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Compumotor

PC21 Indexer User Guide

Compumotor Division
Parker Hannifin Corporation
p/n 88-004100-04 B

Parker

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User Guide Change Summary

The following is a summary of the primary changes to this user guide since the last version was released. This user guide, version 88-004100-04A, supersedes version 88-004100-04Y.

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

The entire user guide has been changed according to the new Compumotor user guide styles, format, and illustration standards. Also, the chapters have been renumbered and reorganized. Technical changes to each chapter are synopsized below.

Chapter 1. Introduction

Chapter 1 was changed as to update the product features and provide a theory of operation.

Chapter 2. Getting Started

Changes to Chapter 2 are summarized as follows:

- New and updated system connection procedures
- Ship kit changes
- Updated functional test procedures

Chapter 3. Installation

Changes to Chapter 3 are summarized as follows:

- Updated I/O connection procedures
- New tests to verify system connections and functionality.

Chapter 4. Application Design

Changes to Chapter 4 are summarized as follows:

- New application considerations
- Updated sample moves and operating mode descriptions
- Updated programming section

Chapter 5. Software Reference

Changes to Chapter 5 are summarized as follows:

This section lists all commands and syntaxes in alphabetical order.

Chapter 6. Hardware Reference

Changes to Chapter 6 are summarized as follows:

- Updated system specifications and dimensional drawings
- New system pin-out tables and I/O circuit illustrations

Chapter 7. Maintenance & Troubleshooting

Changes to Chapter 7 are summarized as follows:

- New suggested spare parts list
- New troubleshooting methods
- New procedures for returning the system to affect repairs or upgrades

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How To Use This Manual

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

Assumptions

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

- IBM (or IBM-compatible) computer experience
- Basic electronics concepts (voltage, switches, current, etc.)
- Basic motion control concepts (torque, velocity, distance, force, etc.)

With this level of understanding, you can effectively use this manual to install, develop, and maintain your system.

Contents of This User Guide

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

Chapter 3: Installation — This chapter will help you 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's needs. Important application considerations are discussed. Sample applications are provided.

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

Chapter 6: Hardware Reference — This chapter contains information on system specifications. This chapter is as a quick-reference tool for proper DIP 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.

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Installation Process Overview

To ensure trouble-free operation, you should pay special attention to the environment in which the PC21 Indexer 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 the PC21 into your facility. Industrial environments may adversely affect solid-state equipment. Electrical noise or atmospheric contamination, may also affect the PC21 Indexer System.

Developing Your Application

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

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

Installation Recommendation

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

1. Review this entire user guide. Become familiar with the manual's contents so that you can quickly find the information you need.
2. Develop a basic understanding of all system components, their functions, and interrelationships.
3. Complete the basic system configuration and wiring instructions provided in *Chapter 2, Getting Started.*
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 user guide. You should try to simulate the task(s) that you expect to perform when you permanently install your application (however, do not attach a load at this time). This will give you a realistic preview of what to expect from the complete configuration.
5. After you have tested all of the system's functions and used or become familiar with all of the system's features, carefully read *Chapter 3, Installation.*
6. After you have read Chapter 3 and clearly understand what must be done to properly install the system, you should begin the installation process. Do not deviate from the sequence or installation methods provided.
7. Before you begin to customize your system, check all of the system functions and features to ensure that you have completed the installation process correctly.

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

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Conventions

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

Warnings & Cautions

Warning and caution notes alert you to possible dangers that may occur if you do not follow instructions correctly. Situations that may cause bodily injury are presented as warnings. Situations that may cause system damage are presented as cautions. Refer to the examples shown below.

WARNING

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

CAUTION

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

Change Bars

When a new user guide version is produced, the new or changed text is differentiated with a change bar in the right margin (e.g., this paragraph). If the entire chapter is changed, the change bar is located to the right of the chapter title.

Related Publications

The following publications may be helpful resources.

Current Parker Compumotor Motion Control Catalog

Operations manual for the IBM or IBM-compatible computer that you will use with the PC21 Indexer

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

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Chapter 1. INTRODUCTION

Chapter Objectives

The information in this chapter will enable you to:

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

Product Description

The Model PC21 Indexer is a board-level product designed to be inserted into an open slot on the IBM PC system expansion bus, or I/O channel. Simple ASCII commands determine all motor functions and can be easily programmed from high-level languages such as BASIC, C, or PASCAL. Additional input and output lines, also controlled by the interface to the IBM PC, can initiate or monitor other external events.

With the PC21 Indexer, you can move a load to a precise position and stop, move at a constant velocity, move back and forth between two positions alternately, or use any combination of these moves. Complex sequences of these moves, time delays, status report-backs and additional action can be programmed through the IBM PC to control any Compumotor Motor/Drive system. The PC21 can also control any standard 200/400 step translator.

For applications that require precise position tracking, the PC21 Indexer can be connected to an incremental optical encoder to form an integral closed-loop feedback system to enhance the accuracy of position control to submicron standards. The Position Tracking feature connects easily to any TTL-compatible encoder and allows you to match the encoder's resolution.

Product Features

- Designed for the IBM PC, AT, XT and most IBM PC compatibles, PS2 (Model 30 only)
- Functions as an intelligent peripheral to the PC
- May be programmed to interrupt the host processor
- 1,400-character memory permits downloading of multiple move sequences
- Software disk supplied
  - User utility programs
  - Set-up and test routines
  - Help information
- Supports motor/drive resolutions up to 50,000 steps/rev
- Open- or closed-loop control standard
- Three user-defined inputs and one user-defined output
- Home limit, CW and CCW end-of-travel limits provided
- User control of pulse source allows complex move profiles

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Theory of Operation

The PC21 Indexer receives acceleration, velocity, and position information (in an ASCII format) from your software, and uses that information to generate motion profile command signals for one axis. Move commands are sent to the drive in the form of *step* pulses at a rate of up to 500 kHz. Additional logic provides other necessary functions, such as monitoring limit switches, setting the direction of motor motion, turning outputs on and off, and waiting for programmable inputs.

With simple indexer commands, you can perform the following moves with the PC21.

- Rotate the axis to a precise position and stop
- Rotate the axis at a constant velocity
- Alternate back and forth between two angular positions
- Use a sequential combination of these moves

You must establish the communication between the IBM PC computer and the PC21 Indexer board with handshaking routines before you can send control commands to the PC21 Indexer. A support disk for DOS-based systems is provided. The disk contains read, write, and reset drivers (handshaking routines). You must set the PC21 Indexer board's address (as defined in this user guide) and develop and install the necessary software to establish communication.

You can use the PC21 for precise position control with no external position feedback with open-loop control systems. Compumotor's *Position Tracking* feature provides for closed-loop operation. This mode of operation uses an incremental encoder to provide a feedback signal to the indexer. The signal indicates the actual motor or load position.

You may use the *Encoder Interface* for applications that require positional accuracy that exceeds the accuracy of the mechanical drive components (such as leadscrew drives on X-Y tables).

Position Tracking is not a general servo system implementation. It does not apply any corrections to open-loop velocity during a positioning move. It can, however, instruct the motor to correct position errors, and actively hold position despite external forces (position servo).

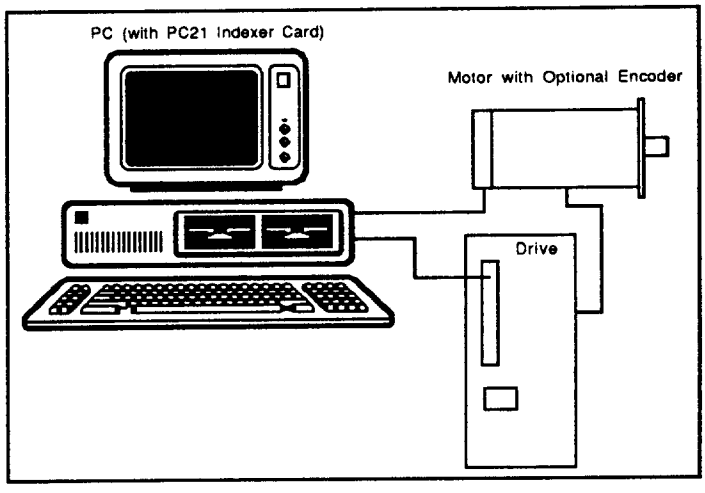


Figure 1-1. PC21 Block Diagram

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Chapter 2. GETTING STARTED

Chapter Objectives

The information in this chapter will enable you to:

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

What You Should Have

Inspect your PC21 Indexer shipment upon receipt for obvious damage to its shipping container. Report any such damage to the shipping company immediately. Parker Compumotor cannot be held responsible for damage incurred in shipment. The items listed in Table 2-1 should be present and in good condition.

Ship Kit Table

Part/Quantity	Part Number
Board Guide IBM PC	58-004144-01
Encoder Bracket	58-004319-01
Cable Assembly PC to Encoder	71-002490-01
Cable Assembly Indexer/Driver	71-004921-10
User Guide	88-004100-04 B
Support Disk	95-004145-01
15-Pin D Connector	43-000739-01
15-Pin D Connector Shell	43-000740-01
Jumpers	43-002435-01

Table 2-1. Ship Kit List

Bench Test

This section provides procedures and information to help you configure and test your PC21 System. *This is a temporary bench-top configuration (see Figure 2-1).*

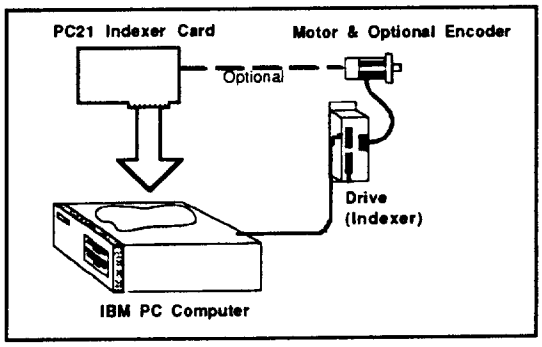


Figure 2-1. Basic System Wiring Diagram

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To complete the Bench Test, you will need the following tools and additional items (not provided with the PC21 ship kit).

- An IBM computer
- A small screw driver
- A set of needle-nose pliers

Functional Test (Hardware)

The PC21 may be functionally tested for proper operation without instructions from the IBM PC. A self-check can be performed as follows:

Installing the PC21 Board

Use the following steps to Install the PC21 board:

1. Remove power from the IBM PC.
2. Remove the cover of the computer to provide access to the internal slots where peripheral circuit boards are added.
3. Remove the metal bracket that covers the external access slot. On IBM computers, this slot is at the rear access panel of the unit. This bracket will later be replaced by the bracket on the end of the main circuit board.
4. The factory default has jumpers on pins **JU3**, **JU6**, **JU9**, **JU13**, **JU16**, **JU17**, and **JU19** installed. No other jumpers are installed. Figure 2-2 shows the location of the pins, jumpers, and DIP switches).

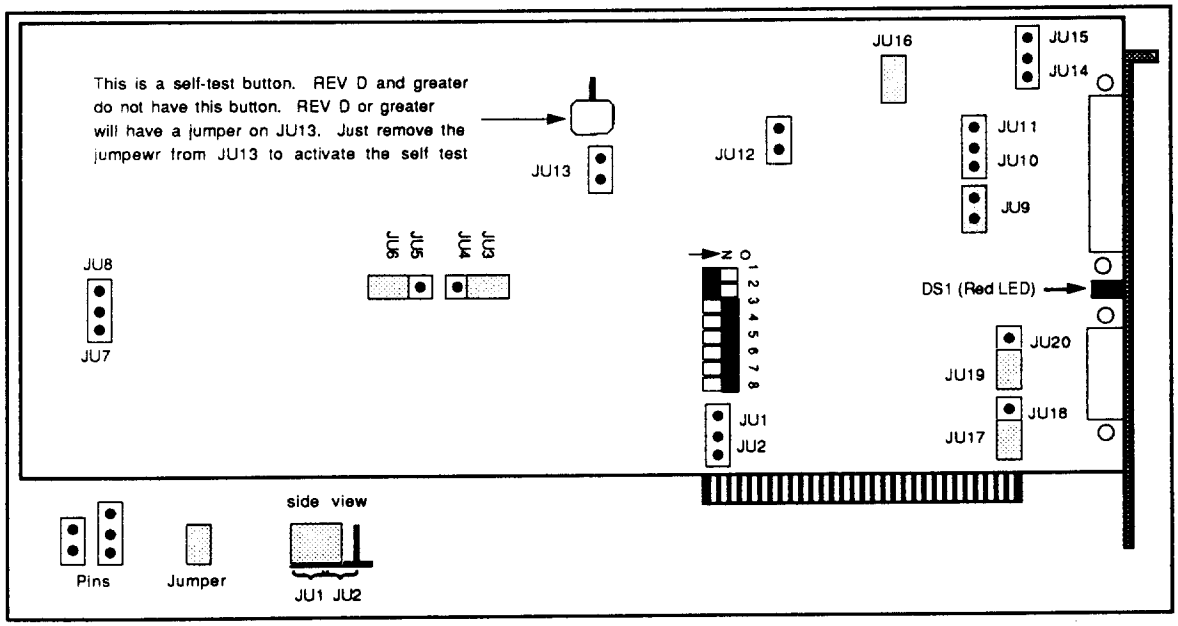


Figure 2-2. Location of DIP Switches and Jumpers

5. Mount the supplied board guide in the computer to support the opposite end of the board. This guide snaps into holes in the chassis of the computer (Figure 2-3).

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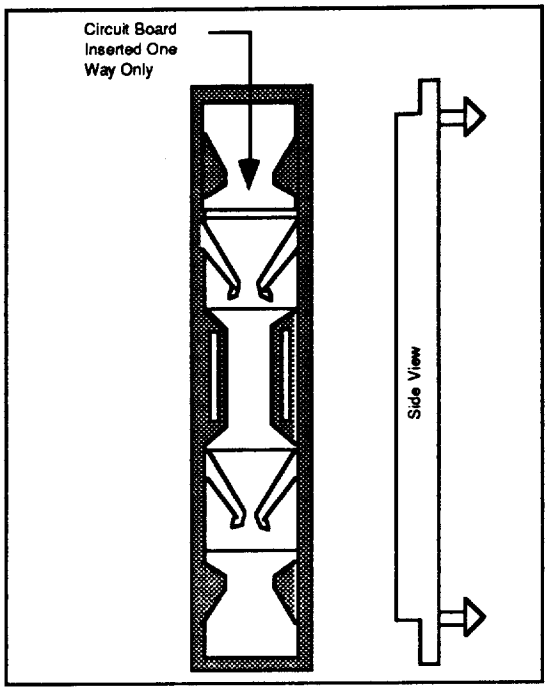


Figure 2-3. Board Guide

6. Insert the bottom corner of the PC21 Indexer board into the board guide slot and ease it and the bracket end simultaneously down into the computer until the circuit board edge connector reaches the mating connector at the bottom. Adjust the board until the edge connector lines up, and press it down into the mating connector.
7. Inspect the installed board to make sure that circuit board contacts are properly aligned with the connector fingers.

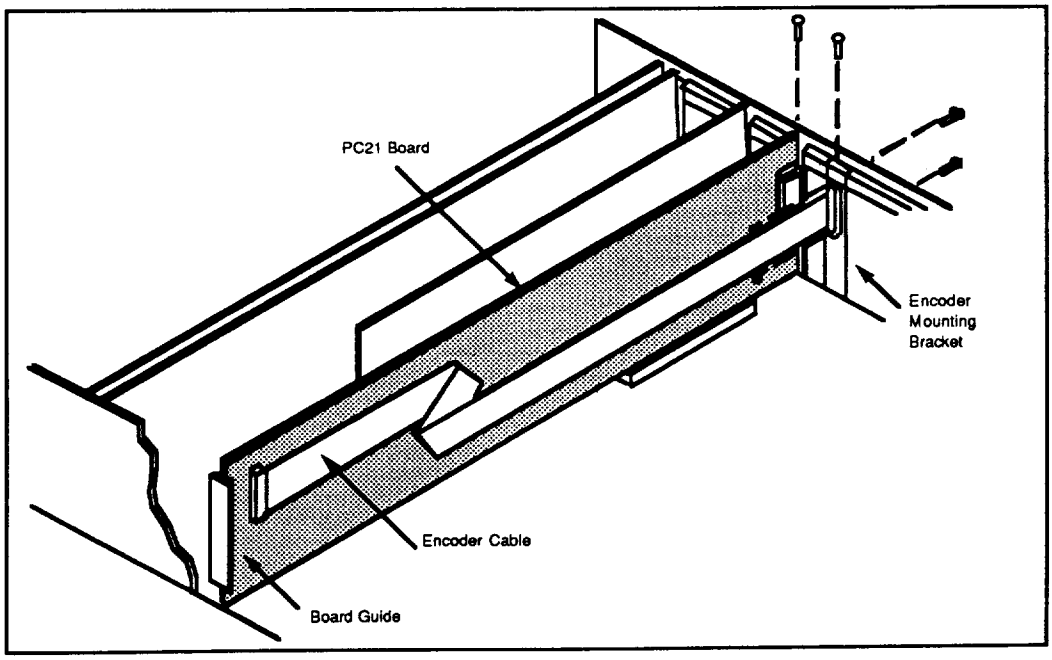


Figure 2-4. Installation Diagram

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8. Use the screw that held the original cover bracket to fasten down the PC21 mounting bracket.
9. Connect your motor/drive to the PC by attaching the motor/drive cable to connector **J2** (9-pin D connector) on the PC21.
10. Set up the motor/drive in accordance with the motor/drive operator manual.
11. If the drive has limit switches, make sure they are disabled.
12. Apply power to both the motor/drive and the PC. Be sure the motor is free to rotate in both directions.
13. ***If you have REV D or higher of the PC21 board,*** remove the jumper from **JU13**. This enables the self-test.

    If you have REV C or lower of the PC21 board, press the self-test button (Figure 2-2). This enables the self-test.

A 25,000 step/rev Compumotor motor will:

1. Rotate one revolution CCW.
2. Stop, then rotate one revolution CW and stop.
3. The board monitor alarm (the red LED, **DS1**, shown in Figure 2-2) will light upon completion of this test.

If the motor is not a 25,000-step/rev Compumotor motor, the self-test may still be performed, but the motor will not turn exactly one revolution. The PC21 issues 25,000 pulses at a rate of 5,000 Hz with the direction line held low (CCW) and then repeats the process with the direction line held high (CW). A 50,000-step/rev motor will turn only one-half revolution. A 200-step/rev motor will rotate 125 revolutions under these conditions.

Less than 25,000-step/rev motors will have an angular velocity of more than 0.2 rps. For example, if you use a 200-step/rev motor, the motor velocity will be 25 rps without the benefit of acceleration ramping, and the motor might stall.

A 200- or 400-step/rev motor (i.e., PK3) may not move due to the PC21's pulse width. The pulse width might be too narrow for the 200- or 400-step translator to recognize. This only affects the self-test function, during normal operation you can change pulse width with the Motor Resolution (**MR**) command (refer to *Chapter 5, Software Reference*).

If the motor does not rotate as described, the problem may be in one of the following areas:

1. The pulse width for the step output is too narrow for the drive to recognize. The PC21 step pulse width for the self-test is 1µs. Many 200- and 400-step translators require a larger pulse width. The PC21's pulse width can be modified with the **MR** command (refer to *Chapter 5, Software Reference*). Changing the **MR** command will not affect the self-test. **You may begin *Chapter 3, Installation.***
2. The indexer is not receiving powered from the IBM PC I/O bus. Check for 5VDC between TP6 and TP7. **Reinsert the PC21 board into the computer.**

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3. The limit switches are not connected or are not bypassed. **Ensure that limit switches are connected and closed and that jumpers are on JU9 and JU16 for this test.**

4. The self-test jumper (**JU13**) has not been removed. **Remove the jumper from JU13 (*If you have REV D or higher*).**

5. The step and direction signal is not transmitted to the drive. **Inspect the cable to ensure that it is not frayed or cut and that it is securely fastened at each end and at its connecting point.**

If problems 1 - 5 are not the source of the system's malfunction, check the motor cable and ensure that it is securely fastened to the driver. Check to see if the motor has torque. It should have torque any time it is powered unless remote power shutdown was engaged.

Reset the PC21

After the self-test, you must reset the board before normal operation may begin.

- ***If you have REV D or greater of the PC21 board***, turn off power to the computer and place the jumper on **JU13** to disable the self-test.
- ***If you have REV C or lower of the PC21 board***, turn off power to the computer and and place a jumper on **JU13** to disable the self-test. An additional jumper is provided with the ship kit.

Functional Test (Software)

1. Turn on power to the computer and insert the PC21 support disk into the computer disk drive.

2. At the **A>** prompt, type **PC21.TERM**.

3. Enter the device address (768), and answer **Y** (yes) to the reset question.

4. You should be in the terminal emulation program. Enter the command sequence below. **If you make a mistake while entering the commands, do not backspace. Instead, re-type the command sequence.**

Command	Description
> A1Ø	Sets acceleration to 10 rps^2
> V1	Sets velocity to 1 rps
> D25ØØØ	Sets distance to 25,000 steps (1 rev at 25,000 steps/rev)
> G	Execute the move (Go)

The motor should rotate one CW revolution and stop. If the motor does not move, issue the following commands:

Command	Description
> MR1	Configure motor resolution
> G	Execute the move (Go)

5. Press **<F10>** to exit the program.

6. After successfully completing the system test, remove power from all components (including the computer).

Proceed to *Chapter 3, Installation* to configure your system for permanent operation.

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Chapter 3. INSTALLATION

Chapter Objectives

The information in this chapter will enable you to:

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

Environmental Considerations

Operating	32 to 122° F (0 to 5°C) 10 to 90% humidity
Storage	-25 to 185° F (35 to 85°C)

Table 3-1. Environmental Specifications

Installation Process Overview

Installation of the PC21 is accomplished in three basic steps:

1. Configuring the PC21 (Setting the DIP Switches and jumpers)
2. Connecting the Motor/Drive
3. Attaching the various I/O connectors needed to interact your PC21 with the rest of your system.

Establish Communications

PC21 Indexer operation begins with its installation into an IBM PC I/O slot (refer to *Chapter 2, Getting Started*) and is followed by connection of the motor/drive. The PC21 may then be self-tested to ensure that it is operating normally, but beyond that, all interaction with the Indexer must be done through the IBM PC.

The PC21 appears to the PC as four address locations, only two of which are significant.

- CONTROL STATUS (base address +1)
- DATA INPUT OUTPUT (base address)

The address locations may appear as any I/O port that the PC will recognize as valid. For this reason the least significant two bits of PC21 address are not specified; they are selected by setting the eight DIP switches. The sum of the binary values of switches **SW-1** through **SW-8** is equal to the board's base address.

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Setting the PC21's Address

For the computer to control the PC21, it must know where to write instructions and read responses. The PC21 must have a unique address. The default address is suitable for testing and general use if no other peripheral devices in the computer have the same address (300 hex). This address does not conflict with typical devices that reside on the I/O bus such as graphics adaptors, disk drives, or serial cards.

The PC21 occupies four address locations on the I/O Bus. This address is set with the DIP switches on the PC21 board. Each DIP switch represents a binary number. Only two of the four address locations are significant: one for control and one for data. Input and output operations each use the same address. The address may be set to any unoccupied device address. When delivered from the factory, the PC21 is configured to occupy I/O address locations 300 hex through 303 hex.

The DIP switches are negative true (i.e., any switch in the position marked on has a binary value of zero). Switches that are off have a non-zero binary value. Table 3-2 shows the values assigned to the eight switches.

DIP Switch	Bit #	Decimal	Hex	Default
SW-8	2	4	4	ON
SW-7	3	8	8	ON
SW-6	4	16	10	ON
SW-5	5	32	20	ON
SW-4	6	64	40	ON
SW-3	7	128	80	ON
SW-2	8	256	100	OFF
SW-1	9	512	200	OFF

Table 3-2. Address Select DIP Switch Values

The allowable address locations are listed in Table 3-3. The data I/O register is located at the address set by the I/O address DIP switches (300 Hex). The control and status register is located 1 address location higher (301 hex). **SW-1** and **SW-2** are OFF. Definitions of specific addresses from the **IBM Technical Reference Guide** are listed in Table 3-3.

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Hex Range	Device
000-01F	DMA Controller 1, 8237A-5
020-03F	Interrupt controller 1, 8259A, Master
040-05F	Timer, 8254-2
060-06F	8042 (Keyboard)
070-07F	Real-time clock, NMI (non-maskable interrupt) mask
080-09F	DMA page register, 74LS612
0A0-0BF	Interrupt Controller 2, 8259A
0C0-ODF	DMA controller 2, 8237A-5
0F0	Clear Math Co-processor Busy
0F1	Reset Math Co-processor
0F8-0FF	Math Co-processor
1F0-1F8	Fixed Disk
200-207	Game I/O
20C-20D	Reserved
21F	Reserved
278-27F	Parallel printer port 2
2B0-2DF	Alternate Enhanced Graphics Adapter
2E1	GPIB (Adapter 0)
2E2 & 2E3	Data Acquisition (Adapter 0)
2F8-2FF	Serial Port 2
300-31F	**Prototype Card (PC21)**
360-363	PC Network (low address)
364-367	Reserved
368-36B	PC Network (high address)
36C-36F	Reserved
378-37F	Parallel printer port1
380-38F	SDLC, bisynchronous 2
390-393	Cluster
3A0-3AF	Bisynchronous 1
3B0-3BF	Monochrome Display and Printer Adapter
3C0-3CF	Enhanced Graphics Adapter
3D0-3DF	Color/Graphics Monitor Adapter
3F0-3F7	Diskette Controller
3F8-3FF	Serial port 1
6E2 & 6E3	Data acquisition (Adapter 1)
790-793	Cluster (Adapter 1)
AE2 & AE3	Data acquisition (Adapter 2)
B90-B93	Cluster (Adapter 2)
EE2 & EE3	Data acquisition (Adapter 3)
1390-1393	Cluster (Adapter 3)
22E1	GPIB (Adapter 1)
2390-2393	Cluster (Adapter 4)
42E1	GPIB (Adapter 2)
62E1	GPIB (Adapter 3)
82E1	GPIB (Adapter 4)
A2E1	GPIB (Adapter 5)
C2E1	GPIB (Adapter 6)
E2E1	GPIB (Adapter 7)
I/O Address, hex 000 to 0FF, are reserved for the system board I/O. Hex 100 to 3FF are available on the I/O channel.	

