Motion Plus™ 473

Control Systems
Installation Manual

Custom Servo Motors Inc.
A Subsidiary of MTS Systems Corporation

2121 Bridge Street
New Ulm, MN 56073
Telephone: 507-354-1616
Fax: 507-354-1611

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1 Introduction

This manual is designed to help you install Motion Plus™/473 Control Systems including chassis, modules, and cables.

A model number and part number reference, at the end of Chapter 2, lists all standard Motion Plus/473 equipment including circuit cards, modules, and cables.

How to Use This Manual

Consult this manual while installing, testing, or troubleshooting all equipment. The following is a brief summary of the contents of this manual:

- Chapter 1 contains instructions for unpacking and handling Motion Plus devices such as cards and chassis, describes required precautions and tools, and describes what steps to take to return materials.
- Chapter 2 provides an overview of the general Motion Plus system, including the functions of all system components. Included in this chapter are diagrams of typical system configurations and the typical memory and I/O addressing.
- Chapter 3 describes general system installation including mechanical and electrical considerations. Included in this chapter are master clock and direction applications.
- Chapters 4 to 9 describe system modules involved in system processing, communication, and motion generation.
- Chapters 10 to 18 describe I/O modules used for interfacing to external equipment for data entry and display.
- Chapters 19 to 28 describe modules used for feedback and translator functions for closed or open loop positioning of various drive and feedback devices.
- Chapter 29 and appendixes describe standard system cables, general system tuning, and system grounding and shielding considerations.

Each chapter in the manual dealing with circuit cards (chapters 4-28) follows a standard format, including the following sections:

- **Introduction.** This section gives a brief description of the function of the module, listing the standard features and basic options. A simplified drawing of the module shows the location of important components such as jumpers, connectors, dip switches, and PROMs.
- **Jumpers, Switches, and PROMs.** This section includes tables of all user jumpers and their functions. It explains how to use either DIP switches or PROMs to set the module address.
- **Wiring.** This section includes lists of pin definitions for all user connectors. Diagrams show both standard and optional cabling, along with optional configurations for specific modules. This section also includes diagrams of internal-to-external interfaces.
- **Installation.** This section describes the required chassis space required for the module. For modules not installed in the chassis, this section gives mounting dimensions, including the required panel dimensions.
- **Setup and Testing.** This section includes specific instructions for checking the module before and during installation. It describes the LED functions and the functions of user test points on the module.
- **Troubleshooting.** This section comprises a basic troubleshooting guide for the module. It includes details of common module problems and lists the steps necessary to analyze each problem. This section may help you determined whether a problem is caused by the specific module, the system, or the system software.
- **Specifications.** Each chapter closes with a table of electrical and mechanical specifications for the module.

Unpacking and Handling Instructions

Avoid subjecting components to mechanical or thermal shock while unpacking. Components should be allowed to reach room temperature before proceeding with installation.

When shipped as a complete system, the Motion Plus/473 control system is normally packed with all circuit cards installed in their appropriate slots in the control chassis. In that case, the control chassis may be handled as a complete assembly with minimal anti-static precautions as long as you do not handle the individual circuit cards or modules. However, if you need to handle modules or circuit cards during unpacking or installation, the following anti-static precautions must be observed:

⚠ CAUTION

Do not remove anti-static packaging materials from a component until you are ready to install it.

Circuit cards should be handled only at an anti-static work station. Anti-static wrist or ankle bands should be attached before touching circuit cards to avoid static discharge, which can damage circuit components.

Avoid touching components or conductive paths on the circuit cards. Cards should be handled similar to handling a photograph, using the edges. The card ejectors should be used if possible.

Some circuit cards contain battery-backed memory. Do not place those circuit cards on a metal surface, which can short out the battery and cause component damage and the loss of data.

⚠ WARNING

Never remove or install a circuit card while power is applied to the chassis. Never remove or install cabling while power is applied to a module. Failure to observe these precautions can cause serious damage to circuit cards, modules, chassis or external power supplies.

Shortage or Order Discrepancy

Immediately after unpacking, check that all ordered equipment is present. If anything is missing or incorrect on your order (on shipments F.O.B. Minneapolis) contact Custom Servo Motors Inc., (507) 354-1616.

Required Tools and Equipment

Motion Plus systems can generally be installed and calibrated with commonly available hand tools. Soldering equipment may be necessary. Special equipment required for installation includes a digital meter (DVM or DMM) with a 3-1/2 digit display, an IBM or compatible personal computer, and INCOL86 software. A 20 MHz oscilloscope is useful, but not necessary, for troubleshooting certain modules.

Returning Materials

When returning defective items, check the service policy described on the following pages.

Custom Servo Motors Inc.
Customer Support and Services

Custom Servo Motors Inc. offers a full line of services for users of Motion Plus controllers including telephone support, spares ordering, circuit module repair or replacement, hardware and software training, application assistance, and on-site field service.

When in need of assistance or if you have any questions regarding Custom Servo Motors Inc. services, please contact us at (507) 354-1616 and ask for customer service.

Technical Telephone Support

Use our toll-free number to consult our technical staff. They can help answer questions about getting your application operating, and they can help solve other (hardware or software) problems that occur.

Circuit Module Repair/Replacement

When a circuit card needs repair or replacement, our repair/exchange program can ship you a replacement module overnight, if the need arises. When calling for a repair/replacement, please help us improve your service by taking the following steps:

1. Before returning any item for repair obtain a Return Materials Authorization number from:

   Custom Servo Motors Inc.
   Customer Service Center
   (507) 354-1616

   You will be asked for the following information:

   - Company name
   - Customer contact
   - Phone number
   - Model number of item being returned
   - Purchase order number for the repair

   A Return Materials Authorization (RMA) number will then be assigned to you for use on this order.

2. Please note the following information on your purchase order.

   - Custom Servo Motors Inc. RMA number
   - Customer contact
   - Phone number
   - Item being returned
   - Reason for return

3. Ship the defective item to the following address:

   Custom Servo Motors Inc.
   2121 Bridge Street
   New Ulm, MN 56073

4. When using the Repair/Exchange program, retain your defective item until you receive the replacement item. A printed return label is enclosed with the replacement. When returning your defective item, please use that printed return label, and include the white copy of the packing list, to help us credit your defective item against your account. Write the RMA number on the outside of the shipping container.

5. Status requests should be directed to Custom Servo Motors Inc. Customer Service Center at (507) 354-1616.

Spares Ordering

Spares can be ordered through the toll-free number. Ask for customer service and refer to the model number list in Chapter 2 of this manual.

Training

Custom Servo Motors Inc. offers training classes in both INCOL86 software and Motion Plus Hardware Maintenance and diagnostics. These classes are designed to introduce the students to the subject. They can be taught at your location, and are offered regularly throughout the year at our headquarters.

Application Assistance

It is recognized that, at times, application engineering assistance is required to successfully complete a project. To meet this need Custom Servo Motors Inc. application engineers can be scheduled to assist you. Contact the customer service group to obtain more information.

Field Service

Custom Servo Motors Inc. field service engineers can be sent to troubleshoot problems on-site. The service engineers are dispatched out of our New Ulm headquarters and can be scheduled by calling (507) 354-1616.

2 The Motion Plus/473 Control System

The Motion Plus Control System is made up of modular electronic devices which perform machine automation functions under computer control. Application programs written in the INCOL86 programming language provide software control of all Motion Plus system functions.

How the System Modules Operate

The chassis, which acts as the main power source for all circuit cards, contains a printed circuit backplane to allow communication between system cards.

The System Processor (or High Speed System Processor) acts as the main central processing unit (CPU). It interprets INCOL86 application programs and controls all other circuit modules in the system.

The Command Generator is an intelligent motion profile generator used to direct axis translator cards. An alternative, the Command Generator/Translator, is a Command Generator plus built-in translator function for stepper command applications.

The Translator cards, Stepper, Stepper Interface, Servo, Encoder, Resolver, and Temposonics Translators, connect to drive and feedback devices. The type of translator card used depends upon the type of feedback used. Normally each axis requires one translator plus one command generator.

The Encoder Interface card is used to interface to a rotary or linear optical encoder.

The RS232 Interface is used as a second or third serial port for communication (in addition to the port on the System Processor).

The Analog I/O Processor is an intelligent data acquisition and distribution card. I/O data can be interpreted at the card level using INCOL86 instructions.

The 32 I/O Interface is used as digital interface to data entry and display devices. Up to 32 inputs or outputs can be used on an individual card.

Four operator devices are available for data input and output: the Remote Keypad, the LCD Display, the Numeric LED Display, and the Thumbwheel Switch Assembly. These devices are connected to the system through the 32 I/O Interface.

The CRT Interface provides a composite video signal for either of two CRT monitors, one with a 9-inch display and an open mounted chassis , the other with a 12-inch display and a closed chassis.

The Remote Terminal Board is used as a convenient method of providing circuit signals at individual termination points.

System cables are used as an interface between circuit cards and modules, or as an interface between circuit cards and drives, feedback devices, or machine interface devices.

How the System Operates

The System Processor acts as the main controlling unit. Its operation is determined by its own operating system stored in an EPROM on board the card known as its RTI (Run Time Interpreter).

System operation is determined by an INCOL86 program. The program is either downloaded from a personal computer using the System Processor serial port or resident in an EPROM mounted on the System Processor and known as the application program EPROM. The System Processor carries out the application program instructions using various addresses and data which it communicates to other cards through the chassis backplane.

The Command Generator interprets these signals to determine what type of motion is required for its specific axis. It controls its specified translator using a pulse stream to generate the specific motion profile. The translator is used as an interface to the drive, feedback, and axis inputs to carry out the specified motion.

Some systems use the Encoder Interface to determine the position of a master encoder. Communication to a second or third serial port may be accomplished using the RS232 Interface. The Analog I/O Interface can be used to monitor analog and digital inputs, and to drive analog and digital outputs. The 32 I/O Interface is used as an interface to data entry and display devices for program parameter entry or display at remote locations.

The CRT Interface is used when operator data display requires more information. The Remote Terminal Board is used to interface circuit card signals to various hookup points or devices.

A general configuration is shown in Figure 2-1. The following numbers refer to the figure:

(1) 473.60c High Speed System Processor. This is the host CPU for the system, directing and coordinating the operations of Command Generators and all other circuit card modules.

(2) 473.61c Command Generators. Each Command Generator can generate a complex motion profile which drives one or more translators.

(2A) 473.61c Command Generator/Translator functions as both a profile generator and a translator.

(3) 473.19c Servo Translator controls a closed-loop servo system.

(4) 473.20c Stepper Translator drives a stepper motor (18), using power from the 473.31c Power Supply (24).

(5), (6), and (7) Direct digital control translators:

(5) 473.21c Temposonics Servo Translator provides direct digital control, using feedback from a Temposonics transducer (20),

OR

(6) 473.66c Encoder Servo Translator provides direct digital control, using feedback from an encoder (21),

OR

(7) 473.65c Resolver Servo Translator provides direct digital control, using feedback from a resolver transducer (22).

(8) 473.08c CRT Interface provides alphanumeric output to a monitor such as the 473.91c CRT Display Monitor (13).

(9) 473.10c 32 I/O Interface connects to remote data bus devices such as the 473.83c Keypad with LCD Display Assembly (14), the 473.07c Thumbwheel Switch (15), or the 473.09c LED Display (16).

(10) Servo driver (such as a Custom Servo Motors MPA Amplifier).

(11) User EPROM, programmed on the GTEK Programmer, then installed on the System Processor.

(12) Servo motor (such as a Max Plus™ Series Servo Motor).

(13) 473.91c CRT Display Monitor.

(14) 473.83c Assembly (473.06c Keypad with 473.13 LCD Display).

(15) 473.07c Thumbwheel Switch.

(16) 473.09c LED Display.

(17) Machine I/O devices connected through the 473.10c 32 I/O Interface(9).

(18) Stepper motor.

(19) Servo motor/driver (such as a Custom Servo Motors Max Plus Motor) or hydraulic servovalve/cylinder.

(20) Temposonics II digital displacement transducer. Provides feedback for 473.21c Temposonics Servo Translator (5).

(21) Incremental optical encoder. Provides feedback for 473.66c Encoder Servo Translator (6) or pulses for 473.10c Encoder Interface (26).

(22) Resolver. Provides feedback for 473.65c Resolver Servo Translator (7).

(23) External driver module.

(24) 473.31c Stepper Translator Power Supply.

(25) 473.70c Analog I/O Processor provides analog I/O, digital I/O, and PID loop control.

(26) 473.10c Encoder Interface connects to an external encoder (21).

(27) 473.04c RS232C Interface. Connects to external serial devices for two-way communication.

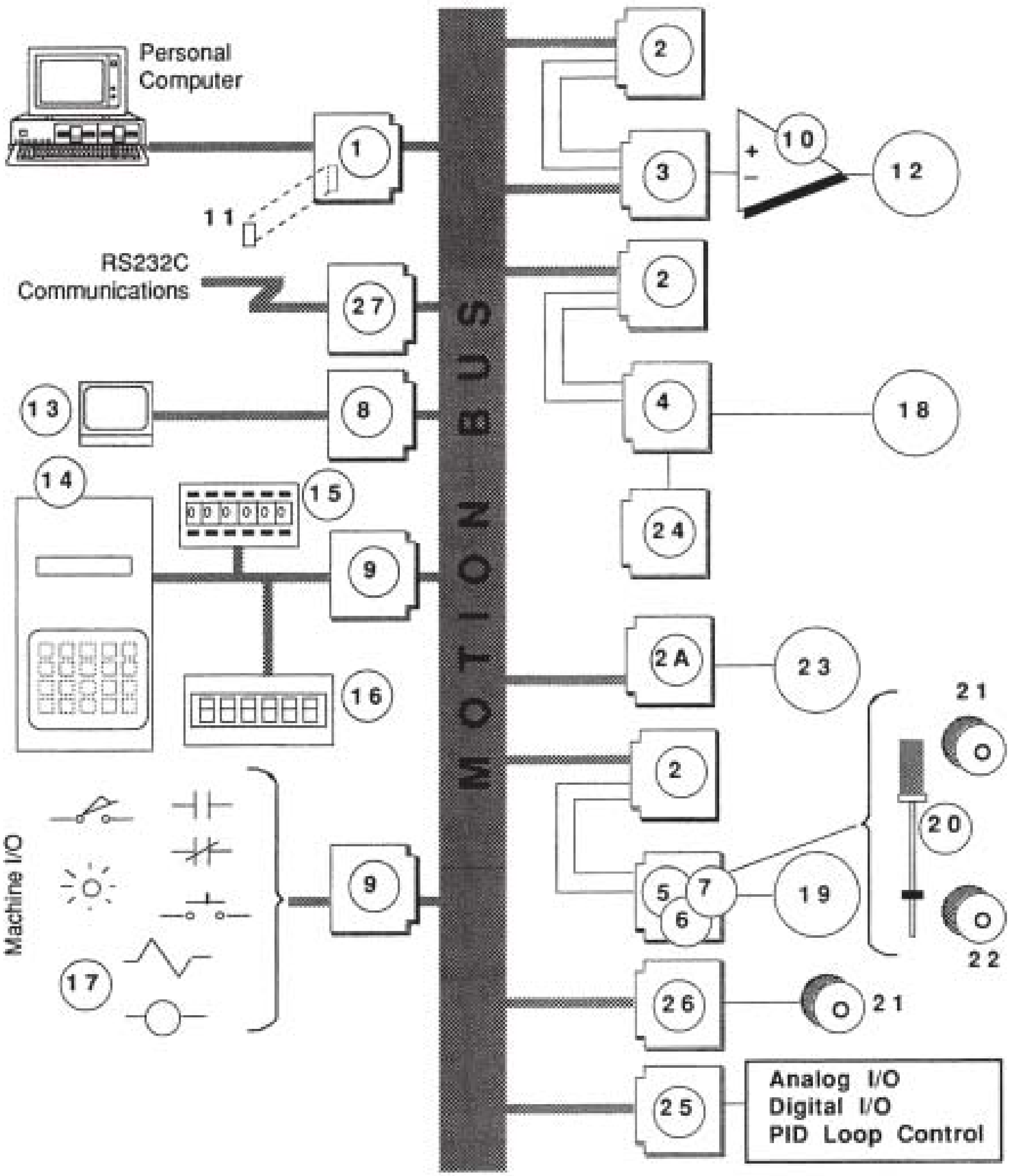


Figure 2-1. General Configuration of the Motion Plus/473 System

Memory and Addressing

The Motion Bus address map of a given Motion Plus system is determined by the RTI, which includes both a memory map of 64 K bytes and a separate 256 byte I/O map. These maps define addresses for all circuit modules connected to the motion bus.

