Compumotor

AL Encoder User Guide

Compumotor Division
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P/N 88-010473-01 B

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Installation Process Overview

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

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

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

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

3. Complete the basic system configuration and wiring instructions (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 tune and 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 operation.

How To Use This Manual

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

Assumptions

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

- IBM (or IBM-Compatible) computer experience
- Programmable logic controller (PLC) experience
- The differences between BCD and binary output
- Basic electronics concepts (voltage, switches, current, etc.)

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

Contents of This Manual

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 the items you should have received with your AL shipment. It will help you to become familiar with the system and ensure that each component functions properly. You will learn how to configure the system properly in this chapter.

Chapter 3: Installation

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

Chapter 4: Application Design

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

Chapter 5. Software Reference

This chapter discusses the X Series commands that are applicable to the AL. It is divided into two sections. The first section explains command syntax and parameters that affect command usage. The second section contains an alphabetical listing of all commands, with a syntax and command description for each command. Examples are provided for each command.

Chapter 6: Hardware Reference

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

Chapter 7: Maintenance & Troubleshooting

This chapter describes Compumotor's recommended system maintenance procedures. It also provides methods for isolating and resolving hardware and software problems. A list of diagnostic codes is included in this chapter.

Developing Your Application

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

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

Conventions

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

Using Commands

Whenever you enter a command on your keyboard, you must enter a carriage return [cr] to prompt the system to process the command. If you are using an IBM computer, an IBM-compatible computer, or a terminal, you can send a carriage return by pressing the Enter key. This will activate processing. In this user guide, you will not be reminded to enter the carriage return. *Generally, all system responses provide a [cr] and line feed [lf]. The system only recognizes* ***upper-case*** *characters.*

Highlighted Text

Italics are to be used to set off important material. Refer to the example below.

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

Related Publications

The following publications may be helpful resources.

Parker Compumotor Motion Control Catalog

Schram, Peter (editor). *The National Electric Code Handbook (Third Edition).* Quincy, MA To receive this publication, contact the National Fire Protection Association (Batterymarch Park, MA 02269)

CHAPTER 1. INTRODUCTION

Chapter Objectives

The information in this chapter will enable you to:

- Understand the product's basic functions and features
- Understand basic motion control concepts and apply them to your application

Product Description

An absolute encoder is a feedback device that provides digital position information corresponding to a mechanical location. This value may be offset and scaled which will be discussed in later sections. This information is independent of the previous value and will output a discrete numeric position. The AL encoder is sold with the -1 Decoder only. Throughout this manual, the -1 Decoder will generally be referred to as simply the ***decoder***.

Product Features

The AL absolute linear encoder provides the following features:

- High-resolution—up to 10,000 discrete positions/in
- Microprocessor decoding eliminates user decoding
- Four communication methods
  - BCD (8- or 16-bit words)
  - Binary (8- or 16-bit words)
  - RS-422/485 (ASCII Decimal or Hexadecimal)
  - RS-232C (ASCII Decimal or Hexadecimal)
- Programmable resolutions
- Multiple encoders may be multi-dropped via RS-422/485
- Microprocessor monitors for errors and sensor failure
- Compatible with AX-A microstepping indexer/drive (only when used with a low-resolution -1 Encoder)

Theory of Operation

The AL linear encoder is a rotary absolute encoder that has its shaft replaced with a pinion and rides on a rack. The output data is obtained when light shines through a disk and is detected by a photo-transistor. Figure 1-1 is a top view of this disk (where the light sources will be aimed). The disk is constructed of metal and is arranged in concentric tracks. Each track has an independent LED, and photo-transistor parallel to the disk. This encoder disk has each track phased in a binary ratio to the next. The inside tracks are coarser, and the outside track has the finest resolution.

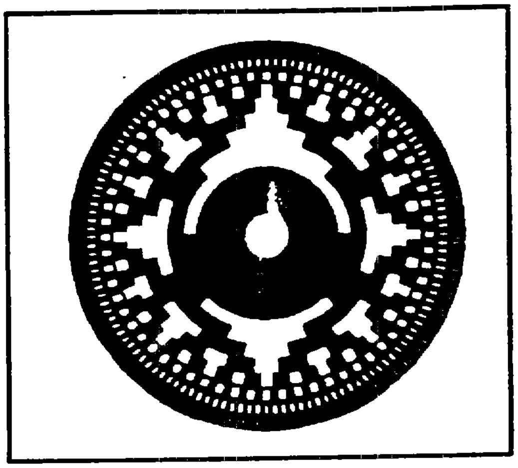


Figure 1-1. Absolute Encoding Disk

Figure 1-2 provides a cross-sectional view of the LED and sensors in relation to the disk. The only moving device is the disk, which is attached to the pinion shaft. As each LED passes an opening on the disk, it causes current to flow to the output circuit. The output circuit is then in a high state. The lights that are blocked by the track have no current flow to the output circuit, which causes a low state. The output circuit then assigns a number for these high and low states. A high signal is assigned with a one (1) and a low signal is assigned with a zero (Ø). Each high or low (1 or Ø) value per light is referred to as a bit. Most encoders use ten tracks on the encoding disk to obtain ten bits of positional data. With the AL, redundancy encoding is employed, which eliminates uncertainty between positions. In this case, only mechanical motion is allowed to change the position. This is commonly referred to as redundant gray code. This form of encoding has been developed by Compumotor using the disk shown in Figure 1-1.

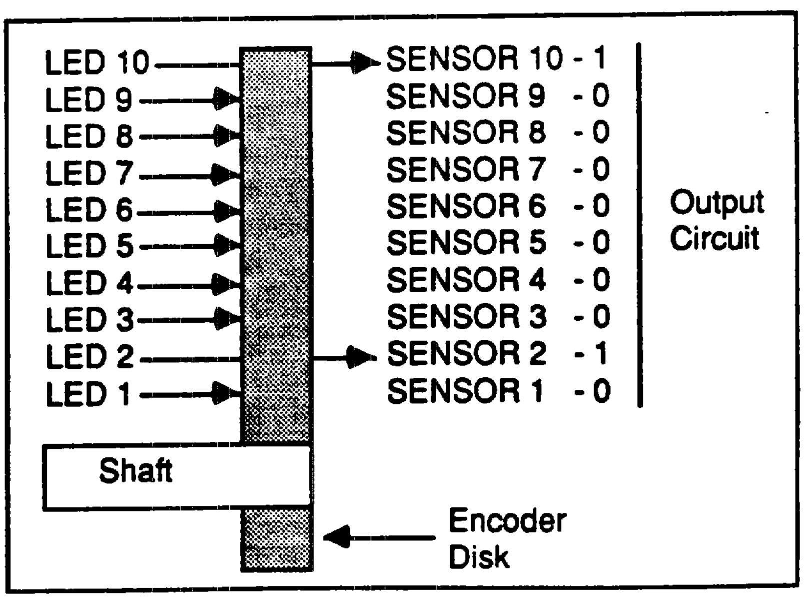


Figure 1-2. Cross-Section Sensing Circuit

The redundant gray code data from the AL encoder head is provided to the AL's output electronics (decoder box) for interface to the user's control system (e.g., AX-A, JSI, computer, PLC, or terminal). With the AL, this circuit's main function is to decode the redundant gray code to a more useful output format. The microprocessor-based decoder performs error checking, resolution scaling, and data formatting. Figure 1-4 shows a block diagram of encoder system.

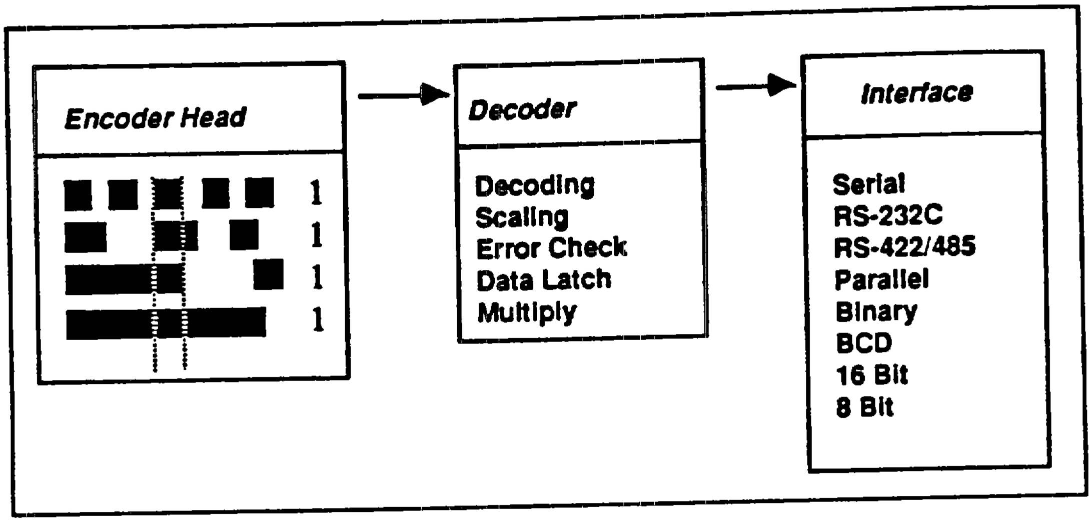


Figure 1-4. Encoder Block Diagram

The encoder signals are transferred to this remote location in a redundant gray code form for a particular position. The processor decodes this information and conforms the position output to the user-selectable format. After this process, you can use this data via a parallel or serial interface. Error checking is a continuously updated feature for encoder status.

Data such as position scale factor, device address, offset, output format, and resolution are maintained in non-volatile electrically erasable programmable read-only memory (EEPROM). The scale factor allows you to obtain data in engineering units. You can use device addresses if more than one unit is interfaced via the serial interface. The serial interface allows up to you to multi-drop up to 16 units, or daisy chain 4 units from 1 port. If you use more than one decoder in parallel output mode (8-bit or 16-bit), you can *multiplex* the parallel outputs. Multiplexing allows you to share common data and control signals between decoders. You may multiplex as many units as your PLC can handle. You can use the offset to define a home position away from a known location. A summary of the commands that define the output data is provided in Chapter 5, Software Reference.

CHAPTER 2. GETTING STARTED

Chapter Objectives

The information in this chapter will enable you to:

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

What You Should Have

You should inspect your AL System upon receipt for obvious damage to its shipping container. Report any such damage to the shipping company as soon as possible. Parker Compumotor cannot be held responsible for damage incurred in shipment.

-1 Decoder Power	Interface Options
(120VAC)	1. RS-232C 2. RS-422/485 3. AX-A Indexer/Drive 4. Digital Servo Controller (JSI) 5. 8-Bit Parallel 6. 16-Bit Parallel

Table 2-1. Decoder Box Power & Options Summary

Decoder Resolution

Decoder resolution is factory-set at one of the following levels based on your order (these levels are based on data being read in the BCD format):

- 2,000 positions/in (part # AL-**1**-XX-1)
- 10,000 positions/in (part # AL-**2**-XX-1)

If you are reading data in the binary format, the decoder resolution is factory-set at the following resolution:

- 2,048 positions/in (part # AL-**1**-XX-1)
- 32,768 positions/in (part # AL-**2**-XX-1)

To operate the AL Encoder with the AX-A interface, you must have a **-1 Decoder** with a resolution of **2,000 positions/in.**

To operate the AL Encoder with the JSI Controller you must have a decoder resolution of **10,000** positions/in.

If you received or ordered a decoder that is not compatible with your system, contact Parker Compumotor.

Configuring the System

Read the following sections carefully for detailed information on how to properly integrate the AL Encoder into your system.

Decoder

The decoder box (refer to Figure 2-1) provides several features.

- Two programmable outputs
- Switch-selectable options
- General status LEDs

The following items should be present and in good condition.

Part/Quantity	Description	Part #
AL Linear Encoder Assembly (1)	Rack/spar assembly calibrated with enclosure without encoder.(XX = " of travel)	73-008073-XXX
AL Encoder Head w/Integral Pinion (1)	This head will include a 10' armored cable if you are using a rack under 64". A 20' armored cable will be included if you are using a rack greater than 64". *This cable will already be installed into the pinion head.*	72-008178-10 72-008178-20
AL Series User Guide (1)		88-010473-01 A
AL/IL Mounting Guide (1)		88-009072-01 Y

Table 2-2. Ship Kit List (-1 Decoder box)

The red status light goes on when the encoder is at the absolute zero position. This LED will not illuminate for any other fault condition.

The parallel outputs are optically isolated for reliable performance. Each output is an open collector with an internal pull-up resistor (+5VDC). *This output should be referenced to the OPTO- (pin # 24) for the interface interconnect.*

Output 1 is activated whenever the encoder position reaches its absolute zero position. You can program Output 2 (using the **SL** command) to activate at any position. Refer to Chapter 5, Software Reference for more information on the **SL** command.

The interface options for this unit are enabled and configured with internal DIP switch and jumper settings. This section contains the proper DIP switch and jumper settings for the various interface modes and a simple test routine that you can run to ensure that the system is operating properly.

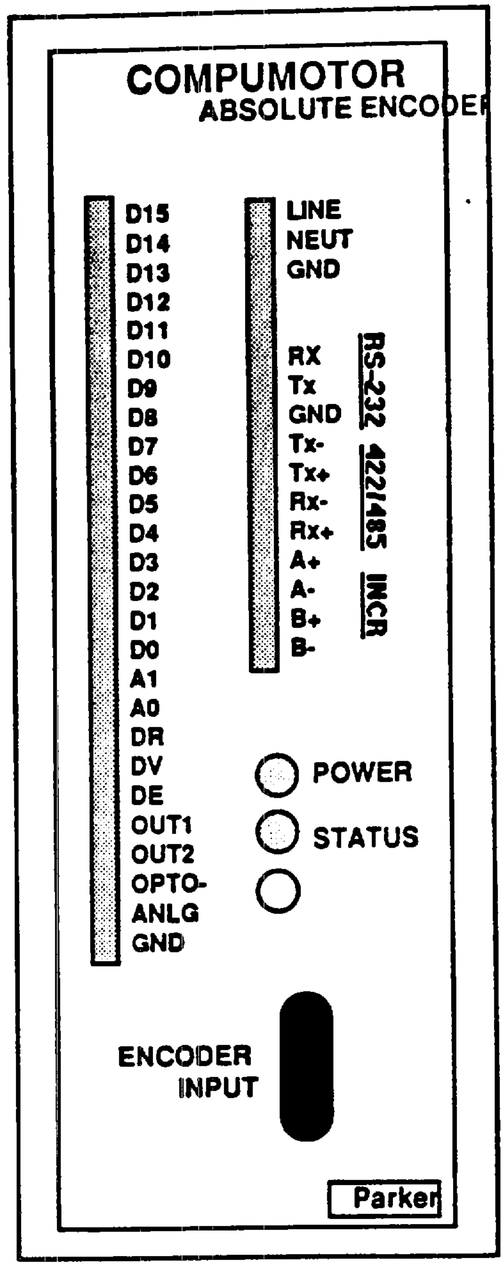


Figure 2-1. -1 Decoder Box

Decoder DIP Switch and Jumper Locations

To properly configure the decoder for your application, you must set the DIP switches and jumpers correctly. To gain access to the DIP switches and jumpers follow the steps described in Figure 2-2 .

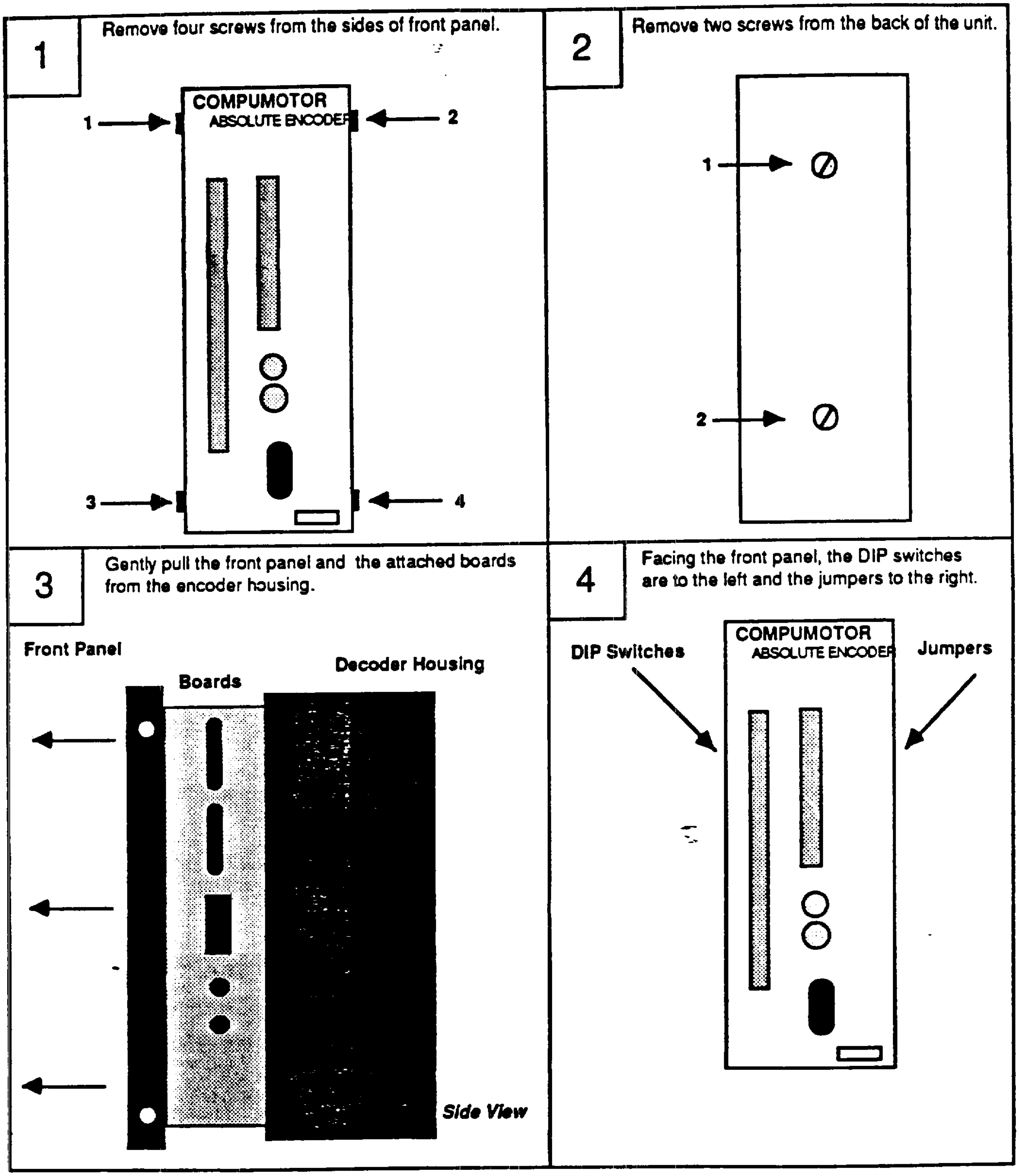


Figure 2-2. Decoder Box DIP Switch and Jumper Location

Decoder Default Settings

Refer to DIP switches marked **S3** on the board (near the top of the board).

Switch #	OFF	ON
S1	RS-232C*	RS-422/485
S2	Full Duplex*	Half Duplex
S3	CCW Direction*	CW Direction
S4	8-Bit Parallel	16-Bit Parallel*
S5	Binary (Hex)*	BCD (Decimal)
S6		AL Encoder*
S7	Binary Mode*	Mode Select
S8	Binary Mode*	Mode Select-
*Factory-default setting		

Table 2-3. Decoder Box Default DIP Switch Settings

Description of DIP Switch Functions

The following section describes the function of each decoder box DIP switch.