Table 3-3. I/O Addresses Map, IBM PC

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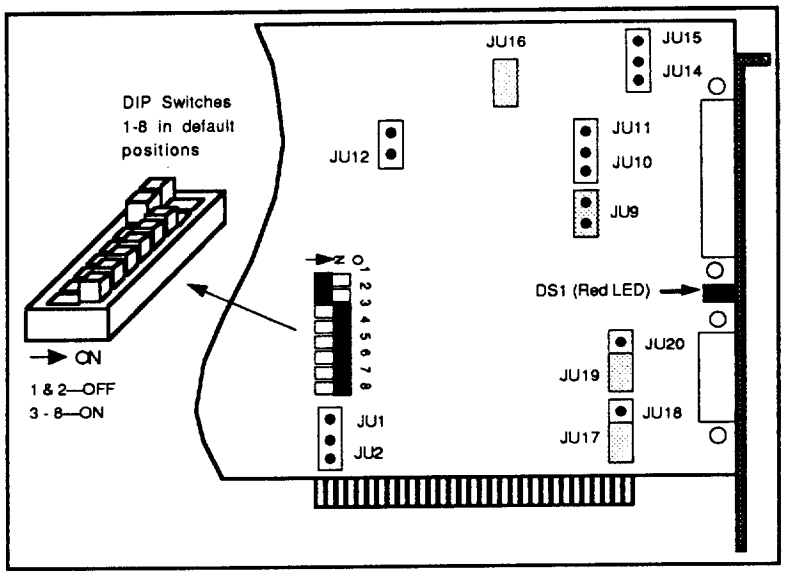


Figure 3-1. Location of DIP Switches and Jumpers

The PC21 is shipped from the factory with DIP switches 1 and 2 on. all others on. The board address is 256 + 512 = 768 (or 100 + 200 = 300 hex). The control and status registers are at the odd address location (301 hex), and data registers are at the even address location (300 hex).

The jumper configuration as shipped from the factory disables the limits, does not use any interrupts, does not select the encoder Z channel polarity, and assumes differential step & direction outputs. Table 3-4 lists the jumpers.

Jumper	Description
JU1	Selects interrupt 3 on PC I/O bus
JU2	Selects Interrupt 4 on PC I/O bus
JU7	Z-Channel input active low
JU8	Z-Channel input active high
JU9	Bypass CCW limit switch
JU10	Installed when CCW limit switch is optically isolated
JU11	Installed when CCW limit switch is directly driven
JU13	Test switch disable
JU14	Installed when CW limit switch is optically isolated
JU15	Installed when CW limit switch is directly driven
JU16	Bypass CW limit switch
JU17	Differential direction output
JU18	Single-ended direction output
JU19	Differential step output
JU20	Single ended step output

Table 3-4. Jumper Functions

Basic System Connections

The motor/driver connection is required for any axis.

- Motor/Driver: Provides the output signals to the drive to step the motor, change direction, or de-energize the motor.
- Encoder: Accepts position feedback signals from an optional incremental encoder.

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Connecting the Motor

A Compumotor motor/drive is connected to the PC21 as shown in Table 3-5.

J2 Pin #	Function
1	Step Output
2	Direction Output
3	CW Step Output
4	CCW Step Output
5	Shield
6	Step Output (RTN* or Ground)
7	Direction Output (RTN or Ground)
8	Shutdown Output
9	Shutdown Output (RTN)

*RTN—Indicates complement of signal for use in differential drive applications

Table 3-5. Motor/Drive (J2) Connector Listing

Non-Compumotor Motor Wiring

The PC21 can control a 200- to 400-step/rev motor. If the motor/drive uses step and direction lines, it can be wired the same as a Compumotor motor/drive. If the non-Compumotor motor/drive uses CW and CCW control lines, use pins 3 and 4 instead of pins 1 and 2. Jumpers should be placed on **JU18** and **JU20**. Pins 6 and 7 of **J2** (9-pin D connector) should be used as the signal returns for the CW and CCW step outputs. The CW and CCW outputs are open collector and should be pulled up to operate properly.

The output driver for the step, direction, and shutdown control lines is a 75174 from Texas Instruments, which provides current for the standard Compumotor optically coupled interface (typically 20 mA). The output voltage for this device is specified to drop no lower than 3V when high, but it will not generally approach +5V. Therefore, a non-Compumotor motor/drive, if it is voltage-driven, not current-driven, should be able to operate with a 3V to 5V high signal.

Differential or Single-Ended Motor/Drive Output

For applications that require single-ended the step and direction outputs to the motor/drive must be , you must install jumpers **JU18** and **JU20**. For differential output, install jumpers **JU17** and **JU19**. Compumotor motors normally use differential step and direction circuits like the one shown in Figure 3-2.

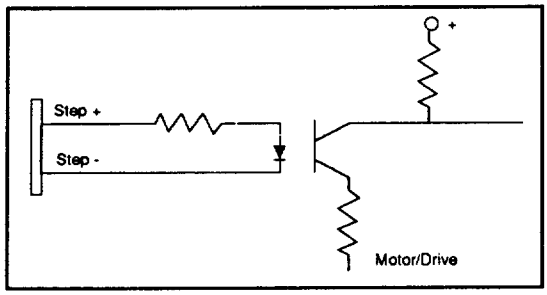


Figure 3-2. Step Input Circuit

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Encoder Connector

Determine if encoder feedback is required. When you select Position Tracking, several choices are available:

1. You can mount the encoder at the load and assure the proper positioning of the load despite any gear play or friction effects of the mechanical transmission between the motor and the load.
2. You can use a motor with the encoder mounted on the motor shaft so that the motor will resist movement induced by externally applied torques.
3. You can use the encoder as a stall detector to identify whether the motor has stalled.
4. You can use the encoder to independently verify the load position.

Encoder Connections

The encoder connection (J3) is located at the end of the board furthest from the mounting bracket. Install the cable so the side of the cable with the dark-colored wire is on top when the PC21 is installed in the IBM PC. (It is advisable to do this before you install the PC21 into your computer.) The end of **J3** is marked with a **1** to signify pin #1 of the connector. The other end of the cable has a 25-pin D connector on it that is attached to the encoder mounting bracket. The bracket is then mounted to the back in a spare slot of the IBM PC (refer to Figures 3-3 and 3-4).

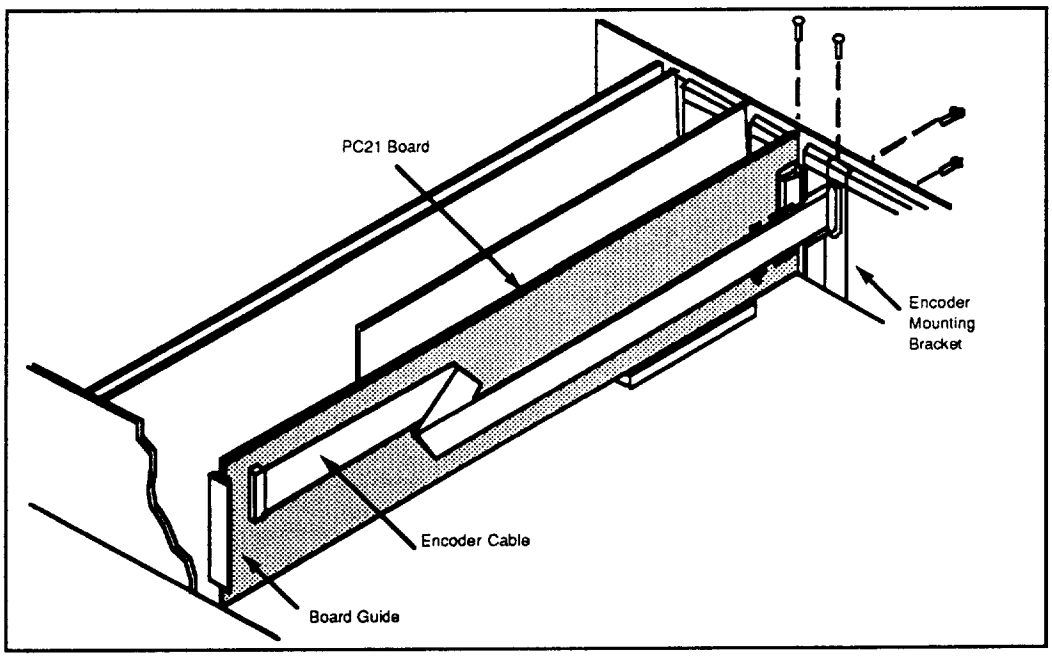


Figure 3-3. Mounting the Encoder

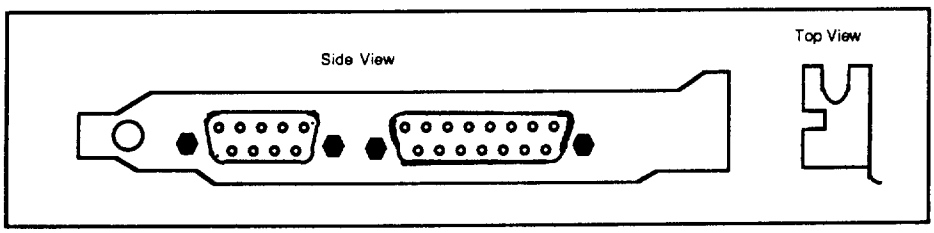


Figure 3-4. Encoder Mounting Bracket

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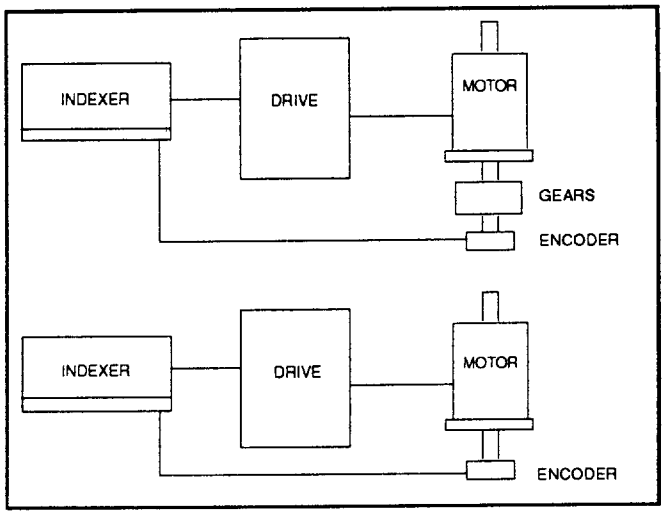


Figure 3-5. Closed-Loop Control of a Stepper Motor

The encoder connects to the PC21 via the 25-pin D connector. The only signals required are Channel A, Channel B, and GND. Channel Z should also be connected if the encoder has a Home output.

The encoder will require +5VDC to operate. You must provide this +5VDC wired into **J1**, the Auxiliary Connector, pin 6. Ground is on **J1**, pin 7.

Encoder Hookup (Compumotor Encoders)

Compumotor provides optional motor-mounted encoders for most motor sizes. The encoders have a resolution of 1000 encoder lines. Compumotor encoders are prewired at the factory and connect directly to the PC21.

To implement the Position Tracking function, connect an encoder to the PC21. Figure 3-6 shows a typical application of an encoder. Encoder outputs must be TTL, not analog (sine wave), and not open collector. The minimum encoder connection requires Channel A+, Channel B+, and Ground. The PC21 is compatible with any TTL output incremental encoder. A flat encoder cable is provided that connects to a header on the PC21. When an encoder is used, this cable is connected to **J3** on the PC21.

The PC21's encoder inputs are compatible with any TTL encoder load mounted or encoder mounted, rotary or linear. The PC21 can be programmed to accept any encoder resolution.

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To set up the PC21 to accept encoder input, you must know the number of encoder pulses that will be returned to the Indexer for a given number of pulses sent to the motor. This is set via the (ER) command.

Motor-mounted rotary encoders are the easiest to specify: multiply the rated resolution of the encoder by four and enter that directly into the command (e.g., ER4000<d>).

This example command specifies the encoder resolution for a 1000-line encoder, the standard offered by Compumotor and the default setting of the PC21. For an encoder with 4096 lines per revolution, the command would be ER16384<d>.

Although this a valid resolution, it would be somewhat high for a 25,000-step/rev motor, as the ratio of motor steps to encoder steps (25,000/16,384) is less than 2:1. This could make system operation unstable because the motor would not have adequate room to position itself with respect to the encoder. Optimum operation is achieved with a ratio of about 4:1.

Encoders that are not mounted on the motor are more complicated to specify. The ratio of motor turns to encoder turns must be considered. A rotary encoder that is mounted on the load can compensate for mechanical components between the motor and the load (e.g., a belt and pulley).

For example, to specify the Encoder Resolution (ER) command for a motor that must turn six revolutions to turn a load-mounted 1000-line encoder one revolution would require multiplying the encoder resolution by four (the multiplier applied by the PC21's encoder input circuitry), then dividing by six (the turns ratio), giving a result of 666.667. This formula is provided below.

(encoder resolution [pre quadrature] x 4)/number of motor turns (to turn encoder 1 rev)

or

(1000 x 4)/6 = 666.667 the command would be ER666.667<d>

A linear incremental encoder may also be used. Linear encoders are usually mounted alongside a screw-driven apparatus (such as an X-Y table). To specify the encoder ratio, you must know the number of encoder pulses per motor revolution. For example, an encoder with a 500-line per inch resolution and 2 channel output, (1 channel 90° out of phase from the other) can be run to the PC21 where it will effectively multiply the motor resolution by 4, giving 2000 encoder pulses per inch.

For example an X-Y table uses two 10-pitch (10 turns per inch) leadscrews, the encoder returns 2000 pulses per 10 motor revolutions. As a formula, this would look like:

((encoder lines/inch x 4))/number of motor turns per inch

or

((500 x 4))/10 = 200 the command would be ER200<d>

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Z Channel Input Polarity Choice Jumpers

If an encoder is used, the proper Z Channel polarity must be chosen. If the Z Channel input signal is an active high signal, you must put a jumper on **JU8**. If the signal is active low, put a jumper on jumper **JU7** for proper operation.

Input/Output Connections

The PC21 has the following input and output connections.

- Limit Switch Inputs
- Home Position Sensor
- Trigger Inputs
- Programmable Output Bit

Limit Switch Inputs

The limit switch inputs are on connector **J1** (pin numbers are shown in Tables 3-6 and 3-7). The CW and CCW limit switch inputs stop sending pulses to a motor/drive in an emergency. The motor response is the same as it would be if using the Kill (K) command. The limit switches provide a signal ground to the limit switch inputs when directly driven under normal operating conditions and allow the inputs to float high when the switch is activated. If a wire breaks anywhere in the limit switch circuit, the motor will immediately stop moving toward the limit switch until the open-circuit condition is corrected.

Signal	J1 Pin #
CW INPUT	11
CW RTN	9
CCW INPUT	1
CCW RTN	3

Table 3-6. Optically Isolated Limit Switch Inputs

Signal	J1 Pin #
CW INPUT	11
CW RTN	10
CCW INPUT	1
CCW RTN	2

Table 3-7. Directly Driven Limit Switch Return

In applications that do not require limit switches, put jumpers on **JU9** and **JU16** (factory-set configuration).

A limit switch is normally a closed, single-pole, single-throw switch, hall-effect proximity sensor, or an optical interrupter that is placed sufficiently far from the load's end of travel to allow the load to stop its maximum running velocity without damage. The switches must be able to provide the following in the Directly Driven mode:

1. 2 mA current sinking capability (2 mA closure to ground)
2. Logic low no greater than +0.5VDC
3. Logic high no greater than +5VDC (unless open collector)
4. Minimum signal high duration of 10 ms

If the limit switch inputs are optically isolated, an external power supply capable of delivering 10mA at 3VDC (minimum) must be provided.

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When the limit switch inputs are in Directly Driven mode, the limit switch returns are the PC21's signal ground. **Do not connect these lines to earth ground or use them for a shield.** Reduced noise immunity and increased susceptibility to damage due to voltage or current spikes on the power line can result from miswiring the limit switch inputs.

You should shield the limit switch wires to prevent voltages from being induced into them that could cause the limit switch inputs to be activated. Suitable switch types are:

1. Vane-activated magnetic switch —*Microswitch* 4AV1C-T1
2. Vane-activated optical switch —*Spectronics* SPX2002
3. Proximity sensor, Hall effect —*Microswitch* 205SR1A

Limit Switch Implementations

Table 3-8 provides the characteristics of the limit switch jumpers. Table 3-9 contains the functions of all PC21 jumpers.

Limit Switch	JU9	JU10	JU11	JU14	JU15	JU16
Optically Isolated	OUT	IN	OUT	IN	OUT	OUT
Directly Driven	OUT	OUT	IN	OUT	IN	OUT
No Limit Switches	IN	OUT	OUT	OUT	OUT	IN

IN = Jumper Installed OUT = Jumper Not Installed

Table 3-8. Limit Switch Jumpers

Jumper	Description
JU1	Selects interrupt 3 on PC I/O bus
JU2	Selects Interrupt 4 on PC I/O bus
JU7	Z-Channel input active low
JU8	Z-Channel input active high
JU9	Bypass CCW limit switch
JU10	Installed when CCW limit switch is optically isolated
JU11	Installed when CCW limit switch is directly driven
JU12	When installed disables the Board Monitor Alarm
JU13	Test switch disable
JU14	Installed when CW limit switch is optically isolated
JU15	Installed when CW limit switch is directly driven
JU16	Bypass CW limit switch
JU17	Differential direction output
JU18	Single-ended direction output
JU19	Differential step output
JU20	Single-ended step output

Table 3-9. Jumper Functions

Mechanical Switches

The traveling load hits a spring-loaded roller or lever actuated mechanical limit switch causing contact between the limit input and ground. The switch should be normally closed and suitable for small signals.

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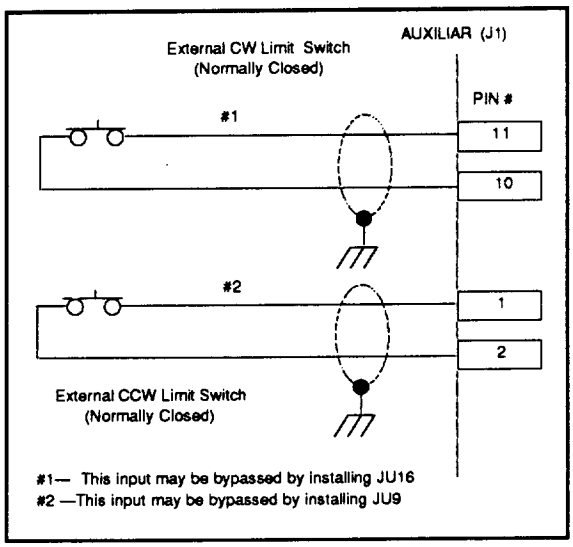


Figure 3-6. Mechanical Limit Switches

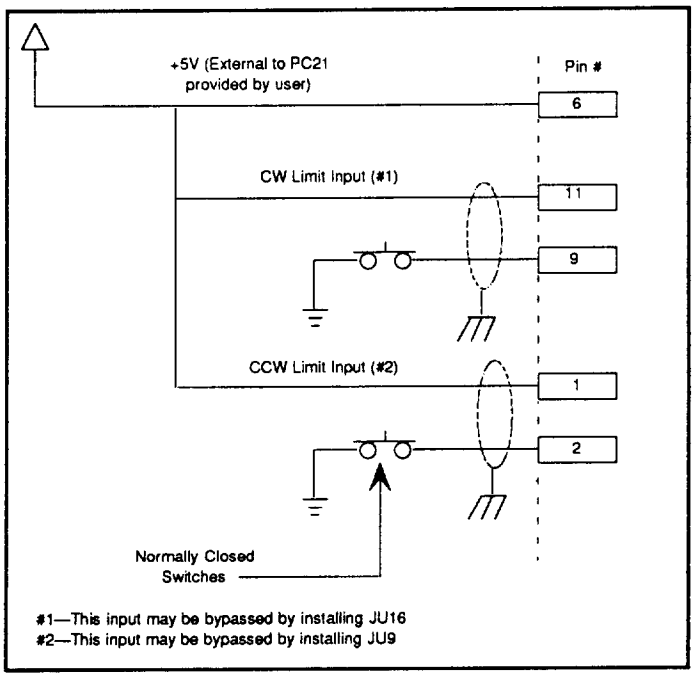


Figure 3-7. Optical Isolation, Mechanical Limit Switches

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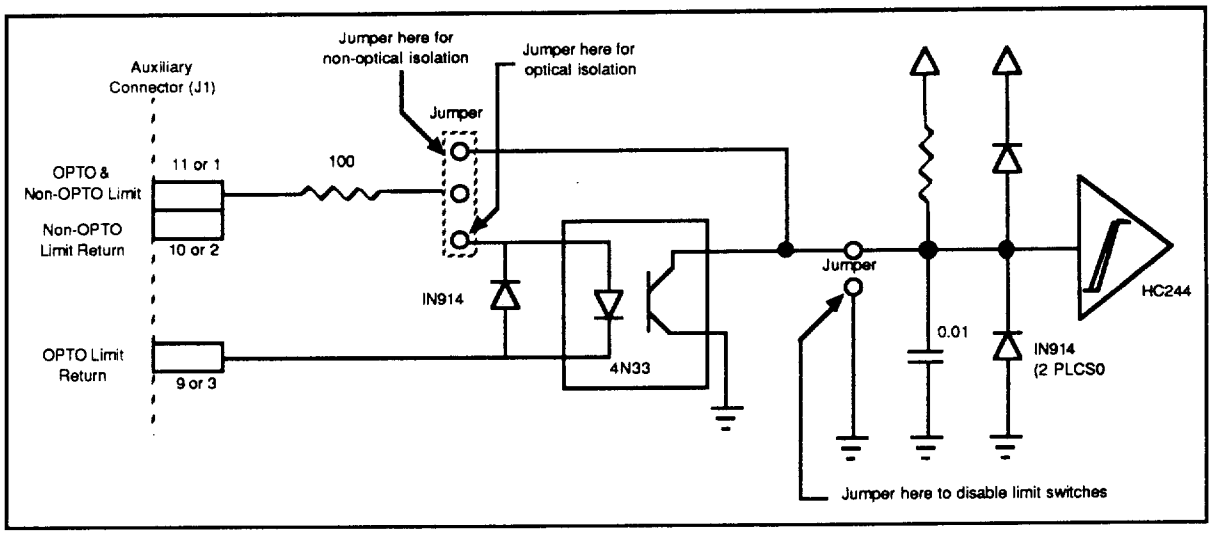


Figure 3-8. Limit Switch Inputs to PC21

The spring-loaded actuator is required to prevent load impact from damaging the switch or shortening its life (see Figure 3-9).

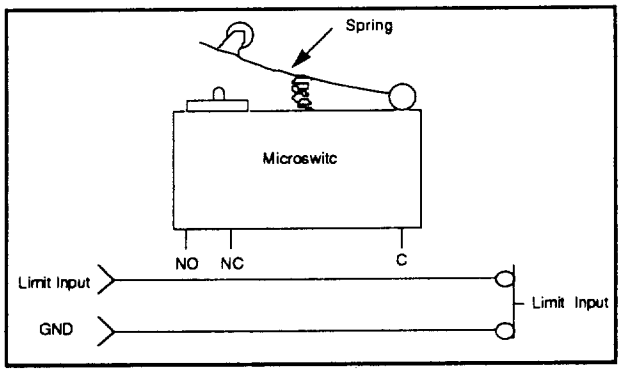


Figure 3-9. Load-Activated Normally Closed Switch

VANE-ACTIVATED MAGNETIC SWITCH

The load has a sheet-metal vane mounted to it that passes either into or out of the switch at the limit depending on switch output polarity. The output must be normally low. The vane must be ferrous (e.g., Microswitch 4AV1C-T1).

VANE-ACTIVATED OPTICAL INTERRUPTER

The load has a vane mounted to it that passes either into or out of the interrupter at the limit depending on interrupter output polarity. The output must be normally low (e.g., *Spectronics* SPX2002). Refer to Figure 3-10.

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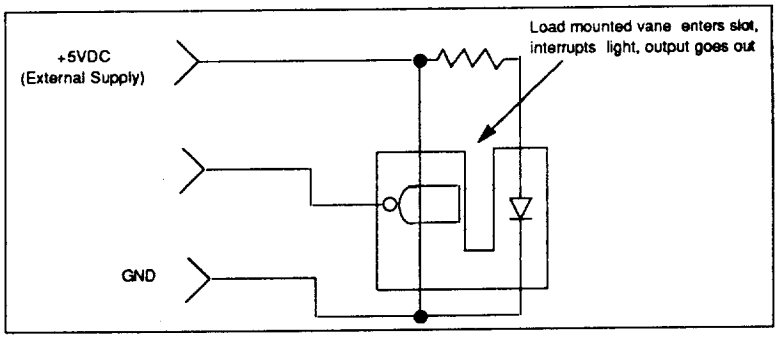


Figure 3-10. Vane-Activated Optical Interrupt Limit Switch

The load has a magnet mounted to it that is detected by the sensor when the load approaches (e.g., Microswitch 205SR1A).

THE HOME POSITION SENSOR

Some motion control systems require an absolute reference (so that a known position may be found prior to attempting a precise move). The Home Position Sensor (connector **J1**, pin 5) is used as a Home Position Sensor in motor step mode and as an enable in Encoder mode.

The home position sensor attached to the home enable input must have all of the electrical characteristics described above for the limit switches in the directly driven mode. The home enable input is ignored when it is not used as a position reference and is active low. Signal ground for the Home Position Sensor is the same as that of the limit switches.

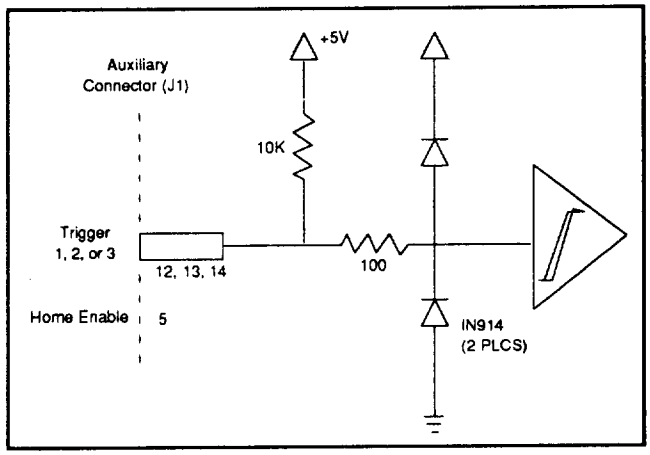


Figure 3-11. Typical Home Enable or Trigger Input Circuit

Trigger Inputs

The Trigger inputs consist of three inputs on the Auxiliary Connector, **J1**, as listed in Table 3-10. The PC21 may be programmed to electronically watch any one of these inputs and perform a predefined function when the proper signal appears. The Trigger inputs are level sensitive.

Pin Number	Description
J1-14	TRIGGER Input 1
J1-13	TRIGGER Input 2
J1-12	TRIGGER Input 3

DC common (signal ground) is on pins 7 and 8.

