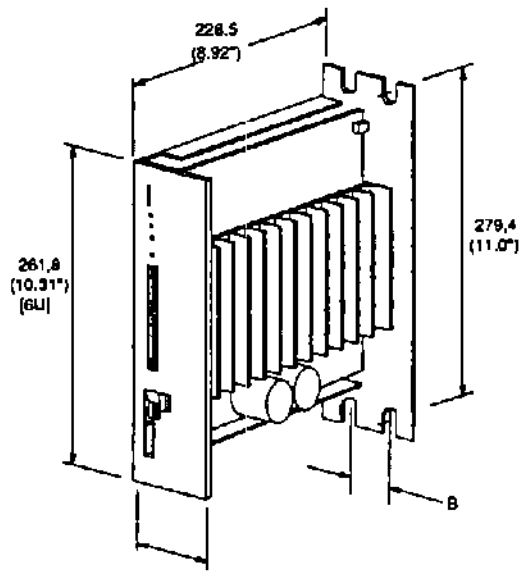
The BL Series of drives have the following power dissipations:

BL30	20W
BL75	30W
BL150	45W

Additional power dissipations could result from the power dump circuits. Since all drives have a 40W continuous rated power dump, these figures should be increased by 40W each, to give the worst case conditions.

Mounting the Drive

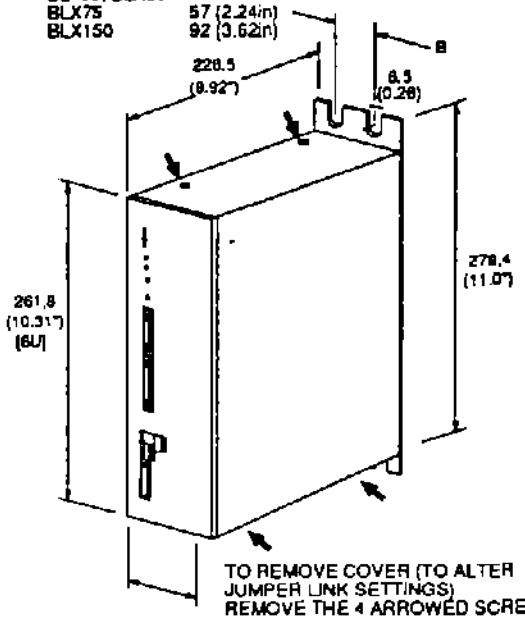
The drives are available with fittings for various methods of mounting. Figure 3-1 shows the mounting methods and the dimensions of the units.



BL30L - 10HP, 50.5 (1.99 in) BLX30L - 21HP, 106.3 (4.19 in)
BL75L - 14HP, 70.8 (2.79 in) BLX75L - 21HP, 106.3 (4.19 in)
BL150L - 21HP, 106.3 (4.19 in) BLX150L - 28HP, 141.9 (5.59 in)

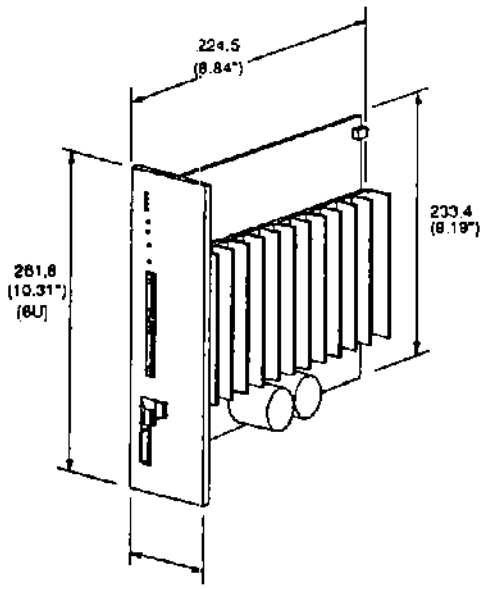
'L' BRACKET

Drive Type	Dimension B
BL30	31 (1.22in)
BL75	41 (1.61in)
BL150, BLX30	
BLX75	57 (2.24in)
BLX150	92 (3.62in)



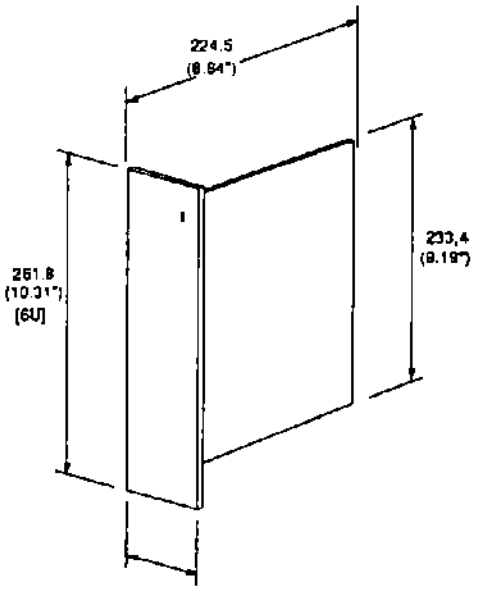
BL30B - 10HP, 50.5 (1.99 in) BLX30B - 21HP, 106.3 (4.19 in)
BL75B - 14HP, 70.8 (2.79 in) BLX75B - 21HP, 106.3 (4.19 in)
BL150B - 21HP, 106.3 (4.19 in) BLX150B - 21HP, 141.9 (5.59 in)

PACKAGED



BL30F - 10HP, 50.5 (1.99 in) BLX30F - 21HP, 106.3 (4.19 in)
BL75F - 14HP, 70.8 (2.79 in) BLX75F - 21HP, 106.3 (4.19 in)
BL150F - 21HP, 106.3 (4.19 in) BLX150F - 28HP, 141.9 (5.59 in)

**RACK MOUNTING,
CONNECTORS AT FRONT**



BL30R - 10HP, 50.5 (1.99 in) BLX30R - 21HP, 106.3 (4.19 in)
BL75R - 14HP, 70.8 (2.79 in) BLX75R - 21HP, 106.3 (4.19 in)
BL150R - 21HP, 106.3 (4.19 in) BLX150R - 28HP, 141.9 (5.59 in)

**RACK MOUNTING,
CONNECTORS AT REAR**

Figure 3-1. Mounting the Drive

Mains Transformer

This section describes the range of mains transformers suitable for use with BL drives available from Digiplan. It is advisable to test that either 61VAC (for an 85V DC motor supply) or 107VAC (for a 150V DC motor supply) is obtained on the secondary of the transformer used before connecting it to the equipment. The equipment will be damaged if the voltage is too high. A qualified electrician should carry out this work.

NOTE: It is our convention to quote transformer secondary voltages in the open circuit condition.

To use the system on a different mains supply, you will need to change the transformer connections. The information given in this section will show you how to do this.

Table 3-1 shows details of the transformers available. These are all for single phase operation.

Type	DC Supply	VA Rating	Suitable Drive
Model TO92	85v	700	BL30
Model TO170	150v	1300	BL75, BL150
Model TO171	150v	2500	BL75, BL150

Table 3-1. Optional Mains Transformers

Figures 3-2 and 3-3 show the transformer connections when used with 240VAC mains supplies and 120VAC mains supplies respectively.

Transformer Connections

Where several drives are to be operated from the same isolating transformer, it is desirable that a separate secondary winding is provided for each drive. If this is not possible, ensure that the wiring impedances to each drive are closely matched by connecting each unit individually back to the transformer using equal lengths of wire. Don't 'daisy chain' drives by looping the AC input from one to the next.

Wire Size

Transformer secondary wiring should use copper conductors with a cross sectional area of at least 1mm^2 (18awg tri-rated cable).