Table 2-1. Sample Motion Bus Memory Map

R/W	Page	Motion Bus Address	80C188 Address (Hex)	Description
	0	0000 0XXX XXXX XXXX	ES:0000-07FF	Spare
R/W	1	0000 1XXX XXXX XXXX	ES:0800-0FFF	Cmd Gen #1 Dual-Port RAM
R/W	2	0001 0XXX XXXX XXXX	ES:1000-17FF	Cmd Gen #2 Dual-Port RAM
R/W	3	0001 1XXX XXXX XXXX	ES:1800-1FFF	Cmd Gen #3 Dual-Port RAM
R/W	4	0010 0XXX XXXX XXXX	ES:2000-27FF	Cmd Gen #4 Dual-Port RAM
R/W	5	0010 1XXX XXXX XXXX	ES:2800-2FFF	Cmd Gen #5 Dual-Port RAM
R/W	6	0011 0XXX XXXX XXXX	ES:3000-37FF	Cmd Gen #6 Dual-Port RAM
R/W	7	0011 1XXX XXXX XXXX	ES:3800-3FFF	Cmd Gen #7 Dual-Port RAM
R/W	8	0100 0XXX XXXX XXXX	ES:4000-47FF	Cmd Gen #8 Dual-Port RAM
R/W	9	0100 1XXX XXXX XXXX	ES:4800-4FFF	Cmd Gen #9 Dual-Port RAM
R/W	10	0101 0XXX XXXX XXXX	ES:5000-57FF	Cmd Gen #10 Dual-Port RAM
R/W	11	0101 1XXX XXXX XXXX	ES:5800-5FFF	Cmd Gen #11 Dual-Port RAM
R/W	12	0110 0XXX XXXX XXXX	ES:6000-67FF	Cmd Gen #12 Dual-Port RAM
R/W	13	0110 1XXX XXXX XXXX	ES:6800-6FFF	Cmd Gen #13 Dual-Port RAM
R/W	14	0111 0XXX XXXX XXXX	ES:7000-77FF	Cmd Gen #14 Dual-Port RAM
R/W	15	0111 1XXX XXXX XXXX	ES:7800-7FFF	Cmd Gen #15 Dual-Port RAM
R/W	16	1000 0XXX XXXX XXXX	ES:8000-87FF	Cmd Gen #16 Dual-Port RAM
	17	1000 1XXX XXXX XXXX	ES:8800-8FFF	Spare
	18	1001 0XXX XXXX XXXX	ES:9000-97FF	Spare
R/W	19	1001 1XXX XXXX XXXX	ES:9800-9FFF	CRT Interface
R/W	20.0	1010 0000 XXXX XXXX	ES:A000-A0FF	Analog I/O Processor #1
R/W	20.1	1010 0001 XXXX XXXX	ES:A100-A1FF	Analog I/O Processor #2
R/W	20.2	1010 0010 XXXX XXXX	ES:A200-A2FF	Analog I/O Processor #3
R/W	20.3	1010 0011 XXXX XXXX	ES:A300-A3FF	Analog I/O Processor #4
R/W	20.4	1010 0100 XXXX XXXX	ES:A400-A4FF	Analog I/O Processor #5
R/W	20.5	1010 0101 XXXX XXXX	ES:A500-A5FF	Analog I/O Processor #6
R/W	20.6	1010 0110 XXXX XXXX	ES:A600-A6FF	Analog I/O Processor #7
R/W	20.7	1010 0111 XXXX XXXX	ES:A700-A7FF	Analog I/O Processor #8

Table 2-1. Sample Motion Bus Memory Map (Continued)

R/W	Page	Motion Bus Address	80C188 Address (Hex)	Description
R/W	21.0	1010 1000 XXXX XXXX	ES:A800-A8FF	Analog I/O Processor #9
R/W	21.1	1010 1001 XXXX XXXX	ES:A900-A9FF	Analog I/O Processor #10
R/W	21.2	1010 1010 XXXX XXXX	ES:AA00-AAFF	Analog I/O Processor #11
R/W	21.3	1010 1011 XXXX XXXX	ES:AB00-ABFF	Analog I/O Processor #12
R/W	21.4	1010 1100 XXXX XXXX	ES:AC00-ACFF	Analog I/O Processor #13
R/W	21.5	1010 1101 XXXX XXXX	ES:AD00-ADFF	Analog I/O Processor #14
R/W	21.6	1010 1110 XXXX XXXX	ES:AE00-AEFF	Analog I/O Processor #15
R/W	21.7	1010 1111 XXXX XXXX	ES:AF00-AFFF	Analog I/O Processor #16
	22	1011 0XXX XXXX XXXX	ES:B000-B7FF	Spare
	23	1011 1XXX XXXX XXXX	ES:B800-BFFF	Spare
	24	1100 0XXX XXXX XXXX	ES:C000-C7FF	Spare
	25	1100 1XXX XXXX XXXX	ES:C800-CFFF	Spare
	26	1101 0XXX XXXX XXXX	ES:D000-D7FF	Spare
	27	1101 1XXX XXXX XXXX	ES:D800-DFFF	RS232 Interface Port #2
	28	1110 0XXX XXXX XXXX	ES:E000-E7FF	RS232 Interface Port #2
	29	1110 1XXX XXXX XXXX	ES:E800-EFFF	RS232 Interface Port #1
	30	1111 0XXX XXXX XXXX	ES:F000-F7FF	RS232 Interface Port #1
	31	1111 1XXX XXXX XXXX	ES:F800-FFFF	ILLEGAL!!!

Table 2-2. Sample Motion Bus I/O Map

Page	80188 Address(Hex)	Description
0	0000–0007	32 Input/Output #1
1	0008–000F	32 Input/Output #2
2	0010–0017	32 Input/Output #3
3	0018–001F	32 Input/Output #4
4	0020–0027	32 Input/Output #5
5	0028–002F	32 Input/Output #6
6	0030–0037	32 Input/Output #7
7	0038–003F	32 Input/Output #8
8	0040–0047	Encoder Interface #1
9	0048–004F	Encoder Interface #2
10	0050–0057	Encoder Interface #3
11	0058–005F	Encoder Interface #4
12	0060–0067	Encoder Interface #5
13	0068–006F	Translator #1
14	0070–0077	Translator #2
15	0078–007F	Translator #3
16	0080–0087	Translator #4
17	0088–008F	Translator #5
18	0090–0097	Translator #6
19	0098–009F	Translator #7
20	00A0–00A7	Translator #8
21	00A8–00AF	Translator #9
22	00B0–00B7	Translator #10
23	00B8–00BF	Translator #11
24	00C0–00C7	Translator #12
25	00C8–00CF	Translator #13
26	00D0–00D7	Translator #14
27	00D8–00DF	Translator #15
28	00E0–00E7	Translator #16
29	00EF	Cmd Gen #16 status buffer
30.0	00F0	Cmd Gen #15 status buffer
30.1	00F1	Cmd Gen #14 status buffer
30.2	00F2	Cmd Gen #13 status buffer
30.3	00F3	Cmd Gen #12 status buffer
30.4	00F4	Cmd Gen #11 status buffer
30.5	00F5	Cmd Gen #10 status buffer
30.6	00F6	Cmd Gen #9 status buffer
30.7	00F7	Cmd Gen #8 status buffer
31.0	00F8	Cmd Gen #7 status buffer
31.1	00F9	Cmd Gen #6 status buffer
31.2	00FA	Cmd Gen #5 status buffer
31.3	00FB	Cmd Gen #4 status buffer
31.4	00FC	Cmd Gen #3 status buffer
31.5	00FD	Cmd Gen #2 status buffer
31.6	00FE	Cmd Gen #1 status buffer
31.7	00FF	spare

Component Parts List

Table 2-3 gives a listing of all standard circuit cards, modules, power supplies, chassis and cabling by model number, part number and description.

Table 2-3. Component Parts of the Motion Plus/473 Control System

Model	Part No	Description
473.04c-01A-002	353747-02	RS232 Interface Port #1
473.04c-01A-003	353747-03	RS232 Interface Port #2
473.06c-01A-000	388149-01	20 Key Keypad Assy
473.07c-01A-002	369771-02	Thumbwheel Switch Assy-2 digits
473.07c-01A-003	369771-03	Thumbwheel Switch Assy-3 digits
473.07c-01A-004	369771-04	Thumbwheel Switch Assy-4 digits
473.07c-01A-005	369771-05	Thumbwheel Switch Assy-5 digits
473.07c-01A-006	369771-06	Thumbwheel Switch Assy-6 digits
473.08c-01A-000	473883-01	CRT Interface
473.09c-01A-000	362414-01	LED Display
473.10c-01A-000	353750-01	32 I/O Interface Assy-12V
473.10c-01A-001	353750-03	32 I/O Interface Assy-5V
473.10c-01A-002	353750-02	32 I/O Interface Assy-24V
473.11c-01A-000	113791-14	Opto 22 Input Module 10-32VDC
473.11c-02A-000	113791-09	Opto 22 Input Module 115VAC
473.12c-01A-000	113791-13	Opto 22 Output Module 2-60VDC
473.12c-03A-000	113791-08	Opto 22 Output Module 115VAC
473.13c-01A-000	392610-01	LCD Assy-2 row by 20 character
473.19c-01A-000	346003-01	Servo Translator
473.20c-01A-000	358329-01	Stepper Translator
473.21c-01A-005	381861-05	Temposonics Servo Translator ±25 mA F.S.
473.21c-01A-008	381861-08	Temposonics Servo Translator ±10 V F.S.
473.24c-01A-000	339351-01	Encoder Interface
473.31c-01A-001	369763-01	Stepper Translator Power Supply-Panel
473.32c-01A-000	111777-25	12VDC @1A Auxiliary Power Supply-Panel
473.32c-12A-001	111777-37	12VDC @3A Auxiliary Power Supply-Panel
473.36c-02A-000	113791-01	Opto 22 Motherboard-16 modules
473.38c-02A-000	375380-01	40 Terminal Remote Terminal Board
473.40c-01A-000	386156-01	6 slot chassis - 115 Vac
473.40c-01A-002	386156-02	6 slot chassis with keypad & display
	386156-03	6 slot chassis - 230 Vac
473.41c-01A-000	386155-01	12 slot chassis
473.41c-01A-002	386155-02	12 slot chassis with keypad & display
	386155-03	12 slot chassis - 230 Vac
473.42c-01A-000	375352-01	18 slot chassis
473.43c-01A-000	375353-01	36 slot chassis
	494621-01	6/12 slot chassis replacement power supply assembly - 115 Vac
	494621-02	6/12 slot chassis replacement power supply assembly - 230 Vac
	111777-64	6/12/18 slot chassis replacement power supply (Power One MAP 130-4010)

Table 2-3. Component Parts of the Motion Plus/473 Control System (Continued)

Model	Part No	Description
	113163-10	36 slot chassis replacement power supply (Switching Systems Int'l SQM225-1022)
	501823-02	18 slot chassis replacement power supply (assembly)
	502393-02	36 slot chassis replacement power supply (assembly)
473.50c-00A-300	383629-02	Cable 32 I/O to open leads-10 ft
473.50c-01A-200	387316-04	Cable 32 I/O (EST) to RTB-4 ft
473.50c-01A-300	368625-02	Cable 32 I/O to RTB-10 ft
473.50c-05A-300	393710-02	Cable 32 I/O to Opto 22 MB-10 ft
473.50c-06A-300	368615-02	Cable 32 I/O to Two Opto 22 MB-10 ft
473.50c-08A-100	371538-01	Cable adapter-1 ft
473.50c-10A-001	393709-01	Cable remote data bus for 1 device
473.50c-10A-002	393709-02	Cable remote data bus for 2 devices
473.50c-10A-003	393709-03	Cable remote data bus for 3 devices
473.50c-13A-300	384976-02	Cable CRT Interface to 9-inch monitor-10 ft
473.50c-25A-300	408344-12	Cable System Proc to IBM PC-10 ft
473.50c-25B-300	426488-02	Cable System Proc to IBM AT-10 ft
473.50c-26A-300	426487-02	Cable IBM PC to GTEK-10 ft
473.50c-26B-300	426489-02	Cable IBM AT to GTEK-10 ft
473.50c-31A-200	382012-01	Cable Servo Trans to RTB-4 ft
473.50c-33A-001	418158-01	Cable Encoder Inter to RTB-5 ft
473.50c-35A-200	389186-01	Cable Temposonics Trans to RTB-4 ft
473.50c-36A-300	453850-01	Cable Assy Analog I/O Processor
473.60c-01A-002	398503-02	System Processor
473.60c-01A-004	446154-04	High Speed System Processor
473.61c-01A-001	395361-02	Command Generator with 2K RAM
473.61c-01A-002	395361-06	Command Generator with 8K RAM
473.61c-02A-001	428476-02	Command Generator Trans with 2K RAM
473.61c-02A-002	428476-04	Command Generator Trans with 8K RAM
473.66c-01A-001	418776-01	Encoder Servo Translator
473.70c-01A-000	446964-01	Analog I/O Processor
473.83c-01A-001	395214-01	LCD Display and 20 Key Keypad with panel
473.91c-09A-003	457570-01	9-inch CRT monitor (KRISTEL)
473.91c-09A-004	114675-03	12-inch CRT monitor (HYUNDAI)
475.03c-05A-000	112988-38	2764A blank EPROM, 250 ns access
475.03c-15A-000	114817-20	27256 blank EPROM, 250 ns access
475.03c-20A-000	114817-25	27512 blank EPROM, 250 ns access
	114817-32	27512 blank EPROM, 120 ns access
475.21c-02A-000	414127-04	Dev Pkg IBM PC
475.21c-02A-001	414127-05	Dev Pkg IBM AT
475.22c-02A-000	455528-01	Version 4 Dev Pkg
475.31c-01A-000	447942-01	GTEK EPROM programmer package IBM PC
475.31c-01A-001	447943-01	GTEK EPROM programmer package IBM AT
475.70c-01A-000	452435-01	Voltage to Current Converter Module
475.71c-01A-000	452432-01	Command Enable Module

3 General Installation

Introduction

This chapter provides general information that applies to the installation of INCOL86/Motion Plus control systems. The following topics are covered:

- Backplane Bus Structure
- Remote Data Bus Structure
- Positioning Cards
- Isolating Backplane Signals
- Chassis Mounting
- Chassis Electrical Installation
- Circuit Module Installation
- Cable Installation
- Environmental Considerations
- System Startup
- Electrical Specifications

Backplane Bus Structure

The control chassis is constructed with an integral backplane containing card-edge connectors for the circuit modules. The backplane consists of a set of parallel printed circuit signal lines routed between connectors. All circuit cards have identical bus-oriented pin definitions. These backplane signals supply power, data,and communications to all circuit cards using the power plane lines, host bus and motion bus. Figure 3-1 shows a complete backplane bus definition.

Signal	Pin	Pin	Signal	Bus
	99	100		
+5V	97	98	+5V	
	95	96		
	93	94		
5 V COMMON	91	92	5 V COMMON	
	89	90		
	87	88		
+12 V	85	86	+12 V	
	83	84		
	81	82		
12 V COMMON	79	80	12 V COMMON	
	77	78		
-12 V	75	76	-12 V	
CHASSIS GROUND	73	74	CHASSIS GROUND	
	71	72		
	69	70		
	67	68		
$\overline{\text{HCLK}}$	65	66	$\overline{\text{HSYNC}}$	
	63	64		**HOST BUS**
	61	62		
	59	60		
	57	58		
	55	56		
	53	54		
	51	52		
MA14	49	50	MA15	
MA12	47	48	MA13	
MA10	45	46	MA11	
MA8	43	44	MA9	
MAD6	41	42	MAD7	
MAD4	39	40	MAD5	**MOTION BUS**
MAD2	37	38	MAD3	
MAD0	35	36	MAD1	
$\overline{\text{MIOR}}$	33	34	$\overline{\text{MALE}}$	
$\overline{\text{MMEMR}}$	31	32	$\overline{\text{MIOW}}$	
$\overline{\text{MRESET}}$	29	30	$\overline{\text{MMEMW}}$	
MRDY	27	28	$\overline{\text{MCLK}}$	
M $\overline{\text{R}}$ /W	25	26	M $\overline{\text{IO}}$ /M	
$\overline{\text{MIRQ0}}$	23	24	$\overline{\text{MIRQ1}}$	
MSYNCHA	21	22	$\overline{\text{MTRAP}}$	
$\overline{\text{CMNDCLK}}$	19	20	$\overline{\text{ENCODERDIR}}$	
$\overline{\text{RATIOCLK1}}$	17	18	$\overline{\text{CMNDDIR}}$	
$\overline{\text{ENCODERCLK}}$	15	16	$\overline{\text{RATIOCLK0}}$	
CHASSIS GROUND	13	14	CHASSIS GROUND	
	11	12		
5 V COMMON	9	10	5 V COMMON	
	7	8		
	5	6		
+5 V	3	4	+5 V	
	1	2		

Figure 3-1. Backplane Bus Structure

Remote Data Bus Structure

The Remote Data Bus is a set of sixteen I/O , two ground, and two power lines dedicated from the Model 473.10c 32 I/O Interface card addressed as number 8. This bus is used to interface to all user input/output devices such as the Model 473.13 LCD or the Model 473.06c Keypad. The power lines are tied to the internal +12 Vdc chassis supply. The sixteen I/O lines are used to transfer data and addresses between the Motion Plus controller and the input/output devices. See Figure 3-2 for a complete remote data bus definition.