Switch 1

This switch allows you to select one of the two forms of serial communication available with this product—RS-232C (OFF) or RS-422/485 (ON). These forms of communication are Electronic Industry Association (EIA) standards for equipment that employs serial binary data exchange. For more information on the standards associated with these modes of communication, contact:

EIA Engineering Department
Standard Sales
2001 Eye Street N.W.
Washington, D.C. 20006
(202) 457-4966

Switch 2

This switch allows you to select full duplex (OFF) or half-duplex (ON) transmission (*This switch should be ON only if you are using RS-422/485 communications or AX-A mode*).

Full Duplex mode allows you to transmit and receive data simultaneously via a four-wire facility.

Half Duplex mode allows you to transmit and receive data, but not simultaneously in both directions. This mode of transmission is performed over two wires and is often referred to as *two-way alternate transmission*.

Switch 3

This switch allows you to determine the encoder's direction. When the switch is OFF, the encoder count increases when the encoder head moves in the **CCW** direction while you are facing the pinion. When the switch is ON, the encoder count increases when the encoder head moves in the **CW** direction while you are facing the pinion. *This switch does not affect incremental encoder output. If you change this switch setting, you will change (complement) the output encoder position.*

Switch 4

This switch allows you to select one of the two forms of parallel communication available with this product—8-bit (OFF) or 16-bit (ON).

Switch 5

This switch allows you to select the form of your output data—binary (OFF) or BCD (ON) for the parallel interface.

For the serial interface, you may select the Hexadecimal output format if you turn S5 OFF. You may select the Decimal output format by turning S5 ON. If S5 is OFF (with a serial interface), you may also select Decimal output with the SP (Define Data Output) command. This command overrides the DIP Switch setting. With a serial interface, DIP Switch S5 is only operable when the SP command is set to Ø. Table 6-2 (Chapter 6, Hardware Reference) shows the relationships between decimal, BCD, binary, and hexadecimal numbers.

Switch 6

This switch is set for you (at the factory) to match the type of encoder that you purchased. For AL Encoder, this switch must always be on.

Switches 7 & 8

These switches allow you to operate your system in a special configuration (AX-A Drive and JSI Controller compatibility). Refer to Table 2-4 for the appropriate DIP switch settings to make your system compatible with these products.

S 7	S 8	Function
OFF	OFF	Standard Product
ON	OFF	Reserved
ON	ON	JSI Controller
OFF	ON	AX-A Drive/Indexer

Table 2-4. Special Configuration DIP Switch Settings

Jumper Location

The jumpers add or remove various termination resistors depending on the particular interface configuration. The jumpers can be moved up or down or left or right on the pins. Figure 2-3 shows the default jumper settings. Modifications to this setting, depending on your configuration, are discussed later in this user guide.

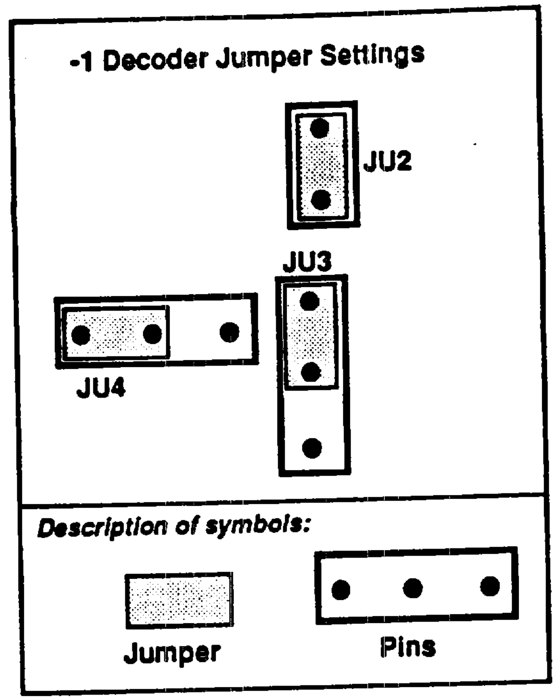


Figure 2-3. Jumper Default Settings

Decoder RS-232C Interface

This interface communicates serially (with ASCII characters). The 3-wire interconnect and proper DIP Switch settings are shown in Figure 2-4. *Do not change the jumper settings (maintain factory default settings).*

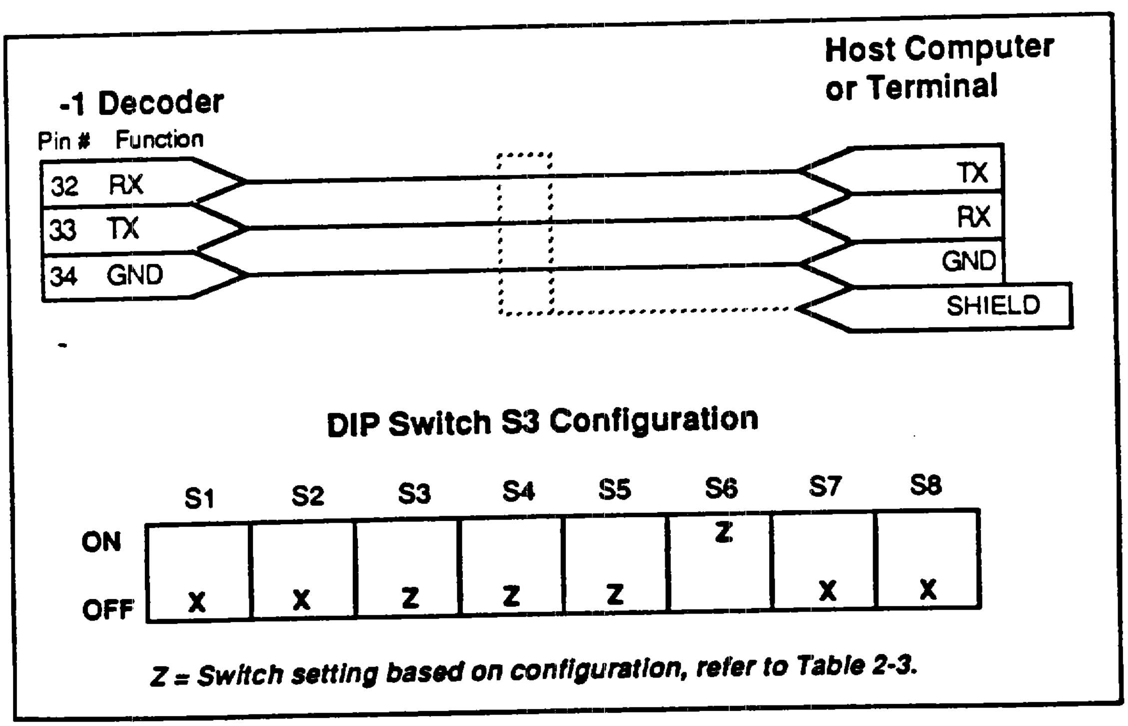


Figure 2-4. RS-232C Serial Communication

RS-232C Verification

To verify that your RS-232C link is operating properly, follow the procedure described below. To perform these steps, you will need a terminal or you may enable your computer to emulate a *dumb terminal*. Several emulation packages (e.g. Pro-Comm™) are available that will allow you to use your computer as a terminal. *Only upper-case ASCII characters are valid.*

1. Be sure that power is not applied to the system. Remove the cover from the AL decoder and set the DIP switches (refer to Figure 2-4). Put the cover back on the unit before proceeding.

2. Connect the interface from the decoder box to the computer/terminal using the instructions shown in Figure 2-4.

3. Plug the encoder head's 15-pin D connector into the decoder box and use the supplied 120VAC input cable to power up the unit. The green power LED should light up.

4. Enable your computer/terminal to operate at the following specifications:

   - Baud Rate: 9,600
   - Data Bits: 8
   - Start/Stop Bit(s): 1
   - Parity: None
   - Full Duplex

5. After you power up the unit, press the space bar on your keyboard to determine if the computer/terminal is operating properly. If your cursor moves on the screen after you press the space bar, you are receiving an *echo*. An echo indicates that communication is occurring from the computer/terminal to the decoder box and from the decoder box back to the computer/ terminal. If you receive an echo, proceed to step 8.

6. If no echo is received, switch the wires labeled **Rx** and **Tx** on the decoder box and press the space bar again. If an echo is received, proceed to step 8.

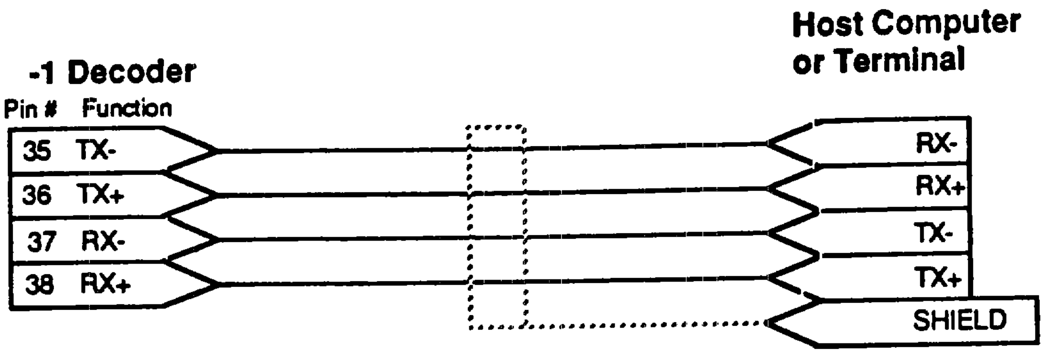
7. If the computer/terminal is still not receiving an echo, refer to Chapter 7, Maintenance & Troubleshooting.

8. After verifying that you have received an echo, type: **ØPR**. You should receive the following response: **Ø_nnnnnnnn** (**Ø** = an error code, **_** = a space, and **n** = a digit from 0 - 9, A - F which represents the current absolute encoder position in hexadecimal). If you do not receive a report such as this, re-enter the command shown above. After any reset, the first character in the **ØPR** command's response will be a **1**. If you are still unable to obtain the appropriate response, refer to Chapter 7, Maintenance & Troubleshooting.

9. Move the encoder shaft manually and repeat Step 8. The position report should change. If the position report does indicate a change in position, the system is operating properly. *Refer to Chapter 5, Software Reference, for further command description information.*

Decoder RS-422/485 Interface

This interface communicates serially (with ASCII characters—only upper case characters are valid). The 4-wire interconnect and proper DIP Switch settings are shown in Figure 2-5.



DIP Switch S3 Configuration

	S1	S2	S3	S4	S5	S6	S7	S8
ON	X					Z		
OFF		X	Z	Z	Z		X	X

Z = Switch setting based on configuration, refer to Table 2-3.

Figure 2-5. RS-422/485 Full-Duplex Serial Communication

You should be aware of the following information if you use the configuration setting shown in Figure 2-5.

- The RS-422/485 interface does not provide character echoes.
- If more than one unit is multi-dropped, remove jumpers JU3 and JU4. *You should do this to all units that you intend to multi-drop, **except one**.* One unit in the configuration should maintain the default jumper settings (jumper settings only). Refer to Chapter 4, Application Design for more information on multi-drop configurations.

RS-422/485 Verification

To verify that your RS-422/485 link is operating properly, follow the procedure described below. Compumotor recommends that you use a Qua-Tech model DS-201/DS-202 if you are using an RS-422/485 interface with an IBM or IBM compatible computer.

1. Be sure that power is not applied to the system. Remove the cover from the AL decoder and set the DIP switches (refer to Figure 2-5). If you are using only one unit with this interface, leave the jumpers at their factory default settings. You will have to change all of the other units' jumper settings. Put the cover back on the unit before proceeding.
2. Connect the interface from the decoder box to the computer/terminal using the instructions shown in Figure 2-5.
3. Plug the encoder head's 15-pin connector into the decoder box and use the supplied 120VAC input cable to power up the unit. The green power LED should light up.
4. Enable your computer/terminal to operate at the following specifications:
   - Baud Rate: 9,600
   - Data Bits: 8
   - Start/Stop Bit(s): 1
   - Parity: None
5. After you power up the unit, type the following command: ØPR. You should receive the following response: Ø_nnnnnnnn (Ø = an error code, _ = a space, and n = a digit from Ø - 9 which represents the current absolute encoder position). If you do not receive a report such as this, re-enter the command shown above. If you are still unable to obtain the appropriate response, refer to Chapter 7, Maintenance & Troubleshooting.
6. Move the encoder shaft manually and repeat Step 5. The position report response should change. If the position report does indicate a change in position, the system is operating properly. *Refer to Chapter 5, Software Reference, for further command description information.*

Decoder AX-A Indexer/Drive Interface

The AL encoder can interface with Compumotor's AX-A Indexer/Drive microstepping package. This interface requires incremental and absolute encoder data. The 7-wire interconnect and proper DIP Switch settings are shown in Figure 2-6. ***To operate this configuration, you must remove the jumpers from JU3 and JU4. The jumper on JU2 must be kept in place. Refer to Figure 2-3 for detailed information on jumper location.***

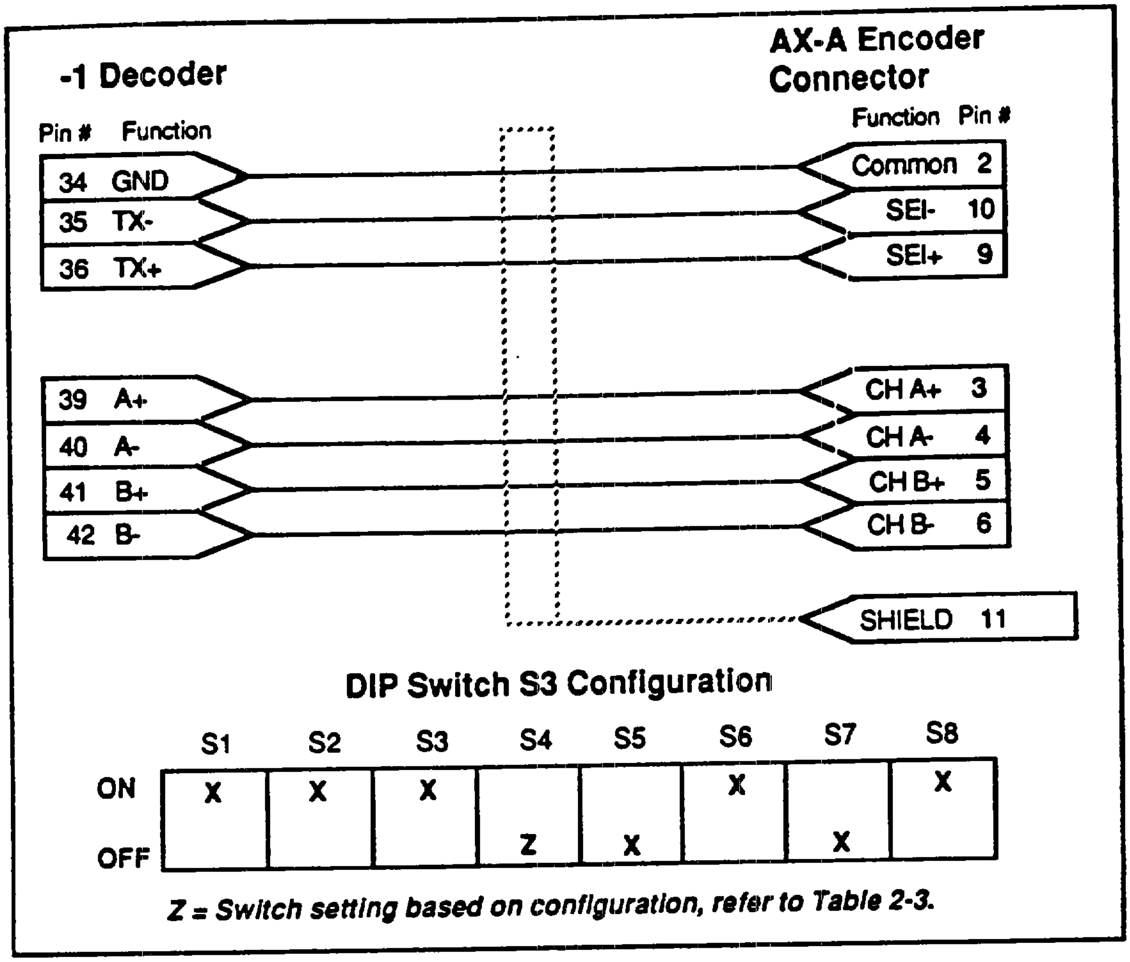


Figure 2-6. AX-A Wiring

AX-A Verification

Before proceeding, be sure that power is not applied to the system. Remove the decoder box cover and set the switches as shown in Figure 2-6. After setting the switches, put the cover back on the decoder To verify that the AL and the AX-A are operating properly together, follow the test procedures provided in the AX-A User Guide.

Decoder JSI Controller Interface

The AL encoder can interface with Compumotor's JSI Digital Servo Controller. The interface between these units is performed through the 8-bit parallel mode. The 14-wire interconnect and proper DIP Switch settings are shown in Figure 2-7. *Jumper settings do not affect this configuration.*

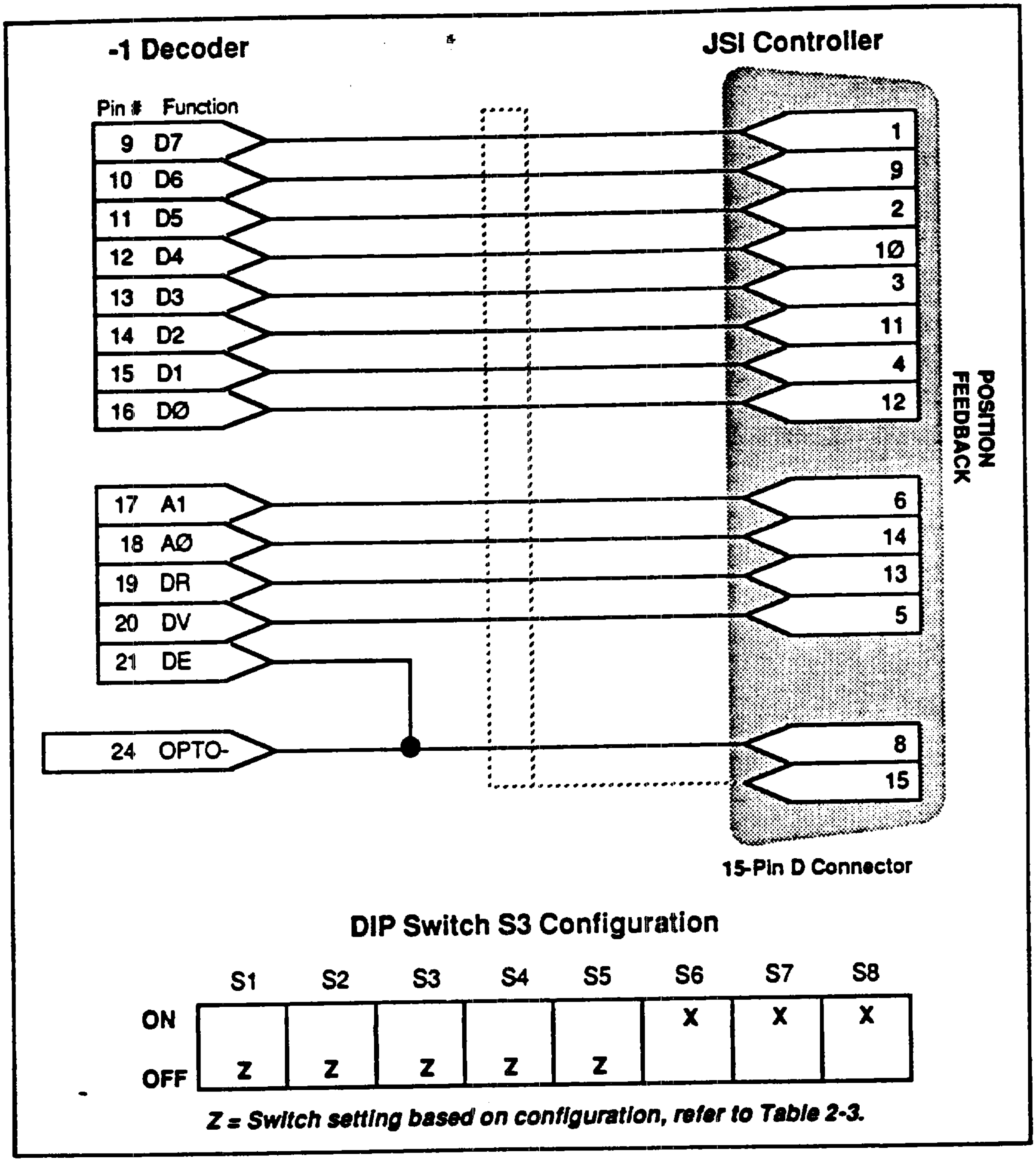


Figure 2-7. JSI Wiring

JSI Verification

Before proceeding, be sure that power is not applied to the system. Remove the decoder box cover and set the switches as shown in Figure 2-7. After setting the switches, put the cover back on the decoder. To verify that the AL and the JSI are operating properly together, follow the test procedures provided in the JSI User Guide.

