Compumotor

Model 72 User Guide

Compumotor Division
Parker Hannifin Corporation
p/n 88-010841-01 D

Parker

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How To Use This Manual

This user guide will help you install, develop, and maintain your system. Each chapter begins with a list of objectives that should be met after you have read the chapter. This section will help you find and use the information in this user guide.

Assumptions

This user guide assumes that you have the skills or understand the information listed below:

- Basic *dumb* computer terminal experience
- Digital electronics concepts (voltage, switches, current, transistors, etc.)
- Basic motion control concepts (torque, velocity, distance, force, etc.)
- Basic serial communication concepts (specifically RS-232C)
- Basic configuration and operation of the AX Drive

With this basic level of understanding, you will be able to effectively use this manual.

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 have received with your Model 72 shipment. It will help you to become familiar with the system and ensure that the Model 72 functions properly.

Chapter 3: Installation — This chapter provides instructions for you to properly make all electrical connections and mount the Model 72. Upon completion of this chapter, your unit should be completely installed and ready to perform basic operations.

Chapter 4: Application Design — This chapter will help you use the Model 72 to meet your application's needs. Important application considerations are discussed. Sample applications are provided.

Chapter 5: Software Reference — This chapter explains the Model 72's programming language in detail. It describes command syntax and system parameters that affect command usage. An alphabetical listing of all commands, with a syntax and command description for each command, is included.

Chapter 6: Hardware Reference — This chapter contains information on the Model 72's specifications (dimensions and performance). This chapter may be used as a quick-reference tool for proper switch settings and I/O connections.

Chapter 7: Trouble-shooting — This chapter describes Compumotor's recommended system maintenance procedures. It also provides methods for isolating and resolving hardware and software problems.

Application Overview

To ensure trouble-free operation, you should pay special attention to the environment in which the Model 72 will operate, the layout and mounting, and the wiring and grounding practices used. These recommendations are intended to help you easily and safely integrate the Model 72 into your manufacturing facility. Industrial environments often contain conditions that may adversely affect solid-state equipment. Electrical noise or atmospheric contamination may also affect the unit.

Developing Your Application

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

1. 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.

Installation Recommendations

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

1. Review this entire user guide. Become familiar with the user guide'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 (in a simulated environment, not a permanent installation) provided in Chapter 2, Getting Started.

4. Perform as many basic moves and functions as you can with the preliminary configuration. You can only perform this task 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 application (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.

Conventions

The conventions used throughout this user guide are explained in this section.

It is important to note that Model 72's features and operations are a subset of the Model 72 I/O's features and operations. The two products are discussed in parallel in this manual. Therefore, whenever the Model 72 is discussed, the information typically applies to the Model 72 I/O as well.

Highlighted Text

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

Commands

All commands that you are instructed to enter are displayed (and must be entered) in all capital letters. 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
A 5	Sets acceleration to 5 rps^2
V 5	Sets velocity to 5 rps
D 1 Ø Ø Ø	Sets distance to 1,000 steps
G	Executes the move (Go)

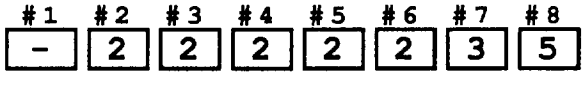
Bold face, quotation marks, or other forms of highlighting are not used for status command responses. Responses are set in all capital letters, as they are on the terminal. An example is provided below.

Command	Response
^2	*-9999999

(***The ^ is not a control—CTRL-character. It is generated by pressing SHIFT-6 on most keyboards. In ASCII, ^ is 94 decimal***). The AX generally ignores command syntax that is not within the valid range for a specific command (valid ranges are provided in Chapter 5, Software Reference). The Model 72 may send values to the AX that are not within its range. Compumotor does not guarantee system performance when the system executes commands that contain invalid syntax (outside valid range).

Thumbwheel Values

The Model 72 has eight thumbwheels. The first thumbwheel is a + or — character. The next seven thumbwheels are digits 0 - 9. Refer to the example below.



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.*

I/O Levels

In this user guide, 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.

OUTPUTS

ON (1)	Current flows
OFF (Ø)	No current flows

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 (*latest edition*)

Parker Compumotor AX Drive/Indexer User Guide (*latest edition*)

Schram, Peter (editor). *The National Electric Code Handbook (Third Edition).* Quincy, MA: National Fire Protection Association

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Chapter 1. INTRODUCTION

Chapter Objectives

The information in this chapter will enable you to:

- Understand the product's basic functions and features

Product Description

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

The Model 72-I/O differs from the Model 72 in that it provides 20 inputs and 12 outputs for additional control of various machine functions. Eight inputs and eight outputs have flat-cable connectors that are compatible with OPTO-22 signal conditioning equipment. The remaining 12 inputs and 4 outputs are 5 - 24VDC rated screw terminal connections.

You can install the Model 72 in a panel-mount or door-mount fashion. You may configure as many as 16 units (daisy chained) to a single indexer/drive. The Model 72 has two RS-232C ports—one for X-version communication (to AX) and one for programming and diagnostics (to terminal).

The Model 72 is only compatible with AX's (and AX-A's) that have a software revision of **E** or later (**F**, **G**, etc.). To use the Model 72, you must have an AX or AX-A of the following revision level or greater:

Product	Revision Level
AX High-Power	2V
AX Low-Power	2S
AX-A High-Power	1K
AX-A Low-Power	1K

Contact your local Compumotor Field Application Engineer or Automation Technology Center (ATC) if your unit has an earlier revision level.

Product Features

- Offers a + or - character and 7 digits of thumbwheel data
- Can be panel-mounted or door-mounted
- Allows you to set and modify AX motion parameters (velocity, acceleration, distance, direction, etc.)
- Allows you to daisy chain 16 units to one AX or AX-A
- Two RS-232C ports—one for communication to an AX and one for diagnostics and programming

- Allows you to scale distance in the units used by the application (steps, inches, etc.). *This is only valid with Distance (D) commands.*

Additional Model 72 I/O Features

- Equipped with 20 inputs and 12 outputs
- Offers 8 OPTO-22 compatible inputs and 8 OPTO-22 compatible outputs
- 12 inputs and 4 outputs that are 5 - 24VDC compatible (screw terminal connections)

Any command that references the Model 72-I/O's outputs or inputs will be ignored by a Model 72.

Theory of Operation

The Model 72 (or a series of Model 72s) is connected to an AX Indexer/Drive. The AX, while executing a programmed sequence of commands, requests data from the Model 72(s) via its RS-232C port. The Model 72 responds with its current thumbwheel settings or the status of its inputs and outputs. The AX's command language has been modified (**Revision E**) to allow the indexer/drive to read a variety of motion and control parameters from the Model 72.

Flexible AX programming allows you to select which of the Model 72's thumbwheel digits are used for each parameter. The AX may also use the Model 72-I/O's 20 inputs.

You may daisy chain as many as 16 Model 72 units from a single AX 's RS-232C port. You will use modified X Series commands to uniquely address each Model 72 in your system and to request data from each unit.

The Model 72's terminal RS-232C port allows you to connect a terminal to monitor and debug the system. This terminal allows you to communicate with the indexer/drive for programming and control tasks. Communication via the terminal port has priority over signals sent from the Model 72's indexer/drive RS-232C port (communication from the first port may be interrupted). Figure 1-1 is a sample Model 72 configuration.

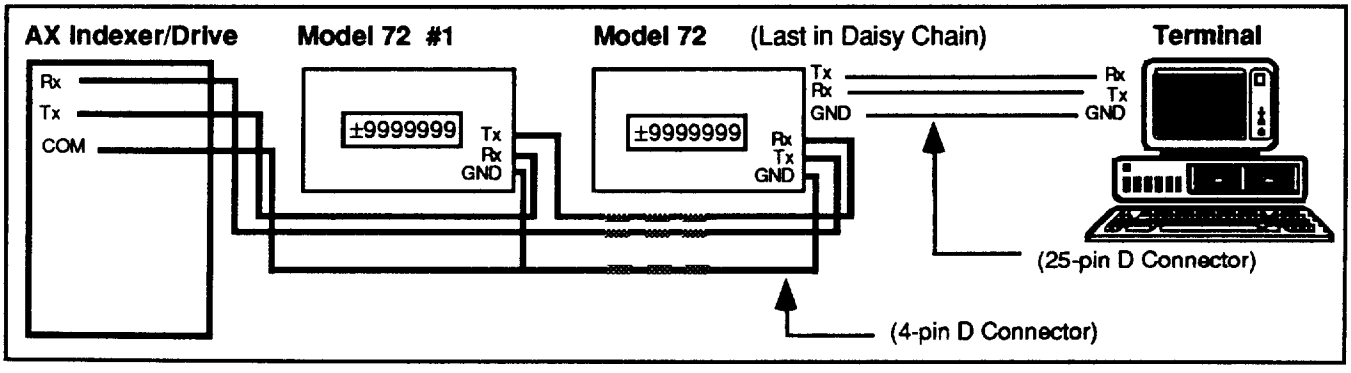


Figure 1-1. Sample Model 72 Configuration

You must connect the last Model 72 in the daisy chain to the terminal to allow for the terminal to continue to access and program the AX. **In other words, you do not have to re-connect the terminal to the AX to program it.**

Chapter 2. GETTING STARTED

Chapter Objectives

The information in this chapter will enable you to:

- Verify that your system has been delivered safely
- Ensure that each component functions properly

What You Should Have

Inspect your Model 72 or Model 72-I/O shipment upon receipt for obvious damage to its shipping container. Report any damage to the shipping company immediately. Compumotor cannot be held responsible for damage incurred in shipment. Report any damage to the carrier. The items listed in Table 2-1 and 2-2 should be present and in good condition.

Ship Kit Table

Part Description	Part Number
Model 72	MODEL 72
Model 72 User Guide	88-010841-01 A
4-Pin Phoenix Plug	43-005560-01
Power Cable w/5-pin phoenix plug	71-010511-01

Table 2-1. Model 72 Ship Kit List

Part Description	Part Number
Model 72 I/O	MODEL 72-I/O
Model 72 User Guide	88-010841-01 A
10-Pin Phoenix Plug (2)	43-005987-01
4-Pin Phoenix Plug	43-005560-01
Power Cable w/5-pin phoenix plug	71-010511-01

Table 2-2. Model 72 I/O Ship Kit List

Basic System Configuration

Follow the procedures and instructions in this section to complete the basic system configuration and system test. If you have more than one unit, complete this test for each unit individually. Figure 2-1 and 2-2 show the location of the connections and thumbwheels on the Model 72 and the Model 72 I/O.

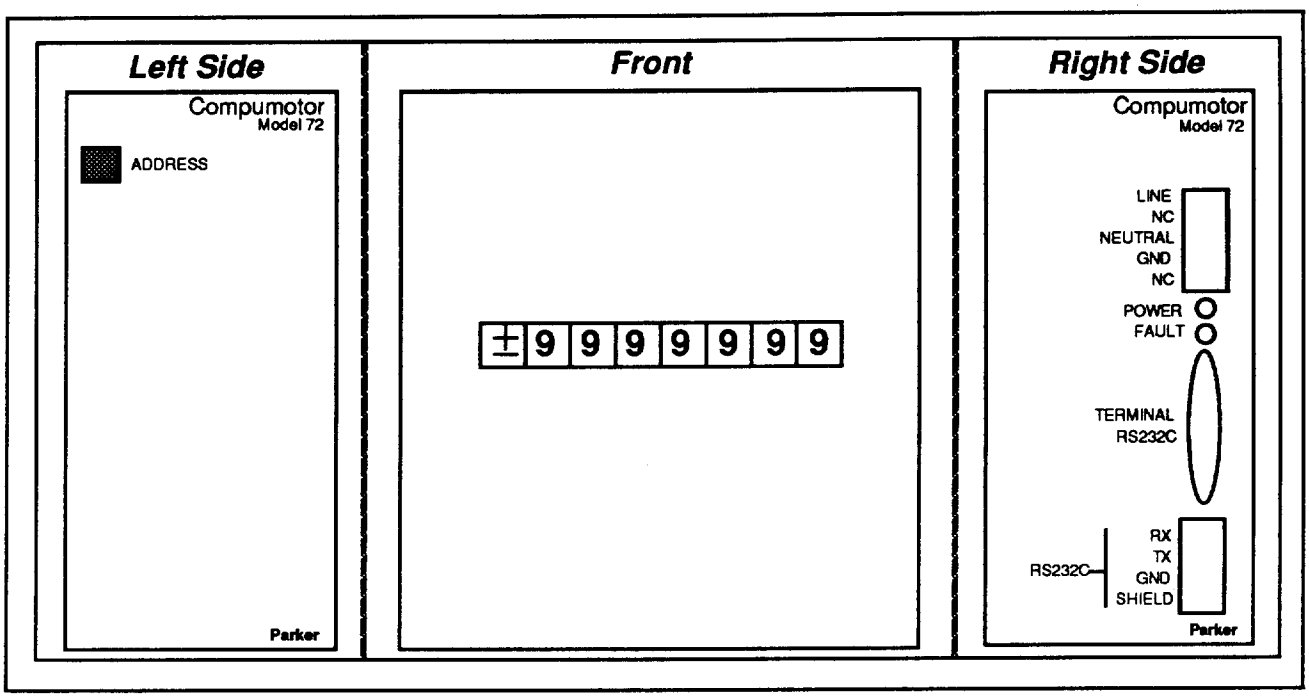


Figure 2-1. Location of Model 72 Connections and Thumbwheels

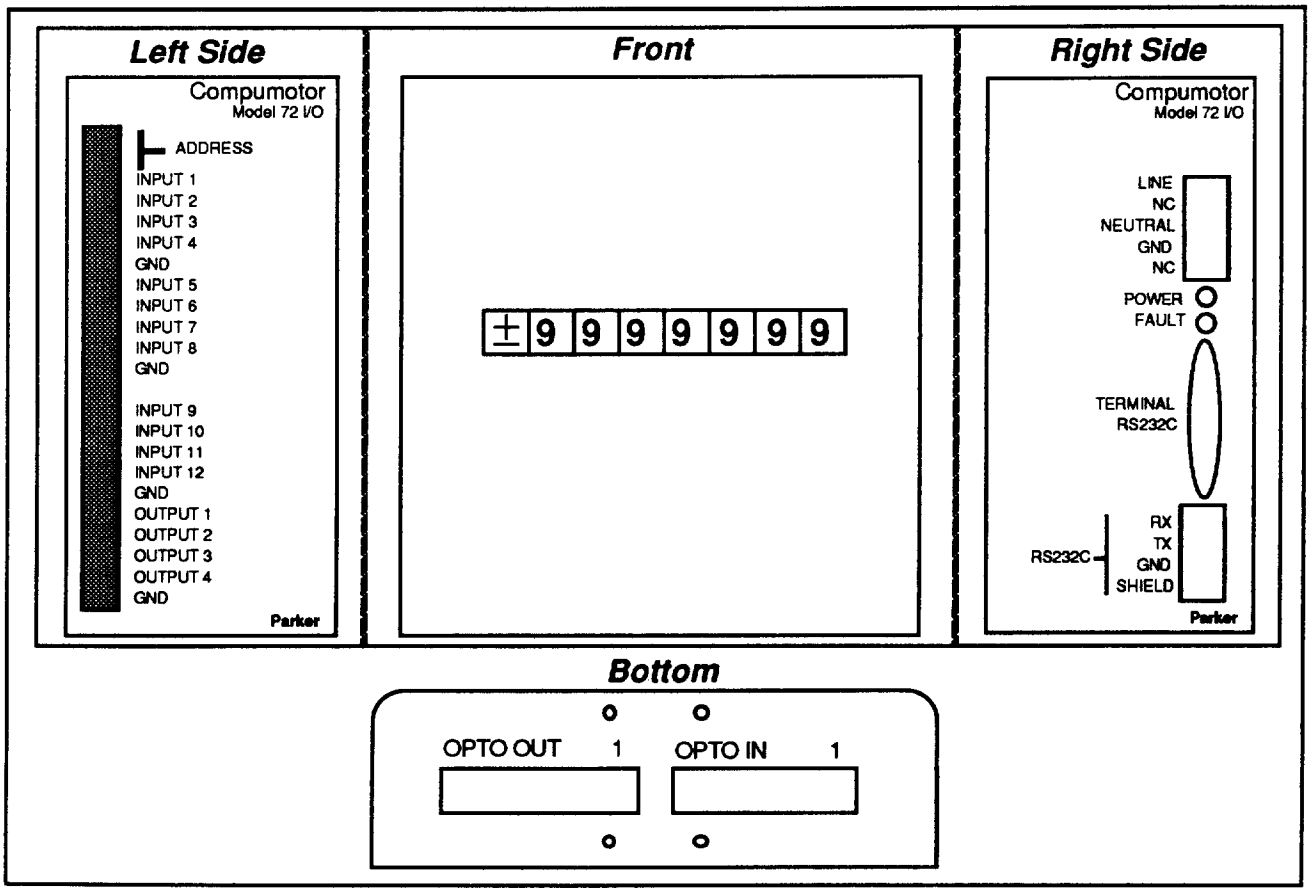


Figure 2-2. Location of Model 72 I/O Connections and Thumbwheels

Verify DIP Switch Settings

Table 2-3 contains the DIP switch settings that you can use to assign unique device addresses to up to 16 Model 72s (when daisy chained to a single AX Indexer/Drive). The DIP switches are located on the left side of the unit (see Figure 2-3).

