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Compumotor

AX Drive User Guide

Compumotor Division
Parker Hannifin Corporation
p/n 88-006938-03 E

Parker

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Table of Contents

CONTENTS i
Table of Contents i
List Of Figures iv
List Of Tables v
How To Use This Manual vi
Assumptions vi
Contents of This Manual vi
Installation Process Overview vii
Developing Your Application vii
Installation Recommendation viii
Key Terms viii
Conventions x
Highlighted Text x
Warnings (Personal Injury) & Cautions (System Damage) xi
Levels xi
Related Publications xi

Chapter 1. INTRODUCTION 1
Chapter Objective 1
Product Description 1
Product Features 2
Theory of Operation 3

Chapter 2. GETTING STARTED 5
Chapter Objectives 5
What You Should Have 5
Ship Kit Table 5
Basic System Configuration 6
Installation Label 6
Setting Drive Functions 6
Basic System Wiring Diagram 8
Transformer Connections (Optional) 9
Motor Connections 10
Power Connections 10
Establish Communications 11
Powering up the System 12
Deactivate Limit Inputs 12
Testing the System 13

Chapter 3. INSTALLATION 15
Chapter Objectives 15
Complete System Configuration 15
Setting Drive Output Current 16
Setting Indexer Address 16
Environmental Considerations 17
System Mounting 17
Motor Mounting 17
Drive Mounting 18
Encoder Mounting 20

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System Connections 21
Wiring Guidelines 21
System Pinouts 23
Extending Motor Cables 24
Transformer Connections (Optional) 24
Power Connections 24
Fan Connections 24
Encoder Connections 25
RS-232C Connections 26
Daisy-Chain Connections 26
I/O Connections 27
Verifying Proper Installation 31
Verifying RS-232 Link 31
Open-Loop Moves 32
Closed-Loop Moves 35
Inputs & Outputs 39
Coupling the Load 41

Chapter 4. APPLICATION DESIGN 43
Chapter Objectives 43
Motion Control Concepts 43
Move Profiles 43
Move Times 45
Incremental vs. Absolute Positioning Modes 46
Positional Accuracy vs. Repeatability 48
Application Considerations 49
Mechanical Resonance 49
Ringing or Overshoot 49
Modes of Operation 50
Open Loop Operation 50
Closed Loop Operation 54
Program Control 61
Triggers 61
Delays 61
Loops 62
POBs (Programmable Output Bits) 63
Move Completion Signal 63
Sequences 64
Stand-alone Operation 66
Host Computer Operation 68
PLC Operation 74
Model 72 (Thumbwheel) Operation 76
Tuning Procedure 76

Chapter 5. SOFTWARE REFERENCE 81
Chapter Objectives 81
Command Descriptions 81
Command Listing 84

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Chapter 6. HARDWARE REFERENCE 165
Chapter Objectives 165
Environmental Specifications 165
System Specifications 166
AX Drive Specifications 166
Motor Specifications (Compumotor-Supplied) 167
Inputs and Outputs 168
Non-Compumotor Motor Connections 174
Determining The 4-Lead Wiring Configuration 174
Determining The 6-Lead Wiring Configuration 174
Determining The 8-Lead Wiring Configuration 175
Terminal Connections 176
Factory Default DIP Switch Settings 177
Current Settings 177
Address Settings 178
Dimensional Drawings 179
AX Drive and Fan Dimensions 179
Motor Dimensions 180
Torque/Speed Curves 185
Special Motor Wiring 187
Wiring The 106-205 Motor 187
Wiring The 106-178 Motor 188

Chapter 7. MAINTENANCE & TROUBLESHOOTING 189
Chapter Objectives 189
Maintenance 189
Spare Parts Table 189
Motor Maintenance 190
Drive Maintenance 190
Troubleshooting 190
Reducing Electrical Noise 194
RS-232C Communications Troubleshooting 199
Returning The System 200

APPENDICES 201
Command Listing 201
ASCII Table 203

Glossary 205
Index 209

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List Of Figures

Figure 1-1. AX Drive System Functional Block Diagram 3

Figure 2-1. DIP Switch Location 6
Figure 2-2. System Wiring Diagram 8
Figure 2-3. Transformer Connections (Optional) 9
Figure 2-4. RS-232C Interface Connections 12

Figure 3-1. DIP Switch Location 15
Figure 3-2. Panel Layout Guidelines 19
Figure 3-3. Minimum-Width Panel Mount 19
Figure 3-4. Minimum-Depth Panel Mount 20
Figure 3-5. Mounting the Encoder to the Motor 21
Figure 3-6. AX Drive Pinouts 23
Figure 3-7. Encoder Connection Diagram 25
Figure 3-8. Encoder Input Circuit 26
Figure 3-9. Daisy-Chaining AX Drives 26
Figure 3-10. I/O Wiring Diagram 27
Figure 3-11. Typical I/O Circuits 27
Figure 3-12. Current Boost Circuits 30
Figure 3-13. Output Connections 30

Figure 4-1. Triangular Profile 44
Figure 4-2. Trapezoidal Profile 44
Figure 4-3. S-Curve Profile 45
Figure 4-4. PLC Connections 74
Figure 4-5. AX DIP Switch and Tuning Pot Locations 79

Figure 5-1. Command Example 81

Figure 6-1. AX Drive Pinouts and Connectors 168
Figure 6-2. Optical Isolation Circuit 171
Figure 6-3. I/O Wiring Diagram (Testing Only) 172
Figure 6-4. Encoder I/O Wiring Diagram 172
Figure 6-5. AX Encoder Connector I/O Circuit Diagram 173
Figure 6-6. Motor Wiring Diagram (Non-Compumotor Motors) 176
Figure 6-7. AX Dimensional Drawing 179
Figure 6-8. NEMA Size 23 Motor Dimensions 180
Figure 6-9. NEMA Size 34 Motor Dimensions 181
Figure 6-10. NEMA Size 42 (AX 106-120) Motor Dimensions 182
Figure 6-11. NEMA Size 42 (AX 106-178) Motor Dimensions 183
Figure 6-12. NEMA Size 42 (AX 106-205) Motor Dimensions 184
Figure 6-13. Wiring Diagram, 106-205 Motor 187
Figure 6-14. Wiring Diagram, 106-178 Motor 188

Figure 7-1. Noise Suppression Devices 194

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List Of Tables

Table 2-1. Ship Kit....5
Table 2-2. Compumotor-Supplied Motors....5
Table 2-3. Motor Current Settings for Compumotor-Supplied Motors....7

Table 3-1. DIP Switch Functions....16
Table 3-2. Valid AX Address Settings....16
Table 3-3. Environmental Specifications....17
Table 3-4. Extended Motor Cables....24
Table 3-5. Motor Wire Resistance Values....24

Table 4-1. Motor-to-encoder Ratios....54
Table 4-2. Sequence Select Inputs....66
Table 4-3. AX Waveform Settings....80

Table 6-1. AX Environmental Specifications....165
Table 6-2. AX Drive Specifications....166
Table 6-3. Compumotor-Supplied Motor Specifications....167
Table 6-4. Encoder Pinout....169
Table 6-5. Interface and I/O Specifications....170
Table 6-6. Encoder I/O Specifications....170
Table 6-7. Sequence Selection Table....171
Table 6-8. Dip Switch Functions....177
Table 6-9. Current Settings for Compumotor-Supplied Motors....177
Table 6-10. Motor Current Settings (Full Range)....178
Table 6-11. Device Address Settings....178
Table 6-12. AX 106-205 Motor Wiring....187
Table 6-13. AX 106-178 Motor Wiring....188

Table 7-1. Recommended Spare Parts for the AX System....189

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How To Use This Manual

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

Assumptions

This user guide assumes that you have the skills or fundamental understanding of the following information:

- IBM (or IBM-compatible) computer experience
- Basic electronics concepts (voltage, switches, current, etc.)
- Basic motion control concepts (torque, velocity, distance, etc.)
- Basic serial communication concepts (specifically RS-232C)

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

Contents of This Manual

This user guide contains the following information.

CHAPTER 1: INTRODUCTION

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

CHAPTER 2: GETTING STARTED

This chapter contains a detailed list of items you should receive with your AX Drive shipment. It will help you to become familiar with the system and ensure that each component functions properly. You will learn how to configure the system properly in this chapter.

CHAPTER 3: INSTALLATION

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

CHAPTER 4: APPLICATION DESIGN

This chapter will help you customize the system to meet your application's needs. Important application considerations are discussed. Sample applications are provided.

CHAPTER 5: SOFTWARE REFERENCE

This chapter explains Compumotor's X-Series programming language in detail. It describes command syntax and system parameters that affect command usage. An alphabetical listing of all commands, including individual command descriptions, is included.

CHAPTER 6: HARDWARE REFERENCE

This chapter contains information on system specifications (dimensions and performance). This chapter may be used as a quick-reference tool for proper switch settings and I/O connections.

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CHAPTER 7: MAINTENANCE & TROUBLESHOOTING

This chapter describes Compumotor's recommended system maintenance procedures. It also provides methods for isolating and resolving hardware and software problems.

Installation Process Overview

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

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

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

Developing Your Application

Before you attempt to develop and implement your application, there are several issues that you should consider and address.

1. Recognize and clarify the requirements of your application. Clearly define what you expect the system to do.
2. Assess your resources and limitations. This will help you find the most efficient and effective means of developing and implementing your application.
3. Follow the guidelines and instructions outlined in this user guide. **Do not skip any steps or procedures.** Proper installation and implementation can only be ensured if all procedures are completed in the proper sequence.

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Installation Recommendation

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

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

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

3. Complete the basic system configuration and wiring instructions provided in Chapter 2, Getting Started. *NOTE: This is a preliminary configuration, not a permanent installation, usually performed in a bench-top environment.*

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

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

6. After you have read Chapter 3 and clearly understand what must be done to properly install the system, you should begin the installation process. Do not deviate from the sequence or installation methods provided.

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

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

Key Terms

You should read and understand these terms and definitions before reading Chapter 1. Additional terms used in this user guide are defined in the Glossary.

BCD Binary coded decimal. A system of representing decimal numbers with binary numbers.

Bipolar The Drive current is bi-directional through each motor phase. There are two motor phases: *Phase A* (A+/A-) and *Phase B* (B+/B-).

Brownout Low-line voltage at which the device no longer functions properly.

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Daisy-chain	A term used to describe linking devices in sequence, such that a single data stream flows through one device and on to the next. Daisy-chained devices are distinguished by device addresses to indicate the desired destination for data in the stream. Up to eight AX Drives may be daisy-chained.
Dead Band	A range of input signals for which there is no system response.
Delimiter	A character (space or carriage return) used to separate fields in a command.
Drive	This is the electronics portion of the system that controls power to the motor. This portion controls the motor to provide micro-stepping.
Indexer	This portion of the system provides communication with the external I/O. It allows you to program sequences and direct motion control.
Micro-stepping	An electronic control technique that proportions the current in a step motor's windings to provide additional intermediate positions between poles. This produces high positional resolution and smoother rotation over a wide speed range.
PLC	Programmable logic controller. An industrial control device that turns on and off outputs based upon responses to inputs.
Quadrature	A type of incremental encoder output in which the two square wave outputs are offset by 90°.
RS-232C	A serial data communications standard that encodes a string of information on a single line in a time sequential format. The standard specifies the proper voltages and timing requirements so that different manufacturers devices are compatible.
Sequence	A series of motion control commands. These commands are created, stored, and executed from the indexer's EEPROM memory.
Short-Circuit	A defect in a winding which causes part of the normal electrical circuit to be bypassed. This frequently results in reducing the resistance or impedance to such an extent (near zero) as to cause overheating of the circuit, and subsequent burnout.

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Conventions

To help you understand and use this user guide effectively, the conventions used throughout this manual are explained in this section.

Highlighted Text

Several methods are used to highlight text. Explanations of special text and the way it is highlighted is presented below.

Commands

The command examples in this user guide are presented vertically to help you read and understand them. When you actually type these commands at your computer keyboard, they will be displayed horizontally on your computer. All commands that you are instructed to enter are displayed in all capital letters, just as they appear on your computer CRT. A one-line explanation of the command is provided next to each example. The command is displayed in boldface. Be sure to add a delimiter (space or carriage return) after each command in a sequence. Refer to the example below:

Command	Description
A5	Sets acceleration to 5 revs/sec^2 (rps^2)
V5	Sets velocity to 5 rps
D128ØØ	Sets distance to 12,800 steps
G	Executes the move (Go)

Bold face, quotation marks, or other forms of highlighting are not be used for command responses. Responses are set in all capital letters, as they are on the terminal. An example is provided below.

Command	Response
1XU4	A5 V5 D128ØØ G

The system generally ignores command syntax that is not within the valid range for a specific command (valid ranges are provided in Chapter 5, Software Reference). Compumotor does not guarantee system performance when the system executes commands that contain invalid syntax (outside the valid range).

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Warnings (Personal Injury) & Cautions (System Damage)

Warning and caution notes alert you to possible dangers that may occur if you do not follow instructions correctly. Situations that may cause bodily injury are presented as warnings. Situations that may cause system damage are presented as cautions. These notes will appear in bold face and the word warning or caution will be centered and in all capital letters. Refer to the examples shown below.

WARNING

Do not touch the motor immediately after it has been in use for an extended period of time. The unit will be hot.

CAUTION

System damage will occur if you power up the system improperly.

Italics are used to highlight other important material. Refer to the example below.

Example: Outputs 1 and 2 are user programmable. *Do not use outputs 3 and 4.*

Voltage Levels

In this manual, you will deal with inputs and outputs that you can turn on or off. We will define the terminologies needed for these inputs and outputs.

Inputs

ON (Ø, *low*)	Current flows
OFF (1, *high*)	No current flows

Command	Description
TRØ11	Waits for Trigger 1 to turn on and Triggers 2 and 3 to turn off

Outputs

ON (1, *high*)	Current flows
OFF (Ø, *low*)	No current flows

Command	Description
OØ1	Turns off Output 1 and turns on Output 2

Related Publications

The following publications may be helpful resources:

- Seyer, Martin. *RS-232C Made Easy: Connecting Computers, Printers, Terminals and Modems*, Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1984
- Parker Compumotor Motion Control Catalog
- Operations manual for the IBM or IBM-compatible computer that you will use with the AX Drive system
- Schram, Peter (editor). *The National Electric Code Handbook (Third Edition)*. Quincy, MA: National Fire Protection Association

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Chapter 1. INTRODUCTION

Chapter Objective

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

Product Description

The AX Drive combines the functions of a micro-stepping drive and an RS-232C Indexer in one compact system. The AX is easily programmed over RS-232C and has a set of 70 commands. The combination of the powerful command language and user-defined inputs and outputs allows you to develop complex motion control programs. You can create and store up to 7 programs in the AX Drive's non-volatile (EEPROM) memory. These programs can be executed remotely with simple BCD switches or a programmable logic controller (PLC). You can also execute these programs by sending an execute command over the three-wire RS-232C interface from a computer or terminal.

The AX Drive is available is the high-powered (6A max.) AXH model or the low-powered (3A max.) AXL model.

An additional feature of the AX Drive is the optically isolated encoder interface which permits closed loop operation. The interface is designed to operate with TTL quadrature (rotary or linear) incremental encoders.

The motors provided with the AX Drives are high-accuracy 1.8° hybrid step motors that have been optimized for smooth micro-stepping operation. Unique lamination materials ensure low power losses and low heating when driven by the AX's 16 to 20 Khz pulse width modulated amplifiers.

AX Drives feature switch-selectable motor currents, eliminating the need for motor/drive matching. Amplifier adjustments are available to the user to compensate for typical motor-to-motor variations. This is important for critical applications that require maximum smoothness.

The AX is compatible with the Compumotor Model 72 and Model 72-I/O interface. The Model 72 provides adjustable thumbwheel switches to enter and change AX motion control parameters.

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Product Features

The AX Drive provides the following features:

- System is available in the high-powered version (AXH) or the low-powered version (AXL)
- Each model includes a motor along with a drive, indexer, heatsink, cables, and power supply in a single compact package
- Drive resolution is 12,800 steps/revolution
- Includes a full-featured RS-232C indexer with a subset of the X Series command language
- Up to 8 drives can be daisy-chained on a single RS-232C port
- 2,000 characters of non-volatile memory can store up to 7 motion programs
- Nine optically isolated inputs:
  End-of travel (2)
  Home
  Triggers (3)
  Sequence (3)
- Two optically isolated programmable outputs
- User-selectable micro-stepping waveforms for optimal smoothness
- Automatic power-up motion sequence execution
- Motion sequence selection via RS-232C or external switches
- Sequence upload, download, and automatic verify
- Incremental encoder interface is standard
- 23, 34, and 42 frame motors available with torques from 50 to 2,400 oz-in. 10 foot motor cables standard
- The system offers high output voltage (170VDC) operation for optimum high-speed performance
- 95-135VAC, 50/60Hz input power
- System is protected from short-circuit (phase-to-phase, but not phase-to-ground), brownout, and over-temperature
- Microprocessor-controlled micro-stepping provides smooth operation over a wide range of speeds, and improved mid-frequency performance

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Theory of Operation

The AX Drive's built-in indexer receives ASCII commands (from a computer, PLC, or terminal) or BCD signals (from remote switches or a PLC). The indexer then converts these commands or signals to step pulses and sends them internally to the drive portion of the AX. These step pulses are coupled with a direction signal to control motor velocity, acceleration, direction, and position. The drive portion converts the step pulses to varied motor currents to control the stepper motor's rotation and angular position. The motor converts electrical pulses into discrete mechanical motion (shaft rotation). An incremental encoder mounted either on the motor or on the load provides positional feedback (encoder pulses) to the built-in indexer. Figure 1-1 is a functional block diagram of the AX Drive system's processes.

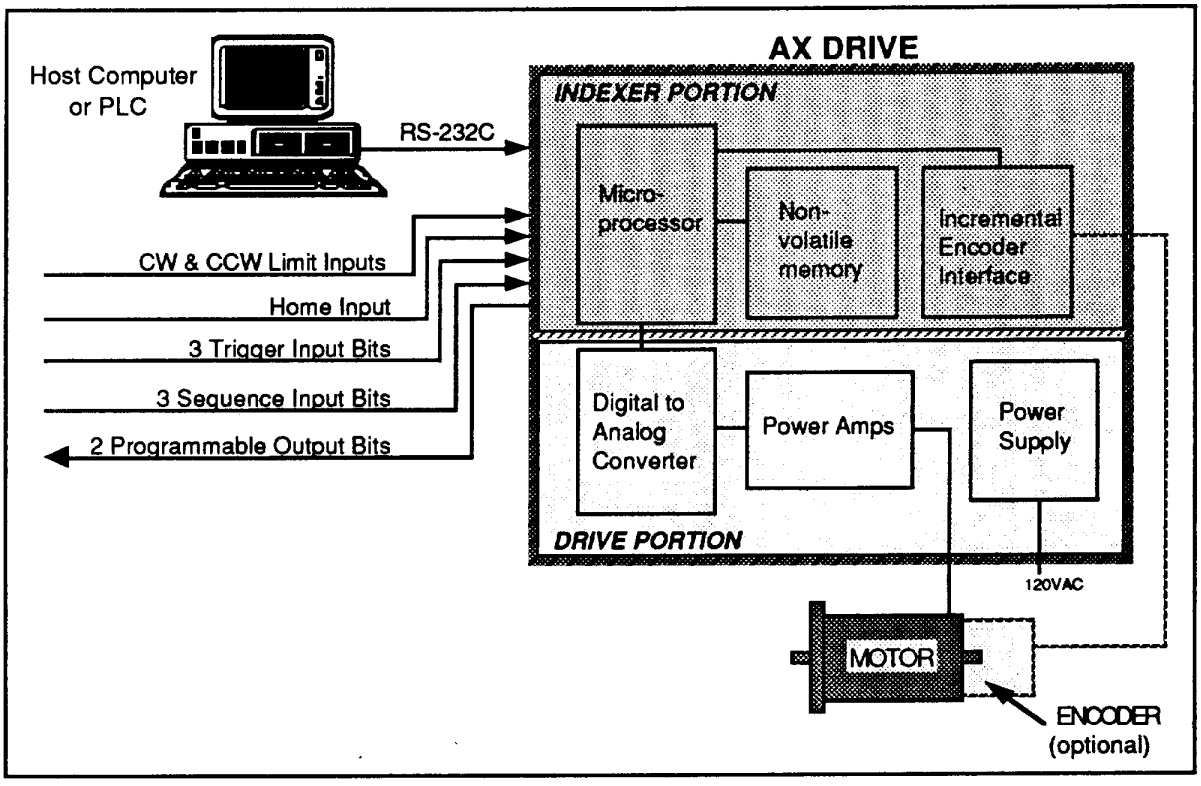


Figure 1-1. AX Drive System Functional Block Diagram

For a detailed description of stepper motor construction and operation, refer to the Compumotor Catalog.

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Chapter 2. GETTING STARTED

Chapter Objectives

The information in this chapter will enable you to:

- Verify that each component of your system has been delivered safely
- Become familiar with system components and their interrelationships
- Ensure that each component functions properly
- Configure the system properly

NOTE: If you are using more than one AX Drive, repeat the configuration and test procedures in this chapter with each drive.

What You Should Have

You should inspect your AX Drive shipment upon receipt for obvious damage to its shipping container. Report any such damage to the shipping company as soon as possible. Parker Compumotor cannot be held responsible for damage incurred in shipment. Carefully unpack and inspect your AX Drive shipment. The items listed in Table 2-1 should be present and in good condition. *NOTE: The only way to determine if you have an AXH Drive or an AXL Drive is to check the serial plate or the installation label on the side of the drive opposite the heatsink fins.*

Ship Kit Table

Part Description	Part Number
Ship Kit	74-006583-02
Choice of two drives:	
AXH	AXH-DRIVE
AXL	AXL-DRIVE
Fan Kit (standard on AXH Drives)	AFK
Mechanical Screws (6-32 x 1/4)	51-006037-01
(2) Universal Mounting Bracket Pkgs.	53-006007-01
Users Guide	88-006938-05
Motor(s): See Table 2-2 for Compumotor-supplied motors.	

Table 2-1. Ship Kit List

Compumotor Motors (Optional)

Compumotor-supplied Motors
AX57-51-MO
AX57-83-MO
AX57-102-MO
AX83-62-MO
AX83-93-MO
AX83-135-MO
AX106-120-MO
AX106-178-MO
AX106-205-MO

MO = Motor Only

Table 2-2. Compumotor-Supplied Motors

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Basic System Configuration

AX drives are protected against brownout, short-circuit (except phase-to-earth ground), and over-temperature. *Compumotor does not recommend that you test these features or operate your system in a way that will induce brownout, short-circuit, or over-temperature situations.*

CAUTION

The AX Drive is not completely open-circuit protected. Ensure the AC power is disconnected before attempting to perform any system connections. Never disconnect or reconnect the motor with power on; this will damage the drive and the motor connector contacts. Follow the steps described below to complete the basic configuration of your system.

Installation Label

The installation label, located on the side of the drive opposite the heatsink fins, provides default DIP switch settings. The label also provides general guidelines for drive mounting, wiring, and I/O connections.

Setting Drive Functions

Drive functions are set using the 8-position DIP switch located on the bottom of the AX Drive (see Figure 2-1). For the procedures in this chapter, leave the address (set with switches 6 through 8) set to 1 (factory-setting).

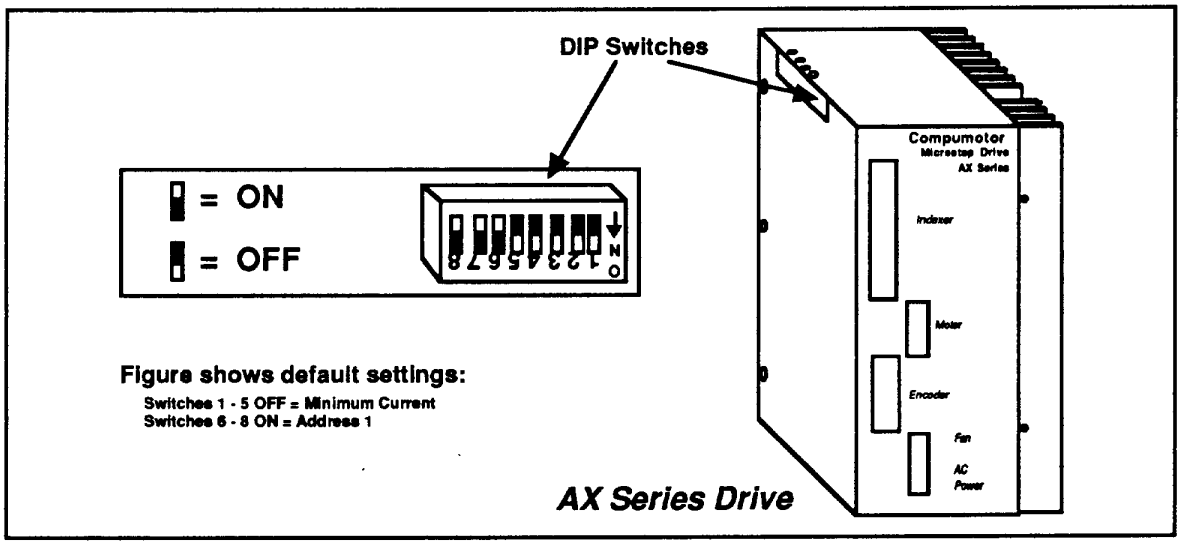


Figure 2-1. DIP Switch Location

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Current Programming

DIP switches 1 through 5 are used for setting drive output current to the motor. See Figure 2-1 for the location of the drive DIP switches. Table 2-3 provides DIP switch settings for Compumotor-supplied motors. Be sure not to confuse the settings for an AXL Drive with the settings for an AXH Drive. *NOTE: When purchased as a motor/drive system, the current is factory-set for the accompanying motor. When purchased as a drive-only system, the drive current is factory set to minimum (0.094A for AXL, 0.188A for AXH).*

Consult Compumotor's Application Department first if you plan to use a motor not supplied by Compumotor. If you are using a motor not supplied by Compumotor, refer to Chapter 6, Hardware Reference, for the full range of motor current settings.

WARNING

NEVER adjust DIP switch settings when the power is on.

Use the following procedure to adjust the DIP switches:

STEP 1 Remove AC power from the AX Drive.

STEP 2 Remove the DIP switch cover panel.

STEP 3 Check all DIP switch settings. Use Table 2-3 as a guide to ensure that the switches are set properly.

STEP 4 If you must adjust the DIP switches, use a narrow instrument such as a thin, flat screw driver.

CAUTION

Improper motor current settings can damage both the drive and the motor.

Motor size	Current	AXL DIP Switch Settings					AXH DIP Switch Settings				
		1	2	3	4	5	1	2	3	4	5
AX57-51	0.375A	OFF	OFF	OFF	ON	ON	Not Recommended				
AX57-83	0.469A	OFF	OFF	ON	OFF	OFF	Not Recommended				
AX57-102	0.750A	OFF	OFF	ON	ON	ON	Not Recommended				
AX83-62	0.844A	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
AX83-93	1.406A	OFF	ON	ON	ON	OFF	OFF	OFF	ON	ON	OFF
AX83-135	1.969A	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	ON
AX106-120	1.875A	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	ON
AX106-178	4.125A	-----	-----	-----	-----	-----	ON	OFF	ON	OFF	ON
AX106-178	6.000A*	-----	-----	-----	-----	-----	ON	ON	ON	ON	ON
AX106-205	6.000A*	-----	-----	-----	-----	-----	ON	ON	ON	ON	ON

* Parallel connect motors

Table 2-3. Motor Current Settings (Compumotor-Supplied Motors

NOTE: The current values in Table 2-3 are approximate settings in the AX Drive. The actual settings will not match these recommended settings exactly. The current setting for 106-205 motors is 6 amps in series and in parallel.

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Basic System Wiring Diagram

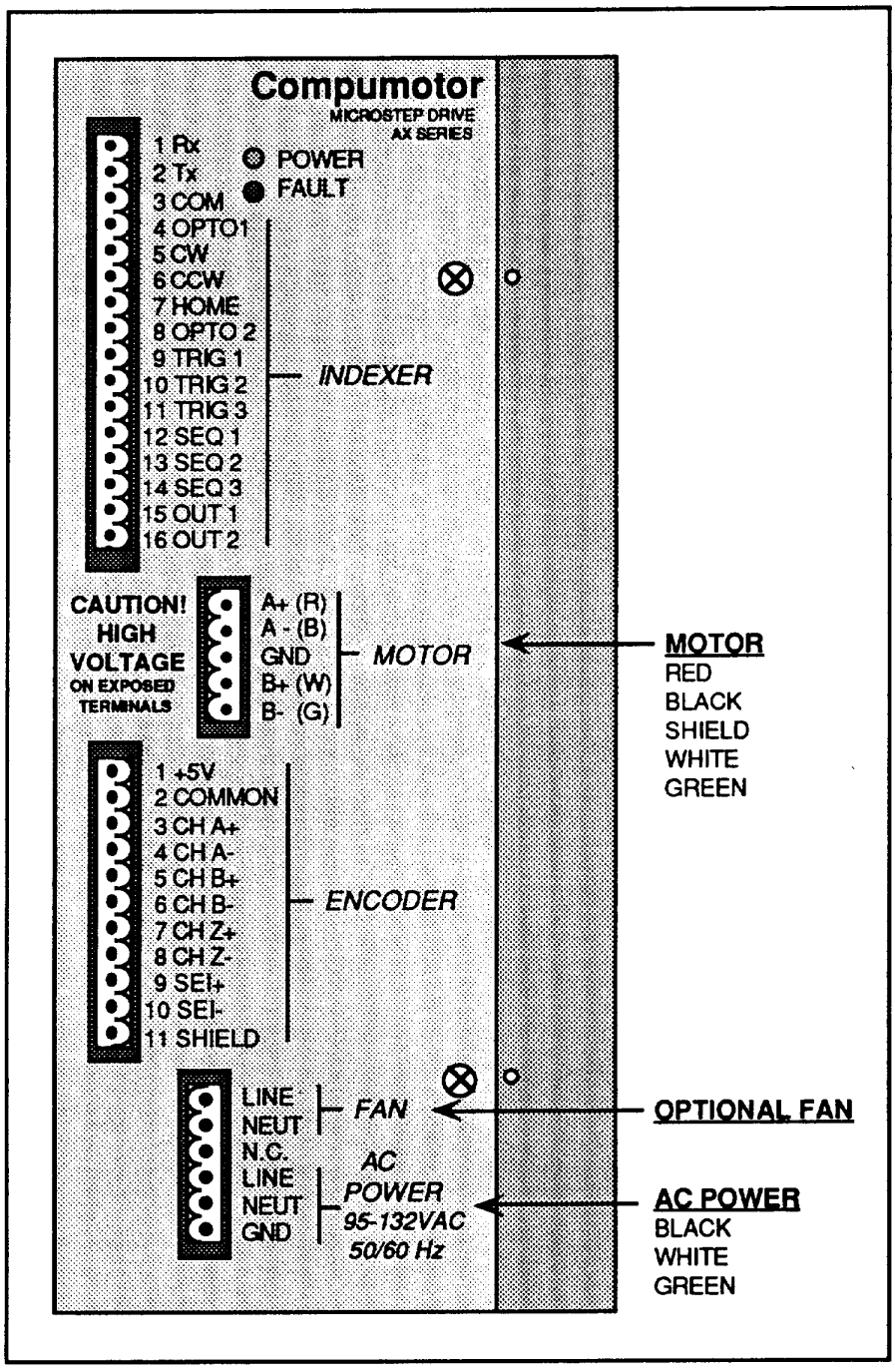


Figure 2-2. System Wiring Diagram

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Transformer Connections (Optional)

This section addresses connecting an optional transformer to the AX system. An isolation transformer can enhance phase-to-earth ground short-circuit protection, personal safety, and electrical noise immunity. If you not are using a transformer with this system, simply proceed to the Motor Connections section. *NOTE: When using a transformer, the AX Drive requires an input current equal to 0.6 x the DIP switch current setting.*

CAUTION

Do not apply power to the AX Drive at this time. AC power to the AX Drive is limited to 132VAC. Higher voltages will damage the drive. The low-voltage limit is 95VAC.

Refer to the transformer user guide to determine which output leads correspond to LINE, NEUTRAL, and GROUND. As illustrated in Figure 2-3, connect the transformer leads to the AC power connector on the drive.

WARNING

Do not connect the transformer to the AX DRIVE while power is applied to the transformer. Do not touch the wiring studs on the transformer after it is plugged into an AC outlet. This can cause serious personal injury.

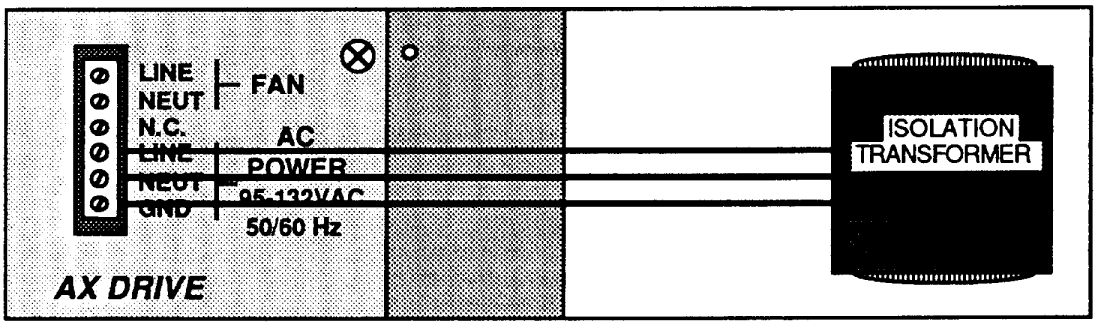


Figure 2-3. Transformer Connections (Optional)

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Motor Connections

CAUTION

Consult a Compumotor Applications Engineer if you intend to use a motor not supplied by Compumotor. Low inductance motors will damage the drive. The AX requires motors with a minimum inductance of 20 mH/phase (measured end-to-end). Chapter 5, Hardware Reference, contains procedures for connecting motors not supplied by Compumotor.

If you purchased an AX drive/motor package, the motor will be pre-wired and ready to connect to the AX Drive motor connector (see Figure 2-2).

Connect your motor to the AX Drive and verify that the color code is correct. The wire colors provided below are for Compumotor-supplied motors.

- A+ = Red
- A- = Black
- GND = Shield
- B+ = White
- B- = Green

For added personal protection, Compumotor includes a motor connector *boot*. Ensure that the boot covers the connector once it is in place.

CAUTION

Be sure to properly connect the motor to the AX Drive. Incorrect connections can cause extensive damage to the drive and the motor. The AX motor outputs are protected from phase-to-phase shorts. They are not protected from phase-to-ground shorts.

Power Connections

Connect the power cable to the AX Drive (see Figure 2-2) and verify that the color codes are correct.

- LINE = Black
- NEUT = White
- GND (Earth) = Green

NOTE: If you are using an isolation transformer, be sure to connect the transformer's output AC line, neutral, and ground to the proper terminals on the AX Drive power/fan connector (see Figure 2-3).

CAUTION

Do not apply power to the AX Drive at this time. AC power to the AX Drive is limited to 132VAC. Higher voltages will damage the drive. The low-voltage limit is 95VAC.

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Establish Communications

To communicate with the AX system, your computer or terminal must have an RS-232C serial port. If it does not, you can purchase one from your local computer dealer.

You cannot change the communication parameters on the AX. Therefore, you must set you computer/terminal to the following RS-232C protocol parameters:

- Baud Rate: 9,600
- Data Bits: 8
- Parity: None
- Stop Bits: 1
- Echo: Off (Full Duplex)

Refer to your computer/terminal user guide for instructions on how to set the communication parameters so that they are compatible with the AX Drive's settings.

RS-232C Connections

The AX Drive uses a simple three-wire implementation of RS-232C serial communication. Receive Data (Rx), Transmit Data (Tx) and Common (COM) signals are transmitted via pins 1, 2, and 3 on the AX Drive's two-part screw terminal connector Use Figure 2-4 as a guide for connecting the AX to the computer/terminal communication port.

CAUTION

The common (COM) connection on drive's auxiliary connector is signal ground, or common, as opposed to earth ground (GND) on the motor and power connectors. The COM on the auxiliary connector should be isolated from the earth ground. Do not connect COM on the auxiliary connector to GND on the motor or power connectors. This type of miswiring can cause system damage.

The AX does not support handshaking of any form; therefore, you should disable the handshaking function of the computer or terminal sending characters to the AX. Typically, the handshaking function is disabled by connecting RTS to CTS (usually pins 4 and 5) and DSR to DTR (usually pins 6 and 20) on the computer's or terminal's 25-pin RS-232C port (see Figure 2-4). Refer to your computer or terminal user guide for the exact instructions to disable handshaking.

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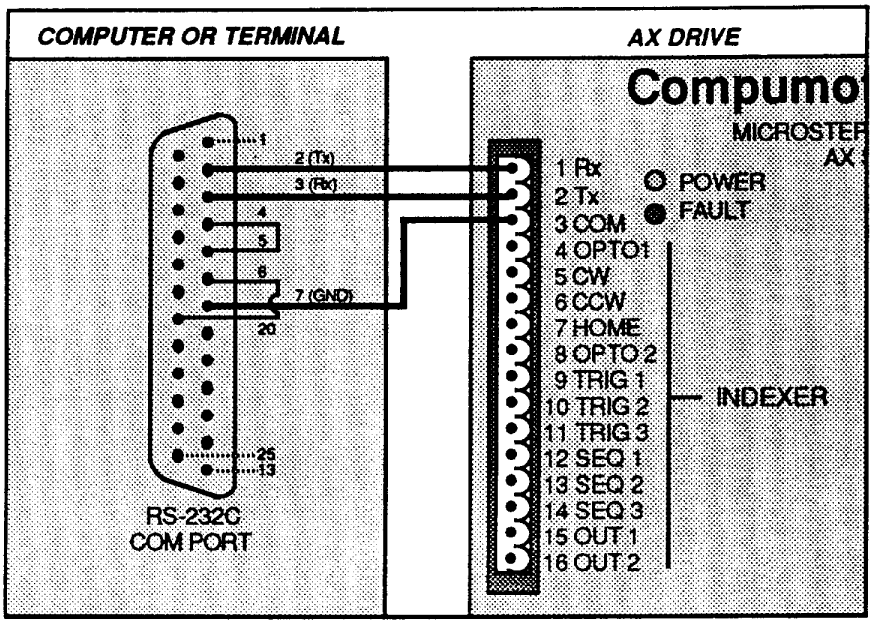


Figure 2-4. RS-232C Interface Connections

Powering up the System

When you apply power to the system, the *POWER* (green) LED on the AX Drive front panel should illuminate. The *FAULT* (red) LED should blink and then turn off. If the *FAULT* LED remains illuminated, immediately disconnect power and consult Chapter 7, Maintenance and Troubleshooting.

Deactivate Limit Inputs for Tests

The AX is equipped with two end-of-travel limit inputs: clockwise (CW) and counter-clockwise (CCW). You can control these inputs with software commands and load-activated switches. The CW and CCW limit inputs prevent the load from crashing into a mechanical stop and damaging equipment or injuring personnel.

At this time, you do not need to set up load-activated switches in your system (you will establish these switches in Chapter 3, Installation). To test your motor and the RS-232C interface, you must now disable the limit inputs by issuing the Limit Disable **(LD3)** command. Compumotor ships the AX from the factory with the limits enabled. This means that the motor will not run unless you issue the **LD3** command.

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Testing the System

Before testing the system, check DIP switches 6, 7, and 8 to make sure they are all set to the ON position (see Figure 2-1). This sets the address to 1.

Testing RS-232C Interface

To test for proper three-wire RS-232C serial communication, power-up your computer or terminal *and then* power-up the AX system. If your terminal displays garbled characters, check the computer's protocol set-up; the baud rate setting is probably not equal to the AX's (9,600 baud). If the baud rates are equal, press the space bar several times. If the cursor does not move, switch the transmit (Tx) and receive (Rx) wires (AX pins 1 and 2) and try this test again.

Once you are able to make the cursor move, enter some characters. These characters should appear on the computer CRT. If each character appears twice, your computer is set to half-duplex. It should be set to full-duplex. Consult your computer user guide for instructions on how to change the set-up to full-duplex.

Test Routine

AX Drives with software revision E2 or higher allow you to issue a **TEST** command to verify the system's operability. *NOTE: The **TEST** command disables the limit switches.* ***Never attach a load when you disable the limit switches.*** When you issue this command, the following sequence is automatically executed:

Commands	Description
LD3	Disables CW and CCW limits
MN	Sets indexer to normal mode
MPI	Sets positioning mode to incremental
A2	Sets acceleration to 2 rps^2
V1	Sets velocity to 1 rps
D128ØØ	Sets distance to 12,800 steps
G	Executes the move (Go)
T.5	Waits 0.5 seconds after finishing the move
H	Changes the direction of the next move
G	Executes the move (Go)

After issuing the **TEST** command the motor turns one CW revolution, pauses for 0.5 seconds, and turns one CCW revolution.

Verifying Indexer Status

Enter the characters shown below. If communication is successful and the indexer is ready for normal operation, the corresponding response will be displayed as follows:

Input from keyboard	AX Response
1R	*R

If you are unsuccessful, check the address setting and interface wiring and type the command again. If you are still unsuccessful, check your wiring and consult Chapter 7, Maintenance & Troubleshooting.

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Making An Open-Loop Move

Type the following commands: *(The following example disables the limit switches.* ***Never attach a load when you disable the limit switches.)***

Commands	Description
LD3	Disables CW and CCW limits (all axes)
A1	Sets acceleration to 1 rps^2
V1	Sets velocity to 1 rps
D128ØØ	Sets distance to 12,800 steps
G	Executes the move (Go)
1PR	Requests the position report for device 1

The motor moves 12,800 steps (one revolution). After the motor stops, you should see the following response on your computer CRT:

+0000012800

If the motor does not move, refer to Chapter 7, Maintenance & Troubleshooting.

If you were able to perform the open-loop move and the test routine successfully, try to perform as many moves as possible with the basic configuration. Simulate the moves you intend to perform with your permanent application. For other applicable commands refer to Chapter 5, Software Reference. After you complete these exercises, read Chapter 3, Installation.

NOTE: If you are using more than one AX Drive, repeat the configuration and test procedures in this chapter with each drive.

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Chapter 3. INSTALLATION

Chapter Objectives

The information in this chapter will enable you to:

- Mount all system components properly
- Connect all electrical and non-electrical system inputs and outputs properly
- Ensure that the complete system is installed properly
- Perform basic system operations

Complete System Configuration

In this section, you will go through complete set-up procedures for setting drive and indexer functions, and setting encoder functions (if you are using an encoder). This section addresses all of the procedures that you must complete before you wire or apply power to your system.

WARNING

Ensure that AC power is disconnected before attempting to do any wiring. NEVER disconnect the motor with power applied to the drive. NEVER adjust DIP switch settings when the power is on. *Lethal voltages* are present inside the drive and on the screw terminals.

Drive and indexer functions are set using the 8-position DIP switch located on the side opposite the heatsink fins (see Figure 3-1). Table 3-1 provides the functions incorporated in the 8-position DIP switch.

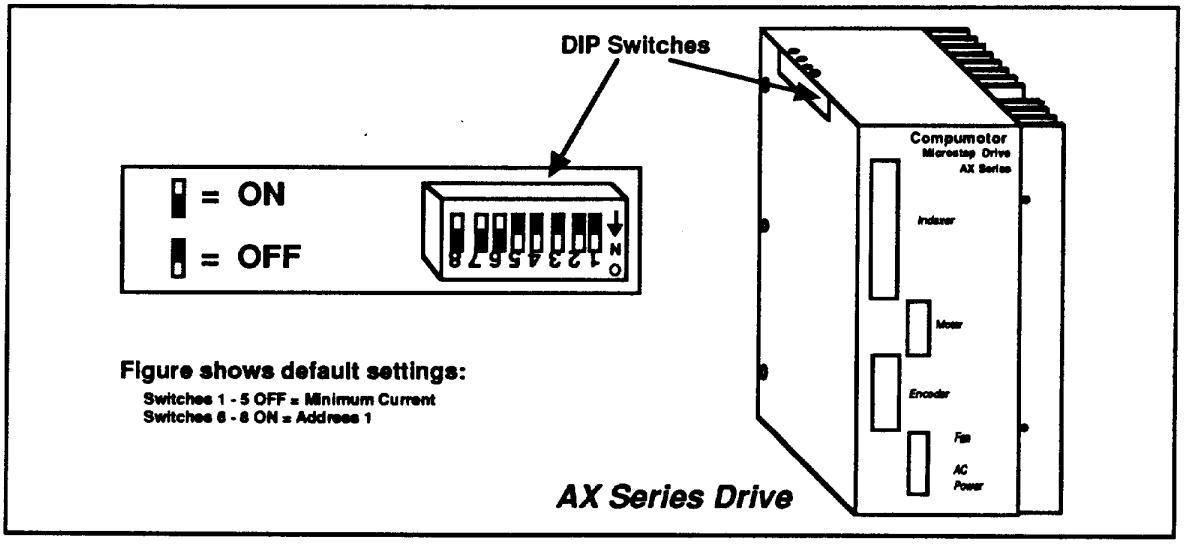


Figure 3-1. DIP Switch Location

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Switch	Function	Optional Settings
1	Current	See Table 3-2
2	"	"
3	"	"
4	"	"
5	"	"
6	Device Address	See Table 3-3
7	"	"
8	"	"

Table 3-1. DIP Switch Functions

When purchased as a motor/drive system, the current is factory-set for the accompanying motor. The address is factory-set to 1. If you need to adjust these DIP switches, use the following procedure:

STEP 1 Remove AC power from the AX Drive.

STEP 1 Remove the DIP switch cover.

STEP 2 Check all DIP switch settings. Use the tables provided in this chapter to ensure that the switches are set properly.

STEP 3 If you must adjust the DIP switches, use a narrow instrument such as a thin, flat screw driver.

Setting Drive Output Current

If you are using motors supplied by Compumotor, refer to Chapter 2, Getting Started, for motor current settings. If you are not using motors supplied by Compumotor, refer to Chapter 6, Hardware Reference, for motor current settings.

Setting Indexer Address

Each AX Drive, as shipped, is factory-set to device address 1. If you ordered more than one AX Drive and you want to daisy-chain (communicate serially with more than one unit), you must establish unique addresses for each AX Drive. The device address can be changed with switches 6 through 8 (see Figure 3-1). Refer to Table 3-2 for valid address settings.

Daisy-chain wiring instructions are discussed later in this chapter.

Address	SW6	SW7	SW8
1*	ON*	ON*	ON*
2	OFF	ON	ON
3	ON	OFF	ON
4	OFF	OFF	ON
5	ON	ON	OFF
6	OFF	ON	OFF
7	ON	OFF	OFF
8	OFF	OFF	OFF
* *Factory Default Setting*			

Table 3-2. Valid AX Address Settings

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Environmental Considerations

The AX Drive system should be operated in accordance with the following environmental constraints:

Parameter	Value
Operating	32°F - 104°F (0°C - 40°C)
Humidity	0 - 95% non-condensing
Storage	-40°F - 185°F (-40°C - 85°C)
Motor	Max. case temp. = 212°F (100°C) - for Compumotor-supplied motors

Table 3-3. Environmental Specifications

An internal thermostat will shut down the drive if the internal drive temperature reaches 149°F (65°C). ***NOTE: Current settings in excess of 4A in high ambient temperature environments (above 104°F) may require fan cooling to keep the heatsink temperature within allowable limits and to keep the drive from shutting itself down due to over-temperature. The fan kit is standard with all AXH Drives.***

System Mounting

You should give special attention to the environment and location in which you will operate your AX Drive system. Consider atmospheric contamination and excess heat before you install and operate your AX Drive system.

Motor Mounting

The AX Drive system will operate rotary stepper motors with the specified minimum inductance only. ***Do not attempt to use this product with a linear motor.*** Refer to Chapter 6, Hardware Reference, for minimum inductance specifications and dimensional drawings of NEMA 23, 34, and 42 stepper motors.

Rotary stepper motors should be mounted using flange bolts and centered by the pilot on the front face. Foot-mount configurations are a less desirable alternative because the torque of the motor is not evenly distributed around the motor case. Any radial load on the motor shaft is multiplied by a much longer lever arm when a foot mount is used rather than a face flange.