Decoder 8-Bit Parallel Interface

This TTL interface allows you to transfer data at a higher rate of speed than the serial interface options (RS-232C and RS-422/485). The 14-wire interconnect and proper DIP Switch settings are shown in Figure 2-8. *Maintain the factory default jumper settings.*

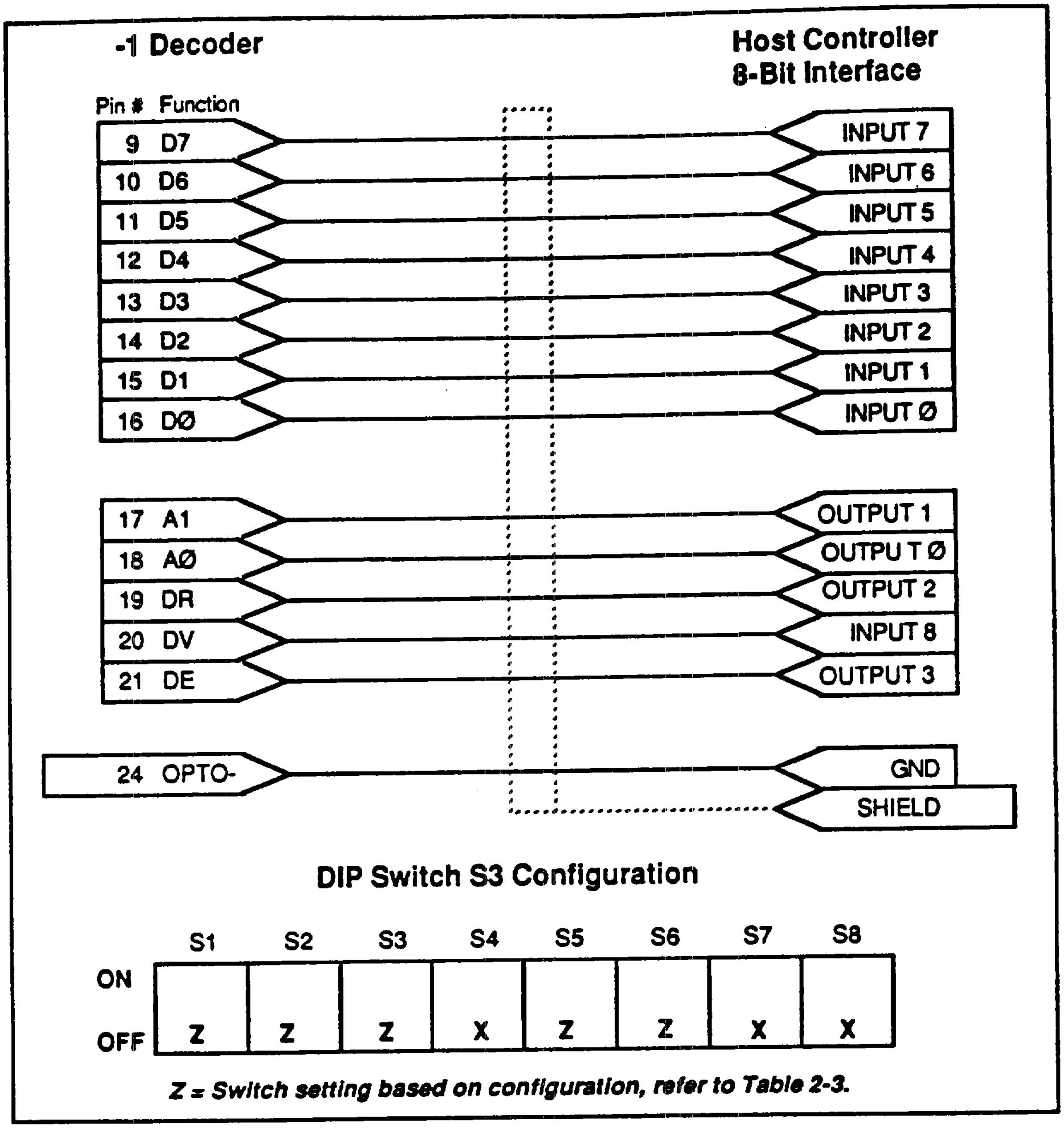


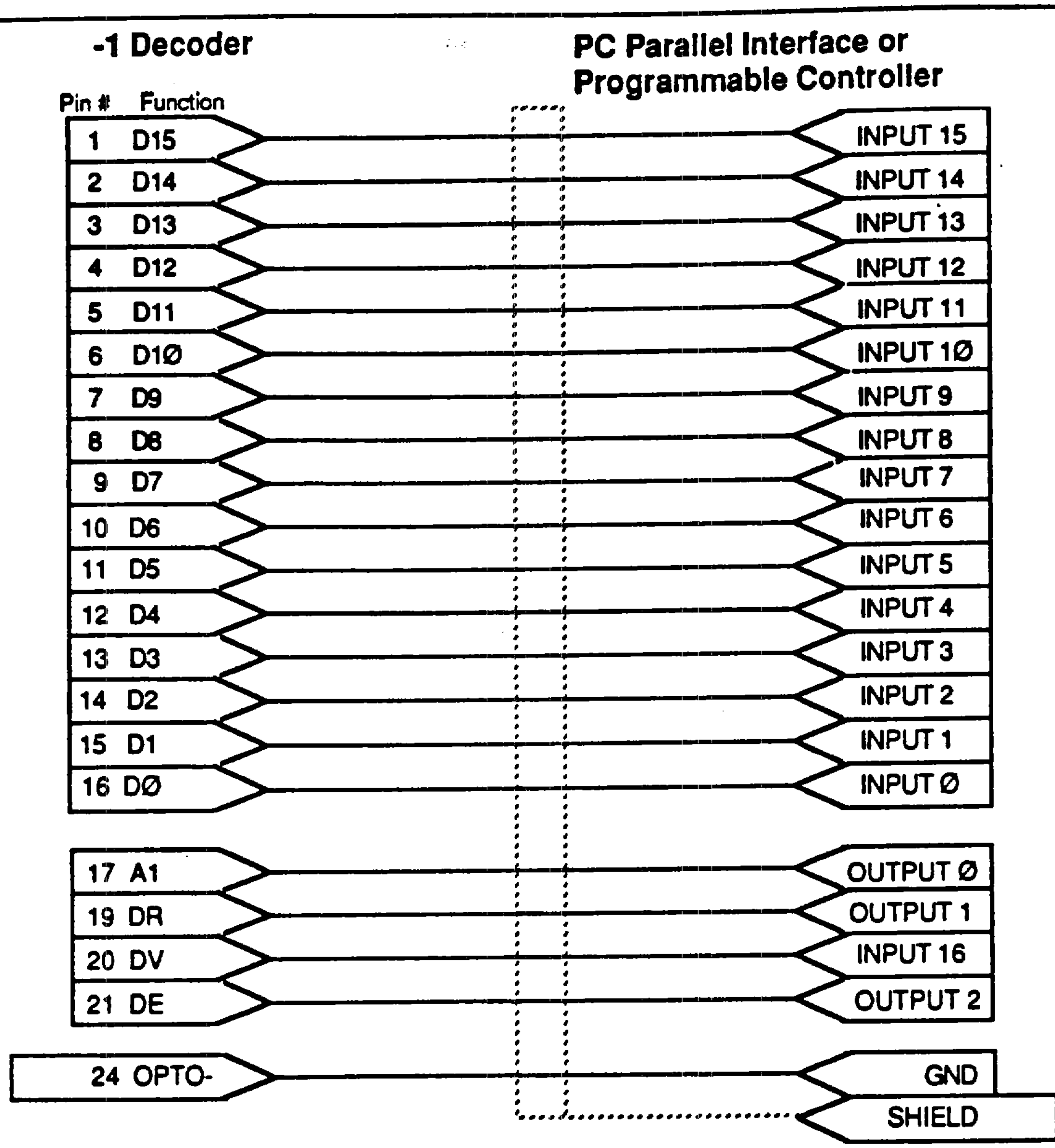
Figure 2-8. 8-Bit Parallel Wiring

8-Bit Parallel Verification

Before proceeding, be sure that power is not applied to the system. Remove the decoder box cover and set the switches as shown in Figure 2-8. After setting the switches, put the cover back on the decoder. To verify that the 8-Bit parallel interface is operating properly, refer to Chapter 4, Application Design.

Decoder 16-Bit Parallel Interface

This TTL interface allows you to transfer data at a higher rate of speed than the 8-bit parallel interface. More interface wires are required for this interface. The 21-wire interconnect and proper DIP Switch settings are shown in Figure 2-9. *Maintain the factory default jumper settings.*



DIP Switch S3 Configuration

	S1	S2	S3	S4	S5	S6	S7	S8
ON				X		Z		
OFF	Z	Z	Z		Z		X	X

Z = Switch setting based on configuration, refer to Table 2-3.

Figure 2-9. 16-Bit Parallel Wiring

16-Bit Parallel Verification

Before proceeding, be sure that power is not applied to the system. Remove the decoder box cover and set the switches as shown in Figure 2-9. After setting the switches, put the cover back on the decoder. To verify that the 16-bit parallel interface is operating properly, refer to Chapter 4, Application Design.

Chapter 3. INSTALLATION

Chapter Objectives

The information in this chapter will enable you to:

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

You must complete the steps in Chapter 2, Getting Started that pertain to your application before you perform the steps in this chapter.

Environmental Considerations

Fluid should not penetrate into the unit through the shaft. You should prevent direct fluid flow onto the unit by altering the flow of fluids. You can accomplish this with a splash guard or some other protective device.

Mounting

Refer to Chapter 6, Hardware Reference for all encoder and decoder box mounting dimensions.

Panel Layout Guidelines

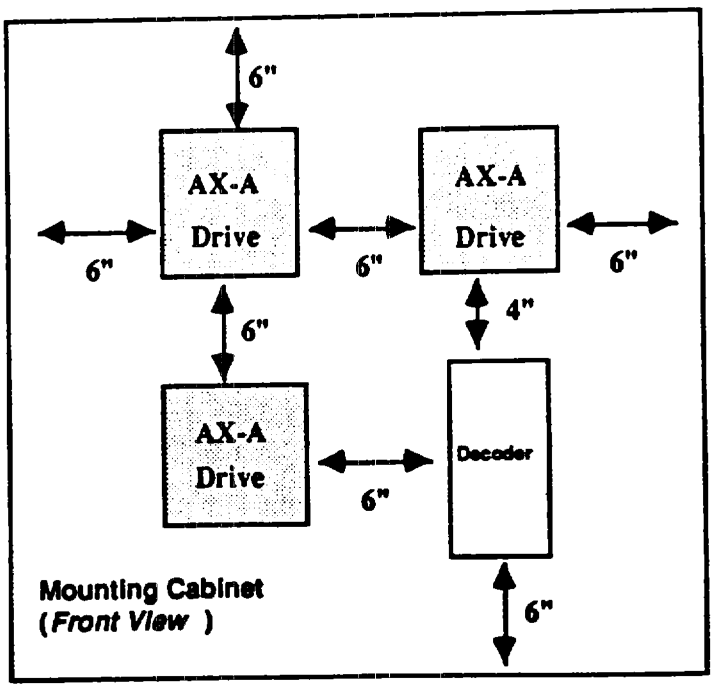


Figure 3-1. Panel Layout

Decoder Mounting

This circuitry is microprocessor based and fully digital (all voltages are within TTL levels). For this reason, the unit should be enclosed within a panel with other control devices. Electrically noisy devices should be suppressed, or housed in separate enclosures.

The electronics box is panel-mounted with two mounting brackets. Chapter 6, Hardware Reference, provides mounting hole dimensions. You may mount the decoder box in two ways: minimum width or minimum depth. Refer to Figures 3-2 and 3-3.

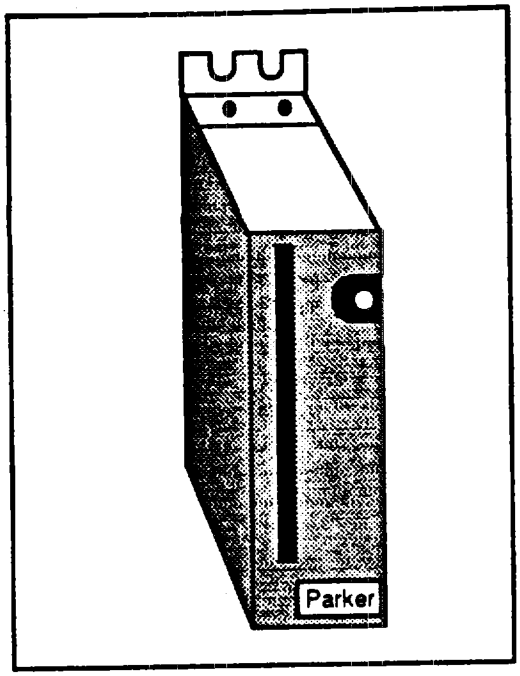


Figure 3-2. Minimum Width Decoder Box Mounting

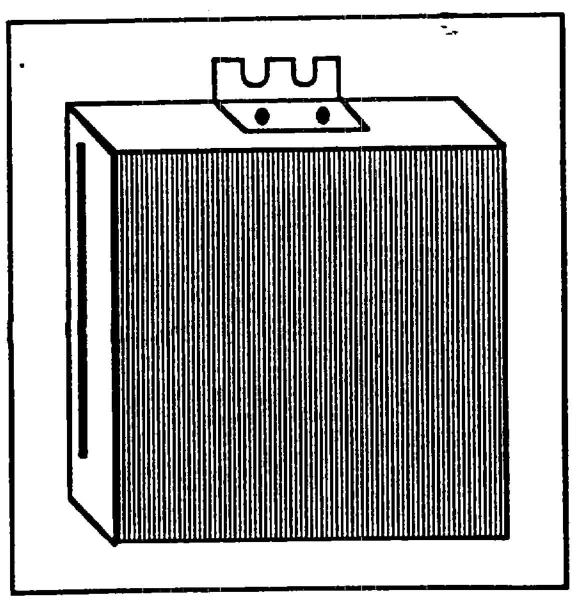


Figure 3-3. Minimum Depth Decoder Box Mounting

Since there are no high-power devices in this circuitry, the box gives off very little heat. However, the unit is not over-temperature protected and must be kept in an ambient environment below 50°C. To maintain this temperature, you may need to vent the enclosure (fan cooling may be necessary if the internal temperature reaches the upper limit). *Logic devices may perform unpredictably if they become too hot.*

Encoder Mounting

Refer to the mounting instructions provided in the *AL/IL Mounting Guide*, which was included with your product shipment. All AL Encoder mounting information is provided in that manual.

System Connections

This section contains directions and procedures to complete all of the AL's electrical connections. Refer to Chapter 2, Getting Started for specific I/O locations.

Wiring Guidelines

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

In general, all components and enclosures must be connected to earth ground through a grounding electrode conductor to provide a low impedance path for ground fault or noise-induced currents. All earth ground connections must be continuous and permanent. Compumotor recommends a single-point grounding setup. Prepare components and mounting surfaces prior to installation so that good electrical contact is made between mounting surfaces of equipment and enclosure. Remove the paint from equipment surfaces where the ground contact will be bolted to a panel and use star washers to ensure solid bare metal contact.

For temporary installation, or when you cannot implement the grounding method described above, connect the GROUND terminal on the AC power connector to the earth ground. Whenever possible, route high-power signals (i.e., motor and power) away from logic signals (i.e., RS-232C, RS-422/485, parallel output) to prevent electrical noise problems.

Drive and Motor Wiring

Refer to the manuals provided with the drive and motor you are using with the AL Encoder to properly wire the motor to the drive. Ensure that you have performed this wiring step successfully by following any test routines or verification procedures that your motor/drive installation recommends.

Cabling

The cable from the encoder head to the decoder box is constructed of 15 conductor #28 gauge flat wire. These wires are not twisted, but they are shielded. The shield is terminated at the decoder box end and is not connected at the encoder end. The standard lengths are 10' and 20'. The maximum length the decoders is 20'.

If you mount the AL in an environment that contains fluids, always route the cable down from the encoder. This prevents fluid flow on the cable from penetrating into the encoder housing. The same precaution should be used at the decoder box end. For further encoder mounting instructions, refer to the *AL/IL Mounting Guide.*

If the requirements of your application prohibit you from routing the cable downward, loop the cable to prevent any direct fluid flow. You may have to order a longer cable.

Any modifications to the cable will void the warranty! Please consult Compumotor prior to making any changes.

Power Supply

For most applications, the power supply ground should be allowed to float with reference to earth (no connection to earth ground). Refer to Chapter 6, Hardware reference for further details.

Chapter 4. APPLICATION DESIGN

Chapter Objectives

The information in this chapter will enable you to:

- Recognize and understand important considerations that you must address before you implement your application
- Understand the capabilities of the system
- Customize the system to meet your requirements

You must complete the steps in Chapter 2, Getting Started, and Chapter 3, Installation, that pertain to your application before you perform the steps in this chapter. ***You only need to follow the examples that apply to your application. You may skip examples that do not apply to your application.***

Interface Modes

There are two interface modes that allow you to obtain the encoder's position—serial and parallel. The serial interface includes RS-232C and RS-422/485. The parallel interface includes 8-bit and 16-bit output. Prior to using either interface, you must define certain parameters within the unit for the application.

These parameters configure the format of the information to be provided to the control system. You must define all of the commands that are available for configuration with the serial interface. These commands include configuration for the following functions:

- Report format
- Position scaling
- Position offset
- Output interface

Factory default values, which should be suitable for most applications, are provided. These default values, as well as the configuration command descriptions, are provided in Chapter 5, Software Reference.

After you configure the encoder, you must save all parameters in non-volatile memory. This chapter provides detailed procedures for using the interface modes that are applicable to the decoder box. The information is divided into two modes of operation: PLC (parallel) and host-computer (serial) operation.

Application Considerations

Electrical noise, which can cause an incremental system to miscount, is a minor problem with the AL. You can eliminate any noise-induced errors by reading the encoder position again. This provides proper position output (as long as the noise is not severe).

It is always good practice to take precautions to prevent problems from occurring. *One precautionary measure is to tie the shield to only one end instead of both ends. Connecting shields at both ends causes a ground loop and may cause problems for the microprocessor when current flows in the logic ground (GND).*

AL Operation with a PLC

Parallel Output Control

This interface can output eight (D0-D7) bits, or sixteen (D0-D15) bits of data. The full-position output of the AL Encoder is 32 bits. This data is read in segments.

All data should be read from the least-significant segment to the most-significant segment. Figure 4-1 clarifies the data's position. The figure shows each portion of the data in bytes.