ADDRESS	SW1	SW2	SW3	SW4
*1	OFF	OFF	OFF	OFF
2	ON	OFF	OFF	OFF
3	OFF	ON	OFF	OFF
4	ON	ON	OFF	OFF
5	OFF	OFF	ON	OFF
6	ON	OFF	ON	OFF
7	OFF	ON	ON	OFF
8	ON	ON	ON	OFF
9	OFF	OFF	OFF	ON
10	ON	OFF	OFF	ON
11	OFF	ON	OFF	ON
12	ON	ON	OFF	ON
13	OFF	OFF	ON	ON
14	ON	OFF	ON	ON
15	OFF	ON	ON	ON
16	ON	ON	ON	ON
*Default Address Setting				

Table 2-3. Address Settings

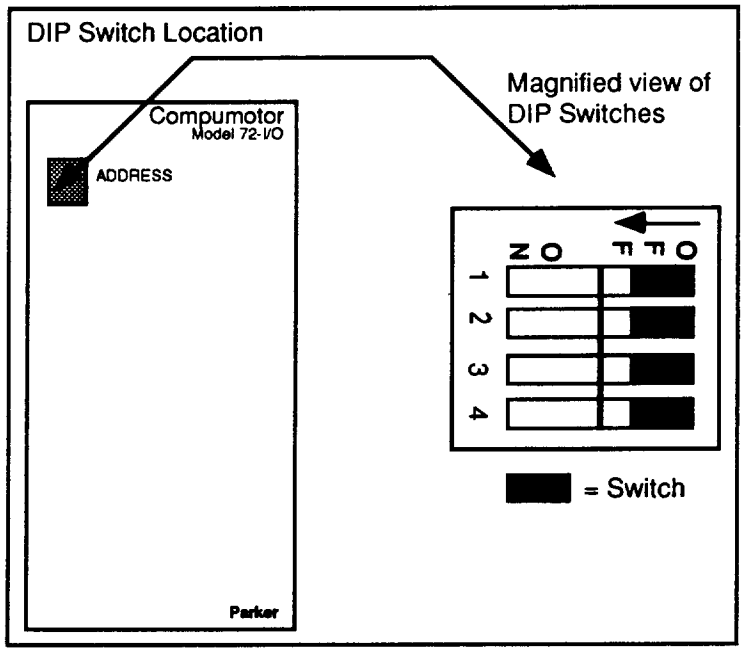


Figure 2-3. Location of the Model 72's DIP Switches

For these tests, use the factory-default DIP switch setting for your unit(s). The factory default address setting is ***1****. Refer to Table 2-2 to set your unit (s).* ***Set each unit to 1****. Chapter 3, Installation provides procedures for setting unique addresses for applications that use more than one Model 72.*

Basic System Wiring

Follow the steps below and refer to Figure 2-4 to properly connect the Model 72 and your terminal.

STEP 1

Use a 25-pin D connector (cable not provided in the ship kit) to connect the Model 72 to a terminal. You may also connect the Model 72 to a computer's RS-232C port if you run a terminal emulation program (converts a computer to a terminal). Refer to Figure 2-4. Your terminal or computer's parameters should be set as follows:

- 9,600 baud rate
- 8 data bits
- No parity
- 1 stop bit

STEP 2

Connect the 5-pin D power connector (cable provided in ship kit) to the Model 72. Plug the other end on the cable into a 115VAC power supply. Refer to Figure 2-4. The POWER LED should be **green** and the FAULT LED should be **off**.

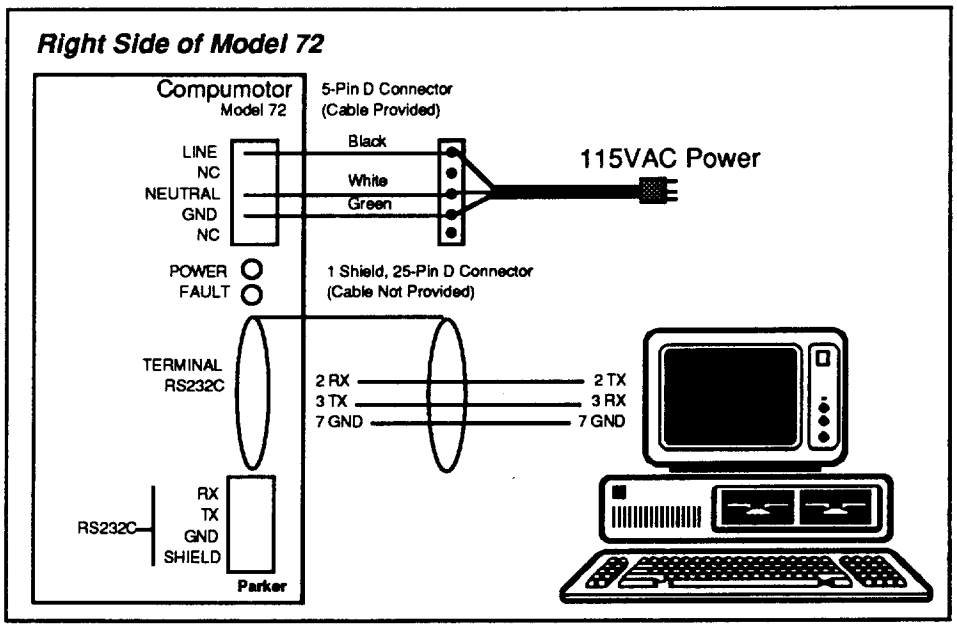


Figure 2-4. Basic Model 72 Wiring

Model 72 LEDs

The Model 72's green POWER LED should always be on (when power is applied to the system). If it is off, it indicates that there is no internal power. This may be caused by an incorrect power hookup or a blown internal fuse.

If the Model 72 is operating correctly, the unit's red FAULT LED should be off. If the internal microprocessor is faulting or resetting on power up, the light will be on. If the FAULT light stays on, refer to Chapter 7, Troubleshooting for assistance. If the problem persists, call Compumotor's Application Engineering Department (1-800-358-9070).

Verify Proper Operation

After you have completed the basic wiring procedure, complete the following steps to ensure the the Model 72 is operating properly. ***These steps do not test any other portion of your system.*** If you intend to use more than one Model 72 in your application, wire and test each unit individually. Configuring and testing multiple units (daisy chaining) is discussed in Chapter 3, Installation.

STEP 1

You must set the terminal to full-duplex mode to perform this test. Press any key on the keyboard. The character that you pressed should appear on your monitor (this is an echo from the Model 72). If the character appears, RS-232C communication has been established between the Model 72 and your computer or terminal.

If you do not receive an echo from your keyboard, check your wiring and attempt the test again. If the problem persists, refer to Chapter 7, Troubleshooting. After successfully completing step 1, try step 2.

STEP 2

Set all seven thumbwheel digits to ***9****. Set the first thumbwheel to —.*

Type the command **^2** (This is obtained by pressing **SHIFT-6** and **2** on most keyboards. The ^ is not a control—CTRL—character). This command activates a test mode that repetitively displays the state of thumbwheel inputs 1-8. If you are testing the Model 72, the characters you will see on your terminal are shown in Figure 2-5. If you are testing the Model 72 I/O, you will see the state of inputs 1-12 and OPTO inputs 13-20 on your terminal or computer. Refer to Figure 2-6. **To exit this mode, press any key.**

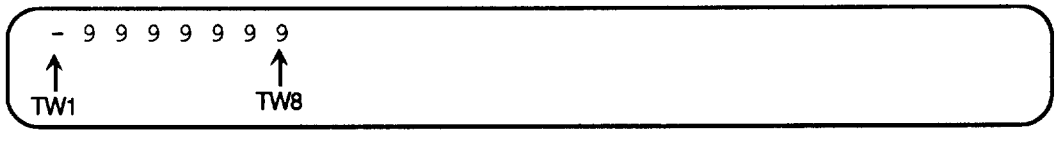


Figure 2-5. Model 72 Response to ^2

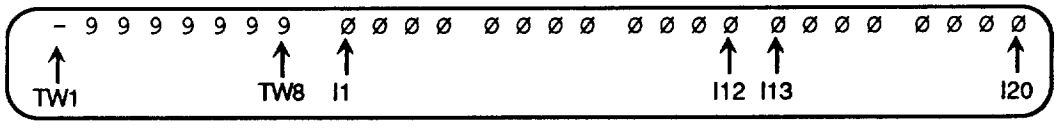


Figure 2-6. Model 72 I/O Response to ^2

You can change the thumbwheels (after activating the test) and see the value change immediately on the screen. The response to this command is immediately updated.

If you are testing a Model 72 I/O, the values for I13 - I20 may change on the screen (Ø or 1). These inputs are floating.

If the Model 72 passes this test, it is performing properly. **Disconnect the RS-232C cable and power down the system.** You are now ready to install your system. Turn to Chapter 3, Installation.

Chapter 3. INSTALLATION

Chapter Objectives

The information in this chapter will enable you to:

- Ensure that the complete system is installed properly
- Mount the unit properly
- Perform basic system operations

You must successfully complete the steps and procedures described in Chapter 2, Getting Started, before you begin this chapter. Power should not be applied to the Model 72.

Environmental Considerations

Parker Compumotor recommends that you operate and store your Model 72 under the following conditions.

- Operating Temperature: 32°F to 122°F (0°C to 50°C)
- Storage Temperature: -22°F to 185°F (-30°C to 85°C)
- Humidity: 0% to 95% non-condensing

Do not install the Model 72 in an area that will subject the unit to atmospheric contamination and excess heat.

Electrical System Connections

This section describes the procedures that you must complete to properly wire your system. The following connections will be addressed

- RS-232C
  - To Terminal
  - To AX Indexer/Drive
- Power
- Inputs & Outputs

Wiring Guidelines

Proper grounding of electrical equipment is essential to ensure safety. You can reduce electrical noise caused by 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, MA.

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

Preparing the Terminal

The parameters for the Model 72's two RS-232C communications ports are fixed at the following settings:

- 9,600 baud rate
- 8 data bits
- No parity
- 1 stop bit

Your terminal or PC must be set to operate at these parameters to communicate with the Model 72. If it is not set to these parameters, refer to your terminal or computer manual to change the communications parameters to comply with the Model 72's settings.

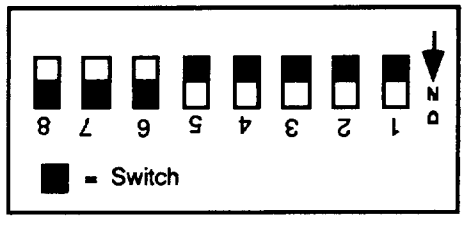
Preparing the AX

The Model 72 sends thumbwheel and I/O data to the AX Indexer/Drive. The AX uses this data to control motor motion and other external parameters. To operate properly, communication must be established between the AX and the Model 72. Several steps must be taken to ensure proper communication. The following steps must be completed before you connect the Model 72 and AX. **Power should not be applied to the AX at this time.**

1. **Set the AX's address setting to 1.** For ease of use, and the purposes of the procedures and tests in this user guide, the AX's address must be set to 1. The AX address is set via DIP switches 6, 7, and 8. Follow the steps below:

   A. Remove the cover that shields the AX's DIP switches. If you are facing the unit, the DIP switches are on the left side of the unit. Refer to the AX User Guide for more information on DIP switch location.

   B. Turn switches 6, 7, and 8 on. Refer to the example (the DIP switches are shown upside down because that is the way you will see them if the unit is sitting upright).



DIP Switches 1 - 5 are motor dependent. The settings shown here are simply for example purposes. Do not change these DIP switches unless you have checked the AX User Guide or the product's installation label.

2. **Wire the motor, RS-232C terminal, and power to the AX**. Refer to the AX User Guide for specific wiring instructions. ***At this point, only the AX is connected to the terminal. The Model 72 should not be connected to the terminal yet.***

3. **Apply power to the AX (turn the unit on).** The address is now set to 1.

4. **Be sure that the AX is operating with the proper software version.** You must be using software version E or greater (i.e., F or G). You can check the software version by issuing the **RV** command to the AX:

   A. Type **1RV**.

   B. Check the response shown on your terminal. The final character of the response is important. It must be E or greater. A sample response is provided below. Please note the highlighted character.

   ```
   *92-7212-01E
   ```

   If you do not have an acceptable version of the software, call Compumotor or your local Automation Technology Center (ATC) for information on software upgrades.

5. **Turn the AX's RS-232C echo function off.** The AX's echo function must be off for proper communication with the Model 72. Issue the **SSA1** command to the AX to turn the echo function off. It will be automatically saved in non-volatile memory. When the echo function is off, the characters you enter you will not be displayed.

   The AX accepts only capital letters. If the echo function is off, you the **1R** command to get a response. The **SSAØ** command will turn the AX's echo function on.

System Configuration

Connecting the Model 72 to the Terminal

Use a 25-pin D connector to connect the Model 72 to the RS-232C port on your terminal or computer. *You did this before in Chapter 2, Getting Started. You must make this connection again now. If you need help, Refer to Figure 2-4.*

Connecting the Model 72 to the AX

Turn the AX's RS-232C echo function off prior to connecting the Model 72 to the AX. Use the Model 72's indexer/drive RS-232C port to connect the unit to the AX Indexer/Drive. Wire the Model 72 to the AX as shown in Figure 3-1.

Complete all other AX connections before moving on to the next step.

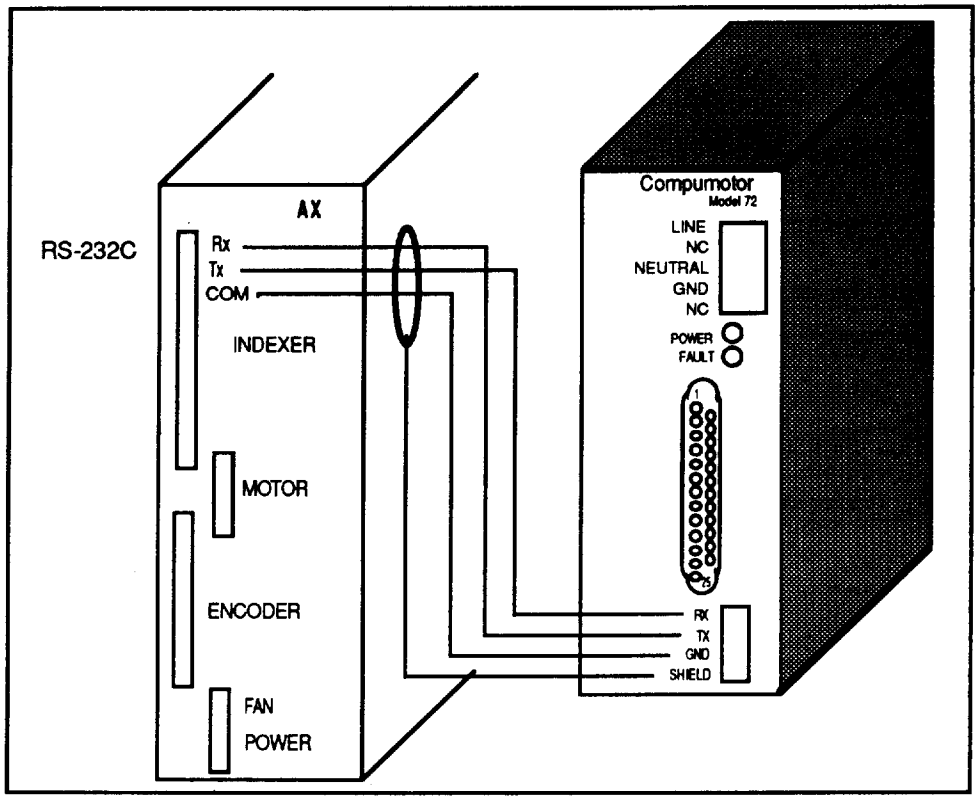


Figure 3-1. RS-232C Connections to AX

Power

Apply 115VAC power to the Model 72. You did this before in Chapter 2, Getting Started. You must make this connection again now. If you need help, Refer to Figure 2-4. Use the power cable (with a 5-pin phoenix connector) to connect the unit to the power source. Follow the instructions provided in Chapter 2 and refer to Figure 2-4 to make this connection properly. **The maximum recommended AC Power Cord length is 25'.**

The completion of this step represents the end of the system wiring procedures. The complete system configuration is shown in Figure 3-2. Compare your wiring to the connections shown in Figure 3-2.

