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CE

# BLHX 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. Note that it may be necessary for the completed installation to comply with the Low Voltage Directive or the Machinery Directive. It is your responsibility as an installer 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.

The installation, set-up, test and maintenance procedures given in this User Guide should only be carried out by competent personnel trained in the installation of electronic equipment. Such personnel should be aware of the potential electrical and mechanical hazards associated with mains-powered motion control equipment - please see the safety warning below. The individual or group having overall responsibility for this equipment must ensure that operators are adequately trained.

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. If the equipment is used in any manner that does not conform to the instructions given in this User Guide, then the protection provided by the equipment may be impaired.

EMC INFORMATION

EMC Information is presented in boxed paragraphs (such as this one). Information in this User Guide consists of recommendations only; compliance is not guaranteed. BLHX drives are sold as complex components for use by professional system builders. They are not intended for sale to end users.

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Since Digiplan constantly strives to improve all of its products, we reserve the right to modify equipment and user guides without prior notice. No part of this user guide may be reproduced in any form without the prior consent of Digiplan.

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## User Guide Change Summary

This user guide, version 1600.224.01, is the first version of the BLHX Brushless Servo Drives User Guide. Previously, both the BLH and the BLHX drives were described in one user guide called: BLH/BLHX Brushless Servo Drives User Guide (part number 1600.188.03).

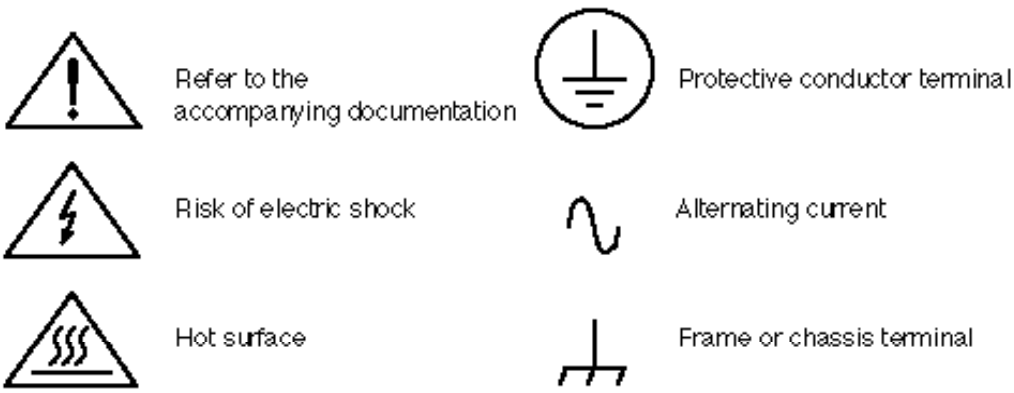
When a user guide is updated, the new or changed text is differentiated with a change bar in the outside margin (this paragraph is an example). If an entire section is changed, the change bar is located on the outside margin of the section title.

## Associated Documentation

This User Guide forms part of the documentation required to use the BLHX Series of brushless servo drives, it should be read in conjunction with the **X150/X150E Software Reference User Guide** (Part Number 1600.221.01) which provides details of individual commands.

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Warning symbols used on the BLHX series of drives have the following meanings:




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**Product Type:** **BLHX30, BLHX75, BLHX150**

**The above products are in compliance with the requirements of the following Directives, when installed in accordance with the instructions contained in this User Guide.**

- **73/23/EEC** **Low Voltage Directive**
- **93/68/EEC** **CE Marking Directive**

The BLHX Series of drives are sold as complex components to professional assemblers, as components they are not compliant with Electromagnetic Compatibility Directive 89/336/EEC. However, information is offered in this User Guide on how to install these drives in a manner most likely to minimise the effects of drive emissions and to maximise the immunity of drives from externally generated interference.

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# Section 1. INTRODUCTION

## Product Description

The BLHX 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 are supplied with an integral positioner which accepts motion control commands over an RS232C link. They are supplied as boxed units and power-plate technology makes them capable of delivering a continuous output power of 100W to 1.2kW. 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.

A choice of three current ratings are available:

| | |
|---|---|
| BLHX30 | 3.75A continuous (7.5A peak) |
| BLHX75 | 7.5A continuous (15A peak) |
| BLHX150 | 15A continuous (30A peak) |

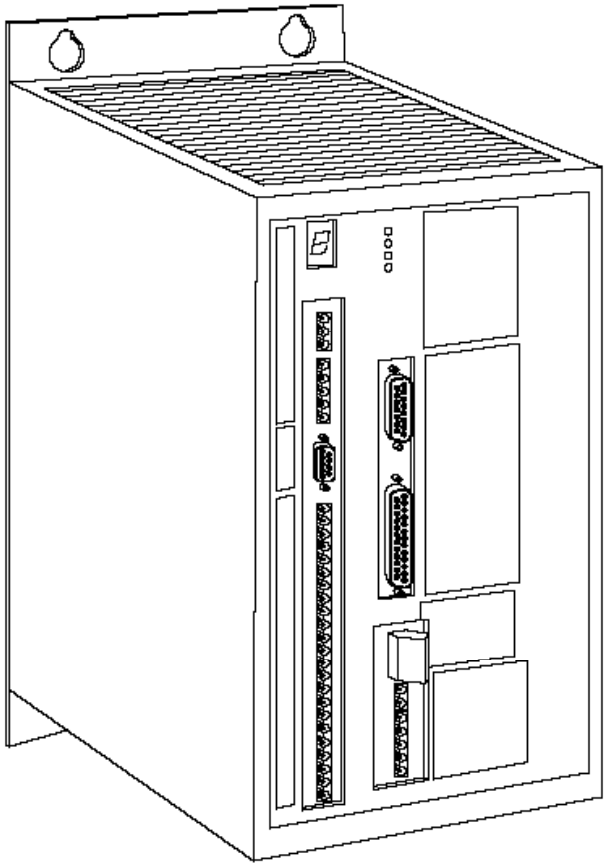


**Figure 1-1. BLHX Brushless Servo Drive**

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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 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

## Outputs and Inputs

Reset/Disable
Fault output
Incremental encoder outputs
Digital tachometer output

## Other Features

Power dump

# System Overview

The drive contains all the necessary circuitry to control a brushless DC servo motor. It must be used with a mains isolating transformer to generate a suitable AC supply voltage from the AC mains supply. It must not be connected directly on-line to the AC mains supply as this would damage the drive and is unsafe.

With the positioner 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.

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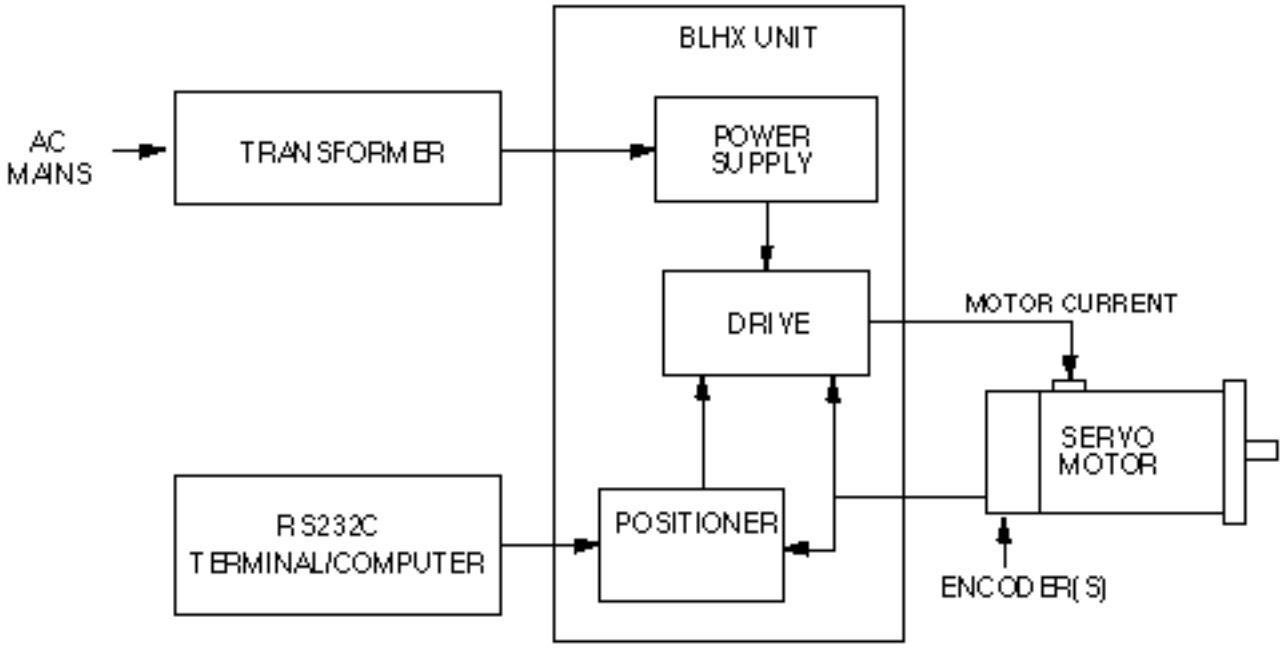



**Figure 1-2. Main Components of a BLHX Servo Control System**

# Controls and Indicators

## LEDs

### *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.

### *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.

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## Jumper Links

BLHX 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.

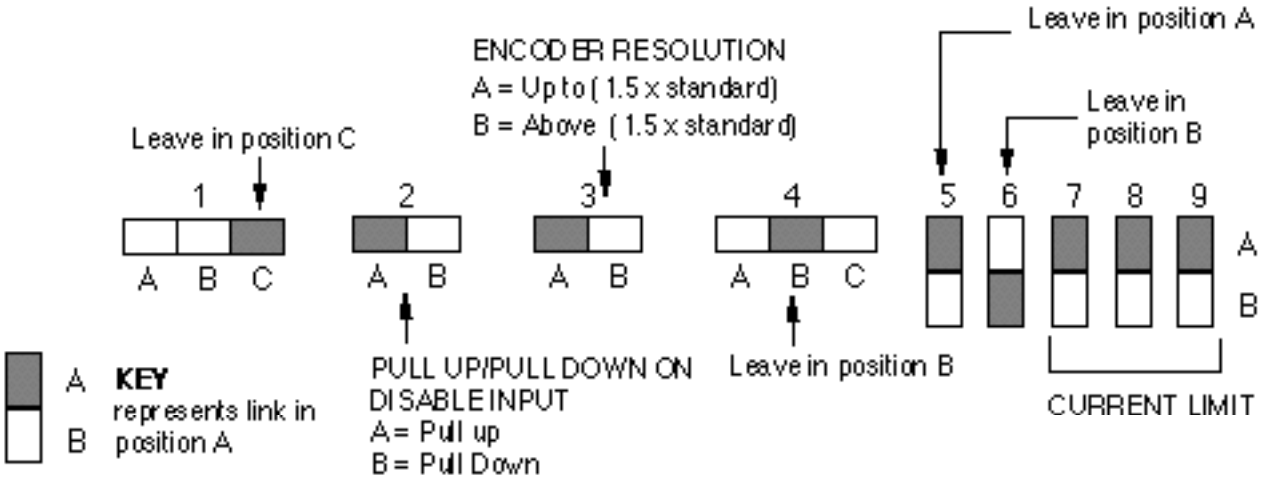



**Figure 1-3. Jumper Link Settings**

## Jumper/Link Settings

Factory default jumper/link settings are shown in Table 1-1.

| Factory Default Link Positions | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| BLHX | C | A | A | B | A | B | A | A | A |

**Table 1-1. Factory Default Jumper Link Positions**

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# Section 2. GETTING STARTED

## What You Should Have

Upon receipt, you should inspect your BLHX Drive 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 |
|---|---|
| BLHX Drive with integral positioner | BLHX30, BLHX75, BLHX150 |
| Optional Transformers:<br>Model TO92<br>Model TO170<br>Model TO171 | <br>2050.036.XX<br>2050.120.XX<br>2050.121.XX |
| BLHX User Guide | 1600.224.XX |
| X150/X150E Software Reference User Guide | 1600.221.XX |
| Motor Cables:<br>For ML2340 motor<br>For ML3450/ML3475 motor<br>For ML1620 | <br>23M-CABLE-XX*<br>34M-CABLE-XX*<br>Supplied with motor, fixed length of 10 feet (3.0m). |
| Encoder Cables<br>For ML23 & ML34 motors<br>For ML1620 | <br>MLEN-CABLE-XX*<br>Supplied with motor, fixed length of 10 feet (3.0m). |

* Length of cable specified in feet. Standard sizes are 10 (3.0m), 25 (7.6m), 50 (15m), 75 (22.8m)

**Table 2-1. BLHX 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 BLHX 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 Section 3, ***Installation***.

Figure 2-1 illustrates the pre-installation test configuration for a BLHX system. BLHX Series drives must be installed by competent personnel familiar with the installation, commissioning and operation of motion control equipment.

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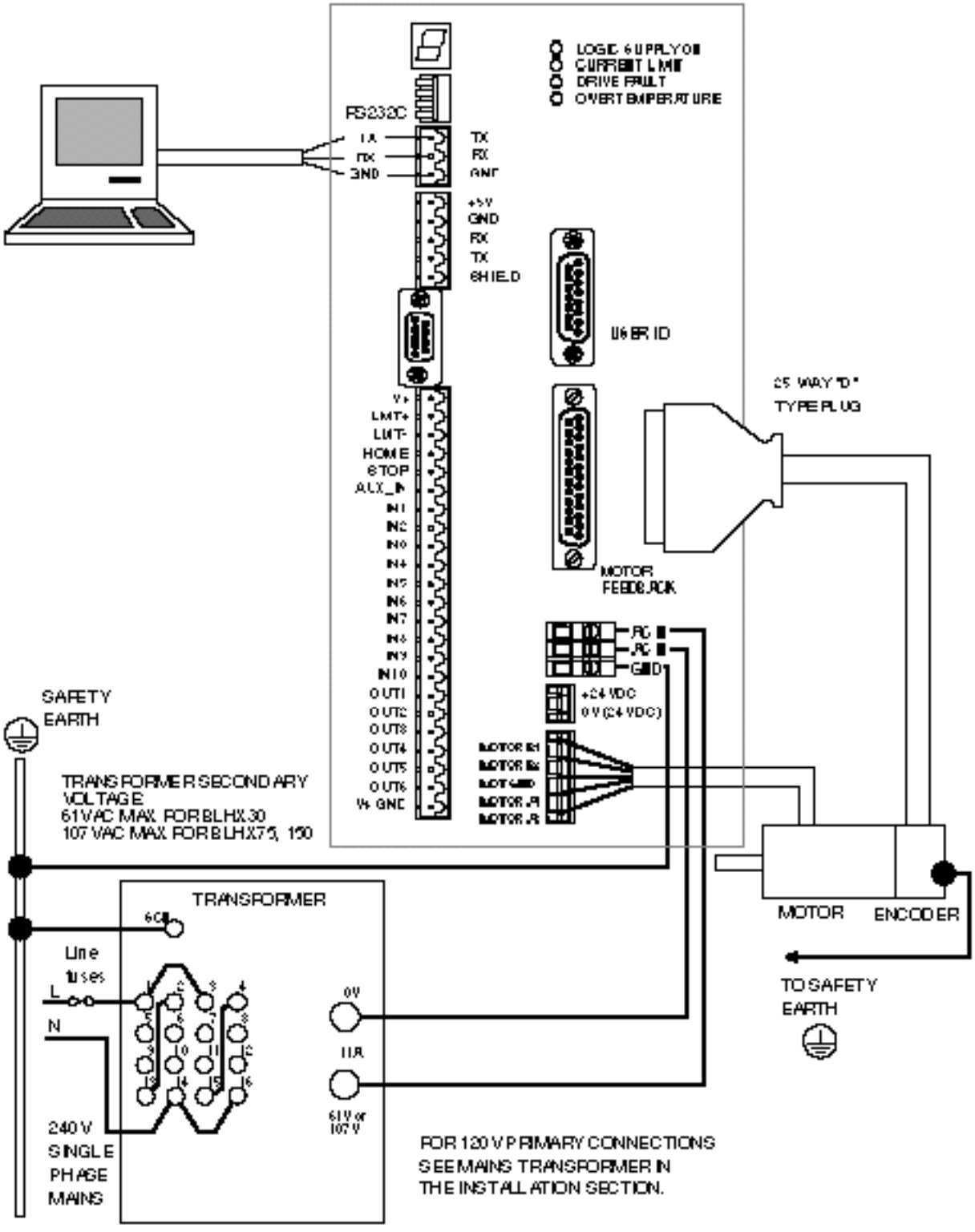



**Figure 2-1. Pre-installation Test Configuration**

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## RS232C Controller

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

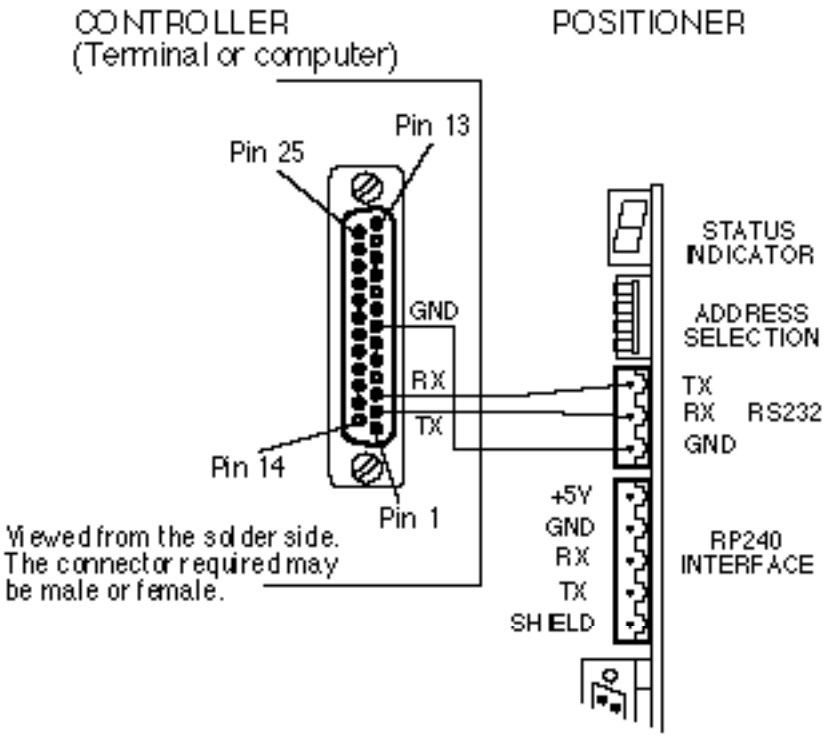



**Figure 2-2. Controller to Positioner RS232C Connections**

## Connect the Motor

**WARNING - danger of electric shock**

**Ensure that AC power is disconnected before attempting to connect or disconnect the motor. Hazardous 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 Section 3, ***Installation***.

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## 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 BLHX30, 6A @ 107V for the BLHX75 and 11A @ 107V for the BLHX150. You should install an in-line fuse suitably rated for the AC supply and the transformer loading in the live lead supplying the transformer primary (see Figure 2-1). Normally, the BLHX system is shipped with one of the Digiplan transformers: TO170, TO171 or TO92.

***Before* connecting the AC supply leads, measure the secondary voltage(s) from the isolating transformer. These should not exceed 61V AC for the BLHX30 or 107V AC for the BLHX75 or BLHX150 at the nominal AC input voltage.**

**WARNING - danger of electric shock**

**Mains voltages are dangerous. Ensure that all terminals are adequately insulated to prevent accidental contact.**

### *Connection Examples*

Figures 2-1 illustrates the connections required for the standard Digiplan transformers.

# Testing the BLHX System

1. Note: the drive potentiometers on BLHX drives are pre-set at the factory. No holes are provided for access.

2. If the drive has been supplied configured for a particular motor type, the drive jumper link settings need not be changed. Factory default settings can be used for performing the pre-installation test.

   Note: The BLHX is always supplied configured as a torque amplifier.

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 the stop input and isolated 24V.

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7. Type the following:

   **CPG5 CVG2 CFG0 CTG0 COFF0**

8. Type the following:

   **MC V1 A500 ON G**

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

10. Type **S OFF** to stop the motor and to disable the drive.

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# Section 3. INSTALLATION

## Section Objectives

The information in this Section 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

The BLHX drive can be installed in two ways:

- Normal installation
- EMC installation

The BLHX Series of drives are not EMC compliant, they are sold as a complex component for use by professional assemblers of motion control systems. Where a system is not required to conform with the European EMC directive the installation procedure described in this Section may be followed. Systems which are are to conform to the European EMC directive should be assembled using these procedures and additionally the EMC specific installation recommendations, described at the end of this Section. Digiplan cannot guarantee EMC compliance.

BLHX Series drives must be installed by competent personnel familiar with the installation, commissioning and operation of motion control equipment.

This section also covers mains transformer information.

### Environment

The operational temperature range for the drive system is 0°C to 50°C (32°F to 122°F) and at a relative humidity between 0 and 95% (non-condensing). Make sure the system is stored in temperatures within the range from -40°C to 85°C (-40°F to 185°F).

The mains input to the isolating transformer is Installation Category III maximum.

The BLHX Series of drives can be used in a Pollution Degree 2 environment i.e., one in which only non-conductive pollution occurs.

The drive system should be installed in an area where there is adequate ventilation above and below the packages. In some applications involving high duty cycles, ventilation fans may be required. In the final application the equipment must be enclosed to prevent the operator coming into contact with any high voltages. This includes the transformer, drive and motor terminations.

Metal equipment cabinets offer the most advantages for siting the equipment since they can provide operator protection, EMC screening and can be readily fitted with interlocks

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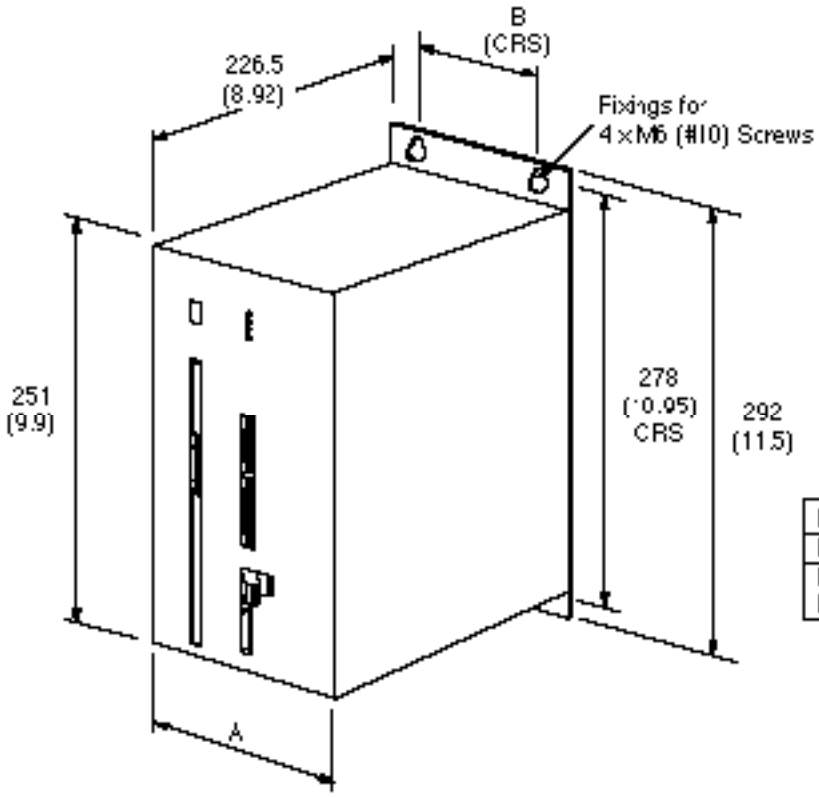
arranged to remove all AC power when the cabinet door is opened. This form of installation also allows the fitting of metal trays beneath the equipment to act as a flame barrier, which should be provided in the final installation, in accordance with LVD requirements.

## Mounting the Drive

All BLHX drives are supplied as packaged units. Figure 3-1 shows the mounting methods and overall dimensions.

### *Enclosure Considerations*

You should install the drive system in an enclosure to protect it against atmospheric contaminants such as oil, moisture, dirt etc. and also to prevent operator access. Ideally, you should install the system in a rack cabinet. In the USA, the National Electrical Manufacturers Association (NEMA) has established standards that define the degree of protection that electrical enclosures provide. The enclosure should conform to NEMA Type 12 standards if the intended environment is industrial and contains airborne contaminants. Proper layout of components is required to ensure sufficient cooling of equipment within the enclosure.




| Drive Type | A | B |
|---|---|---|
| BLHX30 | 112 (4.41) | 56.3 (2.22) |
| BLHX75<br>BLHX150 | 147.6 (5.81) | 92 (3.62) |

**Figure 3-1. Mounting the Drive**

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## Package Assembly

You can gain access to a drive or positioner card by removing the screws shown in Figure 3-2.

**WARNING**
**Ensure AC power is removed before removing any drive covers.**

Note: the position of screws will vary depending on the drive type.

To avoid frequent removal and replacement of panels, you should determine the necessary link connections by reference to ***Setting the Drive Jumper Links*** later in this Section. Link changes will not be necessary if a drive is used which has been pre-configured for a particular motor type.

**REMEMBER - SET LINKS BEFORE INSTALLATION.**

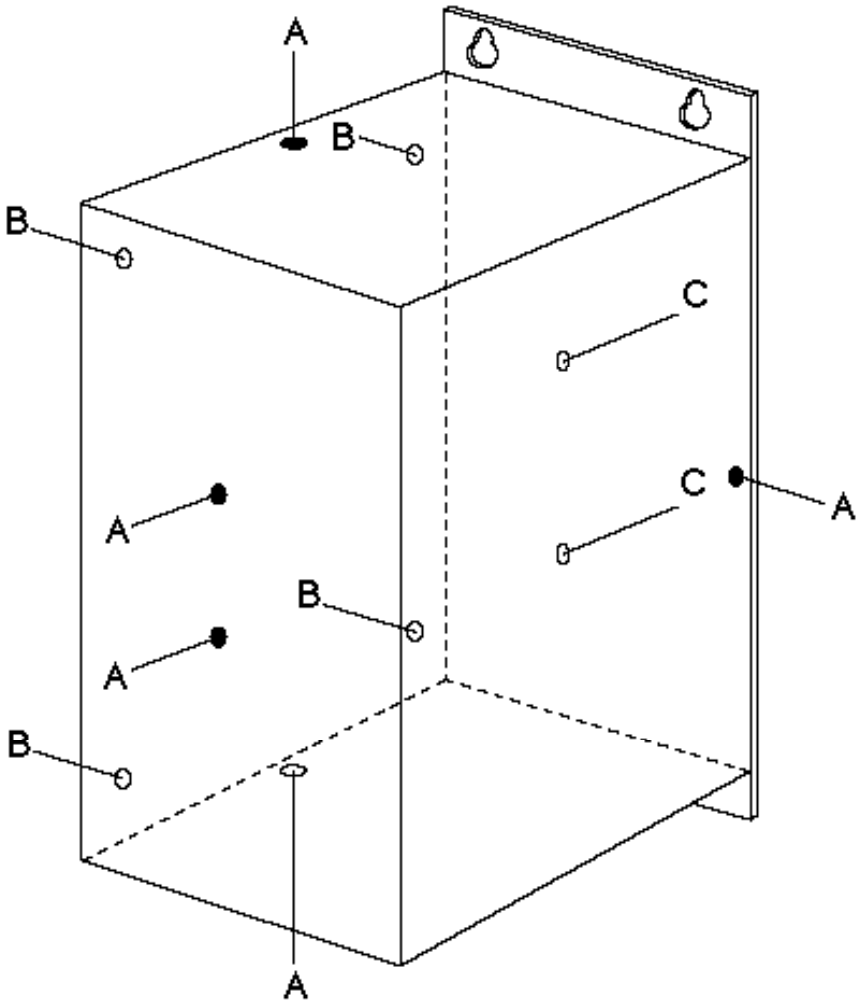



**Figure 3-2. Assembly Screw Locations**

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### *Screw Types*

Screw types A and B, shown in Figure 3-2, are all M3 round head, screw type C is M3 countersunk.

## Mains Transformer

This section describes the range of mains transformers suitable for use with BLHX 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 sub-section will show you how to do this.

For mains wiring use an approved mains cable of at least 0.75mm$^2$ CSA, taking care to keep all mains wiring away from all secondary and signal wiring. Ensure that the transformer terminations are suitably enclosed to prevent operator contact, either by fitting a suitable cover or enclosing the transformer within a housing. Note: If a low power secondary winding is used, e.g., 20V AC, it must be separately fused with an in-line fuse in the wire close to the transformer. The fuse value should be approximately twice the current rating of the secondary winding being used.

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

If an alternative transformer is used it must have an earthed screen between the primary and secondary windings. For safety reasons the insulation between the primary and secondary must be adequate. A minimum of 2300V AC withstand voltage between the primary and secondary is recommended.

| Type | DC Supply | VA Rating | Suitable Drive |
|---|---|---|---|
| Model TO92 | 85v | 700 | BLXH30 |
| Model TO170 | 150v | 1300 | BLHX75, BLHX150 |
| Model TO171 | 150v | 2500 | BLHX75, BLHX150 |

**Table 3-1. Optional Mains Transformers**

Figures 3-3 and 3-4 show the transformer connections when used with 240VAC mains supplies and 120VAC mains supplies respectively.

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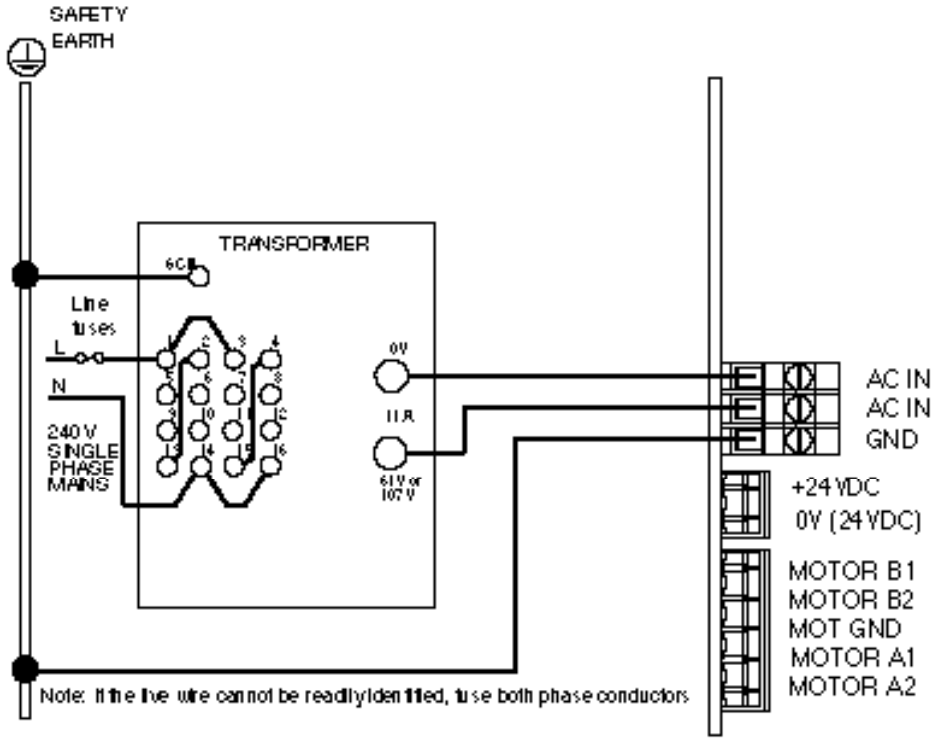



**Figure 3-3. 240VAC Connections**

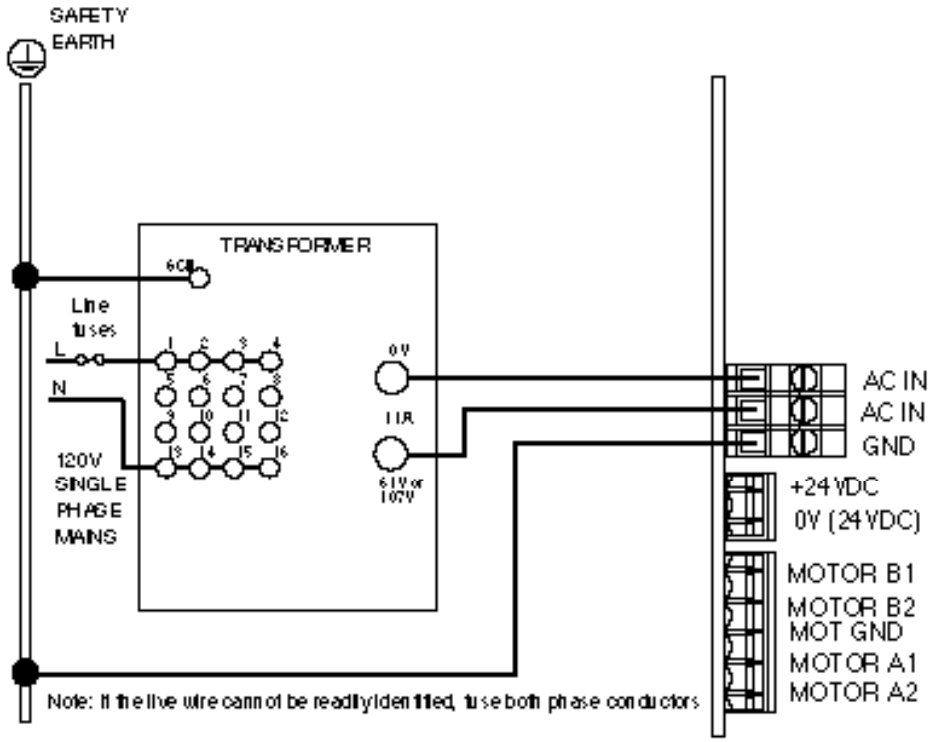



**Figure 3-4. 120VAC Connections**

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## 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:

$$\text{Fuse rating (A)} = \frac{\text{Transformer VA} \times 1.5}{\text{Supply volts}}$$

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 700VA transformer used with a supply of 240V will require a 4.4A fuse, consequently the next highest standard value of 5A will need to be selected.