Table 3-10. Trigger Bits

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Trigger inputs may be either a high or low level to indicate an active condition. Selection of the level triggering is done when issuing the (TR) command. Figure 3-12 is an illustration of an active level-sensitive Trigger Bit.

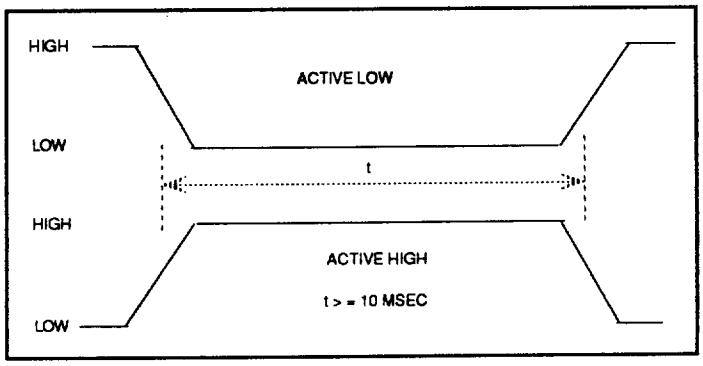


Figure 3-12. Level-Sensitive Trigger Bit

Programmable Output

The Programmable Output Bit (pin 15 of **J1**, the Auxiliary Connector) is capable of driving five LS TTL loads. It can be used to trigger an external event during, or at the completion of, some Compumotor motor-driven action.

External +5VDC Input. If an Optical Encoder is used with the PC21, then a +5VDC +-5% supply capable of supplying 250 mA must be connected to pin 6 of **J1**. +5V return may be obtained on either pin 7 or pin 8 of **J1**.

REMOTE POWER SHUTDOWN (ST COMMAND)

The Remote Power Shutdown control line (**J2**, pins 8 and 9) is a Compumotor feature that allows the motor to be shut down for the purpose of motor/drive cooling or to allow you to manually position the load. Although the standard Compumotor motor/drive is rated for a 100% duty cycle, it is sometimes advantageous to shut down the motor/drive to lessen the amount of heat dissipated into the operating environment. Additionally, since stepper motors normally have full-rated torque at zero velocity, it becomes very difficult to manually position the motor's load with power applied to the motor. Rather than remove power from the motor/drive under these conditions, Compumotor has provided the Remote Power Shutdown feature.

CAUTION

Position can be lost when shutting down the motor and powering it back up again. When you must maintain position while the motor is shut down, use a friction lock or brake to maintain shaft position.

Remote Power Shutdown is found on pins 8 and 9 of J2. Pin 8 goes high with reference to pin 9 when Remote Power Shutdown is activated. Remote Power Shutdown is controlled with the Shutdown (ST) command of the command language. The command to shut down the motor will be ignored if the motor is moving; the PC21 will ignore the command if it is moving when the (ST) command is received.

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Test-Switch Disable Jumper

JU13 is the test-switch disable. You should install this jumper unless the test function is to be executed. When this jumper is not installed, you can test operation of the PC21 without the need for interaction with the PC (Refer to *Chapter 2, Getting Started*).

The test function causes the PC21 to issue 25,000 pulses at 5,000 Hz in the CCW direction and then issue the pulses in the CW direction. At the end of the test sequence, the PC21 tests the Board Monitor Alarm. This means that the PC21 will go into a fault condition, from which it must be reset. This is normal. The red LED, **DS1**, mounted on the rear of the board between **J1** and **J2**, lights when this occurs.

Host Interrupt Jumpers

Several conditions (such as having a byte in the output data register or hitting a limit) can be chosen as a trigger for generating a hardware interrupt to the IBM PC. See the description of the `QS`, `QR`, and `QI` commands. If this is desired, the host interrupt jumpers **JU1** and **JU2** must be configured. Only one jumper, **JU1** or **JU2**, can be installed; take care to ensure that no other board in the PC is generating an interrupt on the selected line (including another PC21 card). Interrupt 3, **JU1**, or Interrupt 4, **JU2**, are pins B24 and B25, respectively, of the PC I/O bus. The appropriate interrupt service routine must exist in your program or unpredictable results will ensue. In BASIC JU1 interrupts on **COM 2** and **JU2** interrupts on **COM 1**.

Establish Communications

Motion control commands and responses are transferred via the Input and Output Data Buffer (`IDB` and `ODB`), at the PC21 base address. Interface control commands and status information are transferred via the Control Byte and Status Byte (`CB` and `SB`), one address location above the base address.

In the PC21, the `ODB` and the `SB` are read-only registers. The `IDB` and the `CB` are write-only registers.

Indexer commands are *strings* or sequences of ASCII characters. Passing a command to the PC21 calls for transferring each character in the command one at a time.

Each character transfer requires that the sender notify the receiver that a character is ready, and that the receiver notify the sender that the character has been received. The notification process makes use of single bit flags of the eight bit SB and CB registers being set high (1) or low (0) to denote the ready or busy condition as described below.

Sample Read and Write routines that access the computer's I/O bus are provided on the demonstration diskette which accompanies the PC21.

Step-by-step procedures for resetting the PC21 (which should be done at the start of any user program), writing a character to the PC21, and reading a character from the PC21 are in *Chapter 4, Application Design*. Followed the instrunctions if you intend to write your own subroutines in other program languages.

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System Test

This section is provided to test for proper system connections and operability.

Utility Commands

The utility commands below may be useful throughout this section while testing your PC21.

Command	Description
> K	Halts the motor immediately. The immediate deceleration may cause a loss of position. **This is a *panic* stop.** The PC21 run this command as soon as you issue it (immediately).
> S	Decelerates the motor to a stop using the last defined acceleration value. The system executes this command immediately after you issue it.
> ^H	Instructs the PC21 to backspace the cursor and delete the last character you entered
> PS	Instructs the motor to pause for a period of time that you specify. Buffered commands that follow the PS command are not executed until the indexer receives a Continue (C) command to clear the pause and resume execution.

1.Enter Terminal Emulation Mode

This system test uses the same terminal emulation mode used for the bench test you performed in Chapter 2. Complete the following steps to enter the terminal emulation mode:

1. Insert PC21 support diskette into the disk drive.
2. At the **A>** prompt, enter **PC21TERM**.
3. Enter device address **768** and answer **Y** (yes) to the reset question.

The PC21 should now be in terminal emulation mode, ready to accept X language commands. Press **<F10>** at the end of this system test if you wish to exit the program.

2. Test CW & CCW Limit Input Connections

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

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

Use the following procedure to test the limit input switches on axis #1 (repeat for each axis):

1. Open both CW and CCW switches.
2. Type **RA**. The response should be ***L** this means that both CW and CCW limits are opened.
3. Close the CW limit switch.
4. Type **RA**. The response to this command should be ***H**, indicating CCW limit switch is open.

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5. Close the CCW limit switch and open the CW limit switch.
6. Type **RA**. The response should be ***D**, indicating the CW limit switch is open.

Once the responses to Steps 1 through 6 are correct, continue with Step #7.

7. To test the CW limit switch, enter the following command string:

Command	Description
> MC	Sets indexer to mode continuous
> A5	Sets acceleration to 5 rps^2
> V2	Sets velocity to 2 rps
> H+	Sets motor direction (+ = CW)
> G	Executes the move (Go)

The motor should move at a constant velocity.

8. Open the CW limit switch. The motor should come to a stop at 5 rps^2.
9. To test the CCW limit switch, enter the following string of commands:

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

The motor should move at a constant velocity.

10. Open the CCW limit switch. The motor should come to a stop at 5 rps^2.

If the motor continues to move, open the CW limit switch. If the motor stops when you open the CW limit switch, swap the CW and CCW limit input wires.

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

3. Test Trigger Input Connections

The three trigger inputs are typically connected to sensors or other signal sources to provide the indexer with information on external conditions. The indexer can be programmed to wait until one or more inputs switch to a desired state (on or off, 1 or 0). The **TR** command causes a pause in the execution of buffered commands if one or more trigger inputs are not in the state specified by the command. The **TS** command reports the state of all three trigger inputs.

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

1. Type **TS**. If all the trigger inputs are open (not grounded), the response should be **ØØØ**.
2. Close the TRIG 1 input switch.

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3. Type **TS**. The response should be **1ØØ**. This verifies that the TRIG 1 input is closed.

Repeat steps 1 through 3 for each trigger input.

4. Enter the following commands:

Command	Description
MN	Sets indexer to normal mode
A2	Sets acceleration to 2 rps^2
V2	Sets velocity to 2 rps
D25ØØØ	Sets distance to 25,000 steps
TR1XX	Wait for Trigger Input 1 to be grounded
G	Executes the move (Go)

5. Ground trigger input 1 (motor will move).

4. Test POB Connection

The PC21 is equipped with three programmable output bit. You may use it to signal a peripheral device that the PC21 has just completed some event. The output is controlled with the **O** Command.

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

1. Type **O1**.

   The response from this command should be 5VDC, as measured between the POB (pin 15) and ground (reference pin 7 or 8).

2. You may change the reading between the POB (pin 15) and the ground reference to logic low (ØVDC) by entering the following command: **OØ**.

5. Test Encoder Resolution

The PC21's encoder feedback functions will not operate properly if the encoder resolution or signal polarity are incorrect.

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

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

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

1. Issue the **FR** status request command to verify that all encoder functions are off. The response should be **ØØØØØØØØ**. If the response is not **ØØØØØØØØ**, refer to the **FR** and **FS** commands in *Chapter 5, Software Reference.*

2. Use the following commands to make the motor move 1 revolution and set the absolute position counter to zero (example assumes use of a 25,000 step/rev motor):

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Command	Description
MN	Sets mode to normal
FSBØ	Sets indexer to motor step mode
A1Ø	Sets acceleration to 10 rps^2
V2	Sets velocity to 2 rps
D25ØØØ	Sets distance to 25,000 steps
PZ	Sets absolute position counter to zero
G	Executes the move (Go)

3. Report the encoder position with the following commands:

Command	Description
FSB1	Place PC21 in encoder step mode
PR	Report encoder counts
FSBØ	Place PC21 in motor step mode

4. Issue the **FSBØ** command and repeat steps 1 through 3 to ensure that the backlash or motor windup are not interfering with the test. Issuing the encoder position report commands should yield a number very close to the parameter that you specified with the encoder resolution (**ER**) command.

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

6. Test the Homing Function

This section provides procedures to test the home switch and the homing function for both open-loop and closed-loop operation. *Open-loop* homing uses only the home switch to establish the home reference position. *Closed-loop* homing uses the home switch and the Z (index) channel from an incremental encoder to establish the home reference position.

Go Home Process

1. To initiate the homing function, you must issue the Go Home (**GH**) command. When you issue the **GH** command, you must include the direction and velocity that the motor should use to search for home. You may also specify the Go Home acceleration with the **GA** command.

2. After you issue the **GH** command, the motor begins to move in the direction and at the velocity and acceleration that you specified. The PC21 waits for the home limit input to go active (usually activated by the load closing a normally-open home switch). If the motor trips an end-of-travel limit switch while it searches for home, it will reverse direction and look for the home limit input to go active. If the motor trips the other limit switch before it detects the home signal, the Go Home move will be aborted and the motor will stop.

3. While the motor (and load) is moving, the PC21 recognizes the *home position* as the position where the home limit signal makes a transition from OFF to ON.

4. The motor decelerates to a stop.

5. The indexer automatically resets its internal absolute position counter for that axis to zero (same as issuing **PZ**).

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You can verify if the homing process was successful by issuing the Go Home Status (RC) command.

There are two situations in which the PC21 can lose track of the *home* position.

- *Overshoot* resulting from a Go Home velocity that is too high,
- A mechanical or electrical home switch signal delay. In such situations, you should reduce the Go Home velocity.

Test Open Loop Homing

Use the following procedure to test the open-loop homing function:

1. Issue the following commands:

Command	Description
GA5	Sets go home acceleration to 5 rps^2
GH+2	Instructs the motor to go home (CW) at 2 rps

The motor should move in the CW direction at a constant velocity of 2 rps. When the load closes the home switch (***if the motor is not connected to the load, you must manually open and close the switch***), the motor decelerates to a stop.

2. Issue the PR command to verify that the homing is complete and that the absolution position counter is reset to zero. The response should be +ØØØØØØØØ.
3. Issue the RC command to verify that the homing was successful. The response should be *C.

Test Closed-Loop Homing

The closed-loop homing function uses the encoder's Z channel and the Home switch for positioning. The Z channel is output once per revolution of the rotary encoder. *Home* is established when the load opens the normally-closed Home Enable switch, and while the switch is open, the encoder outputs its Z Channel pulse. You can adjust Z Channel and the Home switch to coincide by:

1. Decoupling the encoder from the motor and turning the encoder until they coincide
2. Moving the home switch until they coincide

CAUTION

If the Home input is active for more than one encoder revolution, multiple home definitions will result and the repeatability of the homing function will be lost. When no Home Enable switch is needed, this input should be left unconnected.

You can perform closed-loop homing only if the PC21 is in the encoder step mode (set with the FSB1 command).

You can change the active states (active high or low) of the the Z channel with **JU7** and **JU8** (see the jumper descriptions earlier in this chapter).

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Use the following procedure to test the closed-loop homing function:

1. Issue the following commands:

Command	Description
FSB1	Enable encoder step mode
GA5	Sets go home acceleration to 5 rps^2
GH+2	Instructs the motor to go home (CW) at 2 rps

The motor should move in the CW direction at a constant velocity of 2 rps. When the load closes the home switch (***if the motor is not connected to the load, you must manually close the switch***), the motor decelerates to a stop. The motor creeps CW at 0.1 rps and stops when the Z channel pulse from the encoder is received while the home switch is active (closed).

2. Issue the PR command to verify that the homing is complete and that the absolution position counter is reset to zero. The response should be +ØØØØØØØØ.

3. Issue the RC command to verify that the homing was successful. The response should be *B.

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Chapter 4. APPLICATION DESIGN

Chapter Objectives

The information in this chapter will enable you to:

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

Motion Control Concepts

This chapter discusses the control of a single axis, which executes simple motion profiles. Multiple-axis coordination and complex profiles are also discussed.

All indexer applications involve either movement of a motor to a precise position (number of steps) or movement of the motor at a prescribed velocity (steps per second). Output control for both position and velocity can be controlled with a high degree of precision without any additional external encoder feedback.

Position or distance parameters are defined in terms of motor steps, but velocity and acceleration parameters ordinarily use revolutions (or inches for linear motors) as units of distance (i.e., rps). The discussions that follow will refer to velocity in terms of revolutions for rotary motors. Most of the discussions also apply to linear motors (inches are substituted for revolutions when distance, velocity, or acceleration units are discussed).

When commands are structured for the system, you must think in terms of the number of steps/rev (e.g., for a 25,000-step motor, 180° = 12,500 steps, 1 revolution = 25,000 steps, etc.). You must refer the desired load motion for your application to motion of the motor. The indexer accommodates a wide range of resolutions.

Motor motion must be specified in terms of acceleration (rps^2), angular velocity (rps), and angular position (either incremental steps from the current motor position or absolute steps from a reference zero position).

Move Profiles

In any motion control application, the most important requirement is precise position, whether it be with respect to time or velocity. A motion profile represents the velocity of the motor during a period of time in which the motor changes position. The type of motion profile that you need depends on the motion control requirement that you specify. The basic types of motion profiles are described below. *The PC21 can perform all of the profiles discussed in this chapter.*

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Triangular and Trapezoidal Profiles

For constant acceleration indexing systems like the PC21, velocity, acceleration, and distance parameters are defined before the system executes a preset move. The value of these parameters determines the type of motion profile as either triangular or trapezoidal. A motion profiletriangular profile results when the velocity and acceleration are set such that the defined velocity is not attained before the motor travels half of the distance that you specify. This results from either a relatively low acceleration, a relatively high velocity, or both. For example, if the acceleration is set to 1 rps^2, velocity is set to 10 rps, and distance is set to 4,000 steps, a triangular motion profile results. The motor reaches the mid-point of the move before it reaches the set velocity, and begins decelerating at the same rate as the acceleration (back to zero speed). The motion profile for this move will resemble the profile shown in Figure 4-1.

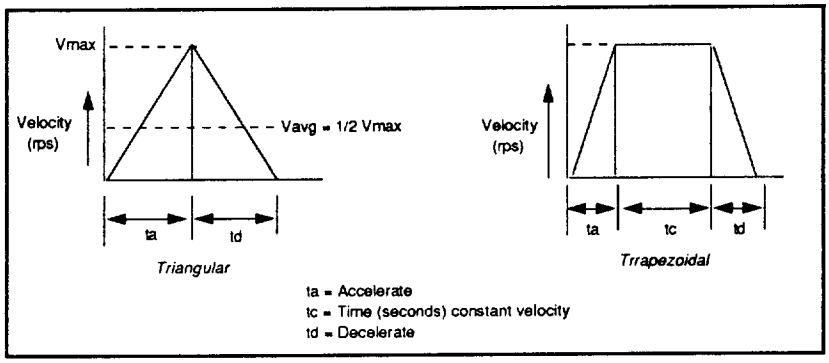


Figure 4-1. Triangular Profile

A motion profiletrapezoidal profile results when the defined velocity is attained before the motor has moved half of the specified distance. A trapezoidal move may occur if you specify a low velocity with a high acceleration or a long distance. The resulting motion profile will resemble the profile shown in Figure 4-1.

Acceleration/ Deceleration

Acceleration is defined as the rate of increase of angular velocity in rps^2. When the indexer accelerates the motor from a stopped position to a given velocity, a series of steps of increasing frequency is sent to the drive. You can also use the acceleration parameter (**A**) to decelerate the motor when you change velocity or make an ordinary stop.

You can use relatively high step rates to drive high-resolution Compumotor motors. Therefore, the shaft motion can be graphically portrayed by a straight line.

The acceleration/deceleration rate must be limited to account for the inertia of the load plus friction, to allow operation within the torque limits of the motor.

For step motor systems, Compumotor recommends a safety margin of 50 to 100% of normal load torque requirements. If you enter an acceleration rate that exceeds the capability of the motor and drive, the system will stall.

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For servo systems, the total torque loading must be kept below the continuous duty torque available. But the system may be intermittently loaded well above the continuous duty rating. If you select an acceleration rate that requires torque in excess of the capability of the motor and drive, an excessive position error or drive fault will result.

Normally, acceleration and deceleration occur at the same rate. In the Continuous mode, you may use different rates.

Move Times— Calculated vs. Actual

You can calculate the time required to complete a move by using the acceleration, velocity, and distance values that you define with the A, V, and D software commands respectively. However, you should not assume that the values that you use will constitute the actual move time. Calculation delay and motor settling time may increase the time required to complete a move. After you issue the Go (G) command, the PC21 may take up to 50 ms to calculate the move before the motor starts moving. You should also expect some time to elapse for the motor and the load to settle.

Determining Motion Parameters

You can use either an analytic approach or an experimental approach to establish the acceleration and velocity parameters appropriate to the application.

Determine the number of motor steps (or encoder steps if appropriate) required to reach a desired angular position of the motor shaft based on the motor resolution and transmission characteristics. The motor/drive must be sized for the application. Refer to the Compumotor Product Catalog for sizing guidelines.

In limited travel situations, you should install end-of-travel limit switches to protect the load.

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Analytic Approach

You must reference the desired load motion pattern to the motor shaft. The motor/drive acts as a stiff drive source. The system analysis should take into account any gear play, coupling effects, transmission elasticity, load inertia, and load friction. These considerations affect positioning accuracy, maximum acceleration, and maximum velocity.

Motion parameters are calculated similarly for positioning and speed control applications. Indexing motion parameters are typically defined by how far the load is to be moved in a specified period of time. For speed control, you must determine how much time passes, or what distance is covered before the load gets to the desired velocity. For indexing, distance divided by move time yields average velocity.

$$V_{ave} = D \div Mt$$

V = velocity
D = distance
Mt = move time

For a triangular motion profile, maximum velocity (V_{max}) is twice the average velocity ($2V_{ave}$). Acceleration time plus deceleration time is half the total move time.

$$\text{Triangular Profile: } V_{max} = 2V_{ave}$$
$$At + Dt = 1/2\ Mt$$

Dt = deceleration time
At = acceleration time

A trapezoidal profile is often desirable to reduce the maximum motor velocity required, or to reduce the RMS (root-mean-square) torque requirement of the system. If you increase acceleration, velocity may be reduced without increasing move time. You can generate a good general-purpose trapezoidal profile (refer to Figure 4-2) when you select a maximum velocity 1.33 (four thirds) times the average velocity, and acceleration (or deceleration) time is one quarter of total move time.

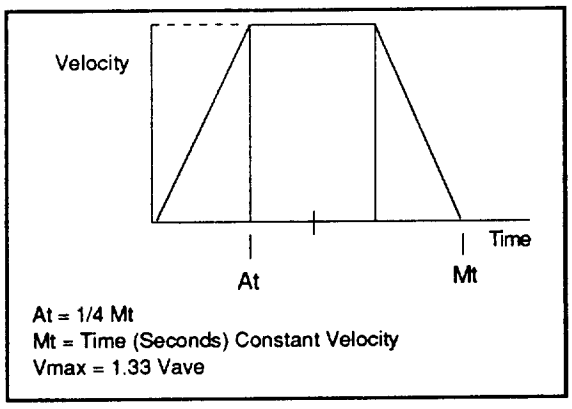


Figure 4-2. General-Purpose Trapezoid

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In all cases, the relationship of the acceleration and velocity settings can be determined by using the equation

$A = (V_f - V_o) \div t_a$

Where A = acceleration
V_f = final velocity
V_o = initial velocity
t_a = acceleration time

For the acceleration distance:

$D_a = 1/2\ A(t_a)^2$

D_a = acceleration distance

You can use these equations to calculate any parameter when the others are known. Velocity and acceleration units should be in terms of revolutions and seconds, to match indexer parameters. You can test and change the calculated parameters quickly with a simple interactive program, like those supplied with the PC21.

S-Curve

S-Curve velocity profiles are often used for gentle acceleration of liquid or fragile loads. The PC21 software (demo diskette) can help you set up the S-curve velocity profile.

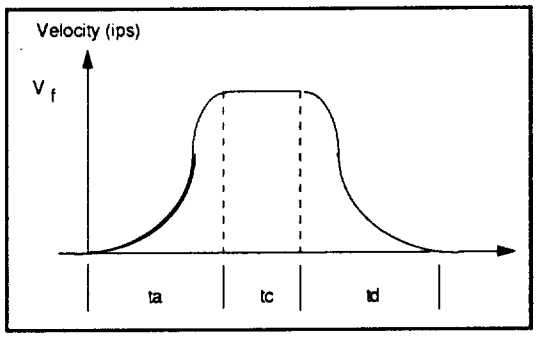


Figure 4-3. S-Curve Profile

Experimental Approach

You must size the motor/drive for the application. Refer to the Compumotor Product Catalog for sizing guidelines. The system will stall (without damage) whenever the performance specified (via commands) exceeds the capability of the motor/drive used.

Basic PC21 Motion Control

This section discusses the operating modes that are available with the PC21. Move parameters and other motion control considerations are also addressed.

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Indexing Modes

Once indexer communications have been established, only a Go (G)command is needed to initiate motor motion. There are two principal indexing modes, the Preset mode (or Normal) and the Continuous mode (for positioning and speed control respectively). The Alternating mode, is a special feature of the Preset mode.

The Preset and Alternate modes require a distance parameter. All modes require acceleration and velocity parameters. If no parameter is supplied before a G command is issued, prior parameters, or the default parameters will be used.

Preset Mode

This is the default indexing mode. It is selected using the Mode Normal (MN) command. The PC21 drives the motor to a specified position at a specified velocity and accelerates and decelerates at a specified rate. No other speed changes are possible until the motor stops. Proceed as follows:

- Determine the distance to be moved. If the distance is stated in revolutions or degrees, convert the data to number of steps required for the move. This distance parameter is set with the Distance (D) command. A {-} sign may precede the specified distance to set the direction of motion ({+} = CW motion, {-} = CCW motion, referenced to the motor mounting face).

- Select an acceleration rate. An easy way to determine the maximum value is to start with a low value, establish the velocity to be used, and then keep increasing the acceleration value until the motor stalls or does not start. This value is set with the Acceleration (A) command.

- Select the velocity to be used and set up this value with the Velocity (V) command. An easy way to determine the maximum value is to start low and then increase the speed until the motor stalls or does not start.

- The Go (G) command initiates each move, whether or not new parameters are entered. Following this, the designated motor shaft will rotate to the commanded position. The axis will then return to the ready state. This cycle will be repeated each time the Go (G) command is used.

Continuous Mode

The Continuous mode (MC) requires only acceleration and velocity values to move the motor. The actual angular velocity depends on the motor resolution setting.

It is possible to switch an axis to low velocity range with the Set Velocity Normal (SSF1) command. This range increases low speed velocity resolution, while reducing the available top speed, both by a factor of ten.

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Once the Go (G) command is given, the motor will accelerate to and rotate at a constant velocity until a Stop (S) or Kill (K) command is received, or until a new velocity (and a new acceleration if desired) and another Go (G) is received.

While running at constant velocity, an axis is *Ready*, not *Busy*. It is free to execute buffered commands that are applicable.

You should not issue some buffered commands while the motor is running [i.e., the Change Direction (H) or Shutdown Motor (ST) commands]. Some buffered commands that are inappropriate while moving will be ignored, the execution of some others is postponed until the motor stops.

Alternating Mode

You can select the Alternating mode with the **MA** command. Set-up for this mode is identical to that for Mode Normal (**MN**). When the Go (G) command is given, the motor shaft will rotate to the commanded position that corresponds to the value set by the D command, and then retrace its path back to the start position. The shaft will continually move between the start position and the command position until a Stop (S) command is received. Then the motor will complete the cycle and stop at the start position. You can configure the PC21 to stop immediately on command with the **SSD1** command. Another Go (G) command will repeat the same motion pattern.

This indexing mode is not functional when the Absolute Positioning mode is selected.

Move Parameters

For rotary motors, velocity and acceleration parameters are expressed in units of motor revolutions. For accurate speed control, each axis needs to know its motor's resolution. Use the Configure Motor Resolution (**MR**) command to change motor resolution from the default as required. This parameter also controls step pulse width and velocity range. Refer to the description of the **MR** command in *Chapter 5, Software Reference.*

It is desirable in many applications for the distance parameter to be specified in units other than motor steps, such as hundredths of a degree or thousandths of an inch. If the desired units correspond to an integer number of motor steps, the indexer's position multiplier (see the **US** command) capability can used to scale the D command position parameter to those units for any axis.

The default interpretation of the Distance (D) parameter is the distance to be moved from the current position in motor steps. The sign of the parameter indicates the direction of travel. The Set Mode to Absolute (**FSA1**) command may be used to switch from this Incremental indexing mode to the Absolute positioning mode where the D parameter represents a position (e.g., the distance from the home position). In this case, the parameter indicates which side of the home position the target location is.