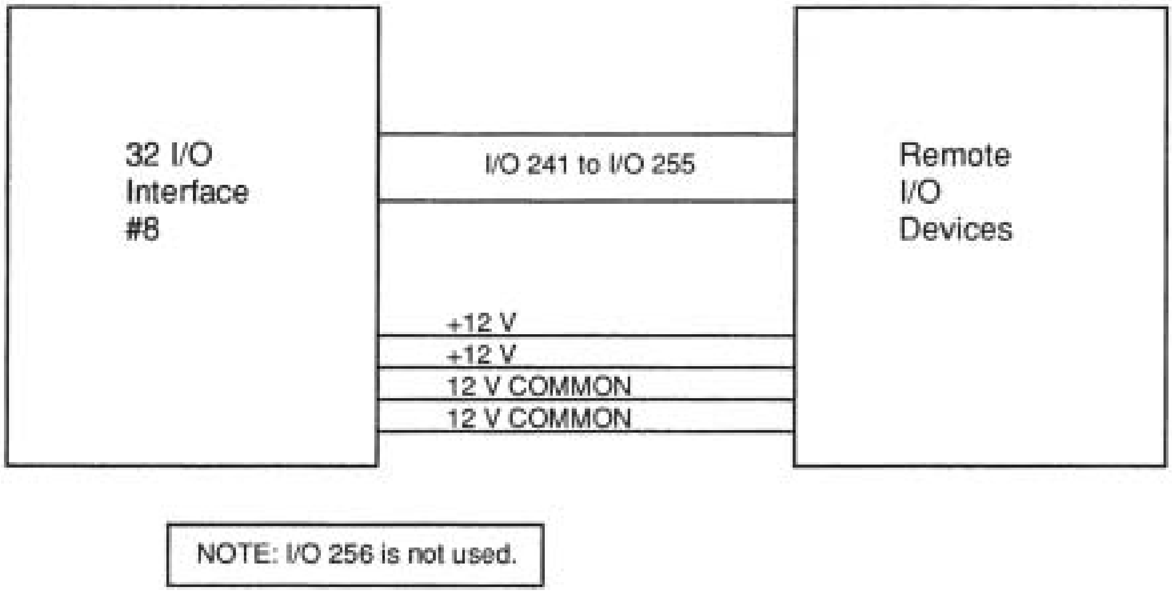


Figure 3-2. Remote Data Bus Configuration

Positioning Cards

Motion Plus control systems are generally packed and shipped with all circuit cards installed in their appropriate locations in the control chassis. The cards are addressed for a specific axis.

Your chassis is configured according to your system block diagram which is in the front of this manual. The cards are also marked with a label on the card ejector indicating the specific slot (slot 1 being the far left slot). On the Model 473.43c chassis (36 slot chassis) the cards are also identified for the top or bottom of the chassis as shown in Figure 3-3. (a) shows a typical label for an 18-slot or smaller chassis, (b) shows a typical label for a 36-slot chassis. (c) shows the slot numbering scheme for the 36-slot chassis.

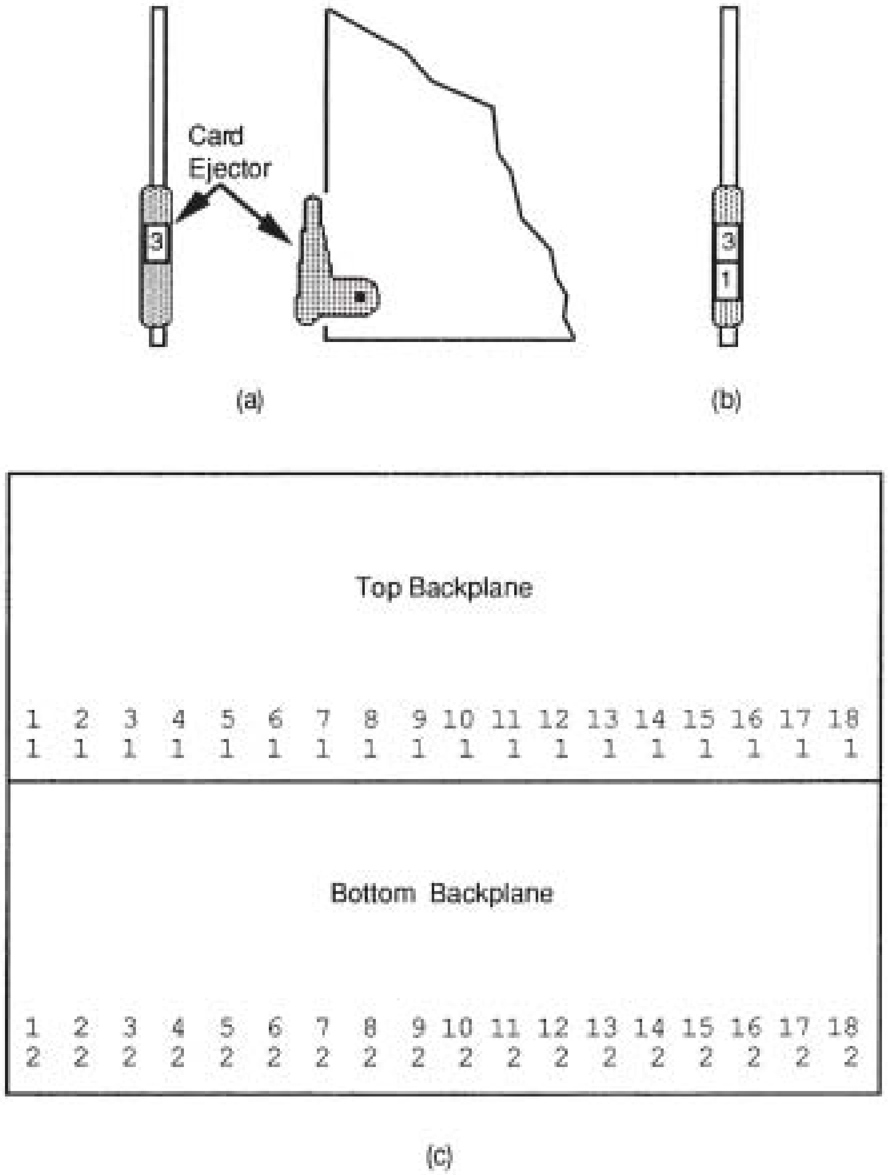


Figure 3-3. Card Labels and Slot Numbers.

NOTE

If you purchased a system, it is tested as a system before shipping . Spare chassis orders are not tested as a system before shipping.

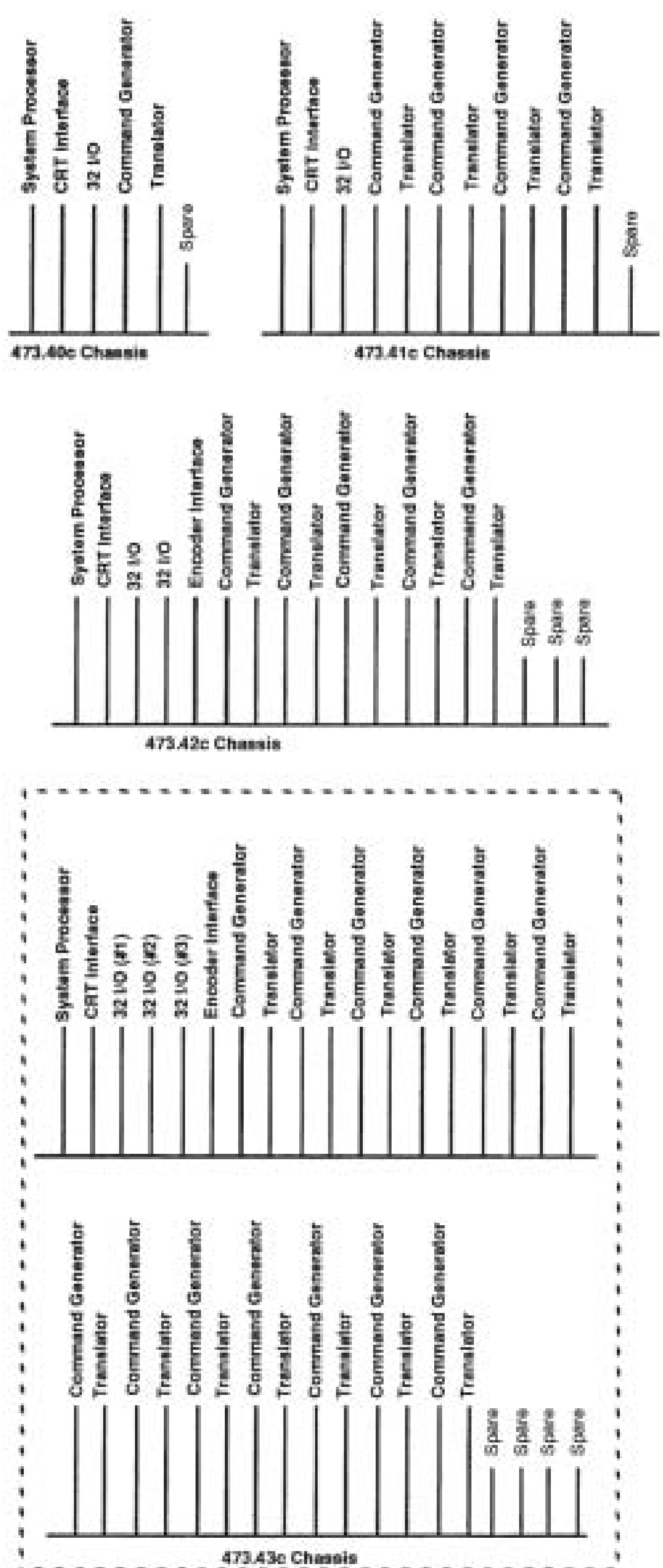


Figure 3-4. Example Systems Showing Card Positions

Motion Plus circuit cards are normally positioned in a chassis as shown in Figure 3-4. The following standard configuration rules apply:

- Make sure you know how many slots to dedicate to each circuit card. Most cards require only one slot, but there are exceptions (such as the System Processor with an SBX card installed, and the Model 473.20c Stepper Translator). See the installation section of the chapter on each specific card.
- The system processor (or high speed system processor) is normally plugged into the far left slot of the chassis. On the Model 473.43c (36-slot) Chassis, it is plugged into the far left slot of the top backplane.
- Motion axis cards are paired for a specific axis. Each translator card is placed next to the command generator that commands it.
- On the Model 473.43c (36-slot) Chassis, each Command Generator and its associated translator must be plugged into the same backplane (top or bottom). The Command Clock and Command Direction lines are isolated between the two backplanes.

Isolating Backplane Signals

NOTE

Backplane cuts are normally done at the factory. If you have ordered a system, the backplane has already been cut. The following procedure is necessary only if you are configuring a spare chassis, if you are adding axes to your configuration, or if you are using multiple master clock references on the same backplane. The backplane cuts must be made before mounting your chassis. Consult the factory before making any cuts, to be sure the cuts are necessary.

Command Clock and Command Direction

Each axis of motion consists of a command generator and translator. The command generator drives its translator using the Command Direction (line 18) and Command Clock (line 19) on the backplane. Each axis must be electrically isolated from other axes of motion. To do this take the following steps:

1. Plan the cuts using the normal configuration drawings shown in this chapter. Refer to Figure 3-5.

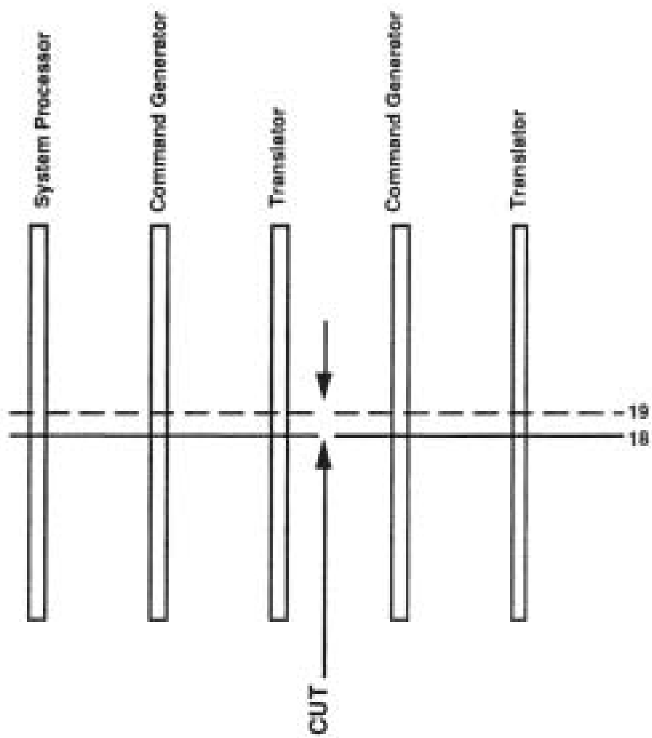


Figure 3-5. Cutting Lines to Isolate Axis Pairs

2. On the Models 473.42c and 473.43c chassis (18 and 36 slot chassis) you must remove the phillips screws holding the back cover in place.

CAUTION

The backplane has inner power and ground layers. Do not cut too deeply into the backplane.

3. Use a sharp knife or hand held routing tool to cut lines 18 and 19 on the backplane. Note that backplane lines are numbered as follows: lines 1 and 2 are at the bottom of the backplane and lines 99 and 100 are at the top; even lines are on one side of the backplane, and odd lines are on the other side. The following table shows the location of these lines on all chassis.

Model	No. Slots	Line 18	Line 19
473.40c	6	Front	Back
473.41c	12	Front	Back
473.42c	18	Back	Front
473.43c	36	Back	Front

Model 473.40c and Model 473.41c (6-Slot and 12-Slot Chassis)

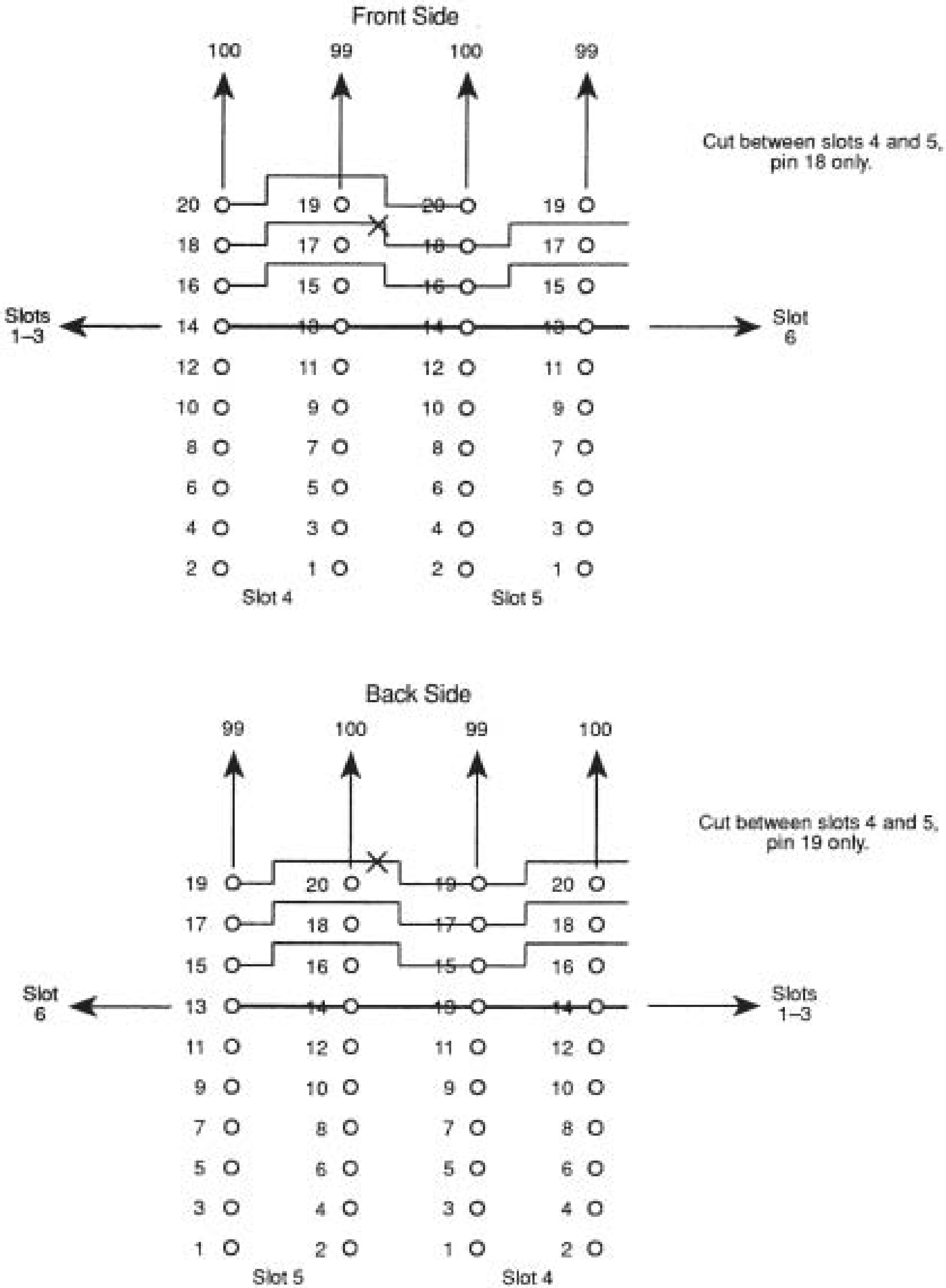


Figure 3-5a. Example of Cuts Between Slots 4 and 5

Model 473.42c and Model 473.43c (18-Slot and 36-Slot Chassis)