## Disconnect Device

A disconnect device must be provided which isolates all mains supply current-carrying conductors. If the mains supply is permanently connected, a switch or circuit breaker must be included in the wiring. It must be placed close to the equipment (less than 1 metre) and marked as the disconnecting device for the equipment.

## 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 |
| 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**

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The mains earth must be connected to the transformer screen on terminal SCN.

## 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 impedance of each drive is closely matched by connecting each unit individually back to the transformer using equal lengths of wire. Do not 'daisy chain' drives by looping the AC input from one to the next.

Insulation rating of the secondary power connections should be at least 600V, where this is between power and signal circuits. Insulation requirements to mains wiring are higher.

## Motor

The motor body must be reliably earthed. The impedance to the earth star point should be less than 0.1Ω.

**WARNING - Hot surface**

**The case of a motor can become hot. Precautions may need to be taken to prevent operator contact.**

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## Drive Signal Connections

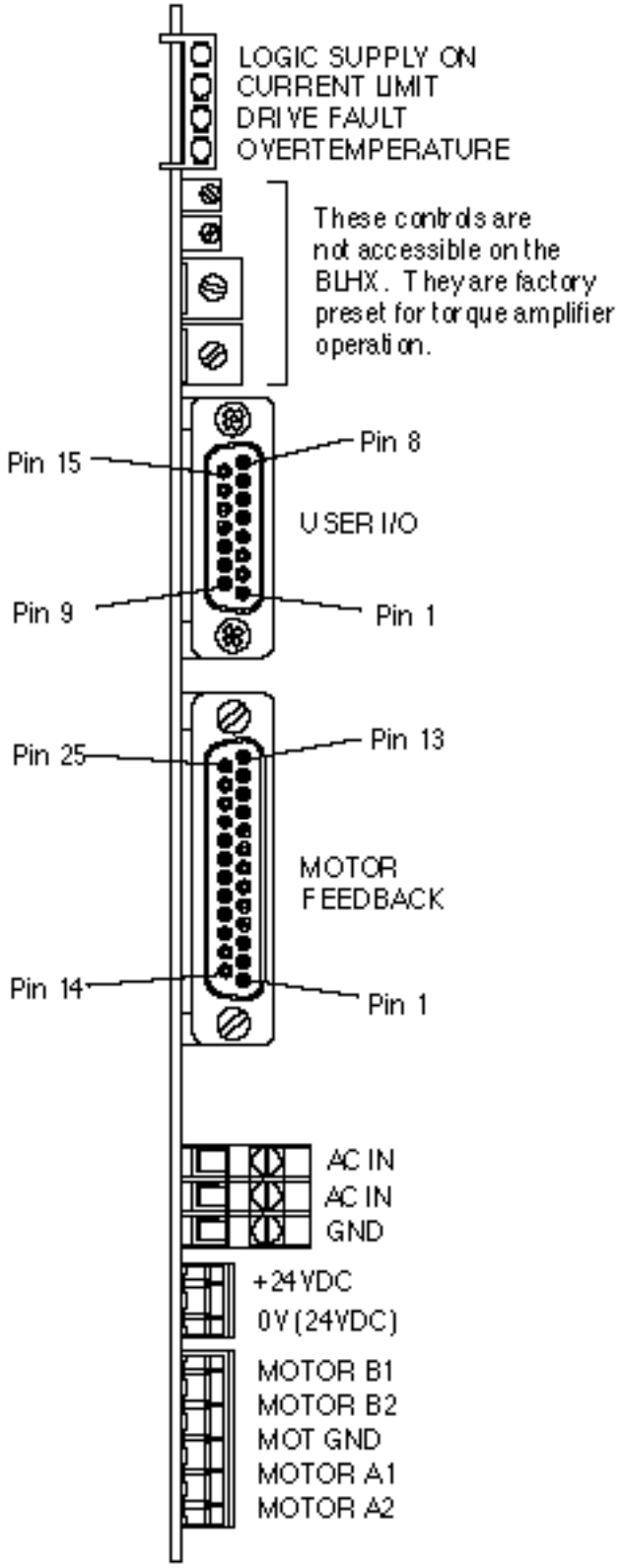



**Figure 3-5. Connectors and Indicators**

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## User I/O Connector Pin Functions

| Pin | Signal Name | Function | Signal Type |
|---|---|---|---|
| 1 | - | reserved | L |
| 2 | - | reserved | L |
| 3 | -15v | Reference voltage | O |
| 4 | GND | Ground | Q |
| 5 | $\overline{\text{RST}}$ | Reset/Disable | P |
| 6 | +15V | Reference voltage | O |
| 7 | Tach out | Digital tachometer output | R |
| 8 | Not used | | |
| 9 | $\overline{\text{FT}}$ | $\overline{\text{Fault}}$ | N |
| 10 | AOP * | A output from incremental encoder | M |
| 11 | $\overline{\text{AOP}}$ | $\overline{\text{A output}}$ | M |
| 12 | BOP * | B output from incremental encoder | M |
| 13 | $\overline{\text{BOP}}$ | $\overline{\text{B output}}$ | M |
| 14 | ZOP ** | Z output from incremental encoder | M |
| 15 | $\overline{\text{ZOP}}$ | $\overline{\text{Z output}}$ | M |

* 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 occurring when AOP and BOP are both high - see below;

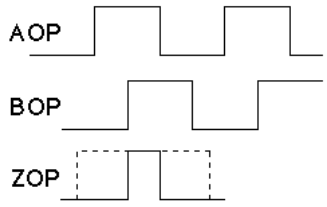



**Table 3-3. User I/O Connector Pin Functions**

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## ML23/34 Motor Connector Pin Functions

| Signal Name | Function | Signal Type | Lead Colour |
|---|---|---|---|
| Motor A1 | Motor phase A1 | I | White |
| Motor A2 | Motor phase A2 | I | Yellow |
| MOT GND | Motor ground | J | Green |
| Motor B1 | Motor phase B1 | I | Brown |
| Motor B2 | Motor phase B2 | I | Grey |

**Table 3-4. ML23/34 Motor Connector Pin Functions at the Drive End**

## ML1620 Motor Connector Pin Functions

| Signal Name | Function | Signal Type | Lead Colour |
|---|---|---|---|
| Motor A1 | Motor phase A1 | I | Red |
| Motor A2 | Motor phase A2 | I | Yellow |
| Motor B1 | Motor phase B1 | I | Brown |
| Motor B2 | Motor phase B2 | I | Orange |

**Table 3-5. ML1620 Motor Connector Pin Functions at the Drive End**

Note: The ML1620 motor should only be used with the BLHX30.

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## Motor Feedback Connector Pin Functions (25-way D-type)

| Pin Number | Function | Signal Type | Original Colours for Motor Connections | Latest Colours for Motor Connections |
|---|---|---|---|---|
| 1 | not used | | | |
| 2 | 0V | E twisted | black | black |
| 3 | +5V | D pair | red | red |
| 4 | NC | | | |
| 5 | NC | | | |
| 6 | *MOT | F twisted | red | grey |
| 7 | MOT | F pair | green | pink |
| 8 | Z- | C twisted | red | yellow/brown |
| 9 | Z+ | C pair | white | white/yellow |
| 10 | B- | C twisted | black | yellow |
| 11 | B+ | C pair | orange | green |
| 12 | A- | C twisted | black | white |
| 13 | A+ | C pair | brown | brown |
| 14 | NC | | | |
| 15 | 0V | E twisted | blue | blue |
| 16 | +5V | D pair | red | violet |
| 17 | NC | | | |
| 18 | *A3 | C twisted | black | red/blue |
| 19 | A3 | C pair | white | grey/pink |
| 20 | *A2 | C twisted | black | white/grey |
| 21 | A2 | C pair | green | grey/brown |
| 22 | *A1 | C twisted | black | white/pink |
| 23 | A1 | C pair | blue | pink/brown |
| 24 | *A0 | C twisted | black | white/green |
| 25 | A0 | C pair | yellow | brown/green |

*indicates the inverse of a signal

**Table 3-6. Motor Feedback Connector Pin Functions**

Note: Encoder cable wire colours have been changed. Each wire now (far right column) has an individual colour, avoiding the potential problem of incorrect wiring caused by multiple black wires. The wiring at the motor end depends upon the type of motor being used ( ML2340 or ML3450/ML3475). For more details of motor wiring see the Hardware Reference Section.

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### 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 | Mains earth safety connection | H |

**Table 3-7. 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 3-8. 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
**R** Analogue tachometer output

## Using an External +24V Supply

The BLHX drive has an on-board switch-mode power supply which also supplies the positioner. 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

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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.

### 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.
If you need to extend the feedback cable, use 20-way (10-pair) twisted-pair shielded cable such as Lapp 0035805, Cablemaster Type OS 10P 24 or Belden Type 9510. Where one lead of a twisted pair is black, take care to use the correct black lead at the other end. See ***Appendix B*** for more detailed information on extending 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. If a longer motor cable is required, remove the existing cable completely and replace it with 5-core shielded cable as follows:

1620 motor - 0.4mm$^2$ (20AWG)
2340 motor - 0.75mm$^2$ (18AWG)
3450 motor - 1.5mm$^2$ (14AWG)
3475 motor - 1.5mm$^2$ (14AWG)

Please consult Digiplan if you propose to extend the motor and feedback leads beyond 50 metres.

## Setting Up the Drive

### 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.

For the BLHX, normally only the peak current setting links 7-9 will need to be adjusted.

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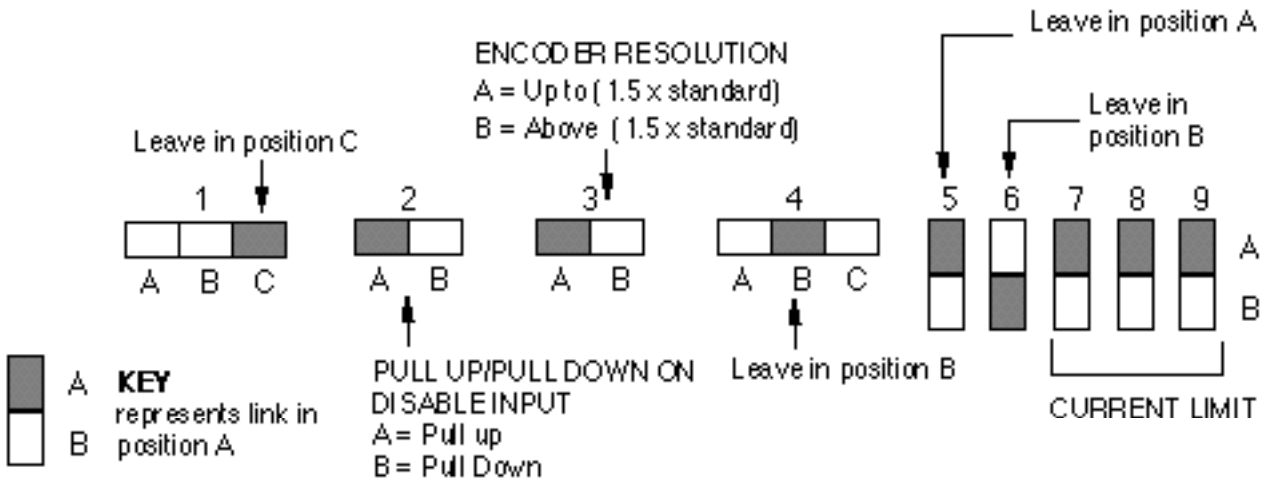



**Figure 3-6. Jumper Link Setting Schematic**

### *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.

The link is fitted in position A in the BLHX indexer drive.

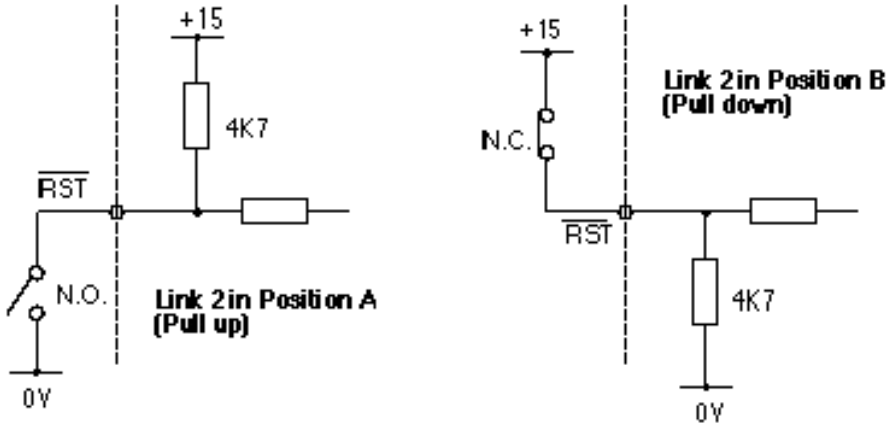



**Figure 3-7. Reset/Disable Input Circuit Options**

### *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.

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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 3-9 shows the Jumper link settings for various peak current levels.

| BLHX30 | BLHX75 | BLHX150 | 7 | 8 | 9 |
|---|---|---|---|---|---|
| 7.5A | 15A | 30A | B | B | B |
| 3.75A | 7.5A | 15A | B | B | A |
| 2.5A | 5A | 10A | B | A | B |
| 2A | 3.75A | 7.5A | B | A | A |
| 1.5A | 3A | 6A | A | B | B |
| 1.25A | 2.5A | 5A | A | B | A |
| 1A | 2A | 4A | A | A | B |

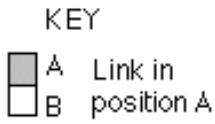



**Table 3-9. Current Limit Link Settings**

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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 | BLHX30 | | | BLHX75 | | | BLHX150 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | LK7 | LK8 | LK9 | LK7 | LK8 | LK9 | LK7 | LK8 | LK9 |
| ML1620 | 3.75A | B | B | A | - | - | - | - | - | - |
| ML2340 | 7.5A | B | B | B | B | B | A | B | A | A |
| ML3450 | 15A | - | - | - | B | B | B | B | B | A |
| ML3475 | 30A | - | - | - | B | B | B | B | B | B |
| Default | | A | A | A | A | A | A | A | A | A |

Table 3-10. 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. Also, if you make the motor go unstable during tuning, disable the drive immediately to prevent damage to the motor.

### *Tuning the BLHX Drive*

Please refer to the ***Servo Tuning*** section for this information.

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## EMC Installation

It should be stressed that although these recommendations are based on the expertise acquired during the development of fully compliant products, and on tests carried out on each of the product types, it is impossible for Digiplan to guarantee the compliance of any particular installation. This will be strongly influenced by the physical and electrical details of the installation and the performance of other system components. Nevertheless it is important to follow *all* the installation instructions if an adequate level of compliance is to be achieved.

### External enclosures

The measures described in these recommendations are primarily for the purpose of controlling conducted emissions. To control radiated emissions, all drives and rack systems must be installed in a steel equipment cabinet which will give adequate screening against radiated emissions. This external enclosure is also required for safety reasons. With the exception of drive front panels in rack-based units, there must be *no user access* while the equipment is operating. This is usually achieved by fitting an isolator switch to the door assembly. Packaged drives, transformers and filters must be mounted to a conductive panel. If this has a paint finish, it will be necessary to remove the paint in certain areas where specified.

To achieve adequate screening of radiated emissions, all panels of the enclosure must be bonded to a central earth point. The enclosure may also contain other equipment such as motion controllers, and the EMC requirements of these must be considered during installation. Always ensure that drives and rack systems are mounted in such a way that there is adequate ventilation.

Before mounting the drive, remove the paint from the rear face of the lower mounting lug as shown in Fig. 3-8 (if not already paint free), and if necessary from the corresponding area on the rear panel of the enclosure. This is to guarantee a good high-frequency low impedance connection between the drive case and the cabinet. Use petroleum jelly on the exposed metal to minimise the risk of future corrosion.

Where P-clips and mains filter modules are specified, they must achieve a good high frequency, low impedance, bond to the earth plane. The panels of the enclosure metalwork should also be bonded to the earth plane.

### AC Supply Filtering

These recommendations are based on the use of proprietary mains filter units which are readily available. However, the full EMC test includes a simulated lightning strike which will damage the filter unless adequate surge suppression devices are fitted. These are not normally incorporated into commercial filters since the lightning strike test can be destructive. This test is normally carried out on the overall system and not on individual components, therefore the surge protection should be provided at the system boundary.

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Try to arrange the layout of transformer and filter so that the AC input cable is kept away from the filter output leads. It is preferable for the current path to be as linear as possible without doubling back on itself - this can negate the effect of the filter. Mount the filter within 50mm of the transformer, and run the input cable and any earth cables close to the panel. See Figure 3-9.

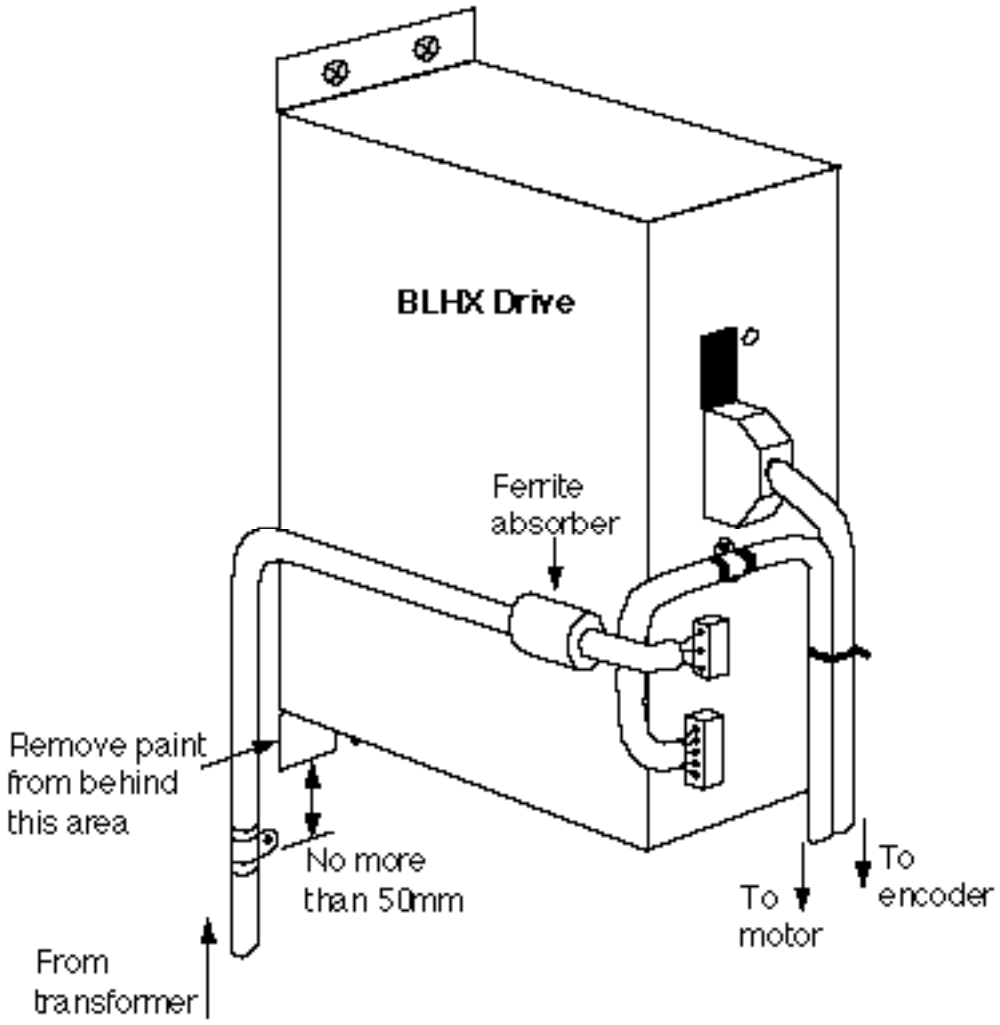



**Figure 3-8. EMC Drive Installation**

A filter must be installed between the incoming AC supply and the isolating transformer. A suitable filter is Corcom 10VV1. Mount the filter within 50mm of the transformer as shown in Fig. 3-9. Ensure that there is no paint on the mounting panel under the filter mounting lugs - it is vital that there is good large-area contact between the filter and the panel.

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Connect the incoming AC supply cable to the push-on terminals on the filter, with the earth lead connected to a local earth stud or bus bar. Route the supply cable so that it runs close to the walls of the enclosure. Connect the filter output terminals to the transformer primary, keeping the leads twisted together and as short as possible. Take an earth connection from the stud to the SCN terminal on the transformer, and run this lead close to the AC supply leads
(see Fig. 3-9).

3-core 1.5mm$^2$ screened cable (with a braided screen) should be used between the transformer and the input to the drive. Use two cores for the output from the secondary winding and the third core for an earth connection from the stud. Run this cable back towards the mounting panel, expose a short length of the screen and anchor the cable close to the filter with a P-clip. When routing this cable to the drive, keep it well away from the input cable to the filter.

At the drive end, fit a ferrite absorber over the cable and connect the three cores to the drive power connector. Locate the absorber as close as possible to the connector using heat-shrink sleeving. Run the cable back under the drive, expose a short length of the braided screen and anchor to the same mounting panel as the drive using a P-clip. Keep this anchor point close to the drive and if necessary remove any paint from the mounting panel under the clip.

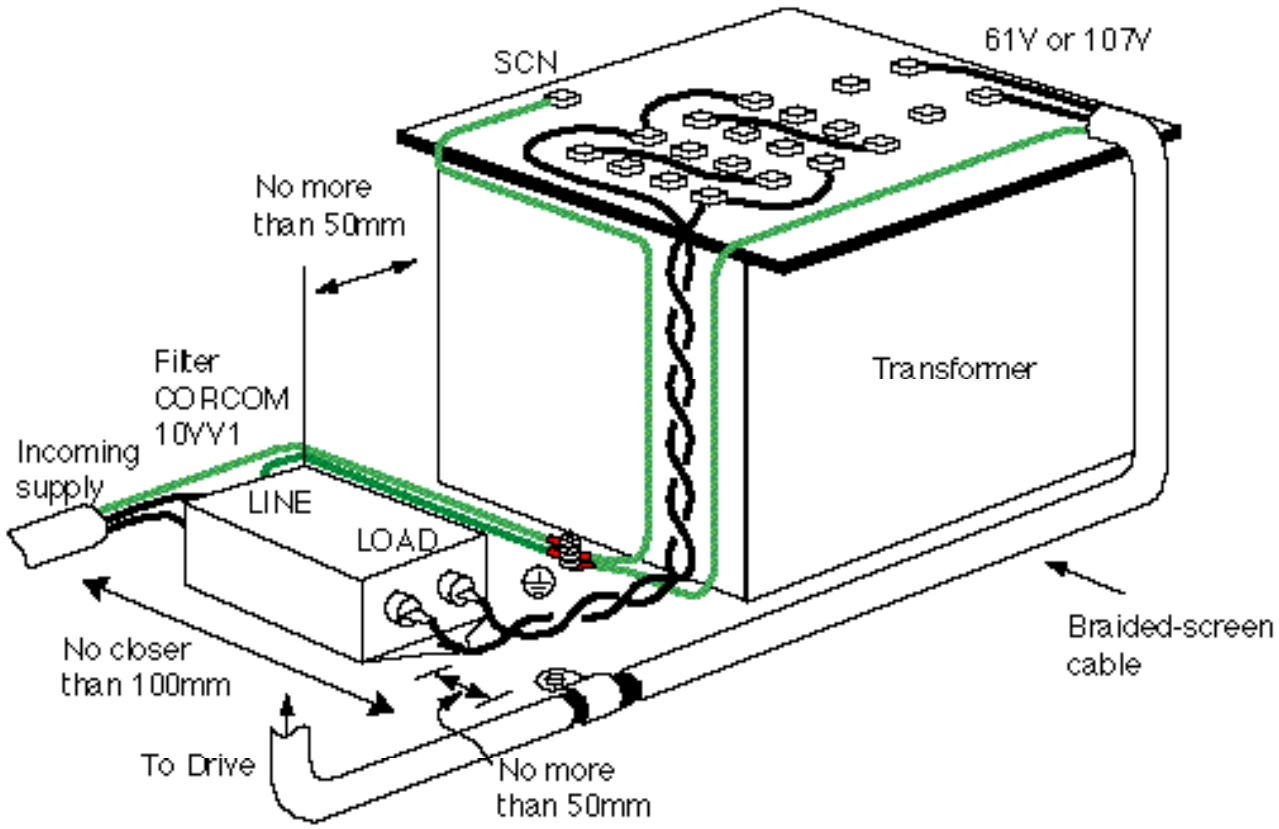



**Figure 3-9. EMC Transformer Installation**

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## Motor and Encoder Connections

ML Series motors are being modified to accommodate EMC installation (ML2340, 3450 and 3475). The modifications include changing the encoder cable to a braided-screen type and fitting different glands to the terminal housing. If it is necessary to adapt an existing motor, the encoder cable should be changed to a 10-pair braided screen type (Lapp Part No. 0035805) and the terminal box glands changed to suit.

The standard 5-core motor cable fitted to the ML motor is retained. Expose a short length of the braided screen approximately 100mm from the drive connector, and use a P-clip to anchor the cable under the lower front panel screw as shown in the diagram. Run the cable underneath the drive to the rear panel. Note that the motor cable should be kept at least 300mm away from I/O cables carrying control signals.

When routing the cables to the motor, make sure that the motor and encoder cables are kept close together throughout their whole length. Unless the cables are laid alongside each other in trunking, use cable ties every 500mm to anchor the two cables together.

## Ferrite absorber specifications

The absorbers described in these installation instructions are made from a low-grade ferrite material which has high losses at radio frequencies. They therefore act like a high impedance in this waveband.

The recommended components are produced by Parker Chomerics and are suitable for use with cable having an outside diameter up to 10mm. The specification is as follows:

| | |
|---|---|
| Chomerics part number | H8FE-1115-NC |
| Outside diameter | 17.5mm |
| Inside diameter | 10.7mm |
| Length | 28.5mm |
| Impedance at 25MHz | 80Ω |
| Impedance at 100MHz | 120Ω |
| Curie temperature | 130°C (the device should not be operated near this temperature) |

## Handling and installing the ferrite absorbers

Take care when handling the absorbers - they can shatter if dropped on a hard surface. For this reason the suggested method of installation is to use a short length of 19mm diameter heat-shrink sleeving. This gives a degree of physical protection while the cable is being installed. The sleeving should have a shrink ratio of at least 2.5:1. Cable ties may be used as an alternative, however they give no physical protection to the absorber.

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## Controller Interface

The X150 Controller interface connections are shown in Figure 3-10.

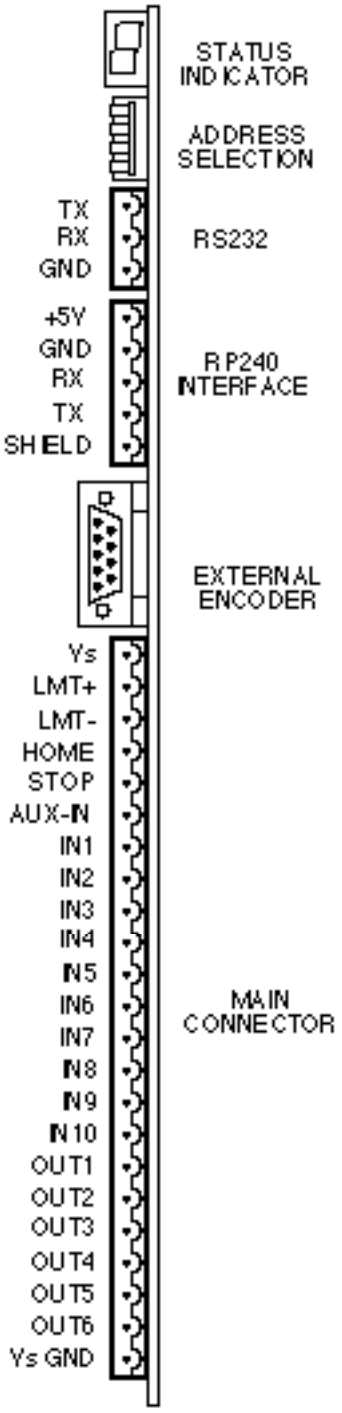



**Figure 3-10. Controller Interface Connections**

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| | Pin | Signal Name | Function | Signal Type |
|---|---|---|---|---|
| **EXTERNAL ENCODER** | 1 | A+/CLK+ | Secondary Encoder | C |
| | 2 | A-/CLK- | | |
| | 3 | B+/DIR+ | Secondary Encoder | C |
| | 4 | B-/DIR- | | |
| | 5 | Z+ | Encoder Z channel | C |
| | 6 | Z- | | |
| | 7 | 5V ENC. | Encoder supply | D |
| | 8 | GND | Encoder GND | D |
| | 9 | GND | Encoder GND | D |
| **RS232** | 1 | TX | Transmit | E |
| | 2 | RX | Receive | E |
| | 3 | GND | Signal GND. | I |
| **RP240 INTERFACE** | 1 | +5V | RP240 Supply | G |
| | 2 | GND | Signal GND | I |
| | 3 | RX | RP240 Receive | F |
| | 4 | TX | RP240 Transmit | F |
| | 5 | SHIELD | Shield | I |
| **MAIN CONN.** | 1 | Vs | +24/5V (100mA) | DC OUTPUT |
| | 2 | LMT+ | +Limit Switch Input | A |
| | 3 | LMT- | -Limit Switch Input | A |
| | 4 | HOME | Home Switch Input | A |
| | 5 | STOP | Stop Input | A |
| | 6 | AUX-IN | Registration Input | A |
| | 7 | IN1 | User Input 1 | A |
| | 8 | IN2 | User Input 2 | A |
| | 9 | IN3 | User Input 3 | A |
| | 10 | IN4 | User Input 4 | A |
| | 11 | IN5 | User Input 5 | A |
| | 12 | IN6 | User Input 6 | A |
| | 13 | IN7 | User Input 7 | A |
| | 14 | IN8 | User Input 8 | A |
| | 15 | IN9 | User Input 9 | A |
| | 16 | IN10 | User Input 10 | A |
| | 17 | OUT1 | User Output 1 | B |
| | 18 | OUT2 | User Output 2 | B |
| | 19 | OUT3 | User Output 3 | B |
| | 20 | OUT4 | User Output 4 | B |
| | 21 | OUT5 | User Output 5 | B |
| | 22 | OUT6 | User Output 6 | B |
| | 23 | Vs GND | 24/5V GND | DC GND RET. |

**Table 3-11. Controller Signal Types**

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## Signal Types

Signal Types identified by letters A, B, C, D, E, F, G and I in Table 3-11 are defined below.

### *Input Circuit Conventions*

Inputs may be configured to be active high or active low.
An active high input has a pull-down resistor inside the controller, and must be connected to Vs to turn the input ON, i.e. make the input active. Alternatively, the input may be turned on by connecting it to an external +5V or +24V supply.
An active low input has a pull-up resistor to Vs inside the controller, and must be connected to 0V to make the input active.

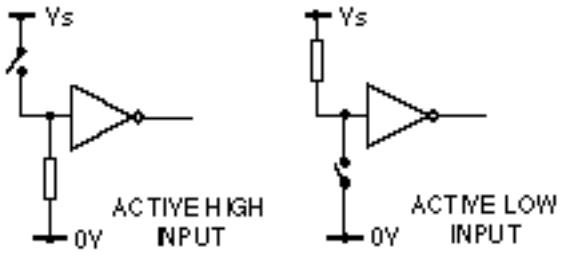



**Figure 3-11. Input Circuit Configurations**

In either case, the input is OFF (i.e. inactive) when in the open circuit condition. This condition is described as the logic 0 state and will return a '0' in response to the input status request IS.

### *Signal Type A*

Apply to all dedicated and user definable inputs. Signal type A inputs can be operated at 5V or 24V and can be configured for operation as active high or active low inputs - all determined by link settings. The input circuit for "A inputs" is shown in Figure 3-12.

