Compumotor

Model 2100 Indexer User Guide

Compumotor Division
Parker Hannifin Corporation
p/n 88-003857-03 A

Parker
Motion & Control

IMPORTANT

User Information

To ensure that the equipment described in this user guide, as well as all the equipment connected to and used with it, operates satisfactorily and safely, all applicable local and national codes that apply to installing and operating the equipment must be followed. Since codes can vary geographically and can change with time, it is the user's responsibility to identify and comply with the applicable standards and codes. WARNING: *Failure to comply with applicable codes and standards can result in damage to equipment and/or serious injury to personnel.*

Personnel who are to install and operate the equipment should study this user guide and all referenced documentation prior to installation and/or operation of the equipment.

In no event will the provider of the equipment be liable for any incidental, consequential, or special damages of any kind or nature whatsoever, including but not limited to lost profits arising from or in any way connected with the use of this user guide or the equipment.

Since Parker Compumotor constantly strives to improve all of its products, we reserve the right to change this user guide and equipment mentioned therein at anyime without notice.

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Chapter 1

INTRODUCTION

1.1 OVERVIEW

The 2100 indexer is a microprocessor based programmable pulse generator for the control of pulsed motor and drive systems. The 2100 provides precision control of pulse rates and total pulse count for motor drive amplifiers that convert pulses to motor power.

The Compumotor 2100 Indexers* (Figure 1-1) will drive any size Compumotor motor/drive set or standard 200/400-step translator and stepper motor combinations. Depending on the particular Compumotor motor/drive used, a single revolution can be subdivided into 1,000, 21,600, 25,000, 25,400, 36,000, or 50,000 individual steps. Using the Indexer, you can rotate the motor shaft to a precise position and stop; or rotate at a constant velocity; or alternately move back and forth between two angular positions; or use a combination of such moves.

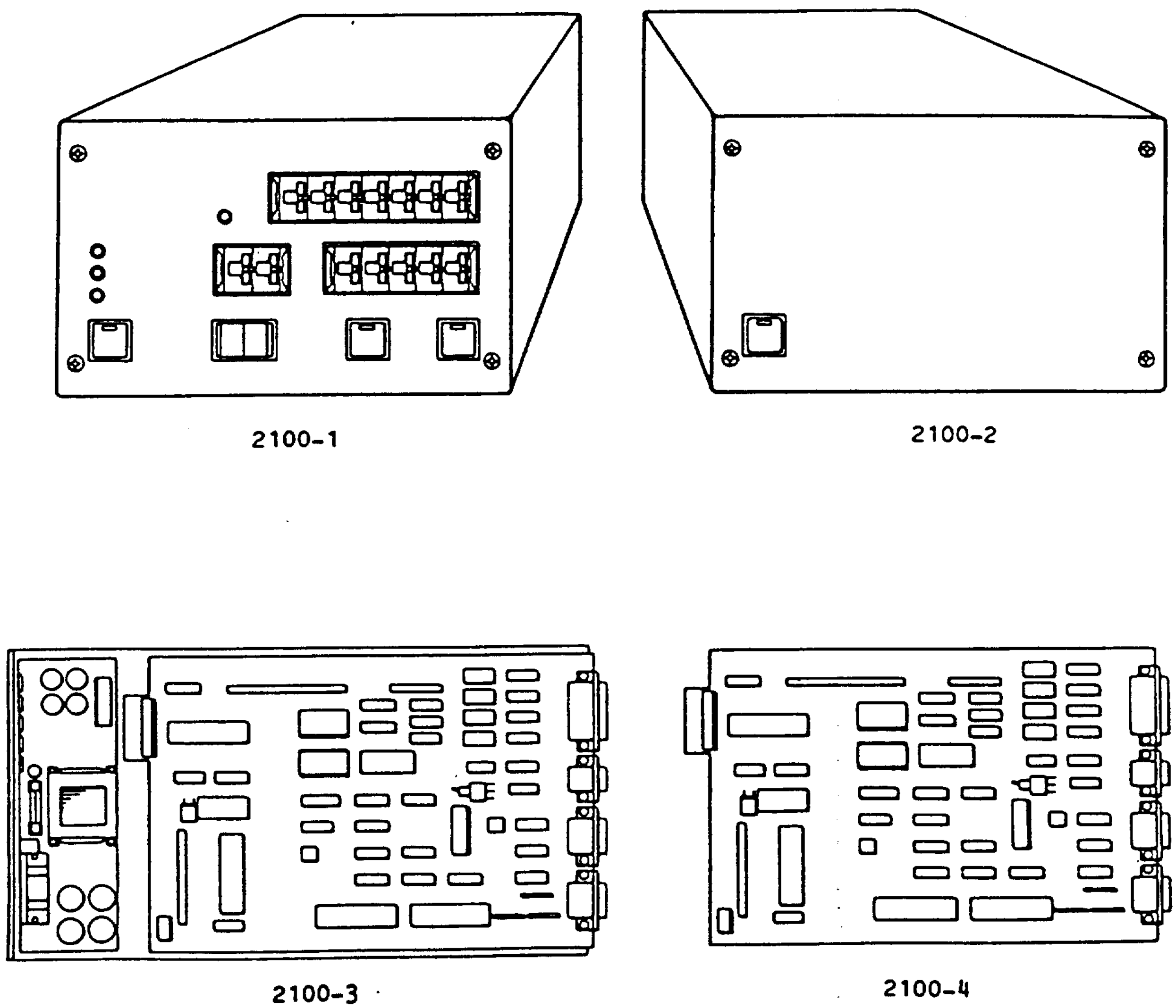
The 2100 can be operated manually, controlled by a remote terminal, or controlled by a computer. You can switch between the different modes of operation at will. When the 2100 is used with either a remote terminal or a computer, up to 16 indexers can be controlled from the same terminal or computer.

The 2100 is normally used for precise position control with no external position feedback. An option is available for closed loop operation to insure the accuracy of position control.

When a terminal or computer is used to control the 2100, a combination of successive positions, rotation rates, and operating functions can be selected. ASCII character commands are used for control of the 2100 from a terminal or computer. (The ASCII character format is standard on many terminals and small computers.) These commands are discussed in detail in Chapter 5.

* Referred to as "2100" or "Indexer" throughout this manual.

Figure 1-1. 2100 Indexers



Note

The Compumotor Driver and the Compumotor motor, are referred toas the motor/drive in this manual.

1.2 GENERAL DESCRIPTION

1.2.1 STANDARD UNIT

The 2100 Indexers are available in four different physical configurations are available. All versions of the 2100 include an RS-232C communications interface capability that allows remote terminal or computer control of the Indexer. The four versions are

2100-1 - Mounted in half EIA Rack enclosure. Includes leverwheel switches on Front Panel for local manual control, circuit card, and internal power supply. Provides for local manual, remote terminal, or computer-controlled modes.

2100-2 - Mounted in half EIA Rack enclosure. Includes circuit card and internal power supply. Provides for remote terminal or computer-controlled modes only.

2100-3 - Supplied without enclosure. Includes circuit card and associated power supply. Provides for remote terminal or computer-controlled modes only.

2100-4 - Supplied without enclosure or power supply. Includes circuit card only. Provides for remote terminal or computer-controlled modes only.

The standard Indexer is configured for operation with 25,000- or 50,000-step motor/drives. Indexers can be ordered with any one of the following resolution options:

R1--Optional resolution for 200-step/rev motor/drives

R2--Optional resolution for 400-step/rev motor/drives

R4--Optional resolution for 1,000-step/rev motor/drives

R5--Optional resolution for 4,096-step/rev motor/drives

R6--Optional resolution for 7,500-step/in. linear motors

R7--Optional resolution for 12,500-step/in. linear motors

R8--Optional resolution for 16,384-step/rev motor/drives

R9--Optional resolution for 15,000-step/in. linear motors

R10--Optional resolution for 21,600-step/rev motor/drives

R11--Optional resolution for 25,000-step/rev motor/drives

R12--Optional resolution for 25,400-step/rev motor/drives

R13--Optional resolution for 36,000-step/rev motor/drives

R14--Optional resolution for 50,000-step/rev motor/drives

Note: These options involve a software change. All of the above resolution options are included with either the -P or -488 options below.

1.3 **OPTIONAL FEATURES**

1.3.1 MODEL 852 JOYSTICK

third. The Model 852 uses a single-chip microcomputer and an analog-to-digital converter to give precisely controlled motor speed and acceleration without the reliability and drift problems associated with analog circuitry.

The Model 852 will drive any Compumotor motor/drive directly or through Compumotor's Model 2100 Preset Indexers. This allows motor control to be transferred between manual and computer control. The features are:

- Acceleration: Proportional to rate of joystick deflection; 100 revolutions per second per second (rev/sec/sec) maximum
- Velocity: Proportional to joystick deflection; 0 to 1 mHz in eight ranges, each with three front panel selected subranges
- Direct, optically isolated interface with 2100 allowing remote terminal or computer control

1.3.2 POSITION TRACKING (-P Option)

The Position Tracking option can be used in applications where desired positional desired accuracy exceeds the accuracy of the mechanical drive components, or where varying loads affect the repeatability of positioning. The option is designed to work with dual-channel incremental encoders that produce TTL quadrature outputs.

This option is not a general servo system implementation. It does not servo velocity during a positioning move. It will cause the motor to drive back to a reference position and act to hold that position if any perturbing torques do not continuously exceed the torque capability of the motor.

The Position Tracking option (encoder interface) provides several alternatives:

a. A means to operate in a closed loop mode to compensate for friction, tolerance buildup, and wear of the mechanical transmission between motor and load

b. A means to independently check the actual position of the load and to detect stalls.

c. A means to increase the resistance of the motor-to-shaft motion induced by external torques using a rotary encoder mounted on the motor.

d. A means to check for motor stall during moves.

The -P option is contained on a printed circuit card and includes the encoder interface software, 2100 expansion cable, encoder interface cable, and encoder interface/721 Display cable.

Note

The -P option can be combined with the IEEE-488 option (section 1.3.3) on a single card.

Installation of the -P options without the use of an optical encoder will provide additional capability including a GO-HOME function and absolute position referenced to HOME (or some other absolute zero position).

1.3.3 IEEE-488 Option (-488 option)

The -488 option provides an IEEE-488 communications interface. The -488 option is contained on a circuit card and includes the 2100 expansion cable, and IEEE-488 connector cable.

As noted in section 1.3.2, the -488 can be combined with the -P option on a single circuit card. The combination of these two options cannot be field installed.

1.4 SPECIFICATIONS

Performance, electrical, environmental and mechanical specifications are presented in Tables 1-1 and 1-2.

Table 1-1. 2100 Series Performance and Electrical Specifications

Parameter	Value
Performance	
Stepping Accuracy	±0 Steps from Preset total
Velocity Accuracy	+0.02% of Set rate, ±0.001 rev/sec
Velocity Repeatability	±0.02% of Set rate above 0.01 rev/sec
Power	
2100-1, 2100-2, 2100-3:	117 VAC, 50/60 Hz, 0.25 A with built-in power supply
2100-4:	+5 VDC at 1.5 A, ±12 VDC at 50 mA regulated
Inputs	
RS-232C Interface	3-wire implementation (TX, RX, GND); Answer (DTE) or Originate (DCE) mode
Control Input Lines Start, Stop	1 Kohm Pullup Active Low: 0.75 VDC maximum, -4.25 mA sink Minimum Pulse Width: 100 microsec
CW, CCW Limit, Load Data, Motor Shutdown Request, Trigger (3 lines)	3 Kohm Pullup Active Low: 0.75 VDC 1.6mA sink Minimum Pulse Width: 2 ms

Table 1-1. 2100 Series Performance and Electrical Specifications (Continued)

Parameter	Value
Outputs	
Step Pulse (TTL)	Active High: <0.75 VDC low, >3.5 VDC high ±60 mA sink maximum
Pulse Widths	
21,600 to 50,000 steps/rev	1 microsec duration nominal
1000 step/rev	5 microsec duration nominal
200 to 400 steps/rev	15 microsec duration nominal
Direction (TTL)	
CW (Logic "1")	3.5 VDC, +60 mA minimum
CCW (Logic "0")	0.75 VDC maximum, -60 mA minimum
In Position; CW, CCW Step	3.5 VDC, +60 mA minimum 0.75 VDC maximum, -60 mA minimum
Load Ready; Programmable Output	
(Logic "0"):	0.4 VDC, 8 mA sink maximum
(Logic "1"):	2.4 VDC minimum, 400 microamps

Table 1-2. 2100 Series Mechanical and Environmental Specifications

Parameter	Value			
Size	2100-1	2100-2	2100-3	2100-4
Height*	5.22 in.(13.20 cm)		2.00 in.(5.08 cm)	1.20 in.(3.05 cm)
Width*	8.38 in.(21.27 cm)		8.00 in.(20.32 cm)	7.75 in.(19.59 cm)
Length*	14.38 in.(36.51 cm)		15.20 in.(38.60 cm)	11.25 in.(28.58 cm)
Weight in Pounds (KG)				
Net	8(3.63)	7.5(3.40)	2(0.91)	1(0.45)
Shipping	12(5.44)	11.5(5.22)	6(2.72)	5(2.27)
Environmental				
Operating	32 to 122oF (0 to 50oC) 0 to 95% Humidity, non-condensing			
Storage	-22 to 185^{o}F (-30 to 85oC)			

* Bench Mount 2100-1, 2100-2

1.5 HOW TO USE THIS MANUAL

You do not have to be an expert in any field to use the 2100 Indexer. This manual contains all information you will need to install and successfully operate the 2100. If a terminal or computer is intended to control the 2100, you will need access to the computer or terminal manuals that define set-up conditions for RS-232C (or IEEE-488) operation of the respective terminal or computer. This manual assumes that you have access to the applicable equipment manuals.

Chapter 2 presents the concepts and terminology used in the manual and identifies the 2100 functional signal inputs and outputs. Read this chapter completely.

Chapter 3 describes installation procedures for the 2100. Separate sections are included in Chapter 3 that describe installation of the RS-232C and IEEE-488 communications interfaces, limit switches, and optional features.

Chapter 4 describes the procedures for local manual operation using the front panel controls and an optional joystick. Use of the optional Model 721 Display is also described in Chapter 4.

Chapter 5 describes the basic 2100 commands.

Chapter 6 describes operation using a terminal and the RS-232C interface.

Chapter 7 describes computer control via the RS-232C or IEEE-488 interface.

Chapter 8 presents maintenance and troubleshooting procedures.

Appendix A presents an application example.

Appendix B summarizes the Indexer commands.

Appendix C summarizes the Indexer connector pinouts.

Appendix D summarizes the Indexer DIP Switch arrangement.

Chapter 2

BASIC SYSTEM CONCEPTS

2.1 GENERAL

All applications of the 2100 Indexers involve either rotation of a Compumotor motor shaft to a precise angular position (number of steps) or rotation of the motor shaft at a prescribed angular velocity (revolutions per second). Compumotor devices use a technique known as microstepping, which is described in the Compumotor Product Catalog.

A standard translator/stepper motor can be stepped in equal increments of 200 or 400 steps/rev, making each step equivalent to 1.8 or 0.9 degrees. Microstepping permits as many as 50,000 steps per revolution depending on the design of the motor/drive. You can choose among Compumotor motor/drive options ranging from 1,000 to 50,000 steps per revolution (steps/rev) for your application. The Indexer must be specified with the appropriate resolution option for the type of Compumotor motor/drive that is used.

Each time the Compumotor motor/drive receives one step pulse, it rotates the motor one angular increment. You may choose to control either angular position or angular velocity with a high degree of precision without any external feedback.

When commands are structured for the system, it is necessary to think in terms of the number of steps/rev; e.g., for a 25,000-step motor, 180 degrees = 12,500 steps, 1 revolution = 25,000 steps, etc. You must refer the desired load motion for your application to rotation of the Compumotor motor shaft. Shaft motion must be specified in terms of acceleration (revolutions per second per second), angular velocity (rev/sec) and angular position (incremental steps from the current motor position).

Both the size and the resolution of the Compumotor motor must be determined for any given application. Refer to the Compumotor Product Catalog for a discussion of motor selection, calculations, and criteria.

2.2 ACCELERATION/VELOCITY PROFILES

As discussed in the Compumotor Product Catalog, the Compumotor motor moves in incremental steps. In practical applications, load inertia tends to smooth the actual motion of the load. The small size of the motor steps minimizes end-of-move settling time at moderate acceleration values.

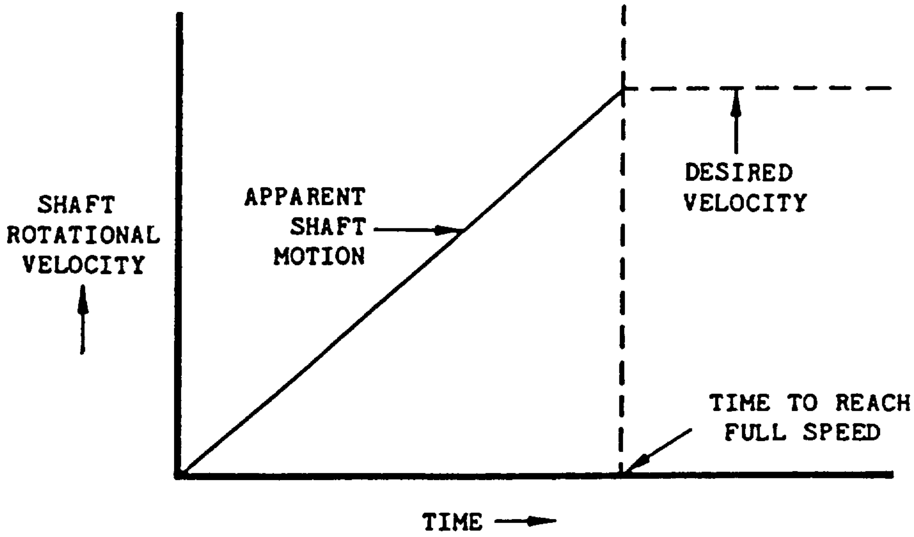
2.2.1 ACCELERATION/DECELERATION

Acceleration/deceleration is defined as the rate of increase/decrease of angular velocity in revolutions per second per second (rev/sec/sec). When the 2100 drives the motor from rest to a given velocity, a string of pulses of increasing frequency is sent to the motor/drive.

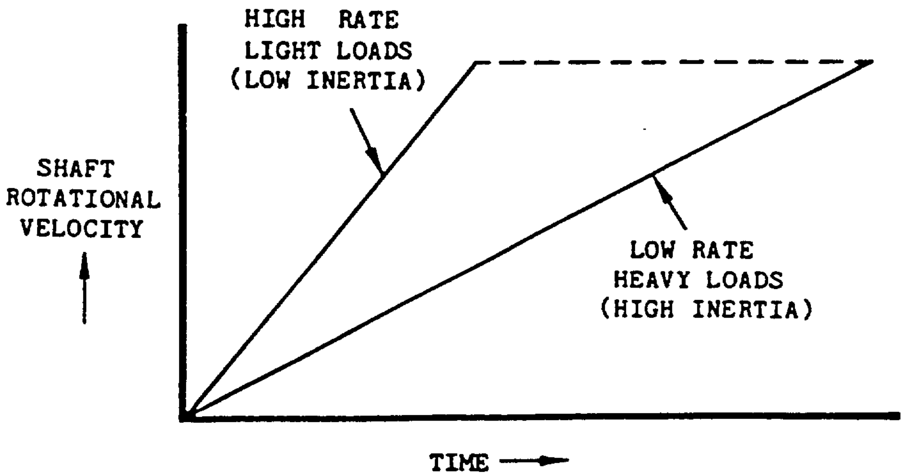
Relatively high pulse rates are used to drive the high-resolution Compumotor motors; therefore, the shaft motion can be graphically portrayed by a straight line, as shown in Figure 2-1.

The acceleration/deceleration rate must be selected as a function of the inertia of the load to allow operation within the torque limits of the motor. A margin of 50 to 100 percent of normal load torque requirements is recommended. If the selected acceleration rate requires torques that exceed the capability of the Compumotor motor/drive, the motor will stall without any damage to the motor.

You can control the acceleration/deceleration rate of the motor with the front panel ACCEL thumbwheel or from a remote terminal or computer via the communications link. The acceleration/deceleration rate can be varied between the limits of 0.01 and 990 rev/sec/sec. When very high acceleration rates are used, there may be a tendency for overshoot and longer settling times.



A. ACCELERATION CURVE



B. 2100 CAPABILITY

Figure 2-1. Acceleration Profile

Normally the acceleration and deceleration rates are equal. In the continuous mode, different acceleration and deceleration rates may be used. (See section 2.3.3).

2.2.2 MOTION PROFILES

Refer to Figure 2-2. The trapezoidal motion pattern, Figure 2-2A, will occur when the angular distance to be covered is large compared with the angular distance required to reach the specified angular velocity. Part of the motion occurs at a constant velocity. An example is a move in which acceleration takes one-fourth of the move time, one-half of the time velocity is constant, and one-fourth of the time is spent in decelerating.

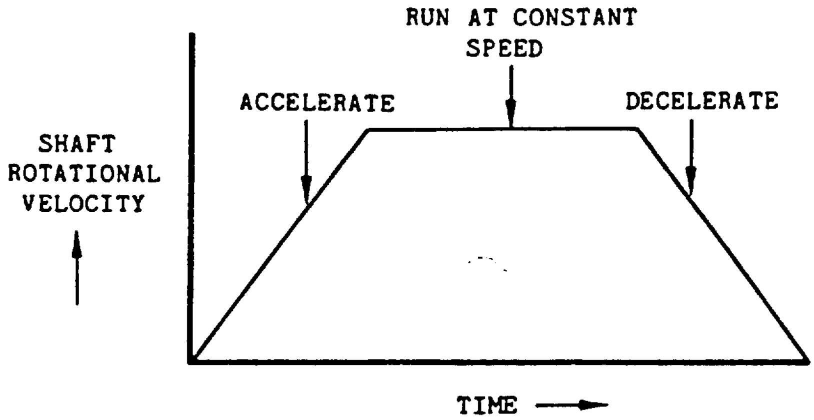
The triangular motion pattern (Figure 2-2B) occurs when the angular distance required to reach the specified velocity is large compared with the angular distance to the new position. In this case the motor shaft velocity is continually changing during the move and there is no constant velocity phase. The average velocity would be one-half the peak velocity.

2.3 MOTOR RESOLUTION, VELOCITY RANGE, ACCELERATION RANGE, AND POSITION RESOLUTION

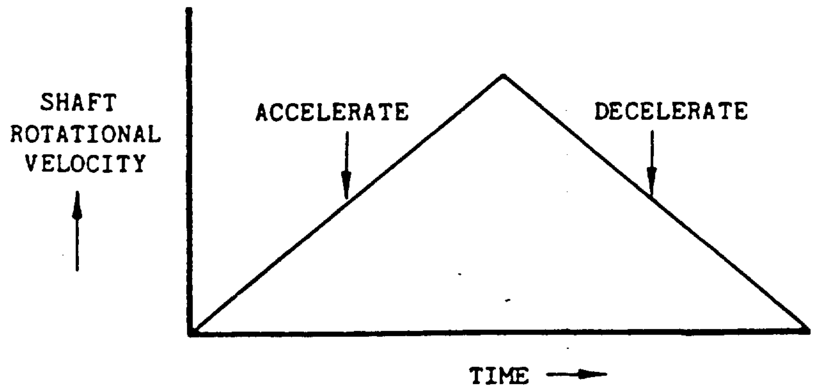
2.3.1 MOTOR RESOLUTION

Motor resolution is defined by the motor/drive used with the 2100 (Table 2-1). The Indexer uses the motor resolution data to calculate the internal move parameters corresponding to the velocity and acceleration commands. DIP Switch S2-5 is set to match standard Indexers to the resolution capability of the motor/drive. Refer to Table 3-4 for selection of motor resolution for standard Indexers.

When the Position Tracking (-P) or IEEE-488 (-488) option is installed, DIP Switch S2-5 is used for a different purpose, and jumpers on the -P or -488 board are used to match the Indexer to the motor/drive.



A. TRAPEZOIDAL PATTERN



B. TRIANGULAR PATTERN

Figure 2-2. Motion Profiles

Table 2-1. Resolution Per Step

Indexer Configuration Option	Motor Resolution (steps/rev)	Equivalent Value Per Step	
		part of rev*	degerees
R14 (STD)	50,000	2.0000×10^{-5}	0.0072
R13	36,000	2.7778×10^{-5}	0.01
R12	25,400	3.9370×10^{-5}	0.01417
R11 (STD)	25,000	4.0000×10^{-5}	0.0144
R10	21,600	4.6296×10^{-5}	0.01667
R4	1,000	1.0000×10^{-3}	0.36
R2	400	2.5000×10^{-3}	0.9
R1	200	5.0000×10^{-3}	1.8

*Rounded values

2.3.2 VELOCITY RANGE

The velocity range can be selected (DIP Switch S2-6) from two ranges for any given motor. The two ranges differ by a factor of 10. Refer to the motor/drive manual for specific information about the motor/drive you are using. Refer to Chapter 3 of this manual for installation details. The installed software selects the proper operation parameters as a function of the setting of DIP Switch S2-6. The choices are summarized in Table 2-2.

There is an implied decimal point (which is a function of the velocity range selected) with the velocity leverwheel switches on the front panel of the 2100-1. If you have used the front panel to set up the parameters for a given application, this may cause confusion when you transfer the values to remote terminal commands. If the front panel reads

03457

this should be interpreted as 03.457 (DIP Switch S2-6 OFF) or 0.3457 (DIP Switch S2-6 ON) rev/sec.

Table 2-2. Velocity Ranges*

Motor Resolution (steps/rev)	Velocity Range A (rev/sec)	Velocity Range B (rev/sec)
50,000	0.001-9.999	0.0001-0.9999
36,000	0.001-14.000	0.0001-1.4000
25,000, 25,400	0.001-20.000	0.0001-2.0000
400	0.0025-80.00	0.0004-10.000
200	0.005-160.000	0.0007-20.000

*Using RS-232C or IEEE-488 Communications Interface

2.3.3 ACCELERATION/DECELERATION RANGE

Four choices are available by setting DIP Switches S6-2 and S6-3. The choices are summarized in Table 2-3.

Table 2-3. Acceleration Ranges

Acceleration Range (rev/sec/sec)	DIP Switch S6-	
	1	2
1-99	OFF	OFF
0.1-9.9	ON	OFF
10-990	OFF	ON
0.01-0.99	ON	ON

The basic considerations in selecting the acceleration range are the torque capability of the motor, risk of load overshoot, and the physical characteristics of the mechanical transmission coupled to the motor/drive. In practice, acceleration is frequently determined by experimentation, starting with a low rate and continuing to increase the acceleration rate until setting time increases or the motor stalls. In the PRESET mode the acceleration and deceleration rates are the same.

2.3.4 POSITION RANGE AND RESOLUTION

There is a limit on the value that can be set for movement to a preset position (distance). This limit is a result of the number of digits allocated for the distance setting. The maximum distance setting (number of revolutions) is different when the front panel leverwheel switches are used and when the setting is made via the communications link (RS-232C or IEEE-488).

Six digits are provided on the front panel and eight digits are available when the communications link is used. In the factory configuration of the 2100, the distance setting represents the number of motor steps to be sent to the motor/drive. Internal switches provide a scale factor that allows multiplying the setting by any number from 1 to 255 to determine the total number of motor steps sent to the motor/drive. This feature allows the user to convert the distance setting from motor pulses to engineering units, such as degrees of rotation or inches of travel, depending on the mechanical system.

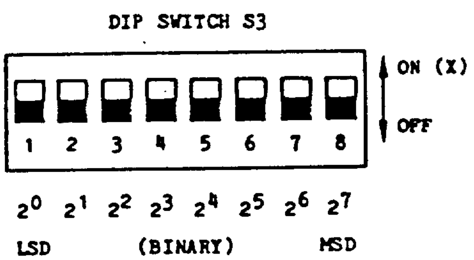
Assume, for example, that the 2100 has been set up to operate a 25,000-step/rev motor, and that the distance setting is configured to represent the actual number of motor pulses to be sent (scale factor = 1). The minimum position change that could be entered would be 1 step (1/25,000 revolution). The maximum value that could be set up on the front panel would be 999,999 steps, which is equivalent to 40 revolutions. Similarly, for operation with the communications link, the maximum value would be 4,000 revolutions.

The scale factor for the distance setting (distance units) can be changed using DIP Switch S3. If the maximum scale factor (255) is used, the minimum move distance is 255 steps. Refer to Figure 2-3 for detailed information on setting up DIP Switch S3.

When operating from the Front Panel, you must make a trade-off between the maximum distance that can be specified and the resolution required for movement to a precise position. When operating under interface control, the scale factor may be changed at will.

BASIC RANGE 0-7	S3-							
	8	7	6	5	4	3	2	1
0								
1								X
2							X	
3							X	X
4						X		
5						X		X
6						X	X	
7						X	X	X
					8-15			
				16-31				
			32-63					
		64-127						
	128-255							

BASIC RANGE OVER 7	SPECIFIC NUMBER	SETTING FOR S3				
		8	7	6	5	4
8-15	8+ [0-7]					X
16-31	16+ [0-7]				X	
	24+ [0-7]				X	X
32-63	32+ [0-7]			X		
	40+ [0-7]			X		X
	48+ [0-7]			X	X	
	56+ [0-7]			X	X	X
64-127	64+ [0-7]		X			
	72+ [0-7]		X			X
	80+ [0-7]		X		X	
	88+ [0-7]		X		X	X
	96+ [0-7]		X	X		
	104+ [0-7]		X	X		X
	112+ [0-7]		X	X	X	
	120+ [0-7]		X	X	X	X
128-255	128+ [0-7]	X				
	136+ [0-7]	X				X
	144+ [0-7]	X			X	
	152+ [0-7]	X			X	X
	160+ [0-7]	X		X		
	168+ [0-7]	X		X		X
	176+ [0-7]	X		X	X	
	188+ [0-7]	X		X	X	X
	192+ [0-7]	X	X			
	200+ [0-7]	X	X			X
	208+ [0-7]	X	X		X	
	216+ [0-7]	X	X		X	X
	224+ [0-7]	X	X	X		
	232+ [0-7]	X	X	X		X
	240+ [0-7]	X	X	X	X	
	248+ [0-7]	X	X	X	X	X



PROCEDURE

1. FIND BASIC RANGE.
2. FIND SPECIFIC NUMBER IN RANGE AND SET S3-4 THROUGH 8 AS INDICATED
3. FIND REQUIRED VALUE BETWEEN 0 AND 7 AND SET S3-1,2,3 PER FIGURE

NOTE: REFER TO SECTION 3.6 FOR INFORMATION ON ACCESS TO DIP SWITCH S3.

Figure 2-3. Scale Factor Conversion Chart for Dip Switch S3

The use of scale factors other than one should be limited to PRESET or ALTERNATE mode operations.

In the CONTINUOUS mode scale factors other than one can result in reports that might be hard to interpret, because in this mode issuing a STOP command or stopping the motor when a limit switch is activated can cause the motor to come to rest at a position that is not an integer multiple of the scale factor.

2.4 ANALYSIS OF YOUR APPLICATIONS

You can choose an analytic approach or an experimental approach. The basic elements that are present in most applications are shown in Figure 2-4. In limited travel situations, end-of-travel limit switches should be installed to protect the load. (See Chapter 3 for installation instructions.)

Determine if encoder feedback is required. When you select the Position Tracking option, you have a number of choices, as follows:

a. 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.

b. You can use a motor with the encoder mounted on the motor shaft so that the motor will resist movement induced by external forces.

c. You can use the encoder as a stall detector to identify whether or not the motor has stalled.

d. You can use the encoder to independently verify the position of the load.

Determine if external Remote Start, Stop, Counterclockwise Limit, Clockwise Limit, and Load Stop inputs are required.

Determine the number of steps required to reach a desired angular position of the Compumotor motor shaft based on the the angular resolution of your system and the scaling factors applied with DIP Switch S3 (see Chapter 3).

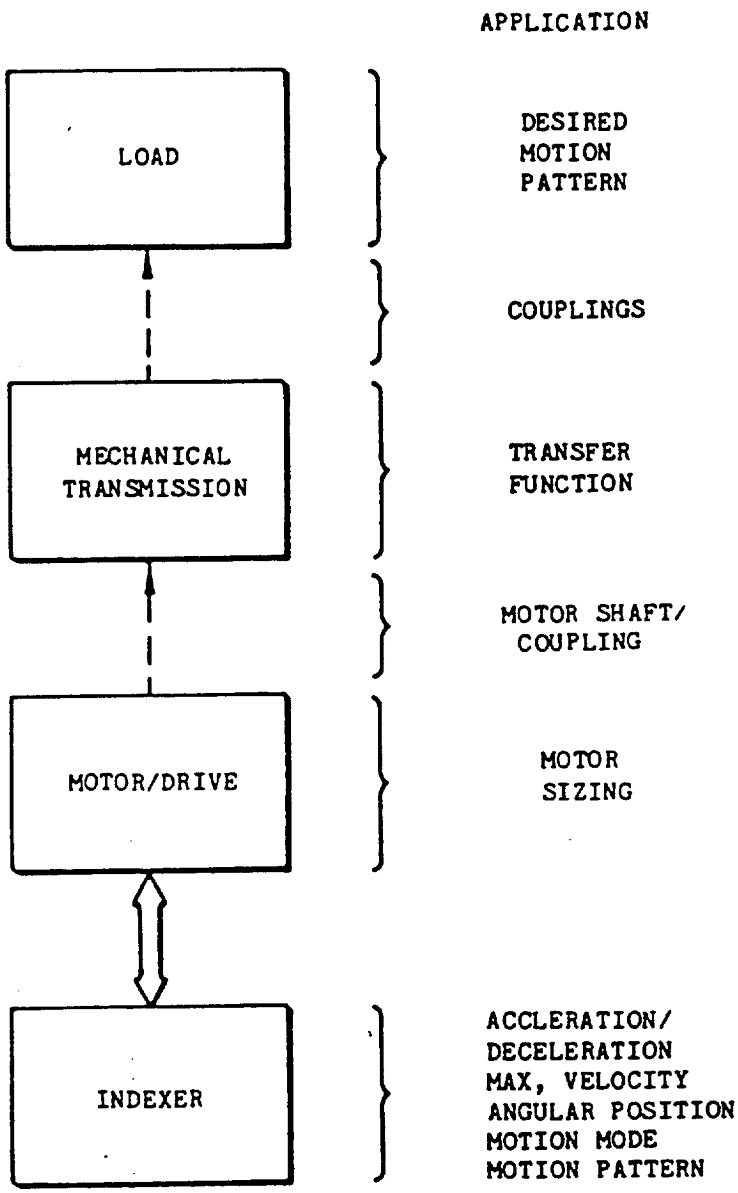


Figure 2-4. Basic Elements to be Analyzed

2.4.1 ANALYTIC APPROACH

The motor/drive must be sized for the application. Refer to the Compumotor Product Catalog for sizing guidelines. The desired load motion pattern must then be referenced to the Compumotor motor shaft. The motor/drive acts as a stiff drive source. Your analysis must include a definition of any gear play, coupling effects, transmission elasticity, load inertia, load friction, etc.

2.4.2 EXPERIMENTAL APPROACH

The motor/drive must be sized for the application. Refer to the Compumotor Product Catalog for sizing guidelines. You can then take advantage of the fact that the motor/drive will stall (without any damage) whenever the performance specified by the command exceeds the capability of the motor/drive being used. The relationship of the acceleration/ deceleration and velocity settings can be determined by using the equation

$$a = (v_f - v_o)/t$$

Where a = angular acceleration, v_f = final angular velocity,
v_o = initial angular velocity, and t = time.

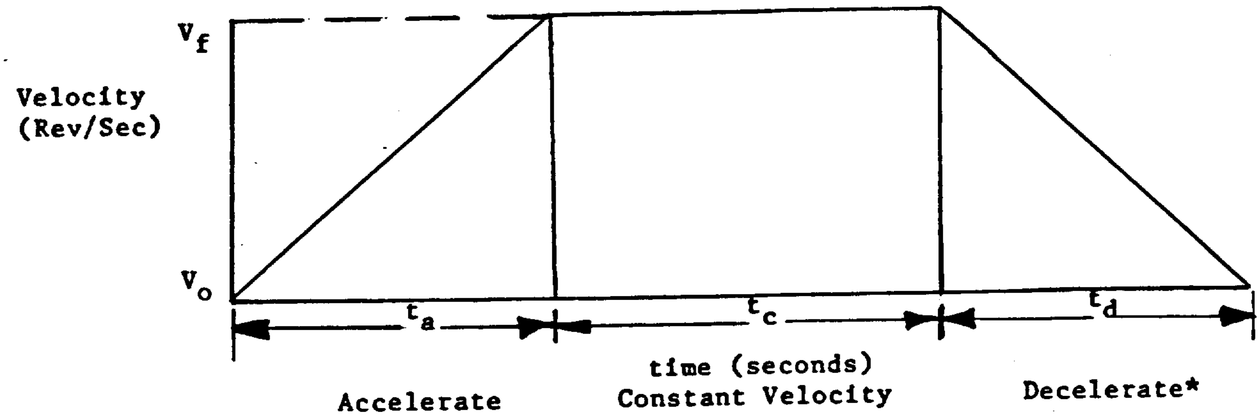
This equation can be used to calculate the time to move, the value of acceleration required, etc. Velocity and acceleration units should be in terms of revolutions and seconds, to match indexer parameters. (See Figures 2-5 and 2-6.) The calculated parameters can be tested and changed quickly using the remote terminal (or the front panel controls if a 2100-1 is being used).

2.5 **CONFIGURATION ALTERNATIVES**

2.5.1 SIMPLEST "LOCAL" MANUAL CONFIGURATION

The simplest configuration that can be used is the 2100-1, as shown in Figure 2-7. The 2100-1 card generates output pulses in response to the front panel switch settings.