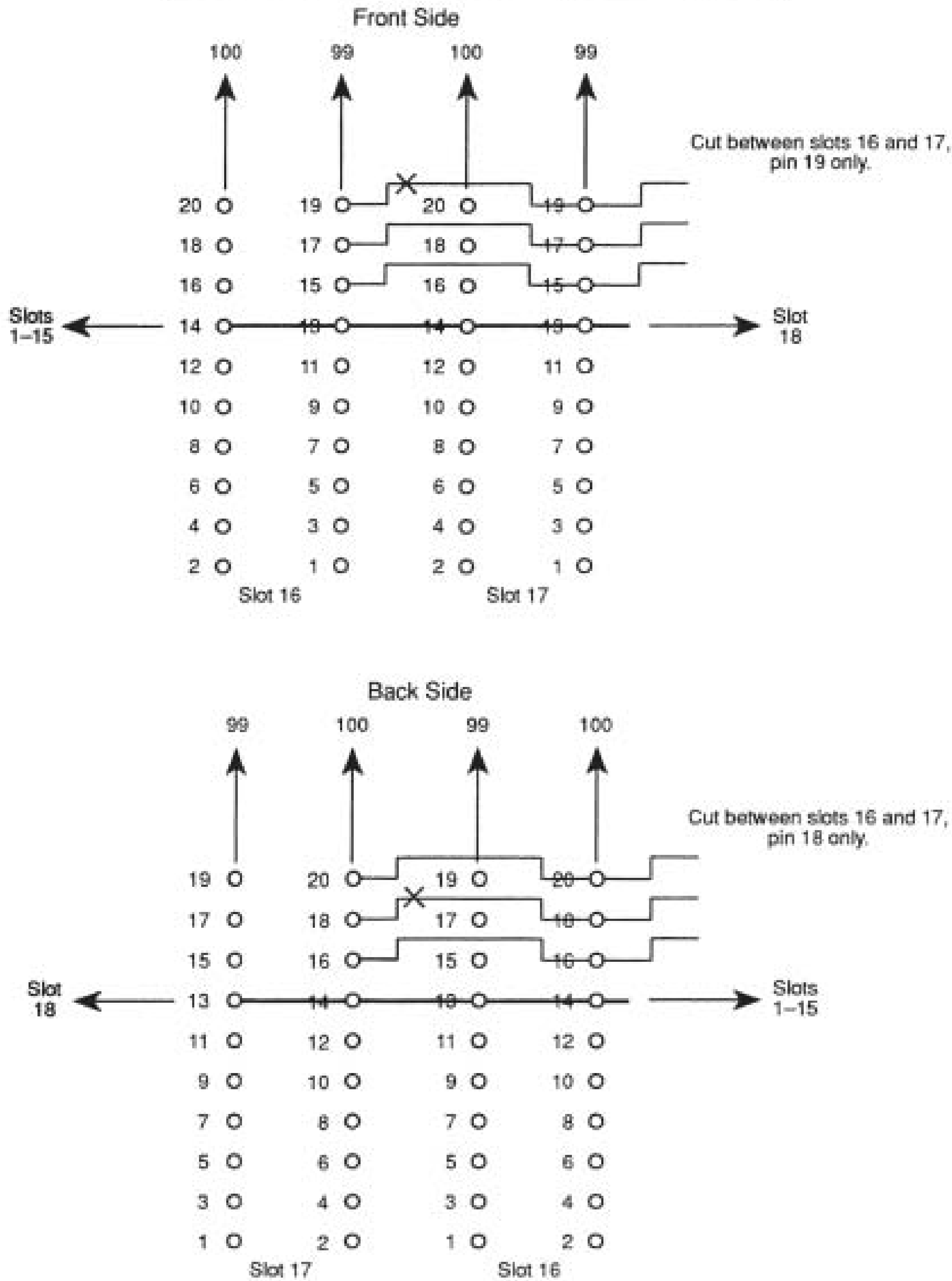


Figure 3-5b. Example of Cuts Between Slots 16 and 17

Ratio 0, Ratio 1, and Encoder Clocks

Certain applications may require the use of a source clock other than the standard clock provided by the system processor on the backplane line called HCLK. A command generator can use the following alternative clocks:

- a master source clock from another Command Generator using the RATIOCLK 0 backplane line
- a master source clock from another Command Generator using the RATIOCLK 1 backplane lines
- a master source clock from an Encoder Interface card using the ENCODERCLK backplane line.

When using another command generator as the master source clock, you must set the appropriate jumpers on the master command generator to drive either the RATIO 0 or RATIO 1 line. The slave command generator selects the master clock source using INCOL86 program instructions and <u>does not</u> require jumper changes.

When using an encoder interface as the master source clock, you do not have to change jumpers. The slave command generator selects the master clock source using INCOL86 program instructions and <u>does not</u> require jumper changes.

If more than one master clock source in a system is driving the same ratio or encoder clock line, the ratio groups must be electrically isolated. To do this take the following steps:

1. Plan the cuts so that the master and any slave are grouped together as shown in Figure 3-6.

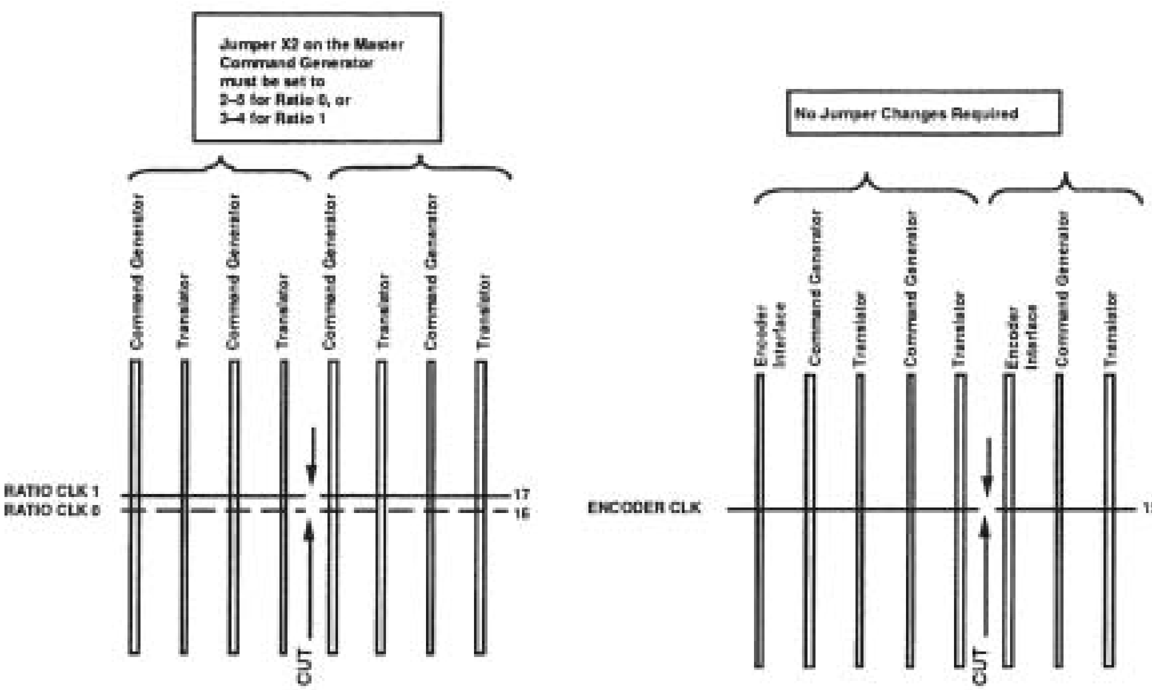


Figure 3-6. Groups of Command Generators for Ratio and Encoder Control

2. On the Models 473.42c and 473.43c chassis (18 and 36 slot chassis) you may need to remove the Phillips screws holding the back cover in place, to provide access to the back of the backplane.

⚠ CAUTION

The backplane has inner power and ground layers. Do not cut too deeply into the backplane.

3. Use a sharp knife or hand held routing tool to cut the desired lines on the backplane. Ratio clock 0 is line 16, ratio clock 1 is line 17 and encoder clock is line 15. Note that backplane lines are numbered as follows: lines 1 and 2 are at the bottom of the backplane and lines 99 and 100 are at the top; even lines are on one side of the backplane, and odd lines are on the other side. The following table shows the location of these lines on all chassis.

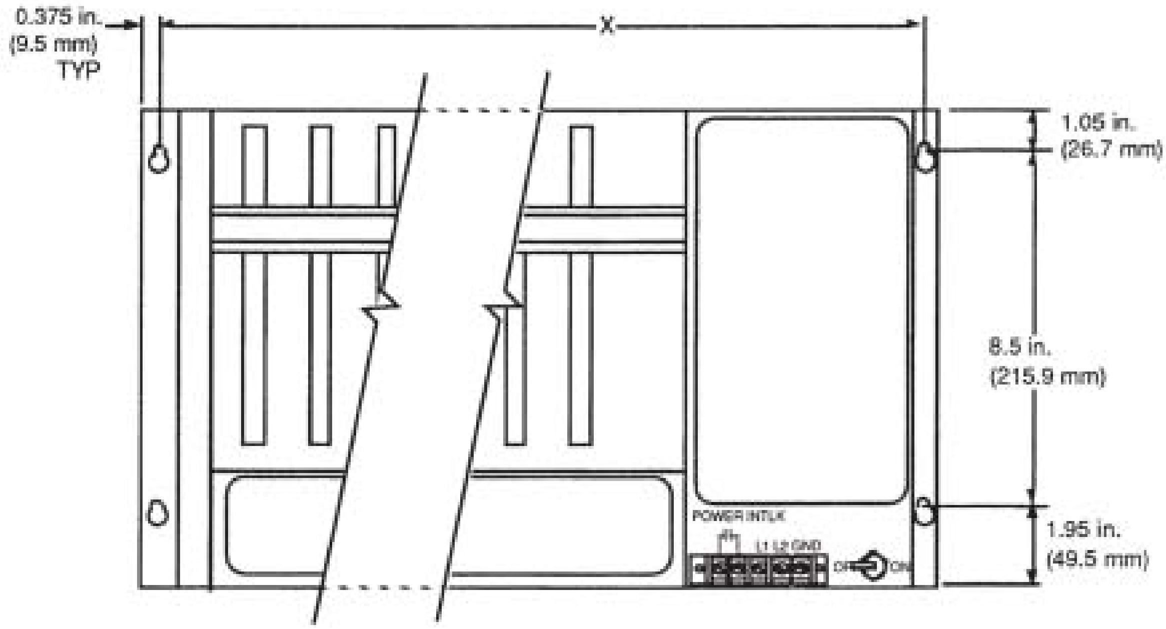
Model	No. Slots	Line 15	Line 16	Line 17
473.40c	6	Back	Front	Back
473.41c	12	Back	Front	Back
473.42c	18	Front	Back	Front
473.43c	36	Front	Back	Front

Chassis Mounting

Four standard control chassis are available for use in Motion Plus systems:

Model Number	Part Number	Description
473.40c	386156-01	6 slot chassis
473.41c	386155-01	12 slot chassis
473.42c	375352-01	18 slot chassis
473.43c	375353-01	36 slot chassis

The mounting dimensions for the Models 473.40c and 473.41c are shown in Figure 3-7. The mounting dimensions for the Models 473.42c and 473.43c are shown in Figure 3-8.



Chassis	Slots	X		Height		Width		Depth	
		in.	mm	in.	mm	in.	mm	in.	mm
473.40c	6	13.20	335.3	11.50	292.1	13.95	354.3	7.70	195.6
473.41c	12	18.00	457.2	11.50	292.1	18.75	476.2	7.70	195.6

Figure 3-7. Mounting Dimensions for Models 473.40c and 473.41c Control Chassis

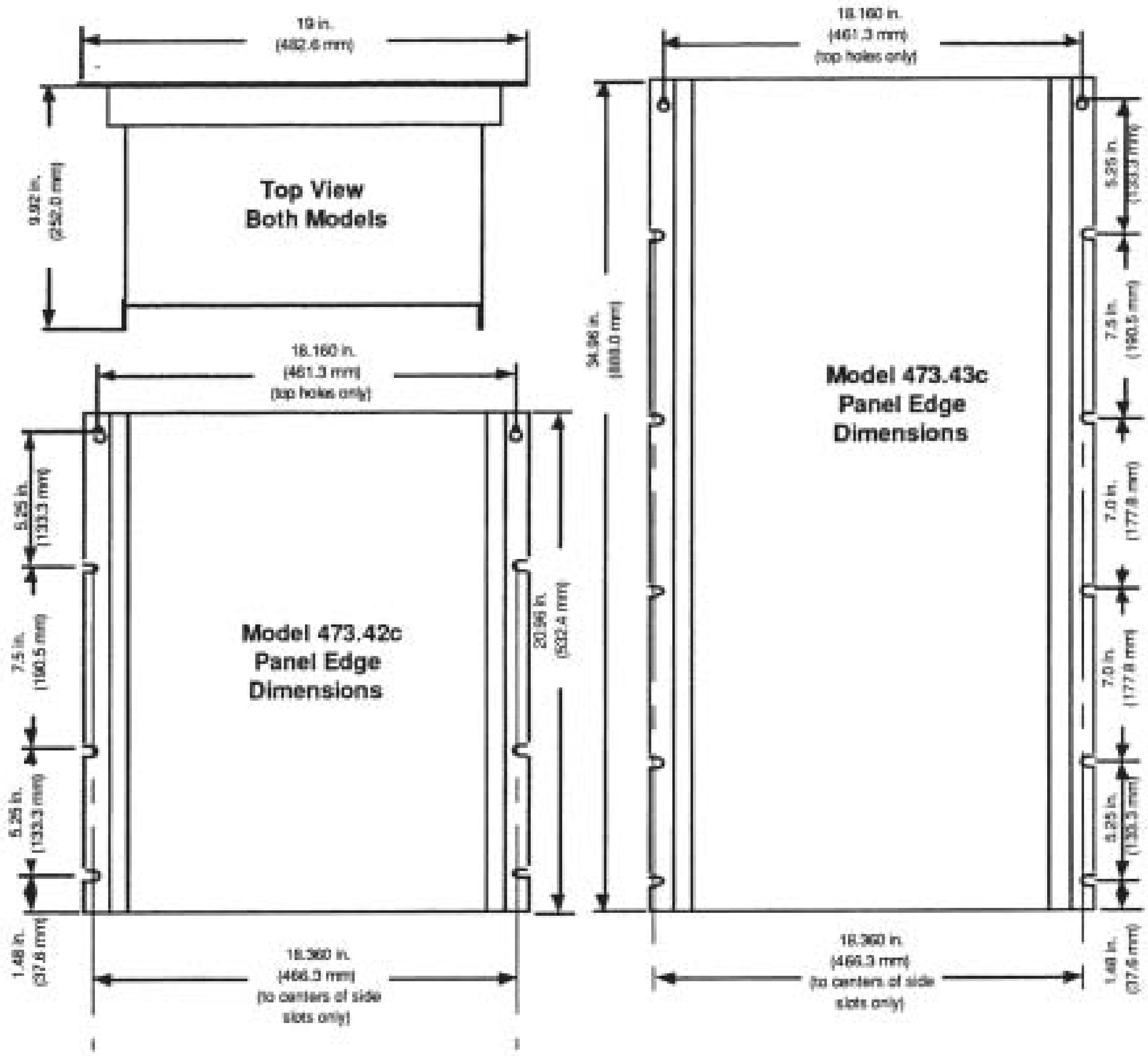


Figure 3-8. Mounting Dimensions for Models 473.42c and 473.43c Control Chassis

Chassis Electrical Installation

⚠ WARNING

Connecting ac power can be dangerous. The ac line power input and associated interlock circuit must be connected only by qualified personnel. Replace the plastic safety cover on the terminals after wiring to prevent accidental shorting.

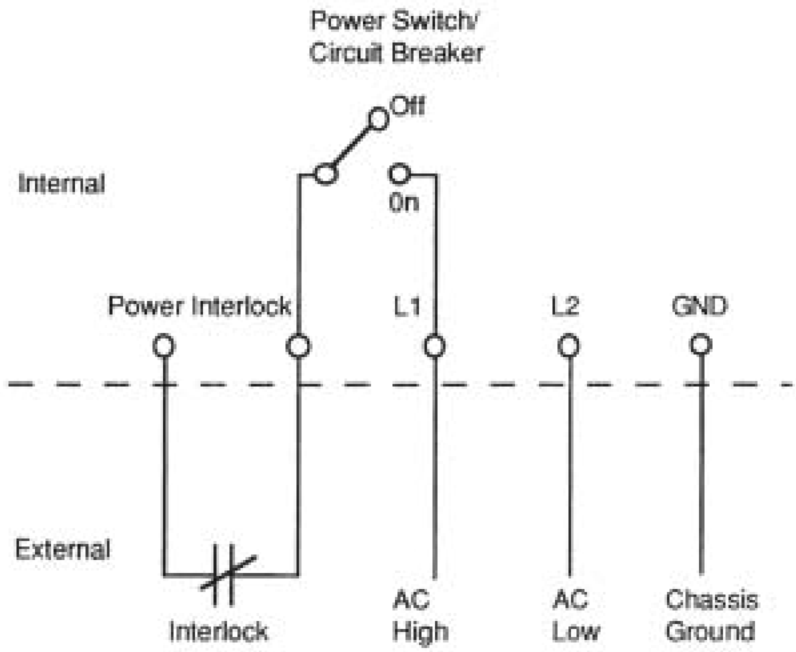


Figure 3-9. Input Power Wiring and Power Interlock

Input Power Wiring

NOTE

The ac power supply must be free of transients due to other electrical equipment. If possible, the chassis should be powered from a lighting circuit, rather than an equipment power circuit. Additional line conditioning equipment may be necessary if the ac line is subject to transients, sags, or brownouts.

Chassis power supplies are factory-set for a nominal 117 Vac, single phase, 60 Hz line power input(unless otherwise designated on your chassis). Protection is provided by an ac line fuse and a combination power switch/circuit breaker located near the terminal strip. Consult the factory for applications requiring non-standard power inputs. For applications where the ac input power may vary beyond nominal levels, a regulated ac input source may be required.