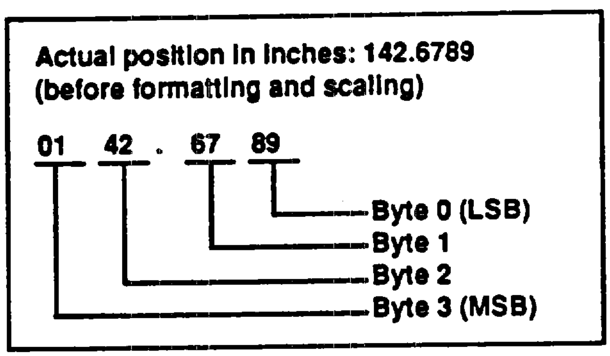


Figure 4-1. Byte Pattern For Output Data

There are three types of data output segments—words, bytes and bits. There are two bytes in each word and eight bits in each byte. Figure 4-2 shows the difference between these segments.

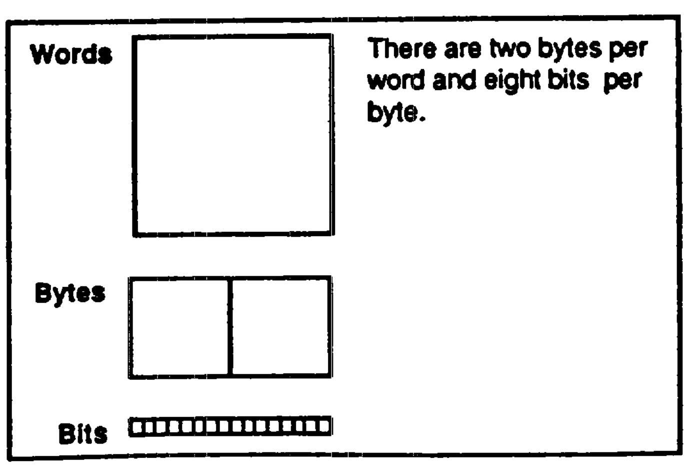


Figure 4-2. Output data types

Figure 4-2. Output data types

Each output can sink or source up to 15 mA of current, with an output voltage level of +5VDC. The output data can be provided in binary or BCD format. The output format is hardware selectable with the DIP switches inside the decoder box. The state of address inputs A0 and A1 determine which segment of position data is to be read.

All inputs are normally high and are pulled up to +5VDC. To activate the inputs, the input must be grounded. Outputs are normally in a high-impedance state with leakage current under 20µA. The following sections provide the step-by-step processes required to read data in the the following formats.

- 8-Bit Parallel Output
- 16-Bit Parallel Output

You only need to read the section that applies to your application.

Explanation of Parallel Output Examples

The examples in this section illustrate how to operate the AL to obtain position data in BCD and binary format for 8-bit and 16-bit output. These examples are based on a random position value.

You must enable the AL for one of the output modes (BCD or Binary) . The decoder's DIP switch settings must correspond to the settings shown in Chapter 2, Getting Started.

To use the data provided from the encoder, you must convert the decoder's output into position information. Tables 4-1 and 4-2 illustrate the mathematical relationship of each byte being read (in Binary and BCD;). The tables also provide the ratio for 8-bit and 16-bit output. The control system should read each byte shown in the tables and perform the math functions shown for accurate and meaningful position data.

Binary Output			
BYTE	8-Bit Representation	WORD	16-Bit Representation
1st (LSB)	0-255 units x 1/65,535	1st (LSW)	0-65,535 units x 1/65,535
2nd	0-255 units x 1/256	2nd (MSW)	0-4,095 units x 1 (mask error code & sign bit)
3rd	0 - 255 units x 1		
4th (MSB)	0-15 units x 256 (mask error code & sign bit)		

Table 4-1. Mathematic Byte Table (Binary Output)

BCD Output			
BYTE	8-Bit Representation	WORD	16-Bit Representation
1st (LSB)	0-99 units x 0.0001	1st (LSW)	0-9,999 units x 0.0001
2nd	0-99 units x 0.01	2nd (MSW)	0-999 units x 1 (mask error code & sign bit)
3rd	0-99 units x 1		
4th (MSB)	0-9 units x 100 (mask error code & sign bit)		

Table 4-2. Mathematical Byte Table (BCD Output)

8-Bit Data Output

This section explains the process of reading a position in 8-bit segments. Wire and configure your decoder (DIP switches and jumpers) as described in Chapter 2, Getting Started (*8-Bit Parallel Interface*). Use DIP switch S5 to select the binary (OFF) or BCD (ON) output format. To read a position (4 bytes) from the AL Encoder, refer to Figure 4-3 and follow the steps below.

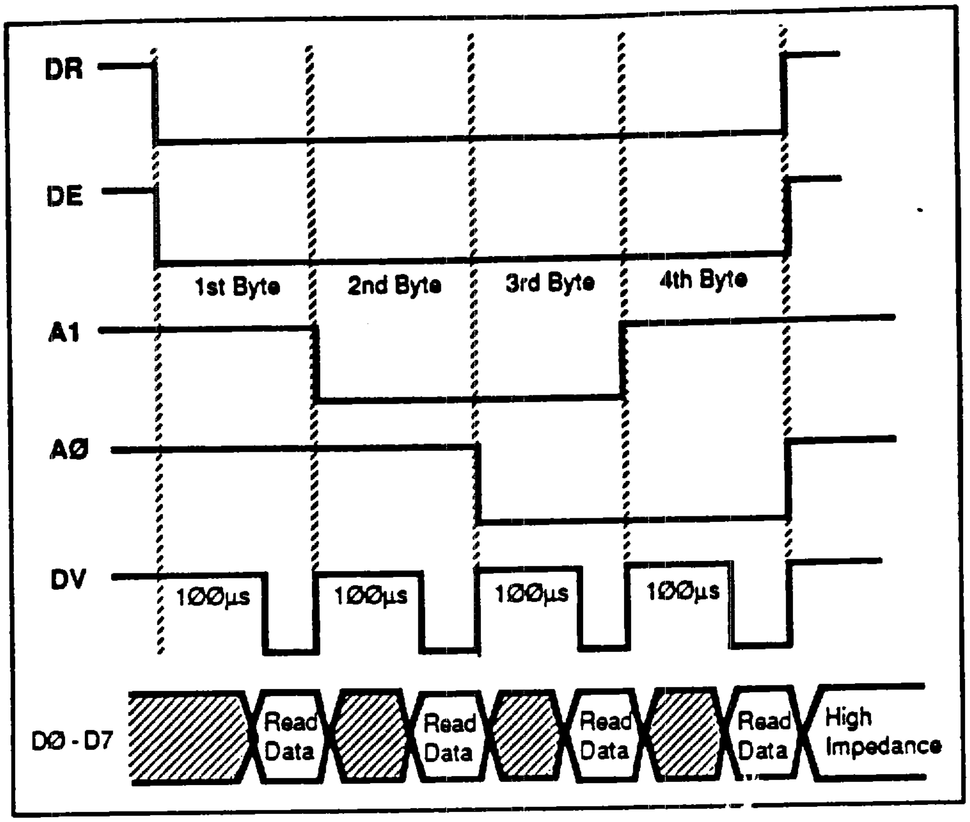


Figure 4-3. Timing—8-Bit Parallel Output

If you are using only one AL Encoder, ground the Device Enable (DE) input. The Device Enable function controls when the output goes in or out of a high-impedance state. (This input must be grounded to allow you to read output data from the device.) If you multiplex more than one unit, the Device Enable input will select which output the system will read. The Data Request (DR) output must remain active during the entire data transfer (all four bytes). A1 and A0 select which segment to read. The Data Valid (DV) output provides a signal to you when the data is stable or ready.

Step 1 Request the first byte (least significant byte—LSB). Bring address selects A0 and A1 high. Ground the Data Request (DR) and Device Enable (DE) outputs.

Step 2 Wait for the Data Valid (DV) output to go low. *This usually takes approximately 100µs.*

Step 3 Read the first byte.

Step 4 Request the second byte. Leave the DR and DE outputs grounded. Leave Address Select A0 high and ground A1.

Step 5 Wait for the Data Valid (DV) output to go low.

Step 6 Read the second byte.

Step 7 Request the third byte. Leave the DR and DE outputs grounded. Leave address select A1 grounded and ground A0.

Step 8 Wait for the Data Valid (DV) output to go low.

Step 9 Read the third byte.

Step 10 Request the fourth byte (most significant byte—MSB). Leave the DR and DE outputs grounded. Leave address select A0 grounded and bring A0 high.

Step 11 Wait for the Data Valid (DV) output to go low.

Step 12 Read the fourth byte.

Step 13 Bring all of the inputs high.

The last three most significant bits (MSB) of the fourth byte contain error code information. Refer to Chapter 7, Maintenance & Troubleshooting for a description of the error codes.

The 4th Byte must always be read. This contains not only the error code, but also the direction indication. This byte will be frozen as long as the data request is active.

If you are using a single-turn encoder, only the first and second bytes contain the encoder's actual position. You must read the third and fourth bytes to obtain error codes.

Interpreting 8-Bit BCD Output

Turn DIP switch 5 (S5) on to select the BCD output format. After the system reads each byte, refer to Table 4-2 (BCD Output) for the mathematic table that corresponds to each byte for the control system.

When you read BCD or binary parallel output, the serial interface will be disabled. You must complete the parallel read cycle (4 bytes) before you can establish the serial interface. In this application, you must complete the read cycle and bring the DR, DE, A1, and A0 inputs to the 5 VDC level before establishing the serial interface.

The encoder position at the time of the read is 0049.3556 inches. The step-by-step process that you must follow to read this position is provided below.

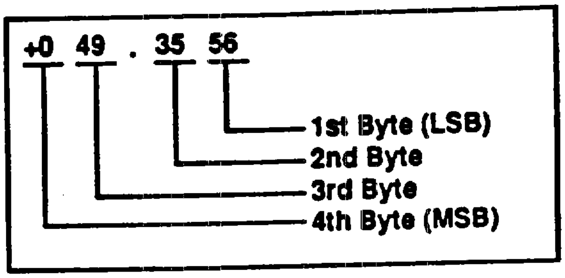
Step 1 Read the four bytes of data as described earlier in this section.

Step 2 Interpret each byte as follows.

1ST BYTE (LSB)	**Position Byte Value**			5				6	
	BCD Value	Ø	1	Ø	1	Ø	1	1	Ø
	Terminal Numbers	D7	D6	D5	D4	D3	D2	D1	DØ
2ND BYTE	**Position Byte Value**			3				5	
	BCD Value	Ø	Ø	1	1	Ø	1	Ø	1
	Terminal Numbers	D7	D6	D5	D4	D3	D2	D1	DØ
3RD BYTE	**Position Byte Value**			4				9	
	BCD Value	Ø	1	Ø	Ø	1	Ø	Ø	1
	Terminal Numbers	D7	D6	D5	D4	D3	D2	D1	DØ

4TH BYTE (MSB)

	D7	D6	D5	D4	D3	D2	D1	DØ
Position Byte Value		No Error		+			0	
BCD Value	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Terminal Numbers	D7	D6	D5	D4	D3	D2	D1	DØ



The value above will be frozen until the Data Request input returns to its high or off state. Notice that D4 is used for the sign bit (0 = +, 1 = -). Also, no bits are used for the decimal point. The location of this point is imaginary and should be signified within the device that is reading the encoder data.

Interpreting 8-Bit Binary Output

Turn DIP switch 5 (S5) off to select the binary output format. Refer to Table 4-1 for the multiplication table to establish corresponding data.

The encoder position at the time of the read is 0049.3556 inches. The step-by-step process that you must follow to read this position is provided below.

Step 1 Read the four bytes of data.

Step 2 Interpret each byte as follows.

1ST BYTE (LSB)

	D7	D6	D5	D4	D3	D2	D1	DØ
Position Byte Value					56			
Binary Value	Ø	Ø	1	1	1	Ø	Ø	Ø
Terminal Numbers	D7	D6	D5	D4	D3	D2	D1	DØ

2ND BYTE

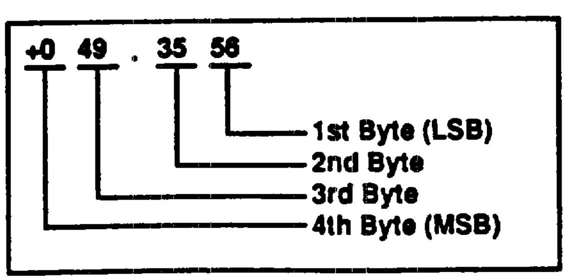
	D7	D6	D5	D4	D3	D2	D1	DØ
Position Byte Value					35			
Binary Value	Ø	Ø	1	Ø	Ø	Ø	1	1
Terminal Numbers	D7	D6	D5	D4	D3	D2	D1	DØ

3RD BYTE

	D7	D6	D5	D4	D3	D2	D1	DØ
Position Byte Value					49			
Binary Value	Ø	Ø	1	1	Ø	Ø	Ø	1
Terminal Numbers	D7	D6	D5	D4	D3	D2	D1	DØ

4TH BYTE (MSB)

	D7	D6	D5	D4	D3	D2	D1	DØ
Position Byte Value					+0			
Binary Value	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Terminal Numbers	D7	D6	D5	D4	D3	D2	D1	DØ



The value above will be frozen until the Data Request input returns to its high or off state. Notice that D4 is used for the sign bit (0 = +, 1 = -). Also, no bits are used for the decimal point. The location of this point is imaginary and should be signified within the device that is reading the encoder data.

16-Bit Data Output

This section explains the process of reading a position in 16-bit segments. Wire and configure your decoder (DIP switches and jumpers) as described in Chapter 2, Getting Started (*Decoder 16-Bit Parallel Interface*). Use DIP switch S5 to select the binary (OFF) or BCD (ON) output format. To read a position (two two-byte segments—also referred to as a *word*) from the AL, refer to Figure 4-4 and follow the steps below.

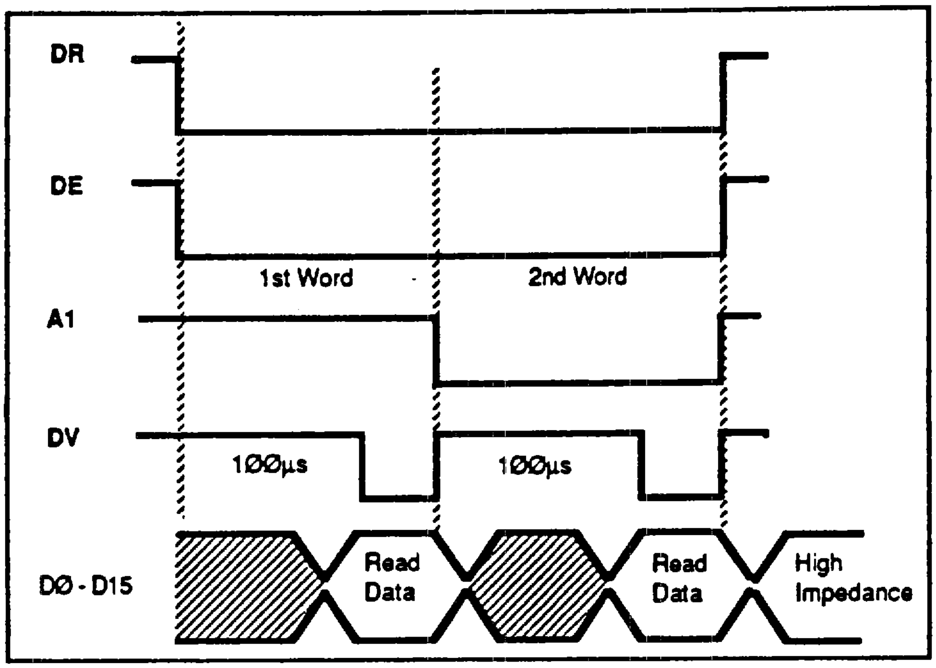


Figure 4-4. Timing—16-Bit Parallel Output

If you are using only one AL Encoder, you can tie the Device Enable input low. The Device Enable function controls when the output goes in or out of a high-impedance state. If you multiplex more than one unit, the Device Enable input will select which output the system will read. The Data Request output must remain active during the entire data transfer (all four bytes). A1 selects which word to read. The Data Valid (DV) output indicates when the data is stable or ready.

Step 1 Request the least significant word (LSW) by bringing Address Select A1 high. Ground the Data Request (DR) and Device Enable (DE) outputs.

Step 2 Wait for the Data Valid (DV) output to go low. *This usually takes approximately 100µs.*

Step 3 Read the LSW.

Step 4 Request the most significant word (MSW) by leaving the DR and DE outputs grounded and grounding Address Select A1.

Step 5 Wait for the Data Valid (DV) output to go low.

Step 6 Read the MSW.

The three MSBs of the second word contain error code information. Refer to Chapter 7, Maintenance & Troubleshooting for a description of the error codes.

The second word must always be read. This contains not only the error code, but also the direction indication. This word will be frozen as long as the Data Request is active.

If you are using a single-turn encoder, only the first word contains the encoder's actual position. You must read the second word to obtain error codes.

If this interface is with a PLC, use a 16-bit TTL input module with a minimum of two TTL-compatible outputs to control output operation. If you are using an IBM PC, use a TTL-compatible I/O card with 16 inputs and at least two outputs. Compumotor recommends that you use a MetraByte™ parallel interface card (p/n PIO12). For more information, contact Metrabyte™ at (617) 880-3000.

Interpreting 16-Bit BCD Output

Prior to implementing a binary output read, you must properly configure the unit. Turn DIP switch 5 (S5) on to select the BCD output format. After the system reads each byte, refer to Tables 4-1 (Binary) and 4-2 (BCD) for multiplication tables to be established for corresponding data. The 16-bit output is used. The encoder position at the time of the read is -54.5802 inches. The process to read the position is as follows:

When you read BCD or binary parallel output, the serial interface will be disabled. You must complete the parallel read cycle (2 words) before you can establish the serial interface. In this application, you must complete the read cycle and bring the DR, DE, A1, and A0 inputs to the 5 VDC level before establishing the serial interface.

Step 1 Read both words (MSW and LSW).

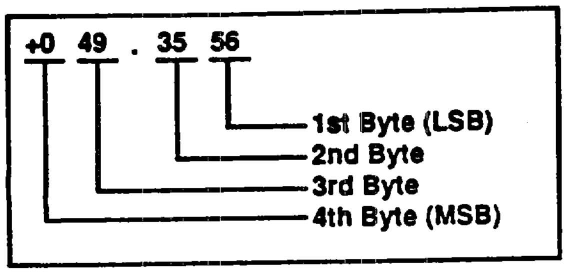
Step 2 Interpret each word as follows.

1st Word

	5				8				0				2			
BCD Value	Ø	1	Ø	1	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1	Ø
Terminal	D15	D14	D13	D12	D11	D1Ø	D9	D8	D7	D6	D5	D4	D3	D2	D1	DØ

2nd Word

	No error			—	0				5				4			
BCD Value	Ø	Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	1	Ø	1	Ø	1	Ø	Ø
Terminal	D15	D14	D13	D12	D11	D1Ø	D9	D8	D7	D6	D5	D4	D3	D2	D1	DØ



No bits are used for the decimal point. This location is imaginary and should be fixed within the device reading the data.

Interpreting 16-Bit Binary Output

Turn DIP switch 5 (S5) off to select the binary output format. After the system reads each byte, refer to Table 4-1 (Binary) for the multiplication table that corresponds to the data.

Assuming the encoder position at the time of the read is **-54.5802** inches, the process to read the position is as follows:

Step 1 Read both words (MSW and LSW).

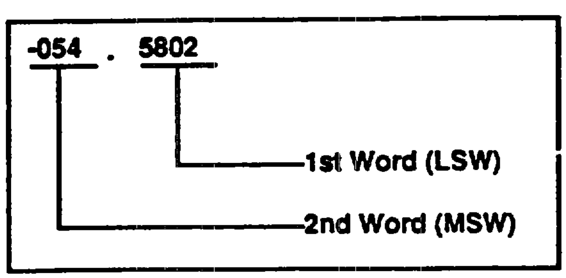
Step 2 Interpret each word as follows.