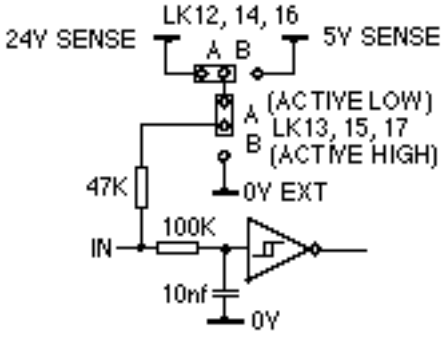



**Figure 3-12. Signal Type A Input Circuit**

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Table 3-12 defines the required link settings for 5V and 24V operation and the different input characteristics between the two settings

| | 5V Operation | | 24v Operation | |
|---|---|---|---|---|
| **Link Settings** K12, 14, 16 | B | | A | |
| **Input Characteristics** | Active high | Active low | Active high | Active low |
| Logic 1 level (Input ON) | >3.0v | <2.5v | >9.0v | <5.7v |
| Logic 0 level (Input OFF) | <2.5v | >3.0v | <5.7v | >9.0v |
| Hysteresis | 0.5v | 0.5v | 3.3v | 3.3v |
| Max. input voltage range | 0-30v | 0-30v | 0-30v | 0-30v |

**Table 3-12. 5V and 24V Operation for Signal Type A Inputs**

Signal type A inputs may be configured active low or active high depending upon the settings of links LK13, 15, 17 (see Table 3-13).

| | Inputs active Low | Inputs active High |
|---|---|---|
| **Link Settings** K13, 15, 17 | A | B |

**Table 3-13. Signal Type A Polarity Link Settings**

### *Signal Type B*

Signal type B outputs are defined at the time of purchase by the type of output board specified, either NPN or PNP. The circuit of each board type is shown in Figure 3-13.

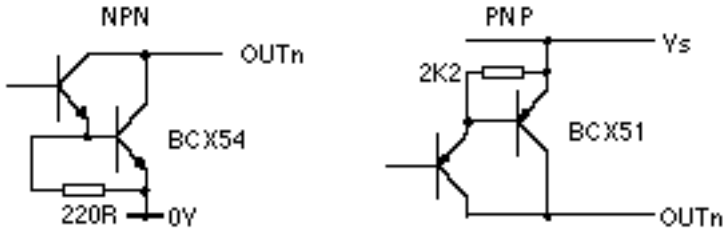



**Figure 3-13. NPN and PNP Output Boards**

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The part numbers and characteristics of each board type are listed in Table 3-14.

| | NPN | PNP |
|---|---|---|
| **Part Numbers** | 1369.947 | 1369.946 |
| **Output Characteristics** | | |
| Circuit configuration | Common emitter | Common emitter |
| Output current max. | 300mA at 1V | 100mA at ($V_S$-2)V |
| Max. OFF signal voltage | 30V | 30V |
| Mode | Current sinking | Current sourcing |

**Table 3-14. Signal Type B Output Board Characteristics**

### *Signal Type C*

Signal type C inputs are used for differential, optically isolated, encoder TTL level inputs. The maximum frequency handled by these inputs is 100KHz.

### *Signal Type D*

Encoder supply of +5V DC at 250mA.

### *Signal Type E*

RS232 data signals.

### *Signal Type F*

RP240 RS232 data signals.

### *Signal Type G*

RP240 +5V DC supply.

### *Signal Type I*

Signal ground.

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## Signal Connections

### In Position Output

User outputs can be configured as in position outputs using the OUTnT command.

For example:

Output 2 is used as an in position indicator. Vs is set to 24V (LK1 in position A) and an NPN output module is used. The LED will be illuminated when the motor position is inside the dead band window defined by CEW for the time specified by CIT. The LED will be off when outside the dead band window.

1OUT2T Set output 2 as in position output.

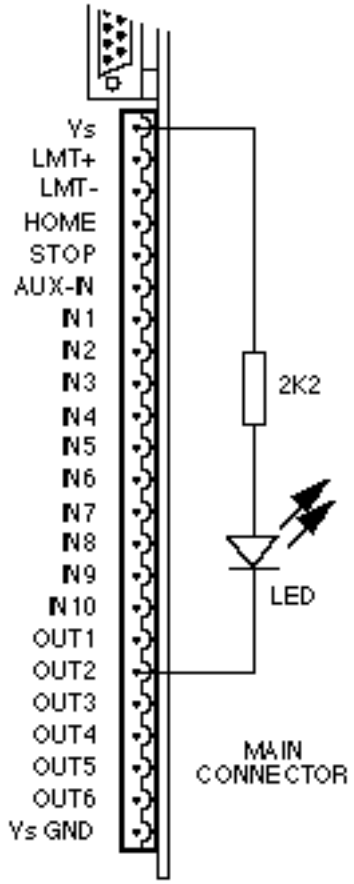



**Figure 3-14. In Position Indicator Connections**

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## Jog Inputs

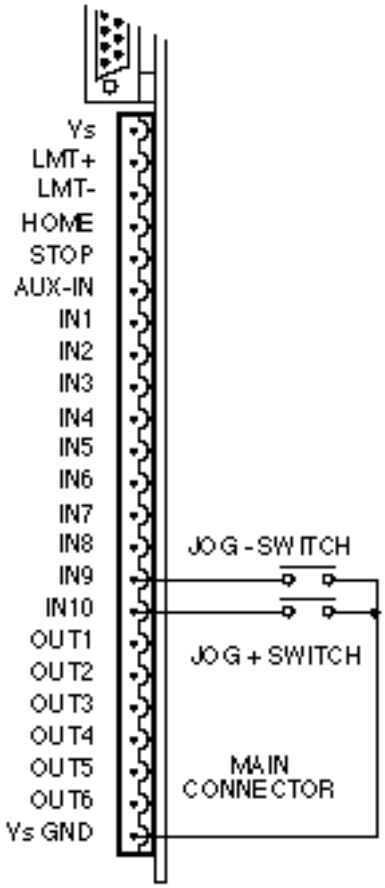



**Figure 3-15. JOG Switch Connections**

### *Jog Input Example*

Using the connections shown in Figure 3-15, INPUT 9 is CCW jog input and INPUT 10 is CW jog input. These inputs are configured to be active low, i.e. LK17=A

| Command | Description |
|---|---|
| **1OSE1** | Enable jogging |
| **1IN9K** | Set input 9 as CCW jog |
| **1IN10J** | Set input 10 as CW jog |
| **1JV10** | Set jog velocity to 10 rps |
| **1JA2** | Set jog acceleration to 2 $rps^2$ |

When either input 9 or input 10 is taken to 0V the motor will jog at 10 rps in the corresponding direction.

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## Jumper Link and Connector Layout

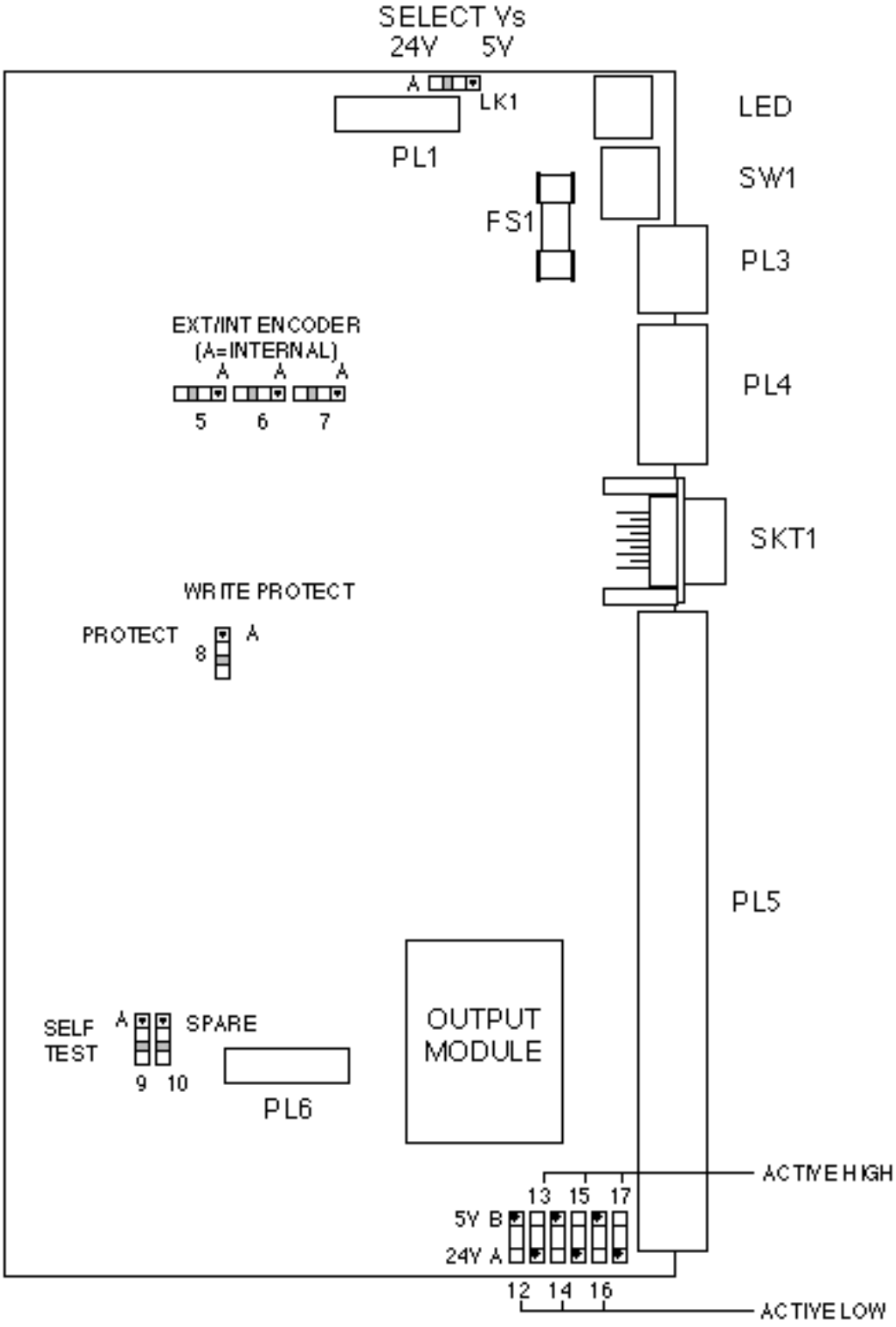



**Figure 3-16. Connector and Link Positions**

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## Jumper Links

Jumper links are used to configure the Controller for a particular application, or for use with other motion control equipment. **You must remove power before making any jumper link changes.** Table 3-15 identifies the use of each jumper link.

| Position | | Jumper Link Number (LK) | Function |
|---|---|---|---|
| A | B | | |
| 24V | 5V | 1 | 5V or 24V selection for Vs |
| INT | EXT | 5 | Internal/External encoder channel Z |
| INT | EXT | 6 | Internal/External encoder channel A |
| INT | EXT | 7 | Internal/External encoder channel B |
| Protect | - | 8 | Write enable |
| Self Test | - | 9 | Self test |
| - | - | 10 | Spare |
| 24V | 5V | 12 | Bank (1) 5V or 24V operation |
| Active Low | Active High | 13 | Bank (1) active high or active low |
| 24V | 5V | 14 | Bank (2)5V or 24V operation |
| Active Low | Active High | 15 | Bank (2) active high or active low |
| 24V | 5V | 16 | Bank (3) 5V or 24V operation |
| Active Low | Active High | 17 | Bank (3) active high or active low |

**Table 3-15. Jumper Link Functions**

### *Input Banks*

The inputs are configured in 3 banks of 5 inputs.

| BANK 1 | BANK 2 | BANK 3 |
|---|---|---|
| LMT+ | IN1 | IN6 |
| LMT- | IN2 | IN7 |
| HOME | IN3 | IN8 |
| STOP | IN4 | IN9 |
| AUX_IN | IN5 | IN10 |

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## Thumbwheel Interface

This section assumes that you are using Parker's TM8 thumbwheel module.

You can use up to 16 digits of the thumbwheel. The controller uses a multiplexed BCD input scheme to read the thumbwheel data. The commands and format that allow for the thumbwheel data entry are :

| | |
|---|---|
| DRDxyz | Read distance via thumbwheel. |
| VRDxyz | Read velocity via thumbwheel. |
| LRDxyz | Read loop count via thumbwheel. |
| TRDxyz | Read time delay via thumbwheel. |
| VARDn,xyz | Read variables via thumbwheel. |
| XRDxyz | Read sequence count via thumbwheel. |
| FRDxyz | Read following ratio via thumbwheel. |

To request 1 digit x=y=the desired digit number.

To request all digits x=0 and y=7 (or do not set xyz fields).

To request a block of digits 0<x<y<7.

The Z field scales the thumbwheel value by 10. When reading digits from the thumbwheel, the least significant digit will be filled first. The z field allows you to position the decimal point were needed.

Note : Either all the fields (xy and z) or none of the fields must be used. Refer to the software section for further explanation.

### *Using the TM8*

**Caution - possibility of equipment damage**

**THE TM8 REQUIRES A 5V SUPPLY. LINK 1 MUST BE IN POSITION B OTHERWISE DAMAGE WILL OCCUR.**

1. Ensure that the controller is fitted with an NPN output stage.
2. Set link 1 to position B. (5V DC operation).
3. You can define any block of 5 inputs for use with the thumbwheel. Therefore you must decide which inputs you intend to use for data (4 inputs required) and sign bit (1 input required).
4. Once you have decided upon the block of inputs, configure the appropriate sense link(s) 12,14,16 to position B. (5V sense level).
5. As with point 4 set the appropriate polarity link(s) 13,15,17 to position A (Active low).
6. Configure the defined inputs for TM8 operation using the INnN command.
7. Configure the defined input for the TM8 sign bit using INnW command.
8. Define appropriate outputs for TM8 operation using the OUTnJ command.

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The TM8 is now ready for operation.

Example:
The TM8 is wired as shown in Figure 3-17.

Inputs 6 to 9 are to be used as data inputs.
Input 10 is to be used as a sign input.
Outputs 3 to 5 are to be used as strobe outputs.

Set up as follows:

1. Set link 1 to position B. Vs is now 5V.

2. Set link 16 to position B. Sensing levels are 5V.

3. Set link 17 to position A. The inputs are active low.

4. Set 1IN6NInput 6 is defined as data input.
   1IN7NInput 7 is defined as data input.
   1IN8NInput 8 is defined as data input.
   1IN9NInput 9 is defined as data input.
   1IN10W Input 10 is defined as sign bit.

5. Set 1OUT3J Output 3 is defined as data strobe.
   1OUT4J Output 4 is defined as data strobe.
   1OUT5J Output 5 is defined as data strobe.

The thumbwheel is now ready for use. Set the thumbwheel to the desired value and enter the information using one of the data entry commands.

For example set the thumbwheel to +12345678

| Command | Description |
|---|---|
| **DRD** | Request distance data from all TM8 digits |
| **1D** | Display the distance read (D+12345678). If you do not receive this response, return to step 1 and retry |

For further information relating to Data entry commands refer to the ***X150/X150E Software Reference User Guide***.

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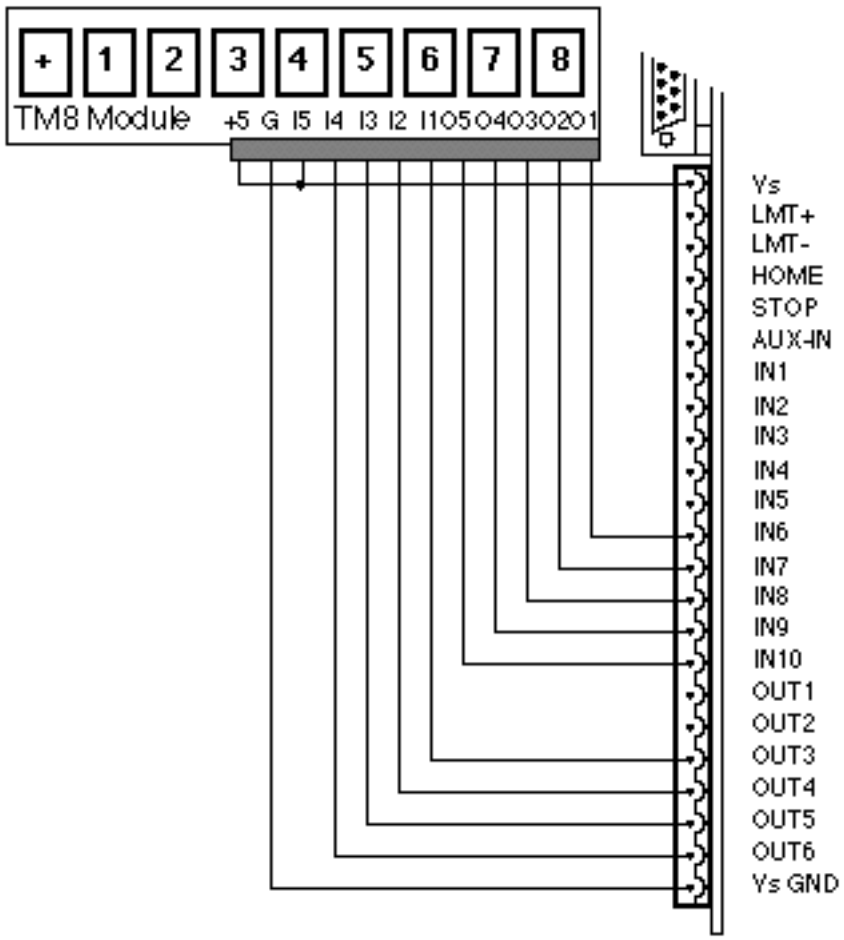



**Figure 3-17. Connections to TM8 Thumbwheel Module**

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### *Using two TM8 Thumbwheels*

Wire the TM8s as shown in Figure 3-18.

Configure as previously described.

Output 6 is used to select which thumbwheel is to be read.

SET 1OUT6A Programmable output.

Enter the following commands.

| Command | Description |
|---|---|
| **OXXXXX0** | Output 6 is low TM8 module #1 is disabled, TM8 module #2 is enabled. |
| **DRD** | Request distance data from thumbwheel #2. |
| **1D** | Display the distance read. |
| **OXXXXX1** | Output 6 is high TM8 module #1 is enabled, TM8 module #2 is disabled. |

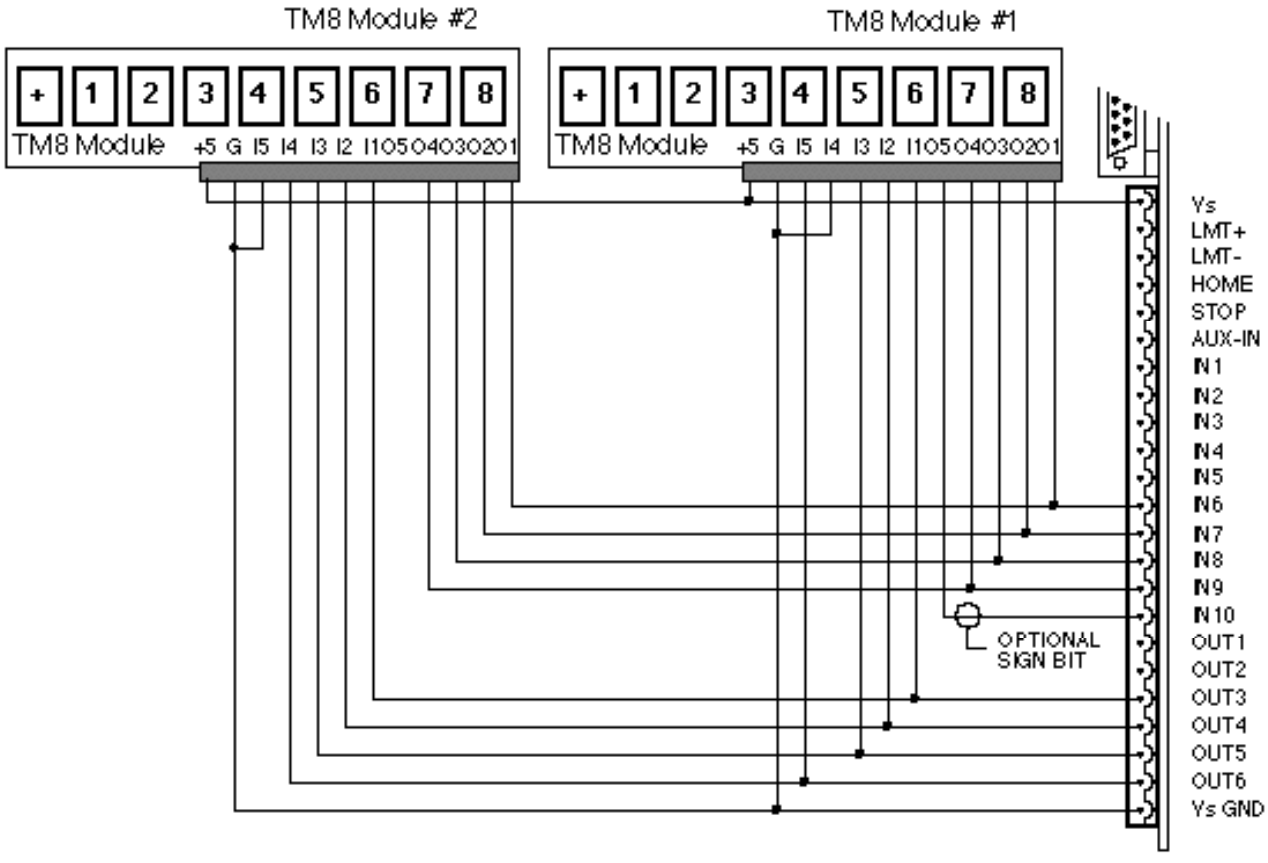



**Figure 3-18. Connections to Dual TM8 Thumbwheel Modules**

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## RP240 Connections

The Controller may be connected to the RP240 Operator Panel using the connections shown in Figure 3-19. You need to use 20 AWG 4-wire shielded cable with a maximum length of 15 metres (50 feet).

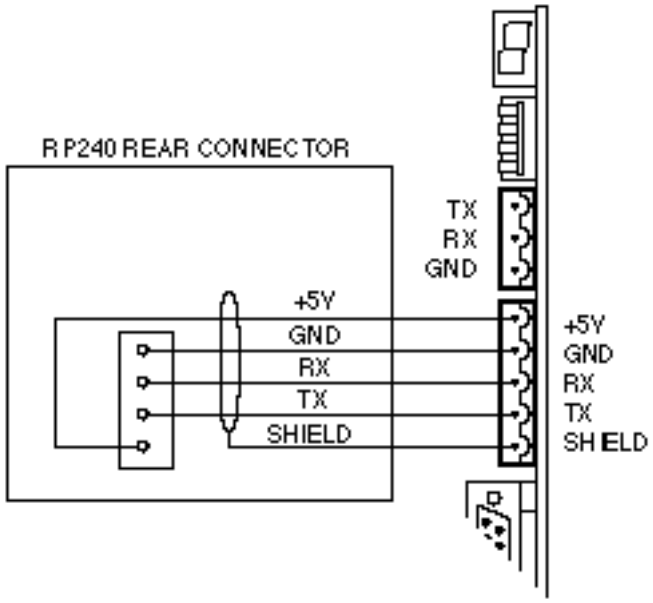



**Figure 3-19. Connections to RP240 Operator Panel**

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# Section 4. HARDWARE REFERENCE

## BLHX Drive Specification

| | BLHX30 | BLHX75 | BLHX150 |
|---|---|---|---|
| Continuous Current | 3.75A | 7.5A | 15A |
| Peak current | 7.5A | 15A | 30A |
| DC bus Voltage | 85V | 150V | 150V |
| AC Input Voltage: Nom.<br>Max.<br>Min. | 61V<br>67V<br>24V | 107V<br>118V<br>48V | 107V<br>118V<br>48V |
| Weights kg (lb) | 3.8 (8.4) | 4.8 (10.6) | 6.0 (13.2) |
| Motor Options | ML-1620, ML-2340 | ML-2340, ML-3450, | ML-3450, ML-3475 |
| Power input | Isolated AC direct from mains transformer | | |
| Frequency | 47-63 Hz | | |
| 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 | | |
| Continuous input power (typ.) | 2.5A @ 61V | 6A @ 107V | 11A @ 107V |
| Max. input power (peak only) | 7A @ 61V | 14A @ 107V | 28A @ 107V |
| Torque amp gain | 0.75AV | 1.5AV | 3AV |
| 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 pull-up, current limit, encoder res. | | |
| 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) | | |

**Table 4-1. BLH Servo Drives Specification**

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## Controller Specification

| Parameter | Value |
|---|---|
| Command Input | RS232C |
| Type | 3-wire (Tx, Rx, Gnd). Minimum voltage swing = ±3V |
| Parameters | 9600 baud, 8 data bits, 1 stop bit, no parity |
| Connector | Removable screw terminals |
| Configuration | Up to 16 interfaces can be controlled from a single RS232C port. Device address set up by DIL switch |
| **Operating Ranges** | |
| Position | ±1 to 268,435,455 steps |
| Velocity | 0.0001 to 200 revs/sec |
| Acceleration | 0.06 to 999,999 revs/sec$^2$ |
| Maximum Encoder Frequency | 100 kHz (lines/sec before multiplication) |
| **Resolution Ranges** | |
| Feedback encoder | 1 to 32,767 counts/rev |
| User-programmed | 1 to 32,767 steps/rev |
| Co-ordinate System | Incremental or absolute |
| Operating Modes | Preset, preset with speed change, continuous, registration, electronic gearbox following, preset following |
| Controller Loop Update | Every 2 milliseconds |
| **Motion Program Storage** | |
| Memory Type | Battery-backed RAM |
| Memory Capacity | 8000 characters total |
| Number of Programs | 64 |
| Program Length | Variable up to memory limit |
| Program Selection | a) Via RS232C<br>b) Automatic execution at power up<br>c) Binary address on sequence select inputs<br>d) RP240<br>e) Thumbwheel (TM8)<br>f) PLC |
| **Digital Servo Loop** | |
| Update Time | 500 microseconds |
| Servo Tuning | RS232C. Values stored in battery-backed RAM. Servo self-tuning facility. |
| Tuning Parameters | PIVF or PID options with digital filter |
| Opto-isolated I/P's | Home, Limits, Aux-in, Stop, 10 user-definable inputs (also used for program selection) |
| Optically-isolated O/P's | 6 programmable |
| **Fuse** | |
| FS1 | 160mA QA External supply protection |

**Table 4-2. Controller Specification**

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## Brushless Motor/Drive Packages

The BLHX 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 4-3.

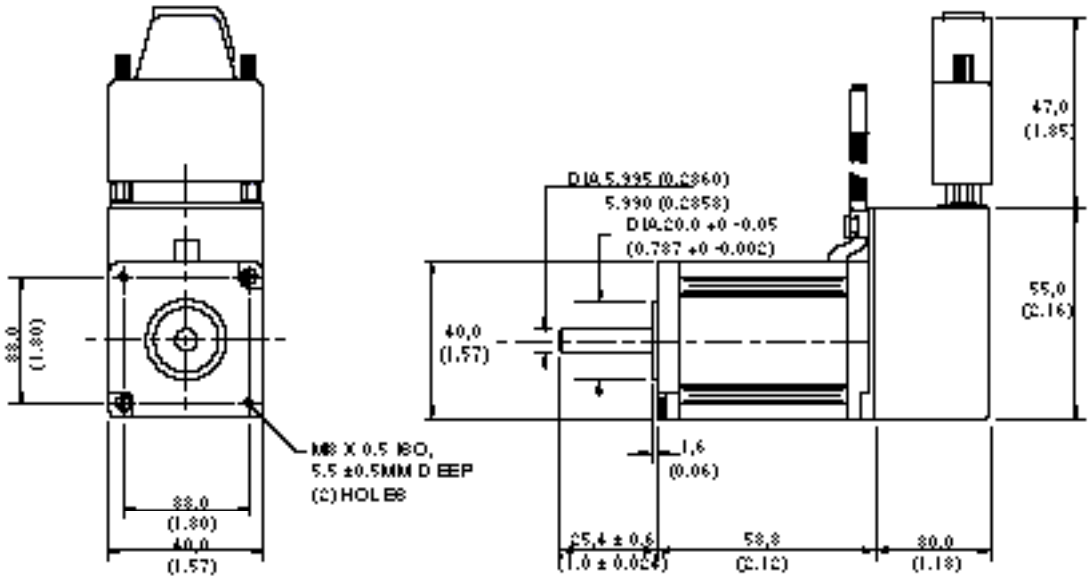



**Figure 4-1. Motor Type ML-1620 Dimensions**

Note: ML-1620 should only be used with the BLHX30 drive.

**CAUTION - high temperatures**

**The motor case will exceed 85°C before the motor overtemperature trip operates.**

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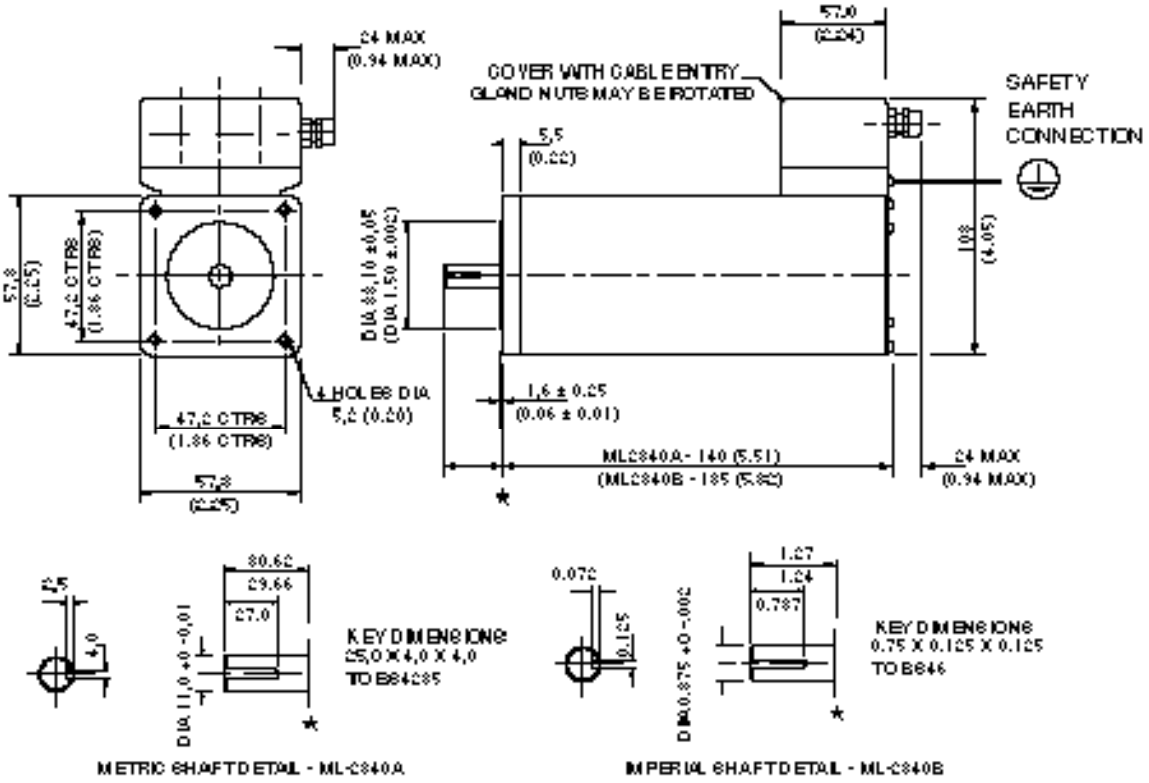



**Figure 4-2. Motor Type ML-2340 Dimensions**

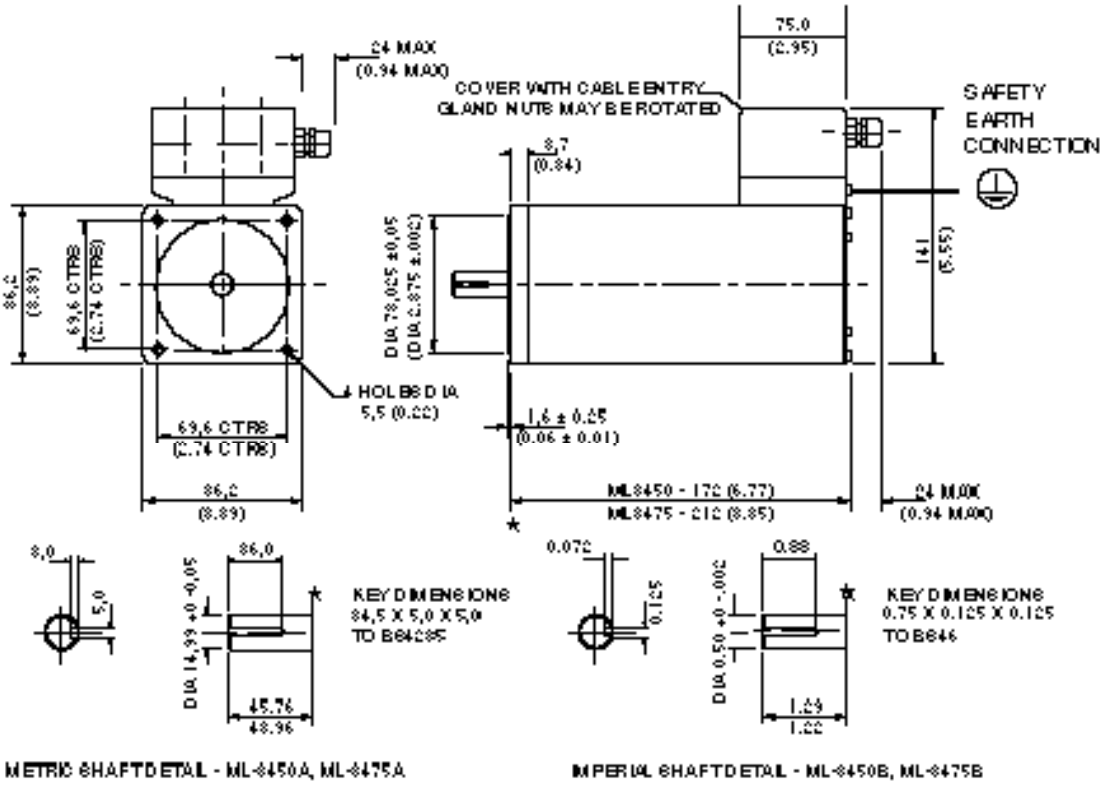


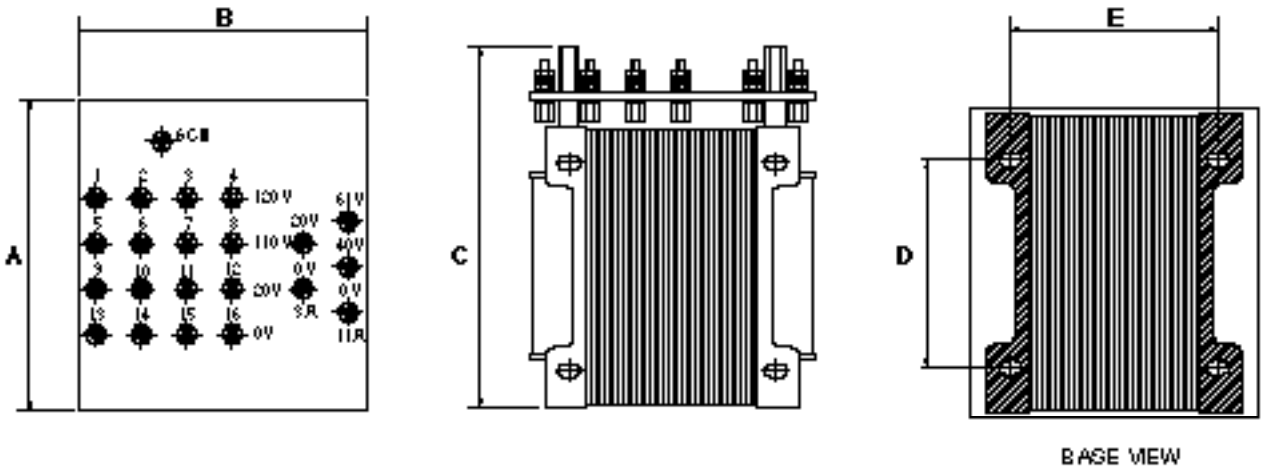

**Figure 4-3. Motor Type ML-3450 & ML-3475 Dimensions**

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### *Safety Earth*

Impedance to main earth star point should be less than 0.1Ω. Use a ring terminal secured directly to the motor body (at the motor's safety earth connection). Note: do not place any form of washer between the ring terminal and the motor body - the connection must be direct.