Figure 2-5. Time to Move --Trapezoidal Move



*Generally, acceleration rate equals deceleration rate

$$t_a = \frac{V_f - V_o}{a}$$ a = acceleration (rev/sec/sec)

$$t_c = \frac{d}{V_f}$$ d = number revolutions

V_f = rev/sec, maximum velocity

$$t_d\ (= t_a) = \frac{V_f - V_o}{a}$$ a = Deceleration (rev/sec/sec)

Example (25,000 step motor)

a = Acceleration set to 1.0 rev/sec/sec (deceleration is same value)

V_f = Velocity set to 3.75 rev/sec

d = Distance set to 19.65 revolution

$$t_a = \frac{V_f - V_o}{a} = \frac{3.75-0}{1.0} = 3.75 \text{ seconds}$$

V_{avg} = Average velocity in period t_a = 3.75/2 = 1.875

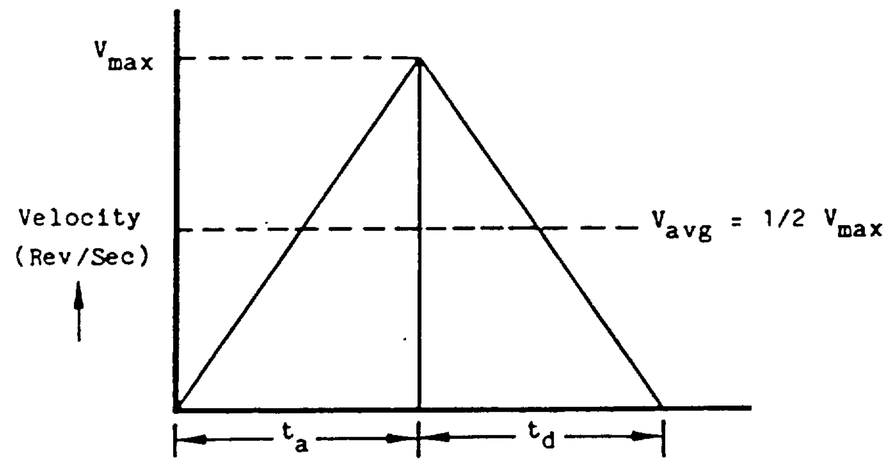
$t_a \times V_{avg}$ = 3.75 x 1.875 = 7.03125 revolution = acceleration distance

$t_d = t_a$, therefore distance moved during deceleration equals 7.03125 revolution

d = Distance to be moved at constant velocity (V_f) equals 19.65-2(7.03.25) = 5.5875 revolutions

$t_c = d/V_f$ = 5.5875/3.75 = 1.49 seconds

Time to move = 2 x 3.75 + 1.49 = 8.99 seconds



$t = t_a + t_d \qquad (t_a = t_d)$

$V_{max} = a\ t_a \qquad$ (a = acceleration rev/sec/sec)

$t = \frac{d}{1/2\ V_{max}}$ (d = distance in revolutions)

$t^2 = \frac{2d}{a} \quad (t_a = 1/2\ t)$

$t = \sqrt{\frac{2d}{a}}$

Example: Move 5 revolutions in 4 seconds
Average velocity = 5/4 = 1.25 rev/sec
Max velocity = 2.5 rev/sec
Acceleration/Deceleration = 2.5/2 = 1.25 rev/sec/sec

Figure 2-6. Time to Move --Triangular Move

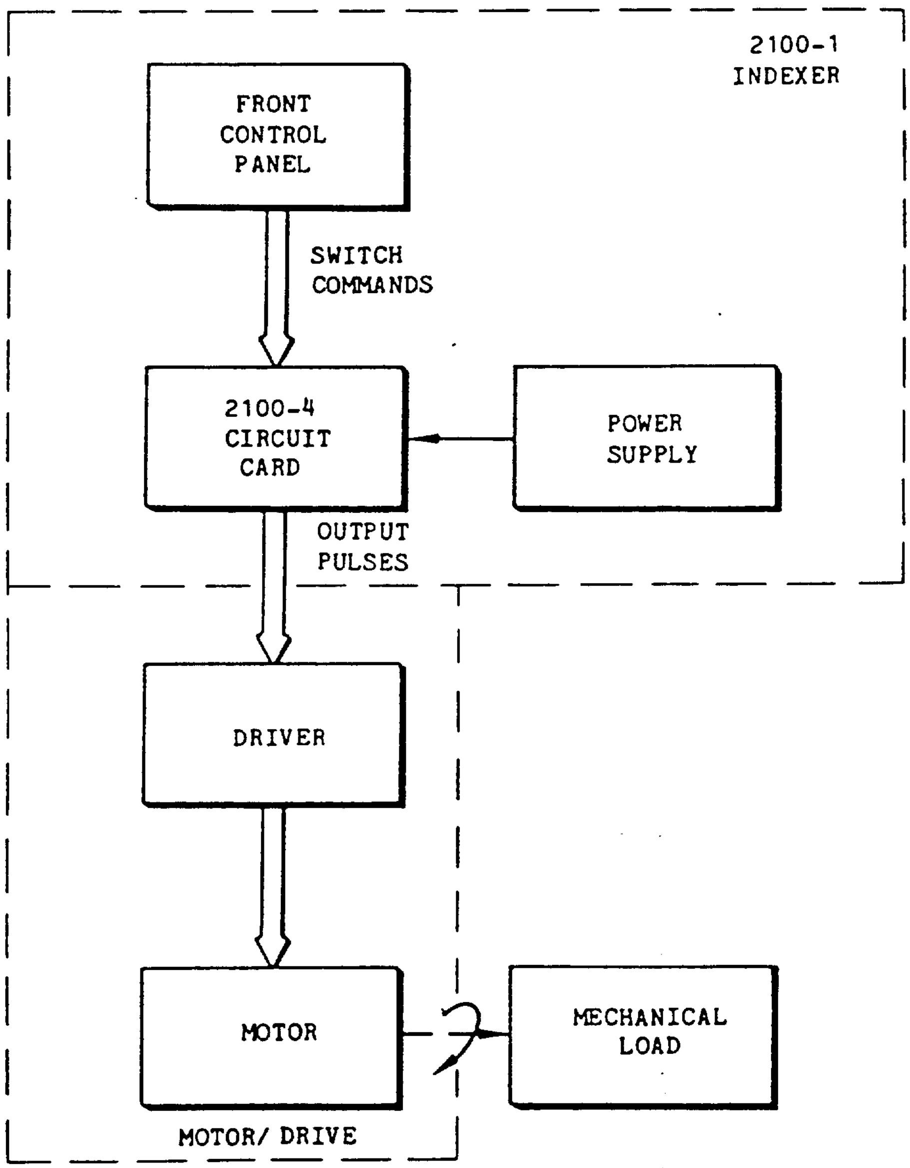


Figure 2-7. Simplest 2100-Based Configuration

Each pulse received by the motor/drive steps the motor one increment. The front panel controls also indicate the direction of motion, which is fed to the motor/drive on one of two output lines, depending on the desired direction.

2.5.2 ENHANCEMENTS OF "LOCAL" MANUAL CONFIGURATIONS

Limit switches can be installed on the load and fed back to the 2100-1 to protect the load from overtravel. This is shown in Figure 2-8. Additional enhancements of local manual systems are shown in Figures 2-9 through 2-11.

Position Tracking is another option that can be added, as shown in Figure 2-12. Position Tracking can be used to

a. Provide closed loop operation for improved load positioning accuracy.

b. Independently verify position.

c. Increase resistance of the motor to external torque.

d. Detect motor stall.

2.5.3 REMOTE TERMINAL CONFIGURATION

A remote terminal can be used in place of front panel controls as shown in Figure 2-13.

When front panel controls are used, only one motion pattern can be set up at any one time. Introduction of the remote terminal provides a number of operational benefits, including the capability to set up sequential multiple-motion patterns by entering strings of commands. Remote terminal command structure is discussed in detail in Chapter 5. Time delays and repetitive loops can be set up and stored in the 2100 command buffer. In addition, status information can be requested from the 2100 and displayed on the terminal. The terminal can be located up to 50 feet away from the 2100. One terminal can control up to 16 indexers.

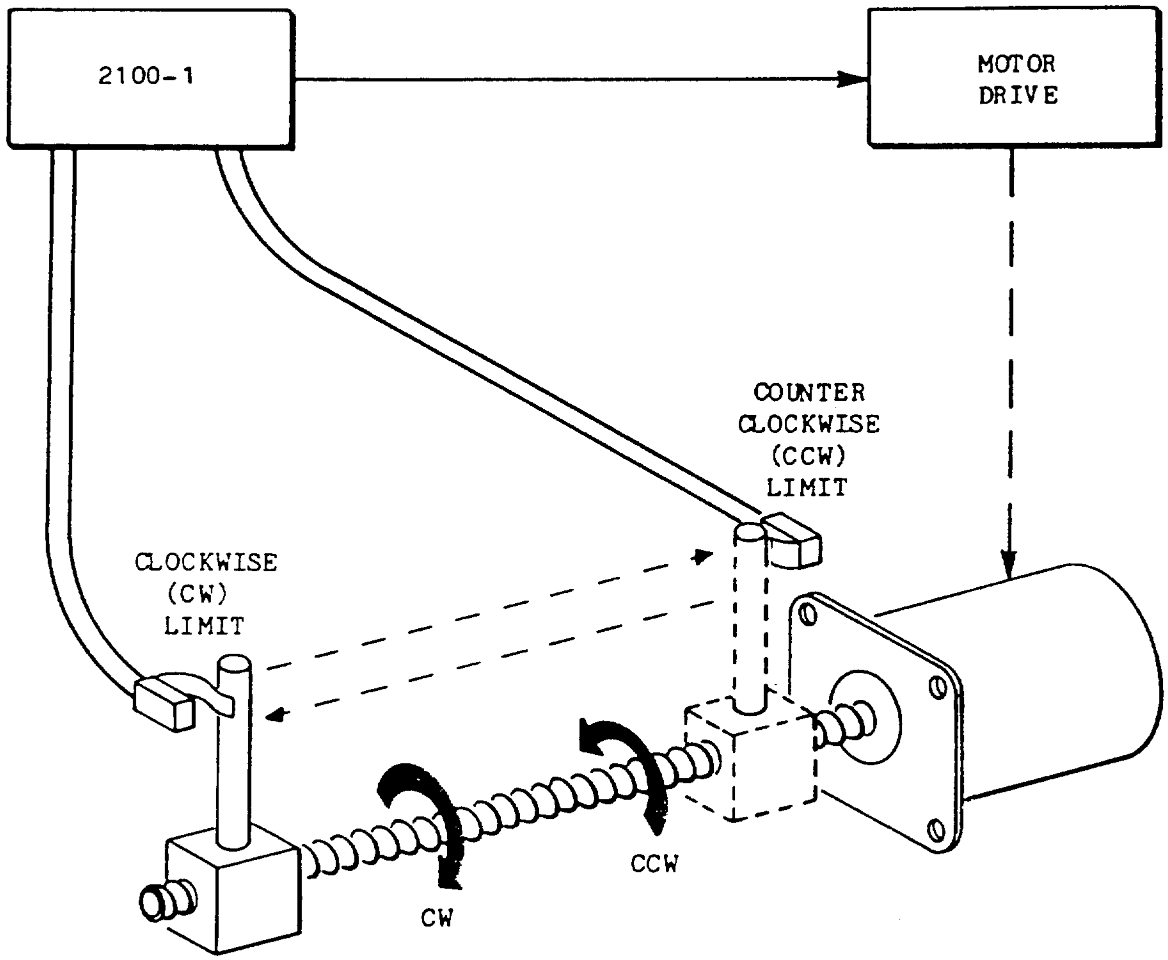


Figure 2-8. Limit Switch Input

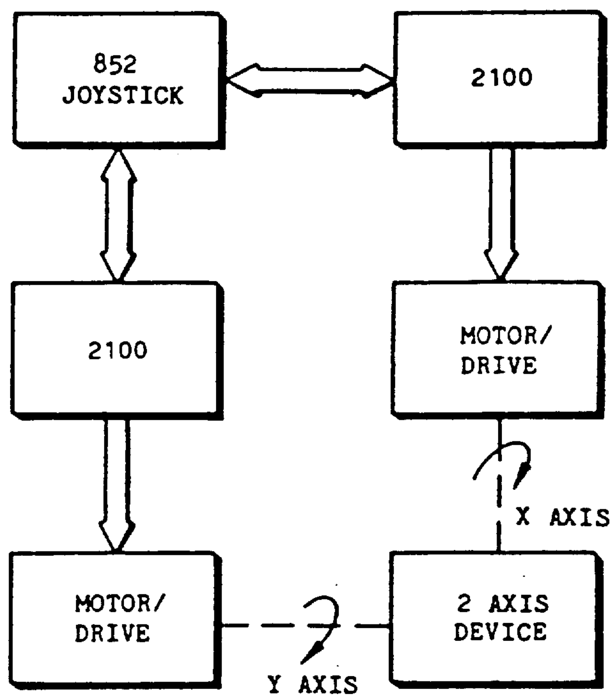


Figure 2-9. Joystick Control

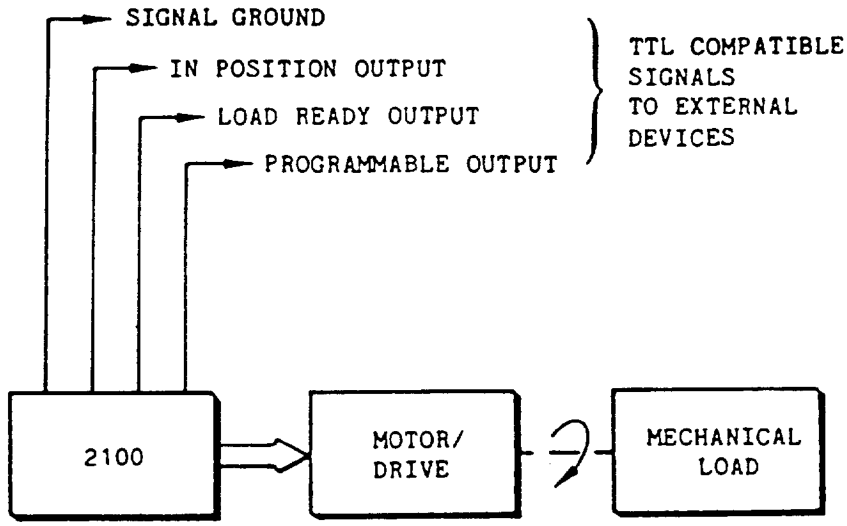


Figure 2-10. Additional Output Lines

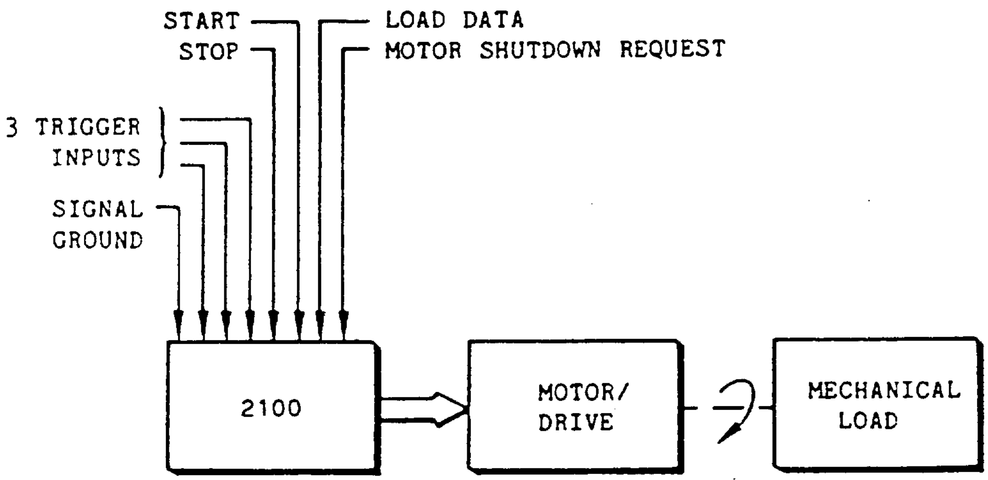


Figure 2-11. Additional Input Lines

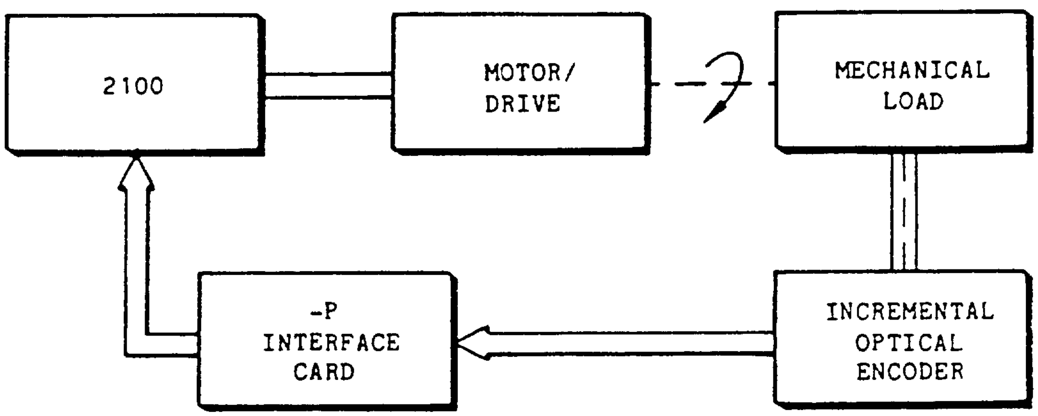


Figure 2-12. Incorporation of Position Tracking

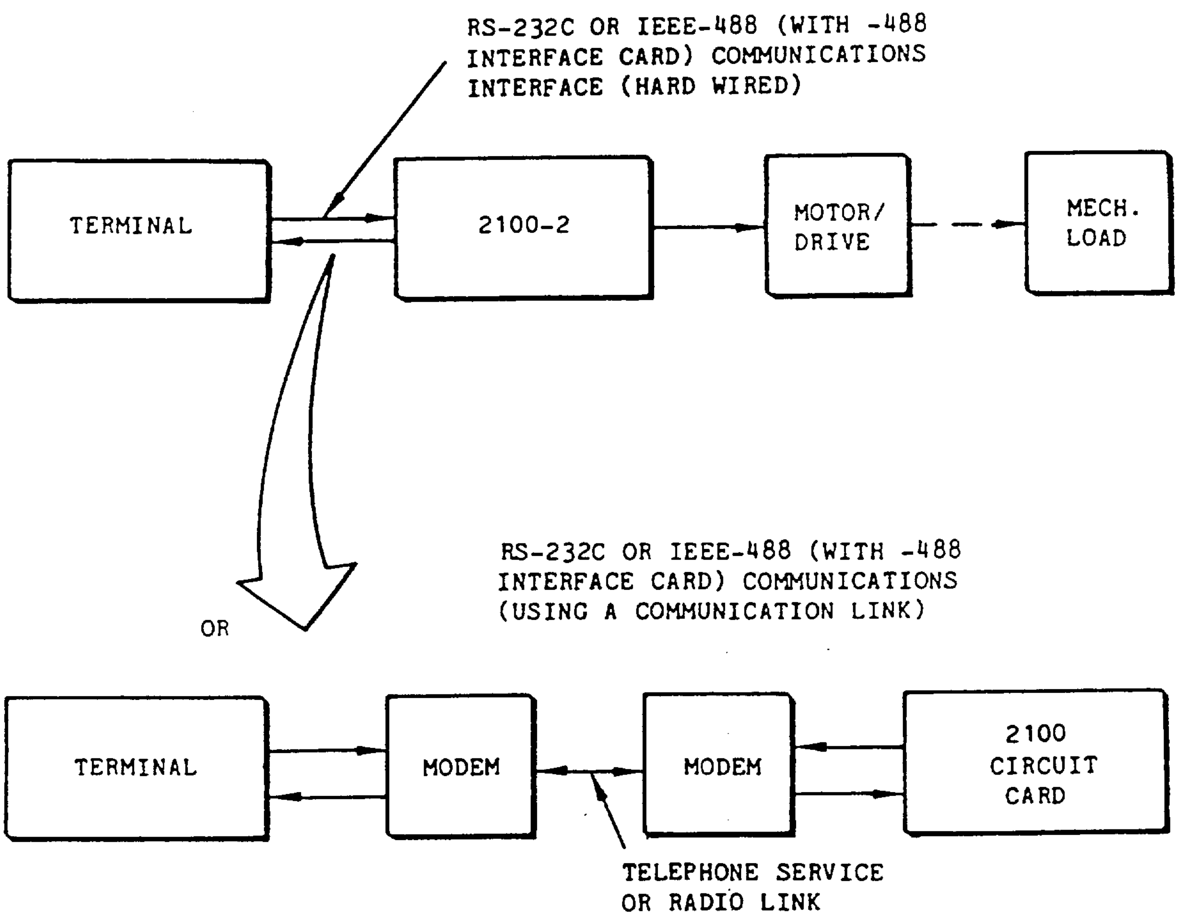


Figure 2-13. Remote Manual Operation with Terminal

2.5.4 COMPUTER-CONTROLLED OPERATION

A computer can be used for controlling the 2100. An example is shown in Figure 2-14. Any computer that can generate a string of ASCII characters and has an operational RS-232C serial port can be used (e.g., IBM PC, Apple, Tandy, etc.). Many programmable controllers also provide an RS-232C interface. An IEEE-488 interface can also be used to control the 2100 in lieu of the RS-232C interface.

One advantage of using a computer is that command messages can be stored and then used repeatedly at different times. A number of programs can be stored and then recalled in response to load conditions. Operation can be automatic and interactive if the proper load sensors and process controllers are installed.

2.6 **2100 INDEXER INPUTS AND OUTPUTS**

2.6.1 2100-1 AND 2100-2

All 2100 connectors are female. The 2100 provides RS-232C, Drive, Joystick, and Auxiliary Connectors for inputs and outputs (Figure 2-15). Installation of the -P and/or -488 options add a Position Sensor and/or IEEE-488 interface connector. These indexer connectors are described below.

A. POSITION SENSOR (when -P option installed)

25-pin "D" connector. Accepts two-phase TTL-compatible inputs from incremental optical encoder.

B. 721 DISPLAY CONNECTOR

Connect directly to optional 721 Display.

C. IEEE-488 INTERFACE

24-pin IEEE-488 connector for IEEE-488 interface.

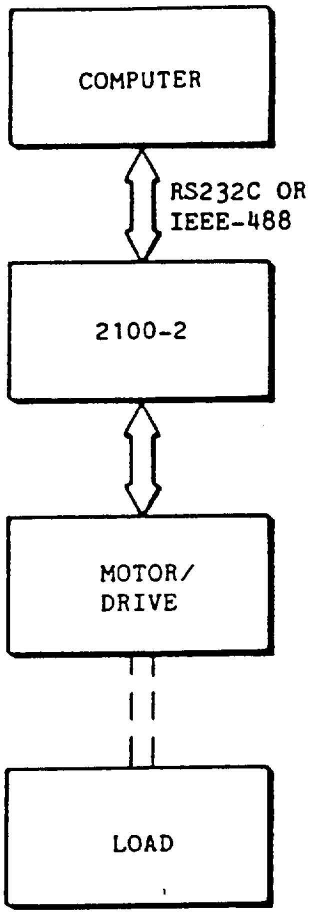


Figure 2-14. Computer-Controlled 2100

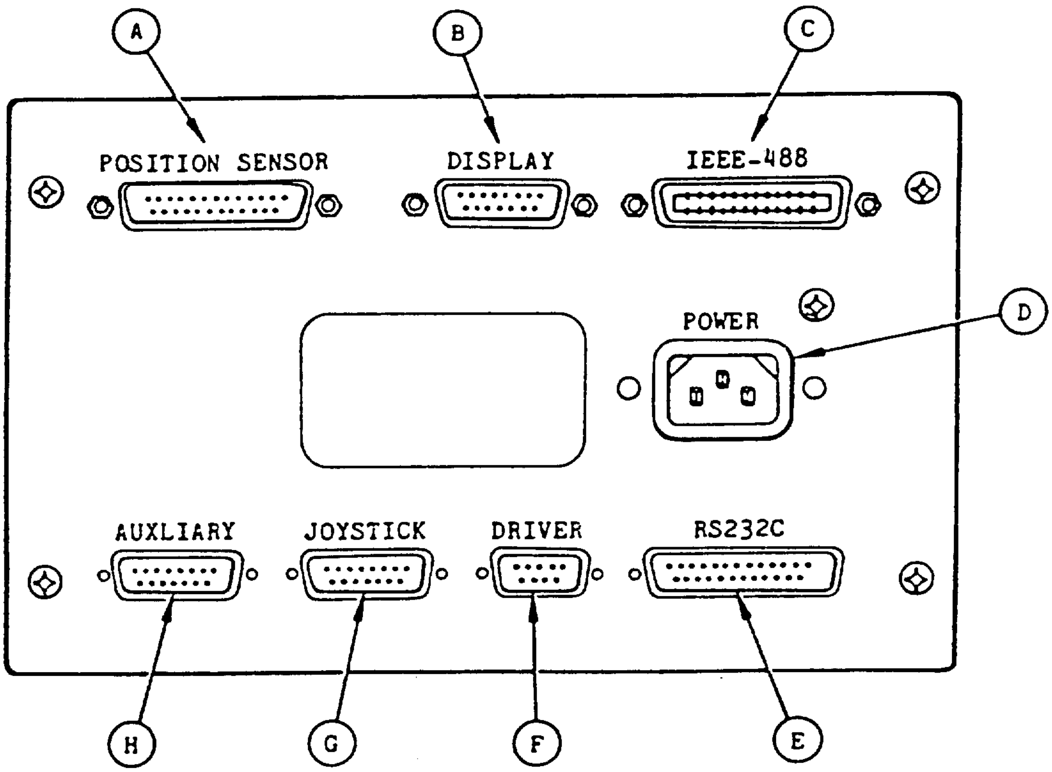


Figure 2-15. 2100-1 and 2100-2 Rear Panel Connectors

D. AC POWER

2100-1, 2100-2, and 2100-3. Provides power for Indexer alone. Motor/drive is separately powered.

E. RS-232C SERIAL DATA PORT

25-pin "D" connector on rear of 2100). Three-wire cable connection (transmit, signal ground, receive).

F. DRIVER CONNECTOR

9-pin "D" connector. Connects Indexer to motor/drive.

G. JOYSTICK CONNECTOR

15-pin "D" connector. Provides connections for Model 852 Joystick.

H. AUXILIARY CONNECTOR

15-pin "D" connector. Provides connections for Limit-Switches; Remote Start; Remote Stop; Load Data; and three trigger inputs; signal grounds; user Programmable Output; Load Ready and In Position outputs.

2.6.2 2100-3 CONNECTORS

The 2100-3 connectors are identified in Figure 2-16.

A. Power Supply connector, J2
B. Expansion connector, J3 (used for -P and/or 488 options)
C. 721 Display connector, J9
D. RS-232C, J5 (same as 2100-1(e))
E. Driver, J6 (same as 2100-1(f))
F. 852 Joystick, J7 (same as 2100-1(g))
H. Auxiliary, J8 (same as 2100-1(h))

2.6.3 2100-4 CONNECTORS

The 2100-4 provides three alternate power connectors (J10 edge connector, and J2/J4 ramp connectors) for the basic 2100 printed circuit board plus the standard 2100 inputs and outputs (Figure 2-17).

A. Power supply connectors, J2, J10
B. Expansion connector, J3 (used for -P and/or 488 options)
C. 721 Display connector, J9
D. RS-232C, J5 (same as 2100-1(e))
E. Driver, J6 (same as 2100-1(f))
F. 852 Joystick, J7 (same as 2100-1(g))
G. Auxiliary, J8 (same as 2100-1(h))

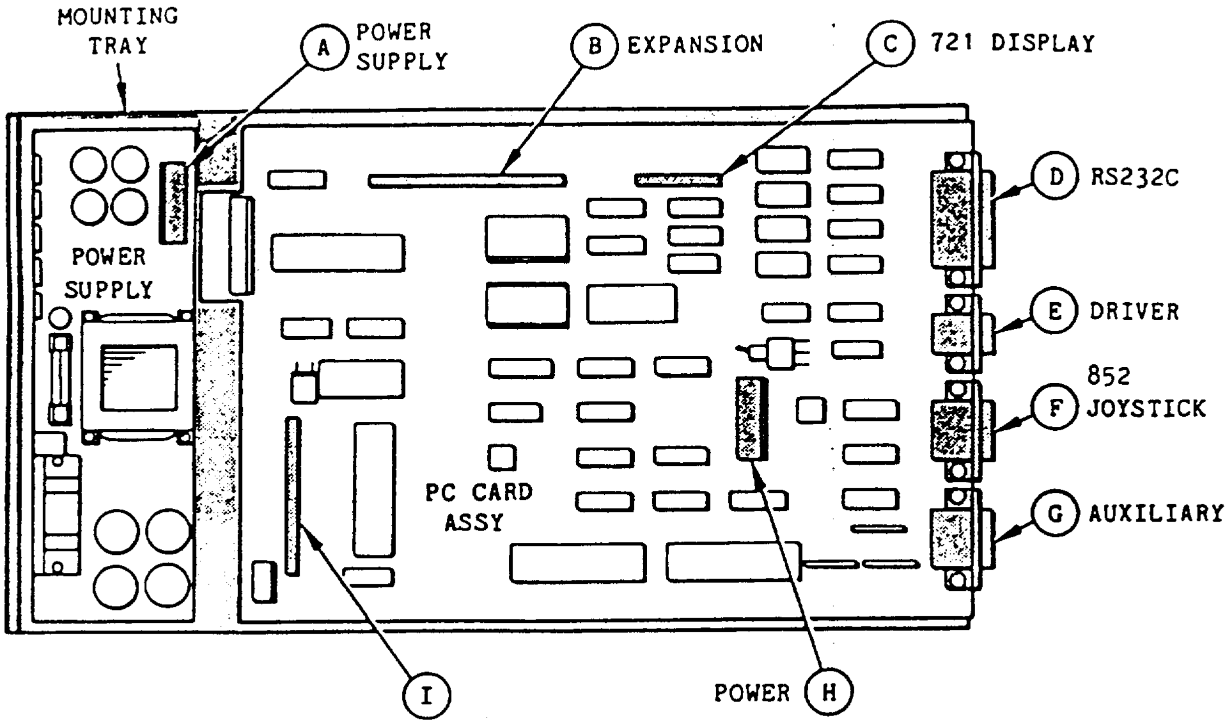


Figure 2-16. 2100-3 Connectors

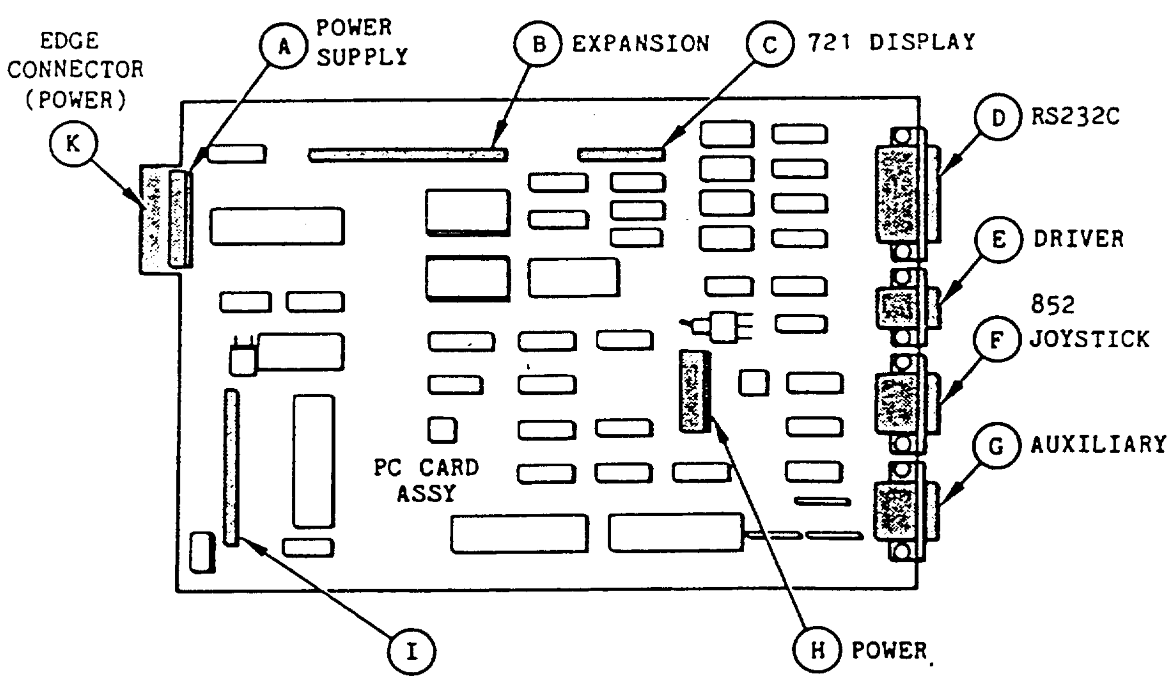


Figure 2-17. 2100-4 Connectors

Chapter 3

INSTALLATION

3.1 OVERVIEW

This chapter describes the installation procedures for 2100 Indexers and their options, including the RS-232C and IEEE-488 interfaces.

3.2 INSPECTION — ALL UNITS

Carefully inspect the shipping carton for any evidence of physical abuse or damage. Report any such findings immediately to your Receiving Department and to the carrier. Compumotor Corporation cannot be responsible for in-transit damage.

Unpack the shipping carton and inspect the Model 2100 Indexer for any damage, cracks, broken parts, or damaged cables. Save the packing materials until functional checks have been completed.

3.3 PHYSICAL ASSEMBLY

3.3.1 2100-1 and 2100-2

The 2100-1 and 2100-2 (Figure 3-1) are delivered as complete, self-contained units. No further assembly of the these units is required. The internal DIP switches should be set to the factory values for the tests of section 3.5. The factory values are presented in Table 3-1. Remove the top cover of the 2100 (4 screws) and verify that the DIP switch settings match Table 3-1.

After the tests of section 3.5 have been successfully completed, the DIP switches can then be set for your specific application. Refer to section 3.6 for a description of the DIP switch choices available.

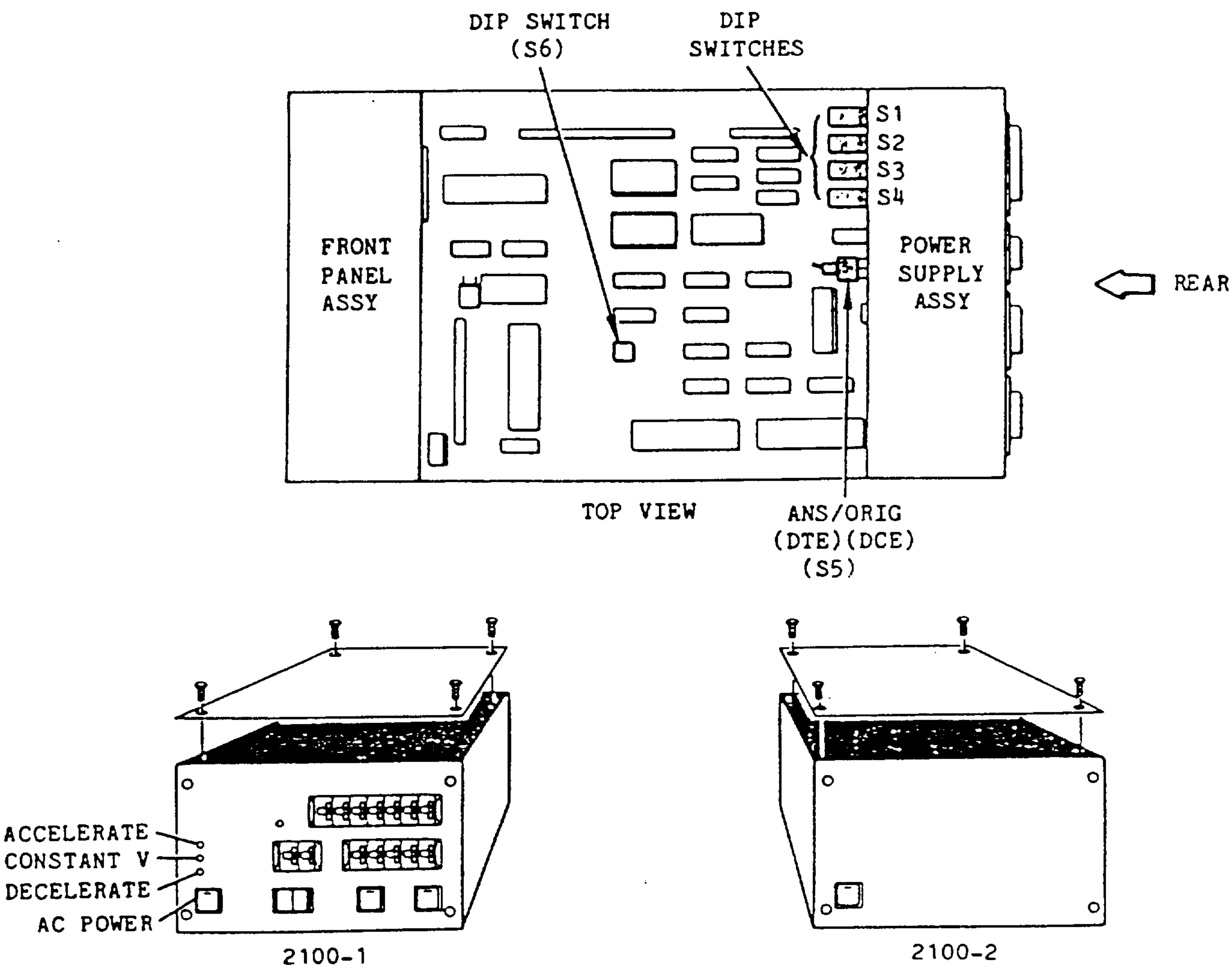


Figure 3-1. 2100-1 and 2100-2 DIP Switches

Table 3-1. DIP Switch Factory Values--25,000 Steps/Rev Motor/Drive.

S1-1	OFF	S2-1	OFF(Note 1)	S3-1	ON	S4-1	OFF
S1-2	ON	S2-2	OFF	S3-2	OFF	S4-2	ON
S1-3	ON	S2-3	OFF	S3-3	OFF	S4-3	OFF
S1-4	OFF	S2-4	OFF	S3-4	OFF	S4-4	OFF
S1-5	OFF	S2-5	OFF(Note 2)	S3-5	OFF	S4-5	OFF
S1-6	OFF	S2-6	OFF	S3-6	OFF	S4-6	OFF
S1-7	ON	S2-7	OFF	S3-7	OFF	S4-7	ON
S1-8	ON	S2-8	OFF	S3-8	OFF	S4-8	OFF
S6-1	OFF	S6-2	OFF	S6-3	ON	S6-4	ON

NOTES: 1. See section 3.6 if -488 option installed.

2. See section 3.6 if motor other than 25,000 steps/rev.

3. AC power/DC power to the Indexer must be cycled after DIP switches are changed in order for the new setting to be used. The exceptions are S4-6, S4-7 and S6-1 through S6-4 inclusive.

CAUTION

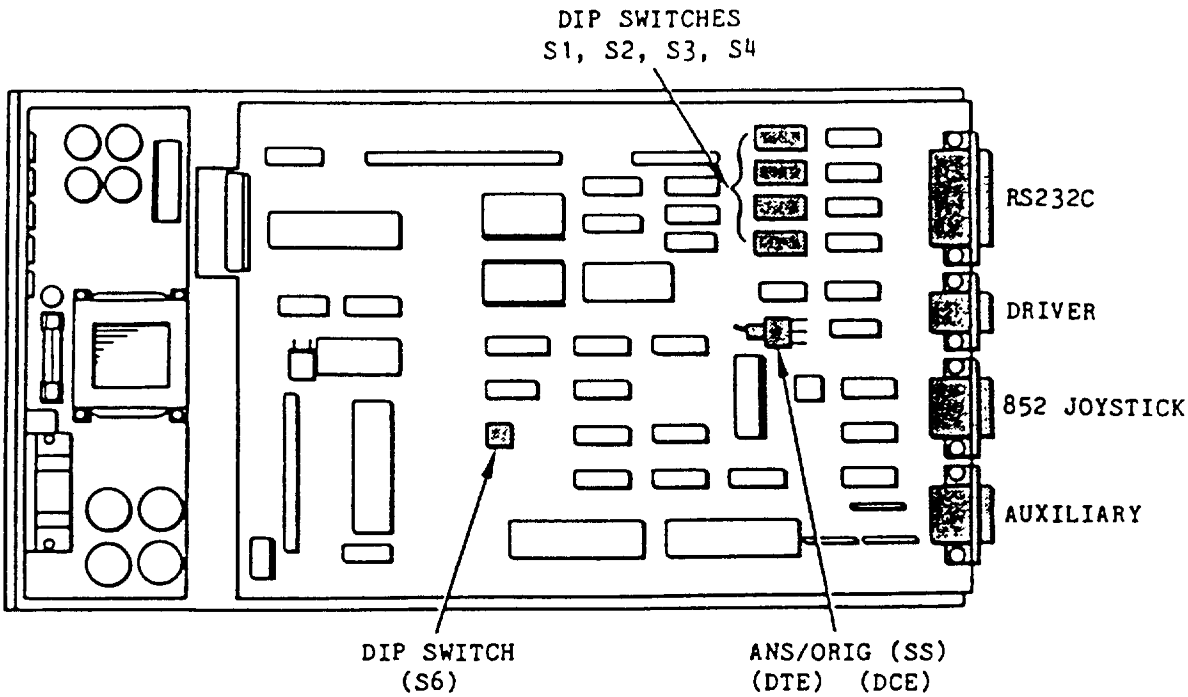
Do not connect the AC power cord at this time.