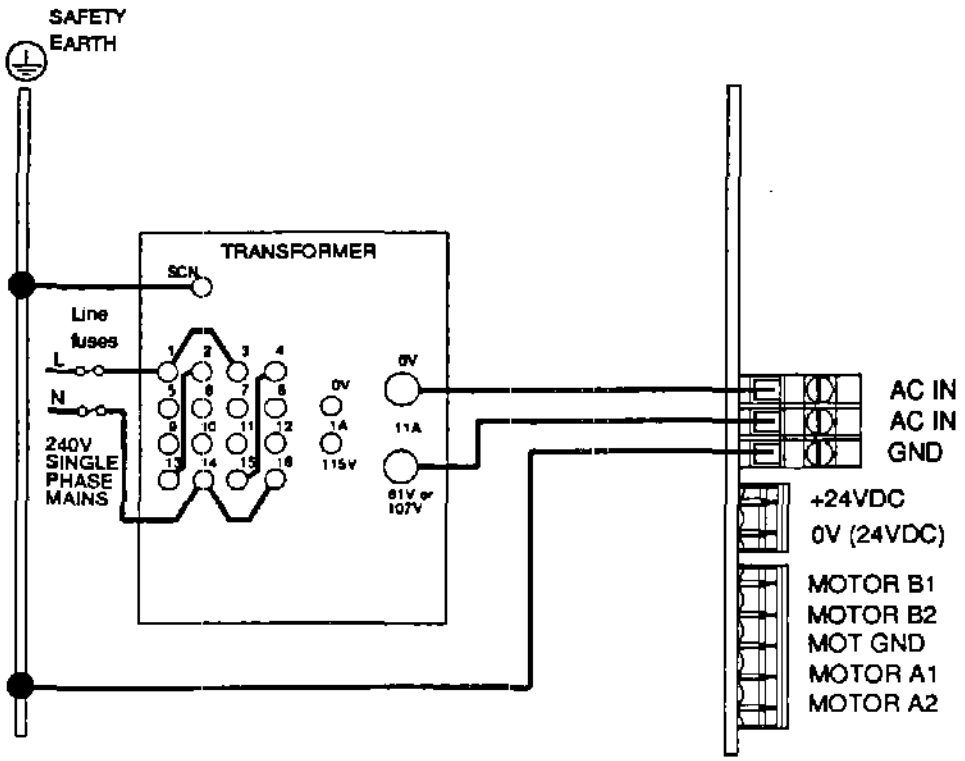


Figure 3-2. 240VAC Connections

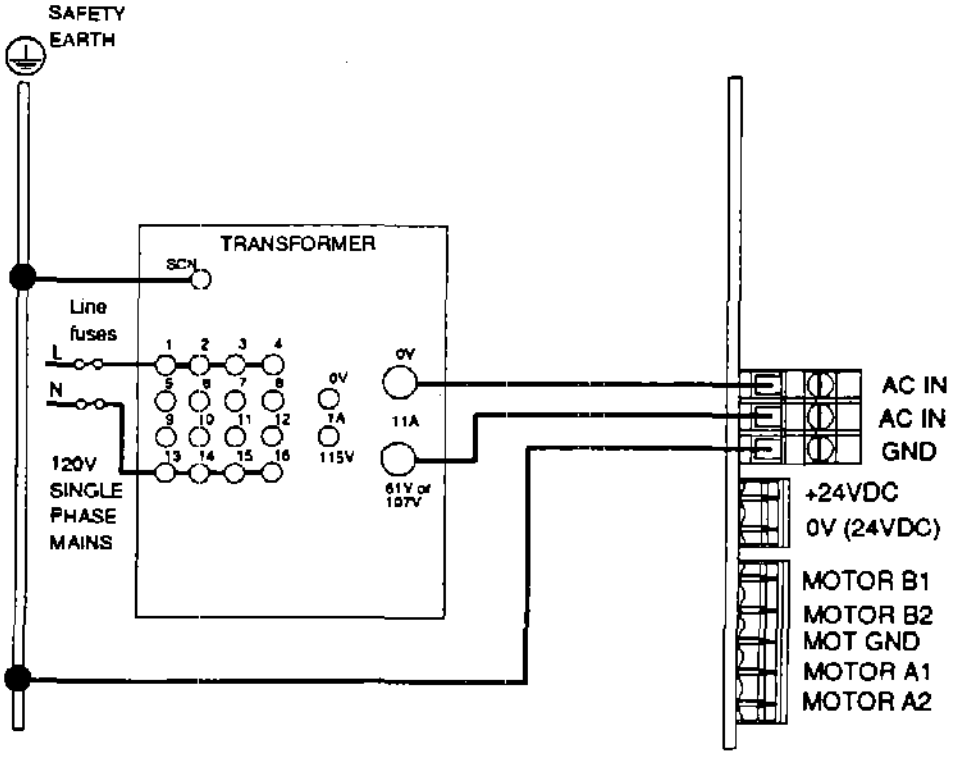


Figure 3-3. 120VAC Connections

Primary Fuse Ratings

Primary fuses need to be rated to protect the transformer and secondary wiring from short circuit faults whilst withstanding the primary in-rush current at power up. The fuse rating can be calculated as follows:

$$\text{Fuse rating (A)} = \frac{\text{Transformer VA} \times 1.2}{\text{Supply volts}}$$

Fuses need to be of the anti-surge high breaking capacity type, which have a limited range of values, consequently you may need to select the next highest standard value rather than the calculated value.

For example, a 300VA transformer used with a supply of 240V will require a 1.5A fuse, consequently the next highest standard value of 2A will need to be selected.

Voltage Adjustment

Table 3-2 gives details of the terminal connections for the range of mains input voltages. Input voltages in the range 360 to 480V are for connection across two phases of a three phase supply.

Input voltage	Primary connections		Jumper Links
	Line 1	Line 2	
100	1	9	1-2-3-4, 9-10-11-12
110	5	13	5-6-7-8, 13-14-15-16
120	1	13	1-2-3-4, 13-14-15-16
200	1	10	9-2, 11-4, 1-3, 10-12
208	5	10	13-2, 5-7, 15-4, 10-12
220	5	14	13-6, 15-8, 5-7, 14-16
230	1	14	1-3, 13-6, 15-8, 14-16
240	1	14	1-3, 13-2, 15-4, 14-16
360	5	12	9-6, 10-7, 11-8
380	5	16	9-6, 10-7, 11-8
400	1	12	9-2, 10-3, 11-4
420	1	16	9-2, 10-3, 11-4
440	5	16	13-6, 14-7, 15-8
460	5	16	13-6, 14-3, 15-4
480	1	16	13-2, 14-3, 15-4

Table 3-2. Transformer Connections

The transformer safety cover must be replaced following adjustment of the terminal connections.

DC Power Input

BL drives may be powered from DC supplies connected through the AC IN connectors. The maximum DC voltage for BL/BLX30 is 85V DC, while the BL/BLX75 and BL/BLX150 is 150V DC.

Power Dump Ratings

The regenerative power dump incorporated in the BL drive has a maximum continuous power rating of 40W. The power actually dissipated in any specific application is not simple to calculate - it depends on a large number of factors including maximum speed, load inertia, deceleration rate, duty cycle, motor/drive losses & time elapsed since acceleration. The worst situation occurs when a high-inertia load is decelerated repeatedly from high speed using the maximum decelerating torque.

The following graph show the relationship between total inertia and maximum speed if the rating of the power dump is not to be exceeded. It is assumed that the load is decelerated from its maximum speed to rest at full torque, and that the operation is repeated at the maximum duty cycle allowable for the motor. If the maximum speed is below the critical speed ω_c then the maximum inertia is not limited by the power dump, but of course the motor duty cycle must not be exceeded. There is no danger of over-rating the power dump when using either the ML1620 or ML2340 motor.