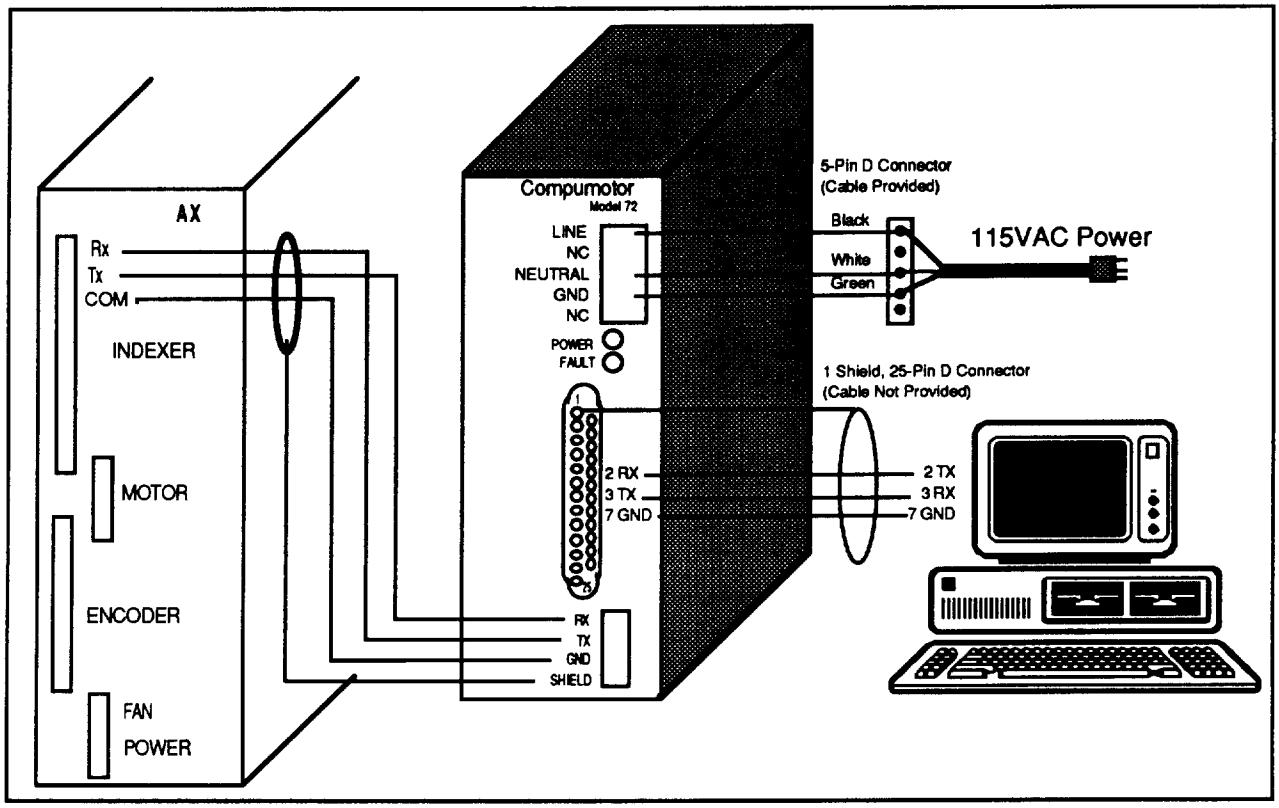


Figure 3-2. Complete Model 72 Configuration

Configuring Multiple Units

You can link as many as 16 Model 72's from a single AX RS-232C port. This configuration is called daisy chaining. **Before you attempt to configure a daisy chain, you must complete the steps discussed in *Preparing the AX* (earlier in this chapter).** After you have completed these steps, configure your system as shown in Figure 3-3. **You cannot daisy chain AX Indexer/Drives when you use the Model 72.**

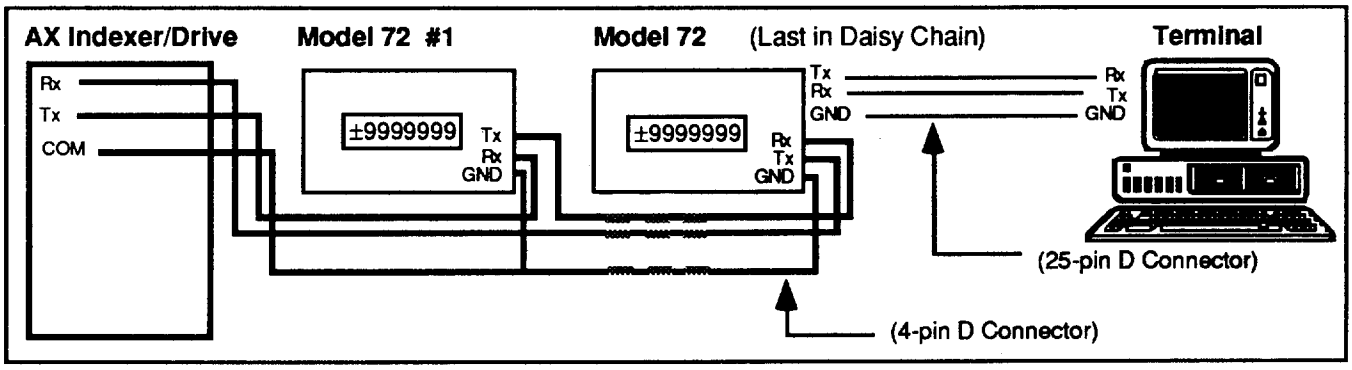


Figure 3-3. Daisy Chain Configuration

Note that the terminal must be wired to the last Model 72 in the daisy chain. ***The last Model 72 in the daisy chain must have its TX connection (from indexer/drive RS-232C port) wired to the AX's RX connection.*** *This configuration requirement allows the terminal or PC to read responses from each Model 72 in the daisy chain.*

Assigning Addresses

Each Model 72 unit in the daisy chain must have a unique device address. You must assign unique addresses to each Model 72 using the DIP switches. The Model 72 only recognizes changes to its *DIP Switches upon power up.*

Refer to Figure 2-3 for DIP switch location and Table 2-3 for address settings.

Use the following procedure to adjust Model 72's DIP switches.

1. **Remove AC power from the Model 72.**
2. Select DIP switch settings (1 - 16, refer to Table 2-3). Use a narrow instrument (i.e., a thin, flat screw driver) to adjust the DIP switches.
3. Apply power to the unit. The new address is set.

Testing System Operation

Model 72/AX Communication

The Model 72 system must pass the following tests to ensure successful system operation. Before you proceed with the final tests, all of the procedures in this chapter and in *Chapter 2, Getting Started,* must have been successfully completed. Check the items listed below.

- ☐ The AX's echo function must be off (Refer to *Preparing the AX* earlier in this chapter).
- ☐ The AX must be operating with the proper version of software—version E or greater (Refer to *Preparing the AX* earlier in this chapter).
- ☐ If you are using daisy chain configuration, each Model 72 must have a unique device address (Refer to *Assigning Addresses* earlier in this chapter).
- ☐ The terminal's communication parameters must be properly set (Refer to *Preparing the Terminal* earlier in this chapter).

When you are sure that each of the conditions is met, power up the system and proceed with the following tests.

Test 1

Type **1PR.** This is the Position Report command. The prefix of 1 indicates that it is requesting information from the AX with device address 1.

The **1PR** should appear on the terminal followed by a numerical response. This response represents the current position status of the specified unit (1). A sample of what you should see on the terminal is provided below.

```
1PR +ØØØØØØØØØØ
```

If no response is given, check your wiring. If a continuous stream of characters is displayed, the AX's echo function is on. Turn the echo function off and try the test again. If you still do not receive a response, check the wiring (daisy chain). Be sure that the address setting on the AX is 1.

Test 2

Set the first thumbwheel to +. Set the remaining thumbwheel digits to 9. Type **D(1,Ø,Ø)**, where 1 is the address of the Model 72 that you are requesting data from, the first **Ø** requests all digits, the second **Ø** instructs the system to multiply the thumbwheel values by 10^0 or 1. The terminal should display your command and a response:

```
*D(1,Ø,Ø) #D+9999999
```

This command does not provide immediate responses. (If you change the thumbwheel now, it will not be shown on the screen. You must reissue the command.) If you daisy chain several Model 72s , repeat this test using each of the Model 72s addresses. If there is no response or you make a mistake, issue the Kill (**K**) command and retry the test. If there is still no response, check the system wiring and the Model 72's address.

If your system passes these tests, your AX and Model 72(s) are communicating properly.

Mounting

Proper mounting and panel layout are essential for trouble-free Model 72 operation.

If you mount the Model 72 in an enclosure, observe the following guidelines:

1. The vertical clearance between the Model 72 and other equipment, or the top or bottom of the enclosure, should be no less than 6 inches (Refer to Figure 3-6).

2. Do not mount large, heat-producing equipment directly beneath the Model 72.

3. The maximum allowable ambient temperature directly below the Model 72 is 50°C. Fan cooling may be necessary if adequate air flow is not provided.

You can mount the Model 72 to a panel or to the rear side of a door with access to the thumbwheels through a rectangular hole.

To mount the Model 72 on the rear panel of an enclosure, drill four holes for the mounting tabs as shown in Figure 3-4. To mount the unit to the rear of a panel, drill four holes for the mounting tabs and mount the unit as shown in Figure 3-5 (Panel Mount).

To mount the Model 72 on the inside of a cabinet and have the thumbwheels accessible from the outside, cut a rectangular hole (to expose the thumbwheels) in the door as shown in Figures 3-5 and 3-7 and drill four holes for the mounting tabs. The 72's mounting tabs must be move to the front hole locations for door mounting. For either mounting option, use four #10 screws to secure the unit.

For door mounts, you may want to put a piece of plastic over the hole in the door to protect the thumbwheels from contaminants. This preventive maintenance measure can help to ensure long life and reliable operation for your Model 72.

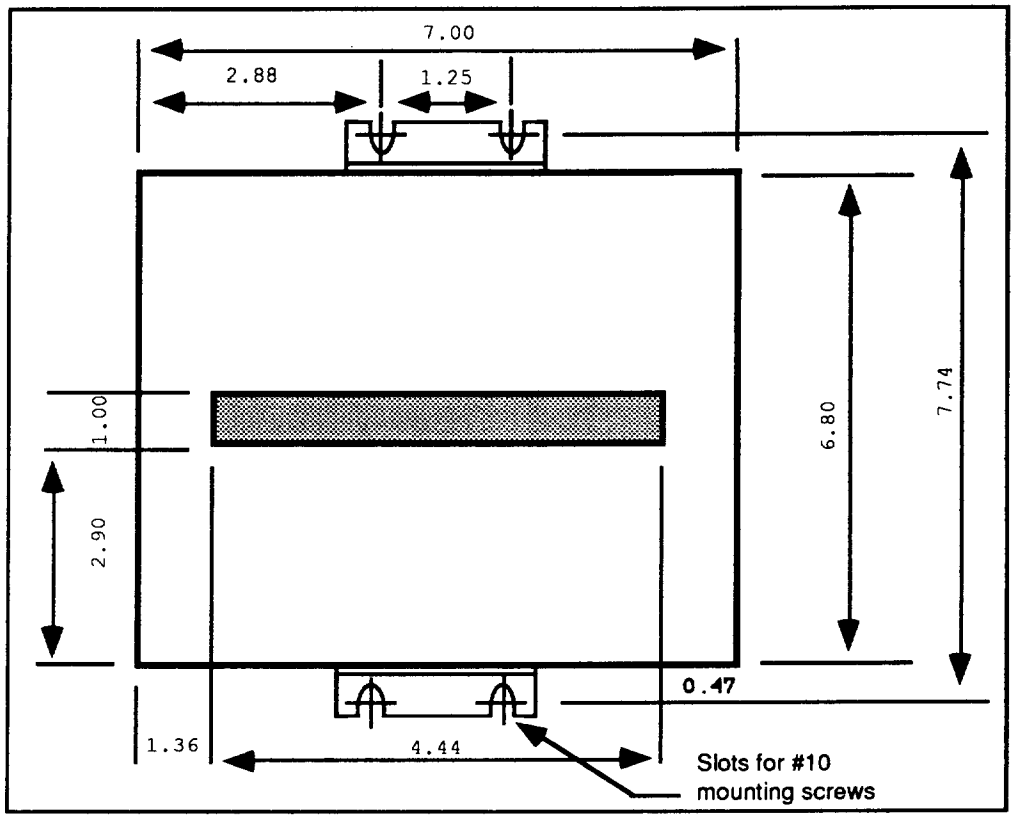


Figure 3-4. Enclosure Mounting Guidelines

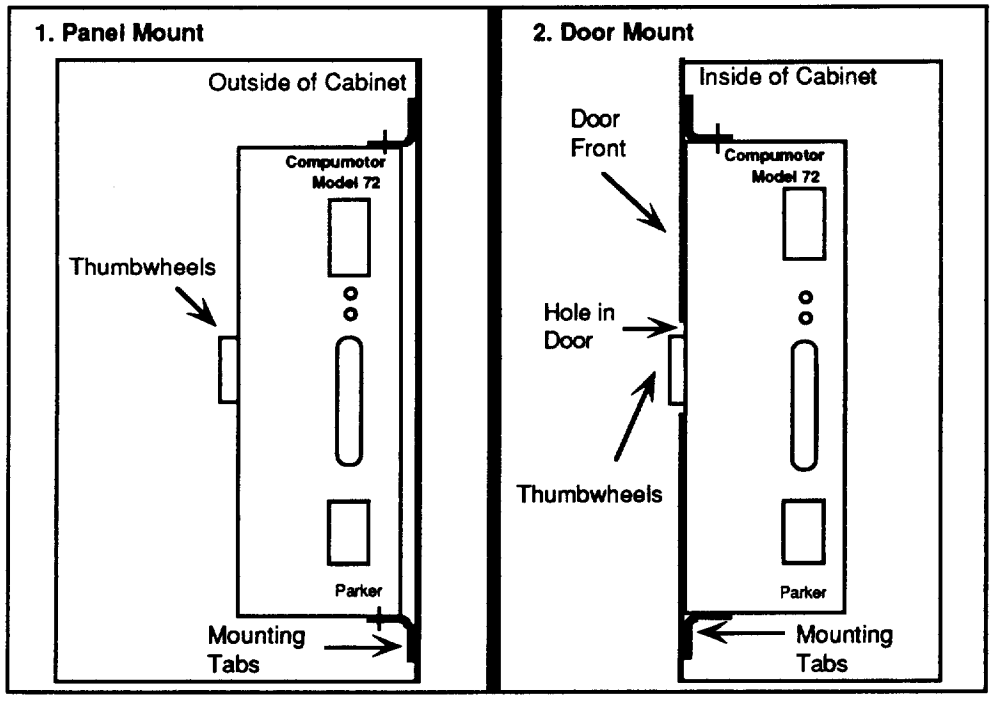


Figure 3-5. Panel & Door Mounting Guidelines

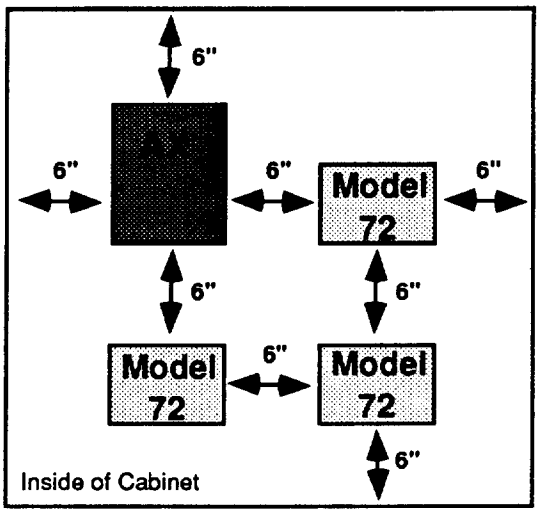


Figure 3-6. Vertical Clearance in Enclosure (Panel Mount)

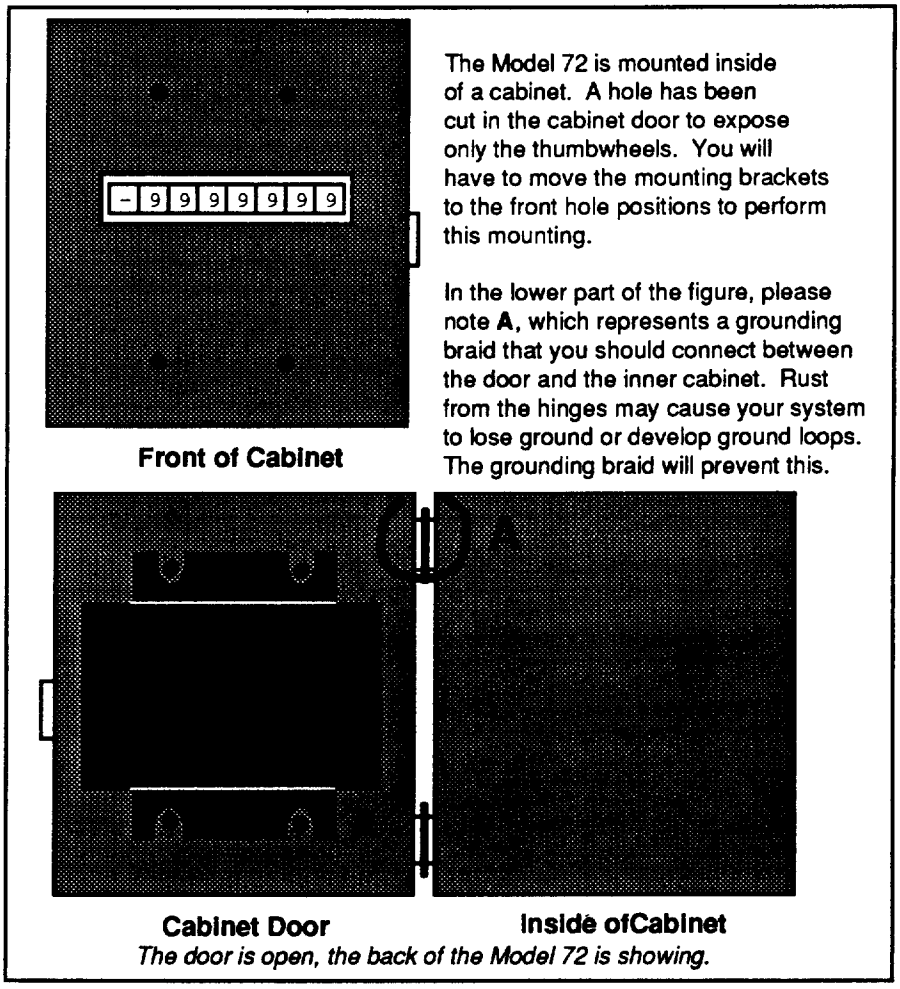


Figure 3-7. Door Mount—Front View

Inputs & Outputs

This section is only applicable for the Model 72 I/O. The following Model 72 I/O inputs and outputs will be discussed:

- Inputs
- OPTO-22 compatible inputs
- Outputs
- OPTO-22 compatible outputs

Inputs

The Model 72 I/O's inputs 1-12 are internally pulled up. They employ TTL 0 - 0.7VDC voltage low and 5-24VDC voltage high. **Since inverted logic is used, you must bring the input low (by tying it to ground) to represent a logic 1. Bringing the input high represents a logic Ø.** Use solid-state (optically isolated) relays. This will prevent electrical noise from impairing the performance of your application. Refer to Figure 3-8.

When you enter BCD data, inputs 1, 5, and 9 are the most significant bits (MSB) and inputs 4, 8, and 12 are the least significant bits (LSB).