Power Interlock

⚠ WARNING

Do not make connections to the power interlock terminals while ac power is applied.

The power interlock terminals are part of the ac power input circuit to allow you to cut off the incoming ac power to the chassis. A normally closed contact with 8 A current capacity can be connected between the two power interlock terminals. If your system does not require remote control of the incoming ac power, you must jumper the power interlock terminals together.

Power Check

After you have verified that the incoming ac line power is wired correctly, you can test the chassis by turning on the power switch on the lower right side of the chassis. The fans in the chassis should start running with the power applied.

The chassis power can be tested using test points on the System Processor, High Speed System Processor, or Command Generator. The power supply output should be within the following limits:

- +5 V ± 0.25 V
- +12 V ±0.6 V
- −12 V ±0.6 V

Turn off the power before proceeding with the installation.

Circuit Module Installation

Each card in a system comes configured in a standard way, as noted in the appropriate chapter in this manual (unless otherwise specified). It may be necessary, however, for you to reconfigure the card under certain circumstances. For example, if you have purchased a spare or replacement module, it is necessary to make sure the replacement is configured the same as the module it replaces. Likewise, if you are initially configuring your system, you may have to reconfigure jumpers to match your application. In either case, the card configuration must match your application before applying power.

When replacing a 473.19c Servo Translator card, you must retune the card (refer to the appropriate chapter of this manual). When replacing DDC servo translator cards (473.21c Temposonics Servo, 473.65c Resolver, or 473.66c Encoder Translator) you must load the card with system values and possibly retune the card (refer to the appropriate chapter of this manual).

⚠ WARNING

Applying power before configuring the card jumpers can cause damage to the card components, to external devices, or to your chassis.

Addressing New Modules

When configuring a new circuit card, the address DIP switch or PROM must be set for the correct number. See the chapter of this manual that applies to the card, for more details on setting the address switch or choosing the correct PROM.

If replacing a defective module with a new module, you must set the DIP switch for the same module number or use the same PROM number. Remove the PROM from the defective module and install it on the new module.

Environmental Considerations

The controller chassis and cables must be placed in a suitable environment, avoiding extremes of temperature and humidity. All controller chassis are designed to operate in an ambient temperature range of 0 to 50 ° C(32 to 122 ° F). This applies whether the controller is placed in an open area or in an enclosure. Operation beyond these limits can cause component or system failure.

Operation in an environment with high particle or vapor concentration can cause component or system failure. Air conditioning or filtering in a sealed cabinet is recommended under these conditions.

Cable Routing

See Appendix B for cable routing considerations.

System Startup

When starting up a new system for the first time, note the following:

1. If you purchased a system, it was tested before leaving the factory.
2. You may need to configure card jumpers to match your application (check the appropriate chapters of this manual).
3. You may need to connect external power supplies (check the appropriate chapters of this manual).
4. You may need to jumper out certain signal lines if you are not using them (check the appropriate chapters of this manual).
5. If problems occur, try to isolate system problems down to card problems. Isolating problems to a particular card can simplify the task of repairing a system. Use the troubleshooting guide for each card (in the appropriate chapter of this manual) along with the LEDs on each module to identify possible problems.

Specifications

Parameter	Specification
System power supply:	
Power supply type	Switching
Efficiency	75% ± 5% rated at full power output and nominal ac input voltage
Input power	115 V Systems: 90 to 132 Vac, 47 to 63 Hz 230 V Systems: 180 to 264 Vac, 47 to 63 Hz
Brownout protection	Regulation is maintained to 90 Vac at full load with no performance loss.
Overload protection	Protected against overload and short circuit with automatic recovery
Input protection	Line fuse provided (on ac power supply circuit board)
Output power:	
6 slot chassis, 12 slot chassis, and 18 slot chassis	+5 Vdc at 20 A max +12 Vdc at 1.5 A max –12 Vdc at 1.5 A max
36 slot chassis	+5 Vdc at 30 A max +12 Vdc at 1.5 A max –12 Vdc at 1.5 A max
Operating environment	0° to 50°C (32° to 122°F) ambient temperature range Up to 90% relative humidity, noncondensing
Circuit card capacity	473.40c: contains 6 card slots 473.41c: contains 12 card slots 473.42c: contains 18 card slots 473.43c: contains 36 card slots

4 Model 473.60c-01A System Processor

Introduction

The Model 473.60c-01A System Processor is a single-board master CPU for INCOL86/Motion Plus™ control systems. It is capable of controlling multiple-axis systems on a single Motion Bus, and it is compatible with Series 473 Motion Bus devices.

Standard features of the System Processor include the following:

- 8 MHz Intel 80188 CPU
- 64K bytes of zero wait state DRAM
- 8K bytes of CMOS static RAM with battery backup
- Configured for 8K bytes of EPROM for INCOL86 application program storage
- 32K bytes of EPROM for INCOL86 system software storage
- SBX card connector for I/O expansion
- RS232c interface
- Nine card-edge LED fault/status indicators

Options include the following:

- Up to 32K bytes of CMOS static RAM with battery backup*
- Up to 64K bytes of EPROM for INCOL86 application program storage*†
- Up to 64K bytes of INCOL86 system software storage*
- Modem control¶

* Requires jumper change and component change.
¶ Requires jumper change and proper cable configuration.
† Hardware can access 64K bytes, software can access only 32K bytes.

Figure 4-1 shows the location of important components on the System Processor.

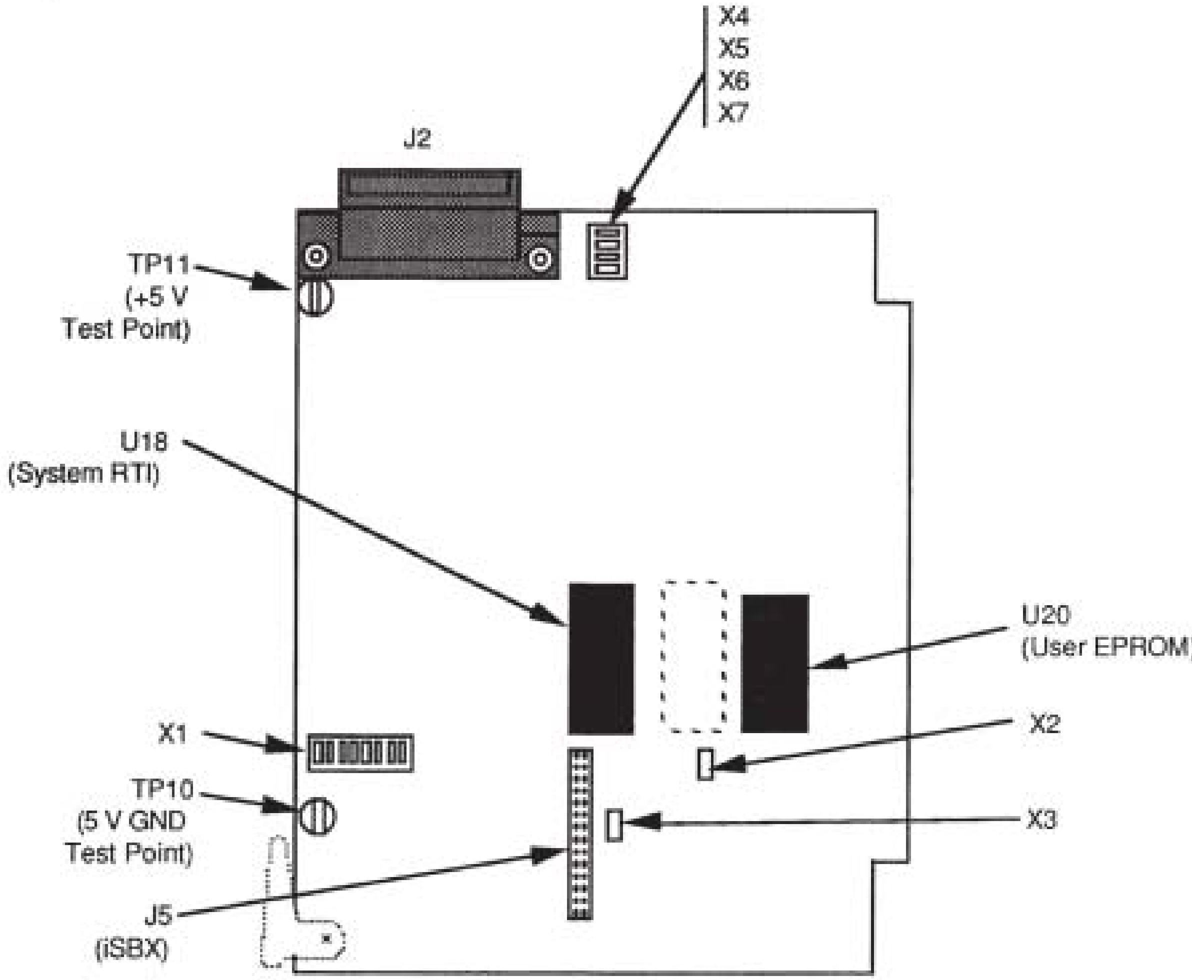


Figure 4-1. Model 473.60c-01A System Processor

Jumpers

Check or change jumper settings according to Table 4-1. The standard connection is noted. Optional settings require extra hardware.

Table 4-1. System Processor Jumper Connections

Jumper	Connection	Description
X1	1-22, 2-21, 3-20 4-19, 5-18, 7-16 8-15, 10-13, 11-12	*
X2 X2 X2 X2 X2 X2 X2 X2	1-2, 16-17 1-2, 17-18 2-3, 16-17 4-5, 8-11 4-5, 10-11 5-6, 10-11 14-15 13-14	System RTI (U18) = 27256* System RTI (U18) = 2764 or 27128 System RTI (U18) = 27512 User PROM (U20) = 2764 or 27128* User PROM (U20) = 27256 User PROM (U20) = 27512 Non-volatile RAM (U19) = 8K x 8* Non-volatile RAM (U19) = 32K x 8
X3 X3 X3 X3 X3 X3	7-8 2-7 6-7 3-4 2-3 3-6	80188 NMI disabled* 80188 NMI = SBX Bus pin MINTR0 80188 NMI = SBX Bus pin MINTR1 80188 INTO disabled* 80188 INTO = SBX Bus pin MINTR0 80188 INTO = SBX Bus pin MINTR1
X4 X5 X6 X4 X5 X6	2-3 2-3 2-3 1-2 1-2 1-2	Serial port handshake lines disabled (no modem control)* Serial port handshake lines enabled (for modem control)
X7 X7	2-3 1-2	Dynamic RAM = 64K x 8* Dynamic RAM = 256K x 8

* Standard connection

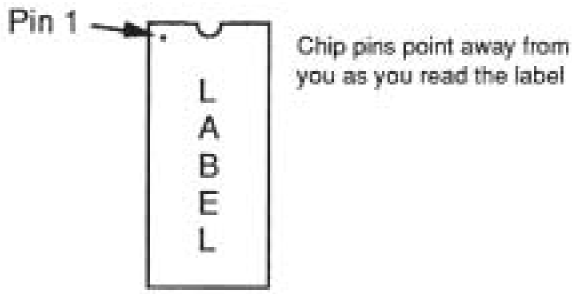
Replacing the System RTI EPROM

EPROM U18 contains the RTI (Run Time Interpreter). This is the firmware used by the System Processor to interpret INCOL86 instructions at run time. In some cases, this EPROM must be replaced (refer to Troubleshooting later in this chapter).

CAUTION

Make sure chassis power is OFF before removing the System Processor to replace this EPROM.

Carefully remove the existing EPROM at site U18 (using a tool such as a flat-bladed screwdriver). Install the new EPROM at U18. Do not plug in this chip upside down. Use pin 1 of this chip as a reference point:



Plug pin 1 of the chip into pin 1 of the socket (pin 1 is in the upper left hand corner of the socket if you position the card with J2 facing up).

Wiring

Table 4-2. System Processor RS232c Connector Pin Definitions (J2)

J2 Pin	Name	Direction	Description
1	CHASSIS GND		Chassis ground
2	TXD	out*	Transmit data
3	RXD	in	Receive data
4	RTS	out	Request to send
5	CTS	in	Clear to send
6	DSR	in	Data set ready
7	SIG GND		Analog ground
8	DCD	in	Data carrier detect
9	+12 V	out	+ 12 Vdc auxiliary power
20	DTR	out	Data terminal ready

*Outward from System Processor

Cabling

Select a cable from those listed in Table 4-3, to connect the System Processor to a personal computer:

Table 4-3. RS232c Communications Cables

Cable Model Number	Cable Part Number	Connects to:
473.50c-25A-300	408344-12	IBM PC
473.50c-25B-300	426488-02	IBM AT
Refer to the "Cables" chapter of this manual for connections		

If your application uses a modem, change jumpers as shown in Table 4-1 and refer to cable connections for J2 (Table 4-2). J2 is configured as an RS232c DTE device.

Installing the System Processor

⚠ CAUTION

Make sure chassis power is OFF before installing the System Processor.

Plug the System Processor into its assigned chassis slot, which is normally the far left slot (on the 36-slot chassis, this is normally the top left slot). If an SBX expansion board is present, two chassis slots are required.

SBX

The iSBX Bus is a standard I/O bus for connecting expansion modules to host cards. Either a single or double-width expansion module can be installed. Contact Custom Servo Motors Inc. for further information.

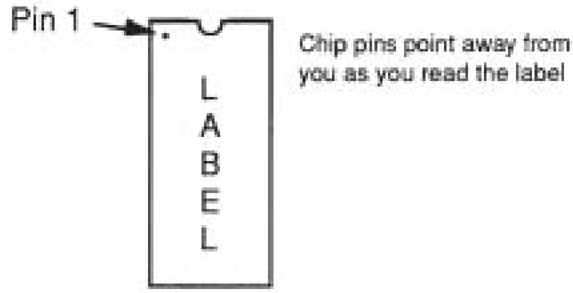
Installing the User EPROM

The System Processor has space for a user EPROM (U20). Use an EPROM programmer (for example, the GTEK EPROM Programmer) to write your application program to an EPROM. The program runs automatically upon power up.

⚠ CAUTION

Make sure chassis power is OFF before removing the System Processor to install your EPROM.

Install the EPROM at user site U20. Use the appropriate jumper configurations according to Table 4-1. Do not plug in this chip upside down. Use pin 1 of this chip as a reference point:

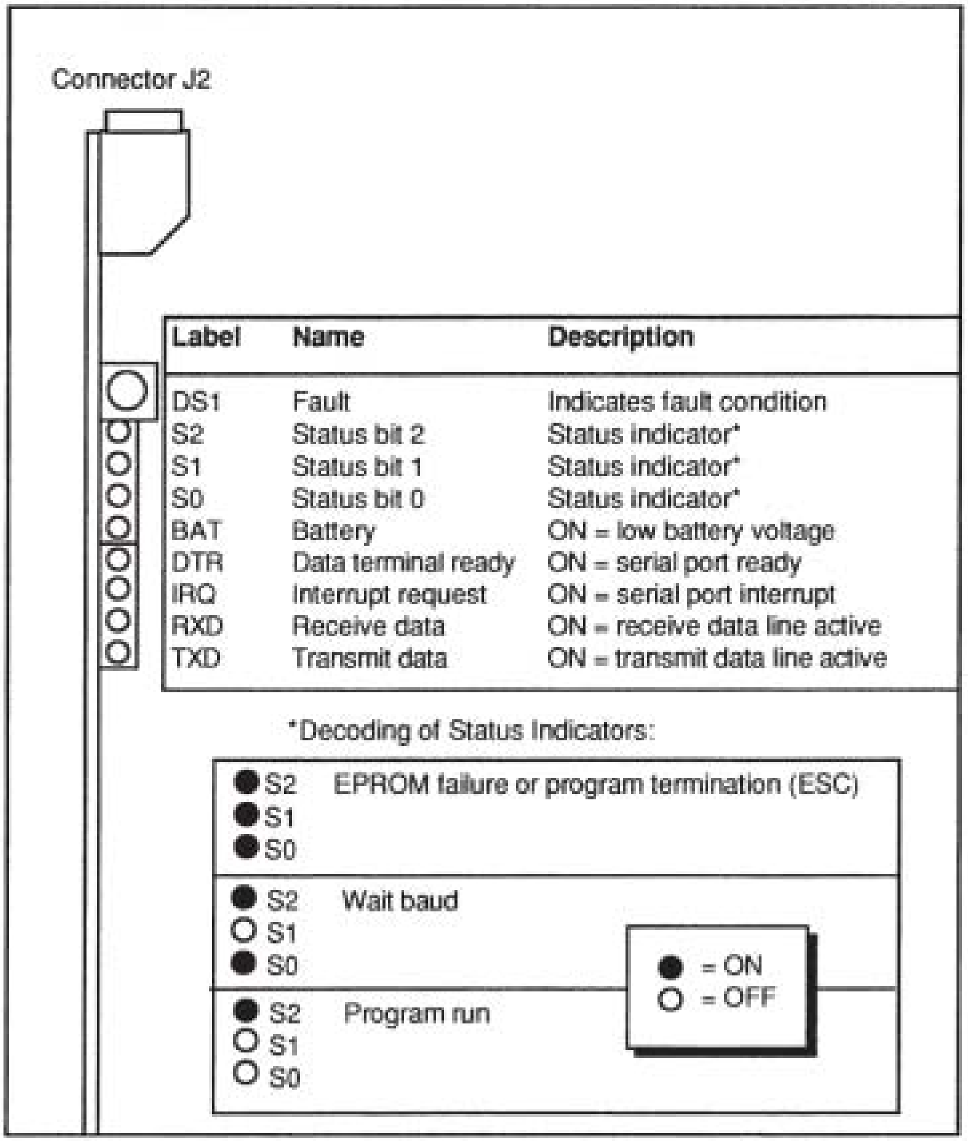


Plug pin 1 of the chip into pin 1 of the socket (pin 1 is in the upper left hand corner of the socket if you position the card with J2 facing up).