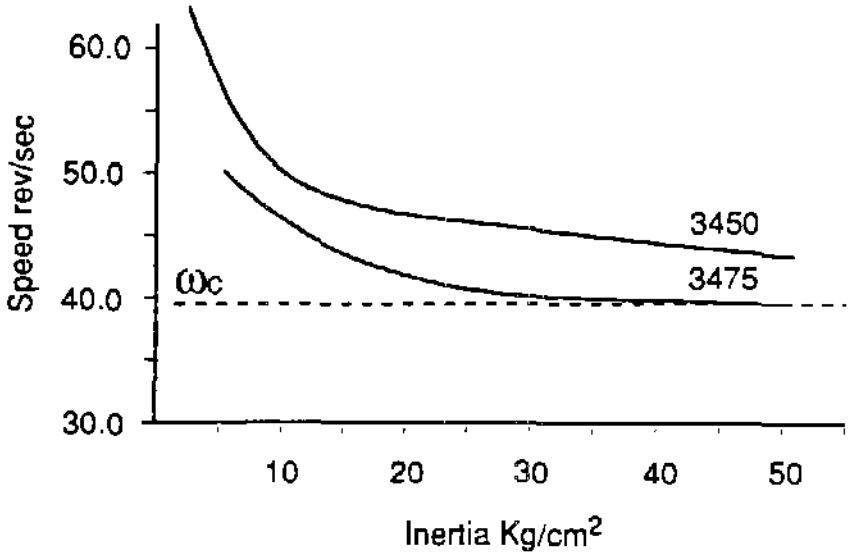


Figure 3-4. Total Inertia plotted against motor speed

The power dump circuit incorporates a fuse which will blow if the dump turns on for an excessive period. This may occur under fault conditions or when a very large inertia is decelerated hard from maximum speed. The largest load inertia which can be decelerated from maximum speed in current limit without blowing the dump fuse is given below:

ML3450 motor with BL150 drive - 40 kg-cm^2
ML3475 motor with BL150 drive - 70 kg-cm^2

It should be stressed that these figures and graphs are provided for guidance only and are based on conservative estimates. Operation outside the quoted limits will not necessarily over-dissipate the power dump depending on other factors as mentioned previously.

Drive Signal Connections

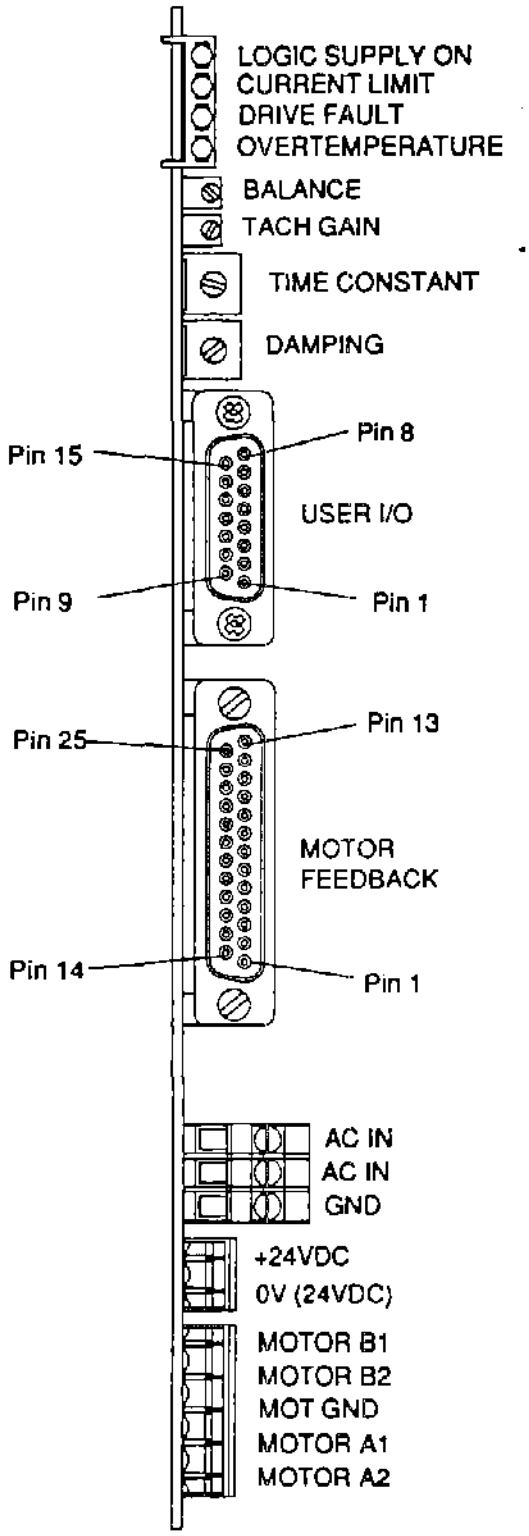


Figure 3-5. Connectors and Indicators

User I/O Connector Pin Functions

Pin	Signal Name	Function	Signal Type
1	V2†	Analogue velocity input	L
2	V1†	Analogue velocity input	L
3	-15v	Reference voltage	O
4	GND	Ground	Q
5	$\overline{RST}$	Reset/Disable	P
6	+15V	Reference voltage	O
7	DIG TACH	Analogue velocity output	
8	Not used		
9	$\overline{FT}$	$\overline{Fault}$	N
10	AOP *	A output from incremental encoder	M
11	$\overline{AOP}$	$\overline{A\ output}$	M
12	BOP *	B output from incremental encoder	M
13	$\overline{BOP}$	$\overline{B\ output}$	M
14	ZOP **	Z output from incremental encoder	M
15	$\overline{ZOP}$	$\overline{Z\ output}$	M

† Positive input on pin 2 (V1) wrt pin 1 (V2) causes CW motion
* AOP leads BOP for CW motor rotation

** ZOP is a once-per-rev high-going pulse, covering $\frac{1}{4}$ of a channel AOP cycle and occuring when AOP and BOP are both high - see below;

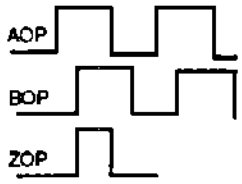


Table 3-3. User I/O Connector Pin Functions

Motor Connector Pin Functions

Signal Name	Signal Type	Lead Colour *
Motor B1	I	Brown
Motor B2	I	Grey
MOT GND	J	Green
Motor A1	I	White
Motor A2	I	Yellow

Table 3-4. Motor Connector Pin Functions

Motor Feedback Connector Pin Functions

Pin Number	Function	Signal Type	Lead Colour
1	Screen	R	Drain Wire
2	0V	E	Bk } Twisted Pair
3	5V	D	Rd }
4			Not connected
5			Not connected
6	$\overline{\text{MOT}}$	F	Rd } Twisted Pair
7	MOT	F	Gn }
8	Z-	C	Rd } Twisted Pair
9	Z+	C	W }
10	B-	C	Bk } Twisted Pair
11	B+	C	Or }
12	A-	C	Bk } Twisted Pair
13	A+	C	Brn }
14 to 17			Not connected
18	$\overline{\text{A3}}$	C	Bk } Twisted Pair
19	A3	C	W }
20	$\overline{\text{A2}}$	C	Bk } Twisted Pair
21	A2	C	Gn }
22	$\overline{\text{A1}}$	C	Bk } Twisted Pair
23	A1	C	Bl }
24	$\overline{\text{A0}}$	C	Bk } Twisted Pair
25	A0	C	Y }

Table 3-5. Motor Feedback Connector Pin Functions

AC In Connector

Signal Name	Function	Signal Type
AC IN	AC supply voltage from mains transformer	G
AC IN	AC supply voltage from mains transformer	G
GND	Ground for mains transformer screen	H

Table 3-6. AC Input Connector Pin Functions

24V DC Connector

Signal Name	Function	Signal Type
+24V DC	+24V DC supply to drive	A
0V (24V DC)	0V of 24V DC supply to drive	B

Table 3-7. 24V Supply Connector Pin Functions

Key to Signal Types

A +24v supply to drive
B 0V of 24V supply to drive
C Differential encoder input
D Encoder supply voltage
E Encoder supply 0V
F Motor overtemperature input
G AC input from mains transformer
H Ground for mains transformer screen
I Motor supply
J Motor Ground
L Analogue velocity demand signal
M Differential output from incremental encoder
N Open collector output
O Reference voltage out (10mA max.)
P Active low control input
Q Logic supply ground

Using an External +24V Supply

The BL drive has an on-board switch-mode power supply which also supplies the positioner, if fitted. This supply normally runs from the AC input. If it is required that the logic supply to the positioner be maintained even when the AC input is removed (to keep the positioner communicating) a 24V DC supply can be connected to this 2 pin socket. This will maintain all the logic supplies when the AC input is removed. When the AC input is restored, the current from the 24V DC supply, normally about 750mA, falls to zero.