3.3.2 2100-3 and 2100-4

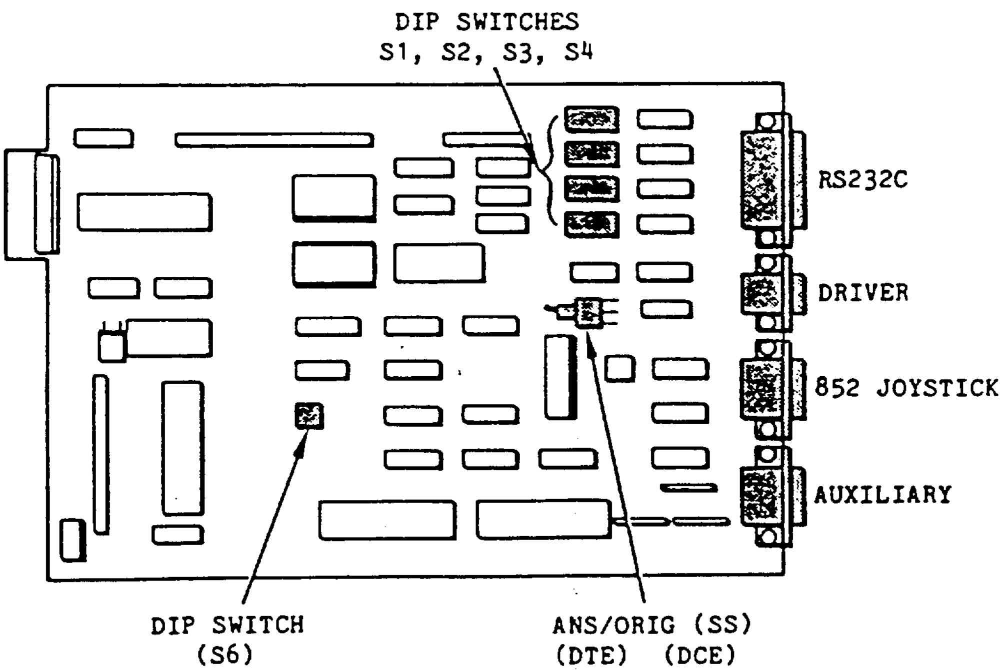
The 2100-3 (Figure 3-2A) is delivered as a circuit card and power supply mounted to an L-frame chassis. Mounting provisions for personnel safety and environmental control are required.

The 2100-4 (Figure 3-2B) is delivered as a bare circuit card. Mounting provisions for personnel safety and environmental control are required. A power supply is required.

A +5 VDC @ 2A regulated power source is required to operate all on-board logic circuitry on the 2100-4. In addition, regulated +12 VDC @ 50 mA and -12 VDC @ 50 mA supplies are required to operate the RS-232C interface. Wiring of the power supply is accomplished by use of the furnished 10-pin edge connector via J10 on the 2100 board (Conn. AMP P/N 530654-2, Compumotor Part No. 33-00124) or J2 = 10 Pin Ramp or J4 = 8 Pin Ramp.



A. 2100-3



B. 2100-4

Figure 3-2. 2100-3 and 2100-4 DIP Switches

Refer to Table 3-2 and Figure 3-3 when making external power supply connections to the Compumotor Model 2100-4 Indexer.

The internal DIP switches should be set to the factory values for the tests of section 3.5. Factory values are presented in Table 3-1. Verify that the DIP switch settings match Table 3-1.

After the tests of section 3.5 have been successfully completed, the DIP switches can then be set for your specific application. Refer to section 3.6 for a description of the DIP switch choices available.

CAUTION
Do not apply power at this time.

3.4 CONNECTION TO MOTOR/DRIVE

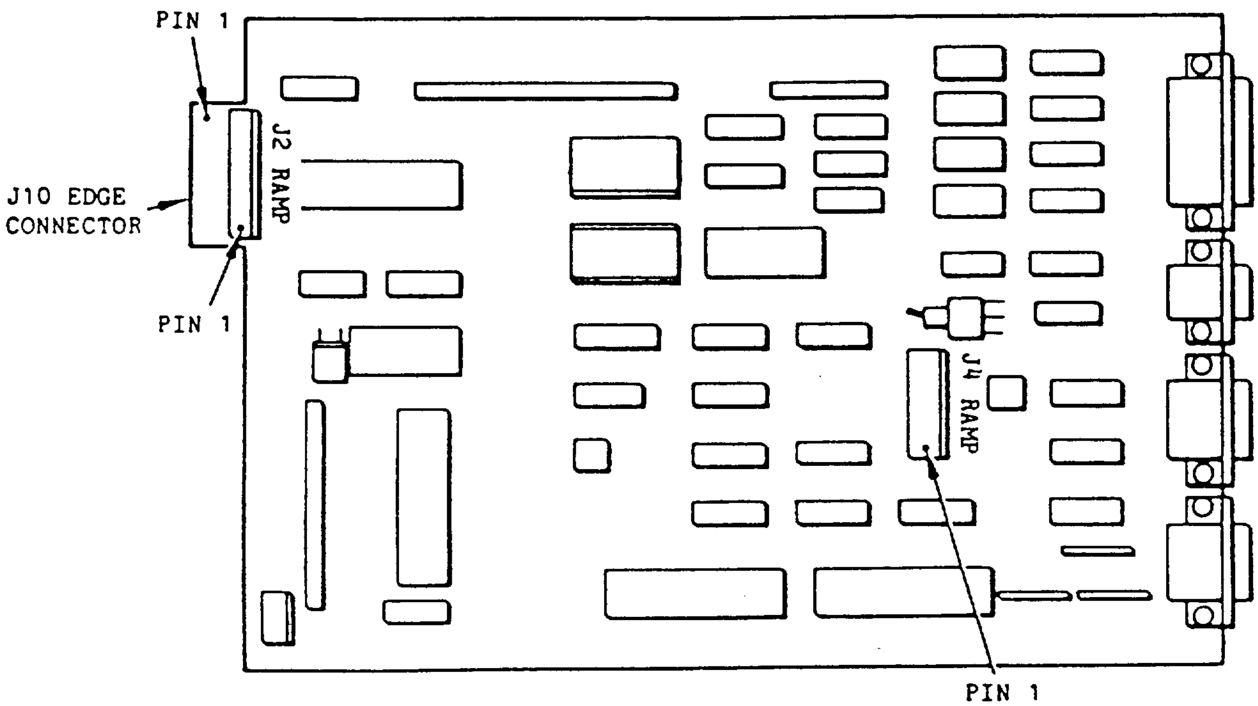
a. Connect the 10-foot (3M) cable supplied with the 2100 from the Motor Connector (9-Pin "D" Canon DE9P or equivalent) to the input of the Driver. The motor connector is located to the left of the AC line input on the Driver and is secured by twisting the metal locking collar. (Refer to Figure 3-4.)

Note
Do not apply power to the Driver until the motor has been connected and the connector's plastic locking collar securely tightened.

b. Connect the Driver to the Indexer as shown in Figure 3-4.

c. Connect the Indexer AC power cable to a properly rated AC outlet (or to the proper power supply for the 2100-4).

d. Connect the Driver AC power cable to a properly rated AC outlet.



NOTE: 2100-4 CARD VIEWED FROM COMPONENT SIDE

Figure 3-3. 2100-4 Power Supply Connectors

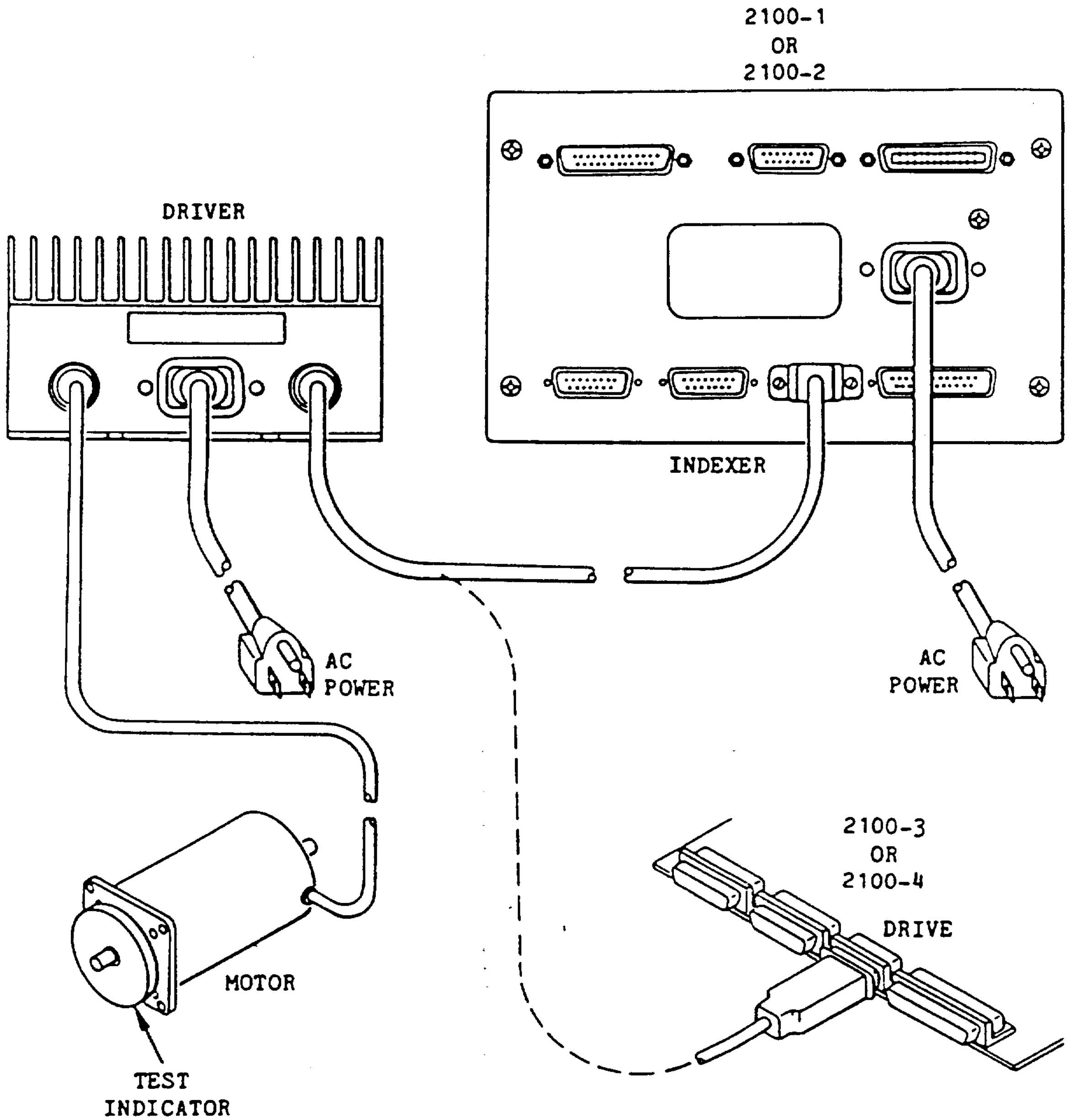


Figure 3-4. Connection of Motor/Drive

Table 3-2. 2100-4 Power Supply Pinout Connections

Description	J10 10 Pin Edge Connector	J2 (10 Pin Ramp)	J4 (8 Pin Ramp)
N.C.	1	10	N.A.
Chassis GND	2	9	7
-12 VDC @ 50 mA	3	8	6
+12 VDC @ 50 mA	4	7	5
+5 VDC 3*	6	5	4
+5 VDC 2*	7	4	3
+5 VDC 1*	8	3	2
DC GND	9	1,2	1
DC GND	10	1,2	1

Note: When wiring a 2100-4, connect +5 VDC Pins 6, 7, and 8 on J10 or Pins 3, 4, and 5 on J2, or Pins 2, 3, and 4 on J4 together for single remote power supply operation.

*All three 5 VDC inputs must be connected together by the user.

3.5 TESTING THE INDEXER-MOTOR/DRIVE COMBINATION

3.5.1 2100-1

a. Mount an indicator on the shaft of the motor.

Note

The indicator should represent a balanced load with an inertia approximately equal to the motor load inertia. For example, a drill chuck may be used. This load is required only for high-speed operation.

b. Position the motor so that the indicator can rotate without interference.

c. Set the Front Control Panel controls as shown below. The numbers in parenthesis describe values that reflect the standard factory DIP switch settings for 25,000 step/rev.

1. Set the ALT/PRESET/CONT switch to PRESET.

2. Set 10 on the ACCEL/DECEL leverwheels (10 rev/sec/sec).

3. Set 10000 on the VELOCITY leverwheels (10.000 rev/sec).

4. Set + and 500000 on the POSITION leverwheels (20 revolutions in the clockwise direction or 500,000 steps at 25,000 step/rev).

d. Press the **POWER** switch on the front panel. The green indicator should light.

e. Press **START**. When the factory default values are used for the DIP switches, a Compumotor 25,000-step motor will be accelerated from 0 to 10 rev/sec (600 rpm) in 1 second (**ACCELERATE** LED on). During this first second, the motor shaft will turn 5 complete revolutions. The motor will then run one second at constant velocity for 10 complete revolutions (**CONSTANT V** indicator ON). The motor will then decelerate for one second from 10 rev/sec to 0 (**DECELERATE** LED ON) and 5 revolutions. When the motor stops, it will have completed 20 full revolutions in 3 seconds.

f. If the Indexer is to be used in the LOCAL MANUAL Mode with no other inputs, restore the top cover. If other devices such as encoders, limit switches, etc., are to be connected, refer to the specific paragraphs for each option.

g. This completes installation of the basic 2100-1 Indexer motor/drive combination.

3.5.2 2100-2, 2100-3 and 2100-4

a. Mount an indicator as described in section 3.5.1a on the shaft of the motor.

b. Position the motor so that the indicator can rotate without interference.

c. Apply power to the Indexer. (Press the **POWER** switch on the front panel of the 2100-2. The green indicator should light.)

d. Set up and test the communications link per section 3.9.3.

Note

Even if you plan to operate with an IEEE-488 interface, you may find it advantageous to initially set up an RS-232C interface to test the Indexer and to become familiar with the 2100 commands.

e. Restore the top cover of the 2100-2. If other devices such as encoders, limit switches, etc., are to be connected, refer to the specific paragraphs for each option.

f. This completes installation of the basic 2100-2, 2100-3, and 2100-4 Indexer motor/drive combinations. Refer to Chapters 5 and 6 or Chapters 5 and 7 for operation via the communications interface.

3.6 SETTING THE DIP SWITCHES

The DIP switch settings are summarized in Table 3-3, which includes references to the portion of the manual that describes the rationale for choosing a particular value or option.

Remove the top cover (four screws) to gain access to the DIP switches.

3.7 LIMIT SWITCHES

The limit switches are connected to Auxiliary Connector J8. Pinouts for this connector are shown in Table 3-5.

If initial systems tests are to be performed with the motor connected to a limited-travel mechanism, it is essential that limit switches be installed to protect the mechanism. The motor itself can be stalled indefinitely without damage.

Typical switches include mechanical contact closures, optical switches, or Hall-effect devices. The easiest to mount and wire are typically the mechanical-type switches.

Note

Limit-switch polarity is determined by DIP Switch S4-8. Normally closed limit switches require S4-8 ON (active high). Normally open limit switches require S4-8 OFF (active low).

a. DIP Switch S1 -- RS-232 Communication. (See section 3.9.)

Baud Rate Selection

	110	300	600	1200	2400	4800	9600*
S1-1	OFF	ON	OFF	ON	OFF	ON	OFF
S1-2	OFF	OFF	ON	ON	OFF	OFF	ON
S1-3	OFF	OFF	OFF	OFF	ON	ON	ON
S1-4	OFF*/ON: Echo ON/OFF						
S1-5	OFF*/ON: Parity OFF/ON						
S1-6	OFF*/ON: Parity ODD/EVEN						
S1-7	OFF/ON*: Data Bits 7/8						
S1-8	OFF/ON*: Stop Bits 1/2						

b. DIP Switch S2

S2-1 through S2-4 Unit Number: Factory Setting 1 (see section 5.5.2)

S2-5 OFF*/ON: Motor Resolution steps/rev (see Tables 3-4 or 3-7 for -P or -488 units)

S2-6 OFF*/ON: Velocity Range Normal/Low (see section 2.3.2)

S2-7 OFF*/ON: Test Routine #1 (Normally OFF) (see section 3.9.3)

S2-8 OFF*/ON: Test Routine #2 (Normally OFF) (see section 3.9.3)

c. DIP Switch S3: Distance Scale Factor (1-255) (see section 2.3.4)

* Factory Setting

Table 3-3. DIP Switch Setting Summary (Continued)

d. DIP Switch S4

S4-1	OFF*/ON:	Set to OFF (obsolete 1200 compatibility)
S4-2	OFF/ON*:	721 Display (Option): Incremental/Absolute Incremental shows distance of last move. Absolute is total count since start up.
S4-3	OFF*/ON:	LOAD AND GO Option: Inactive/Active (See section 5.4.2.)
S4-4	OFF*/ON:	Front panel START able to clear Pause (See (See section 5.4.4a.): No/Yes
S4-5	OFF*/ON:	Direction Source Control: Front Panel/Joystick Connector
S4-6	OFF*/ON:	Direction: Normal/Inverted
S4-7	OFF/ON*:	Joystick Pulse Frequency: Scaled/Not Scaled by 2100 Velocity Value (See section 4.5)
S4-8	OFF*/ON:	Limit Switch inputs Active Low/High (See section 3.7.)

e. DIP Switch S6

Acceleration Range (rev/sec/sec)

	1-99*	0.1-9.9	10-990	0.01-0.99	
#1	OFF	ON	OFF	ON	See section 2.3.3
#2	OFF	OFF	ON	ON	See section 2.3.3

#3 OFF/ON*: START Repeat ENABLE/DISABLE — See section 4.3.8

#4 OFF/ON*: Alternate Mode Stop Control Immediate/End of Current Cycle* See section 4.3.2

NOTES: AC Power/DC Power to the Indexer must be cycled after DIP switches are changed in order for the new setting to be used. The exceptions are S4-6, S4-7 and S6-1 through S6-4 inclusive.

* Factory setting

Table 3-4. Motor Resolution

Configuration	Motor Resolution	Set S-25
R11 (STD)	25,000	OFF
R14 (STD)	50,000	ON
R12	25,400	OFF
R13	36,000	ON
R10	21,600	OFF
R4	1,000	OFF
R4	10,000	ON
R2	400	ON
R1	200	OFF

Disconnect AC power to the motor/drive and rotate the motor by hand to determine in which direction the mechanism moves for clockwise rotation of the motor shaft. The sense of CW and CCW motor rotation is determined as if the observer were looking at the motor from the mounting flange end. (See Figure 3-5.)

Install the limit switches so that there is room to stop. Wire the Common (C) terminal to Pin 9 (GND) of Auxiliary Connector J8 (15 Pin "D" Canon DA15P or equivalent) and the normally open (NO) or normally closed (NC) terminal to Pin 1 (CW Limit).

Place and mount the CCW Limit Switch in a similar fashion, wiring the Common terminal to Pin 10 (GND) and the NC OR NO open terminal to Pin 2 (CCW Limit).

CAUTION

Do not tie the Auxiliary Connector GROUND to the equipment or AC ground. Connect cable shields to the equipment case ground, not the Auxiliary Connector GROUND.

3.8 **AUXILIARY CONNECTOR**

The pinouts are shown in Table 3-5. The limit switches were discussed in section 3.7. The trigger inputs are discussed in section 5.4.4. The PROGRAMMABLE OUTPUT is described in section 5.6.5.

Refer to sections 4.3.4 through 4.3.7 for a discussion of the following functions:

REMOTE START/STOP inputs; MOTOR SHUTDOWN REQUEST inputs; IN POSITION output; LOAD DATA input; LOAD READY output

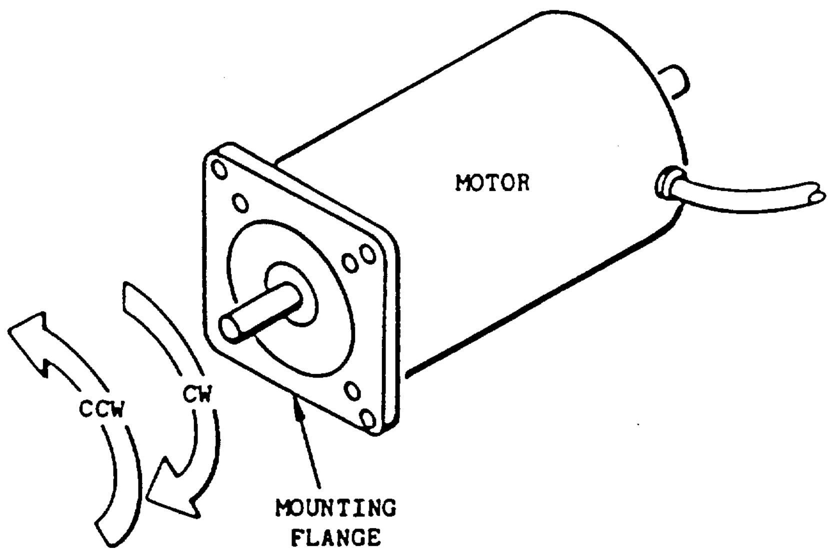


Figure 3-5. Direction of Rotation Determination

Table 3-5. Auxiliary Connector Pinouts

Pin Number	2100 Function
1	CW LIMIT (Input)
2	CCW LIMIT (Input)
3	REMOTE START (Input)
4	REMOTE STOP (Input)
5	MOTOR SHUTDOWN REQUEST (Input)
6	LOAD (Input)
7	TRIGGER (Input) No. 3
8	TRIGGER (Input) No. 2
9	GND
10	GND
11	IN POSITION (Output)
12	LOAD READY (Output)
13	TRIGGER (Input) No. 1
14	REMOTE GO HOME (-P option only)
15	PROGRAMMABLE OUTPUT (Output)

NC = Not Connected

GND = Signal Ground

3.9 RS-232C COMMUNICATIONS INTERFACE

3.9.1 RS-232C CABLE

A three-wire cable is required for the 2100 to transmit and receive signals. The use of a shielded cable is recommended. The pinout connections are shown in Figure 3-6.

Some terminals, DCEs, and computers may require additional signals not supplied by the 2100. A typical DCE connection is shown in Table 3-6. A simple null DCE connector is shown in Figure 3-7. Verify that you have the proper signals.

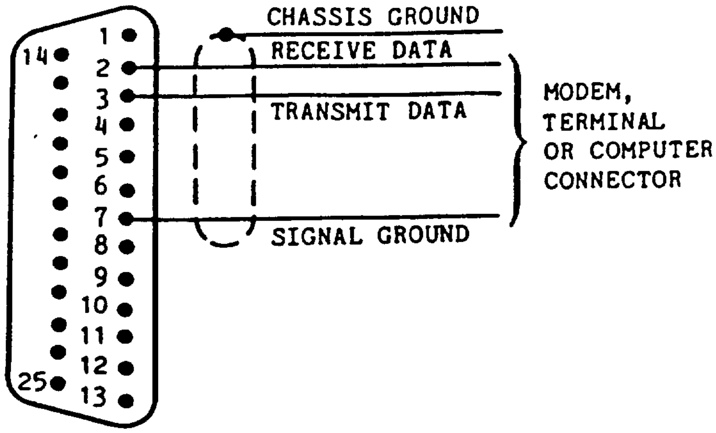
You may have to interconnect some of the 25 pins of the RS-232C "D" connector at the terminal end of the cable to establish the proper signals. The 2100 does not provide signals on any pins other than 2, 3, and 7 of the RS-232C interface connector. An internal switch of the 2100 (S5) marked ANS/ORIG allows you to swap the signals on pins 2 and 3 of the 2100 RS-232C interface connector.

If "daisy-chained" cabling is required, refer to Figure 3-8.

Note

Refer to the equipment manual of your terminal, modem, or computer for instructions on what RS-232C characteristics can be changed and how to set up the desired values. The characteristics of interest are baud rate, parity, data bits, stop bits, and device address.

Turn the Indexer OFF with the AC power switch before changing the DIP switch settings. After the switch settings are made, turn the AC power ON. Any time the DIP switch settings are changed, the AC power must be cycled OFF and back ON before the new settings are recognized by the 2100.



NOTE:

1. CONNECT SHIELD TO PIN 1 ON INDEXER SIDE OF CABLE. CONNECT OTHER END OF SHIELD TO TERMINAL, MODEM OR COMPUTER EARTH GROUND. NO INTERNAL INDEXER CONNECTION TO PIN 1.

2. MAXIMUM LENGTH OF CABLE PER THE EIA RS-232C STANDARD IS 50 FT.

3. VOLTAGE LEVELS PER THE EIA STANDARD ARE 5 TO 15 VOLTS IN MAGNITUDE. EXPECTED LEVELS FOR THE INDEXER ARE 12 VOLTS.

4. INDEXER USES 8251A UART.

5. CONNECTOR IS 25 PIN "D" CONNECTOR (DB25P)

6. VIEW LOOKING AT CABLE CONNECTOR AT INDEXER END

Figure 3-6. RS-232C Cable

Table 3-6. Typical DCE Connection Pinouts

25 Pin Connector Pin No.	EIA Designation	Function	Signal Originated by DTE or DCE
1	AA	Chassis Ground	---
2	BA	Send Data (SD)**	DTE*
3	BB	Receive Data (RD)**	DCE
4	CA	Request To Send (RTS)	DTE
5	CB	Clear to Send (CS)	DCE
6	CC	Data Set Ready (MR)	DCE
7	AB	Signal Ground (SG)	---
8	CF	Received Line Signal Detector (CO)	DCE
20	CD	Data Terminals Ready (TR)	DTE

* DTE -- Data terminal equipment
DCE -- Data communication equipment

** Switch S5 of the 2100 can be used to swap these two signals.

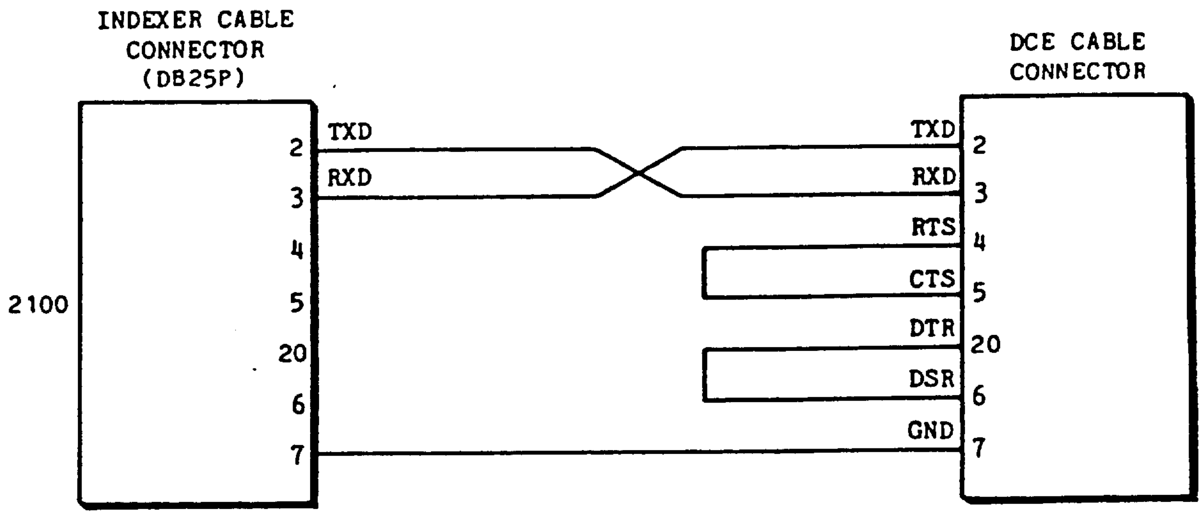


Figure 3-7. Null DCE Connector

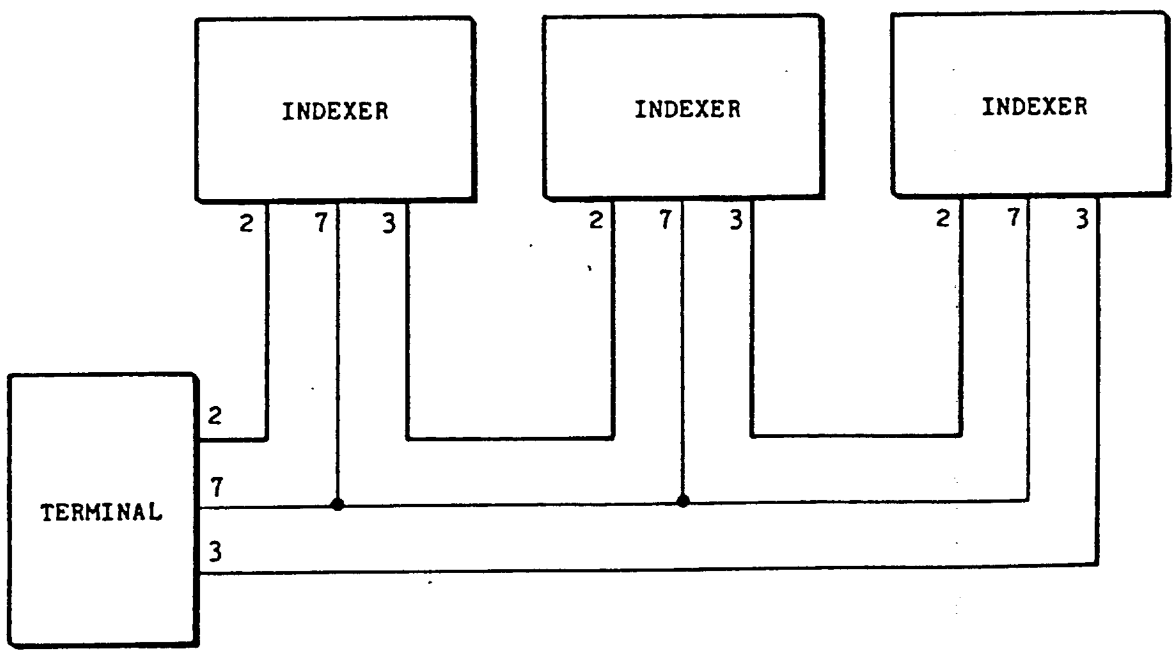


Figure 3-8. "Daisy-Chain" Cabling

3.9.2 MATCHING RS-232C INTERFACE CHARACTERISTICS

As a rule, either the communications equipment protocol can be set to match that of the indexer, or vice versa. The terminal or computer should be configured for Full Duplex operation, and the indexer set to Echo all characters. The following characteristics must be matched for the RS-232C interface.

a. BAUD RATE. Controlled by DIP switch S1. (Refer to Figure 3-1 and Table 3-3.) Set S1-1, S1-2, and S1-3 in accordance with Table 3-3 to match the baud rate of the terminal, DCE, or computer. The baud rate of "dumb" terminals is usually set with a DIP switch on the terminal. Normally the highest usable baud rate is selected.

b. ECHO ON OR OFF. Factory default is ECHO ON. If this switch is on, the indexer will only transmit responses to status requests. Normally echoed commands will not be echoed.

   CAUTION: this switch must be Off when multiple indexers are on the same RS-232 communication channel.

c. PARITY OFF OR ON. Factory set default value is OFF. Set the 2100 to match the other equipment using DIP switch S1-5. (Refer to Figure 3-1 and Table 3-3.)

d. PARITY ODD/EVEN. Factory set default value is ODD. Set this value with DIP switch S1-6. (Refer to Figure 3-1 and Table 3-3.)

e. DATA BITS 7 or 8. Factory set default values is 8. Set this characteristic with DIP switch S1-7. (Refer to Figure 3-1 and Table 3-3.)

f. STOP BITS, 1 or 2. Factory set default value is 2. Set this value with DIP switch S1-8. (Refer to Figure 3-1 and Table 3-3.)

g. UNIT NUMBER. This parameter becomes important when more than one indexer is controlled via the same RS-232C interface. The unit number determines which indexer will respond to a given command. Each indexer is set for a specific unit number. The commands generated by the terminal or modem must include the Unit Numbers for all status request commands. (Refer to Figure 3-1 and Table 3-3. See also Chapter 5 for status request commands.)

Remove the top cover of the 2100-1 or 2100-2 to gain access to the internal DIP switches of the 2100. (See Figure 3-1.)

3.9.3 TESTING THE RS-232C INTERFACE

TRANSMITTER TEST:

a. Using the 3-wire cable described in section 3.9.1, connect the 2100 to the terminal or computer.

b. Turn AC power to the 2100 OFF.

c. Set the internal DIP switches in accordance with section 3.6.

d. Set DIP switch S2-7 to ON.

e. Turn AC power to the 2100 and the terminal or computer ON. Set the terminal keyboard to shift lock, alpha lock, etc. so that you can only enter capital (upper case) letters. If the host device is a terminal, skip step f.

f. If the host is a computer, a simple program must be written to accept the characters being transmitted from the 2100. Remember that the 2100 does not send carriage return (CR = 0D Hex) or line feed (LF = 0A Hex) characters during this test. This means that the U's Test (step g) may quickly overflow the input buffer of some computers and cause a program error.

g. If the host device is a terminal, a string of "U" characters (55 Hex) will be sent to the terminal and displayed on the screen. The test is successful if a string of U's are received. If the test is unsuccessful, make the following checks.

Condition	Action
No characters received	1. Change ANS/ORIG switch to other position
	2. Refer to step f.
Wrong characters received	Change baud rate to proper value
Occasional errors	Check parity, stop bits, and data bits.

h. After a successful "U" test, turn Indexer AC (or DC) power OFF.

i. Set DIP switch S2-7 to OFF.

RECEIVER TEST:

a. Set DIP switch S2-8 to ON.

b. Reapply AC (or DC) power to Indexer.

c. 2100-1 only. Enter the following characters on the terminal keyboard and observe the front panel LEDs indicated below. Refer to Figure 3-1. (Skip this step for 2100-2, 2100-3, and 2100-4 Indexers.)

Character Entered	LED that Lights
A	START
B	STOP
D	ACCELERATE
H	CONSTANT
P	DECELERATE

Other characters may cause combinations of these indicators to light.

If this test is successful, proceed to step n. If this test (or test of steps e-g) is unsuccessful, recheck the wiring, DIP switch settings, and interface compatibility requirements for the test; then return to step a above. If unsuccessful a second time, contact your Compumotor technical service representative.

d. Turn Indexer AC (or DC) power OFF. Set S2-8 to OFF (S2-7 should also be OFF.)

e. Reapply Indexer AC (or DC) power.

f. Press the terminal space bar (20 Hex), then E, then the space bar. The first space character cleared the UART of the 2100. The next two characters enabled the RS-232C Communications Interface. On the 2100-1 the ON-LINE indicator (red) will light to indicate that the RS-232C Interface is active.

Enter the following command sequence from a "dumb" terminal via the RS-232C Communications Interface.

E A10 V10 D500000 G

When the factory default values are used for the DIP switches, a Compumotor 25,000-step motor will be accelerated from 0 to 10 rev/sec (600 rpm) in 1 second (motor shaft will turn 5 complete revolutions). The motor will then run 1 second at constant velocity (10 complete revolutions). Finally the motor will decelerate for 1 second from 10 rev/sec to 0 (5 revolutions). When the motor stops, it will have completed 20 full revolutions in 3 seconds.

Note that the above line consists of six 2100 commands separated by delimeters. The delimeter is the "space". The final "**G**" command must also be followed by a delimeter, either a space or carriage return character.

g. Press **F**, then the space bar to disable the RS-232C interface.

This completes the RS-232C installation procedure.

3.9.4 TROUBLESHOOTING THE RS-232C INTERFACE

Check the following items if you have any difficulty in operating via the RS-232C Communications Interface:

a. Cycling -- Was the Indexer turned off and then powered-up after the DIP switch settings were changed? This cycling is mandatory to establish the new settings.

b. Baud Rate -- Are the terminal and Indexer set for the same baud rate (DIP Switches S1-1,2,3.)?

c. Parity -- Is the matching parity being used to match the terminal (DIP Switches S1-5,6)?

d. Data Bits -- Are the matching number of data bits being used?

e. Stop Bits -- Are the matching number of stop bits being used (DIP Switch S1-8)?

f. Device Address -- Is the proper device address being used (DIP Switches S2-1,2,3,4)?

g. Post Test -- Are test routines #1 and #2 off (DIP Switches S2-7,8 OFF)?

h. Other -- Does the interface cable have any connections other than those specified in Chapter 3? It should be a three-wire cable (shielded if over ten feet long). Is the cable properly seated? Is the right connector (DP25) being used on the terminal?

i. Activate Entry -- Did you use an upper case **E<CR>** to activate the interface? Try entering a space ahead of the **E** to clear the UART.

j. ANS or ORIG -- Did you have the right position for Switch S5 (ANS/ORIG)? Try changing this switch.

k. ASCII Characters -- Does your terminal use ASCII characters? For example, EBCDC used on the IBM mainframes will not work. Are both units set for 7 bits or 8 bits? Correct number of stop bits.

l. Other Signals on RS-232C -- Does your terminal require other signals on its RS-232C port? Have the proper jumpers been installed in the terminal end of the RS-232C cable to provide the extra signals?

m. Is the cable too long? (Fifty feet is the EIA recommended maximum length.

n. Did you use the "Z" or "F" commands and forget to reestablish the communications link (with the "E" command)?

3.10 IEEE-488 COMMUNICATIONS INTERFACE

3.10.1 IEEE-488 INTERFACE FUNCTIONS

The IEEE-488 Interface performs the following functions defined by the IEEE-488 standard.

L -- Listener
T -- Talker
AH -- Acceptor Handshake
SH -- Source Handshake
SR -- Service Request
SP -- Serial Poll
DC -- Device Clear

3.10.2 HARDWARE INSTALLATION

The IEEE-488 interface circuitry is mounted on an optional printed circuit card installed at the factory. This card may also include an encoder interface for position tracking. The circuit card is mounted inside the 2100-1 and -2 as shown in Figure 3-9.

If field installation of the interface is required, proceed as follows:

a. Disconnect the AC power cable to the 2100.

b. Remove the top cover of the 2100.

c. Connect the 2100 expansion cable to connector J3 of the 2100 printed circuit assembly and J4 of the -488 board.

d. Mount the IEEE-488 connector to the 2100 rear panel if any, and connect the interface cable to J5 of the -488 board.

Pinouts for the IEEE-488 interface are shown in Figure 3-10.