1st Word

	5802															
Binary Value	Ø	Ø	Ø	1	Ø	1	1	Ø	1	Ø	1	Ø	1	Ø	1	Ø
Terminal	D15	D14	D13	D12	D11	D1Ø	D9	D8	D7	D6	D5	D4	D3	D2	D1	DØ

2nd Word

	No error			—	054											
Binary Value	Ø	Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	1	1	Ø	1	1	Ø
Terminal	D15	D14	D13	D12	D11	D1Ø	D9	D8	D7	D6	D5	D4	D3	D2	D1	DØ



No bits are used for decimal point. This location is imaginary and should be fixed within the device reading the data.

Host Computer Operation

If you use the AL encoder with a host computer, two interface options are available. The decoder provides a DIP switch selectable interface for either RS-232C or RS-422/485.

Serial Interface Considerations

This section presents the advantages and disadvantages associated with serial communications.

Advantages

- Wiring required is minimal (usually from 3 - 5 wires).
- If you use RS-422/485, the length of wire from decoder box can be up to 4,000 feet. If you use RS-232C, length of wire can be up to 50 feet.
- Greater capabilities available with status commands.
- Cable is much easier to shield for reliable transmission.
- Simple wiring implementation required for multiple unit connection.

Disadvantage

- Transfer of data is limited. Only one bit can be transmitted every 100 microseconds.

Operating the Serial Interface

The host must be a *dumb terminal*, or have software that allows the computer to emulate a *dumb terminal* (such as Pro-Comm™). Before proceeding, enable the host computer for the following protocol:

- Baud Rate: 9,600
- Data Bits: 8
- Start/Stop Bit(s): 1
- Parity: None

All commands must be issued in upper-case characters.

Using Multiple Units on an RS-232C Interface

If you intend to use more than one decoder (i.e., a daisy chain configuration), verify that each unit is communicating properly (as specified in Chapter 2, Getting Started). Ensure proper communications with each unit *before you configure your daisy chain.*

When you use multiple decoders with a single RS-232C interface, you can include a maximum of four decoders in your daisy chain configuration. *Each decoder configured on the daisy chain must have a unique device address.* You can assign a unique device address with the **SN** (Define Device Address) command. The factory default address assigned to every decoder is Ø. Refer to Chapter 5, Software Reference for more information on the **SN** command. This section provides a step-by-step procedure for assigning unique device addresses for your decoders. *Do not attempt to assign device addresses at this time.* Refer to Figure 4-5 for an example of proper daisy chain wiring.

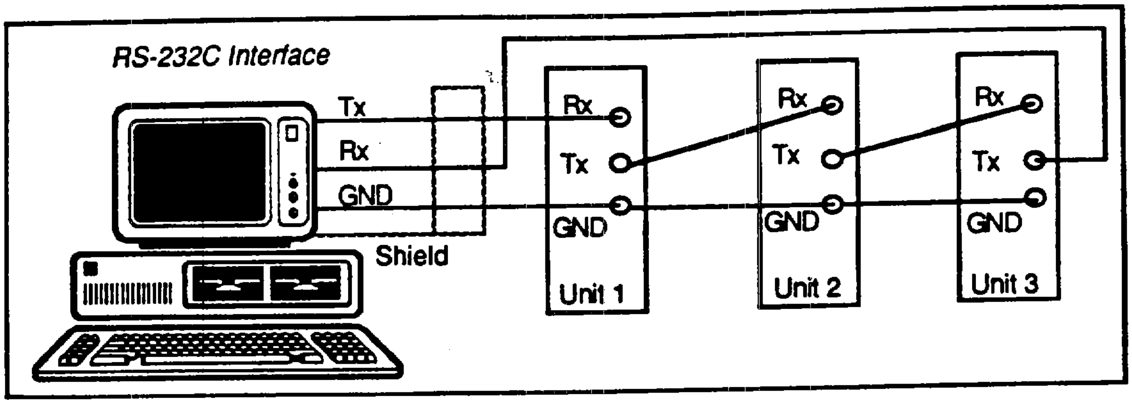


Figure 4-5. RS-232C Daisy Chain Configuration

Daisy Chaining Three Decoders

To perform this example, you must have three decoders. You will wire the units to the single RS-232C interface one at a time to assign unique device addresses for each unit. At the conclusion of this procedure, you will be able to complete the daisy chain configuration.

Step 1

After verifying that each decoder is functioning properly, wire one of the units to the host computer (as per the instructions in Chapter 2, Getting Started) apply power to the all of the units. Enter the following command on your keyboard to the decoder box.

ØSN1

This command changes the device address of this unit to **1.**

Step 2

To save this unique address setting to non-volatile memory, enter the following command:

1SS

This unit now has a unique device of **1**. Remove power from the system. Disconnect this unit from the RS-232C interface and wire another one of the units to the interface. Re-apply power.

Step 3

To assign a unique device address to this unit, enter the following command:

ØSN2

This command changes the device address of this unit to **2.**

Step 4

To save this unique address setting to non-volatile memory, enter the following command:

2SS

This unit now has a unique device of **2**. **Remove power from the system.** Disconnect the unit from the RS-232C interface.

*At this point, all three of the decoders have a unique device address (Ø, 1, and 2—**the decoder you did not change maintains the default address setting of Ø**).*

Step 5

Refer to Figure 4-7 and wire the daisy chain configuration as shown.

Step 6

Apply power to the three decoders and the computer/terminal. Press the space bar on your keyboard. If the cursor on the screen moves, you are receiving an echo. This indicates that the RS-232C communication link is working properly (from computer/terminal to decoder and from decoder back to computer/terminal). If your cursor does not move when you press the space key, check your wiring connections (refer to Figure 4-7 and repeat this step. If the problem persists, refer to Chapter 7, Maintenance & Troubleshooting.

Step 7

After you have successfully received an echo, enter the following commands (you will receive a response after each command):

ØPR
1PR
2PR

The **PR** (Position Report) command provides a position report. You should receive a position report for each decoder with these commands. If you do not receive the position reports, check your wiring.

Step 8

Manually move the encoder shaft position of the encoder with the unique device address of Ø. To see the change in position, type the following command:

ØPR

The position report for this unit's position should differ from the position report you received for this unit in Step 7.

Step 9

Manually move the encoder shaft position of the encoder with the unique device address of **1**. To see the change in position, type the following command:

1PR

The position report for this unit's position should differ from the position report you received for this unit in Step 7.

Step 10

Manually move the encoder shaft position of the encoder with the unique device address of **2**. To see the change in position, type the following command:

2PR

The position report for this unit's position should differ from the position report you received for this unit in Step 7.

The successful completion of these steps verify that all of the decoders configured on your daisy chain are operating properly. If you encounter problems, check your wiring and try this procedure again (from Step 1), or refer to Chapter 7, Maintenance & Troubleshooting.

Using Multiple Units on an RS-422/485 Interface

If you use more than one decoder (i.e., multi-drop), verify that each unit is communicating properly (see Chapter 2, Getting Started). Ensure that each unit is communicating properly *before you configure your multi-drop system.*

When you use multiple units with the RS-422/485 interface, you can multi-drop up to 16 units to one host serial port. *Each decoder wired on a multi-drop configuration must have a unique device address.* You can assign a unique device address with the SN (Define Device Address) command. The factory default address is Ø. Refer to Chapter 5, Software Reference for more information on the SN command. This section provides a step-by-step procedure for assigning unique device addresses for your decoders. *Do not attempt to assign device addresses at this time.* Refer to Figure 4-6 for an example of proper multi-drop wiring.

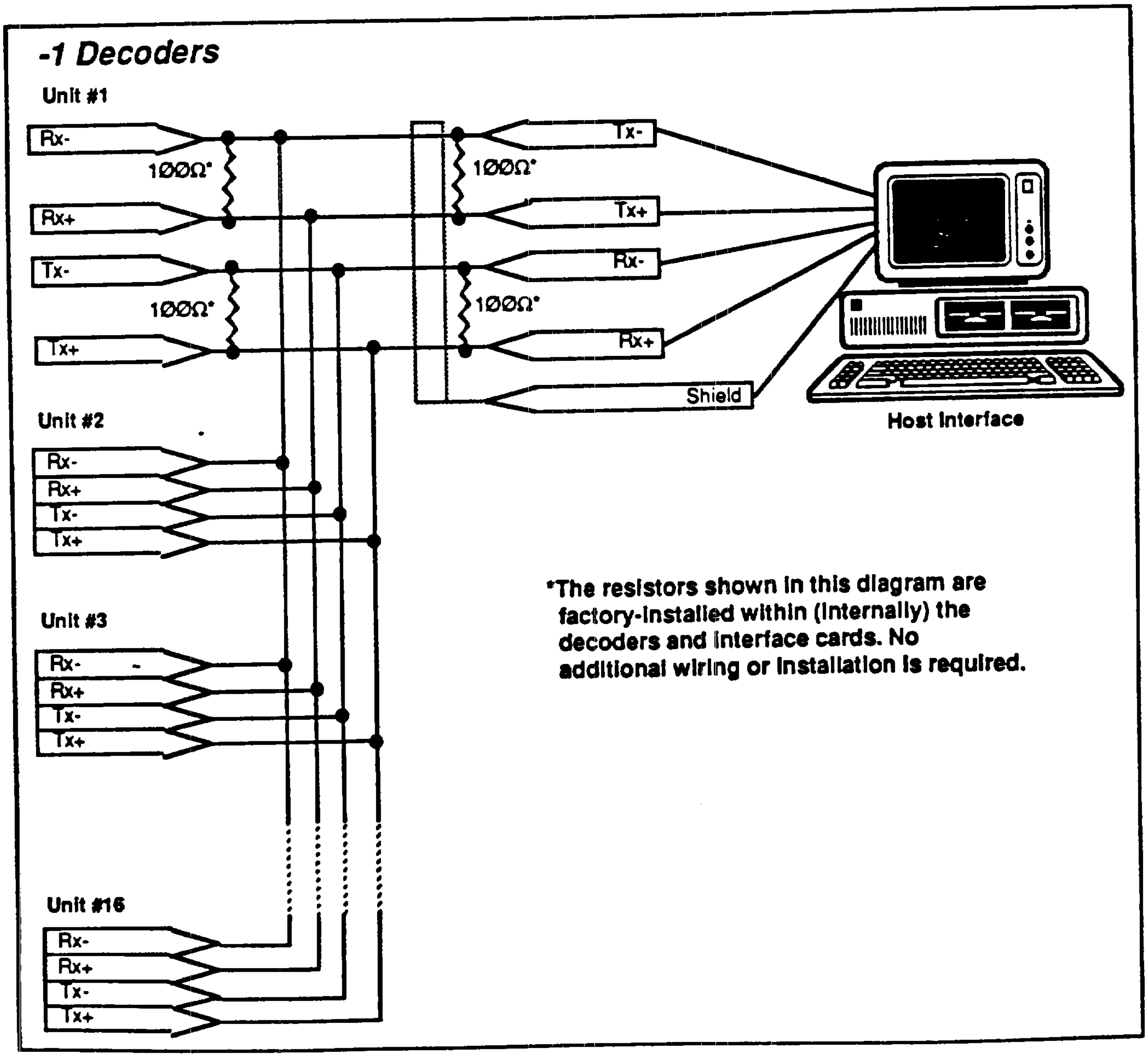


Figure 4-6. AL Multi-Drop Wiring

Multi-Dropping Three Decoders

To perform this example, you must have three decoders. You will wire the units to the single RS-422/485 interface one at a time to assign unique device addresses for each unit. At the conclusion of this procedure, you will be able to complete the multi-drop configuration.

Step 1

After verifying that each decoder is functioning properly, wire one of the units to the host computer (as per the instructions in Chapter 2, Getting Started) apply power to the all of the units. Enter the following command on your keyboard to the decoder box.

ØSN1

This command changes the device address of this unit to **1.**

Step 2

To save this unique address setting to non-volatile memory, enter the following command:

1SS

This unit now has a unique device of **1**. Remove power from the system. Disconnect this unit from the RS-422/485 interface and wire another one of the units to the interface. Re-apply power.

Step 3

To assign a unique device address to this unit, enter the following command:

ØSN2

This command changes the device address of this unit to **2.**

Step 4

To save this unique address setting to non-volatile memory, enter the following command:

2SS

This unit now has a unique device of **2**. **Remove power from the system.** Disconnect the unit from the RS-422/485 interface.

*At this point, all three of the decoders have a unique device address (Ø, 1, and 2—**the decoder you did not change maintains the default address setting of Ø**).*

Step 5

Refer to Figure 4-8 and wire the multi-drop configuration as shown.

Step 6

Apply power to the three decoders and the computer/terminal.

Step 7

After you have successfully received an echo, enter the following commands (you will receive a response after each command):

ØPR
1PR
2PR

The **PR** (Position Report) command provides a position report. You should receive a position report for each decoder with these commands. If you do not receive the position reports, check your wiring.

Step 8

Manually move the encoder shaft position of the encoder with the unique device address of **Ø**. To see the change in position, type the following command:

ØPR

The position report for this unit's position should differ from the position report you received for this unit in Step 7.

Step 9

Manually move the encoder shaft position of the encoder with the unique device address of **1**. To see the change in position, type the following command:

1PR

The position report for this unit's position should differ from the position report you received for this unit in Step 7.

Step 10

Manually move the encoder shaft position of the encoder with the unique device address of **2**. To see the change in position, type the following command:

2PR

The position report for this unit's position should differ from the position report you received for this unit in Step 7.

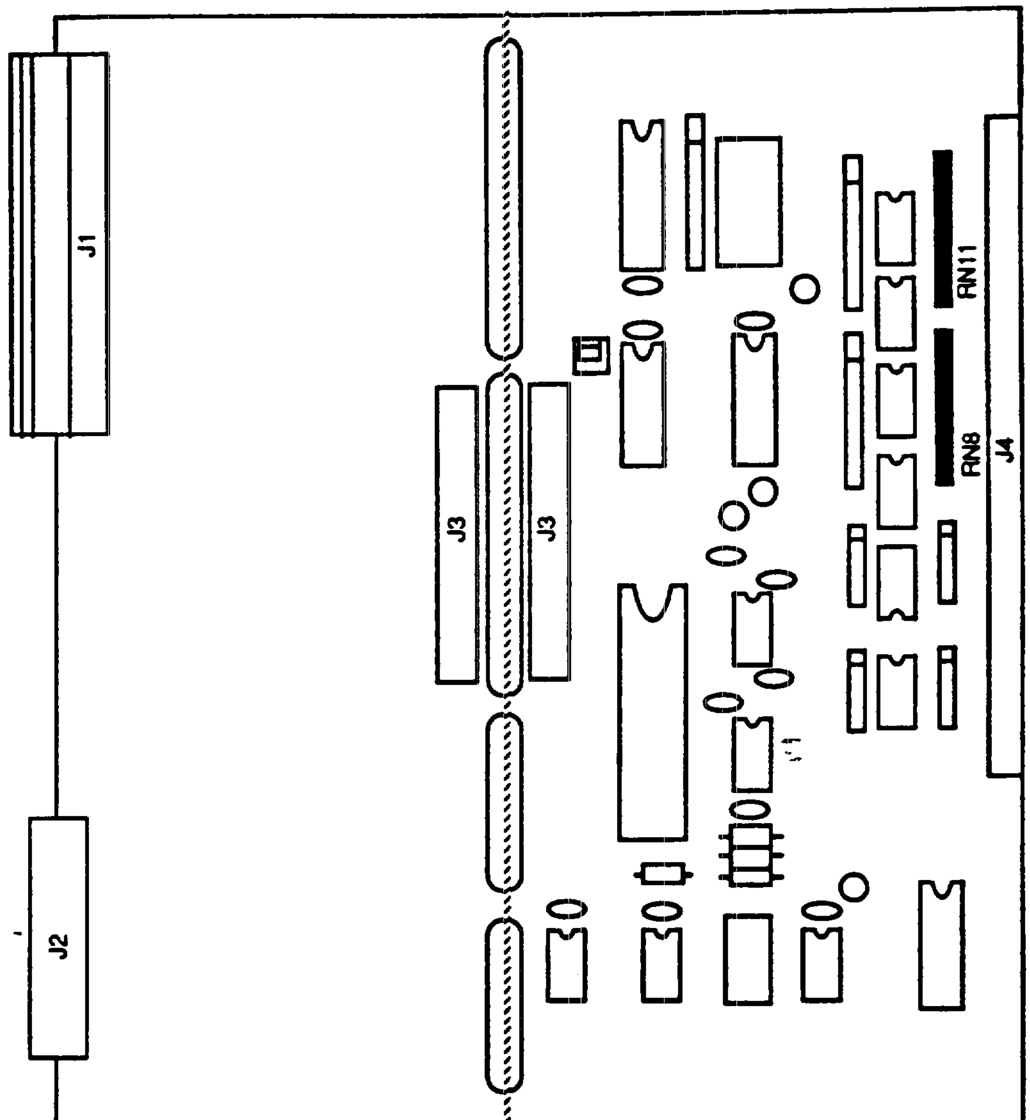
The successful completion of these steps verify that all of the decoders configured on your multi-drop configuration are operating properly. If you encounter problems, check your wiring and try this procedure again (from Step 1), or refer to Chapter 7, Maintenance & Troubleshooting.

Using Multiple Units in Parallel Output Mode

If you intend to use more than one decoder in parallel output mode (8-bit or 16-bit), you can *multiplex* the parallel outputs. Multiplexing allows you to share common data and control signals between decoders. This reduces the number of inputs and outputs that your PLC uses. You may multiplex as many units as your PLC can handle. For example, if your PLC has 16 available inputs (Device Enable) and outputs (Data Valid), you can multiplex 16 units. You are limited only by the capability of your PLC.

You can read only one decoder at a time. Each decoder must have its own distinct input and output on the PLC. Refer to your PLC's user guide for specific information on I/O capabilities and programming.

Before you begin to wire your multiplex configuration, you must remove resistor packs **RN8** and **RN11** from all but one decoder in the multiplex configuration (the last unit). For example, if you multiplex 5 units, you would remove resistor packs **RN8** and **RN11** from units 1 - 4 and keep them in unit 5. Removing these resistors prevents the output transistors from saturating due to low impedance. Refer to Figure 4-7 for the location of these resistors.



This is not a complete drawing of the board. The important information is the location of resistor packs RN8 and RN11 (the shaded areas in this diagram). *Do not remove or manipulate any other components on this board.*

Figure 4-7. Location of RN8 and RN11 Resistor Packs (Decoder Board)

Figure 4-8 illustrates the wiring configuration for multiplexing. Before wiring the units, be sure that each unit complies with the recommendations previously discussed (distinct I/O on PLC and removal of resistors on all but one unit).