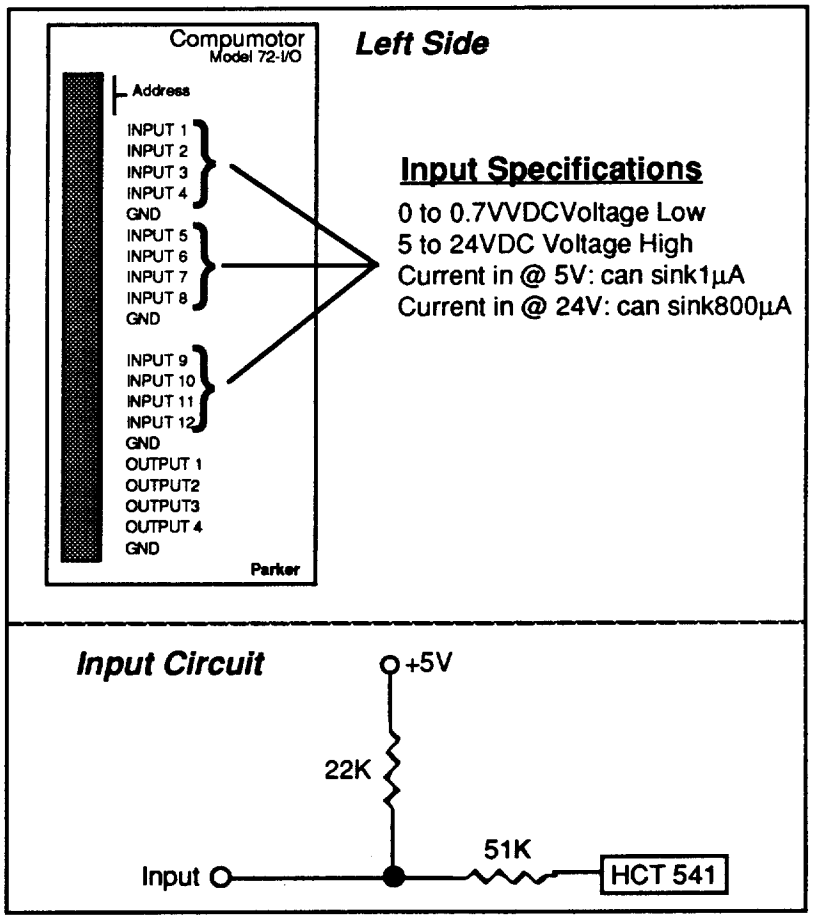


Figure 3-8. Model 72 I/O Inputs

OPTO-22 Compatible Inputs

Inputs 13-20 on the Model 72 I/O are dedicated for OPTO-22 compatible inputs. This connector's pinout is compatible with a PB8 OPTO-22 signal conditioning rack. The input connector provides +5VDC on pin 25 for an OPTO-22 style board. This +5VDC supply is common with pin 25 of the output header. This +5VDC supply delivers a maximum of 200mA.

When you enter BCD data, inputs 13 and 17 are the most significant bits (MSB) and inputs 16 and 20 are the least significant bits (LSB).

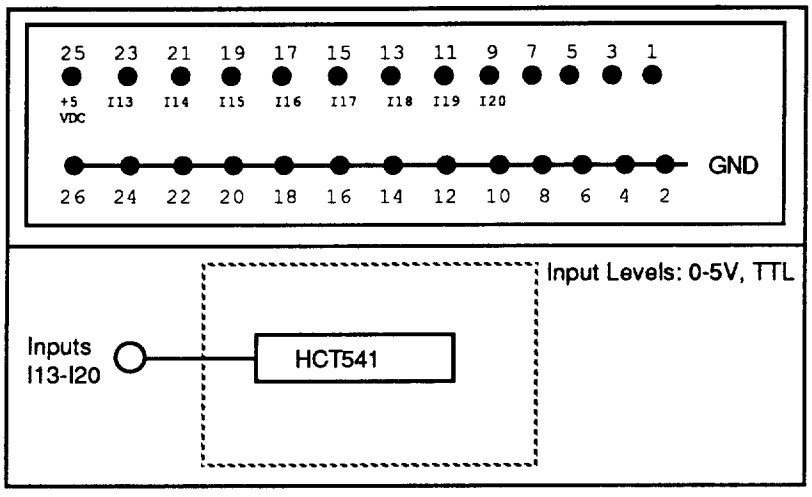


Figure 3-9. OPTO-22 Compatible Connector Pinouts

PB8 Wiring

Since Compumotor supplies +5VDC at pin 25 on the OPTO connectors to power the OPTO-22, PB8-style board (refer to Figure 3-10); you must be sure that pin 25 on the PB8-style board is jumpered to the +5VDC line. This line can handle a total of 200 mA of supply current. If the FAULT LED on the Model 72 comes on after you connect the PB8-style board to the Model 72, the board may be drawing too much current. In this case, remove the jumper from pin 25 and provide your own +5VDC power supply for the PB8-style board.

After you configure the +5VDC power supply to either the Model 72 or the user-supplied source, you can connect the PB8 style board as shown in Figure 3-10. Make sure that pin 1 on the OPTO connector lines up with Pin 1 on the PB8-style board

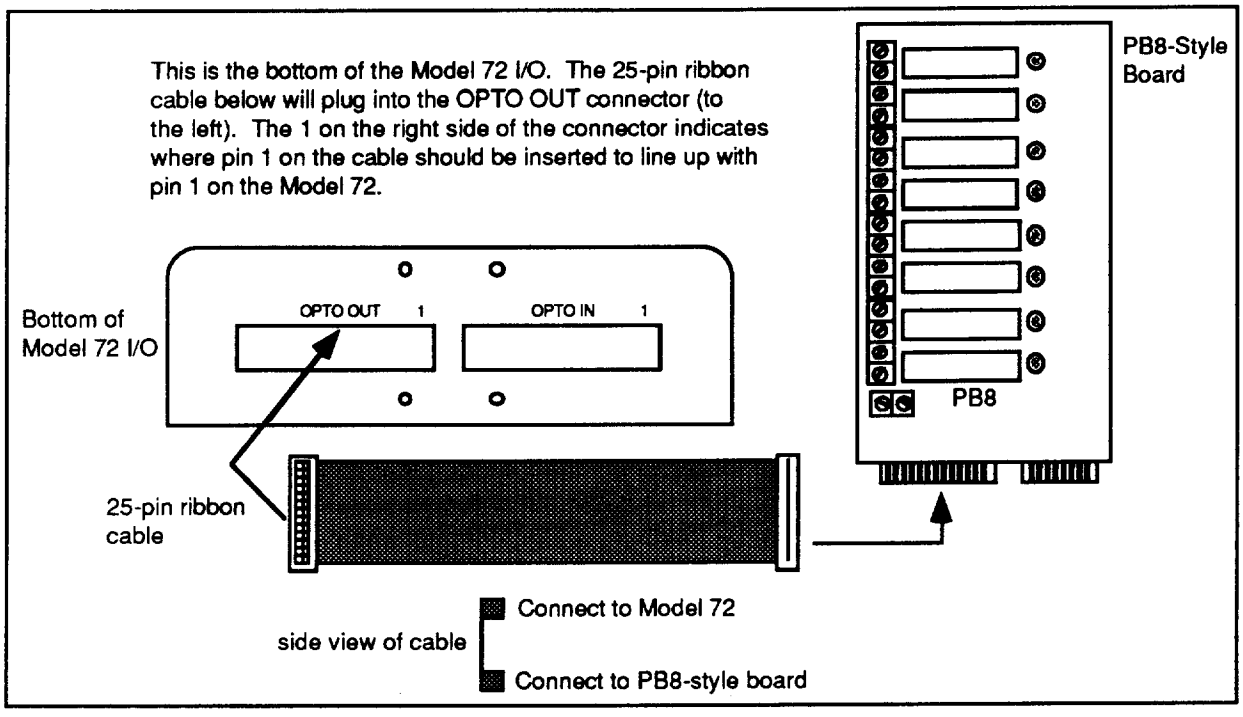


Figure 3-10. PB8 Wiring Diagram

Outputs

The Model 72 I/O's outputs 1-4 are open collector outputs. They can sink up to 240mA @5 - 24VDC. If your system cannot use these outputs directly, you will need a pull-up resistor and an external power supply (5 - 24VDC). *Choose a resistor that limits the current through the open-collector output to less than 240mA. Refer to Figure 3-11.*

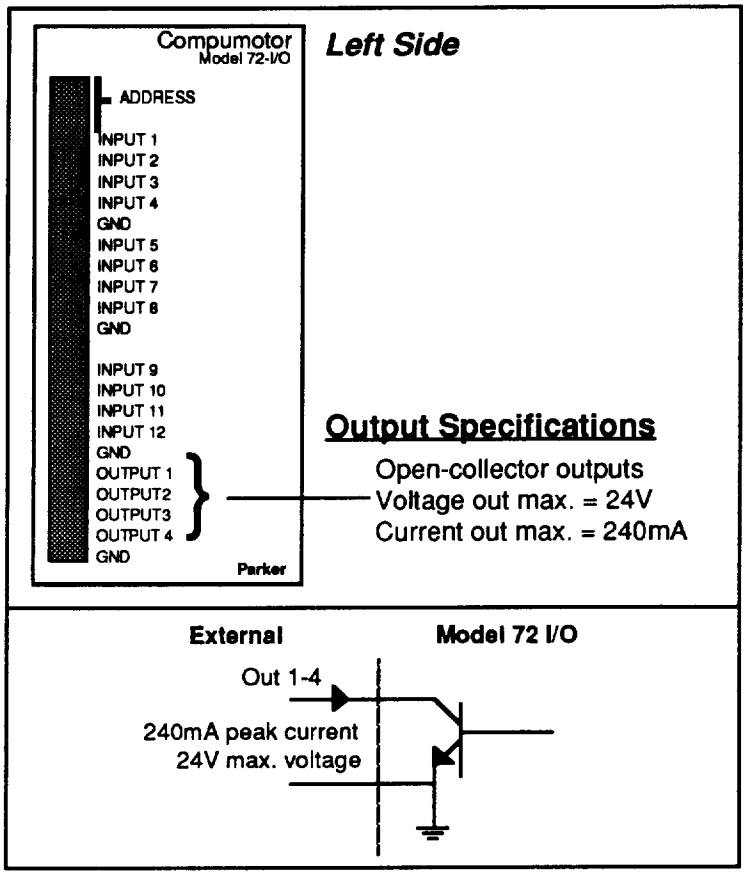


Figure 3-11. Model 72 I/O Outputs

OPTO-22 Compatible Outputs

Outputs 5-12 are TTL level outputs. Each output can drive up to 15-TTL loads. These outputs are compatible with PB8 OPTO-22 style boards. The output connector allows for a +5VDC supply of the OPTO-22 style boards. Refer to Figure 3-12.

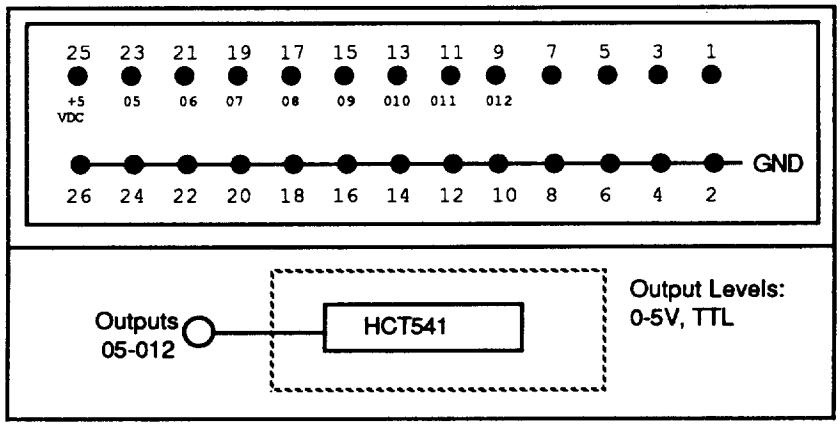


Figure 3-12. OPTO-22 Compatible Output Pinouts

Chapter 4. APPLICATION DESIGN

Chapter Objectives

The information in this chapter will enable you to:

- 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 develop your application

The Model 72 operates with an AX over a RS-232C serial communication line.

The AX requests information about the Model 72's thumbwheels or inputs, or sets the Model 72's outputs (over the RS-232C line). The Model 72 echoes this command, processes it (i.e., thumbwheel input requests), and responds with the proper information.

Application Considerations

You must deal with two issues in your application due to data transfer between the AX and the Model 72.

- Execution Time
- Electrical Noise

If you use the Model 72, the AX's command execution time will be longer than normal to allow data communication over the RS-232C line. Execution time will exceed a normal AX command by 1ms multiplied by the number of characters transmitted by the Model 72. For some commands, 20 ms may be required to complete the transmission.

A second Model 72 application consideration is electrical noise. Since data is transmitted over the RS-232C line, the system is susceptible to noise. A high level of electrical noise may cause the system to fault. Compumotor recommends that you shield the RS-232C lines and keep them away from high electrical noise regions.

If you plan to use the Model 72 I/O in an environment with a high level of electrical noise, use optically isolated solid-state relays to condition the signal inputs and outputs from the Model 72 I/O. Compumotor recommends that you optically isolate the I/O in all environments. Refer to Chapter 7, Troubleshooting for more information on electrical noise.

Modes of Operation

There are three modes of operation for the AX and Model 72 system.

- Standalone operation
- Host computer operation
- Programmable logic controller (PLC) operation

Standalone operation is the most common mode. Only the AX and Model 72(s) are connected and the AX runs stored sequences during operation.

In host computer operation, the host is connected to the Model 72's terminal port to communicate with the Model 72 and the AX.

In PLC mode, a PLC is connected to a Model 72-I/O's inputs and outputs to communicate via I/O or BCD data.

Standalone Operation

Standalone operation means that an application has no host computer or PLC connected to the AX or Model 72. The AX controls the application. The AX is typically pre-programmed with motion sequences (stored in its non-volatile memory).

The AX program examples below demonstrate the X Series language enhancements as described in Chapter 5, Software Reference.

Triggers

The Model 72 I/O's 20 inputs are addressed in groups of four triggers. The enhanced version of the Trigger (TR) command is used in the following example:

Command	Description/Response
`LD3`	Disables limits if connected.
`A10`	Sets acceleration to 10 rps^2.
`V5`	Sets velocity to 5 rps.
`MN`	Sets system to Normal mode.
`D1000`	Set distance to 1,000 steps.
`TR(1,11,Ø1XØ)`	Waits for input status of device #1's (Model 72) inputs 1-4 to have logic levels, low (Ø), high (1), don't care (X), low (Ø) respectively. The Model 72 I/O responds with `#TR` when inputs 1-4 have the levels Ø1XØ.
`G`	Execute the move (Go).

If you need a quicker response, Compumotor recommends that you use the AX's trigger inputs (see the AX User Guide).

You can obtain the status of the Model 72's inputs at any time through the enhanced Trigger Input Status Request (TS) command as can be seen below:

Command	Description
`TS(1,14)`	Requests status of inputs 13 - 16 the system responds with: `#TSØ1ØØ`.

The next several examples assume that the thumbwheels are set to the following values.

Time Delays

The Model 72 allows you to enter time delays through the enhanced Time (T) command.

Command	Description/Response
PS	Waits for a continue.
A10	Sets acceleration to 10 rps^2.
V10	Sets velocity to 10 rps.
MN	Sets system to Normal mode.
D10000	Sets distance to 10,000 steps.
T(1,7-8,1)	Specifies time delay as the value on thumbwheels 7 & 8. The Model 72 I/O responds with the number of seconds on thumbwheels 7 & 8: #T3.5.
G	Execute the move (Go).
C	Continue execution.

The AX waits 3.5 seconds after C is received, then moves 10,000 steps. The AX calculates the time delay after it receives the Model 72 response. The actual delay is slightly longer due to the command request and Model 72 response time.

Loops

You may use the Model 72-I/O to receive a loop count from input values with the enhanced Loop (L) command.

Command	Description/Response
A10	Sets acceleration to 10 rps^2.
V10	Sets velocity to 10 rps.
MN	Sets system to Normal mode.
D100	Sets distance to 100 steps.
L(1,11,Ø)	Specifies loop count as BCD value on inputs 1 - 4. The system responds with the loop number from inputs 1 - 4: #LØ.
G	Execute the move (Go).
N	Continue loop.

Programmable Outputs

The Model 72-I/O has 12 programmable outputs that you can control directly with the Output (O) command.

Command	Description/Response
A10	Sets acceleration to 10 rps^2.
V10	Sets velocity to 10 rps.
D1000	Sets distance to 1,000 steps.
G	Execute the move (Go).
O(1,11,ØØØØ)	Sets outputs 1-4 low.
D100	Sets distance to 100 steps.
G	Executes the Move (Go).
O(1,11,11XX)	Sets outputs 1 & 2 high, outputs 3 & 4 unchanged.

After making the 1,000-step move, outputs 1-4 are cleared. After making the 100-step-move, outputs 1 and 2 are set high.

Preset Mode Move Parameters

You can use the Model 72-I/O to input any or all move parameters (A, V, and D). For example, assume the thumbwheel setting below is in effect and the subsequent commands are issued. Assume BCD value of 3 at inputs 13-16.

Command	Description/Response
L1Ø	Sets loop count to 10.
A(1,14,2)	Requests BCD Data from inputs 13 - 16. Responds with: #A3.
V(1,7-8,1)	Sets the velocity to the values of thumbwheels 7 & 8. Responds with: #V7.8.
D(1,1-6,2)	Sets the distance to the values of thumbwheels 1 - 6. Responds with: #D-12345ØØ.
G	Executes the move (Go).
N	Continues loop.

Each time the AX executes the loop, it requests new values from the Model 72 I/O. If you place the move parameters in a loop, you can change the A, V, and D values for the next move. To speed processing, you may minimize the parameters within the loop that contains the move(s).

Continuous Mode Move Parameters

The AX can change velocity during a Continuous mode move. You define the new velocity and acceleration rate for the Model 72 via the enhanced CV and CA commands respectively. For example, assume the thumbwheel setting below is in effect and the subsequent commands are issued.