## 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)**

**CAUTION**

**Take particular care when lifting larger transformers. Do not lift by the terminal plate or cover, as these could break.**

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## Motor/Drive Package Performance Data

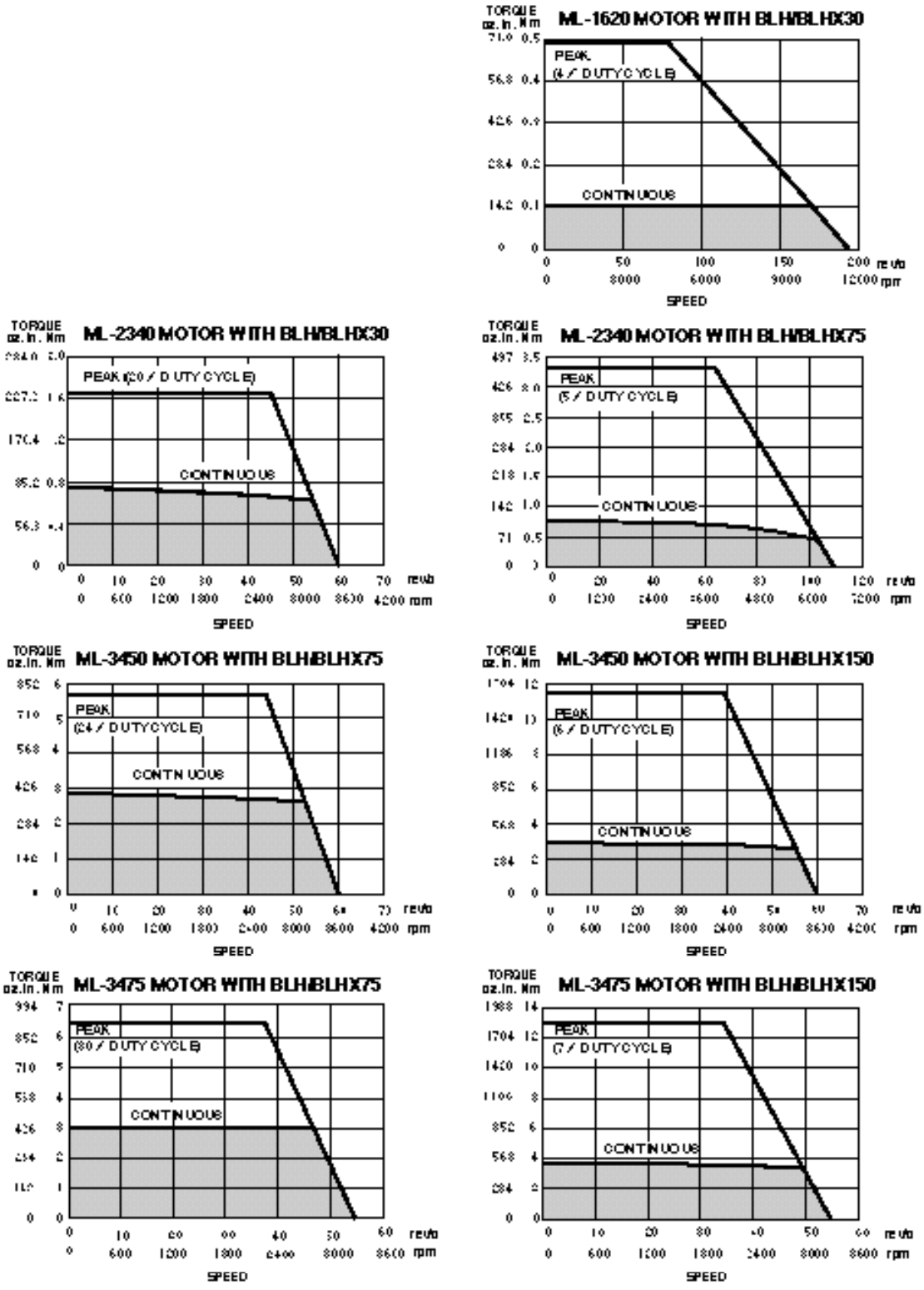



**Figure 4-5. Motor/Drive Packages Torque Curves**

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## Fuse Ratings

BLHX drive board has 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** | **BLHX30** | **BLHX75** | **BLHX150** |
| 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. BLHX Drive Board Fuse Ratings**

### *Controller Board Fuse*

The controller board contains one fuse for external supply protection.

| Fuse No. | Circuit | Type | Rating |
|---|---|---|---|
| FS1 | Ext. supply | 20mm QA | 160mA |

**Table 4-5. BLHX Controller Board Fuse Rating**

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## Motor Wiring

Earlier versions of motors were wired as shown in Figure 4-6.

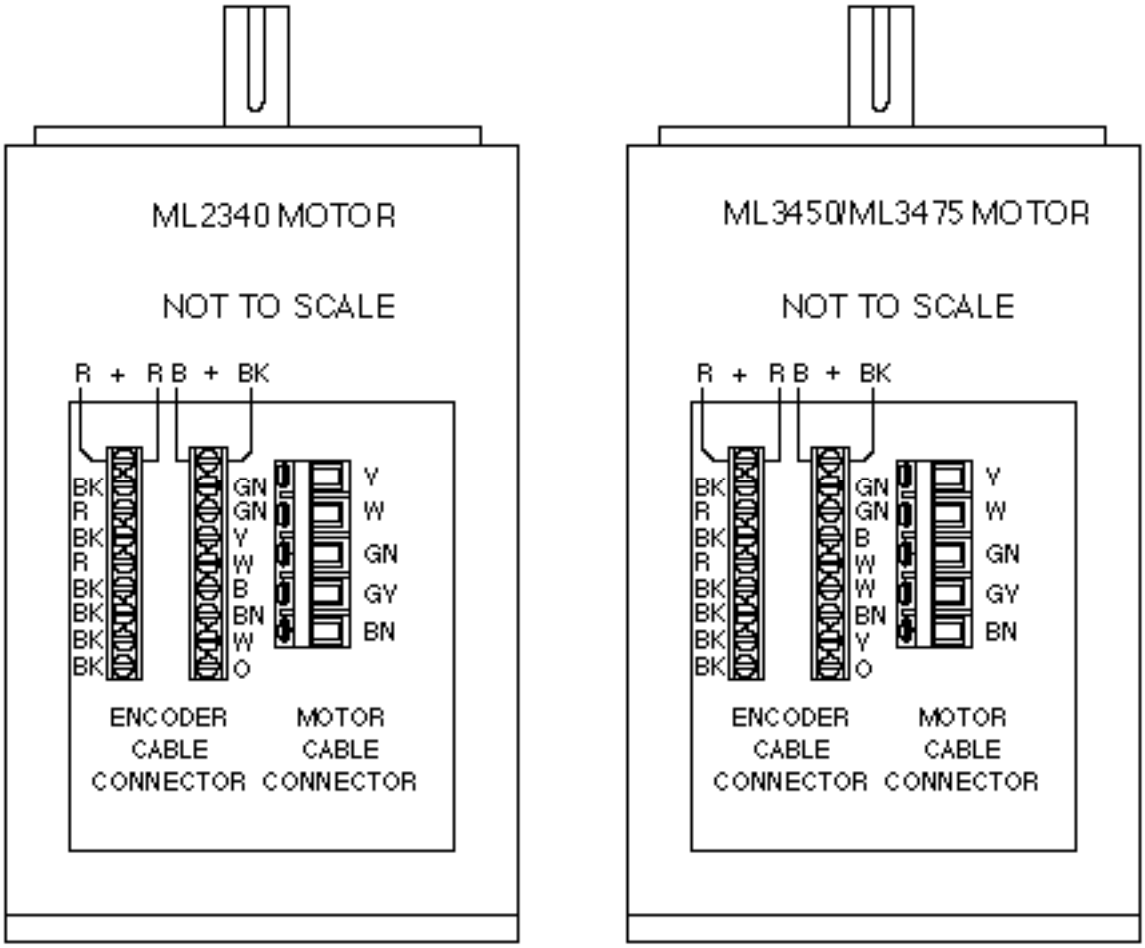



**Figure 4-6. Motor and Encoder Connections at the Motor**

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### *ML Motor PCB*

Later versions of the ML motors will have a silkscreen PCB as shown in Figure 4-7. Refer to Tables 4-6 and 4-7 which detail the encoder wiring required for the ML2340 and ML3450/ML3475 motor types fitted with the PCB.

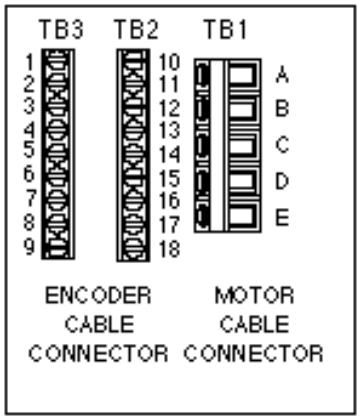



**Figure 4-7. Motor PCB Silkscreen**

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## ML2340 Encoder Connections

| Motor connector number (TB3 & TB2) | Motor feedback connector number (25-way D-type) | Original colours for ML2340 | New colours for ML2340 |
|---|---|---|---|
| 1 | 3 & 16 (+5V) | red + red | red + violet |
| 2 | 20 (*A2) | black | white/grey |
| & 11 | 21 (A2) | green | grey/brown |
| 3 | 6 (*MOT) | red | grey |
| & 12 | 7 (MOT) | green | pink |
| 4 | 24 (*A0) | black | white/green |
| & 13 | 25 (A0) | yellow | brown/green |
| 5 | 8 (Z-) | red | yellow/brown |
| & 14 | 9 (Z+) | white | white/yellow |
| 6 | 22 (*A1) | black | white/pink |
| & 15 | 23 (A1) | blue | pink/brown |
| 7 | 12 (A-) | black | white |
| & 16 | 13 (A+) | brown | brown |
| 8 | 18 (*A3) | black | red/blue |
| & 17 | 19 (A3) | white | grey/pink |
| 9 | 10 (B-) | black | yellow |
| & 18 | 11 (B+) | orange | green |
| 10 | 2 & 15 (0V) | black + blue | black + blue |

* indicates the inverse of the signal.

**Table 4-6. ML2340 Motor Encoder/Drive Connections**

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## ML3450/ML3475 Encoder Connections

| Motor connector number (TB3 & TB2) | Motor feedback connector number (25-way D-type) | Original colours for ML3450 & ML3475 | New colours for ML3450 & ML3475 |
|---|---|---|---|
| 1 | 3 & 16 (+5V) | red + red | red + violet |
| 2 | 20 (*A2) | black | white/grey |
| & 11 | 21 (A2) | green | grey/brown |
| 3 | 6 (*MOT) | red | grey |
| & 12 | 7 (MOT) | green | pink |
| 4 | 22 (*A1) | black | white/pink |
| & 13 | 23 (A1) | blue | pink/brown |
| 5 | 8 (Z-) | red | yellow/brown |
| & 14 | 9 (Z+) | white | white/yellow |
| 6 | 18 (*A3) | black | red/blue |
| & 15 | 19 (A3) | white | grey/pink |
| 7 | 12 (A-) | black | white |
| & 16 | 13 (A+) | brown | brown |
| 8 | 24 (*A0) | black | white/green |
| & 17 | 25 (A0) | yellow | brown/green |
| 9 | 10 (B-) | black | yellow |
| & 18 | 11 (B+) | orange | green |
| 10 | 2 & 15 (0V) | black + blue | blue + black |

* indicates the inverse of the signal.

**Table 4-7. ML3450/ML3475 Motor Encoder/Drive Connections**

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## ML1620 Encoder Connections

Figure 4-8 shows the ML1620 encoder connections at the drive and motor end of the multi-way cable. If you need to re-make this cable to allow routing through panels etc. the drive end connector should be removed in preference to the motor end connector.

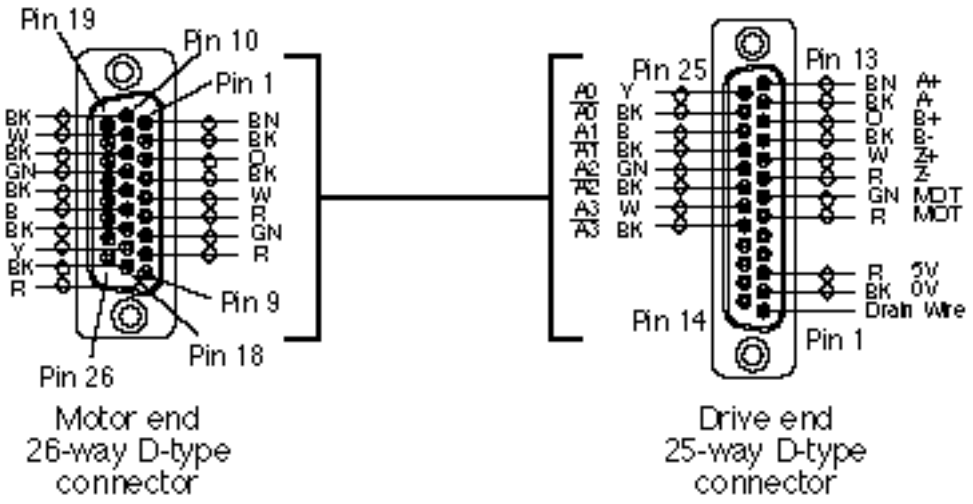



**Figure 4-8. ML1620 Encoder Connections**

Note: The ML1620 motor should only be used with the BLHX30 drive.

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# Section 5. BASIC MOTION CONTROL CONCEPTS

## Section Objectives

To describe some of the basic concepts of motion control systems.

### Motion Profiles

In any motion control application the most important requirement is precise shaft rotation, whether it be with respect to position, time or velocity. The type of motion profile needed will depend upon the motion control requirement. The following sections describe the basic types of motion profiles.

### Preset Moves

A preset move referred to in this manual is a move of a specified distance (in user steps). Preset moves allow the user to position in relation to the motor's previous stopped position (incremental moves) or in relation to a defined zero reference position (absolute moves).

#### *Incremental Preset Moves*

If the positioner is in the incremental mode (MPI command), a preset move will move the shaft of the motor the specified distance (in user steps) from its starting position. For example, to move the motor shaft 1.5 revolutions, a preset move with a distance of +6000 steps would be specified, assuming a 4000 step per rev encoder resolution setup. Every time this move is executed, the motor shaft will move 1.5 revolutions positive from its current position. The direction of the move can be specified at the same time as the distance by using the optional sign (D+6000 or D-6000), or it can be defined separately with the H command (H+ or H-).

#### *Absolute Preset Moves*

A preset move in absolute mode (MPA command) will move the shaft of the motor the specified distance (in user steps) from the absolute zero position. The absolute position can be set to zero with the PZ or SP commands, for instance at the end of a GO HOME move (GH command). The absolute zero position is initially the power-up position, and will remain that way until changed with a PZ command. Any preset move performed while in the absolute mode will position the motor shaft the defined distance (in user steps) from the absolute zero position. For example, with the positioner at the absolute zero position a move with a distance of +4000 will cause the motor shaft to turn 1 revolution in the positive direction. If a move with the same defined distance is executed immediately after this move, the motor shaft will not turn, since it is already +4000 steps from the absolute zero position.

The direction of an absolute preset move will depend upon the shaft position at the beginning of the move and the position that it is being commanded to move to. For example, if the motor shaft is at absolute position +12,800, and commanded position is +5000, then the motor shaft will move in the negative direction a distance of 7800 steps to absolute position +5000.

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The positioner saves the mode that it was in at power down and powers up again in the same mode. Issuing the MPA command will set the mode to absolute. Issuing the MPI command or MN command will switch the mode from absolute to incremental. The positioner retains the absolute position referenced, even while in incremental mode. However, the counter does have an upper limit just slightly more than 268,400,000 counts.

### *Continuous Moves*

Continuous moves (MC command) cause the motor to accelerate and attain the specified velocity and then continue to move. To change velocity while the motor is moving use the V command. Issuing a stop (the S command) will cause the motor to decelerate to a stop at the last defined acceleration rate. The distance parameter is not used, although it is saved in case the mode is changed back to preset.

This mode is useful for applications which require constant spinning of the load, when the motor must stop after a period of time has elapsed rather than after a fixed distance, or when the motor must be synchronised to external events such as trigger input signals.

### *Registration Moves*

A move may be programmed to end a specified distance after a registration pulse appears at AUX-IN. The mode is selected using the TRR command with the required registration distance in the MQ or MC modes. Its use is easiest to understand in the context of an example registration move:

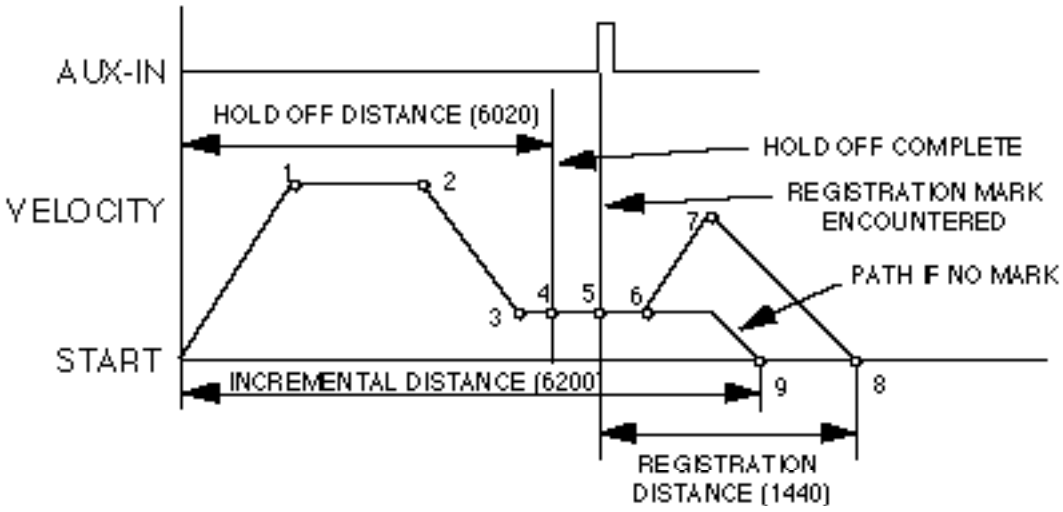



**Figure 5-1. Example Registration Move**

## Example Program

| | |
|---|---|
| **MQ** | Select MQ mode |
| **D6200** | Set move distance to 6200 steps |
| **A100** | Set all accelerations to 100 revs/sec$^2$ |
| **V10** | Set velocity to 10 revs/sec |
| **G** | Go |
| **TRD4000** | At distance = 4000 steps |

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| | |
|---|---|
| **V1** | Change velocity to 1rev/sec |
| **TRD6020** | At distance 6020 look for registration pulse |
| **TRR1440** | Travel 1440 steps from registration pulse |
| **V50** | At a velocity of 50 revs/sec |
| **TRIP** | Set Output 2 when in position |

### *Program Operation*

When executing this program, the axis will first accelerate at 100 steps/rev$^2$ to 10 revs/sec (1) and when it reaches a distance of 4000 steps (2), its speed will be reduced to 1 rev/sec (3) whilst it is waiting for the registration pulse. Shortly after the pulse is received (6), the axis will accelerate towards 50 revs/sec, but will not reach the speed before starting to decelerate (7) to stop at 1440 steps from where the pulse occurred (8).

If the pulse was not received after 6020 steps (4 - the hold off distance) and before 6200 steps (the incremental distance), the axis will stop at 6200 steps (9). This sets a window of 180 steps during which the pulse is expected.

### *Program Criteria*

| | |
|---|---|
| The distance command (D6200) | This command sets the distance the axis will travel if no registration pulse is received and the maximum distance at which the pulse will be recognised. |
| Trigger distance command (TRD4000) | The distance at which the axis will start to decelerate to the slower speed of 1 rev/sec (V1), in readiness for the registration pulse, is set by this command. |
| Trigger distance command (TRD6020) | This command sets the minimum distance at which the system will recognise the registration pulse. |
| The TRR command (TRR1440) | This command sets up the registration mode and the registration distance (the distance the axis will travel after the pulse is received). |
| Registration move velocity (V50) | To save time in travelling the registration distance, the axis then accelerates towards 50 revs/sec (V50), but it does not reach that speed before starting to decelerate to stop at 1440 steps from where the pulse occurred. |

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# Motion Profiles

Velocity, acceleration and distance must be defined before any preset move can be executed. The value of these parameters determines the type of motion profile as either triangular or trapezoidal.

## Triangular Profile

A triangular profile will result when the velocity and acceleration are set such that the designed velocity is not attained before half of the specified distance has been travelled. This results from either a very low acceleration or a very high velocity or both over a relatively short distance. For example, if the acceleration is set to 1 rev/sec/sec, velocity is set to 5 revs/sec and distance is set to 16000 steps (2 revs), a triangular motion profile will result. This is because by the time the motor shaft has reached a velocity of 2 revs/sec, it will also have travelled half of the defined distance due to the acceleration setting of 1 rev/sec/sec. The motion profile for this move is shown in Figure 5-2.

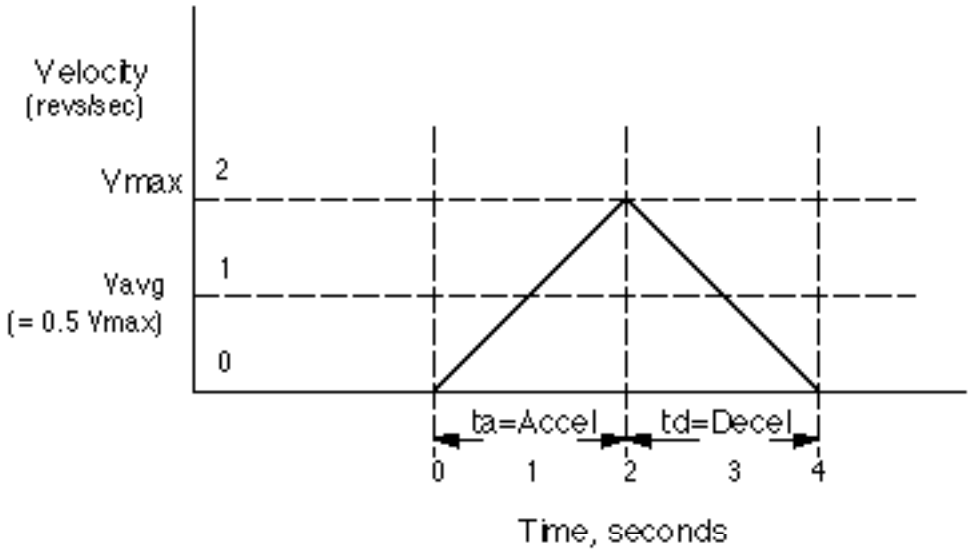
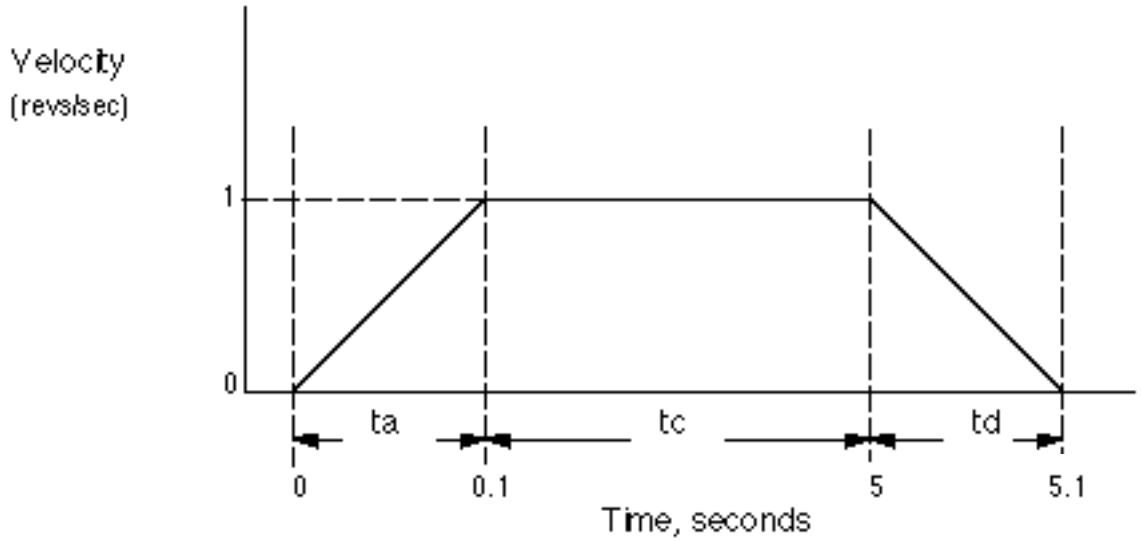



**Figure 5-2. Triangular Profile**

## Trapezoidal Profile

A trapezoidal move profile results when the defined velocity is attained before the motor shaft has moved half of the specified distance. This is due to a defined velocity that is low, a defined acceleration that is high, a move distance that is long, or a combination of all three. For example, if the acceleration is set to 10 revs/sec/sec, velocity is set to 1 rev/sec, and distance is specified as 20000 steps (5 revs), the resulting motion profile would look like this:

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ta = Accelerate
tc = Constant velocity
td = Decelerate

**Figure 5-3. Trapezoidal Profile**

### User Profiles

The user may define a move profile using the MC command to establish the continuous mode. Velocity can be programmed on the fly by the V command.

The positioner also has a mode MQ, which is like the preset move mode in that the move distance is pre-defined, but it is possible to change speed in the middle of the move as required based on a distance, input or time delay trigger.

## Encoder Following

The commands SIM and CCS may be used to allow the motor of one axis to follow the encoder of another axis or an externally-generated step and direction signal. When the control module is to be used in following mode, the input from the encoder to be followed should be connected to the External Encoder connector pins 1 - 9 (as shown in Figure 2-1). These inputs can be configured using the CCS command as an encoder input (x1, x2 or x4) or as a step and direction input.

Externally generated STEP and DIR signals should be connected to pins 1 - 4 of the External Encoder connector (see Figure 2-1 and Table 2-1).

The SIM command may be used to select:

a) Normal indexer operation (SIM0), used for reverting to normal operation by overiding previous SIM commands

b) Encoder following with indexer motion commands inoperative (SIM1).

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c) Encoder following with indexer commands operative (SIM2), allowing the superimposing of indexer moves.

d) Software scaled encoder following (SIM3).

e) Software scaled encoder following with direction reversal (SIM4).

f) Preset following index mode (SIM5).

g) Load mounted encoder feedback (SIM6).

For SIM1 and SIM2 operation the motor output rate follows the encoder input, using hardware scaling, at a ratio of 1 or less.

## Hardware Scaling

This is the scaling of the second encoder input when using the SIM1 and SIM2 commands to achieve following at a ratio of 1 or less relative to the following input. Scaling is achieved using a hardware rate mutiplier, the division ratio of which is set by the RAT command, at a resolution of 16 bit or 24 bit operation determined by the OSJ command.

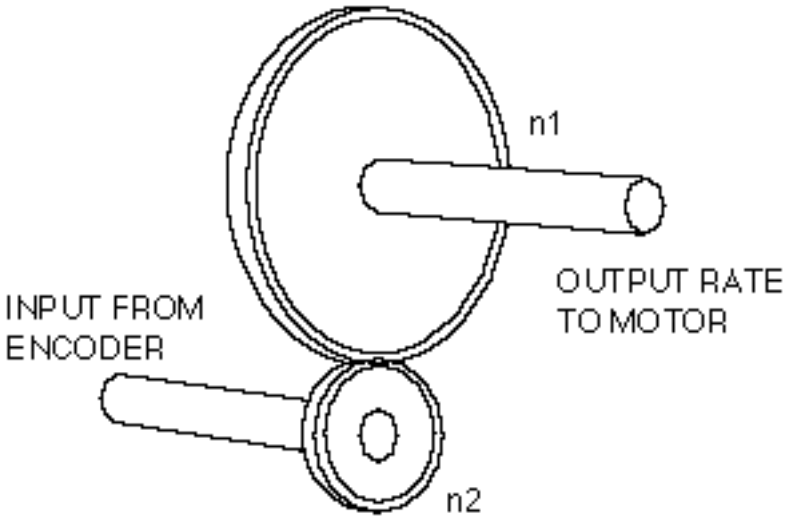



**Figure 5-4. Simple Gearbox**

The operation of the rate multiplier can be compared to that of a simple gearbox (see Figure 5-4), where the ratio of output revolutions to the input revolutions (always less than or equal to 1) is determined by the number of teeth on n2 divided by the number of teeth on n1. If the number of teeth on n1 is fixed, but the number of teeth on n2 is allowed to vary (up to a maximum of n1 teeth), the gearbox will provide a variable output rate which is always a fraction of the input rate. The resolution of the gearbox, that is how fine a gear ratio can be set, will be determined by the number of fixed teeth on n1. In the rate multiplier the RAT value sets the number of teeth on n2, and the resolution (n1 teeth) can have one of two fixed values determined by the OSJ command.

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Using hardware scaling the output motor rate is determined by :

$$\text{Output Motor Rate} = \text{input rate} \times \frac{n}{65536} \quad \text{for OSJ} = 0$$

or

$$\text{Output Motor Rate} = \text{input rate} \times \frac{n}{16777216} \quad \text{for OSJ} = 1$$

Where n = the RAT value

**NOTE**: RAT now controls the division ratio, and the direction will be determined by the sign of the RAT value.

As the resolution (set by OSJ) is a large number, very fine adjustment of the ratio can be set by choosing a suitable value for the RAT command.

A limitation of binary hardware scaling is the lack of certain exact following ratios that can be obtained. Since the division ratio can only be a binary fraction it is impossible to choose an exact ratio such as 1:3, although it could be closely approximated if you were to choose a RAT value of 5592405 with 24-bit resolution selected.

Summary of hardware scaling :

The scaling ratio is determined by the RAT value.
Resolution is fixed at 16-bit or 24-bit , determined by the OSJ command.
Non binary fraction exact division ratios cannot be obtained.

## Software Scaling

This is the scaling of the encoder input when using the SIM3 or SIM4 commands to achieve following at a ratio greater or less than 1. Unlike hardware scaling, exact following ratios can be achieved by controlling both the numerator and denominator parts of the fraction used to set the scaling ratio, thus ratios such as 3:1 can be obtained.

The scaling ratio is set using the CMR command value divided by the CUR command value to give :

$$\text{Motor Output Rate} = \text{input rate} \times \frac{CMR}{CUR}$$

Both CMR values and CUR values are individually limited to a range of 1 to 32,767, and when combined as a fraction are further limited, by software scaling to having both numerator and denominator in the range 1 to 255. This results in a maximum division ratio of 1/255, or at the other extreme a maximum multiplication ratio of 255.
Software scaling does not allow the superimposing of indexer moves.