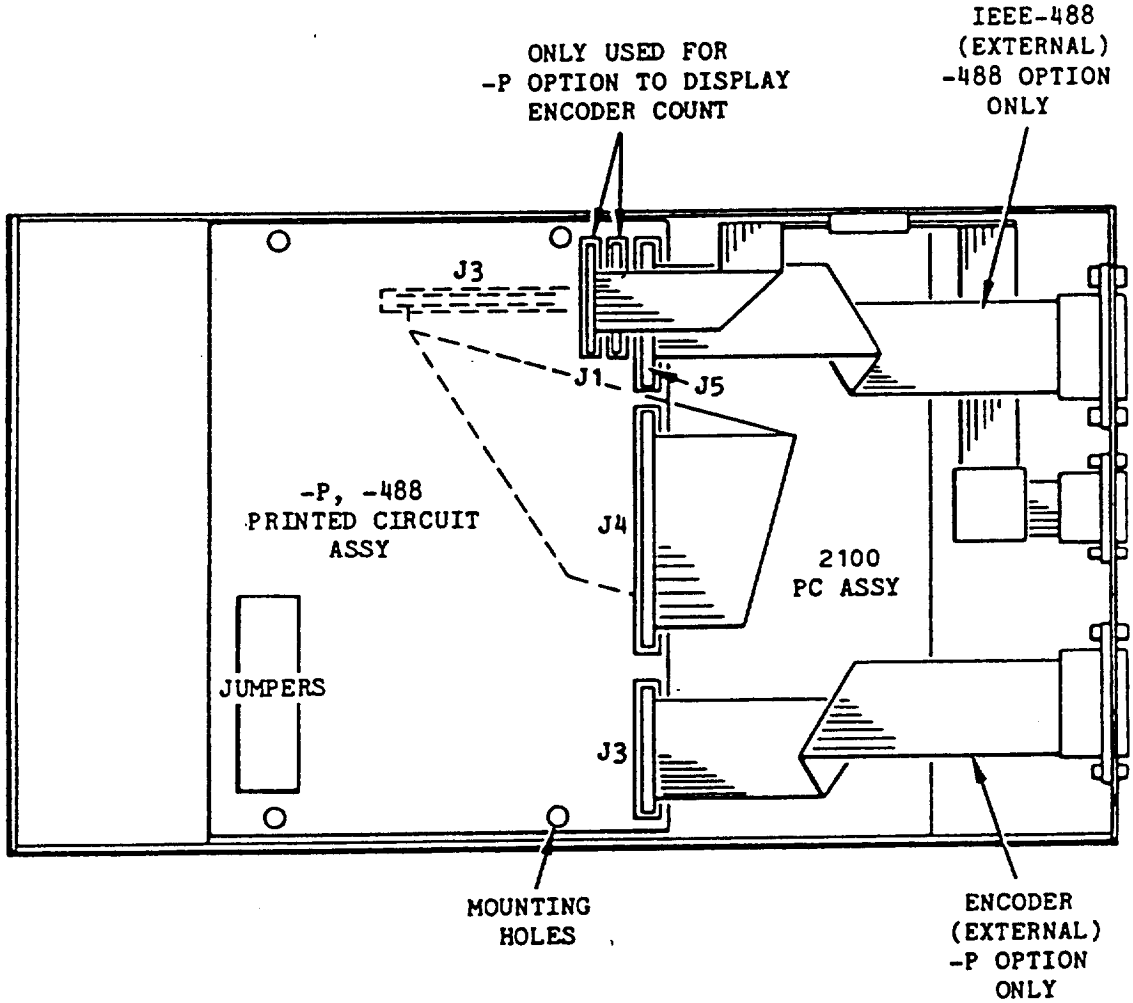


Figure 3-9. -P/-488 Circuit Board

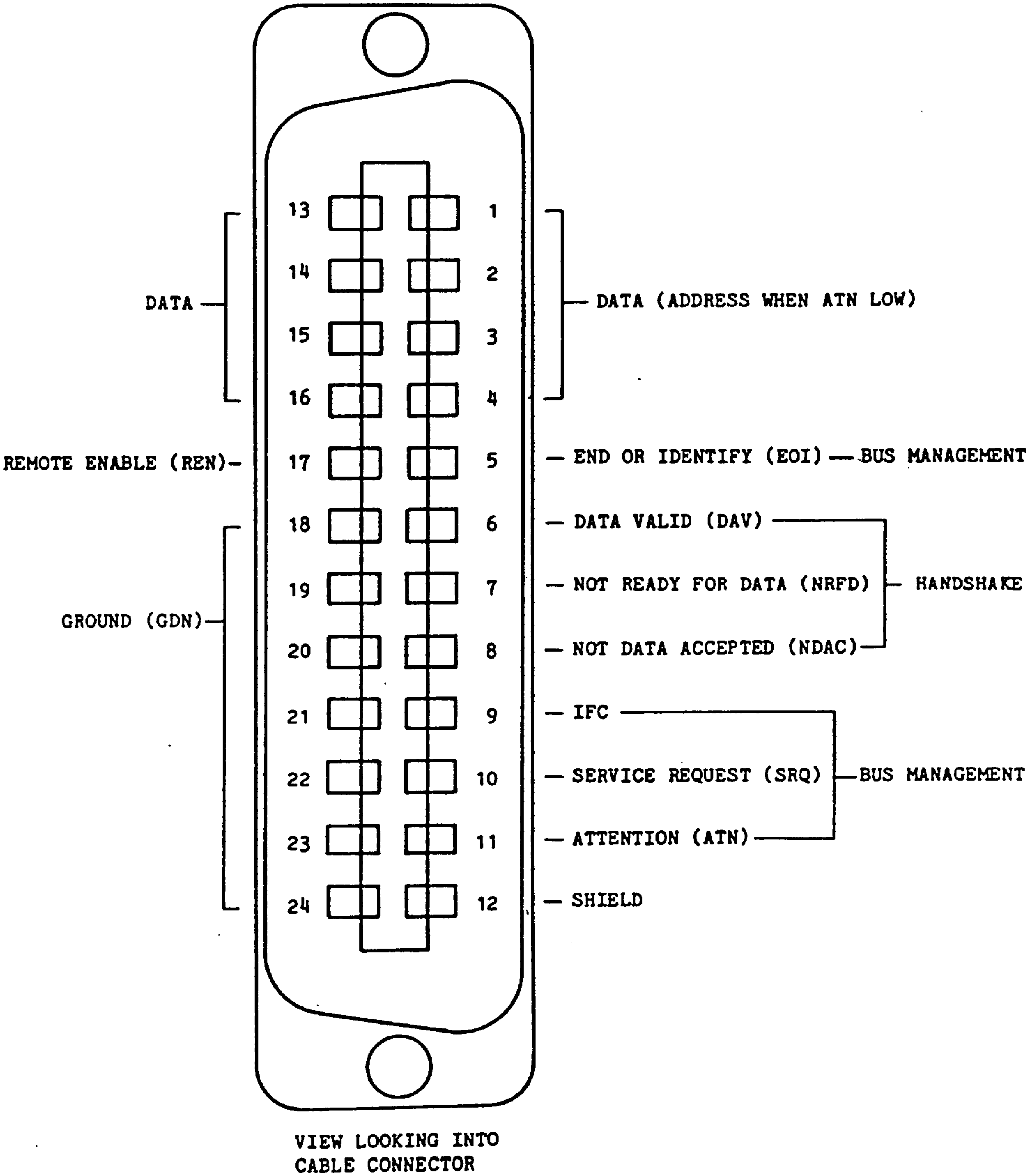


Figure 3-10. IEEE-488 Interface Pinouts

3.10.3 SETTING THE IEEE-488 SWITCHES:

The switches are located on the optional -488 circuit card as shown in Figure 3-11. Set the switches as shown in section 3.10.3.1 (SRQ = Service Request). To start, only S3-1 need be ON to operate the interface.

3.10.3.1 **IEEE-488 Options — Switches S3-1 through S3-8**

S3-1:RS-232 (OFF)/IEEE-488 (ON)

S3-2:SRQ upon move complete OFF/ON

S3-3:SRQ upon joystick request OFF/ON

S3-4:SRQ upon limit OFF/ON

S3-5:SRQ upon ready to transmit reply OFF/ON

S3-6:SRQ (reserved)

S3-7:SRQ upon command buffer full OFF/ON

S3-8:SRQ upon stall or position loss OFF/ON. (For encoder interface options only.)

3.10.3.2 **S4-1 through S4-4: Motor resolution — Switches S4-1 through S4-4**
When the -488 (or -P) option is installed, S2-5 on the main circuit board is not used for motor resolution selection and motor resolution is selected with S4-1 through S4-4 of the -488 board. Fifteen different motor resolutions are selectable by four switches. As discussed in section 2.3.1, the motor resolution switches must be set correctly to assure that velocity and acceleration parameters are correct. (See Table 3-7.)

3.10.4 UNIT NUMBERS (DEVICE ADDRESS)

When the IEEE-488 interface option is installed, DIP Switches S2-1 through S2-5are used for unit number (device address) selection. Addresses 1-31 are valid IEEE-488 unit numbers. (See Table 3-8.)

FACTORY SETTING
POSITION TRACKING AND IEEE-488
OPTION BOARD SWITCHES

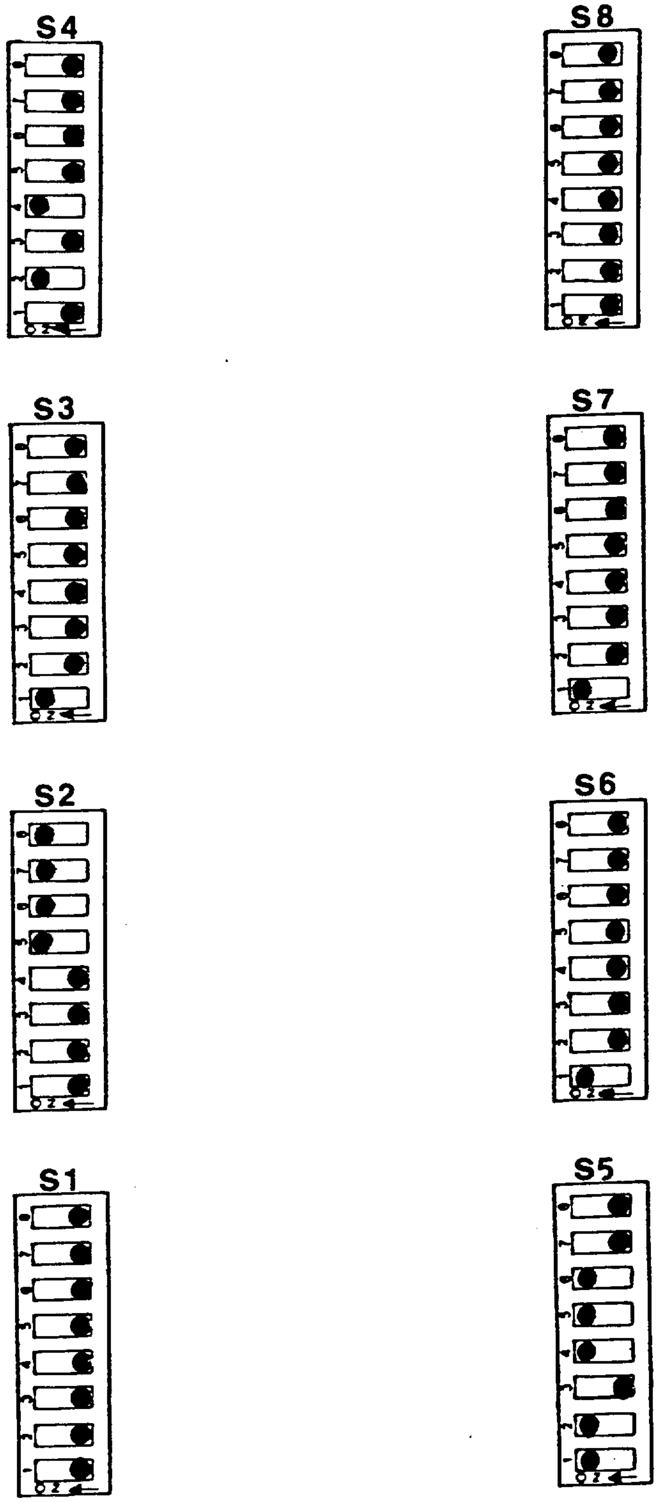


Figure 3-11. Location of Switches

Table 3-7. Switch Settings - Motor Resolution (-P and -488 Option Only)

Motor Resolution (Steps/Revolution)	S4 -- 1	2	3	4
0: 200	OFF	OFF	OFF	OFF
1: 400	ON	OFF	OFF	OFF
2: 800	OFF	ON	OFF	OFF
3: 1000	ON	ON	OFF	OFF
4: 4096	OFF	OFF	ON	OFF
5: 3200	ON	OFF	ON	OFF
6: 5000	OFF	ON	ON	OFF
7: 12,500	ON	ON	ON	OFF
8: 10,000	OFF	OFF	OFF	ON
9: 21,600	ON	OFF	OFF	ON
10: 25,000	OFF	ON	OFF	ON *
11: 25,400	ON	ON	OFF	ON
12: 36,000	OFF	OFF	ON	ON
13: 50,000	ON	OFF	ON	ON
14: 16,384	OFF	ON	ON	ON
15: 20,000	ON	ON	ON	ON

* Factory Setting

Table 3-8. IEEE-488 Option Unit Numbers

IEEE-488 Unit Numbers	DIP Switch**				
	S2-5	S2-4	S2-3	S2-2	S2-1
0	OFF	OFF	OFF	OFF	OFF
1	OFF	OFF	OFF	OFF	ON *
2	OFF	OFF	OFF	ON	OFF
3	OFF	OFF	OFF	ON	ON
4	OFF	OFF	ON	OFF	OFF
5	OFF	OFF	ON	OFF	ON
6	OFF	OFF	ON	ON	OFF
7	OFF	OFF	ON	ON	ON
8	OFF	ON	OFF	OFF	OFF
9	OFF	ON	OFF	OFF	ON
10	OFF	ON	OFF	ON	OFF
11	OFF	ON	OFF	ON	ON
12	OFF	ON	ON	OFF	OFF
13	OFF	ON	ON	OFF	ON
14	OFF	ON	ON	ON	OFF
15	OFF	ON	ON	ON	ON
16	ON	OFF	OFF	OFF	OFF
17	ON	OFF	OFF	OFF	ON
18	ON	OFF	OFF	ON	OFF
19	ON	OFF	OFF	ON	ON
20	ON	OFF	ON	OFF	OFF
21	ON	OFF	ON	ON	OFF
22	ON	OFF	ON	ON	ON
23	ON	OFF	ON	ON	ON
24	ON	ON	OFF	OFF	OFF
25	ON	ON	OFF	OFF	ON
26	ON	ON	OFF	ON	OFF
27	ON	ON	OFF	ON	ON
28	ON	ON	ON	OFF	OFF
29	ON	ON	ON	OFF	ON
30	ON	ON	ON	ON	OFF

* Factory Setting

** Located on 2100 circuit board

3.11 **POSITION TRACKING OPTION**

3.11.1 POSITION TRACKING FUNCTIONS

The -P option provides the circuitry necessary to interface an incremental optical encoder with the 2100. Dual-channel incremental encoders with quadrature and with single-ended or differential-TTL outputs may be used. The encoder may be used as part of a closed loop system 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 functions that are added are:

a. Encoder referenced position
b. Encoder position servo
c. Motor stall detection
d. Position loss detection
e. Multiple axis stop
f. Absolute position coordinates
g. Homing function
h. Multiple motor resolutions

Implementation of the encoder functions listed in a through e above requires connection of the encoder and setup of the appropriate configuration switches. The other functions listed may be implemented without an encoder. Sections 3.11.4 through 3.11.9 below describe the function of these options, section 3.11.12 describes the procedure for setting them.

3.11.2 HARDWARE INSTALLATION

The Position Tracking option is mounted on an optional printed circuit card installed at the factory. This card may also include an IEEE-488 interface. (See section 3.10.) If field installation of the board is required, refer to section 3.10.2. To implement the Position Tracking function, it is necessary to connect an incremental optical encoder to the Indexer. The Indexer will supply power (up to 150 mA) to drive the encoder. Encoder outputs must be 3-5 VDC, square wave, and TTL compatible. When encoders with ended outputs are used, the unused CHANNEL A-, B-, and Z- should be left unconnected.

The pinouts for the encoder connector (25 pin "D") are shown in Table 3-9. Signal characteristics are summarized in Table 3-10. A typical input circuit for channels A, B, and Z is shown in Figure 3-12.

If the 721 Display is to be used, the indexer may be configured to display feedback encoder position rather than motor steps. To do so, it is necessary to reroute the internal Display connector cable. Unplug the display cable from main circuit board J9. Replace it with the small supplied flat cable (p/n 71-002761-01) which must run from J9 on the main board to J2 on the Position Tracking board. The rear panel Display connector is then plugged into J1 on the Position Tracking board.

3.11.3 SELECTING ENCODER RESOLUTION VALUES

The number of encoder steps seen by the Indexer is equal to four times the number of encoder "lines". For example, a 1000-line encoder mounted directly on the motor will generate 4000 encoder steps for each revolution of the motor shaft. A minimum of two motor steps per encoder step is required for successful operation of the Position Maintenance function. In the example above, a motor resolution of better than 8000 steps/rev would be required. Ratios above four motor steps per encoder step insure stability of the Position Maintenance servo function. now the resolution of both the the feedback encoder and the motor for the Position Tracking functions to work properly. These parameters are entered on circuit board switches as the number of encoder lines corresponding to one or more revolutions of the motor.

If a reducer is introduced between the motor shaft and the encoder, the number of encoder steps must be divided by the equivalent gear ratio to define the number of encoder steps received by the Indexer.

For example, using a 25,000-step motor, a 1000-line encoder, and a 10:1 reducer, the ratio of motor revolutions to encoder steps would be changed as shown below:

Parameter	Encoder Direct Mounted to Motor	10:1 Reducer between Motor and Encoder
Number Encoder steps seen by Indexer per motor revolution	4,000	400
Required ratio: motor revs to Encoder steps	1/4,000	1/400
Motor/encoder step ratio	25/4	250/4

Table 3-9. Encoder Connection Pinouts

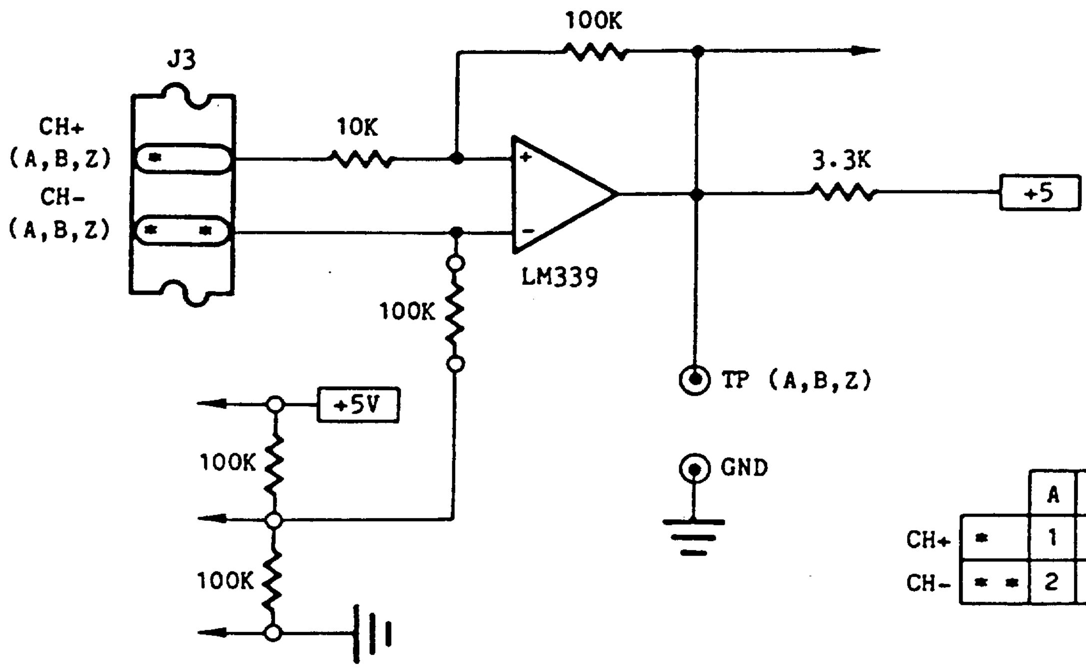
A standard 25-pin male "D" connector (DB25P) is required to connect the feedback encoder to the 2100 "POSITION SENSOR" connector.

Pin	Signal
1.	Quadrature Channel A+ (3v to +5 v square wave required)
2.	Quadrature Channel A- (optional)
3.	Quadrature Channel B+
4.	Quadrature Channel B- (optional)
5.	Channel Z+ (HOME)
6.	Channel Z- (optional)
7.	NC
8.	Shield (case ground)
9.	NC
10.	Encoder Pulse Output (x4 pulse multiplication)
11.	Encoder Direction Output
12.	NC
13.	Home Enable
14.	Ground
15.	Ground
16.	Ground
17.	Ground
18.	Ground
19.	Ground
20.	Ground
21.	NC
22.	NC
23.	+5 VDC (150 mA max)
24.	+5 VDC
25.	+5 VDC

Shell: ITT #DB110963-3

Table 3-10. Encoder Signal Characteristics

Signal	Applies to Pins	Characteristic
Turn-On Voltage	1-6 (signal) (14-20 ground)	2.5 volts with respect to signal ground
Turn-Off Voltage	1-6	2.0 volts with respect to signal ground
Input Impedance	All inputs except HOME ENABLE	100 Kohms
	HOME ENABLE input	3 Kohms (pullup)
Maximum Frequency	All inputs	100 kHz
Maximum Input Voltage	All inputs	5 VDC
Power Drain	23,24,25	150 mA drain



		A	B	Z
CH+	*	1	3	5
CH-	* *	2	4	6

Figure 3-12. Typical Encoder Input Circuit

3.11.4 ENCODER REFERENCED POSITION

The standard 2100 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 making a PRESET move, the Indexer effectively sends out step pulses to the motor until the correct number of encodersteps is returned.

Position information provided by the Indexer may be in units of either encoder steps or motor steps. The power-on configuration is determined by a circuit board switch. An interface command ("FS") allows switching between modes. Both encoder step and motor step absolute positions are always maintained in either mode, and the user may switch from one to the other between moves but not during moves. The encoder step position parameters used must be multiplied by four to account for the quadrature multiplication that takes place in the circuit.

Position data will be reported in the same format. Refer to sections 3.11.12.1 through 3.11.12.3 for switch setting to enable Encoder Step Mode.

3.11.5 ENCODER POSITION SERVO

Although Encoder Step Mode provides that a Preset move ends up in the right position, when the move is complete, the encoder is no longer monitored. The Indexer may be configured to resist any external change in its position when at rest. If external forces cause the encoder position to change, the Indexer will attempt to correct. This Position Maintenance function is selectable via switch (section 3.11.12.3c) or "FS" command. When selected, the system will attempt to maintain the current encoder step reference position. The reference position is established at the end of moves, the end of joystick operations, and when this Servo function is turned ON.

Position Maintenance is effective only while in ENCODER STEP mode. After a move, if it is determined that the encoder position is not changing in spite of steps sent to the motor, this function will be automatically disabled.

3.11.6 MOTOR STALL DETECTION

When the motor is being moved, the Indexer repeatedly compares the number of encoder steps coming in against the number of motor steps being sent out to verify that no gross discrepancy exists as in the case of a motor stall. If the encoder position deviates excessively from the desired position in the course of a move, the 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 (see section 3.11.12.3); terminating the move if a stall is detected (see section 3.11.12.3d); and sending an output signal (see section 3.11.12.3e).

Note

> 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.

a. The Deadband Window parameter may be set with switches (section 3.11.12.5) or by command. Two switches allow a choice of four deadband widths, the DW command allows precise deadband specification in motor pulses. The deadband compensation feature allows mechanical systems with backlash in the geartrain to use the stall detect and position loss detection features. If a nonzero deadband is selected, the position-loss detect and stall detect will not be active until the error exceeds the deadband width and the allowable motor wind-up value.

b. The Stop on Stall function is selectable via switch (section 3.11.12.3d) or "FS" command. If selected, this function will cause termination of a move when a stall is detected. The move will be terminated as soon as the stall is detected, without any delay. This function works either in MOTOR STEP or ENCODER STEP mode.

c. The Output on Stall function is selectable via switch (section 3.11.12.3e) or "FS" command. If selected, the 2100 programmable output will go low when a stall is detected and remain low until a new move begins. If this function is selected, the normal function of the programmable output is inhibited.

3.11.7 POSITION LOSS DETECTION

The Position Loss Detection function may be invoked by switch (section 3.11.12.3g) or by "FS" command. If selected, the system will compare the motor step position and encoder step position at the end of each move. The comparison will also take place upon exit from JOYSTICK mode and following execution of the "K" (kill) or "SV2" (Servo On) commands. The IN POSITION output will not go active and the Indexer will not be "ready" until this comparison is complete. The comparison, which may take 20 to 30 milliseconds, takes into account the selected encoder resolution, motor resolution, and Deadband Window. The comparison will indicate a position loss if the mechanical and electrical synchronization have been lost. The result may be requested via a Status Request command. This function supplements the Stall Detection function by indicating any slippage that may have occurred short of a full stall. The Position Loss Detection function works in both Encoder or Motor Step modes.

Two configuration options pertain to this feature: setting the Deadband Window, as discussed above, and sending an output signal.

The output signal on Position Loss function is selectable via switch (section 3.11.12.3.h) or "FS" command. If selected, the 2100 programmable output will go low when a stall or positioning failure is detected and remain low until a new move begins. If this function is selected, the normal function of the programmable output is inhibited.

3.11.8 MULTIPLE AXIS STOP

In a multi-axis 2100 system, the operator may wish to have all axes stop motion if a stall or position loss is detected on any one axis. This is possible using the KILL on TRIGGER 3 function. This function is selectable via switch (section 3.11.12.3f) or "FS" command. If selected, a low signal on the TRIGGER 3 input will cause immediate termination of the move. By connecting the programmable output from one 2100 to TRIGGER 3 on the next, this function and the output signal functions above will allow the multi-axis move termination.

3.11.9 ABSOLUTE POSITION COORDINATES

In the standard 2100, indexing is incremental, where the operator specifies the distance to be travelled from the current position. The Position Tracking option adds the capability for absolute indexing, where the operator specifies a destination position, referenced to a zero or Home position. The ABSOLUTE POSITIONING mode is selectable via switch (section 3.11.12.3a) or "FS" command. The Home position is used as a zero reference for absolute positioning. A switch determines the power-on configuration for the positioning mode. The power-on position, or the position following a Reset becomes the absolute zero position. Alternatively, the "PZ" command may be used to establish the current position as the zero position.

In this mode, the "PR" instruction may be used to report absolute position in either Motor or Encoder Step Mode. Although the "X1" and "X2" commands also report absolute position, these reports may be referenced to a different zero position. If separate coordinate systems are not desirable, issue the "X0" instruction at the same time that the "PZ" instruction is issued, or following a Homing operation where the "PZ" function is automatic. Otherwise, only the position information yielded by the "PR" instruction will correspond to the absolute position commanded with the "D" instruction.

ABSOLUTE POSITIONING is active only when the LOAD AND GO mode is off. When the LOAD AND GO mode is selected, all positioning will be incremental, even if the ABSOLUTE POSITIONING mode is selected.

Figure 3-13 depicts an Absolute coordinate system with Home.

3.11.10 HOMING FUNCTION

This function may be used to establish a home reference position. The Indexer may be instructed to move the motor to a Home position using either an interface command or an input on the AUXILIARY connector. This Home position is typically established by mounting a load-activated switch so that the switch turns on when the load is in the desired position. When an encoder is used, the Z Channel or Index Channel, if any, may be used to drive the HOME LIMIT input. For either signal, the Home position is located where the HOME LIMIT input signal first becomes active. The homing function is designed to accomodate encoder index signals which are typically of short duration, and works best with this kind of Home signal. All references to the Home limit signal refer to the CHANNEL Z input.

When seeking Home, the indexer will note the motor position when a transition (from "false" to "true") is detected on the CHANNEL Z input. The motor is then decelerated to a stop. The indexer moves back in the opposite direction to a position calculated to be .002 rev counterclockwise from the point where the signal was detected.

> At this point, if the CHANNEL Z input is false, the indexer will creep in the clockwise direction at .1 rev/sec until the signal goes true.
>
> If the input is already true, the indexer stops the motor where it is.

If the CHANNEL Z signal is true when the Go Home instruction is received, the indexer moves the motor .002 rev counterclockwise in an effort to get off the Home position.

> If the signal goes false as a result, the indexer will creep in the clockwise direction at .1 rev/sec until the signal goes true again.
>
> If the signal remains true in spite of the initial move, the indexer stops.

Note: Because the final approach direction is always clockwise, it is necessary to insure that the final approach starts from the counter-clockwise side of the signal. If there is significant backlash and friction in the system, and the indexer is instructed to Go Home in the clockwise direction, the motor can easily end up on the wrong side of the signal, and execute its final approach in the wrong direction.

This problem can also occur if the Go Home speed is high, and the Home limit signal is delayed, by a relay or Programmable Controller for example. In such a situation, it is advisable to initiate homing operations from the clockwise side of home, in the counterclockwise (-) direction. In the case where the Home signal is wide, it will be necessary to initiate the homing operation in the (+) direction from the (-) side of the signal to insure stopping on the signal edge.

When the Homing operation has concluded, the indexer will reset its internal position counter as with the "**PZ**" interface instruction, and will reset the 721 display if any. If the "**X1**" or "**X2**" commands are being used to report absolute position, an "**XO**" command should be issued at this time. Otherwise they will yield an absolute position different from the indexer's assumed position. True indexer position referenced to Home is available using the "**PR**" command.

For rotary encoders, where an indexer signal occurs every revolution, the HOME ENABLE input may be used in conjunction with the CHANNEL Z input to allow selecting one of many index signals. In this situation, a Load-activated switch connected to the HOME ENABLE input locates the general HOME position area, and the indexer channel signal from the encoder is used for final Home positioning. The CHANNEL Z and HOME ENABLE inputs must both be active to mark the Home position.

Under interface control, the GO HOME command has the form GH<direction><velocity>, indicating which direction to move, and at what velocity. For example, the command GH-2 will send the motor in the counterclockwise direction at 2 rev/sec in search of the Home signal. The acceleration parameter used for this move is either 10 or 100 rev/sec/sec, as determined by switch. If an end-of-travel limit is activated before

Home is found, the controller will reverse direction and attempt to find the Home position again. If the other limit is activated before Home is found, the controller will stop trying to go Home. The controller can indicate whether or not the homing process was successful by means of the "R" and "RC" status request commands.

The homing operation may be initiated with hardware by grounding the RESERVED input (pin 14) of the AUXILIARY connector. In this mode the GO HOME velocity and acceleration parameters are determined by switches. The Front Panel +/- Switch is used for direction. A switch is used for direction if no front panel is present. This input may be alternatively configured to instruct the indexer to zero its encoder position counters, setting the current position as the Home position. This is done with the Go Home/Set Home switch (section 3.11.12.4a).

Another switch (section 3.11.12.4b) allows automatic homing on power-up or after a reset ("Z" command). The parameters for this move are the same as for the hardware GO HOME command above.

Upon completion of a homing operation, both the encoder-referenced position and the motor-step position are automatically set to zero, as with the "PZ" instruction.

Figure 3-13 depicts an Absolute coordinate system with Home.

3.11.11 MULTIPLE MOTOR RESOLUTIONS

The standard 2100 provides a switch (S2-5) that allows two options for matching the Indexer to the resolution of the motor. Four switches on the Position Tracking board allow sixteen such options. These switches (Table 3-7) replace the function of the switch (which is then used by the IEEE-488 option, if present). The resolution setting corrects the indexer velocity and acceleration parameters; it does not change the resolution of the position units, which are in steps.

TYPICAL LIMITED TRAVEL APPLICATION

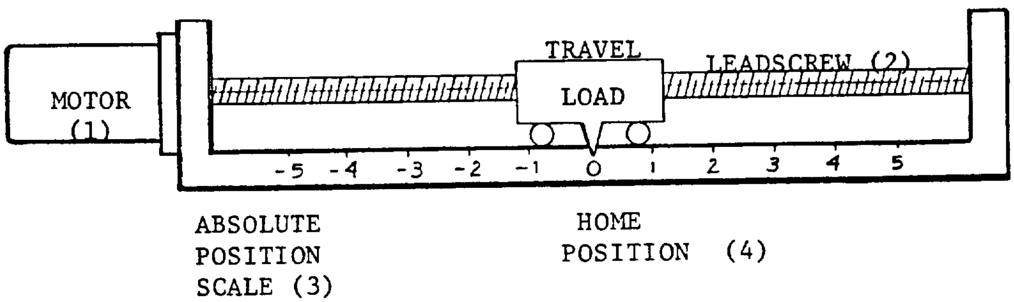


Figure 3-13. Absolute coordinate system

(1) The motor turns the leadscrew, 25,000 steps per revolution

(2) The leadscrew pitch is 4 revolutions per inch

(3) Absolute Positions are; then in inches from HOME, 100,000 motor steps per inch

(4) The Indexer must be notified as to the location of the Home position on the system. If a switch is located there, the Indexer homing function can establish this zero position.

3.11.12 POSITION TRACKING OPTION SWITCH SETTINGS

The Position Tracking circuit board contains a large number of configuration switches. Several functions controlled by these switches are critical to the proper operation of the equipment.

The factory default settings of these switches are such that the machine may be operated from the front panel, or via the interface, for initial testing without setting any switches. To implement the Position Tracking function, it is necessary to remove the top of the 2100 and set the switches. Priority for setting switches follows, with default settings indicated in parentheses.

To operate with encoder:

1. Set the motor resolution: S4-1 through S4-4 (25000 steps)
2. Set the encoder resolution: S6,S7,S8 (1:1000)
3. Set the encoder direction: S5-6 (ChA leads CHB for CCW)
4. Set the desired encoder functions: S1-1 through S1-8 (OFF)

To optimize performance:

5. Set the Home Limit polarity: S5-7 (high true)
6. Set the Go Home parameters: S4-5 through S4-8 (OFF)
7. Set the Go Home velocity: S5-1 through S5-3 (5 rev/sec)
8. Set the Deadband Width: S5-4,S5-5 (1 rev)
9. Set the Position Maintenance parameters: S2-1 through S2-8

3.11.12.1 **Motor Resolution — Switches S4-1 through S4-4.** Refer to Table 3-7 for the motor resolution switch settings. (See Figure 3-11.)

3.11.12.2 **Encoder Resolution — Switches S6-1 through S8-8.** The ratio of motor revolutions to encoder feedback counts is set on switches as follows:

Number of motor revolutions: S6-1 to S6-4 (one digit, 1 to 9 revs)
Number of encoder lines: S6-5 to S8-8 (five digits, 1 to 99,999 lines)

The motor/encoder switches are arranged as six groups of 4 switches, each group of four representing a digit in BCD code. Switches S6-1 through S6-4 represent the number of motor revolutions. Switches S6-5 through S6-8 represent the most significant digit of the number of encoder lines; S8-4 through S8-8 the least significant digit. Refer to table 3-11.

The factory default setting is for a 1,000 line encoder mounted to the motor. The switches are set for 1,000 encoder lines and 1 motor revolution. If a 3 to 1 gear reduction were installed between the motor and encoder, this setting would be changed to 1,000 lines and 3 revolutions. For a 6 to 1 reduction, the numbers are 500 lines and 3 revolutions.

For linear encoders, it is necessary to determine how many lines are traversed for each motor revolution.

In some cases, the easiest way to determine this number is to measure it with the indexer. See Section 3.11.14.

> Example: The user determines that 6 motor revolutions results in a count of 49,380 encoder steps on his 721 display. Dividing by four to account for quadrature detection gives him 12,345 lines. He must set his switches for 12,345 lines in 6 revolutions. The following switches must be turned ON, the rest OFF.
>
> 6 revolutions: S6-2 and S6-3 ON
>
> | | | |
> |---|---|---|
> | 12,345 lines: | S6-5 | (10,000) |
> | | S7-2 | (2,000) |
> | | S7-5 and S7-6 | (100+200=300) |
> | | S8-3 | (40) |
> | | S8-5 and S6-7 | (1+4=5) |

Table 3-11. Encoder Resolution

Number of Motor Revolutions					
	S4-1	S4-2	S4-3	S4-4	BCD Switches
Number of Encoder Lines					
x 10,000	S6-5	S6-6	S6-7	S6-8	
x 1,000	S7-1	S7-2	S7-3	S7-4	
x 100	S7-5	S7-6	S7-7	S7-8	BCD Switches
x 10	S8-1	S8-2	S8-3	S8-4	
x 1	S8-5	S8-6	S8-7	S8-8	

BCD value	BCD switch pattern			
1	ON	OFF	OFF	OFF
2	OFF	ON	OFF	OFF
3	ON	ON	OFF	OFF
4	OFF	OFF	ON	OFF
5	ON	OFF	ON	OFF
6	OFF	ON	ON	OFF
7	ON	ON	ON	OFF
8	OFF	OFF	OFF	ON
9	ON	OFF	OFF	ON

1. Determine the number of encoder lines for one (or more) motor revo lutions. Add leading zeroes to make five digits (ie. 00123).

2. Locate the BCD switch pattern corresponding to the desired number of motor revolutions. Set switches S4-1 through S4-4 accordingly.

3. Locate the BCD switch pattern for each of the five digits corresponding to the number of encoder lines. Set switches S4-5 through S8-8 accordingly in groups of four switches.

3.11.12.3 **Encoder Interface — Switches 1 through 8.** These functions can also be set with the "FS" command described in Chapter 5.

a. **Relative/Absolute Referenced Positioning.** The home position is used as a zero reference for absolute positioning. DIP switch S1-1 will allow selection of a normal relative move, in which a distance from the current position is specified; or of an absolute referenced move, in which the position specified is relative to the home position. Absolute positioning is active only when the LOAD/GO mode is off. When the LOAD/GO mode is selected, all positioning will be relative, even if the absolute positioning mode is selected.

Switch S1-1: Relative/Absolute positioning: OFF/ON

Note

The GO-HOME and ABSOLUTE positioning functions do not require an encoder to be attached. If MOTOR STEP mode is selected, and Switches S1-3 through 8 are set OFF, the Position Tracking board provides the GO-HOME and ABSOLUTE positioning functions without an encoder being attached.

b. **MOTOR STEP mode/ENCODER STEP mode.** In ENCODER STEP mode, the distance specifications and position reports are in encoder steps after quadrature detection. In MOTOR STEP mode the distance specifications and position reports are in motor steps. Both encoder step and motor step absolute positions are always maintained in either mode, and the user may switch from one to the other between moves, but not during moves.

Switch S1-2: MOTOR STEP mode/ENCODER STEP mode: OFF/ON

c. **Encoder Position Maintenance.** When this function is selected, the system will attempt to maintain the current encoder step reference position while stopped. The reference position is established at the end of moves, the end of joystick operation, and when this function is turned on. Position maintenance is only effective while in ENCODER STEP mode. When external forces result in a chnage in encoder position, the indexer will attempt to correct. If it is determined that the encoder position is not changing in spite of steps being sent to the motor, this function will be automatically disabled.

Switch S1-3: Encoder position maintenance: OFF/ON

d. **Stop On Stall.** If selected, this function will cause termination of a move when a stall is detected. The move will be terminated as soon as the stall is detected.

Switch S1-4: Stop On Stall: OFF/ON

e. **Output On Stall.** If this function is selected, the PROGRAMMABLE OUTPUT will be set high, and will go low when a stall is detected and remain low until a new move begins. If this function is selected, the normal function of the programmable output is inhibited.

Switch S1-5: Output On Stall: OFF/ON

f. **Kill Motion On TRIGGER 3.** If selected, this function will watch for a low signal on the TRIGGER 3 input. If the input goes low, any motion in process is abruptly terminated as with a Kill command (K). This function allows multiple axis systems to halt if one axis stalls. The Programmable Output from one axis is connected to the TRIGGER 3 input of the next, and the Programmable Output of the last is connected to the TRIGGER 3 input of the first.

When this function is enabled, if a TRIGGER 3 signal is received, the Programmable Output is set low, allowing this chaining of signals.