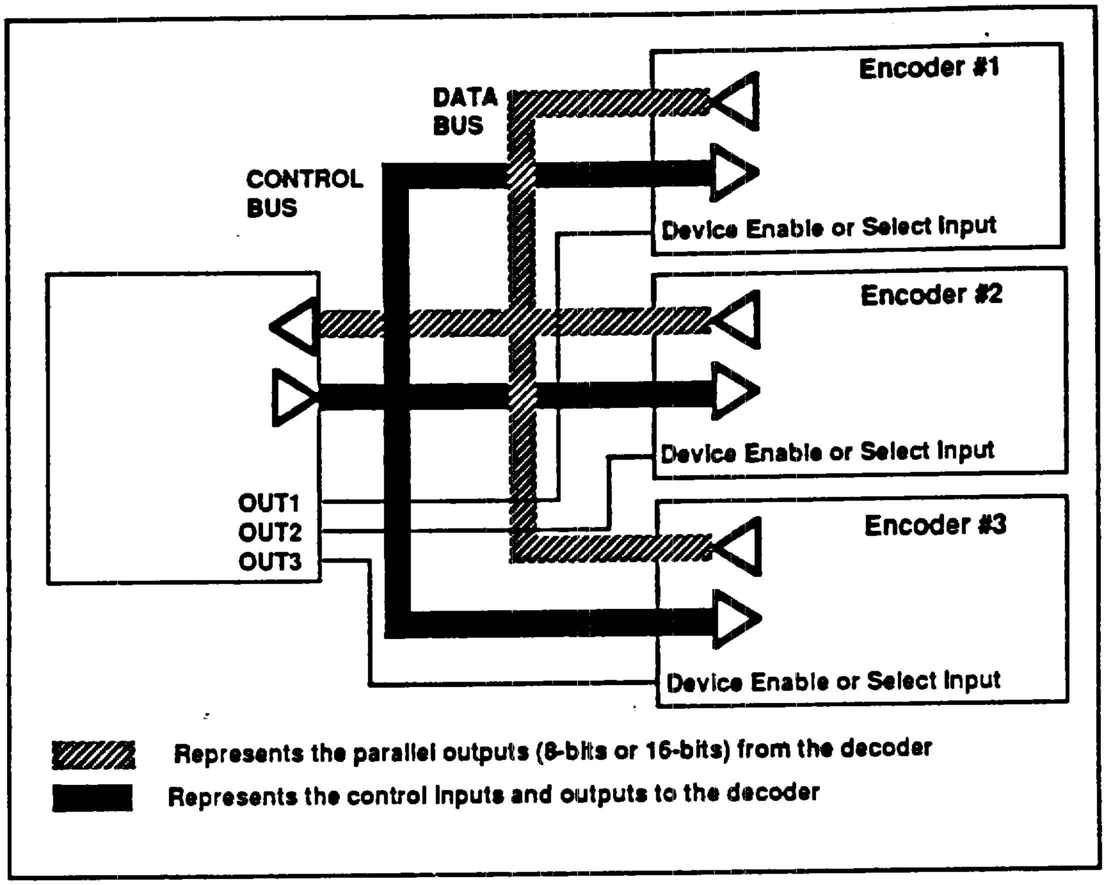


Figure 4-8. Multiplexing Configuration

The decoder also has a Data Valid (DV) output. The PLC can handshake with the decoder using the DV output and the Device Enable (DE) input of the decoder.

Chapter 5. SOFTWARE REFERENCE

Chapter Objectives

The information in this chapter will enable you to:

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

Command Descriptions

The AL allows you to communicate over the serial interface with several software commands.

(1) SO (2) Set-Up	(3) Define Offset Position			(4) VALID Software Version
(5) SYNTAX aSOnnnnnnnn	(6) UNITS n = offset	(7) RANGE 0 - 255, A	(8) DEFAULT 0	(9) ATTRIBUTES Immediate Independenty Saved
(10) EXECUTION TIME <2 ms		(11) SEE ALSO SS		
(12) RESPONSE TO aSOnnnnnnnn IS N/A				

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

2. Type This portion of the box contains the command's type. The four command types are listed below.

Status Status commands respond (report back) with information.

Set-Up Setup commands define setup conditions for the application. Setup commands include the following types of commands:

- Homing (Go home acceleration and velocity, etc.)
- Input/Output (Limits, scan time, in-position time, etc.)
- Tuning (Servo or position tracking)
- General (Set switches, return to factory settings, etc.)

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

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 software when the command was added or modified. If the revision level of the 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.

5. Syntax

The proper syntax for the command is shown here. The specific parameters associated with the command are also shown. Definitions of the parameters are described below.

a This indicates that a device address must accompany the command. Only the device specified by this parameter receives and executes the command. If this parameter, or any other parameter appears within brackets <a>, it is optional.

n This represents an integer. You may use an integer to specify a variety of values (acceleration, velocity, etc.).

6. Units

This field describes what unit of measurement the parameter in the command syntax represents.

7. Range

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

8. Default

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

9. Attributes

This box indicates if the command is ***immediate*** or ***buffered.*** The system executes immediate commands as soon as it receives them. Buffered commands are executed in the order that they are received with other buffered commands. You can store buffered commands in a sequence and save them in permanent memory.

The lower portion of the box explains how you can save the command—Independently Saved or Never Saved

You must enter an SS (Save Parameters) command to maintain parameters that are ***independently saved***. A command that is ***never saved*** is never placed in the system's permanent memory.

10. Execution Time

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

11. See Also

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

12. Response

A sample status command is given (next to **RESPONSE TO**) and the system response is shown in the adjoining box. ***This box will only be provided if the system provides a response to the command. If no response is provided. this box will not be included with the command description.***

Special Programming Note

If you are using a decoder, you may press the Enter key (carriage return—[cr]) or the space bar (_) on your keyboard to serve as a .i.delimiter;.

Command Listing

AR Status	Automatic Position Report			VALID Software Version Y
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
<a>**AR**n	n = enable or disable	0 or 1	1	Immediate Never Saved
EXECUTION TIME <2 ms		**SEE ALSO** SS, SP		

Description

This command enables/disables the automatic serial position report. When enabled, the position will be updated 15 times each second. If you enter **0**, you will disable the function. If you enter **1**, you will enable the function. You can only use this command while you are in the serial mode (RS-232C & RS-422/485). If your application requires daisy chaining, you must disable the Automatic Report function (position reports do not contain addresses). Once you enable this function, it reports position information continuously until you issue a**ARØ** to disable the function.

Example

Command	Description
ØAR1	Enables automatic position report

PB Status	Binary Position Report			VALID Software Version Y
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
aPBn	revolutions	N/A	N/A	Immediate Never Saved
EXECUTION TIME <2 ms		**SEE ALSO** PR, P		
RESPONSE TO aPB **IS** ØØØØØØØØØ11ØØØ1ØØØ1ØØØ111ØØ1				

Description

When you enter this command, the AL reports the encoder's current position in binary format. This position will be offset and scaled by programmed parameters. The position report will not appear in ASCII format, therefore, you must read the response as a binary report. If the AL is searching for ASCII characters, the unit's response will be in the form of ASCII characters that correspond to the binary pattern.

Example

Command	Response
ØPB	ØØØØØØØØØ11ØØØ1ØØØ111ØØ1 (represents 0.6239 inches)

PR Status	Position Report			VALID Software Version Y
SYNTAX aPR	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2 ms		**SEE ALSO** PB		
RESPONSE TO aPR **IS** Ø_Ø5458Ø2				

Description

This command reports the current absolute position. Upon execution, the AL provides formatted and scaled encoder position information over the serial port. The encoder's position is reported with seven digits. The last four digits represent the fraction of a revolution that the encoder is located at. The first three digits represent the absolute number of encoder turns. The report is given in one of the following formats, depending on how you set the **SP** command:

SPØ Response is in hexadecimal format
SP1 Response is in decimal format (no decimal point)
SP2 Response is in decimal format (decimal point automatically inserted)

Example

Command	Response
ØPR	Ø_Ø5458Ø2 (Ø = an error code, _ = a space, and the seven-digit number represents the current absolute encoder position). The space will contain a minus sign [-] if you create a position offset (so command) and the encoder rotates beyond the new zero point in the decreasing counts direction.

RP Status	Report Set-Up Parameters			VALID Software Version Y
SYNTAX aRP	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2 ms		**SEE ALSO** N/A		

Description

This command reports the current set-up parameters. The report is sent via the serial port in ASCII decimal format only.

Example

Command	Decoder Response
ØRP	SN=Ø SP=ØØ SE=Ø1 AR=ØØ SO=ØØØØØØØØ SF=ØØ5ØØØ SL=ØØØØØØØØ

(these represent default settings)

RV Status	Revision Level			VALID Software Version Y
SYNTAX aRVn	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2 ms		**SEE ALSO** PR		
RESPONSE TO aRV **IS** RV 92-9109-01A				

Description

The **RV** (Revision) command provides the current software revision level. The response is given in the following format: RV 92-9109-01n (n = the level of the revision, the preceding 8-digit number is the part number). The revision level indicates when the software was written. You may want to record this information in your own records for future use. This type of information is especially useful when directing questions about software to Parker Compumotor's Applications Department.

Example

Command	Description
ØRV	Indicates the software revision level for this unit

SE Set-Up	Enable Error Checking			VALID Software Version Y
SYNTAX aSDn	**UNITS** n = enable or disable	**RANGE** 0 or 1	**DEFAULT** 1	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2 ms		**SEE ALSO** SS		

Description

This command enables/disables the error checking function. If you enter **1**, you will enable error checking. If you enter **0**, you will disable error checking. The error code is the most significant (first) digit of the position report in serial mode, and the two most significant bits (first two) in parallel mode. Four possible error codes may be reported. These error codes are described in Chapter 7, Troubleshooting & Maintenance.

Example

Command	Description
ØSE1	Enables error checking

SF Set-Up	Define Scale Factor			VALID Software Version Y
SYNTAX aSFnnnnn	**UNITS** n = 0.001	**RANGE** 00001 - 29999	**DEFAULT** 5000	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2 ms		**SEE ALSO** SS		

Description

This command scales the encoder position output in desired units. This is multiplied by the present position before a position output is reported. There is an imaginary decimal after the first number.

Example

Command	Description
ØSFØ5ØØØ	Defines the scale factor as 0.5
SF2ØØØØ	Defines the scale factor as 2.0000

SL Set-Up	Define Output 2 Position			VALID Software Version Y
SYNTAX aSLnnnnn	**UNITS** n = 0.01	**RANGE** 000001 - 99999	**DEFAULT** 0	**ATTRIBUTES** Immediate Independently Saved
EXECUTION TIME <2 ms		**SEE ALSO** SS		

Description

The decoder has a dead band value of 0.01 inches. This command defines a position where Output 2 is turned on. This command indicates to a remote controller that the AL has reached its home position. Output 1 is used in the same manner as the status LED (Output 1 and the status LED will be on if the encoder reaches the absolute zero position). You cannot control Output 1 with the **SL** command. It has a dead band value of 0.01 inches. *If the encoder cable is not connected, the decoder will interpret the encoder's position as zero (Ø) and illuminate the status LED.*

Example

Command	Description
ØSLØ4ØØ1	Defines Output 2 as active at position Ø40.01. Output 2 will remain active between encoder position Ø40.0100 and Ø40.0199.

SN Set-Up	Define Device Address			VALID Software Version Y
SYNTAX aSNn	**UNITS** n = device address	**RANGE** 0 to 9, A - F	**DEFAULT** 0	**ATTRIBUTES** Immediate Independently Saved
EXECUTION TIME <2 ms		**SEE ALSO** N/A		

Description

This command defines the device address of each unit. Use this command when more than one unit is connected to same serial port. These addresses are valid for daisy chain and multi-drop configurations. The maximum address capability is 16 units (0 - 9, A - F). Only four units may be configured on an RS-232C daisy chain, however, the units may be assigned any valid address (i.e., the addresses do not have to be sequential—1, 2, 3, 4).

Example

Command	Description
ØSN5	Defines new address as 5 (address was previously 0)

SO Set Up	Define Position Offset			VALID Software Version Y
SYNTAX aSOnnnnnnn	**UNITS** n = position offset	**RANGE** 0 - 255, A	**DEFAULT** 0	**ATTRIBUTES** Immediate Independently Saved
EXECUTION TIME <2 ms		**SEE ALSO** SS		

Description

This command has an imaginary decimal point after the third digit. It allows you to establish an absolute zero point without turning the shaft until position zero is present. The system compares the value that you enter to the actual position before you entered the command. The difference between the two represents the offset. If you enter A after the command, the offset will be reset to Ø. The offset value that you enter after ØSO becomes the new encoder position corresponding to the present mechanical encoder position. *The offset value that you enter cannot be greater than the current encoder value or 2,550,000. Values beyond this range will elicit invalid data from the system.*

Example

Command	Description
ØSOØ	Defines present position as zero

SP Set-Up	Define Position Offset			VALID Software Version Y
SYNTAX aSPn	**UNITS** n = data output format	**RANGE** 0 (binary/hex), 1 (BCD/decimal), or 2 (enable decimal)	**DEFAULT** 0	**ATTRIBUTES** Immediate Independently Saved
EXECUTION TIME <2 ms			**SEE ALSO** SS	

Description

This command defines the format of position output data. Zero (Ø) defines the data format to be binary for parallel output and ASCII hexadecimal for serial output. If you enter **1**, you will define the data format as BCD for parallel output and ASCII decimal for serial output. If you enter **2**, the decimal point will be enabled at the fourth place from right. *You must turn DIP switch 5 off.* If you are reading from the parallel output (BCD or binary), set this command to its factory default setting (SP2). The setup should be performed with DIP Switch 3.

Example

Command	Description
ØSPØ	Enables serial output format as ASCII hexadecimal

SS Set-Up	Save Parameters			VALID Software Version Y
SYNTAX aSS	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2 ms			**SEE ALSO** N/A	

Description

Saves all currently defined set-up parameters in non-volatile memory. All commands previously entered will be lost if you do not execute this command.

Example

Command	Description
ØSS	Saves all current set-up parameters

Z Set-Up	Software Reset			VALID Software Version Y
SYNTAX Z	**UNITS** N/A	**RANGE** N/A	**DEFAULT** N/A	**ATTRIBUTES** Immediate Never Saved
EXECUTION TIME <2 ms		**SEE ALSO** N/A		

Description

The z (Reset) command is equivalent to cycling power to the decoder. This command returns all internal settings to their default values, unless they were modified and saved with the ss command. This command does not require a device address.

Example

Command	Description
z	Resets any and all decoders on the system

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 switch settings and proper I/O connections

AL System Specifications

This section provides pertinent technical data for the AL Encoder.

Mechanical

Resolution

0.0005"—2,000 steps per inch or 0.0001"—10,000 steps per inch (if you are reading data in BCD format)

2,048 (0.00048") or 32,768 (0.00003") positions/inch. (if you are reading data in binary format)

Accuracy

±0.001 (25 microns) bidirectional independent of length

Repeatability

±0.0001 (2.5 microns)

Starting Force

8.0 ozs. (225gms.)
(Assumes preload of 1 - 2 lbs for pinion)

Inertia

0.0005 oz-in^2 (0.5487 gm-cm)

Weight of Encoder Housing

1.0 lb (0.45 Kg)

Housing Material

Aluminum

Rack Material

#416 hardened and ground stainless steel

Speed

Slew Speed

50 ips

Maximum Operating Speed

10 ips
If you run the unit at higher speeds, you will not be able to read the least significant bit.

Electrical

Input Power

120VAC ±10%, 0.5A

Output Characteristics

TTL-compatible
Binary (8 or 16 bit words)
BCD (8 or 16 bit words)
RS-422 (9,600 baud)
RS-232C (9,600 baud)

Cable Length

10' standard from the encoder head to the decoder box (Compumotor supplied for Models AL8 - AL64)
20' maximum from the encoder head to the decoder box (Compumotor supplied for Models AL80 - AL144)
Maximum cable length is 4,000' using RS-422

Update Time

2 ms

Environment

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)