Command	Description/Response
MC	Selects Continuous mode.
A6Ø	Sets acceleration to 60 rps^2.
V18	Sets velocity to 18 rps.
G	Executes the move (go).
CL	Initiates a continuous loop.
CV(1,4-6,1)	Sets new Continuous mode velocity for thumbwheels 4 - 6 to $X10^{-1}$. Responds with 1.7 rps: #CV1.7.
CA(1,7-8,2)	Sets new Continuous mode acceleration to thumbwheels 7 & 8. Responds with 25 rps^2: #CA25.
CN	Ends the continuous loop.

The motor accelerates to 18 rps, at an acceleration rate of 60 rps^2. At this point, you can change the continuous acceleration or velocity rates ***on the fly*** *by changing* thumbwheels 4 - 8. *In Continuous mode (MC), you cannot use the Model 72 I/O's inputs. Use the AX's I/O instead.*

You can only perform on-the-fly velocity and acceleration changes with AX or AX-A software Rev. F and greater and Model 72 software Rev. C and greater.

To use the change of acceleration or velocity feature most effeciently in Continuous mode ***on the fly***, you must remove jumper JP8 on the Model 72. **Before you remove the Model 72's cover, remove power from the unit (it must be off)!** To remove jumper JP8, you must remove the Model 72's cover. Figure 4-1 shows the location of the screws that you must remove to take off the cover. Figure 4-2 shows the location of JP8 on the board.

If you daisy chain Model 72s, only the last unit in the chain must have jumper JP8 removed. With JP8 removed, the Model 72 will not echo data requests back to the AX. This enables the AX to parse commands more efficently, promoting smoother motor operation.

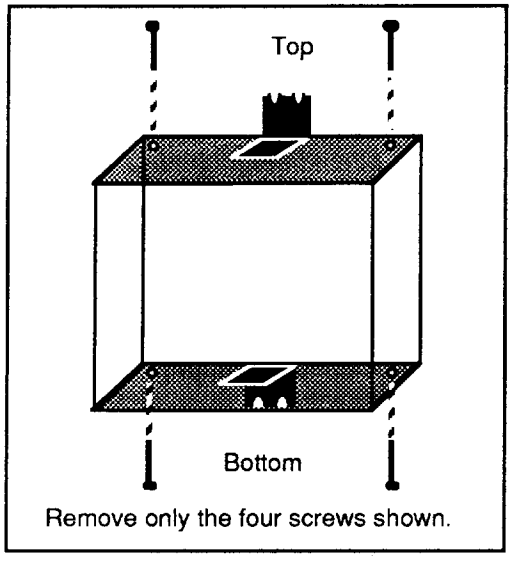


Figure 4-1. Remove Model 72 Cover

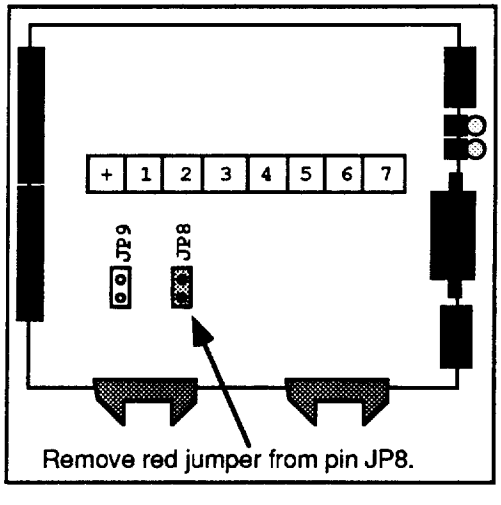


Figure 4-2. Location of Jumper JP8 on Model 72

Daisy Chaining

You may daisy chain up to 16 Model 72's with one AX. However, AXs may not be daisy chained with the Model 72's connected. Refer to Chapter 3, Installation. In the example below, three Model 72's are on a RS-232C daisy chain. Three moves are to be made repetitively with the thumbwheels, each representing the distance of the move. Assume the following thumbwheel settings:

#1	-	1	1	1	1	1	1	1
#2	-	2	2	2	2	2	2	2
#3	-	3	3	3	3	3	3	3

Command	Description/Response
`A5`	Sets acceleration to 5 rps^2.
`V5`	Sets velocity to 5 rps.
`MN`	Selects Normal mode.
`D(1,Ø,Ø)`	Defines distance as value on all 8 thumbwheels of device 1. Responds with the distance from all thumbwheels: `#D-1111111.`
`G`	Executes the move (Go).
`D(2,Ø,Ø)`	Defines distance as value on all 8 thumbwheels of device 2. Responds with the distance from all thumbwheels: `#D-2222222.`
`G`	Executes the move (Go).
`D(3,Ø,Ø)`	Define distance as value on all 8 thumbwheels of device 3. Responds with the distance from all thumbwheels: `#D-3333333.`
`G`	Executes the move (Go).

Multiple Parameters

A single Model 72 can be used to modify several AX parameters. Assume the following thumbwheel settings:

+	6	3	7	9	4	Ø	5

Command	Description/Response
`A(1,7-8,2)`	Sets acceleration to thumbwheel digits 7-8. Responds with `#A5.`
`V15`	Sets velocity to 15 rps.
`D(1,1-5,Ø)`	Sets distance to thumbwheel digits 1-5. Responds with: `#D+6379.`
`L(1,6,Ø)`	Sets loop count to thumbwheel digit 6. Responds with: `#L4.`

Distance Scaling

The AX can scale the distance specified by the `D` command to a number of steps per least significant digit (`US` command). This is used to allow distance to be programmed in linear units (inches, mm, etc.).

In the example below, assume the AX (12,800 steps/rev) drives a 5-pitch leadscrew (5 turns/inch). You may want to multiply the distance value by 64 to program distance in thousandths of inches (12,800 x 5 = 64,000 steps/inch, 64 steps = 0.0001 inches). The following thumbwheel setting is in effect.

+	Ø	3	1	7	5	9	9

Command	Description/Response
US64	Scales distance to 64 steps/LSD.
D(1,1-6,Ø)	Defines distance as thumbwheels 1-6. Responds with distance = 3175: **#D+3175.**
G	Executes the move, (Go) 3.175 inches (3,175 x 64 steps).

Selecting Sequences

The Model 72 allows you to select the AX sequence that you want to execute.

Command	Description/Response
XR(1,2)	Executes sequence displayed on thumbwheel digit 2. Responds with sequence 3: **#XR3.**

One possibility for using this command is running a sequence on powerup which contains a Model 72 sequence on request.

A power-up sequence for the AX-A might be programmed as follows.:

Command	Description/Response
XDØ4	Downloads power-up sequence.
SSA1	Turns echo function off.
A12	Sets acceleration to 12 rps^2.
V3	Sets velocity to 3 rps.
GH-2	Searches for home position.
MPA	Selects absolute positioning mode.
XT	Ends sequence definition.

Host Computer Operation

Host computer operation refers to a Model 72/AX cluster connected to computer via the last Model 72's terminal port. The host controls the application and issues commands to the AX. The application may or may not make use of the AX's non-volatile sequence storage.

There are no restrictions on issuing AX commands in this mode, with the exception of the Upload Sequence (XU). All examples discussed in the section on standalone operation will work with host computer operation.

You can download AX motion sequences to the AX or upload them from the AX via the Model 72's terminal port. No restrictions apply to downloading (XD) or running (XR) sequences. Sequence uploading (XU) requires some caution because the AX will issue the sequence and the Model 72 will insert replies to some commands and corrupt the relay to the host. To prevent this problem, turn off the Model 72's echo function (with the Echo ON/OFF [^E] command).

The host computer must be prepared to handle the Model 72's echoed responses. The computer must process or purge its RS-232C buffer.

Before you issue a Sequence Upload (XU) command, ensure that the Model 72's echo function is off. The Model 72's echo function is toggled ON or OFF with the ^E command. With the echo function off, the uploaded AX sequence passes through the Model 72 to your terminal without echoing back to the AX. You must turn the echo function back ON to allow proper Model 72-to-AX communication.

Uploading verifies the contents of an AX sequence and is not necessarily done by the host computer. In fact, uploading is most often used when a programmer is editing sequences with a terminal.

PLC Operation

A PLC can interact in several ways with an AX and Model 72. Figure 4-1 shows the PLC interacting with the AX's I/O, the Model 72 I/O's expanded inputs and outputs, or the Model 72 I/O's terminal RS-232C port.

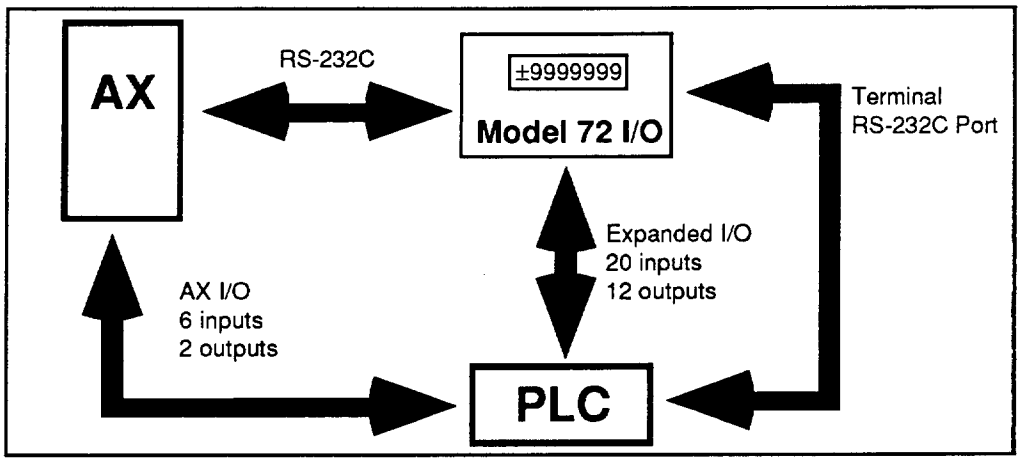


Figure 4-3. Model 72 I/O and PLC Operation

The following example uses a PLC to select one of two sequences through the AX's XP9 mode (refer to AX User Guide). A parameter is then input via the Model 72 I/O as defined by the PLC. The first sequence uses the PLC to trigger a move of distance supplied by the Model 72 I/O's thumbwheel digits 1 - 6.

Command	Description
XP9	Enters Sequence Scan mode.
XE7	Erases sequence #7.
XD7	Begins sequence #7 definition.
A1Ø	Sets acceleration to 10 rps^2.
V1Ø	Sets velocity to 10 rps.
O(1,11,1ØØØ)	Turns on output 1.
D(1,1-6,Ø)	Retrieves distance from thumbwheels 1 - 6.
G	Executes the move (Go).
O(1,11,ØØØØ)	Turns off output 1.
XT	Ends sequence #7 definition.

The second sequence uses the PLC to set a loop count

Command	Description
XE6	Erases sequence #6.
XD6	Begins sequence #6 definition.
O(1,11,1ØØØ)	Turns on output 1.
LD3	Disables the limits
A1Ø	Sets acceleration to 10 rps^2.
V1Ø	Sets velocity to 10 rps.
D1ØØØØ	Retrieves distance from thumbwheels 1 - 6.
L(1,11-12,Ø)	Reads the loop count from the PLC at input banks 11 and 12, which represents inputs 1 - 8.
G	Executes the move (Go).
N	Ends loops.
O(1,11,ØØØØ)	After completing loops, turns off output 1.
XT	Ends sequence #6 definition.
Z	Resets the drive.

This completes the programming for the two sequences.

To execute sequence #7, the PLC must verify that the Model 72 I/O's output 1 is off. This indicates that no sequences are currently being executed. The PLC will then turn on an output that is connected to the AX's sequence #1 input. This selects sequence #7, turns on the Model 72 I/O's output 1, and executes a move (distance defined by the Model 72's thumbwheels. When the move is complete, output 1 is turned off.

To execute sequence #6, the PLC must verify that the Model 72 I/O's output 1 is off. The PLC turns on an output that is connected to the AX's sequence #2 input. Output 1 will be turned on and the motor will move 10,000 steps n times (n is the two-digit BCD value at inputs 1 - 8). When the moves are complete, output 1 is cleared.

Move Parameters

A PLC can be used to input velocity data and initiate the move.

Command	Description/Response
A1Ø	Sets acceleration to 10 rps^2.
V(1,11,2)	Gets velocity from Model 72 I/O. Responds with the velocity of the BCD value at inputs 1 - 4.
D+1234	Sets distance to 1,234 steps.
TR(1,12,ØØØØ)	Waits until Model 72 I/O inputs 5-8 are logic Ø. Responds with: #TR.
G	Executes the move (Go).

When you use the PLC to enter numerical parameters through the Model 72's inputs, you must set the values 4 ms before the AX requests information from the Model 72.

Sequence Run

A PLC is connected to the Model 72-I/O's inputs 1-5 and will be used to select an AX sequence

Command	Description/Response
TR(1,12,ØXXX)	Waits for PLC to set input 5 to logic Ø. Responds with: #TR.
XR(1,11)	Runs the sequence corresponding to BCD value on inputs 1-4 from the PLC.

Chapter 5. SOFTWARE REFERENCE

Chapter Objectives

The information in this chapter will enable you to:

- Use the Model 72 and Model 72-I/O in conjunction with an AX Drive.

Description of Format (Definition of Fields)

①TR ②Programming	③Trigger			④VALID Model 72-I/O only Software Version
⑤SYNTAX	⑥UNITS	⑦RANGE	⑧DEFAULT	⑨ATTRIBUTES
TR(a, d, n)	a = address d = digits n = trigger or multiplier data	a = 1 - 16 d = 11 - 15 n = 0 or 1	N/A	Buffered Independently Saved
⑩AX REQUEST IS *TR(a,d,n)				
⑪MODEL 72 RESPONSE TO *TR(a,d,n,) IS #TR (if the condition is met)				

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

2. ***Command Type*** — This portion of the box contains the command type. The four command types are listed below.

STATUS — Status commands respond (report back) with information.

SET-UP — Setup commands define initial conditions and parameters for the application. Setup commands include the following types:

- Homing (Go home acceleration and velocity, etc.)
- Input/Output (Limits, scan time, in-position time, etc.)
- General (Set switches, EEPROM storage, return to factory settings, etc.)
- Motion (Positioning mode, encoder parameters, scaling, etc.)

PROGRAMMING Programming commands affect programming and program flow. For example, trigger, output, all sequence commands, quote, time delays, pause and continue, enable, loop and end loop, line feed, carriage return, and backspace.

MOTION Motion commands affect motor motion (i.e., acceleration, velocity, distance, go home, stop, direction, mode, etc.).

3. *Full Name*

This field contains the full command name.

4. *Valid Revision Level*

This field contains the revision history of the command. It includes the revision of AX software when the command was added or modified. If the revision level of the AX software you are using is equal to or greater than the revision level listed in this field, you are using the proper version of the software. *This field also tells you if the command is only valid in the Model 72 I/O. Remember, Model 72 commands are a subset of the Model 72 I/O's commands.*

The Model 72 only operates with AX's that have enhanced software (revision E or greater). The enhanced software allows you to address the Model 72 via a new addressing format.

5. *Syntax (Addressing Matrix)*

The addressing matrix contains two or three fields that are divided by commas and set off by parentheses.

a : The first field is the Model 72's device address. If you are using a daisy chain configuration, you must enter a unique Model 72 address in this field.

d : The second field determines which thumbwheel(s) or input(s)/output(s) the command will use.

d	Input	Output
Ø	All thumbwheel digits	
1	Thumbwheel #1(±)	
2	Thumbwheel #2 (MSD)	
3	Thumbwheel #3	
4	Thumbwheel #4	
5	Thumbwheel #5	
6	Thumbwheel #6	
7	Thumbwheel #7	
8	Thumbwheel #8	
-		
10	All 20 Inputs	
11	Inputs 1-4	Outputs 1-4
12	Inputs 5-8	Outputs 5-8
13	Inputs 9-12	Outputs 9-12
14	Inputs 13-16	
15	Inputs 17-20	

Table 5-1. Thumbwheel Selection Table

Refer to the Enhanced AX Command List for examples of the addressing matrix.

The I/O selection values 11, 12, 13, 14, and 15 each address 4 inputs (or outputs). These groups of 4 are referred to as input banks (and output banks). Each bank is referred to by its value. For instance, input bank 11 refers to inputs 1 - 4 (refer to Table 5-1).

n : The third field (for Model 72's only) is the data field. You can use this field for scaling or defining input/output requests.

When the data field is used as a scaling multiplier, the variable **n** is the exponent (10^n) of the scaling factor (i.e., 0.01×10^n). The complete scaling mutiplier is shown in parentheses in the **UNITS** field of each command example.

When the data field is used for trigger and output commands, **n** represents a bank of four digits. These digits represent the I/O levels of the I/O selected. The variable **n** may be **0**, **1**, or **X**.

6. Units This field describes what unit of measurement the parameters in the command 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 AX executes immediate commands as soon as it receives them. Buffered commands are executed in the order that they are received with other buffered commands. You can store buffered commands in a sequence and save them in permanent memory.

10. Request In all cases, enhanced X commands cause the AX to transmit the command to the Model 72(s) preceded by an asterisk. This transmission follows **AX REQUEST IS.**

11. Model 72 Response In most cases, the Model 72 provides a response to the AX request. This response is shown in the box after **MODEL 72 RESPONSE TO ___ IS ___** ***This box will appear only if the system provides a response to the command.***

Any software command that addresses the Model 72-I/O's inputs or outputs will be ignored by the Model 72. Any improper software commands are ignored by both the Model 72 and Model 72-I/O. The AX, however, may lock-up if Model 72 I/O commands are sent to a Model 72. (You may use the Reset [z] command or cycle power to unlock the system.

Execution Time

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.

The Model 72 and AX communicate data and commands over a serial interface. Therefore, the processing time for Model 72 commands will be significantly greater than for AX commands, which do not invoke communication with the Model 72. For example, the distance (D) command takes less than 2 ms, commands that request all the thumbwheel data will take 23 ms. In this case, the command's execution time is approximately 12 times as long as a non-Model 72 command. For smaller data fields, the difference will be less. In some applications, you must consider this delay as you plan your application.