WARNING

Improper mounting can compromise system performance and jeopardize personal safety.

CAUTION

Do not machine the motor shaft without consulting a Compumotor Applications Engineer at (800) 358-9070. Improper shaft machining can destroy the motor bearings.

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The motors used with the AX Drive can produce very large torques. These motors can also produce high accelerations. This combination can shear shafts and mounting hardware if the mounting is not up to the task. High accelerations can produce shocks and vibrations that require much heavier hardware than would be expected for static loads of the same magnitude. The motor, under certain profiles, can produce low-frequency vibrations in the mounting structure. These vibrations can also cause metal fatigue in structural members if harmonic resonances are induced by the move profiles you are using. A mechanical engineer should check the machine design to ensure that the mounting structure is adequate.

CAUTION

Do not attach the load to the motor yet. Methods for coupling the load to the motor are discussed later in this chapter.

Drive Mounting

Proper mounting and panel layout are essential for trouble-free operation of the AX Drive. You should allow sufficient space for unrestricted air flow over the heatsink.

Since stepper motors are drawing full current at all times, heat transfer is very important. For best results the drive should be mounted vertically to allow convective heat transfer along the heatsink and through the enclosure's vents. In addition, the drive should always be enclosed and have at least six inches of clearance in all directions.

The AX Drive is designed to be mounted for either minimum depth or minimum width, depending on how the mounting clips are attached to the AX Drive. Use #10 mounting screws.

Enclosure Considerations

You should install the AX Drive system in an enclosure to protect it against atmospheric contaminants such as oil, moisture, and dirt (see Figure 3-2). 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. If you mount the AX Drive in an enclosure, observe the following guidelines:

- The vertical clearance between the AX Drive and other equipment, or the top or bottom of the enclosure, should be no less than 6 inches (see Figure 3-2).
- The horizontal clearance should be no less than 6 inches.
- Do not mount large, heat-producing equipment directly beneath the AX Drive.
- The maximum allowable ambient temperature directly below the AX Drive is 40°C. Fan cooling may be necessary if adequate air flow is not provided. Compumotor offers an optional fan kit for the AXL Drive. The fan kit is standard with all AXH Drives.

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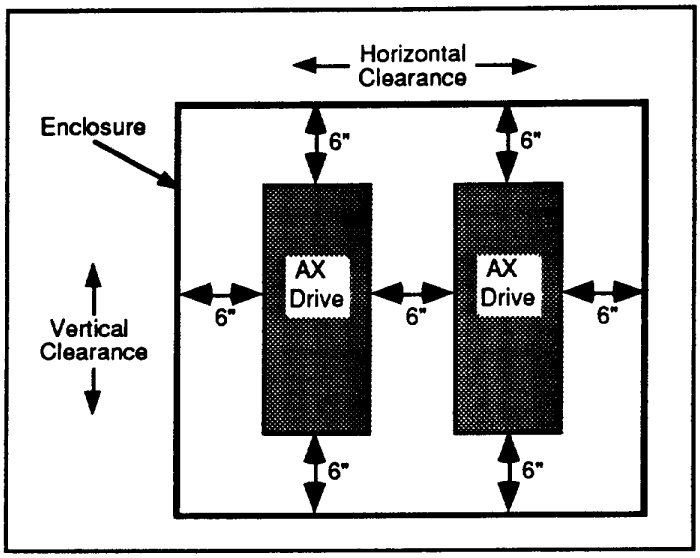


Figure 3-2. Panel Layout Guidelines

Minimum Width

Two mounting brackets are attached to the side of the drive opposite the power connectors for minimum panel width (see Figure 3-3). This gives the user the maximum amount of panel space possible. *NOTE: Units are shipped in this configuration.*

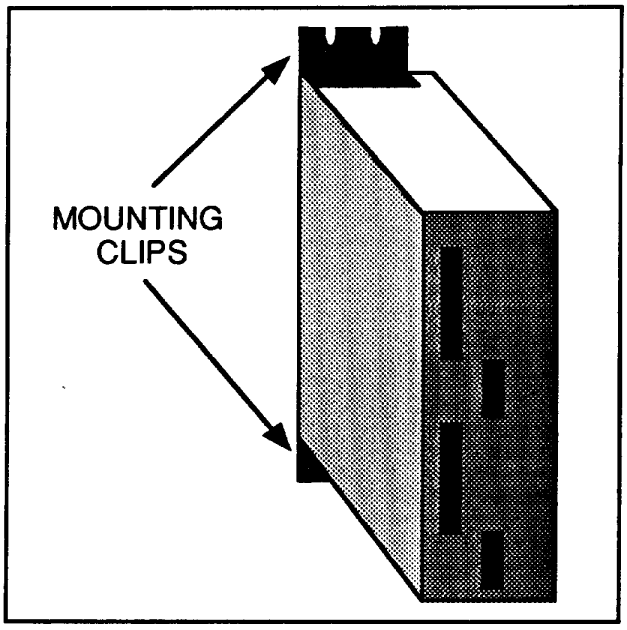


Figure 3-3. Minimum-Width Panel Mount

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Minimum Depth

To mount the drive for minimum depth, remove the two existing mounting brackets and, together with the two extra brackets from the ship kit, attach them to the drive on the side opposite the heatsink (see Figure 3-4). This allows you to mount the drive in the shallowest possible mounting enclosure.

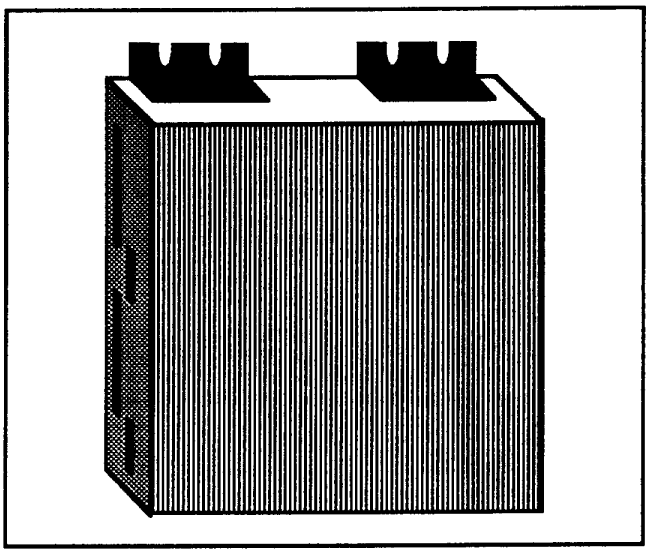


Figure 3-4. Minimum-Depth Panel Mount

Encoder Mounting

When mounting the encoder on the load, make sure to accurately align the encoder. This will ensure accurate positional feedback.

If you are using the IL encoder, refer to the *AL/IL Linear Encoder Mounting Guide* shipped with the IL encoder.

Use the following procedure for mounting Compumotor encoders to the motor. The 106-E encoder must be mounted with the heat isolation bracket (see Figure 3-5). *NOTE: If you are using an encoder from another vendor, refer to the manufacturer's installation instructions.*

STEP 1 Remove the retaining screws on the back plate of the motor.

STEP 2 Attach the coupler to the end of the encoder shaft and tighten with an allen wrench.

STEP 3 Align the encoder on the back of the motor, making sure to slide the coupler onto the motor shaft and aligning the screw holes on the encoder with the mounting holes on the back plate of the motor.

STEP 4 Tighten the coupler to the motor shaft with the allen wrench.

STEP 5 Re-install the retaining screws, fastening the encoder mounting flange to the back plate of the motor.

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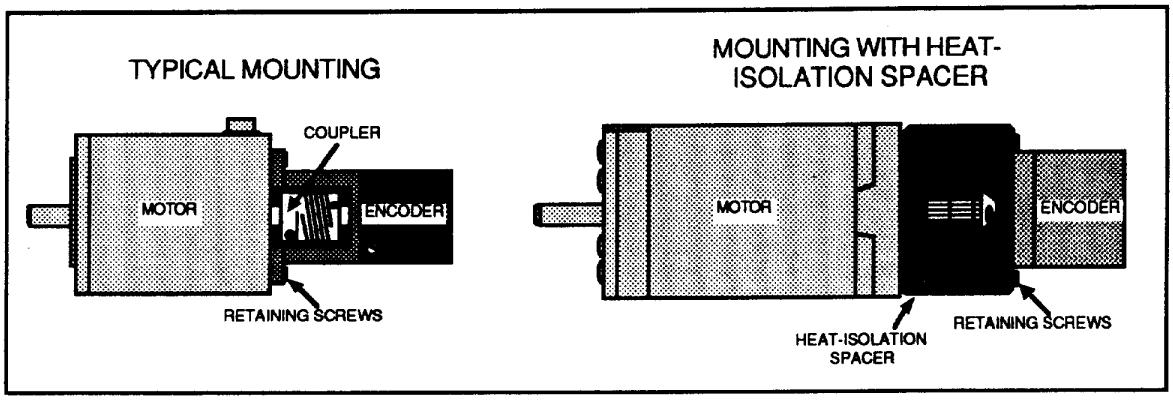


Figure 3-5. Mounting the Encoder to the Motor

System Connections

Wiring Guidelines

Proper grounding of electrical equipment is essential to ensure the safety of personnel. You can reduce the effects of electrical noise due to electromagnetic interference (EMI) by grounding. All Compumotor equipment should be properly grounded. A good source of information on grounding requirements is the National Electrical Code published by the National Fire Protection Association of Boston, Massachusetts.

CAUTION

The common (COM) connection on drive's auxiliary connector is signal ground, or common, as opposed to earth ground (GND) on the motor and power connectors. The COM on the auxiliary connector should be isolated from the earth ground. Do not connect COM on the auxiliary connector to GND on the motor or power connectors. This type of miswiring can cause system damage.

In general, all components and enclosures must be connected to earth ground through a grounding electrode conductor to provide a low impedance path for ground fault or noise-induced currents. All earth ground connections must be continuous and permanent. Compumotor recommends a single-point grounding setup.

One commonly used method is to prepare components and mounting surfaces prior to installation so that good electrical contact is made between mounting surfaces of equipment and enclosure. Remove the paint from equipment surfaces where the ground contact will be bolted to a panel and use star washers to ensure solid bare metal contact. You should connect the case of the motor to the motor GND terminal on the AX Drive. (This is done for you with Compumotor-supplied cables.)

You must connect the GND terminal on the AC power connector to the earth ground.

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Electrical Noise

The AX Drive provides power to the motor by switching 170 VDC at 20 KHz (lo-power), 16 KHz (hi-power). This has the potential to radiate or conduct electrical noise along the motor cable, through the motor, and into the frame to which the motor is attached. It can also be conducted out of the drive into the AC power line as the AX Drive does not have a transformer on its input to isolate the bridge circuitry from the line.

If electrical noise generated by the AX Drive causes problems with your equipment, you should take note of the following steps:

1. Shield the motor cable in conduit and ensure the conduit is taken to a low impedance earth ground (tied to one end only).
2. Avoid extended motor cable runs. Be sure to separate logic and high-power cables.
3. Provide a separate power line for the AX Drive. Do not use the same power circuit for the sensitive electronics and the AX Drive.
4. Ground the motor casing. (This is already done for you with Compumotor-supplied motors).
5. Mount the sensitive equipment as far as possible from the AX Drive and motor.
6. Filter the power to the AX Drive using an active filter or an isolation transformer.
7. If more details are needed, contact a Compumotor Applications Engineer at (800) 358-9070.

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System Pinouts

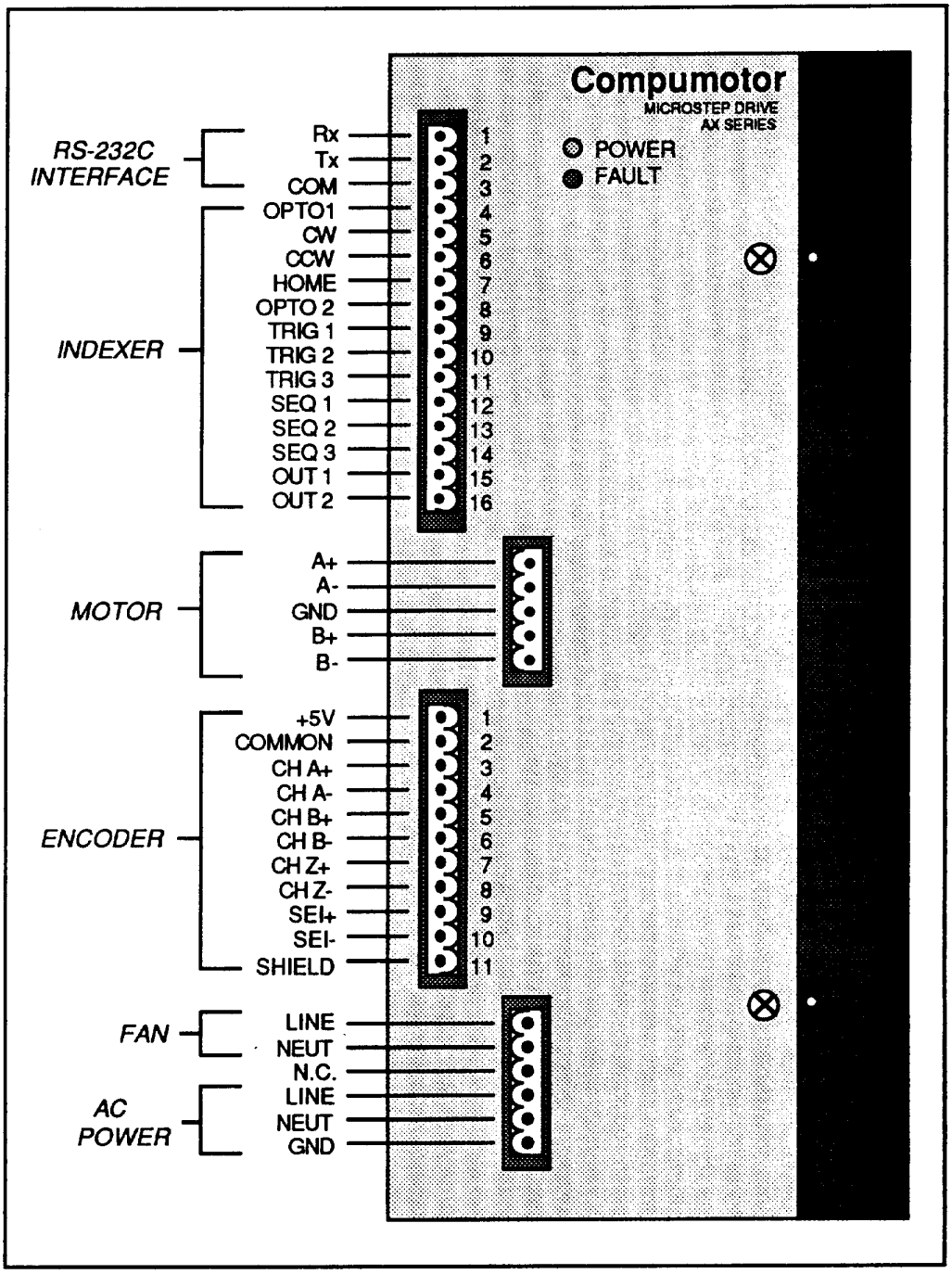


Figure 3-6. AX Drive Pinouts

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Extending Motor Cables

The minimum recommended wire sizes (AWG) for motor cable extensions are presented in Table 3-4. Table 3-5 supplies the resistance values of the various wire sizes. Refer also to the guidelines on the AX label (located on the bottom of the drive, below the DIP switches).

Motor Series	Maximum current/phase	Up to 100 ft (20.5M)	100 to 200 feet (30.5 to 71M)
AX57	0.68A	22AWG	20AWG
AX83	1.90A	20AWG	18AWG
AX106	6.00A	16AWG	14AWG

Table 3-4. Extended Motor Cables

NOTE: Cable runs over 200 feet (71M) are not recommended.

Wire size (AWG)	Resistance (ohms/100 ft)
14	0.26
16	0.40
18	0.64
20	1.00
22	1.60

Table 3-5. Motor Wire Resistance Values

Transformer Connections (Optional)

An isolation transformer can enhance phase-to-earth ground short-circuit protection, personal safety, and electrical noise immunity. Chapter 2, Getting Started, provides detailed instructions for connecting a transformer to the AX.

WARNING

Do not connect the transformer to the AX DRIVE while power is applied to the transformer. Do not touch the wiring studs on the transformer after it is plugged into an AC outlet. This can cause serious personal injury.

Power Connections

Refer to Chapter 2, Getting Started, for power connection procedures.

Fan Connections

The fan kit is a standard feature of the AXH Drive. If you wish, you may order the fan kit from your Automated Technology Center or Compumotor Distributor.

The fan kit for the AX drive is precabled for easy connection to the fan connector terminals. Connect the leads to the LINE and NEUT terminals (see Figure 3-6).

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Encoder Connections

To implement the closed loop functions, it is necessary to connect an incremental optical encoder to the AX. The AX will supply up to 250 mA to drive the encoder. Encoder outputs must be 3-5 VDC, square wave, and TTL compatible. When encoders with single ended outputs are used, the unused Channel A-, B- and Z- should be left unconnected. See Figure 3-7 for connections.

AX Drives ordered with encoders (-E option) are shipped with the encoder leads prewired to the AX phoenix connector. Pinouts and color codes for Compumotor encoders are provide in Chapter 6, Hardware Reference. Figure 3-8 illustrates the encoder input circuit to the AX.

NOTE: Compumotor does not recommend extending the encoder cables. If you think extending the cables is necessary, contact a Compumotor Applications Engineer first.

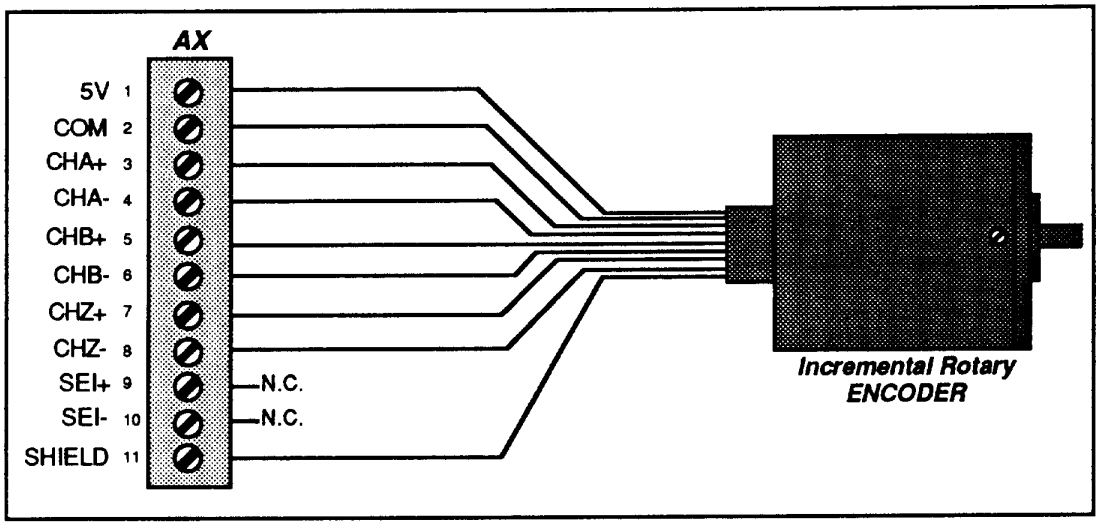


Figure 3-7. Encoder Connection Diagram

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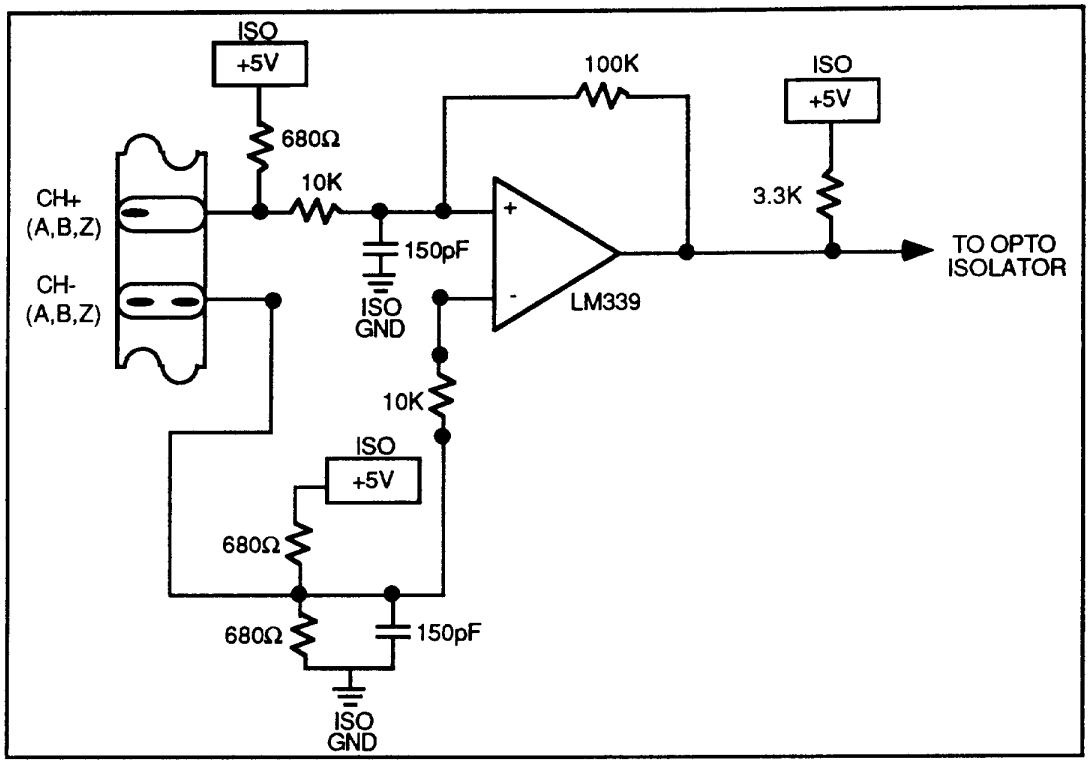


Figure 3-8. Encoder Input Circuit to the AX Drive

RS-232C Connections

Detailed instructions for establishing the RS-232C interface are provided in Chapter 2, Getting Started.

Daisy-Chain Connections

You can daisy-chain up to 8 AX Drives to a single RS-232C port on a computer or terminal. Use Figure 3-9 as a guide for daisy-chain connections. You must establish a unique device address for each AX Drive so that you can distinguish them when programming. The device address is set with DIP switches 6 through 8 (refer to Chapter 6, Hardware Reference, for valid address settings).

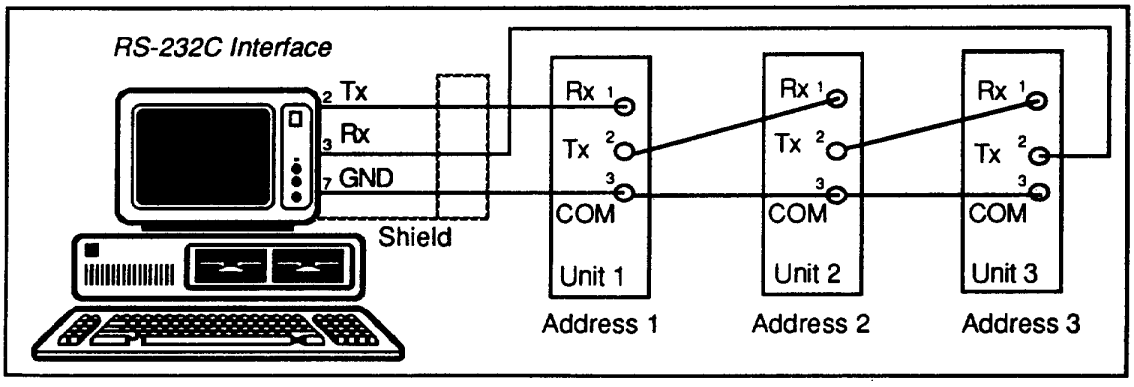


Figure 3-9. Daisy-Chaining AX Drives

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I/O Connections

This section discusses wiring the user I/O interface circuits from the 16-pin connector on the AX Drive. *Note that pins 1, 2, and 3 are for RS-232C communication with the computer or terminal.* Figure 3-10 illustrates the other I/O connections.

NOTE: The AX I/O should be wired as shown with optical isolation in actual applications. This will prevent erratic behavior due to electrical noise.

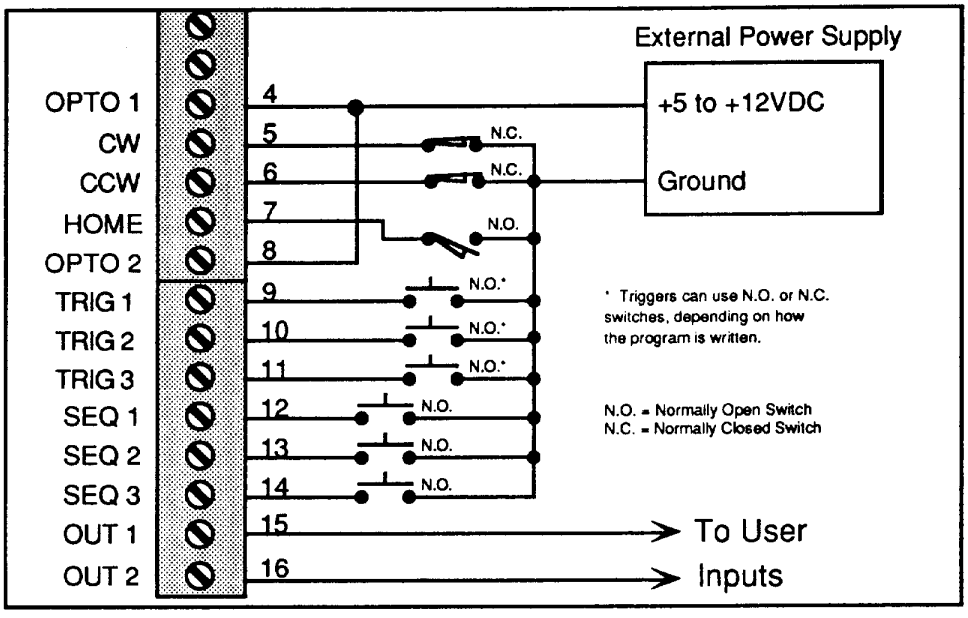


Figure 3-10. I/O Wiring Diagram

Typical I/O Circuits

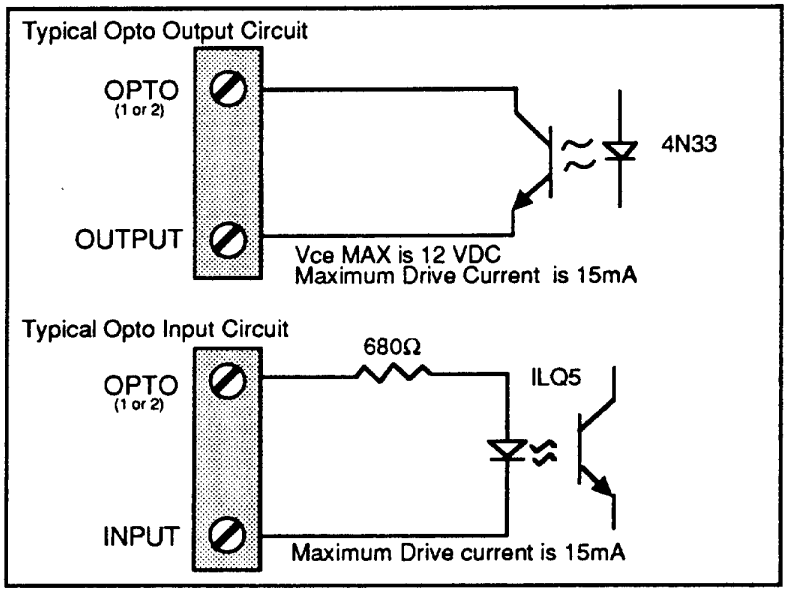


Figure 3-11. Typical I/O Circuits

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Opto 1 & 2

These inputs (pins 4 and 8) require a user-supplied 5 - 12 VDC to optically isolate the AX's I/O. An external supply is strongly recommended but is not required for operation. *NOTE: Pin 1 one the encoder connector (+5V) can also be used **only if the encoder is not connected.*** The Opto 1 input powers the limit and home switches, and the Opto 2 input powers the other I/O. In most cases, Opto 1 and Opto 2 are connected together. Refer to Figure 3-10 for connections.

End-of-Travel Inputs

Pins 5 and 6 are the Clockwise and Counter-clockwise end-of-travel limit inputs. The CW and CCW limit inputs are activated in the high state and require a normally closed load-activated switch to the external supply ground. It is also necessary to connect a +5 to +12VDC power source to the OPTO 1 input (Pin 4); the Ground of this supply is used as the ground for the limit inputs. Refer to Figure 3-10 for limit switch connections.

When the motor is traveling in the direction of the active limit, the limit switch input (either CW or CCW) goes active and brings the motor to an immediate halt (no deceleration); the motor will not be able to move in the direction of the active limit until the limit input goes inactive. If the motor is not moving in the direction of the active limit, motion will not be affected.

These inputs therefore prevent the load from crashing into a mechanical stop and damaging equipment or injuring personnel. These inputs are optically isolated to increase the AX's noise immunity.

HOME INPUT

You can use the home input (pin 7) to establish a home reference position. The Home limit input on the AX is optically isolated, and is normally high. A normally open, load-activated switch to the external supply ground is the most common way for determining the home position in both motor step and encoder step mode. In encoder step mode, the Z channel pulse from the encoder is used in conjunction with the home limit switch to determine the home position. Refer to Figure 3-10 for switch connections.

You can initiate the Go Home function by issuing the Go Home (**GH**) command. When you issue the **GH** command, you must include the direction and velocity that the motor should use to search for home. When you issue the **GH** command to the AX, the motor will begin to move in the direction and at the velocity specified. It performs this move at the last defined acceleration rate, and looks for the home limit input to go active. If the motor encounters an end-of-travel limit while searching for home, it will reverse direction and look for the home limit input to go active in the opposite direction. If the motor encounters the other limit before is detects the home signal, the Go Home move will be aborted and the motor will stop.

NOTE: Compumotor cannot guarantee performance with Home and End-of-Travel limits tied together. It is also not possible to keep the home input grounded and search for the Z Channel in encoder step mode.

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Trigger Inputs

The AX has three trigger inputs. They are normally high and optically isolated. Trigger inputs 1 - 3 are connected to pins 9 - 11 respectively (see Figure 3-10). The +5 to +12VDC power source is still needed at the OPTO 2 input (Pin 8). The return line for the Trigger inputs is the OPTO 2 power source ground. See the **TR** and the **TS** command descriptions in Chapter 7 for functional description of these inputs.

Sequence Inputs

The AX has three optically isolated Sequence Select inputs (SEQ1, SEQ2, and SEQ3). They are normally in the high state. These optically isolated inputs require that 5 - 12 VDC be connected to the OPTO 2 input (pin 8). These inputs (pins 12 - 14) are active *low*, which means to energize them they must be at logic *0* or, ground. Therefore, *ON* is equivalent to the input being energized, or *pulled down* to 0VDC. *OFF* is equivalent to the input being de-energized, or logic *high*. These inputs are normally high. Refer to Figure 3-10 for Sequence switch connections.

Outputs

The AX is equipped with 2 optically isolated programmable output bits. They are open-emitter outputs and are normally in the high state (not conducting current). Due to the TTL current capabilities of these outputs, a current boost circuit may be needed to drive your input (see Figure 3-12). Pins 15 and 16 are Outputs #1 and #2. Both of these outputs are programmable and may be used to signal a peripheral device that some event in the AX has just been completed, such as completing a move or meeting a required trigger input configuration. An external 5 - 12 VDC power supply is required at the OPTO 2 input in order for these outputs to function. Refer to Figure 3-13 for output connections.

These outputs are controlled with the **O** command.

NOTE: Output terminals are open emitter. The maximum current is 15mA.

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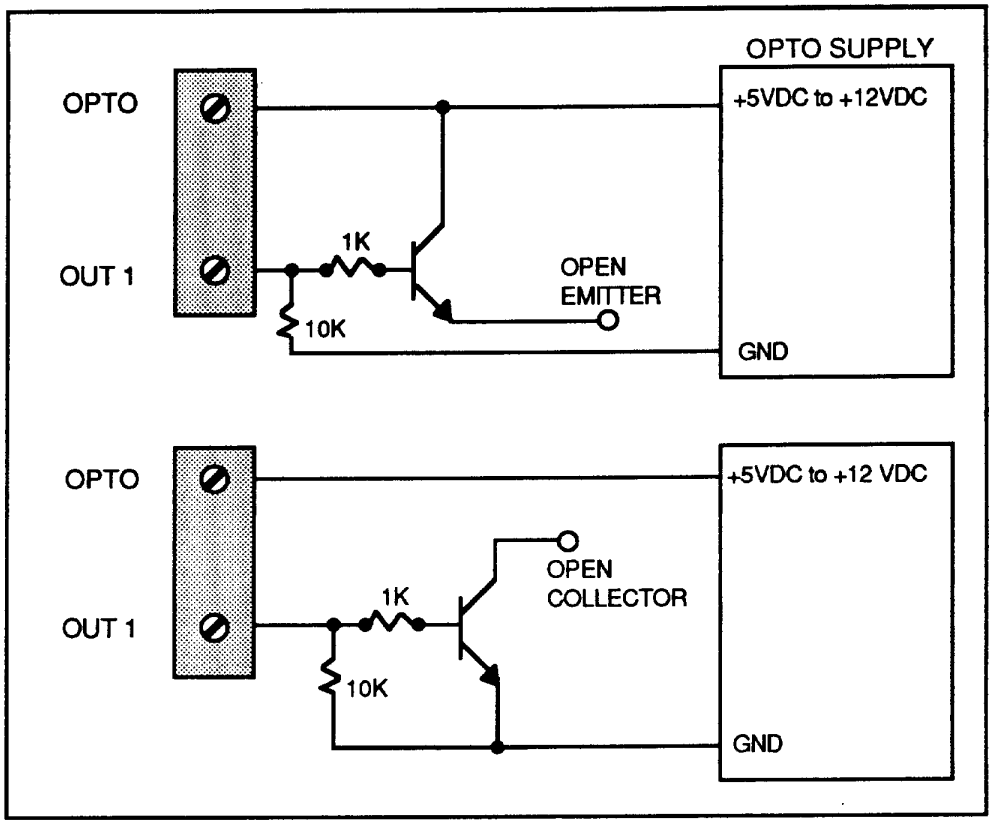


Figure 3-12. Current Boost Circuits for OUT 1 and OUT 2

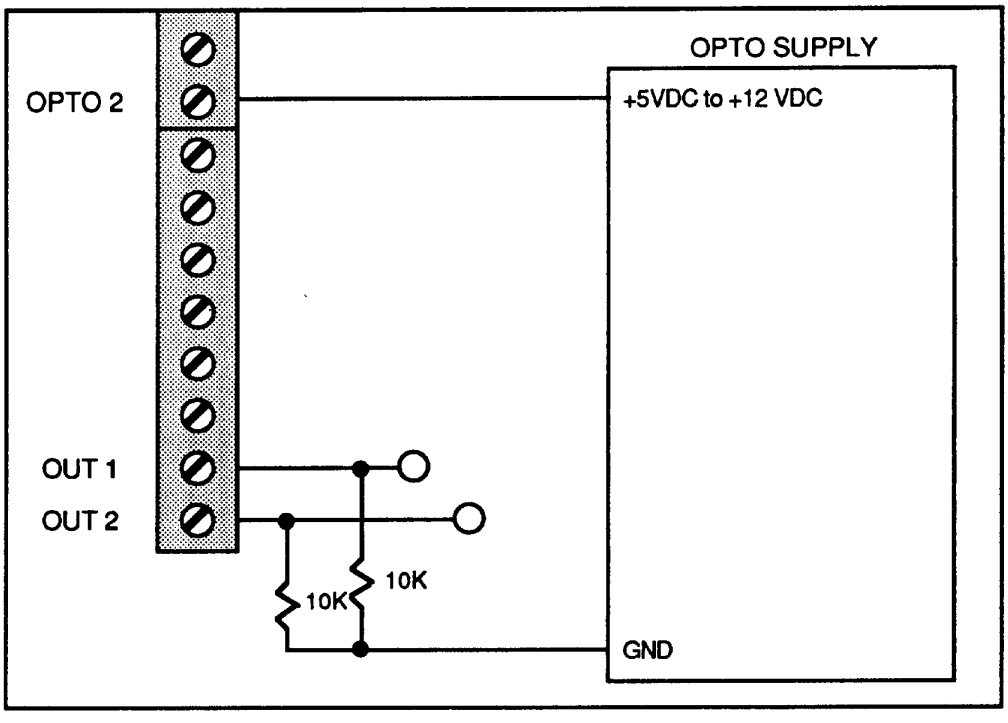


Figure 3-13. Output Connections

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Verifying Proper Installation

Now that you have connected the power, motor, RS-232C interface, I/O switches, and encoder to the AX Drive, you should verify if the AX system operates properly with these connections.

CAUTION

Do not attach the load to the motor yet.

This section is provides instructions to test proper installation of a single-axis AX system. If you have a multi-axis (daisy-chained) system, you should test every axis. To test every axis, you must repeat every device-specific command for each axis. All universal commands will be performed by every AX unit in the chain. Status reports for each axis should yield the same response. For example, the following is a series of universal commands which will be performed by every axis:

Command	Description
LD3	Disables limit switches (*use **only** if limits are not installed*)
MN	Sets mode to normal (all axes)
A1Ø	Sets acceleration to 10 rev/sec^2
V2	Sets velocity to 2 rps
D12,8ØØ	Sets distance to 12,800 steps (1 rev)
G	Executes the move (Go)
PZ	Sets absolute counter to zero (all axes)
G	Executes the move (Go)

Each motor on every axis will perform a 12,800-step (1 rev) move.

To Report the encoder position on all axes, you will have to issue a **PX** command (a device-specific command) with the appropriate device address as follows:

Command	Description
FSB1	Sets Indexer to Encoder Step Mode (all axes)
1PX	Reports Encoder Position for AX unit 1
2PX	Reports Encoder Position for AX unit 2
3PX	Reports Encoder Position for AX unit 3

The encoder position report for each axis should be the same.

Verifying RS-232 Link

You should test for proper RS-232C communication before continuing with this section. Refer to Testing the System in Chapter 2, Getting Started, for RS-232C testing procedures.

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Open-Loop Moves

This section contains examples of open-loop moves that you can perform with the AX system. Open-loop moves *do not* use external sensors to provide position correction.

Testing Normal Mode Moves

To test the Normal Mode (**MN**) moves, enter the following string of commands.

Command	Description
LD3	Disables limit switches (*use **only** if limits are not installed*)
MN	Sets move to normal mode
A5	Sets acceleration to 5 rev/sec^2
V2	Sets velocity to 2 rps
D128ØØ	Sets distance to 12,800 steps
G	Executes the move (Go)

The motor moves CW one revolution. To move the motor in the opposite direction (CCW), enter the following string of commands:

Command	Description
D-128ØØ	Sets distance to 12,800 steps
G	Executes the move (Go)

The motor will move the same distance in the opposite direction.

Testing Continuous Mode Moves

The Continuous Mode (**MC**) is useful for applications that require constant movement 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 synchronized to external events such as trigger input signals. To test continuous mode moves, enter the following string of commands. Use the **S** or **K** command to stop the motor in an emergency.

Command	Description
MC	Move continuous
A25	Sets acceleration to 25 rev/sec^2
V5	Sets velocity to 5 rev/sec
CTM5	Remain at velocity for 5 seconds
CV1	Decelerate at 25 rev/sec^2 to 1 rev/sec
CTRXXØ	Wait for trigger input 3 to go low
CA5	Accelerate at 5 rev/sec^2
CV1Ø	To velocity 10 rev/sec
CTM5	Remain at previous velocity for 5 seconds
CVØ	Change velocity to zero rev/sec (stop)
G	Executes the move (Go)

This sequence sets the indexer to the Continuous Mode. The motor reaches 5 rps, waits 5 seconds, changes velocity to 1 rps, and waits for trigger three to go low. When you ground trigger three, the motor accelerates at 5 rps^2 to 10 rps, waits 5 seconds, and then stops. Note that the buffered **CVØ** command stops the motor (the **S** command is not a buffered command and cannot be used in a sequence).

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Testing CW and CCW Limit Switch Operation

Before you verify that the limit switches are working properly, check the following connections:

- Ensure that the CW and CCW limit switches are wired properly (normally closed switches that open when the load moves to the limit position).
- Make sure that the load is not attached to the motor.
- Make sure that you can manually open and close the limit switches.

Use the following procedures to test the limit input switches:

STEP 1 Open both CW and CCW switches.

STEP 2 Type **1IS** . If no other inputs are closed, the response should be 1111001111; this means that both CW and CCW limits (represented by the 5^{th} and 6^{th} digits) are on.

STEP 3 Turn off (close) the CW limit.

STEP 4 Type **1IS**. Assuming no other inputs are closed, the response to this command should be 1111101111.

STEP 5 Turn off (close) the CCW limit switch.

STEP 6 Type **1IS**. The response should be 1111001111.

To test the CW limit with the AX system, enter the following string of commands:

Command	Description
LDØ	Enables CW and CCW limits
MC	Sets indexer to continuous mode
A5	Sets acceleration to 5 revs/sec^2
V2	Sets velocity to 2 rps
H+	Changes motor direction (+ = CW)
G	Executes the move (G0)

The motor moves at a constant velocity until you close the CW limit switch. The motor then comes to an immediate halt.

To test the CCW limit, enter the following string of commands:

Command	Description
MC	Sets indexer to Continuous mode
A1	Sets acceleration to 1 rev/sec^2
V1	Sets velocity to 1 rps
H-	Sets move to the CCW direction
G	Executes the move (Go)

The motor moves at a constant velocity until you close the CCW limit switch. The motor then comes to an immediate halt. If the motor continues to move, open the CW limit switch. If the motor stops when you open the CW limit input, switch the CW and CCW limit wires.

If neither of these limit switches stop the motor, recheck your switch wiring and refer to Chapter 7, Maintenance and Troubleshooting.

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Homing The Motor

You can initiate the Go Home function by issuing the Go Home (**GH**) command. When you issue the Go Home command, you must include the direction and velocity that the motor should use to search for home. The home limit input on the AX is optically isolated, and is normally high. A normally open, load-activated switch to ground is the most common way to determine the home position in both motor step and encoder step mode.

When you command the AX to go home, the motor begins to move in the direction and at the velocity you specified. It performs this move at the last defined acceleration rate, and looks for the home limit input to go active. If the motor encounters an end-of-travel limit while it searches for home, it will reverse direction and look for the home limit input to go active in the opposite direction. If the motor encounters the other limit before it detects the home signal, the Go Home move will be aborted and the motor will stop.

To test the functionality of the home input switch, manually open the switch and type **1IS** . Assuming your end-of-travel limits are closed and all other inputs are open, the response will be 1111001111. The last digit in the response represents the home input status. Now close the home switch and type **1IS**; the response should be 1111001110. This verifies that the switch is functioning properly.

Use the following procedure to test the AX's homing function:

STEP 1 Enter the following string of characters:

Command	Description
A5	Sets acceleration to 5 revs/sec^2
GH+2	Instructs the motor to go home at 2 rps

The motor moves in the positive direction at a constant velocity (2 rps).

STEP 2 Momentarily ground (close) the home limit input (turn it on).

The motor decelerates to a stop, then moves in a negative direction.

STEP 3 Momentarily close the home switch again to stop the motor.

When the home limit input (pin 7) goes active after a **GH** command, the system recognizes the location where the input became active as *home*. The drive decelerates the motor at the last rate specified. At the end of the Go Home move, the indexer automatically resets the absolute counter to zero. This is equivalent of issuing the Position Zero **(PZ)** command.

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Closed-Loop Moves

This section contains examples of closed-loop moves that you can perform with the AX system. Closed-loop moves *use* external sensors to provide position or velocity correction.

Testing Encoder Resolution

The AX system's encoder feedback functions will not operate properly if the encoder resolution or signal polarity are wrong. The effects of an erroneous Encoder Resolution **(ER)** command are not always obvious. As you set up your system, verify that the system functions as expected without active encoder feedback (open loop), before the encoder functions are enabled.

The best tests for proper function involve status requests. You should be familiar with open-loop commands and status requests before attempting to execute the tests described below.

The Encoder Resolution (**ER**) command defines the number of positions (steps) received by the drive per revolution of motor movement. If you have an encoder, refer to the operator's manual for the resolution of your encoder. Use the following example as a guide for setting your encoder resolution:

Command	Description
ER4000	Tells the indexer that the encoder has a resolution of 4,000 steps/rev after quadrature (1,000 lines)

You may test the encoder resolution setting with the following procedure. The idea is to move the motor with open-loop moves and verify that the number of feedback encoder counts meet with your expectations.

STEP 1 Issue the **1FR** status request command to verify that all encoder functions are off for the test axis. The response should be: 00000000.

STEP 2 Set the internal position to zero with the Position Zero (**PZ**) command. Make the motor move 1 revolution.

Command	Description
MN	Sets mode to normal
FSBØ	Sets indexer to motor step mode
A1Ø	Sets acceleration to 10 rev/sec^2
V2	Sets velocity to 2 rps
D128ØØ	Sets distance to 12,800 steps
G	Executes the move (Go)
PZ	Sets absolute counter to zero
G	Executes the move (Go)

STEP 3 Report the encoder position with the following commands:

Command	Description
FSB1	Sets indexer to encoder step mode
1PX	Reports Encoder Position

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STEP 4

Repeat the test to ensure that the backlash or motor windup are not interfering with the test. Issuing the encoder position report (**PX**) command should yield a number very close to the parameter that you specify with the Encoder Resolution (**ER**) command.

If the encoder position report is negative, encoder channels A and B are reversed. You can correct this by either swapping Pin 1 and Pin 2 on the motor connector (reversing motor direction), or by swapping encoder channel A+ with B+ and A- with B- (reversing encoder direction). ***Be sure to turn power off before reversing any wires.***

Once the encoder resolution is set, it should be safe to enable Encoder Step Mode (**FSB1**) and enable Position Maintenance (**FSC1**), and all other encoder functions *except* stop-on-stall. Verify proper operation of the Go Home function *before* enabling Stop-on-Stall.

Testing the Closed-Loop Homing Function

You can use this function to establish a home reference position. You can instruct the AX to move the motor to a home position with the Go Home (**GH**) command. This home position is typically established by mounting a load-activated switch and connecting it to the home limit input so that the switch turns on when the load is in the desired position.

When you use an encoder, the Z Channel or Index Channel, if any, must be used in conjunction with the home limit switch to establish the home position. The home position is located between the referenced edges selected with the **OSH** command. (i.e., the AX recognizes the home position as the position where the home limit signal makes a transition from ON to OFF, or from OFF to ON, depending on the selected edge and the initial direction of the Go Home move). Once it recognizes the selected edge, the motor decelerates to a stop. After coming to a stop, the AX positions the motor 1/32 of a revolution away from the selected edge of home limit signal in the opposite direction of the initial direction of the Go Home move. After coming to a stop a second time, the AX creeps the motor towards the selected edge at 0.1 rps until the home limit input becomes active again (open loop = no encoder connected), or the home limit and the encoder Z Channel pulse are active at the same time (closed loop = encoder connected). The homing function is designed to accommodate encoder index signals that are typically of short duration. The function works best with this kind of home signal.

You must ensure that the final approach starts from the opposite side of the signal from the selected edge. If the final approach direction is positive, the final move must start from the negative side of the selected edge. If there is significant overshoot in the system, and the indexer is instructed to go home in the clockwise direction, the motor may end up on the wrong side of the signal and execute its final approach in the wrong direction.

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This problem can also occur if the motor's Go Home speed is high, and the Home limit signal is delayed (by a relay or Programmable Controller, for example). In such a situation, you should initiate homing operations from the opposite side of the selected edge of home.

When you conclude the homing operation, the indexer automatically resets its internal position counter to zero. You can determine the true indexer position referenced to an encoder with the Report Absolute Encoder Position (**PX**) command.