Using an External Positioner

The incremental encoder incorporated in the motor may be used to provide position information to an external positioner. Terminals 10-15 on the User I/O connector provide the true and complementary signals from all three encoder channels (see Table 3-3). These outputs are generated by 26LS31 line drivers.

Rewiring the Motor Connections

If it is necessary to disconnect the feedback cable for any reason (to feed it through a conduit, for example) it is recommended that it is disconnected at the motor end. To do this, loosen both gland nuts, take off the terminal cover by removing the 4 retaining bolts, **make a careful note of where each pair of wires is connected** and then loosen all the screw terminals to remove the cable.

The main motor cable has 5 leads and is terminated in a 5-way screw terminal connector. This connector is easily removed and refitted where necessary. The lead colours are shown in Table 3-4; make a note of where each colour wire is connected before proceeding and take particular care that the leads are reconnected correctly.

Direction of Rotation

The motor shaft will rotate clockwise (viewing the motor from the shaft end) when the V1 signal is positive with respect to V2. When used as a torque amplifier, clockwise torque wil be produced when V1 is positive with respect to V2.

Tach Feedback

Pin 7 of the User I/O connector is available to monitor the motor velocity. Motors with an incremental encoder line count of 1000 will generate signals of 3V/1000 rpm ±20%, whilst motors with an incremental line count of 500 will generate 1.5V/1000 rpm ±20%.

Setting Up the Drive

Application Types

There are two basic types of applications (described below) for the BL servo drive. Each type of application requires a different type of tuning.

Velocity Following

For this application, it is required that the axis follows programmed velocities as accurately as possible. A high amplifier gain is needed so that the small signals resulting from small velocity errors will produce large correcting torques.

Torque Amplifier

In this type of application, the torque produced is required to be proportional to the input voltage. Low amplifier gain is needed in this case. The torque produced directly relates to the motor current. For example, a gain of 1A/Volt would produce 1A of motor current for each volt at the input (±10V at the input would produce ±10A of motor current).

Initial Precaution

Before starting to tune the drive ensure that the motor mechanism is clear of obstructions. Position the mechanical system at the mid-position of its total travel. Do not allow the motor to remain unstable for more than a second or two.

Setting the Drive Jumper Links

Depending on how you want to use the drive, you may need to change some of the factory-set link positions. Figure 3-6 shows the positions and functions of all the jumper links. See Table 3-8 for Current Limit link settings and Figure 3-7 for the Pull Up/Pull Down on Disable Input.

WARNING - Electric shock hazard

Remove power before changing jumper links.

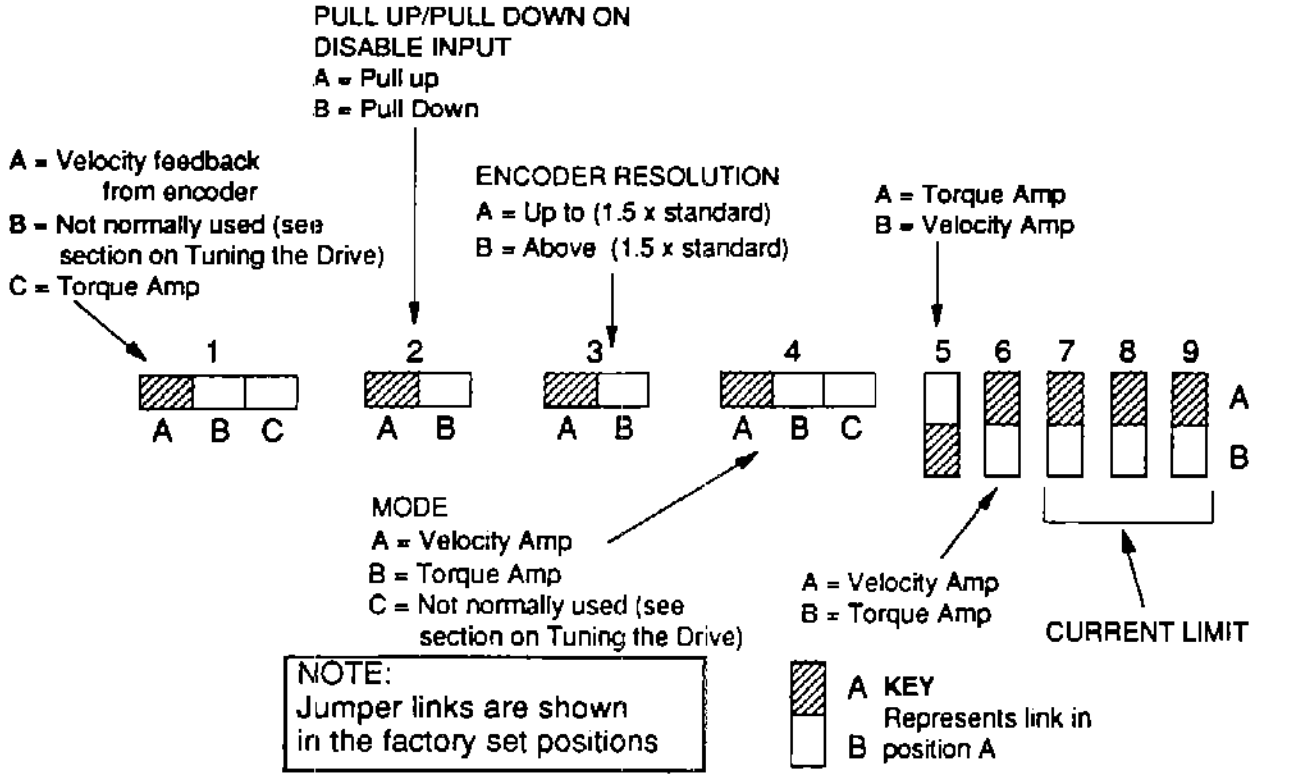


Figure 3-6. Jumper Link Setting Schematic

Jumper Link Information

LINK 1	A	Digital Tach Velocity Feedback (VA)
	B	Scaled Torque Demand via Tach Gain pot (TA)
	C	Link Park for the Fixed Torque Amp Gain (TA) or Velocity Feedback from Tachometer (VA)
LINK 2	A	Disable input Pull Up
	B	Disable input Pull Down
LINK 3	A	Digital Tach Gain Standard resolution encoder
	B	Digital Tach High Res encoder
LINK 4	A	Standard velocity demand setting (VA)
	B	Fixed Gain Torque amp (TA) Low velocity demand setting (VA) (Recommended for BL/BLX30)
	C	Link Park for Scaled Torque Demand (TA)

LINK 5 & 6

TORQUE AMP :LINK 5 A & LINK 6 B

VELOCITY AMP :AS BELOW

LINK 5	LINK 6	GAIN
None	None	.66
A	B	6.5
A	A	51
B	B	500
B	A	5000

LINK 7, 8, 9 CURRENT LIMIT - see Table 3-8

Velocity or Torque Amplifier

The BL drive would normally be used as a velocity amplifier, in which case the jumper links are set as follows:

Link 1 = A Link 5 = B
Link 4 = A Link 6 = A

To use the drive as a torque amplifier (so that input voltage now determines torque rather than velocity), set the jumper links as follows:

Link 1 = C Link 5 = A
Link 4 = B Link 6 = B

When the drive is used as a torque amplifier, turn the Time Constant control fully CW and the Damping control fully CCW.