The communication delay between the Model 72 and AX is approximately 1ms per character transmitted between them.

Enhanced AX Commands

The revised AX software (rev. E or later) allows you to transfer data between the Model 72 and the AX. Only 13 of the X commands are enhanced. These commands are **A**, **CA**, **CTM**, **CV**, **D**, **H**, **L**, **O**, **T**, **TR**, **TS**, **V**, and **XR**. The enhancements all use a similar format. This format adds an *addressing matrix* suffix to the original X command.

Command List

A Motion	**Acceleration**			**VALID** AX Software Revision E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
A(a, d, n)	a = address d = digits n = multiplier (0.01 X 10^n)	a = 1 - 16 d = 0 - 15 n = 0 - 9	N/A	Buffered
AX REQUEST IS *A(a,d,n)				
MODEL 72 RESPONSE TO *A(a,d,n) **IS** #A<digits x .01 x 10^n>				

MODEL 72 DESCRIPTION

This command requires all addressing fields. With **n = 0**, the least significant thumbwheel digit is one hundredth of an rps^2.

AX DESCRIPTION

The **A** 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 **G** commands. Accelerations beyond the valid range cause the acceleration to remain in the previous valid acceleration setting. The maximum acceleration that the AX will accept is 999.99 rps^2.

EXAMPLE

Assume the input banks have the following values: Bank 11 = **BCD 5**, Bank 12 = **BCD 3**, Bank 13 = **BCD 7**, Bank 14 = **BCD 9**, Bank 15 = **BCD Ø**. The thumbwheel setting below is used.

Command	AX Request	Model 72 Response	Description
A(1,7-8,2)	*A(1,7-8,2)	#A67	Reads Model 72 #1 and sets the acceleration to the BCD values of thumbwheel digits 7 & 8 (**67 rps^2**).
A(2,13,3)	*A(2,13,3)	#A7Ø	Reads Model 72 #1 and sets the acceleration to the BCD values on input bank13 multiplied by 10 (**70 rps^2**)

CA Motion	**Change Acceleration**			**VALID** AX Software Revision E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
CA(a, d, n)	a = address d = digits n = multiplier (0.01 X 10^n)	a = 1 - 16 d = 0 - 15 n = 0 - 9	N/A	Buffered
AX REQUEST IS *CA(a,d,n)				
MODEL 72 RESPONSE TO *CA(a,d,n) **IS** #CA<digits x .01 x 10^n>				

MODEL 72 DESCRIPTION

The Change Acceleration (**CA**) command requires all addressing fields. With **n** = 0, the least significant thumbwheel digit is one hundredth of an rps^2.

AX DESCRIPTION

The Change Acceleration (**CA**) command allows you to change the acceleration rate in Continuous mode, at a constant velocity. The maximum acceleration that the AX will accept is 99.99 rps^2.

EXAMPLE

Assume the input banks have the following values: Bank 11 = **BCD 5**, Bank 12 = **BCD 3**, Bank 13 = **BCD 7**, Bank 14 = **BCD 9**, Bank 15 = **BCD Ø**. The thumbwheel setting below is used.

Command	AX Request	Model 72 Response	Description
CA(1,7-8,2)	*CA(1,7-8,2)	#CA67	Reads Model 72 #1 and sets the acceleration to the BCD values of thumbwheel digits 7 & 8 (**67 rps^2**).
CA(2,13,3)	*CA(2,13,3)	#CA7Ø	Reads Model 72 #1 and sets the acceleration to the BCD values on input bank13 multiplied by 10 (**70 rps^2**)

Refer to Chapter 4, Application Design for examples uses of the **CA** command with other commands.

CTM Programming	**Constant Velocity Time Delay**			**VALID** AX Software Revision E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
CTM(a, d, n)	a = address d = input bank n = multiplier (0.01 X 10^n)	a = 1 - 16 d = 0 - 15 n = 0 - 9	N/A	Buffered
AX REQUEST IS *CTM(a,d,n)				
MODEL 72 RESPONSE TO *CTM(a,d,n) **IS** #CTM<digits x .01 x 10^n>				

MODEL 72 DESCRIPTION

The Constant Velocity Time Delay (**CTM**) command requires all three addressing fields. The variable **n** = Ø. The least significant digit represents one hundredth of a second.

AX DESCRIPTION

The **CTM** command causes the indexer to wait the number of seconds that you specify before it executes the next command in the buffer (in Continuous mode at constant velocity).

EXAMPLE

Assume the input banks have the following values: Bank 11 = **BCD 5**, Bank 12 = **BCD 3**, Bank 13 = **BCD 7**, Bank 14 = **BCD 9**, Bank 14 = **BCD Ø**. The thumbwheel setting below is used.

Command	AX Request	Model 72 Response	Description
CTM(2,2-4,1)	*CTM(2,2-4,1)	#CTM12.3	Changes the time delay to the BCD values of thumbwheel digits 2 -4 multiplied by 0.1 on Model 72 #2 (**12.3 seconds**)

CV Motion	**Velocity**			**Valid** AX Software Revision E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
CV(a, d, n)	a = address d = digits n = multiplier (0.01 X 10^n)	a = 1 - 16 d = 10 - 15 n = 0-9	N/A	Buffered
AX REQUEST IS *CV(a,d,n)				
MODEL 72 RESPONSE TO *CV(a,d,n) **IS** #CV <digits x .01 x 10^n>in rps				

MODEL 72 DESCRIPTION

The Change Velocity (CV) command requires all three addressing fields. The variable **n** = 0. The least significant digit is one hundredth of an rps.

AX DESCRIPTION

The CV command allows you to change the velocity in Continuous mode, at a constant velocity. The maximum velocity you can define in the AX is 50 rps. The AX will ignore a velocity command greater than 50 rps.

EXAMPLE

Assume the input banks have the following values: Bank 11 = **BCD 5**, Bank 12 = **BCD 3**, Bank 13 = **BCD 7**, Bank 14 = **BCD 9**, Bank 15 = **BCD Ø**. The thumbwheel setting below is used.

-	1	2	3	4	5	6	7

Command	AX Request	Model 72 Response	Description
CV(1,2-3,1)	*CV(1,2-3,1)	#CV1.2	Changes velocity to the thumbwheel values of digits 2 and 3 from Model 72 #1 multiplied by 0.1 (**1.2 rps**)

D Motion	**Distance**			**VALID** AX Software Revision E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
D(a, d, n)	a = address d = digits or input bank n = multiplier (10^n)	a = 1 - 16 d = 0 - 15 n = 0 - 9	N/A	Buffered
AX REQUEST IS *D(a,d,n)				
MODEL 72 RESPONSE TO *D(a,d,n,) **IS** #D <Digits x 10^n>				

MODEL 72 DESCRIPTION

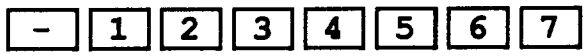
The Distance (D) command requires all three addressing fields. With **n** = 0, the least significant digit is in the ones place in steps.

AX 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.

EXAMPLE

Assume the input banks have the following values: Bank 11 = **BCD 5**, Bank 12 = **BCD 3**, Bank 13 = **BCD 7**, Bank 14 = **BCD 9**, Bank 15 = **BCD Ø**. The thumbwheel setting below is used.



Command	AX Request	Model 72 Response	Description
D(1,Ø,Ø)	*D(1,Ø,Ø)	#D-1234567	Sets the distance to the values of all thumbwheel digits (**-1234567 steps**)
D(4,12-15,2)	*D(4,12-15,2)	#D379ØØØ	Sets distance to BCD value of inputs 12 - 15 multiplied by 100 (**379,000 steps**)

Note: To make the thumbwheel setting be in familiar user units, use the User Scaling (US) command in conjunction with Distance (D) command. If the command US32 preceded the D(a,d,n) or Dnnn command, the distance would be multiplied by 32 to yield the actual number of steps (or position) for the next move.

H Motion	Set Direction			VALID AX Software Revision E
SYNTAX H(a,1)	**UNITS** a = address	**RANGE** a = 1 - 16	**DEFAULT** N/A	**ATTRIBUTES** Buffered
AX REQUEST IS *H(a,1)				
RESPONSE TO *H(a, 1) **IS** #H±				

MODEL 72 DESCRIPTION

The Set Direction (**H**) command makes the AX request the direction from the Model 72 thumbwheel digit 1 (+/-). The third field is not used with this command.

AX 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 **H** command can set the direction of motion.

EXAMPLE

Command	AX Request	Model 72 I/O Response	Description
H(3,1)	*H(3,1)	#H±	Model 72 #3 thumbwheel 1 sets the direction of the move

L Motion	**Loop**			**VALID** AX Software Revision E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
L(a, d, n)	a = address d = digits n = multiplier (10^n)	a = 1 - 16 d = 0 - 15 n = 0 - 9	N/A	Buffered
AX REQUEST IS *L(a,d,n,)				
MODEL 72 RESPONSE TO *L(a,d,n) **IS** #L <Digits x 10^n>				

MODEL 72 DESCRIPTION

The L command requires all three addressing with fields. With n = Ø, the least significant bit is in the ones place.

AX 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 a direct numerical input or a Model 72's response to an AX request. 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. Refer to the AX User Guide for more information on the Y command. The Immediate Pause (U) command allows you to temporarily halt loop execution. You can use the Continue (C) command to resume loop execution.

EXAMPLE

Assume the input banks have the following values: Bank 11 = **BCD 5**, Bank 12 = **BCD 3**, Bank 13 = **BCD 7**, Bank 14 = **BCD 9**, Bank 15 = **BCD Ø**. The thumbwheel setting below is used.

Command	AX Request	Model 72 Response	Description
L(1,6,2)	*L(1,6,2)	#L5ØØ	Sets the loop count to the thumbwheel digit 6 multiplied by 100 (**500 loops**).
L(1,11-12,Ø)	*L(1,11-12,Ø)	#L53	Sets the loop count to the BCD values at inputs 1-4 and 5-8 (**53 loops**).

O Programming	Output			VALID AX Software Revision E Model 72-I/O only
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
O(a, d, n)	a = address d = output bank n = output data	a = 1 - 16 d = 11 - 13 n = 0,1, or x	N/A	Buffered
AX REQUEST IS *O(a,d,n)				

MODEL 72 I/O DESCRIPTION

The Output (O) command requires all three addressing fields. The third field (n) represents the output data. You must enter one of the following values in this field:

Ø = low; current does not flow
1 = high; current flows
X = do not change

The output command may only address one bank of four outputs at a time.

AX DESCRIPTION

The Output (O) command turns the programmable output bits 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.

EXAMPLE

Command	AX Request	Model 72-I/O Response	Description
O(1,11,ØØØØ)	*O(1,11,ØØØØ)	None	Sets outputs 1-4 low at device #1.
O(1,11,XX1X)	*O(1,11,XX1X)	None	Sets output 3 high at device #1

T Programming	**Time Delay**			**VALID** AX Software Revision E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
T(a, d, n)	a = address d = input bank n = multiplier (0.01 X 10^n)	a = 1 - 16 d = 0 - 15 n = 0 - 9	N/A	Buffered
AX REQUEST IS *T(a,d,n)				
MODEL 72 RESPONSE TO *T(a,d,n) **IS** #T<digits x .01 x 10^n>				

MODEL 72 DESCRIPTION

The Time Delay (**T**) command requires all three addressing fields. With n = Ø, the least significant digit represents one hundredth of a second.

AX DESCRIPTION

The Time Delay (**T**) command causes the indexer to wait the number of seconds that you specify before it executes the next command in the buffer. This command is useful whenever you need to delay the motor's actions.

EXAMPLE

Assume the input banks have the following values: Bank 11 = **BCD 5**, Bank 12 = **BCD 3**, Bank 13 = **BCD 7**, Bank 14 = **BCD 9**, Bank 15 = **BCD Ø**. The thumbwheel setting below is used.

Command	AX Request	Model 72 Response	Description
T(2,2-4,1)	*T(2,2-4,1)	#T12.3	Sets the time delay to the values of thumbwheel digits 2 -4 multiplied by 0.1 (**12.3 seconds**).

TR Programming	**Trigger**			**VALID** AX Software Revision E Model 72-I/O only
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
TR(a, d, n)	a = address d = input bank n = trigger conditions	a = 1 - 16 d = 11 - 15 n = 0,1, or x	N/A	Buffered
AX REQUEST IS *TR(a,d,n)				
MODEL 72-I/O RESPONSE TO *TR(a,d,n) **IS** #TR *(When condition is met)*				

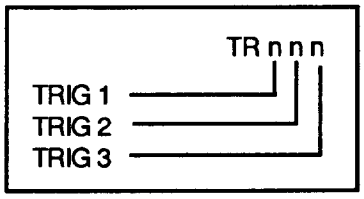
MODEL 72-I/O DESCRIPTION

The **TR** command uses all three address fields. The third field represents the trigger condition (Ø = high, 1 = GND, X = don't care), for the input bank selected by the second field prior to the trigger condition, the AX halts buffered command processing. When the trigger condition occurs, the Model 72-I/O response is **#TR**. This permits the AX to resume execution. Only one input bank may be addressed per **TR** command.

AX DESCRIPTION

Triggers synchronize indexer operations with external events. You can use them to invoke a handshaking function with other devices. The nnn variables are listed below:

1 = Input grounded (ON)
0 = Input not grounded (OFF)
X = Don't care



When the indexer receives the **TR** command in a buffer, it waits until the input pattern is matched before going on to the next command.

EXAMPLE

Command	AX Request	Model 72-I/O Response	Description
TR(1,15,Ø1XX)	*TR(1,15,Ø1XX)	#TR	The AX stops buffered command processing until the Model 72 I/O's inputs 17 & 18 are low and high respectively.

TS Programming	**Trigger Status**			**VALID** AX Software Revision E Model 72-I/O
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
TS(a, d)	a = address d = input bank	a = 1 - 16 d = 10 - 15	N/A	Buffered
AX RESPONSE TO TS(a,d) **IS** *TS(a,d)				
MODEL 72 RESPONSE TO *TS(a,d) **IS** #TS <input levels 0 or 1>				

MODEL 72 DESCRIPTION

The Trigger Status (**TS**) command shows the state of the trigger inputs. The **TS** command does not require the third addressing field. Input level 0 corresponds to a 5-24VDC high and Input level 1 corresponds to a 0 - 0.7VDC low.

AX DESCRIPTION

This command retrieves the state of the trigger inputs. **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 ensure that your trigger pattern is met, enter the **TS** command.

EXAMPLE

Assume the input banks have the following values: Bank 11 = **BCD 5**, Bank 12 = **BCD 3**, Bank 13 = **BCD 7**, Bank 14 = **BCD 9**, Bank 15 = **BCD Ø**.

Command	AX Request	Model 72-I/O Response	Description
TS(1,12)	*TS(1,12)	#TSØØ11	Displays the values of inputs 5-8 of device #1 (inputs 5 - 8 have logic levels of .ØØ11).
TS(2,1Ø)	*TS(2,10)	#TSØØ1...Ø	Displays all of the input values 1-20 of device #2.

US Programming	**User Scaling**			**VALID** AX Software Revision E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
USn	n = nnn.nnn	n = .001-999.999	1	Buffered

MODEL 72 DESCRIPTION

The User Scaling (US) command allows you to use user units (inches, mm, etc.) with the AX. Any Distance (D) command that follows a US command will be multiplied by the US value. Fractional parts are rounded to the nearest step.

EXAMPLE

Command	Description
US132.500	Sets scaling factor to 132.5. A distance of 1 would be multiplied by 132.5—yielding 133 steps.
US52.499	Sets scaling factor to 52.499. A distance of 1 would be multiplied by 52.499—yielding 52 steps.

V Motion	**Velocity**			**Valid** AX Software Revision E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
V(a, d, n)	a = address d = digits n = multiplier (0.01 X 10^n)	a = 1 - 16 d = 10 - 15 n = 0-9	N/A	Buffered
AX REQUEST IS *V(a,d,n)				
MODEL 72 RESPONSE TO *V(a,d,n) **IS** #V <digits x .01 x 10^n>in rps				

MODEL 72 DESCRIPTION

The Velocity (V) command requires all three addressing fields. With n = 0 as the least significant digit is one hundredth of an rps.

AX DESCRIPTION

The V command defines the maximum speed at which the motor will run when given the Go (G) command.

The top speed of the motor drive is limited by the size motor and the amount of the load. Entering a velocity higher than the top speed of your AX system will cause the motor to stall.

The maximum velocity you can define in the AX is 50 rps. The AX will ignore a velocity command greater than 50 rps.

EXAMPLE

Assume the input banks have the following values: Bank 11 = **BCD 5**, Bank 12 = **BCD 3**, Bank 13 = **BCD 7**, Bank 14 = **BCD 9**, Bank 15 = **BCD Ø**. The thumbwheel setting below is used.

Command	AX Request	Model 72 Response	Description
V(1,2-3,1)	*V(1,2-3,1)	#V1.2	Sets velocity to values of thumbwheel digits 2 and 3 multiplied by 0.1 (**1.2 rps**)

XR Programming	**Sequence Run**			**VALID** AX Software Revision E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
XR(a, d)	a = address d = digits or input bank	a = 1 - 16 d = 0 - 15	N/A	Buffered
AX REQUEST IS *XR(a,d)				
MODEL 72 RESPONSE TO *XR(a,d) **IS** #XR<digits>				

MODEL 72 DESCRIPTION

The Sequence Run (**XR**) command allows you to use the Model 72 I/O's thumbwheels or inputs to run in a sequence. Only the first two of the addressing fields are required for this command.

AX DESCRIPTION

This command loads a predefined sequence 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 (e.g., **XR** acts like GOTO, not GOSUB). If you are in Continuous mode, the velocity must be 0 rps when you call another sequence. *An* ***XR*** *command within a loop will be ignored.*

EXAMPLE

Assume the input banks have the following values: Bank 11 = **BCD 5**, Bank 12 = **BCD 3**, Bank 13 = **BCD 7**, Bank 14 = **BCD 9**, Bank 15 = **BCD Ø**. The thumbwheel setting below is used.