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When using SIM3 or SIM 4 operation for short moves it is possible to predict the number of steps the motor will take using the formula :

Number of motor steps to move =

$$\mathrm{INT}\left(\frac{\mathrm{CMR} \times \text{no. of pulses received} + \text{prev. remainder}}{\mathrm{CUR}}\right)$$

where INT means "take the integer part of", with the value rounded towards zero whether positive or negative. The controller can repeatedly apply this formula to establish an iterative calculation. In situations where short moves have been programmed the ratio of CMR/CUR may only approximate the number of steps the motor is required to move, but since the remainder is carried forward no steps are lost. This allows the CMR/CUR value to better approximate the following ratio in subsequent moves.
In summary, short moves may only approximate the defined following ratio, but no positioning accuracy is lost in later moves.

## Buffered Clock Mode

SIM3 or SIM4 work in a buffered clock mode, which allows the controller to buffer an unprofiled following-input pulse stream until the output velocity equals the following input velocity. The controller accelerates the output velocity to match the input velocity using an exponential acceleration profile, the time constant of which is set using the CAG command. The default time constant value of CAG is 1.00ms to accept already profiled follower inputs.

The input pulses are buffered (or stored) at the input resolution, the actual number being stored at any particular instant being termed the following error. This can lead to input pulses being lost above a maximum speed, due to excessive following error.

The maximum number of input pulses that can be buffered is

+/-32767 which requires CAG to be less than $\frac{32767}{\text{input pulse rate}}$ to prevent overflow.

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***Comparison of following features***

| Hardware Scaling SIM1, SIM2 | Software Scaling SIM3, SIM4 |
|---|---|
| The motor always moves by the same or fewer pulses than received. The pulse stream is effectively divided. | The motor can move by more or less pulses than received. The input pulse stream can be multiplied or divided. |
| The ratio is programmed by the RAT command with 16 or 24 bit resolution as a binary fraction. | The RAT command has no effect. |
| CMR and CUR have no effect. | The ratio is programmed by CMR and CUR. |
| Superposition onto an additional internally generated indexer motion is available. | Superposition is not available. |
| The pulse stream is followed directly without additional profiling. | The pulse stream is profiled (filtered) by a programmable exponential characteristic (CAG command) |

## Preset Following Index Mode

The following mode SIM5 selects indexing at a speed determined by the external input. In this mode the controller sets the motor velocity to a speed in rps determined as a percentage of the following input speed in rps. The percentage following factor is set by the FOL command which can be varied between 0.0 and 5000.0%.

When using this mode the acceleration is fixed to whatever is defined by the A command, and the V command value has no effect since the FOL command percentage value will now control the velocity.

The velocity is dependent on the user resolution (CUR value) and the motor resolution (CMR value). CUR and CMR set the encoder / motor resolution ratio so that the input shaft speed will match the output shaft speed with FOL set to 100%.

The FOL value can be entered from a variable, for example:

1FOL(VAR1)

**Pulses must be present at the input when the G command is executed.**

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## Load Encoder Following (SIM 6)

In certain applications it is beneficial to close the position loop around the actual load position rather than the motor position, in order to improve positional accuracy.
A typical example is a feed-to-length system in which positioning accuracy is adversely affected by slippage and compression of the feed roller.

If we close the position loop around the load then we can compensate for the majority of system errors, such as out of tolerance feed rollers and other transmission devices. This is achieved by mounting an incremental encoder to the load mechanics or via a low inertia wheel in the case of feed to length applications.

Position feedback is taken from this encoder rather than the incremental encoder fitted to the motor. The load position becomes the true closed loop controlled position, compensating for the effect of the indirect coupling between the motor and load.

The load encoder is connected to the EXT ENC 9 way D type. The motor encoder feedback remains in use to provide velocity feedback. Velocity feedback is derived in this manner rather than from the load encoder as the indirect coupling of the load encoder would result in a low bandwidth system and therefore limit performance. In applications were the ratio between the load encoder and the motor is not 1:1 then the velocity feed forward gain (CFG) must be scaled by that ratio.
Note that links 5, 6 and 7 are transferred to position B to use an external encoder.

In order to provide continuity between following modes, the current reported motor position will be retained when switching between modes. This prevents any anomalies when entering and exiting the load encoder following mode.

When using this mode the motor resolution (CMR) should be set to the load encoder resolution. Velocity and acceleration will now be referenced to the load. Set OSO to 1, this will suppress units and will avoid later confusion.

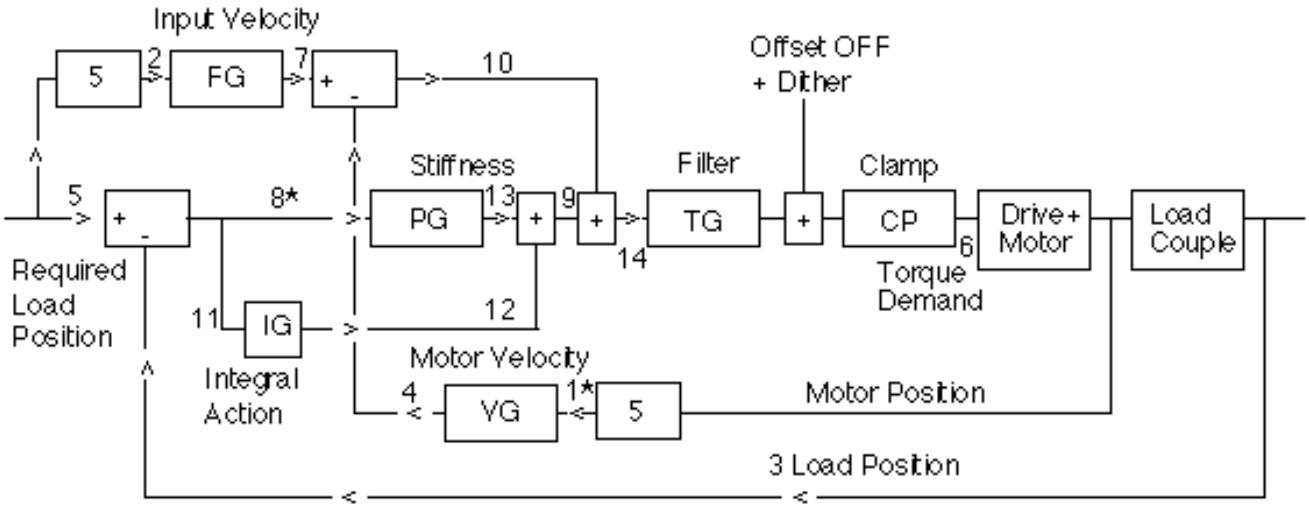



**Figure 5-5. SIM6 Operation**

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### Coupling

In order to gain good system performance care must be taken in selection of the coupling. The quality of the coupling will have considerable effect on performance. Poor coupling will prevent CPG and CVG being set to the optimum, this will therefore affect speed of response, stiffness and accuracy of the system.

Note: As an additional safety feature and to prevent mechanical damage, the motor velocity trip (CVT) should be set to a value just greater than the system requirements. If the coupling should break and the motor race away, once the velocity has reached that set by CVT the motor will de-energise.

## Torque control applications

In most applications, the fundamental parameter controlled is position. Velocity, acceleration and direction are all derived from position, so are automatically determined. The value we cannot directly control is torque, since this depends upon the load characteristics as well as the move parameters.

However, there are applications in which the torque is the chief parameter we want to control - winding material onto a drum is one example. When operating as a torque motor we have no control over position, velocity, acceleration or direction, though we can set limits to any of these parameters. (In the same way, we can set a limit to the torque in a position control application).

### Tuning the Controller for torque control

Most torque applications need a limit to be placed on velocity should the load torque be less than the programmed value. In the winding application, this would limit the drum speed if the material breaks. We therefore set up the controller as a *velocity* controller but determine the maximum torque using the clamp command CCP.

The proportional gain CPG must be set to zero for velocity control, and we must also set CPE to zero to stop the system tripping out on excessive position error. The feedforward term CFG, which depends on the rate of change of input position, converts the position demand to a velocity demand. We need to use CDG to set the velocity gain because it is essential that the feedforward and feedback terms are the same, otherwise the demanded velocity will not be the same as the programmed V value. The block diagram of the servo is shown in Figure 5-6.

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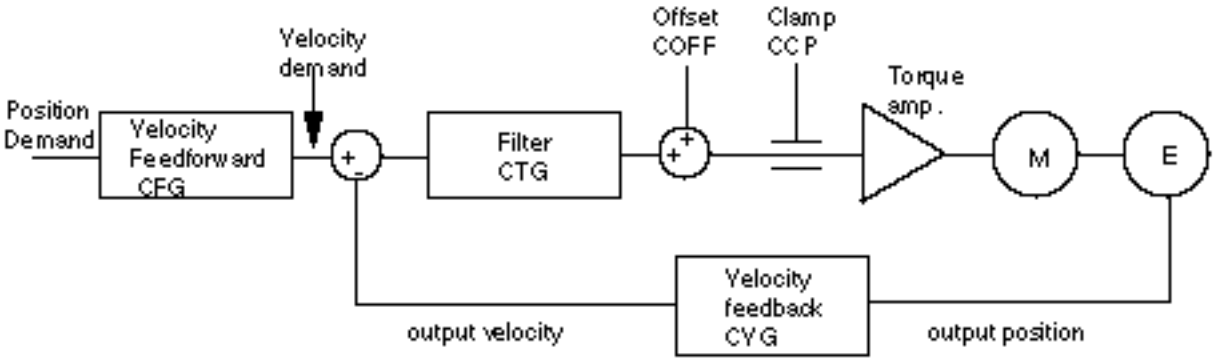



**Figure 5-6. Torque Control Operation**

The clamp command CCP can now be used to determine the torque - a value of 1023 will correspond with the peak torque available from the motor & drive. When the G is issued, the motor will accelerate at the programmed A value until the load torque matches the CCP level. If the load torque is less than the CCP value, the motor will run at the speed programmed by V. In practice there will be a small velocity error generating the torque necessary to keep the motor running at this speed; setting CDG to a high value will minimise this error. It will usually be necessary to increase the filter time constant CTG in order to reduce the bandwidth when using a high velocity gain.

The programmed D value will limit the overall distance if you are using the indexing mode MN. If there is no preset limit to the total travel you can use the continuous mode MC.

### *Switching between position and velocity modes*

In an application like the closing and clamping of an injection mould, we need to switch between position control (when the mould is opening) to torque-limited velocity control during the closing process. This switchover demands a significant change to the tuning values on the fly, and could result in a large discontinuity in position or torque. The command **RST1** allows the torque demand to be frozen momentarily while we make the tuning changes, which effectively opens the control loop. **RST0** then releases the torque demand and closes the loop again. Between the RST1 and RST0 commands will be the new tuning values entered as buffered commands, for example:

**RST1 BCPG0 BCDG100 BCTG3 RST0**

When switching between control modes, the difficulty arises in maintaining continuity of the torque demand before and after the switch. In position mode, the torque demand arises primarily from a position error; in velocity mode it comes from a velocity error which is comparatively small because gains are usually higher. So when switching modes, the correct error conditions must be established *before* the torque demand can be unfrozen.

The RST0 command achieves this by setting either a position error or a torque offset as appropriate. When the new value of CPG is zero (as in the example), the controller is considered to be entering velocity mode and a torque offset is introduced (COFF command) equivalent to the previous torque demand under position control. When the new value of

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CPG is greater than zero, the controller must be returning to position mode; the demand position is adjusted so that previously-existing torque is now generated by a position error.

The following points should be kept in mind when switching between control modes:

Aim to switch from position to velocity mode when there is no torque on the shaft, preferably when stationary. This will minimise the COFF value introduced.

You can switch from velocity to position mode on the fly provided that the system is under velocity control at the time, i.e. the load torque is less than the CCP value. You should not allow the system to become saturated (i.e. CCP-limited) in position mode; this will cause a position error to build up.

When returning to position mode, include BCOFF0 to clear the torque offset.

If your application requires mode-switching we recommend that you request programming assistance from Digiplan.

## Program Storage

The non-volatile program memory is battery backed up RAM with memory retention of 10,000 hours. The RAM has 8K characters available for sequence storage and a write protect facility is provided.
Programs are stored in variable length buffers and the total length cannot exceed 8K.

### Write Protection

A write protection facility is incorporated for the protection of stored sequences and parameters, stored by the SV command. If LK8 on the positioner card (see Figure 2-6) is fitted in position A then the memory is write protected. An attempted SV command when the jumper link is in position A will result in the following error message being displayed:

#15 BACKUP RAM IS WRITE PROTECTED

### Motion Program Selection

The system may be set up so that no sequence is executed at power-up. In this case sequence execution would be initiated from the controller over the RS232C.

Alternatively, a single sequence to be automatically executed at power-up can be programmed. After that sequence is executed, control can pass to another sequence or to the RS232C interface.

Sequence selection may also be initiated via thumbwheel, RP240, and PLC inputs. Up to 64 user defined sequences can be selected for execution in this way.

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## Parameter Ranges

Table 5-1 gives the internal arithmetic positioner limits based on 4000 encoder steps/rev. These parameters apply only to the positioner, the motor/drive combination will not necessarily be able to respond to the full ranges stated:

| | Position | Velocity | Acceleration |
|---|---|---|---|
| **Smallest** | 1 step | 0.488 steps/sec<br>0.000122 RPS<br>0.00732 RPM | 244 steps/sec/sec<br>0.061 $RPS^2$<br>3.66 RPM/sec |
| **Largest** | ±268,435,455 steps<br>±67,108 revs at 4000 steps/rev | $4 \times 10^6$ steps/sec<br>999 RPS | $4 \times 10^9$ steps/sec/sec<br>999,999 $RPS^2$ |

**Table 5-1. Parameter Ranges**

**NOTE:** Longer distances than 268,435,455 steps can be achieved using a sequence of incremental moves or continuous motion mode.

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# Section 6. COMMUNICATING WITH THE POSITIONER

## Section Objectives

The information contained in this chapter will enable you to set up communications with the positioner. If more than one positioner is present in the system, details are provided on the connection of multiple positioners using the RS-232 Daisy Chain.

### Command Interface

The interface is a three wire implementation (Tx, Rx, Ground) of RS232C. The Tx and Rx lines require a minimum voltage swing of ±3 volts.

Hardware handshaking is not supported in any form. The computer or terminal sending characters to the positioner should have its handshaking disabled by either hardware or software.

### Communication Parameters

The positioner communications protocol is fixed and as follows:

9600 baud, 8 data bits, no parity, 1 start bit, 1 stop bit

Device address: 1-16

Echo function: all characters received are immediately re-transmitted. This function can be enabled using the SSA0 command or disabled using the SSA1 command.

Once entered, a parameter will be remembered until power down. It is not necessary to keep re-stating the same parameter value.

When you power up the positioner all parameters are assigned default values which the 1DR command will show you. You can change any of these and then make them the new default value by typing the SV (Save) command - see also commands RFS and RIFS.

XON, XOFF software handshaking is supported.

### Installing the RS232C

RS232C connections from the controller to the positioner are as shown in Figure 6-1. Note that the Tx and Rx lines are cross-connected so that transmit output is connected to receive input.

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## Address Selection

A unique address must be assigned to each positioner in the chain. Normally positioner 1 will be the first in the serial communications link. The positioner's address is assigned by configuring DIL switch SW1 (refer to Figure 3-16) on each Controller Module in a binary pattern as shown in Table 6-1.

| | SW1 4 Bit DIL Switch Setting | | | |
|---|---|---|---|---|
| **Address** | **Bit 4** | **Bit 3** | **Bit 2** | **Bit 1** |
| 1 | ON | OFF | OFF | OFF |
| 2 | OFF | ON | OFF | OFF |
| 3 | ON | ON | OFF | OFF |
| 4 | OFF | OFF | ON | OFF |
| 5 | ON | OFF | ON | OFF |
| 6 | OFF | ON | ON | OFF |
| 7 | ON | ON | ON | OFF |
| 8 | OFF | OFF | OFF | ON |
| 9 | ON | OFF | OFF | ON |
| 10 | OFF | ON | OFF | ON |
| 11 | ON | ON | OFF | ON |
| 12 | OFF | OFF | ON | ON |
| 13 | ON | OFF | ON | ON |
| 14 | OFF | ON | ON | ON |
| 15 | ON | ON | ON | ON |
| 16 | OFF | OFF | OFF | OFF |

**Table 6-1. Positioner Address Selection**

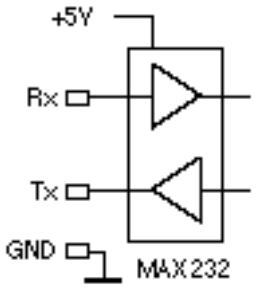



**Figure 6-1. RS232 Input Circuit**

## Controller Daisy Chain Wiring

You may daisy chain up to 16 axes. Individual drive addresses are set with the Controller DIP switches (see Table 6-1). When daisy chained, the units may be addressed individually or simultaneously. You should establish a unique address for each axis. Refer to Figure 6-2 for Controller daisy chain wiring configuration.

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Commands prefixed with a device address command only the unit specified. Commands without an address command all units on the daisy chain. The general rule is: *Any command that causes the drive to transmit information from the RS-232C port (such as a status or report command), must be prefixed with a device address*. This prevents daisy chained units from all transmitting at the same time.

Attach device identifiers to the front of the command. The Go (G) command instructs all units on the daisy chain to go, while 1G tells only unit #1 to go.

When you use a single communications port to control more than one Controller, all units in the daisy chain receive and echo the same commands. Each device executes these commands, unless this command is preceded with an address that differs from the units on the daisy chain. This becomes critical if you instruct any indexer to transmit information. To prevent all of the units on the daisy chain from responding to a command, you must precede the command with the device address of the designated unit.

No Controller executes a device-specific command unless the unit number specified with the command matches the Controller unit number. Device-specific commands include both buffered and immediate commands.

You must use status-request commands in an orderly fashion. Commands should only be issued when the host is ready to read the response. You should not send new commands until you receive a response from the previous status-request command. In particular, you should not issue an immediate-status command until the host receives a buffered command status response. If this is not followed, the command responses will be intertwined, rendering the data useless.

If you enable the Interactive mode (EX1), the Controller that is currently echoing will respond with a prompt (>). This prevents all the Controllers from sending out > in a daisy chain. Typically, you should disable the Interactive mode when you use a host computer with the Controller. The default for the EX command is enabled (EX1).

Figure 6-2 shows a multiple-drive configuration (daisy-chain) of RS-232C ports from one controlling terminal or computer.

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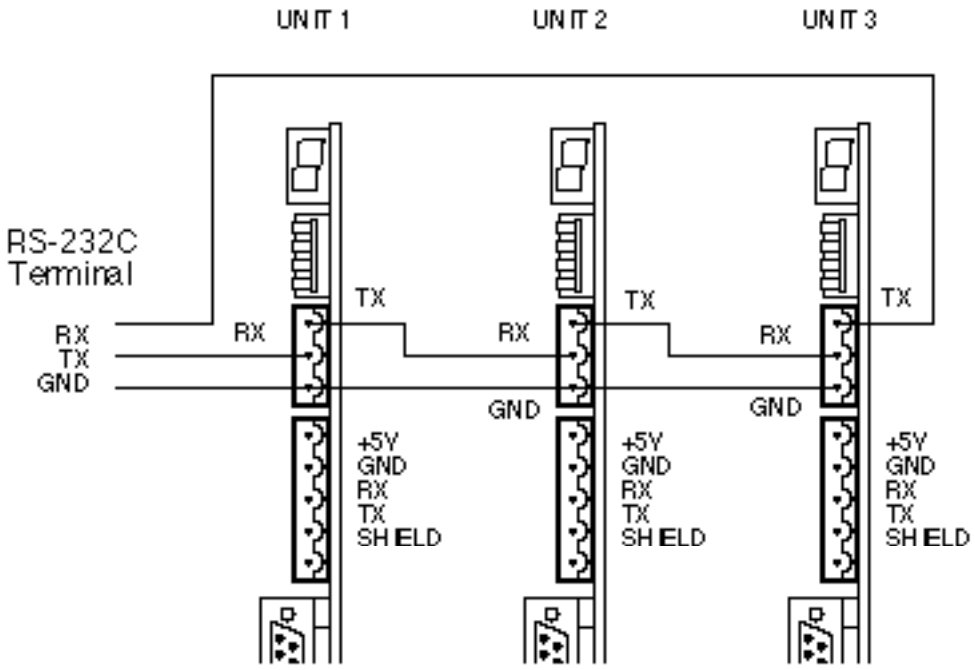



**Figure 6-2. RS-232C Daisy Chain Configuration**

Example
Three Controllers are connected to an RS-232C daisy chain. Send the following commands:

| Command | Description |
|---|---|
| **MN** | Sets unit to Preset mode for all three controllers |
| **A5** | Sets acceleration to 5 $rps^2$ for all three controllers |
| **V10** | Sets velocity to 10 rps for all three controllers |
| **LD3** | Disables limits (if they are not connected) |
| **1D25000** | Sets axis 1 distance to 25,000 steps |
| **2D50000** | Sets axis 2 distance to 50,000 steps |
| **3D100000** | Sets axis 3 distance to 100,000 steps |
| **G** | Moves all axes |

Unit 1 moves 25,000 steps, unit 2 moves 50,000 steps and unit 3 moves 100,000 steps. All three units use the same acceleration and velocity rates.

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## Interactive operation with a PC/PLC

To create a reliable, trouble free interactive RS232 communications control program between a PC/PLC and the serial interface you should note the following points :

- Use the X-WARE package for terminal emulation on an IBM PC or equivalent computer system.

- The interface should only be operated in computer mode to suppress error messages and extended text output.

- The program should operate the interface with a response check during critical processes, such as sequence download. The response check will need to detect :

    - No response at all
    - Incorrect characters
    - More characters than expected
    - Less characters than expected
    - Control characters such as EOF caused by errors
    - Correct response

The response expected should be either echoback, or characters returned by interrogation commands, or a sequence of the two.

•If there is no check for echoback on each character, you should include a delay of up to 1ms between each character sent . This may require characters to be sent individually rather than as strings.

•You should not use the simple BASIC INPUT statement as this 'hangs' the link without time out if an error causes no carriage-return character to be received from the interface.

•Interpreted BASIC should not be used, as it is too slow for most applications.

•Interrupt error handling, such as the BASIC 'ON ERROR" statement, should be enabled.

•Commands such as SV, Z, RFS and RIFS take several seconds to execute. This also applies to status commands like DR and HELP. It is recommended you insert a suitable delay after these commands to allow them to fully execute their intended function without corrupting immediately following commands, although the use of these commands in an interactive situation is unlikely.

•If problems arise, the communications error responses actioned by the R command will help diagnosis. In some cases a recovery can be attempted by sending the command again (such as the R command itself). But this may not always be appropriate, for example LD3 altered to L3 would not be fully corrected by simply sending LD3 again.

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•A routine that breaks some of these rules may appear to work satisfactorily, but is not necessarily safe. The worst case communications response condition may involve a number of coincidences, such as sending a status request just as the interface hits a limit, just as it starts decelerating. Any motion control requirement explicitly takes priority over communications under these circumstances, and can therefore cause a communications problem unless you wait for echoback. Also different issues of software may have different execution time characteristics which can make a routine based on delays work at one software issue, and not another.

*Accurate defensive programming is required if safety constraints are to be met and possible damage to hardware prevented.*

## Using Windows™

Microsoft Windows™ comes with a terminal emulation program which can be used in place of XWARE. The terminal emulation program is configured as follows:

Run the terminal program.

From the FILE menu select NEW.

From the SETTINGS menu, setup the following options:

| | |
|---|---|
| Terminal emulation sub-menu | DEC VT-100 (ANSI) |
| Terminal preferences sub-menu | Terminal modes Line wrap ON |
| | Local echo OFF |
| | CR_>CR/LF Inbound ON |
| Communications sub-menu | Baud rate 9600 |
| | Data bits 8 |
| | Stop bits 1 |
| | Parity NONE |
| | Flow control NONE |

Also choose the appropriate connector

These basic configurations will allow operation with the terminal only.

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## Interactive Programming

To help you achieve reliable, trouble free interactive programming between a Controller Positioner and a PC/PLC the following guidelines will be useful.

•The interface should be operated in terse mode (EX0) to suppress unsolicited error messages and extended text output. This will also allow for extra communication time.

•The program should include an interface response check, especially during critical processes such as sequence download. Checks should be made for:

*No response at all
*Incorrect characters
*More or less characters than expected
*Control characters such as EOF formed by errors
*The correct response

Where the correct response is the echoback of the transmitted characters or characters returned by interrogation commands or a combination of the two.

•The command buffer is 256 characters long. When it has filled up, the interface will echo a <CTRL>G instead of the correct character. Subsequent characters received will 'overwrite' the last character in the buffer until a 'free' space occurs.

•Given the above, it is preferable to transmit one character and wait for correct echoback before transmitting the next character. This enables an error to be rectified immediately.

•When monitoring the echoback characters in verbose mode (EX1), some are echoed as a combination of characters, for example:

<CR> is echoed as <CR> <LF>.

This is not the case in terse mode (EX0).

•If there is no check for echoback on each individual character, an explicit delay of at least 1ms between each character must be included. This may mean sending characters individually rather than in strings.

•Certain interface commands, notably ON, Z etc. take some time to execute and consequently momentarily interfere with communications. An explicit delay (several seconds is typical) should be inserted after these commands before another is sent.

•This interference of communications can involve temporarily not servicing the RS-232 interrupt on the Controller, allowing subsequent characters received by the UART, during this condition, to cause an overrun error within the UART. The status request command (R) can be used to provide helpful diagnostics. The responses generated by the interface are as follows:

*R<CR> - ready for a command with no errors
*S<CR> - ready for a command with function error
*T<CR> - ready for a command with previous comms error
*U<CR> - ready for a command with function error and previous comms error

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*B<CR> - busy performing a move with no errors
*C<CR> - busy performing a move with function error
*D<CR> - busy performing a move with previous comms error
*E<CR> - busy performing a move with function error and previous comms error

•The average execution time of commands is approximately 1.5ms. The execution time is dependent upon the activity of the indexer. When performing a move, especially during acceleration and deceleration, there is generally less time available for command execution. This time will delay the execution of subsequent commands, and hence reduce the rate at which the command input buffer is cleared.

•The interface will correctly respond to XON/XOFF protocol, but will not be able to generate the XON/XOFF signals when the command input buffer is full.

•If the control program does not use the echo back facility provided by the interface it may be disabled by sending the command SSA1. This will speed up the character handling routine a little, but will stop any commands from being transmitted to axes further down the chain, so should be used with care.

The fact that a routine that breaks some of these rules 'works' is irrelevant. Worst case communication response conditions may involve a number of coincidences such as sending a status request just as the interface hits a limit, just as it starts to decelerate, just as the servo is responding to a load glitch etc. Any motion control requirement explicitly takes priority over communications under these circumstances and can therefore cause a communication problem unless you wait for echoback.

If the Controller echoback is turned off by accident, causing an apparent loss of communication (hanging), it may be re-enabled by typing the following sequence:

CTRL-Q<space>E<space>1R<carriage return>

Note:
[1] This sequence is case sensitive - make sure you are in upper case.

[2] CTRL-Q means hold the 'control' key down and press the Q key at the same time. This sends the X-ON ASCII character. The Controller obeys the X-ON X-OFF communications protocol which is used to hold up communications if an interface is sending too much data too quickly. This means that if X-OFF is sent down the chain (the character CTRL-S) all communications from the axes stop until CTRL-Q (X-ON) is sent down the chain. This includes echoback of commands. If CTRL-Q is never sent the system will 'hang'.

[3] You may type CTRL-S by mistake. This condition can be cleared by cycling the power.

[4] The E command is the enable RS-232 command which can easily be mis-typed as the F command which will lock out the keyboard. Cycling the power will not cure this problem since SV cannot be typed following a keyboard lock out.

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[5] The <space>1 in <space>1R is important. It sets axis 1 as the echoback device (as would <carriage return>1). If you make a typing error, such as TRD<space>3000 instead of TRD3000 the <space>3 sets axis 3 as the echoback device, where R can be any command.

Certain 'tidy up' commands can be useful. For example:

- If you are not getting the typed characters echoed back you may need to use the SSA0 command.
- To get a prompt ($ or >) you may need to use the EX1 command.
- To get out of a $ prompt (indicating a sequence definition) type XT.
- If buffered commands are being ignored, type S in case the indexer is busy. You should avoid typing Z or cycling the power.

In summary:

- Don't type CTRL-S
- Don't type the command F
- Don't address a non-existent axis
- Don't rubout a device address
- Type carefully

None of the above conditions is an error so the status LED on the Controller will not indicate a fault and the axis may well be energised or even moving.

---

# Programming With the RP240

## Prompting an Operator or Displaying Information

In many motion control applications, the most important requirement is the operator interface. Presenting information to an operator in a desired format is often difficult. The RP240 has two visual indicators to help present information to the operator . The simplest indicator is the set of 8 LEDs on the panel. These LEDs can be turned on or off with the DLED command. The LEDs can be used in conjunction with the outputs to show the state of an output, or they can be used to show status, such as motor moving, specific sequences in progress, etc.

If a DLED10001011 command is issued, the LEDs shown below would be illuminated. These eight LEDs can be labelled, using the slide in card provided, to represent cycle status, output status, etc.

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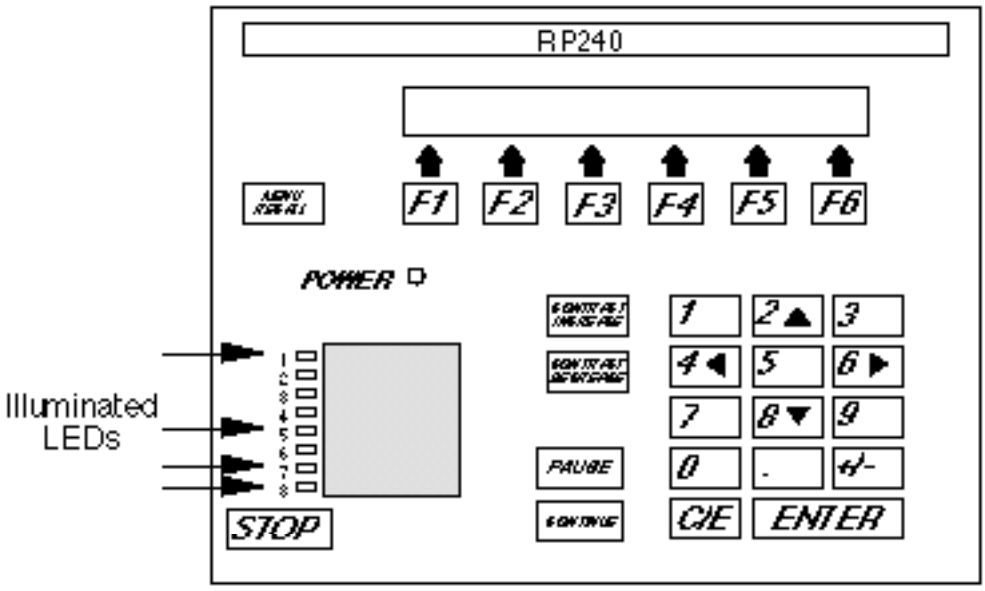
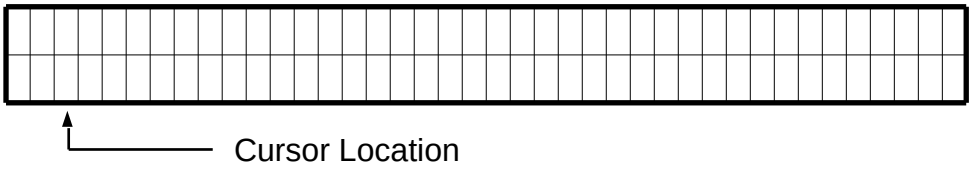



**Figure 6-3. Status LEDs**

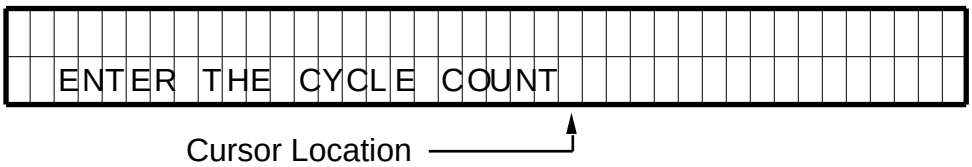
The other indicator is the two line, 40 character LCD display. This display can be controlled with specific Extended X Code commands. The Position Cursor (DPC) command allows the user to program the location of the cursor on the LCD display. The 'Display Text Data on RP240 Display (DTXT) command allows the user to place text, beginning at the current cursor location, on the LCD display. For example: A user wishes their operator to see the message ENTER THE CYCLE COUNT. The user wants this message placed on line two, starting after two spaces in from the left. Following the message by three spaces the cycle count is to be entered. Below are the steps required to accomplish this.

The cursor does not appear on the display. The cursor is displayed when the VARn=NUM or DPC commands are used.