Switch S1-6: Kill Motion On TRIGGER 3: OFF/ON

g. **Post Move Position Loss Detection.** If selected, the system will compare the motor step position and encoder step position at the end of each move. The comparison will also take place on EXIT FROM JOYSTICK mode, and at the KILL or SV2 commands. The comparison will indicate a position loss if the mechanical and electrical synchronization has been lost. The IN POSITION output will not go active and the indexer will not be "ready" until this comparison is complete. The comparison is scaled according to the selected encoder resolution and motor resolution and may take 20 to 30 milliseconds. The results may be requested via a status request command.

Switch S1-7: Post Move Position Loss Detection: OFF/ON

h. **Output On Position Loss.** This function may be active only if the Position Loss Detection function has been selected. If both are selected, the Programmable Output will be set high and will go low when the position loss is detected. It will stay low until the next move begins. The state of the output for this function will not be valid until the IN POSITION output is also active.

Switch S1-8: Output On Position Loss: OFF/ON

3.11.12.4 GO-HOME Parameters -- Switches S4-5 through S5-3.

a. **GO_HOME/SET HOME** This function may be used to change the function of the AUXILIARY Go Home input so that an absolute zero reference position can be established anywhere. When the Set Home function is selected, issuing a Go Home command via the hardware Go Home input will cause the indexer to establish the current position as absolute zero. The Set Home function works only in Front Panel mode, and not while "On Line".

Switch S4-7: Go Home/Set Home: OFF/ON (Set Home:Front Panel only)

b. **Power-On Go Home.** The indexer may be configured to automatically seek the Home position on Power up, or following a Reset command ("Z"). Velocity and acceleration parameters for this operation are determined by switch settings described below. The Power-On Go Home will begin in the direction indicated by the Front Panel Direction switch, or by switch S4-6 if no Front Panel is present.

Switch S4-5: Power-On Go Home Enable/Disable: ON/OFF

c. **GO HOME VELOCITY and ACCELERATION.** For the Power On Go Home or the Go Home input, homing velocity and acceleration parameters are determined by switches S4-8 and S5-1 through S5-3 as indicated in the following table.

Go Home Velocity	Switch		
	S5-1	S5-2	S5-3
0.1 rev/sec	OFF	OFF	OFF
0.5 rev/sec	ON	OFF	OFF
1.0 rev/sec	OFF	ON	OFF
5.0 rev/sec	ON	ON	OFF*
10.0 rev/sec	OFF	OFF	ON
20.0 rev/sec	ON	OFF	ON
50.0 rev/sec	OFF	ON	ON
100.0 rev/sec	ON	ON	ON

Switch S4-6: GO HOME accel, 10/100 rev/sec/sec: OFF/ON

d. **Default Go Home Direction.** If FRONT PANEL mode selected, the FRONT PANEL direction switch determines the Go Home direction. If no FRONT PANEL is present, switch S4-6 determines the direction of the power-on GO HOME.

Switch S4-6: GO HOME CCW/CW If No Front Panel present: OFF/ON

3.11.12.5 **Backlash Deadband -- Switches S5-4 and S5-5.** These switches allow a choice of four backlash deadband widths, as indicated in the table below. The backlash deadband allows systems with backlash in the geartrain to use the stall detection and position loss detection features. If a nonzero deadband is selected, the position loss detection and stall detection will not take action until the error exceeds the deadband width.

Switches S5-4,S5-5: Backlash Deadband

Backlash (revs)	Switch S5-4	5
0.0	OFF	OFF
0.05	ON	OFF
0.1	OFF	ON
1.0	ON	ON*

3.11.12.6 **Encoder Input Polarities — Switches S5-6 and S5-7.**

Switch S5-6: invert encoder direction (Channel A and B reversed)
Switch S5-7: home limit polarity (Z Channel input)
Switch S5-8: not used

*Factory Setting

3.11.12.7 **Position Maintenance Parameters**

In the POSITION SERVO 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 magnitude of the correction response. The correction response calculation yields a correction velocity, and the nature of the servo is to drive until the correction velocity (and error) is zero. The formula for generating the correction velocity is as follows:

V=K(f(e)), V less than or equal to Vmax

V = correction velocity in motor steps/sec
K = correction gain constant in steps/sec/encoder step
f = correction mode formula
e = error in encoder steps
Vmax = maximum correction velocity

There are three switch options for how the error is used to calculate the correction velocity:

S2-1	S2-2		
OFF	OFF	Linear:	f(e) = e
OFF	ON	Square root:	f(e) = square root of e
ON	OFF	Square:	f(e) = e squared

There are eight switch options for the gain constant, ranging from 15 to 1920. (See Gain Constant Table.)

There are eight switch options for the maximum correction velocity ranging from 250 to 32,000 steps per second (in powers of 2 times 250). (See Maximum Correction Velocity Table.)

Lower encoder resolution requires 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 and maximum correction velocity are 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 setting them at low values and increasing them to the point where the system begins to show signs of overshoot.

Gain Constant

Value	S2-		
	3	4	5
15	OFF	OFF	OFF
30	ON	OFF	OFF
60	OFF	ON	OFF
120	ON	ON	OFF
240	OFF	OFF	ON
480	ON	OFF	ON
960	OFF	ON	ON
1920	ON	ON	ON

Maximum Correction Velocity

Value (Steps/sec)	S2-		
	6	7	8
250	OFF	OFF	OFF
500	ON	OFF	OFF
1000	OFF	ON	OFF
2000	ON	ON	OFF
4000	OFF	OFF	ON
8000	ON	OFF	ON
16000	OFF	ON	ON
32000	ON	ON	ON

3.11.13 TESTING THE ENCODER INTERFACE

Refer to Figure 3-13. Proceed as follows:

a. Connect the incremental optical encoder to the POSITION SENSOR connector of the 2100.

b. Remove AC power from the motor/drive.

c. Connect an oscilloscope between test point A and ground (Figure 3-14).

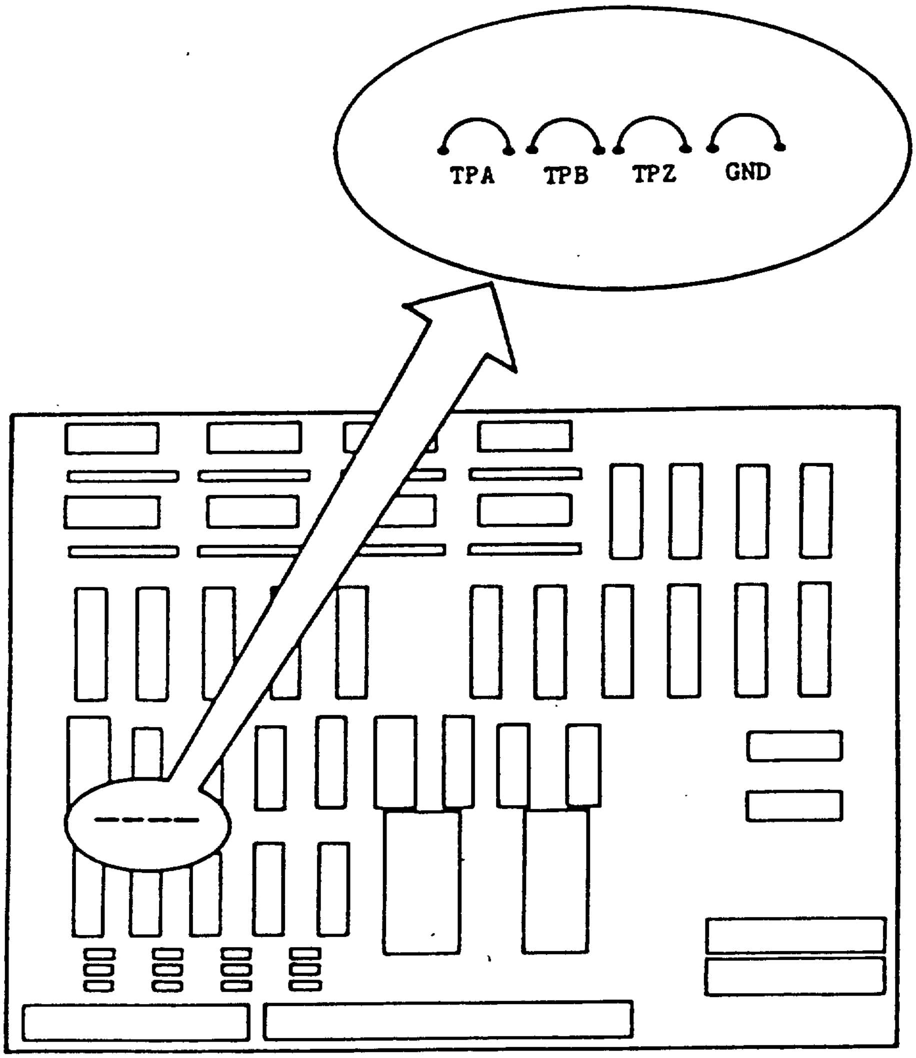
d. Turn the Indexer ON.

e. Slowly rotate the encoder. The voltage at test point A should switch between 0 and +5 volts.

f. Transfer the oscilloscope to test point B and repeat step e.

g. Transfer the oscilloscope to test point Z. The signal on this test point will briefly appear when the encoder is moved through its reference position.

h. If any of the test point signals do not meet the above requirements, recheck the encoder connections.



-P CIRCUIT CARD

Figure 3-13. Encoder Test Points

3.11.14 **TESTING POSITION TRACKING SETUP PARAMETERS**

a. Testing encoder resolution:

Encoder switches: The encoder feedback functions of the 2100 will inevitably foul up if encoder resolution or signal polarity are wrong. The effects of mis-setting the switches is not always obvious at all. In the process of setting up a system, it is wise to verify that the system functions as expected without active encoder feedback, before the encoder functions are turned on. Set Position Tracking board switches S1-1 through 8 OFF.

The best tests for proper function involve interface status requests. It is advisable that two way interface communications be established, that the operator has equipment to communicate interactively with the 2100, and that the operator be familiar with the way open loop commands and status requests are used before attempting to execute the tests below.

The encoder resolution setting may be tested using interface commands, or with the 721 Display if one is available. The idea is to move the motor open loop and verify that the number of feedback encoder counts meets with expectation.

For the 721:

Step 1 - Verify that the 721 is reading encoder steps, that the 2100 rear panel Display connector cable goes to the Position Tracking board as discussed in Section 3.11.2. Set the 2100 Front Panel controls to move the motor one revolution in the "+" direction.

Push the 721 Reset button. Push the 2100 START button. The motor should move one revolution clockwise, and the display should indicate the corresponding feedback count.

Proceed to Step 2.

Using the interface:

Step 1 - Assuming that the indexer under test is "On Line" and is Unit Number 1, use the "**1FR**" status request to verify that all encoder functions are off. The response should be "00000000".

Set the internal encoder position to zero: "**PZ** ". Have the motor move one revolution: "MN A1 V2 D25000 G " (for a 25,000 motor). Report encoder position: "FSB1 1PR FSB0 ".

Step 2 - Repeat the test to insure that backlash or motor windup are not interfering with the test. Divide the number displayed by four. The result should be very close to the number set on switches S6-5 through S8-8 as discussed in Section 3.11.12.2. If the number is negative, reverse switch S5-6.

It should now be safe to enable Encoder Step Mode and Position Maintenance, and all other encoder functions except Stop on Stall. Verify proper operation of the Go Home function before enabling Stop on Stall.

b. Testing the Go Home function:

Limited travel systems need End-of-Travel limit switches to prevent over-travel during this test. It is advisable that the limit switches be tested first to verify that (1) they will allow the motor to move and (2) they will stop the motor as intended.

If the HOME ENABLE input is connected, force it to the true (high) state to avoid interference.

Use the interface "**GH-1**" command or ground the Go Home command input to initiate the Home search.

If the motor encounters both limit switches, or just runs forever, the Home limit signal (CHANNEL Z) was not asserted.

If the motor makes a very short move in the "-" direction, the Home signal is active. This indicates that either the signal is wide, or its polarity is reversed. If the motor is not even at the Home position, reverse Home signal polarity switch S5-7. If the signal is wide, it will be necessary to approach it in the "+" direction. The repeatability of the Homing operation may be tested using the "**X1**" or "**X2**" commands.

c. Testing the Stop on Stall function:

The Stop on Stall function is dependent on the setting for Backlash to give optimum operation, as is the Position Loss Detection function. The factory default setting for this parameter is 1 motor revolution, a fairly large value. If the encoder is mounted on the motor, this parameter should be set to zero for the most timely response.

The actual backlash may be measured using interface commands. The idea is to move in one direction, stop, and make a series of one step moves in the opposite direction. No change in encoder position will occur while the Backlash is being taken up. The number of motor steps counted before any encoder counts are received is the measure of the backlash.

Move the motor in one direction, clear position counters:

"MN A10 V1 D-1000 G X0 PZ "

Execute a series of one step moves and report both motor and encoder position each time:

"D1 PS L G 1X1 FSB1 1PR FSB0 T.5 N C "

This command sequence will move one step, report both motor and encoder position, wait a half second and repeat. The "**PS**" command allows entering the entire sequence before any motion occurs. The "**U**" command may be used to pause the execution, "**S**" to stop.

3.12 MODEL 721 DISPLAY

The Model 721 Display is shown in Figure 3-15.

a. Place the Display on top of the Indexer per the 721 Display installation instructions.

b. Connect the ribbon cable between the 721 Display and the DISPLAY connector of the 2100-1 or 2100-2.

Note

The display is connected to J9 of the 2100 printed circuit assembly for the 2100-3 and 2100-4 options.

3.13 MODEL 852 JOYSTICK

The Model 852 is connected to the Indexer and the motor/drive is controlled by that Indexer. The operation of the Joystick is described in detailed in the Model 852 Operations Manual.

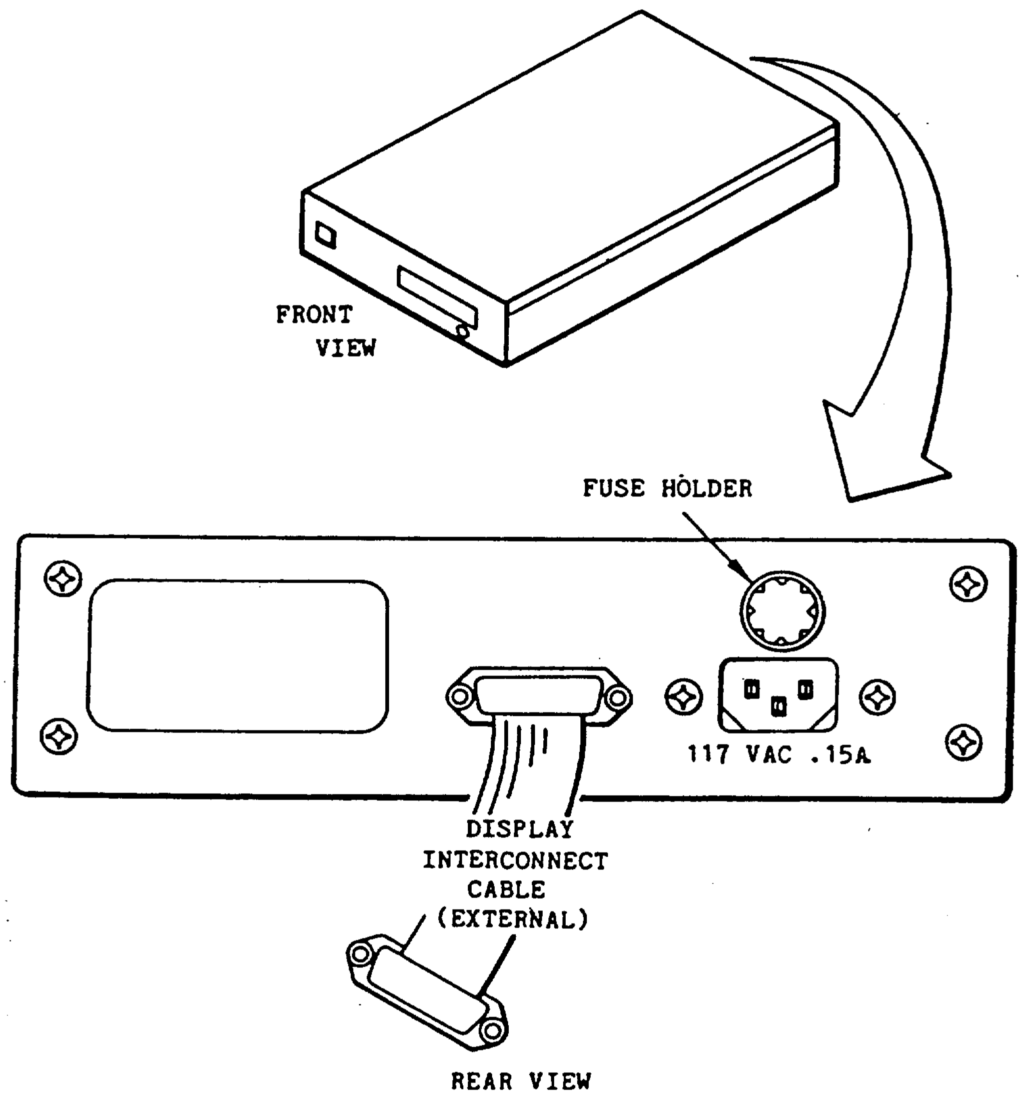


Figure 3-15. 721 Display

Chapter 4

OPERATING PROCEDURES — LOCAL MANUAL CONTROL

4.1 OVERVIEW

This chapter describes the Local Manual Control operations that can be performed using the 2100-1 front panel controls (or their equivalent). (See Figure 4-1.) Using Local Manual Control, you can move the shaft to a preset distance (PRESET mode), run at a constant velocity (CONTINUOUS mode), or rotate back and forth between a start position and a specified position (ALTERNATE mode). Additional operations can be performed using a combination of the front panel controls and the AUXILIARY inputs and outputs.

In LOCAL MANUAL CONTROL mode the parameters that control motion are set with the front panel controls. The front panel or the AUXILIARY inputs can be used to start and stop operation of the motor/drive.

Additional capability can be obtained by adding limit switches, the optional 721 Display, the Model 852 Joystick, and the Position Tracking option.

4.2 2100-1 CONTROLS AND INDICATORS

The 2100-1 Indexer and 721 Display front panel controls and indicators are shown in Figure 4-2 and are described below.

a. **POWER** — AC Power button and indicator (green). Turns the Indexer ON and OFF. Also used to reset Indexer when internal DIP switch settings are changed.

b. **ALT/PRESET/CONT** — Mode Select switch. Allows choice of ALT (alternate between start and a fixed point specified with the PRESET POSITION leverwheels), PRESET (the distance specified with the PRESET POSITION leverwheel switches), or CONT (continuously rotate at the velocity specified with the VELOCITY leverwheel switches).

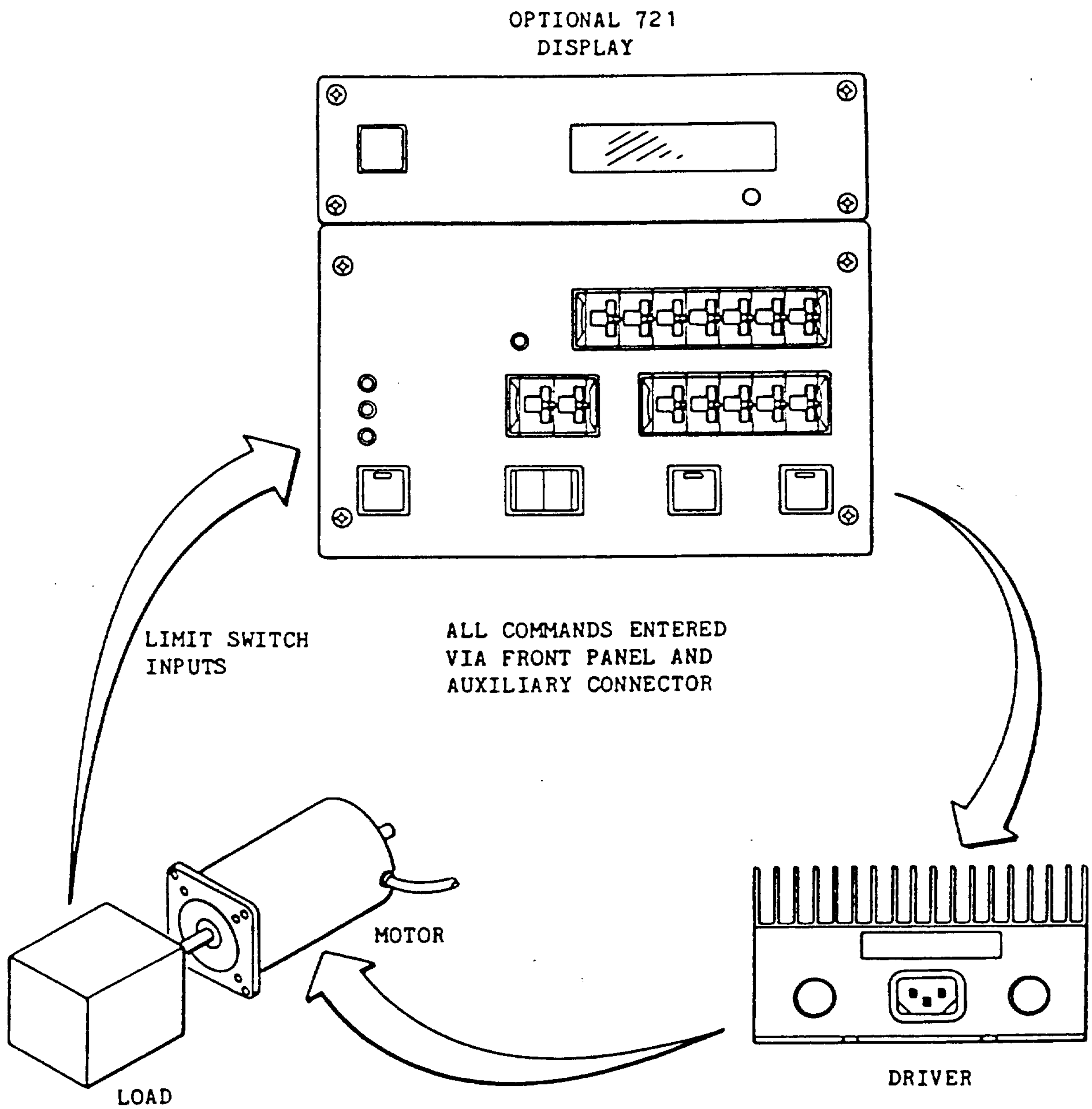


Figure 4-1. Local Manual Control (Open Loop)

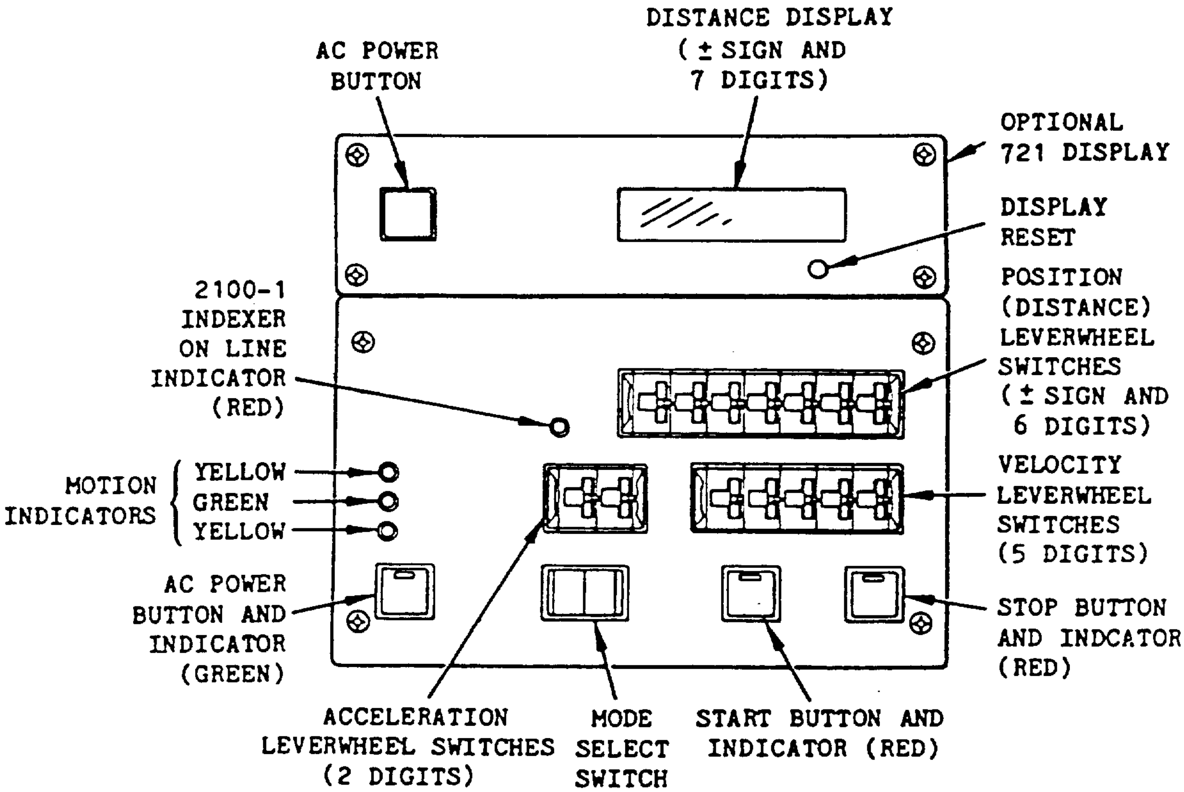


Figure 4-2. 2100-1 Indexer and 721 Display Front Panel Controls and Indicators

c. **ACCEL** — Acceleration leverwheel switches. Sets acceleration/deceleration rate in rev/sec/sec that will be used. Two-digit leverwheel assembly. Values can be selected from one of four ranges, depending upon the setting of internal DIP Switch No. S6, as follows: 10-990, 1.0-99.0, 0.10-09.9, 0.01-0.99 rev/sec/sec.

d. **START** — Start button and indicator (red). Used to start operation of the motor/drive. Operation is dependent upon the setting of internal DIP Switch S4-4 and S6-3. (See Table 3-3.) Lights when Indexer is ready to execute a new command.

e. **STOP** — Stop button and indicator (red). Used to decelerate motor to a stop. Effect of pressing this button is dependent upon the setting of internal DIP Switch No. S6-4. (See section 3.6.) Lights during a STOP operation.

f. **VELOCITY** — Velocity leverwheel switches. Sets the velocity that will be used in all moves rev/sec. Five digits read as XX.XXX or X.XXXX rev/sec depending upon the setting of internal DIP Switch S2-6 (see section 3.6). For a standard 25,000-step motor/drive, the choices are either 0.001 to 20.000 (S2-6 OFF) or 0.0001 to 2.0000 rev/sec (S2-6 ON). See Table 2-2 for velocity limitations. Invalid parameters will cause no action of the motor/drive.

g. **PRESET POSITION** — Position (distance) leverwheel switches. Sets the distance for ALTERNATE mode (ALT) and PRESET mode moves. Sign (±) plus 6 digits.

h. **ON LINE** -- On-line indicator (red). Lights when RS-232C or IEEE-488 communications link is being used to control the Indexer. When lighted, indicates that the front panel motion control switches and leverwheel switches are disabled. If Indexer power button is pressed OFF and then ON, front panel control is restored and communication link is disabled. (The same thing will occur if there is a power failure.)

i. **ACCELERATE, CONSTANT, DECELERATE** -- Motion indicators. ACCELERATE indicator (yellow) lights during periods of acceleration, CONSTANT velocity (green) lights during any constant velocity, and DECELERATE indicator (yellow) lights during deceleration portion of a move.

Note

All three indicators light when Model 852 Joystick is connected to the 2100 and is in control of Indexer operations. The three indicators will blink if an invalid 2100 velocity value is selected when the Model 852 is connected to the 2100.

4.3 OPERATING PROCEDURES

Connect the limit switches (if required) and the load. (See section 3.7.)

Start with low acceleration and velocity values and experimentally determine the upper limits for your application. The internal DIP switches can then be set to keep the ranges shown on the front panel within the specific application limits. Record these values for future reference.

CAUTION

Be sure to install and activate any limit switches that are to be used before you turn the Indexer ON and drive the mechanical load coupled to the Compumotor motor.

4.3.1 PRESET MODE

In this mode the Indexer drives the motor to a specified position at a given velocity and accelerates and decelerates at the same (ACCEL) preset value. Proceed as follows:

a. 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. Remember that the reading set with the PRESET POSITION leverwheel switches is multiplied by the distance scale factor set with internal DIP Switch S3. See Table 2-4 for the value that corresponds with the switch setting. Divide the number of steps required for the move by the scale factor and set the resultant value with the PRESET POSITION leverwheels. The leftmost leverwheel of this group is used to set the direction of motion (+ = clockwise motion, - = counterclockwise motion, referenced to viewing the motor from the load to the motor mount).

   Note

   If scaling is desired, use values that are easy to multiply, such as 2, 3, 10, 20, etc., or engineering unit conversions referenced to the load motion. Any time scaling is used, the resolution available to you is reduced. That is, if you used a scale factor of 10, the smallest net increment of motion would be equivalent to motor steps.

   If scale factors other than 1 are used for the CONTINUOUS mode, and a preset move is interrupted with a STOP or by activation of a limit switch, the final position may not be a multiple of the scale factor.

b. Select an acceleration rate and set this value with the ACCEL leverwheel switches. Remember that the actual value is a function of the internal DIP switch setting. An easy way to set this 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. Reduce the maximum setting slightly for maximum acceleration and reliable operation.

c. Select the velocity to be used and set up this value with the VELOCITY leverwheels. Remember that there will be digits to the right of the decimal point, depending upon the internal DIP switch setting. An easy way to set the value is to start low and then increase the speed until the motor stalls or does not start. Reduce the maximum setting slightly for maximum velocity and reliable operation.

d. When you are ready, press **START**. (The START indicator will be lighted.) The motor shaft will rotate to the commanded position. The Indexer will then return to the ready state (START indicator ON). This cycle will be repeated each time the **START** button is pressed.

4.3.2 ALTERNATE MODE

Set-up for this mode is identical to that for MODE NORMAL, and the procedures of section 4.3.1 apply to this mode. The difference will be that when **START** is pressed, the motor shaft will rotate to the commanded position corresponding to the value set into the PRESET POSITION leverwheels and then retrace the path back to the start position. The shaft will continually move between the start position and the PRESET POSITION until **STOP** is pressed. When **STOP** is pressed, the motor will immediately stop or complete the cycle and stop at the start position, depending upon the setting of Indexer internal DIP Switch S6-4. (See section 3.7.) The factory-set default value is end of current loop. Pressing **START** again will repeat the same motion pattern.

4.3.3 CONTINUOUS MODE

This mode requires only that the acceleration and velocity values be set on the Front Panel. The same considerations described in sections 4.3.1b and 4.3.1c above apply to this mode. Remember that the actual angular velocity depends upon the setting of the VELOCITY leverwheels and the velocity range (x1 or x0.1) set with internal DIP Switch S2-6. Once **START** is pressed, the motor will rotate at a constant velocity until the **STOP** button is pressed or until a new velocity (and a new acceleration if desired) is selected and **START** is pressed again.

4.3.4 USING AUXILIARY CONNECTOR REMOTE STOP AND REMOTE START INPUTS

These two inputs can be used instead of the front panel **START/STOP** switches. REMOTE START (pin 3) can be used instead of the **START** button on the front panel of the 2100-1.

REMOTE START is activated by connecting Auxiliary Connector pin 3 to signal ground (pin 9 or 10 of the same connector) (active low).

REMOTE STOP is activated by connecting Auxiliary Connector pin 4 to signal ground (pin 9 or 10 of the same connector) (active low).

4.3.5 USING AUXILIARY CONNECTOR MOTOR SHUTDOWN REQUEST INPUT

The MOTOR SHUTDOWN REQUEST input (pin 5) can be used to remove power (remove torque) from the motor. This input is activated by connecting Auxiliary Connector pin 5 to signal ground (pin 9 or 10) when the motor is stopped.

Note

This function can be used only when the motor is stopped. When the motor is shut down, it does not produce holding torque and the precise position of the shaft may be lost.

4.3.6 USING AUXILIARY LOAD DATA INPUT/LOAD READY OUTPUT

LOAD DATA input (pin 6)/LOAD READY output (pin 12) are used for the LOAD AND GO option. Prior to any move, the microprocessor in the Indexer must calculate a number of move parameters. There can be a delay of up to 35 milliseconds (msec) from START until the first step pulse is generated. In some applications this delay may be excessive. The delay can be reduced by the use of the LOAD AND GO option. The calculations may be performed ahead of time and the Indexer told to wait for the START command, at which time pulse generation begins immediately.

The LOAD DATA command is given by grounding the LOAD DATA input (Auxiliary Connector pin 6). Any time after the LOAD READY output goes High (Auxiliary Connector pin 12), pressing the **START** button or activating REMOTE START (section 4.3.4) will initiate the move within 2 milliseconds.

Note

DIP switch S4-3 must be ON for the LOAD DATA AND GO option. If S4-3 is ON, the front panel **START** button will ignore any new parameters until a new LOAD DATA operation is performed. The LOAD DATA AND GO option works in the the PRESET and ALTERNATE modes.

4.3.7 USING THE AUXILIARY OUTPUTS

Two other outputs are provided on the AUXILIARY connector. These are the In Position output and the Programmable Output. The Programmable Output is controlled with the "O" command, and certain Position Tracking functions. See sections 5.6.5 and 3.11.12.3. See Table 1-1 for output electrical specifications.

The In Position output is normally low, and goes high while the indexer is conducting a move. (The output remains low during Position Maintenance corrections if this function is active.)

4.3.8 USING START REPEAT

When DIP Switch S6-3 is set ON and a 2100-1 is used in the FRONT PANEL mode, this option allows continuous repeat of a PRESET move by pressing and holding the **START** button or activating the REMOTE START input of the Auxiliary Connector.

4.4 **POSITION TRACKING OPTION**

Position Tracking is discussed in detail in sections 2.4 and 3.11. When used with dual-channel incremental encoders with quadrature, this option provides

a. Increased resistance to perturbing external torques.
b. Compensation for friction and gear play.
c. A means to independently determine load position.
d. Stall detection.

Once the system is installed and operating, no further operator action is required.

4.5 OPTIONAL JOYSTICK OPERATION

Refer to the Model 852 Joystick manual for detailed information.

a. Motor movement is implemented by deflection of the joystick. Motor velocity is proportional to the angle of deflection of the joystick. Right and left deflection yields movement of the X channel motor; forward and backward deflection moves the Y motor. Deflection to the right is "positive," yielding clockwise rotation of the X motor as the default direction. Forward deflection gives the same result for the Y motor.

   Velocity scaling involves dividing the Joystick input frequency by a factor inversely proportional to the current 2100 maximum velocity parameter, whether it is a front panel value or a value programmed via the 2100's serial interface (RS-232C). When the 2100 velocity parameter is at its maximum of 20 rev/sec, the circuit divides the input frequency by two. At the Model 852 Joystick's default HI range maximum frequency of 250 kHz (full deflection), the scaled 2100 output frequency will be 125 kHz (5 rev/sec). If for example, the 2100 velocity parameter is reduced by half (10 rev/sec), then the scaled output for full deflection will be 1/4 the input, or 62.5 kHz (5 rev/sec).

   Because of this "divide by two" characteristic of the 2100, the Model 852 is supplied with a doubled output frequency jumper option (20 rev/sec maximum, or 500 kHz). This allows the Model 852 user to get the nominal 20 rev/sec at full deflection when the 2100 is set for 20 rev/sec with the velocity scaling feature enabled. Actual output pulse rate equals (input pulse rate times velocity setting) divided by 40.96.

Note

In order for the 2100 to recognize any change in its maximum velocity parameter, the Model 852 must be briefly disabled via the DISABLE switch on the control panel, or the "J0" command under interface control.

b. Full-scale velocity may be set to one of three switch-selectable ranges via the HI/MED/LO switch. For direct driving of standard Compumotor microsteppers, the default values for full-scale deflection are 10 rev/sec, 1 rev/sec, and 0.1 rev/sec for HI, MED, and LO respectively (250 kHz, 25 kHz, and 2.5 kHz). The Joystick (or control voltage) must be returned to the midpoint "zero" position in both axes to realize a velocity range change.

c. The Model 852 STATUS CONTROL switch must be in the ENABLE position for any Joystick motor movement to take place. If the Model 852 is enabled and no external conditions are inhibiting motor function, the status indicator LED for both channels will turn green. Even so, no pulses will be sent to the motor unless the Joystick (or the control voltage) has been returned to the midpoint after the unit has been enabled. In the case of a remote enable, or the clearing of a limit condition, only the affected axis must be returned to zero.

If the STATUS CONTROL switch is in the DISABLE position, or a remote disable signal is received (e.g., from the 2100), the indicator LED for that channel will be OFF and motor pulse output will be inhibited. Placing the STATUS CONTROL switch in the SHUTDOWN position causes the SHUTDOWN REQUEST OUTPUT to the 2100 to be activated and the LED status indicators turn red. REMOTE POWER SHUTDOWN shuts off motor current and holding torque.

Note

When the motor is shut down, it does not produce holding torque, and the precise position of the motor shaft may be lost.

Chapter 5

INDEXER COMMANDS

5.1 OVERVIEW

This chapter describes the Indexer commands that are used with a remote terminal or computer to control the Indexer via a communications interface.

Using a remote terminal or computer, you can instruct the Indexer to execute a series of commands, including a sequential change of the basic shaft motion parameters, time delays, pauses, and repeating (looping) operations.

Note

All commands **must** be entered as upper-case (capital) letters. Be sure to set your shift lock or alpha lock key to the upper-case position.

5.2 COMMAND CONVENTIONS and DEFINITIONS

5.2.1 DELIMITER

All individual commands end in a delimiter that signifies that the command is complete. A delimiter serves the same function as the space between words in a sentence. The delimiter, which is part of the command, is a space character (entered with the keyboard space bar) or a carriage return (<CR>). The use of a space character as the delimiter is recommended. The reasons for using a space character are discussed later in this chapter.