Decoder Box Pin Out

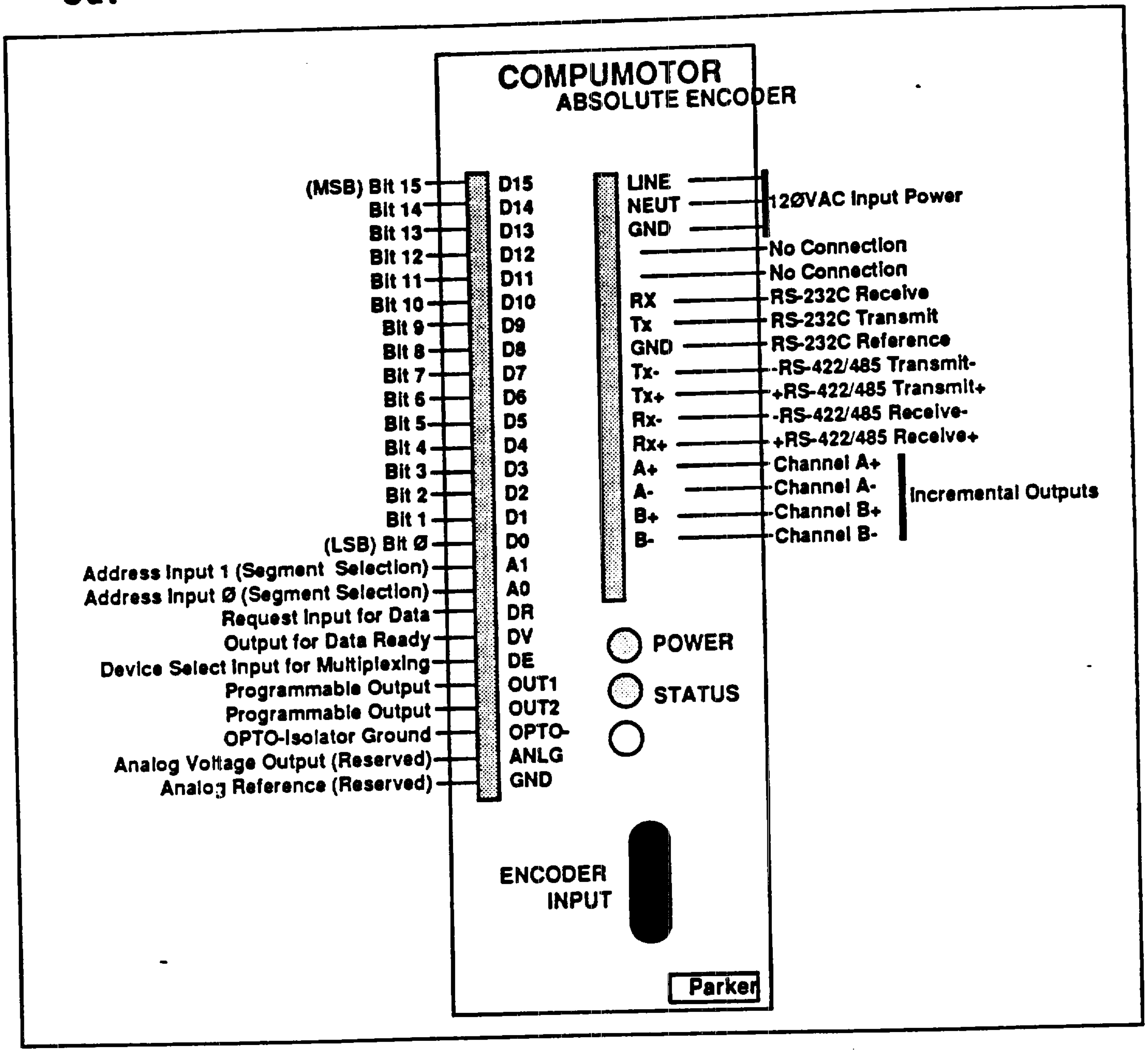


Figure 6-1. Decoder Box Pin Out

AL Dimensional Drawing

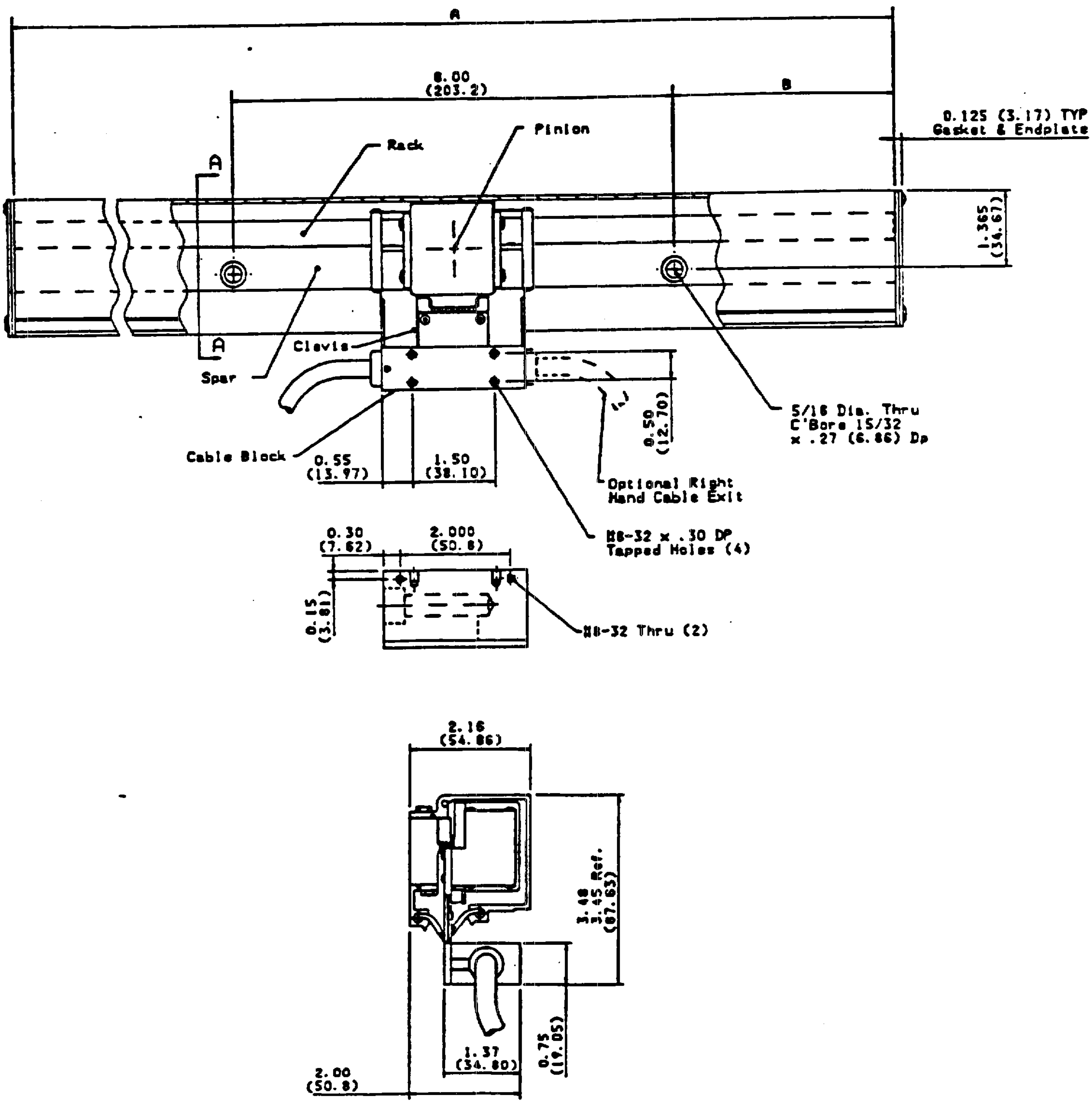


Figure 6-2. AL Encoder Dimensions

Decoder Box Dimensions

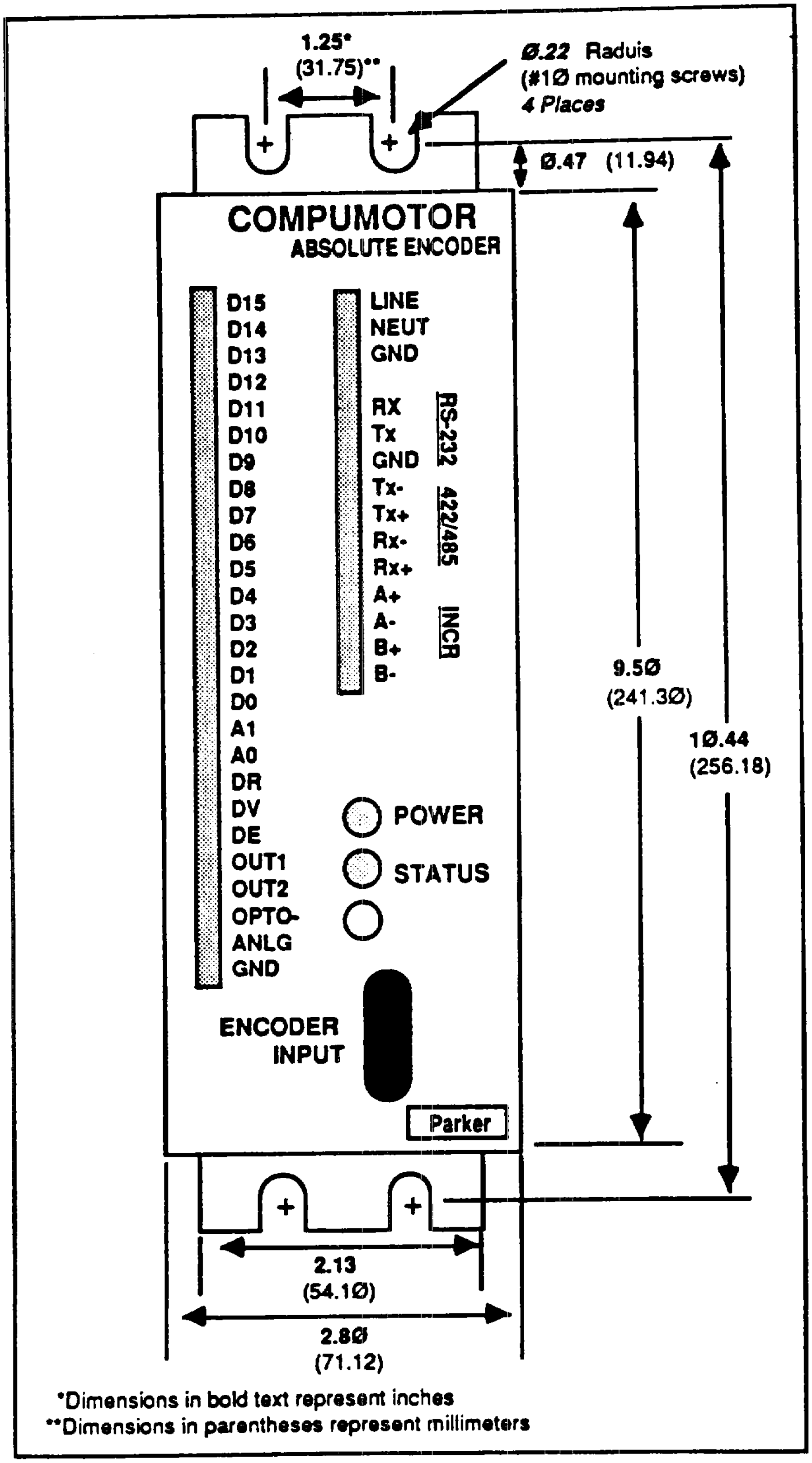


Figure 6-3. Decoder Box Dimensions (Minimum Width Mounting)

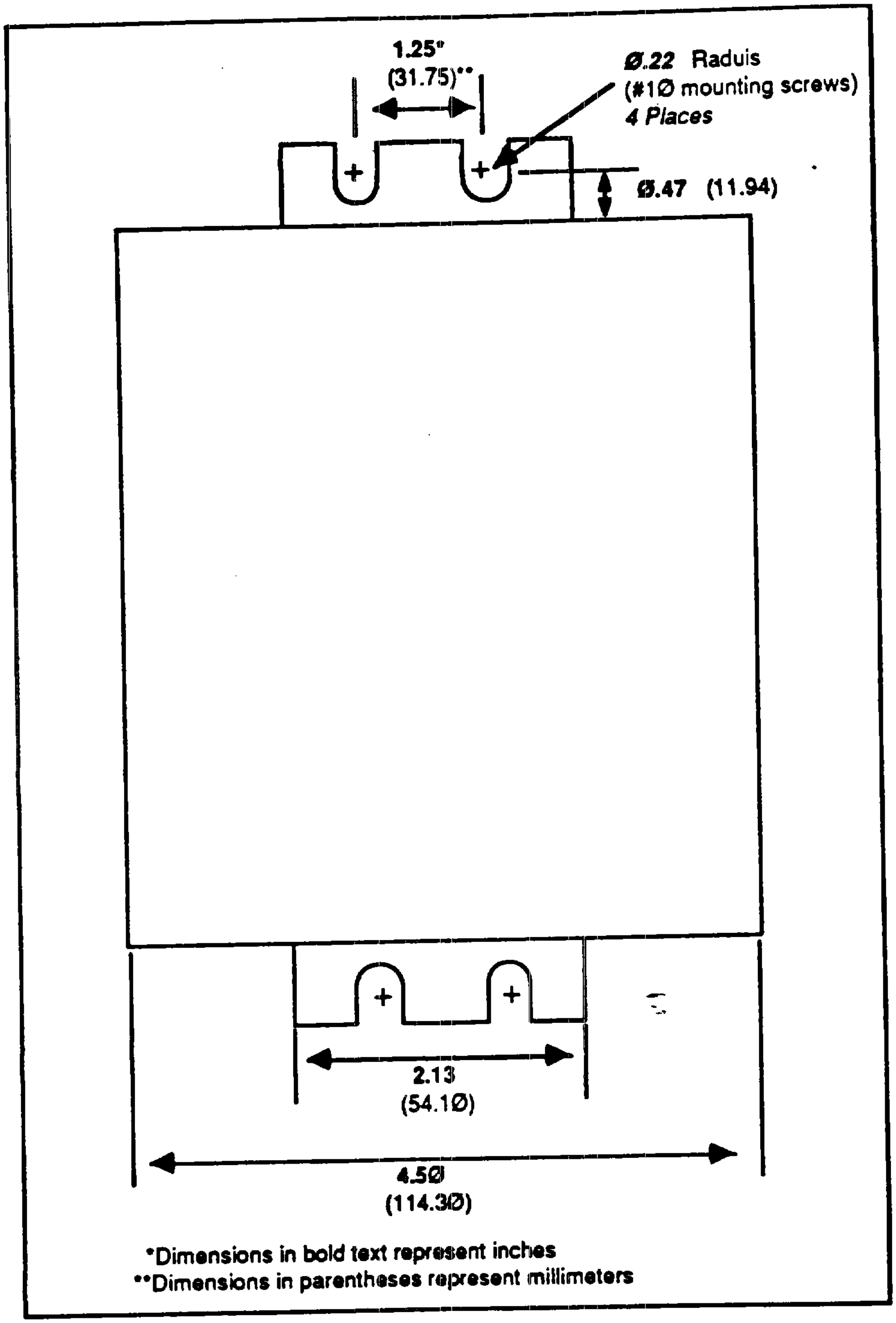


Figure 6-4. Decoder Box Dimensions (Minimum Depth Mounting)

Decoder Schematics

-1 Decoder

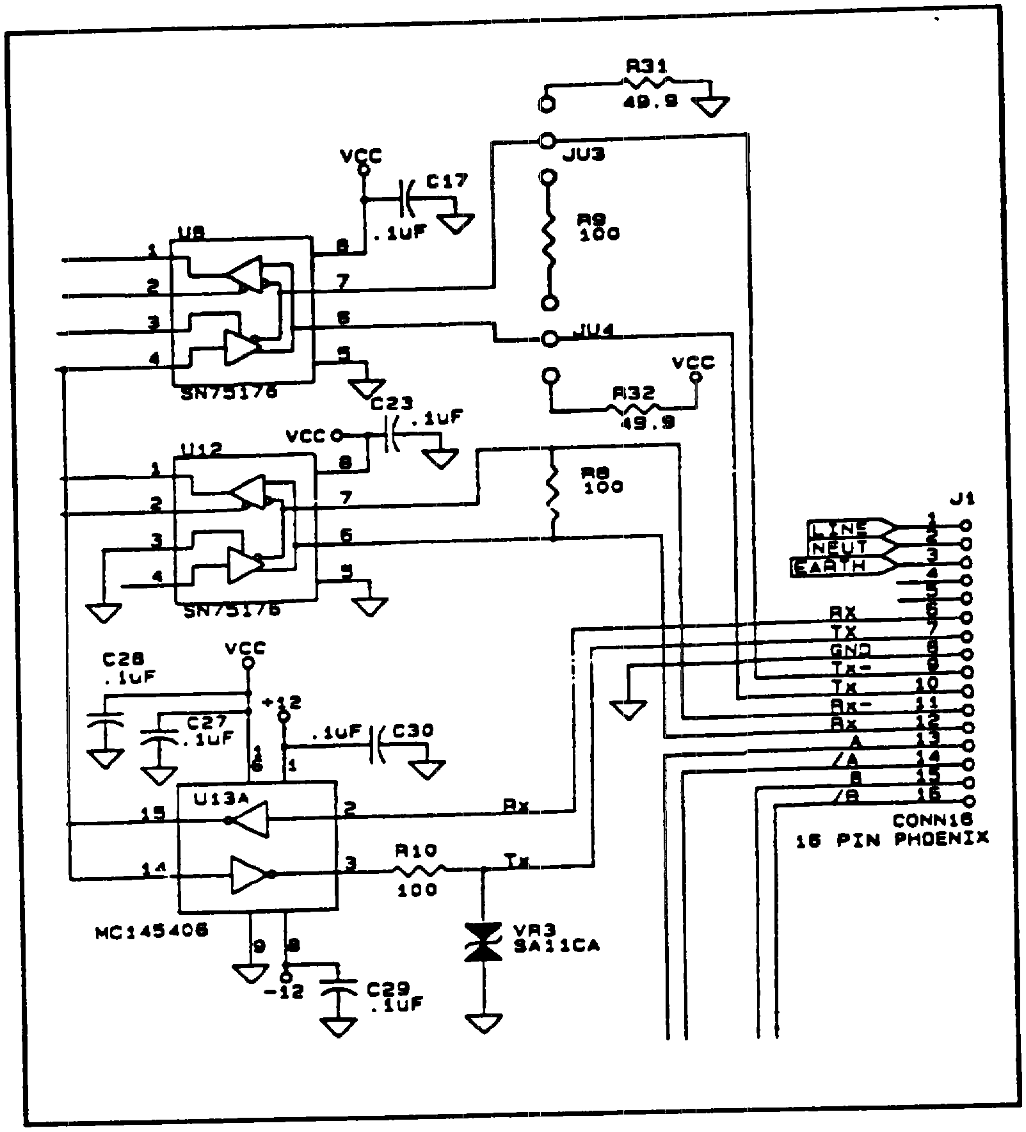


Figure 6-5. Serial Interface

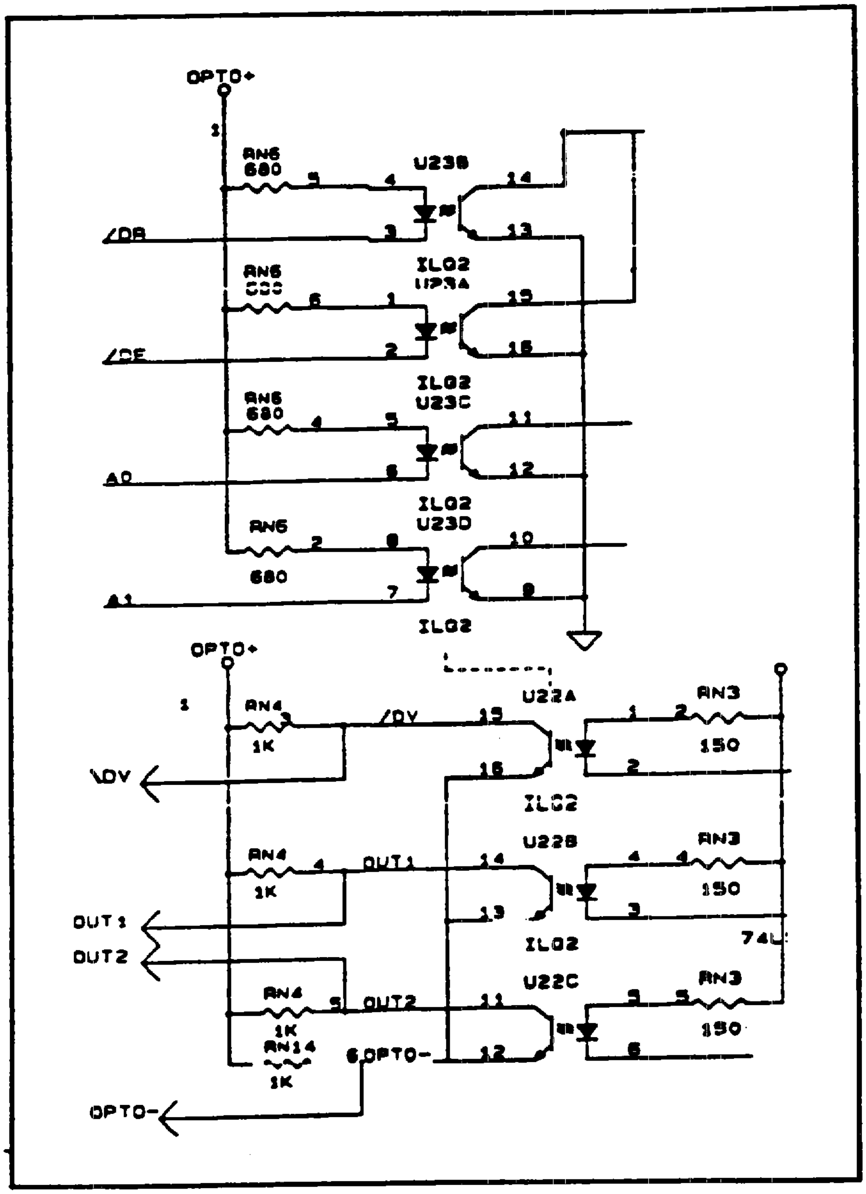


Figure 6-6. Parallel Control Inputs

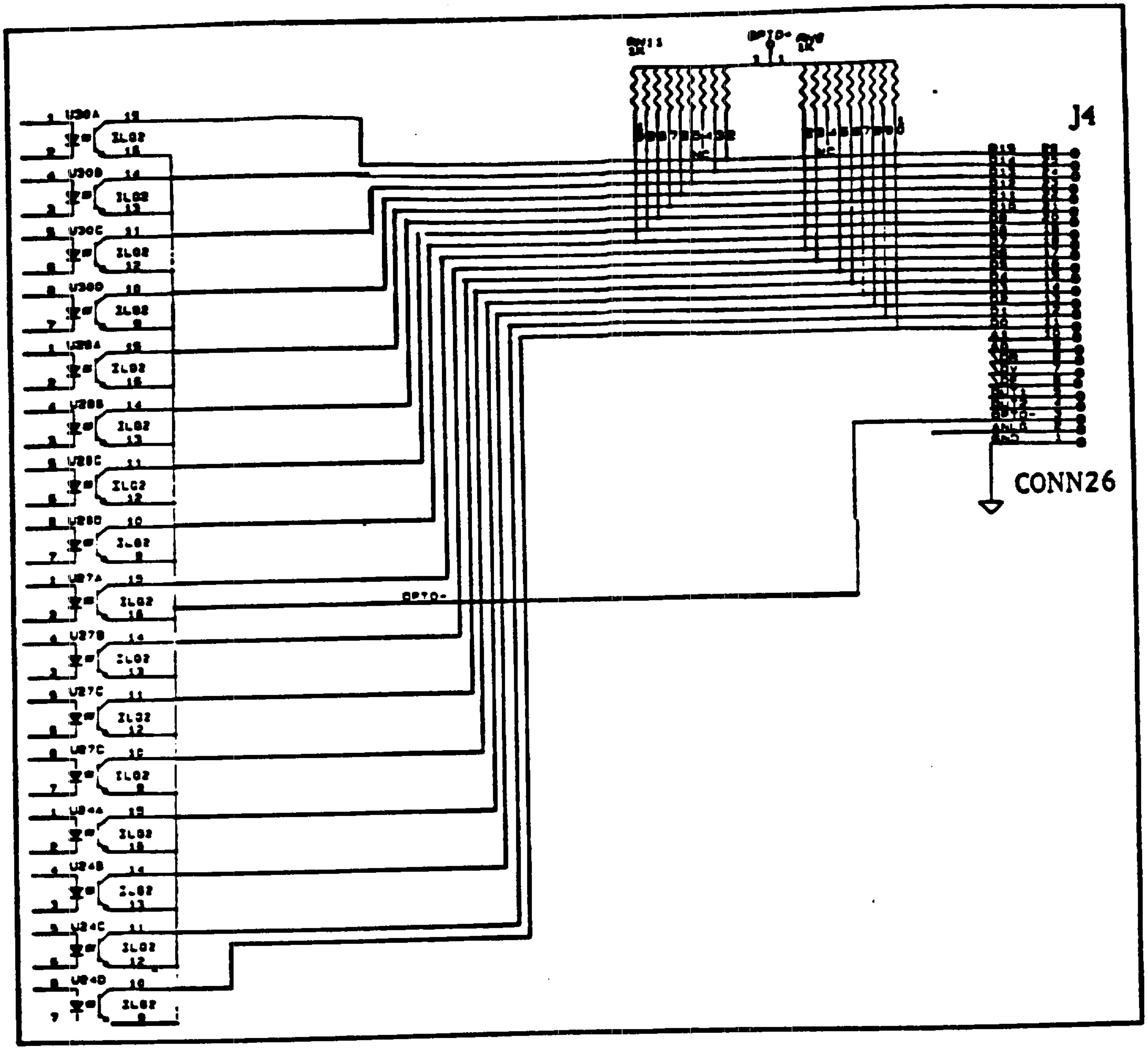


Figure 6-7. Parallel Outputs

Decoder Box DIP Switch and Jumper Settings

Setting Description: Switch 3

Switch #	OFF	ON
S1	RS-232C*	RS-422/485
S2	Full Duplex*	Half Duplex
S3	CCW Direction*	CW Direction
S4	8-Bit Parallel	16-Bit Parallel*
S5	Binary (Hex)*	BCD (Decimal)
S6	Single turn	Multi-turn
S7	Binary Mode*	Mode Select
S8	Binary Mode*	Mode Select-
*Factory-default setting		