Command	AX Request	Model 72 Response	Description
XR(2,3-4)	*XR(2,3-4)	#XR23	Sets the sequence run to the values of thumbwheels 3 & 4 on device #2 (**Run Sequence #23**).
XR(1,13)	*XR(1,13)	#XR7	Sets the sequence run to the BCD values of inputs 9-12 on device #1 (**Run Sequence #7**).

Model 72 Commands

The following commands are not part of the enhanced AX command set. These commands are strictly designed for the Model 72. ***The ^ is not a control—CTRL-character. It is generated by pressing SHIFT-6 on most keyboards. In ASCII, ^ is 94 decimal.***

^2 Programming	Test Thumbwheels and Inputs			VALID Model 72 Software Revision A
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
^2(n)	None	None	None	Buffered

MODEL 72 DESCRIPTION

Typing ^2 will command the Model 72 and Model 72-I/O to display (repeatedly) their thumbwheel and/or input values. To exit this mode, press any key.

Since inputs 13 - 20 are not pulled up internally, they are floating inputs. Their values may alternate from Ø to 1.

EXAMPLE

Command	Model 72 I/O Response	Description
^2	- 9999999 ØØØØ ØØØØ ØØØØ ØØØØ ØØØØ	Activates test mode and displays current state of thumbwheel inputs 1 - 8, discrete inputs 1-12, and OPTO outputs 13 - 20 8 (for the Model 72, only thumbwheel inputs 1 - 8 are displayed)

^A Programming	Address Request			VALID Model 72 Software Revision B
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
^A(n)	None	None	None	Buffered

MODEL 72 DESCRIPTION

If you enter **^A** via the terminal port, you will request an address report back from the Model 72. The Model 72 will respond with its current address (a value between 1 and 16).

^E Programming	Echo ON/OFF			VALID Model 72 Software Revision A
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
^E(n)	None	None	None	Buffered

MODEL 72 DESCRIPTION

If you enter **^E**, the Model 72 will toggle the echoes off at each Model 72 port. ***The ^ is not a control—CTRL-character. It is generated by pressing SHIFT-6 on most keyboards. In ASCII, ^ is 94 decimal.*** Data entered into Port 1 or 2 will be sent out the other port but will not be echoed out the same port where it was entered. To re-enable the echo function, type **^E**.

You should use this command when you upload sequences from an AX through a Model 72's terminal port. The Model 72's echo function must be OFF when you upload an AX sequence.

^RV Programming	Revision Request			VALID Model 72 Software Revision B
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
^RV(n)	None	None	None	Buffered

MODEL 72 DESCRIPTION

If you enter **^RV** via the terminal port, you will request a software revision report back from the Model 72. Model 72s with software levels B and greater will provide the following response: **92-010649-01XX**.

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)
- Use this chapter as a quick-reference tool for proper I/O connections

Environmental Specifications

Compumotor recommends that you operate and store your Model 72 under the following conditions:

- Operating Temperature: 32°F to 122°F (0°C to 50°C)
- Storage Temperature: -22°F to 185°F (-30°C to 85°C)
- Humidity: 0% to 95% non-condensing

Electrical Specifications

I/O Specifications

This section refers to the Model 72 and Model 72 I/O's inputs and outputs.

Power

You must supply 115VAC ±10% to the input (see Figure 6-1).

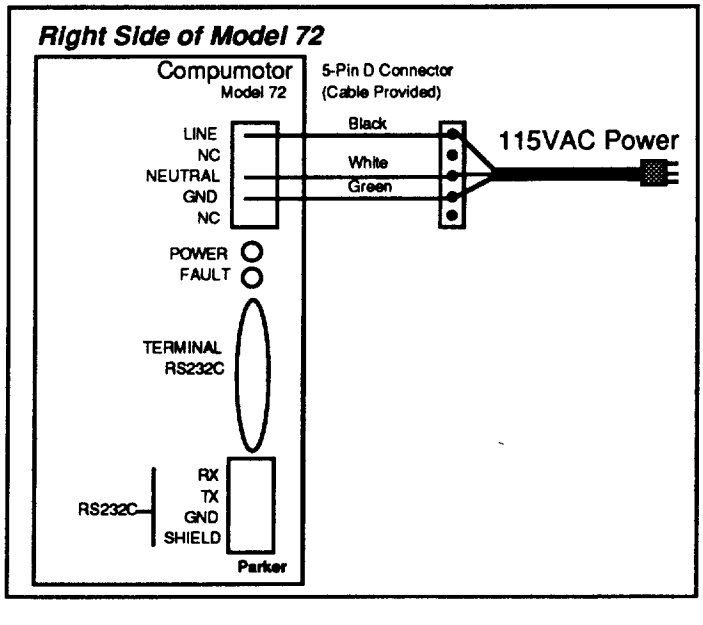


Figure 6-1. Power Supply

Terminal Communication

You can communicate with the Model 72 and the AX via the Model 72's terminal RS-232C port. You must wire the TX , RX , and GND (logic ground) inputs as shown in Figure 6-2.

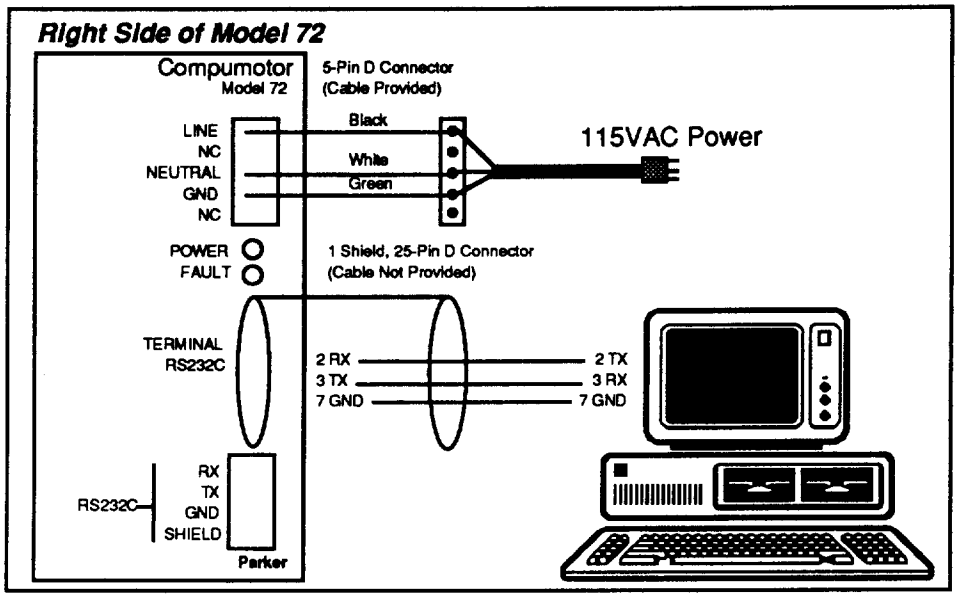


Figure 6-2. Basic Wiring

RS-232C Communication

To allow for communication between the Model 72 and AX, you must wire the TX, RX, and GND inputs as shown in Figure 6-3. RS-232C communication parameters are fixed at :

- 9,600 baud rate
- 8 data bits
- 1 stop bit
- No parity

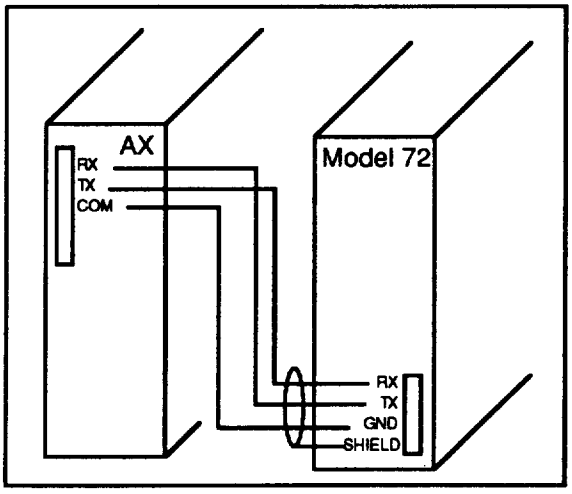


Figure 6-3. RS-232C Wiring

Inputs 1-12 (Model 72-I/O)

There are 12 general-purpose inputs, with three I/O grounds. The inputs do not have an internally isolated supply. **Input voltage**: TTL logic levels 5 - 24VDC (high current limiting resistor not needed).

These inputs are normally high or logic 0. You must close contact to 0V (GND) or sink 220µA to bring the input low or logic 1. The Model 72-I/O uses negative logic. *The input configuration must be stable for 4 ms to be recognized by the Model 72-I/O.*

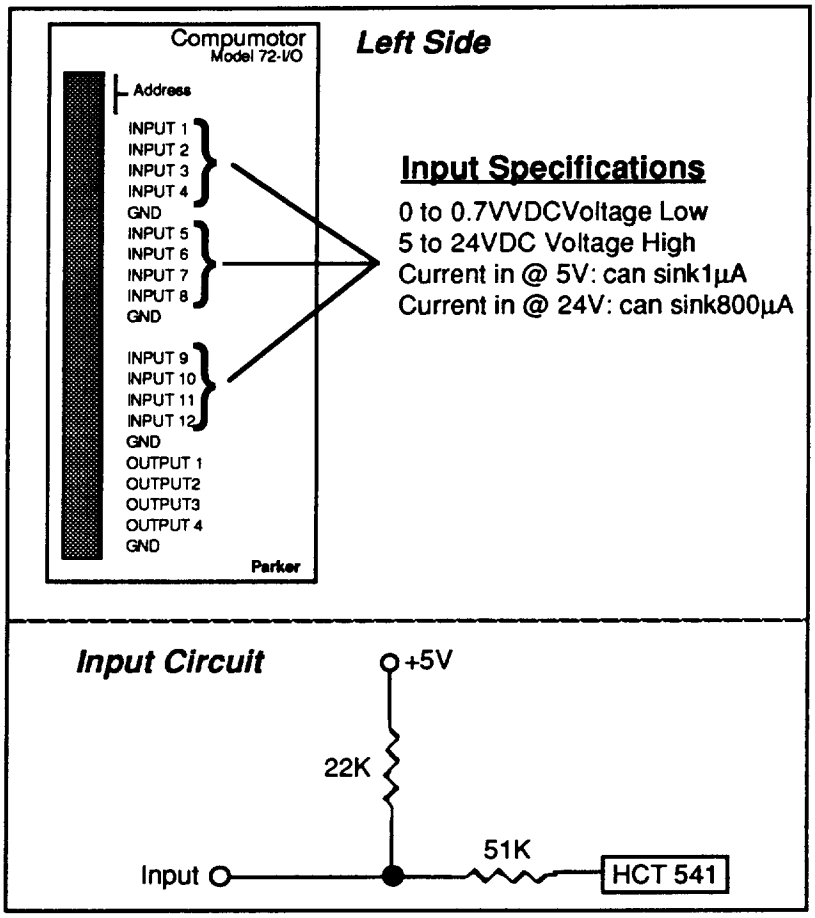


Figure 6-4. Inputs 1-12, Input Circuit

OPTO-22 Compatible Inputs 13-20 (Model 72-I/O)

There are eight OPTO-22 compatible inputs (TTL input levels). They can sink up to 20mA, therefore allowing opto operation. Pin 25 is also configured to supply 5V. The current supplied must be less than 100mA. See Figure 6-5 for pinouts

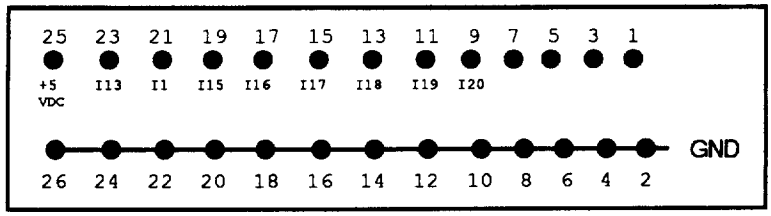


Figure 6-5. Input Pinouts

Outputs 1-4 (Model 72-I/O)

Outputs 1-4 on the Model 72 I/O are open collector. **You must supply 5 to 24VDC and a pull-up resistor with a minimum resistance of 100Ω.** Refer to Figure 6-6.

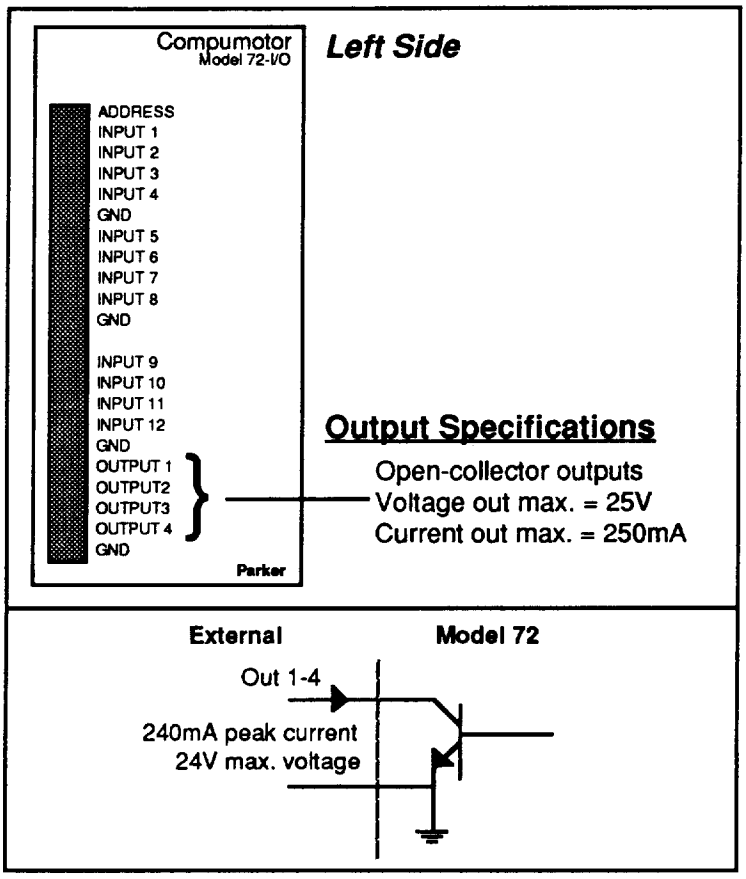


Figure 6-6. Outputs 5 - 12, Output Circuit

Discrete Outputs 5-12 (Model 72-I/O)

These outputs are dedicated for an OPTO-22 compatible PB8 header. The outputs are at TTL levels and can drive 10-lb TTL loads. A 5VDC pin is supplied to power the OPTO board, which can supply 100mA. See Figure 6-7 for pinouts.

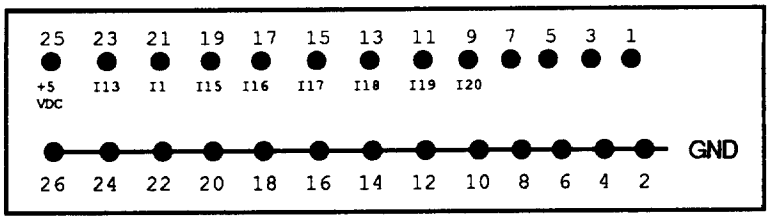


Figure 6-7. OPTO-22 Pinouts for Outputs 5-12

Visual Indicators

Power LED: **ON** (Green) whenever AC power is applied
Fault LED: **OFF** when Model 72 is functioning properly

The Fault LED will be **ON** when the following conditions exist:

1. Power on reset
2. Faulted microprocessor (If the microprocessor faults, refer to *Chapter 7, Troubleshooting*)

Dimensional Drawings

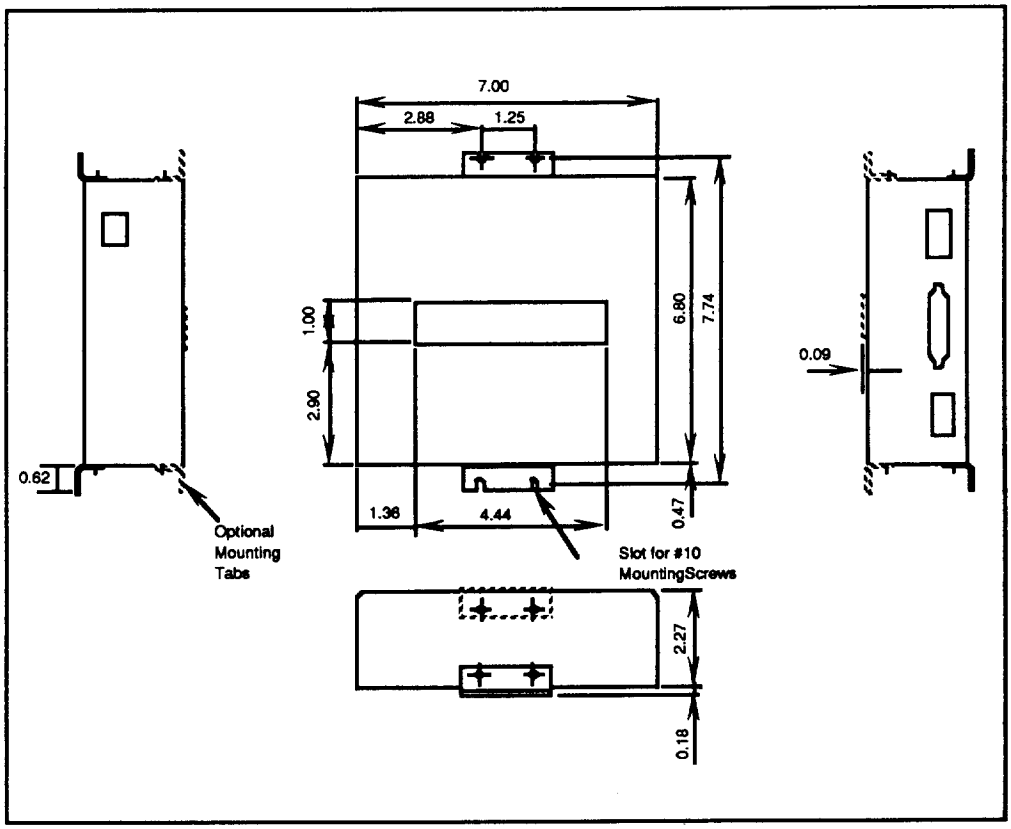


Figure 6-8. Model 72 Dimensional Drawing

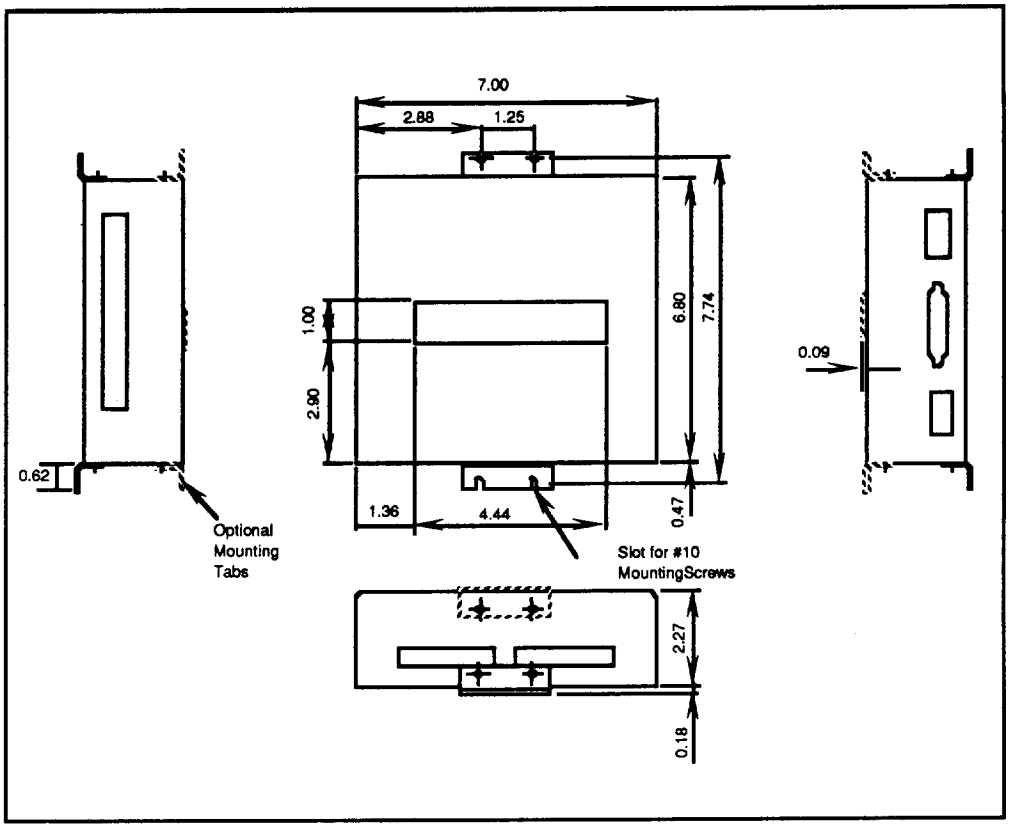


Figure 6-9. Model 72 I/O Dimensional Drawing

Chapter 7. TROUBLESHOOTING

Chapter Objectives

The information in this chapter will enable you to:

- Maintain the system to ensure smooth, efficient operation
- Isolate and resolve system hardware & software problems

Spare Parts

If you lose or damage a bracket, you may order repalacement brackets from Compumotor. Call 1-800-358-9070 and order the part using the name and part number shown below.

Mounting Bracket: 53-006007-01

Troubleshooting

This section discusses methods to identify, isolate, and resolve problems that may occur with your Model 72.

Isolating Problems

When your system does 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 resolve the problem.

The first step is to isolate each system component and ensure that each component functions properly when it is run independently. You may have to dismantle your system and put it back together piece by piece to detect the problem. If you have additional units available, you may want to use them to replace existing components in your system to help identify the source of the problem.

Try to determine if the problem is mechanical, electrical, or software-related. Can you repeat or re-create the problem? Do not 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.

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.

Problems & Solutions

Problem	Solution
The Model 72 does not respond to AX data requests.	Check the Model 72's address and the enhanced X command for format validity.
No AX request is visible.	Check RS-232C wiring.
Multiple characters stream across terminal display.	Turn the AX's echo function off (**SSA1**).
The Model 72 does not echo to the terminal.	Turn on the Model 72's echo function (**^E**).
After turning the Model 72's echo function on, the unit is still not echoing to the terminal.	Check the earth ground connection at the power supply. Cycle power.
The POWER LED is **OFF**	Check the AC power wiring. If voltage is present and the LED is still off, remove power from the system and check the fuse inside of the Model 72. If the fuse is blown, replace it with a 250V, 1A, 20 mm long fuse. If the LED will not come on with the new fuse, call Compumotor—1-800-358-9070.
The red FAULT light is on or is flickering.	Check the AC voltage level. It should be 115VAC ±10%. Ensure that the unit is shielded from noise. If this does not solve the problem, call Compumotor—1-800-358-9070.

Table 7-1. Model 72 Problems and Solutions Table

RS-232C Communications

If you are having problems communicating with the Model 72, try the following procedure to troubleshoot the communications interface.

1. Make certain the transmit of the host is wired to the receive of the peripheral, and receive of the host (terminal or computer) is wired to the transmit of the peripheral.

   Try switching the receive and transmit wires on either the host or peripheral if you fail to get any communication.

2. Some serial ports require handshaking. You can establish three-wire communication by connecting RTS to CTS (usually pins 4 & 5) and DSR to DTR (usually pins 6 - 20).

3. Configure the host and peripheral to the same baud rate, number of data bits, number of stop bits, and parity.

4. If you receive double characters, for instance typing **A** and receiving **AA**, your computer is set for half duplex. Change the setup to full duplex.

5. Use DC common or signal ground as your reference, *not* earth ground.

6. Cable lengths should not exceed 50 ft. unless you are using a line driver, optical coupler, or shield. As with any control signal, be sure to shield the cable to earth ground at one end only.

7. To test your terminal or terminal emulation software for proper three-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. Connect 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.

Reducing Electrical Noise

This section discusses the sources and methods of suppressing electrical noise.

Electrical Noise

When you operate the Model 72 in an environment where there is a large amount of electrical noise, you must take measures to eliminate sources of 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 Model 72 in a NEMA enclosure. 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.

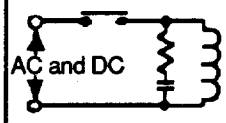
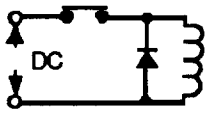
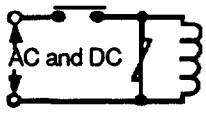
RC	DIODE	VARISTOR (MOV)
		
1. Can be saved for both AC and DC circuits 2. Use 500-1000 ohm for R and 0.1 - 0.2 microF @ 200V	For DC circuit only	Can be used for both AC and DC circuits

Figure 7-1. Noise Suppression Devices

Enclosure Considerations

You should install the Model 72 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.

Sources of Electrical Noise

Noise-related difficulties can range in severity from minor positioning errors to damaged equipment from runaway 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 an instruction or access the wrong data. This can be catastrophic to the program and force you to reset the processor. Most Compumotor indexers are designed to with a watchdog timer that shuts the system down if the program is interrupted. This prevents the most damaging failures.

Since electrical noise is not visible, it is very difficult to detect. Noise is generated from the following sources:

- Power line disturbances
- 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 drives (transmitted and power line noise)
- Welders: electric (transmitted and power line noise)

Power line disturbances are 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, like MOVs (General Electric) 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.

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 solve 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 *leek*. 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 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.

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 25 kW transmitters have been solved using enclosures, conduit, optical isolation,and single point ground techniques.

Ground Loops

Ground Loops are 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.

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.

Defeating Noise

The best time to handle electrical noise problems is before they occur. When a motion 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 connection, 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 poser 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 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.

APPENDICES

Command Listing

Enhanced AX Commands

A	Acceleration
CA	Change Acceleration
CTM	Constant Velocity Time Delay
CV	Change Velocity
D	Distance
H±	Set Direction
I	Inputs
L	Loop
O	Output
T	Time
TR	Trigger
TS	Trigger Status
V	Velocity
US	Unit Scaling
XT	Sequence Termination
XR	Run Sequence

Model 72 Commands

^E	Echo ON/OFF
^2	Test Thumbwheels and Inputs

Warranty

The items described in this document are hereby offered for sale at prices to be established by Parker Hannifin Corporation, its subsidiaries, and its authorized distributors. This offer and its acceptance by any customer ('Buyer') shall be governed by all of the following Terms and Conditions. Buyer's order for any item described in its document, when communicated to Parker Hannifin Corporation, its subsidiary, or an authorized distributor ('Seller') verbally or in writing, shall constitute acceptance of this offer.

1. Terms and Conditions of Sale
All descriptions, quotations, proposals, offers, acknowledgements, acceptances, and sales of Seller's products are subject to and shall be governed exclusively by the terms and conditions stated herein. Buyer's acceptance of any offer to sell is limited to these terms and conditions. Any terms or conditions in addition to, or inconsistent with those stated herein, proposed by Buyer in any acceptance of any offer by Seller, are hereby objected to. No such additional, different or inconsistent terms and conditions shall become part of the contract between Buyer and Seller unless expressly accepted in writing by Seller. Seller's acceptance of any offer to purchase by Buyer is expressly conditional upon Buyer's assent to all the terms and conditions stated herein, including any terms in addition to, or inconsistent with those contained in Buyer's offer. Acceptance of Seller's products shall in all events constitute such assent.

2. Payment
Payment shall be made by Buyer net 30 days from the date of delivery of the items purchased hereunder. Amounts not timely paid shall bear interest at the rate of 1-1/2% for each month or a portion thereof that Buyer is late in making payment. Any claims by Buyer for omissions or shortages in a shipment shall be waived unless Seller receives notice thereof within 30 days after Buyer's receipt of the shipment.

3. Delivery
Unless otherwise provided on the face hereof, delivery shall be made F.O.B.Seller's plant. Regardless of the method of delivery, however, risk of loss shall pass to Buyer upon Seller's delivery to a carrier. Any delivery dates shown are approximate only and Seller shall have no liability for any delays in delivery.

4. Warranty
Seller warrants that the items sold hereunder shall be free from defects in material or workmanship for a period of 365 days from the date of shipment to Buyer. THIS WARRANTY COMPRISES THE SOLE AND ENTIRE WARRANTY PERTAINING TO ITEMS PROVIDED HEREUNDER. SELLER MAKES NO OTHER WARRANTY, GUARANTEE, OR REPRESENTATION OF ANY KIND WHATSOEVER. ALL OTHER WARRANTIES, INCLUDING BUT NOT LIMITED TO, MERCHANTABILITY AND FITNESS FOR PURPOSE, WHETHER EXPRESS, IMPLIED, OR ARISING BY OPERATION OF LAW, TRADE USAGE, OR COURSE OF DEALING ARE HEREBY DISCLAIMED. NOTWITHSTANDING THE FOREGOING, THERE ARE NO WARRANTIES WHATSOEVER ON ITEMS BUILT OR ACQUIRED WHOLLY OR PARTIALLY, TO BUYER'S DESIGNS OR SPECIFICATIONS.

5. Limitation of Remedy
SELLER'S LIABILITY ARISING FROM OR IN ANY WAY CONNECTED WITH THE ITEMS SOLD OR THIS CONTRACT SHALL BE LIMITED EXCLUSIVELY TO REPAIR OR REPLACEMENT OF THE ITEMS SOLD OR REFUND OF THE PURCHASE PRICE PAID BY BUYER, AT SELLER'S SOLE OPTION. IN NO EVENT SHALL SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL, OR SPECIAL DAMAGES OF ANY KIND OR NATURE WHATSOEVER, INCLUDING BUT NOT LIMITED TO LOST PROFITS ARISING FROM OR IN ANY WAY CONNECTED WITH THIS AGREEMENT OR ITEMS SOLD HEREUNDER, WHETHER ALLEGED TO ARISE FROM BREACH OF CONTRACT, EXPRESS OR IMPLIED WARRANTY, OR IN TORT, INCLUDING WITHOUT LIMITATION, NEGLIGENCE, FAILURE TO WARN, OR STRICT LIABILITY.

6. Changes, Reschedules and Cancellations
Buyer may request to modify the designs or specifications from the items sold hereunder as well as the quantities and delivery dates thereof, or may request to cancel all or part of this order, however, no such requested modification or cancellation shall become part of the contract between Buyer and Seller unless accepted by Seller in a written amendment to this Agreement. Acceptance of any such requested modification or cancellation shall be at Seller's discretion, and shall be upon such items and conditions as Seller may require.

7. Special Tooling
A tooling charge may be imposed for any special tooling, including without limitation, dies, fixtures, molds and patterns, acquired to manufacture items sold pursuant to this contract. Such special tooling shall be and remain Seller's property notwithstanding payment of any charges therefore by Buyer. In no event will Buyer acquire any interest in apparatus belonging to Seller which is utilized in the manufacture of the items sold hereunder, even if such apparatus has been specially converted or adapted for such manufacture and notwithstanding any charges paid by Buyer therefor. Unless otherwise agreed, Seller shall have the right to alter, discard or otherwise dispose of any special

tooling or other property in its sole discretion at any time.

8. Buyers Property
Any designs, tools, patterns, materials, drawings, confidential information, or equipment furnished by Buyer or any other items which become Buyer's property, may be considered obsolete and may be destroyed by Seller after two (2) consecutive years have elapsed without Buyer placing an order for the items which are manufactured using such property. Seller shall not be responsible for any loss or damage to such property while it is in Seller's possession or control.

9. Taxes
Unless otherwise indicated on the face hereof, all prices and changes are exclusive of excise, sales, use, property, occupational or like taxes which may be imposed by any taxing authority upon the manufacture, sale, or delivery of the terms sold hereunder. If any such taxes must be paid by Seller or if Seller is liable for the collection of such tax, the amount thereof shall be in addition to the amount for the items sold. Buyer agrees to pay all such taxes or to reimburse Seller therefore upon receipt of its invoice. If Buyer claims exemption from any sales, use, or other tax imposed by any taxing authority, Buyer shall save Seller harmless from and against any such tax, together with any interest or penalties thereon which may be assessed if the items are held to be taxable.

10. Indemnity for Infringement of Intellectual Property Rights
Seller shall have no liability for infringement of any patents, trademarks, copyrights, trade dress, trade secrets, or similar rights except as provided in the Part 10. Seller will defend and indemnify Buyer against allegations of infringement of US patents, US trademarks, copyrights, trade dress, and trade secrets (hereinafter 'Intellectual Property Rights'). Seller will defend at its expense and will pay the cost of any settlement or damages awarded in any action brought against Buyer based on an allegation that an item sold pursuant to this contract infringes the Intellectual Property Rights of a third party. Seller's obligation to defend and indemnify Buyer is contingent on Buyer notifying Seller within ten (10) days after Buyer becomes aware of such allegations of infringement, and Seller having sole control over the defense of any allegations or actions including all negotiations for settlement or compromise. If an item sold hereunder is subject to a claim that it infringes the Intellectual Property Rights of a third party, Seller may, at his sole expense and option, procure for Buyer the right to continue using said item, replace or modify said item so as to make it non-infringing, or offer to accept return of said item and return the purchase price less a reasonable allowance for depreciation. Notwithstanding the foregoing, Seller shall have no liability for claims of infringement based on information provided by Buyer, or directed to items delivered hereunder for which the designs are specified in whole or part by Buyer, or infringements resulting from the modification, combination, or use in a system of any item sold hereunder. The foregoing provisions of this Part 10 shall constitute Seller's sole and exclusive liability and Buyer's sole and exclusive remedy for infringement of Intellectual Property Rights.

If a claim is based on information provided by Buyer or if the design for an item delivered hereunder is specified in whole or in part by Buyer, Buyer shall defend and indemnify Seller for all costs, expenses, or judgments resulting from any claim that such item infringes any patent, trademark, copyright, trade dress, trade secret, or any similar right.

11. Force Majeure
Seller does not assume the risk of and shall not be liable for delay or failure to perform any of Seller's obligations by reason of circumstances beyond the reasonable control of Seller (hereinafter 'Events of Force Majeure'). Events of Force Majeure shall include without limitation, accidents, acts of God, strikes or labor disputes, acts, laws, rules or regulations of any government or government agency, fires, floods, delays or failures in delivery of carriers or suppliers, shortages of materials, and any other cause beyond Seller's control.

12. Entire Agreement /Governing Law
The terms and conditions set forth herein, together with any amendments, modifications, and any different terms or conditions expressly accepted by Seller in writing, shall constitute the entire Agreement concerning the items sold, and there are no oral or other representations or agreements which pertain thereto. This Agreement shall be governed in all respects by the law of the State of Ohio. No actions arising out of the sale of the items sold hereunder of this Agreement may be brought by either party more than two (2) years after the cause of action accrues.

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;1,200; 2,400; 4,800; 9,600; and 19,200. At a 9,600 baud rate, 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.

DCE
Data Communications Equipment transmits on pin three and receives on pin two.

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
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.

DTE
Data Communications Equipment transmits on pin two and receives on pin three.

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.

Lead Compensation Algorithm
A mathematical equation implemented by a computer to decrease the delay between the input and output of a system.

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.

Microstepping
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° and the phase angle of a system at its crossover frequency.

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 rps.

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.

Synchronism
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.

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 **0** or **low** is represented by a voltage of less than 0.8V and a logical **1** or **high** is represented by a voltage from 2.5 to 5V.

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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