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Example

A 25,000-step motor drives a 5-turn per inch leadscrew. The system resolution is 125,000 steps per inch. To have the distance parameter expressed in thousandths of an inch, the operator uses the command Set Position Scale Factor (US125) to set a distance multiplier of 125. If he then gives a Distance (D) command D1ØØØ, the motor will move 1,000 units of 125 steps each (one inch) on the next Go (G) command. See the US command.

When scale factors greater than 1 are used, and an indexed move is interrupted by a Stop (S) command or by activation of a limit switch, the final position may not be a multiple of the scale factor. Repeatability is affected.

Incremental vs. Absolute Positioning

Incremental moves allow you to position the motor in relation to the motor's previous stopped position, absolute moves are referenced to a defined zero position established by the Go Home (GH) or Set Position to Zero (PZ) commands. You can select incremental moves with the Mode Position Incremental (FSAØ) command and absolute moves with the Mode Position Absolute (FSA1) command.

Incremental Preset Mode Moves

When you are in Incremental mode (FSAØ), a preset move moves the motor the specified distance from its starting position. For example, to move a 25,000-step per rev motor two revs CW, you must specify a move with a distance of +50,000 steps. Every time the PC21 executes this move, the motor will move two revs from its resting position. You can specify the direction with an optional sign (D+50000 or D-50000). You can also define direction separately with the Set Direction (H+ or H-) command.

Command	Description
FSAØ	Sets unit to Incremental Position Mode
A2	Sets acceleration to 2 rps^2
V5	Sets velocity to 5 rps
D5ØØØØ	Sets distance to 50,000 steps
G	Executes the move (Go)
G	Repeats the move (Go)
H	Reverses the direction of the move
G	Executes the move (Go)

The motor moves two revs (CW) and stops, moves two more revs and stops, changes direction and moves two CCW revs.

Absolute Position Coordinates

The Absolute Positioning mode may be selected for any axis with the FSA1 command.

The Home position is used as a zero reference for absolute positioning. The homing function (GH) command is normally used to establish the absolute zero position. Alternatively, the Position Zero (PZ) command may be used to establish the current position as the zero position for any axis.

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In Absolute mode, you may use the **PR** command to report absolute position in either Motor or Encoder Step mode. The position data from the **PR** command corresponds to absolute command positions established with the **D** command.

A preset move in the Absolute mode (**FSA1**) moves the motor or the encoder the distance that you specify from the absolute zero position. The absolute zero position is the initial power-up position.

The direction of an absolute preset move depends on the motor's position at the beginning of the move and the position you command it to move to. For example, if the motor is at absolute position +4,000, and you instruct the motor to move to position +2,000, the motor will move in the negative (CCW) direction a distance of 2,000 steps to reach the absolute position of +2,000.

The PC21 powers up in Incremental mode. When you issue the Mode Position Absolute (**FSA1**) command, it sets the mode to absolute. When you issue the Mode Position Incremental (**FSAØ**) command, the unit operates in Incremental mode. The PC21 retains the absolute position, even when the unit is in Incremental mode. You can use the Position Report (**PR**) command to read the absolute position.

Command	Description
FSA1	Sets unit to Absolute Position Mode
A2	Sets acceleration to 2 rps^2
V1Ø	Sets velocity to 10 rps
D25ØØØ	Sets distance to 25,000 steps
G	Executes the move (Go)
D25ØØØ	Sets distance to 25,000 steps
G	Executes the move (Go)
D-5ØØØØ	Sets distance to -50,000 steps
G	Executes the move (Go)
DØ	Sets distance to 0 steps
G	Executes the move (Go)

The motor moves one rev CW and stops. When the second **G** command is received, the motor does not move. After the third move, the motor moves in the CCW direction 3 revs. Then the motor moves 2 revs in the CW direction, back to the absolute zero position.

Programming

Operation of the PC21 is independent of the programming language used. The programmer need only have the means to read to and write from the I/O bus of the computer. Most programming languages have in and out type instructions for this.

The PC21 occupies four address locations on the bus. Two of these are not used (*they are duplicates of the other two*).

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The control program writes commands to and reads data from registers at the base address of the PC21. A register or buffer in this case refers to a temporary storage area for holding one character (or one eight bit byte). This transfer takes place one character at a time.

Each character transfer requires that the program write control bytes to and read status bytes from register at the address immediately above the base address.

Control Byte and Status Byte

The Control Byte and Status Byte provide access to PC21 operating conditions. The control byte allows setting certain operating conditions and the status byte reports others.

Each refers to an eight bit PC21 register accessible on the I/O bus, where each of the eight bits is a flag with a specific meaning. Control Byte flags allow the host program to signal the PC21 with messages like, take a command character . The Status Byte flags allow the host program to check on the PC21 regarding such conditions as motor X is moving .

Signalling the PC21 involves setting or clearing control bits or flags which means forcing them to a binary value of one or zero. Clearing or resetting a bit means forcing it to zero. All eight Control register bits are forced to one state or the other when the computer writes to the registers address.

Control Byte (CB)

Table 4-1 shows the Control Byte flags available to the programmer for signalling the PC21. Both this register and the Status Byte are used to communicate with the PC21.

Bit	Definition
0	Unused
1	Unused
2	Stop Watchdog Timer (active high pulse)
3	Acknowledge Interrupt (active high pulse)
4	IDB Command Character Ready (active high handshake)
5	Restart Watchdog Timer (active low pulse)
6	Reset Interrupt Output (active low pulse)
7	ODB Message Character Accepted (active high handshake)

Table 4-1. Control Byte

BIT 2 Causes the PC21's Watchdog Timer to time out and stop. When the timer stops, it forces a hardware reset. The reset condition may be cleared by cycling power or restarting the timer. See Bit 5 below.

BIT 3 Tells the PC21 that its interrupt signal to the computer has been noted and is no longer needed. See Bit 6 below.

BIT 4 Tells the indexer that a command character has been put into the Input Data Buffer. The indexer then clears Bit 4 of the status byte to indicate that the input data buffer is unavailable, reads the character in the input data buffer, and then sets Bit 4 of the status byte to indicate to the host that the input data buffer is again ready for a new character.

BIT 5 Restarts the Watchdog Timer. It must first be cleared, then the timer will start up when the bit is set again. This bit should never be toggled unless the timer has timed out.

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BIT 6 Resets the hardware interrupt latch and thus the interrupt output. The interrupt output cannot be reset unless the interrupt is first acknowledged with Bit 3 above. These bits should be cleared during Reset or Interrupt acknowledge.

BIT 7 Tells the Indexer that a response character, previously placed in the output data buffer by the indexer, has been received by the host, and a new character may be placed in the output data buffer.

Status Byte (SB) The Status Byte provides several information flags for the programmer as shown in Table 4-2. The function of the status byte is used to assist in the communications process, and to provide run-time status information without the need to burden the indexer with routine status request commands.

Power-Up	Definition	
Bit	State	(When Set)
0	Cleared	Unused
1	Set	In position
2	Set	Load Ready
3	Cleared	ODB Ready
4	Set	IDB Ready
5	Cleared	Board Fail
6	Cleared	Interrupt Active
7	Cleared	Unused

Table 4-2. Status Byte Format

BITS Indicate whether the motor is moving. At the beginning of any move, the bit is cleared. Specifically, the bit indicates whether or not the indexer is sending step pulses to the drive. The bit will not indicate if Position Maintenance is in effect.

BIT 2 When the Load and Go option is enabled via the Set Load and Go Mode (SSC1) command, this bit indicates when the move parameters have been calculated, the start of which is initiated by the Load Move Data (I) command. It is reset at the beginning of the calculation and set approximately 25 ms later when the calculations are finished.

BIT 3 Is set when the Output Data Buffer contains an output character for the host, signalling the host to read the information it contains.

BIT 4 Is set when the Input Data Buffer is ready, telling the computer it may write a character to the input data buffer.

BIT 5 Tells the PC that the Watchdog Timer of the PC21 has timed out, possibly indicating an internal failure from which it cannot recover. The only way to clear this bit is to reset the indexer. This is discussed below. Exercising the self-test function will also set this bit.

In this condition, the motor shutdown output will go on, removing motor torque, and generating a Drive Fault.

BIT 6 Indicates to the host that a conditional interrupt has been armed and that an interrupt has occurred. If either jumper JU1 or JU2 is installed, the PC21 will also generate a hardware interrupt signal to IRQ3 or IRQ4.

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Program Control

The PC21 comes supplied with a floppy diskette containing support routines written in BASIC, C, and PASCAL.

The support disk is divided up logically into subdirectories. To go between these subdirectories type: **cd** subdirectory name. To back up o subdirectory type: **cd..**

The BASIC support routine is contained in the BASIC subdirectory. Th C support routine is contained in the C subdirectory. The PASCAL support routine is contained in the PASCAL subdirectory.

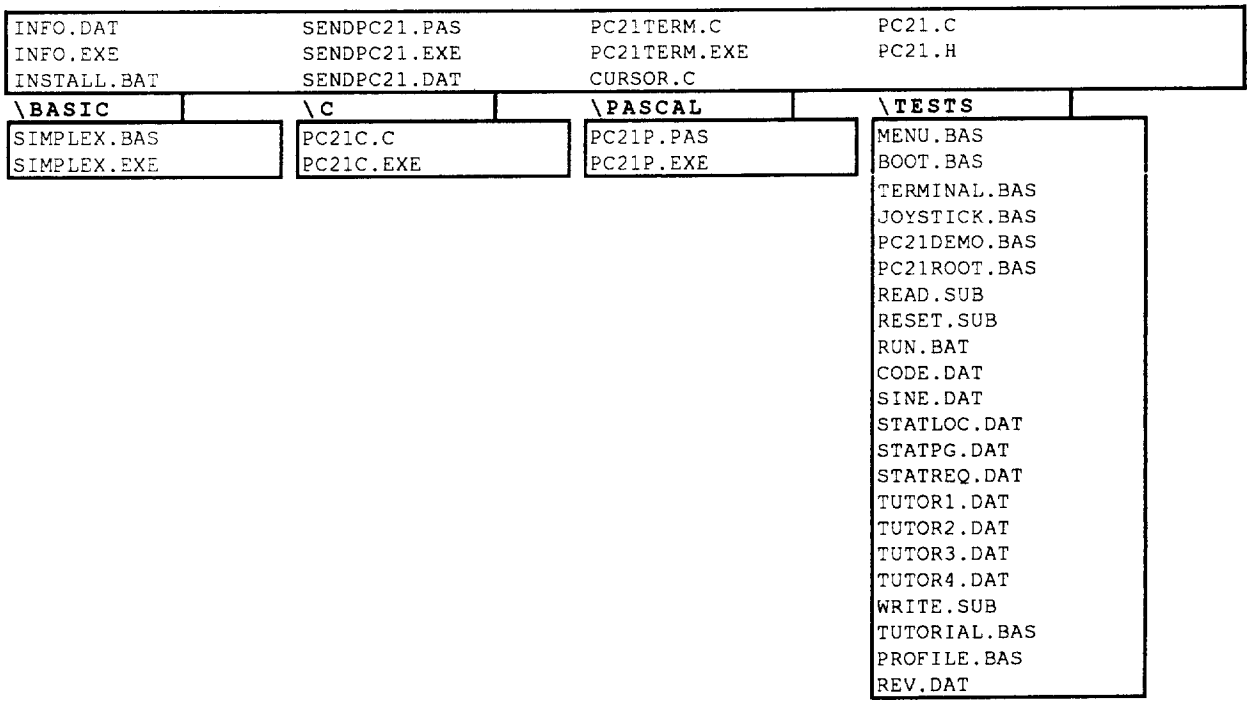
Information about the support diskettes is contained in a menu driven program called **INFO.EXE**. To run this program, type **INFO** at the DO prompt. If you would like a hard copy of the information presented in **INFO.EXE**, print the fine called **INFO.DAT**.

To copy the support routines to your hard disk, do the following:

1. Create a subdirectory to put the routines (**mkdir PC21**).
2. Change directories to the newly created subdirectory (**cd PC21**).
3. Copy the file **INSTALL.BAT** to this subdirectory (copy a:**\INSTALL.BAT**).
4. Type: **INSTALL**

Support Disk File Structure

The support disk is divided logically into a root directory and four subdirectories. A file tree is shown below.



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Reading and Writing

Motion control commands and responses are transferred via the Input and Output Data Buffers, at the PC21 base address. Interface control commands and status information are transferred via the Control Byte and Status Byte, one address location above the base address.

In the PC21, the output data buffer and the status byte are read-only registers. The input data buffer and the control byte are write-only registers. Indexer commands are strings or sequences of ASCII characters. Passing a command to the PC21 calls for transferring each character in the command one at a time.

Each character transfer requires that the sender notify the receiver that a character is ready, and that the receiver notify the sender that the character has been received. The notification process makes use of single bit flags of the eight bit SB and CB registers being set high (1) or low (0) to denote the ready or busy condition as described below.

Sample Read and Write routines which access the computer's I/O bus are provided on the demonstration diskette which accompanies the PC21. Step by step procedures for resetting the PC21 (which should be done at the start of any user program), Writing a Character to the PC21, and Reading a Character from the PC21 are at the end of this chapter. Procedures will need to be followed if you intend to write your own custom subroutines in other program languages.

For examples of these procedures, refer to the following files on the support disks:

- `SIMPLEX.BAS` Written in BASIC
- `PC21C.C` Written in C
- `PC21P.PAS` Written in Pascal

Designing the Computer Program

Responsibility for creating computer programs lies with the user. Creating and interactive program should pose no problems for an experienced programmer. If you are not familiar with programming for your computer, it would be prudent to seek the advice or assistance of someone familiar with both programming and your computer.

The PC21 is designed to operate motor axes in a fashion largely independent of the computer, requiring only a small number of high level commands and interaction. This interaction is almost exclusively in the form of characters and strings rather than numbers. The programmer will need knowledge of string handling in the programming language to be used. Regardless of what the ultimate product of the program is intended, it must include subroutines or procedures to do the following (in order of importance):

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a. Reset the indexer
b. Send a command string to the indexer
c. Receive a character string from the indexer
d. Decode Status Request responses
e. Allow input of indexer command files

Ideally the programs should be set up so that a non-programmer operator can routinely modify appropriate parameters or otherwise change the process being controlled, without requiring that the program be rewritten or compiled. The examples in this chapter are designed to illustrate the approach you would use to communicate with the indexer and are not necessarily optimum for any specific application.

To Create Your Own PC21 Program in BASIC

1. Make a copy of **SIMPLEX.BAS**.
2. Edit the copy starting at line 5000.
3. To send a command, place the X language commands in **CMD$**. (**CMD$= A1Ø V1Ø D25ØØØ G**).
4. To get a response from the PC21 use the **GOSUB 3ØØØ**. The response is returned in **ANSWER$**.

```
5ØØØ CMD$ = "PR "
5Ø1Ø GOSUB 1ØØØ    ' write to PC21
5Ø2Ø GOSUB 3ØØØ    ' read from PC21
5Ø3Ø IF ANSWER$ = "" THEN 5Ø2Ø
5Ø4Ø PRINT ANSWER$
```

5. Compile and run the program.

To Create Your Own PC21 Program in C

1. Make a copy of **PC21C.C**.
2. Edit the main program of the copied file.
3. To send a command, place the X language in message (message = **A1Ø V1Ø D25ØØØ G**). Then make a call to procedure **writecmd** (message).
4. To get a response from the PC21, use the procedure **readanswer** (answer). The response is returned in **answer**.
5. Example:

```
main ()   {
char   *message,*answer;
answer="";
initialize();       /*resets  PC21*/
message = " PR ";
writecmd  (message);
readanswer  (answer);
printf  (answer);
} /* end of main*/
```

6. Compile and run the program.

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To Create Your Own PC21 Program in PASCAL

1. Make a copy of **PC21P.PAS.**
2. Edit the main program of the copied file.
3. To send a command, place the X language commands in message (cmd = **A1Ø V1Ø D25ØØØ G**). Then make a call to procedure **writecmd** (768,cmd). *Where 768 is the PC21 board address.*
4. To get a response from the PC21 use procedure **readanswer** (768,answer). The response is returned in **answer**.
5. Example:

```
Begin
answer:='';
Initialize  (768);
cmd:=' A10  V10  D250000  G  PR  ';
Writecmd  (768,cmd);
while  answer=''  do  Readanswer  (768,answer);
writeln  (answer);
End
```

6. Compile and run your program.

Sending and Receiving Strings

The basic procedure for sending and receiving single characters is shown above. The algorithms discussed are required building blocks for any program.

Sending command strings of varying lengths is easy because the length of the string is easily known. Any general purpose programming language will have the string length and string pointer functions needed to put together an iterative algorithm to send a string one character at a time.

Receiving response strings is complicated by the fact that not all responses are the same length, it is not always possible to predict when a response will occur, some responses are strings representing numbers, and some responses are codes represented by strings.

The choice of commands will influence the kind of data returned by the indexer, so provisions must be made to interpret the indexer responses to status requests. When the response is a single character such as @, A, B, M, etc., the meaning of the character is a function of the requesting command.

There is nothing inherent in a response that identifies which process of decoding should be applied to the single character of the response. Position report responses are a function of the specific command to the Indexer and can be decimal, hexadecimal, or binary data, with varying zero reference positions.

One approach would be to structure the program so that only one unexecuted status request is pending in the indexer command buffer at any one time. In this way the program knows what the command is and how to interpret the response.

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Sending a Character to the PC21

1. Read SB until bit 4 is set.
2. Write a byte into IDB.
3. Write to CB and set bits 4, 5, and 6.
4. Read SB until bit 4 is cleared.
5. Write to CB to clear bit 4, and set bits 5 and 6.

Receiving a Character from the PC21

1. Read SB until bit 3 is set.
2. Read a byte from ODB.
3. Write to CB and set bits 5, 6, and 7.
4. Read SB until bit 3 is cleared.
5. Write to CB to clear bit 7, and set bits 5 and 6.

Support Disk files that provide read, write, and reset routines for the PC21.

- `SIMPLEX.BAS` written in *BASIC*
- `PC21P.PAS` written in *PASCAL*
- `PC21C.C` written in *C*

These files provide the foundation from which you can design a motion control program for the PC21.

Reading Responses from the PC21

Commands that require the PC21 to respond via the IBM PC bus require a seven-step handshaking process. The first step is the procedure for writing to the Indexer; steps 2 through 7 result in the PC reading the message in the ODB.

1. Follow the six-step process for sending a command byte to the PC21 until the complete command string is transferred.
2. Read the SB and check Bit 3, the ODB-Ready bit. If this bit is set, go on to step 5, otherwise repeat this step.
3. Read the message byte in the ODB.
4. Write to the CB and set Bit 7, the Message-Accepted ODB. This will indicate to the Indexer that the message byte it placed in the ODB for the host has been read.
5. Write to the CB and reset Bit 7, the Message-Accepted bit.

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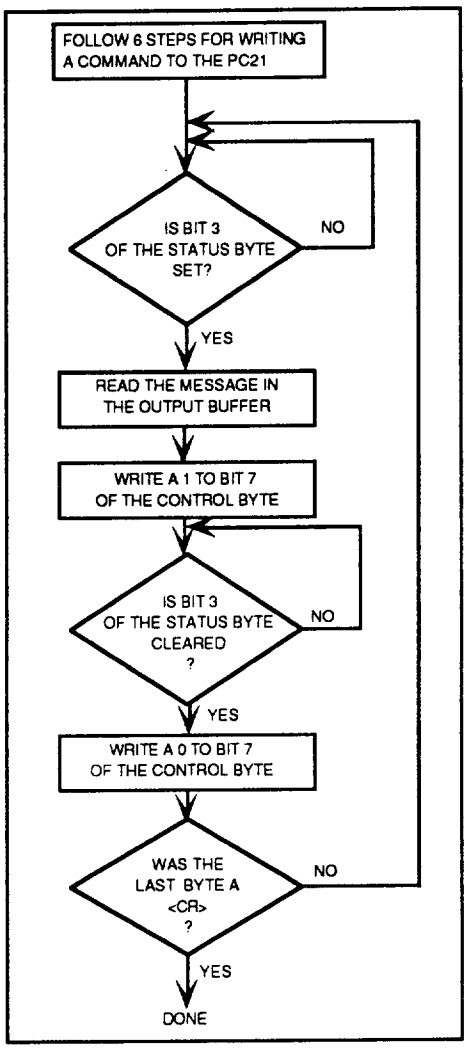


Figure 4-4. Reading a Response from the PC21

6. Read the SB and check Bit 3, the ODB ready bit. If this bit is cleared, go to step 7; otherwise repeat this step.

7. Repeat steps 2 through 6 until a <cr> is encountered.

Software Reset Procedure

To reset the PC21 without removing power, Bit 2 in the CB must be set, and then cleared. This will initiate a time out of the Board Monitor Alarm (BMA). When the BMA times out the worst case is approximately 100ms), the board is placed in the reset state. To trigger the board to function again, Bit 5 of the CB must be cleared, then set.

To compute pulse width, use the formula:

$$\frac{1}{2} = \frac{1}{\text{Max PPS}}$$

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To verify board operation without a motor, connect an oscilloscope to TP1, Step Output, and Ground (TP7). Each motor pulse will be seen as a high-going pulse. The relationship of pulse frequency to motor velocity is shown in Table 4-3. The motor velocity for a given pulse rate depends on the resolution of the motor. Motors with lower resolution (fewer steps per revolution) will rotate at higher velocities (motors with higher resolution will rotate at lower velocities). The minimum rate of 0.125 Hz shown in Table 2-2 for the lower-resolution motors represents the slowest pulse rate the PC21 can send to the motor because the PC21 divides the velocity range for the motor into 0.125 Hz increments.

Motor Resolution	Frequency Range (Hz)	Velocity Range (RPS)	Pulse W. (µsec)	PC21 Cmd
200	1.018- 2000	0.01-160	15	MR0
400	1.018-32000	0.01-80	15	MR1
800	2.036-64000	0.01-80	7.5	MR2
1000	3.052-100000	0.01-100	4	MR3
1600	3.052-96000	0.01-60	4	MR4
3200	7.629-250000	0.01-80	2	MR5
5000	15.259-50000	0.01-100	1	MR6
6400	15.259-512000	0.01-80	1	MR7
10000	15.259-500000	0.001-50	1	MR8
21600	15.259-496800	0.001-23	1	MR9
25000	15.259-500000	0.001-20	1	MR10
25400	15.259-508000	0.001-20	1	MR11
36000	15.259-504000	0.001-14	1	MR12
50000	15.259-500000	0.001-10	1	MR13
50800	15.259-500000	0.001-10	1	MR14
4096	15.259-500000	0.01-124	1	MR15
12800	15.259-500000	0.001-39	1	MR16
25600	15.259-500000	0.01-19	1	MR17
12500	15.259-500000	0.01-40	1	MR18
16384	15.259-500000	0.01-30	1	MR19
20000	15.259-500000	0.01-25	1	MR20
25000	15.259-500000	0.01-20	1	MR21

* Default for Compumotor Motors

Table 4-3. Motor Resolution and Velocity

To control a PK3 with a 400 step/rev resolution, use the following command:

Command	Description
MR1	Sets Pulse width for 400 steps/rev translator

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Loops

You may use the Loop (L) command to repeat certain sequences.

Command	Description
PS	Pauses command execution until the indexer receives a Continue (C) command
FSAØ	Sets mode to incremental
A5	Sets acceleration to 5 rps
V5	Sets velocity to 5 rps
L5	Loops 5 times
D2ØØØ	Sets distance to 2,000 steps
G	Executes the move (Go)
T2	Delays 2 seconds after the move
N	Ends Loop
C	Initiates command execution to resume

POBs (Programmable Output Bits)

You can turn the programmable outputs on and off using the Output (O)command. One (1) turns on a given output and zero (Ø) turns the output off. The outputs conduct when they are on and do not conduct when they are off (see the O command descriptions in *Chapter 5, Software Reference*).

Command	Description
O1	Turn on Out #1

Move Completion Signal

When you complete a move, you may use the PC21's programming capability to signal the end of the current move. In a preset move, you may use one of the following commands:

- PR Report Absolute Position
- CR Carriage return
- O Output command
- PX Report Absolute Encoder Position

You may also use the moving/stopped bits of the Status register to determine if an axis has completed its move.

Example# 1

Command	Description
A2	Sets acceleration to 2 rps^2
V.1	Sets velocity to 0.1 rps
D125ØØ	Sets distance to 12,500 steps
G	Executes the move (Go)
CR	Sends a carriage return back to the PC

The motor moves 12,500 steps. When you complete the move, the unit issues a carriage return.

Example #2

Command	Description
A2	Sets acceleration to 2 rps^2
V.1	Sets velocity to 0.1 rps
D125ØØ	Sets distance to 12,500 steps
G	Executes the move (Go)
O1	Turns on Output #1

The motor moves 12,500 steps. When the PC21 completes the move, Output 1 is turned on.

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Closed Loop-Position Tracking

Position Tracking is Compumotor's closed-loop positioning system. Several parameters must be defined to enable closed loop operation. All commands dealing with the encoder interface are described in Chapter 5, Software Reference. The Position Tracking function provides any or all of the following capabilities:

- Increased resistance to external forces.
- Compensation for friction and gear play.
- A means to independently determine load position.
- Stall detection.

The encoder may be used as feedback for closed-loop positioning or as an independent means to verify position. The encoder may also be used to detect whether a stall has occurred during a move. The encoder functions include:

- Encoder referenced position
- Encoder position servo
- Motor stall detection
- Position loss detection
- Multiple axis stop
- Absolute position coordinates
- Homing function

Implementation of the encoder functions listed above require connection of the encoder and issuing the appropriate configuration commands.

Encoder Referenced Position

In the factory configuration, the indexer operates using position parameters in units of motor steps. With the position tracking option the parameters may be in units of encoder steps. In this mode, when moving a specified distance, the indexer in effect sends out steps to the motor until the correct number of encoder steps are returned.

Position information provided by any axis may be in units of either encoder steps or motor steps. The default power-on configuration is motor steps, but can be programmed to encoder steps. The Position Tracking (**FSB**) command allows switching between modes. The absolute position is always maintained both in encoder steps and motor steps in either mode. The user may switch from one mode to the other between moves but not during moves. Position data will be reported in the same format. Refer to the section regarding the functions of the **FSB** command.

Encoder Position Servo

The Encoder Step mode ensures that a preset move ends up in the right position. But when the move is complete, the encoder is no longer monitored. External forces may move the load, and the indexer will not take any corrective action.

An axis may be configured to resist any external change in its position when it is at rest. If external forces change the encoder's, the indexer will attempt to correct its position.

The Position Maintenance function is selected via the **FSB** command. When selected, the axis will attempt to maintain the current encoder step reference position. The reference position is established at the end of a move or whenever this Servo function is turned on.