You can use the home limit input in conjunction with the encoder's Z Channel input to select one of many index signals. You must use the Set Indexer to Encoder Mode (**FSB1**) command to activate the Z Channel input as a final home position. In this situation, a load-activated switch connected to the Home Limit input locates the general home position area, and the indexer channel signal from the encoder is used for final Home positioning. The Z Channel and Home Enable inputs must both be active to mark the home position.

Under interface control, the Go Home (**GH**) command has the form **GH**<direction><velocity>. This indicates which direction to move, and at what velocity. For example, the command **GH-2** sends the motor in the negative direction at 2 rps in search of the home signal. The acceleration parameter for this move is the last defined value for acceleration (**A** command). If an end-of-travel limit is activated before home is found, the AX reverses direction and attempts to find the home position again. If the other end-of-travel limit is activated before the AX finds home, the AX will stop trying to go Home. The AX can indicate whether or not the homing process was successful by responding to the Request Indexer Status (**R**) and Go Home Status (**RC**) commands.

STEP 1 Issue the following commands:

Command	Description
FSB1	Enable encoder step mode
LDØ	Enable positive and negative limit inputs
A1	Sets acceleration to 1 rev/sec^2
GH+1	Set Go Home in the positive direction at 1 rev/sec

STEP 2 While the motor is moving, turn on (close) the home input switch.

Upon encountering the home switch, the motor will come to a stop. The motor will change direction and search the home switch again. When it sees the switch, the motor changes direction again and looks for the Z channel to turn on while the home limit switch is closed. When it finds the Z channel, it will stop. In encoder mode, the home limit switch and the Z channel input must be on at the same time to Go Home successfully.

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Testing Motor Stall Detection

When the motor moves, with the Stall Detect function enabled (**FSH1**), the AX repeatedly compares the number of encoder steps coming in against the number of motor steps being sent out to verify that no gross discrepancy exists (as in the case of a motor stall). If the encoder position deviates excessively from the desired position in the course of a move, the AX assumes that the motor has stalled.

Several configuration options pertain to this feature. These include setting a *window* of allowable deviation to account for mechanical backlash. This is set with the Dead Band Window (**DW**) command. The AX detects a stall when the encoder position lags the motor position by the distance set with the **DW** command. You can set the AX to stop the motor when it detects a stall (**FSD1** command). The AX can also activate an output when it detects a stall (**FSE1** command).

Each comparison is independent of the prior one. Hence, if an allowable error exists every time the comparison is made, the AX will not detect a stall. Such a condition might occur, for example, if there is minor slipping in the motor or encoder coupling, or slop in the gear train.

Enter the following commands to verify that the Stall Detect function is operating properly.

STEP 1

Command	Description
FSB1	Enable Encoder mode
FSH1	Enable Stall detect
FSD1	Terminate move on stall detect
DW1ØØ	Sets backlash to 100 motor steps
A1	Sets acceleration to 1 rev sec^2
V.1	Sets velocity to .1 rps
D128ØØ	Sets distance to 12,800 steps
G	Executes the move (Go)

While the motor is making its move you should inhibit the move either by holding the motor shaft or by carefully disconnecting the +5V lead from encoder connector pin #1. The motor then stalls and abandons the current move.

STEP 2

Use the **RC** command to verify the stall detection. The response to this command should be either *A or *C, depending on the status of the Go Home command. *A means the stall was detected and the Go Home was successful. *C means the stall was detected, and the Go Home was unsuccessful.

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Testing Stop-On-Stall

When you enable the Stop-on-Stall function with the **FSD1** command, the move will terminate, without any delay, as soon as a stall is detected. This function works either in Motor Step or Encoder Step mode.

CAUTION

Disabling the Stop-on-Stall function with the FSDØ command will allow the AX to finish the move regardless of a stall detection, even if the load is jammed. This can potentially damage user equipment.

The **FSD1** command is valid only if the Enable Stall Detection (**FSH1**) command has been issued.

The Stop-on-Stall function depends on the setting for backlash (set with the **DW** command) to give optimum operation. The factory default setting for backlash is 0 motor steps. If you mount the encoder on the motor, you should leave this parameter set to zero for the most accurate response.

To test the stop-on-stall function, carefully disconnect the +5V lead from encoder connector pin #1. Then use the following command sequence:

Command	Description
MN	Sets Mode normal
FSBØ	Sets indexer to motor step mode
FSH1	Enables stall detect.
FSD1	Enables stop on stall.
DW1ØØ	Sets backlash to 100 motor steps
A5	Sets acceleration to 5 revs/sec^2
V1	Sets velocity to 1 rps
D1000	Sets distance to 1000 steps
G	Executes the move (Go)

Having disconnected the encoder power, the AX does not receive any encoder pulses. The AX does not detect a stall until the encoder position lags the motor position by a distance equal to the backlash (set by the **DW** command). Therefore, after the motor moves 100 steps, the AX will automatically detect a stall and stop the motor immediately.

Inputs & Outputs

This section presents information about the AX's inputs and outputs. The following inputs and outputs will be addressed:

- Trigger Inputs
- Programmable Outputs

Inputs

The AX has three trigger inputs: TRIG 1, TRIG 2, and TRIG 3 (AX I/O connector pins 9 - 11). See Chapter 5, Software Reference for a functional description of these inputs.

Verifying Proper Trigger Input Wiring

Use the following steps to verify that you have wired the trigger inputs properly.

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STEP 1 Type **1TS**. If all the Trigger and Sequence inputs are off, you should receive the following response:

111

STEP 2 Turn on (close) the TRIG 1 input switch.

STEP 3 Type **1TS**. You should receive the following response:

011

STEP 4 This verifies that TRIG 1 input is turned on.

Repeat this process for each trigger input.

Verifying Proper Trigger Function

To verify that the Trigger function is operating properly, type the following:

Command	Description
FSHØ	Disable Stall Detect
LD3	Disables all limits
A2	Sets acceleration to 2 revs/sec^2
V2	Sets velocity to 2 rps
D128ØØ	Sets distance to 12,800 steps
TRØXX	Wait for Trigger Input 1 to turn on
G	Executes the move (Go)

The motor moves when you turn on trigger input 1.

Verifying Proper Programmable Output Function

The AX is equipped with two programmable output bits. You may use them to signal a peripheral device that the AX has just completed some event. These outputs are controlled with the **O** Command.

Perform the following steps to verify that you have wired the outputs properly:

STEP 1 Type **O11**.

The response from this command should be a ØVDC, as measured between OPTO 2 and OUT 1 or OUT 2. The output LEDs (if installed) for OUT1 and OUT2 should light.

STEP 2 You may change the reading for outputs 1 and 2 to 12VDC by entering the following command: **OØØ**. The LEDs (if installed) should turn off.

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Coupling the Load

Special couplings that accommodate different types of misalignments are available. The following are the three types of misalignments; they can exist in any combination.

- Parallel Misalignment. The offset of two mating shaft center lines, although the center lines remain parallel to each other
- Angular Misalignment. When two shaft center lines intersect at an angle other than zero degrees
- End Float. A change in the relative distance between the ends of two shafts

Special couplings are used to accommodate the above misalignments and to transmit the desired torque. The coupling manufacturer should be consulted to ensure that the coupling is being used within its specified torque capacity and misalignment ranges.

Shaft couplings may be divided into three types: single-flex, double-flex, and rigid. Like a hinge, a single-flex coupling accepts angular misalignment only. A double-flex coupling accepts both angular and parallel misalignments. Both single-flex and double-flex, depending on their design, may or may not accept end-play. A rigid coupling cannot compensate for any misalignment.

CAUTION

Do not machine the motor shaft without consulting a Compumotor Applications Engineer at (800) 358-9070. Improper shaft machining can destroy the motor bearings.

Single-Flex Coupling

When a single-flex coupling is used, one and only one of the shafts must be free to move in the radial direction without constraint. *Do not use a double-flex coupling in this situation because it will allow too much freedom and the shaft will rotate eccentrically; this will cause large vibrations and immediate failure.*

Double-Flex Coupling

Use a double-flexed coupling whenever two shafts are joined that are fixed in the radial and angular direction (angular misalignment). *Do not use a single-flex coupling with a parallel misalignment; this will bend the shafts, causing excessive bearing leads and premature failure.*

Rigid Coupling

Rigid couplings are generally not recommended. They should be used only if the motor is on some form of floating mounts which allow for alignment compensation.

Coupling Manufacturers

HELI-CAL
901 McCoy Lane
P.O. Box 1460
Santa Maria, CA 93456
(805) 928-3851

ROCOM CORP
5957 Engineer Drive
Huntington Beach, CA 92649
(714) 891-9922

For unusual motor installations contact a Compumotor Applications Engineer for assistance.

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Chapter 4. APPLICATION DESIGN

Chapter Objectives

The information in this chapter will enable you to:

- Understand basic motion control concepts and apply them to your application
- Recognize and understand important considerations that must be addressed before you implement your application
- Understand the capabilities of the system
- Customize the system to meet your requirements
- Use sample applications to help you develop your application

Motion Control Concepts

This section discusses and describes basic motion control concepts that you should be familiar with as you develop your application.

Move Profiles

In any motion control application, the most important requirement is precise position, whether it be with respect to time or velocity. A motion profile represents the velocity of the motor during a period of time in which the motor changes position. The type of motion profile that you need depends upon the motion control requirement that you specify. The basic types of motion profiles are described below. All of the profiles discussed in this chapter can be performed with the AX Drive.

Most indexers can only accelerate at a constant rate, which produces triangular or trapezoidal profiles. The AX, however, allows you to define your own velocity profile or use pre-programmed profiles that optimize the performance of the motor. You can define any acceleration by using **RM** commands.

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Triangular and Trapezoidal Profiles

For constant acceleration indexing systems, velocity, acceleration, and distance parameters are defined before the system can execute a preset move. The value of these parameters determines the type of motion profile as either triangular or trapezoidal. A triangular profile results when the velocity and acceleration are set such that the defined velocity is not attained before the motor travels half of the specified distance. This results from either a relatively low acceleration, a relatively high velocity, or both. For example, if the acceleration is set to 1rps^2, velocity is set to 20 rps, and distance is set to 2,590 steps, a triangular motion profile is the result. By the time the motor has traveled half of the defined distance based on the acceleration setting of 1rps, the motor begins decelerating to complete the move. The motion profile for this move is shown in Figure 4-1.

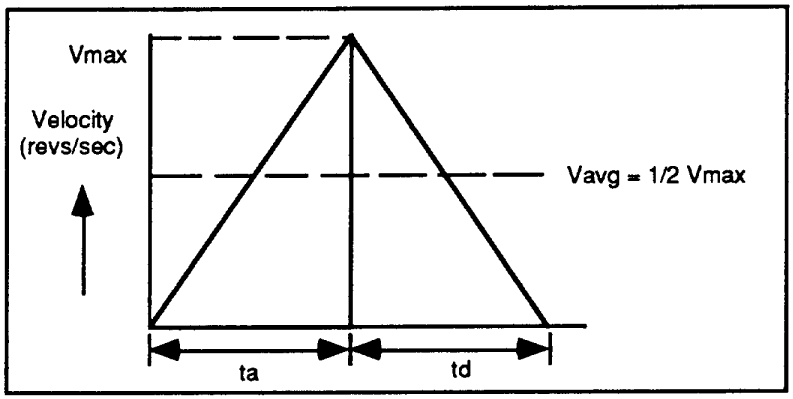


Figure 4-1. Triangular Profile

A trapezoidal move profile results when the defined velocity is attained before the motor has moved half of the specified distance. A trapezoidal move may occur if you specify a low velocity with a high acceleration or a long distance. The resulting motion profile will resemble the profile shown in Figure 4-2.

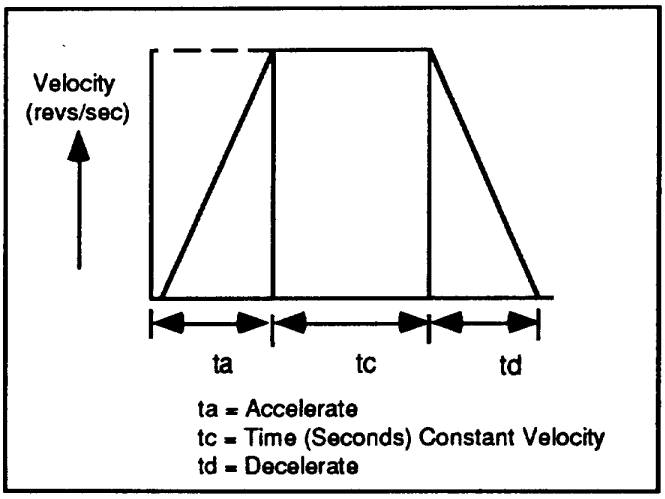


Figure 4-2. Trapezoidal Profile

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Custom Profiles

You can define a custom profile with the Rate Multiplier in Velocity Streaming Mode (**RM**) command. With this command, the AX makes an instantaneous change to the specified velocity. The timing between issuing each **RM** command determines the exact move profile. Sending **RM** commands to the AX in rapid succession provides smoother motion by virtue of an S-curve acceleration (see Figure 4-3). Testing and modification may be required to establish the correct sequence of **RM** commands.

*NOTE: To perform custom profiling with the **RM** command, you must first set the AX Drive to the Velocity Profiling Mode with the **Q1** command. Use the **QØ** command to exit the velocity profiling mode.*

Command	Description
Q 1	Enter Velocity streaming mode
RMØ19Ø	Accelerate to 1 rev/sec
RMØ32Ø	Accelerate to 2 revs/sec
RMØ46Ø	Accelerate to 3 revs/sec
RMØ64Ø	Accelerate to 4 revs/sec
RMØ46Ø	Decelerate to 3 revs/sec
RMØ32Ø	Decelerate to 2 revs/sec
RMØ19Ø	Decelerate to 1 rev/sec
RMØØØØ	Decelerate to 0 revs/sec
Q Ø	Exit velocity streaming mode

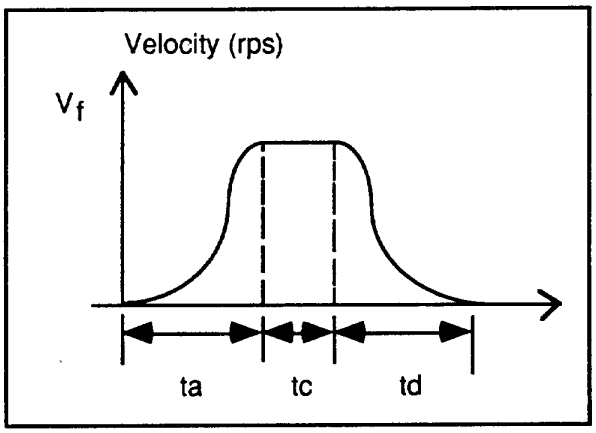


Figure 4-3. S-Curve Profile

Move Times: Calculated vs Actual

You can calculate the time it takes to complete a move by using the acceleration, velocity, and distance values that you define. However, you should not assume that this value is the actual move time. There is calculation delay and motor settling time that make your move longer. After you issue the Go (**G**) command, the indexer can take up to 5 milliseconds to calculate the move before the motor starts moving. You should also expect some time for the motor to settle into position. Settling time varies depending on the load, but it can be 50 milliseconds or longer.

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Incremental vs. Absolute Positioning Modes

A preset move is a move distance that you specify (in micro-steps). You can select preset moves by putting the AX into normal mode using the Mode Normal (**MN**) command. Preset moves allow you to position the motor in relation to the motor's previous stopped position (incremental moves) or in relation to a defined zero reference position (absolute moves). You can select incremental moves by using the Mode Position Incremental (**MPI**) command. You can select absolute moves using the Mode Position Absolute (**MPA**) command.

Incremental Preset Mode Moves

When you are in the Incremental mode (**MPI**), a preset move moves the shaft of the motor the specified distance from its starting position. For example, to move the motor shaft 1.5 revolutions, a preset move with a distance of +19,200 steps (1.5 revs @ 12,800 steps/rev) would be specified. Every time the indexer executes this move, the motor moves 1.5 revs from its resting position. You can specify the direction of the move in one command. You specify the direction by using the optional sign (**D+2Ø,ØØØ** or **D-1Ø,ØØØ**), or you can define it separately with the Set Direction (**H**) command (**H+** or **H-**).

Command	Description
MPI	Sets unit to Incremental Position Mode
A 2	Sets acceleration to 2 rps^2
V 5	Sets velocity to 5 rps
D 2 5 6 Ø Ø	Sets distance to 25,600 steps
G	Executes the move (Go)
G	Repeats the move (Go)
H	Reverses direction of next move
G	Executes the move (Go)

The motor moves two CW revolutions and stops. It then moves two more CW revolutions in the same direction and stops. The motor changes direction and moves two revolutions.

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Absolute Preset Mode Moves

A preset move in the absolute mode (**MPA**) moves the motor the distance that you specify (in motor steps) from the absolute zero position. You can set the absolute position to zero with the Position Zero (**PZ**) command, by issuing the Go Home (**GH**) command, or by cycling the power to the drive. The absolute zero position is initially the power-up position.

The direction of an absolute preset move depends upon the motor position at the beginning of the move and the position you command it to move to. For example, if the motor is at absolute position +12,800, and you instruct the motor to move to position +5,000, the motor will move in the negative direction a distance of 7,800 steps to reach the absolute position of +5,000.

The AX powers up in Incremental mode. When you issue the Mode Position Absolute (**MPA**) command, it sets the mode to absolute. When you issue the Mode Position incremental (**MPI**) command the unit switches to Incremental mode. The AX Drive retains the absolute position, even while the unit is in the Incremental mode. You can use the Position Report (**PR**) command to read the absolute position.

Command	Description
MPA	Sets unit to Absolute Position mode
A2	Sets acceleration to 2 rps^2
V1Ø	Sets velocity to 10 rps
PZ	Sets the current position to as home
D128ØØ	Sets distance to 12,800 steps
G	Executes the move (Go)
D256ØØ	Sets distance to 25,600 steps
G	Moves the motor to absolute position 25,600 (Go)
DØ	Sets the move distance to 0
G	Executes the move (Go)
MPI	Sets indexer to Incremental Position mode

The motor moves 1 revolution and stops. It then moves another revolution and stops. Then the motor moves in the opposite direction two revolutions.

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Positional Accuracy vs. Repeatability

In positioning systems, some applications require high absolute accuracy. Others require repeatability. You should clearly define and distinguish these two concepts when you address the issue of system performance.

If the positioning system is taken to a fixed place and the coordinates of that point are recorded, the only concern is how well the system repeats when you command it to go back to the same point. For many systems, what is meant by accuracy is really repeatability. Repeatability measures how accurately you can repeat moves to the same position.

Accuracy, on the other hand, is the error in finding a random position. For example, suppose the job is to measure the size of an object. The size of the object is determined by moving the positioning system to a point on the object and using the move distance required to get there as the measurement value. In this situation, basic system accuracy is important. The system accuracy must be better than the tolerance on the measurement that is desired.

For more information on accuracy and repeatability, consult the technical data section of the Compumotor Catalog.

Open Loop Accuracy

Open-loop absolute accuracy of a step motor is typically less than a precision-grade system, but is better than most tangential drive systems. Of course, when you close the loop with an incremental encoder, the accuracy of these systems is equivalent to the encoder's accuracy.

The worst case accuracy of the system is the sum of the following errors. Accuracy = A + B.

A Uni-directional Repeatability: The error measured by repeated moves to the same point from different distances in the same direction.

B Hysteresis: The backlash of the motor and mechanical linkage when it changes direction due to magnetic and mechanical friction.

Closed Loop Accuracy

Closed-loop accuracy is determined by the resolution of the encoder. When enabled, the AX attempts to position the motor within the specified dead band from the encoder. Typically, this means the motor will be positioned to within one encoder step. To do this satisfactorily, the encoder must have a lower resolution than the motor. If the step size of the motor is equal to or greater than the step size of the encoder, the motor will be unable to maintain the position and may become unstable. In a system with adequate motor-to-encoder resolution (4:1), the motor is able to maintain accuracy within one encoder step. See also, Selecting Encoder Resolution Values discussed later in this chapter.

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Application Considerations

Successful application of a rotary motor system requires careful consideration of the following important factors:

- Mechanical Resonance
- Ringing or Overshoot

Mechanical Resonance

Resonance, a characteristic of all stepper motors, can cause the motor to stall at low speeds. Most full-step motor controllers *jump* the motor to a set minimum starting speed to avoid this resonance region. This causes poor performance below one rev per second. In nearly all cases, the stepping features of the AX will overcome these problems. However, in some cases the drive will need to be optimized with some simple adjustments to overcome resonance.

Resonance occurs at speeds which approach the natural frequency of the motor's rotor and the first and second harmonics of those speeds. It causes the motor to vibrate at these speeds. The speed at which fundamental resonance occurs is typically between 0.3 and 0.8 revs per second and is highest for small motors and lowest for large motors.

Motors which will not accelerate past one rev per second may be stalling due to resonance. The resonance point may be lowered to some extent by adding inertia to the motor shaft. This may be accomplished by putting a drill chuck on the back shaft. *Note that this technique is applicable only to double-shaft motors with the shaft extending from both ends of the motor.* In extreme cases, you may also need a viscous damper to balance the load. One of the manufacturers of viscous dampers is listed below:

Ferrofluidics Corporation
40 Simon Street
Nashua, NH 03061
(603) 883-9800

Adjusting the waveform (**WV** command) or changing the velocity (**V** command) and acceleration (**A** command) may also help a resonance problem.

Ringing or Overshoot

The motor's springiness, along with its mass, form an underdamped resonant system that *rings* in response to acceleration transients (such as at the end of a move). Ringing at the end of a move prolongs settling time. *Overshoot* occurs when the motor rotates beyond the actual final position. The actual settling time of a system depends on the motor's stiffness, the mass of the load, and any frictional forces that may be present. By adding a little friction, you can decrease the motor's settling time.

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Modes of Operation

Open Loop Operation

This section contains examples of open loop moves that you can perform with the AX Drive. Open-loop moves *do not* use external sensors to provide position correction signals.

Utility Commands

The utility commands below may be useful throughout the following section while testing your AX.

Command	Description
K	Halts the motor immediately. The immediate deceleration may cause a loss of position. This is a *panic* stop. This command takes effect immediately after you issue it.
S	Decelerates the motor to a stop using the last defined acceleration value. The system executes this command immediately after you issue it.

Command	Description
LD3	Disables the limit switch functions. It allows motor motion with no limits connected.

Command	Description
^H	Instructs the AX to backspace the cursor and delete the last character you entered

Command	Description
P S	Instructs the motor to pause for a period of time that you specify. Commands that following the Pause command are not executed until the indexer receives a Continue (**C**) command to clear the pause and resume execution resume.

Command	Description
Z	Resets the system (like cycling power)

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Sample Incremental Mode Moves

The moves shown below are incremental moves. The distance specified is relative to the motor's current position. This is the default (power-up) positioning mode. You can invoke this mode with the Mode Position Incremental (**MPI**) command Whenever you do not specify the direction, the unit defaults to the positive direction.

Command	Description
LDØ	*Enables CW and CCW Limits*
MN	Performs a single preset move
A2	Sets acceleration to 2 revs/sec^2
V5	Sets velocity to 5 rps
D4ØØØ	Sets distance to 4,000 steps
G	Executes the move (Go)

The motor moves 4,000 steps in the positive (CW) direction.

Command	Description
D-4ØØØ	Changes the distance to 4,000 steps in the opposite (CCW) direction.
G	Executes the move (Go)

The motor returns to its original starting position.

Command	Description
H	Toggles the motor direction of the next move, but maintains existing acceleration, velocity, and distance parameters.
G	Executes the same move profile as the previous move, but in the opposite direction(Go)

Command	Description
D1ØØØ	Sets distance to 1,000 steps.
G	Executes 1,000-step move (Go)
T2.5	Waits 2.5 seconds after finishing the move
D5ØØØ	Sets distance to 5,000 steps
G	Executes 5,000-step move (Go)

As soon as you enter the **T2.5** command, the time delay starts. If you wish to load all the commands before executing them, you may use the Pause (**PS**) and Continue (**C**) commands.

Command	Description
PS	Pauses execution until the indexer receives a Continue (**C**) command
G	Executes the 5,000-step move (Go)
T3	Waits 3 seconds after the move
G	Moves 5,000 steps
C	Starts **G T3 G** commands

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Sample Absolute Mode Moves

The moves shown below are absolute mode (**MPA**) moves. The distance specified is relative to the AX's absolute zero position.

Command	Description
MN	Sets the AX in Preset Move mode
MPA	Sets the AX to the Absolute Position mode

Command	Description
PZ	Sets the current absolute position to zero
A5	Sets acceleration to 5 revs/sec^2
V3	Sets velocity to 3 rps
D5ØØØ	Sets distance to 5,000 steps
G	Executes 5,000-step move (Go)

Command	Description
D1ØØØØ	Moves the motor to absolute position 10,000. (Since the motor was already at position 5,000, it moves 5,000 additional steps in the same direction.)
G	Executes the move (Go)
DØ	Moves the motor to absolute position 0. (Since the motor is at absolute position 10,000, the motor moves 10,000 steps in the opposite direction.)
G	Executes the move (Go)

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Sample Continuous Mode Moves

The Continuous Mode (**MC**) is useful for applications that require constant movement 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 synchronized to external events such as trigger input signals. You can manipulate the motor movement with either buffered or immediate commands. After you issue the **G** command , buffered commands are executed in the order in which they were programmed. Immediate commands are used to instantaneously change the motor's acceleration and velocity when the motor is already in continuous motion.

The following example demonstrates buffered commands in the continuous mode.

Command	Description
MC	Sets mode to continuous
A1Ø	Sets acceleration to 10 rev/sec^2
V5	Sets velocity to 5 rev/sec
CL2	Loop continuously 2 times
CV5	Changes velocity to 5 rev/sec
CTM5	Waits 5 seconds
CV2	Changes velocity to 2 rev/sec
CTM3	Waits 3 seconds
CN	Ends continuous mode loop
CVØ	Changes velocity to 0
G	Executes the move (Go)

The motor accelerates to 5 rps, waits 5 seconds, decelerates to 2 rps, waits 3 seconds, accelerates to 5 rps, waits 5 seconds, decelerates to 2 rps, waits 3 seconds, then comes to a stop. Note that issuing the **CVØ** command stops the motor (the **S** command is not a buffered command and cannot be used in a sequence).

The following Continuous Mode (**MC**) commands will accelerate or decelerate the motor to a specified velocity and continue at that velocity. To make an immediate change in acceleration while the motor is moving, use the Acceleration Change (**AC**) command. To immediately change the velocity while the motor is moving, use the Velocity Change (**VC**) command. To stop the motor, issue the Stop (**S**) command or enter **VCØ** . The motor will stop if a limit is encountered.

Command	Description
LDØ	*Enables CW and CCW limits*
MC	Sets all moves to the Continuous mode
A1	Sets acceleration to 1 rev/sec^2
V.5	Sets final velocity to 0.5 rps
G	Executes move (moves continuously at 0.5 rps

While the motor is in motion, enter the following commands:

Command	Description
VC.4	Immediately changes velocity to 0.4 rps

Command	Description
AC3	Immediately changes acceleration to 3 rps^2
VC.2	Immediately changes velocity to 0.2 rps at 3 rps^2

Command	Description
VCØ	Decelerates the motor to a stop

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Closed Loop Operation

This section contains examples of closed-loop moves that you can perform with the AX Drive. Closed-loop moves *use* external sensors to provide position correction signals. Motor position may be adjusted to reach the desired position.

Encoder Compatibility

The AX Drive is capable of interfacing with an optical encoder. Incremental encoders with quadrature (single-ended or differential) TTL Square wave outputs may be used. The encoder may also be used as a means of creating a closed-loop system or as an independent means of verifying motor position. The functions that are added to a system when an encoder is used are listed below:

- Encoder referenced positioning
- Encoder position servoing
- Motor stall detection
- Higher accuracy homing function
- Multi-axis stop (also available without an encoder - see **FSF** command description in Chapter 5)

To implement the closed-loop functions, you must connect an incremental optical encoder to the AX. The AX can supply up to 250mA to power the encoder. When you use encoders with single-ended outputs, do not connect channels A-, B-, and Z- to the AX Drive's encoder connector.

Selecting Encoder Resolution Values

The number of encoder steps that the AX system recognizes is equal to four times the number of encoder *lines*. For example, a 1000-line encoder mounted directly on the motor will generate 4000 encoder steps per revolution of the motor shaft. A minimum of three motor steps per encoder step is required for successful operation of the Position Maintenance function. Ratios above three motor steps per encoder step ensure stability of the position maintenance servo function. Positional resolution is determined by encoder resolution.

If you install a reducer between the motor shaft and the encoder, the number of encoder steps that the indexer receives is equivalent to the number of encoder steps divided by the encoder gear ratio.

For example, using a 12,800 steps/rev motor, a 1,000-line encoder, and a 10:1 reducer, the ratio of motor revolutions to encoder steps would be changed as described in Table 4-1 below.

Parameter	1:1 Ratio	10:1 Ratio
Number of encoder steps recognized by the AX (per motor rev)	4,000	400
Required ratio of motor revs to encoder steps	1/4,000	1/400
Motor-to-encoder step ratio	3.2/1	32/1

Table 4-1. Motor-to-encoder Ratios

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SETTING ENCODER RESOLUTION

You can use the encoder to achieve greater accuracy or stall detection. Typically, the incremental encoder improves the overall accuracy of your system.

Since there are many different encoders with different resolutions, you must specify for the AX what type of encoder you have connected to the system. Using the following example as a guide, you can specify the encoder's resolution to the indexer with the Encoder Resolution (**ER**) command.

Command	Description
ER4000	Tells the indexer that the encoder has a resolution of 4,000 steps/rev after quadrature (1,000 lines)

Encoder Step Mode

The indexer can perform moves in either motor steps or encoder steps. In Motor Step mode (**FSBØ**), the distance command (**D**) defines moves in motor steps. In Encoder Step mode (**FSB1**), the distance command defines moves in encoder steps.

You must set up the indexer for the correct encoder resolution The Encoder Resolution (**ER**) command is used to define the encoder resolution.

The sample move below assumes the use of an encoder with an encoder-to-motor step ratio of 4:1.

Command	Description
MN	Sets mode to normal
ER4ØØØ	Sets up encoder where 4,000 encoder steps (1,000 lines) are produced per 1 revolution of the motor.
FSB1	Sets move to encoder step mode
A1Ø	Set acceleration to 10 revs/sec^2
V5	Set velocity to 5 revs/sec
D4ØØØ	Set distance to 4,000 encoder steps
G	Executes the move (Go)

The motor will turn in the CW direction until 4,000 encoder steps (1 revolution) are received.

If this move does not work, refer to Chapter 7, Maintenance and Troubleshooting.

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Position Maintenance

This Position Maintenance (**FSC**) command enables and disables the position maintenance function.

You must enable Position Maintenance (**FSC1**) to activate closed loop servoing and ensure that encoder step moves are positioned to the exact encoder step commanded. Enabling position maintenance will cause the indexer to servo the motor until the correct encoder position is achieved. This occurs at the end of a move (if the final position is incorrect) or any time the indexer senses a change in position while the motor is at zero velocity. You must have an encoder connected, and the indexer set in Encoder Step mode (**FSB1**) in order to enable position maintenance.

Position maintenance will be disabled (turned OFF) automatically if a stall is detected (refer to the **FSH** command in Chapter 5), or if the encoder is forced outside of the dead band window.

The sample move below assumes the use of an encoder with a encoder-to-motor step ratio of 4:1.

Example

Command	Description
ER4ØØØ	Sets up encoder where 4,000 encoder pulses (1,000 lines) are produced per 1 revolution of the motor.
FSB1	Sets move to encoder step mode
FSC1	Enables Position Maintenance
MN	Set indexer to normal mode
A1Ø	Set acceleration to 10 revs/sec^2
V5	Set velocity to 5 revs/sec
D4ØØØ	Set distance to 4,000 encoder steps
G	Executes the move (Go)

The motor will turn in the CW direction until 4,000 encoder pulses (1 revolution) are received. The Position Maintenance function instructs the AX to servo the motor until the correct encoder position is achieved.

If this move does not work, refer to Chapter 7, Maintenance and Troubleshooting.

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Stop-On-Stall

You can enable the Stop-on-Stall function with the **FSD1** command. The move will terminate, without any delay, as soon as a stall is detected This function works either in Motor Step or Encoder Step mode.

CAUTION

Disabling the Stop-on-Stall function with the FSDØ command will allow the AX to finish the move regardless of a stall detection, even if the load is jammed. This can potentially damage user equipment.

The **FSD1** command is valid only if the Enable Stall Detection (**FSH1**) command has been issued.

The Stop-on-Stall function depends on the setting for backlash (set with the **DW** command) to give optimum operation. The factory default setting for backlash is 0 motor steps. **If you mount the encoder on the motor, you should leave this parameter set to zero for the most accurate response.**

Command	Description
DW1ØØ	Sets backlash value to 100 steps.
ER4ØØØ	Sets encoder resolution to 4,000 steps/rev.
FSH1	Enables stall detect.
FSD1	Enables stop on stall.

Stall detection does not occur until the error exceeds the dead band backlash (set with the **DW** command). Consequently, if the indexer does not see an encoder pulse after moving the motor 100 steps, the AX will detect a stall and stop the motor immediately.

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Determining Backlash

You can measure the actual backlash with the following procedure. The idea is to move in one direction, stop, and make a series of one-step moves in the opposite direction. No change in encoder position occurs while the indexer takes up the backlash. The number of motor steps counted before any encoder counts are received is the measure of the backlash. *NOTE: When the encoder is mounted directly to the motor, this is mainly a magnetic backlash (or hysteresis), otherwise, gear backlash is also measured.*

Move the motor in one direction and clear the position counters with the following commands.

Command	Description
FSBØ	Sets indexer to motor step mode
MN	Sets Mode normal
A1Ø	Sets acceleration to 10 revs/sec^2
V1	Sets velocity to 1 rps
D64ØØ	Sets distance to 6400 steps
G	Executes the move (Go)
PZ	Sets absolute position counter to zero

Now execute a series of one-step moves and report both motor and encoder position each time:

Command	Description
D1	Sets distance to 1 step
PS	Pauses execution of the following commands until the indexer receives the Continue (**C**) command
L	Causes the sequence to repeat
G	Executes the move (Go)
1LF	Sends a line feed
1PR	Reports absolute motor position in motor steps
T1.Ø	Pauses the motor for 1 second
1LF	Sends a line feed
1PX	Reports the number of encoder pulses (steps) that the encoder has received since the Position Zero (**PZ**) command was issued
T1.Ø	Pauses the motor for 1 second
N	Ends the loop
C	Clears pause and executes the move

While this command string is running, you may compare the position reports from the Position Report (**PR**) command and the Report Absolute Encoder Position (**PX**) command. The **1PR** report represents the number of motor steps traveled, and the **1PX** report represents the number of encoder steps traveled. When the response from the **1PX** command changes from 0 to 1, note the response from the **1PR** command. This **1PR** command report is the actual backlash of your system.

To use the AX's stall detection function, set the Dead Band Window (**DW**) command equal to the value of the backlash determined above and then Enable Stall Detect (**FSH1**).

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Output-On-Stall

You can select the Output-on-Stall function with the Turn on Output #1 on Stall Detect (**FSE**) command. This is useful for signaling other components in your system that a stall has occurred.

If you enter the **FSE1** command, the AX programmable Output #1 goes on (current flows) when a stall is detected and remains on until a new move begins. This command is valid only if the Stall Detection has been enabled (**FSH1**), and if the AX is set to Encoder Step Mode (**FSB1**).

Command	Description
MN	Sets the system in the preset mode
FSB1	Enables encoder mode
DW1Ø	Selects backlash to be 10 motor steps
FSH1	Enables stall detect function
FSD1	Stops motor if a stall is detected
FSE1	Turns on Output 1 if stall is detected
A2	Sets acceleration to 2 revs/sec^2
V.1	Sets velocity to 0.1 rps
D128ØØ	Sets distance to 12,800 encoder steps
G	Execute the move (Go)

While the motor is moving, you can cause a stall by holding the shaft. If you can not manually stall the motor, you can simulate a stall by carefully disconnecting the +5V encoder lead from pin #1 on the AX encoder connector. When the stall occurs, Output 1 is turned on and the motor stops (this signals you that the motor has stalled). The motor will come to a stop.

Multi-Axis Stop

On a multi-axis AX system, you may wish to have all axes stop motion if a stall is detected on any axis. You can select this function via the Kill Motion on Trigger 3 (**FSF**) command. When selected with the **FSF1** command, a signal on the Trigger 3 input terminates the move immediately, thus functioning as a remote stop input.

Follow the following steps to set up your AX system to terminate the multi-axis moves when a stall is detected on any axis:

1. Set the first AX unit to Turn on Output 1 on Stall (**FSE1**)

2. Connect Output 1 (pin 15) on the first AX unit to Trigger 3 (pin 11) on all the other AX units in the daisy-chain.

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Output on Position Loss

The Turn on Output #2 When Within Dead Band (**FSG**) command allows the AX to signal other system components when the motor is within the dead band. This command is valid only if Stall Detection (**FSH1**) has been enabled; it will have no effect otherwise.

At the end of the move, if the motor is within the specified dead band (**DB**), Output #2 will be turned on.

Command	Description
MN	Sets the system in the preset mode
FSB1	Sets indexer to encoder step mode
FSC1	Enables position maintenance
DB1Ø	Selects dead band at 10 encoder steps (Position Maintenance is activated if the motor's end-of-move position is off by more than 10 encoder steps.)
FSH1	Enables stall detect function
FSG1	Turns on Output 2 if the motor's end-of-move position is within the 10 encoder step dead band range
A2	Sets acceleration to 2 revs/sec^2
V5	Sets velocity to 5 rps
D5ØØ	Sets distance to 500 steps
G	Execute the move (Go)

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Program Control

Triggers

You can use the Wait for Trigger (**TR**) command to specify a configuration of trigger conditions to be matched before executing a sequence of buffered commands. The trigger inputs are TRIG 1, TRIG 2, and TRIG 3. The three possible conditions you can specify are as follows:

- 1 = Wait for the trigger input to be high (no current flows)
- Ø = Wait for the trigger input to be low (current flows)
- X = Ignore the trigger input

Command	Description
MN	Sets unit to Preset mode
A2	Sets acceleration to 2 revs/sec^2
V5	Sets velocity to 5 rps
D256ØØ	Sets distance to 25,600 steps
TRØ1X	Waits for Trigger Input 1 to turn on and Trigger Input 2 to turn off (ignores Trigger Input 3)
G	Executes 4,000-step move (Go)

The move will not be executed until current flows on the TRIG 1 input and no current flows on the TRIG 2 input.

The **TS** command is useful for checking the status of the trigger inputs when it appears as though execution is being halted by the **TR** command and all conditions for matching the trigger input configuration defined by the **TR** command appear to be met. It may also be used to initiate external actions by monitoring the trigger inputs manually with a computer controlling the AX.

Delays

You can use the Time Delay (**T**) command to halt the operation of the indexer function for a preset time. If you are in the Continuous Mode (**MC**), you may use the Continous Time (**CTM**) command to run the motor at continuous velocity for a set time, then change to a different velocity.

In the Preset mode (**MN**), the motor finishes the move before the indexer executes the time delay.

Command	Description
PS	Waits for the AX to receive a Continue (**C**) command before executing next command
A7	Sets acceleration to 7 revs/sec^2
V6	Sets velocity to 6 rps
D256ØØ	Sets distance to 25,600 steps
G	Moves motor 25,600 steps
T5.Ø	Waits 5 seconds after the move ends
H	Changes motor direction
G	Moves motor 25,600 steps in the opposite direction
C	Cancels Pause and executes the move

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Loops

This section discusses methods of establishing loops in the programs you write for you application. Loops can be created individually or nested within each other.

Single Loops

You may use the Loop (**L**) command to repeat certain programs the one provided below. All the commands between the **L** command and the **N** command are looped (repeated) the number of times indicated in the **L** command. You can use the Immediate Pause (**U**) command to temporarily halt execution of the loop while it is in progress. *NOTE: The **U** command does not work in continuous mode.* To resume loop execution, issue the Continue (**C**) command.

Command	Description
P S	Pauses command execution until the indexer receives a Continue (**C**) command
MPI	Sets mode to incremental
MN	Sets move to normal mode
A 5	Sets acceleration to 5 revs/sec^2
V 5	Sets velocity to 5 rps
L 5	Performs the Loop 5 times
D 1 2 8 Ø Ø	Sets distance to 12,800 steps
G	Executes the move (Go)
T 2 . Ø	Delays 2 seconds after the move
N	Ends Loop
C	Initiates command execution

The motor moves a total of 64,000 steps (a succession of five 12,800-step moves with a 2-second pause between each move).

Nested Loops

The example below shows how you can nest a small loop inside a major loop. The only way you can nest a loop is by using the Constant Velocity Loop (**CL**) and End Loop (**CN**) commands in the continuous mode (**MC**). You may nest a constant velocity loop within a standard loop, but not within another CL loop. The following sequence turns on output 1, then output 2, then turns then both off. You can issue the Stop Loop (**Y**) command to terminate both loops.

Command	Description
P	Pauses execution until C command
MC	Sets move to continuous mode
V1	Sets velocity to 1 rps
L10	Loops 10 times
CL5	Constant velocity loop 5 times
CO1X	Turns on output 1
CTM1	Waits 1 second
COX1	Turns on output 2
CV2	Changes velocity to 2 rps
COØØ	Turns off both outputs
CV1	Changes velocity to 1 rps
CN	Ends continuous velocity nested loop
CVØ	Changes velocity to 0 (stop)
G	Executes move
H	Changes direction
N	Ends outer loop
C	Cancels pause and executes move

Nested Loop

Outer Loop

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POBs (Programmable Output Bits)

You can turn the programmable output bits (OUT 1 and OUT 2) on and off using the Output (**O**) command. You can use the outputs to signal remote controllers, turn on LEDs, sound buzzers, etc. A one (1) turns on a given output, a zero (0) turns the output off, and an X leaves the output unchanged. The outputs conduct current when they are on and do not conduct when they are off (see the **O** command description in Chapter 5, Software Reference).

Command	Description
MN	Set move to Mode Normal
PS	Pauses execution until indexer receives a Continue (**C**) command
A1Ø	Sets acceleration to 10 revs/sec^2
V5	Sets velocity to 5 revs/sec
D384ØØ	Sets move distance to 38,400 steps
OØ1	Sets programmable output 1 off and output 2 on
G	Executes the move (Go)
OXØ	After the move ends, leaves output 1 unchanged and sets output 2 off
C	Cancels the Pause and executes the move

Move Completion Signal

When you complete a move, you may use the AX's programming capability to signal the end of the current move. In a preset move, you may use one of the following commands:

- **LF** Line feed (see example #1)
- **CR** Carriage return (see example #2)
- **O** Output command (see example #3)
- **"** Quote command (see example #4)

Example #1

Command	Description
PS	Pauses execution until indexer receives a Continue (**C**) command
MN	Sets move to normal mode
A2	Sets acceleration to 2 revs/sec^2
V2	Sets velocity to 2 rps
D384ØØ	Sets distance to 38,400 steps
G	Executes the move (Go)
1LF	Sends a line feed over the RS-232C interface
C	Cancels the Pause and executes the move

The motor moves 38,400 steps. When you complete the move, the unit issues a line feed from the AX to the host over the RS-232C interface.

Example #2

Command	Description
PS	Pauses execution until indexer receives a Continue (**C**) command
MN	Sets move to normal mode
A2	Sets acceleration to 2 revs/sec^2
V2	Sets velocity to 2 rps
D384ØØ	Sets distance to 38,400 steps
G	Executes the move (Go)
1CR	Sends a carriage return
C	Cancels the Pause and executes the move

The motor moves 38,400 steps. When the AX completes the move, it issues a carriage return to the host over the RS-232C interface.

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Example #3

Command	Description
PS	Pauses execution until indexer receives a Continue (**C**) command
MN	Sets move to normal mode
A2	Sets acceleration to 2 revs/sec^2
V2	Sets velocity to 2 rps
D384ØØ	Sets distance to 38,400 steps
G	Executes the move (Go)
O1X	Turns on Output 1
C	Cancels the Pause and executes the move

The motor moves 38,400 steps. When the AX completes the move, Output 1 is turned on.

Example #4

Command	Description
PS	Pauses execution until indexer receives a Continue (**C**) command
MN	Sets move to normal mode
A2	Sets acceleration to 2 revs/sec^2
V2	Sets velocity to 2 rps
D384ØØ	Sets distance to 38,400 steps
G	Executes the move (Go)
"DONE	Sends the message, DONE, to the terminal
C	Cancels the Pause and executes the move

The motor moves 38,400 steps. When you complete the move, the AX issues the DONE message to the host over the RS-232C interface.

Sequences

A sequence is a series of commands. These commands are executed in their programmed order whenever the sequence is run. Immediate commands cannot be stored in a sequence, just as they cannot be stored in the command buffer. Only buffered commands may be used in a sequence.

Sequence Programming

The AX has 2,000 bytes of non-volatile memory (EEPROM) to store up to 7 sequences. Each sequence may have up to 256 characters (including delimiters). Note that one sequence cannot borrow any unused portion of another sequence's allocated memory. Use the following commands to define, erase, and run sequences:

Command	Description
XD	Starts sequence definition
XE	Deletes sequence from EEPROM
XP	Sets Power-up Sequence Mode
XQ	Sets/resets interrupted Run mode
XR	Runs a sequence
XRP	Runs a sequence with a pause
XT	Ends sequence definition
XU	Uploads sequence
XZ	Sets power-up sequence to zero

The commands that you enter to define a sequence are presented vertically in the examples below. This was done to help you read and understand the commands. When you are actually typing these commands into your terminal, they will be displayed horizontally.

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It is a good practise to erase the sequence with the **XE** command before defining the sequence with the **XD** command. To begin the definition of a sequence, enter the **XD** command immediately followed by sequence identifier number (1 to 7) and a delimiter (pressing the space bar or the carriage return key). The **XT** command ends the sequence definition and automatically loads the sequence into the AX's EEPROM. All commands entered after the **XD** command and before the **XT** command are executed when the sequence is run. An example is provided below.

Command	Description
XE1	Erases Sequence 1
XD1	Begins definition of sequence 1
MN	Sets move to normal mode
A2	Sets acceleration to 2 revs/sec^2
V1Ø	Sets velocity to 10 rps
D128ØØ	Sets distance to 12,800 steps
G	Executes the move (Go)
H	Reverses direction
G	Executes the move (Go)
XT	Ends definition of sequence 1
XR1	Runs Sequence 1

Once you define a sequence, it cannot be redefined until you delete it. You can delete a sequence from EEPROM by entering the **XE** command immediately followed by a sequence identifier (1 to 7) and a delimiter. You may then redefine that sequence into EEPROM . You can issue the Sequence Status Definition (**XSD**) command (preceded by a device address) to verify if the last sequence definition was successful. The possible responses seen on your terminal are *0*, *1*, or *2*. A *0* means the sequence was successfully defined. A *1* means the sequence already exists with the number you have specified. A *2* means there was not enough space in the sequence buffer for that sequence.

To check the status of a sequence, issue the Sequence Status (**XSS**) command. This command must be preceded by a device address and followed immediately by the number (1 to 7) of the sequence and a delimiter. The possible responses are *0* (Empty), *1* (Bad checksum), or *3* (O.K.).

If you wish to check the contents of a sequence, enter the **XU** command. For example, issuing the **1XU1** command causes the AX to send the contents of sequence number 1 to the computer 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. We are assuming in this example that the AX is set up at device address 1.

Sequence Selection

After you define the sequences over the RS-232C interface, you can execute the sequences by using one of the following modes of operation:

- *Stand-alone Operation*
- *Host Computer Operation*
- *Programmable Logic Controller (PLC) Operation*

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Stand-alone Operation

This section explains and provides examples of how to store sequences to be automatically executed when you power-up the system, or executed by remote switches. You will first have to define the sequences into the AX non-volatile memory. You will need a computer or PLC with RS-232C communication capabilities for programming the AX .

Power-up Sequence Execution

A single, pre-defined sequence may be executed on power-up by issuing the **XP** command immediately followed by a sequence identifier number (1 to 7) and a delimiter. For example, if an **XP1** command was entered, sequence #1 would be executed the next time the AX was powered up. Sequence #1 would continue to execute on each subsequent power-up until you issue an **XZ** command or a new **XP(0-9)** command. Once the pre-defined sequence is finished executing, the AX returns control to the RS-232C communications port. If no sequence had been defined as Sequence 1, control would automatically go to the RS-232C communications port.