During power-up, if U20 is not present, the system waits on the RS-232 port for the program to be downloaded from a PC.

LED Functions

Nine LEDs, summarized in Figure 4-2, are provided at the card edge for fault and status indication. Four are available to the 80188 for software status and error reporting. Five are hard-wired indicators of battery level and serial port status.



Label	Name	Description
DS1	Fault	Indicates fault condition
S2	Status bit 2	Status indicator*
S1	Status bit 1	Status indicator*
S0	Status bit 0	Status indicator*
BAT	Battery	ON = low battery voltage
DTR	Data terminal ready	ON = serial port ready
IRQ	Interrupt request	ON = serial port interrupt
RXD	Receive data	ON = receive data line active
TXD	Transmit data	ON = transmit data line active

*Decoding of Status Indicators:

S2	S1	S0	Meaning
●	●	●	EPROM failure or program termination (ESC)
●	○	●	Wait baud
●	○	○	Program run

● = ON
○ = OFF

Figure 4-2. System Processor Indicators and Test Points

Troubleshooting the System Processor

Normal Power-Up

The normal power-up sequence of the System Processor can help you diagnose the condition of the System Processor. If no application EPROM is plugged into the System Processor the normal power up sequence is as follows:

1. S0 LED lights
2. S0 and S2 LEDs light. This is the Wait Baud condition. The System Processor is waiting for information to be downloaded from the computer.

Use this information to help you in troubleshooting your System Processor.

Problem

Error message "Target Connection Bad" appears on the computer screen when running INCOL86 and using START to start a program. The computer can not communicate with the System Processor. Possible causes include the following:

- System Processor is "locked up". That is, communication is not possible between the 473 system and the computer because of a pre-existing condition on the System Processor.
- Defective cable from the computer to the System Processor.
- Defective power supply in the Motion Plus chassis.
- Defective circuit card in chassis causing error.
- Defective serial port on the computer.
- Defective System Processor.

Steps

1. Turn power off, then on to the 473 chassis, then try to start the program again. If the error goes away, the problem was the "locked up" condition of the System Processor. This can also happen if you have an application EPROM plugged into the System processor.

2. Check out the cable against the appropriate figure in the Cables chapter of this manual.

⚠ CAUTION

Be sure to turn off the chassis power before installing or removing any circuit card from the chassis. Installing or removing cards with the power on can damage the system.

3. Remove all the circuit cards from the chassis except the System Processor, then check the power supply. If the power supply is working, try to start the program again. If the error goes away then the problem is that one of the circuit cards in the chassis is not allowing the System Processor to establish communications. Install the circuit cards one at a time to determine which card is causing the

problem. When installing each circuit card remember to turn off the power, turn it back on, and restart the program.

4. Check the serial port on your computer. This can be done by monitoring the Receive and Transmit LEDs on the front of the System Processor. When you start the program, you should see the RXD (receive) and the TXD (transmit) LEDs flash. If this does not happen, then check the computer serial port.

5. The System Processor is defective and needs to be replaced. Contact Custom Servo Motors Inc. for replacement procedures.

Problem

The error message "Wrong version RTI" appears on the computer screen when running INCOL86 and using START to start a program. This message means that the version of INCOL86 you are using is not compatible with the version of the RTI (Run Time Interpreter) at U18 on the System Processor. Possible causes include the following:

- System Processor is "locked up"
- an application EPROM is plugged into the System Processor
- Wrong version RTI (U18) on the System Processor

1. Turn power off, then on to the 473 chassis, then try to start the program again. If the error goes away the problem was that communication was not possible between the two systems because of an existing condition on the System Processor. This is the "locked up" condition. This can also happen if you have an application EPROM plugged into the System processor.

2. If power cycling has no effect, then you must update either the RTI (U18) on the System Processor or the version of INCOL86 you are using. Contact Custom Servo Motors Inc. for software updating procedures.

Problem

The application program will not run from an EPROM but will run when downloaded from the computer. The System Processor's status LEDs are in the wait baud condition. Possible causes include the following:

- wrong speed application EPROM
- jumpers not set correctly for the size of application EPROM used

Steps

1. The speed (access time) of the EPROM that you have stored the application on has to be 250 nanoseconds or faster. Check the specifications of the EPROM to insure access time is correct.

	2. The System Processor is set at the factory to use either a 2764 EPROM or a 27128 EPROM. If you are using an EPROM of a different size refer to the jumper settings in this chapter to correctly set up the System Processor.
Problem	Large fault LED is flashing on the System Processor. Possible causes include the following: • defective RAM chips on the System Processor • other defective components on the System Processor.
Steps	1. The System Processor must be replaced. Contact Custom Servo Motors Inc. for replacement procedures.
Problem	All LEDs on the System Processor are flickering. Possible causes include the following: • the RTI (U18) is not plugged in correctly on the System Processor • the System Processor is bad.
Steps	1. Turn off power. Reinsert the RTI (U18) on the System Processor, then turn on power again. 2. If the error persists then the System Processor is defective. Contact Custom Servo Motors Inc. for replacement procedures.
Problem	BAT LED is lit on the System Processor. This condition exists when the battery that is used to power the battery-backed RAM is defective. Because the battery is factory-removable only, the System Processor must be replaced.
Steps	Contact Custom Servo Motors Inc. for replacement procedures.

Specifications

Parameter	Specification
CPU:	
Microprocessor	Intel 8/16-bit 80188
System clock frequency	8 MHz
Addressing range	1 megabyte (1,048,576 bytes)
Internal I/O space	640 bytes assigned
On-board ROM capacity:	
"System" site	8K, 16K, 32K, or 64K byte EPROM
"User" site	8K, 16K, 32K, or 64K† byte EPROM (250 ns access max)
On-board RAM capacity:	
Dynamic RAM	Standard 64K bytes zero wait state DRAM
Static RAM	Standard 8K bytes CMOS static RAM (150 ns maximum) with lithium battery backup (10 year typical standby current/shelf life rating) Optional 32 K bytes CMOS static RAM (150 ns maximum)
Communications interface:	
Interface type	RS232c serial interface with jumper-selectable handshaking capability (standard DB-25 female connector mounted on card edge)
Transmission mode	Half-duplex or full-duplex (acquired automatically)
Transmission rate	Up to 19,200 baud (acquired automatically)
On-board expansion interface	Standard SBX card connector, accepts one single-width or double-width SBX function card
System requirements:	One System Processor per Motion Bus, requires one card slot in INCOL/473 control chassis (two card slots required with SBX card installed)
Operating environment	0 to 50° C(32 to 122° F) operating temperature Up to 90% relative humidity, noncondensing
Power requirements	+5 V ± 0.25 V at 1.4 A +12 V ± 0.6 V at 22 mA -12 V ± 0.6 V at 22 mA

†Provides 64K hardware access, but only 32K software access

5 Model 473.60c-01A High Speed System Processor

Introduction

The Model 473.60c-01A High Speed System Processor is a single-board master CPU for INCOL86/Motion Plus™ control systems. It is capable of controlling multiple-axis systems on a single Motion Bus, and it is compatible with Series 473 Motion Bus devices.

Standard features of the High Speed System Processor include the following:

- 16 MHz Intel 80C188 CPU
- 96K bytes of SRAM (static RAM) ¶
- 32K bytes of CMOS static RAM with battery backup
- Configured for 8K bytes of EPROM for INCOL86 application program storage
- 64K bytes of EPROM for INCOL86 system software storage
- SBX card connector for I/O expansion
- RS232c interface
- Nine card-edge LED fault/status indicators

Options include the following:

- Up to 64K bytes of EPROM for INCOL86 application program storage*†
- Modem control §

* Requires jumper change and component change.
§ Requires jumper change and proper cable configuration.
† Hardware can access 64K bytes, software can access only 32K bytes.
¶ Only 48K available for programming use.

Figure 5-1 shows the location of important components on the High Speed System Processor.

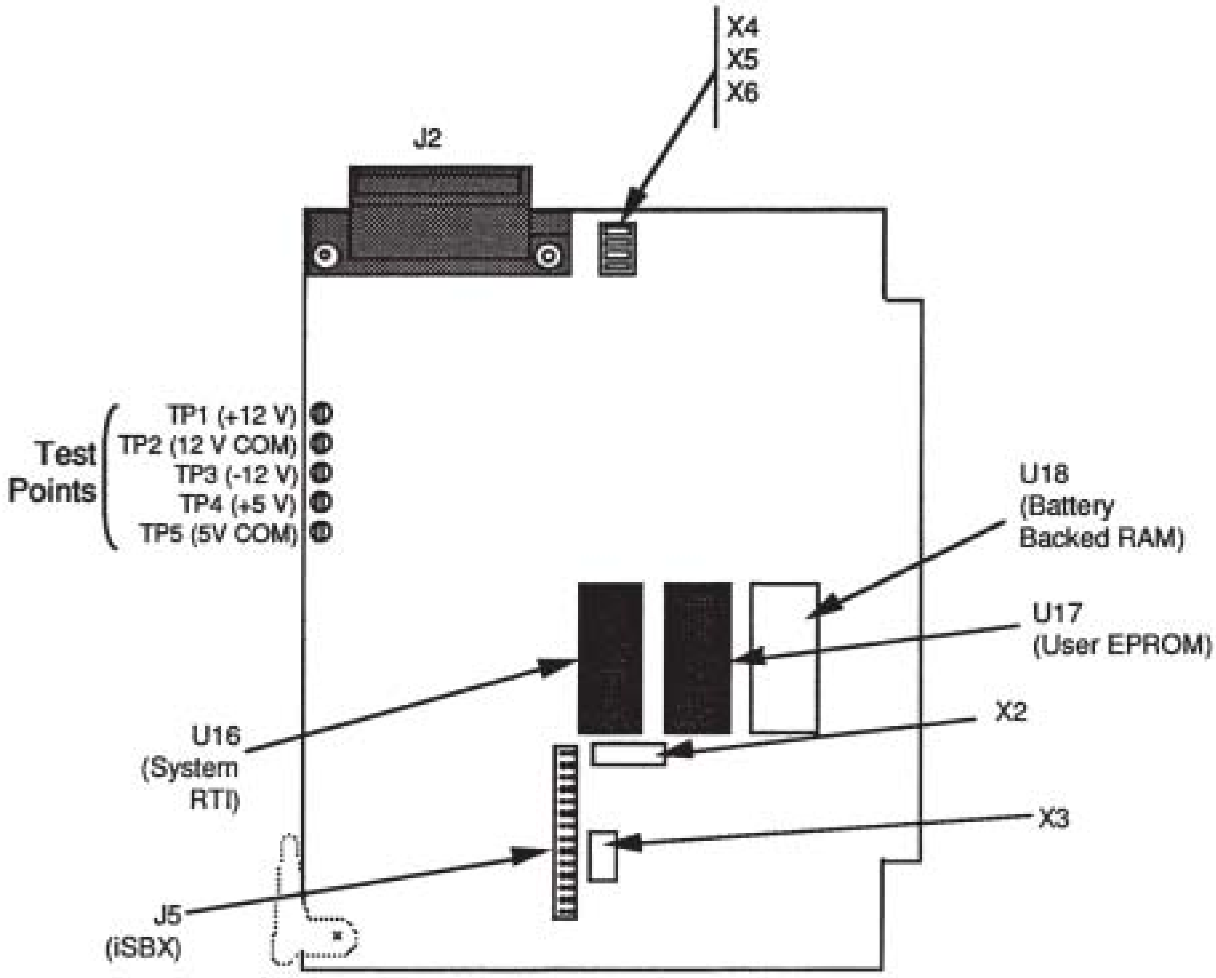


Figure 5-1. Model 473.60c-01A High Speed System Processor

Jumpers

Check or change jumper settings according to Table 5-1. The standard connection is noted. Optional settings may require extra hardware.

Table 5-1. High Speed System Processor Jumper Connections

Jumper	Connection	Description
X2 X2 X2 X2 X2 X2 X2 X2	2-3, 16-17 1-2, 17-18 1-2, 16-17 4-5, 8-11 4-5, 10-11 5-6, 10-11 14-15 13-14	System RTI (U16) = 27512* System RTI (U16) = 2764 or 27128 System RTI (U16) = 27256 User PROM (U17) = 2764 or 27128* User PROM (U17) = 27256 User PROM (U17) = 27512 Non-volatile RAM (U18) = 8K X 8 Non-volatile RAM (U18) = 32K X 8*
X3 X3 X3 X3 X3 X3	7-8 2-7 6-7 3-4 2-3 3-6	80188 NMI disabled* 80188 NMI = SBX Bus pin MINTR0 80188 NMI = SBX Bus pin MINTR1 80188 INTO disabled* 80188 INTO = SBX Bus pin MINTR0 80188 INTO = SBX Bus pin MINTR1
X4 X5 X6 X4 X5 X6	2-3 2-3 2-3 1-2 1-2 1-2	Serial port handshake lines disabled (no modem control)* Serial port handshake lines enabled (for modem control)
X8 X8	1-2 2-3	32 MHz oscillator* 16 MHz oscillator (not user selectable)
* Standard Connection		

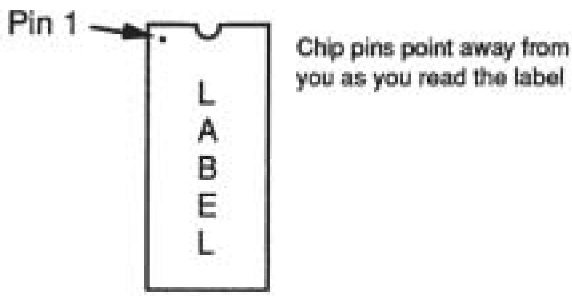
Replacing the System RTI EPROM

EPROM U16 contains the RTI (Run Time Interpreter). This is the firmware used by the High Speed System Processor to interpret INCOL86 instructions at run time. In some cases, this EPROM must be replaced (refer to Troubleshooting later in this chapter). Notice that the access time of the replacement EPROM must be 120 ns or less.

⚠ CAUTION

Make sure chassis power is OFF before removing the High Speed System Processor to replace this EPROM.

Carefully remove the existing EPROM at site U16. Install the new EPROM at U16. <u>Do not plug in this chip upside down</u>. Use pin 1 of this chip as a reference point:



Plug pin 1 of the chip into pin 1 of the socket (pin 1 is in the upper left hand corner of the socket if you position the card with J2 facing up).

Wiring

Table 5-2. High Speed System Processor RS232c Connector Pin Definitions (J2)

J2 Pin	Name	Direction	Description
1	CHASSIS GND		Chassis ground
2	TXD	out*	Transmit data
3	RXD	in	Receive data
4	RTS	out	Request to send
5	CTS	in	Clear to send
6	DSR	in	Data set ready
7	SIG GND		Analog ground
8	DCD	in	Data carrier detect
9	+12 V	out	+ 12 Vdc auxiliary power
20	DTR	out	Data terminal ready

*Outward from High Speed System Processor

Cabling

Select a cable from those listed in Table 5-3, to connect the High Speed System Processor to a personal computer:

Table 5-3. RS232c Communications Cables

Cable Model Number	Cable Part Number	Connects to:
473.50c-25A-300	408344-12	IBM PC
473.50c-25B-300	426488-02	IBM AT
Refer to the "Cables" chapter of this manual for connections		

If your application uses a modem, change jumpers as shown in Table 5-1 and refer to cable connections for J2 (Table 5-2). J2 is configured as an RS232c DTE device.

Options

Model Number	Part Number	Description
473.60c-01A-003	446154-03	32K battery-backed RAM, 32K R/W memory for user programming.

Installing the High Speed System Processor

CAUTION

Make sure chassis power is OFF before installing the High Speed System Processor.

Plug the High Speed System Processor into its assigned chassis slot, which is normally the far left slot (on the 36-slot chassis, this is normally the top left slot). If an SBX expansion board is present, two chassis slots are required.

SBX

The iSBX Bus is a standard I/O bus for connecting expansion modules to host cards. Either a single or double-width expansion module can be installed. Contact Custom Servo Motors Inc. for further information.

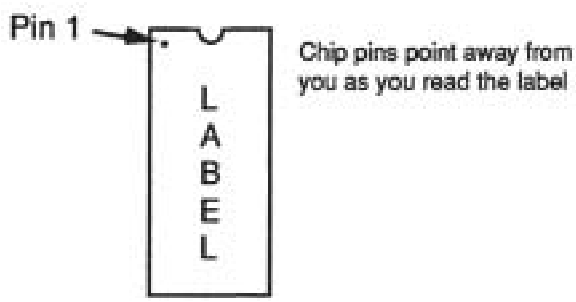
Installing the User EPROM

The High Speed System Processor has space for a user EPROM (U17). Use an EPROM programmer (for example, the GTEK EPROM Programmer) to write your application program to an EPROM. The program runs automatically upon power up.

CAUTION

Make sure chassis power is OFF before removing the High Speed System Processor to install your EPROM.