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Position Maintenance is effective only while in Encoder Step mode (FSB1) . If after a move it is determined that the encoder position is not changing in spite of steps sent to the motor, this function is automatically disabled.

Position Maintenance Parameters

The FSC command is used to invoke the Position Maintenance mode. In this mode, the indexer repeatedly compares the actual encoder position with the desired position while the motor is stopped. If an error is detected, the magnitude of the error determines the velocity parameter used in the correction response.

The correction response calculation yields a correction velocity according to the Gain parameter. The Correction Gain (CG) command is used to set the gain parameter.

The numerical values of the gain is a velocity, specified with the same format and limitations as the Velocity (V) command. The velocity gain value is multiplied by the encoder step error (or the square or the square root of that error) to yield a correction velocity. The factory default gain is 0.01 rps/encoder step error.

The Maximum Correction Velocity parameter sets the upper limit for servo response speed. This limit may take any value the regular move velocity can. The Maximum Velocity (MV) command is used to establish this parameter.

Lower encoder resolutions require higher gain. Load inertia also affects gain selection. The higher the load inertia, the lower the gain must be.

As with any servo, if the gain is set too high, the system will overshoot, and oscillation about the desired point will result. When the gain is too low, the system responds slowly. The ratio of motor pulses to encoder pulses has a significant impact on the performance of the system.

An empirical approach to optimizing these parameters calls for first selecting an appropriate maximum correction velocity. The gain is established by setting it at a low value, then increasing it to the point where the system begins to show signs of overshoot. Then reduce it a small amount.

Motor Stall Detection

When the motor is being moved, an axis compares the number of encoder steps coming in against the number of motor steps being sent to verify that no gross discrepancy exists, as in the case of a motor stall. If the encoder position deviates excessively from the expected position in the course of a move, the indexer assumes the motor has stalled.

Several configuration options pertain to this feature. These include setting a window of allowable deviation to account for mechanical backlash, halting the move if a stall is detected and sending an output signal.

Each comparison is independent of the prior one, so that if an allowable error exists every time the comparison is made, no stall is detected. Such a condition might occur, for example, if there is minor slipping in the motor or encoder coupling.

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1. The Deadband Window parameter is set by command. The (DW) command allows precise deadband specification in motor pulses. ***The DW command must be specified before stall detection will take place.*** The deadband compensation feature allows mechanical systems with backlash in the gear train to use the stall detect and position loss detection features. When a nonzero deadband is selected, the position-loss detection and stall detection will not be triggered until the error exceeds the deadband.
2. The Stop on Stall function is selected via the (FSD) command. If selected, this function will cause termination of a move when a stall is detected. The move will stop as soon as the stall is detected, without any deceleration. This function works either in Motor Step or Encoder Step mode.
3. The Output on Stall function is also selected via the (FSE) command. If selected, the programmable output will go high when a stall is detected and remain high until a new move begins.

Multi-Axis Stop

On a multi-axis PC21 system, you may wish to have all axes stop motion if a stall is detected on any axis. You can select this function via the Kill Motion on Trigger (FSF) command. If selected, a signal on the Trigger 3 input terminates the move immediately. By driving Trigger 3 on one PC21, with the Stall Detect Output on another PC21, you can terminate the multi-axis moves when a stall is detected on any axis.

Sample Closed-Loop Incremental Moves

The following example commands assume that you have checked the encoder and are sure that it works properly. You can refer to *Chapter 3, Installation*, for proper wiring and testing of the encoder.

Command	Description
> MN	Sets all moves to the Preset mode
> FSB1	Sets all moves to encoder step mode
> ER2ØØØ	Sets encoder resolution to 2,000 steps
> A2	Sets acceleration to 2 rps^2
> V1Ø	Sets velocity to 10 rps
> D2ØØØ	Sets the distance to 2,000 motor steps (2,000 encoder steps)
> G	Moves the motor until encoder moves 1 rev (2,000 encoder steps)

If these moves do not work, refer to *Chapter 7, Maintenance and Troubleshooting.*

Immediate Velocity Streaming Mode

In this mode, the host computer software supplies a Rate Multiplier in Immediate Velocity Streaming Mode (RM) command for real-time control of motor speed. The PC21 has no control of acceleration. **The operator controls all velocity changes and must take care that no change is too abrupt for the motor to follow. Otherwise the motor will stall or fault.**

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Once this operating mode is entered with the Enter Immediate Velocity Profiling Mode (Q1) command, the PC21 clears out any buffered commands waiting for execution and waits for Rate Multiplier in Velocity Streaming Mode (RM) commands. With these commands, the PC21 makes instantaneous changes to the specified velocity. The timing between issuing each RM command determines the exact move profile. Sending RM commands to the PC21 in rapid succession provides smoother motion by virtue of an S-curve acceleration (see Figure 4-3). Testing and modification may be required to establish the correct sequence of RM commands.

CAUTION

Be careful not to make the velocity changes too abrupt. Otherwise, you may make the motor stall.

In the default high velocity range, with the default motor resolution (25,000 steps/rev) and a 25,000-step motor, a data increment of 1 produces a velocity increment of about 15.259 steps per second.

RM commands are issued in real-time. Consequently, it is not possible to download a list of RM values to the PC21, and execute it afterward.

To exit the Velocity Profiling mode, you must use the Q0 command. When a Q1 or Q0 command is received, it is performed before any buffered commands.

Syntax, Range, and Output Control for RM Commands

The syntax for RM commands is RM$n_1n_2n_3n_4$ where $n_1n_2n_3n_4$ represents a 4-digit hexadecimal number. The most significant bit of n_1 is interpreted as a direction bit. If the most significant bit =1, the motor will turn in the CW direction. If the most significant bit = 0, the motor will turn in the CCW direction.

For example, issuing RM0666 changes the velocity of Axis #1 to 24,994 Hz (666 Hex • 15.259 Hz) in the CCW direction. *This assumes a motor resolution of 25,000 steps/rev.*

To change the direction, you must enter a zero (0) point (RM0000 if the motor was traveling CCW or RM8000 if the motor was traveling CW). *If you do not enter the zero point, the new RM data point will be ignored.*

Table 4-4 summarizes the RM command parameter range.

	CW Rotation		CCW Rotation	
Parameter	Decimal	Hex	Decimal	Hex
Zero	32,768	8000	0	000
Maximum	65,523	FFFD	32,755	7FFD

Table 4-4. RM Streaming Mode Parameter Range

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The hex values 7FFE and 7FFF, and FFFE and FFFF are not listed above. These are special function values that do not produce a motor speed value. Instead, they provide a signal on the programmable output in the middle of the velocity profiling operation. This values may be inserted in the data stream to generate a signal when the PC21 gets to critical points in the process. The functions of these values are shown in Table 4-5.

Output	To set low	To set high
POB	7FFE or FFFE	7FFF or FFFF

Table 4-5. Streaming Mode Output Control

Immediate Streaming Example

Command	Description
Q1	Enter Velocity Profiling mode
RMØØ11	Go to RM velocity of 249 Hz in CCW direction
RMØØ55	Go to RM velocity of 1,105 Hz in CCW direction
RMØ1ØØ	Go to RM velocity of 3,906 Hz in CCW direction
RMØØ55	Go to RM velocity of 1,105 Hz in CCW direction
RMØØ11	Go to RM velocity of 249 Hz in CCW direction
RMØØØØ	Go to zero velocity (mandatory) to change direction
RM8Ø11	Go to RM velocity of 249 Hz in CW direction
RM8Ø55	Go to RM velocity of 1,105 Hz in CW direction
RM81ØØ	Go to RM velocity of 3,906 Hz in CW direction
RMFFF5	Set Output #1 high
RM8Ø55	Go to RM velocity of 1,105 Hz in CW direction
RM8Ø11	Go to RM velocity of 249 Hz in CW direction
QØ	Exit velocity profiling mode

Using Interrupts

The PC21 has one interrupt signal available to be activated upon specific conditions. This interrupt signal can be directed at either of two interrupt request lines, IRQ3 or IRQ4. Jumper 1/2 is located just above the edge connector on the PC21 indexer card, determines which interrupt request line is activated. Installing a jumper on the **JU1** pins selects IRQ3, and installing a jumper on the JU2 pins selects IRQ4.

You, the user, are responsible to enable the 8259 interrupt controller chip in the PC to accept the interrupt request. You must also set the corresponding interrupt vectors to accommodate the interrupt request.

8259 Interrupt Controller Chip

Use the following procedure to enable the 8259 interrupt controller chip:

1. Read in the current interrupt mask register (IMR) located at the I/O address (21 HEX).
2. Clear the appropriate bit to enable the interrupt hardware (IRQ3 = bit #3, IRQ4 = bit#4).
3. Write the IMR back to the 8259 chip.

EXAMPLE

```
unsigned char int_8259;       /* Byte to read IMR into */
int_8259 = inportb(0x21);     /* Read IMR for current settings
*/
int_8259 = int_8259 & 0xF7;   /* Clear bit 3 */
outportb(0x21,int_8259);      /* Write new IMR */
```

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Interrupt Vector

The IRQ3 interrupt corresponds to the 11th interrupt vector. Since each vector is 4 bytes long, the user must modify the 4 bytes located at memory address ØØØØ:ØØ2C to point to the interrupt service routine. For IRQ4, modify the 4 bytes at memory address ØØØØ:ØØ3Ø.

Usually, IRQ3 and IRQ4 are assigned to the computer's serial ports COM2 and COM1 respectively. Therefore, when making changes to these vectors, **take care to avoid conflicts with communication cards that may require these vectors.**

EXAMPLE

The following is an example of changing the interrupt vector for IRQ3:

```
struct address { char far *p; };
struct address far *addr = (struct address far *) 44;/* 2c HEX = 44 decimal */
addr->p = (char far *) pc21_irq3;  /* pc21_irq3 is the name of the interrupt
                                      service routine */
```

Interrupt Commands

You can activate the PC21's interrupt output based on several conditions for each axis. The QS command allows you to enable or disable the *interrupt-on-condition* functions. No hardware interrupt will be generated until a specific QS command has been issued and the corresponding condition is met. The possible interrupt-on-condition functions are as follows:

- Interrupt on Move Complete (QSB command)
- Interrupt on Encountered Limit Switch (QSD command)
- Interrupt on Ready to Respond (QSE command)
- Interrupt on Command Buffer Full (QSG command)
- Interrupt on Motor Stall (QSH command)

The QR command reports which interrupt-on-condition functions have been selected with the QSA through QSH commands. The QI command reports which interruptible conditions are active. *The QI command always shows a response to in position (QSB1), even if the interrupt is not enabled (QSBØ).*

You can take advantage of the PC21's interrupt capabilities without actually generating any host interrupts. This is done by arming whatever interrupt conditions are desired, and then polling the status byte (SB) to see if the *Interrupt Active* bit (bit #6) is set. Then, the QI command can be used to determine the source of the signal.

Clearing the Interrupt Signal

Once an interrupt signal is generated, two steps are required to remove that signal.

1. The hardware device (*latch*) that holds the signal must be cleared. **Toggle the *Reset Interrupt Output* bit (bit #6) in the control byte (CB).**

2. The host must acknowledge the interrupt. **Toggle the PC21's *Interrupt Acknowledge* bit (bit #3) in the CB.**

EXAMPLE

The following is example code used to clear an interrupt:

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```
int pc21addr  =  0x300;                    /*HEX 300 = decimal 768 */
int i;
outportb(pc21addr+1,   0x20);              /*clear bit 6 to restore hardware interrupt */
for(i=1;i<200;i++);                        /* time delay for strobing bit 6 low*/
outportb(pc21addr+1,   0x68);              /* set bit 4 to acknowledge interrupt*/
while((inportb (pc21addr+1) & 0x40));      /* wait for interrupt signal to go low*/
outportb(pc21addr+1,   );                  /* normal state of CB */
```

When your interrupt service routine is complete, remember to send an EOI (end-of-interrupt) signal to the 8259 chip, as shown below:

```
outportb(0x20,   0x20);                    /*clear interrupt from 8259 chip */
```

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Chapter 5. SOFTWARE REFERENCE

Chapter Objectives

The information in this chapter will enable you to:

- Identify the four types of commands in Compumotor's X-Series Language
- Use this chapter as a reference for the function, range, default, and sample use of each command

Description of Format (Definition of Fields)

①A ②Motion	③Acceleration			④VALID Software Version
⑤SYNTAX An	⑥UNITS n = rps^2	⑦RANGE 0.01 to 10 motor dependent	⑧DEFAULT 0.02	⑨ATTRIBUTES Buffered Independently Saved
⑩EXECUTION TIME		⑪SEE ALSO D, V, G		

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

Set-up commands define setup conditions for the application. Set-up 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.

Motion

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

3. Full Name

This field contains the full command name.

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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.

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.

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.***

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Command List

A Motion	**Acceleration**			**VALID** Software Version E
SYNTAX **An**	**UNITS** n = rps²	**RANGE** 0.001 to 999.999 (motor dependent)	**DEFAULT** 100	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** D, G, V		

Description

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

Example

Command	Description
> MN	Sets the moves to mode normal (preset moves)
> A5	Sets Acceleration to 5 rps²
> V1Ø	Sets Velocity to 10 rps
> D1ØØØØ	Sets Distance to 10,000 steps
> G	Executes the move (Go)

B Status	**Report Buffer Status**			**VALID** Software Version E
SYNTAX B	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Immediate
EXECUTION TIME <10 ms		**SEE ALSO** None		
RESPONSE TO B IS *R or *B				

Description

The buffer status command will report the status of the command buffer. The command buffer is 1,400 bytes long. The response to this command is:

*R = More than 31 bytes are free
*B = Less than 32 bytes are free

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

Example

Command	Description
B	Response = *R (more than 31 bytes of the buffer are free)

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C Programming	Continue			VALID Software Version E
SYNTAX C	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Immediate
EXECUTION TIME <5 ms		**SEE ALSO** PS, U		

Description

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

Example

Command	Description
PS	Pauses and wait for a c command
MC	Sets move to Continuous mode
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
G	Executes the move (Go)
T1Ø	Waits 10 seconds after the move
VØ	Sets velocity to zero
G	Decelerates the motor to zero velocity
C	Starts executing commands in buffer

CG Set-Up	Set Correction Gain			VALID Software Version E
SYNTAX CGn	**UNITS** n = steps	**RANGE** 0 - 20	**DEFAULT** 8	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** FSB, FSC, DW, CM, MV		

Description

The Set Correction Gain (CG) command allows you to set the amount of error (steps) that should be corrected on the initial position maintenance (**FSC1**) command correction move (which takes place whenever the motor is stationary). This function is only valid in the Encoder Step mode (**FSB1**) command.

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

Example

Command	Description
FSB1	Sets system to Encoder Step mode
CG3	The system corrects 3/8 of the final-position error on the initial correction move

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CM Set-Up	Set Correction Mode For Position Maintenance			VALID Software Version E
SYNTAX CMn	**UNITS** n = correction algorithm	**RANGE** 0, 1, or 2	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** CG		

Description

The Set Correction Mode for Position Maintenance (CM) command sets the position maintenance functions to one of the following algorithms:

When **n** is **Ø**, the correction algorithm is:

(encoder position error) • (position maintenance gain)

When **n** is **1**, the correction algorithm is:

$$\text{(encoder position error)} \cdot \sqrt{\text{(position maintenance gain)}}$$

When **n** is **2**, the correction algorithm is:

$$\text{(encoder position error)} \cdot \text{(position maintenance gain)}^2$$

Example

Command	Description
CMØ	Sets position maintenance correction mode

CR Set-Up	Carriage Return			VALID Software Version E
SYNTAX CR	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <2 ms		**SEE ALSO** None		

Description

The Carriage Return (CR) command determines when the indexer reaches a particular point in the execution buffer. When the indexer reaches this command in the buffer, it responds by issuing a carriage return (ASCII 13) over its interface back to the host computer. If you place the CR command after a Go (G) command, it will indicate when a move is complete. If you put the CR command after a Trigger (TR) command, it will indicate when the trigger condition is met.

Example

Command	Description
MN	Sets indexer to mode normal
FSA1	Sets mode for absolute position
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D5ØØØ	Sets distance to 5,000 steps
G	Executes the move (Go)
CR	Sends a carriage return

The motor moves 5,000 steps. When the motor stops, the indexer sends a carriage return over its interface.

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D Motion	Set Distance			VALID Software Version E
SYNTAX Dn	UNITS n = steps	RANGE ±99,999,999	DEFAULT 25,000	ATTRIBUTES Buffered
EXECUTION TIME <10 ms		SEE ALSO A, G, V, MN		

Description

The Distance (D) command defines either the number of steps the motor will move or the absolute position it will seek after a Go (G) command is entered. In incremental mode (FSAØ), the value set with the D command will be the distance (in steps) the motor will travel on all subsequent G commands.

In Absolute mode (FSA1), the distance moved by the motor will be the difference between the current motor position and the position (referenced to the zero position) set with the D command The **D** command has no effect on continuous moves (MC).

Example

Command	Description
MN	Sets indexer to normal mode (preset)
A5	Sets acceleration to 5 rps^2
V10	Sets velocity to 10 rps
D5ØØØØ	Sets distance to 50,000 steps
G	Executes the move (Go)

The motor will travel 50,000 steps in the CW direction after the G command is issued.

DW Set-Up	Set Dead Band Window			VALID Software Version E
SYNTAX DWn	UNITS n = steps	RANGE 0 - 99,999,999	DEFAULT 0	ATTRIBUTES Buffered
EXECUTION TIME <10 ms		SEE ALSO FS Commands, MR		

Description

This command specifies a backlash deadband in motor steps. The backlash deadband compensates for mechanical systems with backlash and *allows you to use the Stall Detect function.* Stall detection does not occur until the error exceeds the deadband width of one mechanical motor step. In a 25,000 step/rev drive/motor combination, this corresponds to 500 steps (2500 ÷ 50 poles = 500). In a 200 step/rev drive motor, this corresponds to four steps (200 ÷ 50 poles = 4).

Any DW command specified with a deadband less than the minimum of one mechanical motor step will default to the minimum.

Example

Command	Description
DW6ØØ	600 motor steps of backlash are expected by the indexer. A stall will not be detected until the motor lags the motor position by more than 600 motor steps.

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ER Set-Up	Set Encoder Resolution			VALID Software Version E
SYNTAX **ER**n	**UNITS** n = encoder	**RANGE** 1 - 50,000	**DEFAULT** 4,000	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** DW, FS commands		

Description

This command defines the number of encoder counts per one revolution of the motor. The number of lines on an encoder should be multiplied by 4 to arrive at the correct encoder resolution value per revolution of the motor.

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

A 4:1 ratio of motor steps to encoder steps is necessary for proper closed-loop operation. If a lower ratio is used, it may be difficult to tune the position maintenance (Servoing) feature of your indexer.

Example

Command	Description
ER8ØØØ	Sets encoder resolution to 8,000 steps

FR Status	Report Encoder Functions			VALID Software Version E
SYNTAX **FR**	**UNITS** n = function	**RANGE** 0 = function off 1 = function on	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <5 ms		**SEE ALSO** FS commands		
RESPONSE TO FR IS *nnnnnnnn				

Description

This command allows you to request the status of **FS** command functions. The response contains one ASCII digit per function (zero [Ø] or one [1]). The digits (n) correspond to the functions, (A - H, left to right). One (**1**) means an **FS** function is on. Zero (**Ø**) means an **FS** function is off.

A Incremental = OFF (Ø) Absolute = ON (1) Defines the move distances (D) as either incremental from current position, or as absolute referenced to the absolute 0 position).

B Motor step mode = OFF (Ø) Encoder step mode = ON (1) Defines the distance in motor steps or encoder steps.

C Position Maintenance = OFF (Ø), = ON (1) Enables position maintenance. This causes the indexer to servo the motor to the desired position if it is not in the correct position at the end of a move, or, if the motor is forced out of position while at rest.

D Terminate Move on Stall Detect = OFF (Ø), = ON (1) Instructs the indexer to abort a move if it detects a stall.

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E Turn on Output on Stall Detect = OFF (Ø), = ON (1) Instructs the indexer to turn an output on if it detects a stall.

F Kills Motion on Trigger 3 = OFF (Ø), = ON (1) Instructs the indexer to stop all motion when trigger 3 becomes active

G = OFF (Ø), = ON (1) Reserved
H = OFF (Ø), = ON (1) Reserved

Example

Command	Response
FR	11000000 The indexer is in absolute encoder step mode. All other **FS** functions are OFF.

FS Set-Up	**Encoder Functions**			**VALID** Software Version E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
FSn	n = function	0 = off 1 = on	0	Buffered
EXECUTION TIME <5 ms		**SEE ALSO** PZ, PR, FR		

Description

This command allows you to set your PC21 to Absolute, Incremental, or Indexing Modes.

Bit	Function
A	Set Absolute/Incremental Positioning Mode
B	Set Motor Step/Encoder Step Indexing Mode
C	Enable Position Maintenance
D	Enable Stop on Stall
E	Enable Output on Stall
F	Kill Motion on Trigger #3

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FSA Set-Up	Set Absolute/Incremental Positioning Mode			VALID Software Version E
SYNTAX FSAn	UNITS n = function	RANGE 0 = off 1 = on	DEFAULT 0	ATTRIBUTES Buffered
EXECUTION TIME <5 ms		SEE ALSO PZ, PR, FR		

Description

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

- **FSAØ** Incremental mode
- **FSA1** Absolute mode

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

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

Example

Command	Description
MN	Sets indexer to mode normal
FSA1	Sets Indexer to absolute mode
PZ	Resets the absolute counter to zero
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D25ØØØ	Moves motor to absolute position 25,000
G	Executes the move (Go)
D5ØØØØ	Move motor to absolute position 50,000
G	Executes the move (Go)

The motor moves 25,000 steps, then moves an additional 25,000 steps to reach the absolute position of 50,000.

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FSB Set-Up	Set Motor Step/Encoder Step Indexer Mode			VALID Software Version E
SYNTAX **FSB**n	**UNITS** n = function	**RANGE** 0 = off 1 = on	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <5 ms		**SEE ALSO** D, ER, FR, MR		

Description

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

- **FSBØ** Motor steps
- **FSB1** Encoder steps

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

In Encoder Step mode, the distance command defines moves in post-quadrature encoder steps. You must set up the indexer for the correct encoder resolution The Encoder Resolution (**ER**) command is used to define the post-quadrature encoder resolution.

Enabling Encoder Step mode does not guarantee that your moves will position to the exact encoder step commanded. Position maintenance (**FSC**) must be enabled to activate closed loop servoing.

Example

Command	Description
ER4ØØØ	Sets up 4,000 encoder pulses
FSB1	Sets moves to encoder step mode
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D4ØØØ	Sets distance to 4,000 encoder steps
G	Executes the move (Go)

The motor moves in the positive direction until 4,000 encoder pulses are received.

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FSC Set-Up	Enable Position Maintenance			VALID Software Version E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
FSCn	n = function	0 = off 1 = on	0	Buffered
EXECUTION TIME <5 ms		**SEE ALSO** DW, ER, FSB, CM, FR, FSD		

Description

This command enables and disables the position maintenance function.

- **FSC1** Enable Position Maintenance
- **FSCØ** Disable Position Maintenance

Enabling position maintenance will cause the indexer to servo the motor until the correct encoder position is achieved. This occurs at the end of a move (if the final position is incorrect) or any time the indexer senses a change in position while the motor is at zero velocity. You must have an encoder connected, and set the indexer in Encoder Step mode (**FSB1**) in order to enable position maintenance.

If you have enabled position maintenance and your motor drifts, this is an indication that the encoder is not hooked up properly. The motor will drift at 0.1 rps for one revolution.

If you are making a move with position maintenance enabled (**FSC1**), and your encoder becomes disconnected, the PC21 will continue to output pulses trying to get to the desired position. This means that the PC21 could conceivably output pulses forever, or until a limit is hit. ***For the safety of the machine, you should enable stop on stall (FSD1).*** This will bring the motor to a stop. (You must also give a deadband [**DWØ**]).

Example

Command	Description
ER4ØØØ	Sets encoder resolution to 4,000
FSB1	Sets to encoder step mode
DWØ	Enables stall detection
FSC1	Enables position maintenance

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FSD Set-Up	Enable Stop on Stall			VALID Software Version E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
FSDn	n = function	0 = function off 1 = function on	0	Buffered
EXECUTION TIME <5 ms		**SEE ALSO** DW, ER, SS, FR		

Description

This command enables/disables the Stop on Stall function.

- **FSD1** Enable Stop on Stall
- **FSDØ** Disable Stop on Stall

Entering **FSD1** will cause the indexer to stop the move in progress when a stall is detected. The move is stopped immediately; no deceleration. This command is only valid if stall detection has been enabled by issuing any Deadband (**DW**) command. It will have no effect otherwise. Stall detect will work in either motor step mode or encoder step mode.

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

Example

Command	Description
DW6ØØ	Sets backlash value to 600 steps
ER2ØØØ	Sets encoder resolution to 2,000 steps/rev
FSD1	Enables stop on stall

FSE Set-Up	Enable Output on Stall			VALID Software Version
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
FSEn	n = output	0 or 1	0	Buffered
EXECUTION TIME <5 ms		**SEE ALSO** DW, ER, FR, O		

Description

This command enables and disables the Output on Stall function.

- **FSEØ** Disable Output on stall
- **FSE1** Enable Output on stall

Entering **FSE1** will cause the indexer to turn on the programmable output when a stall is detected. This is useful for signaling other components in you system that a stall has occurred. This command will only be valid if Stall Detect has been enabled (**DW** command). The output is unaffected by a stall when **FSEØ** is entered. This output will turn on if **FSE1** and Kill Motion On Trigger (**FSF**) are both enabled.

Example

Command	Description
ER4ØØØ	Set encoder resolution to 4,000 steps/rev.
DW6ØØ	Set backlash deadband to 600 motor steps.
FSE1	Turn on the output when a stall is detected.

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FSF Set-Up	Kill Motion on Trigger #3			VALID Software Version
SYNTAX FSEn	**UNITS** n = output	**RANGE** 0 or 1	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <5 ms		**SEE ALSO** FR, TR		

Description

This command enables and disables motion on Trigger #3.

FSFØ: Disable kill motion on Trigger #3
FSF1: Enable kill motion on Trigger #3

If trigger 3 becomes active with the **FSF1**, all motion will be stopped (refer to the **K** command).

G Motion	Go			VALID Software Version E
SYNTAX G	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <30 ms		**SEE ALSO** A, D, MN, V, MC, FSA, FSB		

Description

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

A **G** command in the Absolute Preset mode (**FSA1**) will not cause motion unless you enter a change in distance (**D** command) first.

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

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

If motion does not occur with the **G** command, an end-of-travel limit switch may be on. Check the limit switches.

Example

Command	Description
MN	Sets mode to normal (preset)
FSAØ	Sets mode to incremental
FSBØ	Sets indexer to motor step mode
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D25ØØØ	Sets distance to 25,000 steps
G	Executes the move (Go)
A1	Sets acceleration to 1 rps^2
G	Executes the move (Go)

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GA Motion	Go Home Acceleration			VALID Software Version E
SYNTAX GAn	**UNITS** n = rps²	**RANGE** 0.001 - 999.999	**DEFAULT** 10	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** GH		

Description

The Go Home Acceleration (GA) command sets the linear acceleration value that the motor will use during any subsequent Go Home (GH) moves.

Example

Command	Description
GA5	Sets go home acceleration to 5 rps²
GH-5	The motor accelerates at 5 rps² to 5 rps in the CCW direction and searches for home

GH Motion	Go Home			VALID Software Version E
SYNTAX GHsn	**UNITS** n = rps s = + or -	**RANGE** 0.001 - 20 (25,000 step/rev motor)	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <30 ms		**SEE ALSO** GA		

Description

The Go Home (GH) command instructs the controller to search for the home position, either in the motor step mode or the encoder step mode. When in the motor step mode, the controller looks only at the Home Limit input. It will define Home as the CCW edge of the Home Limit signal (the edge closest to the CCW limit input).

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

The indexer will reverse direction if an End-of-Travel limit is activated while searching for Home. However, if a second End-of-Travel limit is encountered in the new direction, the Go Home procedure will stop and the operation will be aborted.

After the GH command is issued, the motor will run in the direction and velocity specified. The motor will keep running after the home switch is activated until it is deactivated. It will then decelerate and reverse direction.

Example

Command	Description
GH-2Ø	The motor moves in the CCW direction at 20 rps and looks for the Home Limit input to go active

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H Motion	Set Direction (CW or CCW)			VALID Software Version E
SYNTAX H<s>	**UNITS** s = direction	**RANGE** + or -	**DEFAULT** +	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** None		

Description

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

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

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

Examples

Command	Description
MN	Sets Normal mode
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D25ØØØ	Sets distance to 25,000 steps
G	Executes the move (Go) in + direction
H	Reverses direction
G	Executes the move (Go) in - direction
MC	Sets mode to continuous
H+	Sets direction to + direction
G	Moves continuously in + direction

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I Programming	Load Move Data			VALID Software Version E
SYNTAX I	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** G, SSC		

Description

The Load Data (I) command allows the indexer to precalculate move data sent, so that execution of the move will begin within 10 ms of receiving a Go (G) command. The move profile may be repeatedly executed with a only a 10 ms calculation delay until any one of the three move parameters: Acceleration (A), Velocity (V), or Distance (D) is changed.

Without use of the I command, a delay of up to 30 ms per axis will occur before execution of the move. The Set Load and Go Mode (SSC) command must be enabled before the I command will work.

Example

Command	Description
MN	Sets mode to normal (preset)
SSC1	Enable load and go mode
A5	Sets acceleration to 5 rps^2
V1Ø	Sets velocity to 10 rps
D25ØØØ	Sets distance to 25,000 steps
I	Loads move data (precalculates move profile)
TR1XX	Wait for trigger 1 to go high
G	Executes the move (Go)

K Motion	Kill Motion			VALID Software Version E
SYNTAX K	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Immediate
EXECUTION TIME <10 ms		**SEE ALSO** S		

Description

The Kill (K) command is an emergency stop command and should only be used as such. This command causes indexing to cease immediately. There is no deceleration of the motor. If Kill causes the motor to slip (i.e., large loads at high speed), the load could be driven past limit switches and cause damage to the mechanism and possibly to the operation.

In addition to stopping the motor, the K command will terminate a loop, end a time delay and clear the command buffer.

Example

Command	Description
A5	Sets acceleration to 5 rps^2
V2	Sets velocity to 2 rps
MC	Sets mode to continuous
G	Executes the move (Go)
K	Stops the motor instantly

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L Programming	Loop			VALID Software Version E
SYNTAX Ln	**UNITS** n = number of loops	**RANGE** 0 = infinite otherwise 1 - 4299467294	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** C, N, U, Y		

Description

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

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

The accuracy of single-step moves (D1) within a loop is limited to 0.009%. Loops that contain more than 10,000 single-step moves may generate one too many or one too few steps.

Example

Command	Description
L 5	Loops 5 times .
A 5	Sets acceleration to 5 rps^2
V 1 Ø	Sets velocity to 10 rps
D 1 Ø Ø Ø Ø	Sets distance to 10,000 steps
G	Executes the move (Go)
N	Specifies the above 10,000-step move to be repeated five times

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MA Motion	Set Mode Alternate			VALID Software Version E
SYNTAX MA	UNITS None	RANGE None	DEFAULT None	ATTRIBUTES Buffered
EXECUTION TIME <10 ms		SEE ALSO D, MC, MN, SSD, A, V, G		

Description

The Mode Alternate (MA) command, like the Mode Normal (MN) and the Mode Continuous (MC) commands, effects the way moves are preformed. In Mode Alternate (MA), a move is made to a position that you define with the Distance (D) command. When the motor reaches the specified distance it reverses direction and returns to the starting position. This cycle will continue until you issue a Stop (S) or Kill (K) command.

Examples

Command	Description
MA	Sets indexer mode to alternate
A5	Sets acceleration to 5 rps^2
V1	Sets velocity to 1 rps
D1ØØØ	Sets distance to 1,000 steps
G	Executes the move (Go)

The motor moves 1,000 steps (CW). It then reverses direction and moves 1,000 steps (CCW) direction. This motion continues until you issue a Stop (S) or Kill (K) command.

MC Motion	Set Mode Continuous			VALID Software Version E
SYNTAX MC	UNITS None	RANGE None	DEFAULT None	ATTRIBUTES Buffered
EXECUTION TIME <10 ms		SEE ALSO A, MA, MN, T, TR, V, H, G		

Description

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

The indexer uses the Acceleration (A) and Velocity (V) commands to reach continuous velocity. The direction of the move should be specified with the (H+) or H-) command.

Using the Time Delay (T), Trigger (TR), and Velocity (V) commands, you can achieve basic velocity profiling.

Example

Command	Description
MC	Sets mode to continuous
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
H+	Set direction to CW
G	Executes the move (Go)

The motor turns at 5 rps CW until it is halted by the Stop (S) command, Kill (K) command, a limit switch, or by a new velocity specification (V10 G).

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MN Motion	Set Mode Normal			VALID Software Version E
SYNTAX MN	UNITS None	RANGE None	DEFAULT None	ATTRIBUTES Buffered
EXECUTION TIME <10 ms		SEE ALSO A, D, G, MC, V		

Description

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

Example

Command	Description
MN	Set the system to mode normal
A5	Set acceleration to 5 rps^2
V5	Set velocity to 5 rps
D1ØØØ	Set distance to 1,000 steps
G	Executes the move (Go)

MR Set-Up	Select Motor Resolution			VALID Software Version E
SYNTAX MRn	UNITS n = number	RANGE 0 - 20	DEFAULT 10	ATTRIBUTES Buffered
EXECUTION TIME <50 ms		SEE ALSO A, V, ER		

Description

The Motor Resolution (MR) command sets the number of steps/rev. This command allows the indexer to control drives of different resolutions while maintaining the commanded acceleration and velocity. MR values greater than 20 are ignored.

Example

Command	Description
MN	Sets system to mode normal
MR1	Sets motor resolution to 400 steps/rev
A5	Sets acceleration to 5 rps^2
V1Ø	Sets velocity to 10 rps
D8ØØ	Sets distance of move to 800 steps
G	Executes the move (Go)

A 400 step per revolution motor/drive will turn 800 steps (two units) CW at an acceleration of 5 rps^2 and a velocity of 10 rps after the G command.

If this command set is sent to a motor/drive with a resolution of 4,000, the motor will still turn 800 steps (1/5 of a rev). However, the actual acceleration would only be 0.5 rps^2 and the actual velocity would only be 1 rps. Indexer resolution and motor/drive resolution must match to get the commanded velocity and acceleration. *This command does NOT affect distance.*

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Motor Resolution	Frequency Range (Hz)	Velocity Range (rps)	Pulse W (µsec)	PC21 Cmd
200	1.018- 2000	0.01-160	15	MR0
400	1.018-32000	0.01-80	15	MR1
800	2.036-64000	0.01-80	7.5	MR2
1000	3.052-100000	0.01-100	4	MR3
1600	3.052-96000	0.01-60	4	MR4
3200	7.629-250000	0.01-80	2	MR5
5000	15.259-50000	0.01-100	1	MR6
6400	15.259-512000	0.01-80	1	MR7
10000	15.259-500000	0.001-50	1	MR8
21600	15.259-496800	0.001-23	1	MR9
25000	15.259-500000	0.001-20	1	MR10
25400	15.259-508000	0.001-20	1	MR11
36000	15.259-504000	0.001-14	1	MR12
50000	15.259-500000	0.001-10	1	MR13
50800	15.259-500000	0.001-10	1	MR14
4096	15.259-500000	0.01-124	1	MR15
12800	15.259-500000	0.001-39	1	MR16
25600	15.259-500000	0.01-19	1	MR17
12500	15.259-500000	0.01-40	1	MR18
16384	15.259-500000	0.01-30	1	MR19
20000	15.259-500000	0.01-25	1	MR20

MV Set-Up	**Set Maximum Correction Velocity**			**VALID** Software Version E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
MVd	n = rps	0.001 - 20.00	0	Immediate
EXECUTION TIME <10 ms		**SEE ALSO** CG, CM, ER, FS		

Description

If the motor is running with the encoder feedback, and position maintenance is turned on, this command will specify the maximum velocity for correction moves. **MV** values greater than 20 are ignored.

Examples

Command	Description
MN	Mode normal (preset moves)
MV2	Set the maximum correction velocity to 2 rps
FSB1	Set motion in encoder mode
FSC1	Set position maintenance on

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N Programming	End of Loop			VALID Software Version E
SYNTAX N	UNITS None	RANGE None	DEFAULT None	ATTRIBUTES Buffered
EXECUTION TIME <10 ms		SEE ALSO C, L, PS, Y		

Description

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

Example

Command	Description
PS	Pauses the execution of buffered commands until the indexer receives a Continue (C) command
MN	Sets move to mode normal
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D1ØØØØ	Sets move distance to 10,000 steps
L5	Loops the following commands five times
G	Executes the move (Go)
N	Ends the loop
C	Clears pause and executes all the buffered commands

The motor makes a 10,000 step move 5 times.

O Programming	Output			VALID Software Version E
SYNTAX On	UNITS n = output	RANGE 0 = off 1 = on	DEFAULT None	ATTRIBUTES Buffered
EXECUTION TIME <10 ms		SEE ALSO TR, FSE		

Description

The Output (O) command turns the programmable output bit (POB) on and off. This is used for signaling remote controllers, turning on LEDs, or sounding whistles. The output can indicate that the motor is in position, about to begin its move, or is at constant velocity, etc.

Example

Command	Description
A5	Set acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D2ØØØØ	Sets move distance to 20,000 steps
O1	Sets programmable output 1 on
G	Executes the move (Go)
OØ	After the move ends, turn off output

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P Status	Report Incremental Position			VALID Software Version E
SYNTAX P	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <20 ms		**SEE ALSO** FSB, PB, PR, W, X		
RESPONSE TO P IS ±nnnnnnnn (n = 0 - 9) encoder or motor steps = 0 to ±99,999,999				

Description

Reports incremental distance traveled during the last move in decimal format. The command reports positions in an 8-digit number preceded by sign (±), and followed by a carriage return. If the indexer is in the encoder mode, the report is in encoder steps. If the indexer is in motor mode, the report is in motor steps.

Example

Command	Description
MN	Set moves to mode normal
FSBØ	Set motor step mode
A1Ø	Set acceleration to 10 rps^2
V5	Set velocity to 5 rps
D25ØØØ	Set move distance to 25,000 steps
G	Executes the move (Go)
P	Request Position
	Response = +ØØØ25ØØØ

The motor will move 25,000 motor steps, then the indexer will report the distance moved in the last move.

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PB Status	Incremental Binary Position Report			VALID Software Version
SYNTAX PB	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered Not Saved
EXECUTION TIME		**SEE ALSO** PR, P, W, X		
RESPONSE TO PB **IS** 4 ASCII Characters				

Description

Reports incremental distance traveled during the last move. Format is in 4 ASCII characters. The first ASCII character received back from the PC21 is the most significant byte of a four byte number. ***If the most significant bit of the most significant byte is set, the response if negative. If the most significant bit it cleared the response is positive (80 HEX-FFHEX are negative, ØØ-7F are positive). This is not 2's complement notation***. As you receive the characters you will need to convert them to a decimal number. This is done by following the steps below.

1. Compare the ASCII code for the first character to hex 8Ø (check to see if the most significant bit is set). If it is greater than or equal to hex 8Ø, subtract hex 8Ø, and make the sign of your result negative.

2. Convert all four ASCII characters to decimal numbers.

3. Multiply the first character by 16,777,216
   Multiply the second character by 65,536
   Multiply the third character by 256
   Multiply the fourth character by 1

4. Add all the decimal results in step 3 together

Example

ASCII characters Received ¢ J ! Q
ASCII HEX equivalent 9B 4A 21 51

STEP 1

9B > 8Ø
Result will be negative
Subtract 80 from 9B = 1B
New string = 1B 4A 21 51

STEP 2

HEX 1B = decimal 27
HEX 4A = decimal 74
HEX 21 = decimal 33
HEX 51 = decimal 81

STEP 3

27 x 16,777,216 = 452984832
74 x 65,536 = 4849664
33 x 256 = 8448
81 x 1 = 81

STEP 4

452984832 + 4849664 + 8448 + 81 = 457843025

Thus the last move was 457843025 steps CCW.

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PR Status	Report Absolute Position			VALID Software Version E
SYNTAX PR	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <15 ms		**SEE ALSO** D, MN, PZ, W, X		
RESPONSE TO PR IS ±nnnnnnnn (n = 0 - 9) encoder or motor steps 0 to 99,999,999				

Description

This is an absolute position command. It reports motor position with respect to power-up position. The absolute position counter can track up to ± 99,999,999 steps. If the counter is overrun in the relative position mode, the absolute position will be invalid.

If in the encoder mode, position will be reported in encoder steps. If you are in motor mode, position will be reported in motor steps. In preset mode, response to this command will be reported after the move is done. In continuous mode, the response to this command will be reported after the motor reaches constant velocity.

The Position Report (PR) command responds with the cumulative position of the motor in respect to the zero position. The zero position can be defined by the position of the motor after a Position Zero (PZ) command is issued or by the successful completion of a Go Home (GH) command.

This command can only respond when the motor is not being commanded to move. Should you need relative positional information when the motor is moving, see the Report Position Relative to Start of Current Move (W) command.

Examples

Command	Description
MN	Set moves to mode normal
FSBØ	Set motor step mode
A1Ø	Set acceleration to 10 rps^2
V5	Set velocity to 5 rps
D25ØØØ	Set move distance to 25,000 steps
G	Executes the move (Go)
G	Executes the move (Go)
PR	Request Position Response = +ØØØ5ØØØØ

The motor will move 50,000 motor steps, then the indexer will report the distance moved in the last move.

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PS Programming	Pause			VALID Software Version E
SYNTAX **PS**	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** C, U		

Description

This command pauses execution of a command string or sequence following the Pause (**PS**) command until the indexer receives a Continue (**C**) command. This command is useful if you need to enter a complete string of commands before you can execute your other commands.

This command is useful for interactive tests and in synchronizing multiple indexes that have long command strings.

Example

Command	Description
PS	Pauses execution of following commands until the indexer receives the Continue (C) command
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D25ØØØ	Sets move distance to 25,000 steps
G	Executes the move (Go)
T2	Delays the move for 2 sec
G	Executes the move (Go)
C	Continues Execution

When the indexer receives the Continue (**C**) command, the motor moves 25,000 steps twice with a two-second delay between moves.

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PZ Status	Set Zero Position			VALID Software Version E
SYNTAX PZ	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** D, MN, PR		

Description

This command sets the absolute position counter to zero. When your indexer powers up, the absolute counter sets to zero. After moving the motor, the PZ command is used to reset the absolute counter to zero.

In Absolute Mode (FSA1), all the moves will be made with respect to the absolute counter.

Examples

Command	Description
PZ	Sets the absolute counter to zero
FSA1	Makes all preset moves with respect to Absolute zero position
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D2500	Sets move distance to 2,500 steps
G	Executes the move (Go)
PR	Reports Absolute Position
	Response = +0000250
PZ	Sets the absolute counter to zero
PR	Reports absolute position
	Response = +0000000

Q Programming	Complete Current Command and Clear Command Buffer			VALID Software Version E
SYNTAX Q	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Immediate
EXECUTION TIME <10 ms		**SEE ALSO** K, S		

Description

The Q command completes the current and clears the remainder of the command buffer.

Example

Command	Description
Q	Completes current command and clears command buffer

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QØ Set-Up	Exit Profiling Mode			VALID Software Version E
SYNTAX QØ	UNITS None	RANGE None	DEFAULT None	ATTRIBUTES Immediate
EXECUTION TIME <10 ms		SEE ALSO Q1, RM		

Description

The QØ command is an exit command for the velocity profiling mode. The motor will stop when QØ is issued.

Example

See Q1 command.

Q1 Set-Up	Enter Immediate Velocity Profiling Mode			VALID Software Version E
SYNTAX Q1	UNITS None	RANGE None	DEFAULT None	ATTRIBUTES Immediate
EXECUTION TIME <10 ms		SEE ALSO QØ, RM		

Description

The Q1 command enters the immediate velocity profiling mode. *The command buffer is cleared and any motion is killed on the specified axis.* Subsequent RM commands will cause an immediate change in motor velocity. Use QØ to exit this mode.

Before the status of this command is updated, the interrupt must be acknowledged (refer to *Chapter 4, Software Reference*).

Example

Command	Description
Q1	Enter Velocity Profiling mode
RMØØ11	Go to RM velocity of (11 hex) RM rps
RMØØ55	Go to RM velocity of (55 hex) RM rps
RMØ1ØØ	Go to RM velocity of (100 hex) RM rps
RMØØ55	Go to RM velocity of (55 hex) RM rps
RMØØ11	Go to RM velocity of (11 hex) RM rps
QØ	Exit velocity profiling mode

Motor movement will stop when the QØ command is entered. See RM command for more details.

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QI Status	Report QS Command Status			VALID Software Version E
SYNTAX QI	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <15 ms		**SEE ALSO** QS		
RESPONSE TO QI IS nnnnnnn (n = 0 or 1)				

Description

The QI command requests the status of the functions set by the QS command which will cause an interrupt to be sent depending on various conditions. The reply is eight digits, each of the functions are shown below:

Function	Options		Value
A Not Used		(0)	0
B Move Complete	NO/YES	(n = 0,1)	n
C Not Used		(0)	0
D Limit Encountered	NO/YES	(n = 0,1)	n
E Ready to Respond*		(0)	0
F Not Used		(0)	0
G Command Buffer Full	NO/YES	(n = 0,1)	n
H Motor Stall	NO/YES	(n = 0,1)	n

*The ODBRDY bit in the status register is set. Refer to *Chapter 4, Application Design*, for more on communication.

Move complete will always display a result, even if QSB is not enabled.

Example

Command	Description
QI	Request source interrupt status Response = ø1øøøøøø. According to the indexer response, the move is complete.

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QR Status	Report QS Command Function Enable Status			VALID Software Version E
SYNTAX QR	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <20 ms		**SEE ALSO** QS, QI		
RESPONSE TO QR IS nnnnnnn (n = 0 or 1)				

Description

Request for the functions enabled or disabled by the QSA through QSH commands. The reply is eight digits, indicating which signal functions are active, as shown below:

Function	Options		Value
A Not Used		(0)	0
B Move Complete	NO/YES	(n = 0,1)	n
C Not Used		(0)	0
D Limit Encountered	NO/YES	(n = 0,1)	n
E Ready to Respond*		(0)	0
F Not Used		(0)	0
G Command Buffer Full	NO/YES	(n = 0,1)	n
H Motor Stall	NO/YES	(n = 0,1)	n

QS Set-Up	Interrupt on Signal Commands			VALID Software Version E
SYNTAX QSBxn	**UNITS** x = function n = on/off	**RANGE** x = A, B, D, E, F, G, H n = 0 or 1	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** None		

Description

The QS commands allow the PC21 to send an interrupt to the host computer when attention is required. Once enabled, QS commands reside in the PC21's background during normal operation. When the condition that prompts the interrupt is met, the interrupt is generated. The interrupt is determined by the host computer via the QI command. The interrupt will be generated each time the condition occurs, until the function is disabled. Refer to *Chapter 4, Application Design*, for information on setting hardware interrupts.

Bit	Function
A	Not Used
B	Interrupt on Move Complete
C	Not Used
D	Interrupt on Limit Encountered
E	Interrupt on Ready to Respond
F	Not Used
G	Interrupt on Command Buffer Full
H	Interrupt on Motor Stall

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QSB Set-Up	Interrupt on Move Complete			VALID Software Version E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
QSBn	n = function	0 or 1	0	Buffered
EXECUTION TIME <10 ms		**SEE ALSO** None		

Description

- QSBØ Do not send interrupt on move complete
- QSB1 Interrupt signal on move complete

Entering QSB1 causes the indexer to transmit an interrupt to the host computer whenever a preset move has finished, been stopped (S) or killed (K) commands.

In continuous mode (MC), the indexer will generate an interrupt when motion has been stopped or killed.

QSBØ causes the indexer to no longer generate an interrupt if the above conditions are present.

Example

Command	Description
QSB1	An interrupt will be transmitted to the host on completion of a move.

QSD Set-Up	Interrupt Signal on Limit Encountered			VALID Software Version E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
QSDn	n = function	0 or 1	0	Buffered
EXECUTION TIME <10 ms		**SEE ALSO**		

Description

- QSDØ Do not interrupt signal upon reaching a limit
- QSD1 Interrupt signal upon reaching a limit

Example

Command	Description
QSD1	An interrupt will be generated if a limit has been hit. This refers only to the CW and CCW end-of-travel limits

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QSE Set-Up	Interrupt on Ready to Respond			VALID Software Version E
SYNTAX QSEn	**UNITS** n = function	**RANGE** 0 or 1	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** None		

Description

- **QSEØ** Do not interrupt when indexer is ready to respond. Causes the indexer to no longer generate an interrupt on a response
- **QSE1** Interrupt when indexer is ready to respond

Example

Command	Description
QSE1	An interrupt will be generated an instant before the indexer is ready to transmit a response to the host.

The commands **B**, **CR**, **FR**, **P**, **PB**, **PR**, **QI**, **QR**, **R**, **RA**, **RB**, **RC**, **RV**, **SR**, **TS**, **UR**, **W1**, **W2**, **W3**, and **X1** will all generate an interrupt

QSG Set-Up	Interrupt on Command Buffer Full			VALID Software Version E
SYNTAX QSGn	**UNITS** n = function	**RANGE** 0 or 1	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** None		

Description

- **QSGØ** Do not interrupt on buffer full (less than 32 bytes free)
- **QSG1** Interrupt on buffer full

Example

Command	Description
QSG1	When the command buffer has less than 32 bytes available an interrupt will be generated. (One character = 1 byte.)

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QSH Set-Up	Interrupt on Motor Stall			VALID Software Version E
SYNTAX QSHn	**UNITS** n = function	**RANGE** 0 or 1	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** DW		

Description

- **QSHØ** Do not interrupt on stall
- **QSH1** Interrupt on stall detect

Entering **QSH1** causes the indexer to transmit an interrupt signal to the host computer whenever a stall is detected. how the interrupt is handled is dependent upon the host computer and your own program within the host.

A stall is detected when the indexer detects the encoder count fall behind the motor step count by one full tooth on the motor (250 n-steps for a 25,000 step motor). You must specify a backlash with the define backlash (**DW**) command, before stall detection is enabled.

Entering **QSHØ** causes no interrupt to be transmitted by the indexer when a stall is detected.

Example

Command	Description
QSH1	An interrupt will be transmitted to the host when a stall occurs.

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R Status	Report Indexer Status			VALID Software Version E
SYNTAX R	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Immediate
EXECUTION TIME <5 ms		**SEE ALSO** RA, RB, RC		
RESPONSE TO R IS *x (x = R, B, S, or C)				

Description

You can use the Request Indexer Status (R) command to review the status of the indexer. Possible responses are:

Response	Definition
*R	Ready
*S	Ready, Attention Needed
*B	Busy
*C	Busy, Attention Needed

When the indexer is prepared to execute another command, the following conditions delay further execution:

- Performing a preset move
- Accelerating/decelerating during a continuous move
- A time delay is in progress (T command)
- Paused (PS)
- Waiting on a Trigger (TR)
- Going Home
- Executing a loop

The following conditions cause error responses.

- A feedback error condition exits.
- Go home failed
- Limit has been encountered

You can obtain details on the error condition with the **RA**, **RB**, or **RC** commands. *Compumotor does not recommended that you use this command in tight poling loops. It may overload the microprocessor. Time delays can alleviate this problem.*

Do not use this command to determine if a move is complete. Use it after a move is complete to determine if other errors or faults exist. Use a buffered status request command or a programmable output to verify move completion.

Example

Command	Response
R	*R The indexer is ready to accept a command—no error conditions require attention

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RA Status	Report Limit Switch Status			VALID Software Version E
SYNTAX RA	UNITS None	RANGE None	DEFAULT None	ATTRIBUTES Immediate
EXECUTION TIME <10 ms		SEE ALSO R, RB, RC		
RESPONSE TO RA IS *x (x = @, A, B, C, D, E, F, G, H, I, J, K, L, M, N, or O)				

Description

The RA command should not be used in new applications. In some instances, this command reports erroneous limit conditions. Since some PC21 users may have this command in existing programs, Compumotor chose not to make changes that might cause problems for these users.

RB Status	Report Pause and Trigger Status			VALID Software Version E
SYNTAX RB	UNITS None	RANGE None	DEFAULT None	ATTRIBUTES Immediate
EXECUTION TIME <10 ms		SEE ALSO L, PS, R, RA, ST, TR, RC		
RESPONSE TO RB IS *x (x = @, A, B, C, D, E, F, G, H, I, J, K, L, M, N, or O)				

Description

The RB command responds with the status of the command buffer if it is presently executing a Loop (L) or a Shutdown (ST) command. It will also indicate if a Pause (PS) command is being executed or if a Trigger (TR) condition is presently being waited on.

The controller responds with one of 16 different characters, each of which represents one of the conditions listed below.

Response Character	Buffer Pause Active	Immediate Pause Active	Trigger Active
*@	NO	NO	NO
*B	YES	NO	NO
*D	NO	YES	NO
*F	YES	YES	NO
*H	NO	NO	YES
*L	NO	YES	YES

This command is useful to determine the present status of the execution buffer. Especially when execution is held up or the response is unclear.

Example

Command	Response
RB	*A (The indexer is currently executing a loop)

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RC Status	Report Closed Loop Status			VALID Software Version E
SYNTAX RC	UNITS None	RANGE None	DEFAULT None	ATTRIBUTES Immediate
EXECUTION TIME <10 ms		SEE ALSO R, RA, RB		
RESPONSE TO RC IS *x (x = @, A)				

Description

The Report Closed Loop Status (RC) command responds with a character that represents the condition described below. ***This function is only operable when you use encoder feedback.***

STALL

In this condition, the controller detects either a deviation between motor and encoder position that is larger than one pole of the motor while running, or a deviation larger than one pole of the motor plus the backlash parameter following a direction change.

Examples

Command	Response
RC	*A (the indexer detected a stall)

RM Set-Up	Rate Multiplier in Immediate Velocity Streaming Mode			VALID Software Version E
SYNTAX RMxxxx	UNITS xxxx = rps (hexadecimal)	RANGE 0000 - FFFF	DEFAULT 0000	ATTRIBUTES Immediate
EXECUTION TIME <5 ms		SEE ALSO Q1, QØ		

Description

The RM command, followed by 4 hexadecimal digits, represents an immediate velocity setting. The variable nnnn is a hex value (in ASCII format) ranging from 0000 - FFFF that corresponds to 15.259 Hz - 500 KHz in increments of 15.259 Hz. In low velocity range, 1.5259Hz to 50Khz, in increments of 1.5259Hz the velocity change is almost instant. There is no acceleration/ deceleration ramp between velocities. A limit switch-closure stops movement while the axis is in Velocity Profiling mode, but does not cause the PC21 to exit Immediate Velocity Streaming mode. Hex values 0000 - 7FFD result in CCW rotation. Hex values 8000 to FFFD result in CW rotation. Hex values 7FFE - 7FFF and FFFE- FFFF are special values that you can use to set the POB.

Example

Command	Description
Q1	Enter Velocity Streaming mode
RMØ666	Accelerate to 1 rps in the CCW direction
RMØCCC	Accelerate to 2 rps
RM1332	Accelerate to 3 rps
RM1998	Accelerate to 4 rps
RM1332	Decelerate to 3 rps
RMØCCC	Decelerate to 2 rps
RMØ666	Decelerate to 1 rps
RMØØØØ	Decelerate to 0 rps
QØ	Exit Velocity Streaming mode

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RV Status	Report Software Part Number			VALID Software Version
SYNTAX RV	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO**		
RESPONSE TO RV IS *92-nnnnnn-nn<xn> (n = 0 - 9, x = A - Z)				

Description

The RV command responds with the software part number and its revision level. The response is shown below:

```
*92-nnnnnn-nn<xn>
part number rev. level
```

The part number identifies which product the software is written for, as well as any special features that the software may include. The revision level identifies when the software was written. You may want to record this information for future use. This type of information is useful when you consult Compumotor's Applications Engineering Dept.

Example

Command	Description
RV	Response = *92-008754-01E

The product is identified by 92-008754. The revision level is identified by 01E. Older revisions, D and below, do not have this command.

S Motion	Stop			VALID Software Version E
SYNTAX S	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Immediate
EXECUTION TIME <5 ms		**SEE ALSO** K, SSH, A, SSD		

Description

This command decelerates the motor to a stop using the last defined Acceleration (A) command. This command normally clears any remaining commands in the command buffer, unless prevented from doing so by the Save Command Buffer On Stop (SSH1) command. When the SSH1 command is executed, the S command stops only the current move and goes on to the next command in the buffer.

Example

Command	Description
MC	Sets move in continuous mode
A1	Sets acceleration to 1 rps^2
V1Ø	Sets velocity to 10 rps
G	Executes the move (Go)
S	Stops motor—0 rps (decel rate of 1 rps^2)

The S command cannot be put into the buffer since it is an immediate command. This means that you cannot use this command in a sequence. When the indexer receives the S command, it stops motion.

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SR Status	Report Configuration Status			VALID Software Version E
SYNTAX SR	UNITS None	RANGE None	DEFAULT None	ATTRIBUTES Buffered
EXECUTION TIME <10 ms		SEE ALSO SS		
RESPONSE TO SR IS nnnnnnnn (b = 0,1)				

Description

The SR command is a special status request command. It provides information on the status of up to 5 soft switches that you use to turn configuration options on and off. You can set these options with the SS command. The table below lists the response functions that you can receive status data on.

Code	Function	On/Off Status
A	Not Used	N/A
B	Not Used	N/A
C	Load and Go Mode	Ø = Disabled 1 = Enabled
D	Alternate Mode Stop	Ø = Cycle End 1 = Immediate
E	Not Used	N/A
F	Velocity Range	Ø = Normal 1 = Low
G	Command Buffer on Limit	Ø = Purge 1 = Save
H	Command Buffer on Stop	Ø = Purge 1 = Save

Example

Command	Response
SR	ØØØØØ1ØØ (the indexer is in the low-velocity range)

SSC Set-Up	Set Load and Go Mode			VALID Software Version E
SYNTAX SSCn	UNITS n = mode	RANGE 0 or 1	DEFAULT 0	ATTRIBUTES Buffered
EXECUTION TIME <10 ms		SEE ALSO G, SR		

Description

- SSCØ Load and Go mode disabled
- SSC1 Load and Go mode enabled

If you issue a SSC1, a Go (G) command will not execute until a Load and Go (I or IC) command has been executed.

Example

Command	Description
SSC1	Enables the Load and Go mode

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SSD Set-Up	Mode Alternate Stop Mode			VALID Software Version E
SYNTAX SSDn	**UNITS** n = mode	**RANGE** 0 or 1	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** MA, SR		

Description

This command determines the method of stopping when in the **MA** move mode.

- **SSD1** Stop immediately
- **SSDØ** Stop at the end of the current loop

Example

Command	Description
SSDØ	Stops at end of loops in mode alternate

SSF Set-Up	Normal/Low Velocity Range			VALID Software Version E
SYNTAX SSFn	**UNITS** n = range	**RANGE** 0.001 - 20.000 0.0002 - 2.0000	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** IM, SN, SS, SSJ, SR, V		

Description

This command sets the velocity range for the Velocity (**V**) and Rate Multiplier (**RM**) commands. The normal range (**SSFØ**) for a 25,000-step/rev motor is .0001 - 20.000 rps. The low range (**SSF1**) for a 25,000-step/rev motor is .0002 - 2.0000 rps.

Example

Command	Description
SSF1	Set low velocity range

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SSG Set-Up	Clear/Save the Command Buffer on Limit			VALID Software Version E
SYNTAX SSGn	**UNITS** n = limit	**RANGE** 0 or 1	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** LD, SR		

Description

If you enter SSGØand an end-of-travel limit is reached, all motion will cease until the problem causing the over-travel is rectified. All commands pending execution in the command buffer are cleared when a limit is reached. If SSG1 is specified and a limit is activated, the current move is aborted, but the remaining commands in the buffer continue to be executed.

Example

Command	Description
SSG1	Save buffer on limit
A5	Set acceleration to 5 rps^2
V5	Set velocity to 5 rps
D25ØØØ	Set distance to 25,000 steps
G	Executes the move (Go)
O1	Turn on programmable output

SSH Set-Up	Clear/Save the Command Buffer on Stop			VALID Software Version E
SYNTAX SSHn	**UNITS** n = function	**RANGE** 0 or 1	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** S, SR		

Description

- SSHØ Clears command buffer on stop
- SSH1 Saves command buffer on stop

In Normal Operation (SSHØ) the Stop (S) command will cause any commands in the command buffer to be cleared. If you select the Save Command Buffer On Stop (SSH1) command, a Stop (S) command will only stop a move in progress. It will not stop any commands that remain in the buffer.

Example

Command	Description
SSHØ	Clears command buffer on stop
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D25ØØØ	Sets distance to 25,000 steps
L5Ø	Loop 50 Times
G	Executes the move (Go)
T.5	Pauses the motor 500 ms
N	Ends Loop
S	Stops motion

When you issue the S command, the indexer clears the buffer and stops the move.

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ST Programming	Shutdown			VALID Software Version E
SYNTAX STn	**UNITS** n = function	**RANGE** 0 or 1	**DEFAULT** 1	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** None		

Description

The Shutdown (**ST0**) command rapidly decreases the motor current to zero. The system ignores move commands that you issue after the **ST0** command. Torque on the motor is not maintained after you issue the **ST0** command.

The **ST1** command rapidly increases the motor current to normal. Once you restore the current, you can execute moves.

This command is useful for reducing motor heating and allows you to manually position the load. The motor position counter is set to zero when you re-energize the motor using the **ST1** command.

Example

Command	Description
ST0	Shuts off current to the motor

SV Programming	Shutdown and Position Maintenance			VALID Software Version
SYNTAX SVn	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered Not Saved
EXECUTION TIME		**SEE ALSO** None		

Description

These buffered commands provide a way of simultaneously changing the state of motor shutdown and position maintenance functions.

SV0 Causes the Position Maintenance function to be turned off, but does not turn off motor power. It is identical in function to the **FSC0** command.

SV1 Causes the position maintenance function to be turned off and the motor to be shut down simultaneously.

SV2 Causes the position maintenance to be turned on and turns the motor power back on if it was turned off due to a **SV1** or **SV0** command. The encoder position will be read and this newest position will be maintained.

SV3 Causes the position maintenance to be turned on and turns the motor power on if it was turned off. The encoder position will not be read by this command. The position maintenance will be the last position held before the position maintenance function was disabled.

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T Programming	Time Delay			VALID Software Version E
SYNTAX Tn	**UNITS** n = seconds	**RANGE** 0.01 to 999.99	**DEFAULT** None	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** None		

Description

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

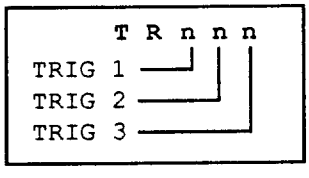
Example

Command	Description
MN	Sets mode to normal
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D25ØØØ	Sets distance to 25,000 steps
T1Ø	Pauses motor movement 10 seconds
G	Executes the move (Go)
T5	Pauses the motor for 5 seconds after the move ends
G	Executes the move (Go)

TR Programming	Wait for Trigger			VALID Software Version E
SYNTAX TRnnn	**UNITS** n = function	**RANGE** 0 = Closed 1 = Open X = Don't Care	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** TS		

Description

Triggers are used to synchronize indexer operations with external events. They can be used to implement a handshaking function with other devices. There are three triggers (see below).



When TR command is used in a buffer, the indexer will get to this command and wait until the input pattern is matched before going on to the next command.

Example

Command	Description
TR1ØX	Wait for input #1 to be opened and input #2 to be grounded before going on to the next command. Inputs #3 is ignored.
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D25ØØØ	Sets distance to 25,000 steps
G	Executes the move (Go)

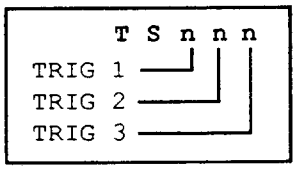
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TS Status	Report Trigger Input Status			VALID Software Version E
SYNTAX TS	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Immediate
EXECUTION TIME <10 ms		**SEE ALSO** O, SSI, TS		
RESPONSE TO TS IS nnn (n = 0, 1)				

Description

The Trigger Status command shows trigger input status.

- n= 1 (Input is not grounded)
- n = 0 (Input is grounded)



Since the TS command is immediate, the host controller can determine the status of the trigger inputs at any time, even during execution of other commands. You can use this command to make sure that your trigger pattern is met, when you have issued the Trigger (TR) command.

Example

Command	Response
TS	1Ø1 (Trigger bits 1 & 3 are open—trigger bit 2 is grounded)

U Programming	Pause and Wait for Continue			VALID Software Version E
SYNTAX U	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Immediate
EXECUTION TIME <10 ms		**SEE ALSO** C, PS		

Description

This command causes the indexer to complete the move in progress, then wait until it receives a Continue (C) to resume processing. Since the buffer is saved, the indexer continues to run the program (at the point where it was interrupted). The indexer continues processing when it receives the C command. This command is typically used to stop a machine while it is unattended.

Example

Command	Description
MN	Sets move to Normal mode
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
LØ	Loops indefinitely
D256ØØ	Sets distance to 25,600 steps
G	Executes the move (Go)
T1Ø	Waits 10 seconds after the move
N	Ends loop
U	Pauses until the indexer receives the **C** command

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UR Status	Report Scale Factor Status			VALID Software Version E
SYNTAX UR	UNITS None	RANGE None	DEFAULT None	ATTRIBUTES Immediate
EXECUTION TIME <10 ms		SEE ALSO US		
RESPONSE TO UR IS nnn (n = 001 to 255)				

Description

Reports the scale factor set using US command. The actual number of steps sent to the motor drive during a Preset move will be, the current distance parameter setting multiplied by this scale factor.

Example

Command	Description
MN	Sets move to continuous
A1Ø	Sets acceleration to 10 rps^2
V5	Sets velocity to 5 rps
US2Ø	Sets scale factor to 20
UR	Requests scale factor. The response is Ø2Ø Verify that scale factor is set to 20
D2ØØØØ	Sets distance to 20,000 steps
G	Executes the move (Go)

Axis #1 sends out 20,000 • 20 = 400,000 steps.

US Set-Up	Set Position Scale Factor			VALID Software Version E
SYNTAX USnnn	UNITS n = steps	RANGE 1 - 255	DEFAULT 1	ATTRIBUTES Buffered
EXECUTION TIME <10 ms		SEE ALSO UR		

Description

Set distance scale factor. Where *n* = 1 to 255. Any distance value set with the D command after setting the US command, will be multiplied by the value set by US command. This value will remain valid until the indexer is reset or a new US value is defined. Any US command not in the range 001 - 225 will default to 1.

If 200 steps will yield 0.001 inches of rotary movement, you can issue a US2ØØ command and program distance in 0.001-inch increments.

Example

Command	Description
MN	Sets move to continuous
A1Ø	Sets acceleration to 10 rps^2
V5	Sets velocity to 5 rps
US2ØØ	Sets scale factor to 200
D1ØØØØ	Sets distance to 10,000 steps
G	Executes the move (Go)

The motor moves 2,000,000 steps.

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V Motion	Set Velocity			VALID Software Version E
SYNTAX Vn	**UNITS** n = rps	**RANGE** 0.001 to 20.000	**DEFAULT** 1	**ATTRIBUTES** Buffered
EXECUTION TIME <10 ms		**SEE ALSO** A, D, G, MR, SSF		

Description

The Velocity (V) command defines the maximum speed at which the motor will run when given the Go (G) command. The actual speed of the motor or output frequency of the indexer will vary, depending on the motor drive resolution (MR) and the velocity range (SSF). The following formula is used to determine the output frequency of the indexer:

Frequency = (n) • (Motor Resolution) in *steps/rev.*

The top speed of the motor drive is limited by the motor type. Entering a velocity higher than the top speed of a motor drive system will cause the motor to stall and may cause the drive to fault.

Example

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

In preset mode, Mode Normal (MN) the maximum velocity may also be limited when the resulting move profile is triangular. In Mode Continuous (MC), a Go (G) command is completed—the indexer moves on to the next command in the buffer once the specified velocity is reached.

VS Motion	Set Start/Stop Velocity			VALID Software Version E
SYNTAX VSn	**UNITS** n = rps	**RANGE** 0.001 to 20.000	**DEFAULT** 0	**ATTRIBUTES** Buffered
EXECUTION TIME <2 ms		**SEE ALSO** A, D, G, MR, SSF		

Description

The Set Start/Stop Velocity (VS) command sets the velocity at which all subsequent moves start from before ramping to the specific acceleration rate defined for the move (at the completion of the move, the axis will come to a stop at the velocity rate specified with the VS command. *This command is only in effect if it is issued prior to a Velocity command (V). The velocity input is altered by this command.*

Example

Command	Description
VS1	Sets start/stop velocity at 1 rps.

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W Status	**Report Immediate Position**			**VALID** Software Version E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
Wn	n = form of response	1 = binary 3 = hex ASCII	1	Immediate
EXECUTION TIME <10 ms		**SEE ALSO** PR		
RESPONSE TO W3 **IS** *(4 ASCII characters)				

Description

The Immediate Position Request (W) command provides a position report of a specified axis while the motor is moving. The report indicates position relative to the start of the current move or the completion of the last move.

If you specify the variable **n** as 1, the response format will be a 4 byte binary number (with no carriage return). The four byte binary number will be an unsigned magnitude of the current move or the last move completed. This command only works while in motor step mode. If you specify the variable **n** as 3, the response format will be an asterisk followed by eight hex ASCII characters in two's complement signed notation (with a carriage return). This command works in either motor step mode (FSBØ) or encoder step mode (FSB1).

Interpreting Binary Position Reports

This form of position report (bbbb), consists of four bytes. The four bytes must be linked together (concatenated) to form a 32-bit binary number. A typical PC21 communications algorithm expects to handle characters rather than binary numbers and may have problems with this kind of response. Assume that a response equivalent to the ASCII characters ^@, #, 0, and / (^@ refers to the CTRL key and @, an unprintable character) is given. The binary code for this response should be:

^@	#	Ø	/
ØØØØØØØØ	ØØ1ØØØ11	ØØ11ØØØØ	ØØ1Ø1111

This code has to be interpreted by the computer. The four characters must be converted to their ASCII code numbers and multiplied by the appropriate power of 256. The first character received is the most significant byte. Refer to Table 5-1 for a conversion technique for ^@ # Ø /. The formula used for the binary conversion is:

ASCII Value • Character Multiplier = Character Value

Response	ASCII HEX Value	ASCII Decimal Value	Character Multiplier	Conversion (steps)
^@	0	0	16,777,216 (256^3)	0
#	23	35	65,536 (256^2)	2,293,760
0	30	48	256 (256^1)	12,288
/	2F	47	1 (256^0)	47
			Position Total:	2,306,095

Table 5-1. Binary Position Conversion

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Interpreting Hexadecimal Position Reports

This form of position report (*hhhhhhhh) is generated by the W3 command. It consists of an asterisk followed by eight hexadecimal characters; 0 - 9 and A - F. The position report is followed by a carriage return. The decimal value of the hexadecimal expression can be determined using the technique demonstrated in Table 5-2. The response is in two's complement notation reflecting direction. Negative numbers imply CCW motion. Both commands are designed for computer-controlled situations where the computer can translate the hexadecimal.

Positive W3 Response Interpretation

The system provides responses in the following format:

MSD LSD
*hhhhhhhh

The first digit is the most significant digit (MSD). The last digit is the least significant digit (LSD). Refer to Table 5-2.

Digit	Digit Multiplier
h (MSD)	$h \cdot 16^7 = h \cdot 268,435,456 =$
h	$h \cdot 16^6 = h \cdot 16,777,216 =$
h	$h \cdot 16^5 = h \cdot 1,048,576 =$
h	$h \cdot 16^4 = h \cdot 65,536 =$
h	$h \cdot 16^3 = h \cdot 4,096 =$
h	$h \cdot 16^2 = h \cdot 256 =$
h	$h \cdot 16^1 = h \cdot 16 =$
h (LSD)	$h \cdot 16^0 = h \cdot 1 =$

Table 5-2. Value of Decimal Responses

The decimal (h) may have one of the values shown in Table 5-3.

Decimal Value	Hexadecimal Value	Decimal Value	Hexadecimal Value
0	0	8	8
1	1	9	9
2	2	10	A
3	3	11	B
4	4	12	C
5	5	13	D
6	6	14	E
7	7	15	F

Table 5-3. Value of Decimal Responses

Using Tables 5-2 - 5-3, review the decimal value that would be calculated if the following hexadecimal response were given:

*ØØØ433AE

Hexadecimal	Character Multiplier	Conversion (steps)
Ø	0 • 268,435,456	0
Ø	0 • 16,777,216	0
Ø	0 • 1,048,576	0
4	4 • 65,536	262,288
3	3 • 4,096	12,288
3	3 • 256	768
A (= 10)	10 • 16	160
E (= 14)	14 • 1	14
	Total Steps:	275,374

Table 5-4. Sample Hexadecimal Response Conversion

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Negative W3 Response Interpretation

If the first digit of the response is an **8**, **9**, **A**, **B**, **C**, **D**, **E**, or **F**, the response represents a *two's complement* negative number. This implies the direction of the last move was CCW. Any response other than ***Fhhhhhhh**, ***Ehhhhhhh**, ***Dhhhhhhh**, ***Chhhhhhh**, ***Bhhhhhhh**, ***Ahhhhhhh**, ***9hhhhhhh** , ***8hhhhhhh** should be interpreted per Figure 5-2. There are several ways to convert an 8-digit two's complement hexadecimal number to decimal.

The Binary Approach

1. Convert the hexadecimal response to binary form.
2. Complement the binary number.
3. Add 1 to the binary result.
4. Convert the binary result to decimal value with a minus sign placed ahead of the decimal value.

EXAMPLE Response to W3 = EFFE271Ø

STEP 1

E	F	F	E	2	7	1	Ø
1110	1111	1111	1110	ØØ1Ø	Ø111	ØØØ1	ØØØØ

STEP 2

ØØØ1	ØØØØ	ØØØØ	ØØØ1	11Ø1	1ØØØ	1110	1111

STEP 3

ØØØ1	ØØØØ	ØØØØ	ØØØ1	11Ø1	1ØØØ	1111	ØØØØ

STEP 4

1	Ø	Ø	1	D	8	F	Ø

1ØØ1D8FØ Hexadecimal = 26,8556,528 decimal

The result is 268,556,528 steps CCW.

The Computer Approach

1. Convert the hexadecimal response to decimal.
2. Subtract 16^8 (232 or 4,294,967,296) from the decimal number in step #1.

EXAMPLE Response to W3 = *EFFE271Ø

STEP 1

Hexadecimal	Character Multiplier	Conversion (steps)
E (=14)	14 • 268,435,456	3,758,096,384
F (=15)	15 • 16,777,216	251,658,240
F (=15)	15 • 1,048,576	15,728,640
E (=14)	14 • 65,536	917,504
2	2 • 4,096	8,192
7	7 • 256	1,792
1	1 • 16	16
Ø	Ø • 1	Ø
	Total steps:	4,026,410,768

STEP 2