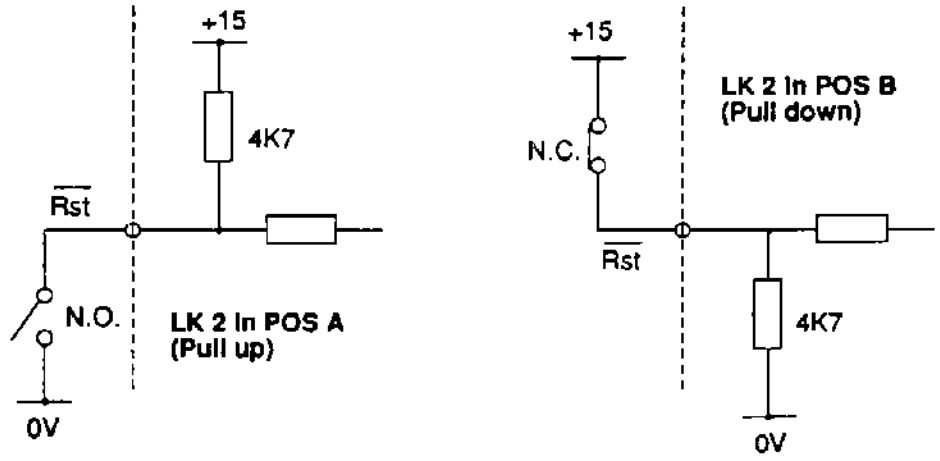


Figure 3-7. Reset/Disable Input Circuit Options

Polarity of the 'Disable' Input

Jumper link 2 determines whether the internal resistor on the disable input is pulled up or down. In position A, the resistor is pulled up to +15V and the drive can be disabled by connecting the disable input to 0V using a switch or open-collector transistor. In position B the input resistor is returned to 0V, requiring a normally-closed switch up to +15V to keep the drive energised. The options are illustrated in Figure 3-7. The preferred 'fail safe' connection is with the link in position B, since the drive de-energises if the connection is broken.

Encoder Resolution

With all standard motors, jumper link 3 should be left in position A. If the motor has been fitted with a non-standard encoder (available to special order only), and its resolution is greater than 1500 lines, transfer the jumper link to position B.

Standard encoder resolutions are 500 lines for size 16 and 23 motors, and 1000 lines for size 34 motors. After quadrature decoding these produce working resolutions of 2000 and 4000 counts/rev respectively.

Current Limit Setting

Jumper links 7, 8 and 9 are used to set the peak current which the drive will deliver. Table 3-8 shows the Jumper link settings for various peak current levels.

The jumper settings limit the peak current of the drive. This is achieved by the drive amplifier clamping current to the level selected, effectively reducing the dynamic range of the signal. For example an input of ±10V will generate an output current of ±Ipeak (±30A for the BL150). When the jumpers are set to limit the current to 10A the input voltage will be restricted to a range of ±3.3V to achieve ±10A, any voltage beyond 3.3V will still only produce 10A.

BL30	BL75	BL150	7	8	9	
7.5A	15A	30A				A B
3.75A	7.5A	15A				A B
2.5A	5A	10A				A B
2A	3.75A	7.5A				A B
1.5A	3A	6A				A B
1.25A	2.5A	5A				A B
1A	2A	4A				A B

A **KEY**
Represents link in
B position A

Table 3-8. Current Limit Link Settings

It is normal to set the peak current at approximately 3 times the continuous current rating of the motor. The table below shows the recommended peak current setting for each motor size:

Motor	Peak Current
1620	3.75A
2340	7.5A
3450	15A
3475	30A

Table 3-9. Recommended Peak Current

You can use peak current settings higher than the values shown above provided you take great care not to exceed the appropriate duty cycle, otherwise you may burn out the motor. Information on duty cycle calculation will be found in Digiplan's Analogue Servo Application Guide, or you can obtain engineering assistance from Digiplan or your local distributor. Also, if you make the motor go unstable during tuning, disable the drive immediately to prevent damage to the motor.

Tuning the Drive

The appropriate tuning procedure should be carried out on each axis. The procedures in this section assume that you have completed the connection and test procedures provided in Chapters 2 and 3. The motor should be coupled to the load at this stage.

Tuning the Drive without a Positioner

Tuning for use as a Velocity Amplifier

Use the following procedure to tune the drive.

Step 1 Set jumper links.

Step 2 Make sure the power to the drive is off and that the motor is held securely and the shaft is free to rotate.

Step 3 Adjust the front panel controls as follows:

TACH GAIN	Fully CW
DAMPING	Fully CCW
TIME CONSTANT	Fully CCW

Step 4 Apply zero velocity demand to the input by connecting both signal inputs (VEL1 and VEL2) together.

Step 5 Switch on the power to the drive. Should the motor rotate, adjust the Balance potentiometer in the opposite direction to the motor rotation until stationary.

If any fault LEDs illuminate, refer to Chapter 5, "Maintenance & Troubleshooting".

Step 6 Set the velocity amplifier sensitivity by applying a signal of 20% of maximum input (2V for ±10V operation) and adjusting the Tach Gain 20-turn potentiometer to give 20% of maximum speed.

Step 7 Reduce the input signal to zero to stop the motor.

Step 8 Rotate the Time Constant control clockwise until the motor shaft starts to oscillate (characterized by a high-pitched ringing sound). Optimum drive performance is achieved at the point when the motor first starts to ring. Do not allow the motor to oscillate for more than a second or two.

Step 9 Increase the input signal to run the motor at high speed (**not full speed**) and check for smooth behaviour. If there is excessive noise or vibration, try turning the Time Constant control anti-clockwise.

Step 10 Periodically apply and remove short 20% velocity input signal pulses at approximately 1-second intervals. If the control system will not permit this method of control, remove the signal connections and use a separate DC power source (i.e., a battery or a DC power supply) to provide the signal.

Note the response of the system. The velocity may be monitored by attaching an oscilloscope probe to LK1 with the earth clip on pin 4 of the user I/O connector (15 way D type). The objective is to optimise the motor's responsiveness to the input signal. Adjust the Damping control to give the shortest settling time without overshoot and without sluggishness. Turning the control CCW makes the motor more responsive (stiff), and turning the control CW makes the motor more sluggish.

If the final speed changes considerably, you may want to change the velocity input signal to compensate. If the motor begins to oscillate (or oscillate louder than the setting derived from step 10) adjust the Time Constant control.

Step 11 Remove the input signal and ground VEL1 and VEL2 to each other, and, if necessary, readjust the Balance control until the shaft remains stationary.

Tuning for use as a Torque Amplifier

Use the following procedure to tune the drive.

Step 1 Set jumper links.

Step 2 Make sure the power to the drive is off and that the motor is held securely and the shaft is free to rotate.

Step 3 Adjust the front panel controls as follows:

DAMPING	Fully CCW
TIME CONSTANT	Fully CW

In some torque amp applications it is necessary to set an accurate torque amp gain (i.e. Amps/Volt or Nm/Volt). This can be achieved by setting LK1 in position B and LK4 in position C. In this mode, the otherwise redundant TACH GAIN pot is used as a gain control.

Tuning the Drive with a Positioner

Please refer to the Positioner User Guide for this information.

Chapter 4. HARDWARE REFERENCE

Chapter Objectives

This chapter is designed to function as a quick reference tool for system specifications.