Install the EPROM at user site U17. Use the appropriate jumper configurations according to Table 5-1. Do not plug in this chip upside down. Use pin 1 of this chip as a reference point:



Plug pin 1 of the chip into pin 1 of the socket (pin 1 is in the upper left hand corner of the socket if you position the card with J2 facing up).

During power-up, if U17 is not present, the system waits on the RS232 port for the program to be downloaded from a PC.

LED Functions

Nine LEDs, summarized in Figure 5-2, are provided at the card edge for fault and status indication. Four are available to the 80C188 for software status and error reporting. Five are hard-wired indicators of battery level and serial port status.

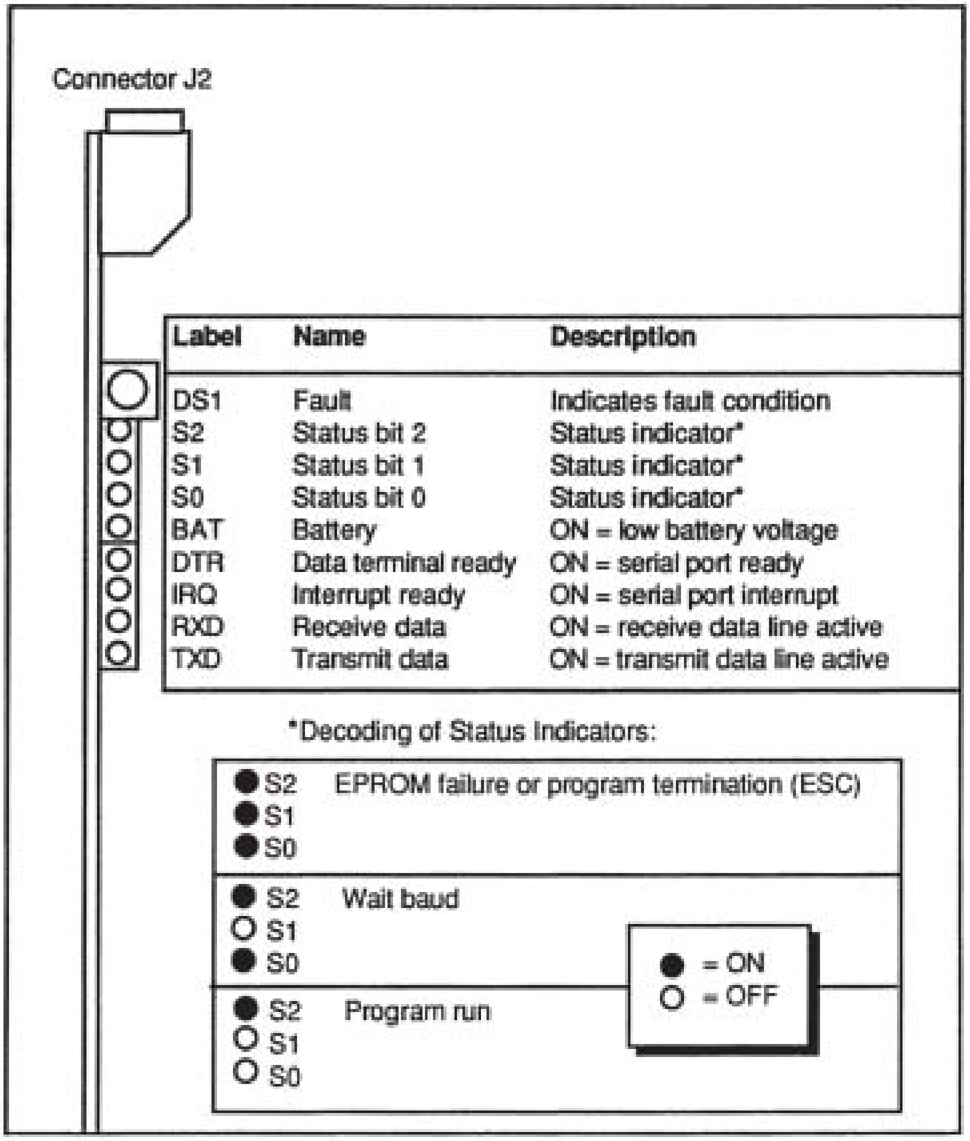


Figure 5-2. High Speed System Processor Indicators

Troubleshooting the High Speed High Speed System Processor

Normal Power-Up

The normal power-up sequence of the High Speed System Processor can help you diagnose the condition of the High Speed System Processor. If no application EPROM is plugged into the High Speed System Processor the normal power up sequence is as follows:

1. S0 LED lights
2. S0 and S2 LEDs light. This is the Wait Baud condition. The High Speed System Processor is waiting for information to be downloaded from the computer.

Use this information to help you in troubleshooting your High Speed System Processor.

Problem

Error message "Target Connection Bad" appears on the computer screen when running INCOL86 and using START to start a program. The computer can not communicate with the High Speed System Processor. Possible causes include the following:

- High Speed System Processor is "locked up". That is, communication is not possible between the 473 system and the computer because of a pre-existing condition on the High Speed System Processor.
- Defective cable from the computer to the High Speed System Processor.
- Defective power supply in the Motion Plus chassis.
- Defective circuit card in chassis causing error.
- Defective serial port on the computer.
- Defective High Speed System Processor.

Steps

1. Turn power off, then on to the 473 chassis, then try to start the program again. If the error goes away, the problem was the "locked up" condition of the High Speed System Processor. This can also happen if you have an application EPROM plugged into the System processor.

2. Check out the cable against the appropriate figure in the Cables chapter of this manual.

CAUTION

Be sure to turn off the chassis power before installing or removing any circuit card from the chassis. Installing or removing cards with the power on can damage the system.

3. Remove all the circuit cards from the chassis except the High Speed System Processor, then check the power supply at test points TP1 to TP5. If the power supply is working then try to start the program again. If the error goes away

then the problem is that one of the circuit cards in the chassis is not allowing the High Speed System Processor to establish communications. Install the circuit cards one at a time to determine which card is causing the problem. When installing each circuit card remember to turn off the power, turn it back on, and restart the program.

4. Check the serial port on your computer. This can be done by monitoring the Receive and Transmit LEDs on the front of the High Speed System Processor. When you start the program, you should see the RXD (receive) and the TXD (transmit) LEDs flash. If this does not happen, then check the computer serial port.

5. The High Speed System Processor is defective and needs to be replaced. Contact Custom Servo Motors Inc. for replacement procedures.

Problem

The error message "Wrong version RTI" appears on the computer screen when running INCOL86 and using START to start a program. The reason for the error is that the version of INCOL86 you are using is not compatible with the version of the RTI (Run Time Interpreter) on the High Speed System Processor. Possible causes include the following:

- High Speed System Processor is "locked up"
- an application EPROM is plugged into the High Speed System Processor
- Wrong version RTI on the High Speed System Processor

1. Turn power off, then on to the 473 chassis, then try to start the program again. If the error goes away the problem was that communication was not possible between the two systems because of an existing condition on the High Speed System Processor. This is the "locked up" condition. This can also happen if you have an application EPROM plugged into the System processor.

2. If power cycling has no effect, then you must update either the RTI on the High Speed System Processor or the version of INCOL86 you are using. Contact Custom Servo Motors Inc. for software updating procedures.

Problem

The application program will not run from an EPROM but will run when downloaded from the computer. The High Speed System Processor's status LEDs are in the wait baud condition. Possible causes include the following:

- wrong speed (access time) application EPROM
- jumpers not set correctly for the size of application EPROM used

Steps	1. The speed of the EPROM that you have the application stored on has to be 250 nanoseconds or faster. Check the specifications of the EPROM to insure access time is correct. 2. The High Speed System Processor is set at the factory to use either a 2764 EPROM or a 27128 EPROM. If you are using an EPROM of a different size refer to the jumper settings in this chapter to correctly set up the High Speed System Processor.
Problem	Large fault LED is flashing on the High Speed System Processor. Possible causes include the following: • defective RAM chips on the High Speed System Processor • other defective components on the High Speed System Processor.
Steps	1. The High Speed System Processor must be replaced. Contact Custom Servo Motors Inc. for replacement procedures.
Problem	All LEDs on the High Speed System Processor are flickering. Possible causes include the following: • the RTI (U16) is not plugged in correctly on the High Speed System Processor • the High Speed System Processor is bad.
Steps	1. Turn off power. Reinsert the RTI on the High Speed System Processor, then turn on power again. 2. If the error persists then the High Speed System Processor is defective. Contact Custom Servo Motors Inc. for replacement procedures.
Problem	BAT LED is lit on the High Speed System Processor. This condition exists when the battery that is used to power the battery-backed RAM is defective. Because the battery is factory-removable only, the High Speed System Processor must be replaced.
Steps	Contact Custom Servo Motors Inc. for replacement procedures.

Specifications

Parameter	Specification
CPU:	
Microprocessor	Intel 8/16-bit 80C188
System clock frequency	16 MHz
Addressing range	1 megabyte (1,048,576 bytes)
Internal I/O space	640 bytes assigned
On-board ROM capacity:	
"System" site	8K, 16K, 32K, or 64K byte EPROM (120 ns access max)
"User" site	8K, 16K, 32K, or 64K byte EPROM (250 ns access max)
On-board RAM capacity:	
Static RAM	Standard 96K bytes
Low-Power Static RAM	Standard 32K bytes CMOS static RAM (150 ns access maximum) with lithium battery backup (10 year typical standby current/shelf life rating)
Communications interface:	
Interface type	RS232c serial interface with jumper-selectable handshaking capability (standard DB-25 female connector mounted on card edge)
Transmission mode	Half-duplex or full-duplex (acquired automatically)
Transmission rate	Up to 19,200 baud (acquired automatically)
On-board expansion interface	Standard SBX card connector, accepts one single-width or double-width SBX function card
System requirements:	One System Processor per Motion Bus, requires one card slot in INCOL/473 control chassis (two card slots required with SBX card installed)
Operating environment	0° to 50°C (32° to 122° F) operating temperature Up to 95% humidity noncondensing
Power requirements	+5 V ± 0.25 V at 1.6 A +12 V ± 0.6 V at 13 mA -12 V ± 0.6 V at 14 mA

6 Model 473.61c-01A Command Generator

Introduction

The Model 473.61c-01A Command Generator is a microprocessor-based motion profiler suitable for multiple-axis systems requiring simultaneous motion or complex profiles.

Standard features of the Command Generator include the following:

- 5 MHz Intel 8085A-2 microprocessor
- 8K bytes of EPROM for system software storage
- 8K bytes of dual-port RAM
- Sensor input
- Nine card-edge LED fault and status indicators

Optionally, the Command Generator may include 2K bytes of RAM (This option requires a jumper change and a component change [part number 395361-02]).

Figure 6-1 shows the location of important components on the Command Generator

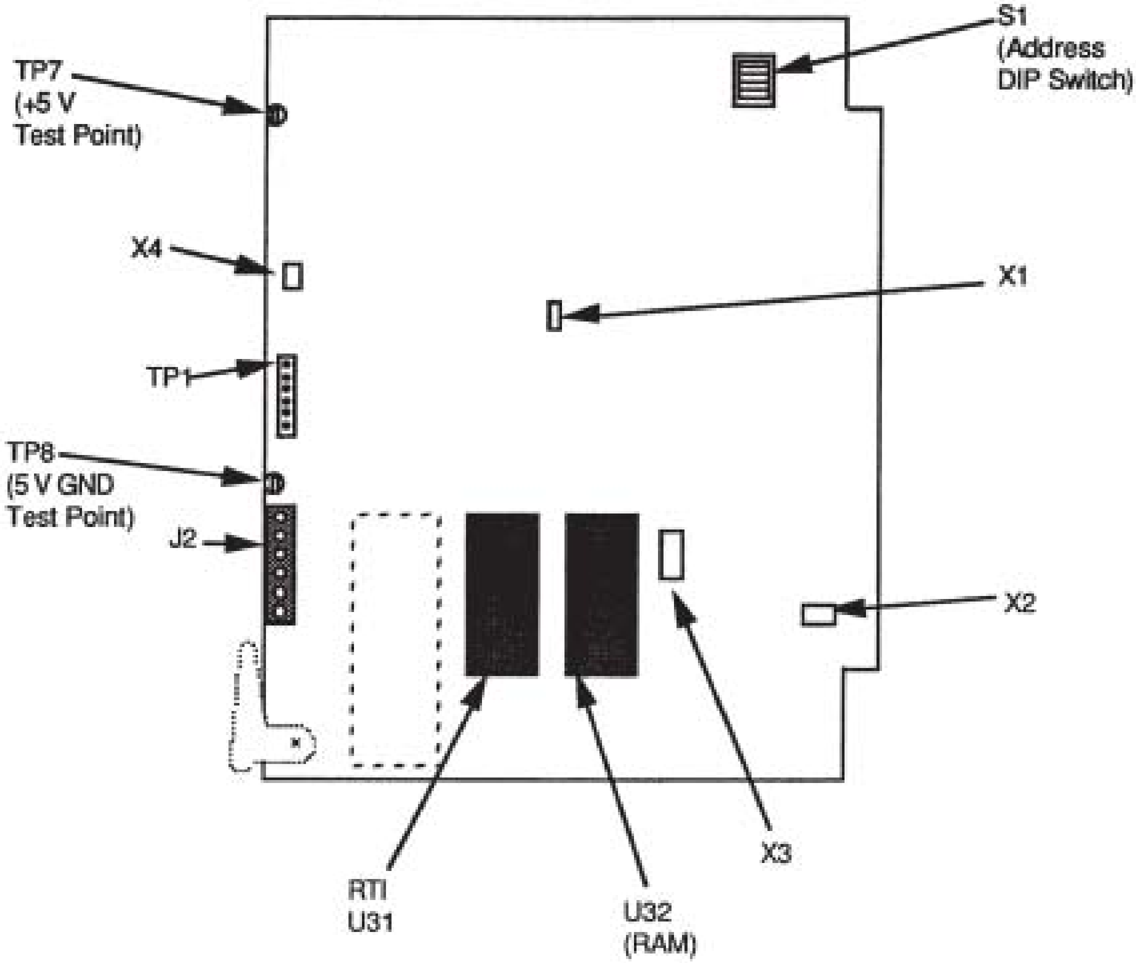


Figure 6-1. Model 473.61c-01A Command Generator

Jumpers

Check or change the jumper settings according to Table 6-1. The standard connection is marked *. Optional settings may require additional components.

Table 6-1. 473.61c-01A Command Generator Jumper Connections

Jumper	Connection	Description
X1	1-2*	STC clock source is HCLK from Motion Bus†
X1	2-3	STC clock source is local 8085 CPU clock†
X2	1-6*	No effect
X2	2-5	Local BRM drives RATIO 0 on Motion Bus†
X2	3-4	Local BRM drives RATIO 1 on Motion Bus†
X3	1-2	2K bytes dual-port RAM
X3	2-3*	6K bytes additional private RAM (8K total)
X4	1-4*	Sensor normally open to 12 V common
X4	2-3	Sensor normally closed to 12 V common

*Standard connection
†Refer to the INCOL86 Programming Manual for software-selectable ratio clock sources.

DIP Switch

Set the DIP switch to locate the Command Generator in the host CPU memory and I/O maps according to Table 6-2.

CAUTION

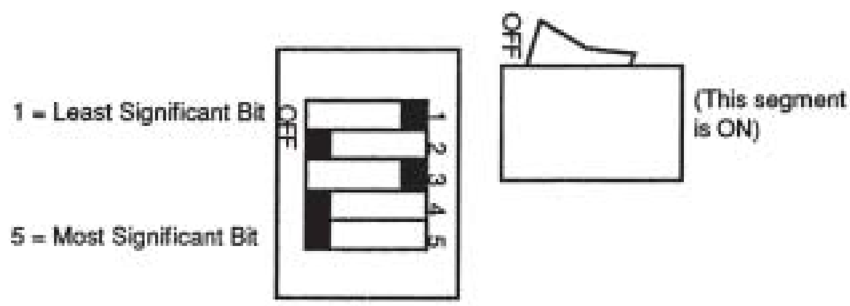
Do not set the DIP switch to all ones (all ON).

Table 6-2. Address Switch Setting for all Command Generators

Switch Settings:

1 = ON
0 = OFF

Example:



bit pattern = 00101
Axis No. = 5

Axis No.	Setting* 54321	Axis No.	Setting* 54321
1	00001	9	01001
2	00010	10	01010
3	00011	11	01011
4	00100	12	01100
5	00101	13	01101
6	00110	14	01110
7	00111	15	01111
8	01000		

*Never set the DIP switch to all ones (all ON).

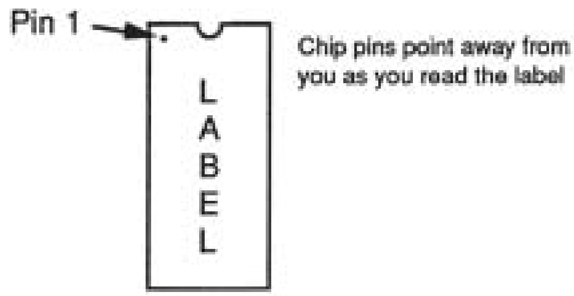
Replacing the RTI EPROM

EPROM U31 contains the RTI (Run Time Interpreter). This is the firmware used by the Command Generator to interpret INCOL86 instructions at run time. In some cases (using custom firmware) this EPROM must be replaced.

⚠ CAUTION

Make sure chassis power is OFF before removing the Command Generator to replace this EPROM.