Table 6-1. Decoder Box Default DIP Switch Settings

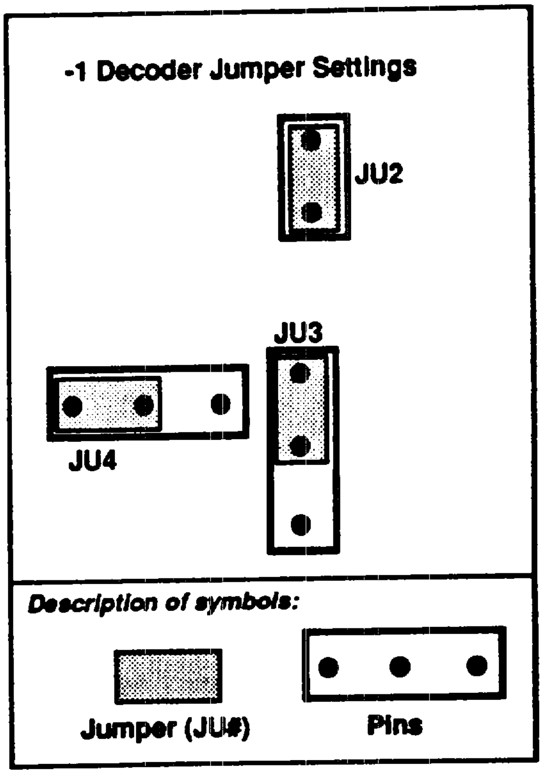


Figure 6-8. Jumper Default Settings

Numbering Code Table

Decimal Digit	BCD Code	Binary Code	Hexadecimal Code
Ø	ØØØØ	ØØØØ	Ø
1	ØØØ1	ØØØ1	1
2	ØØ1Ø	ØØ1Ø	2
3	ØØ11	ØØ11	3
4	Ø1ØØ	Ø1ØØ	4
5	Ø1Ø1	Ø1Ø1	5
6	Ø11Ø	Ø11Ø	6
7	Ø111	Ø111	7
8	1ØØØ	1ØØØ	8
9	1ØØ1	1ØØ1	9
1Ø	1 ØØØØ	1Ø1Ø	A
11	1 ØØØ1	1Ø11	B
12	1 ØØ1Ø	11ØØ	C
13	1 ØØ11	11Ø1	D
14	1 Ø1ØØ	111Ø	E
15	1 Ø1Ø1	1111	F

Table 6-2. Numbering Codes

Chapter 7. MAINTENANCE & TROUBLESHOOTING

Chapter Objectives

The information in this chapter will enable you to:

- Maintain the system's components to ensure smooth, efficient operation
- Isolate and resolve system hardware problems
- Use this chapter as a quick-reference tool for a description of system error codes

---

Troubleshooting

This section covers the step-by-step procedure to identify and resolve system problems. Troubleshooting is broken into two sections covering serial interface mode only. Each section provides suggestions to help you identify the source of the problem and eliminate the problem.

RS-232C Communications

Enter **ØRP** to determine if the AL reports the set-up parameters. If no echo is even received, switch wires going into decoder box labeled **Rx** and **Tx**. Enter the command again. If you still do not receive a response, remove the decoder box cover and make sure encoder cable is firmly connected to encoder circuit. You will not have to remove the cover, since the connection is external (outside of the decoder box).

If you are having problems communicating with the indexer, 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 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 then establish three-wire communication by connecting RTS to CTS (usually pins 4 and 5) and DSR to DTR (usually pins 6 to 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 20 ft. unless you are using some form of line driver, optical coupler, or shield. As with any control signal, be sure to shield the cable to earth ground at one end only.

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.

If the computer is looking for handshaking signals, you may need to install jumper wires at the terminal end to disable this function. Since the pin-out from various computers are different, refer to your computer's operator's manual for instructions on how to disable the handshaking function. Most computers, however, use the pins shown in Figure 7-1 to install jumpers. For more detailed information on this topic, refer to *RS-232C Made Easy*, published by Prentice -Hall, Inc.

After you have checked your computer, enter [cr]ØRP. The system should respond with set-up parameters. The reason for entering a [cr] before the command is to clear the buffer before you enter the command.

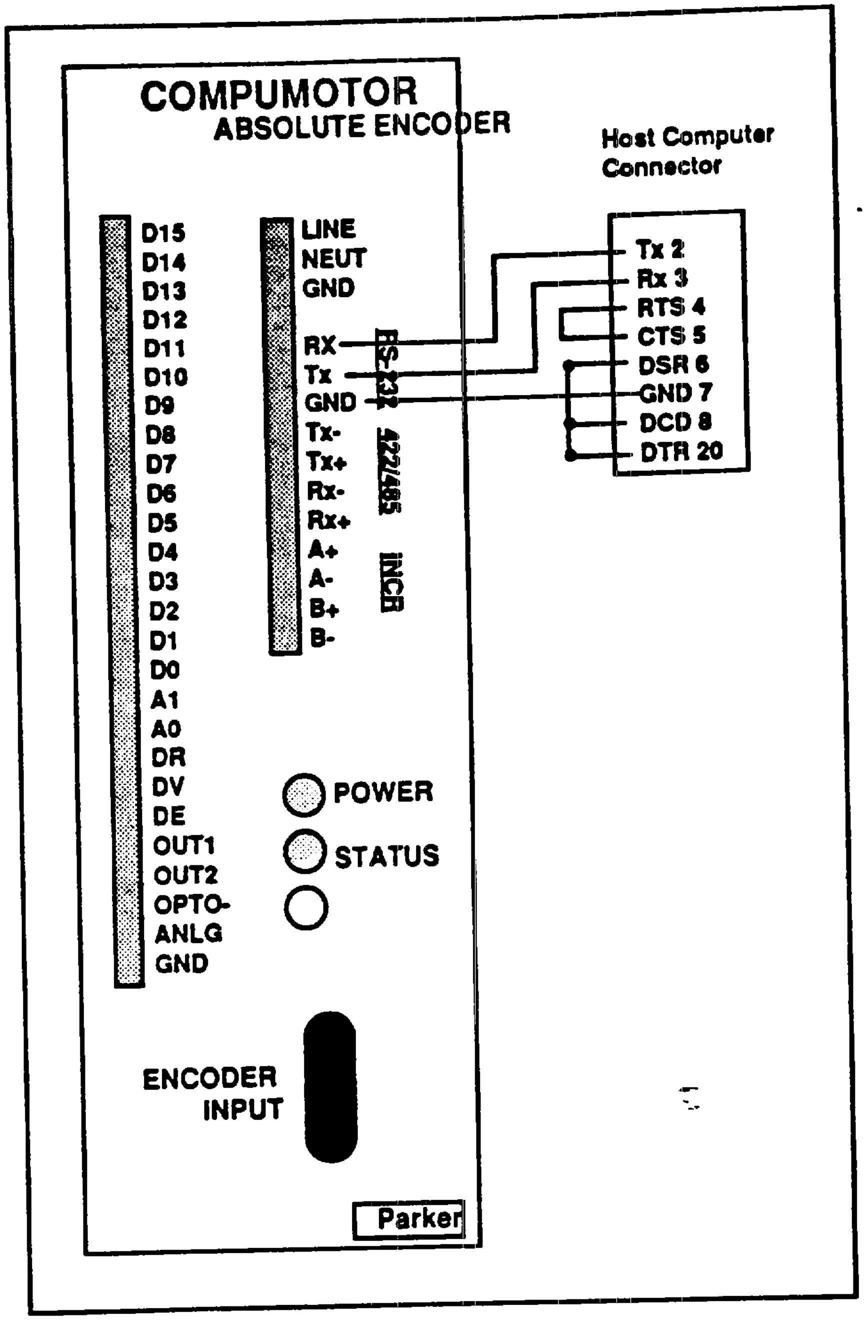


Figure 7-1. Disabling the Handshaking Function

If you still do not received an echo, use another computer to complete this test (determine if the serial port is not compatible with the system or if it is malfunctioning). If this is not possible, contact our Application Department at (800) 358-9068.

If you receive echoed characters, but no parameters are reported, the address preceding the **RP** *command may be something other than Ø. The only way to find the proper address is to try all of the numbers in range (ØRP - FRP).*

RS-422/485 Communications

If you are using a decoder, verify that the DIP switches are properly set (as shown in Chapter 2, Getting Started). Double check the system connections (review Chapter 3, Installation). Type the following command:

ØRP

The response to this command will help you to determine if set-up parameters are reported. If no data is reported, there may be a compatibility problem with the interface circuit that you are using. Since there is no echo with RS-422/485, the next step is to verify that the interface circuit is operating with the following parameters:

- Baud Rate: 9,600
- Data Bits: 8
- Start/Stop Bit(s): 1
- Parity: None

If you receive echoed characters, but no parameters are reported, the address preceding the **RP** *command may be something other than Ø. The only way to find the proper address is to try all of the numbers in range (ØRP - FRP).*

Recommended RS-422/485 Interface Devices

Some customers have made special interface boards that were not compatible with RS-422/485 standards. A listing of interface products that have been used successfully by a variety of AL users is provided below.

1. ***RS-422/485 to RS-232C converter -B & B model 422CON.*** Phone number: (815) 434-0846.

2. ***IBM RS-422/485 interface board - Qua-Tech model DS-2Ø1/DS-2Ø2.*** Phone number: (216) 434-3154.

If communication problems arise, contact Compumotor's Application Engineering Department at (800) 358-9068.

Reducing Electrical Noise

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

System Installation Recommendations

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

Electrical Noise

When an AL is operated in an environment where there is an excess amount of electrical noise, special care must be taken to eliminate sources of possible noise interference. Potential sources of electrical noise include inductive devices such as solenoids, relays, motors, and motor starters when they are operated by a hard contact. 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 7-2 shows some recommended suppression devices for most small loads. For best results, install these devices as close as possible to the inductive load.

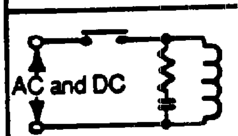
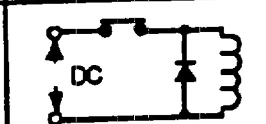
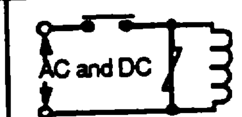
RC	DIODE	VARISTOR (MOV)
		
1. Can be saved for both AC and DC circuits 2. Use 500-1000 ohm for R and 0.1 - 0.2 microF @ 200V	For DC circuit only	Can be used for both AC and DC circuits

Figure 7-2. Noise Suppression Devices

Enclosure Considerations

You should install the AL 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 instruction or access the wrong data. The 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 down the system if the program is interrupted. This prevents the most damaging failures from occurring.

Since electrical noise is not visible, it is very difficult to detect. You can be certain, however, that 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 motor 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 eliminate this problem. See Figure 7-2.

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 600A welders and 25kW transmitters have been solved using enclosures, conduit, optical isolation,and single point ground techniques.

Ground Loops

Ground Loops are the most mysterious noise problems. They seem to occur most often in systems where a control computer is using RS-232C communication. Symptoms like garbled transmissions and intermittent operation are typical.

The problem occurs in systems where multiple Earth ground connections exist, particularly when these connections are far apart.

Suppose a Model 2100 is controlling an axis, and the limit switches use an external power supply. The 2100 is controlled by a computer in another room. If the power supply Common is connected to Earth, the potential exists for ground loop problems. This is because most computers have their RS-232C signal common tied to Earth. The loop starts at the 2100's limit switch ground, goes to Earth through the poser supply to Earth at the computer. From there, the loop returns to the 2100 through RS-232C signal ground. If a voltage potential exists between power supply Earth and remote computer Earth, ground current will flow through the RS-232C ground creating unpredictable results.

The way to test for and ultimately eliminate a ground loop is to lift or *cheat* earth ground connections in the system until the symptoms disappear.

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.

Error Code Descriptions

Error Code	Description	Course of Action
Ø	No error present. System is functioning properly.	
1	Not ready for read. Reset must have occurred.	Check your AC power line and ensure that it is clean. If the power line is O.K., apply power and try reading the position again.
2	EEPROM failure. Under this condition, the AL will automatically default to factory parameters. If parameters cannot be saved with the SS command, the EEPROM has failed.	Try saving the parameters using the SS command. Cycle power after you complete the save and the error should not re-appear. If the problem persists, you may have a EEPROM problem. Call the factory.
3	Data error. Positional read will need to be repeated. If this persists, noise or a bad component may be the cause.	Check for noise in the encoder. (Refer to the noise reduction procedures explained in this chapter).
5	Fine resolution data error. Position read will need to be repeated. This usually occurs when the electronics are not tuned to the encoder head.	Try to read the position again. If you receive this error on a regular basis, call the factory.

Table 7-1. Error Code Descriptions

APPENDICES

Command Summary

Command	Description	Default Setting
AR	Auto position report in ASCII	Ø/Auto report disabled
PB	Report present position in binary	
PR	Report present position in ASCII	
RP	Report present parameter settings	
RV	Report software revision level	
SD	Set Direction of system	Ø/Increasing output CCW
SE	Set (enable) error check	1/Error check enabled
SF	Define scale factor	1/Scale factor multiplier
SL	Define position for Output 2	511.99/Set Output 2 position
SM	Define RS-422/485 full/half duplex	Ø/Full Duplex
SN	Define device address	Ø/Address Ø
SO	Define position offset	Ø/Ø Offset
SP	Define positional data format	1/Output format ASCII decimal
SS	Save set-up parameters in EEPROM	
Z	Hardware and software reset	

All parameters must be saved with the SS *command or they will be lost after power is cycled.*

Recommended Third-Party Vendors

Vendor	Product(s)	Address
Metrabyte	Models PIO12, COM485, DUAL 422	440 Myles Standish Blvd. Taunton, MA 02780 Phone: (508) 880-3000
Datastorm Technologies	Pro-Comm™	P.O. Box 1471 Columbia, MO 65205 Phone: (314) 449-9401

GLOSSARY

Absolute Positioning
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.

Absolute Programming
Refers to a motion control system employing position feedback devices (absolute encoders) to maintain a given mechanical location.

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.

Baud Rate
The number of bits transmitted per second. Typical rates include 3ØØ, 6ØØ,12ØØ, 24ØØ, 48ØØ, 96ØØ, 19,2ØØ. This means at 96ØØ baud, one character (-1Ø bits) can be sent nearly every millisecond.

BCD
Binary Coded Decimal is an encoding technique used to describe the numbers Ø through 9 with four digital (on or off) signal lines. Popular in machine tool equipment.

Bit
Abbreviation of Binary Digit, the smallest unit of memory equal to 1 or Ø.

Block Diagram
A simplified schematic representing components and signal flow through a 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. Characters are stored as bytes.

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.

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.

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 of a 25 pin D connector.

Dead Band
A range of input signals (steps) for which there is no system response or correction.

Detent Torque
The minimal torque present in an un-energized 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 characters on pin two and receives on pin three of a 25 pin D connector.

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.

Half Duplex
In half duplex mode, a terminal will display every character transmitted. It may also display the received character, resulting in double character displays.

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

without causing the rotor to rotate continuously.

Home
A reference position in a motion control system, usually derived from a mechanical datum. Often designated as the "zero" position.

Hysteresis
The difference in response of a system to an increasing or a decreasing input signal.

IEEE-488
A digital data communications standard popular in instrumentation electronics. This parallel interface is also known as GPIB, or General Purpose Interface Bus.

Incremental Motion
A motion control term that is used to describe a device that produces one step of motion for each step command (usually a pulse) received.

Incremental Programming
A coordinated system where position or distances are specified relative to the current position.

Inertia
A measure of an object's resistance to a change in velocity. The larger an object's inertia, the larger the torque that is required to accelerate or decelerate it. Inertia is a function of an object's mass and its shape.

Inertial Match
For most efficient operation, the system coupling ratio should be selected so that the reflected inertia of the load is equal to the rotor inertia of the motor.

Limits
Properly designed motion control systems have sensors called limits that alert the control electronics that the physical end of travel is being approached and that motion should stop.

Logic Ground
An electrical potential to which all control signals in a particular system are referenced.

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

Multi-Dropping
A method of linking several RS-422/485 devices in parallel fashion. The data still flows one bit at a time, but it is faster than RS-232C because the information reaches all devices at the same time. Multi-dropped devices must have unique device addresses. These addresses are used in software command syntax to send data to specific units.

Multiplexing
A method of linking several parallel output devices into a single unit and reading only one unit at a time. This mode of operation involves input/output handshaking. It allows the host to communicate with multiple units while requiring fewer inputs and outputs.

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.

The frequency of the step pulses applied to a motor driver. The pulse rate multiplied by the resolution of the motor/drive combination (in steps per revolution) yields the rotational speed in revolutions per second.

Ramping
The acceleration and deceleration of a motor. May also refer to the change in frequency of the applied step pulse train.

Rated Torque
The torque producing capacity of a motor at a given speed. This is the maximum torque the motor can deliver to a load and is usually specified with a torque/speed curve.

Relative Accuracy
Also referred to as "Step to Step Accuracy," this specification tells how microsteps can change in size. In a perfect system, microsteps would all be exactly the same size, but drive characteristics and the absolute accuracy of the motor cause the steps to expand and contract by an amount up to the relative accuracy figure. The error in not cumulative.

Repeatability
The degree to which the positioning accuracy for a given move performed repetitively can be duplicated.

Resolution
The smallest positioning increment that can be achieved. Frequently defined as the number of steps required for a motor's shaft to rotate one complete revolution.

Ringing
Oscillation of a system following a sudden change in state.

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.

RS-422/485
A data communications standard that encodes a string of information on a single line in a time sequential format. The standard runs at high voltage (±15VDC), which allows for longer cable lengths and fewer

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.

Transistor-Transistor Logic. Describes a common digital logic device family that is used in most modern digital electronics. TTL signals have two distinct states that are described with a voltage—a logical "zero" or "low" is represented by a voltage of less than Ø.8 volts and a logical "one" or "high" is represented by a voltage from 2.5 to 5 volts.

XON/XOFF
Two ASCII characters supported in some serial communication programs. If supported, the receiving device transmits an XOFF character to the host when its character buffer is full. The XOFF character directs the host to stop transmitting characters to the device. Once the buffer empties the device will transmit an XON character to signal the host to resume transmission.

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