BL Drive Specification

	BL30	BL75	BL150
Continuous Current	3.75A	7.5A	15A
Peak current	7.5A	15A	30A
DC bus Voltage	85V	150V	150V
AC Input Voltage: Nom. Max. Min.	61V 67V 24V	107V 118V 48V	107V 118V 48V
Weights *	0.8Kg	1.7Kg	2.8Kg
Motor Options	ML-1620, ML-2340	ML-2340, ML-3450, ML-1620	ML-3450, ML-3475
Power input	AC direct from mains transformer		
Control input	±10V analogue (torque or velocity)		
Reference outputs	±15V at 10mA		
Velocity feedback	Built-in incremental encoder		
Commutation method	4 bit absolute encoder		
Torque amplifier bandwidth	>2500Hz		
Switching frequency	20Khz		
Velocity amp gain	0.66/6.6/51/500/4800 set by links		
Torque amp gain	0.75/0.075AV	1.5/0.15AV	3/0.3 AV
Gain linearity	±4%		
Typ. input amp drift	10µV/°C		
Power dump current	9A @ 100V	16A @ 100V	16A @ 100V
Max. cont. dump power	40W		
Min recommended load inductance	0.5mH		
Jumper link settings	Input range, current limit, torque/vel. mode		
Potentiometer settings	Time constant, damping, balance, tach gain		
Diagnostic LED's (Front)	Power on, current limit, overtemperature, drive/motor fault		
Diagnostic LED's (Rear)	Power on, composite fault		
Dimensions	See Figure 3-1 (Chapter 3)		

* If the drive is supplied with the positioner option, add 0.5Kg to this weight.

Table 4-1. BL Servo Drives Specification

Input/Output Specification

Signal	Input/Output	Characteristics
Command Voltage Sense	Inputs	Differential input between V2 (pin 1) & V1 (pin 2) Range ±10V
+15V & -15V Reference Voltages	Outputs	Maximum current source = 10mA Not short circuit protected
Reset	Input	Vih > 10V Vil > 0.8V Vin(max)=30V DC
Fault	Output	Open collector, active low Vmax=+30V DC Imax=80mA Vsat=0.2V @ 80mA
Incremental Encoder	Outputs	26LS31 line driver outputs

Table 4-2. User I/O Specification

Brushless Motor/Drive Packages

The BL Series drives may be matched with motors in the Digiplan brushless range and supplied as ready-wired motor/drive packages. Details of the range of four motors (Types ML-1620, ML-2340, ML-3450 and ML-3475) are given in Table 4-3.

Type	Weights (including cable)	Rotor Inertia Kg-cm^2	Incremental Encoder Line Count
ML-1620	0.85Kg	0.056	500
ML-2340	2.1Kg	0.28	500
ML-3450	5.1Kg	1.6	1000
ML-3475	6.4Kg	2.4	1000

Table 4-3. Brushless Motor Data

The dimensions of the motors are shown in Figures 4-1 to 4-4.

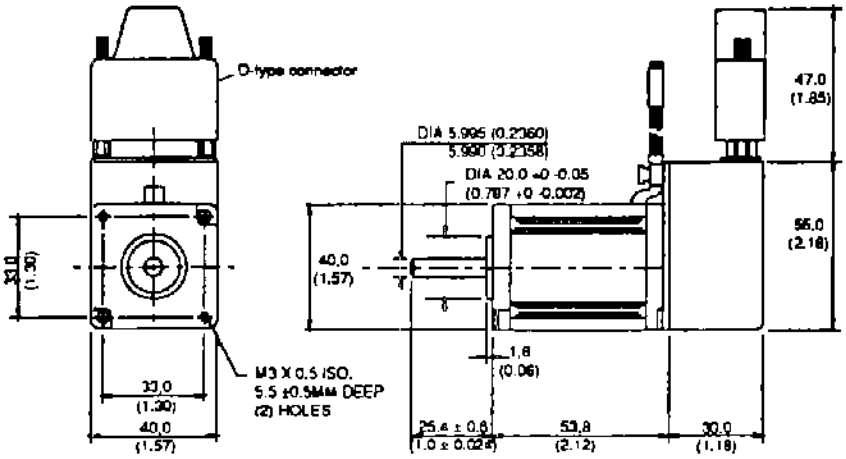


Figure 4-1. Motor Type ML-1620 Dimensions

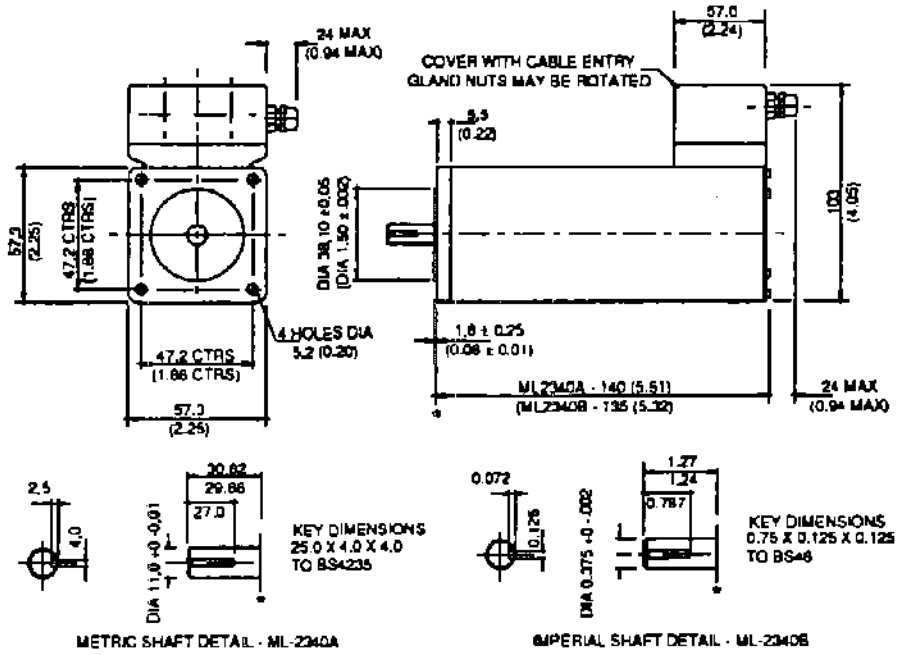


Figure 4-2. Motor Type ML-2340 Dimensions

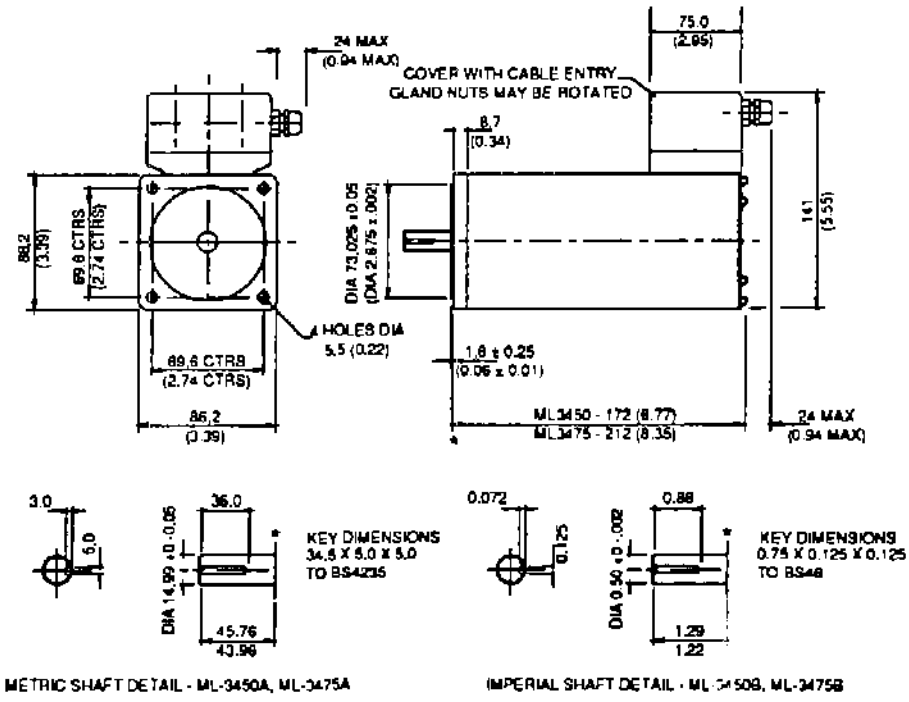
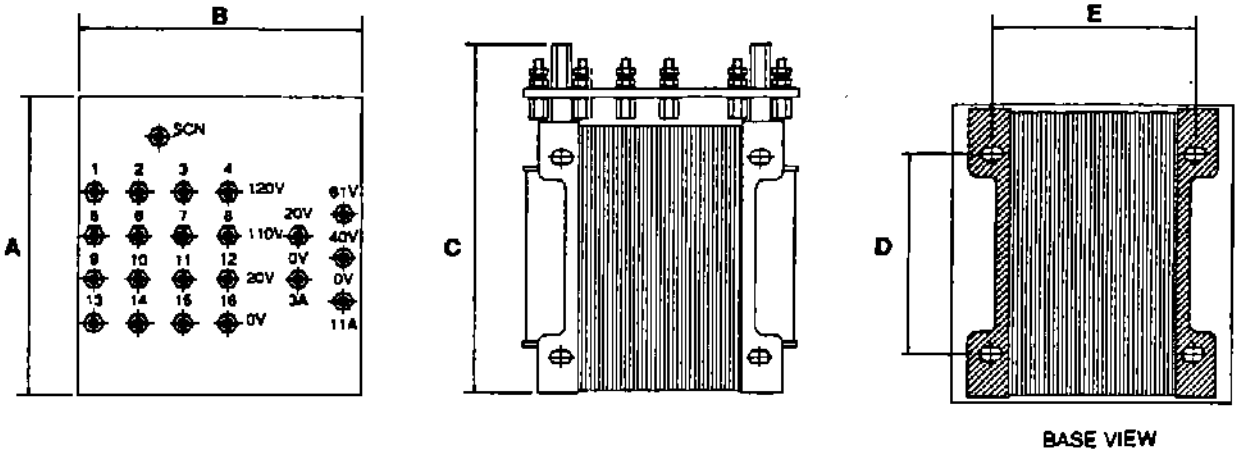