The **XP** command may be issued at any time, except during sequence definition. Once an **XP** command is entered, it is automatically saved in the AX's non-volatile memory.

To determine which, if any, sequence will be executed on power-up, issue the Sequence Status Power-up (**XSP**) command.

Using Remote Sequence Inputs

One method of executing sequences is performed by issuing the **XP9** command. The **XP9** command will not cause any sequence to be immediately executed. Once you issue the **XP9** command, the AX reads the sequence select inputs (Pins 12-14 on AX I/O connector) every time it is powered-up, or every time the **Z** (software reset) command is issued. The status of the sequence select inputs will be interpreted by the AX as a sequence number (see Table 4-2). If, at the time of power up, the number represented by the sequence select inputs is a valid pre-defined sequence (numbers 1 to 7), the AX will automatically execute that sequence. When this first sequence is finished executing, the AX will once again read the sequence select inputs and execute the next valid sequence number present on these inputs. The AX will continue to execute sequences in this fashion until you issue an **S** (stop) or a **K** (kill) command, or if an end-of- travel limit is encountered. If the AX reads the number 8, or any number that has no sequence defined, it will wait until the status of the inputs changes to a valid, pre-defined sequence.

Sequence	SEQ 1	SEQ 2	SEQ 3
1	ON	ON	ON
2	OFF	ON	ON
3	ON	OFF	ON
4	OFF	OFF	ON
5	ON	ON	OFF
6	OFF	ON	OFF
7	ON	OFF	OFF
8*	OFF	OFF	OFF
* Non-valid sequence	OFF = open switch (not pulled to ground) ON = closed switch (pulled to ground)		

Table 4-2. Sequence Select Inputs

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When in the XP9 mode, it is possible to cause the AX to pause between sequence execution. This is done with the **XQ1** command. When the **XQ1** command is present within a sequence, the AX will pause after the execution of the sequence and will wait for all sequence select inputs to be OFF (see sequence #8 in Table 4-2). The AX will then read the status of the sequence select inputs and execute the corresponding sequence number. This interrupted run mode will continue until you issue the **XQØ** command.

You can also program the AX to read the sequence select lines on power-up with the **XP8** command. This command will cause the AX to execute the first valid sequence number it reads on the sequence select inputs after power-up (exactly like the **XP9** command). It differs from the **XP9** command in that it returns control to the RS-232C communications port after it finishes executing the first sequence, rather than reading the sequence select lines again and executing another sequence.

Sample Applications and Commands

The following are step-by-step procedures demonstrating how to run sequences. Using a terminal or a computer, key in the following commands:

STEP 1 Issue the **XP9** command.

STEP 2 Define the following sequences:

Command	Description
XE6	Erases Sequence 6
XD6	Defines Sequence 6
MN	Sets move to normal mode
A1	Sets acceleration to 1 rev/sec^2
V20	Set velocity to 20 rps
D128ØØ	Sets distance to 12,800 steps
G	Executes the move (Go)
XT	Ends Sequence 6 definition

Command	Description
XE7	Erases Sequence 7
XD7	Defines Sequence 7
MN	Sets move to normal mode
A1	Sets acceleration to 1 rev/sec^2
V20	Set velocity to 20 rps
D-448ØØ	Sets distance to 44,800 steps (CCW)
G	Executes the move (Go)
XT	Ends Sequence 7 definition

STEP 3 Verify that your programs were stored properly by uploading each entered sequence (**XU** followed by the number of the sequence). If you receive responses that differ from what you programmed, re-enter those sequences.

STEP 4 Make sure all the sequence select inputs are off (not grounded).

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STEP 5 Cycle Power or enter the **Z** command. The AX will go through the normal XP9 mode operation. In XP9 mode, the AX scans the sequence select inputs, looking for a valid sequence according to the binary value of the three inputs (see Table 4-2).

STEP 6 Momentarily turn on (ground) the SEQ 2 input. This will execute sequence number 6. *NOTE: After the sequence has finished executing, the inputs are again scanned to execute another sequence.*

STEP 7 Momentarily turn on (ground) the SEQ 1 input. This will execute sequence number 7.

Host Computer Operation

This section assumes you have successfully communicated with the AX. If you have not verified that your RS-232C communications link is functioning properly, return to Chapter 2, Getting Started, and complete this check before attempting to complete this section.

An IBM-compatible software diskette providing terminal emulation is available from Parker Compumotor. To operate the software, you will need BASICA or GW BASIC programming language programs installed in your computer.

Immediate Sequence Execution

You can execute a sequence by entering the **XR** command immediately followed by a sequence identifier number (1 to 7) and a delimiter. The sequence will be executed immediately after the delimiter.

You can issue the Sequence Status Run (**XSR**) command to verify if the last sequence you issued was executed successfully. The possible responses are as follows:

- **Ø** Running
- *Non-Zero* Not running:
  - **1** In a loop
  - **2** Invalid sequence
  - **3** Erased
  - **4** Bad checksum

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Single-Axis Control

The AX system is capable of single and multiple axis applications. The principles developed for a single-axis system apply as well to multi-axis systems.

Single-Axis Interface Program Example

If you already have BASICA or GW BASIC programming languages on your computer, you may use the following sample program designed to open a serial communication port and send and receive AX commands. The program performs the following steps:

- Executes the first move upon user input
- Waits for a line feed from the AX , which indicates the end of the move.
- Upon user input, executes the second move
- Waits for a line feed from the AX, which indicates the end of the move. It then begins the process again.

This application can be looked on as moving a part out, machining the part, then bringing the part back.

```
1 '              AX.BAS PROGRAM
2 '
3 '
    ********************************************************************
4 ' *                                                                  *
5 ' * This program controls the RS232 Communication line to execute 2  *
6 ' * different moves using the AX                                     *
7 ' *                                                                  *
8 ' *                                                                  *
    ********************************************************************
15 OPEN "COM1:9600,N,8,1,RS,CS,DS,CD" AS #1       ' Open Communication port
20 V$ = "": Q$ = "": ECHO$ = "": LF$ = "":        ' Initialize variables
90 CLS
100 LOCATE 12,15
105 PRINT " PRESS ANY KEY TO START THE PROGRAM "
107 V$ = INKEY$: IF LEN(V$) = 0 THEN 100          ' Wait for input from user
120 Z$ = "Z"                          '.Reset the AX indexer
122 PRINT #1,Z$;
124 Q$ = INPUT$(2,1)
900 '
    ********************************************************************
901 ' *                                                                  *
902 ' *  Line 1000-1060 sends a move down to the first AX.  Computer     *
903 ' *  waits for the Line Feed from the AX indicating that the motor   *
904 ' *  has finished its move.   Computer will not command second AX to move *
905 ' *                                                                  *
906 ' *                                                                  *
    ********************************************************************
```

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```
1000 MOVE1$ = "1A1 1V2 1D25,600 1G 1LF "          ' Define move for Axis 1
1005 CLS
1007 LOCATE 12,15: PRINT " DOING MOVE 1 "
1010 PRINT #1,MOVE1$                              ' Move axis 1.
1015 ECHO$ = INPUT$(23,1)                         ' Read echoes from AX
1020 LF$ = INPUT$(1,1)                            ' Wait for line feed from AX
1040 IF LF$ <> CHR$(10) GOTO 1020                       ' indicating end of move.
1045 CLS
1047 LOCATE 12,15
1050 PRINT "MOVE 1 DONE"                          ' Let user know axis 1 is done
1060 LOCATE 15,15: PRINT " PRESS ANY KEY TO GO ON TO SECOND MOVE "
1070 V$ = INKEY$: IF LEN(V$) = 0 THEN 1060
1900 ' ************************************************************************
1901 ' *                                                                      *
1902 ' * After axis one is done, we request that you press any key to go on   *
1903 ' * to the second move.  In real application, we would expect you to      *
1904 ' * go ahead with the process and work on the part before going on to     *
1905 ' * next move.  (i.e.  Activate a punch)                                  *
1906 ' *                                                                      *
1907 ' * Now that first move is finished, we go on to move #2.                *
1908 ' * AX also prints a line feed after finishing the second move.          *
1909 ' * As soon as computer receives the line feed from AX, program will     *
1910 ' * go back to the first move.                                           *
1911 ' *                                                                      *
1912 ' ************************************************************************
2000 MOVE2$ = "A10 V5 D-64000 G H G 1LF"
2005 CLS
2007 LOCATE 12,15: PRINT " DOING MOVE 2 "
2010 PRINT #1,MOVE2$
2015 ECHO$ = INPUT$(25,1)
2020 LF$ = INPUT$(1,1)
2040 IF LF$ <> CHR$(10) GOTO 2020
2045 CLS
2047 LOCATE 12,15
2050 PRINT "MOVE 2 DONE "
2060 FOR I = 1 TO 1000: NEXT I
2070 GOTO 20                              ' Go back to beginning of program.
```

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Multi-Axis Control

Device-specific commands require that a device address precede them. The AX will not execute a device-specific command if there is no device address preceding the command, or if the device address setting in the AX does not match the address preceding the command. *Universal* commands do not require device identifiers preceding them. A universal command with no device address will be executed regardless of the address setting of the AX. If a device address does precede a universal command, it will only be executed by an AX set to that particular address.

The **E** (Enable RS-232 communication) and **F** (Disable RS-232 communication) commands are useful in a daisy chain for locking out particular indexers from responding to universal commands with no preceding device address.

NOTE: The **F** *command will keep the AX from executing any commands (except the* **E** *command) sent to it over the RS-232C interface, but will not prevent the command from being echoed.*

For Example, to lock-out the AX unit set to device address 1, so that universal commands are only executed by the AX's set to address 2 and 3, the following step is performed:

- Send the **1F** command over the RS-232C communication line, locking out the AX at device address 1.

All universal commands (with no preceding device address) will now be executed only by the AX's at Device addresses 2 and 3. Entering a **2F** command in addition to **1F** command would allow only the AX at device address 3 to execute universal commands with no preceding device address. This eliminates the need to precede every command intended for a specific AX (in this case, the AX at device address 3) with a device address. Sending an **E** command over the RS-232C line will re-enable all drives previously disabled with the **F** command. Preceding the **E** command with a device address will re-enable only the AX set to that particular device address.

When using the **XU** command to upload the contents of a specified sequence from an AX in a daisy-chain, it is necessary to disable all the drives in the chain that come after the drive being queried with the **F** command (as described above). This will prevent subsequent drives from executing the commands being sent back to the terminal. See the **XU** command description in Chapter 5, Software Reference .

For daisy-chain wiring instructions, refer to Chapter 2, Getting Started.

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Sample Application and Commands

Example: Three indexers are on an RS-232C daisy chain. Send the following commands:

Command	Description
MN	Sets unit to Preset mode
A5	Sets acceleration to 5 revs/sec^2 for all three indexers
V1Ø	Sets velocity to 10 rps for all three indexers
1D64ØØ	Sets Axis 1 distance to 6,400 steps
2D128ØØ	Sets Axis 2 distance to 12,800 steps
3D192ØØ	Sets Axis 3 distance to 19,200 steps
G	Moves all axes.

Unit 1 moves 6,400 steps, unit 2 moves 12,800 steps, and unit 3 moves 19,200 steps. All three units use the same acceleration and velocity rates. Units 1, 2, and 3 will start at about the same time (2mS apart, due to a propagation delay of 2 characters over the RS-232C interface).

Multi-Axis Interface Program Example

The following program is very similar to AX.BAS, except this program controls 2 AX's on a daisy chain. This program assumes the device address of 2 AX's to be 1 and 2 respectively. The program does the following:

- Executes the first move upon user input
- Waits for a line feed from the LX drive, which indicates the end of the move.
- Upon user input, executes the second move on axis 2
- Waits for a line feed from the second AX, which indicates the end of the move. It then begins the process again.

```
1 '             AX2.BAS PROGRAM
2 '
3 '   ********************************************************************
4 ' *                                                                    *
5 ' * This program controls the RS232 Communication line to execute 2    *
6 ' * different moves using 2 AX units..                                 *
7 ' *                                                                    *
8 ' *                                                                    *
   ********************************************************************
15 OPEN "COM1:9600,N,8,1,RS,CS,DS,CD" AS #1      ' Open Communication port
20 V$ = "": Q$ = "": ECHO$ = "": LF$ = "":       ' Initialize variables
90 CLS
100 LOCATE 12,15
105 PRINT " PRESS ANY KEY TO START THE PROGRAM "
107 V$ = INKEY$: IF LEN(V$) = 0 THEN 100         ' Wait for input from user
120 Z$ = "Z "                          ' Reset the AX indexer
122 PRINT #1,Z$;
124 Q$ = INPUT$(2,1)
```

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```
900 '
    ********************************************************************
901 ' *                                                                  *
902 ' *  Line 1000-1060 sends a move down to the first AX.  Computer     *
903 ' *  waits for the Line Feed from the AX indicating that the motor   *
904 ' *  has finished its move.                                          *
905 ' *                                                                  *
906 ' *                                                                  *
    ********************************************************************
1000 MOVE1$ = "1A1 1V2 1D25,600 1G 1LF "          ' Define move for Axis 1
1005 CLS
1007 LOCATE 12,15: PRINT " MOVING AXIS 1 "
1010 PRINT #1,MOVE1$                              ' Move axis 1.
1015 ECHO$ = INPUT$(22,1)                         ' Read echoes from AX
1020 LF$ = INPUT$(1,1)                            ' Wait for line feed from AX
1040 IF LF$ <> CHR$(10) GOTO 1020                 ' indicating end of move.
1045 CLS
1047 LOCATE 12,15
1050 PRINT "AXIS 1 FINISHED ITS MOVE "            ' Let user know axis 1 done
1060 LOCATE 15,15: PRINT " PRESS ANY KEY TO MOVE SECOND AXIS "
1070 V$ = INKEY$: IF LEN(V$) = 0 THEN 1060
1900 ' ***************************************************************
1901 ' *                                                               *
1902 ' * After axis one is done, we request that you hit any key to go on *
1903 ' * to second move.  In real application, we would expect you to   *
1904 ' * go ahead with the process and work on the part before going on to *
1905 ' * next move.  (i.e.  Activate a punch)                           *
1906 ' *                                                               *
1907 ' * Now that first axis finished its move, we go on to move axis 2. *
1908 ' * Second AX also prints a line feed after finishing the move.    *
1909 ' * As soon as computer receives the line feed from AX, program will *
1910 ' * go back to the first move.                                     *
1911 ' *                                                               *
1912 ' ***************************************************************
2000 MOVE2$ = "2A1 2V2 2D6,400 2G 2LF "
2005 CLS
2007 LOCATE 12,15: PRINT " AXIS 2 MOVING "
2010 PRINT #1,MOVE2$
2015 ECHO$ = INPUT$(22,1)
2020 LF$ = INPUT$(1,1)
2040 IF LF$ <> CHR$(10) GOTO 2020
2045 CLS
2047 LOCATE 12,15
2050 PRINT "AXIS 2 FINISHED ITS MOVE "
2060 FOR I = 1 TO 1000: NEXT I
2070 GOTO 20                          ' Go back to beginning of program.
```

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PLC Operation

You can use a PLC to execute 7 different sequences that are stored in the AX non-volatile memory. Three outputs from the PLC can be used to execute sequences, and two inputs to the PLC can be used to monitor AX outputs.

PLC Connections

Assuming your PLC accepts open-emitter outputs, connect the inputs and outputs as shown in Figure 4-4. If not, contact a Compumotor Applications Engineer at (800) 358-9070.

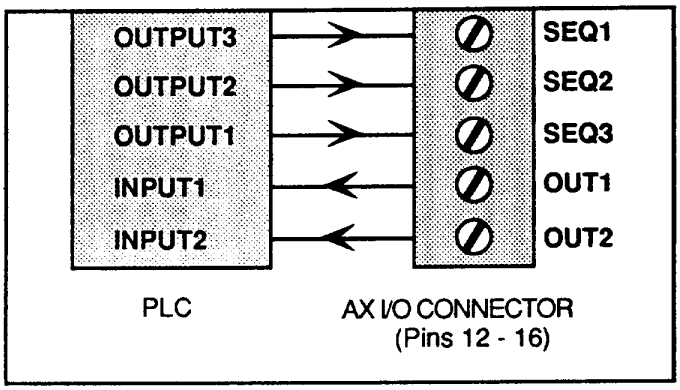


Figure 4-4. PLC Connections

Scanning for Sequence Execution

Changing the BCD values of sequence input lines results in a new sequence being run that corresponds to the new value. As indicated in Table 4-2, the configuration of the values issued determines which sequence the indexer will run. For example, turning on SEQ2 and SEQ3 and turning off SEQ1 executes Sequence 2.

Issuing the **XP8** or the **XP9** commands causes the AX to scan the sequence select inputs and execute the fist valid sequence it encounters (on power-up). When in XP8 mode, the AX returns control to the RS-232C port after executing the first valid sequence. When in the XP9 mode, the AX will continue scanning inputs and executing valid sequences until you issue an **S** or a **K** command.

When you issue the **XP** command identifying sequences 1 - 7, this over-rides the sequence input configuration used when you issue the **XP8** and the **XP9** commands.

The Scan (**SN**) command determines how long the sequence select input must be maintained before the indexer executes the program. This is a debounce time.

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Sample Applications and Commands

This section provides step-by-step procedures to run sequences from your PLC. First, you need to enter the programs into the AX drive. You will need a terminal or a computer with RS-232C communication capability. You need to define the sequences before you can execute them with your PLC's BCD outputs.

Using a terminal or a computer, key in the following commands:

STEP 1 Issue the **XP9** command.

STEP 2 Define the following sequences:

Command	Description
XE1	Erases Sequence 1
XD1	Defines Sequence 1
MN	Sets move to normal mode
A1	Sets acceleration to 1 rev/sec^2
V10	Set velocity to 10 rps
D64ØØ	Sets distance to 6,400 steps
G	Executes the move (Go)
XT	Ends Sequence 1 definition

Command	Description
XE2	Erases Sequence 2
XD2	Defines Sequence 2
MN	Sets move to normal mode
A1	Sets acceleration to 1 rev/sec^2
V10	Set velocity to 10 rps
D32ØØ	Sets distance to 3,200 steps
G	Executes the move (Go)
XT	Ends Sequence 2 definition

Command	Description
XE3	Erases Sequence 3
XD3	Defines Sequence 3
MN	Sets move to normal mode
A1	Sets acceleration to 1 rev/sec^2
V10	Set velocity to 10 rps
D128ØØ	Sets distance to 12,800 steps
G	Executes the move (Go)
XT	Ends Sequence 3 definition

Command	Description
XE4	Erases Sequence 4
MN	Sets move to normal mode
XD4	Defines Sequence 4
A1	Sets acceleration to 1 rev/sec^2
V10	Set velocity to 10 rps
D-448ØØ	Sets distance to 44,800 steps (CCW)
G	Executes the move (Go)
XT	Ends Sequence 4 definition

STEP 3 Verify that your programs were stored properly by uploading each entered sequence (**XU** command preceded by the device address and followed by the number of the sequence). If you receive responses that differ from what you programmed, re-enter those sequences.

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STEP 4

Cycle Power or enter the **Z** command. The AX will go through the normal XP9 mode operation. In XP9 mode, the AX scans the sequence select inputs and selects and executes the first available valid sequence according to the binary value of the three inputs (see Table 4-2). After the sequence is executed, the inputs are again scanned to execute another sequence. The AX will continue to execute sequence in this fashion until you issue an **S** or a **K** command, or if an end-of-travel limit is encountered.

STEP 4

To run sequence #1, ground sequence inputs 1, 2, and 3 at the same time (refer to table 4-2 for sequence input configurations to run other sequences).

Model 72 (Thumbwheel) Operation

The Model 72 and Model 72-I/O units interface with the AX Drive via an RS-232C interface. The Model 72 provides adjustable thumbwheel switches to enter and change AX motion control parameters. These switches allow you to set and modify velocity, acceleration, distance, direction, dwell time, loop count, and other parameters.

If you wish to purchase a Model 72 or Model 72-I/O, contact your Automated Technology Center or Compumotor Distributor. The *Model 72 User Guide* contains all pertinent information for use with the AX.

Tuning Procedure

NOTE: For most applications, tuning an AX Drive to a motor is not necessary.

Should certain aspects of the systems performance come under scrutiny in the area of velocity ripple, resonant frequencies or step-to-step accuracy, the following procedure could offer improved performance.

Velocity ripple is a term used to express a variance of angular speed. It is usually expressed as a percentage of the commanded velocity. This is due to the mechanical inaccuracies of the motor resulting in unequal step sizes. It can also be enhanced by running the motor at its' natural frequency causing resonance. Adding solid inertia to the system can shift or modify the phenomenon but does little to eliminate it. If your system can handle more inertia, consider using viscous dampers.

A 10:1 load to rotor inertia ratio is the maximum value recommended.

To a certain extent, adding friction to the system can actually dampen the effects of both resonance and velocity ripple.

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The recommended system frictional load for a step motor is approximately 5% of the motor's maximum torque capability. For motor specifications and speed/torque curves, refer to Chapter 6, Hardware Reference.

The step-to-step accuracy of the step motor should not be confused with the motors absolute accuracy. Absolute accuracy is based on the quality of the mechanical construction of the motor. This means that tuning of an open-loop stepper motor and drive will not improve this spec. On the other hand, the drive electronics are responsible for adjusting current in the two phases of the motor which create the microsteps found between each 1.8° full motor step. The amount of distance each step can vary is referred to as the step-to-step accuracy of the system and it may be possible to improve this by tuning.

The motor should be tuned to its drive while under normal loaded conditions. Tuning prior to this is useless since changes in the load or the system's transmission will result in a new natural frequency for the motor.

Tuning the drive affects the profile of current being sent to the motor. You will need to re-tune the drive if the current setting switches are changed. Refer to Chapter 6 for valid settings for DIP switches 1 through 5.

Controlling motor velocity

When using the AX Drive, the built-in indexer will solve this problem. Using an RS-232C communications device, place the AX in Mode Continuous (**MC**) and use the Acceleration (**A**) and the Velocity (**V**) commands to get the motor moving, then vary the velocity using the Immediate Velocity (**VC**) command.

Command	Description
MC	Set to Mode continuous
A10	Set acceleration to 10 rev/sec
V1	Set velocity to 1 rev/sec
G	Execute the move (Go)
•	
•	
•	
VC2	Set immediate velocity to 2 rev/sec
•	
•	
•	
VC.5	Set immediate velocity to .5 rev/sec

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Gauging Motor Resonance

Selecting a method of gauging motor resonance can be accomplished in a number of ways;

TACHOMETER METHOD Using an oscilloscope to look at the output of a tachometer attached to the motor shaft. The tachometer will output a DC voltage, proportional to speed. This voltage will oscillate around an average voltage when the motor is resonating. The amplitude of this oscillation will be at a maximum when the natural frequency of the motor is located. Using this method your goal is to tune for the lowest oscillation amplitude.

SOUNDING BOARD METHOD When practicing your tuning skills, an unloaded motor can be placed on a sounding board or a table. When a velocity is commanded which is near the motors natural frequency, the phenomenon will cause vibration which will become audible. Using this method your goals is to tune for the lease amount of vibration.

STETHOSCOPE METHOD When tuning under loaded conditions the audible vibration caused by the motors natural frequency can be heard by placing the tip of a screw drive against the motor casing and holding the handle of the screw driver close to your ear (as you would a stethoscope). This will also allow you to hear the different magnitudes of vibration caused by the motors natural frequency. Using this method your goal is to tune for the least amount of vibration.

TOUCH METHOD After some experience with tuning, it is possible to locate a motor's natural frequency by simply placing your fingertips on the motor shaft and adjusting the motor velocity. Once the critical velocity is located, tuning for maximum smoothness can be done in the same way.

CAUTION

Exercise extreme caution whenever you are near any moving part of a mechanical system. Also, be wary of touching the motor, as it is very hot during normal operating conditions.

To tune the drive you will need a small non-conductive screw driver.

Locate the natural frequency of the System

Before you can tune the drive to its motor, you will need to locate the natural frequency of the motor and its load. This can be accomplished using the following procedure:

STEP 1 Let the motor and driver warm up for 30 minutes to an hour.

STEP 2 Locate the tuning pots on the drive you are using. Figure 4-5 below shows the location of the AX Drive tuning pots. Note that the small metal plate held in place with two screws must be removed to reveal the tuning pots.

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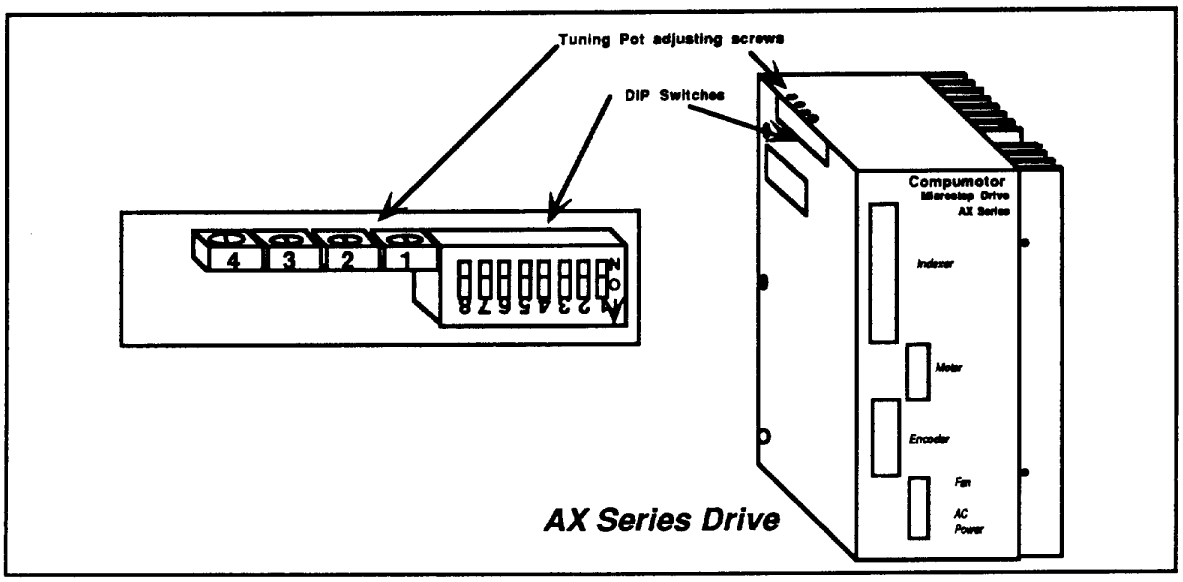


Figure 4-5. AX DIP Switch and Tuning Pot Locations

STEP 3 Position all four tuning pots to the center of their adjustment range.

STEP 4 Start the motor moving at one of the velocities shown below, depending on the motor frame size. These velocities should get you close to the natural frequency of the motor.

57 Series (NEMA 23)	3.6 rps
83 Series (NEMA 32)	2.8 rps
106 Series (NEMA 42)	2.0 rps

STEP 5 Using one of the gauging methods mentioned above, increase and decrease the velocity in small increments (.1 rps and lower) until you have located the velocity where the natural frequency seems to be most prominent.

Adjusting the Drive to the Motor

Now that you have located the natural frequency of your system, the following procedure will adjust the current waveform of the drive to the mechanical characteristics of the system.

STEP 1 Adjust the **current trim** if necessary (pot #1)

The current trim pot allows you to select a current setting that lies between any two dip switch settings. In most applications, adjustment of this setting is not necessary.

STEP 2 Adjust **phase balance** (pot #4).

Adjust this pot for maximum smoothness. This pot adjusts the amplitude of current in phase B to within ±10% of the current in Phase A.

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STEP 3 Adjust **phase B offset** (pot #2) and **phase A offset** (pot #3).

Alternately adjust these two pots for maximum smoothness as well. These pots adjust the zero (0) crossing point of the current in each phase.

STEP 4 Re-locate the natural frequency again.

Increase and decrease the velocity in small increments (.1 rps and lower) until you have re-located the velocity where the natural frequency seems to be most prominent.

STEP 5 Repeat steps 1 through 4 until you have maximized the motor's performance.

Selecting a new Wave Shape

All the above adjustments have affected only the total amount of current being sent to the motor and the amount in each phase of the motor with respect to each other. This can be very effective in most applications, but it may be possible to take your tuning procedure one step further by changing the shape of the *current waveform* itself. See Table 4-3.

Waveform	% of 3rd Harmonic
#1	-8%
#2	-6%
#3	-4%
#4	-2%
#5	0%
#6	+2%
#7	+4%
#8	+6%
#9	+8%

Table 4-3. AX Waveform Settings

WAVE SHAPING FOR THE AX DRIVE

STEP 1 Stop motion to the motor.

STEP 2 Use the **WV** (Select Micro-stepping Waveform) command to select a new waveform. The new waveform will take effect immediately. There are 9 different waveforms available and waveform #5 is the default setting.

STEP 3 Re-locate the natural frequency again.

STEP 4 Repeat the section titled **Adjusting the Driver to the Motor**

STEP 5 Repeat steps 1 through 3 in this section until maximum performance is achieved.

STEP 6 Once you have chosen the new waveform, you will need to command the new value every time you power up or the command can be made part of a non-volatile memory sequence that is executed on power up.

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Chapter 5. SOFTWARE REFERENCE

Chapter Objectives

Use this chapter as a reference for the function, range, default, and sample use of each command

Command Descriptions

① **A** ② Motion	③ **Acceleration**			④ **VALID** Software Version E2
SYNTAX ⑤ <a>An	**UNITS** ⑥ n = revs/sec^2	⑦ **RANGE** 0.00 to 999.99	**DEFAULT** 0.00	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS ⑩		**SEE ALSO** D, V, G ⑪		
RESPONSE TO <a>An **IS** No Response ⑫				

Figure 5-1. Command Example

1. ***Command Mnemonic*** — This box contains the command's mnemonic value and type. The command types are described below.

2. ***Command Type***

   Set-up — Set-up commands define set-up conditions for the application. These commands establish the output data format from the encoder, as well as other functions.

   Motion — Motion commands affect motor motion, such as acceleration, velocity, distance, go home, stop, direction, mode, etc.

   Programming — Programming commands affect programming and program flow for trigger, output, all sequence commands, quote, time delays, pause and continue, enable and disable, loop and end-loop, line feed, carriage return, and backspace.

   Status — Status commands respond (report back) with information. These commands instruct the system to send data out from the serial port for host computer use.

3. ***Command Name*** — This field contains the actual (and complete) name of the command.

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4. *Valid* — This field contains the current revision level of the command at the time this user guide was released.

5. *Syntax* — The proper syntax for the command is shown here. The specific parameters associated with the command are also shown. If any of these parameters are shown in brackets, such as <a>, they are optional. Definitions of the parameters are described below.

- **a** — An ***a*** indicates that a device address must accompany the command. Only the device specified by this parameter will receive and execute the command. Valid addresses are 1-8.
- **n** — An ***n*** represents an integer. An integer may be used to specify a variety of values (acceleration, velocity, etc.).
- **s** — An ***s*** indicates that a sign character, either positive or negative (+ or -), is required.
- **x** — An ***x*** represents any character or string of characters.

6. *Units* — This field describes what unit of measurement the parameter in the command syntax represents.

7. *Range* — This is the range of valid values that you can specify for n (or any other parameter specified).

8. *Default* — The default setting for the command is shown in this box. A command will perform its function with the default setting if you do not provide a value.

9. *Attributes* — This box indicates if the command is ***immediate*** or ***buffered.***

The system executes immediate commands as soon as it receives them. Buffered commands are executed in the order that they are received with other buffered commands. All buffered commands can be stored in a sequence and saved in permanent memory.

The lower portion of the box explains how you can save the command.

- Savable in Sequence
- Never Saved
- Automatically Saved

Savable in Sequence commands are those commands which when defined in a sequence, are saved in that sequence with the **XT** command. A command that is **Never Saved** is executed without being saved into the system's permanent memory (EEPROM). **Automatically Saved** commands are automatically saved into EEPROM upon execution.

10. *Execution Time* — The execution time is the span of time that passes from the moment you issue a command to the moment the system begins to execute it.

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11. See Also Commands that are related or similar to the command described are listed here.

12. Response A sample status command is given (next to **RESPONSE TO**) and the system response is shown (next to **IS**). When the command has no response, this field is not shown.

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Command Listing

A Motion	Acceleration			VALID Software Version E2
SYNTAX <a>**An**	**UNITS** n = revs/sec^2	**RANGE** 0.00 - 999.99	**DEFAULT** 0.00	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** D, V, G		

Description

The Acceleration command specifies the acceleration rate to be used upon executing the next Go (**G**) command. The acceleration remains set until you change it. You do not need to reissue this command for subsequent Go (**G**) commands. Accelerations outside the valid range causes the acceleration to remain at the previous valid acceleration setting.

Example

Command	Description
MN	Sets the moves to mode normal (preset moves)
A5	Sets Acceleration to 5 revs/sec^2
V1Ø	Sets Velocity to 10 revs/sec
D256ØØ	Sets Distance to 25,600 steps
G	Executes the move (Go)

AC Motion	Acceleration Change			VALID Software Version E2
SYNTAX <a>**ACn**	**UNITS** revs/sec	**RANGE** 0.00 - 999.99	**DEFAULT** 0	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** MC, A, VC		

Description

The Acceleration Change (**AC**) command is used only when the motor is moving in Continuous Mode (**MC**). The command allows velocity changes at different acceleration while moving. The command is used in conjunction with the velocity change command (**VC**).

This command is independent of the Acceleration (**A**) command, which affects the acceleration for preset moves and the initial acceleration for continuous moves. If the **AC** command is not issued during a continuous move the motor decelerates using the previous value of acceleration.

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Example

Command	Description
MC	Sets indexer to continuous mode
A1Ø	Sets acceleration to 10 rev/sec^2
V1Ø	Sets velocity to 10 rev/sec
G	Executes the move (Go)
AC5	Change acceleration to 5 rev/sec^2
VCØ	Decelerate to Zero Velocity

B Status	**Buffer Status Report**			**VALID** Software Version E2
SYNTAX aB	**UNITS** N/A	**RANGE** B, R	**DEFAULT** R	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2ms		**SEE ALSO** BS		
RESPONSE TO aB **IS** *B or *R				

Description

The buffer status command will report the status of the command buffer. If the command buffer is empty or less than 90% full, the controller will respond with a ***R**[cr].

The command buffer is 512 bytes long. A ***B**[cr] response will be issued if less than 10% of the command buffer is free.

***R** = More than 10% of the buffer is free
***B** = Less than 10% of the buffer is free

This command is commonly used when a long series of commands will be loaded remotely. If the buffer size is exceeded, the extra commands will not be received by the Controller.

Example

Command	Response
1 B	***R** (more than 10% of the Buffer is free)

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BS Status	Buffer Size Status			VALID Software Version E2
SYNTAX aBS	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2ms		**SEE ALSO** B		
RESPONSE TO aBS **IS** nnn				

Description

This command reports the number of bytes remaining in the command buffer. When entering long string commands, check the buffer status to be sure that there is enough room in the buffer. Otherwise, commands may be lost. Each character (including delimiters) uses one byte. The range for the response is 000 - 512 bytes.

Example

Command	Response
1BS	**1ØØ** (Space for 100 characters is remaining in the command buffer.)

C Status	Continue			VALID Software Version E2
SYNTAX <a>C	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2ms		**SEE ALSO** PS, U		

Description

The Continue (**C**) command ends a pause state. It enables your indexer to continue executing buffered commands. After you initiate a pause with the Pause (**PS**) command or the Pause and Wait for Continue (**U**) command, you can clear it with a Continue (**C**) command. This command is useful when you want to transmit a string of commands to the command buffer before you actually need to execute them.

Example

Command	Description
PS	Pauses execution until the indexer receives a C command
MC	Sets move to Continuous mode
A5	Sets acceleration to 5 rev/sec^2
V5	Sets velocity to 5 rev/sec
G	Executes the move (Go)
C	Starts executing commands in buffer

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CA Motion	Change Acceleration			VALID Software Version E2
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
<a>**CA**n	n = revs/sec^2	00.00 - 999.99	0	Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** MC, A, CV, CTR, CTM, CBC		

Description

Functionally, the **CA** command is the same as the **AC** command. If an acceleration change is required while the motor is moving, use the **AC** command. If the change is needed within a sequence, or needs to be buffered with other commands, the **CA** command must be used rather than the **AC** command. The new acceleration value entered with the **CA** command becomes the value used with all subsequent changes in velocity until a new **CA** is entered or the velocity reaches zero.

*NOTE: Both **CA** and **AC** commands can be used only in continuous mode (**MC**) operation.*

Example

Command	Description
MC	Move continuous
A25	Sets acceleration to 25 rev/sec^2
V5	Sets velocity to 5 rev/sec
CTM5	Remain at velocity for 5 seconds
CV1	Decelerate at 25 rev/sec^2 to 1 rev/sec
CTRXX1	Wait for trigger input 3 to go high
CA5	Accelerate at 5 rev/sec^2
CV1Ø	To velocity 10 rev/sec
CTM5	Remain at previous velocity for 5 seconds
CVØ	Change velocity to zero rev/sec
G	Executes the move (Go)

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CBC Programming	Clear Buffered Commands			VALID Software Version E2
SYNTAX <a>**CBC**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** CA, CV, CTR, CTM		

Description

The **CBC** command clears the command buffer while in continuous mode at constant velocity. The **K** (Kill) and **S** (Stop) commands will clear the buffers but these are immediate commands and will stop all motion as well. The **CBC** command will clear the command buffer without affecting the move in progress.

Example

Command	Description
MC	Move continuous
A25	Sets acceleration to 25 rev/sec^2
V5	Sets velocity to 5 rev/sec
CTM5	Remain at previous velocity for 5 seconds
CV1	Change velocity to 1 rev/sec
CA5	Change acceleration to 5 rev/sec^2
G	Executes the move (Go)
CBC	Clear command buffer of above commands. System will remain at last entered constant velocity (1 rev/sec)

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CG Set-up	Correction Gain			VALID Software Version E2
SYNTAX <a>CGn	**UNITS** N/A	**RANGE** n = 1 - 8	**DEFAULT** 8	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** FSB, FSC, DB		

Description

This command allows you to set the amount of error (steps) that should be corrected on the initial position maintenance (**FSC1** command) correction move (which takes place whenever the motor is stationary and outside the dead-band region (set with the **DB** command). This function is valid only in the Encoder Step mode (**FSB1**) and Position Maintenance (**FSC1**).

The percentage of error that the Position Maintenance function will attempt to correct on its correction moves is n/8 x 100%. If you set n to 1, the system will correct the error slowly (1/8 of the error is corrected on the first try). This type of correction is performed smoothly. If you set n to 8, the system will correct the error faster. However, there may be more overshoot and ringing at the end of this type of correction move.

Example

Command	Description
CG3	The system corrects 3/8 of the final-position error on the initial correction move

CL Programming	Continuous Velocity Loop			VALID Software Version E2
SYNTAX <a>CLn	**UNITS** n = Loops	**RANGE** 0 - 65,535	**DEFAULT** 0 (Infinite)	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** CN, Y		

Description

This command, along with the **CN** command, allows loops to be run in the continuous velocity mode. All the commands between **CL***n* and **CN** will be repeated the number of times indicated by *n* (**CLØ** = infinite). Continuous loops may be placed within the standard loop command. Within the loop created by the **CL** and **CN** commands, the velocity of the motor cannot go to zero.

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Example

Command	Description
MC	Sets mode to continuous
A1Ø	Sets acceleration to 10 rev/sec^2
V5	Sets velocity to 5 rev/sec
CL2	Loop continuously 2 times
CV5	Changes velocity to 5 rev/sec
CTM5	Waits 5 seconds
CV2	Changes velocity to 2 rev/sec
CTM3	Waits 3 seconds
CN	Ends continuous mode
CVØ	Changes velocity to 0
G	Executes the move (Go)

The motor accelerates to 5 rev/sec, waits 5 seconds, decelerates to 2 rev/sec, waits 3 seconds, accelerates to 5 rev/sec, waits 5 seconds, decelerates to 2 rev/sec, waits 3 seconds, then comes to a stop.

CN Programming	Continuous Mode End Loop			VALID Software Version E2
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
<a>CN	N/A	N/A	N/A	Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** CL, Y		

Description This command ends the continuous loop definition. The constant velocity commands between **CL** and **CN** are looped.

Example See **CL** command.

CO Programming	Continuous Mode Output			VALID Software Version E2
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
<a>COnn	N/A	n = 0, 1	None	Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** None		

Description This command controls outputs 1 and 2 while running in the continuous mode. The outputs will turn ON (current flows) or OFF (no current flows) only after the motor has reached its set velocity.

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Example

Command	Description
MC	Sets to mode continuous
A1Ø	Sets acceleration to 10 rev/sec^2
V5	Sets velocity to 5 rev/sec
CO11	Turn both outputs on
CTM5	Waits 5 seconds
CV2	Changes velocity to 2 rev /sec
COØØ	Turn both outputs off
CTM2	Waits 2 seconds
CVØ	Changes velocity to 0 rev/sec
G	Go

The motor accelerates to 5 rev/sec. As soon as it reaches 5 rev/sec, outputs 1 and 2 will be turned on. The AX will stay at 5 rev/sec for 5 seconds, then decelerate to 2 rev/sec, turn off outputs 1 and 2, stay at 2 rev/sec for 2 seconds, then come to a stop.)

CR Programming	**Carriage Return**			**VALID** Software Version E2
SYNTAX aCR	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** LF, " (Quote)		

Description

When the indexer reaches this command in the buffer, it responds by issuing a carriage return (ASCII 13) over its interface back to the host computer. If you place the **CR** command after a Go (**G**) command, it indicates when a move is complete. If you place the **CR** command after a Trigger (**TR**) command, it indicates when the trigger condition is met.

Example

Command	Description
MPA	Sets mode for absolute position
A5Ø	Sets acceleration to 50 units/sec^2
V5	Sets Velocity to 5 units/sec
D256ØØ	Sets distance to 25,600 steps
G	Executes the move (Go)
CR	Sends a carriage return

The motor moves 25,600 steps. When the motor stops, the indexer sends a carriage return over its interface.

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CTM Programming	Continuous Time			VALID Software Version E2
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
<a>**CTM**n	n = seconds	0.01 - 999.99	0	Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** CV, CA, CTR, T		

Description

Issuing this command while in continuous mode will cause a delay of the specified number of seconds before executing the next command in the buffer. A Time Delay (**T**) command will not work in continuous mode.

Example

Command	Description
MC	Sets Continuous Mode.
A25	Sets Acceleration to 25 rev/sec^2.
V5	Sets Velocity to 5 rev/sec.
CTM5	Wait 5 seconds before executing the next command.
CVØ	Change Velocity to 0 rev/sec.
G	Go (Execute the move profile.)

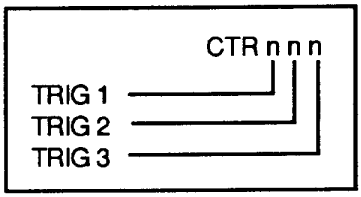
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CTR Motion	Constant Velocity Wait for Trigger			VALID Software Version E2
SYNTAX <a>CTRn	**UNITS** N/A	**RANGE** n = 0, 1, or X	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** CA, CV, CTM, CBC		

Description

Triggers are used to synchronize indexer operations with external events. They can be used to implement a handshaking function with other devices. The three characters used for nnn variables are listed below:

n=1: Wait for the trigger input to be high (opened)
n=0: Wait for the trigger input to be low (grounded)
n=X: Ignore the trigger input



When **CTR** command is used in a buffer, the indexer will get to this command and wait until the input pattern is matched before going on to the next command. ***NOTE: This command is used only for moves in the continuous mode.***

Example

Command	Description
MC	Sets mode to continuous
A25	Sets acceleration to 25 rev/sec^2
V5	Sets velocity to 5 rev/sec
CTM5	Dwell 5 seconds after reaching constant velocity
CV1	Ramp at last set acceleration to 1 rev/sec
CTRXX1	Wait on trigger 3 to go high before continuing (ignore triggers 1 & 2)
CA5	Sets acceleration for continuous mode velocity changes during this move.
CV1Ø	Ramp to a velocity 10 rev/sec at acceleration rate set with CA command
CTM5	Dwell for 5 seconds
CVØ	Ramp to a velocity of zero at acceleration rate set with CA command
G	Executes the move (Go)

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CV Motion	Change Velocity			VALID Software Version E2
SYNTAX <a>**CV**n	**UNITS** n = revs/sec	**RANGE** 00.001 to 50.000	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** CA, TR, CTM, CBC, VC		

Description

This command allows you to change the motor's velocity while operating in the continuous mode (**MC**). This command does not change the velocity value set by the **V** command.

Example

Command	Description
MC	Sets mode to continuous
A25	Sets acceleration to 25 rev/sec^2
V5	Sets velocity to 5 rev/sec
CTM5	Dwell 5 seconds after reaching constant velocity
CV1	Ramp at last set acceleration to 1 rev/sec
CTRXX1	Wait on trigger 3 to go high before continuing
CA5	Sets acceleration to 5 revs/sec^2 for continuous mode velocity changes during this move.
CV1Ø	Ramp to a velocity 10 rev/sec at acceleration rate set with CA command
CTM5	Dwell for 5 seconds
CVØ	Ramp to a velocity of zero at acceleration rate set with CA command
G	Executes the move (Go)

After the **G** command is issued, the motor will accelerate at 25 rps^2 to a velocity of 5 rps. The motor will remain at 5 rps for 5 seconds and then decelerate at 25 rps^2 to 1 rps; it will operate continuously at the velocity until Trigger input 3 goes high (+5V). When Trigger input 3 goes high, the motor will accelerate at 5 rps^2 to 10 rps. The motor will remain at 10 rps for 5 seconds, and then decelerate at 5 rps2 to zero velocity.

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D Motion	**Distance**			**VALID** Software Version E2
SYNTAX <a>Dn	**UNITS** n = steps	**RANGE** 0 - ±1,999,999,999	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** A, G, V, MN		

Description

The Distance (**D**) command defines either the number of steps the motor will move or the absolute position it will seek after a Go (**G**) command is entered.

In incremental mode (**MPI** or **FSAØ**), the value set with the Distance (**D**) command will be the distance (in steps) the motor will travel on all subsequent Go (**G**) commands.

In absolute mode (**MPA** or **FSA1**), the distance moved by the motor will be the difference between the current motor position and the position (referenced to the zero position) set with the **D** command. A distance must be defined with the **D** command before a preset move can be executed. The Distance (**D**) command has no effect on continuous moves (**MC**).

Example

Command	Description
MN	Preset mode to normal (preset)
A5	Set Acceleration to 5 rev/sec^2
V1Ø	Set velocity to 10 rev/sec
D64ØØØ	Set Distance to 64,000 steps
G	Executes the move (Go)

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DB Set-up	Dead Band			VALID Software Version E2
SYNTAX <a>DBn	**UNITS** n = steps	**RANGE** 0 - 999,999	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** FSG, CG		

Description

This command specifies a positioning range (in encoder steps) that the motor may not exceed after completing a move. If the motor's position is closer to the desired position than the number specified, no position maintenance correction will be performed. If the motor's position is not within the allowable range, position maintenance is performed (if enabled by the Enable Position Maintenance **[FSC1]** command).

The purpose of the **DB** command is to prevent the motor from searching for a set position when it is within an allowable dead band range.

Examples

Command	Description
DB1ØØ	Sets Position Maintenance to activate if the motor's end-of-move position is off by more than 100 encoder steps.

DW Set-up	Dead Band Window			VALID Software Version E2
SYNTAX <a>DWn	**UNITS** n = steps	**RANGE** 0 - 999,999	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** FS commands		

Description

This command allows precise dead band specification in motor steps. The backlash dead band allows systems with backlash to use stall detect (**FSH** command) features. If a non-zero dead band is selected, stall detection will not occur until the error exceeds the dead band width. This command is most effective when the encoder is mounted on the load.

Example

Command	Description
FSB1	Set indexer to Encoder Step mode
FSH1	Enable Stall Detect
DW1ØØ	Set Dead Band Window to 100 motor steps

100 motor steps of Backlash are expected by the indexer. A stall will not be detected until the encoder lags the motor position by more then 100 motor steps.