**Step 1**
Issue the DPC202 command

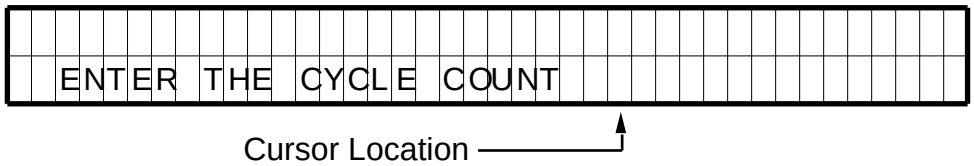



**Step 2**
Issue the DTXT"ENTER THE CYCLE COUNT" command.



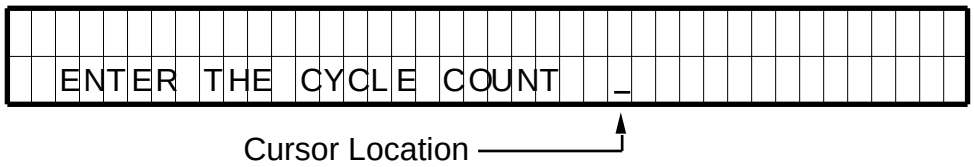

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**Step 3**
Issue the DPC225 command.

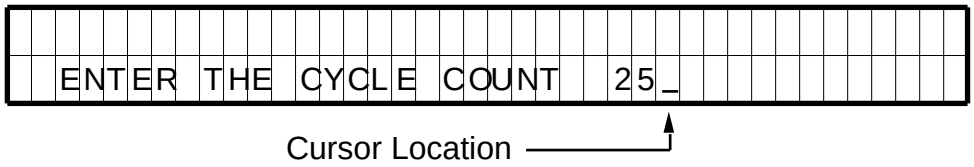



Once the operator has been provided with the prompting message, the actual cycle count data is provided using the Read and Enable Numeric Keypad (VARn=NUM) or Read and Enable Function Keys (VARn=FUN). The VARn=NUM command will enable the numeric keypad and allow the operator to enter information. The numbers, as entered, will be displayed at the current cursor location. Once the ENTER key is pressed, the number will be accepted by the Controller.

**Step 4**
Issue the VAR1=NUM command.

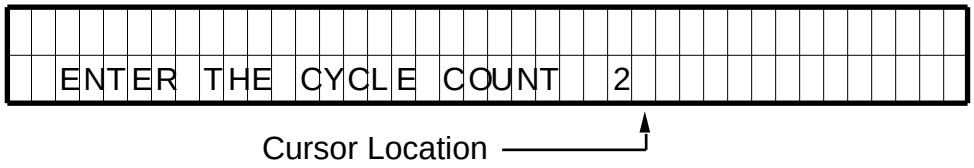



**Step 5**
Press a 2, followed by a 5.



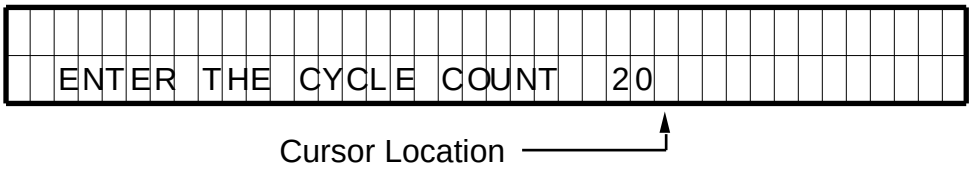

If the wrong value is entered press the C/E key and re-enter the value.

**Step 6**
Press the C/E key.

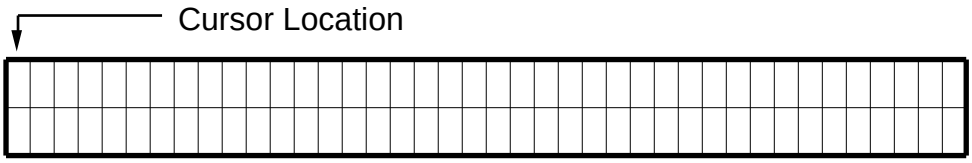



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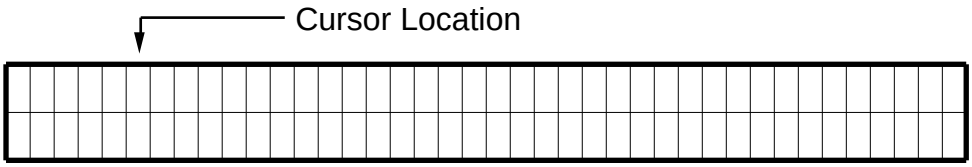
**Step 7**
Press a 0 followed by an ENTER.



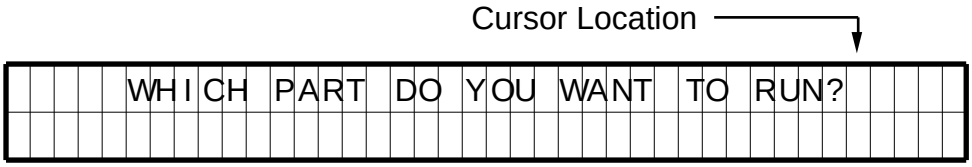

**Step 8**
DCLR0 command is issued.



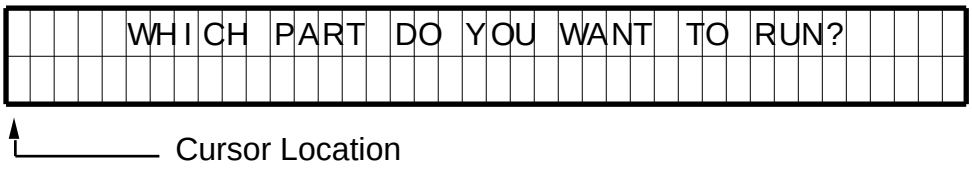

**Step 9**
Issue the DPC105 command.




**Step 10**
Issue the DTXT"WHICH PART DO YOU WANT TO RUN?" command.

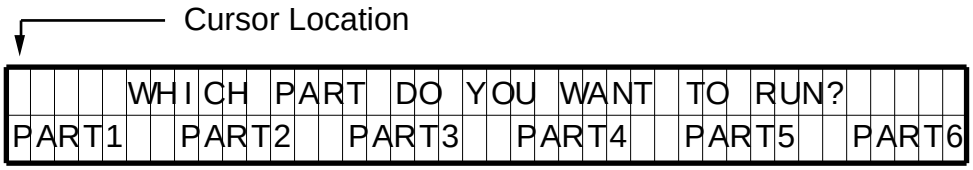



**Step 11**
Issue the DPC200 command.




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**Step 12**
Issue the DTXT"PART1 PART2 PART3 PART4 PART5 PART6" command. This text serves as an operator menu for the function keys.




**Step 13**
Issue the VAR2=FUN command.

The VARn=FUN command enables the function (F1 - F6), and the MENU RECALL keys. When any of these keys are pressed, the number corresponding to the function key will be transmitted from the RP240 to the Controller. Function keys 1 - 6 will return the values 1 - 6. The MENU RECALL key will return a zero.

**Step 14**
Press F1

After the F1 key is pressed, the RP240 will transmit the value 1 to the Controller. This value will be stored in variable 2.

## Processing Information

Variables can be used in conditional statements like IF, WHILE and REPEAT or as data values in D, V, A, L, or T commands. In step 7 above, the value 20 was entered and stored in variable 1 to be used as the cycle count. The following is a command example:

| Command | Description |
|---|---|
| **D2400** | Set distance to 2400 steps |
| **V1** | Set velocity to 1 rps |
| **L(VAR1)** | Loop the number of times as specified by variable 1 |
| **G** | Initiate motion |
| **T1** | Wait one second |
| **N** | End the loop |

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In step 14 above, the operator pressed the F1 key. This value was stored in variable 2, and was used to select PART1. The following is a command example:

| Command | Description |
|---|---|
| L | Infinite loop |
| IF(VAR2=1) XG11 NIF | Branch to sequence 11 if F1 is pressed |
| IF(VAR2=2) XG12 NIF | Branch to sequence 12 if F2 is pressed |
| IF(VAR2=3) XG13 NIF | Branch to sequence 13 if F3 is pressed |
| IF(VAR2=4) XG14 NIF | Branch to sequence 14 if F4 is pressed |
| IF(VAR2=5) XG15 NIF | Branch to sequence 15 if F5 is pressed |
| IF(VAR2=6) XG16 NIF | Branch to sequence 16 if F6 is pressed |
| N | End the loop |

For further information on the commands used in the example above, refer to the software reference guide for the Controller.

## Enabling STOP and PAUSE Keys

In addition to the function keys and numeric keypad, there are three other keys. The STOP key, and the PAUSE and CONTINUE keys are enabled by default, and can be disabled by user commands.

Typically, if an application uses the STOP key, the key will be enabled (DSTP1) in the power-up sequence. However, the STOP key can be enabled and disabled in any sequence, and at any time.

The PAUSE and CONTINUE keys can be enabled in any sequence. The DCNT command enables the PAUSE and CONTINUE keys.

If SSH is enabled (SSH1), the STOP key will function as a controlled stop. After motion is halted, the Controller will resume command processing with the command directly following the command that was stopped with the STOP key.

## Sample Program

This section provides an example of an RP240 application program. Refer to the Software Reference Guide for a more detailed description of the commands.

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### *Power-up Sequence*

A configuration sequence can be used to initialize the Controller to a state compatible with the RP240 and used to initialize variables.

```
XE63
XD63
LD3 1DSTP1
VAR20=5
VAR21=1
XG21
XT
```

### *Sequence*

In this example sequence #21 provides the main menu for a demonstration program. Control is transferred to another sequence based on a function key input.

```
XE21
XD21
1DCLR0
1DPC106
1DTXT"DIGIPLAN'S RP240 DEMO PROGRAM"
1DPC200
1DTXT"ACCESS"
1DPC235
1DTXT"EXIT"
VAR1=FUN
IF(VAR1=1)
        XG22
ELSE
        IF(VAR1=6)
                1DCLR0
                HALT
        ELSE
                1DPC220
                1DTXT"WRONG BUTTON!"
                T1
                XG21
        NIF
NIF
XT
```

### *Sequence #22*

Sequence #22 prompts you for a password, and then transfers control to sequence #23. If the password is incorrect, control is passed to sequence #21.

```
XE22
XD22
1DCLR0
1DPC100
1DTXT"ENTER CODE NUMBER xxxx"
1DPC118
VAR1=NUM
IF(VAR1<1234 OR VAR1>1234)
        1DPC220
        1DTXT"WRONG NUMBER"
```

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```
        T1
        XG21
ELSE
        XG23
NIF
XT
```

### *Sequence #23*

Sequence #23 asks you to make a selection via the function keys. Control is passed to a sequence based upon the function key pressed.

```
XE23
XD23
1DCLR0
1DPC101
1DTXT"JOG  I/O   TEACH  MAKE  FEED        EXIT"
1DPC201
1DTXT"AXIS TEST MODE   MOVE TO LENGTH"
VAR1=FUN
IF(VAR1=1)
        XR24
ELSE
        IF(VAR1=2)
                XR25
        ELSE
                IF(VAR1=3)
                        XR26
                ELSE
                        IF(VAR=4)
                                XR27
                        ELSE
                                IF(VAR1=5)
                                        XG28
                                ELSE
                                        IF(VAR1=6)
                                                XG21
                                        NIF
                                NIF
                        NIF
                NIF
        NIF
NIF
XG23
XT
```

Note a more compact form of the IF, ELSE code would be:

```
.
IF(VAR1=1) XR24 NIF
IF (VAR1=2) XR25 NIF
IF (VAR1=3) XR26 NIF
.
etc
```

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### *Sequence #24*

Sequence #24 simulates jogging. You can select CW or CCW jog options of either high or low velocity. The default jog velocities are stored in variables 20 and 21, which were assigned in sequence #63. The MENU RECALL key is used to exit Jog mode.

```
XE24
XD24
A75
VAR1=0
1DCLR0
1DPC101
1DTXT"CW   CW    CCW  CCW  STOP"
1DPC201
1DTXT"LOW  HIGH  LOW   HIGH  MOTION"
MC
VAR1=FUN
REPEAT
        VAR3=0
        WHILE(VAR3=0)
                IF(VAR1=1) H+ V(VAR21) G NIF
                IF(VAR1=2) H+ V(VAR20) G NIF
                IF(VAR1=3) H- V(VAR21) G NIF
                IF(VAR1=4) H- V(VAR20) G NIF
                IF(VAR1=5) 1DCLR0 1DPC212 1DTXT"INVALID SELECTION" T1 XG23 NIF
        VAR3=1
        NWHILE
        REPEAT
                VAR1=FUN
        UNTIL(VAR1=6)
        SB
        T0.3
        VAR1=FUN
UNTIL(VAR1=0)
V0
MN
XT
```

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### *Sequence #25*

Sequence #25 provides input status information and changes the state of LEDs.

```
XE25
XD25
1DCLR0
1DPC100
1DTXT"INPUT STATUS"
1DPC200
1DTXT"UPDATES"
1DPC233
1DTXT"OUTPUTS"
REPEAT
        VAR1=FUN
        1DPC113
        IF(IN_1) 1DTXT"1" ELSE 1DTXT"0" NIF
        IF(IN_X1) 1DTXT"1" ELSE 1DTXT"0" NIF
        IF(IN_XX1) 1DTXT"1" ELSE 1DTXT"0" NIF
        IF(IN_XXX1) 1DTXT"1" ELSE 1DTXT"0" NIF
        IF(IN_XXXX1) 1DTXT"1" ELSE 1DTXT"0" NIF
        IF(IN_XXXXX1) 1DTXT"1" ELSE 1DTXT"0" NIF
        IF(IN_XXXXXX1) 1DTXT"1" ELSE 1DTXT"0" NIF
        IF(IN_XXXXXXX1) 1DTXT"1" ELSE 1DTXT"0" NIF
        IF(IN_XXXXXXXX1) 1DTXT"1" ELSE 1DTXT"0" NIF
        IF(IN_XXXXXXXXX1) 1DTXT"1" ELSE 1DTXT"0" NIF
UNTIL(VAR1=6)
1DCLR0
1DPC100
1DTXT"THE LEDS BELOW WILL CHANGE STATE"
1DLED00000001 T1
1DLED00000011 T1
1DLED00000111 T1
1DLED00001111 T1
1DLED00011111 T1
1DLED00111111 T1
1DLED01111111 T1
1DLED11111111 T1
1DLED00000000 T1
VAR=0
XT
```

The 10 input bits in sequence #25 correspond to the total number of Controller user inputs.

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### *Sequence #26*

Sequence #26 sets up the learning mode for moves.

```
XE26
XD26
MPA
MN
VAR30=1
VAR29=1
VAR28=33
REPEAT
        1DCLR0
        1DTXT"HOW MANY MOVES TO TEACH?_x"
        1DPC200
        1DTXT"(MAXIMUM OF THREE MOVES)"
        1DPC125
        VAR30=NUM
UNTIL(VAR30>0 AND VAR30<4)
L(VAR30)
PZ
1DCLR0
1DTXT"PLEASE MAKE MOVE# "
1DVO29,2,0,0
1DPC200
T1
XR24
XR(VAR28)
VAR29=VAR29+1
VAR28=VAR28+1
N
VAR1=0
XT
```

### *Sequence #27*

Sequence #27 runs the pre-programmed moves defined by sequence #28.

```
XE27
XD27
A100
MPI
PZ
V10
VAR29=40
L(VAR30)
XR(VAR29)
G
VAR29=VAR29+1
N
VAR1=0
XT
```

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### *Sequence #28*

Sequence #28 prompts the operator to select the feed length, maximum speed and to count the number of items to be cut.

```
XE28 XD28
1DCLR0 1DPC100
1DTXT"SELECT FEED LENGTH, MAX SPEED, AND COUNT"
T2 1DCLR1
REPEAT
        VAR30=0
        1DPC102
        1DTXT"ENTER FEED LENGTH IN INCHES: (0-99.9)"
        1DPC212
        1DTXT"FEED LENGTH=xx.x"
        1DPC224
        VAR2=NUM
        IF(VAR2>99.9 OR VAR2<0)
                1DCLR0
                1DPC215
                1DTXT"OUT OF RANGE"
                T2
                1DCLR2
                VAR30=1
        NIF
        IF(VAR30=0)
                1DCLR0
                1DPC112
                1DTXT"FEED LENGTH="
                1DPC125
                1DVO2,2,1,0
                1DPC202
                1DTXT"YES"
                1DPC236
                1DTXT"NO"
                VAR22=FUN
        NIF
        IF(VAR22>1)
                1DCLR0
                1VAR30=1
        NIF
UNTIL(VAR30=0)
1DCLR0
REPEAT
        VAR30=0
        1DPC101
        1DTXT"ENTER MAX SPEED (RPM): (0-2400RPM)"
        1DPC215
        1DTXT"MAX SPEED=xxxx"
        1DPC225
        VAR3=NUM
        IF(VAR3>2400 OR VAR3<0)
                1DCLR0
                1DPC215
                1DTXT"OUT OF RANGE"
                T2
                1DCLR2
                VAR30=1
        NIF
```

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```
        IF(VAR30=0)
                1DCLR0
                1DPC114
                1DTXT"MAX SPEED"
                1DPC125
                1DVO3,4,2,0
                1DPC202
                1DTXT"YES"
                1DPC236
                1DTXT"NO"
                VAR22=FUN
        NIF
        IF(VAR22>1)
                1DCLR0
                VAR30=1
        NIF
UNTIL(VAR30=0)
1DCLR0
REPEAT
        VAR30=0
        1DPC103
        1DTXT"ENTER TOTAL NUMBER OF CUTS: (1-100)"
        1DPC210
        1DTXT"TOTAL # OF CUTS=xxx"
        1DPC226
        VAR4=NUM
        IF(VAR>4100 OR VAR4<1)
                1DCLR2
                1DPC215
                1DTXT"OUT OF RANGE"
                T2
                1DCLR2
                VAR30=1
        NIF
        IF(VAR30=0)
                1DCLR0
                1DPC113
                1DTXT"# OF CUTS="
                1DPC124
                1DVO4,3,0,0
                1DPC202
                1DTXT"YES"
                1DPC236
                1DTXT"NO"
                VAR22=FUN
        NIF
        IF(VAR22>1)
                1DCLR0
                VAR30=1
        NIF
UNTIL(VAR30=0)
1DCLR0
1DPC201
1DTXT"START"
1DPC235
1DTXT"EXIT"
REPEAT
        VAR22=FUN
        IF(VAR22<6 AND VAR22>1)
                1DCLR0
                1DPC212
```

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```
            1DTXT"INVALID SELECTION"
            T2
            1DCLR0
      NIF
UNTIL(VAR22=6 OR VAR22=1)
IF(VAR22=6)
      XG23
NIF
1DCLR0
VAR5=VAR2*25000
VAR6=VAR3/60
VAR7=VAR4


LD3 MN A100 V(VAR6) D(VAR5) 1DPC211 1DTXT"# LEFT TO CUT:"
L(VAR4) 1DPC225 1DVO7,3,0,0
G VAR7=VAR7-1
T.1 N
1DCLR0 1DPC213 1DTXT"JOB COMPLETED!" T1.5 1DCLR0 XG23
XT
```

Short service sequences used to set up distances in the self learn mode.