```
 4,026,410,768
-4,294,967,296
  -268,556,528
```

The result is 268,556,528 steps in the CCW direction.

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XØ Status	Reset Cumulative Position Counter			VALID Software Version
SYNTAX XØ	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered Never Saved
EXECUTION TIME		**SEE ALSO** X1, X1B		

Description

The **XØ** command resets the cumulative position counter to zero. It only affects the **X1** and **X1B** commands. It does not affect the **PR**, **P**, **PB**, **W1**, or **W3** commands.

Example

Command	Description
MN	Set to Mode Normal
A1Ø	Set acceleration to 10 rps^2
V10	Set velocity to 10 rps
D25ØØØ	Set distance to 25,000 steps
G	Execute the move (Go)
X1	Report cumulative position +00025000
XØ	Set cumulative position counter to zero
X1	Report cumulative position +00000000

X1 Status	Cumulative Position Report			VALID Software Version
SYNTAX X1	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered Never Saved
EXECUTION TIME		**SEE ALSO** P, PR, FS, W1, W3, X1B		
RESPONSE TO X1 **IS** ±nnnnnnnn = 0 - 99999999 steps				

Description

The **X1** command provides a position report as a decimal value. The value represents a cumulative position in steps. The cumulative position is the count from power up or from the position at which a **XØ** command was given. The report will be in either motor steps or encoder steps depending on which mode was selected with the **FSB** command. This command will not provide current information when the motor is moving in the continuous mode. The cumulative position counter will not be reset by the PZ command.

The only way to reset this counter is to reset the PC21 or to issue an **XØ** command .

Example

Command	Response
X1	+00319842 steps

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X1B Status	Cumulative Position Report (Binary)			VALID Software Version
SYNTAX X1B	**UNITS** None	**RANGE** None	**DEFAULT** None	**ATTRIBUTES** Buffered Never Saved
EXECUTION TIME		**SEE ALSO** W1, PB, P, X1, W1, W3		
RESPONSE TO X1B **IS** 4 digit ASCII characters or 0-2,147,483,647				

Description

The **X1B** command provides cumulative position (cumulative count from power-up or from the position at which an **XØ** command is given). The report is in the form of 4 characters. The first ASCII character received back from the PC21 is the most significant byte of the four byte number. ***If the most significant bit of the most significant byte is set, the response if negative. If the most significant bit it cleared the response is positive (80 HEX-FFHEX are negative, ØØ-7F are positive). This is not 2's complement notation.*** As you receive the characters you will need to convert them to a decimal number. This is done by following the steps below.

1. Compare the ASCII code for the first character to HEX 8Ø (check to see if the most significant bit is set). If it is greater than or equal to HEX 8Ø, subtract HEX 8Ø, and make the sign of your result negative.
2. Convert all four ASCII characters to decimal numbers.
3. Multiply the first character by 16,777,216
   Multiply the second character by 65,536
   Multiply the third character by 256
   Multiply the fourth character by 1
4. Add all the decimal results in step 3 together

Example

ASCII characters Received ¢ J ! Q
ASCII HEX equivalent 9B 4A 21 51

STEP 1

9B > 8Ø
Result will be negative
Subtract 80 from 9B = 1B
New string = 1B 4A 21 51

STEP 2

HEX 1B = decimal 27
HEX 4A = decimal 74
HEX 21 = decimal 33
HEX 51 = decimal 81

STEP 3

27 x 16,777,216 = 452984832
74 x 65,536 = 4849664
33 x 256 = 8448
81 x 1 = 81

STEP 4

452984832 + 4849664 + 8448 + 81 = 457843025

Thus the last move was 457843025 steps CCW.

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Y Programming	Stop Loop			VALID Software Version E
SYNTAX	**UNITS**	**RANGE**	**DEFAULT**	**ATTRIBUTES**
Y	None	None	None	Immediate
EXECUTION TIME <10 ms		**SEE ALSO** L, N		

Description

The Stop Loop (Y) command takes you out of inner loop when the loop completes its current pass. This command does not halt processing of the commands in the loop until the indexer processes reach the last command of the current loop. At that time, the indexer executes the command that follows the End Loop (N) command.

Example

Command	Description
L	Loops indefinitely
A5	Sets acceleration to 5 rps^2
V5	Sets velocity to 5 rps
D25ØØØ	Sets distance to 25,000 steps
T2	Waits 2 seconds
G	Executes the move (Go)
N	Ends loop
Y	Stops loop

The loop requires the motor to move 25,000 steps and then wait for two seconds. The loop terminates at the end of the loop cycle it is executing when it receives the Y command.

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Chapter 6. HARDWARE REFERENCE

Chapter Objectives

The information in this chapter will enable you to:

- Use this chapter as a quick reference tool for proper I/O wiring, jumper settings and system specifications

Environmental Specifications

Operating Temperature: 32 to 122°F (0 to 50°C)
Storage Temperature: -22 to 185°F (-30 to 85°C)
Humidity: O to 90% non-condensing

Performance

Stepping Accuracy: ±0 steps from Preset total
Velocity Accuracy: ±0.02% of max rate (±0.001 rps)
Velocity Repeatability: ±0.02% of max rate

Velocity Range

25,000 steps/rev motor: 0.01 to 20.00 rps
5,000 step/rev motor: 0.01 to 100.00 rps

Acceleration Range

25,000 and 5,000 step/rev motor: 0.01 to 999.99

Position Range

All resolutions: 0 to 99,999,999 steps

I/O Specifications

Interface Inputs

The PC21 provides an IBM PC interface in accordance with IBM I/O Channel signal specifications and definitions. The PC21 uses the following I/O Channel Signal Lines:

- +A0
- +A2 through +A9
- +D0 through +D7
- +AEN
- RESET
- -IOR
- -IOW
- +IRQ3
- +IRQ4
- +5V
- GND

CW and CCW Limit Switch OPTO Inputs

+3VDC minimum at 10mA source inputs
Signal Duration: ≥ 10ms

CW and CCW Limit

The CW & CCW limits are direct inputs.

Type: Active high
Signal high: +4.5VDC min
Signal low: 0.5VDC max, -2.0mA sink
Signal duration: > 10 ms

Home Enable Input

Type: Active high
Signal high: +4.5VDC min
Signal low: 0.5VDC max, -2.0mA sink
Signal duration: > 10 ms

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Trigger

The PC21's trigger inputs can be active high or low (user selectable).

Signal high: +3.5VDC min
Signal low: 0.5VDC max, -2.0mA sink
Signal duration: > 10 ms

Encoder Inputs (Channels A, B, and Z)

Type: Active high
Signal high: +4.5VDC min
Signal low: 0.5VDC max, -2.0mA sink
Signal duration: > 1.5 ms
User must provide: +5 V +-5% at 250 mA min (to provide +5VDC power source for optical encoders)

Outputs (General)

All PC21 outputs share the following characteristics.

Open Collector: 3 to 40VDC, -300mA sink
CW/CCW Step: 5ms nominal step outputs, (200,400 step/rev), 1µs nominal (21600/50000 steps/rev) 1

Step, Direction, and Shutdown Outputs

The PC21's step, direction, and Shutdown outputs are differential outputs.

Type: Active high
Signal high: +3.5VDC min, +60 mA source
Signal low: +0.75VDC max, -60 mA sink
Signal duration: 15µs nominal (200,400 steps/rev), 1µs nominal (21600/50000 steps/rev)

Programmable Output Bit

Signal high: +2.36VDC min, +0.4mA source
Signal low: +0.8VDC max, -4.0mA sink

Motor Drive Connections

J2 Pin #	Function
1	Step Output
2	Direction Output
3	CW Step Output
4	CCW Step Output
5	Shield
6	Step Output (RTN or Ground)
7	Direction Output (RTN or Ground)
8	Shutdown Output
9	Shutdown Output (RTN)

Table 6-1. Motor Drive Pinouts

Motor Resolution

(steps/rev)	part of rev*	min of arc*
50,000	2.0000 x 10-5	0.4320
36,000	2.7778 x 10-5	0.6000
25,400	3.9370 x 10-5	0.8504
25,000	4.0000 x 10-5	0.8640
21,600	4.6296 x 10-5	1.0000
4,096	2.4410 x 10-4	5.2734
1,000	1.0000 x 10-3	21.6000
400	2.5000 x 10-3	54.0000
200	5.0000 x 10-3	108.0000

Table 6-2. Motor Resolution

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Input/Output Connections

J1 Pin #	Function
1	CCW Limit Input
2	CCW Limit Direction Drive Return
3	CCW Limit Opto Return
4	NC
5	Home Enable Input
6	External +5VDC Input
7	GND (Reference or External input)
8	GND (Reference or External input)
9	CW Limit Opto Return
10	CW Limit Direct Drive Return
11	CW Limit Input
12	Trigger 3
13	Trigger 2
14	Trigger 1
15	Output 1

Table 6-3. I/O Connections

DIP Switch Settings

		Binary Value (OFF)	
Switch #	Address	Decimal	Hex
8	2	4	4
7	3	8	8
6	4	16	10
5	5	32	20
4	6	64	40
3	7	128	80
2	8	256	100
1	9	512	200

Table 6-5. Address Select Switch (S2) Values

DIP Switch Settings for S2	
Pin	Position
1	OFF
2	OFF
3	ON
4	ON
5	ON
6	ON
7	ON
8	ON

Table 6-6. DIP Switch Settings for S2

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Encoder Connector

The PC21's encoder connector is a 25-pin D connectors.

Pin #	Function
1	Quadrature Channel A+
2	Quadrature Channel A- (optional)
3	Quadrature Channel B+
4	Quadrature Channel B-(optional)
5	Channel Z+ (index)
6	Channel Z- (optional)
7	NC
8	Shield
9	NC
10	NC
11	NC
12	NC
13	NC
14	Ground
15	Ground
16	Ground
17	Ground
18	Ground
19	Ground
20	Ground
21	NC
22	NC
23	+5VDC (250ma max) User supplied
24	+5VDC (250ma max) User supplied
25	+5VDC (250ma max) User supplied

Table 6-4. PC21 Encoder Connector

Dimensional Drawings

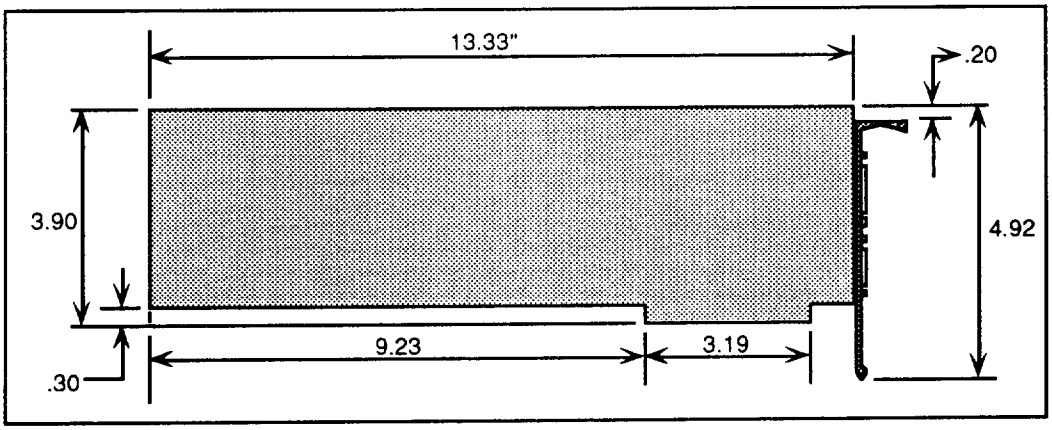


Figure 6-1. PC21 Indexer Dimension Drawing

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Chapter 7. MAINTENANCE & TROUBLESHOOTING

Chapter Objective

The information in this chapter will enable you to:

- Isolate and resolve system software problems

Maintenance

Spare Parts List

Part Number	Description
43-000739-01	15 Pin D Connector (Male)
43-000740-01	15 Pin D Connector (Female)
43-002435-01	Jumper 2 pin
51-000689-01	Jacksocket D Connector

Table 7-1. Spare Parts

Troubleshooting

This section discusses methods to identify, isolate, and resolve problems that may occur with your PC21 Indexer.

Isolating Problems

When your system does function properly (or as you expect it to operate), the first thing that you must do is identify and isolate the problem. When you accomplish this, you can effectively begin to resolve the problem.

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

Try to determine if the problem is mechanical, electrical, or software-related. Can you repeat or re-create the problem? Do not make quick rationalizations about problems. Random events may appear to be related, but they are not necessarily contributing factors to your problem. You must carefully investigate and decipher the events that occur before the subsequent system problem.

You may be experiencing more than one problem. You must solve one problem at a time. Log (document) all testing and problem isolation procedures. You may need to review and consult these notes later. This will also prevent you from duplicating your testing efforts.

Once you isolate the problem, take the necessary steps to resolve it. Refer to the solutions contained in this chapter. If your system's problem persists, contact Parker Compumotor's Applications Department (800) 358-9070.

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Problems & Solutions

Problem	Cause	Solution
No Communication	1. Wrong Address 2. Two boards have same address 3. Board not seated	1. Change jumpers or software address 2. Change address on one board (unique addresses) 3. Seat board in IBM PC
No Motion	2. Step pulse width too narrow for drive to recognize 3. Limits engaged 4. Improper Wiring: Drive Faults Motor plugged to encoder Encoder to wrong axis Shutdown line miswired	2. Issue MRnn command to set motor resolution. 3. Move load off of limit or disable limits (JU9, JU16). 4. Check wiring, be sure the self-test jumper (JU13) is not removed. Refer to Chapter 6.
No Torque	1. Improper wiring 2. Blown drive 3. Drive faulted 4. Drive Shutdown	1. Check wiring. Refer to Chapter 6. 2. Return drive for repair. 3. Remove fault condition. 4. Issue the STØ command to energize the drive.
Fault Light Comes On	1. Jumper JU13 removed 2. Hardware failure	1. Ensure the self-test jumper JU13 is not removed. 2. Return unit for repair.
Wrong Speed or Distance	1. Wrong resolution setting	1. Issue MRnn command to set motor resolution.
Missing Encoder Counts	1. Miswiring 2. Encoder slipping 3. Encoder too hot	1. Check wiring. Refer to Chapter 6. 2. Tighten encoder coupler. 3. Reduce encoder temperature with heatsink, thermal insulator, etc.
Motor Creeps	1. Wrong encoder/motor polarity 2. Encoder connected to wrong axis 3. In position maintenance mode (FSC1)	1. Swap Channel A & Channel B of encoder, or issue OSA1 command. 2. Swap encoder to indexer connection. 3. Issue FSCØ command
No POB Operation	1. Improper wiring 2. Shorted POB	1. Check wiring. Refer to Chapter 6. 2. Check for shorts on open collector POB outputs.
No Trigger Inputs	1. Improper wiring	1. Check wiring. Refer to Chapter 6.

Table 7-2. PC21 Problems and Solutions Table

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Returning the System

If you must return your PC21 Indexer system to effect repairs or upgrades, use the following steps:

STEP 1 Get the serial number and the model number of the defective unit, and a purchase order number to cover repair costs in the event the unit is determined by Parker Compumotor to be out of warranty.

STEP 2 Before you ship the drive to Parker Compumotor, have someone from your organization with a technical understanding of the PC21 Indexer system and its application include answers to the following questions:

- What is the extent of the failure/reason for return?
- How long did it operate?
- How many units are still working?
- How many units failed?
- What was happening when the unit failed (i.e., installing the unit, cycling power, starting other equipment, etc)?
- How was the product configured (in detail)?
- What, if any, cables were modified and how?
- With wnat equipment is the unit interfaced?
- What was the application?
- What was the system sizing (speed, acceleration, duty cycle, inertia, spacing, unit orientation, contaminants, etc)?
- What upgrades, if any, are required (software, user guide)?

STEP 3 Call Parker Compumotor for a Return Material Authorization (RMA) number. Returned products cannot be accepted without an RMA number. The phone number for Parker Compumotor Applications Department is (800) 358-9070.

STEP 4 Ship the unit to:

Parker Compumotor Corporation
5500 Business Park Drive
Rohnert Park, CA 94928
Attn: RMA # xxxxxxx

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APPENDICES

Command Listing

A (Acceleration)

B (Buffer Status)

C (Continue)
CG (Correction Gain)
CM (Set Correction Mode for Position Maintenance)
CR (Carriage Return)

D (Distance)
DW (Dead Band Window)

ER (Encoder Resolution)

FR (Encoder Functions Report)
FSA (Set Incremental/Absolute Mode)
FSB (Set Indexer to Motor/Encoder Mode)
FSC (Position Maintenance)
FSD (Stop on Stall)
FSE (Turn on Output on Stall)
FSF (Kill Motion on Trigger)

G (Go)
GA (Go Home Acceleration)
GH (Go Home)

H± (Set Direction)

I (Load and Go)

K (Kill)

L (Loop)

MA (Mode Alternate)
MC (Mode Continuous)
MN (Mode Normal)
MR (Select Motor Resolution)
MV (Set Maximum Correction Velocity)

N (End of Loop)

O (Output)

P (Report Incremental Position)
PB(Incremental Binary Position Report)
PR (Position Report)
PS (Pause)
PZ (Position Zero)

Q (Complete Current Command and Clear Buffer)
QØ (Exit Profiling Mode)
Q1 (Enter Immediate Velocity Profiling Mode)
Ql (Report QS Command Status)
QR (Report QS Command Function Enable Status)
QS (Interrupt on Signal Commands)
QSB (Interrupt on Move Complete)
QSDInterrupt Signal on Limit Encountered)
QSE (Interrupt on Ready to Respond)
QSG (Interrupt on Command Buffer Full)
QSH (Interrupt on Motor Stall)

R (Request Indexer Status)
RA (Limit Switch Status Report)
RB (Loop, Pause, Shutdown, Trigger Status Request)
RC (Closed Loop Status)
RM (Rate Multiplier in Immediate Velocity Streaming Mode)
RV (Revision)

S (Stop)
SR (Report Configuration Status)
SSD (Mode Alternate Stop Mode)
SSF (Normal/Low Velocity Range)
SSG (Clear/Save the Command Buffer On Limit)
SSH (Clear/Save the Command Buffer on Stop)
SV (Shutdown and Position Maintenance)
ST (Shutdown)

T (Time)
TR (Trigger)
TS (Trigger Status)

U (Pause and Wait for Continue)
UR (Report Scale Factor Status)
US (Set Position Scale Factor)

V (Velocity)
VS (Set Start/Stop Velocity)

W1 (Signed Binary Position Report)
W3 (Hexadecimal Position Report)

XØ (Reset Cumulative Position Counter)
X1(Cumulative Position Report)
X1B (Cumulative Position Count [Binary])

Y (Stop Loop)

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ASCII Table

DEC	HEX	CHAR	DEC	HEX	CHAR	DEC	HEX	CHAR	DEC	HEX	CHAR
Ø	ØØ	NUL	32	2Ø	SPACE	64	4Ø	@	96	6Ø	'
1	Ø1	SOH	33	21	!	65	41	A	97	61	a
2	Ø2	STX	34	22	"	66	42	B	98	62	b
3	Ø3	EXT	35	23	#	67	43	C	99	63	c
4	Ø4	EOT	36	24	$	68	44	D	1ØØ	64	d
5	Ø5	ENQ	37	25	%	69	45	E	1Ø1	65	e
6	Ø6	ACK	38	26	&	7Ø	46	F	1Ø2	66	f
7	Ø7	BEL	39	27	`	71	47	G	1Ø3	67	g
8	Ø8	BS	4Ø	28	(	72	48	H	1Ø4	68	h
9	Ø9	HT	41	29	)	73	49	I	1Ø5	69	i
1Ø	ØA	LF	42	2A	*	74	4A	J	1Ø6	6A	j
11	ØB	VT	43	2B	+	75	4B	K	1Ø7	6B	k
12	ØC	FF	44	2C	,	76	4C	L	1Ø8	6C	l
13	ØD	CR	45	2D	-	77	4D	M	1Ø9	6D	m
14	ØE	SO	46	2E	.	78	4E	N	11Ø	6E	n
15	ØF	S1	47	2F	/	79	4F	O	111	6F	o
16	1Ø	DLE	48	3Ø	Ø	8Ø	5Ø	P	112	7Ø	p
17	11	DC1	49	31	1	81	51	Q	113	71	q
18	12	DC2	5Ø	32	2	82	52	R	114	72	r
19	13	DC3	51	33	3	83	53	S	115	73	s
2Ø	14	DC4	52	34	4	84	54	T	116	74	t
21	15	NAK	53	35	5	85	55	U	117	75	u
22	16	SYN	54	36	6	86	56	V	118	76	v
23	17	ETB	55	37	7	87	57	W	119	77	w
24	18	CAN	56	38	8	88	58	X	12Ø	78	x
25	19	EM	57	39	9	89	59	Y	121	79	y
26	1A	SUB	58	3A	:	9Ø	5A	Z	122	7A	z
27	1B	ESC	59	3B	;	91	5B	[	123	7B	{
28	1C	FS	6Ø	3C	<	92	5C	\	124	7C	|
29	1D	GS	61	3D	=	93	5D	]	125	7D	}
3Ø	1E	RS	62	3E	>	94	5E	^	126	7E	~
31	1F	US	63	3F	?	95	5F	_	127	7F	DEL

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DEC	HEX	CHAR	DEC	HEX	CHAR	DEC	HEX	CHAR	DEC	HEX	CHAR
128	80	Ç	160	A0	á	192	C0	└	224	E0	α
129	81	ü	161	A1	í	193	C1	┴	225	E1	β
130	82	é	162	A2	ó	194	C2	┬	226	E2	Γ
131	83	â	163	A3	ú	195	C3	├	227	E3	π
132	84	ä	164	A4	ñ	196	C4	─	228	E4	Σ
133	85	à	165	A5	Ñ	197	C5	┼	229	E5	σ
134	86	å	166	A6	ª	198	C6	╞	230	E6	µ
135	87	ç	167	A7	º	199	C7	╟	231	E7	τ
136	88	ê	168	A8	¿	200	C8	╚	232	E8	Φ
137	89	ë	169	A9	⌐	201	C9	╔	233	E9	θ
138	8A	è	170	AA	¬	202	CA	╩	234	EA	Ω
139	8B	ï	171	AB	1/2	203	CB	╦	235	EB	δ
140	8C	î	172	AC	1/4	204	CC	╠	236	EC	∞
141	8D	ì	173	AD	¡	205	CD	═	237	ED	∅
142	8E	Ä	174	AE	«	206	CE	╬	238	EE	∈
143	8F	è	175	AF	»	207	CF	╧	239	EF	∩
144	90	É	176	B0	▒	208	D0	╨	240	F0	≡
145	91	æ	177	B1	▒	209	D1	╤	241	F1	±
146	92	Æ	178	B2	▓	210	D2	╥	242	F2	≥
147	93	ô	179	B3	│	211	D3	╙	243	F3	≤
148	94	î	180	B4	┤	212	D4	╘	244	F4	⌠
149	95	ò	181	B5	╡	213	D5	╒	245	F5	⌡
150	96	û	182	B6	╢	214	D6	╓	246	F6	÷
151	97	ù	183	B7	╖	215	D7	╫	247	F7	≈
152	98	ÿ	184	B8	╕	216	D8	╪	248	F8	°
153	99	Ö	185	B9	╣	217	D9	┘	249	F9	∙
154	9A	Ü	186	BA	║	218	DA	┌	250	FA	·
155	9B	¢	187	BB	╗	219	DB	▮	251	FB	√
156	9C	£	188	BC	╝	220	DC	▄	252	FC	η
157	9D	¥	189	BD	╜	221	DD	▌	253	FD	2
158	9E	Pt	190	BE	╛	222	DE	▐	254	FE	■
159	9F	ƒ	191	BF	┐	223	DF	▀	255	FF	

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Glossary

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

Absolute Programming
A positioning coordinate reference wherein all positions are specified relative to some reference, or "home" position. This is different from incremental programming, where distances are specified relative to the current position.

Acceleration
The change in velocity as a function of time. Acceleration usually refers to increasing velocity and deceleration describes decreasing velocity.

Accuracy
A measure of the difference between expected position and actual position of a motor or mechanical system. Motor accuracy is usually specified as an angle representing the maximum deviation from expected position.

Address
Multiple devices, each with a separate address or unit number, can be controlled on the same bus, . The address allows the host to communicate individually to each device.

Ambient Temperature
The temperature of the cooling medium, usually air, immediately surrounding the motor or another device.

ASCII
American Standard Code for Information Interchange. This code assigns a number to each numeral and letter of the alphabet. In this manner, information can be transmitted between machines as a series of binary numbers.

Bandwidth
The frequency range in which the magnitude of the system gain expressed in dB is greater than -3 dB.

Baud Rate
The number of bits transmitted per second. Typical rates include 300, 600,1200, 2400, 4800, 9600, 19,200. This means at 9600 baud, one character can be sent nearly every millisecond.

BCD
Binary Coded Decimal is an encoding technique used to describe the numbers 0 through 9 with four digital (on or off) signal lines. Popular in machine tool equipment, BCD interfaces are now giving way to interfaces requiring fewer wires—such as RS-232C.

Bit
Abbreviation of Binary Digit, the smallest unit of memory equal to 1 or 0.

Block Diagram
A simplified schematic representing components and signal flow through a system.

Break Frequency
Frequency(ies) at which the gain changes slope on a Bode plot. (Break frequencies correspond to the poles and zeroes of the system.)

Byte
A group of 8 bits treated as a whole, with 256 possible combinations of ones and zeros, each combination representing a unique piece of information.

Closed Loop
A broadly applied term relating to any system where the output is measured and compared to the input. The output is then adjusted to reach the desired condition. In motion control, the term is used to describe a system wherein a velocity or position (or both) transducer is used to generate correction signals by comparison to desired parameters.

Critical Damping
A system is critically damped when the response to a step change in desired velocity or position is achieved in the minimum possible time with little or no overshoot.

Crossover Frequency
The frequency at which the gain intercepts the 0 dB point on a Bode Plot. (Used in reference to the open-loop gain plot.)

Daisy-Chain
A term used to describe the linking of several RS-232C devices in sequence such that a single data stream flows through one device and on to the next. Daisy-chained devices usually are distinguished by device addresses, which serve to indicate the desired destination for data in the stream.

Damping
An indication of the rate of decay of a signal to its steady state value. Related to settling time.

Damping Ratio
Ratio of actual damping to critical damping. Less than one is an underdamped system and greater than one is an overdamped system.

Data Bits
Since the ASCII character set consists of 128 characters, computers may transmit only seven bits of data. However, most computers support an eight bit extended ASCII character set.

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

Dead Band
A range of input signals for which there is no system response.

Decibel
A logarithmic measurement of gain. If G is a system gain (ratio of output to input), then 20 log G equals gain in decibels (dB).

Detent Torque
The minimal torque present in an unenergized motor. The detent torque of a Compumotor or step motor is typically about one percent of its static energized torque.

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

Duty Cycle
For a repetitive cycle, the ratio of on time to total cycle time.
Duty Cycle = *On Time* ÷ *On Time + Off Time*

Efficiency
The ratio of power output to power input.

Encoder
A device which translates mechanical motion into electronic signals used for monitoring position or velocity.

Friction
A resistance to motion caused by surfaces rubbing together. Friction can be constant with varying speed (Coulomb friction) or proportional to speed (viscous friction).

Full Duplex
The terminal will display only received or echoed characters.

Gain
The ratio of system output signal to system input signal.

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

Hand Shaking Signals
RST: Request To Send
CTS: Clear To Send
DSR: Data Set Ready
DTR: Data Terminal Ready
IDB: Input Data Buffer
ODB: Output Data Buffer

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Holding Torque
Sometimes called static torque, it specifies the maximum external force or torque that can be applied to a stopped, energized motor without causing the rotor to rotate continuously.

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

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

IEEE-488
A digital data communications standard popular in instrumentation electronics. This parallel interface is also known as

GPIB, or General Purpose Interface Bus.

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

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

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

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

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

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

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

Microstepping
An electronic control technique that proportions the current in a step motor's windings to provide additional intermediate positions between poles. Produces smooth rotation over a wide speed range and high positional resolution.

Null Modem
A simple device or set of connectors which switches the receive and transmit lines of a three wire RS-232C connector.

Open Collector
A term used to describe a signal output that is performed with a transistor. An open collector output acts like a switch closure with one end of the switch at ground potential and the other end of the switch accessible.

Open Loop
Refers to a motion control system where no external sensors are used to provide position or velocity correction signals.

Opto-Isolated
A method of sending a signal from one piece of equipment to another without the usual requirement of common ground potentials. The signal is transmitted optically with a light source (usually a Light Emitting Diode) and a light sensor (usually a photosensitive transistor). These optical components provide electrical isolation.

Parallel
Refers to a data communication format wherein many signal lines are used to communicate more than one piece of data at the same time.

Parity
An RS-232C error detection scheme which can detect an odd number of transmission errors.

Phase Angle
The angle at which the steady state input signal to a system leads the output signal.

Phase Margin
The difference between 180 degrees and the phase angle of a system at its crossover frequency.

Pole
A frequency at which the transfer function of a system goes to infinity.

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

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

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

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

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

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

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

RMS Torque
For an intermittent duty cycle application, the RMS Torque is equal to the steady state torque which would produce the same amount of motor heating over long periods of time.

Where:
T_i = Torque during interval i
t = Time of interval i

RS-232C
A data communications standard that encodes a string of information on a single line in a time sequential format. The standard specifies the proper voltage and timing requirements so that different manufacturers' devices are compatible.

Slew
In motion control, the portion of a move made at a constant non-zero velocity.

Speed
Used to describe the linear or rotational velocity of a motor or other object in motion.

Start Bits
RS-232C character transmissions begin with a bit which signals the receiver that data is now being transmitted.

Static Torque
The maximum torque available at zero speed.

Step Angle
The angle the shaft rotates upon receipt of a single step command.

Stiffness
The ability to resist movement induced by an applied torque. Is often specified

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as a torque displacement curve, indicating the amount a motor shaft will rotate upon application of a known external force when stopped.

Stop Bits
When using RS-232C, one or two bits are added to every character to signal the end of a character.

Synchonism
A motor rotating at a speed correctly corresponding to the applied step pulse frequency is said to be in synchronism. Load torques in excess of the motor's capacity (rated torque) will cause a loss of synchronism. This condition is not damaging to a step motor.

Text/Echo (Off/On)
This setup allows received characters to be re-transmitted back to the original sending device. Echoing characters can be used to verify or "close the loop" on a transmission.

Torque
Force tending to produce rotation.

Torque-to Inertia Ratio
Defined as a motor's holding torque divided by the inertia of its rotor. The higher the ratio, the higher a motor's maximum acceleration capability will be.

Transfer Function
A mathematical means of expressing the output to input relationship of a system.

TTL
Transistor-Transistor Logic. Describes a common digital logic device family that is used in most modern digital electronics. TTL signals have two distinct states that are described with a voltage—a logical "zero" or "low" is represented by a voltage of less than 0.8 volts and a logical "one" or "high" is represented by a voltage from 2.5 to 5 volts.

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

Zero
A frequency at which the transfer function of a system goes to zero.

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