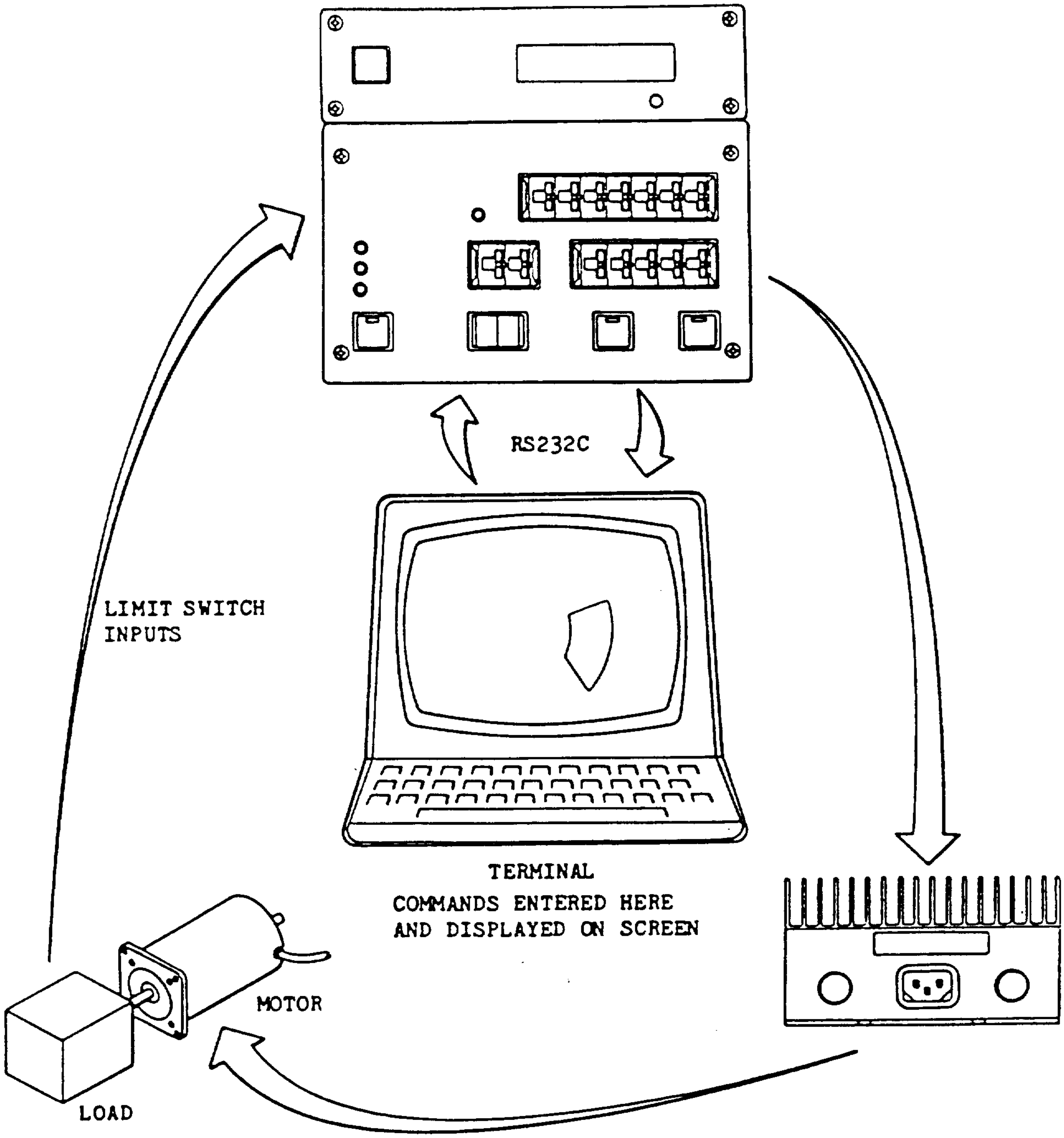


Figure 5-1. Remote Terminal Operation (Open Loop)

5.2.2 INDIVIDUAL COMMANDS

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

> BUFFERED COMMANDS: Commands that are identified as "Buffered" are received by the indexer and stored (in the command buffer) if the indexer is not free to execute them. Stored commands are executed as soon as the indexer can get to them, in the order they were received.
>
> IMMEDIATE COMMANDS: Commands that are identified as "Immediate" are executed immediately on receipt and will take priority over whatever operation is in progress. These commands include various Stop commands that clear the command buffer, and various Status Request commands that have no affect on the command buffer.

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

Typical commands have the form:

S A10 V3 D46000

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

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

MN A10 V2 D25000 L10 G N

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

Note

Pressing carriage return on some terminals will return the cursor to the start of the line. The line-feed key may also have to be pressed to move the cursor to the next line. This will not affect the delimiter entered using carriage return.

The example that follows shows the effect of using carriage return/line feed as the delimiter.

```
MN
A10
V2
D25000
L10
G
N
```

5.2.3 MULTIPLE INDEXERS

When multiple indexers are on the communications line, commands like the previous example are executed by all indexers on the line. To send commands to a single unit, the Unit Number of that indexer should be put in front of the instruction. The Unit Number is set with internal switches S2-1 through S2-4 as discussed in section 5.5. See Table 5-4 for setting the switches. Example: Three indexers are on an RS-232 "daisy chain". They are sent the following commands:

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

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

5.2.4 BUFFER CAPACITY

Any combination of individual commands and command groups can be entered in the buffer until the total number of characters currently stored (including the delimiters) equals 500. The Indexer uses a first-in-first-out serial buffer. As the commands are read from the buffer, additional commands can be entered to replace them. Therefore, the possibility exists that a command set could actually consist of more than 500 characters. Examples of command sets that might be used for different applications are presented later in this chapter.

Note

If you want to build up complex command sets and save them for use at a later time, you will need a host computer rather than a 'dumb' terminal. See Chapter 7 for a description of computer-controlled operation.

5.2.5 FUNCTIONAL GROUPING OF COMMANDS

The basic Indexer individual commands can be subdivided into four categories: Motion Parameter commands; Execution commands; Status Request commands; and General Purpose commands. These commands are discussed in sections 5.3 through 5.6. A summary table is included in each section that indicates the character combination used to enter the commands, the command classification (Buffered or Immediate), and for some, the section of the chapter that describes them.

5.3 **MOTION PARAMETER COMMANDS**

These commands, which set up the way the Compumotor motor shaft will move, are summarized in Table 5-1. All of these commands can be stored in the Indexer buffer. They are the equivalents of the settings implemented with the leverwheel and mode select switches on the front panel of the 2100-1.

When you first activate the communications interface, you **must** enter initial values for motion parameters, at least acceleration and velocity. After the initial entry, the Indexer will continue to use these values until you enter a new value for one or more of the motion parameters. If you do not enter the type of motion command when the interface is enabled, the Indexer will operate in the MN (MODE NORMAL) mode and a Distance parameter will be required.

Once entered, a parameter will be remembered. It is not necessary to enter the same parameter value twice unless the indexer is reset, or goes back to Front Panel Mode.

If the acceleration or velocity command values entered exceed the capability of the motor/drive, it will stall without damage.

Note

Lower case alpha characters are used in this text to denote character entries that must be defined by the user for a given application. The notation "nnn" is used for numerical parameters and "bbb" for binary numbers.

Table 5-1. Shaft Motion Commands

Command Controls	Format of Entry (Note 1)	Description of Commands	Classification (Note 2)
Motion Parameters	Annn.nn	Set Acceleration/Deceleration	B
	D±nnnnnnnn	Set Direction (optional) and Distance (position) Value	B
	H	Reverse Motor Direction	B
	H±	Set Direction of Motion + = Clockwise - = counterclockwise	B
	Vnn.nnn	Set Velocity	B
	VSnn.nnn	Set STOP/START Velocity	B
Type of Motion	MN	PRESET MODE (Go to Position)	B
	MC	CONTINUOUS MODE (Rotate at constant velocity)	B
	MA	ALTERNATE MODE (Continuous back and forth)	B

NOTE 1. All entries must be upper case. nnn indicates numeric value to be entered.

2. B = Buffered command that is stored and executed in sequence.

5.3.1 MOTION PARAMETERS

The commands for shaft motion parameters are:

Annn.nn Acceleration -- The range of choices are from 0.01 to 990.00 rev/sec/sec

Typical commands:(10-99 range)

A.1 (set acceleration to 0.1 rev/sec/sec)
A10 (set acceleration to 10 rev/sec/sec)
A89 (set acceleration to 89 rev/sec/sec)

Vnn.nnn Velocity -- The range of choices are a function of the specific motor/drive and the velocity range (x1 or x0.1) selected with internal DIP Switch S2-6. (See section 2.3.2.)

Typical Commands: (x1 range, S2-6 OFF)

V3.49 (set velocity to 3.49 rev/sec)
V10 (set velocity to 10 rev/sec)

VSnn.nnn Set Start/Stop Velocity -- This command sets a start/stop velocity to be used on all future moves. The velocity is specified in rev/sec. This command should be issued before a velocity command is entered via the communications interface because the remote velocity input is altered by this command.

H Change motor direction -- This command will reverse the current motor direction, effective at the beginning of the move.

H± Direction of Motion -- The choices are clockwise rotation (+) or counterclockwise rotation (-).

Typical commands:

H+ (rotate clockwise)

H- (rotate counterclockwise)

D±nnnnnnnn Distance -- May be combined with direction command. Choices are a function of the scale factor selected (x1-255) with DIP Switch S3 for the distance units and the motor resolution scale factor set with DIP Switch S2-5. (See section 2.3.4.) May be combined with direction.

Typical commands: (x1 scale factor)

D25000 (move clockwise one complete revolution for a 25000-step motor)

D-43570 (rotate counterclockwise 43570 steps)

5.3.2 TYPE OF MOTION COMMANDS

The commands for the three modes of motion are:

MN NORMAL Mode -- Move to a preset position and stop. (Shaft will rotate a distance corresponding to the "D" value entered.)

MC CONTINUOUS Mode -- Accelerate at the last rate specified ("A") to the velocity ("V") and continue to run at the specified velocity until stopped.

MA ALTERNATE Mode -- Alternately move between an initial start position to a distance position "D". Backtrack from the specified position to return to the start point. Accelerate at last rate, "A" and velocity, "V" specified.

5.3.3 **Examples** - MOTION PARAMETER COMMANDS

==

Example One: Individual Parameter Command for Shaft Motion

Function: Set acceleration/deceleration value

```
                                                          Annn _
Set Acceleration/Deceleration Value─────────────────────────┘ │  │
Numeric Value associated with Acceleration Command────────────┘  │
Enter Delimiter (either space or carriage return)────────────────┘
```

Sample Command: A109

==========================End Example One==========================

==

Example Two: Two Individual Parameter Commands for Shaft Motion.

Function: Set acceleration/deceleration; set direction of shaft rotation.

```
                                                   Ann _ H+ _
Set Acceleration/Deceleration Value─────────────────┘  │  │  │
Enter Delimiter (either space or carriage return)──────┘  │  │
Set Direction (+ = clockwise rotation)────────────────────┘  │
Enter Delimiter (either space or carriage return)────────────┘
```

Sample Command: A14 H+

==========================End Example Two==========================

==

Example Three: Three Individual Parameter Commands for Shaft Motion.

Function: Set acceleration/deceleration value; set direction and distance; and set velocity for shaft motion.

```
                                  Ann.nn_D±nnnnn_Vn.nn_
Set Acceleration/Deceleration
Enter Delimiter
Set Direction & Distance
Enter Delimiter
Set Velocity
Enter Delimiter
```

Sample Command: A23.66 D-29763 V3.71

==========================End Example Three==========================

5.4 EXECUTION COMMANDS

The Shaft Motion parameter commands described in section 5.3 will not cause any shaft motion unless they are combined with an Execution command such as GO.

The Execution commands are summarized in Table 5-2. These commands instruct the indexer to start a move, to pause or delay, or to repeat (loop) a sequence of commands. The Execution commands also include power shutdown and power-on reset sequences.

Additional execution commands are added with the Position Tracking (-P) option as discussed in Section 5.7.

Table 5-2. Execution Commands

Command Controls	Format of Entry (Note 1)	Description of Command	Class. (Note 2)	Refer to Section
Start Move	G	GO (start executing move)	B	5.4.1
	C	Continue (End Pause)	I	
Load Data (LOAD AND GO OPTION)	I	Load Move Parameters, Compute Move Profile	B	5.4.2
	uIC	Load Move Parameters, Compute Move Profile, Transmit carriage return when done	B,D*	
Stop Move	Y	Exit from Loop after the current cycle	I	5.4.3
	Q	Clear buffer following execution of the current command	I	
	S	Stop (now) at deceleration rate equal to last used acceleration rate	I	
	K	Kill (stop pulse generation now)	I	
	Z	Software Reset (stop pulse generation now and reset 2100)	I	
Pause	PS	Pause and Wait for the CONTINUE entry	B	5.4.4
	Tnnn.nn	Delay processing subsequent commands in buffer for indicated number of seconds (0-999.99)	B	
	TRxxx	Trigger Pause in processing commands	B	
	U	Pause and wait for CONTINUE entry	I	

Table 5-2. Execution Commands (Continued)

Command Controls	Format of Entry (Note 1)	Description of Command	Class. (Note 2)	Refer to Section
Loop (Repeat Cycle)	L	Loop continuously	B	5.4.5
	Lnnnnnnn	Set loop counter (0-9,999,999)	B	
	N	End of loop	B	
Remote Power On/Off	STØ	Denergize Drive (OFF)	B	
	ST1	Energize Drive (ON)		
Reset	Z	Software equivalent of Power-on reset	I	5.4.3
	XØ	Reset Cumulative (Absolute) Position Counter	B	

NOTE 1. All entries must be upper case, followed by a delimeter.
"nnn" indicates variable numeric parameter
"xxx" indicates variable parameter, x=1 or 0 (or X)
(the maximum number of parameter digits is shown)

2. B = Buffered command that is stored and executed in sequence.
I = Immediate command that will be executed as soon as delimiter is entered.

* The "IC" command is a "Device Specific" command, see section 5.5.

5.4.1 START MOVE COMMANDS

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

> Note
>
> You must enter an entire set of motion parameters **with the "A", "V", "D"** and mode commands when the communications interface is activated. The system initially defaults to the NORMAL ("MN") mode of operation. If power is turned off, you will have to re-enter the motion commands with any other commands you want to use.

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

A123 G

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

When the RS-232C interface is initially activated, a series of commands of the form " MN Annn Vnn Dnnnnn G" is required. This command sets up the initial operating conditions for the Indexer. After the Indexer has been initialized, single move parameter commands can be used.

If only "**G** " is entered, the Indexer will repeat the previous motion pattern. For example, a string of GO commands

G G G G

would instruct the Indexer to move the same way four times.

You do not have to re-enter all the Shaft Motion commands to change one of the variables. If one or more of the motion parameters is changed by a command entry and the GO command is then entered, the prior pattern will be repeated using the new motion parameter(s) that were entered prior to the latest GO command. For example,

A14 G V2.6 G D-27634 G

would change acceleration to 14 and move, then change velocity to 2.6 and move with 14 as the acceleration value, then change position and move again using 14 and 2.6 as the acceleration and velocity values.

The CONTINUE command "**C** " is used following execution of a PAUSE command, "**PS** " or "**U** ". CONTINUE will allow execution of the next command waiting in the command buffer (if any command is stored).

5.4.2 LOAD COMMANDS

These two commands are functional only if DIP Switch S4-3 is ON during power-up or if the LOAD feature is turned ON via the "**SS** " command.

Note

The symbol "u" is used in this manual to indicate that a Unit Number (Device Address) must be entered for a "Device Specific" command.

The LOAD command "**I** " or "**uIC** " is used for the LOAD AND GO option. Prior to any move, the microprocessor in the Indexer must calculate a number of move parameters. There can be a delay of up to 25 milliseconds (msec) from entry of the GO command until the first step pulse is generated. In some applications this delay may be excessive. The delay between the GO command and actual motor motion can be reduced by the use of the LOAD AND GO option. The precalculations may be performed at any time using the "I" or "uIC" commands. Once calculations are complete, the next start command will commence pulse generation within 2 msec.

Note

The 25-millisecond set-up period must be available prior to the GO to take full advantage of this option. This applies for any change of move parameters that require a new LOAD command.

If you wish the Indexer to transmit a carriage return to the host when it has finished parameter calculations, use the "uIC " command. (See section 5.5 for details on the use of Unit Numbers and Status Requests.)

Note

DIP Switch S4-3, must be ON for the LOAD DATA AND GO option. If DIP Switch S4-3 is ON, an I or IC command must be issued before a GO can be executed. The LOAD DATA AND GO option may also be selected with the "SS" command.

LOAD DATA AND GO commands apply only to preset moves.

5.4.3 STOP MOVE COMMANDS

The STOP MOVE commands presented in Table 5-2 are arranged in the order of severity of response. SOFTWARE RESET "Z " command is the most abrupt and severe stop command you can use. The STOP AT END OF CURRENT LOOP command "Y " is the least abrupt and severe stop command.

a. STOP AT END OF CURRENT LOOP Y

This command will not halt processing until command processing reaches the character N at the end of the command loop. At that time, the Indexer will execute the next command in the buffer after N, if any. The command loop cannot be restarted.

b. STOP AT END OF CURRENT COMMAND Q

This command clears any commands awaiting execution in the buffer after the current command has been processed.

c. CONTROLLED STOP COMMAND S

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

The response to "S " in the ALTERNATE mode depends on the setting of DIP Switch S6-9. If set to OFF, the motor is decelerated immediately. If set to ON, the motor stops at the end of the current Alternate loop.

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

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

Note

Normally, the motor is decelerated to a stop at the same rate it was accelerated. A different deceleration rate may be programmed in CONTINUOUS mode only by calling for a velocity of zero rev/sec with a new acceleration and executing a "G " rather than a "S " command. Example: " **MC A1 V10 G ... A100 V0 G** "
The advisability of a steeper deceleration curve should be checked by computing the rotational momentum of the load in question and the amount of energy which may be taken from the load without the motor losing synchronism.

d. EMERGENCY STOP COMMAND **K**

The "**K** " or KILL command causes the output pulses to cease immediately. This should not be used under anything but **emergency situations** since the motor and load are not brought to a controlled stop. For large loads at high speeds, the load could be driven past limit switches and cause damage to the mechanism and possibly the operator.

The "**K** " command clears the remainder of the Command buffer unless specified to retain the commands via the "SS" command.

e. SOFTWARE POWER-ON RESET **Z**

The "**Z** " command is equivalent to cycling the AC power to the Indexer; that is, it disables the communications interface and returns all internal settings to their power-on values. The command buffer is cleared. Like the "**K** " command, "**Z** " causes an immediate cessation of output pulses to the motor.

Note

When the "**Z** " command is used, the Indexer is busy for 500 msec and will ignore any commands.

5.4.4 PAUSE COMMANDS

Four choices are available.

a. **PS** pause and wait for operator entry (or computer entry) to continue. A common use of the Buffered Pause PS is to hold execution of individual commands in a Command Loop until the entire Loop has been loaded. DIP Switch S4-4 can be set to ON to allow the **START** inputs of the 2100-1 to clear a pause.

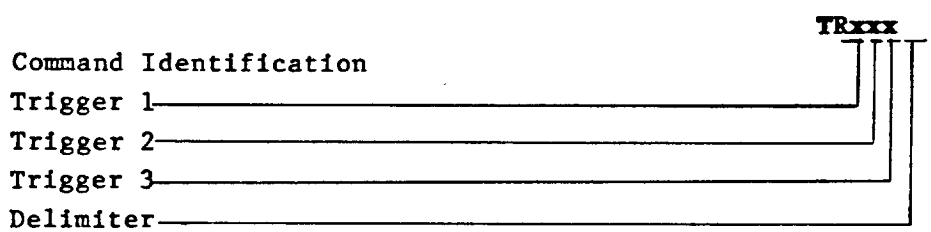
b. **Tnnn.nn** pause in processing commands for a given number of seconds and then continue.

c. **U** HOLD (PAUSE) NOW AND WAIT FOR CONTINUE. This is an Immediate command. DIP Switch S4-4 can be set to ON to allow a **START** signal to clear a pause or a hold.

d. **TRxxx** pause in processing commands until the designated TRIGGER input pattern is present.

The Indexer has three external TTL inputs used to coordinate command execution without the intervention of the host. Pull-up resistors normally hold these lines "High" (1); switch closures to ground, TTL circuits or open collector circuits sinking 1.6 mA at +5VDC nominal will pull these lines "Low" (0).

Triggers are used to synchronize 2100 operations with external events. They can be used to implement a "handshaking" function with other devices. The TRIGGER command syntax is:



The three characters used for "xxx" are variables and can be one of the following:

0 = low; 1 = high; X = don't care

==

Example Four: TRIGGER Command

```
                                                          TR1X0
Command Identification ____________________________________||||  |
Trigger Input 1 high _______________________________________|||  |
Trigger Input 2 don't care __________________________________||  |
Trigger Input 3 low __________________________________________|  |
Delimiter _______________________________________________________|
```

The Indexer would interpret this command as PAUSE until Trigger Input 1 is high and Trigger Input 3 is low. (Trigger Input 2 is ignored.)

Example:

" **TR1X0 G** "

(Wait for Trigger 1 to go high, and Trigger 3 to go low, then move.)

===========================End Example Four============================

5.4.5 LOOP COMMANDS

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

5.4.6 EXAMPLES OF EXECUTION COMMANDS

The examples presented in section 5.3.3 dealt solely with individual commands for motion parameters. The examples in this section demonstrate the inclusion of Mode commands and Execution commands. Keep in mind that the absence of Execution commands in examples one, two, and three means the motion parameter commands were executed without any shaft movement. An Execution command MUST follow any buffered commands entered for a move to be executed.

==

Example Five: Execution Command

Function: Set mode, direction, and velocity; and start move

```
                                                  MN _ H+ _ Vn.n _ G _
Set Mode (MN = Mode Normal)
Enter Delimiter
Set Direction (+ = Clockwise Rotation
Enter Delimiter
Set Velocity (X.Y revs/sec)
Enter Delimiter
GO (Buffered execute command sets 'Start' flag)
Enter Delimiter
```

Sample Command: MC H- V2.9 G

==========================End Example Five==========================

==

Example Six: Loop Command

Function: Set Loop; move; wait; repeat cycle.

Lnnn Dnnnn G Tn N

Loop nnn Times
Enter Delimiter
Move nnnn steps
Enter Delimiter
Start
Enter Delimiter
Delay n seconds
Enter Delimiter
End of Loop (Go back to move nnnn steps again)
Enter Delimiter

Sample Command: L265 D1476 G T2 N

========================End Example Six==========================

==

Example Seven: Pause Command with Continue

Function: Change Mode and direction and execute; change direction and execute; set Pause; Continue when operator indicates

MN H- PS G H+ G C

Set Mode (MN=Mode Normal)
Enter Delimiter
Set Direction (- = Counter Clockwise)
Enter Delimiter
Pause
GO
Enter Delimiter
Change Direction
Enter Delimiter
GO
Enter Delimiter
Continue (Operator enters Immediate Execute Command)
Enter Delimiter (part of "C" Command)

Sample Command: MN H+ PS G H- G C

========================End Example Seven========================

5.5 **STATUS REQUEST COMMANDS**

5.5.1 GENERAL

You can determine the status of the Indexer using the Status Request commands summarized in Table 5-3. In reply to a Status Request command, the Indexer will transmit the responses to a remote terminal, where they will be displayed on the screen, or provide a set of characters that have to be interpreted by a computer. The format and interpretation of the responses to Status Request commands are described in sections 5.5.3 through 5.5.16.

5.5.2 IDENTIFICATION OF UNITS (UNIT NUMBERS)

When a single communications port is used to control more than one indexer, much confusion is possible. This is because all indexers in a daisy chain receive and echo the same commands, and will execute them unless prevented from doing so. This becomes critical if any indexer is instructed to transmit some information itself. To prevent all of the units on the line from responding to an instruction, that instruction must be preceded by the Unit Number of the designated indexer.

All Status Request commands result in a transmission initiated by the indexer. To prevent multiple indexers from all responding at once, the Status Request commands are given the classification "Device Specific" meaning that the Unit Number of the responding indexer must be placed in front of the command. No indexer will execute a Device Specific command without its Unit Number. There are very few Device Specific commands that are not Status Requests. The Device Specific commands include both Buffered and Immediate commands.

Each indexer should be set with DIP Switches S2-1, S2-2, S2-3, and S2-4 for a unique code called a Unit Number. (See Table 5-4.) The Unit Number is entered by the operator as part of an individual command. Unit Numbers apply only to individual commands.

For example, **13A10** indicates the command is for Unit Number 13.

Table 5-3. Status Request Commands

Command Controls	Format of Entry	Description	Response Format	Class	Refer to Section
Operator Immediate Status Requests	uB	Buffer Status	*a<CR>	I,D	5.5.5
	uR	Indexer Status	*a<CR>	I,D	5.5.6
	uRA	Limit Switch Status	*a<CR>	I,D	5.5.7
	uRB	Special Status	*a<CR>	I,D	5.5.8
	uSJ	Joystick Status	xxxx	I,D	5.5.9
	uTS	Trigger Status	xxx	I,D	5.5.10
	uW	Position:		I,D	5.5.11
		uW1 binary	bbbb	I,D	5.5.14
		uW2 Hexadecimal	*hhhhhhhh<CR>	I,D	5.5.13
		uW3 Hexadecimal	*hhhhhhhh<CR>	I,D	5.5.13
Operator Buffered Status Requests	uCR	Command Execution Status	<CR>	B,D	5.5.16
	uP	Relative Position Status (decimal value)	±nnnnnnnn<CR>	B,D	5.5.12
	uPB	Relative Position Status (binary)	bbbb	B,D	5.5.14
	uSR	Parameter status request	xxxxxxxx<CR>	B,D	5.5.15
	uUR	Scale Factor Status	nnn<CR>	B,D	5.5.17
	uX1	Cumulative position status (decimal value)	±nnnnnnnn<CR>	B,D	5.5.11
	uX1B	Cumulative position status (binary)	bbbb	B,D	5.5.11

NOTE 1. All entries must be upper case, followed by a delimeter.
"nnn" indicates numeric response
"hhh" indicates hexadecimal response
"xxx" indicates digital response, x=1 or 0
"bbb" indicates binary response
"a" indicates a single alpha character response
(the number of response characters is shown)

2. B = Buffered command that is stored and executed in sequence.
I =Immediatecommand that will be executedassoonas delimiter is entered.
D = Device Specific Command

Table 5-4. Unit Number (Device Address)

Unit Number	S2 Switch Setting -1	-2	-3	-4
1	OFF	OFF	OFF	OFF
2	ON	OFF	OFF	OFF
3	OFF	ON	OFF	OFF
4	ON	ON	OFF	OFF
5	OFF	OFF	ON	OFF
6	ON	OFF	ON	OFF
7	OFF	ON	ON	OFF
8	ON	ON	ON	OFF
9	OFF	OFF	OFF	ON
10	ON	OFF	OFF	ON
11	OFF	ON	OFF	ON
12	ON	ON	OFF	ON
13	OFF	OFF	ON	ON
14	ON	OFF	ON	ON
15	OFF	ON	ON	ON
16	ON	ON	ON	ON

All status requests must include the Unit Number. When the Unit Number is used, an individual command has the syntax shown below:

uRn

Unit Number (0-16)
Individual Command
Numeric As Required
Delimiter

5.5.3 FORMAT OF THE RESPONSE TO STATUS REQUEST COMMANDS

Depending upon the type of status request command used, the response will be in one of the following formats:

a. A set of three characters: an asterisk (*), an @ sign or a letter, and a carriage return (<CR>). Typical examples are ***A<CR>, *M<CR>, *@<CR>**. This format is used for status reports other than position reports. A special case is used when the Indexer transmits a single carriage return to indicate completion of a move. On a remote terminal these returns would be displayed as ***A, *M, *@**, respectively. If a computer is used to control the Indexer, the computer would interpret the responses and present the information for the operator or use the data to command additional operations. Refer to section 5.5.4 for a description of the interpretation process for this type of return.

b. A set of ten characters for position reporting consisting of a plus or minus sign (+ -), eight numbers, and a carriage return. On a remote terminal these returns would be displayed as **+12123434, -98765432,** etc. Refer to section 5.5.5 for a description of the interpretation process for this type of return. (P and X1 commands only)

c. A set of eight characters representing eight hexadecimal characters that may be used for the relative position report obtained in response to the **uW2** or **uW3** status request command. If a remote terminal is used, the operator must interpret this return to determine the equivalent decimal value. If a computer is used, the computer would have to perform the interpretation operation. A typical example of this type of return is ***000433AE<cr>**. Refer to section 5.5.13 for a description of the interpretation process for this type of return.

d. A set of four 8-bit chacracters representing a 32-bit binary word can be used for responses to buffered position report request commands. The four bytes must be concatenated to determine the binary value of the response. If a remote terminal is used, the operator must interpret this return to determine the equivalent decimal value. If a computer is used, the computer would have to perform the translation operation. Typical examples of this type of return (if displayed by a remote terminal) are **x/&d, OH#!, ABCD,** where the characters can be any one of the full set of ASCII characters, including nonprintable characters. Refer to section 5.5.14 for a description of the interpretation process for this type of return.

e. Three or four digits with a value of 0 or 1 followed by a carriage return (Trigger status, Joystick status).

f. Three decimal digits followed by a carriage return (Scale Factor status only).

g. Eight digits with a value of 0 or 1 followed by a carriage return (Parameter status).

Note

You may have to enter a line feed command to keep the responses separate. The carriage return alone will only return the cursor to the start of the line. All Status Requests except binary reports are followed by a carriage return character.

5.5.4 INTERPRETING STATUS REQUEST RETURNS OF THE FORM *A<CR>

When you connect a "Full Duplex" terminal to the Indexer RS-232C interface, any character command you enter on the remote terminal keyboard shows on the terminal display. The displayed character does not originate within the terminal. The displayed character is transmitted from the Indexer back to the terminal (echoed back) so that the operator can verify what command the Indexer received in response to the keyboard entry.

An asterisk (*) is placed in front of the responses to Status Request commands to differentiate these responses from Echoed commands. The carriage return at the end of the response message serves the same purpose as the command delimiter and signifies the end of the character set that comprises the response. The characters that are transmitted by the Indexer are represented by an 8-bit (or 7-bit) binary code, the ASCII code. For example:

Carriage return = 0000 1010 (13)

* = 0010 1010 (42)	1 = 0011 0001 (49)	@ = 0100 0000 (64)
+ = 0010 1011 (43)	2 = 0011 0010 (50)	A = 0100 0001 (65)
- = 0010 1101 (45)	3 = 0011 0011 (51)	B = 0100 0010 (66)

The decimal equivalent of each binary code is shown in parentheses.

Single character (@ or letters) replies have a specific meaning for each type of status request. You must know the status request command that caused the reply before you can decode the meaning of the single character A specific response table for each status request is indicated in this manual for each single character response. See sections 5.5.8 through 5.5.16.

5.5.5 BUFFER STATUS RESPONSE: **uB** Command

Format of response --***A<CR>**

***B<CR>** Buffer Full

***R<CR>** Buffer Not Full

5.5.6 INDEXER STATUS RESPONSE: **uR** Command

Format of response --***A<CR>**

***B<CR>** = Busy, No Attention

***C<CR>** = Busy, Attention

***R<CR>** = Ready, No Attention

***S<CR>** = Ready, Attention

Busy and Ready refer to move execution,pauses, loops, and time delays. For the Preset mode, Busy means that the Preset move is still in progress. The Continuous mode will give a Busy reply when the motor is being either accelerated or decelerated, and a Ready reply while running at the designated velocity.

Attention is indicated when an End-of-Travel limit switch was tripped in the previous move, when the Model 852 Joystick is requesting control, or if a Stall condition exists (-P option only). To determine which, use the **RA** or **RB** (or **RC**) commands, sections 5.5.10 and 5.5.11.

5.5.7 LIMIT SWITCH STATUS: **uRA** Command

Format of response --***A<CR>**

The reply indicates both the current Limit Switch status and the status on the previous move. Refer to the **RA** Response Table.

RA Response Table

Response Character	Limit Switch Status			
	Last Move Terminated by		Current Move Limited by	
	CW Limit	CCW Limit	CW Limit	CCW Limit
@	NO	NO	NO	NO
A	YES	NO	NO	NO
B	NO	YES	NO	NO
C	YES	YES	NO	NO
D	NO	NO	YES	NO
E	YES	NO	YES	NO
F	NO	YES	YES	NO
G	YES	YES	YES	NO
H	NO	NO	NO	YES
I	YES	NO	NO	YES
J	NO	YES	NO	YES
K	YES	YES	NO	YES
L	NO	NO	YES	YES
M	YES	NO	YES	YES
N	NO	YES	YES	YES
O	YES	YES	YES	YES

5.5.8 SPECIAL STATUS: u**RB** Command

Format of response --***A<CR>**

Refer to the **RB** Response Table.

RB Response Table

Response	Special Status			
	Joystick Enable Request	Pause "PS"	Hold "U"	Waiting for Trigger
@	NO	NO	NO	NO
A	YES	NO	NO	NO
B	NO	YES	NO	NO
C	YES	YES	NO	NO
D	NO	NO	YES	NO
E	YES	NO	YES	NO
F	NO	YES	YES	NO
G	YES	YES	YES	NO
H	NO	NO	NO	YES
I	YES	NO	NO	YES
J	NO	YES	NO	YES
K	YES	YES	NO	YES
L	NO	NO	YES	YES
M	YES	NO	YES	YES
N	NO	YES	YES	YES
O	YES	YES	YES	YES

5.5.9 JOYSTICK STATUS: uSJ Command

Format of response **xxxx** (x = 0 or 1)

Refer to the **SJ** Response Table.

SJ Response Table

Response Character	Joystick Status			
	Joystick Request	Direction	At Zero	Shutdown Request
0000	NO	CCW	NO	NO
1000	YES	CCW	NO	NO
0100	NO	CW	NO	NO
1100	YES	CW	NO	NO
0010	NO	CCW	YES	NO
1010	YES	CCW	YES	NO
0110	NO	CW	YES	NO
1110	YES	CW	YES	NO
0001	NO	CCW	NO	YES
1001	YES	CCW	NO	YES
0101	NO	CW	NO	YES
1101	YES	CW	NO	YES
0011	NO	CCW	YES	YES
1011	YES	CCW	YES	YES
0111	NO	CW	YES	YES
1111	YES	CW	YES	YES

5.5.10 TRIGGER INPUT STATUS: uTS Command

Format of response **xxx** (x = 0 or 1).

The three digits indicate the status of trigger inputs 1, 2 and 3, respectively. (0 = low, 1 = high.)

5.5.11 POSITION REPORTING

Position reports are based on counting the number of pulses sent to the motor/drive and are independent of the scale factor.
Three different basic position report request commands are available as follows:

a. **uW1 , uW2 , or uW3** -- Immediate commands that provide the current incremental distance from the position where the motor was last at rest. As immediate commands, these respond regardless of any other instructions that are being executed, and are typically used to obtain position data "on the fly" (while moving).

   The **W1** command is fastest, providing a four character response (**bbbb**) which is interpreted as 32 bit binary number (see section 5.5.13). This value, like the **W2** response is unsigned (always positive), and gives no information as to the direction of motor rotation. **W3** supecedes the **W2** command and reports incremental position in two's complement signed notation. Counterclockwise is negative. Both **W2** and **W3** respond in hexadecimal format (***hhhhhhhh<CR>**) (see section 5.5.13).

   When the joystick is used, the **W3** command will report position relative to the position at which JOYSTICK mode was entered. The W1 and W2 commands reports the position relative to the last joystick center position. All three commands are Immediate and Device Specific.

   CAUTION

   Do not use the four digit binary format when multiple 2100s are daisy-chained on a single RS-232C Interface.

b. **uP or uPB** -- Buffered commands that provide the incremental distance travelled during the last move, where the **P** command provides the decimal-values format (±nnnnnnn<CR>) (see section 5.5.11) and the **PB** command provides the four character binary-number format (see section 5.5.14).

c. **uX1** or **uX1B** -- Buffered commands that provide cumulative position (cumulative count from power-up or from the position at which an **X0** command is given) where the **X** command provides decimal values the same as the **P** command and the **XB** command provides four character binary numbers the same as the **PB** command.

Your computer must have an 8-bit capability to use the **W1**, **PB**, and **X1B** options.

The rate at which a new position can be reported depends upon the baud rate selected and can be as high as 500 times a second (every 7 to 8 ms).

5.5.12 INTERPRETING DECIMAL POSITION REPORTS: **X1**, **P**

The **X1** and **P** instructions provide the position report as a decimal value. The report has the form **±nnnnnnn<CR>** consisting of ten characters; an eight digit number preceded by sign (+/-), and followed by a carriage return. The value represents either cumulative position in steps (**X1**), or the number of steps generated in the last move (**P**). The sign indicates either which side of the zero position the motor is on (**X1**), or the direction of motion of the last move (**P**). Neither instruction provides current information when the motor is moving in the CONTINUOUS mode.

5.5.13 INTERPRETING HEXADECIMAL POSITION REPORTS: **W2**, **W3**

This form of position report (***hhhhhhhh<CR>**) consists of an asterisk followed by eight hexadecimal characters; 0 through 9 and A through 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 tables 5-2 and 5-3. The **W2** report is always positive regardless of direction. Both commands are designed for use in a computer controlled situation where the computer can translate from the hexadecimal.

Figure 5-2. **W2** and **W3** Response Interpretation

```
MSD           LSD
*h h h h h h h h <CR>
                 |______________ h x 160 = h x 1 = ____________
               |________________ h x 161 = h x 16 = ____________
             |__________________ h x 162 = h x 256 = ____________
           |____________________ h x 163 = h x 4,096 = ____________
         |______________________ h x 164 = h x 65,536 = ____________
       |________________________ h x 165 = h x 1,048,576 = ____________
     |__________________________ h x 166 = h x 16,777,216 = ____________
   |____________________________ h x 167 = h x 268,435,456 = ____________

                                                      Total= ____________
```

where h can be one of the following values

Decimal Value	Hexadecimal Value (h)	Decimal Value	Hexadecimal Value (h)
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

Example:

Assume the response was *000433AE. The decimal value would be

```
0 0 0 4 3 3 A E
              |      (E=14)       14 x 1    =       14
            |        (A=10)       10 x 16   =      160
          |_______________________ 3 x 256  =      768
        |_________________________ 3 x 4096 =   12,288
      |___________________________ 4 x 65,536 = 262,144
|_|_|_____________________________ 0 x      =        0
                                   Total = 275,374 pulses
```

Figure 5-3. **W3** Response Interpretation

If the first digit of the response is an "F"
Fhhhhhhhh
then response represents a "two´s complement" negative number

Any response but **Fhhhhhhhh** should be interpreted per Figure 5-2.

To interpret a negative number (starting with **Fhhhhhhhh**)

The binary approach:

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

The computer approach: Subtract the hexadecimal number from 168 (232) (4,294,967,296).

The easy way:

1. Chop off all the leading "F"´s, and convert to decimal
2. Convert and subtract the next largest power of 16.

Example: the indexer responds to W3 as follows:

*FFFF9E58

1. Chop off the F´s:	9E58 hex	=	40,536
2. Subtract from 164	10000 hex	=	65,536
	Result:	=	-25,000

5.5.14 INTERPRETING BINARY POSITION REPORTS: **W1**, **PB**, **X1B**

This form of position report (**bbbb**), consists of four bytes that must be linked together (concatenated). Assume that the response is equivalent to the ASCII characters ^A#0/<CR> ("^A" refers to "Control A", an unprintable character). The actual binary code for this would be assembled as

^A # 0 /

00000001001000110011000000101111

This code would then have to be interpreted by the computer. A terminal will interpret the four bytes as ASCII characters. The operator may not be able to read the response, since many characters are unprintable. The four characters must be converted to their ASCII code numbers, and multiplied by a power of 256. The first character received is the most significant byte. Refer to table 5-5 for a conversion technique.