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E Programming	Enable Communications Interface			VALID Software Version E2
SYNTAX <a>**E**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2ms		**SEE ALSO** F		

Description

The Enable Communications Interface (**E**) command allows the indexer to accept commands over the communications interface. You can re-enable the communications interface with this command if you had previously disabled the interface with the Disable Communications Interface (**F**) command. This command is useful when units are daisy-chained and you want to upload a sequence.

Example

Command	Description
F	Disables all units (axes) on the communications interface
4 E	Enable unit 4
4XU5	Upload Sequence from Device 4
E	Enable all devices

ER Set-up	Encoder Resolution			VALID Software Version E2
SYNTAX <a>**ER**n	**UNITS** n = steps/rev	**RANGE** 1 - 50,000	**DEFAULT** 4,000	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** FS, DW		

Description

The encoder resolution defines the number of encoder steps the indexer will see per revolution of the motor. The number of lines on an encoder should be multiplied by 4 to arrive at the correct **ER** value per revolution of the motor .

In other words, one line of an encoder will produce 4 encoder steps.

Example

Command	Description
ER2ØØØ	Sets encoder resolution to 2,000 encoder steps per 1 motor revolution

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F Programming	Disable Communications Interface			VALID Software Version E2
SYNTAX <a>**F**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2ms		**SEE ALSO** E		

Description

The Disable Communications Interface (**F**) command is useful when you are programming multiple units on a single interface. Axes that are not intended to process global commands receive device specific **F** commands. This allows you to program other units without specifying a device identifier on every command. If you do not disable other units in a daisy chain, uploading programs may cause other units on the daisy chain to perform uploaded commands.

Example

Command	Description
1 F	Disables the communications interface on the unit with device address 1
3 F	Disables the communications interface on the unit with device address 3
G	All of the indexers except 1 and 3 will execute a move (Go)

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FR Status	Encoder Functions Report			VALID Software Version E2
SYNTAX a**FR**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** FS Commands		
RESPONSE TO a**FR** **IS** nnnnnnnn				

Description

This command allows you to request the status of encoder functions set by **FS** commands. The response contains one ASCII digit per function set by the **FS** command, each of which is a zero or a one. The digits correspond to the functions, left to right, A through H. The digit **1** corresponds to a function that has been turned on, or enabled. The digit **0** corresponds to a function that has been turned off, or disabled.

A Incremental = OFF (0); Absolute = ON (1)

Defines the move distances (**D**) as either incremental from current position, or as absolute (referenced to the absolute zero position).

B Motor step mode = OFF (0); Encoder step mode = ON (1)

Defines the distance (**D**) parameter in units of motor steps or encoder steps

C Position Maintenance: 0 = OFF, 1 = ON

Enables position maintenance. This will cause the indexer to servo the motor to the desired position if not in the correct position at the end of a move, or, if the motor is forced out of position while at rest.

D Terminate move on Stall Detect: 0 = OFF, 1 = ON

Instructs the indexer to abort any move if a stall is detected.

E Turn on Output 1 on Stall Detect: 0 = OFF,1 = ON

Instructs the indexer to set output 1 if a stall is detected.

F Multiple axis stop: 0 = OFF, 1 = ON

Instructs the indexer to abort any move if a signal is received on the Trigger 3 input. If output on stall is enabled (**FSE1**), the indexer will also turn on Output E when a trigger is seen. Used when daisy chaining multiple axes together.

G Turn on Output 2 when in dead band: 0 = OFF, 1 = ON

H Enable Stall detect: 0 = OFF, 1 = ON.

Example

Command	Response
1FR	11ØØØØØØ (The indexer is in absolute encoder step mode with all other **FS** functions turned OFF.)

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FSA Set-up	Set Indexer to Incremental/Absolute Mode			VALID Software Version E2
SYNTAX <a>**FSA**n	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** MPI, MPA, PZ, PR		

Description

This command sets the indexer to perform its moves in either absolute or incremental positioning mode.

FSAØ = Incremental mode
FSA1 = Absolute mode

In Incremental mode (**FSAØ**), all moves are made with respect to the position at the beginning of the move. This mode is useful for repeating moves of the same distance.

In Absolute mode (**FSA1**), all moves are made with respect to the absolute zero position. The absolute zero position is set to zero when you power up the indexer or execute the Position Zero (**PZ**) command.

The Absolute mode is useful when you need to move to specific locations.

Example

Command	Description
FSA1	Sets Indexer to Absolute mode
PZ	Resets the absolute position counter to zero
A1Ø	Sets acceleration to 12 revs
V5	Sets velocity to 5 revs
D256ØØ	Moves motor to absolute position 25,600
G	Executes the move (Go)
D64ØØØ	Move motor to absolute position 64,000
G	Executes the move (Go)

The motor moves 25,600 steps. Then the motor moves an additional 38,400 steps in the same direction to reach the absolute position of 64,000.

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FSB Set-up	Set Indexer to Motor/Encoder Step Mode			VALID Software Version E2
SYNTAX <a>**FSB**n	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** ER, D, FSC		

Description

This command sets up the indexer to perform moves in either motor steps or encoder steps.

FSBØ = Motor step mode
FSB1 = Encoder step mode

In Motor Step mode, the distance command (**D**) defines moves in motor steps.

In Encoder Step mode, the distance command defines moves in encoder steps.

You must set up the indexer for the correct encoder resolution The Encoder Resolution (**ER**) command is used to define the number of encoder steps per revolution of the motor.

Example

Command	Description
ER4ØØØ	Set up encoder where 4,000 encoder pulses (1,000 lines) are produced per 1 motor rev.
FSB1	Set moves to encoder step mode
A1Ø	Set acceleration to 10 rev/sec^2
V5	Set velocity to 5 rev/sec
D4ØØØ	Set distance to 4,000 encoder steps
G	Executes the move (Go)

The motor will turn in the CW direction until 4,000 encoder pulses (equal to 1 motor revolution) are received.

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FSC Set-up	Enable/Disable Position Maintenance			VALID Software Version E2
SYNTAX <a>**FSC**n	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** FSB, ER, DB		

Description

FSC1 = Enable Position Maintenance
FSCØ = Disable Position Maintenance

Enabling position maintenance will cause the indexer to servo the motor until the correct encoder position is achieved. This occurs at the end of a move (if the final position is incorrect) or any time the indexer senses a change in position while the motor is at zero velocity. You must have an encoder connected, and set the indexer in Encoder Step mode in order to enable position maintenance.

Position maintenance will be disabled (turned OFF) automatically if a stall is detected while doing position maintenance.

Position maintenance may be turned off temporarily by issuing a **K** command. The next move will re-enable it. If using position maintenance, the user should also enable **FSD1** and **FSH1** to make certain motion stops if encoder feedback is lost.

NOTE: ***FSC1*** *will work only if* ***FSB1*** *is enabled.*

Example

Command	Description
ER2ØØØ	Set encoder resolution to 2,000.
FSB1	Set encoder step mode.
FSC1	Enable position maintenance
FSH1	Enable stall detection
FSD1	Enable stop on stall

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FSD Set-up	Stop on Stall			VALID Software Version E2
SYNTAX <a>**FSD**n	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** SS, DW, ER, FSH		

Description

Entering **FSDØ** will cause the indexer to attempt to finish the move when a stall is detected, even if the load is jammed.

Entering **FSD1** will cause the indexer to stop the move in progress when a stall is detected. The move is stopped immediately; no deceleration. This command is valid only if stall detection (**FSH1**) and encoder step mode (**FSB1**) have been enabled. It will have no effect otherwise.

Example

Command	Description
DW1ØØ	Set backlash value to 100 steps.
ER2ØØØ	Set encoder resolution to 2,000 steps/rev.
FSB1	Set indexer to encoder step mode
FSH1	Enable stall detect.
FSD1	Enable stop on stall.

FSE Set-up	Turn on Output Number 1 on Stall			VALID Software Version E2
SYNTAX <a>**FSE**n	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** SS, DW, ER, FSH, FSF		

Description

FSEØ = Do not turn on output #1 on stall
FSE1 = Turn on output #1 on stall

Entering **FSE1** will cause the indexer to turn on output number 1 when a stall is detected. This is useful for signaling other components in you system that a stall has occurred. This command will be valid only if Stall Detect (**FSH1**) and encoder step mode (**FSB1**) have been enabled.

Output number 1 is uneffected by a stall when **FSEØ** is entered.

This output will also turn on if Stop Motion On Trigger 3 (**FSF1**) is enabled.

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Example

Command	Description
ER2ØØØ	Set encoder resolution to 2,000 steps/rev.
DW2ØØ	Set backlash dead band to 200 motor steps.
FSB1	Set indexer to encoder step mode
FSH1	Enable stall detect.
FSE1	Turn on output number 1 when a stall is detected.

FSF Set-up	**Stop Motion on Trigger 3**			**VALID** Software Version E2
SYNTAX <a>**FSF**n	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** TR, FSE		

Description

FSFØ = Do not terminate move on Trigger #3
FSF1 = Terminate move when Trigger #3 is low.

Entering **FSF1** will cause any move in progress to be stopped whenever Trigger #3 is brought low. Setting up another unit to turn on Output #1 when it detects a stall with the Turn on Output on Stall (**FSE**) command, enables the user to implement a multi-axis stop on stall axis by connecting output 1 of one axis to the trigger 3 input on the other. The move is stopped immediately; no deceleration. The input may be used as a trigger, but will stop motion when **TR3** is entered.

Entering **FSFØ** will turn this feature off.

Example

Command	Description
FSF1	Trigger #3 is now dedicated as a remote stop input.

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FSG Set-up	Turn on Output 2 when within Dead Band			VALID Software Version E2
SYNTAX <a>**FSG**n	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** DB, FSB, FSC, FSH		

Description

FSGØ = Do not turn on output #2 when the motor is within dead band.

FSG1 = Turn on output #2 when within dead band.

The dead band is set using the **DB** command.

FSB1 and **FSC1** must be used for this command to function correctly. The output is updated by position maintenance.

Example

Command	Description
ER4ØØØ	Set encoder resolution to 4,000 steps/rev.
DB5Ø	Dead band is set to 50 steps.
FSB1	Set indexer to encoder step mode
FSC1	Enable Position Maintenance
FSG1	Enable post move position loss detection.

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FSH Set-up	Enable Stall Detect			VALID Software Version E2
SYNTAX <a>**FSH**n	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** FS commands, DW, ER		

Description

FSHØ = Disable Stall Detect
FSH1 = Enable Stall Detect

This command must be used to detect a stall condition. After enabling stall detection, stop on stall (**FSD1**) and output on stall (**FSE1**) can be used.

It is necessary to define the Dead band Window (**DW**) command and the Encoder Resolution (**ER**) command before this feature will operate properly. Stall Detection is only possible when an encoder is being used.

Stall Detect (**FSH1**) will function only if encoder step mode (**FSB1**) is enabled.

Example

Command	Description
DW1ØØØ	Set dead band window to 1,000 steps
ER2ØØØ	Set encoder resolution to 2,000 steps (500 lines)
FSB1	Set indexer to encoder step mode
FSH1	Enable stall detection
FSD1	Stop motor movement if stall detected.

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G Motion	Go			VALID Software Version E2
SYNTAX <a>G	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** S, MN, MC, A, V, D, RA, RB, RC		

Description

The Go (**G**) command instructs the motor to make a move using motion parameters that you have previously entered. You do not have to re-enter Acceleration (**A**), Velocity (**V**), Distance (**D**), or the current mode (**MN** or **MC**) commands with each **G** command. In the Incremental Preset mode (**MPI**), a **G** command will initiate the steps you specified with the **D** command.

A Go (**G**) command in the Absolute Preset mode (**MPA**) will not cause motion unless you enter a change in **D** command first.

In the Continuous mode (**MC**), you only need to enter the **A** and **V** commands prior to the **G** command. The system ignores the **D** command in this mode.

No motor motion will occur until you enter the **G** command in both the Normal (**MN**) and Continuous (**MC**) modes.

If motion does not occur with the **G** command, enter the status commands **RA**, **RB**, and **RC**.

Example

Command	Description
MN	Sets mode to normal (preset)
A5	Sets acceleration to 5 rev/sec^2
V1Ø	Sets velocity to 10 rev/sec
D256ØØ	Sets distance to 25,600 steps
G	Executes the move (Go)
A1	Sets acceleration to 1 rev/sec^2
G	Executes the move (Go), moves 25,000 steps

Assuming the indexer is in the incremental preset mode (MPI), the motor turns 25,600 steps, then repeats the 25,600-step move using the new Acceleration (A) value of 1 rps^2 (total distance moved = 51,200 steps).

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GH Motion	Go Home			VALID Software Version E2
SYNTAX <a>**GH**sn	**UNITS** n = revs/sec	**RANGE** ±0.001 - ±50.000	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** RC, OS commands, V		

Description

The Go Home (**GH**) command instructs the controller to search for a home switch in the positive or negative direction at the commanded velocity. This value overwrites the old **V** command value at the commanded velocity. It causes the controller to seek the home position, whether in the motor step mode, or the encoder step mode. If in the motor step mode, the controller looks only at the Home Limit input. It will define Home as the position where the Home Limit signal changed states nearest the edge selected with the **OS** command. As soon as the selected edge is detected (usually via a load activated switch) the motor decelerates to a velocity of 0. The controller will then position the motor 1/32 of a rev on the outside of the selected edge. Finally, the motor will creep at .1 rps in the direction of the home active region, it will then stop, and the Homing process will be complete.

The process is the same in encoder step mode (**FSB1**), except the controller also looks for the Z Channel input as well as the Home Limit input to be active at the same time. This means that the Z Channel pulse must be *enveloped* by the active region of the Home Limit input. When both are active the controller defines that position as the home position.

The controller will reverse direction if an End-Of-Travel limit is activated while searching for Home; however, if a second End-Of-Travel limit is encountered in the new direction, the Go Home procedure will stop and the operation will be aborted. The **RC** command will indicate if the operation was successful. If the Backup To Home Switch function is disabled with the **OSBØ** command, the motor will be considered at Home only if the Home limit input is still active at the end of the deceleration, following the encounter of the selected edge of the home switch. *See the* **OS** *command descriptions.*

When the Go Home routine is complete, the indexer automatically resets the absolute position counter to zero. This is equivelent to issuing the Position Zero (**PZ**) command.

Example

Command	Description
GH-2	The motor moves in the negative direction (CCW) at 2 rps and looks for the Home Limit input to go active.

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^H Programming	Delete			VALID Software Version E2
SYNTAX ^H	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** None		

Description This command allows you to delete the last character that you entered (unless it was a delimiter). The **^H** command will not prevent execution of an immediate command. A new character may be entered at that position to replace the existing character. (**^H** indicates that the Ctrl key is held down when the **H** key is pressed.) This command prompts the indexer to backup one character in the command buffer, regardless of what appears on the terminal. On some terminals, the Ctrl and the left arrow <-- keys produce the same character. *NOTE: Pressing the delete key does not delete the previous character.*

Example None

H Motion	Set Direction			VALID Software Version E2
SYNTAX <a>Hs	**UNITS** N/A	**RANGE** s = + or -	**DEFAULT** +	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** D		

Description The Set Direction (**H**) command changes or defines the direction of the next move that the system will execute. This command does not effect moves already in progress.

H+ = Sets move to CW direction
H– = Sets move to CCW direction
H = Changes direction from the previous setting

In preset moves, a Distance (**D**) command entered after the Set Direction (**H**) command overrides the direction set by the **H** command. In Continuous mode(**MC**) only the Set Direction (**H**) command can set the direction of motion.

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Example

Command	Description
MN	Sets Normal mode
A5	Sets acceleration to 5 revs/sec^2
V5	Sets velocity to 5 revs/sec
D256ØØ	Sets distance to 25,600 steps
G	Executes the move (Go) in CW direction
H	Reverses direction
G	Executes the move (Go) in CCW direction
MC	Sets mode to continuous
H+	Sets direction to CW
G	Moves continuously in CW direction

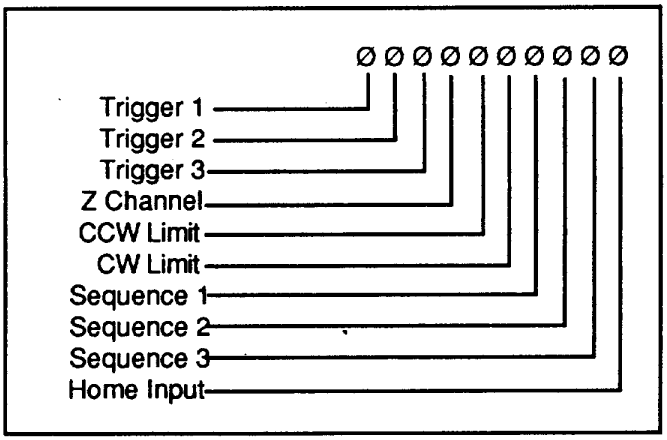
IS Status	**Input Status**			**VALID** Software Version E2
SYNTAX <a>IS	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** None		
RESPONSE TO <a>IS **IS** nnnnnnnnnn				

Description

This command reports the status of all hardware inputs, including trigger, sequence select lines, and limits.

This is not a software status. It will report the actual hardware status of the inputs. This command is useful for troubleshooting an application, to verify that Limit switches, TRIGGER inputs and Home switches work.

The response format is illustrated below. 1 = open (high) and Ø = closed (low).



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Example

Command	Response
2IS	0001000000 (The input status of device #2 is reported: The Z Channel is open [high] and all other inputs are closed [low].)

K Motion	**Kill**			**VALID** Software Version E2
SYNTAX <a>**K**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** S, FSC		

Description

The Kill (**K**) command is an emergency stop command and should only be used as such. This command causes indexing to cease immediately. There is *NO* deceleration of the motor.

WARNING

The Kill command may cause the motor to lose torque. The load could be driven past limit switches and cause damage to the mechanism and possibly to the operator.

In addition to stopping the motor, the **K** command will terminate a loop, end a time delay, abort down-loading a sequence (**XD**), temporarily turn off position maintenance, and clear the command buffer.

Example

Command	Description
A 5	Sets acceleration to 5 rev/sec^2
V 2	Sets velocity to 2 rev/sec
MC	Sets mode to continuous
G	Executes the move (Go)
•	
•	
•	
K	Stops the motor instantly

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L Programming	Loop			VALID Software Version E2
SYNTAX <a>Ln	**UNITS** n = Loops	**RANGE** n = 0 - 65,535	**DEFAULT** 0 (Infinite)	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** Y, N, U, C		

Description

When you combine the Loop (**L**) command with the End-of-Loop (**N**) command, all of the commands between **L** and **N** will be repeated the number of times indicated by *n*. If you enter the **L** command without a value specified for *n*, or with a Ø, subsequent commands will be repeated continuously.

The End-of-Loop command prompts the indexer to proceed with further commands after the designated number of loops have been executed. The Stop Loop (**Y**) command causes Loop execution to stop. The Immediate Pause (**U**) command allows you to temporarily halt loop execution. You can use the Continue (**C**) command to resume loop execution.

Example

Command	Description
A5	Sets acceleration to 5 rev/sec^2
V1Ø	Sets velocity to 10 rev/sec
D256ØØ	Sets distance to 25,600 steps
L5	Loops 5 times
G	Executes the move (Go)
N	Specifies the above 25,600-step move to be repeated five times

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LD Set-up	Limit Disable			VALID Software Version E2
SYNTAX <a>LDn	**UNITS** N/A	**RANGE** n = 0 - 3	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** RA		

Description

The Limit Disable (**LD**) command allows you to enable/disable the end-of-travel limit switch protection. The **LDØ** condition does not allow the motor to turn without properly installing the limit inputs. If you want motion without wiring the limits, you must issue the **LD3** command.

n = 0: Enable CCW and CW limits
n = 1: Disable CW limit
n = 2: Disable CCW limit
n = 3: Disable CCW and CW limit

Example

Command	Description
LDØ	Enables CW and CCW limits. The motor will move only if the limit inputs are bypassed or connected to normally closed limit switches.
LD3	Allows you to make any move, regardless of the limit input state.

LF Execute	Line Feed			VALID Software Version E2
SYNTAX a**LF**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2ms		**SEE ALSO** " (Quote), CR		
RESPONSE TO a**LF** **IS** [LF]				

Description

Issuing the **LF** command transmits a line feed over the RS-232C link. This command is useful when you send messages during buffered moves or sequences, for display screen control, and to signal move completion when interfacing with a host computer.

You can use the **LF**, ", and **CR** commands to display multiple lines of text via the RS-232C interface.

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Example

Command	Description
MPA	Sets mode position to absolute
A1	Sets acceleration to 1 rev/sec^2
V1	Sets velocity to 1 rev/sec
D64ØØ	Sets distance to 6,400 steps
G	Executes the move (Go)
"DONE	Transmit message
CR	Transmits a carriage return
LF	Transmits a line feed

The motor will move to an absolute position of 6,400 steps. Upon completion of this move, the AX will transmit "DONE" message and a carriage return with a line feed.

MC Motion	**Mode Continuous**			**VALID** Software Version E2
SYNTAX <a>**MC**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** MN, MA, CA, CV, CTR, CTM, CO, CL, CN		

Description

The Mode Continuous (**MC**) command causes subsequent moves to ignore any distance parameter and move continuously. You can clear the **MC** command with the Move Normal (**MN**) command.

The indexer uses the Acceleration (**A**) and Velocity (**V**) commands to reach continuous velocity.

Using the Time Delay (**CTM**), Trigger (**CTR**), and Change Acceleration (**CA**) commands, you can achieve basic velocity profiling.

Example

Command	Description
MC	Sets mode to continuous
A5	Sets acceleration to 5 rev/sec^2
V5	Sets velocity to 5 rev/sec
G	Executes the move (Go)

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MN Motion	Mode Normal			VALID Software Version E2
SYNTAX <a>**MN**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** MC, D, A, V		

Description

The Mode Normal (**MN**) command sets the positioning mode to preset. In Mode Normal, the motor will move the distance specified with the distance (**D**) command. To define the complete move profile, you must define Acceleration (**A**), Velocity (**V**), and the Distance (**D**). The **MN** command is used to change the mode of operation from Mode Continuous (**MC**) to Mode Normal, or *preset*.

To use the **MPA** or **MPI** commands, the indexer must be in mode normal (**MN**).

Example

Command	Description
MN	Set positioning mode to preset
A5	Set acceleration to 5 rev/sec^2
V5	Set velocity to 5 rev/sec
D64ØØ	Set distance to 6,400 steps
G	Executes the move (Go)

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MPA Set-up	Mode Position Absolute			VALID Software Version E2
SYNTAX <a>**MPA**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** MN, MPI, D, PZ, FSA		

Description

This command sets the positioning mode to absolute. In this mode all move distances are referenced to absolute zero. *NOTE: In absolute preset mode (MPA), giving two consecutive go (G) commands will cause the motor to move once, since the motor will have achieved its desired absolute position at the end of the first move.*

Mode Position Absolute (**MPA**) is most useful in applications that require moves to specific locations, while keeping track of the beginning position..

You can set the absolute counter to zero by cycling power or issuing a Position Zero (**PZ**) command.

The indexer must be in Mode Normal (**MN**) to use this command. In Continuous Mode (**MC**), this command is ignored.

Example

Command	Description
MN	Set mode normal (preset)
MPA	Set position mode absolute
A5	Set acceleration to 5 rev/sec^2
V1Ø	Set velocity to 10 rev/sec
D256ØØ	Set distance to +25,600 steps
G	Motor will move to absolute position +25,600
D128ØØ	Set absolute position to +12,800 steps
G	Motor will move CCW to absolute position +12,800

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MPI Set-up	Mode Position Incremental			VALID Software Version E2
SYNTAX <a>**MPI**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** MN, MPA, D, FSA		

Description

This command sets the positioning mode to incremental. In incremental mode all move distances specified with the Distance (**D**) command will be referenced to the current position. Mode Position Incremental (**MPI**) is most useful in applications that require repetitive movements, such as feed to length applications.

The indexer must be in Mode Normal (**MN**) to use this command. In Continuous Mode (**MC**), this command is ignored.

Example

Command	Description
MN	Set positioning mode normal (preset)
MPI	Set positioning mode incremental
A5	Sets acceleration to 5 rev/sec^2
V1Ø	Sets velocity to 10 rev/sec
D64ØØ	Sets distance of move to 6,400 steps
G	Move 6,400 steps CW
G	Move another 6,400 steps CW

The motor moves 6,400 steps CW after each **G** command (total move = 12,800 steps).

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N Programming	End of Loop			VALID Software Version E2
SYNTAX <a>N	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** L, PS, C, Y		

Description

This command marks the end of loop. You can use this command in conjunction with the Loop (**L**) command. All buffered commands that you enter between the **L** and **N** commands are executed as many times as the number that you enter following the **L** command.

Example

Command	Description
P S	Pauses the execution of buffered commands until the indexer receives a Continue (**C**) command
M N	Sets move to mode normal
A 5	Sets acceleration to 5 rev/sec^2
V 5	Sets velocity to 5 rev/sec
D 2 5 6 Ø Ø	Sets move distance to 25,600 steps
L 5	Loops five times
G	Executes the move (Go)
N	Ends the loop
C	Clears pause and executes all the buffered commands

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O Programming	Output			VALID Software Version E2
SYNTAX <a>Onn	**UNITS** N/A	**RANGE** n = 0, 1 or X	**DEFAULT** None	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** FSE, FSG		

Description

The Output (**O**) command turns programmable output bits #1 and #2 on and off. This is used for signaling remote controllers, turning on LEDs, or sounding whistles. The output can indicate that the motor is in position, about to begin its move, or is at constant velocity, etc. The command is in the form **O***nn*, where *nn* represents output #1 and output #2 respectively. The valid values for *n* are as follows:

1 = Turns on output
0 = Turns off output
X = Leaves output unchanged

Example

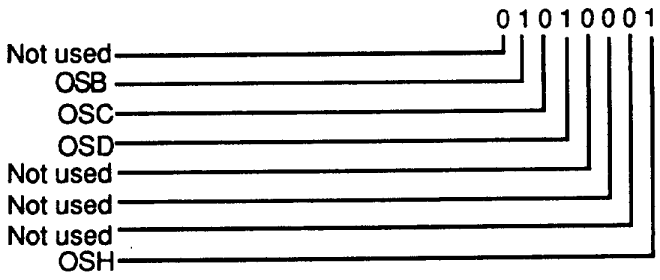
Command	Description
A1Ø	Set acceleration to 10 rev/sec^2
V5	Sets velocity to 5 rev/sec
D256ØØ	Set move distance to 25,600 steps
O1X	Set programmable output 1 to on
G	Executes the move (Go)
OXØ	After the move ends, turn off output 2

OR Status	Report Homing Function Set-ups			VALID Software Version E2
SYNTAX a**OR**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** OS		
RESPONSE TO a OR IS nnnnnnnn				

Description

This command results in a report of which software switches have been set by the **OS** command. The reply is eight digits. This command reports **OSA** through **OSH** Set-up status in binary format. The digit *1* represent ON (enabled), the digit *0* represents OFF (disabled). The default response is **01010001**.

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Example None

OSB Set-up	**Backup to Home Switch**			**VALID** Software Version E2
SYNTAX <a>OSBn	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 1	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** FS, GH		

Description

OSBØ = Do not back up to home switch
OSB1 = Back up to home switch

If this function is disabled (**OSBØ**), the AX will consider the motor at Home if the home input is active at the end of deceleration after encountering the active edge of Home region. If this function is enabled (**OSB1**), the AX will decelerate the motor to a stop after encountering the active edge of the Home region, and then move the motor in the opposite direction of the initial Go Home move at .1 rev/sec until the active edge of the Home region is encountered. The AX will then consider the motor at Home. This will occur regardless of whether or not the home input is active at the end of the deceleration of the initial Go Home move.

Example

Command	Description
OSB1	Enables back up to home
OSCØ	Sets the active state of the home input to closed
OSD1	Sets the active state of the Z Channel input to high
OSH1	Sets the reference edge of home switch to be CCW

In this example, the home limit will be active when the opto is on, and the Z Channel is high. The AX will recognize the CCW edge of the switch as the home limit and will back up to that edge to complete the Go Home move.

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OSC Set-up	Define Active State of Home Switch			VALID Software Version E2
SYNTAX <a>OSCn	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** GH, OSB, OSH		

Description

OSCØ = Active state of home input is n = 0 (closed)
OSC1 = Active state of home input is n = 1 (open)

This command inverts the active state of the home input. It enables you to use either a normally closed or a normally open switch for homing.

OSCØ requires that a normally open (high) switch be connected to the home limit input. **OSC1** requires that a normally closed (low) switch be connected to the home limit input.

Example

Command	Description
OSC1	Sets the active state of the home input to open

OSD Set-up	Define Active State of Encoder Z Channel Input			VALID Software Version E2
SYNTAX <a>OSDn	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 1	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** OSA, OSB, OSC, OSE, OSF, GH		

Description

OSDØ = Active Low
OSD1 = Active high

This command allows you to define the recognized active state of the Z channel coming from the encoder. The Z channel is used (in conjunction with a load activated switch connected to home limit) to determine the home position. The switch determines the home region. The Z channel determines the exact position in that region that will be used as the home reference.

Compumotor supplied incremental encoders will supply an active (high) Z channel.

Example

Command	Description
OSD1	Recognizes active state of Z channel is High (5VDC)

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OSH Set-up	Reference Edge of Home Switch			VALID Software Version E2
SYNTAX <a>OSHn	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 1	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** OSG		

Description

OSHØ Selects the clockwise side of the Home signal as the *edge* on which the final approach will stop

OSH1 Selects the counterclockwise side of the home signal as the *edge* on which the final approach will stop

The clockwise edge of the Home switch is defined as the first switch transition seen by the indexer when traveling off of the CW limit in the CCW direction. If n = 1, the counterclockwise edge of the Home switch will be referenced as the Home position. The counterclockwise edge of the Home switch is defined as the first switch transition seen by the indexer when traveling off of the CCW limit in the CW direction.

Example

See **OSB** example.

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PR Status	**Absolute Position Report**			**VALID** Software Version E2
SYNTAX a**PR**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** MPI, MPA, MN, PZ, D		
RESPONSE TO a PR IS ±nnnnnnnnnn				

Description

Reports motor position with respect to power up position or last place a **PZ** command was issued. The absolute position counter can track (report on) up to $\pm 2^{31}$ -1, or 2,147,483,647 steps. If the counter is over-run in the relative position mode (by running the motor continuously for long periods of time, 24 hours at 20 RPS and 5,000 steps per rev), the absolute position will be invalid.

If in the encoder step mode (**FSB1**), the position will be reported in encoder steps. If you are in motor step mode (**FSBØ**), the position will be reported in motor steps. The response to this command will be reported after the move is complete.

You may reset the position counter to zero with the Position Zero (**PZ**) command.

Example

Command	Description
PZ	Resets the absolute counter to zero
LD3	Disable both CW & CCW limits
MN	Set indexer to normal mode
A1Ø	Set Acceleration to 10 rev/sec^2
V5	Set velocity to 5 rev/sec
D256ØØ	Set move distance to 25,600 steps
G	Executes the move (Go)
1PR	Request absolute position report. (Response should be +0000025600)

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PS Programming	Pause			VALID Software Version E2
SYNTAX <a>**PS**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** C, U		

Description

This command pauses execution of a command string or sequence following the Pause (**PS**) command until the indexer receives a Continue (**C**) command. This command is useful if you need to enter a complete string of commands before you can execute your other commands.

This command is useful for interactive tests and in synchronizing multiple indexes that have long command strings.

Example

Command	Description
P S	Pauses execution of following commands until the indexer receives the Continue (**C**) command
A 5	Sets acceleration to 5 rev/sec^2
V 5	Sets velocity to 5 rev/sec
D256ØØ	Sets move distance to 25,600 steps
G	Executes the move (Go)
T 2	Delays the move for 2 sec
G	Executes the move (Go)
C	Continues Execution

When the indexer receives the **C** command, the motor moves 25,600 steps twice with a 2 second delay between them.

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PX Status	Report Absolute Encoder Position			VALID Software Version E2
SYNTAX a**PX**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** W3, PR, FSB		
RESPONSE TO aPX **IS** ±nnnnnnnnnn				

Description

This command returns a decimal value indicating the absolute position of the incremental encoder. The absolute position is based on the zero position. The zero position is established when you power up the system. The zero position can also be established after the indexer performs a Position Zero (**PZ**) command. Whether in Motor Step mode or Encoder Step mode, the position is reported in encoder steps.

The range of the response is 0 - ±9,999,999,999.

This command is useful in the following situations:

- Encoder Set-up
- Closing the loop with the host though positioning with *n* steps
- End of move (verification of position)

Example

Command	Description
MN	Presets mode
PZ	Sets the absolute counter to zero
A1Ø	Sets acceleration to 10 rev/sec^2
V5	Sets velocity to 5 rev/sec
D256ØØ	Sets move distance to 25,600 steps
G	Executes the move (Go)
FSB1	Sets indexer to encoder step mode
1PX	After the motor executes the move, the encoder position is reported: The response is *+0000008000, assuming the **ER** command is set to 4000.

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PZ Set-up	Set Absolute Counter to Zero			VALID Software Version E2
SYNTAX <a>**PZ**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** MN, MPI, MPA, PR, D, PX		

Description

This command sets the absolute position counter to zero. If the motor does not move after the last **PZ** command, the response to the **PR** and **PX** commands will be 0s.

Example

Command	Description
MPA	Make all preset moves with respect to absolute zero position
A1Ø	Set Acceleration to 10 rev/sec^2
V5	Set Velocity to 5 rev/sec
D256ØØ	Set move distance to 25,600 steps
G	Executes the move (Go)
1PR	Report Absolute Position (Response = *+0000025600)
PZ	Sets the absolute counter to zero
1PR	Report absolute position (Response = *+0000000000)

" Programming	Quote			VALID Software Version E2
SYNTAX <a>"x	**UNITS** x = characters	**RANGE** up to any 12 ASCII characters	**DEFAULT** None	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME		**SEE ALSO** CR		
RESPONSE TO <a>"x **IS** x				

Description

Any characters entered after the quotation marks (") (up to 12 characters) will be transmitted, exactly as they were entered over the RS-232C link. A space entered by the space bar indicates the end of the command. A space is always sent after the last character in the string. This command is used during buffered moves or sequences, or to command other Compumotor devices to move.

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Example 1

Command	Description
MN	Set to mode normal (Preset Moves)
A1Ø	Set acceleration to 10 rev/sec2
V5	Set velocity to 5 rev/sec
D128ØØ	Set distance to 12,800 steps
G	Executes the move (Go)
"MOVE_DONE	After motor finished the move, the Compumotor Indexer will send the message MOVE_DONE out from the RS-232C port.

Example 2

Command	Description
MN	Set to mode normal (Preset Moves)
A1Ø	Set acceleration to 10 rev/sec2
V5	Set velocity to 5 rev/sec
D128ØØ	Set distance to 12,800 steps
G	Executes the move (Go)
"2XR1	Once the move is done, Run Sequence 1 is commanded on a unit with device address 2.

QØ Set-up	**Exit Velocity Profiling Mode**			**VALID** Software Version E2
SYNTAX <a>QØ	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** Q1, RM		

Description The **QØ** command exits the velocity profiling mode. The motor will stop when **QØ** is issued.

Example See **Q1** example

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Q1 Set-up	Enter Velocity Profiling Mode			VALID Software Version E2
SYNTAX <a>Q1	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** Q0, RM		

Description

The **Q1** command enters the indexer in velocity profiling mode. Subsequent **RM** commands will cause an immediate change in motor velocity. Use **Q0** to exit this mode.

Example

Command	Description
Q 1	Enter Velocity streaming mode
RMØ19Ø	Accelerate to 1 rev/sec
RMØ32Ø	Accelerate to 2 revs/sec
RMØ46Ø	Accelerate to 3 revs/sec
RMØ64Ø	Accelerate to 4 revs/sec
RMØ46Ø	Decelerate to 3 revs/sec
RMØ32Ø	Decelerate to 2 revs/sec
RMØ19Ø	Decelerate to 1 rev/sec
RMØØØØ	Decelerate to 0 revs/sec
Q Ø	Exit velocity streaming mode

Motor movement will stop when **QØ** command is entered.

R Status	Request Indexer Status			VALID Software Version E2
SYNTAX aR	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** RA, RB, RC		
RESPONSE TO aR IS *x				

Description

The Request Indexer Status (**R**) command can be used to indicate the general status of the indexer. Possible responses are as follows:

Response Character	Definition
***R**	Ready
***S**	Ready, Attention Needed
***B**	Busy
***C**	Busy, Attention Needed

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The following conditions will cause a response indicating that the indexer is busy:

- Performing a preset move
- Accelerating/decelerating during a continuous move
- A time delay is in progress. (**T** command)
- In **RM** mode
- Paused
- Waiting on a Trigger
- Going Home
- Running a sequence
- Executing a loop

The following conditions will cause a response indicating than an error exists.

- A feedback error condition exits.
- Go home failed
- Limit has been encountered
- Sequence execution was unsuccessful

When the response indicates that attention is required, more details on the error condition are available by using the **RA**, **RB**, or **RC** commands.

It is not recommended that this command be used in tight polling loops which could result in microprocessor over load. Time delays can alleviate this problem.

This command is not intended to be used to determine if a move is complete. Rather, it should be used after the move is complete to determine if there might be other errors or faults.

Use a buffered status request command or a programmable output to indicate move completion.

Example

Command	Response
1R	***R** (Indexer ready to accept a command and no error conditions require attention)

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RA Status	Limit Switch Status Report			VALID Software Version E2
SYNTAX aRA	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** R, RB		
RESPONSE TO aRA IS *x				

Description

The Limit Switch Status Report (**RA**) command responds with the status of the end of travel limits during the last move as well as the present condition. This is done by responding with one of 16 characters representing the conditions listed below.

Response Character	Last Move Terminated by CW Limit	Last Move Terminated by CCW Limit	Current Limit Status CW Limit	Current Limit Status CCW Limit
*@	NO	NO	OFF	OFF
*A	YES	NO	OFF	OFF
*B	NO	YES	OFF	OFF
*C	YES	YES	OFF	OFF
*D	NO	NO	ON	OFF
*E	YES	NO	ON	OFF
*F	NO	YES	ON	OFF
*G	YES	YES	ON	OFF
*H	NO	NO	OFF	ON
*I	YES	NO	OFF	ON
*J	NO	YES	OFF	ON
*K	YES	YES	OFF	ON
*L	NO	NO	ON	ON
*M	YES	NO	ON	ON
*N	NO	YES	ON	ON
*O	YES	YES	ON	ON

The **RA** command is useful when the motor will not move in either or both directions. The report back will indicate whether or not the last move was terminated by one or both end-of-travel limits.

NOTE: This command is not intended to be used to determine if a move is complete. Rather, it should be used after the move is complete to determine if there might be other errors or faults.

Example

Command	Response
1RA	*@ (By issuing a **1RA** command to the indexer with address of 1, the indexer responded with *@ indicating that the last move was not terminated by a limit and that no limits are currently active.)

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RB Status	Loop, Pause, Shutdown, Trigger Status Report			VALID Software Version E2
SYNTAX aRB	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Not Saved
EXECUTION TIME <2mS		**SEE ALSO** R, RA, TR, PS, L, ST		
RESPONSE TO aRB IS *x				

Description

This command receives a response from ***@** to ***O**, as defined below. The four conditions for which status is indicated are as follows:

Loop Active: A loop is in progress.

Pause Active: Buffered commands are not being executed due to a Pause (**PS**) command (waiting for a **C** command).

Shutdown Active: The motor is shutdown by the **ST1** command.

Trigger Active: At least one trigger is active.

Response Character	Loop Active	Pause Active	Shutdown Active	Trigger Active
*@	NO	NO	NO	NO
*A	YES	NO	NO	NO
*B	NO	YES	NO	NO
*C	YES	YES	NO	NO
*D	NO	NO	YES	NO
*E	YES	NO	YES	NO
*F	NO	YES	YES	NO
*G	YES	YES	YES	NO
*H	NO	NO	NO	YES
*I	YES	NO	NO	YES
*J	NO	YES	NO	YES
*K	YES	YES	NO	YES
*L	NO	NO	YES	YES
*M	YES	NO	YES	YES
*N	NO	YES	YES	YES
*O	YES	YES	YES	YES

NOTE: This command is not intended to be used to determine if a move is complete. Rather, it should be used after the move is complete to determine if there might be other errors or faults.

Example

Command	Response
1RB	***A** (After issuing **1RB**, the response came back as ***A.** This means that the indexer is currently within a loop.)

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RC Status	Closed Loop Status			VALID Software Version E2
SYNTAX aRC	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** R, RA, RB		
RESPONSE TO aRC **IS** *x				

Description

The **RC** command has the same response format of **RA** and **RB**. The four conditions for which status is indicated are:

Static Position Loss:

In this condition, the indexer has detected motion of the load while the motor was stopped. The indexer was not able to correct the position, resulting in Position Maintenance being disabled.

Post Move Position Loss:

In this condition, the indexer has detected a deviation between actual and desired position at the end of a move which exceeds the backlash/dead band parameter. This may involve a Stall, or slipping of the load short of a stall.

Homing Function Failure:

In this condition, the indexer has encountered both End-of-Travel limits or one of several possible Stop commands or conditions. Go Home motion was concluded, but not at Home.

Stall:

In this condition, the indexer has detected a deviation between motor and encoder position larger than one pole of the motor while running, or a deviation larger than that plus the backlash parameter following a direction change.

NOTE: This command is not intended to be used to determine if a move is complete. Rather, it should be used after the move is complete to determine if there might be other errors or faults.

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RC
Response
Table

Response Character	Stall Detected?	Go Home Successful?
*@	NO	YES
*A	YES	YES
*B	NO	NO
*C	YES	NO

Example

Command
1RC

Response
***A** (This means that while attempting the last move, the indexer detected a stall.)

RM Motion	**Rate Multiplier in Velocity Streaming Mode**			**VALID** Software Version E2
SYNTAX <a>**RM**n	**UNITS** revs/sec	**RANGE** n = 0000 - 4E20 (0.0 - 50.0)	**DEFAULT** 0000	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME		**SEE ALSO** Q1, Q0		

Description

The **RM** command followed by 4 hexadecimal digits represents a velocity. The 4 hex digit range is 000 to 4E20, representing 0.0 to 50.0 rps, in units of 1/400 (0.0025) rps.

The velocity change is essentially instantaneous; there is no acceleration/deceleration ramp between velocities. A limit switch-closure will stop movement while in velocity profiling mode, but does not cause the Indexer to exit velocity streaming mode. **RM** (profiling) mode is unidirectional. The direction will be the last activated direction either from an actual move or from a **D** or **H** command. Bi-directional moves using this mode can be made by returning to velocity zero, switching off **RM** mode, changing the direction, and re-enabling **RM** mode. This extra overhead should be acceptable given the need to change to velocity zero when changing directions in real situations.

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Situations requiring non-linear accelerations may use the **QØ**, **Q1**, and **RM** commands. **Q1** is used to enter the velocity profiling mode, and **QØ** is used to exit. While in this mode the **RM** command is used to generate velocity values that are immediately implemented while the motor is moving. This means that the **RM** command must be sent to the AX at the time the change in velocity is required. This creates a stair-step effect in velocity change. By implementing a large number of very small instantaneous velocity changes, a smooth, non-linear acceleration ramp can be achieved.

Example

Command	Description
Q 1	Enter Velocity streaming mode
RMØ19Ø	Accelerate to 1 rev/sec
RMØ32Ø	Accelerate to 2 revs/sec
RMØ4BØ	Accelerate to 3 revs/sec
RMØ64Ø	Accelerate to 4 revs/sec
RMØ4BØ	Decelerate to 3 revs/sec
RMØ32Ø	Decelerate to 2 revs/sec
RMØ19Ø	Decelerate to 1 rev/sec
RMØØØØ	Decelerate to 0 revs/sec
Q Ø	Exit velocity streaming mode

RS Status	**Status of Sequence Execution**			**VALID** Software Version E2
SYNTAX aRS	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** R, RA, RB, RC		
RESPONSE TO aRS **IS** *x				

Description

The **RS** command indicates the status of the latest sequence execution. Possible responses are as follows:

Response Character	Sequence Started	Sequence Ended
*@	NO	NO
*A	YES	NO
*B	NO	YES

Whenever a sequence is started, the sequence start bit is set and the sequence end bit is cleared (this only occurs if the sequence is valid and is actually run). Bit 0: Sequence started; Bit 1: Sequence Ended. Whenever a sequence is ended, the start bit is cleared and the end bit is set. Any abrupt move termination (e.g., limit activation), or a **K** or **S** command clears both bits.

Example

Command	Response
1RS	***A** (Sequence in progress)

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RV Status	Revision Level			VALID Software Version E2
SYNTAX aRV	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Never Saved
EXECUTION TIME <2mS		**SEE ALSO** None		
RESPONSE TO aRV IS *nn-nnnn-nn<xn>				

Description

The Revision (**RV**) command responds with the software part number and its revision level. The response is in the form shown below:

*nn-nnnn-nn<xn>[cr]
(nn-nnnn-nn = part number; <xn> = revision level)

The part number identifies which product the software is written for, as well as any special features that the software may include. The revision level identifies when the software was written. You may want to record this information in your own records for future use. This type of information is useful when you consult Parker Compumotor's Applications Department.

Example

Command	Response
1RV	*92-7212-01E2

The product is identified by 92-7212-01. The revision level is identified by E2.

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S Motion	Stop			VALID Software Version E2
SYNTAX <a>S	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** K, SSH, QØ, A, SSG		

Description

This command decelerates the motor to a stop using the last defined Acceleration (**A**) command. This command normally clears any remaining commands in the command buffer, unless prevented from doing so by the Clear/Save The Command Buffer On Stop (**SSH1**) command. When the **SSH1** command is present, the **S** command stops only the current move. The indexer executes the next command in the buffer. The Stop (**S**) command does not stop the motor if in Rate Multiplier (**RM**) mode. If you are in the **RM** mode, issue an Exit Velocity Profiling Mode (**Q0**) command to stop the motor.

Example

Command	Description
MC	Sets move in continuous mode
A1	Sets acceleration to 1 rev/sec^2
V1Ø	Sets velocity to 10 rev/sec
G	Executes the move (Go)
S	Stops motor (motor comes to 0 rev/sec at a deceleration rate of 1 rev/sec^2

The **S** command is not buffered since it is an immediate command. As soon as the indexer receives the **S** command, it stops motion.

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SC Programming	Standby Current			VALID Software Version E2
SYNTAX <a>SCn	**UNITS** N/A	**RANGE** n = 1 - 8	**DEFAULT** 8	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** SCA		

Description

This command reduces motor current when the motor is not moving. The percentage of maximum current going to the motor is listed below:

n	Percentage of Maximum Current
1	13%
2	25%
3	38%
4	50%
5	63%
6	75%
7	88%
8	100%

This command keeps the motor cooler and saves energy; however, you sacrifice some holding torque at zero speed. Once the motor starts moving, full motor current is restored.

This command is valid only while the motor is stationary. When the motor starts moving, you must re-issue the command to reduce current after the move.

Example

Command	Description
SC1	Sets standby current level to 13%

When the motor stops moving, current is immediately set to 1/8 of the maximum current.

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SCA Programming	Standby Current Automatically			VALID Software Version E2
SYNTAX <a>**SCA**n	**UNITS** N/A	**RANGE** n = 1 - 8	**DEFAULT** 8	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** SC		

Description

This command reduces current going to the motor after move is complete. The percentage of maximum current going to the motor is n/8 x 100% of maximum current. When the motor starts moving again, full current is restored to the motor. This standby current will reduce holding torque when motor is not moving, however the motor will run cooler and uses less energy.

Example

Command	Description
SCA2	Every time motor comes to a stop, the current to the motor will be set to 2/8 x 100% of the maximum current.

SN Set-up	Scan			VALID Software Version E2
SYNTAX <a>**SN**n	**UNITS** n = mS	**RANGE** 1 - 1000	**DEFAULT** 50	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** None		

Description

The Scan (**SN**) command allows you to define the debounce time (in milliseconds) for external sequence selection inputs. The debounce time is the amount of time that the sequence inputs must remain constant for a proper reading from a remote controller, such as a programmable logic controller (PLC). If you are using a PLC you should change the debounce time to match the *on time* of the PLC outputs.

Example

Command	Description
SN15Ø	Sets scan time of sequence select inputs to 150 milliseconds.