```
XE33 XD33
VAR6=POS XT
XE34 XD34
VAR7=POS XT
XE35 XD35
VAR8=POS XT
XE40 XD40
D(VAR6) XT
XE41 XD41
D(VAR7) XT
XE42 XD42
D(VAR8) XT
```

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# Section 7. PROGRAMMING

## Communicating with the Positioner

The positioner is designed to work in one of two modes:

a) The human interactive mode
b) The computer host mode

The command EX1 enables the first of these and the command EX0 the second. In the human interactive mode, the positioner will respond to a dumb terminal in an intelligent, user friendly manner and provide the user with help facilities and error messages if errors occur. In the host computer mode all unsolicited output and help information is suppressed so that communication may be handled by software resident in the host computer.

If a computer is to be used for the terminal function, terminal emulation software will be required. The X-Ware program available from Digiplan for use with IBM PC's and compatibles is suitable for this purpose. X-Ware is supplied with the product.

### Individual Commands

An individual positioner command controls a single parameter, function, or action such as acceleration, velocity, position, time delay, pause, loop, go, etc. There are two classes of individual commands, Immediate and Buffered.

Individual commands are variable in length. They can consist of one or more letters with a delimiter (carriage return or space character) and one or more letters and numbers with a delimiter. Each command is entered as a character/delimiter combination. Some commands include a sign (±) to denote direction of motion. The number of characters used depends on the type of command entered.

Typical commands have the form:

**1E**
**S**
**A10**
**V3**
**D46000**

When two or more individual commands are entered on the same line, they are separated by spaces, and multiple command entries will be displayed on a single line of your terminal screen.

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The example below shows a set of individual command entries with space delimiters on the same line:

**MN A10 V2 D25000 L10 G N**

If spaces are used as the delimiter and a large number of multiple command entries are made, you could exceed the ability of your terminal to display characters as a single line (80 characters per line is a typical value). When the carriage return is used as a delimiter, the cursor returns to the beginning of the next line.

**NOTE**: The Positioner will normally echo carriage return with carriage return line feed in terminal mode. If you get double line spacing you need to turn off the auto line feed facility on your terminal. In computer mode (EX0) only the characters received are echoed.

The example that follows shows the effect of using carriage return as the delimiter when the terminal is not in auto line feed.

**MN**
**A10**
**V2**
**D25000**
**L10**
**G**

## Immediate Commands

Commands that are identified as "Immediate" are executed immediately on receipt and will take priority over whatever operation is in progress. These commands include various Stop commands that clear the command buffer, and various Status Request commands that have no effect on the command buffer.

## Buffered Commands

Commands that are identified as "Buffered" are received by the positioner and stored (in the command buffer) if the positioner is not free to execute them. Stored commands are executed as soon as the positioner gets to them, in the order that they were received.

### *Buffer Capacity*

Any combination of individual commands and command groups can be entered in the buffer until the total number of characters currently stored (including the delimiters) equals 2000. The positioner uses a first-in-first-out serial buffer. As the commands are read from the buffer, additional commands can be entered to replace them. Therefore, the possibility exists that a command set could actually consist of more than 2000 characters. Examples of command sets that might be used for different applications are presented later.

The sequence buffer is different from the command buffer in that it can be copied to battery backed up RAM using the SV command, while the command buffer is not battery backed up, so its contents are lost on power down.

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### Multiple Positioner Commands

When multiple positioners are on the communications daisy chain, commands like the previous example are executed by all positioners on the chain. To send commands to a single positioner, the device address of that positioner should be put in front of the instruction. The device address is set using the DIP switch on the individual positioner.

Example:

Three positioners are on an RS232C chain. They are sent the following commands:

**MN A10 V10 1D25000 2D50000 3T1 3D100000 G**

Unit 1 moves 25000 steps, unit 2 moves 50000 steps, and unit 3 waits 1 second and moves 100000 steps. All three use the same move profile rates.

During sequence download to one axis in a chain, all of the other axes must have their communication switched off by use of the F command. The alternative is to make each command in the sequence device specific by adding the device address.

## Programming Modes

### Normal Mode

The command MN selects normal mode. In this mode moves are set by the D command. Within normal mode there are two options, absolute mode and incremental mode.

#### *Absolute Mode*

The command MPA puts the positioner into absolute position mode. Distances entered using the D command are interpreted as absolute positions relative to absolute zero.

Example:

| | |
|---|---|
| **MPA** | Sets absolute mode |
| **PZ** | Sets current position to be absolute zero |
| **D4000** | Sets move to absolute position 4000 |
| **G** | Execute move |
| **D2500** | Sets move to absolute position 2500 |
| **G** | Executes move of 1500 steps CCW |

#### *Incremental Mode*

The command MPI puts the positioner into incremental positioning mode. D command distances are interpreted as the number of steps to move from the current position.

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Example:

| | |
|---|---|
| **1MPI** | Sets incremental mode |
| **1PR** | Response=1500 (current position) |
| **1D4000** | Sets move to be 4000 steps CW |
| **1G** | Executes move to position 5500 |
| **1D-3000** | Sets move to 3000 steps CCW |
| **1G** | Executes move to position 2500 |

### *Continuous Mode*

The command MC selects continuous mode in which the motor runs continuously at the specified velocity until stopped or a new velocity is programmed. Distance data is ignored.

Example:

| | |
|---|---|
| **MC** | Sets continuous mode |
| **D4000** | Ignored in continuous mode |
| **A50** | Sets acceleration to 50 revs/sec$^2$ |
| **V20** | Sets velocity to 20 revs/sec |
| **G** | Motor runs at 20 revs/sec continuously |
| **V10** | Motor speed changes to 10 revs/sec |
| **S** | Motor stops |

The MQ command allows speed changes to be made during a preset move. The speed changes can be triggered at a set distance using the TRD command or by an input using the TRE command.

Example:

| | |
|---|---|
| **3MQ** | Set MQ mode for axis 3 |
| **3A50** | Set axis 3 acceleration to 50 revs/sec$^2$ |
| **V15** | Set velocity to 15 revs/sec |
| **D8000** | Set move distance to 8000 steps |
| **G** | Start move |
| **TRD3000** | Go to next command at D = 3000 steps |
| **V5** | Change velocity to 5 revs/sec |
| **TRE_X1** | Go to next command when Input 2 goes high |
| **V2** | Change velocity to 2 revs/sec |

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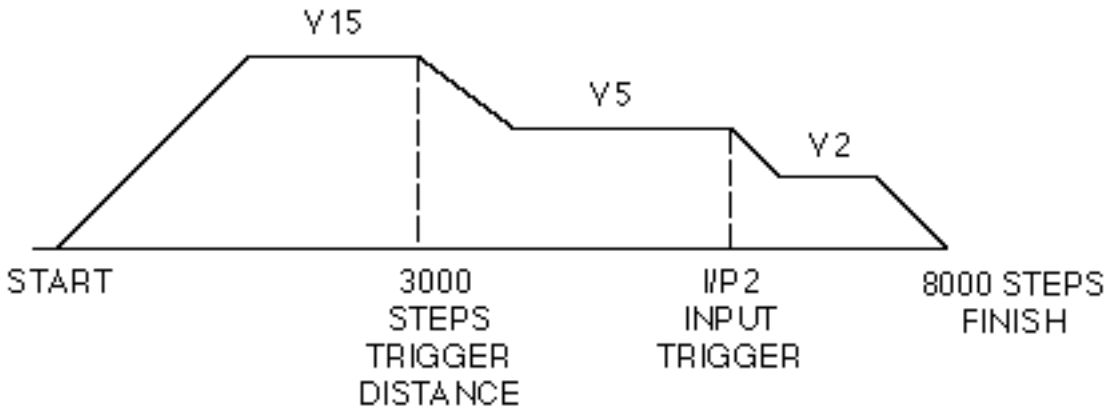



**Figure 7-1. Speed Change Mode**

# Command Types

## Start Move Commands

The positioner reads and stores individual commands in the order they are entered. Each command is read and executed before the next command is read. The GO command "G" is the principal buffered command that initiates shaft motion. When the buffer reads a GO command, the motor will then move in accordance with the move parameters that reside in the positioner at the time the Go command is read.

When the Go command is read, the positioner will incorporate any motion parameter command that was encountered prior to the Go command. For example, the "A " command would be combined with the Go command to change the acceleration value as follows:

**A123 G**

These commands instructs the Positioner to change the acceleration value to 123 rev/sec/sec and then execute the move using the last mode, velocity, and distance values that were previously entered.

When the RS232C positioner is initially activated, a series of commands of the form " MN An Vn Dn G " is required. These command sets up the initial operating conditions for the positioner. After the positioner has been initialised, single move parameter commands can be used.

If only "G " is entered, the positioner will repeat the previous motion pattern. For example, a string of Go commands:

**G G G G**

would instruct the positioner to move the motor the same way four times.

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There is no need to re-enter all the shaft motion commands to change one of the variables. If one or more of the motion parameters is changed by a command entry and the Go command is then entered, the prior pattern will be repeated using the new motion parameter(s) that were entered prior to the latest GO command.

For example:

**A14 G V2.6 G D-27634 G**

would change acceleration to 14 and move, then change velocity to 2.6 and move with 14 as the acceleration value, then change position and move again using 14 and 2.6 as the acceleration and velocity values.
The CONTINUE command "C " is used following execution of a PAUSE command, "PS " or "U ". CONTINUE will allow execution of the next command waiting in the command buffer (if any command is stored).

## Loop Commands

The LOOP command allows a cycle to be repeated continuously "L" or a given number of times "Ln" up to 65535. The END-OF-LOOP command "N" indicates where the loop ends. The "N" command can be used to indicate that the positioner should proceed with further commands after the designated numbers of loops have been executed, or in combination with the "Y" command to indicate where execution is to stop. The "U" command may be used to temporarily halt Loop execution, the C command will then cause the loop to resume execution.

## Stop Move Commands

The STOP MOVE commands are presented in order of severity of response. SOFTWARE RESET "Z" command is the most abrupt and severe stop command you can use. The STOP AT END OF CURRENT LOOP command "Y" is the least abrupt and severe stop command.

### *Stop at End of Current Loop Y*

Also the 'stop sequence' command.

This command will not halt processing until command processing reaches the character N at the end of the command loop. At that time, the Positioner will execute the next command in the buffer after N, if any. The command loop cannot be restarted without re-entering the commands.

### *Controlled Stop command S*

In the PRESET or CONTINUOUS mode this command will decelerate the motor to a stop at the last used acceleration rate.

An "S " command will always cause a deceleration to velocity zero at the last used acceleration.

The "S " command clears any remaining commands in the command buffer unless prevented from doing so via the SSH command.

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**NOTE**: Normally, the motor is decelerated to a stop at the same rate as it was accelerated.

### *Controlled Stop command LS*

The LS or 'Limit Stop' command will decelerate the motor to a stop at the deceleration rate defined by the LA or 'Limit Acceleration' command.

### *Kill Command K*

This command stops positioner commands to the motor. In addition it terminates a loop, ends a time delay, and aborts a command sequence download in progress (XD command). The command buffer is also cleared.

### *Software Power-on Reset Z*

The "Z " command is equivalent to cycling the AC power to the Positioner; that is, it disables the communications interface and returns all internal settings to their power-on values. The command buffer is cleared. Like the "K " command, "Z " causes an immediate cessation of torque signal to the motor. Z also de-energises and resets the drive ready for re-initialisation at power up.

**NOTE**: When the "Z " command is used, the Positioner is busy for up to 2 sec and will ignore any commands. The status indicator will be blank for this period.

## Pause Commands

There are four types of pause commands available as follows:

### *Pause and wait for continue command C to continue*

A common use of the Buffered Pause PS is to hold execution of individual commands in a Command Loop until the entire loop has been loaded.

### *Tnnn*

Pause in processing commands for a given number of seconds and then continue.

### *U*

Hold (pause) now and wait for continue. This is an immediate command.

### *TRE*

Pause in processing commands until the designated TRIGGER condition is met.

Triggers are used to synchronise positioner operations with external events. They can be used to implement a "handshaking" function with other devices. See command details for exact syntax.

## Status Request Commands

All status request commands result in data being returned to the controller from the positioner. To prevent multiple positioners from all responding at once, the status request commands are given the classification "Device Specific" meaning that the device address of

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the responding positioner must be placed in front of the command. No positioner will execute a Device Specific command without its device number.

The use of status request commands must be conducted in an orderly fashion. Commands should only be issued when the host is ready to read the response. New commands should not be sent until the response is received. In particular, after a buffered status command, an immediate status command should not be sent until the response has been received by the host. If this procedure is not followed, the command responses will be intertwined, rendering the information useless.

There are two status commands that can be used to request position.

The DPA Command will report how many steps the motor has moved relative to the absolute zero position. This position is calculated by summing the total number of moves commanded since the positioner was at the absolute zero position. If position reports are needed that are relative to the beginning of each individual move, the PR command should be used.

## Using the Evaluation Commands

The IF, WHILE and UNTIL commands contain fields that are evaluated to provide conditional program flow. The evaluation statement is contained in parentheses after the IF, WHILE and UNTIL commands. A space or underscore (_) indicates each comparison.

IF(condition)..commands..ELSE..commands..NIF
REPEAT..commands..UNTIL(condition)
WHILE(conditional)..commands..NWHILE

The conditions take the form of a set of evaluation statements:

1. INnnnnn_nnnnnnnnnn: compare to input status

LMT+ LMT- HOME AUX_IN STOP _
IN1 IN2 IN3 IN4 IN5 IN6 IN7 IN8 IN9 IN10

2. Variable compares:

   VARn>VARn
   VARn=VARn
   VARn<VARn

A constant, POS (the present value of the position counter), ABS (the present value of the absolute position) or FEP (follower encoder position) can be substituted for the variable.

3. AND: Boolean AND operation

4. OR: Boolean OR operation

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**Example**

| Command | Description |
|---|---|
| **IF(IN_10 OR VAR1=3)** | If input 1 is active and input 2 inactive or the user variable 1 equals 3 then execute sequence 1, else execute sequence 2 |
| **XR1** | Execute sequence 1 |
| **ELSE** | ELSE command |
| **XR2** | Execute sequence 2 |
| **NIF** | End of IF |
| **VAR5=POS** | Set variable 5 to current indexer position |
| **REPEAT** | Repeat command |
| **XR5** | Execute sequence 5 |
| **T5.0** | Delay 5 seconds |
| **H** | Change direction |
| **UNTIL(POS>VAR5 AND IN_00)** | If inputs 1 and 2 are inactive and the position counter is greater than VAR5, execute the next command. Else, jump to the repeat command |
| **VAR6=POS** | Set variable 6 to current indexer position |
| **WHILE(ABS>VAR6 AND IN_00)** | If the absolute position is greater than VAR6 and inputs 1 and 2 are inactive, execute the following commands, else execute the command following the NWHILE command |
| **XR7** | Execute sequence 7 |
| **T2.0** | Delay 2 seconds |
| **NWHILE** | End of WHILE - jump to WHILE command |

## Drive Energise/De-energise Function

Energising and de-energising the drive is subject to the commands given and error status as follows:

*The drive will energise if:-*

The ST0 or ON command is given when the WATCHDOG signal is inactive.

*The drive will de-energise if :-*

The ST1 or OFF command is given.

The WATCHDOG signal become operative.

An EXCESSIVE POSITIONING ERROR or an EXCESS TORQUE demand occurs.

The de-energising signal must be restored, then the ST0 or ON command must be given to re-energise the drive.

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## Homing Function

The GH command causes the motor to rotate in the direction and at the speed specified until the home position is reached. In practice, it continues a little beyond this point but you can locate the home position accurately by then using the commands:

**MPA D0 G**

This move is unnecessary if the first move after homing is made in absolute mode (MPA). (The GH command always makes the home position zero)

The SP command can be used after homing to change the accurate home position from zero if required.

If the home position is not found in the direction given in the GH command, the limit switch position will be reached and the switch will be operated. The motor will then reverse and seek the home position in the opposite direction. For recognised home detection, the home switch must always be activated from the direction specified in the command (shown by the arrow in Figure 7-2), so as illustrated in this figure, a limit switch reversal will take place if the direction given in the GH command is away from the home position (GH+ in the illustration).

If the limit switches are activated and no home position is found, the homing routine is aborted and an error message is returned.

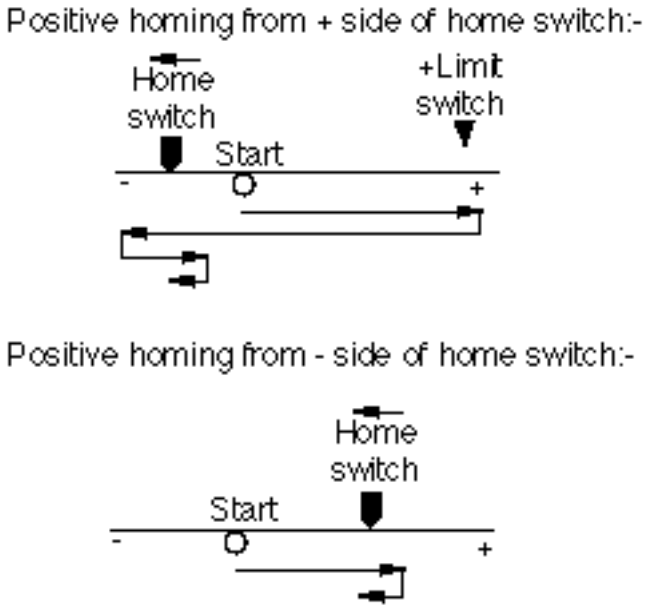



**Figure 7-2. Positive Homing**

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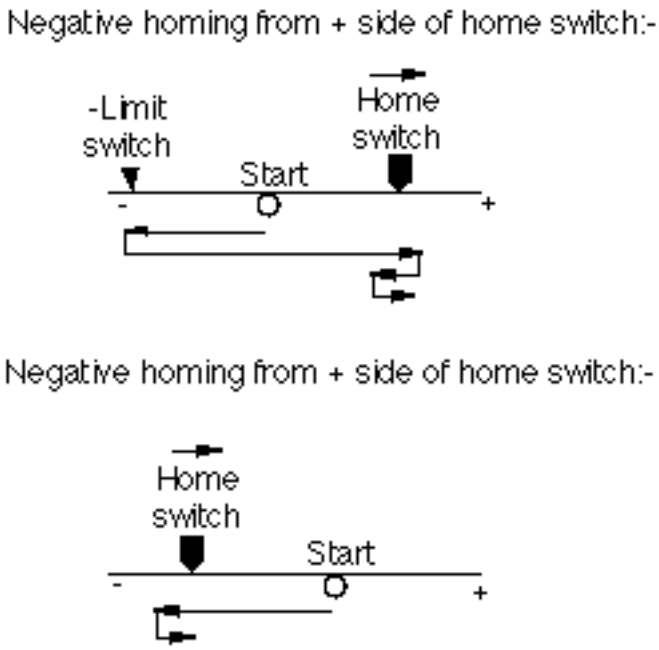



**Figure 7-3. Negative Homing**

Option OSA enables homing to an encoder index mark within the home proximity range, as opposed to the home switch edge. The mark is always approached from the specified direction. Using an index mark to determine the stopping point results in the home position remaining fixed even if there are small variations in the operating point of the home switch. The final home position will be the leading edge of the first index pulse following detection of the home switch edge.

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## Basic Programming Guide

This section uses examples of simple programs as an introduction to programming and explains the use of the command language.

The system configuration is a brushless servo motor with a 500 line/rev encoder. 4X decoding is used and the user resolution has been set to 2000 steps/rev. Tuning the servo loop is dealt with in the section headed "Servo Tuning", so we will assume that it has been completed. The address select switch has been set for unit 1. The motor starting position is 400 steps CW from the home position.

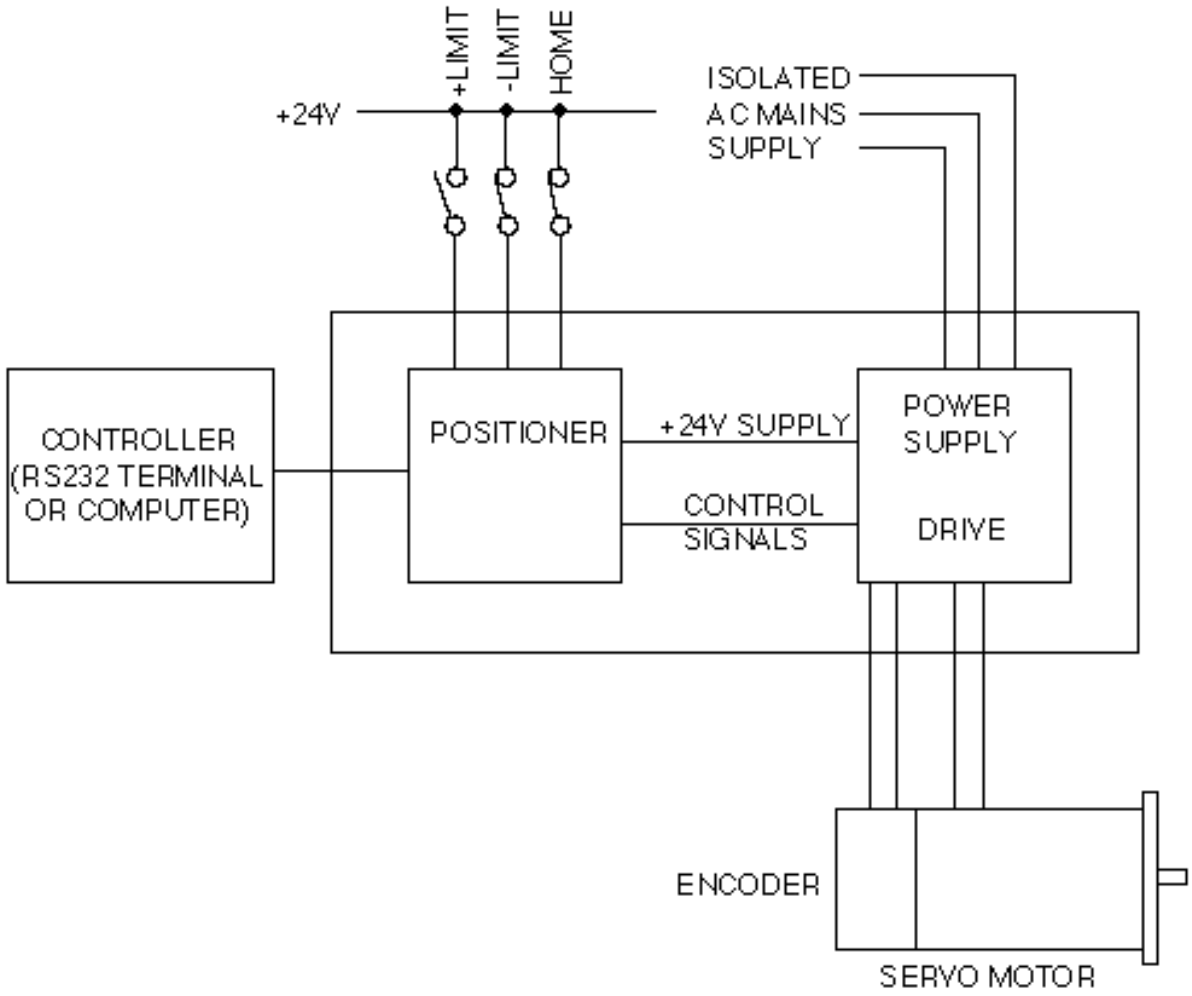



**Figure 7-4. System Used in Example Programs**

### *Example 1*

In this simple example the requirement is to cause the motor to perform two revolutions in a CW direction and stop.

The following commands in the order shown will fulfil the requirement:

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| Command | Purpose |
|---|---|
| **MN** | Set move mode to normal |
| **1A10** | Set acceleration motor 1 = 10 |
| **1V5** | Set velocity motor 1 = 5 |
| **1D8000** | Set move distance motor 1 = CW 2 revs |
| **1G** | Start move - motor 1 moves 2 revs CW |

### *Description*

Commands cause motor 1 to accelerate at 10 revs/sec$^2$ to a velocity of 5 RPM, travelling CW for 8000 steps (2 revs) at the G command.

### *Example 2*

This example causes axis 1 to go to the home position, then turn 5 revolutions CCW at 10 revs/sec and set the resulting position as absolute zero. The motor finally turns 8 revolutions CW to finish at absolute position 32000.

| Command | Purpose |
|---|---|
| **ST1** | Energise the drive |
| **A10** | Set acceleration to 10 revs/sec$^2$ |
| **V10** | Set velocity to 10 revs/sec |
| **GH-2** | Send axis 1 to go home (2 revs/sec CCW) |
| **1D-20000** | Set axis 1 to go 5 revs CCW |
| **G** | The axis moves to the required absolute position |
| **MPA** | Set absolute position mode |
| **PZ** | Set position to absolute zero |
| **1D32000** | Set move to abs. position 32000 (8 revs CW) |
| **G** | Move to position 32000 (1 rev CW from starting position) |
| **1PR** | Report absolute position |

### *Description*

Commands 2 - 6 cause the motor to go to the home position and then turn 5 revolutions CCW. Command 7 sets the absolute positioning mode and Command 8 sets the resulting position as absolute zero. Commands 9 and 10 cause the motor to turn 8 revolutions CW to absolute position 32000.

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# Programmable I/O Functions

## Programmable Inputs

You can program each input or define them to correspond to a function. To define an input to a particular function use the IN command. The user definable inputs are labeled IN1 to IN10 on the front panel. The remaining inputs are dedicated as Limit+, Limit-, Home, Stop and Aux-In.

All input functions have be assigned a letter - refer to the IN command in the ***X150/X150E Software Reference User Guide***.

To program an input to perform a function, use the IN command followed by the input number and the corresponding function letter.

For example

**1IN7H** Set input 7 as direction toggle.

The active input level can be defined using the polarity links 13,15 and 17. Refer to Section 3 for information relating to link selection.

To view the current status of the user definable inputs type 1IN. All user definable inputs will be displayed.

## Verifing Input Wiring

To verify that you have wired the inputs correctly for your application use the IS command. This command reports the active state of all inputs regardless of the function assigned to them.

| Command | Response |
|---|---|
| 1IS | 000000_0000000000 |

This indicates that no inputs are active.

The switching level and active state of the inputs can be configured using links. 3 banks of 5 inputs can be set using links 12-17. The active level of the input will be affected by the position of these links, however the IS command will always indicate the on/off status of any input regardless of the position of these links.

| Command | Response |
|---|---|
| 1IS | 000000_1000000000 |

This indicates that input 1 is active.

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### *Set Up Example*

The limit inputs are to be connected to PNP normally closed proximity switches. The Home switch is connected to a normally open PNP proximity switch. Input 4 is to be configured as a kill input active when 0V is applied to the input. Inputs 6,7 and 8 are sequence select lines and input 9 is a sequence strobe line which is connected to the PNP ouput stages of a PLC. The stop input is active when +24V is applied to the input. All inputs operate at 24V dc.

LK1 in position A (+24V DC)
LK12 in position A (+24V DC sense)
LK13 in position B (active high)
LK14 in position A (+24V DC sense)
LK15 in position A (active low)
LK16 in position A (+24V DC sense)
LK17 in position A (active low)

Configure inputs as follows :

1IN4C Configure input 4 as kill input
1IN6N Configure input 6 as a data input
1IN7N Configure input 7 as a data input
1IN8N Configure input 8 as a data input
1IN9N Configure input 9 as a data input
1IN10W Configure input 10 as a sign bit
1OUT3J Configure output 3 as a strobe output
1OUT4J Configure output 4 as a strobe output
1OUT5J Configure output 5 as a strobe output

Note the limit switches are normally closed. When a limit is reached the switch will open and the controller input will get pulled low by the pull-down resistor on the active high input. This is the reverse of what the controller is expecting, therefore the sense levels of both limit inputs will need to be reveresed using the INL command.

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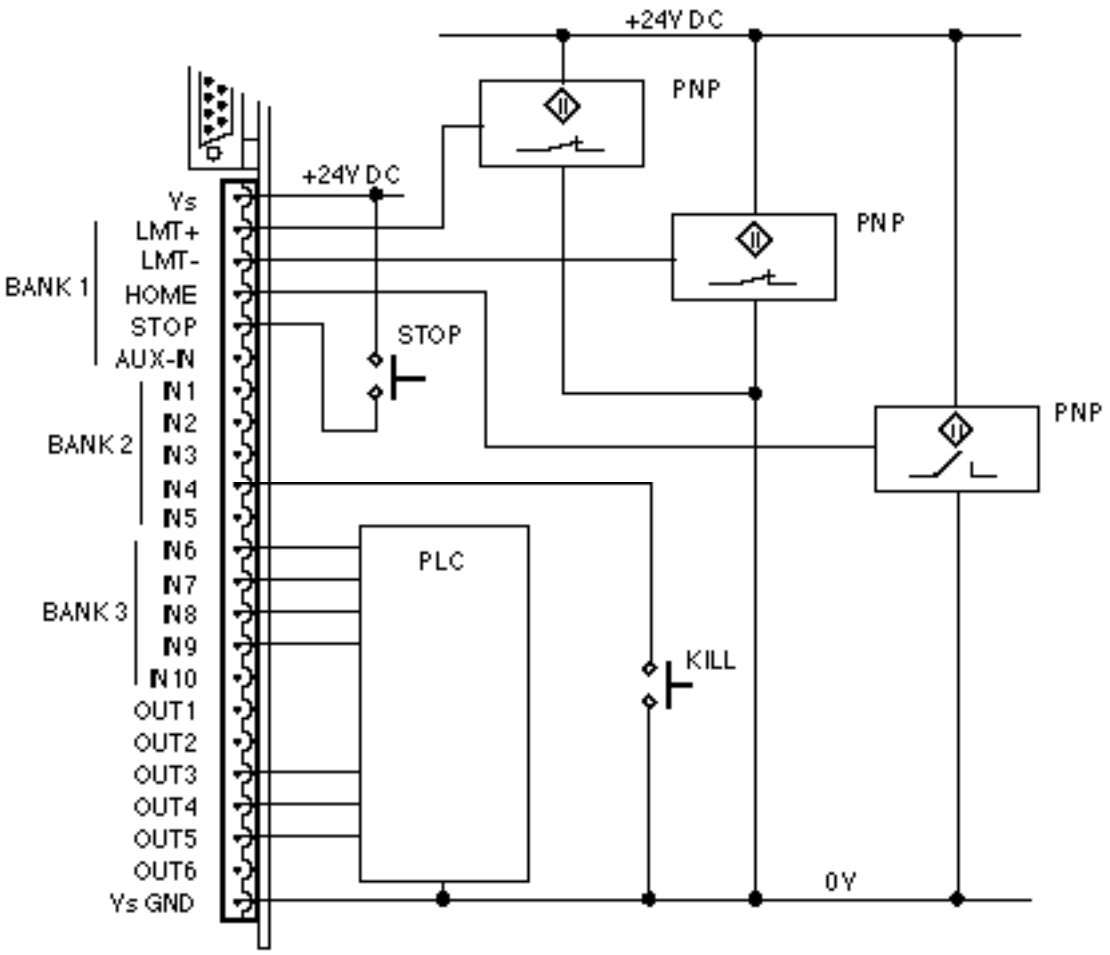



**Figure 7-5 Input Example**

## Programmable Output

You can program each output, or configure it to perform to a particular function. There are 6 user definable outputs which can be NPN or PNP (specified by the user at purchase). The outputs are provided on an interchangeable PCB (refer to Section 3).

To allocate an output to a particular function use the OUT command. The user definable outputs are labelled OUT1 to OUT6 on the front panel. All output functions have been assigned a letter, refer to the OUT command in the software section.

To program an output to perform a function, use the OUT command followed by the output number and the corresponding function letter.

For example

**1OUT3T** Set output 3 as in position.

To view the current status of the user definable output type 1OUT. All user definable outputs will be displayed.

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The response of the output to an active level will depend upon the type of output module fitted.

Note: Although it has been stated that all output functions can be defined using the OUT command there is one exception to this:

OUTPUT 1 can be configured as a composite fault output using the SSD command. When SSD is set to 1 then output 1 is configured as a composite fault output and overrides the function defined by OUT. SSD must be set to 0 for output 1 to be configured using the OUT command.

### *Verifying Output Operation*

You can directly control each output using the output command 0. Using this command you can force any output to the desired state, in order to do this the output must be configured as a programmable output (function A).

| Command | Description |
|---|---|
| **> 1O1X0** | Turn output 1 on, ignore output 2 and turn off output 3. |

### *Using Programmable Outputs*

Programmable outputs can be used to interface with other parts of the system in order to indicate such things as in position, sequence in progress, fault or a user defined function.

The following steps demonstrate how you can configure these outputs.

Example
Output 1 is to be configured as a composite fault output. Output 3 is to indicate when the motor is moving and Output 5 is to indicate when the motor is in position.

| | |
|---|---|
| **1SSD1** | Set output 1 as composite fault |
| **1OUT3B** | Set output 3 as moving / not moving |
| **1OUT5T** | Set output 5 as in position output |

Typing 1OUT will display

```
;Output 01 Function F
;Output 02 Function A
;Output 03 Function B
;Output 04 Function A
;Output 05 Function T
;Output 06 Function A
```

## Output Hardware

Outputs can be NPN or PNP, supplied on a plug in module. The two possible output circuits are shown in Figure 7-6.

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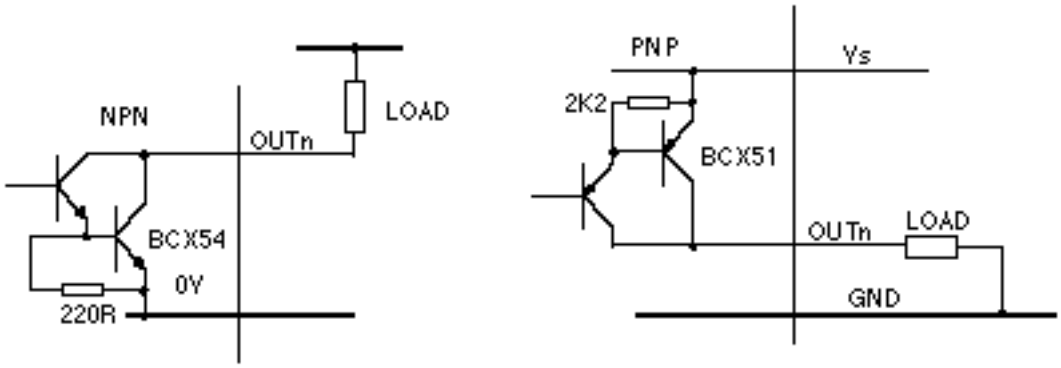



**Figure 7-6 Output Hardware Modules**

# Sequences

## Introduction

A sequence is a series of commands that is executed in order whenever the sequence is run. Immediate commands cannot be stored in a sequence since they cannot be stored in the command buffer. *The only "saveable in sequence" commands are buffered commands.*

The positioner has a section of non-volatile RAM totalling 8000 characters allocated for storing up to 64 sequences. The sequence buffers are of variable length, so they can store long sequences of up to 8000 characters or several shorter ones, provided that the total length of all sequences does not exceed the allocated 8000 character space.

During normal operation a command can specify the execution of any sequence stored in memory.

Sequence identifiers: number from 1 - 64.

When a sequence is programmed, the controller automatically calculates a checksum for the sequence and stores the length of the sequence and its checksum in an internal directory.

The command XSS can be used to verify the existence of a sequence.

If a power-on sequence is used, the sequence and its sequence number are stored in the non-volatile RAM.

## Programming Sequences

Sequences are programmed by first sending a special start command XD, which clears the command buffer. All subsequent commands are stored in the command buffer (but not

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executed) until an end of sequence command (XT) is received. Any condition which prevents proper recording of the sequence is saved and can be accessed with the status command XSD. The programmed sequence can be tested with the run sequence command XR, which executes any specified sequence.

The XU command can be used to read back the entered sequence.

To begin the programming of a sequence, the XD command immediately followed by sequence identifier number (1 to 64) and a delimiter must be entered. An XT command ends the sequence. The save command SV should be used to store the sequence into the controller's non-volatile memory.

The commands entered after the XD command and before the XT command will be executed in the order in which they were entered when the sequence is run.

Example:

**NOTE**: The ">" prompt is replaced by the "$" prompt when in sequence edit mode. If the numbered sequence already exists, it must first be erased using the XE command.

| Command | Description |
|---|---|
| **XE1** | Erase previous sequence No.1 |
| **XD1** | Begin definition of sequence No.1 |
| **A10** | Set acceleration to 10 revs/sec/sec |
| **V10** | Set velocity to 10 revs/sec |
| **D4000** | Set move distance to 4000 steps |
| **G** | Go |
| **H** | Reverse next move |
| **G** | Go |
| **XT** | End of sequence |

* The definition of sequence No.1 is terminated by XT but the sequence is NOT stored in non-volatile memory until
the save command SV is given.

**NOTE**: Put LK8 in position A on the controller card (see Figure 3-16) to write-protect sequences.

Whenever the above sequence is run, the motor will turn 1 revolution CW and then 1 revolution CCW.

## Running Sequences

### *By Command Input*

A sequence can be run by entering the XR command immediately followed by a sequence identifier number (1 - 64) and a delimiter.

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Example:

XR3[space] runs sequence No.3

### *Standalone Operation*

Stored sequences may be automatically executed when you power up the system or executed by remote switches, RP240, TM8 and thumbwheel.

A sequence selected as a binary pattern, set on inputs using the INnO command can be run in response to a sequence strobe set on an input using the INnB command.

Example
Inputs 1 to 4 are to be used as sequence select lines.
Input 5 is to be used as a sequence strobe line.
Programs have been stored in sequences 1 to 16.

| | |
|---|---|
| LSD | 1IN1OSet input 1 as sequence data input |
| . | 1IN2OSet input 2 as sequence data input |
| . | 1IN3OSet input 3 as sequence data input |
| . | 1IN4OSet input 4 as sequence data input |
| MSD | 1IN5BSet input 5 as sequence strobe input. |

A binary pattern is configured on the inputs corresponding to the decimal sequence number. On a logic 0 to 1 transition of the sequence strobe input, the sequence corresponding to the binary pattern will be executed.

If a sequence is already running when the sequence strobe is activated the sequence strobe will be ignored. A sequence in progress must be terminated before execution of the next sequence strobe.

### *Power On Sequence*

One of the stored sequences can be designated to be executed when the device is powered up. The sequence to be executed can be selected by prior RS232C command (XP1-64). The single sequence specified is executed once; control then passes to the RS232 link. Alternatively, power-on execution can be disabled with either the XP0 or XZ commands.

It is possible to have the controller execute a sequence on power up by defining the commands within a sequence using the XD, XT and XP commands. To define sequence No.1 the operator enters:

**XP1 XD1 MN A10 V5 D40000 G XT 1SV**

In this example the operator would not power the unit on until he was ready for the sequence to begin. The XP1 command enables a single run of sequence No.1 after power on. The XD1 command signifies the start of the definition of sequence No.1 and the XT

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command signifies the end of the sequence No.1 definition. When the operator applies power to the positioner, sequence number 1 will be executed (the motor will turn 10 revolutions in the positive direction). The sequence can be stopped using the S command or, if necessary, by using the emergency stop.

### *Changing a Programmed Sequence*

Once a sequence is defined it cannot be redefined until it has been deleted. A new sequence cannot be downloaded over an existing one.

To change a sequence, it must be deleted from memory and then redefined as a new sequence using the same number.

First, the sequence must be deleted from memory using the XE command. It will not be deleted from back-up RAM unless the SV command is used after the XE.

Example:

**XE1** erases sequence No.1

The changed sequence should then be entered. It will not be saved to non-volatile memory until the SV command is issued.

### *Examining the Contents of a Sequence*

If the operator wishes to check the contents of the sequence, he would enter:

**1XU1**

This would cause the positioner to send the contents of sequence number 1 to the terminal's screen. The 1 preceding the XU command is the device address which must be present since the XU command is a "device specific" command. After issuing this command the following will be displayed on the terminal's screen:

**;Sequence 1 is: MN A10 V5 D40000 G**

This is the command string that is performed when sequence number 1 is executed.

If the operator does not wish to have the sequence execute on power up, it can be cancelled by issuing either the XP0 or XZ command.

Sequence no.1 can also be run manually using the XR command.

### *Sequence Status Requests*

Sequence status commands include XC, XSD, XSP, XSR, XSS. The XC command can be used to verify that the memory in the back-up RAM has not been corrupted in any way since last power down. The XC command will cause the positioner to send a checksum in the form of three decimal digits (000 - 255) to the terminal. The checksum may be recorded when sequences have been defined, so that it may be used for comparison later, such as each time the positioner is powered up.

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### *Sequence Debugging Tools*

After creating your sequences, you may need to debug them to ensure that they are performing properly. The Controller provides several debugging tools.

- In trace mode, you can trace a sequence as it is executing
- You can single step through a program
- Error messages can be enabled explaining why the Controller has stopped execution

### *Trace Mode*

You can use the trace mode to debug a sequence or a program of sequences. The trace mode allows you to track, command by command, the entire sequence. It displays to your terminal, over the RS-232C serial link, all of the commands as they are executed. The following example demonstrates the trace mode.

Step 1
Create the following sequence:

| Command | Description |
|---|---|
| **XE1** | Erases sequence #1 |
| **XD1** | Begins definition of sequence #1 |
| **A10** | Acceleration is 10 $rps^2$ |
| **V5** | Velocity is 5 rps |
| **L5** | Loop 5 times |
| **GOSUB3** | Jump to sequence #3 |
| **N** | Ends the loop |
| **XT** | Ends the definition of sequence #1 |

Step 2
Define the sequence #3.

| Command | Description |
|---|---|
| **XE3** | Erases sequence #3 |
| **XD3** | Begins definition of sequence #3 |
| **D50000** | Sets the distance to 50000 steps |
| **G** | Initiates motion |
| **XT** | Ends the definition of sequence #3 |

Step 3
Enter the following command to enable the Trace mode.

| Command | Description |
|---|---|
| **1XTR1** | Enable the trace mode |

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Step 4
You will now execute the sequence. The commands will be displayed on the terminal as each command in the sequence is run. Enter the following command:

| Command | Description |
|---|---|
| **XR1** | Run sequence #1 - response is: |