Figure 4-3. Motor Type ML-3450 & ML-3475 Dimensions

Transformer Dimensions



Dimensions	T092	T0170	T0171
A	136.0 (5.35)	195.0 (7.68)	215.0 (8.47)
B	126.0 (4.96)	135.0 (5.32)	172.0 (6.77)
C	155.0 Max. (6.10 Max.)	215.0 Max. (8.47 Max.)	242.0 Max. (9.53 Max.)
D	89.0 (3.50)	102.0 (4.02)	115.0 (4.53)
E	89.0 (3.50)	82.0 (3.23)	110.0 (4.33)
Weight	8Kg	15.5Kg	24.5Kg

Figure 4-4. Transformer Dimensions for T092, T0170 and T0171 - mm(ins)

Motor/Drive Package Performance Data

The torque curves for the possible motor/drive combinations are shown in Figure 4-4.

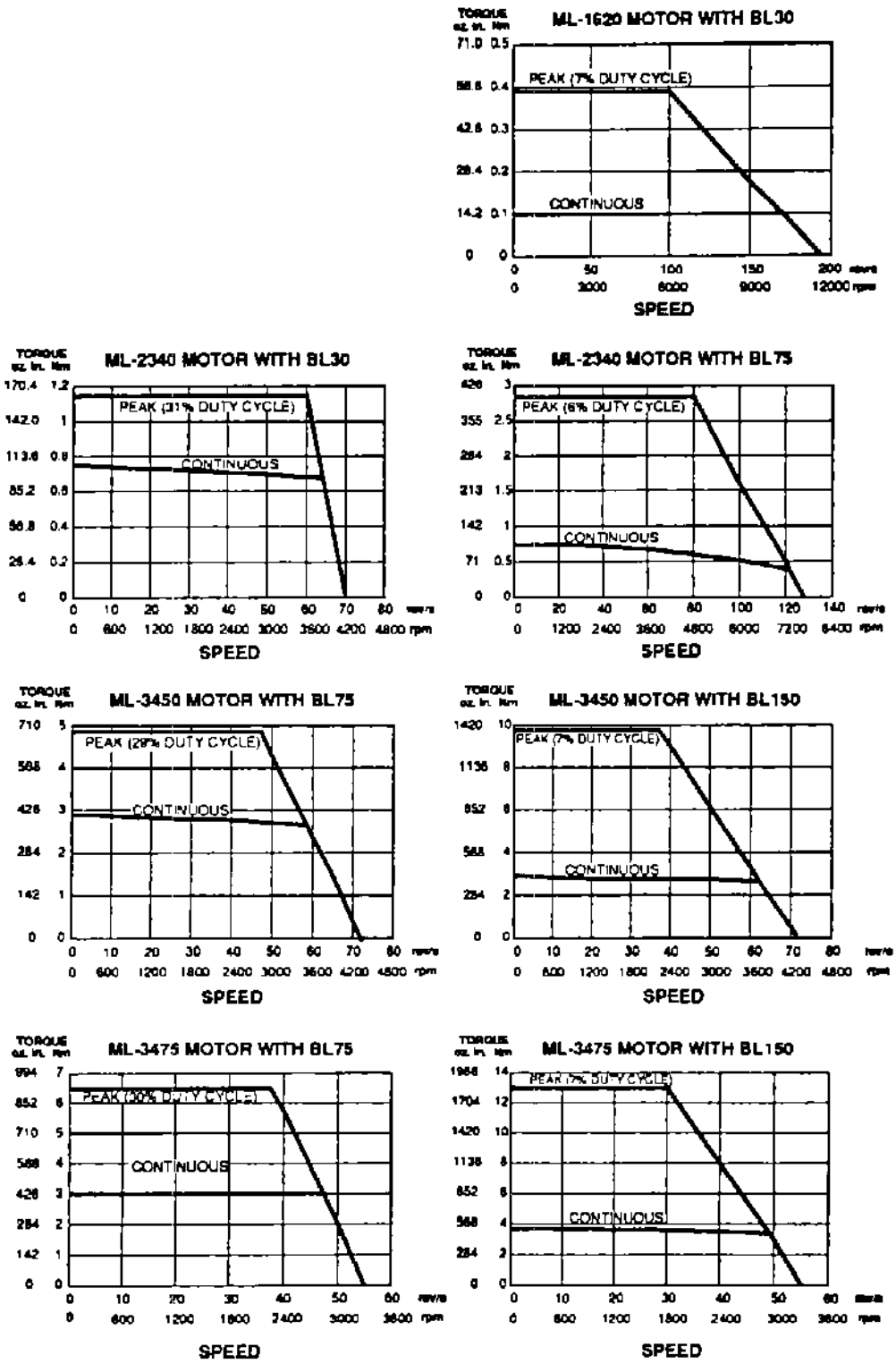


Figure 4-5. Motor/Drive Packages Torque Curves

Fuse Ratings

BL drives incorporate four fuses - two AC input fuses, a DC bus fuse and a power dump fuse. Types and ratings are shown in Table 4-4.

			Rating		
Fuse No.	**Circuit**	**Type**	**BL30**	**BL75**	**BL150**
FS1	AC input	32mm TL HBC	8A	15 or 16A	30 or 32A
FS2	AC input	32mm TL HBC	8A	15 or 16A	30 or 32A
FS3	DC bus	32mm QA HBC	8A	10A	20A
FS10	Power dump	20mm TL LBC	2A	2A	2A

TL - Time lag
QA - Quick acting
HBC - High breaking capacity
LBC - Low breaking capacity

Table 4-4. BL Fuse Ratings

Chapter 5. MAINTENANCE & TROUBLESHOOTING

Chapter Objectives

The information in this chapter will enable you to isolate and resolve hardware problems.

General

In order to minimise field failures, all drives are soak tested at elevated temperatures. In spite of this the occasional failure may still occur and the following notes are intended as a brief guide to enable the cause of the fault to be located.

Repairs

Whenever possible units should be returned to the manufacturers for repair, since automatic test equipment not available in the field is used when testing these drives. All repairs are soak tested before being returned to the customer.

Drive Removal

Before disconnecting a drive prior to removal, ensure that all supplies are switched off and wait for the Power On LED to go out.