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SSA Set-up	RS-232C Echo Control			VALID Software Version E2
SYNTAX <a>**SSA**n	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** None		

Description

This command turns the RS-232C echo (transmission of characters received from the remote device by the indexer) on and off.

SSAØ = Echo on
SSA1 = Echo off

In the Echo On (**SSAØ**) mode, characters that are received by the indexer are echoed automatically. In the Echo Off (**SSA1**) mode, characters are not echoed from the indexer. This command is useful if your computer cannot handle echoes. In a daisy chain, you must have the echo turned on (**SSAØ**) to allow indexers further down the chain to receive commands.

Status commands do not echo the command sent, but transmit the requested status report.

Example

Command	Description
SSA1	Turns echo off (Characters sent to the indexer are not echoed back to the host.)

SSD Set-up	Limit Inputs for Stopping			VALID Software Version E2
SYNTAX <a>**SSD**n	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** S, SS		

Description

The hardware limit switches can act as remote stop inputs (can be controlled from PLC rather than via RS-232C link). **SSDØ** uses limits as simple limit switch inputs. When this function is enabled (**SSD1**), (and when the CW and CCW limit inputs are both opened), the Stop (**S**) command will be executed, until one or both of the limits are grounded (closed). The **LD** command will not affect the **SSD** command.

Example

Command	Description
SSD1	This command enables CW and CCW limits as stop inputs.

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SSG Set-up	Clear/Save the Command Buffer on Limit			VALID Software Version E2
SYNTAX <a>SSGn	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** LD		

Description

In most cases, it is desirable that upon activating an end of travel limit input, all motion should cease until the problem causing the over-travel is rectified. This will be assured if all commands pending execution in the command buffer are cleared when hitting a limit. This is the case if **SSG0** is specified. If **SSG1** is specified and a limit is activated, the current move is aborted, but the remaining commands in the buffer continue to be executed.

Example

Command	Description
SSG1	Save buffer on limit
A1Ø	Set acceleration to 10 rev/sec^2
V5	Set velocity to 5 rev/sec
MC	Set to mode continuous
L5	Loop 5 times
G	Execute the move (Go)
H+	Sets direction to CW
N	End loop

The motor will move back and forth between limits.

SSH Set-up	Clear/Save the Command Buffer on Stop			VALID Software Version E2
SYNTAX <a>SSHn	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** LD, S, FSF		

Description

SSHØ = Clears command buffer on stop
SSH1 = Saves command buffer on stop

In Normal Operation (**SSHØ**) the Stop (**S**) command will cause any commands in the command buffer to be cleared. If you select the Save Buffer On Stop (**SSH1**) command a Stop (**S**) command will only stop execution of a move in progress. It will not stop execution of any commands that remain in the buffer.

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Example

Command	Description
SSHØ	Clears buffer on stop
A1Ø	Sets acceleration to 10 rev/sec^2
V5	Sets velocity to 5 rev/sec
MN	Sets indexer to Mode Normal
D256ØØ	Sets distance to 25,600 steps
L5Ø	Loops 50 times
G	Executes the move (Go)
T.5	Pauses the motor 500 msec
N	Ends Loop
S	Stops motion

When you issue the **S** command, the indexer will clear the buffer and stop the move. Stalls, Stop, **FSF**, **SSD1** and **TRIG3** move terminate are treated as stops.

ST Programming	**Shutdown**			**VALID** Software Version E2
SYNTAX <a>**ST**n	**UNITS** N/A	**RANGE** n = 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** None		

Description

The Shutdown (**ST1**) command rapidly decreases the motor current to zero. The system ignores move commands that you issue after the **ST1** command. Torque on the motor is not maintained after you issue the **ST1** command.

The **STØ** command rapidly increases the motor current to normal. Once you restore the current, you can execute moves.

This command is useful for reducing motor heating and allows you to manually position the load.

Example

Command	Description
ST1	Shuts off current to the motor

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SV Programming	Servoing Parameter			VALID Software Version E2
SYNTAX <a>**SV**n	**UNITS** N/A	**RANGE** n = 0 - 3	**DEFAULT** None	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** FSC, ST		

Description

The Servoing Parameter (**SV**) command provides four different ways of simultaneously changing state of the motor shutdown and position maintenance functions. The four commands are as follows:

SVØ This command causes the position maintenance function to be turned off, but does not turn off motor power. It is identical in function to the **FSCØ** command.

SV1 This command causes the position maintenance function to be turned off and the motor to be shut down simultaneously.

SV2 This command causes the position maintenance function to be turned on and turns the motor power back on if it was turned off due to **SV1** or **SVØ** command. The encoder position will be read and this newest position will be maintained.

SV3 This command causes the position maintenance function to be turned on and turns the motor power on if it was turned off. The indexer will servo back to the *rest* position held before the position maintenance function was disabled.

Example

Command	Description
SV1	Simultaneously turns off Position Maintenance function and shuts down the motor.

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T Programming	Time Delay			VALID Software Version E2
SYNTAX <a>Tn	**UNITS** n = seconds	**RANGE** 0.01 - 999.99	**DEFAULT** None	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** None		

Description

The Time (**T**) command causes the indexer to wait the number of seconds that you specify (n) before it executes the next command in the buffer. This command is useful whenever you need to delay the motor's actions or when you wish to move the motor in continuous velocity for preset time..

Position maintenance is not active during a Time delay.

Example

Command	Description
MN	Set to mode normal
A5	Set acceleration to 5 rev/sec^2
V6	Set velocity to 6 rev/sec
D128ØØ	Set distance to 12,800 steps
G	Execute the move (Go)
T3	Delays 3 seconds between moves
G	Execute the move (Go)

TEST Motion	Test Routine			VALID Software Version E2
SYNTAX <a>**TEST**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME		**SEE ALSO** None		

Description

The Test Routine (**TEST**) command is intended for use as an initial checkout command to verify if the system functions properly. Immediately after you issue the TEST command, the following sequence is executed:

LD3 MN MPI A2 V1 D128ØØ G T.5 H G

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Example

Command	Description
TEST	Executes a test sequence
Test Sequence:	
LD3	Disables CW and CCW limits (all axes)
MN	Sets indexer to normal mode
MPI	Sets positioning mode to incremental
A2	Sets acceleration to 2 rps^2
V1	Sets velocity to 1 rps
D128ØØ	Sets distance to 12,800 steps
G	Executes the move (Go)
T.5	Waits 0.5 seconds after finishing the move
H	Changes the direction of the next move
G	Executes the move (Go)

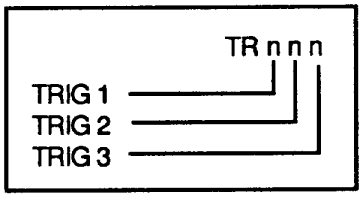
After issuing the **TEST** command the motor turns one CW revolution, pauses for 0.5 seconds, and turns one CCW revolution.

TR Programming	**Wait for Trigger**			**VALID** Software Version E2
SYNTAX <a>**TR**n	**UNITS** n = input	**RANGE** n = 0, 1, x	**DEFAULT** None	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** TS		

Description

This command allows you to specify a trigger configuration to be matched before continuing execution of the move. The command is in the form TR*nnn*, where *nnn* corresponds to triggers 1, 2, and 3 respectively. The possible values for *n* are as follows:

n = 1 Wait for the trigger input to be high (opened)
n = 0 Wait for the trigger input to be low (grounded)
n = X Ignore the trigger input



When **TR** command is used in a buffer, the indexer will get to this command and wait until the input pattern is matched before going on to the next command.

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Example

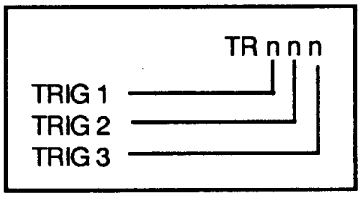
Command	Description
TR1ØX	Wait for input 1 to be opened and input 2 to be grounded before going on to the next command. Input 3 will be ignored.
A1Ø	Sets acceleration to 10 rev/sec^2
V5	Sets velocity to 5 rev/sec
D256ØØ	Sets distance to 25,600 steps
G	Executes the move (Go)

TS Status	**Trigger Input Status**			**VALID** Software Version E2
SYNTAX aTS	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** TR		
RESPONSE TO aTS **IS** nnn				

Description

This command retrieves the state of the trigger inputs. The response is in the form nnn, where nnn reports the status of triggers 1, 2, and 3 respectively. The possible values for n are as follows:

n = 1 Input is high (opened)
n = 0 Input is low (closed)



TS command is useful for checking the status of the trigger inputs when it appears as though execution is being halted by a **TR** command. To make sure that your trigger pattern is met, you can check with **TS** command.

Example

Command	Response
1TS	101

Trigger bits 1 and 3 are high (opened) and Trigger bit 2 is low (closed).

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U Programming	Pause and Wait for Continue			VALID Software Version E2
SYNTAX <a>U	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** PS, C		

Description

This command causes the indexer to complete the move in progress, then wait until it receives a Continue (**C**) to resume processing. Since the buffer is saved, the indexer continues to execute the program (at the point where it was interrupted). The indexer continues processing when it receives the **C** command. This command is typically used to stop a machine while it is unattended.

Example

Command	Description
MN	Sets move to Normal mode
A5	Sets acceleration to 5 rev/sec^2
V5	Sets velocity to 5 rev/sec
L	Loops indefinitely
D256ØØ	Sets distance to 25,600 steps
G	Executes the move (G)
T1Ø	Waits 10 seconds after the move
N	Ends loop
U	Halts execution until the indexer receives the Continue command.

This command string pauses at the point where the **U** command is entered. A Continue (**C**) command causes execution to resume at the point where it was paused. In this example, the loop stops at the end of a move, and resumes when the indexer receives the **C** command. There may be a 10-second delay before motion resumes after the **C** command is executed, depending on when the Pause and Wait for Continue (**U**) command is completed.

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V Motion	Velocity			VALID Software Version E2
SYNTAX <a>Vn	**UNITS** n = revs/sec^2	**RANGE** 0.001-50.000	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** A, D, G		

Description

The Velocity (**V**) command defines the maximum speed at which the motor will run when given the Go (**G**) command.

Example

Command	Description
MC	Sets move to continuous
A 5	Sets acceleration to 5 rev/sec^2
V 5	Sets velocity to 5 rev/sec
G	Go (Begin motion)

In preset mode, Mode Normal (**MN**) the maximum velocity may also be limited when the resulting move profile is triangular. In Mode Continuous (**MC**), when a Go (**G**) command is completed, the indexer moves on to the next command in the buffer once the specified velocity is reached.

When the Go Home (**GH**) command is executed, the velocity is changed accordingly; subsequent moves should include a new **V** command unless the Go Home velocity is applicable.

Once you define the velocity, that velocity will be valid until you define another velocity, cycle AC power or issue a **Z** command.

*NOTE: If the value specified for the **V** command is not valid, the AX ignores that value and defaults to the value specified in the last **V** command.*

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VC Motion	**Change Velocity in Continuous Mode**			**VALID** Software Version E2
SYNTAX <a>VCn	**UNITS** n = rev/sec	**RANGE** 0.001 - 50.000	**DEFAULT** None	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** V, AC		

Description

This command changes the velocity while moving in continuous mode. Valid velocities for this command range from 0.001 to 50.000 revolutions per second. This command is effective only when running at constant velocity. Velocity change occurs immediately following the issuance of the **VC** command. Not more than 2 digits before the decimal point are allowed. This command does not change the velocity value set by the **V** command.

Example

Command	Description
MC	Do moves in continuous mode
A1Ø	Sets acceleration to 10 rev/sec^2
V5	Sets velocity to 5 rev/sec
G	Executes the move (Go)
VC7	Change velocity to 7 rev/sec2 at acceleration of 10 rev/sec^2

The motor will ramp up to constant velocity at 5 rps after the first **G** command is entered. The motor will ramp up to a constant velocity of 7 rps after the **VC** command is entered.

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W1 Status	Signed Binary Position Report			VALID Software Version E2
SYNTAX a**W1**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME		**SEE ALSO** W3, PR		
RESPONSE TO a**W1** **IS** *nnnn				

Description

Report back gives immediate binary representation of position relative to start of the current move. The format of the response is a four character response (*nnnn) that is interpreted as a 32-bit binary number. The number must then be interpreted by the computer to give a numerical position in steps. The format is in 2's complement notation. Moves in the negative direction (CCW) will report back negative numbers (bit 31 is set to 1).

If you are using a terminal to communicate with the indexer, the response may not be a printable character. The response must be decoded using a computer.

This command is useful if you want to receive a position report while the motor is moving.

Example

None

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W3 Status	Hexadecimal Position Report			VALID Software Version E2
SYNTAX aW3	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** W1, PR		
RESPONSE TO aW3 **IS** *FFFFnnnn				

Description

This command will respond with an immediate hexadecimal character position report back in 2's complement format. The position response indicates the motor position relative to the current move. The format of the response is an eight digit ASCII hexadecimal number. The **PZ** command does not affect this value.

Assume the response was *0000024E. The decimal value would be 590 (pulses).

If the first digit of the response is an *F* (e.g., *Fnnnnnnnn), then the response represents a *2s complement* negative number.

Use the following steps to interpret a negative number (starting with *F*)

The binary approach:

1. Convert the hexadecimal response to binary form.
2. Complement the binary number
3. Add 1 to the binary result
4. Convert the binary result to decimal value with a minus sign placed ahead of the decimal value.

The computer approach:

Subtract the hexadecimal number from 168 (232) (4,294,967,296).

The easy way:

1. Leave off all the leading *F*s, and convert to decimal
2. Convert and subtract the next largest power of 16.

Example: *FFFF9E58

1. Leave off the *F*s:	9E58 hex	=	40,536
2. Subtract from 164	10000 hex	=	65,536
	Results	=	-25,000

Example

Command	Response
1W3	***FFFFA19C** In the current move, you are at 24,163 steps from initiation of move.

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WV Programming	Select Waveform			VALID Software Version E2
SYNTAX <a>**WV**n	**UNITS** N/A	**RANGE** n = 1 - 9	**DEFAULT** 5	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** None		

Description

The **WV** command will select 1 of 9 stored waveforms. The waveforms differ in the amount of 3rd harmonic that each has. Generally, the higher the current in the motor, the greater the percentage of out-of-phase 3rd harmonic you would want. Empirical determination of the best sine wave for a given motor and load is the best means for selecting a waveform.

Waveform	% of 3rd Harmonic
#1	-8
#2	-6
#3	-4
#4	-2
#5	0
#6	+2
#7	+4
#8	+6
#9	+8

Example

Command	Description
1WV1	Waveform #1 is selected

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XC Status	Sequence Checksum			VALID Software Version E2
SYNTAX a**XC**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** XD, XE		
RESPONSE TO a**XC** **IS** nnn				

Description

This command computes the EEPROM checksum. After the indexer has been programmed, the response can be used for system error checking. The response is in the form nnn, where the range for nnn is 000 - 255. The number reported does not indicate the number of bytes programmed. This response is designed to be used for comparison. As long as the indexer is not reprogrammmed, the checksum response should always be the same.

Example

Command	Response
1XC	149

XD Programming	Sequence Definition			VALID Software Version E2
SYNTAX <a>**XD**n	**UNITS** n = sequences	**RANGE** 1 - 7	**DEFAULT** None	**ATTRIBUTES** Buffered Never Saved
EXECUTION TIME <2mS		**SEE ALSO** XE, XR, XRP, XSD, XT		

Description

This command begins sequence definition for a specific sequence. All the commands between the **XD** command and the Sequence Termination (**XT**) command will be defined as a sequence. The sequences will automatically be saved when the **XT** command is issued. If a sequence you are trying to define already exists, you must erase that sequence (**XE** command) before defining it. Each sequence cannot be longer than 256 characters

Immediate commands cannot be entered into a sequence.

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Example

Command	Description
XE1	Erase sequence #1
XD1	Define sequence #1
MN	Set to mode normal
A1Ø	Sets acceleration to 10 rev/sec^2
V5	Sets acceleration to 5 rev/sec
D256ØØ	Sets distance to 25,600 steps
G	Executes the move (Go)
XT	End defining sequence #1
XR1	Execute sequence #1

The commands in sequence 1 are defined and executed.

XE Programming	**Sequence Erase**			**VALID** Software Version E2
SYNTAX <a>**XE**n	**UNITS** n = sequences	**RANGE** 1 - 7	**DEFAULT** None	**ATTRIBUTES** Buffered Never Saved
EXECUTION TIME <2mS		**SEE ALSO** XD, XT, XR, XRP		

Description

This command allows you to delete a sequence. The sequence that you specify (n) will be deleted when you issue the command.

As a good practice, you should delete a sequence before defining it.

Example

See example for **XD** command.

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XP Set-up	Set Power-up Sequence Mode			VALID Software Version E2
SYNTAX <a>**XP**n	**UNITS** N/A	**RANGE** n = 0 - 9	**DEFAULT** 0	**ATTRIBUTES** Buffered Automatically Saved
EXECUTION TIME <2mS		**SEE ALSO** K, S, XR, XQ, XSP, XSSR, XZ		

Description

Set power-on sequence mode. This command will cause a single sequence or multiple sequences to be executed on power-up. The possible settings for *n* are as follows:

n=0	No sequence is executed
n=1-7	Sequence 1 - 7 is executed on power-up
n=8	Sequence Select inputs are read (single run)
n=9	Sequence Select inputs are read (continuous run)

A value of 1-7 for *n* will result in the sequence whose value = *n* being executed on power-up. Control will then be passed to the RS-232C interface.

A value of 8 for *n* will result in the sequence whose number appears on the sequence select inputs to be executed on power-up. Control will then be passed to the RS-232C interface.

A value of 9 for *n* will cause the sequence whose number appears on the Sequence Select inputs to be executed on power-up. When the first sequence is finished in XP9 mode, the AX will scan the Sequence Select inputs again and execute the next sequence whose number appears on the inputs. This cycle will continue until a Stop (**S**) or Kill (**K**) command is issued, a limit is encountered, or the unit is powered down.

Example

Command	Description
XP1	Execute Sequence #1 on power-up
XE1	Erase sequence #1
XD1	Define sequence #1
A1Ø	Sets acceleration to 10 rev/sec^2
D256ØØ	Sets distance to 25,600 steps
SN1Ø	Set sequence debounce time to 10mS
GH5	Go Home at 5 rev/sec
XT	End of sequence #1
Z	Reset the indexer

The motor will move 25,600 steps every time you power-up or reset using **Z** command.

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XQ Set-up	Sequence Interrupted Run Mode			VALID Software Version E2
SYNTAX <a>**XQ**n	**UNITS** N/A	**RANGE** 0, 1	**DEFAULT** 0	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** XD, XE, XT, XZ, XP		

Description

XQ1 = Set interrupted run mode (on)
XQØ = Clear interrupted run mode (off)

This command can be used only when stand-alone power-up sequencing in XP9 mode. If **XQ1** is executed, the indexer will ignore sequence select inputs, until all sequence select lines have been brought to a high state. After all lines have simultaneously been brought to a high state, the indexer will then read the sequence select lines and execute the sequence whose number appears there. This paused mode will continue until an **XQØ** command is executed. You may use **S** or **K** command to stop sequence execution.

The interrupted run mode is cleared at the start of execution of a sequence.

Example

Command	Description
XE1	Erase sequence #1
XD1	Define sequence #1
LD3	Disable CW & CCW limits
XQ1	Sets interrupted mode on
XT	End Sequence #1
XP9	Sets power-up sequences as sequence select inputs
Z	Resets the AX to start sequence scanning

If you execute Sequence 1 upon power-up by setting **SEQ1-SEQ3** inputs properly, the interrupted run mode will be set. Sequence select input lines all need to go high (open) before selecting any other sequences.

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XR Programming	Run A Sequence			VALID Software Version E2
SYNTAX <a>**XR**n	**UNITS** n = sequences	**RANGE** 1 - 7	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** XE, XD, XT, XRP, SN		

Description

This command loads a predefined sequence (identified by *n*) into the command buffer (clears the buffer first) and executes these commands as a normal set of commands. This command automatically recalls the sequence from EEPROM.

An **XR** command can be used within one sequence to start execution of another sequence; however, all commands in the first sequence following the **XR** will be ignored (in this respect an **XR** acts like a GOTO not a GOSUB). If using continuous mode, the velocity must be 0 rps when calling another sequence. An **XR** command placed within a loop will be ignored.

Example

Command	Description
XE1	Erase sequence #1
XD1	Define sequence #1
A1Ø	Sets acceleration to 10 rev/sec^2
V5	Sets acceleration to 5 rev/sec
D256ØØ	Sets distance to 25,600 steps
G	Executes the move (Go)
XT	End defining sequence #1
XR1	Execute sequence #1

Sequence 1 is defined and executed using **XD1** and **XR1** commands respectively

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XRP Programming	Sequence Run With Pause			VALID Software Version E2
SYNTAX <a>**XRP**n	**UNITS** n = sequences	**RANGE** 1 - 7	**DEFAULT** None	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** XR, XD, XT, XE, C, SN		

Description

This command is identical to the Sequence Run (**XR**) command, except that it automatically generates a pause condition. You muse clear this condition with the Continue (**C**) command before the indexer executes the command buffer. The pause condition is asserted only if the sequence is valid. This allows you to execute a sequence without the delay of buffering that sequence.

Example

Command	Description
XE5	Erases Sequence #5
XD5	Defines Sequence #5
A1Ø	Sets acceleration to 10 rev/sec^2
V5	Sets velocity to 5 rev/sec
D256ØØ	Sets distance to 25,600 units
G	Executes the move (Go)
XT	Ends defining Sequence #5
XRP5	Runs Sequence #5 with a pause
C	Indexer executes Sequence #5

Upon issuing **XRP5**, Sequence #5 is entered into the command buffer, but is not executed. You must issue a Continue (**C**) command to execute Sequence #5.

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XSD Status	Sequence Download Status			VALID Software Version E2
SYNTAX a**XSD**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Never Saved
EXECUTION TIME <2mS		**SEE ALSO** XD, XE, XT		
RESPONSE TO a**XSD** **IS** n				

Description

This command reports back the status of the previous sequence definition (**XD**...**XT**). The response is 0 - 3. The VALID values and descriptions of possible responses are shown below:

0= Download O.K.

1= A sequence already exists with the number you have specified.

2= Out of memory. The sequence buffer is full.

3= EEPROM write error.

The **XSD** command is useful for verifying that the last sequence definition attempt was successful.

Example

Command	Response
1XSD	**1** (This response indicates that you need to erase the existing sequence to define that specific sequence.)

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XSP Status	Power-up Mode Sequence Status			VALID Software Version E2
SYNTAX a**XSP**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Savable in Sequence
EXECUTION TIME <2mS		**SEE ALSO** XP, XSR, XQ, XZ		
RESPONSE TO a**XSP** **IS** n				

Description

The Sequence Status Power-up (**XSP**) determines which, if any, sequence will be executed on power-up. After setting a power-up sequence using the Sequence Power-up (**XP**) command, you can check to make sure that proper sequence will be executed on power-up using the **XSP** command. The command reports back the sequence that the system will execute during power-up. The range of the response is 0 - 9.

Example

Command	Response
1XSP	**3** (indicates that sequence number #3, if it exists, will be executed upon power-up or reset)

XSR Status	Sequence Run Status			VALID Software Version E2
SYNTAX a**XSR**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Never Saved
EXECUTION TIME <2mS		**SEE ALSO** XR, XRP		
RESPONSE TO a**XSR** **IS** n				

Description

This command allows you to check whether or not the last sequence you issued was executed successfully without hitting limits, Stop (**S**), or Kill (**K**). The valid values and descriptions for *n* are shown below:

0 = Last attempt to run the sequence was successful
Non-zero = Not running:
- **1** = In a loop
- **2** = NON-VALID sequence was requested
- **3** = Erased sequence
- **4** = Bad checksum

Example

Command	Response
XR2	Runs Sequence 2
1XSR	**0** (Sequence ran OK)

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XSS Status	Sequence Status			VALID Software Version E2
SYNTAX a**XSS**n	**UNITS** n = sequences	**RANGE** 1 - 7	**DEFAULT** None	**ATTRIBUTES** Buffered Never Saved
EXECUTION TIME <2mS		**SEE ALSO** XD, XE, XT		
RESPONSE TO a**XSS**n **IS** n				

Description

This command reports whether the sequence specified by n (representing one of seven sequences) is empty, has a bad checksum, or is OK. The possible responses are as follows:

0 = Empty
1 = Bad Checksum
3 = O.K.

This command is useful to see if the particular sequence exists and if that portion of memory has been corrupted.

Example

Command	Response
1XSS1	**0** (Nothing programmed in sequence #1)

XT Programming	Sequence Termination			VALID Software Version E2
SYNTAX <a>**XT**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Buffered Never Saved
EXECUTION TIME		**SEE ALSO** XD, XE, XR		

Description

The **XT** command is a sequence terminator. This command flags the end of the sequence currently being defined. Sequence definition is not complete (saved) until this command is issued.

Example

Command	Description
XD1	Define sequence #1
MN	Sets move to continuous
A1Ø	Sets acceleration to 10 rev/sec^2
V5	Sets velocity to 5 rev/sec
D256ØØ	Sets distance to 25,600 steps
G	Executes the move (Go)
XT	End sequence definition

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XU Status	Upload Sequence			VALID Software Version E2
SYNTAX a**XU**n	**UNITS** n = sequences	**RANGE** 1 - 7	**DEFAULT** N/A	**ATTRIBUTES** Buffered Never Saved
EXECUTION TIME		**SEE ALSO** XD, XE, XT, F		

Description

This command sends the contents of sequence *n* to the host computer via RS-232C interface. All commands in sequence n are displayed on the CRT. All command delimiters in the sequence will be sent out as spaces (20H). Any device identifiers that were included in the original sequence will also be eliminated (they are not stored in the sequence).

NOTE: When using a daisy-chain, this command must be used cautiously as the contents of the sequence will go to all controllers in the loop between the indexer that is uploading and the host. The ***F*** *command may be useful in this context to turn off communication on units you are not uploading from.*

Example

Command	Description
F	Turn off communication to all units
1 E	Turn on communication to unit #1
1XU7	Upload sequence #7 from unit #1
E	Enable other units

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XZ Programming	Set power-up Sequence to Zero			VALID Software Version E2
SYNTAX <a>**XZ**	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME		**SEE ALSO** Z, XSP, XSR, XP, XQ		

Description

This command sets the power-up sequence number to zero (thereby disabling sequence activation on power-up). The purpose of this command is to handle the situation in which the set power-up sequence has a checksum error, causing control to pass to the error routine (flashing LED); only immediate commands are active in this error state. In testing externally controlled sequences, it can also be used to disable continuous run sequencing (followed by a **Z** command to reset the indexer).

The main difference between the **XZ** command and the **XPØ** command is that **XZ** is executed immediately and **XP0** is entered into a buffer. If you are already running a sequence, use this command.

Example

None

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Y Programming	Stop Loop			VALID Software Version E2
SYNTAX <a>Y	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2mS		**SEE ALSO** L, N, CL, CN		

Description

The Stop Loop (**Y**) command takes you out of a loop when the loop completes its current pass. This command does not halt processing of the commands in the loop until the indexer processes reach the last command of the current loop. At that time, the indexer executes the command that follows the End Loop (**N**) command. You cannot restart the command loop unless you enter the entire command structure, including the Loop (**L**) and End Loop (**N**) commands.

Example

Command	Description
L	Loops indefinitely
A1Ø	Sets acceleration to 10 rev/sec^2
V5	Sets velocity to 5 rev/sec
D256ØØ	Sets distance to 25,600 steps
T2	Waits 2 seconds
G	Executes the move (Go)
N	Ends loop
Y	Stops loop

The loop requires the motor to move 25,600 steps CW and then wait for 2 seconds. The loop terminates at the end of the loop cycle it is executing when it receives the **Y** command.

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Z Programming	Reset			VALID Software Version E2
SYNTAX <a>Z	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME 800mS		**SEE ALSO** S, K		

Description

The Reset (**Z**) command is equivalent to cycling AC power to the indexer. This command returns all internal settings to their power-up values. It clears the command buffer. Like the Kill (**K**) command, the **Z** command immediately stops output pulses to the motor.

Any commands entered while resetting are ignored.

This command sets all position counters to zero.

Example

None

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Chapter 6. HARDWARE REFERENCE

Chapter Objectives

The information in this chapter will enable you to:

- Use this chapter as a quick reference tool for most system specifications (dimensions & performance) and switch settings
- Use this chapter as a quick reference tool for proper system connections

Environmental Specifications

The AX Drive system should be operated in accordance with the following environmental constraints:

Parameter	Value
Operating	32°F - 104°F (0°C - 40°C)
Humidity	0 - 95% non-condensing
Storage	-40°F - 185°F (-40°C - 85°C)
Motor	Max. case temp. = 212°F (100°C) - for Compumotor-supplied motors *(actual temperature rise is dependent on duty cycle)*

Table 6-1. AX Environmental Specifications

An internal thermostat will shut down the drive if the internal drive temperature reaches 149°F (65°C). ***NOTE: Current settings in excess of 4A in high ambient temperature environments (above 104°F) require fan cooling to keep the heatsink temperature within allowable limits and to keep the drive from shutting itself down due to over-temperature. The fan kit is standard with all AXH Drives.***

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System Specifications

AX Drive Specifications

Parameter	Value
Input Power	
Direct	95 - 132VAC @ 50/60Hz
From a Transformer	60% of the DIP switch setting for motor current
Output Power	
AHL	0.23 - 3A per phase @ 170VDC
AXH	0.46 - 6A per phase @ 170VDC
Amplifiers	
Type	2-Phase MOSFET bipolar (H-bridge) switching @ 20Khz (AXL) and 16Khz (AXH) pulse width modulated
Protection	
Short-circuit	Phase-to-phase (not phase-to-ground)
Brown-out	If AC supply drops below 95VAC
Over-temperature	If internal air temperature exceeds 158°F (70°C)
Performance	
Resolution	64 microsteps/full step. - *(12,800 steps/rev with a 1.8° step motor)*
Position Range	±0 - 1,999,999,999 steps
Coordinate System	Absolute or incremental
Velocity Range	±0.01 - 50.0 rps (0.6 - 3,000 RPM)*
Acceleration Range	0.01 - 999.999 rps^{2}*
Command Interface	
Type	RS-232C, three-wire (Tx, Rx, GND) implementation. Required minimum voltage swing on Rx line is ±3V.
Communications Parameters	Fixed at 9600 baud, 8 data bits, 1 stop bit, no parity
Configuration	Up to 8 AX drives controlled from one RS-232C port (connected in daisy-chain). Each drive must have unique address set with DIP switches.
Sequence Storage	
Memory Type	EEPROM (2K characters)
Number of Motion Programs	7
Program Length	Up to 256 characters/sequence
Motors	
Type	2-phase hybrid permanent magnet. (ROTARY ONLY)
Breakdowm Voltage (HIPOT)	750VAC minimum
Number of Leads	4, 6, or 8
Minimum Inductance	20mH/phase (measured series or end-to-end), No max.
Accuracy Grade	3%

Table 6-2. AX Drive Specifications

* These specifications are software-related. Refer to the torque/speed curves provided later in this chapter for actual usable torque at specified velocities. *NOTE: Parker Compumotor does not guarantee proper torque/speed performance at velocities above 30 RPS.*

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Motor Specifications (Compumotor-Supplied)

		NEMA SIZE 23			NEMA SIZE 34			NEMA SIZE 42		
		AX 57-51	AX 57-83	AX 57-102	AX 83-62	AX 83-93	AX 83-135	AX 106-120	AX 106-178	AX 106-205
Static Torque										
oz-in		60	80	120	140	260	380	450	950	1600
(N-m)		(0.42)	(0.55)	(0.85)	(1.00)	(1.85)	(2.70)	(3.21)	(6.78)	(11.42)
Rotor Inertia										
oz-in^2		0.48	1.28	1.75	3.50	6.70	10.24	21.5	44.0	52.0
(Kg-cm^2)		(0.088)	(0.234)	(0.320)	(0.64)	(1.23)	1.87)	(3.92)	(8.05)	(9.51)
Bearings										
Thrust load	lb.	25	25	25	50	50	50	50	50	50
	(Kg)	(11.32)	(11.32)	(11.32)	(22.64)	(22.64)	(22.64)	(22.64)	(22.64)	(22.64)
Radial load	lb.	15	15	15	25	25	25	25	25	25
	(Kg)	(6.79)	(6.79)	(6.79)	(11.32)	(11.32)	(11.32)	(11.32)	(11.32)	(11.32)
End play (Reversing load equal to 1lb.)	in.	0.005 (same for all motors)								
	(cm)	(0.013) (same for all motors)								
Radial play (per 0.5 lbs load)	in.	0.0008 (same for all motors)								
	(cm)	(0.002) (same for all motors)								
Motor cable length		10' (same for all motors)								
Weight (motor/drive +cable + container)	lb.	1.6	2.4	3.2	3.8	5.12	8.3	8.5	19.11	23.4
	(Kg)	(0.73)	(1.09)	(1.45)	(1.73)	(2.33)	(3.77)	(3.86)	(8.69)	(10.64)
Accuracy										
Loaded		0.0167° (same for all motors)								
Unloaded-bidirectional		0.0833° (same for all motors)								
Repeatability (unloaded)		0.0014° (same for all motors)								
Hysteresis (unloaded-bi-directional)		≤0.0334° (same for all)								
Inductance (mH/phase)		41mH	100mH	74mH	64mH	39mH	29mH	32mH*	28mH*	30mH*

* Wired in series

Table 6-3. Compumotor-Supplied Motor Specifications

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Inputs and Outputs

This section contains detailed illustrations, descriptions, and specifications of the AX system inputs and outputs.

System Pinouts and Connectors

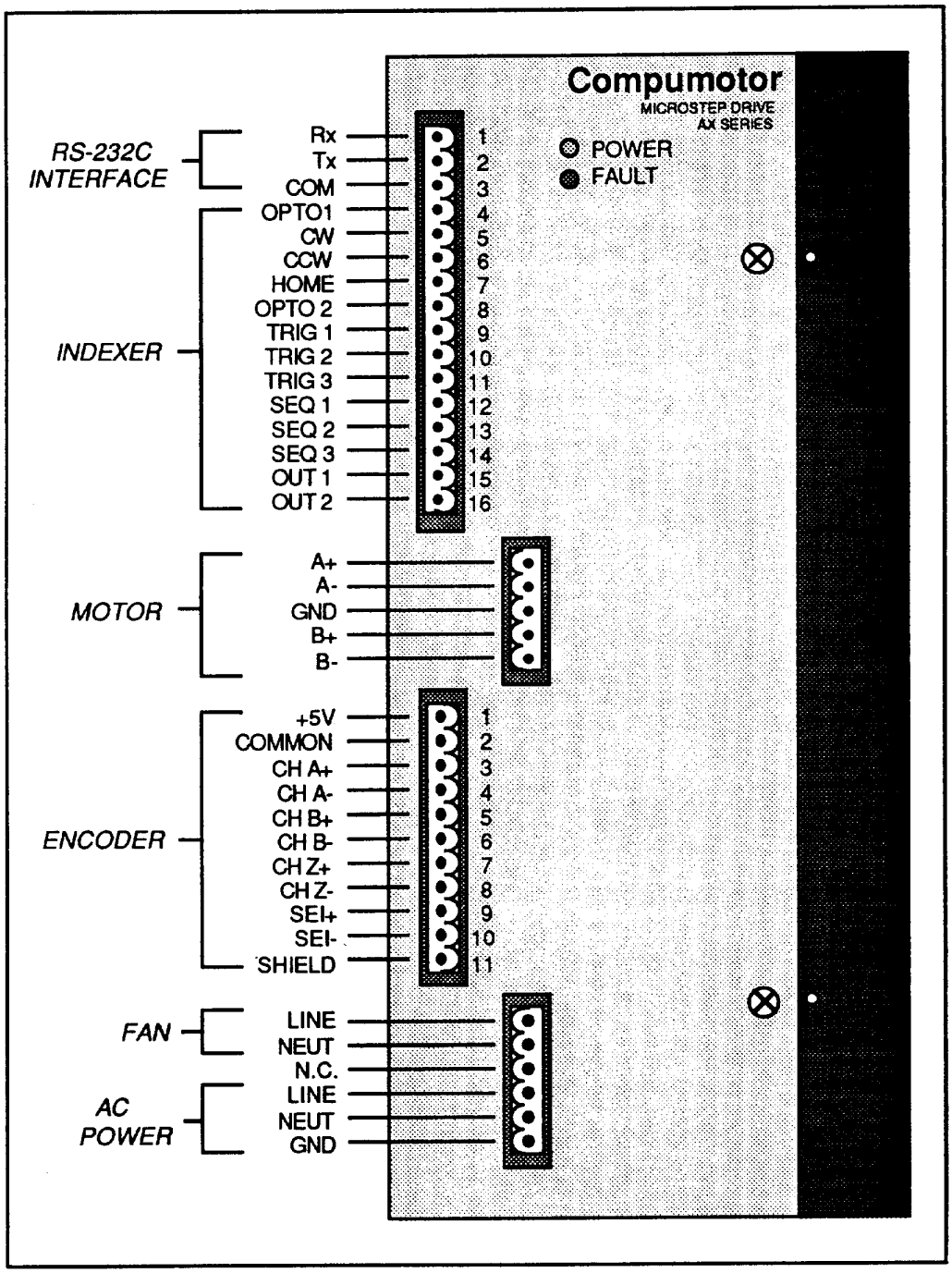


Figure 6-1. AX Drive Pinouts and Connectors

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SPECIAL ENCODER PINOUTS (COMPUMOTOR ENCODERS)

AX Drive Connector Pin #	AX Drive Function Pinout	25-D Encoder Connector Pinout	57 Series Encoder Color Code	83 & 106 Series Encoder Color Code	IL Encoder Color Code
1	+5VDC	23	Red	Red	Red (1)
2	COMMON	14	Black	Black	Black (1)*
3	CHA A+	1	Brown	Yellow	Blue (2)
4	CHA A-	2	Brown/White	White/Yellow	Black (2)
5	CHA B+	3	Green	Blue	Green (3)
6	CHA B-	4	Green/White	White/Blue	Black (3)
7	CHA Z+	5	Orange	Orange	White (4)
8	CHA Z-	6	Orange/White	Orange/White	Black (4)
9	SEI+	N.A.	N.A.	N.A.	N.A.
10	SEI-	N.A.	N.A.	N.A.	N.A.
11	SHIELD	8	Shield	Shield	Shield

**Pin 20 on the IL connector must be jumpered to pin 14.*

Table 6-4. Encoder Pinout List

NOTE: The IL encoder cable has four twisted pairs: (1), (2), (3), and (4).

NOTE: Compumotor does not recommend extending the encoder cables. If you think extending the cables is necessary, contact a Compumotor Applications Engineer first.

I/O Specifications

The different types of I/O identified in the following tables are as follows:

GROUND = Isolated ground for logic signals.

RS-232C = Standard RS-232C I/O. Optically isolated inside the drive. +12 to -12VDC.

SNK = Sinking input. Optically isolated. Requires a ground to activate.

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INTERFACE AND I/O

PIN	NAME	TYPE	INPUT/OUTPUT	CURRENT	VOLTAGE
1	Rx	RS-232C	Input	----------	+12 to -12VDC
2	Tx	RS-232C	Output	----------	+12 to -12VDC
3	COM	GROUND	Ground	----------	----------
4	OPTO 1	SNK	Input*	50mA	5 - 12VDC
5	CW	"	Input	5mA - 15mA	"
6	CCW	"	"	"	"
7	HOME	"	"	"	"
8	OPTO 2	"	Input*	400mA	"
9	TRIG 1	"	Input	5mA - 15mA	"
10	TRIG 2	"	"	"	"
11	TRIG 3	"	"	"	"
12	SEQ 1	"	"	"	"
13	SEQ 2	"	"	"	"
14	SEQ 3	"	"	"	"
15	OUT 1	Source (Open emitter)	Output	12mA	"
16	OUT 2	Source (Open emitter)	Output	12mA	"

* User must supply +5V to OPTO 1 & 2

Table 6-5. Interface and I/O Specifications

ENCODER INPUT

PIN	NAME	TYPE	INPUT/OUTPUT	CURRENT	VOLTAGE
1	+5V	POWER	Output	250mA	5V
2	COMMON	GROUND	Ground	----------	----------
3	CH A+	SNK	Input	10mA	5V
4	CH A-	"	"	"	"
5	CH B+	"	"	"	"
6	CH B-	"	"	"	"
7	CH Z+	"	"	"	"
8	CH Z-	"	"	"	"
9	SEI+	----------	----------	----------	----------
10	SEI-	----------	----------	----------	----------
11	SHIELD	GROUND (earth)	Ground	----------	----------

Table 6-6. Encoder I/O Specifications

I/O Descriptions

OPTO 1 & 2 Opto 1: 5 to 12 VDC @ 50mA
Opto 2: 5 to 12 VDC @ 400mA

TRIG 1, 2 & 3 Optically isolated inputs. Normally *high* or OFF. Requires closed contact to Opto Gnd to bring *low* or turn ON. Trigger configuration must remain stable for 1 msec to be recognized by the AX.

SEQ 1, 2 & 3 Optically isolated inputs. Normally high or, OFF. Requires closed contact to Opto Gnd to bring low or turn ON. Sequence number must remain stable for 50 msec to be recognized (default). To set a custom debounce time, refer to the **SN** command description in Chapter 5, Software Reference.

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OUT 1 & 2 Optically isolated open emitter outputs. Normally high or, OFF (not conducting current). Active low or, ON (conducting current) provides 5 - 12 VDC @ 15mA.

ENCODER INPUTS Optically isolated TTL (0 - 5 VDC) inputs receiving differential A, B, and Z channel outputs from incremental encoder. Z channel is active high.

LIMITS CW, CCW, and Home Limits: Optically isolated inputs. Normally high or ON. Require normally closed contact to Opto Gnd to disable. Limits may also be disabled over RS-232 interface.

Sequence Selection Table

Sequence	SEQ 1	SEQ 2	SEQ 3
1	ON	ON	ON
2	OFF	ON	ON
3	ON	OFF	ON
4	OFF	OFF	ON
5	ON	ON	OFF
6	OFF	ON	OFF
7	ON	OFF	OFF
8*	OFF	OFF	OFF
* Non-valid sequence	OFF = open switch (not pulled to ground) ON = closed switch (pulled to ground)		

Table 6-7. Sequence Selection Table

I/O Wiring Diagrams

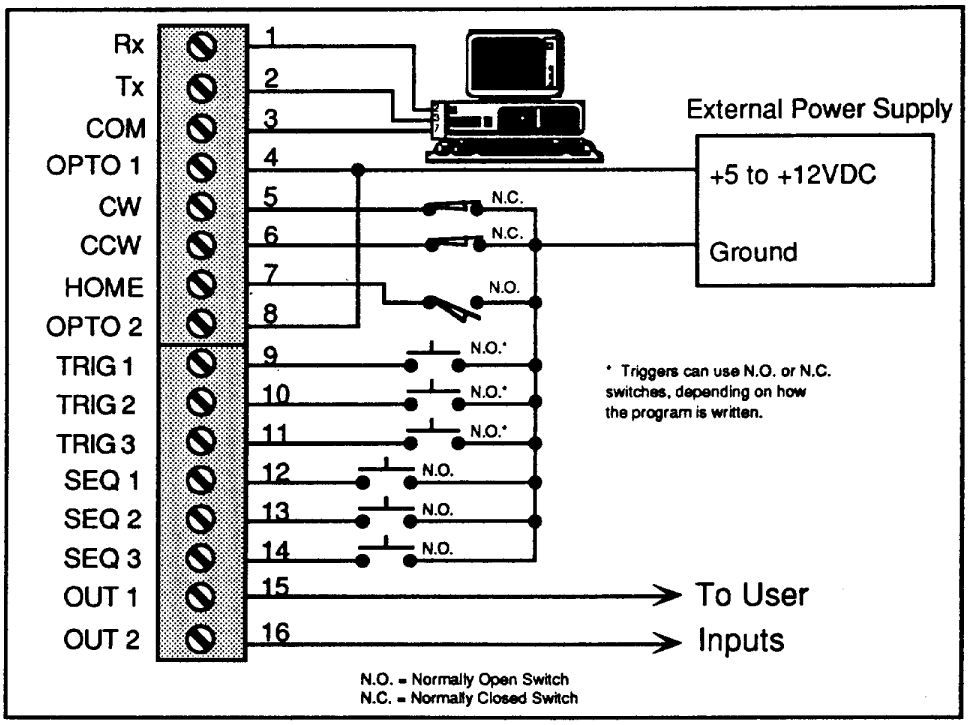


Figure 6-2. Optical Isolation Circuit

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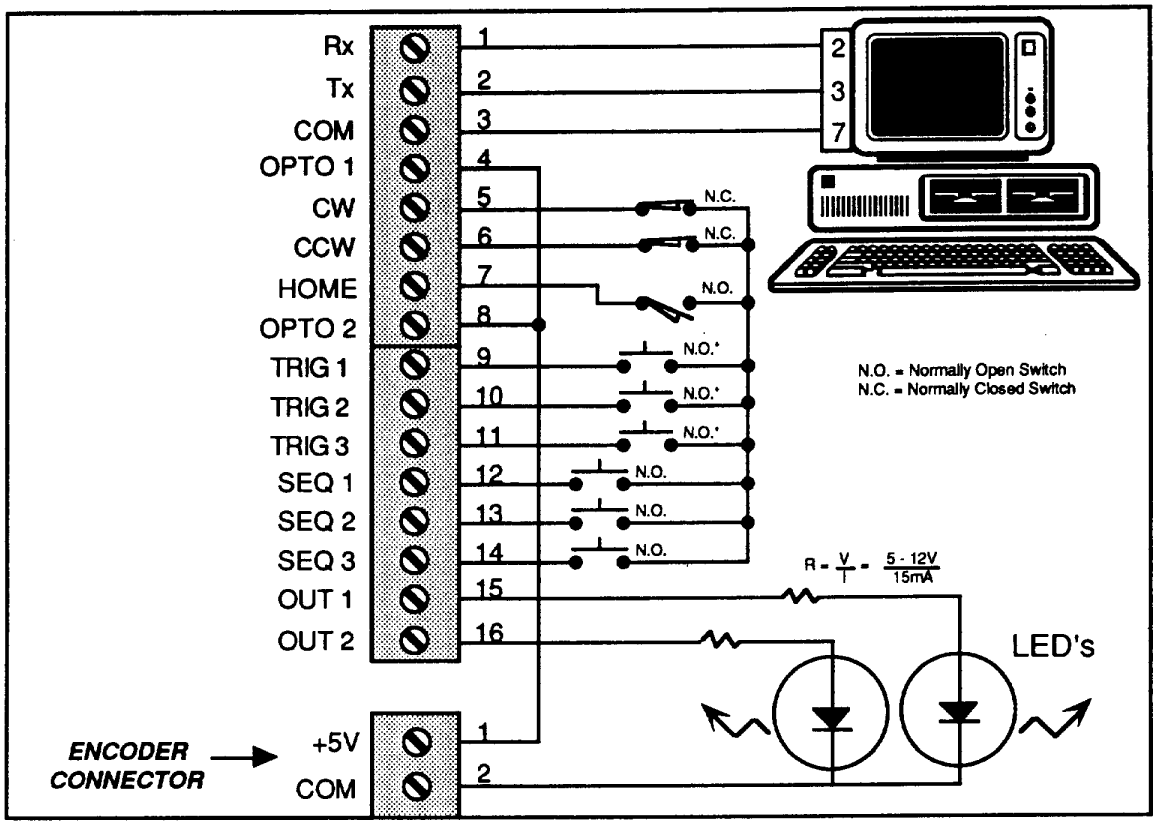


Figure 6-3. I/O Wiring Diagram (Testing Only)

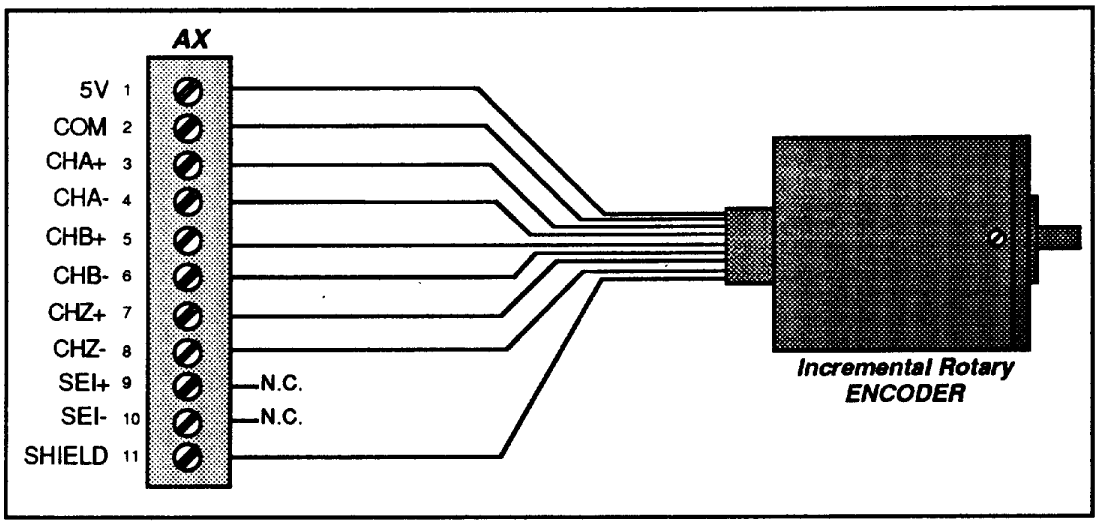


Figure 6-4. Encoder I/O Wiring Diagram

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I/O Circuits

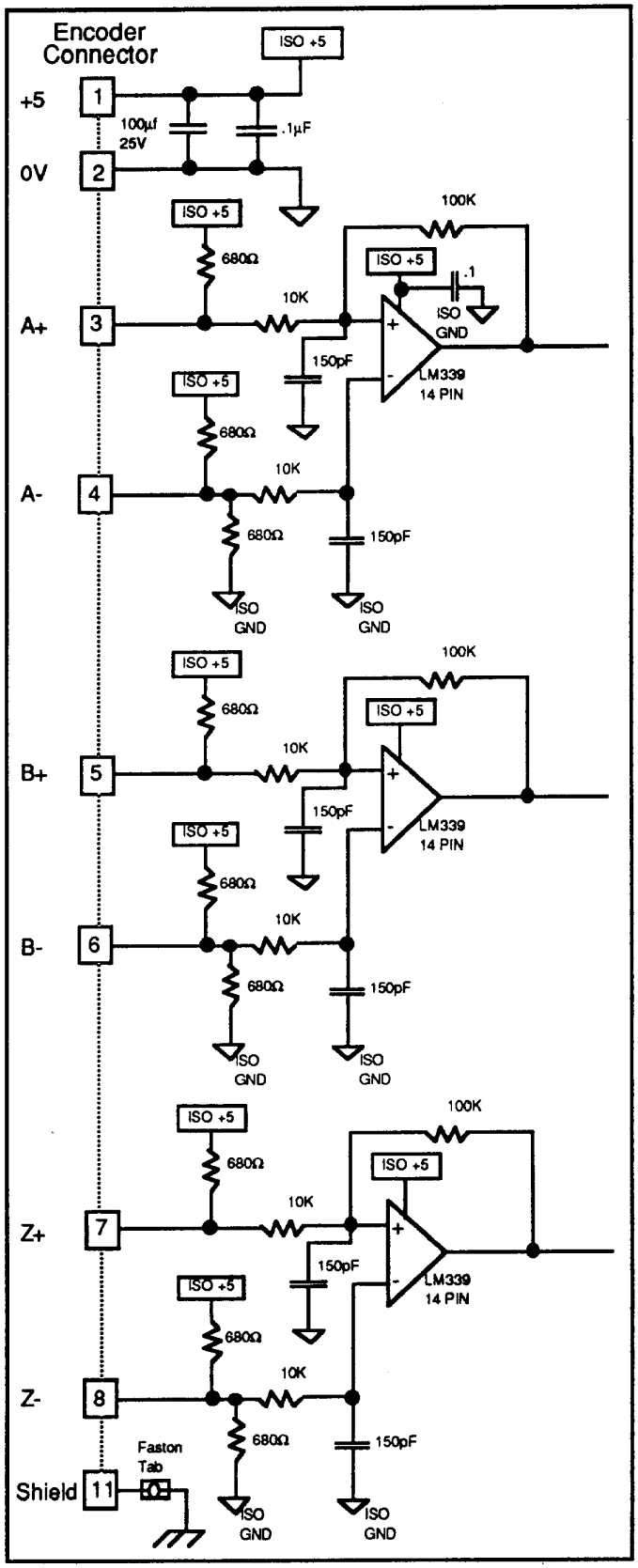


Figure 6-5. AX Encoder Connector I/O Circuit Diagram

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Non-Compumotor Motor Connections

CAUTION

Consult a Compumotor Applications Engineer if you intend to use a motor not supplied by Compumotor. Low inductance motors will damage the drive. The AX requires motors with a minimum inductance of 20mH/phase (measured end-to-end).