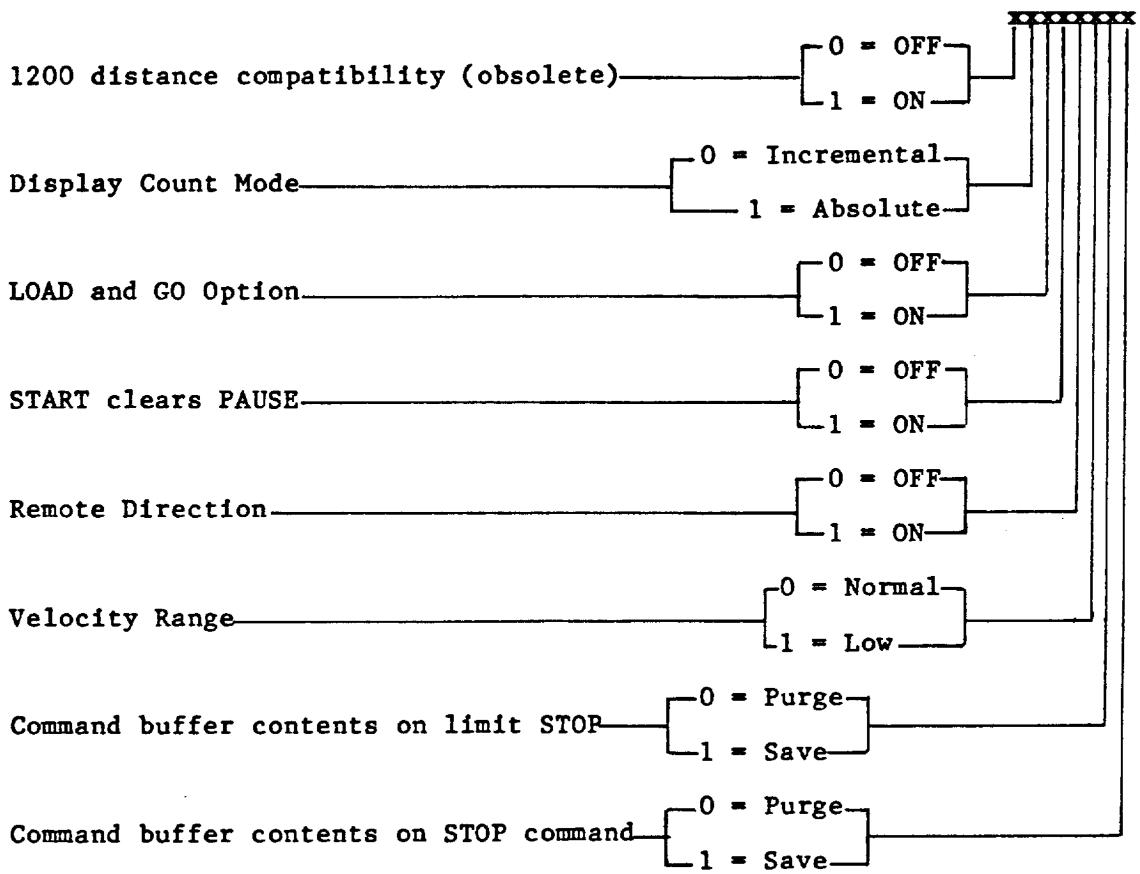
Table 5-5. Binary Position Conversion

<table>
<tr><th>Response
^A#0/</th><th>ASCII
value</th><th>character
multiplier</th><th></th><th></th><th>character
value</th></tr>
<tr><td>||||</td><td>47</td><td>x 1</td><td>(256 to the 0 power)</td><td>=</td><td>57</td></tr>
<tr><td>|||</td><td>48</td><td>x 256</td><td>(256 to the 1st power)</td><td>=</td><td>12,288</td></tr>
<tr><td>||</td><td>35</td><td>x 65,536</td><td>(256 to the 2nd power)</td><td>=</td><td>2,293,760</td></tr>
<tr><td>|</td><td>1</td><td>x 16,777,216</td><td>(256 to the 3rd power)</td><td>=</td><td>16,777,216</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>=</td><td>19,083,321</td></tr>
</table>

The **PB** and **X1B** responses provide direction information. If the direction of the last move was counterclockwise (**PB**), or the current cumulative position is negative (**X1B**), then the most significant bit of the 32 bit response will be set. That is, the first (most significant) character will have an ASCII code number greater than 127.

5.5.15 PARAMETER STATUS: uSR Command

The format of the response is **xxxxxxxx<CR>**, where x = 0 or 1. The response can be interpreted from the diagram that follows.



5.5.16 COMMAND EXECUTION STATUS: **uCR** Command

This status request command is a special case where the indexer transmits a carriage return alone. When the CR command is included in a sequence of commands, the indexer will send a carriage return character after prior commands have been executed. The **CR** command is used to notify a host computer that a sequence of instructions has been completed. For exaample:

MC A10 L V4 G T2 V0 G 1CR N

In this example, the motor repetitively starts, moves at the designated speed for two seconds and stops. The carriage return is transmitted each time the Loop is executed to indicate completion of the motion.

5.5.17 SCALE FACTOR STATUS: **uUR** Command

Format of response **nnn<CR>**.

The "nnn" will be a three digit value between 1 amd 255. This number reflects the position scale factor set either on Dip switch S3 or set using command US (section 5.6.7). 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.

5.6 GENERAL PURPOSE COMMANDS

5.6.1 GENERAL

These commands are summarized in Table 5-5 and described in sections 5.6.2 through 5.6.8.

5.6.2 721 REMOTE DISPLAY COMMANDS

The three functions of set zero, display blanking, and display blinking can be controlled via the communications interface. These commands are self-explanatory.

5.6.3 COMMUNICATIONS INTERFACE ENABLE/DISABLE

The commands "**E** " or " **E** " will enable the RS-232C communications interface. An extra leading delimeter serves to clear the 2100 RS-232 receiving device. When the Indexer does not have a front panel installed (Models 2100-2, 3 and 4), the RS-232C (or IEEE-488) Communications Interface is enabled all the time. "**F** " disables the interface and enables the front panel.

5.6.4 BACKSPACE

The "**^H**" command backspaces one character. A new character may be entered at that position to replace the existing character. (^H indicates that the CONTROL or CTRL key is held down when the H key is pressed.) The effect of this command character is to cause the 2100 to back up one character in the command buffer regardless of what appears on the terminal. On some terminals pressing the BACKSPACE key will produce the same character.

5.6.5 PROGRAMMABLE OUTPUT

A single output line is available that can be controlled from the remote terminal or computer. The line can be set low **0Ø** or high **01** . The line provides TTL-compatible high and low signals.

Table 5-5. General Purpose Commands

Command Controls	Format of Entry (Note 1)	Description of Command	Classification (Note 2)	Refer to Section
721 REMOTE DISPLAY	**DA**	Sets Remote Display to zero	B	5.6.2
	DBØ	Blanks Remote Display	B	5.6.2
	DB1	Unblanks Remote Display	B	5.6.2
	DCØ	Stops Remote Display Blinking	B	5.6.2
	DC1	Starts Remote Display Blinking	B	5.6.2
COMMUNI-CATION INTERFACE	**E**	Enable Comm I/F; Disable Front Panel	I	5.6.3
	F	Disable Comm I/F; Enable Front Panel	I	5.6.3
KEYBOARD ENTRIES	**^H**	(Control plus H) Back-space and Delete character	I	5.6.4
PROGRAM-MABLE OUTPUT	**O1** **OØ**	Set programmable output 1 = high, 0 = low	B	5.6.5

Table 5-5. General Purpose Commands (Continued)

Command Controls	Format of Entry (Note 1)	Description of Command	Classification (Note 2)	Refer to Section
SPECIAL FUNCTIONS	**SSax**	Sets Parameter Status	B	5.6.6
POSITION SCALE FACTOR	**USnnn**	Least Significant Digit Scale Factor (1-255 times Distance)	B	5.6.7
JOYSTICK (852)	**J1**	Enable joystick and disable indexer control of the motor	I	
	JØ	Restores indexer control of the motor and disables joystick		

NOTE 1. All entries must be upper case, followed by a delimeter.
"nnn" indicates numeric parameter
"xxx" indicates digital parameter, x=1 or 0
"a" indicates a single alpha character parameter

2. B = Buffered command that is stored and executed in sequence.
I = Immediate command that will be executed as soon as delimiter is entered.

5.6.6 PARAMETER STATUS: SS Command

This command sets up the functions in the table that follows. The form of the command is "**SSax** " where "a" indicates one of the letters from the table below is to be entered. Enter x = 0 or 1 as shown in the table below to obtain the desired result.

a	Parameter	x	
		0	1
A	Distance Compatibility (No longer used)	OFF	ON
B	Display Mode	Incre-mental	Absolute
C	LOAD and GO Option	OFF	ON
D	START signal Clears Pause	NO	YES
E	Direction Parameter	Front Panel	Remote
F	Velocity Range	Normal	Low
G	Save Command Buffer After Limit Stop	NO	YES
H	Save Command Buffer After STOP Command	NO	YES

Notes:

A Set to OFF (obsolete)

B Controls the 721 display. x = 0 provides the incremental move since the last move. x = 1 provides an absolute count (cumulative).

C LOAD AND GO option is discussed in section 5.4.2.

D Allows operator to clear a pause using the START button or Remote START input in place of the CONTINUE command (if x = 1).

E Allows direction of motion to be set from front panel of 2100-1 (x = 0) or Joystick Connector pin 2 (x = 1).

F Reduces velocity range by a factor of 10 (x = 1).

G, H Determines buffer response on limit or stop. x = 1 saves the contents of the Indexer command buffer.

5.6.7 DISTANCE UNIT SCALE FACTOR CONTROL: **USnnn, uUR** Commands

The Scale Factor can be controlled with these commands. The default value for the Scale Fcator is set with DIP Switch S3 (see section 2.3.4). This value may be changed using "**USnnn** " where "nnn" is any number between 1 and 255. The current value can be determined using the STATUS REQUEST Command "uUR ". The response is a three digit number from 1 to 255 ("**nnn<CR>**").

5.6.8 JOYSTICK ENABLE and DISABLE: **J1, J0** Commands

When the indexer is in Front Panel mode, with an 852 Joystick connected, the Joystick may take control of the motor using the Enable switch, if the motor is stopped. When the interface is enabled, a "J1" command is required to yield control to the Joystick. The "J1" command is a Buffered command and can be included in a string of commands.

In interface mode, the indexer treats Joystick operations like a pause, and will not execute subsequent buffered commands until the indexer exits Joystick mode. Meanwhile, the "W" commands may be used to determine position.

The "J0" command is used to exit from Joystick mode. This command is Immediate, the indexer will exit Joystick mode as soon as the command is received, regardless of motor activity.

5.7 ENCODER/POSITION TRACKING COMMANDS

Installation of the Position Tracking option adds several commands.

5.7.1 ADDITIONAL COMMANDS AVAILABLE WITH THE -P OPTION

a. **FSax** — SET ENCODER FUNCTIONS

This command allows the user to change the effective settings of the encoder function-select switch bank S1 without actually changing the switches. The valid letters for "a" are A through H, which correspond to switches 1 through 8, respectively. The number "x" sets the switch OFF = (0), or ON = (1). The letters that correspond to the functions of S1-1 through 8 are listed below:

A: Incremental (OFF)/Absolute (ON) positioning
B: MOTOR STEP mode (OFF)/ENCODER STEP mode (ON)
C: Encoder Position Maintenance OFF/ON
D: Stop on Stall OFF/ON
E: Output On Stall OFF/ON
F: Kill Motion On Trigger 3 OFF/ON
G: Post Move Position Loss Detection OFF/ON
H: Output On Position Loss OFF/ON

Example: " **FSB1** " (enable ENCODER STEP Mode)

The "**FS** " command is buffered.

b. **uFR** — READ ENCODER FUNCTIONS

This command is a request for the status of the functions set or cleared by the "**FS** " command. The reply is eight digits, each of functions, left to right, 1-8 as shown below:

xxxxxxxx<CR>

S1-1 S1-8

x = 0 or 1

Example: the 2100 responds "**00011000<CR>**"

It is set to stop and signal if the motor stalls.

c. **SVn** -- CHANGE MOTOR SHUTDOWN AND POSITION MAINTENANCE FUNCTION

These commands provide a way to simultaneously change the state of motor-shutdown and position-maintenance functions.

SVØ causes the position-maintenance function to be turned off, but does not turn off motor power. It is identical in function to the "**FSCØ**" command.

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

SV2 causes the position-maintenance function 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 function to be turned on and turns the motor power on if it was turned off. The indexer will servo back to the rest position held before the position maintenance function was disabled.

These commands are buffered.

d. **GH±nn.nnn** GO HOME

This command causes the controller to seek the home position. The sign is optional (a "+" or CW is assumed if omitted). The controller will reverse direction if a limit is activated; will cease the attempt to go home. The "nn.nnn" parameter sets the velocity for the Homing function, and has the same range as the "**V** " command. See section 3.11.10 for a discussion of the Homing function. This command is buffered.

e. **uPR** REPORT ABSOLUTE POSITION

A variant of the normal position report back command. This indicates absolute position relative to Home, rather than the incremental distance of the last move. The format of the position information is identical to the normal 'P' command. The command is buffered and device specific.

f. **PZ** SET CURRENT POSITION AS HOME POSITION

Causes the controller to set the current position as the home position. The command is buffered.

g. **uRC** POSITION TRACKING STATUS REPORT

Refer to the **RC** Response Table. The command is immediate and device specific.

h. **uX2** REPORT ABSOLUTE ENCODER POSITION

This command is identical to the X1 command when ENCODER STEP Mode is used, except that the encoder position is read and the cumulative position is updated before the response is sent. It may be used in ENCODER STEP mode only, while the motor is not moving. The zero reference position may be different than that used by the "**PR** " command. The command is buffered and device specific.

i. **DWnnnnn** SET BACKLASH DEADBAND WIDTH

Backlash deadband select. This command allows precise deadband specification in motor pulses. The backlash deadband allows systems with backlash in the geartrain to use the stall-detect and position-loss detection features. If a nonzero deadband is selected, the position-loss detect and stall-detect will not be active until the error exceeds the deadband width. See section 3.11.14 for a discussion of how to establish this parameter. This command is buffered.

RC Response Table

Response Character	Static Position Loss Between Moves	Position Loss Detected	Go Home Sequence Terminated Normally	Stall During Last Attempted Move
@	NO	NO	NO	NO
A	NO	NO	NO	YES
B	NO	NO	YES	NO
C	NO	NO	YES	YES
D	NO	YES	NO	NO
E	NO	YES	NO	YES
F	NO	YES	YES	NO
G	NO	YES	YES	YES
H	YES	NO	NO	NO
I	YES	NO	NO	YES
J	YES	NO	YES	NO
K	YES	NO	YES	YES
L	YES	YES	NO	NO
M	YES	YES	NO	YES
N	YES	YES	YES	NO
O	YES	YES	YES	YES

5.7.2 MODIFICATIONS OF STANDARD INDEXER COMMANDS

The following existing commands have modifications when in use with the encoder interface features of the Position Tracking board.

a. **uR**

The status request command will indicate that attention is required (response = "*S" or "*C") on four additional conditions: if a stall has occurred, if the go home sequence has not been completed, if a position loss has been detected, or if a static position loss has been detected. A response of "*U" will be returned if an invalid value has been set for one of the encoder resolution digits on switches S4-1 through S4-4. Use the "uRC " command for a more detailed status report.

b. uSR , SS

The "A" parameter in these commands is not used with the encoder interface options because the obsolete 1200 distance compatibility is not implemented with encoder interface options.

c. uW2

The W2 command is not used in ENCODER STEP mode. The W3 command should be used in its place.

5.8 **IEEE-488 COMMANDS**

Additional 2100 commands pertaining to the Service Request Function are provided when the the -488 option is installed. Refer to Chapter 7.

5.9 **EXAMPLES OF VARIOUS TYPES OF BUFFERED COMMAND SEQUENCES**

5.9.1 BASIC INITIALIZATION

The following command set prepares the Indexer to receive a GO command

E MN A10 V10 D50000<CR>

Other initialization parameters may be set with command sequences such as

XO SSC1 SSF1 US25 OO<CR>

These commands perform the following functions, which could also be done by setting DIP switches and cycling the power (to reset the indexer):

a. Set absolute position counter to zero
b. Put the Indexer in the LOAD AND GO mode
c. Put the Indexer in the low velocity range
d. Set the position scale factor to 25 steps
e. Set the Programmable output low

5.9.2 MOTION PARAMETER CHANGES

Any of the basic motion parameters may be changed without affecting the others. These include Mode (Preset, etc.), Acceleration, Velocity, Distance, and Direction parameters. The following example will accelerate quickly, run the motor for two seconds at one speed, decelerate slowly, reverse, and turn two revolutions at another speed. All of the above parameters except distance are changed.

A50 V5 D-50000 MC G T2 A1 V0 G V.5 MN H+ G<CR>

To implement this string from a terminal,

>> Insert a pause command **PS** "in front of the command sequence

>> Complete entry of the entire command set

>> Type: **C<CR>** to clear the pause and initiate action.

This procedure allows you to enter the entire command set before any move is initiated.

5.9.3 LOOPS

Loops allow repetitive action. Move parameters should be left outside the loop where possible. The simplest loop command might look like this:

L G N<CR>

where Preset move parameters have already been entered. The Preset move will be repeated until a Stop or Hold command ("**S** " or "**U** ") is generated.

The most commonly used type of loop command structure has the indexer perform some repetitive indexing operation every time it is signalled to do so. For this, the Trigger pause command (**TRxxx**) is used. For example,

E MN A10 V5 D100000 L100 TR0XX G N<CR>

Here each indexing operation takes place only after the TRIGGER 1 input is switched to Ground. TRIGGERS 2 and 3 are ignored. It is often necessary to use a combination TRIGGER pause command of the form "**TR0XX TR1XX**" to make sure the TRIGGER signal is removed before proceeding to avoid multiple indexes on a single TRIGGER signal. This Loop example also serves the purpose of counting index operations or TRIGGER signals.

5.9.4 STATUS REQUESTS

Typical use of the 2100 Indexer with a computer has the computer download a sequence of commands, usually with a LOOP command, that may be rather long. Then the Indexer may be left to operate on its own without additional input from the computer. If it is desirable for the computer to know the status of the Indexer, a number of status requests may be used.

To indicate what part of a sequence the Indexer is executing, the "**CR**" command may be imbedded in the sequence, and the Indexer will send a carriage return character when it gets to that location in the sequence.

To indicate the status of external inputs (TRIGGERS) at any time, the "**TS**" command is used to return the state of the three inputs.

To determine the current position of the motor, the "**X1**" command is used. This is a buffered command, and no response will be received until all prior commands are completed. If an immediate response is required, the "**W3** commands may be used, but the computer must be prepared to convert the response from hexadecimal notation to the desired format.

Other commands allow determining the set-up parameter status discussed above, and the status of Joystick and Limit Switch inputs.

All these commands require that the Unit Number be appended to the front of the command when using the RS-232 interface.

Chapter 6

REMOTE TERMINAL OPERATION

6.1 OVERVIEW

This chapter describes operation of the Indexer using a "dumb terminal" with an RS-232C communications interface, as shown in Figure 6-1. Using a terminal, you can instruct the Indexer to execute a series of commands, including a sequential change of the basic shaft motion parameters, time delays, pauses, and repeating (looping) operations. A portion of these commands (buffered commands) can be temporarily stored in the Indexer buffer.

The basic characteristics of the RS-232C Communications Interface are described in section 6.3. See section 3.9 for RS-232C installation requirements.

Note

When the Encoder/Position Tracking option is installed, the capability of the Indexer is expanded further by the addition of functions and commands that are not available with the basic unit alone. (See section 5.7.)

Note

All commands **must** be entered as upper-case (capital) letters. Be sure to set your shift lock or alpha lock key to the upper-case position.

6.2 OPERATION

The major operational difference between using a "dumb terminal" and using a computer is that a "dumb terminal" cannot be used as part of an interactive process, while a computer is inherently capable of interactive operation.

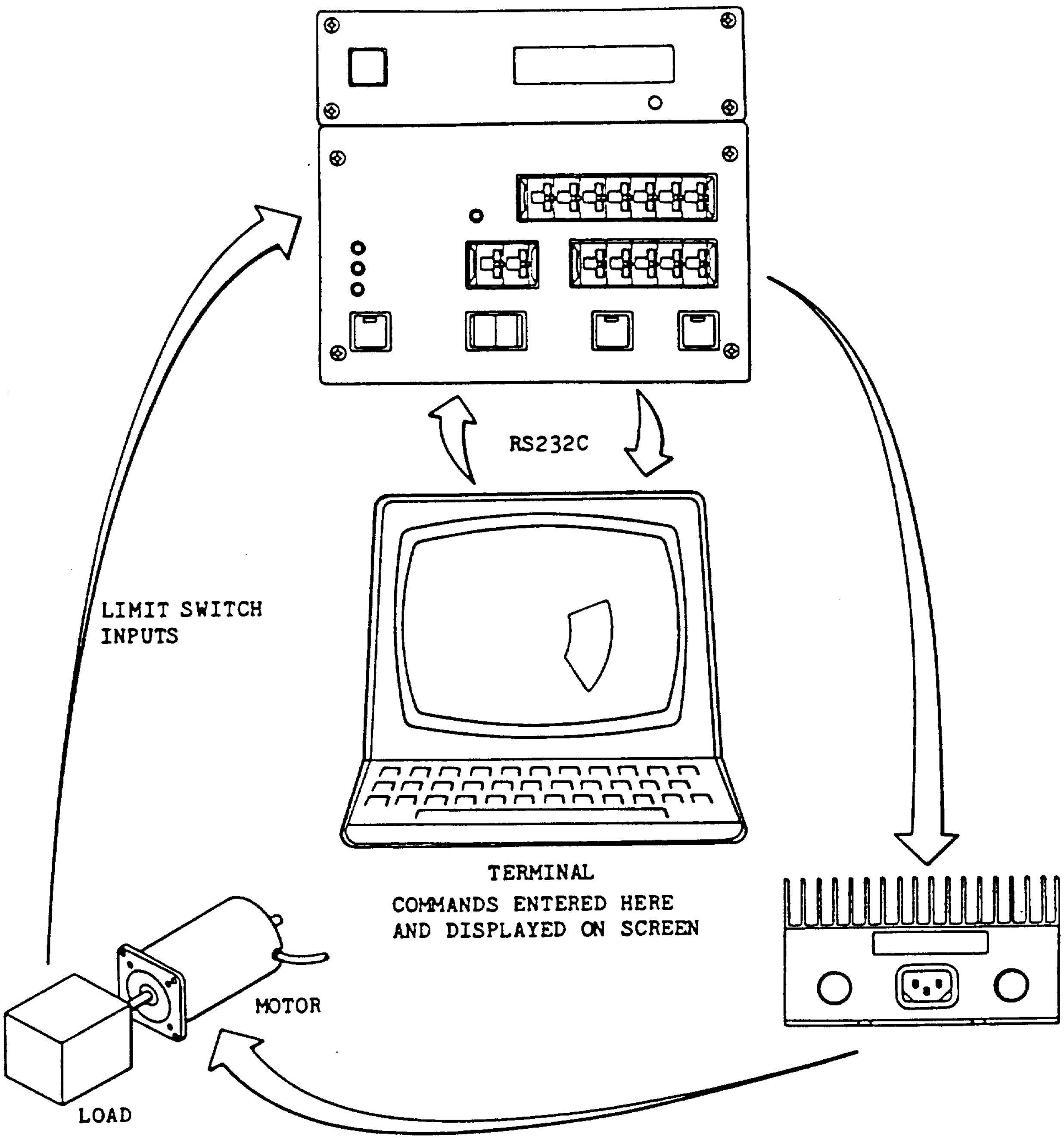


Figure 6-1. Remote Terminal Operation

A "dumb terminal" in combination with the 2100 (which is a "smart" Indexer) can be used for automatic or semiautomatic operation. For example, the terminal could be used to set up the parameters and sequence of moves for a manufacturing process. Assume the motor drives a rotary index table. Parts are loaded at the start point, drilled at the 90 degree location, chamferred at 180 degrees, and cleaned at 270 degrees. Sensors at 90 and 180 degrees detect when machining is complete, a third sensor detects when the chamfer tooling is out of the way. The indexer must signal the loading device when it wants a new part. The process consists of the following steps:

a. The indexer signals the loader to load the part onto the turntable stage. When the part is loaded, a sensor will pulse the Remote START input low to rotate the turntable 1/4 revolution (6,250 steps).

b. The turntable rotates to the drill station and waits for a signal on the first external trigger input while the part is drilled. After drilling, the trigger input is pulsed high.

c. Rotate the turntable 1/4 revolution and wait for the second sensor connected to the second trigger input. When the chamfer complete signal is received, reverse direction and go back 1/8 revolution and wait for the tooling to be moved out of the way. A third sensor, connected to the third trigger input, will signal when it is safe to move on to the cleaning station.

d. Rotate 3/8 revolution to the cleaning station, and wait 2.5 seconds while cleaning.

e. Rotate 1/4 revolution to the initial START position and stop. Remove and replace the part, repeat the cycle.

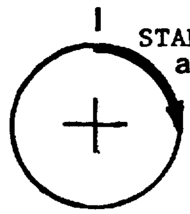
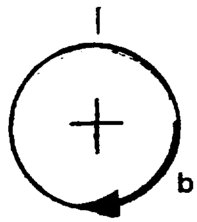
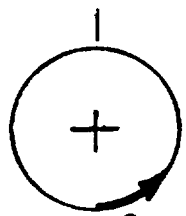
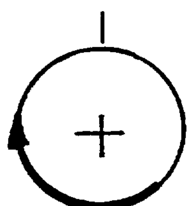
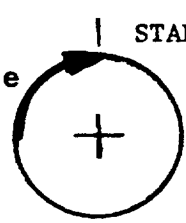
STEP	ACTION
	1. Wait for a low pulse on the remote START input. Then rotate 1/4 revolution (6250 steps, all moves to be at acceleration = 4 rev/sec/sec and velocity = 3.97 rev/sec.). Command structure, initial setup parameters: **E SSD1 MN A4 V3.97 D6250** Add start of loop, wait for START, then move. **LO PS G**
	3. Wait for a high pulse on external trigger input #1, then rotate another 1/4 revolution. Add external trigger input and Go. **TR1XX G**
	4. Wait for a high pulse on external trigger input #2, then go back 1/8 revolution Add reverse distance, external trigger input, and Go. **D-3175 TRX1X G**
	5. Wait for a high pulse on external trigger input #3, then reverse direction, and rotate 3/8 revolutions. Add forward distance, external trigger input and Go. **D9425 TRXX1 G**
	6. Wait 2.5 seconds, rotate 1/4 revolution more to the initial START point. Add time delay and change distance, end loop. **T2.5 D6250 G N**

Figure 6-2. Command Groups for Hypothetical Manufacturing Process

This process is shown in Figure 6-2. The command set for the example shown in Figure 6-2 would be:

E SSD1 MN A4 V3 D6250 LO PS G TR1XX G TRX1X
D-3175 G TRXX1 D9425 G T2.5 D6250 G N

This loop would continue automatically until stopped by the operator.

Note

In this example, it is assumed that the trigger bits were single, momentary pulses (active high), which allows these bits to be used to control initiation of the various moves where trigger bits were included as part of the command group. The "**SSD1**" command allows using the Remote START input as a fourth Trigger with the "**PS**" command.

The possibilities open to the user of Remote Terminal Operation are limited only by the imagination of the designer. As long as the terminal is not asked to make an interactive decision, many combinations of processes are possible. These combinations are extended even more when the equipment is set up for semiautomatic operation, with the operator making decisions and performing certain operations.

If automatic operation is desired, the commands must be structured in some form of loop to avoid the requirement to re-enter the commands after each process cycle.

6.3 RS-232C COMMUNICATIONS INTERFACE

6.3.1 OVERVIEW

RS-232C is the designation of an internationally accepted EIA (Electronic Industries Association) standard for a serial digital communications interface. The standard covers both asynchronous and synchronous transmissions. The Indexer is configured for asynchronous operation (data is sent back and forth without the receiver taking any action).

The Indexer operates in a full-duplex mode. Reset your terminal to full duplex if it is set to half-duplex.

The Indexer can act as an answerer or originator. The choice is made with the internal switch marked **ANS-ORIG.** The **ANS** setting configures the indexer as DTE (Data Terminal Equipment), and the **ORIG** setting configures the indexer as DCE (Data Communications Equipment). In the Indexer application, if characters typed on the terminal are not displayed, changing the switch may solve the problem.

The Indexer is designed so that it can be configured to match a wide variety of terminals, modems, and computers. The Indexer has DIP switches (internally located) so that it can be properly matched with other devices. (See Chapter 3.)

6.3.2 MULTI-UNIT OPERATION

The Indexer capability includes recognition of a "unit number." This allows one terminal to control and communicate with up to 16 indexers connected in a "daisy chain" configuration. The cabling requirements for "daisy chain" operation were shown in Figure 3-8. The switch settings for the "unit numbers" are summarized in Table 6-1.

The factory setting is Unit Number one.

6.3.3 ACTIVATING THE COMMUNICATIONS INTERFACE

Once the Indexer is connected and matched with the terminal, the RS-232C Communications Interface can be activated by entering an upper case **E<CR>** on the terminal keyboard. The Indexer will respond by lighting the red ON LINE indicator on the front panel. Commands can then be sent to the Indexer via the terminal keyboard in the form of individual commands, command groups, and command sets as described in Chapter 4. Verify that the indexer responds to a Status Request toinsure that the number of Data bits and Stop bits are properly set.

Table 6-1. "Unit Numbers" -- S2 Switch Setting

Unit Number	S-2			
	#1	#2	#3	#4
1	OFF	OFF	OFF	OFF
2	ON	OFF	OFF	OFF
3	OFF	ON	OFF	OFF
4	ON	ON	OFF	OFF
5	OFF	OFF	ON	OFF
6	ON	OFF	ON	OFF
7	OFF	ON	ON	OFF
8	ON	ON	ON	OFF
9	OFF	OFF	OFF	ON
10	ON	OFF	OFF	ON
11	OFF	ON	OFF	ON
12	ON	ON	OFF	ON
13	OFF	OFF	ON	ON
14	ON	OFF	ON	ON
15	OFF	ON	ON	ON
16	ON	ON	ON	ON

6.3.4 RS-232C OPERATION

The digital code that defines the numeric value for each character is another standard known as ASCII. Any device that is selected to communicate with the Indexer must be capable of transmitting and receiving ASCII characters. Once the communications interface has been successfully activated, no further operator action concerning the communications interface is required. Commands can be sent to the Indexer by following the instructions in Chapter 4.

6.3.5 DEACTIVATING THE COMMUNICATIONS INTERFACE

The RS-232C Communications Interface can be deactivated by entering an "F<CR>" on the terminal keyboard.

6.3.6 TROUBLESHOOTING THE COMMUNICATIONS INTERFACE

Check the following items if you have any difficulty in operating via the RS-232C Communications Interface.

a. Cycling -- Was the Indexer turned off and then powered-up after the DIP switch settings were changed? This cycling is mandatory to establish the new settings.

b. Baud Rate -- Are the terminal and Indexer set for the same baud rate? (DIP Switches S1-1,2,3.)

c. Parity -- Is the matching parity being used to match the terminal? (DIP Switches S1-5,6.)

d. Data Bits -- Are the matching number of data bits being used? (DIP Switch S1-7.)

e. Stop Bits -- Are the matching number of stop bits being used? (DIP Switch S1-8.)

f. Device Address -- Is the proper device address being used? (DIP Switches S2-1,2,3,4.)

g. Test Routines -- Are test routines #1 and #2 off. (DIP Switches S2-7,8 OFF.)

h. Other -- Does the interface cable have any connections other than those specified in Chapter 3? It should be a shielded three-wire cable. Is the cable properly seated? Is the right connector being used on the terminal?

i. Activate Entry -- Did you use an upper case **E<CR>** to activate the interface? Try entering a space ahead of the **E** to clear the UART.

j. ANS or ORIG -- Did you have the right position for Switch S5 (ANS/ORIG)? Try changing this switch if the character is not being echoed on the screen.

k. ASCII Characters -- Does your terminal use ASCII characters? For example, EBCDC used on the IBM mainframes will not work. Are both units set for 7 bits or 8 data bits? Correct number of stop bits.

l. Other Signals on RS-232C -- Does your terminal require other signals on its RS-232C port? Have the proper jumpers been installed in the terminal end of the RS-232C cable to defeat the extra signals?

m. Is the cable too long? (Fifty feet is the EIA recommended maximum length.

n. Did you use the "**Z** " or "**F** " and forget to reestablish the communications link with the "**E** " command?

Chapter 7

COMPUTER CONTROLLED OPERATION

7.1 OVERVIEW

Computer control of the Indexer provides the capability for automatic interactive processing. Either an RS-232C serial communications link (section 7.5) or an IEEE-488 parallel communications link (section 7.6) can be used to control the Indexer.

There are some fundamental differences when operating with the two types of links. When an RS-232C link is used for computer-controlled operation, the Indexer echoes back all commands. In addition, the time of indexer response to status/position requests is not controlled by the computer. These factors complicate management of the communications interface, especially when multiple indexers are controlled by a single computer. The IEEE-488 link (also known as General Purpose Instrumentation Bus) is designed for total control of data transfer.

The basic commands described in Chapter 5 are used by the computer to control the Indexer. Additional commands become available when the optional IEEE-488 feature is installed. These additional commands are discussed in section 7.6.8.

7.2 DATA INTERPRETATION AND DISPLAY

As discussed in Chapter 5, the choice of commands will influence the kind of data return transmitted by the Indexer. If the computer is to be used interactively with the Indexer, 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 the response that identifies what set of data should be applied to the single character of the response. Position report responses (section 5.5.11) are a function of the specific command to the Indexer and can be decimal, hexadecimal, or binary data.

The logic of your program must be set up to deal with the response issue. The issue can be further complicated by the fact that the timing of responses to buffered commands is a function of the structure of the command set containing the status request command. The timing becomes even more indeterminate if external triggers are part of the control process.

One approach (see Figure 7-1) would be to structure the computer program so that there is only one unexecuted status request stored in the Indexer Command Buffer at any one time. When the status response is received by the computer, a second status request command can then be issued. The computer program must be designed to decode the response as a function of specific status request commands sent to the Indexer.

The program must include instructions on what to do with or how to react to the decoded response data. A comprehensive program will contain a facility to detect indexer problems, either load related, or communications related. Diagnostic routines that take advantage of the many Status Request commands can significantly reduce troubleshooting time.

Note

When the RS-232C Communications Interface is used, the Indexer echos all commands read into the Indexer Command Buffer. The echoes may mix with delayed response data and may further complicate the response interpretation problem. Single indexer applications may eliminate this possibility by shutting off the Echo feature (S1-4). This problem does not exist when the IEEE-488 Communications Interface is used.

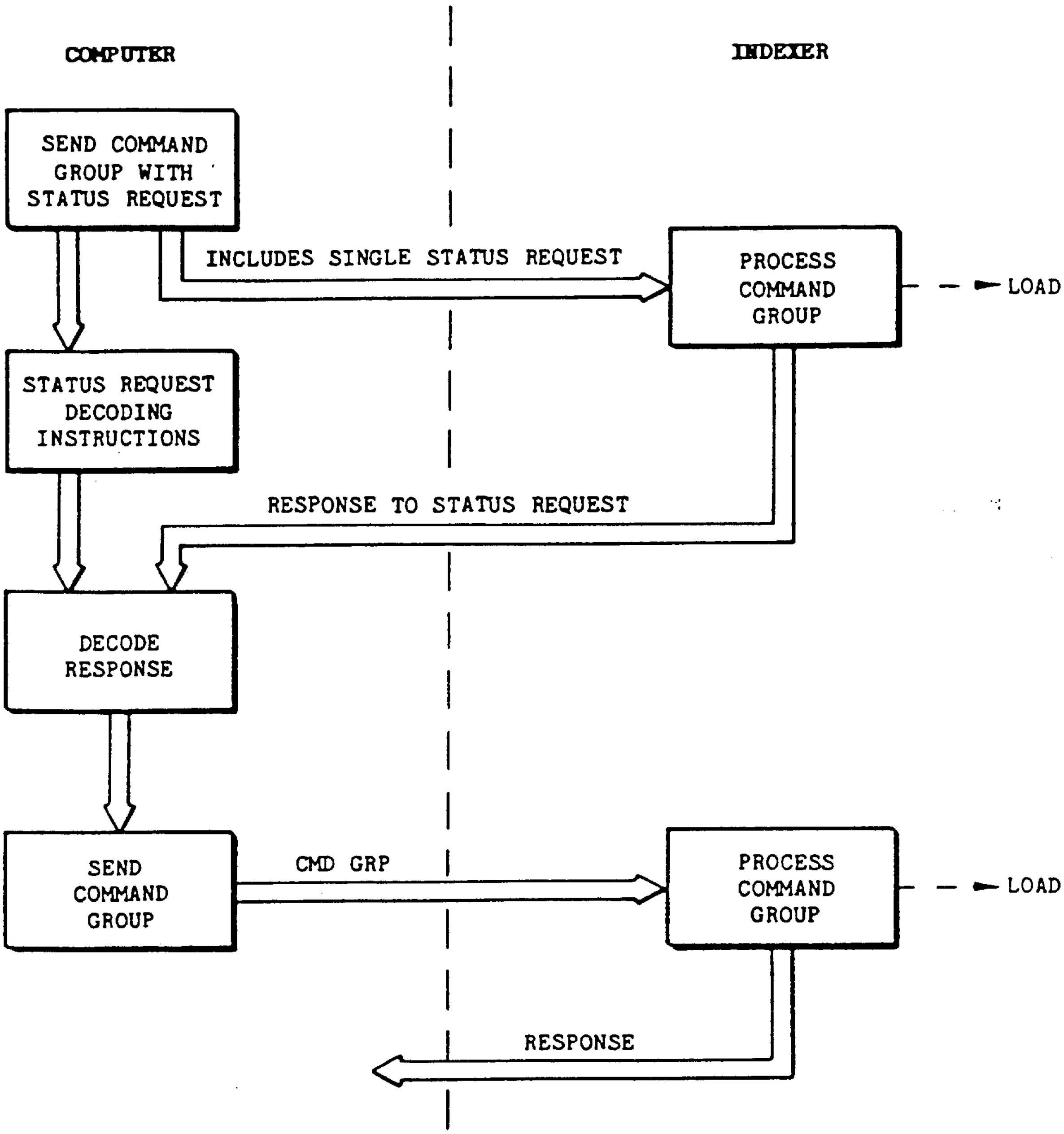


Figure 7-1. Single Status Request Command Sequence

7.3 DESIGNING THE COMPUTER PROGRAM

The computer must be programmed to:

a. Use the communications interface to send commands to the Indexer and optionally to receive data from the Indexer.

b. Distinguish between "echoed" commands and data if an RS-232C link is used.

c. Interpret data received from the Indexer and display the data for use by an operator or use the data for interactive motor control.

d. Allow preparation of files containing sets of commands and/or programs to control the Indexer.

e. Deal with the issues involved in controlling more than one Indexer from a single computer.

Responsibility for creating computer programs lies with the user. Creating an interactive program should pose no problems for an experienced programmer. If you are not familiar with programming for your specific computer, it would be prudent to seek the assistance of someone familiar with both programming and your computer. Ideally the programs should be set up so that a nonprogrammer operator can routinely insert appropriate Indexer commands to 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 to use to communicate with the Indexer and do not include desirable "user-friendly interactive program" features.

The basic steps required are:

a. Enable communications from the computer to the Indexer via the RS-232C or IEEE-488 Interface.

b. Enable transmission of data from the Indexer to the computer via the RS-232C or IEEE-488 Interface.

c. Prepare programs containing the embedded Indexer commands and the functions described in a. and b. above.

d. Prepare programs to receive data from the Indexer that include the routines necessary to interpret the returns and display the data or operate interactively with the Indexer.

Some specific programming examples for both the RS-232C and the IEEE-488 Communications Interfaces are presented in sections 7.4 and 7.5.

7.4 SETTING UP AN RS-232C COMMUNICATIONS LINK

7.4.1 BASIC CONSIDERATIONS

Once the RS-232C Interface is working successfully, no further action with regard to the communications interface per se is required.

The basic commands to control the Indexer are discussed in detail in Chapter 5. A program must be written to allow the computer to send Indexer commands to the Indexer and to receive data from the Indexer via the computer serial RS-232C I/O port. The baud rate of the Indexer **must** be set to match the baud rate of the computer port that is to be used to control the Indexer. (See section 3.9.2.) DIP Switch S2-8 must be set to ON.