Drive Fault LED

The majority of faults that can occur in the drive will result in illumination of the Drive Fault LED. The causes of this are as follows:

1. HT Overvoltage

Failure of the dump circuit to cope with regeneration. Check the dump fuse, FS4. Check if the fault occurs during a period of deceleration, if so, then consult Digiplan with a view to increasing the dump capability. If when the motor is stationary the DC supply normally has a value of more than 165V then there is a danger of the overvoltage protection operating under average regeneration conditions. Lowering the normal operating value of the supply may well cure this apparent fault.

2. Overcurrent

The drive fault LED will also be illuminated in the event of a short circuit occurring between the motor terminals or if either terminal is shorted to earth.

If no external reason can be found, switch off the supply, then remove the associated motor connections. Switch on the supply. If the fault LED is now illuminated then the drive is at fault and should be returned for repair. It may be necessary to request motion in either direction to obtain the fault.

3. Loss of Incremental Encoder Signal

The LED will be illuminated if the signal from the incremental encoder is not present. The motor would run away out of control if this was not detected.

If previous tests have not enabled the fault to be isolated, then substitution of the drive should enable the fault to be narrowed down to one drive which can then be returned for repair.

Overtemperature LED

This LED indicates an overtemperature fault. It may be the result of a drive fault, which can of course be proven by substitution. If this does not identify the fault then checks should be made to ensure that the ambient temperature does not exceed 40°C, when all units in the vicinity of the drive have reached their normal operating temperature. A cooling fan may be necessary if high duty cycles are required.
If the LED comes on at power-up and cannot be reset, this indicates an excessive voltage drop in the feedback cable to the motor and may be due to over-long cables of inadequate size. Please refer to Appendix 1 for information on extending the motor cables.
The LED may also indicate motor overtemperature.

Power On LED

This LED indicates that the logic supplies are present. It will remain illuminated for a short time after the drive has been switched off, due to the stored charge in the capacitors.

Incorrect Operation

Noise from Motor or Unstable Motor Operation

This is usually caused by the Damping or Time Constant controls requiring adjustment. Re-adjustment of either of these two controls should cure this. If none of these checks has isolated the problem then substitution of the drive should be used to prove whether or not the drive module is at fault.

Motor Creep

This is usually caused by an incorrect setting of the Balance control, so first check this setting by confirming that there is zero velocity command on V1 and V2 inputs. Then adjust the Balance control until the motor shaft is stationary.

Ensure that all signals are supplied in twisted pairs or screened cables.

If none of these steps resolves the problem then, once again, try substitution of the drive module to prove if the drive is at fault.

Returning the System

Contact the Parker Automation Technology Centre or the machinery manufacturer who supplied the product. Equipment for repair should NOT be returned directly to Digiplan without prior authorisation. Repairs will be carried out by Digiplan but will be processed via your supplier.

Digiplan may at their discretion authorise direct shipment to and from Poole or Rohnert Park, but only by prior arrangement with your supplier. Existing UK and USA customers who purchase equipment directly from Digiplan should contact Poole or Rohnert Park for further information (contact numbers are at the front of this User Guide).

Appendix 1.

Fitting Longer Cables

When you order an ML motor, you can specify cable lengths up to 75 feet (22.5 metres). Whenever possible, it's better to order the motor with sufficient cable in the first place rather than try to extend it afterwards. If you need cables longer than 75 feet, you can make your own up to a maximum of 300 feet (90 metres) provided you follow the guidelines below.

Motor cables can be lengthened by simply replacing the cable with a longer one using the standard cable as a pattern. It needs to have 5 cores with an overall screen. Use 1 mm^2 (or 16 AWG) cores with a 2340 motor, and 1.5 mm^2 (or 14 AWG) with a 3450 or 3475.

The 1620 motor is pre-wired with 4-core cable, so it is only necessary to use 4-core screened cable when extending the lead.

Recommended Cable Sizes

Motor Frame Size	Motor Cable	
	<100ft	100-300ft
16	0.5mm^2 20 AWG 4-core	0.75mm^2 18 AWG 4-core
23	0.75mm^2 18 AWG 5-core	1mm^2 16 AWG 5-core
34	1mm^2 16 AWG 5-core	1.5mm^2 16 AWG 5-core

Table A-2. Motor Cable Sizes

Feedback Cables

The feedback cable may be extended up to a maximum of 50 feet (15 metres) using the same type of cable as that supplied with the motor. Each conductor in this cable is 0.2mm^2 (24 AWG). This type of cable is unsuitable for longer lengths owing to the voltage drop in the 5-volt supply to the encoder.

Encoder cables can be up to 300 feet long before any noise problem is encountered, but it's important to consider the voltage drop in the 5V supply leads to the encoder. If the voltage at the encoder is too low, it can cause curious problems such as continuous illumination of the overtemperature LED. The encoder must have a minimum supply voltage of 4.5 volts and it draws a current of about 300mA. Thus the total resistance of the 5V and 0V wires must be less than about 1.7 ohms. When you calculate this resistance, remember to multiply the resistance per metre (or per foot) by twice the cable length.

Probably the easiest way to lengthen the encoder cable is to cut the existing cable close to the motor and again close to the drive, and to insert a new length of the same type of cable using in-line connectors or terminal boxes. Suitable cable types are Cablemaster OS1024P and Belden 9510. Try to keep the two wires in any pair close to each other as they pass through the terminal box. Remember to connect the screen of the new section to the screens of the two short lengths of original cable.

Having done this, now locate the red and black pair (which carry 5V and 0V) and run two larger wires in parallel with this pair between the two terminal boxes. Each of these wires must have a resistance of less than 0.85 ohm. For example, use 1 mm^2 (or 16 AWG) cable for leads up to 150 feet (45m) long, and 2.5 mm^2 (or 14 AWG) cable for leads up to 300 feet (90m) long.

Inserting in-line connectors

It's sometimes necessary to be able to disconnect the motor easily, and a convenient solution is to fit in-line connectors. Generally the closer the connector is to the motor the better. Here are the part numbers for suitable MIL Spec connectors from Amphenol:

19-way Encoder Connectors	62GB-11F14-19PN	62GB-16F14-19SN
5-way Motor Connectors	62GB-11F14-05PN	62GB-16F14-05SN
8-way Motor Connectors	62GB-11F16-08PN	62GB-16F16-08SN

The connector shown above for the encoder cable has 19 pins; the 19th pin is used for the drain wire, i.e. the connection to the cable screen. If the connectors are within 500mm (18") of the motor, you can use a 5-way connector in the motor cable and leave the screen unconnected. In other cases, use the 8-way (which is a larger shell size) and use pin 6 to link the screens on either side of the connector. Don't connect the screen or drain wire to 0v.

Take great care to make sure that both connector halves are wired correctly, otherwise the encoder or drive may be damaged. If the encoder cable has 10 pairs, the red and blue pair should be connected in parallel with the red and black pair (i.e. red parallel with red, blue parallel with black).

Proprietary Cable Types

Motor Size	No. of cores	mm^2	ODmm	Lapp	Belden	Alpha
16	4	0.5	7.0	0034 604		
16	4	0.5	6.0			5464C
16	4	0.75	6.0		9418	
23	5	0.75	8.2	0034 705		
23	6	0.75	7.8			5386C
23/34	5	1.0	9.0	0034 805		
23/34	6	1.0	8.9			5366C
34	5	1.5	13.2			5450/5

Table A-3. Motor Cable Types

No. of cores	mm^2	ODmm	Lapp	Cable-master	Belden	Alpha	National
9 x 2	0.2	9.2		OS9P24	9509		
9 x 2	0.75	15.0				2249C	
10 x 2	0.2	9.4		OS10P24	9510		
10 x 2	0.25	10.1	0035805				
10 x 2	0.5	11.8					NQP-1020FSJ
12 x 2	0.75	16.8				2249/12C	
12 x 2	0.75	14.0					NQP-1218FSJ

Table A-4. Feedback Cable Types

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