```
*SEQUENCE 001 COMMAND A10
*SEQUENCE 001 COMMAND V5
*SEQUENCE 001 COMMAND L5
*SEQUENCE 001 COMMAND GOSUB3 LOOP COUNT 1
*SEQUENCE 003 COMMAND D50000 LOOP COUNT 1
*SEQUENCE 003 COMMAND G LOOP COUNT 1
*SEQUENCE 003 COMMAND XT LOOP COUNT 1
*SEQUENCE 001 COMMAND N LOOP COUNT 1
*SEQUENCE 001 COMMAND GOSUB3 LOOP COUNT 2
*SEQUENCE 003 COMMAND D50000 LOOP COUNT 2
*SEQUENCE 003 COMMAND G LOOP COUNT 2
*SEQUENCE 003 COMMAND XT LOOP COUNT 2
*SEQUENCE 001 COMMAND N LOOP COUNT 2
*SEQUENCE 001 COMMAND GOSUB3 LOOP COUNT 3
*SEQUENCE 003 COMMAND D50000 LOOP COUNT 3
.
.
.
.
.
*SEQUENCE 003 COMMAND G LOOP COUNT 5
*SEQUENCE 003 COMMAND XT LOOP COUNT 5
*SEQUENCE 001 COMMAND N LOOP COUNT 5
*SEQUENCE 001 COMMAND XT
```

The format for the trace mode display is:

Sequence Number Command Loop Count

Step 5
To exit the trace mode, enter the following command:

| Command | Description |
|---|---|
| **XTR0** | Exits Trace mode |

### *Single-Step Mode*

You can debug your program with another level of debugging using the Single-Step mode. Single-Step mode allows you to execute one command at a time when you want the

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command to be executed. Use the XST command to enable Single-Step mode. Once you are in the mode, you can execute a sequence one command at a time. To execute a command, you must use the # sign. By entering a # followed by a delimiter, you will execute the next command in the sequence. If you follow the # sign with a number (n) and a delimiter, you will execute the next n commands. The following steps illustrate the use of Single Step mode:

Step 1
Enter Single-Step mode

**XST1**

Step 2
Begin execution of sequence #1

**XR1**

Step 3
You will not execute any commands until you use the # command. Type the following:

| Command | Description |
|---|---|
| # | Executes one command |

The response will be:

*SEQUENCE 001 COMMAND A10

Step 4
To execute more than one command at a time, follow the # sign with the number of commands you want executed.

| Command | Description |
|---|---|
| **#3** | Executes 3 commands, then pauses sequence execution |

To complete the sequence, use the # sign until all the commands are completed. To exit Single-Step mode, type:

**XST0**

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# Section 8. SERVO TUNING

## Tuning the Drive with a Positioner

The positioner is designed to operate with the drive configured as a torque amp, and this is the usual mode of operation described here.

### Tuning Positioner with Drive in Torque Amp

To obtain smooth rotation at optimum speed and accurate positioning of the motor without overshoot or oscillation, with the motor connected to your system, you must tune the gain and damping characteristics of the servo loop. The TUNET command provides a self-tuning feature but for some applications the best results will be obtained by manual tuning using the commands listed at the end of this appendix, together with those from the ***X150/X150E Software Reference User Guide***. Refer to the servo loop block diagram shown in Figure 8-1. The parameters affecting tuning are as follows.

### Tuning Parameters

#### *Proportional gain (CPG command)*

Proportional gain determines the amount of torque produced in response to a given position error. It sets the stiffness of the system and affects the following error. A high proportional gain gives a stiff, responsive system but results in overshoot and oscillation which require damping.

#### *Velocity gain (CVG command)*

Velocity feedback is a signal which increases with shaft speed. It acts in a negative sense opposing the proportional action and helping to stabilise the motion. The damping action of velocity feedback allows a higher proportional gain to be used.

#### *Integral gain (CIG command)*

Proportional action may be insufficient to overcome static position errors due to friction. Integral action accumulates a steady state error until sufficient torque is produced to move the load. It improves overall positioning accuracy but may produce low frequency oscillation around the commanded position.

#### *Feedforward gain (CFG command)*

The opposing action of proportional and velocity gains result in a position error which depends on speed. This is called "following error". Feedforward gain can be used to offset the following error and improve tracking accuracy. This is important in contouring applications.

#### *Filter time constant (CTG command)*

Fast positioning systems need high proportional and velocity gains. By limiting the bandwidth, the digital filter prevents a high gain system from becoming too lively. The filter also serves to average the effects of the digital control loop, reducing the jitter at standstill and the audible noise. The value of CTG should be kept as low as possible.

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You can examine these parameters by using the DR command.

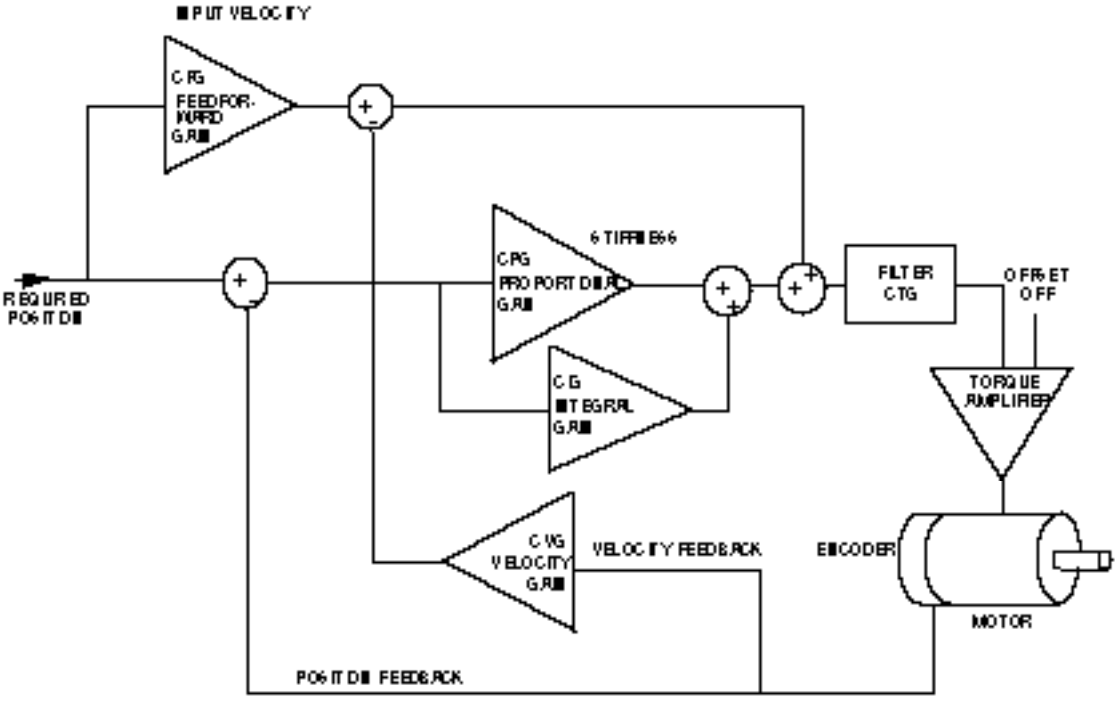



**Figure 8-1. Servo Control Loop**

### *Terminal/Computer*

The terminal/computer communication should be set to to 9600 baud, no parity, full duplex (not local), 1 stop bit.

After power up, the sign on message "DON'T PANIC Type HELP"' and the > prompt will appear on the screen unless you have previously set the positioner into the terse computer communications mode using EX0. In any case using the command 1DR will display the status of the positioner.

## Connecting the Loop

### *Safety*

It is advisable to have the STOP input wired to a stop switch located in an easily accessible position so that the system can be halted quickly in the event of instability causing oscillation. An alternative is to cut the power using the command OFF[CR] but this takes longer.

Unless you have saved data in the past while the motor was energised, the positioner will power on without attempting to move or energise the motor.

If any of the motor or encoder connections have been re-made or changed, the first step is to check the integrity and polarity of the motor connections. Proceed as follows:

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Make sure the axis is de-energized, type OFF[CR], if in doubt. Use the command :

aDS3[CR]

where a = the device address
to display the feedback position continuously (approximately 0).

Turn the motor shaft CW and check that the displayed value increases, turn the shaft CCW and it should decrease. If this does not happen you must not close the loop with ON at any time since the feedback will be positive.

Press [CR] to restore the > prompt.

## Manual Tuning Procedure

### *1. Initial Setting Up*

Type the commands CFG0 CPG0 CVG0 COFF0 CIG0 CTG0 to software disable the servo. Check the result of these commands with the command 1DR.

When the axis is energised, it will be open loop with a slight torque demand due to amplifier offsets. This may cause motion of the motor. You may have to restrain the axis and be prepared to switch off, or type OFF[CR]. In any case there is an automatic software limit set by the command CPE on the distance it will drift.

### *2. Position Error Window Setting*

The drive is disabled to protect the system if the position error goes outside of the position error window. The window can be set to a low number of steps to avoid damage due to overshoot or oscillation.

The value of CPE defines the size of the window in steps. It can be displayed by using the CPE command.

During tuning, CPE is normally set to 4000 steps i.e. 1 rev either way at the usual 4000 steps/rev. If in doubt set a lower value. The effect of going beyond the set error limit will be to automatically de-energise the motor.

Type the command RSE (report servo errors). This may show quite a list of errors. "Drive disabled by software command", "error limit exceeded" and "failed checksum of backup ram" are all acceptable at this point but "Drive fault" should not come up. If it does, check the LED on the drive front panel and try powering down the system and then powering it up again.

**DO NOT PROCEED IF A DRIVE FAULT PERSISTS**

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### *3. Energising the Axis*

Energise the axis by typing ON [CR]. You may find it convenient to restrain the axis to stop it drifting out of the error limit and de-energising. If it does de-energise, it can be restarted by typing ON.

### *4. Cancelling Drift*

Cancel any offset using the command aCOFF<value>[CR]. Negative values stop CW drift; positive values stop CCW drift. Values up to a few thousand are acceptable (the maximum is 32,000 corresponding to full torque demand). Only small values are normally required, for example 1COFF10.

Check that making COFF more positive tends to turn the motor CW and making it more negative tends to turn it CCW. If this does not happen, do not proceed, as the loop will have a net positive feedback and will oscillate (although probably slowly) when the loop is closed.

### *5. Closing the Loop*

Set a small position error limit (2000 steps for example) so that if oscillation occurs during tuning, the resulting overshoot producing large position errors will exceed the limit set by CPE and shut down the drive.

If necessary, first move the axis to a good starting point, then type ON[CR] to energise the motor and CPG1[CR] to close the loop. If a slight vibration appears at this point, it indicates positive feedback.
This should only occur if you have changed the motor or encoder connections. Taking care, displace the axis slightly and then let go. You should experience a slight spring effect and the axis should return to its original position - approximately. The closed loop is now working.

## Setting Up Servo Parameters

**NOTE:** When setting up servo parameters, do not allow the motor to go unstable for more than a second or two.

### *Tracking Applications*

For tracking applications (PID tuning), where minimum following error is required, velocity feedforward should be used to improve the tracking accuracy. This can be set using the CFG command or the CDG command can be used to set feedforward gain and velocity feedback gain to the same value.

## Point to Point Positioning Applications

For fast point to point positioning applications (PIVF tuning), a high proportional gain (CPG) damped by velocity gain (CVG)
should be used.

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### *Help Setting Loop Parameters*

A guide to servo loop parameter settings for a fully damped non-oscillating response is provided in HELP 11. To use HELP 11 you will need to be in terminal mode (EX set to 1) and you will need to provide a terminal address for the CJL and CTQ commands for the entry of inertia and torque data.

HELP 11 uses the maximum low speed motor torque entered by the CTQ command and the total moment of inertia entered by the CJL command in calculating suggested settings for the loop parameters.

First enter the values of CTQ and CJL (Motor + load inertia) for your system, then use HELP 11 to display recommended servo loop parameter settings calculated from the data you have entered. For example, if 3.6 is entered for the CTQ command to indicate a maximum torque of 3.6 Nm available and 1.6 is entered for the CJL command indicating a total inertia of 1.6 Kg/cm$^2$ , the following table will be displayed:

| Gain CPG | Velocity Gain CVG/CFG /CDG | Stiffness mNm/ step | Error @ maximum torque (fb steps) | Doubled T Constant (msecs) | 1/2 moved time (msecs) | Closed loop bandwidth (3db) (Hz) |
|---|---|---|---|---|---|---|
| 1000 | 190 | 110 | 33 | 1 | 2 | 67 |
| 500 | 130 | 55 | 66 | 2 | 3 | 48 |
| 250 | 95 | 27 | 130 | 3 | 5 | 34 |
| 120 | 67 | 14 | 260 | 7 | 7 | 24 |
| 62 | 47 | 6 | 520 | 6 | 10 | 17 |

**Table 8-1. HELP 11 - Servo Setup Table**

Each successive line of the table corresponds to a less highly tuned servo system with reduced stiffness and speed of response. These reduced values may be used in matching the servo to lower specification mechanics.

The following describes in more detail the terms used in the table:

### *Velocity Gain*

The settings of CVG, CDG and CFG depend upon the application as described above.

For the figures in the rest of the line of the table to apply, the CDG or CVG setting should be as in column 2.

For Position Integral Derivative (PID) applications, setting CDG to the figure quoted in the table will automatically set CVG and CFG to the same value.

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### *Stiffness*

Stiffness is the restoring force per unit of displacement. The force is dependent on the number of steps displaced from the demanded position. For example, a displacement of 100 steps with a stiffness of 10 mNm/step would produce a restoring force of 1 Nm.

### *Error at Maximum Torque*

As the axis is increasingly displaced from the demanded position, the restoring torque increases at the quoted stiffness until the maximum available torque is applied. The Error at Max Torque is the number of steps of displacement required to produce a restoring force of the maximum available torque.

### *Doubled T Constant*

When the damping is critical, the response of the servo loop is that of two simple filters in series, each having a time constant T. The value of T is quoted in the table.

### *1/2 Moved Time*

The following is an example move using servo values taken from the top line of the HELP 11 table to show the 1/2 moved time. The move is at maximum acceleration and velocity and it is initiated by the command string: D100 A0 V0 G

Figure 8-2 represents instantaneous position plotted against time for the resulting servo movement .

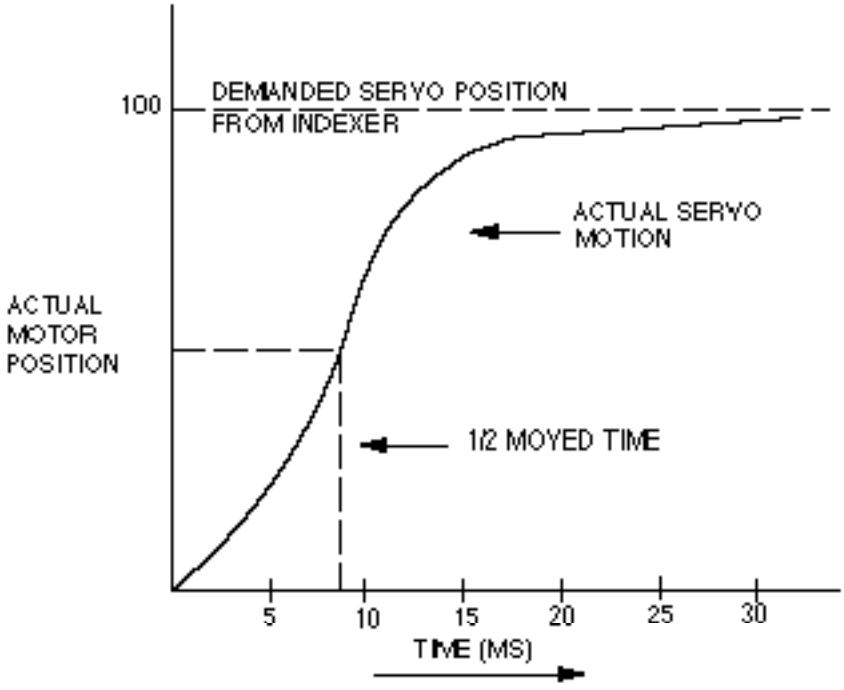



**Figure 8-2. Example Servo Response Curve**

The 1/2 moved time is the time taken to complete half of the move, 50 steps in this example.

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The move will be half complete in the time 1.7T (column 6 of the table) or 1.7 x 5 = 8 milliseconds approx.

The move will be 96% complete at time 5T. In the example, the motor will have moved 96 steps in 25ms.

### *Bandwidth*

The bandwidth of the servo system is the range of frequencies at which a sine wave move pattern input will be followed within 3db by the actual motion of the motor. Figure 8-3 shows the sine wave position demand input and the graphical representation of the motor movement.

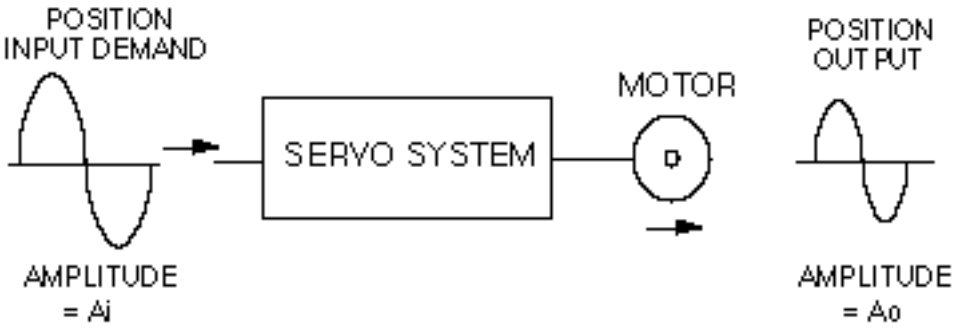



**Figure 8-3. Servo System Bandwidth**

As the frequency of the sine wave of demanded positions at the input (Ai) increases, the ability of the servo system to follow is reduced and the amplitude of the sine wave of the resulting output positions (Ao) decreases. The frequency at which it is reduced by 3db is the upper limit of the bandwidth.

### *Coarse Tuning the Loop*

Attach a nylon cable tie to the shaft of the motor. The loose end can be used as a coarse indicator for overshoot and oscillation.

Use the command string A0 V0 D200 G to produce a short, sharp rotation of the shaft. Observe the movement, watching the cable tie for overshoot and oscillation. Repeat the movement, increasing CPG using the settings suggested in HELP11 until overshoot just occurs.

Balance the increasing gain with damping by setting CVG to 10, 20, 40 ... Increase it until the oscillation and overshoot indicated by the cable tie ceases.

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### *Fine Tuning*

After coarse tuning the loop, continue balancing the gain and damping, monitoring the overshoot at the terminal by typing:

aDPE [space] G [space] [CR]

where a=the device address.

The CR should be entered quickly after typing the space following the G command - this will stop the position error display with the final positioning readings on screen to allow you to analyse them. Overshoot is indicated by the position error reading passing through zero at the end of the movement, then returning back through zero in the opposite direction, oscillating with decreasing error readings about the zero position before finally settling within the position error window. The damping should be increased to the point where overshoot just disappears. Too much damping will result in a sluggish movement.

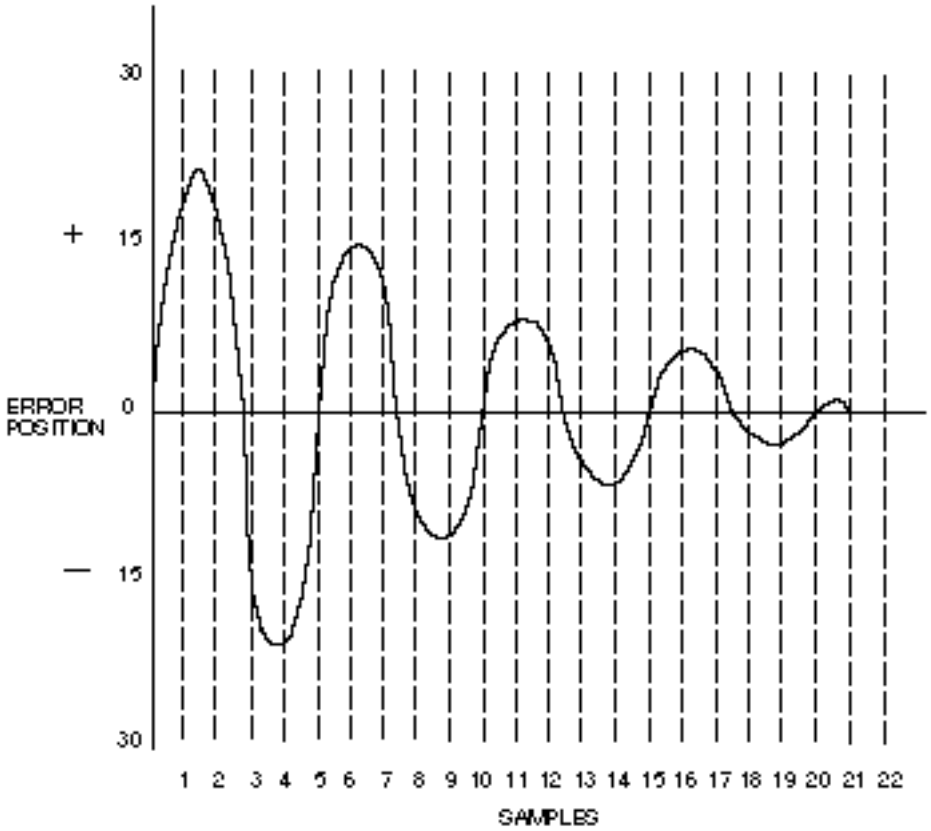



**Figure 8-4. Overshoot During Positioning**

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The following table shows the DPE readings for the final positioning graph of Figure 8-4. This is only an example to illustrate the general principles involved in tuning - in practice, the resulting figures may differ considerably from those given, but they will follow the general pattern shown. The overshoot shown here is rather more severe than might be generally expected.

| Samples | Readings | | | | | | |
|---|---|---|---|---|---|---|---|
| **1 - 7** | 23 | 22 | -17 | -20 | -5 | 14 | 12 |
| **8 - 14** | -7 | -10 | 0 | 6 | 4 | -3 | -4 |
| **15 - 21** | -2 | 4 | 3 | -2 | -3 | -1 | 0 |

**Table 8-2. DPE Readings During Final Positioning**

### *Notes on Tuning*

The TUNE command will show how much torque was used, with 1023 corresponding to saturation. If the maximum torque demand is significantly less than 1023 you should try increasing CPG. You will normally need to increase CVG as well in order to prevent overshoot. Make sure that the maximum torque never exceeds about 1000 to guarantee that the servo loop does not saturate.

The TUNE command also shows the time taken for the complete move as well as the settling time. This information is also useful in optimising the response.

To summarise:

1. Use DPE to look for overshoot and oscillation.
2. Use TUNE to check maximum torque demand, move time and settling time.

CFG, the feedforward gain should never be set very much larger than the velocity feedback gain (CVG). A setting of 20% more than CVG is the largest practical value.

An increase in gain is always best matched by an increase in damping; when this is no longer true you have reached the optimum values. A useful guideline is that an increase of times X in gain is best matched by an increase of times square root X in velocity feedback (think of this as an X% increase in gain matches an X/2% increase in damping e.g. 30% more gain matches 15% more damping). This will keep the shape of the response the same and just increase its frequency (you are holding a quantity called the damping ratio constant).

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### *Servo Self-tuning*

A facility for self-tuning the servo is included in the positioner software, using the command TUNET. The servo parameters are set at the time that they are executed and there is no continuous on-going adjustment (known as adaptive control).

Tuning is for the following characteristics:

- Stability - does not oscillate as it moves or settles
- Maximised stiffness and accuracy - deflects as little as possible in response to external forces
- Maximised bandwidth and speed of response - settles to the commanded position as quickly as possible at the end of a move
- Does not overshoot the end position in a move
- Minimal sound during motion or when holding position
- Tracks a profile of constantly changing position or velocity with as little error as possible
- Resistant to change as friction and other load characteristics vary from time to time, machine to machine, application to application and with production variations
- Operates for smaller loads than that used for tuning down to no load.

There are a number of other move related requirements:

- Make full use of the torque and power available so that the longest, fastest move possible can be made
- Perform equally well for fast or slow motions and for short or long moves
- Minimise heating effects in the motor and drive

It is not correct to adjust the servo loop parameters to meet these requirements as the general servo performance would be adversely affected. They are best met by adjusting the move profile (D, V and A values) and possibly the feedforward CFG value whilst watching for saturation effects.

If the application is purely velocity control with no requirement for positioning, then the tuning is best carried out manually. The self-tuning settings will work, but they will not produce the best achievable results.

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# Section 9. MAINTENANCE & TROUBLESHOOTING

## Section Objectives

The information within this section will help you to isolate and resolve system 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.

### 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:

#### *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.

#### *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.

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### *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 50°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. 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.

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## LED Display Messages

| Symptoms | Possible Causes | Solution |
|---|---|---|
| LED display 1 | Drive has been de-energised by user | Energise using STO or ON command |
| LED display 2 | Drive has failed | See drive manual |
| LED display 3 | Memory erased | Reconfigure controller |
| LED display 4 | Excessive positioning error | Check mechanics and system parameters. Check integrity of drive |
| LED display 5 | Memory failure | Reconfigure controller and save parameters, if fault persists contact Parker representative |
| LED display 7 | Torque demand exceeded | Ensure drive is capable of producing torque required. Check mechanics. |
| LED display 8 | Watchdog failure - Processor has run out of time | Cycle power. If fault persists contact Parker representative |
| LED display U | Communication error | Type 1R at system prompt. Check communication parameters |
| LED display E | Non recoverable communication error | Cycle power to controller |
| LED display P | Power levels to controller incorrect | Contact Parker representative |
| Motor will not move, but controller display is 0 | Stop or limits active | Ensure that the limits are set or disabled. Ensure stop is active |
| Cannot communicate with controller, but display is 0. | Ensure communication has not been disabled using the F command | Issue <a>E command |

**Table 9-1. LED Display Messages**

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## RS-232C Problems

Use the following procedure to troubleshoot communication problems that you may have with the controller.

[1] Be sure that the host computer's transmit (Tx) wire is connected to the peripheral's receiver (Rx) connection and the host computer's receive (Rx) wire is connected to the peripheral's transmit (Tx) connection. Switch the receive and transmit wires on either the host or peripheral if the problem persists.

[2] Confirm that the host is configured for 9600 baud, 8 data bits, 1 stop bit and no parity.

[3] If you receive double characters, for instance typing A and receiving AA, the computer is set to half duplex mode. Change the setup to full duplex mode.

[4} Cable lengths should not exceed 15 metres (50 ft.) unless you are using some form of line driver, optical coupler, or shield.

[5] To test the terminal or terminal emulation software and the RS-232C cable for 3-wire communication, disconnect the controller end and enter a character. You should not receive an echoed character. If you do, you are in half duplex mode. Connect the host's transmit and receive lines together and send another character. You should receive the echoed character. If not, consult the manufacturer of the host's serial interface for proper pin outs.

## Software Debugging Tips

This section offers some helpful tips for debugging your programs. The controller has several tools that can be used to diagnose system design problems. The software tools are listed below:

| | |
|---|---|
| IS | Input status |
| R | Report status |
| RA | Report limit status |
| RB | Report miscellaneous status |
| RE | Report drive status |
| RS | Report sequence status |
| RSE | Report servo errors |
| XSD | Report sequence download |
| XSR | Report sequence run status |
| XSS | Report sequence status |
| XST | Single step mode |
| XTR | Trace mode |

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### *Trace Mode*

Trace mode is used to display what is occurring as you execute a sequence. By running the trace mode you can see what commands are being executed and if the program stops running you can see what command was last executed. The trace mode will help you to find commands that the indexer may not recognise. Trace mode is enabled and disabled with the XTR command. When enabled, you will execute sequences as you normally would using XR. As the sequence is running, the commands are displayed on the screen. XTR1 enables the Trace mode, XTR0 disables it.

### *Displaying Status*

There are several command that you can use to check the controller status. You can report back the value or setting of almost all commands by typing the device address followed by the command then a carriage return or a space bar. In this way, you can find out what values you have entered in different commands. The DR command reports the current state of the controller. Use this to verify that the controller is configured as you want it.

The DFX command is also useful in determining the current status of the controller. The listing in chapter 5 (Software Reference) will allow you to interpret the response to DFX.

## 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).

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# Appendix A

## SIMPLE X150 COMMUNICATIONS PROGRAM FOR IBM PC OR COMPATIBLE (TURBO C)

```
#include <dos.h>
#include <bios.h>
#include <conio.h>

#define COM1                    0               /* Port number  */
#define PORT                    0x3F8           /* Port address */
#define DATA_READY              0x01            /* Line Status for Received data */
#define TRUE                    1
#define FALSE                   (!TRUE)

#define SETTINGS (0xE0 | 0x03 | 0x00 | 0x00)    /* 9600 BAUD, 8 Data bit
                                                   No Parity, 1 Stop bit */
void main(void)
{
        int ky, end = FALSE;
        char ch;

        clrscr();
        bioscom (0, SETTINGS, COM1);                    /* Setup port */
        cprintf("LIMITED X150 TERMINAL [ESC] to exit ...\n\r");
        while (!end)                    /* Main loop */
            {
            while (inportb (PORT+5) & DATA_READY)       * Data received ? */
                if ((ch = inportb (PORT)) != 0)
                    {
                    putch(ch);                          /* Show character */
                    if (ch == 0x0D) putch ('\n');
                    }
                if (kbhit())                            /* Keyboard pressed */
                    {
                    if ((ky = getch()) == '\x1B')       /* Was it ESCape ? */
                        end = TRUE;                     /* Signal quit */
                    outportb (PORT, ky);                /* Transmit keypress */
                    }
            }
}
```

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## BUFFERED COMMUNICATION PROGRAM USING COM1 ON AN IBM PC OR COMPATIBLE (BORLAND TURBO C)

```
#include  <conio.h>
#include  <dos.h>
#include  <stdio.h>
#include  <bios.h>
#include  "X150.h"                                  /* Header file for serial interface */

static char CircBuf [BSize];                        /* Declare circular buffer */
unsigned int BufStart = 0, BufEnd = 0;              /* Set buffer pointers up */
int Port;                                           /* Contains serial port address */
char *X150 = "\r1D\r1V\r1A\r1R\r";                   /* Settings commands for X150 */

void interrupt (*orgvect)();                        /* Interrupt function pointer */

/* Function prototypes */
void Enable_Int (void);                             /* Start everything */
void Disable_Int (void);                            /* Reset serial port */
void interrupt RX_Handler (void);                   /* Data Received handler */
int Send (char c);                                  /* Transmit a character */
void SendAString (char *string);                    /* Transmit a string */
int Receive (void);                                 /* Get received data from buffer */

void main (void)
{
        int c, end = FALSE;

        clrscr();
        Enable_Int();                               /* Start Interrupts */
        fprintf(stdout, "X150 TERMINAL\npress [ESC] to quit...\n\n");
        SendAString (X150);                         /* Interrogate X150 status */
        do {                                        /* Main loop */
             if (kbhit())                           /* Keyboard pressed ? */
                {
                if ((c = getch()) == 0x1B)
                    end = TRUE;                     /* if Escape pressed end program */
                Send (c);                           /* Transmit character */
                }
            if ((c = Receive()) != FALSE)           /* Anything received from X150 ? */
                {
                fputc (c & 0x07F, stdout);          /* Display character */
                 if (c == 0x0D) fputc ('\n', stdout);/* If CR do Carriage Return */
                }
            } while (!end);
            Disable_Int();                          /* Stop interrupts and tidy up */
}

void Enable_Int (void)                              /* Turn on communications interrupts */
{
        int c, far *Addr;

        bioscom (0, SETTINGS, 0);                   /* Setup comms parameters */
        Addr = MK_FP (0x0040, 0x00);                /* Find address of COM1 */
        Port = *Addr;
```

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```
        orgvect = getvect (0x0C);                       /* Install the interrupt handler */
        disable();
        setvect (0x0C, RX_Handler);
        c = inportb (Port + MCR) | MC_INT;              /* Setup Modem Control Register */
        outportb (Port + MCR, c);
        outportb (Port + IER, RX_INT);                  /* Enable interrupts for data received */
        c = inportb (IMR) & IRQ4;                       /* Tell PIC to interrupt on COM1 */
        outportb (IMR, c);
        enable();
}

void Disable_Int (void)                                 /* Turn off communications interrupts */
{
          int c;

        disable();
        c = inportb (IMR) | ~IRQ4;                      /* Stop PIC interrupts for COM1 */
        outportb (IMR, c);
        outportb (Port + IER, 0);                       /* Reset Interrupt Enable Register */
        outportb (Port + MCR, 0);                       /* Reset Modem Control Register */
        setvect  (0x0C, orgvect);                       /* Restore original vector */
        enable();
}

void interrupt RX_Handler (void)                        /* Interrupt handler - data to CircBuf */
{
        disable();
        if ((inportb (Port + IIR) & RX_MASK) == RX_ID)   /* Data received ? */
           {
           CircBuf[BufEnd++] = inportb (Port);
           BufEnd &= BSize - 1;
           }
        outportb (ICR, EOI);                            /* Acknowledge end of hardware interrupt */
        enable();
}

int Send (char c)                                       /* Output character to the serial port */
{
        long int TimeOut = 0xFFFFL;

        while ((inportb (Port + LSR) & XMTRDY) == 0)    /* Wait for transmitter */
        if (!(--TimeOut)) return (FALSE);
        disable();
        outportb (Port, c);                             /* Do transmit */
        enable();
        return (TRUE);
}
```

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```
void SendAString (char *string)                    /* Output a string to the serial port */
{
        while (*string)
            {
            delay(25); Send (*string++);
            }
}

int Receive (void)                                 /* Get the current value in the buffer */
{
        int RX;

        if (BufEnd == BufStart) return (FALSE);    /* Nothing received/Overflow */
        RX = (int) CircBuf[BufStart++];
        BufStart %= BSize;
        return (RX);
}
```

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## X150.H HEADER FILE FOR BUFFERED COMMUNICATION PROGRAM (BORLAND TURBO C)

```
#define BAUD            0xE0            /* BAUD rate of 9600        */
#define DATA            0x03            /* 8 Data bits              */
#define NOPARITY        0x00            /* No parity                */
#define STOP            0x00            /* 1 Stop bit               */
#define SETTINGS (BAUD | DATA | NOPARITY | STOP)

#define IER             1               /* Interrupt Enable         */
#define IIR             2               /* Interrupt ID             */
#define MCR             4               /* Modem control             */
#define LSR             5               /* Line Status              */

#define XMTRDY          0x20            /* Line Status Register TX ready    */
#define MC_INT          0x0F            /* Modem Control Register Setup     */

#define RX_INT          0x01            /* Interrupt when data is received  */

#define RX_ID           0x04            /* Interrupt Ident. Register Data Received  */
#define RX_MASK         0x07            /* Interrupt Ident. Register Mask           */

/* 8259 Programmable Interrupt Controller port addresses */
#define IMR             0x21            /* Interrupt Mask Register port     */
#define ICR             0x20            /* Interrupt Control Port           */
#define EOI             0x20            /* 8259 end of hardware interrupt   */
#define IRQ4            0xEF            /* COM1 mask for PIC                */

/* General definitions */
#define FALSE           0
#define TRUE            (!FALSE)
#define BSize           0x4000          /* Serial buffer size */
```

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## QUICK BASIC COMMUNICATIONS PROGRAM USING COM1 ON AN IBM PC OR COMPATIBLE

```
DECLARE SUB CommsError ()
DECLARE SUB ReportStat ()

FALSE = 0
TRUE = NOT (FALSE)

Setup the RS232 port to the following:-
9600 BAUD, No Parity, 8 Data bits, 1 Stop bit. Buffer size is 512 bytes
OPEN "COM1:9600,N,8,1,RS,CS,DS,CD,RB512" FOR RANDOM AS #1
PRINT #1, ""                            'Clear the buffer
CLOSE #1

'Re-establish communication port settings and data stream
OPEN "COM1:9600,N,8,1,RS,CS,DS,CD,RB512" FOR RANDOM AS #1

Finish = FALSE
CLS
DO
        INPUT "Enter the move or status string : "; STEPMOVE$       'Read in command
        IF STEPMOVE$ = "QUIT" THEN
                Finish = TRUE                                       ‘Enter QUIT to stop program
        ELSE
                FOR C = 1 TO LEN(STEPMOVE$)                         'Set loop count to string length
                B$ = MID$(STEPMOVE$, C, 1)                          'Get one char from string
                PRINT #1, B                                         'Transmit char to RS232 serial port
                R$ = INPUT$(1, #1)                                  'Read char in from port (Echoed char)
                IF R$ <> B$ THEN CommsError
                NEXT C

                PRINT #1, CHR$(13);                                 ‘Send a carriage return
                R$ = INPUT$(1, #1)                                  'Get Echoed response

                FOR cnt = 1 TO 500                                  ‘A short delay before response
                NEXT cnt

                CLS
                IF LOC(1) > 0 THEN ReportStat                       'Now check for rec buffer not empty
                END IF
LOOP UNTIL (Finish = TRUE)
CLOSE #1
END

SUB CommsError
        PRINT "There has been a communications error"
        CLOSE #1
        STOP
END SUB
```

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```
SUB ReportStat
        PRINT : PRINT "The reported status is as follows :-";
        PRINT : PRINT
        DO WHILE NOT (LOC(1) = 0)
                Report$ = INPUT$(1, #1)                 'Input status string data
                PRINT Report$;                          'Display status string
        LOOP
        PRINT
END SUB
```

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# Appendix B

## Fitting Longer Cables

When you order an ML motor, you can specify cable lengths up to 75 feet (22.5 metres). If possible, it is better to order the motor with the required cable length 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.
Note: extending cables as described here will degrade EMC performance of the system, by reducing the effectiveness of screen connections.
Motor cables can be lengthened by simply replacing the cable with a longer one using the standard cable as a pattern. It should 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 | 0.5$mm^2$<br>20 AWG<br>4-core | 0.75$mm^2$<br>18 AWG<br>4-core |
| 23 | 0.75$mm^2$<br>18 AWG<br>5-core | 1$mm^2$<br>16 AWG<br>5-core |
| 34 | 1.5$mm^2$<br>14 AWG<br>5-core | 1.5$mm^2$<br>14 AWG<br>5-core |

**Table B-1. 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 0.2$mm^2$ (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

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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 Lapp 0035805, 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 (Lapp 0034802 1 $mm^2$) and 2.5 $mm^2$ (or 14 AWG) cable for leads up to 300 feet (90m) long.

## Inserting in-line connectors

It is 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. Do not 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).

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## 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 | 5 | 1.0 | 9.0 | 0034 805 | | |
| 23 | 6 | 1.0 | 8.9 | | | 5366C |
| 23 | 6 | 0.75 | 7.8 | | | 5386C |
| 34 | 5 | 1.5 | 9.9 | 0034 905 | | |
| 34 | 5 | 1.5 | 13.2 | | | 5450/5 |

**Table B-2. Motor Cable Types**

| No. of cores | $mm^2$ | ODmm | Lapp | Cable-master | Belden | Alpha | National |
|---|---|---|---|---|---|---|---|
| 10 x 2 | 0.2 | 9.7 | | 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 B-3. Feedback Cable Types**

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