You can determine the motor's wiring configuration by referencing the manufacturer's motor specification document supplied with the motor. You can also determine the wiring configuration with an ohm meter using the following procedures. Once you are sure you have determined the correct motor wiring configuration, follow the terminal connection procedures below for connection to the AX motor connector.

Determining 4-Lead Wiring Configuration

STEP 1 Label one motor lead **A+**.

STEP 2 Connect one lead of an ohm meter to the **A+** lead and touch the other lead of the ohm meter to the three remaining motor leads until you find the lead the makes continuity. Label this lead **A-**.

STEP 3 Label the two remaining leads **B+** and **B-**. *NOTE: Verify that there is continuity between the B+ and B- leads.*

STEP 4 Proceed to the Terminal Connections section below.

Determining 6-Lead Wiring Configuration

STEP 1 Determine, with an ohm meter, which three of the six motor leads are common (one phase).

STEP 2 Label each one of these three motor leads **A**.

STEP 3 Using the ohm meter, verify that the remaining three leads are common.

STEP 4 Label the other three leads **B**.

STEP 5 Set the ohm meter range to approximately the 100 ohm scale.

STEP 6 Connect the negative lead of the ohm meter to one of the motor leads labeled **A**. Alternately measure the resistance to the two remaining motor leads also labeled **A**. The resistance measurements will reflect one of the following scenarios:

Scenario #1: The resistance measurements to the two remaining motor leads are virtually identical. Label the two remaining motor leads **A+** and **A-**. Label the motor lead connected to the negative lead of the ohm meter **A-CT**. Proceed to step 7.

Scenario #2: The resistance measurement to the second of the three motor leads measures 50% of the resistance measurement to the third of the three motor leads. Label the second motor lead **A-CT**. Label the third motor lead **A-**. Label the motor lead connected to the ohm meter **A+**. Proceed to step 7.

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STEP 7 Repeat the procedure as outlined in step 6 for the three leads labeled **B**.

STEP 8 Cover the two motor leads labeled **A-CT** and **B-CT** with electrical tape or shrink tubing to prevent these leads from shorting out to anything else. Do not connect these leads to anything else.

STEP 9 Proceed to the Terminal Connections section below.

Determining 8-Lead Wiring Configuration

Because of the complexity involved in phasing an 8-lead motor, the only practical way to determine the motor lead configuration is to reference the manufacturer's motor specification document. The 8-lead motor has the advantage of being configured in parallel or series. Referencing the manufacturer's documentation, label the motor leads as shown in Figure 6-6. Then use the following procedures for parallel or series configurations.

Parallel Configuration

STEP 1 Connect motor leads labeled A1 and A3 together and relabel this common point **A+**.

STEP 2 Connect motor leads labeled A2 and A4 together and relabel this common point **A-**.

STEP 3 Connect motor leads labeled B1 and B3 together and relabel this common point **B+**.

STEP 4 Connect motor leads labeled B2 and B4 together and relabel this common point **B-**.

Series Configuration

STEP 1 Connect the motor leads labeled A2 and A3 together and cover this connection with electrical tape or shrink tubing. Make sure these leads are not connected to the AX Drive.

STEP 2 Relabel the A1 lead to **A+**.

STEP 3 Relabel the A4 lead to **A-**.

STEP 4 Connect the motor leads labeled B2 and B3 together and cover this connection with electrical tape or shrink tubing. Make sure these leads are not connected to the AX Drive.

STEP 5 Relabel the B1 lead to **B+**.

STEP 6 Relabel the B4 lead to **B-**.

STEP 7 Proceed to the Terminal Connections section below.

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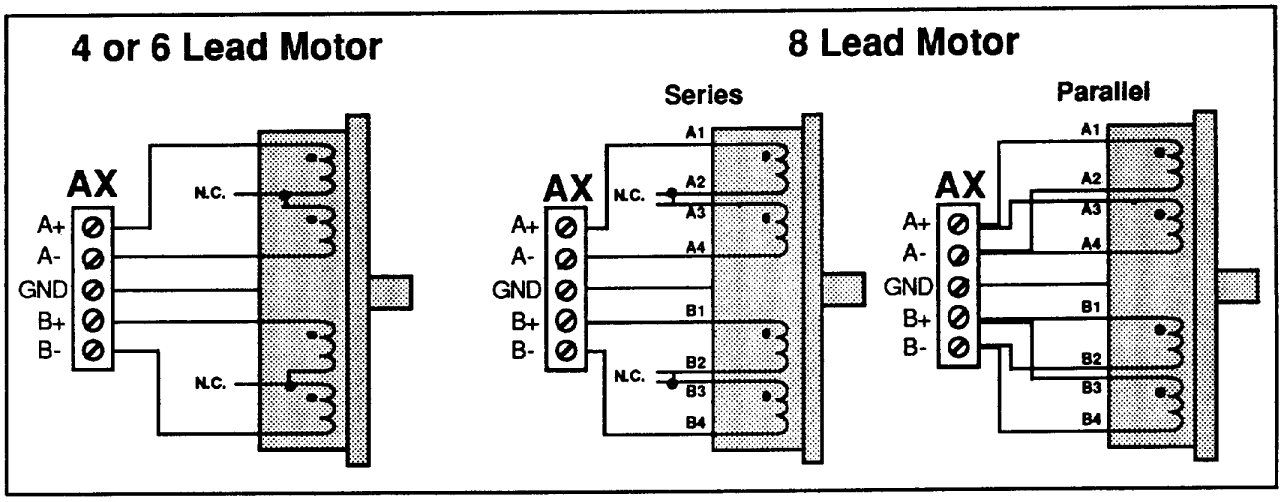


Figure 6-6. Motor Wiring Diagram (Non-Compumotor Motors)

Terminal Connections

After you determine the motor's wiring configuration, connect the motor leads to the five-pin, two-part screw terminal motor connector (see Figure 6-6) according to the following 7-step procedure:

CAUTION

Do not connect or disconnect the motor with the power on. This will damage the contacts of the motor connector and possibly damage the drive.

STEP 1 Make sure that there is a ground wire leading from the motor case. ***If your motor does not include a case ground wire, then you must add one. You may connect this wire to the motor at one of the mounting holes with a ground lug. The ground wire must then be run with the rest of the motor leads to the motor connector.***

STEP 2 Connect phase **A+** motor lead to motor terminal pin 1

STEP 3 Connect phase **A-** motor lead to motor terminal pin 2.

STEP 4 Connect phase **B+** motor lead to motor terminal pin 4.

STEP 5 Connect phase **B-** motor lead to motor terminal pin 5.

STEP 6 Connect the motor case ground wire to motor terminal pin 3. *This is a very important safety precaution.*

STEP 7 Carefully inspect the wires after they have been connected to the motor connector to verify that there are no *whiskers* that can short out the motor connections.

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Factory Default DIP Switch Settings

Switch	Function	Optional Settings
1	Current	See Table 3-2
2	"	"
3	"	"
4	"	"
5	"	"
6	Device Address	See Table 3-3
7	"	"
8	"	"

Table 6-8. Dip Switch Functions

Current Settings

If you are using a motor supplied by Compumotor, refer to Table 6-9 for appropriate DIP switch settings. If you are not using a Compumotor-supplied motor, refer to Table 6-10 for the full range of motor current settings. AX Drives shipped without accompanying motors have DIP switches 1 - 5 set to the OFF position.

NOTE: AX Drive systems ordered with Compumotor Motors are shipped with the current DIP switches set to the accompanying motor.

		AXL					AXH				
		DIP Switch Settings					DIP Switch Settings				
Motor size	Current	1	2	3	4	5	1	2	3	4	5
AX57-51	0.375A	OFF	OFF	OFF	ON	ON	Not Recommended				
AX57-83	0.469A	OFF	OFF	ON	OFF	OFF	Not Recommended				
AX57-102	0.750A	OFF	OFF	ON	ON	ON	Not Recommended				
AX83-62	0.844A	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
AX83-93	1.406A	OFF	ON	ON	ON	OFF	OFF	OFF	ON	ON	OFF
AX83-135	1.969A	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	ON
AX106-120	1.875A	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	ON
AX106-178	4.125A	-----	-----	-----	-----	-----	ON	OFF	ON	OFF	ON
AX106-178	6.000A*	-----	-----	-----	-----	-----	ON	ON	ON	ON	ON
AX106-205	6.000A*	-----	-----	-----	-----	-----	ON	ON	ON	ON	ON

* Parallel connect motors

Table 6-9. Current Settings for Compumotor-Supplied Motors

NOTE: The current values in Table 6-9 are approximate settings in the AX Drive. The actual settings will not match these recommended settings exactly. The current settings for 106-205 motors is 6 amps in series and in parallel.

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SW1	SW2	SW3	SW4	SW5	Current in amps AXL	Current in amps AXH
OFF	OFF	OFF	OFF	OFF	0.094	0.188
OFF	OFF	OFF	OFF	ON	0.188	0.375
OFF	OFF	OFF	ON	OFF	0.281	0.563
OFF	OFF	OFF	ON	ON	0.375	0.750
OFF	OFF	ON	OFF	OFF	0.469	0.938
OFF	OFF	ON	OFF	ON	0.563	1.125
OFF	OFF	ON	ON	OFF	0.656	1.313
OFF	OFF	ON	ON	ON	0.750	1.500
OFF	ON	OFF	OFF	OFF	0.844	1.688
OFF	ON	OFF	OFF	ON	0.938	1.875
OFF	ON	OFF	ON	OFF	1.031	2.063
OFF	ON	OFF	ON	ON	1.125	2.250
OFF	ON	ON	OFF	OFF	1.219	2.438
OFF	ON	ON	OFF	ON	1.313	2.625
OFF	ON	ON	ON	OFF	1.406	2.813
OFF	ON	ON	ON	ON	1.500	3.000
ON	OFF	OFF	OFF	OFF	1.594	3.188
ON	OFF	OFF	OFF	ON	1.688	3.375
ON	OFF	OFF	ON	OFF	1.781	3.563
ON	OFF	OFF	ON	ON	1.875	3.750
ON	OFF	ON	OFF	OFF	1.969	3.938
ON	OFF	ON	OFF	ON	2.063	4.125
ON	OFF	ON	ON	OFF	2.156	4.313
ON	OFF	ON	ON	ON	2.250	4.500
ON	ON	OFF	OFF	OFF	2.344	4.688
ON	ON	OFF	OFF	ON	2.438	4.875
ON	ON	OFF	ON	OFF	2.531	5.063
ON	ON	OFF	ON	ON	2.625	5.250
ON	ON	ON	OFF	OFF	2.719	5.438
ON	ON	ON	OFF	ON	2.813	5.625
ON	ON	ON	ON	OFF	2.906	5.813
ON	ON	ON	ON	ON	3.000	6.000

Table 6-10. Motor Current Settings (Full Range)

Address Settings

Address	SW6	SW7	SW8
1*	ON*	ON*	ON*
2	OFF	ON	ON
3	ON	OFF	ON
4	OFF	OFF	ON
5	ON	ON	OFF
6	OFF	ON	OFF
7	ON	OFF	OFF
8	OFF	OFF	OFF
* *Factory Default Setting*			

Table 6-11. Device Address Settings

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Dimensional Drawings

AX Drive and Fan Dimensions

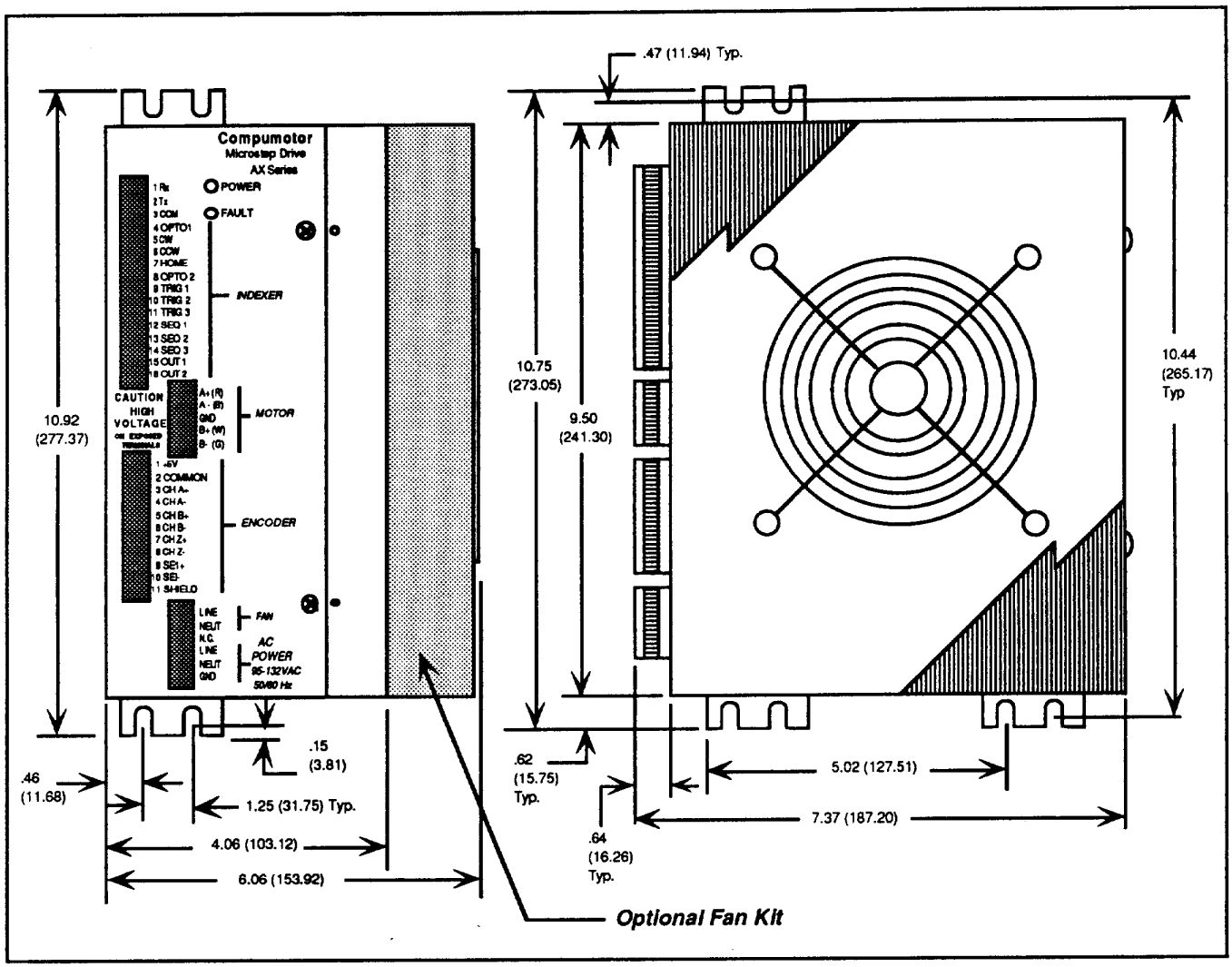
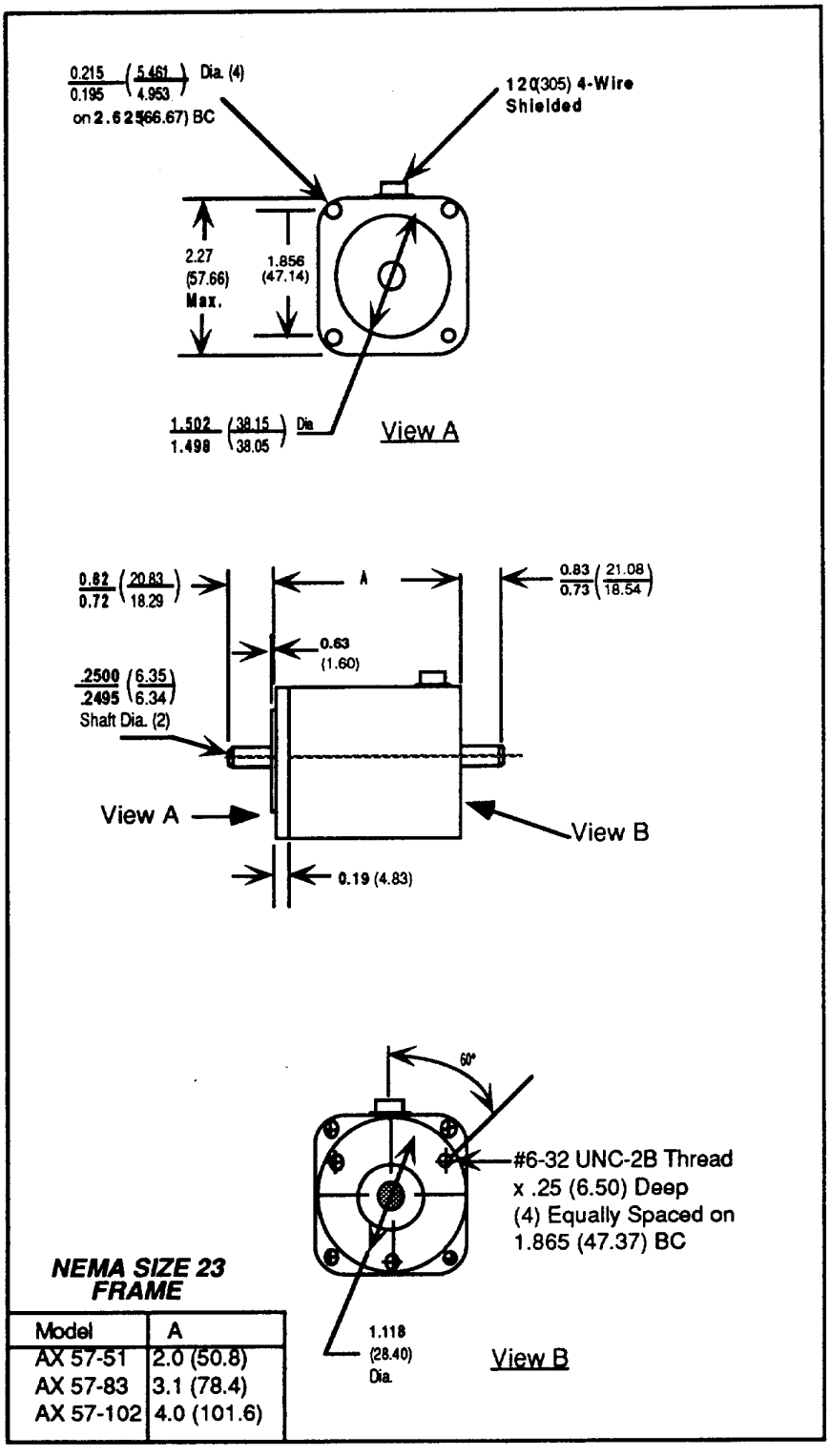


Figure 6-7. AX Dimensional Drawing

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Motor Dimensions



NEMA SIZE 23 FRAME

Model	A
AX 57-51	2.0 (50.8)
AX 57-83	3.1 (78.4)
AX 57-102	4.0 (101.6)

Figure 6-8. NEMA Size 23 Motor Dimensions

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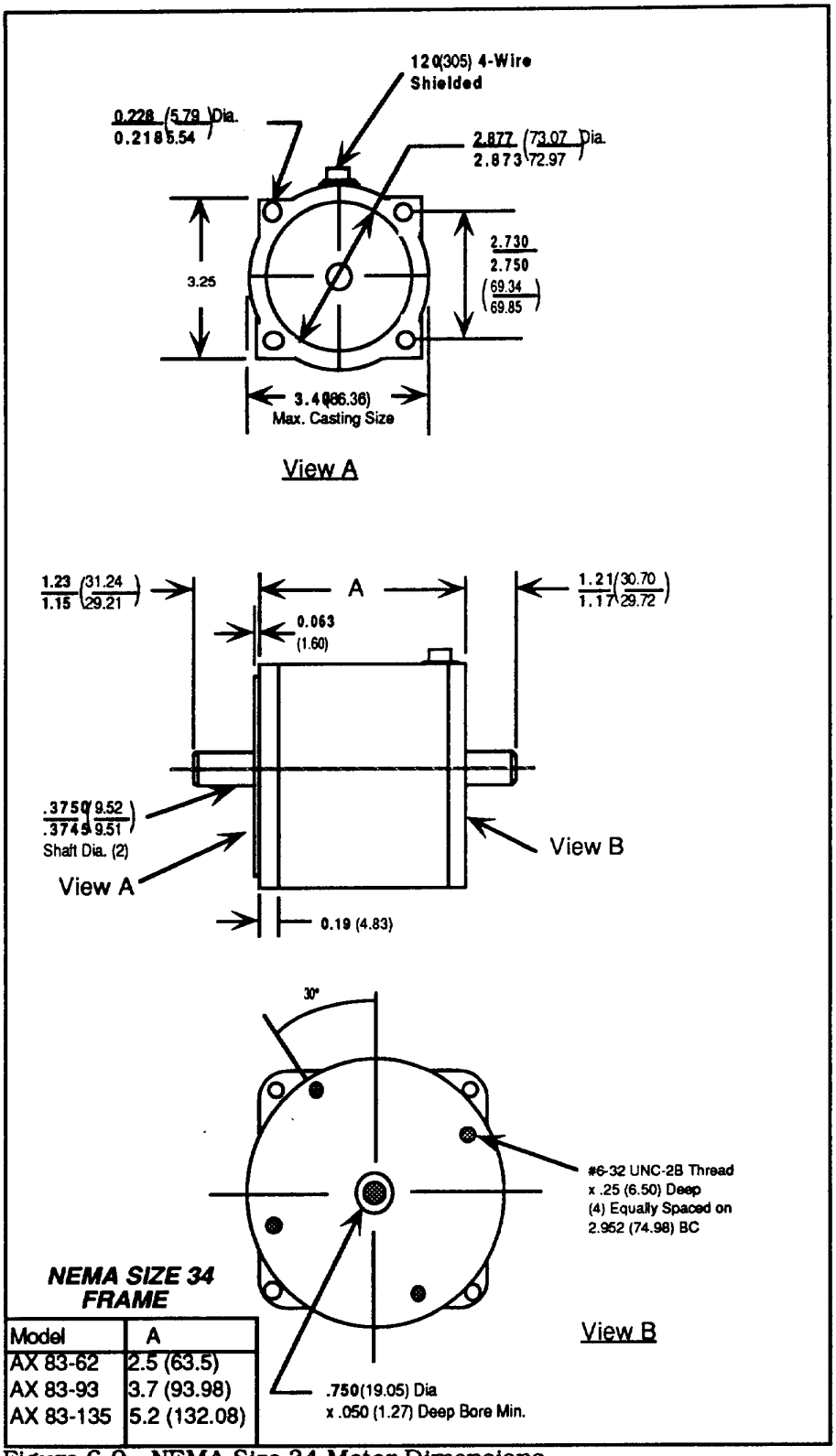


Figure 6-9. NEMA Size 34 Motor Dimensions

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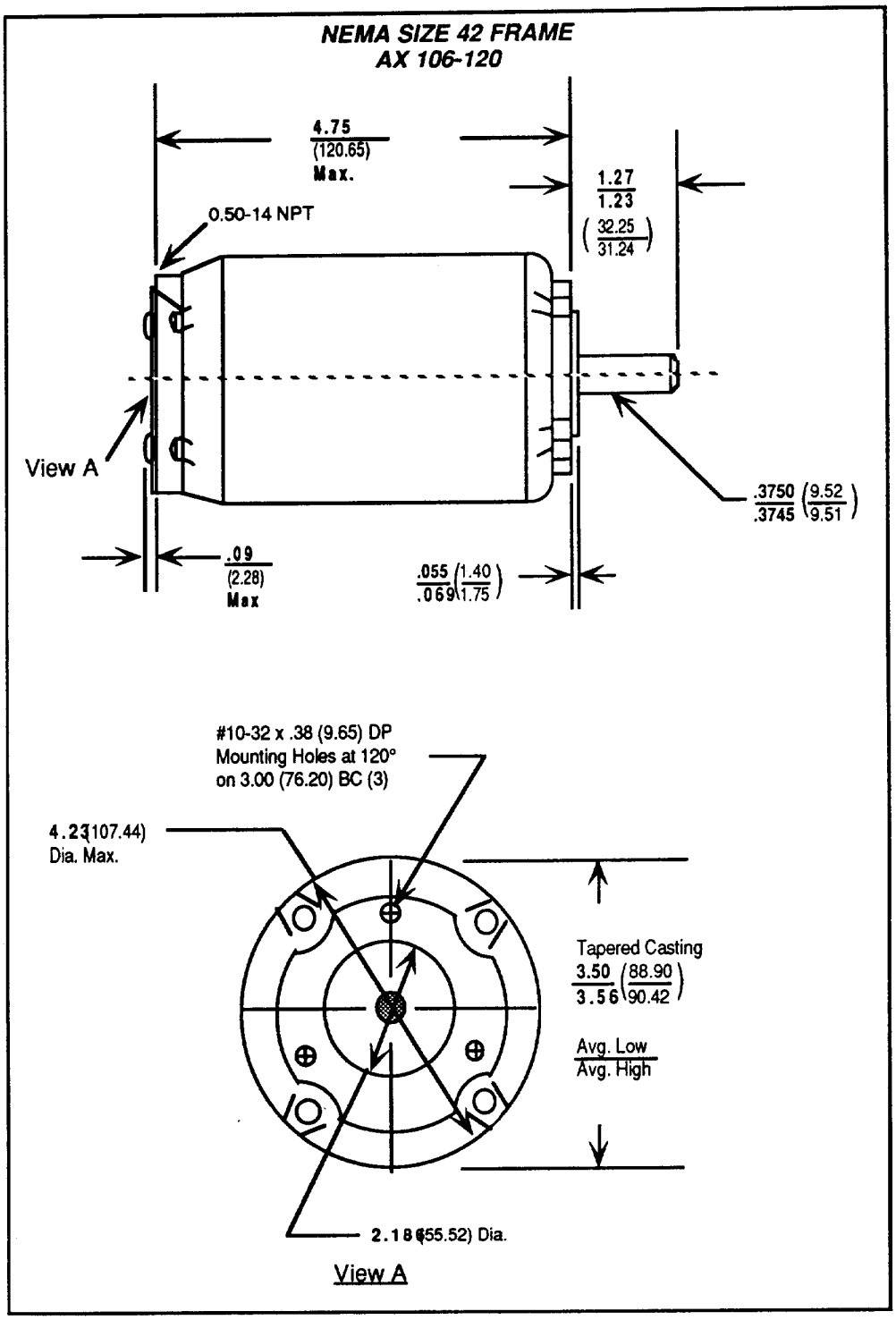


Figure 6-10. NEMA Size 42 (AX 106-120) Motor Dimensions

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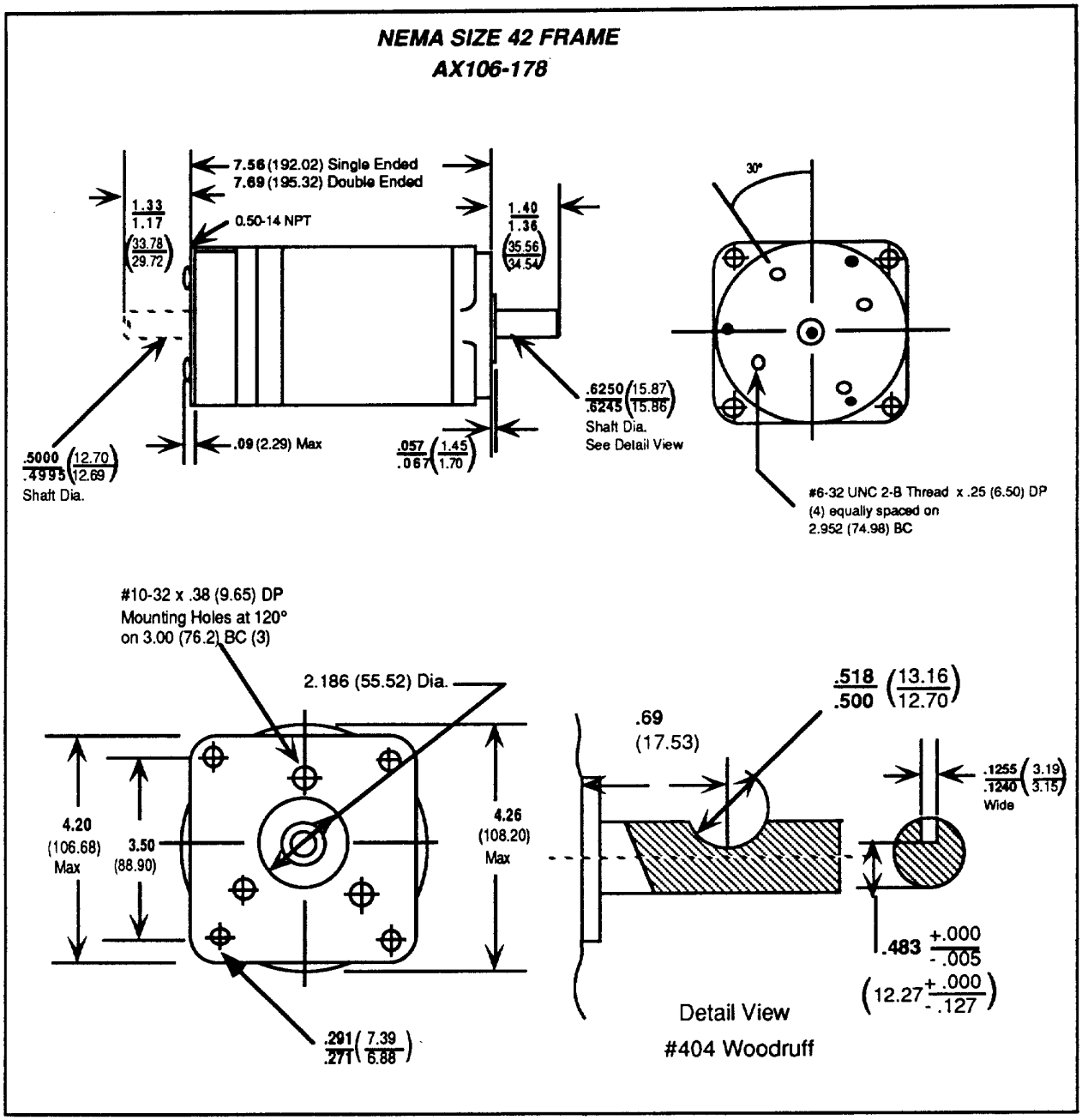


Figure 6-11. NEMA Size 42 (AX 106-178) Motor Dimensions

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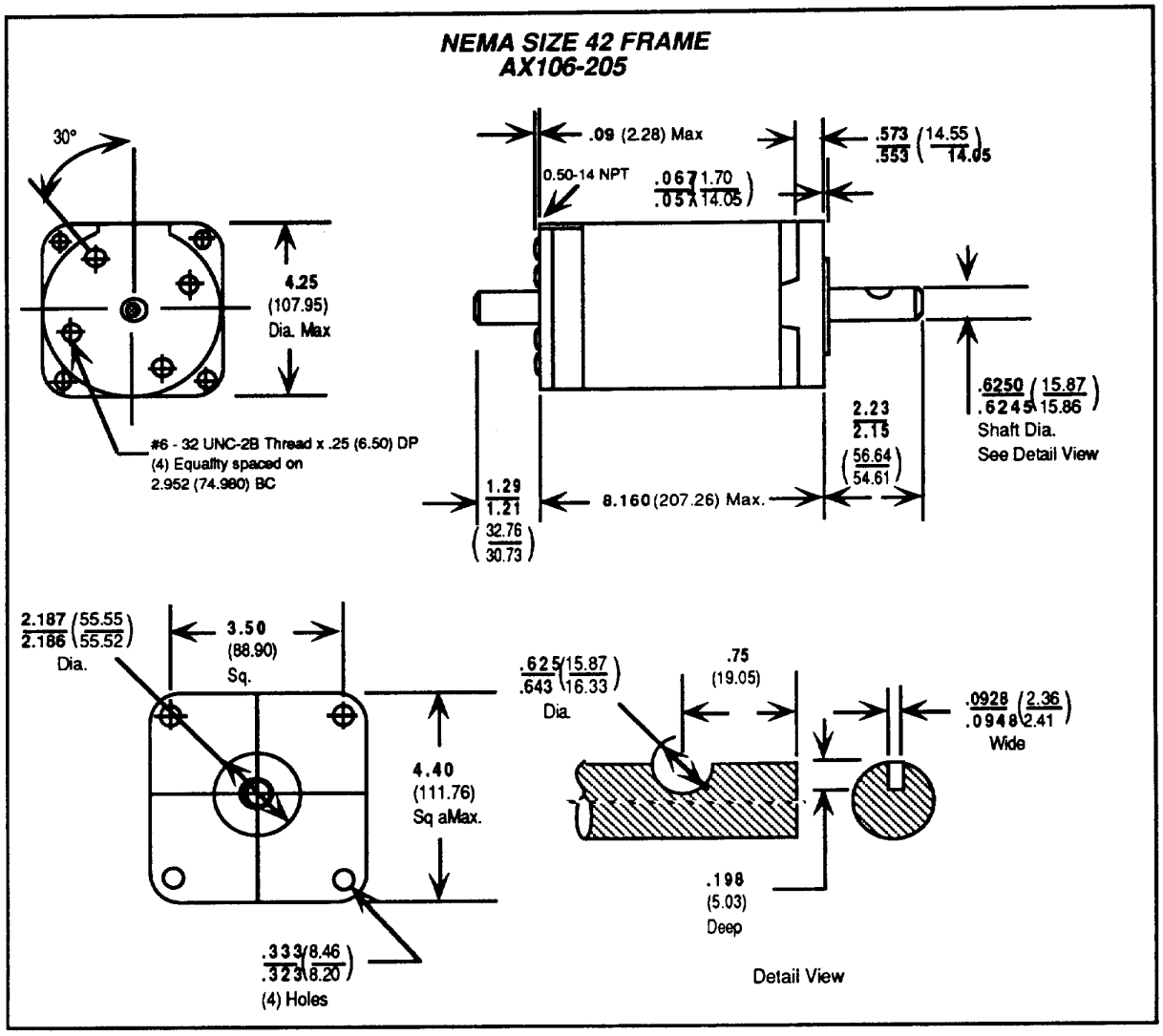
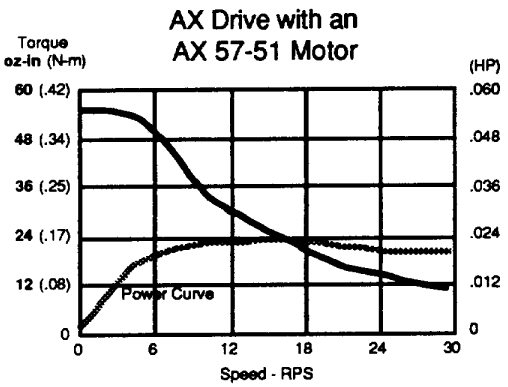
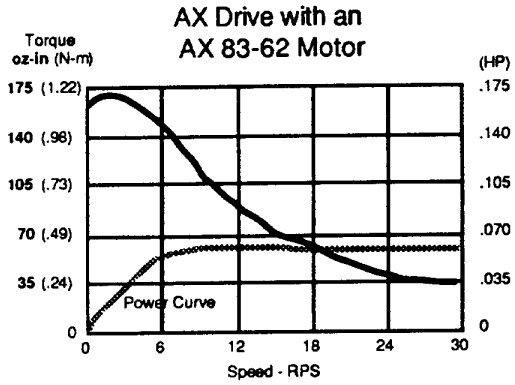


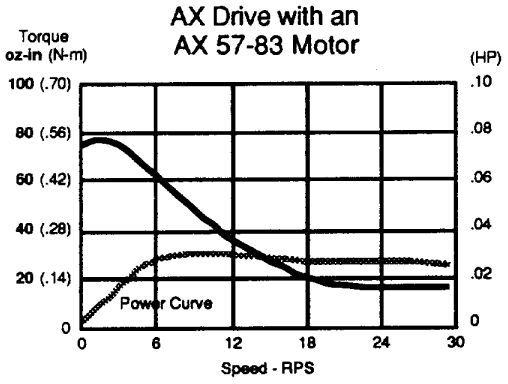
Figure 6-12. NEMA Size 42 (AX 106-205) Motor Dimensions

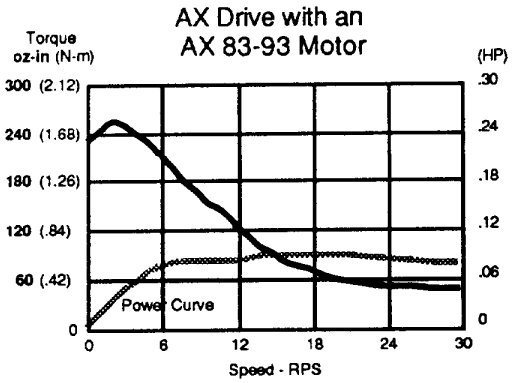
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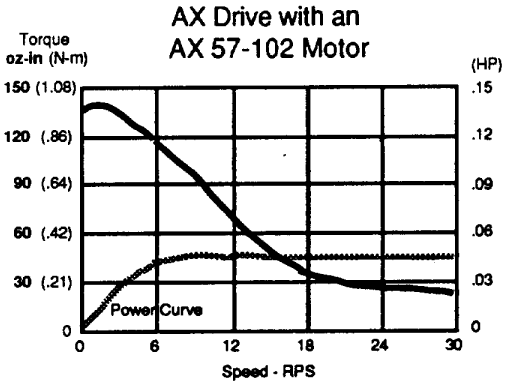
Torque/Speed Curves

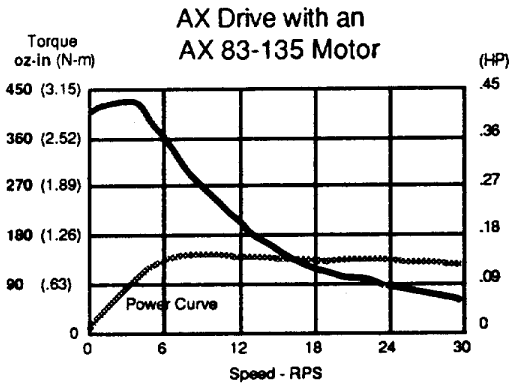








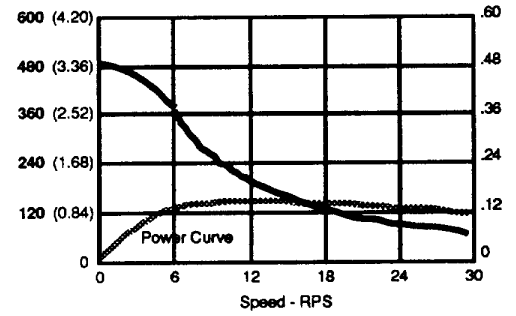




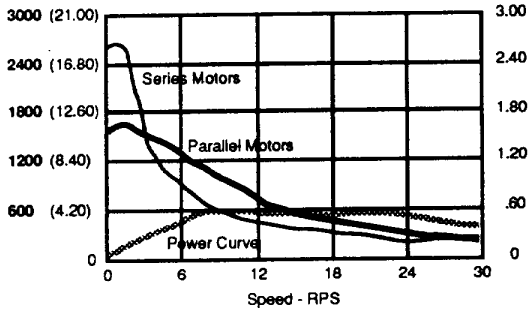
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Torque/Speed Curves (Cont.)

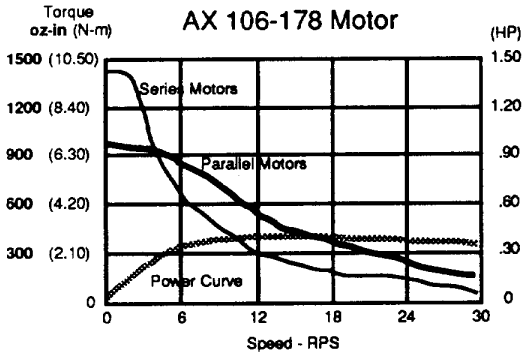
AX Drive with an AX 106-120 Motor



AX Drive with an AX 106-205 Motor



AX Drive with an AX 106-178 Motor



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Special Motor Wiring

Wiring The 106-205 Motor

The 106-205 motor comes from the factory wired in Parallel. By removing the back panel, you may rewire the motor in Series.

Connecting an AX106-205 in Series:	Jumper 6 & 5 Jumper 2 & 4
Connecting an AX106-205 in Parallel:	Jumper 1 & 5 Jumper 6 & 3 Jumper 8 & 4 Jumper 2 & 7

Table 6-12. AX 106-205 Motor: Series and Parallel Connections

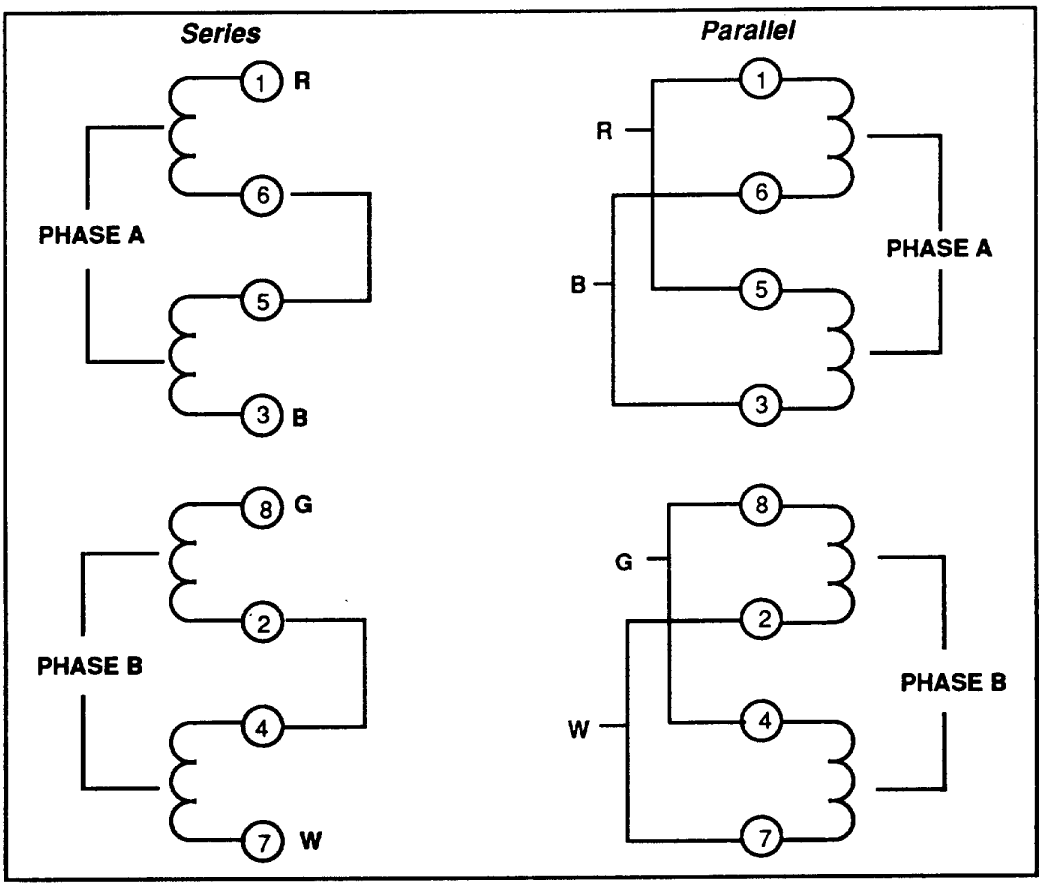


Figure 6-13. Wiring Diagram, 106-205 Motor

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Wiring The 106-178 Motor

The 106-178 Motor comes from the factory wired in Series. By removing the back panel, you may rewire the motor in Parallel.