When the RS-232C Interface is used, the Indexer echoes the commands as they are read into the Indexer Command Buffer. If commands are entered during the time the Indexer is transmitting back data when multiple Indexers are daisy chained, there can be an intermix of character sets on the communications link, which would make it difficult to separate data from commands.

One approach that can be used for daisy-chained systems takes advantage of the fact that all data returns from the Indexer to the terminal or computer end in a carriage return (except binary numbers). The delimiter can be either a space or a carriage return. Therefore, if space delimiters are reserved for commands and carriage returns for responses, separation of the character sets is much easier.

Under RS-232C operations, the computer does not control the Indexer time of response. In many cases there will be a relatively long (and variable) time delay between the time a buffered status request is read into the Indexer Command Buffer and the time that the data is transmitted to the computer. Time delay effects can be further complicated if Immediate commands are used while Buffered commands are being executed.

The program must be (and can be) designed to deal with the problem, which is further complicated when multiple indexers are to be controlled. The program should be set up to minimize the opportunity for response ambiguity.

When multiple indexers are involved, using a sequential one-unit-at-a-time approach for status requests can reduce the complexity of the problem. Using this approach, one unit at a time would be addressed (by Unit Number) and the computer would wait for the response from that unit before proceeding to interrogate the second unit.

When separating responses from echoed commands, the programmer can also take advantage of the fact that all commands to the Indexer consist of an alphabetic first character or a unit number followed by an alphabetic character. Any additional characters can only be ±, a letter, or a set of numbers. The first character of any 2100 response will be 0, 1, +, -, *, or <CR>.

The response formats are

<CR>;	Carriage return alone
*A<CR>;	An asterisk, alpha character, and carriage return
±nnnnnnnn<CR>;	Sign, 8 decimal digits, and carriage return
*hhhhhhhh<CR>;	An asterisk, 8 hex digits, and carriage return
xxxxxxxx<CR>;	3, 4, or 8 digits, 1 or 0, and carriage return
nnn<CR>;	three decimal digits, and carriage return
bbbb;	four characters forming a 32 bit binary number

A program that deals with the binary report format must be prepared to accept any ASCII character including "Control" characters, "Delete," "Escape," etc. The binary form (bbbb) could be confused with a command echo. The program could be designed to incorporate the following restrictions on the use of the status or position requests:

a. No additional commands should be sent to the Indexer after a status or position request is issued until the response to this command was received.

b. The status request would not be issued while data was being received by the computer.

7.4.2 RS-232C COMMUNICATIONS FILE

7.4.2.1 **General.** The choice of programming language may be an important consideration. The timing between the program and the Indexer is critical to correctly receiving all characters. High-level languages such as BASIC often cannot receive the data as fast as the Indexer can send it because the Indexer will send the character stream back at the set baud rate with no inter-character delay.

Some approaches that can be used to eliminate the timing problem (in order of least to greatest difficulty) are:

a. Reduce the baud rate of the data channel to 300 or 110 baud. (This will slow the transmission rate of long character strings for programming moves, however.)

b. Provide a tight-loop subroutine for grabbing and storing the received characters.

c. Compile your BASIC or other high-level language program and run from the object program.

d. Write a machine language subroutine for scanning and emptying the receive buffer in your computer. The locations chosen for the data can be accessed by BASIC or other high-level languages.

The programming examples in this section are based on the use of one version of the BASIC programming language. Equivalent programs must be prepared for computers that use another language, such as PASCAL, C, FORTRAN, etc.

The BASIC LPRINT command could be used to send a command from the computer to the Indexer. This command would not allow the Indexer to report back to the computer. Two-way communication requires that you OPEN a communication file. In BASIC the OPEN command is used to do this, and it allows setting the RS-232C parameters.

Computer operating systems assign names to Input/Output (I/O) devices such as the keyboard, screen, and printer ports. For MS/DOS operating systems, names typically employed are:

Video screen	SCRN:
Keyboard	KYBD:
Printer port	LPT1:
RS-232C port	COM1:

Note
The port could typically be COM1: or COM2:

An example of the OPEN statement for an IBM PC for an Indexer set to the factory default settings is as follows:

OPEN "COM1:9600,N,8,2,RS,CS,DS,CD" AS #1

Each of the parameters following the COM1 controls parameters as follows:

9600	Baud rate
N	No parity
8	8 Data bits
2	2 Stop bits
RS	Omit "Request To Send" output
CS	Ignore "Clear To Send" input
DS	Ignore "Data Set Ready" input
CD	Ignore "Carrier Detect" input

There may be some difference for other versions of BASIC. Many formats will replace the baud rate with a single digit, where "1" means 300 baud, and "6" means 9600 baud. Likewise, the configuration of the handshake signals (RS, CS, etc.) will be designated by a single letter. The above statement might look like this, where the "D" means no handshaking:

OPEN "COM1:6,N,8,2,D" AS #1

As another example, if you are using Radio Shack Model 100, COM1: is replaced by COM: because there is only one RS-232C port. If the computer allows input and output on the same open statement, it may be necessary to open two separate files as follows:

```
OPEN "COM:88N2D" FOR OUTPUT AS #1
OPEN "COM:88N2D" FOR INPUT AS #2
```

Note

Be sure to consult the specific manuals for your computer to obtain detailed instructions on how to establish a communications file.

7.4.2.2 **Input-Output Statements.** After the communications file has been established, INPUT/OUTPUT statements are required to use the RS-232C serial port. Commands may be printed to the 2100 using the "PRINT #1" statement, and responses may be taken in using the "LINE INPUT #2", "INPUT #2" OR "INPUT$" statements.

The LINE INPUT #2 statement captures all alphanumeric characters up to a "Carriage Return." If a Report Status or Position command is sent to the 2100 without a carriage return, this input statement will capture both the command and the response because the 2100 sends its own carriage return.

The INPUT #2 statement is for numerical data only.

The INPUT$ #2 captures a specified number of characters in a statement like this:

```
RESPONSE$=INPUT$(1,#2)
```

This statement will capture one character from file 2 and assign the string variable RESPONSE$ to equal that character.

The INPUT statements require managing the character input buffer in order to separate the responses from the command echoes. They will usually have an option that allows specifying the number of characters to assign to a variable. Other helpful BASIC features include the LOF and LOC functions to determine the size of input character strings.

7.4.2.3 **Example for the IBM PC.** The following program will work when an IBM PC is connected to the Indexer via the RS-232C Interface. The example sets up operation at 300 baud.

Programming Example One:

To set up the IBM Personal Computer as 300 baud terminal. (It may be necessary to modify the syntax for various versions of BASIC.)

```
 10   CLS
 20   OPEN "COM1:300,N,8,2,RS,CS0,DS0,CD0" AS #1
 30   'open the RS-232 I/O file
 40   LOCATE ,,1
 50   'put the cursor on the screen
 60   K$=INKEY$:IF K$<>"" THEN PRINT #1,K$;
 70   'send any keyboard character out on RS-232
 80   IF EOF(1) THEN 50
 90   'if no characters have been received, go back
100   'and look at the keyboard
110   R$=INPUT$(LOC(1),#1)
120   'assign all input characters to R$
130   PRINT R$;
140   'send input to screen
150   GOTO 40
```

To use this program with a 2100, the 2100 must be set to 300 baud, no parity, 8 data bits, 2 stop bits.

------------------ End Programming Example One ------------------

7.5 IEEE-488 COMMUNICATIONS INTERFACE

7.5.1 GENERAL

The -488 or -P/488 option must be installed in the Indexer to establish an IEEE-488 Communications Interface.

The IEEE-488 interface performs the following functions defined by the IEEE-488 standard:

L	-	Listener
T	-	Talker
AH	-	Acceptor Handshake
SH	-	Source Handshake
SR	-	Service Request
SP	-	Serial Poll
DC	-	Device Clear

The following functions defined by the IEEE-488 standard are **not** supported:

PP	-	Parallel Poll
LE	-	Extended Addressing
TE	-	Extended Addressing
RL	-	Remote/Local with Local Lockout
DT	-	Device Trigger

In a properly configured system where a host computer controls one or more motion axes with 2100's, the operator will not be able to distinguish between operation of the RS-232 versus the IEEE-488 interfaces. It is in the host computer programming where the real differences will show. The 488 bus architecture is such that it eliminates the need for frequent status requests (or polling) of the Indexer to determine, for example, if a given move has been completed. The programmer has better control of communication timing because there is no need to receive transmissions from the 2100 until the program calls for the data.

Note
The IEEE-488 examples in this section referto the HP 9826 and HP 85 computers.

7.5.2 DESCRIPTION OF THE IEEE-488 INTERFACE BUS

The IEEE-488 Interface bus consists of eight data lines and a number of control lines. Data is transferred on the bus eight bits at a time in a parallel configuration. One ASCII character is transferred with each bus operation. Binary data may also be transmitted as for the binary position report commands of the 2100.

Three of the control lines are used as handshake signals between instruments that insure proper timing (DAC, RFD, DAV). One line gives an "end-of-message" signal (EOI). Another is used to distinguish data on the bus as either bus control commands or data (ATN). In this case, all Indexer communications are defined as data. One more command line is used by devices on the bus to request service from the bus controller (SRQ).

There are three principal bus operations that the bus controller (host computer) will execute in communicating with the 2100. These include instructing the Indexer to "listen," to "talk," and to report its "status." Likewise, the Indexer has three principal operations: to talk, to listen, and to request service.

For the HP 85, the listener and talker aspects of bus communications are usually handled by the computer. The programmer uses the OUTPUT or ENTER statements respectively, specifying the device address, and the computer handles the handshaking . Aside from device addressing, the programming for this will be very much like that for RS-232 communications.

To summarize the operation of the IEEE-488 bus, if the controller needs to communicate with one or more bus devices, it instructs them to become listeners and transmits its message. If the controller needs to receive a transmission, it instructs the appropriate device to become a talker. If the controller gets a Service Request, it conducts a serial poll to find out which device requested service and why.

7.5.3 SERVICE REQUESTS AND SERIAL POLL

The instruction to report status is given to the Indexer when the bus controller conducts a Serial Poll. This function of the 488 bus is typically executed by the bus controller in response to a Service Request from one of the devices on the bus. For example, the 2100 can be configured to request service if it encounters an end-of-travel limit switch. The computer will have a special command in its instruction set for conducting a Serial Poll. This procedure automatically returns a Status Word from the polled device. A Service Request is not required before a Serial Poll is conducted. Several bits of 2100 status information are always present in the 2100's Serial Poll register, where the Status Word is maintained. Using the Serial Poll can eliminate much of the need for actual talk/listen status requests to the 2100. A Serial Poll may be conducted to read the register at any time. The eight bits of the Serial Poll Register are assigned to the following conditions:

Condition	Serial Poll Bit
Move complete	0
Joystick request	1
Limit	2
Ready to transmit reply	3
(not used)	4
Command buffer full	5
Service requested	6
Stall or step fault (-P options only)	7

The 2100 may be configured to initiate a Service Request on any one or more of the above conditions (see section 7.5,8, the "QS " command). Serial Poll bits are set to 1 when their assigned condition is true. Serial Poll bit 6 will be high if the 2100 is the device that requested service.

On the HP 9826 and HP 85 computers, the 2100 may be addressed to listen, to talk, or to report Serial Poll status with the following commands. The syntax assumes that the 488 bus is communication channel 7, and that the 2100 is at device address 1.

To send commands:

```
9826:     OUTPUT 701 USING "#,K;" < command >",END

HP 85:    OUTPUT 701 ;" < command > "
```

To receive data from the 2100:

```
9826:     ENTER 701 USING "K";A$

HP 85:    ENTER 701 USING "%,#%K",A$
```

("A$" is the string variable to which the response characters will be assigned.)

To conduct a Serial Poll on the HP 9826 or HP 85:

```
X=SPOLL (701)
```

where X is the numerical variable to which the response characters will be assigned. Numerical testing will determine which bits are set.

The 2100's Serial Poll response will be a single byte, usually returned in the form of an integer between zero and 255. The following set of BASIC instructions will serve to decode this number:

```
10 X=SPOLL(701)
20 DISP "Serial Poll response= ";X
30 IF X>127 THEN DISP "Motor Stall or Position Loss detected":X=X-128
40 IF X>63 THEN DISP "This 2100 is Requesting Service":X=X-64
50 IF X>31 THEN DISP "The Command Buffer is full":X=X-32
60 IF X>15 THEN X=X-16
70 IF X>7 THEN DISP "The 2100 is ready to respond":X=X-8
80 IF X>3 THEN DISP "A Limit switch was encountered!":X=X-4
90 IF X>1 THEN DISP "The Joystick interface is requesting
control!":X=X-2
100 IF X>0 THEN DISP "The 2100 has completed its move." ELSE DISP
"The motor is still moving..."
```

7.5.4 INDEXER RESPONSE TO INTERFACE CLEAR OR DEVICE CLEAR

The 2100 will reinitialize itself (Z command) when it sees the INTERFACE CLEAR signal or receives a Device Clear command. Note that no commands should be sent to the 2100 for 500 milliseconds after an INTERFACE CLEAR.

To send the Interface Clear command:

To HP 9826: ABORT (7)

To HP 85: ABORTIO (7)

To send the Interface Clear command to the HP 9826 or HP-85:

CLEAR (701)

When the 2100 is enabled on the bus using the 'E' command, the front control panel is locked out. This is indicated by the ON LINE light. If this light is off, bus commands are ignored.

The 2100 will reinitialize itself ('Z' command) when it sees the DEVICE CLEAR signal.

Note

No commands should be sent to the 2100 for500 milliseconds after a DEVICE CLEAR.

7.5.5 DIP SWITCH SETTINGS -488 OPTION

The following modifications to Indexer main board DIP switch settings are made when the IEEE-488/Position Tracking board is installed.

S4-1 is not used.

S2-5 will not be used as motor resolution select because the motor resolution is selected on S4-1 through S4-4 of the IEEE-488/Position Tracking board. (Refer to sections 3.9 and 3.10)

If the IEEE-488 interface option is selected, S2-1 through S2-5 are used as bus device address select. Addresses 1-31 (Table 7-1) are valid IEEE-488 device addresses.

7.5.6 COMMAND CONSIDERATIONS

The 2100 command language using the IEEE-488 interface is the same as with the RS-232 interface, except that Unit Numbers device addresses are not required as part of the 2100 command language for device specific commands.

7.5.6.1 **Sending commands to the 2100.** The IEEE-488 expects all Indexer commands to be delimited by a space or carriage return. The Indexer will interpret an EOI (end or inquire) on a character as equivalent to the space delimiter. Thus, any one of the following command strings will cause the Indexer to move the motor 25,000 steps.

D25000 G

or

D25000 G<CR>

or

```
          E
          O
          I
D25000 G
```

Table 7-1. IEEE-488 Device Address

IEEE-488 Device Address	S2 --				
	#5	#4	#3	#2	#1
1	OFF	OFF	OFF	OFF	ON *
2	OFF	OFF	OFF	ON	OFF
3	OFF	OFF	OFF	ON	ON
4	OFF	OFF	ON	OFF	OFF
5	OFF	OFF	ON	OFF	ON
6	OFF	OFF	ON	ON	OFF
7	OFF	OFF	ON	ON	ON
8	OFF	ON	OFF	OFF	OFF
9	OFF	ON	OFF	OFF	ON
10	OFF	ON	OFF	ON	OFF
11	OFF	ON	OFF	ON	ON
12	OFF	ON	ON	OFF	OFF
13	OFF	ON	ON	OFF	ON
14	OFF	ON	ON	ON	OFF
15	OFF	ON	ON	ON	ON
16	ON	OFF	OFF	OFF	OFF
17	ON	OFF	OFF	OFF	ON
18	ON	OFF	OFF	ON	OFF
19	ON	OFF	OFF	ON	ON
20	ON	OFF	ON	OFF	OFF
21	ON	OFF	ON	ON	OFF
22	ON	OFF	ON	ON	ON
23	ON	OFF	ON	ON	ON
24	ON	ON	OFF	OFF	OFF
25	ON	ON	OFF	OFF	ON
26	ON	ON	OFF	ON	OFF
27	ON	ON	OFF	ON	ON
28	ON	ON	ON	OFF	OFF
29	ON	ON	ON	OFF	ON
30	ON	ON	ON	ON	OFF
31	ON	ON	ON	ON	ON

* Factory Setting

7.5.6.2 **Receiving Responses from the 2100.** When the 2100 has been commanded to send a reply to the host CPU and the host CPU has set the Indexer in the TALKER state, it will send a reply string. The reply string can have two formats.

The ASCII reply string has the following format:

```
                E
                O
                I
reply string &lt;CR&gt;
```

The response to the binary position report commands, "**W1**", "**PB**", or "**X1B**" consists of four bytes which must be concatenated to make a 32 bit binary value. The format of the binary reply is

```
   E
   O
   I
BBBB
```

where the four binary bytes are represented by the letter B.

7.5.7 ADDITIONAL COMMANDS AVAILABLE WITH THE -488 OPTION

a). **QSax** SET SERVICE REQUEST FUNCTION

This command allows the user to change the effective settings of the IEEE-488 option switch bank S3-1 through S3-8 without actually changing the jumpers. This command is buffered.

There are 2 values for x;

0 corresponds to switch OFF,
1 corresponds to switch ON.

The valid letters for "a" are A through H, which correspond to switches 1 through 8 respectively. A through H are listed below.

A -- S3-1 RS232 (off)/ IEEE-488 (on)
B -- S3-2 SRQ upon move complete OFF/ON
C -- S3-3 SRQ upon joystick request OFF/ON
D -- S3-4 SRQ upon limit OFF/ON
E -- S3-5 SRQ upon ready to transmit reply OFF/ON
F -- S3-6 reserved
G -- S3-7 SRQ upon command buffer full OFF/ON
H -- S3-8 SRQ upon stall or position loss OFF/ON. (For encoder interface options only.)

b. **QR** READ SERVICE REQUEST FUNCTIONS

This command is a request for the status of the functions set or cleared by the "QS " command above.

Response format is eight digits, each of which is a 0 or a 1. The eight digits correspond to the eight functions shown below.

The command is buffered and device specific.

```
                                        * x x x x x x x x <CR>
1 -- RS-232/IEEE-488
2 -- SRQ move Complete
3 -- SRQ joystick req OFF/ON
4 -- SRQ limit OFF/ON
5 -- SRQ ready to transmit reply OFF/ON
6 -- Reserved
7 -- SRQ command buffer full OFF/ON
8 -- SRQ stall/position loss OFF/ON
     (Encoder Option)                    x = 0 = OFF / x = 1 = ON
```

For example: The user wishes to operate the 2100 under computer control on the 488 bus. At one point in his program, he wants the operator to take control of the motor using the Model 852 Joystick unit. To do so, it is necessary to instruct the computer to yield control to the Joystick. The Joystick is to be used in only one part of the operation and must not interrupt the computer otherwise.

At the right moment, the computer issues the command "QSC1 ". This instructs the 2100 to generate a Service Request if the Joystick unit is switched to ENABLE, generating a signal on the Joystick Request input of the 2100 Joystick connector. This condition can be verified with the command QR. The 2100, if stopped, responds: 01000101 (decimal 69, indicating "service requested", "joystick request", and "move complete"). A "QSC0 " command restores the Indexer to its power-on configuration. The QS command then yields the response: 00000001 (1).

7.5.8 PROGRAMMING EXAMPLES FOR HP 9826 AND HP 85

Two examples are shown.

a. HP 9826 Model 200, Indexer at IEEE-488 device address 1. The purpose of Example Three is to move the motor 25000 steps and check for limit switches.

b. HP 85 Indexer at IEEE-488 device address 1. The purpose of Example Four is to move the motor 25000 steps and check for limit switches.

==

Programming Example Two: HP 9826 Model 200 Computer

Assume that the 2100 is at IEEE-488 device address 1.

Move the motor 2500 steps and read its position

```
 10   OUTPUT 701 USING "#,K";"E X0 MN A1.0 V5.0 D25000 G ",END
 20   REM START MOTION
 30   X = SPOLL(701)
 40   IF BIT(X,1) = 0 THEN GOTO 30
 50   REM REM WAIT FOR MOVE TO FINISH
 60   REM  READ THE POSITION
 70   OUTPUT 701 USING "#,K";"X1 ",END
 80   REM TEST FOR READY TO TRANSMIT POSITION
 90   X = SPOLL(701)
100   IF BIT (X,3) = 0 THEN GOTO 90
110   REM READ THE POSITION REPORT
120   ENTER 701 USING "K";P
130   REM CHECK FOR CORRECT POSITION
140   IF P=25000 THEN DISP "Position is correct!":GOTO 200
150   DISP "Wrong answer, position reported = ";P
160   DISP "...should be 25000"
170   END
```

------------------ End Programming Example Two ------------------

==

==

Programming Example Three: HP 85 Computer

Assumes that the 2100 is at device address 1.

Move the motor 2500 steps and read its position

```
 10   OUTPUT 701 ;"E X0 MN A1.0 V5.0 D25000 G "
 20   REM START MOTION
 30   X = SPOLL(701)
 40   REM TEST FOR END OF MOVE
 50   IF BIT(X,1) = 0 THEN GOTO 30
 90   REM  REQUEST POSITION
100   OUTPUT 701 ;"X1 "
110   X = SPOLL(701)
120   REM WAIT UNTIL READY TO TRANSMIT POSITION
130   IF BIT(X,3) = 0 THEN GOTO 120
140   REM READ THE POSITION REPORT
150   ENTER 701 USING "%,#%K";P
160   REM CHECK FOR CORRECT POSITION
170   IF P=25000 THEN DISP "Position is correct!":GOTO 200
180   DISP "Wrong answer, position reported = ";P
190   DISP "...should be 25000"
200   END
```

------------------ End Programming Example Three ------------------
==

7.6 TIME DELAY CONSIDERATIONS USING IEEE-488 INTERFACE

7.6.1 GENERAL

The computer program design must include consideration of the read and execute time of both the computer and the Indexer. Refer to your computer manual for details on the computer cycles. This section describes some of the Indexer time delays.

The IEEE-488 bus is considerably faster than an RS-232 link at 9600 baud. When the Indexer is NOT moving the motor, it will read command characters as fast as the bus can send them. (This could be at a baud rate of 9600.) When the Indexer encounters a delimiter, it processes the command and does not complete the bus handshake for the next character until the command has been processed. Each time the Indexer encounters a delimiter, it will stop reading characters and process the command. For some commands this can take around 2 milliseconds. For the "G ", and "IC " commands, the processing time can take up to 30 milliseconds. The Reset ("Z ") command requires 500 milliseconds.

The time delays when the motor is at rest or in motion are described in sections 7.6.2 and 7.6.3.

7.6.2 TIME REQUIRED WHEN MOTOR AT REST

Assume the following command group was sent to the Indexer controlling a 25,000-step motor/drive:

```
OUTPUT 701 USING "#,K";"E MN A3.1 V5.4 D25000 G ",END
```

The time in microseconds required to process the command group above when the Indexer is NOT moving the motor is shown in Table 7-2. The delay from start of transmission to execution would be about 35 milliseconds (35,000 microseconds). The IEEE-488 bus would be busy for about 35 milli-seconds. When the 2100 encounters a space it goes to process the command and does not complete the bus handshake for the next character until the command has been processed.

7.6.3 TIME REQUIRED WHEN MOTOR IS IN MOTION

Assume the position request commands below are sent to the Indexer. The response time delay in microseconds in shown in Table 7-3.

```
OUTPUT 701 USING "#,K";"1W2 ",END

ENTER 701 USING "K";A$
```

Table 7-2. Time Required When Motor at Rest

Time (Microseconds)	Operation
200	read E
500	process the "E " command
200	read M
200	read N
800	process the "MN " command
200	read A
200	read 3
200	read .
200	read 1
2,500	process the "A3.1 " command
200	read V
200	read 5
200	read .
200	read 4
2,600	process the "V5.4 " command
200	read D
200	read 2
200	read 5
200	read 0
200	read 0
200	read 0
1,200	process the "D25000 " command
200	read G
25,000	process the "G " command
35,000	Total

Table 7-3. Time Required When Motor is in Motion

PROCESSING THE COMMAND

Time (Microseconds)	Operation
200	read 1
200	read W
200	read 2
800	process the "1W " command
1600	Subtotal

RESPONSE

The response would have the form

*XXXXXXXX

The response delay would be:

Time (Microseconds)	Operation
200	write *
200	write x
200	write x
200	write x
200	write x
200	write x
200	write x
200	write x
200	write x
1800	Subtotal

The total delay from initiation of the "1W2 " command to transmission of the response would be 3.4 milliseconds (3,400 microseconds).

Chapter 8

MAINTENANCE AND TROUBLESHOOTING

8.1 OVERVIEW

This section is designed to help you find the source of the problem if you are having trouble with your 2100 Indexer.

If your 2100 begins behaving erratically, or not at all, the answers to the questions in Sections 8.2 through 8.6 should be obtained:

8.2 AC POWER

Does the unit have proper power? The 2100-1, 2100-2, or 2100-3 require 90-130 Vac at 50-60 Hz. 2100-4 units require +5, +12, and -12 volts to operate. Refer to Table 3.2 for pinouts.

8.3 COMMAND READINESS

Is the unit ready to accept commands?

a. If you are using a 2100-1, the POWER and START switches must be illuminated before a start command will be accepted.

b. Is the velocity specified within range? The front panel lever wheels (2100-1) must be set from 00000 to 20000. Any remote velocity command that specifies a velocity above 20.000 revs per second will cause the velocity value to be ignored.

c. Are one or both limit switch inputs activated? Make sure DIP switch S4-8 is in the correct position for the polarity of the limit input you are using (see Section 3.7).

d. Has the drive been de-energized with the motor shutdown command? This could be in the form of a hardware input (see Section 3.8 and 4.3.5) or a remote command (see Table 5.2).

e. Has Load Data mode been specified and no data loaded? Refer to Section 4.3.6 (Rear Panel) and Section 5.4.2 (Remote Interface).

f. Is the 852 Joystick enabled? This can be done through the Rear Panel (Section 3.13) or with the Remote Interface (Table 5.5).

g. Does the unit have position tracking? If so, an incremental optical encoder must be properly interfaced. Refer to Section 3.11. If jumper number 3 on the position tracking board is on (position maintenance selected), the encoder must be operational.

h. Has any DIP switch been changed? If so, the power must be cycled off and on to the unit to read the new values.

8.4 COOLING

Is the unit cool enough? The 2100 is designed to operate in a 0-50oC environment. If it is hotter than that, a fan or other cooling may be required.

8.5 ERRATIC BEHAVIOR

Does the unit exhibit erratic behavior that could be caused by electrical interference or noise? Check to make sure that all cables (auxiliary, encoder connector, etc.) are shielded and that the shield is connected to earth ground (case ground) and not to logic ground. If the incoming AC power is noisy, a line filter (manufactured by CORCOM and others) may help.

8.6 COMMUNICATION INTERFACE

Does the unit seem to have trouble with its RS-232C or IEEE-488 link? Check for loose cables and also ensure that the RS-232C parameters (refer to Section 3.9) or IEEE-488 parameters (Section 3.10) have not changed in the host computer or terminal.

8.7 TECHNICAL ASSISTANCE AND SERVICE

If all questions have been answered satisfactorily, the next step should be to call an Applications Engineer at Compumotor. Most problems can be solved over the telephone. Applications Engineers are available from 7 a.m. to 5 p.m. Pacific Time, Monday through Friday. Call 800-358-9068 or 707-778-1244 (collect from California).

If you and the Applications Engineer determine that there is a problem, it may be necessary to return the unit for repair. All units must have a Return Material Authorization (RMA) number prior to returning them. This may be obtained from the applications engineer or from the Customer Service Department. The RMA number prefaced by the letters "RMA" should be marked on the shipping container. It should be sent to Compumotor Corporation, 1179 North McDowell Street, Petaluma, California, 94952. Please feel free to call Compumotor at the numbers listed above if you have any questions.

Appendix A

Application Example

A user wishes to use his personal computer to control a glue application machine. He does not want the computer to be tied up controlling the machine, but the computer needs to know when the operation is completed each time. The machine has two axes in the X/Y configuration. A hot glue dispensing head must move in a rectangular to glue the bottom onto a box. The required sequence of events is as follows:

1. Move both motors to a retracted starting position (the box is placed for gluing)
2. The X axis moves to the glue position, and checks for the presence of the box
3. The X axis moves down one side at a slow rate, applying the glue (motor rotation is clockwise)
4. The Y axis moves down the adjoining side (clockwise)
5. The X axis moves along the third side (counterclockwise)
6. The Y axis moves along the fourth side, completing the glue application (counterclockwise)
7. The glue is turned off, and the computer is notified

The X axis 2100 is set to be Unit Number 1, Y is Number 2. The following connections are made to the equipment, in addition to the End-of-travel Limit switches. All switches close to Ground of the 2100 Auxiliary connector, the two indexer grounds are connected together.

X 2100:

1. The Programmable Output is wired to the glue head - when turned ON, glue is dispensed.

2. The Trigger 1 input is wired to the In Position Output of the Y 2100.

3. The Trigger 2 input is wired to a limit switch which is tripped when the X motor is in the Start position.

4. The Trigger 3 input is wired to limit switch that detects the presence of the box.

Y 2100:

1. The Trigger 1 input is wired to the In Position Output of the X 2100.

2. The Trigger 2 input is wired to a limit switch which is tripped when the Y motor is in the Start position.

The wiring of the In Position outputs to the Trigger 1 inputs allows each 2100 to know when the other has finished its move. The computer is programmed to send two different command sequences. One sends the two motors back to the Start position, and the other performs the gluing operation. After the computer has sent the instructions to do either operation, it is programmed to interrupt the other things it is doing when it gets a transmission from the indexers.

This arrangement allows the computer to send the "Find the Start position" sequence independently of the other sequence, at start up, and after each operation. The operations both be transmitted at once, or in a loop if desired.

The 2100 command sequences look like this:

1. Find the Start position

E MC A50 V1 H- G TRXOX V0 G 1CR 2CR

These commands cause each axis to move toward the Start position which is at the maximum counterlclockwise position. They will move slowly until the Start position limit switches are detected, then they stop, and each sends a carriage return character to signal completion of the operation.

2. Glue the part:

E MN A10 V5 1D100000 1G (move X to the glue position)

1TRXXO 01 T1 V1 1D1230500 G (if the box is present, the glue is turned on, and 1 second later, X moves)

2TROXX 2TR1XX 2D150230 G (the Y 2100 waits to make sure X has started its first pass, then waits until the X move is finished, and then starts its own move)

1TROXX 1TR1XX H- G (the X 2100 waits to make sure Y has finished, and then starts its second pass)

2TROXX 2TR1XX G 00 2CR (the Y 2100 waits to make sure X has finished, and then starts its final pass, after which the glue is turned off, and a carriage return is sent to the computer)

There are a number of enchancements that could be added to the 2100 command sequences above. These could include a final "creep in" operation on the first sequence for maximum position accuracy, and the following loop routines for the gluing operation to reduce the number of characters sent to the 2100's:

01 T1 1D1230500 2D150230 L2 1G 2TROXX 2TR1XX 2G H 1TROXX 1TR1XX N 00 1CR

Appendix B

ALPHABETICAL COMMAND SUMMARY

Command	Description	Type	Page
Annn.nn	Set acceleration/deceleration	B	5-8
B	buffer status	I,D	5-27
C	Continue (end pause)	I	5-15
CR	Command execution status	B,D	5-35
D±nnnnnnnn	Set direction (optional) and distance (position) value	B	5-9
DA	Sets remote display to zero	B	5-37
DB1	Unblanks remote display	B	5-37
DBØ	Blanks remote display	B	5-37
DC1	Starts remote display blinking	B	5-37
DCØ	Stops remote display blinking	B	5-37
DWnnnnnnnn	Backlash deadband select	B	5-43
E	Enable comm I/F; disable front panel	I	5-36
F	Disable comm I/F; enable front panel	I	5-36
FR	Request JU 1-8 status	B	5-40
FSax	Set encoder functions	B	5-40
G	GO (start executing move)	B	5-14
GH±nn.nnn	Seek the home position	B	5-41
^H	(Control H) Back-space and delete character	I	5-36

(n = 0 to 9, a = A to H, x = 0 or 1)

ALPHABETICAL COMMAND SUMMARY (Continued)

Command	Description	Type	Page
H	Change motor direction	B	5-8
H±	Set direction of motion	B	5-9
I	Load move parameters, Compute move profile	B	5-15
IC	Load move parameters, Compute move profile, Transmit carriage return when done	B,D	5-15
J1	Enable joystick and disable RS-232C control of the motor	B	5-38
JØ	Restores RS-232C control of the motor and disables joystick	I	5-38
K	Kill (stop pulse generation now)	I	5-17
L	Loop continuously	B	5-20
Lnnnnnn	Loop "nnnnnn" times (0-9,999,999)	B	5-20
MA	ALTERNATE mode (Continuous back and forth)	B	5-9
MC	CONTINUOUS mode (Rotate at constant velocity)	B	5-9
MN	PRESET mode (go to position)	B	5-9
N	End-of-loop move	B	5-20
O1	Set programmable output high	B	5-36
OØ	Set programmable output low	B	5-36

(n = 0 to 9, a = A to H, x = 0 or 1)

ALPHABETICAL COMMAND SUMMARY (Continued)

Command	Description	Type	Page
P	Report Incremental Position (decimal)	B,D	5-31
PB	Report Incremental Position (binary)	B,D	5-31
PR	Report Absolute Position (from Home)	B,D	5-42
PS	Pause and wait for CONTINUE entry	B	5-18
PZ	Set current position as home position	B	5-42
Q	Clear buffer at end of execution of current command	I	5-17
QR	Report -488 SRQ Functions	B ,D	7-21
QSax	Set -488 SRQ Functions	B	7-20
R	Report execution status	I,D	5-27,5-43
RA	Report Limit status	I,D	5-27
RB	Report Pause status	I,D	5-28
RC	Report Encoder status	I,D	5-42
S	Stop (now) at deceleration rate equal to last used acceleration rate	I	5-17
SJ	Report Joystick status	I,D	5-29

(n = 0 to 9, a = A to H, x = 0 or 1)

ALPHABETICAL COMMAND SUMMARY (Continued)

Command	Description	Type	Page
SR	Report Parameter status	B,D	5-34
SSax	Set parameter status	B,D	5-36
STØ	Denergize drive (OFF)	B	5-13
ST1	Energize drive (ON)		
SVn	Change motor shutdown and position maintenance function	B	5-41
Tnnn.nn	Delay processing subsequent commands in buffer for indicated number of seconds (0-999.99)	B	5-18
TRxxx	Trigger pause in processing commands	B	5-18
TS	Trigger status	I,D	5-29
U	Pause and wait for **CONTINUE** entry	I	5-19
UR	report Scale factor	B,D	5-35
USnnn	Set Scale factor (1-255)	B,D	5-40
Vnn.nnn	Set velocity	B	5-8
VSnn.nnn	Set STOP/START velocity	B	5-8
W1	Report Position (binary)	I,D	5-30
W2	Report Position (Hexadecimal)	I,D	5-32
W3	Report Position (Hexadecimal, two's complement notation)	I,D	5-33

ALPHABETICAL COMMAND SUMMARY (Continued)

Command	Description	Type	Page
X1	Report Cumulative position	B,D	5-35
X1B	Report Cumulative position (binary)	B,D	5-30
X2	Similar to the X1 command	B,D	5-43
XØ	Set cumulative position to zero	B	5-13
Y	Exit at end-of-loop in process	I	5-16
Z	Software reset (stop pulse generation now and reset 2100)	I	5-18

APPENDIX C: 2100 CONNECTORS

AUXILIARY

1.	CW LIMIT In
2.	CCW LIMIT In
3.	REMOTE START In *
4.	REMOTE STOP In *
5.	MOTOR SHUTDOWN In *
6.	LOAD In *
7.	TRIGGER 3 In
8.	TRIGGER 2 In
9.	GND
10.	GND
11.	IN POSITION Out
12.	LOAD READY Out
13.	TRIGGER 1 In
14.	REMOTE GO HOME In *
15.	PROGRAMMABLE OUTPUT

DRIVER

1.	STEP Out
2.	DIRECTION Out
3.	CW STEP Out *
4.	CCW STEP Out *
5.	Shield
6.	STEP Return (GND)
7.	DIRECTION Return (GND)
8.	SHUTDOWN Out
9.	SHUTDOWN Return (GND)

* Low true

GND = Signal Ground

JOYSTICK

1.	Joystick Request In *
2.	Remote Direction
3.	At Zero In *
4.	Step In
5.	nc
6.	Joystick Acknowledge Out *
7.	Shutdown Request In *
8.	nc
9.	GND
10.	GND
11.	+5VDC Out (100 mA)
12.	+12 VDC Out (10 mA)
13.	-12 VDC Out (10 mA)
14.	nc
15.	nc

* Low True

DISPLAY (J9)

		(J9)
1.	GND	1
2.	GND	3
3.	GND	5
4.	GND	7
5.	RESET Out *	9
6.	1200 MODE (obs.)	11
7.	nc	13
8.	nc	15
9.	+10VDC (unreg.)	2
10.	+10VDC (unreg.)	4
11.	STEP Out	6
12.	DIRECTION Out	8
13.	BLANK Out *	10
14.	BLINK Out *	12
15.	nc	14

POSITION SENSOR

1.	Channel A+	14.	GND
2.	Channel A- (optional)	15.	GND
3.	Channel B+	16.	GND
4.	Channel B- (optional)	17.	GND
5.	Channel Z+ (HOME)	18.	GND
6.	Channel Z- (optional)	19.	GND
7.	nc	20.	GND
8.	Shield	21.	nc
9.	nc	22.	nc
10.	Encoder Pulse Output (x4)	23.	+5 VDC
11.	Encoder Direction Output	24.	+5 VDC
12.	nc	25.	+5 VDC
13.	Home Enable		

POWER SUPPLY

Description	J10	J2	J4
nc	1	10	N/A
Chassis GND	2	9	7
-12 VDC @ 50 mA	3	8	6
+12 VDC @ 50 mA	4	7	5
+5 VDC	6	5	4
+5 VDC	7	4	3
+5 VDC	8	3	2
DC GND	9	1,2	1
DC GND	10	1,2	1

APPENDIX D: STATUS REQUEST RESPONSE SUMMARY

RA Response Table
Limit Switch Status

Response Character	Last Move Terminated by: CW Limit	Last Move Terminated by: CCW Limit	Current Move Limited by: CW Limit	Current Move Limited by: CCW Limit
@	NO	NO	NO	NO
A	YES	NO	NO	NO
B	NO	YES	NO	NO
C	YES	YES	NO	NO
D	NO	NO	YES	NO
E	YES	NO	YES	NO
F	NO	YES	YES	NO
G	YES	YES	YES	NO
H	NO	NO	NO	YES
I	YES	NO	NO	YES
J	NO	YES	NO	YES
K	YES	YES	NO	YES
L	NO	NO	YES	YES
M	YES	NO	YES	YES
N	NO	YES	YES	YES
O	YES	YES	YES	YES

RB Response Table
Special Status

Response	Joystick Enable Request	Pause "PS"	Hold "U"	Waiting for Trigger
@	NO	NO	NO	NO
A	YES	NO	NO	NO
B	NO	YES	NO	NO
C	YES	YES	NO	NO
D	NO	NO	YES	NO
E	YES	NO	YES	NO
F	NO	YES	YES	NO
G	YES	YES	YES	NO
H	NO	NO	NO	YES
I	YES	NO	NO	YES
J	NO	YES	NO	YES
K	YES	YES	NO	YES
L	NO	NO	YES	YES
M	YES	NO	YES	YES
N	NO	YES	YES	YES
O	YES	YES	YES	YES