Connecting an AX106-178 in Series:	Jumper 2 & 6 Jumper 7 & 8
Connecting an AX106-178 in Parallel:	Jumper 1 & 2 Jumper 3 & 6 Jumper 5 & 8 Jumper 4 & 7

Table 6-13. AX 106-178 Motor: Series and Parallel Connections

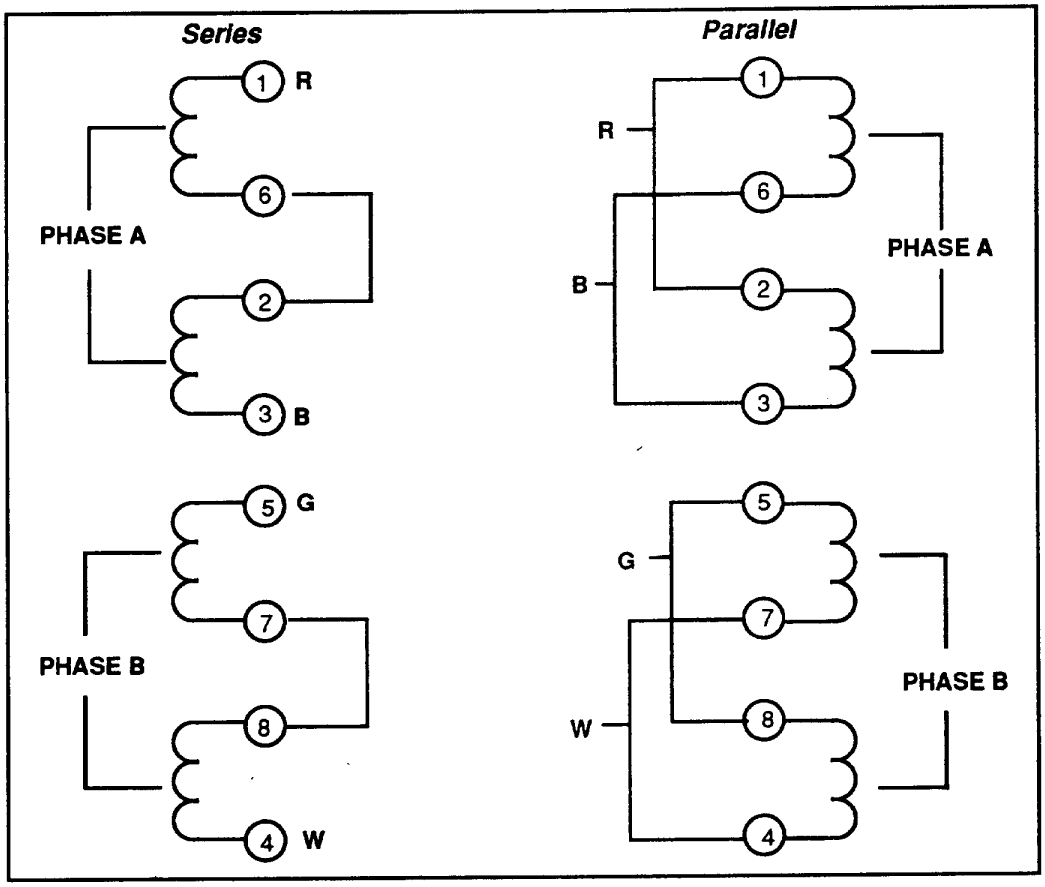


Figure 6-14. Wiring Diagram, 106-178 Motor

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Chapter 7. MAINTENANCE & TROUBLESHOOTING

Chapter Objectives

The information in this chapter will enable you to:

- Maintain the system's components to ensure smooth, efficient operation
- Isolate and resolve system hardware and software problems
- Use this chapter as a quick reference tool for a description of system error codes

Maintenance

The following system components require periodic maintenance:

- The Motor
- The Drive

Spare Parts Table

Table 7-1 provides a list of recommended spare parts to use with the AX system.

Part Description	Part Number
Choice of two drives: AXH AXL	 AXH-DRIVE AXL-DRIVE
Mechanical Screws (6-32 x 1/4)	51-006037-01
Universal Mounting Bracket	53-006007-01
5-Position Terminal Connector, Phoenix	43-005561-01
6-Position Terminal Connector, Phoenix	43-006606-01
8-Position Terminal Connector, Phoenix	43-006786-01
11-Position Terminal Connector, Phoenix	43-007085-01
Fan Kit (standard on AXH Drives)	AFK

Table 7-1. Recommended Spare Parts for the AX System

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Motor Maintenance

You should inspect all mechanical parts of the motor regularly to ensure that no bolts or couplings have become loose during normal operation. This will prevent minor problems from developing into more serious problems.

The ball bearings used in the Compumotor-supplied motors are not sealed against severe environments, but are permanently lubricated and do not require any maintenance.

You should inspect the motor cables periodically for signs of wear. This inspection interval is duty-cycle, environment, and travel-length dependent. You should not apply excessive tensile force to the cable. Do not bend the cable beyond a one-inch radius of curvature during normal operation. Tighten all cable connectors.

Drive Maintenance

Check that the drive heatsink is free of particles and has a free flow of air over its entire surface. Enclosures must be connected to earth ground through a grounding electrode conductor to provide a low-impedance path for ground-fault or noise-induced currents. All earth ground connections must be continuous and permanent.

Troubleshooting

This section discusses methods to identify, isolate, and resolve problems that may occur with your AX Drive.

Problem Isolation

When your system does not function properly (or as you expect it to operate), the first thing that you must do is identify and isolate the problem. When you accomplish this, you can effectively begin to eradicate and resolve the problem.

Try to determine if the problem is mechanical, electrical, or software-related. *Can you repeat or re-create the problem?* Do not attempt to make quick rationalizations about problems. Random events may appear to be related, but they are not necessarily contributing factors to your problem. You must carefully investigate and decipher the events that occur before the subsequent system problem.

You may be experiencing more than one problem. You must solve one problem at a time. Log (document) all testing and problem isolation procedures. You may need to review and consult these notes later. This will also prevent you from duplicating your testing efforts.

Isolate each system component and ensure that each component functions properly when it is run independently. You may have to remove your system components and re-install them component-by-component to detect the problem. If you have additional components available, you may want to use them to replace existing components in your system to help identify the source of the problem.

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Once you have isolated the problem, take the necessary steps to resolve it. Refer to the problem solutions contained in this chapter. If your system's problem persist, contact Parker Compumotor's Applications Department at (800) 358-9070.

Motor Fails to Move

Test the motor to see if it has holding torque. If there is no holding torque, here are some probable causes:

- There is no AC power.
- Current selection DIP switches are not set properly (see the motor current selection table in Chapter 6, Hardware Reference).
- There are bad connections or bad cables. Disconnect the power connector, then use an ohm meter to monitor continuity between the motor-to-drive cable.
- The drive may be disabled through software (**ST1** command).

If the unit has holding torque and the motor shaft still fails to move, here are some probable causes:

- The limit switches have been tripped or are faulty. Make sure that your limit switches are OFF or that the limits are disabled (**LD3** command).
- The load is jammed. You should *hear* the drive attempting to move the motor. Remove AC power from the drive and verify that you can move the load manually away from the point of the jam.
- Indexer parameters are incorrectly set up. If certain parameters are out of range or are missing, the motor will not move when you issue the Go (**G**) command.

Use **R, RA, RB,** and **RS** status commands to determine what is preventing the move. Also check **A, V,** and **D** commands to make sure that all the parameters are set properly. The following are additional troubleshooting techniques:

- Check the motor for damage. Also check the motor cable to see if it is damaged or shortened. These conditions may cause the drive to fault.
- Ohm the motor and cables to make sure that short-circuits do not exist between phases or to earth GND. On your most sensitive scale, the resistance across each motor phase should be consistently low (but not zero) and similar to each other. On your highest scale, the resistance between motor phases and between each phase and earth ground should be infinite.

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Fault LED

There is a red *FAULT* LED located on the connector-side of the AX drive. The LED may be activated (illuminated) if one of the following conditions exists:

- *Shutdown*: You commanded the drive to shutdown. Use the **STØ** command to turn the drive on again.
- *Over-temperature*: The drive may be overheating (heatsink temperature is above 149°F (65°C). You may consider cooling the drive and/or enclosure. Installing a fan kit on the drive would help the problem.
- *Short-circuit*: A short-circuit exists in the motor current output. Use an ohm meter to make sure that there is not a short-circuit between phase A, phase B, or to earth ground. ***NOTE: Make sure power has been removed before you test the motor.***
- *Brown-out*: Check the AC input voltage to make sure that the drive is receiving more than 95VAC.

Motor Stalls

A motor stall during acceleration may be caused by one or more of the following factors:

- The torque requirements may be excessive
- The acceleration ramp may be too steep
- The load inertia and motor inertia may be grossly mismatched.

Lower acceleration may be required.

If the motor stalls during the constant velocity portion of a move, the shaft and/or coupler may be damaged or binding due to improper coupling or excessive motor load.

A stall may occur if the DIP switch setting for the motor current selection is incorrect. The motor may not be receiving enough current to operate.

A stall may also be detected in closed loop mode if the encoder resolution (**ER**) is not set properly, or if the encoder input channels (A and B) are reversed.

Motor Fails to Run at High Speeds

The motor may fail to run at high speeds due to the following factors:

- It is possible that the motor may not produce enough torque to move a given load at these velocities. Check the torque/speed curve in Chapter 6 and make sure you are trying to run the motor in the proper range.
- The indexer can produce pulses faster than the drive can make the motor move.
- The motor may not have the proper load-to-rotor inertia. The maximum ratio is 10:1.

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Motor is Jerky or Weak

Check that there are no mechanical problems at the load causing highly variable loading condition. Disconnect the motor from the load and run it without a load connected. *Keep in mind that the motor will run best with a load of equal inertia; with no load, it will not attain full speed.* Try to manually turn the motor shaft; this will determine if the motor is maintaining full holding torque. Check the DIP switches for proper current settings.

Motor Overheats

If the motor exceeds its maximum motor case temperature rating, failure will eventually result. Check your DIP Switch settings to ensure that the current setting is correct for the motor you are using (refer to Chapter 6, Hardware Reference).

The Standby Current feature (set with the **SC** or the **SCA** command) allows you to reduce the motor current from 13% to 100% when the motor is not moving. If the motor is hot after a long period at standstill, check the standby current with a current probe.

Motor Shaft Wears

The motor shaft may wear prematurely if there is foreign material rubbing against the shaft, or if the load is not coupled properly.

I/O Switch failure

If you are having problems using the Trigger (**TR**), Home (**GH**) commands, and the Trigger, Home, CW, CCW and Sequence Select inputs, you must first check your wiring for proper installation. Use an Ohm meter to verify proper connection of the switches and inputs. If the hardware connection seems correct, you can manually change the input switches and use the **IS** command to verify if the AX recognizes the input change. The **IS** command provides a hardware status of the AX inputs. If the status does not change, check the hardware settings and wiring.

Remote Sequencing (BCD Inputs) failure

If you are having problems trying to run sequences from BCD interfaces, the first thing you must verify is the hardware interface. Use the Ohm meter to verify proper wiring. Then use the **IS** command to read the status of the inputs. Change the input setting and check the Input Status (**IS**) again to make sure that the AX recognized the change in the sequence select input. Make sure that your BCD input is calling the proper sequences. Check Chapter 6, Hardware Reference, for the Sequence Select Table. If you have a problem running a sequence from the remote input, try running the sequence using the **XR** command before attempting to run it using BCD input. Make sure you cycle power or issue a **Z** command after you enter an **XP8** or **XP9** command.

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Reducing Electrical Noise

This section discusses the sources and methods of suppressing electrical noise.

Electrical Noise

When an AX Drive system is operated in an environment in which there is an excessive amount of electrical noise, special care must be taken to eliminate sources of possible noise interference. Potential sources of electrical noise include inductive devices such as solenoids, relays, motors, and motor starters when they are operated by a hard contact. Compumotor recommends that you mount the AX Drive in a NEMA enclosure to protect the drive from electrical noise. For further information on avoiding electrical noise, refer to the technical data section of the *Compumotor Motion Control Catalog*.

Noise suppression devices may be necessary when sources of electrical noise are connected to the same AC power source or are in close proximity to electronic equipment. You may also need to install noise suppression devices if you have multiple drives attached to the same AC power source. Figure 7-1 shows some recommended suppression devices for most small loads. For best results, install these devices as close as possible to the inductive load.

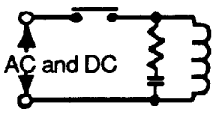
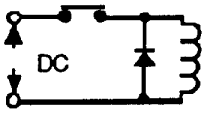
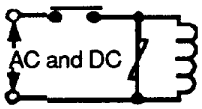
RC	DIODE	VARISTOR (MOV)
		
1. Can be saved for both AC and DC circuits 2. Use 500-1000 ohm for R and 0.1 - 0.2 microF @ 200V	For DC circuit only	Can be used for both AC and DC circuits

Figure 7-1. Noise Suppression Devices

Enclosure Considerations

You should install the AX Drive in an enclosure to protect it against atmospheric contaminants such as oil, moisture, and dirt. 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.

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Sources of Electrical Noise

Noise-related difficulties can range in severity from minor positioning errors to damaged equipment from run-away motors crashing through limit switches. In microprocessor-controlled equipment, the processor constantly retrieves instructions from memory in a controlled sequence. If an electrical disturbance occurs, it may cause the processor to misinterpret instructions or access the wrong data. This can be catastrophic to the program and force you to reset the processor.

Since electrical noise is not visible, it is very difficult to detect. Some possible sources are as follows:

- Power line noise
- Externally conducted noise
- Transmitted noise
- Ground loops

The following electrical devices are particularly apt to generate unwanted electrical noise conditions:

- Coil-driven devices (conducted and power line noise)
- SCR-fired heaters (transmitted and power line noise)
- Motors and motor drives (transmitted and power line noise)
- Welders: electric (transmitted and power line noise)

The AX Drive is capable of delivering 6 amps on a 170V rail to the motor. This is pulse width modulated at a 20 kHz rate; consequently, *the AX Drive must be considered a source of electrical noise.*

POWER LINE NOISE

Power line noise is usually easy to resolve due to the wide variety of line filtering equipment that is available to the motion control industry. Only the most severe electrical noise problems will require you to use an isolation transformer. You will have to use line filtering equipment when other devices connected to the local power line are switching large amounts of current (especially if the switching occurs at a high frequency).

Any device that has coils is likely to disrupt the power line when it is switched off. Surge suppressors, such as metal oxide varistors (MOV's) are capable of limiting this type of electrical noise. A series RC network across the coil is also an effective means of eliminating the problem (resistance: 500 to 1,000 Ω; capacitance: 0.1 to 0.2 μF). Coil-driven devices (inductive loads) include relays, solenoids, contactors, clutches, brakes, and motor starters.

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EXTERNALLY CONDUCTED NOISE

Externally-conducted noise is similar to power line noise, but the disturbances are created on signal and ground wires that are connected to the indexer. This kind of noise can get into logic circuit ground or into the processor power supply and scramble the program. The problem in this instance is that control equipment often shares a common DC ground wire that may be connected to several devices (such as a DC power supply, programmable controller, remote switches, etc.). When a source of noise like a relay or solenoid is attached to the DC ground, it may cause disturbances within the indexer.

To solve the noise problem caused by DC mechanical relays and solenoids, you must connect a diode backwards across the coil to clamp the induced voltage kick that the coil will produce. The diode should be rated a four times the coil voltage and ten times the coil current. Using solid state relays is another way to eliminate this problem. See Figure 7-1.

Multiple devices on the same circuit should be grounded together at a single point.

Furthermore, power supplies and programmable controllers often have DC common tied to Earth (AC power ground). As a rule, it is preferable to have the indexer signal ground or DC common floating with respect to Earth. This prevents sources of electrical noise that are grounded to Earth from sending noise into the indexer. When you cannot float the signal ground, you should make the Earth ground connection at only one point.

In many cases, optical isolation may be required to completely eliminate electrical contact between the indexer and a noisy environment. Solid state relays provide this type of isolation.

TRANSMITTED NOISE

Transmitted noise is picked up by external connections to the indexer, and in severe cases can attack an indexer with no external connections. The indexer enclosure will typically shield the electronics from this, but openings in the enclosure for connections and front panel controls may *leak*. As with all electrical equipment, the indexer chassis should be scrupulously connected to Earth to minimize this effect.

When high current contacts open, they draw an arc, producing a burst of broad spectrum radio frequency noise that can be picked up on an indexer limit switch or other wiring. High-current and high-voltage wires have an electrical field around them, and may induce noise on signal wiring, especially when they are tied in the same wiring bundle or conduit.

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When this kind of problem occurs, it is time to think about shielding signal cables or isolating the signals. A proper shield surrounds the signal wires to intercept electrical fields, but this shield must be tied to Earth to drain the induced voltages. At the very least, wires should be run in twisted pairs to limit straight line antenna effects.

Most Compumotor cables have shields tied to Earth, but in some cases the shields must be grounded at installation time. Installing the indexer in a NEMA electrical enclosure ensures protection from this kind of noise, unless noise-producing equipment is also mounted inside the enclosure. Connections external to the enclosure must be shielded.

Even the worst noise problems in environments near 600 amp welders and 25kW transmitters have been solved using enclosures, conduit, optical isolation,and single point ground techniques.

GROUND LOOPS

Ground Loops are the most mysterious noise problems. They seem to occur most often in systems where a control computer is using RS-232C communication. Symptoms like garbled transmissions and intermittent operation are typical.

The problem occurs in systems where multiple Earth ground connections exist, particularly when these connections are far apart.

Suppose an AX is controlling an axis, and the limit switches use an external power supply. The AX is controlled by a computer in another room. If the power supply Common is connected to Earth, the potential exists for ground loop problems. This is because most computers have their RS-232C signal common tied to Earth. The loop starts at the AX limit switch ground, goes to Earth through the power supply to Earth at the computer. From there, the loop returns to the AX through RS-232C signal ground. If a voltage potential exists between power supply Earth and remote computer Earth, ground current will flow through the RS-232C ground creating unpredictable results.

The way to test for and ultimately eliminate a ground loop is to lift or *cheat* Earth ground connections in the system until the symptoms disappear.

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Defeating Noise

The best time to handle electrical noise problems is before they occur. When a motion control system is in the design process, the designer should consider the following set of guidelines for system wiring in order of importance:

1. Put surge suppression components on all electrical coils: Resistor/capacitor filters, MOVs, Zener and clamping diodes.
2. Shield all remote connections, use twisted pairs. Shield should be tied to Earth at one end.
3. Put all microelectrical components in an enclosure. Keep noisy devices outside, watch internal temperature.
4. Ground signal common wiring at one point. Float this ground from Earth if possible.
5. Tie all mechanical grounds to Earth at one point. Run chassis and motor grounds to the frame, frame to Earth.
6. Isolate remote signals. Solid state relays or opto isolators are recommended.
7. Filter the power line. Use common RF filters, isolation transformer for worst case.

A noise problem must be identified before it can be solved. The obvious way to approach a problem situation is to eliminate potential noise sources until the symptoms disappear, as in the case of ground loops. When this is not practical, use the above guidelines to *shotgun* the installation.

References

Information about the equipment referred to in this chapter may be obtained by calling the numbers listed below:

- Corcom line filters, (312) 680-7400
- Opto-22 optically isolated relays, (714) 891-5861
- Crydom optically isolated relays, (213) 322-4987
- Potter Brumfield optically isolated relays, (812) 386-1000
- General Electric MOVs, (315) 456-3266
- Teal Electronics Corporation–specializing in power line products, (800) 888-TEAL.

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RS-232C Communications Troubleshooting

Procedures for troubleshooting three-wire RS-232C communications are as follows:

1. For single-axis applications, make certain the transmit (pin 2) of the host is wired to the receive (pin 1) of the AX unit. Also, make sure that the receive (pin 3) of the host is wired to the transmit (pin 2) of the AX unit.

   NOTE: Try switching the receive and transmit wires on either the host or peripheral if you fail to get any communication.

2. If you have a daisy-chained system, make sure the following connections are made:
   - Transmit (AX pin 2) connected to receive (AX pin 1) of the successive AX units in the chain
   - COM (AX pin 3) is connected between AX units and to GND (pin 7) on the host
   - Transmit (AX pin 2) of the last AX unit in the chain connected to the receive (pin 3) on the host
   - Transmit (pin 2) of the host connected to the receive (AX pin 2) on the first AX unit in the chain

3. Some computer serial ports require handshaking. Typically, you can disable the handshaking function by jumpering RTS to CTS (usually pins 4 and 5) and DSR to DTR (usually pins 6 and 20). Refer to your computer or terminal user guide for exact instructions.

4. Configure the host and peripheral to the same baud rate, number of data bits, number of stop bits, and parity.

5. If you receive double characters (for instance, if you type **A** and receive **AA**), your computer is set to half-duplex. Consult your computer or terminal emulator user manual for instructions on how to change the set-up to full-duplex.

6. Use DC common or signal ground as your reference. *DO NOT use earth ground.*

7. Cable lengths should not exceed 50 ft. unless you are using some form of line driver, optical coupler, or shield. As with any control signal, be sure to shield the cable to earth ground at one end only.

8. To test your terminal or terminal emulation software for proper 3-wire communication, unhook your peripheral device and transmit a character. You should not receive an echoed character. If you do, you are in half-duplex mode. Jumper the host's transmit and receive lines 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.

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Returning The System

If you must return your AX system to effect repairs or upgrades, use the following steps:

1. Get the serial number and the model number of the defective unit, and a purchase order number to cover repair costs in the event the unit is determined by Parker Compumotor to be out of warranty.

2. Before you ship the drive to Parker Compumotor, have someone from your organization with a technical understanding of the AX system and its application include answers to the following questions:

   - What is the extent of the failure/reason for return?
   - How long did it operate?
   - How many units are still working?
   - How many units failed?
   - What was happening when the unit failed (i.e., installing the unit, cycling power, starting other equipment, etc)?
   - How was the product configured (in detail)?
   - What, if any, cables were modified and how?
   - With what equipment is the unit interfaced?
   - What was the application?
   - What was the system sizing (speed, acceleration, duty cycle, inertia torque, friction, etc.)?
   - What was the system environment (temperature, enclosure, spacing, unit orientation, contaminants, etc.)?
   - What upgrades, if any, are required (hardware, software, user guide)?

3. Call Parker Compumotor for a Return Material Authorization (RMA) number. Returned products cannot be accepted without an RMA number. The phone number for Parker Compumotor Applications Department is (800) 358-9070.

4. Ship the unit to: Parker Compumotor Corporation
   5500 Business Park Drive
   Rohnert Park, CA 94928
   Attn: RMA # xxxxxxx

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APPENDICES

Command Listing

A (Acceleration)
AC (Acceleration Change)
B (Buffer Status Report)
B S (Buffer Size Status)
C (Continue)
CA (Change Acceleration)
CBC (Clear Buffered Commands)
CG (Correction Gain)
CL (Continuous Velocity Loop)
CN (Continuous Mode End Loop)
CO (Continuous Mode Output)
CR (Carriage Return)
CTM (Continuous Mode Time Delay)
CTR (Constant Velocity Wait for Trigger)
CV (Change Velocity)
D (Distance)
DB (Dead Band)
DW (Dead Band Window)
E (Enable Communications)
ER (Encoder Resolution)
F (Disable Communications)
FR (Encoder Functions Report)
FSA (Set Indexer to Incremental/Absolute Mode)
FSB (Set Indexer to Motor/Encoder Mode)
FSC (Enable/Disable Position Maintenance)
FSD (Stop on Stall)
FSE (Turn on Output 1 on Stall)
FSF (Kill Motion on Trigger 3)
FSG (Turn on Output 2 when within Dead Band)
FSH (Stall Detection)
G (Go)
GH (Go Home)
^H (Delete)
H (Set Direction)
IS (Input Status)
K (Kill)
L (Loop)
LD (Limit Disable)
LF (Line Feed)
MC (Mode Continuous)
MN (Mode Normal)
MPA (Mode Position Absolute)
MPI (Mode Position Incremental)
N (End of Loop)
O (Output)
OR (Report Homing Function Set-up)
OSB (Back up to Home Switch)
OSC (Define Active State of Home)
OSD (Define Active State of Z Channel Input)
OSH (Reference Edge of Home Switch)
PR (Position Report)
PS (Pause)
PX (Report Absolute Encoder Position)
PZ (Position Zero)
" (Quote)
QØ (Exit Velocity Profiling Mode)
Q1 (Enter Velocity Profiling Mode)
R (Request Indexer Status)
RA (Limit Switch Status Report)
RB (Loop, Pause, Shutdown, Trigger Status Request)
RC (Closed Loop Status)
RM (Rate Multiplier in Velocity Streaming Mode)
RS (Status of Sequence Execution)
RV (Revision)
S (Stop)
SC (Standby Current)
SCA (Standby Current Automatically)
SN (Scan)
SSA (RS-232C Echo Control)
SSD (Stop on Limit Input)
SSG (Clear/Save the Command Buffer On Limit)
SSH (Clear/Save the Command Buffer on Stop)
ST (Shutdown)
SV (Servoing Parameter)
T (Time Delay)
TEST (System Test Routine)
TR (Wait for Trigger)
TS (Trigger Input Status)
U (Pause and Wait for Continue)
V (Velocity)
VC (Change Velocity in Continuous Mode)
W1 (Signed Binary Position Report)
W3 (Hexadecimal Position Report)
WV (Select Waveform)
XC (Sequence Checksum)
XD (Sequence Definition)
XE (Sequence Erase)
XP (Set Power-up Sequence Mode
XQ (Sequence Interrupted Run Mode)
XR (Sequence Run)
XRP (Sequence Run with Pause)
XSD (Sequence Download Status)
XSP (Sequence Status Power-up)
XSR (Sequence Run Status)
XSS (Sequence Status)
XT (Sequence Termination)
XU (Sequence Upload)
XZ (Set power-up Sequence to Zero)
Y (Stop Loop)
Z (Reset)

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ASCII Table

DEC	HEX	GRAPHIC	DEC	HEX	GRAPHIC	DEC	HEX	GRAPHIC
ØØØ	ØØ	NUL	Ø58	3A	:	116	74	t
ØØ1	Ø1	SOH	Ø59	3B	;	117	75	u
ØØ2	Ø2	STX	Ø6Ø	3C	<	118	76	v
ØØ3	Ø3	ETX	Ø61	3D	=	119	77	w
ØØ4	Ø4	EOT	Ø62	3E	>	12Ø	78	x
ØØ5	Ø5	ENQ	Ø63	3F	?	121	79	y
ØØ6	Ø6	ACK	Ø64	4Ø	@	122	7A	z
ØØ7	Ø7	BEL	Ø65	41	A	123	7B	{
ØØ8	Ø8	BS	Ø66	42	B	124	7C	|
ØØ9	Ø9	HT	Ø67	43	C	125	7D	}
Ø1Ø	ØA	LF	Ø68	44	D	126	7E	~
Ø11	ØB	VT	Ø69	45	E	127	7F	DEL
Ø12	ØC	FF	Ø7Ø	46	F			
Ø13	ØD	CR	Ø71	47	G			
Ø14	ØE	SO	Ø72	48	H			
Ø15	ØF	S1	Ø73	49	I			
Ø16	1Ø	DLE	Ø74	4A	J			
Ø17	11	DC1	Ø75	4B	K			
Ø18	12	DC2	Ø76	4C	L			
Ø19	13	DC3	Ø77	4D	M			
Ø2Ø	14	DC4	Ø78	4E	N			
Ø21	15	NAK	Ø79	4F	O			
Ø22	16	SYN	Ø8Ø	5Ø	P			
Ø23	17	ETB	Ø81	51	Q			
Ø24	18	CAN	Ø82	52	R			
Ø25	19	EM	Ø83	53	S			
Ø26	1A	SUB	Ø84	54	T			
Ø27	1B	ESC	Ø85	55	U			
Ø28	1C	FS	Ø86	56	V			
Ø29	1D	GS	Ø87	57	W			
Ø3Ø	1E	RS	Ø88	58	X			
Ø31	1F	US	Ø89	59	Y			
Ø32	2Ø	SPACE	Ø9Ø	5A	Z			
Ø33	21	!	Ø91	5B	[			
Ø34	22	"	Ø92	5C	\			
Ø35	23	#	Ø93	5D	]			
Ø36	24	$	Ø94	5E	^			
Ø37	25	%	Ø95	5F	_			
Ø38	26	&	Ø96	6Ø	`			
Ø39	27	'	Ø97	61	a			
Ø4Ø	28	(	Ø98	62	b			
Ø41	29	)	Ø99	63	c			
Ø42	2A	*	1ØØ	64	d			
Ø43	2B	+	1Ø1	65	e			
Ø44	2C	,	1Ø2	66	f			
Ø45	2D	-	1Ø3	67	g			
Ø46	2E	.	1Ø4	68	h			
Ø47	2F	/	1Ø5	69	i			
Ø48	3Ø	Ø	1Ø6	6A	j			
Ø49	31	1	1Ø7	6B	k			
Ø5Ø	32	2	1Ø8	6C	l			
Ø51	33	3	1Ø9	6D	m			
Ø52	34	4	11Ø	6E	n			
Ø53	35	5	111	6F	o			
Ø54	36	6	112	7Ø	p			
Ø55	37	7	113	71	q			
Ø56	38	8	114	72	r			
Ø57	39	9	115	73	s			

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Glossary

Absolute Positioning
Refers to a motion control system employing position feedback devices (absolute encoders) to maintain a given mechanical location.

Absolute Programming
A positioning coordinate reference wherein all positions are specified relative to some reference, or *home* position. This is different from incremental programming, where distances are specified relative to the current position.

Acceleration
The change in velocity as a function of time. Acceleration usually refers to increasing velocity and deceleration describes decreasing velocity.

Accuracy
A measure of the difference between expected position and actual position of a motor or mechanical system. Motor accuracy is usually specified as an angle representing the maximum deviation from expected position.

Address
Multiple devices, each with a separate address or unit number, can be controlled on the same bus, . The address allows the host to communicate individually to each device.

Ambient Temperature
The temperature of the cooling medium, usually air, immediately surrounding the motor or another device.

ASCII
American Standard Code for Information Interchange. This code assigns a number to each numeral and letter of the alphabet. In this manner, information can be transmitted between machines as a series of binary numbers.

Bandwidth
The frequency range in which the magnitude of the system gain expressed in dB is greater than -3 dB.

Baud Rate
The number of bits transmitted per second. Typical rates include 300, 600,1200, 2400, 4800, 9600, 19,200. This means at 9600 baud, one character can be sent nearly every millisecond.

BCD
Binary Coded Decimal is an encoding technique used to describe the numbers 0 through 9 with four digital (on or off) signal lines. Popular in machine tool equipment, BCD interfaces are now giving way to interfaces requiring fewer wires—such as RS-232C.

Bit
Abbreviation of Binary Digit, the smallest unit of memory equal to 1 or 0.

Block Diagram
A simplified schematic representing components and signal flow through a system.

Bode Plot
A graph of system gain and phase versus input frequency which graphically illustrates the steady state characteristics of the system.

Break Frequency
Frequency(ies) at which the gain changes slope on a Bode plot. (Break frequencies correspond to the poles and zeroes of the system.)

Byte
A group of 8 bits treated as a whole, with 256 possible combinations of ones and zeros, each combination representing a unique piece of information.

Closed Loop
A broadly applied term relating to any system where the output is measured and compared to the input. The output is then adjusted to reach the desired condition. In motion control, the term is used to describe a system wherein a velocity or position (or both) transducer is used to generate correction signals by comparison to desired parameters.

Critical Damping
A system is critically damped when the response to a step change in desired velocity or position is achieved in the minimum possible time with little or no overshoot.

Crossover Frequency
The frequency at which the gain intercepts the 0 dB point on a Bode Plot. (Used in reference to the open-loop gain plot.)

Daisy-Chain
A term used to describe the linking of several RS-232C devices in sequence such that a single data stream flows through one device and on to the next. Daisy-chained devices usually are distinguished by device addresses, which serve to indicate the desired destination for data in the stream.

Damping
An indication of the rate of decay of a signal to its steady state value. Related to settling time.

Damping Ratio
Ratio of actual damping to critical damping. Less than one is an underdamped system and greater than one is an overdamped system.

Data Bits
Since the ASCII character set consists of 128 characters, computers may transmit only seven bits of data. However, most computers support an eight bit extended ASCII character set.

Dead Band
A range of input signals for which there is no system response.

Decibel
A logarithmic measurement of gain. If G is a system gain (ratio of output to input), then 20 log G equals gain in decibels (dB).

Detent Torque

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The minimal torque present in an unenergized motor. The detent torque of a Compumotor or step motor is typically about one percent of its static energized torque.

Duty Cycle
For a repetitive cycle, the ratio of on time to total cycle time.
Duty Cycle = *On Time* + *On Time + Off Time*

Efficiency
The ratio of power output to power input.

Encoder
A device which translates mechanical motion into electronic signals used for monitoring position or velocity.

Friction
A resistance to motion caused by surfaces rubbing together. Friction can be constant with varying speed (Coulomb friction) or proportional to speed (viscous friction).

Full Duplex
The terminal will display only received or echoed characters.

Gain
The ratio of system output signal to system input signal.

Half Duplex
In half duplex mode, a terminal will display every character transmitted. It may also display the received character.

Hand Shaking Signals
RST: Request To Send
CTS: Clear To Send
DSR: Data Set Ready
DTR: Data Terminal Ready
IDB: Input Data Buffer
ODB: Output Data Buffer

Holding Torque
Sometimes called static torque, it specifies the maximum external force or torque that can be applied to a stopped, energized motor without causing the rotor to rotate continuously.

Home
A reference position in a motion control system, usually derived from a mechanical datum. Often designated as the "zero" position.

Hysteresis
The difference in response of a system to an increasing or a decreasing input signal.

IEEE-488
A digital data communications standard popular in instrumentation electronics. This parallel interface is also known as GPIB, or General Purpose Interface Bus.

Incremental Motion
A motion control term that is used to describe a device that produces one step of motion for each step command (usually a pulse) received.

Incremental Programming
A coordinated system where position or distances are specified relative to the current position.

Inertia
A measure of an object's resistance to a change in velocity. The larger an object's inertia, the larger the torque that is required to accelerate or decelerate it. Inertia is a function of an object's mass and its shape.

Inertial Match
For most efficient operation, the system coupling ratio should be selected so that the reflected inertia of the load is equal to the rotor inertia of the motor.

Limits
Properly designed motion control systems have sensors called limits that alert the control electronics that the physical end of travel is being approached and that motion should stop.

Logic Ground
An electrical potential to which all control signals in a particular system are referenced.

Micro-stepping
An electronic control technique that proportions the current in a step motor's windings to provide additional intermediate positions between poles. Produces smooth rotation over a wide speed range and high positional resolution.

Null Modem
A simple device or set of connectors which switches the receive and transmit lines of a three wire RS-232C connector.

Open Collector
A term used to describe a signal output that is performed with a transistor. An open collector output acts like a switch closure with one end of the switch at ground potential and the other end of the switch accessible.

Open Loop
Refers to a motion control system where no external sensors are used to provide position or velocity correction signals.

Opto-isolated
A method of sending a signal from one piece of equipment to another without the usual requirement of common ground potentials. The signal is transmitted optically with a light source (usually a Light Emitting Diode) and a light sensor (usually a photosensitive transistor). These optical components provide electrical isolation.

Parallel
Refers to a data communication format wherein many signal lines are used to communicate more than one piece of data at the same time.

Parity
An RS-232C error detection scheme which can detect an odd number of transmission errors.

Phase Angle
The angle at which the steady state input signal to a system leads the output signal.

Phase Margin
The difference between 180 degrees and the phase angle of a system at its crossover frequency.

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Pole
A frequency at which the transfer function of a system goes to infinity.

Pulse Rate
The frequency of the step pulses applied to a motor driver. The pulse rate multiplied by the resolution of the motor/drive combination (in steps per revolution) yields the rotational speed in revolutions per second.

Ramping
The acceleration and deceleration of a motor. May also refer to the change in frequency of the applied step pulse train.

Rated Torque
The torque producing capacity of a motor at a given speed. This is the maximum torque the motor can deliver to a load and is usually specified with a torque/speed curve.

Relative Accuracy
Also referred to as *Step-to-Step Accuracy*, this specification tells how microsteps can change in size. In a perfect system, microsteps would all be exactly the same size, but drive characteristics and the absolute accuracy of the motor cause the steps to expand and contract by an amount up to the relative accuracy figure. The error in not cumulative.

Repeatability
The degree to which the positioning accuracy for a given move performed repetitively can be duplicated.

Resolution
The smallest positioning increment that can be achieved. Frequently defined as the number of steps required for a motor's shaft to rotate one complete revolution.

Ringing
Oscillation of a system following a sudden change in state.

RMS Torque
For an intermittent duty cycle application, the RMS Torque is equal to the steady state torque which would produce the same amount of motor heating over long periods of time.

Where:

Ti	= Torque during interval i
t	= Time of interval i

RS-232C
A data communications standard that encodes a string of information on a single line in a time sequential format. The standard specifies the proper voltage and timing requirements so that different manufacturers' devices are compatible.

Slew
In motion control, the portion of a move made at a constant non-zero velocity.

Speed
Used to describe the linear or rotational velocity of a motor or other object in motion.

Start Bits
RS-232C character transmissions begin with a bit which signals the receiver that data is now being transmitted.

Static Torque
The maximum torque available at zero speed.

Step Angle
The angle the shaft rotates upon receipt of a single step command.

Stiffness
The ability to resist movement induced by an applied torque. Is often specified as a torque displacement curve, indicating the amount a motor shaft will rotate upon application of a known external force when stopped.

Stop Bits
When using RS-232C, one or two bits are added to every character to signal the end of a character.

Synchonism
A motor rotating at a speed correctly corresponding to the applied step pulse frequency is said to be in synchronism. Load torques in excess of the motor's capacity (rated torque) will cause a loss of synchronism. This condition is not damaging to a step motor.

Text/Echo (Off/On)
This setup allows received characters to be re-transmitted back to the original sending device. Echoing characters can be used to verify or *close the loop* on a transmission.

Torque
Force tending to produce rotation.

Torque-to-Inertia Ratio
Defined as a motor's holding torque divided by the inertia of its rotor. The higher the ratio, the higher a motor's maximum acceleration capability will be.

Transfer Function
A mathematical means of expressing the output to input relationship of a system.

TTL
Transistor-Transistor Logic. Describes a common digital logic device family that is used in most modern digital electronics. TTL signals have two distinct states that are described with a voltage—a logical *zero* or *low* is represented by a voltage of less than 0.8 volts and a logical *one* or *high* is represented by a voltage from 2.5 to 5 volts.

XON/XOFF
Two ASCII characters supported in some serial communication programs. If supported, the receiving device transmits an XOFF character to the host when its character buffer is full. The XOFF character directs the host to stop transmitting characters to the device. Once the buffer empties the device will transmit an XON character to signal the host to resume transmission.

Zero
A frequency at which the transfer function of a system goes to zero.

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Index

Absolute Mode (MPA) Moves, 47, 52
Accuracy, 48
Address Settings, 16
Adjusting the Drive to the Motor, 79
Ambient Temperature, 18
Application Considerations, 49
ASCII, 3
ASCII Table, 203
Assumptions, vi
Atmospheric Contamination, 17
Automatically Saved Commands, 82
AX Drive Specifications, 166
AX Drive and Fan Dimensions, 179

Backlash, 58
Basic Electronics, vi
Basic Motion Control, vi
Basic Serial Communication, vi
BCD, viii
Bipolar, viii
Brownout, viii
Buffered commands, 82

Closed Loop Accuracy, 48
Closed Loop Operation, 54
Closed-Loop Homing Function, 36
Closed-Loop Moves, 35
Command Descriptions, 81
Command Listing, 84, 201
Command Syntax, 82
Compumotor-Supplied Motors, 5
Contents of This Manual, vi
Continue (C) Command, 50
Continuous Mode (MC) Moves, 32, 53, 61
Controlling Motor Velocity, 77
Conventions, x
Coupling Manufacturers, 41
Coupling the Load, 41
Current Boost Circuits, 30
Current Programming, 7
Current Settings, 177
Current Trim (pot, 1)
Current Waveform, 80
Custom Profiles, 45

Daisy-chain, ix, 16
Daisy-Chain Connections, 26
DC Common, 196
DC Ground Wire, 196
Deactivate Limit Inputs, 12
Dead Band, ix
Dead Band Window (DW) command, 38, 58
Defeating Noise, 198
Delays, 61
Delimiter, ix
Developing Your Application, vii
Device Address Settings, 178
Device-specific Command, 31
Dimensional Drawings, 179
DIP Switch, 6, 15
DIP Switch Settings, 7, 16, 192
Drive, ix
Drive Functions, 6
Drive Maintenance, 190
Drive Mounting, 18
Drive Output Current, 16
Drive Specifications, 166

Earth Ground, 196
EEPROM, 64, 65
Electrical Noise, 22, 194
EMI, 21
Enclosure Considerations, 18, 194
Encoder Compatibility, 54
Encoder Connections, 25
Encoder Feedback, 35
Encoder I/O Specifications, 170
Encoder I/O Wiring Diagram, 172
Encoder Input Circuit, 26
Encoder Mode (FSB1) Command, 37
Encoder Mounting, 20
Encoder Pinouts (Compumotor Encoders), 169
Encoder Resolution, 35, 54, 55
Encoder Step Mode, 55
End-of-Travel Inputs, 28
Environmental Considerations, 17
Execution, 82
Extending Motor Cables, 24
Externally Conducted Noise, 196

Factory Default DIP Switch Settings, 177
Fan Connections, 24
Fan Kit, 17
Fault LED, 192
FR status request command, 35
Full-duplex, 199

Glossary, *205*
Go (G) command, 45, 191
Go Home (GH) command, 28, 34, 36, 37
Go Home function, 28, 34
Go Home Status (RC) commands, 37
Ground Loops, 197
Ground Signal, 198
Grounding, 21

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Half-duplex, 199
Handshaking, 11, 199
Home Enable, 37
Home Input, 28
Homing Function, 36
Homing The Motor, 34
Horizontal Clearance, 18
Host Computer Operation, 68
Hysteresis, 48, 58

I/O Circuits, 27, 173
I/O Connections, 27
I/O Descriptions, 170
I/O Specifications, 169
I/O Switch Failure, 193
I/O Wiring Diagram (Testing Only), 172
I/O Wiring Diagrams, 171
IBM or IBM-compatible Computer, vi, xi
IL Encoder, 20
Immediate Commands, 64, 82
Incremental Encoders, 54
Incremental Mode (MPI) Moves, 46, 51
Incremental vs. Absolute Positioning Modes, 46
Index Channel, 36
Indexer, ix
Indexer Address, 16
Indexer Status, 13
Inputs, xi, 39
Inputs and Outputs, 39, 168
Installation Label, 6
Installation Process Overview, vii
Installation Recommendation, viii
Isolating Remote Signals, 198

Key Terms, viii

Limit Disable (LD3) command, 12
Limit Inputs, 28
Limit Switch Operation, 33
Loop (L) command, 62

Maintenance, 189
Mechanical Resonance, 49
Micro-stepping, ix
Microelectrical Components, 198
Misalignments, 41
Mode Position Absolute (MPA) command, 46
Mode Position Incremental (MPI) , 46, 51
Model 72 (Thumbwheel) Operation, 1, 76
Model 72-I/O interface, 1, 76
Modes of Operation, 50
Motion Commands, 81
Motion Control Concepts, 43
Motor Connections, 10
Motor Current, 7
Motor Current Settings (Full Range), 178
Motor Dimensions, 180
Motor Fails to Move, 191
Motor Fails to Run at High Speeds, 192
Motor is Jerky or Weak, 193
Motor Maintenance, 190
Motor Mounting, 17
Motor Overheating, 193
Motor Resonance, 78
Motor Shaft Wear, 193
Motor Specifications (Compumotor-Supplied), 167
Motor Stall Detection, 38
Motor Stalls, 192
Motor Wire Resistance Values, 24
Motor-to-Encoder Ratios, 54
MOV's, 195
Move Completion Signal, 63
Move Profiles, 43
Move Times: Calculated vs Actual, 45
Multi-Axis Control, 71
Multi-Axis Stop, 59

National Electrical Code, 21
Natural Frequency, 80
NEMA, 194
Nested Loops, 62
Never Saved Commands, 82
Noise Suppression Devices, 194
Non-Compumotor Motor Connections, 174
Normal Mode Moves, 32

Open Loop Accuracy, 48
Open Loop Operation, 50
Open-Loop Moves, 32
Optical Encoder, 54
Optical Isolation Circuit, 171
Output on Position Loss, 60
Output-On-Stall, 59
Outputs, xi, 29
Overshoot, 49

Panel Layout, 18
Pause (PS) Command, 51
Phase A Offset (pot, 3), 80
Phase B Offset (pot, 2), 80
Phase Balance (pot, 4), 79
Pinouts, 23, 168
PLC, ix
PLC Connections, 74
PLC Operation, 74
POBs (Programmable Output Bits), 63
Position Maintenance Function, 56
Position Report (PR) Command, 47, 58
Position Zero (PZ) Command, 34, 37, 47
Positional Accuracy vs. Repeatability, 48
Power Connections, 10, 24
Power Line Noise, 195
Power-up Sequence Execution, 66
Preset Move, 46
Problem Isolation, 190
Product Description, 1
Product Features, 2
Program Control, 61

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Program Loops, 62
Programmable Output Function, 40
Programming Commands, 81
Proper Mounting, 18

Quadrature, ix

Rate Multiplier (RM) command, 45
Reducing Electrical Noise, 194
References, 198
Related Publications, xi
Remote Connections, 198
Remote Sequence Inputs, 66
Remote Sequencing (BCD Inputs) Failure, 193
Report Absolute Encoder Position (PX) command, 58
Request Indexer Status (R), 37
Return Material Authorization (RMA) number, 200
Returning The System, 200
Ringing, 49
Ringing or Overshoot, 49
RS-232C, vi, ix, 72, 75, 197
RS-232C Communications Troubleshooting, 199
RS-232C Connections, 11, 26
RS-232C Protocol Parameters, 11

Savable in Sequence Commands, 82
Scan (SN) Command, 74
Scanning for Sequence Execution, 74
Sequence, ix
Sequence Inputs, 29
Sequence Programming, 64
Sequence Select Inputs, 66
Sequence Selection, 65
Sequence Selection Table, 171
Sequence Status (XSS) Command, 65
Sequence Status Power-up (XSP) Command, 66
Sequence Status Run (XSR), 68
Sequence Upload, 71
Sequences, 64
Set Direction (H) Command, 46
Set-up Commands, 81
Set-up Procedures, 15
Ship Kit, 5
Short-Circuit, ix
Signal Polarity, 35
Single Loops, 62
Single-Axis Control, 69
Sources of Electrical Noise, 195
Spare Parts, 189
Special Motor Wiring, 187
Stall Detect Function, 38
Standby Current Feature, 193
Status Commands, 81
Stop (S) command, 53
Stop-On-Stall, 39, 57
Stop-on-Stall Function, 39
Surge Suppression, 198
System Pinouts, 23
System Pinouts and Connectors, 168
System Response, 83
System Specifications, 166

Test Routine, 13
Testing the System, 13
Theory of Operation, 3
Time Delay (T) command, 61
Torque/Speed Curves, 185
Transformer Connections (Optional), 9, 24
Transmitted Noise, 196
Triangular and Trapezoidal Profiles, 44
Trigger Function, 40
Trigger Input Wiring, 39
Triggers, 61
Troubleshooting, 190
Tuning Pot Locations, 79
Tuning Procedure, 76

Universal Commands, 31, 71
Utility Commands, 50

Velocity Profiling Mode, 45
Vertical Clearance, 18

Wait for Trigger (TR) Command, 61
Warnings & Cautions, xi

Wave Shape, 80
Wave Shaping, 80
Waveform, 49
Waveform Settings, 80
Wire Sizes, 24
Wiring Diagram, 8
Wiring Diagram, 106-178 Motor, 188
Wiring Diagram, 106-205 Motor, 187
Wiring Guidelines, 21

XP9 Mode Operation, 68

Z Channel, 36, 37

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