Carefully remove the existing EPROM at site U31 (using a tool such as a flat-bladed screwdriver). Install the new EPROM at U31. Do not plug in this chip upside down. Use pin 1 of this chip as a reference point:



Plug pin 1 of the chip into pin 1 of the socket (pin 1 is in the upper left hand corner of the socket if you position the card with J2 facing up).

Wiring

Connector J2 on the Command Generator allows a sensor input to enable rapid profile modifications. Sample Command Generator sensor cables are shown in Figure 6-3 for normally-open or normally-closed switches. Refer to Table 6-1 when setting the jumpers.

Table 6-3. Command Generator Connector Pin Definitions

J2 Pin	Name	Definition
1	+12 V	+12 V from chassis power supply
2	SENSE-1	Sinking input
3	SENSE-2	Sourcing input
4	12 V COM	12 V common from chassis power supply
5	-12 V	-12 V from chassis power supply
6	CHASSIS GND	Chassis ground

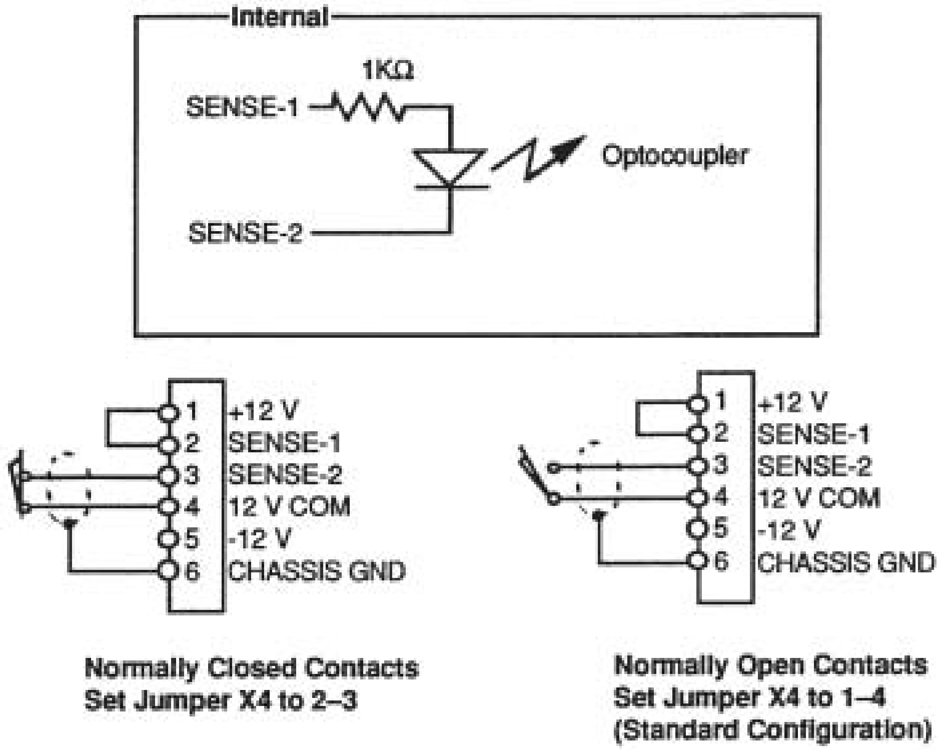


Figure 6-3. Sample Sensor Cables

Installing the Command Generator

⚠ CAUTION

Make sure chassis power is OFF before installing the Command Generator.

The Command Generator requires one slot in the chassis.

LEDs

LEDs are provided on the Command Generator for both fault and status indication. The designated label assigned to each LED is marked on the module next to the LED. The status LEDs for the Command Generator are described in Table 6-4 (includes 9 LEDs).

Table 6-4. Command Generator Status LEDs

TP7 +5 V (from chassis power supply)

Label	Name	Description
DS1	Fault	Indicates fault condition
S2	Status bit 2	Status indicator*
S1	Status bit 1	Status indicator*
S0	Status bit 0	Status indicator*
INT	Internal	ON = command direction set internally OFF = set by ENCODER DIR
HLT	Halt	ON = command halt OFF = command go
ACC	Acceleration	ON = accelerate OFF = decelerate
DIR	Direction	ON = clockwise OFF = counterclockwise
SEN	Sensor	ON = on sensor OFF = not on sensor

Test Points

- TP1
- TP2
- TP3 CMND CLK
- TP4
- TP5
- TP6 5 V GND

TP8 5 V GND (from chassis power supply)

Connector J2

*Decoding of Status Indicators:

S2	S1	S0	State
O	O	O	Stopped
O	O	●	Moving in profile
O	●	O	Ramping in Run mode
●	O	O	DSTOP in progress

● = ON
O = OFF

You can use the Fault and Status indicators on the Command Generator to help in troubleshooting problems which occur when installing the Command Generator. The status LEDs are in known states during the following operations:

- Normal power-up
- Ramp execution*
- Profile execution*
- DSTOP execution*

* This operation can only take place in response to an INCOL86 program. Refer to the INCOL86 System Programming Manual for an explanation of how to program this operation.

Status Indicators During Normal Power-Up

After power-up and before the System Processor has issued any commands to the Command Generator the status LEDs are in the following state:

INT	ON
HLT	ON
ACC	ON

All other LEDs are off.

Status Indicators During Ramp Execution

While the system is executing a ramp motion, the status LEDs are in the following state:

S1	ON
INT	ON
ACC	ON if the command is accelerating or has just accelerated to a higher velocity, or
ACC	OFF if the command is decelerating or has just decelerated to a lower velocity.
DIR	ON if + direction is commanded, or
DIR	OFF if - direction is commanded

All of the other LEDs are off.

Status Indicators During Profile Execution

While the system is executing a motion profile, the status LEDs are in the following state:

S0	ON
INT	ON
ACC	ON if the command is accelerating or has just accelerated to a higher velocity.
ACC	OFF if command is decelerating or has just decelerated to a lower velocity.
DIR	ON if + direction is commanded
DIR	OFF if - direction is commanded

All of the other LEDs are off.

Status Indicators During DSTOP Execution

While the system is executing a DSTOP motion, the status LEDs are in the following state:

S2	ON
INT	ON
DIR	ON if + direction is commanded
DIR	OFF if - direction is commanded

All of the other LEDs are off.

⚠ CAUTION

Make sure chassis power is OFF before removing or installing the Command Generator.

Troubleshooting the Command Generator

Problem	Flashing Fault LED or all LEDs flashing on Command Generator. Possible causes are bad RAM or other component failure on Command Generator.
Steps	Replace Command Generator
Problem	Large fault LED lights on the Command Generator. Possible cause is fault when moving axis.
Steps	1. Fault has occurred when trying to move the axis. Look for open limits on the axis or drive faults or excess error on the translator. All of these faults actually occurred on the translator but are reported on the Command Generator also. 2. When using the Servo Translator model number 473.19C-01A, the excess error fault is not reported on the translator so the only indication is the fault on the Command Generator. 3. Check address switch on the Command Generator to insure that it is addressed correctly. If the fault is occurring without actually trying to move the axis the Command Generator could have a component failure.
Problem	No fault, but axis not moving.
Steps	1. Command Generator not addressed correctly. Check that the Command Generator is addressed correctly and that the translator is addressed correctly. 2. The Command Generator and the translator are not in the correct slots. In a system that has multiple axes, two lines on the backplane are separated between axis pairs (pins 18 and 19). An axis pair consists of a Command Generator and its associated translator. The lines on the backplane are the command clock and the command direction. Check to see that the Command Generator and its associated translator are in the correct slots. 3. Software not correct. The software has to correctly initialize the Command Generator and the translator. Check the INCOL86 software manual for more detailed programming information.

Problem	Ratio axis not working correctly.
Steps	1. Ratioing is a combination of software and hardware. Check to see that all of the jumpers are set correctly on the Command Generator and the translator for your application. Ratioing may require changing some of the jumpers from factory settings. 2. Software is not correct. Refer to the INCOL86 software manual for more information on programming ratio axes.
Problem	Sensor input not working properly
Steps	The sensor is used for rapid profile modifications. You must have software in place to use the sensor. The sensor input does not have to be configured if you are not using it. Typical applications for the sensor are stopping on a mark or registration of material to a specific position. To test the sensor input, take the following steps: 1. Set jumper X4 to the factory setting . 2. Connect a wire between pin 1 and pin 2 of connector J2. 3. Connect a wire from pin 4 to pin 3 of J2 and the SEN LED will turn on. This is an indication that the sensor input is working. If you are still having problems with the sensor input, check your software or contact Custom Servo Motors Inc. for a replacement Command Generator.

Specifications

Parameter	Specification
Microprocessor	Intel 8085A-2 8-bit microprocessor
On-board memory:	
ROM capacity	8K bytes of EPROM
RAM capacity	8K bytes standard (2K bytes dual-port, plus 6K bytes internal)
Command clock frequency	2.5 MHz max
Velocity resolution	1 part in 65536 (nominal)
Sensor contacts	10 mA at 0 Vdc
System requirements	Requires one card slot in Motion Plus/473 chassis
Power requirements	+5 Vdc ±0.25 V at 1.40 A max +12 Vdc ±1.2 V at 0.022 A max -12 Vdc (no requirements)
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing

7 Model 473.61c-02A Command Generator/Translator

Introduction

The Model 473.61c-02A Command Generator/Translator is a microprocessor-based motion profiler suitable for multiple-axis systems requiring simultaneous motion or complex profiles and a stepper interface.

Standard features of the Command Generator/Translator include the following:

- 5 MHz Intel 8085A-2 microprocessor
- 8K bytes of EPROM for system software storage
- 8K bytes of dual-port RAM
- \+ Limit, -Limit, and Home inputs
- Eleven card-edge LED fault and status indicators
- Pulse and direction outputs
- Clockwise/counterclockwise outputs
- Optical isolation of inputs and outputs

Options include the following:

- Selectable pulse widths*
- Internal power supply for inputs and outputs*
- Pulse and direction to other translator cards*

* Requires jumper change.

Figure 7-1 shows the location of important components on the Command Generator/Translator

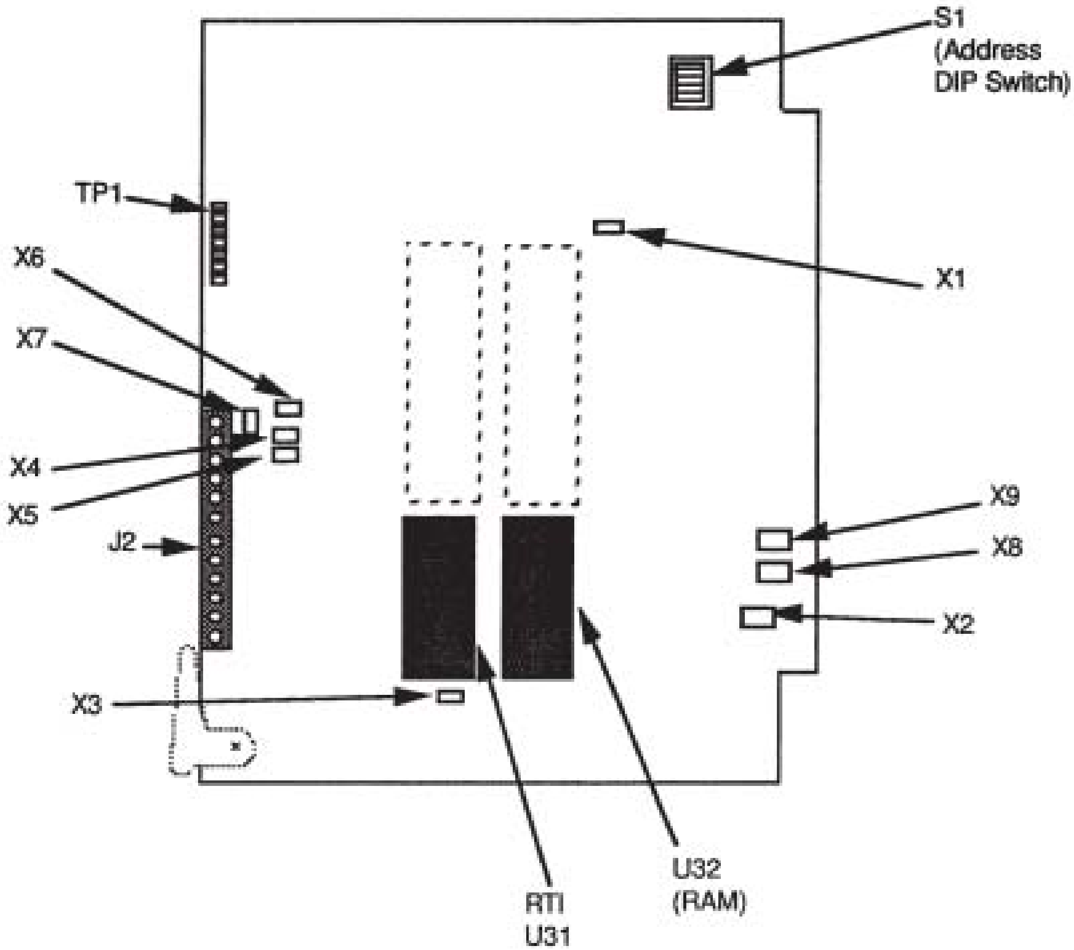


Figure 7-1. Model 473.61c-02A Command Generator/Translator

Jumpers

Check or change the jumper settings according to Table 7-1. The standard connection is marked *. Optional settings may require additional components.

Table 7-1. 473.61c-02A Command Generator/Translator Jumper Connections

Jumper	Connection	Description
X1	1-2*	STC clock source is HCLK from Motion Bus†
X1	2-3	STC clock source is local 8085 CPU clock†
X2	1-6*	No effect
X2	2-5	Local BRM drives RATIO 0 on Motion Bus†
X2	3-4	Local BRM drives RATIO 1 on Motion Bus†
X3	1-2	2K bytes dual-port RAM
X3	2-3*	6K bytes additional private RAM (8K total)
X4	NC*	External supply + voltage (+5 to +12 Vdc)¶
X4	1-2	Internal +12 Vdc supply
X5	NC*	External supply ground¶
X5	1-2	Internal +12 Vdc common
X6, X7	Vary the pulse width using jumpers X6 and X7:	
X8	NC*	No CMND DIR to bus
X8	1-2	CMND DIR to bus§
X9	NC*	No CMND CLK to bus
X9	1-2	CMND CLK to bus§

Pulse width	X6	X7
500 ns	2-3	NC (for use with pulse/direction only)
1000 ns	2-3	1-2 (for use with pulse/direction only)
15 µs	1-2*	NC* (standard)
30 µs	1-2	1-2

*Standard connection
†Refer to the INCOL86 Programming Manual for software-selectable ratio clock sources.
¶Jumpers X4 and X5 must be removed before connecting the external supply.
§Requires a translator card addressed to a different axis

DIP Switch

Set the DIP switch to locate the Command Generator/Translator in the host CPU memory and I/O maps according to Table 7-2.

⚠ CAUTION

Do not set the DIP switch to all ones (all ON).

Table 7-2. Address Switch Setting for all Command Generator/Translators

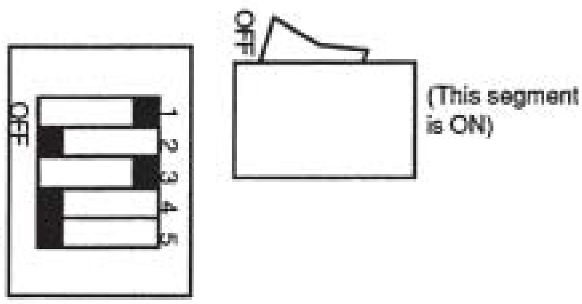
Switch Settings:

1 = ON
0 = OFF

Example:

1 = Least Significant Bit

5 = Most Significant Bit



bit pattern = 00101
Axis No. = 5

Axis No.	Setting* 54321	Axis No.	Setting* 54321
1	00001	9	01001
2	00010	10	01010
3	00011	11	01011
4	00100	12	01100
5	00101	13	01101
6	00110	14	01110
7	00111	15	01111
8	01000		

*Never set the DIP switch to all ones (all ON).

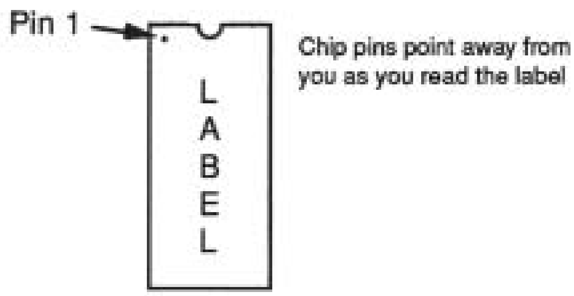
Replacing the RTI EPROM

EPROM U31 contains the RTI (Run Time Interpreter). This is the firmware used by the Command Generator/Translator to interpret INCOL86 instructions at run time. In some cases (using custom firmware) this EPROM must be replaced.

CAUTION

Make sure chassis power is OFF before removing the Command Generator/Translator to replace this EPROM.

Carefully remove the existing EPROM at site U31 (using a tool such as a flat-bladed screwdriver). Install the new EPROM at U31. Do not plug in this chip upside down. Use pin 1 of this chip as a reference point:



Plug pin 1 of the chip into pin 1 of the socket (pin 1 is in the upper left hand corner of the socket if you position the card with J2 facing up).

Wiring

Connector J2 on the Command Generator/Translator provides translator connections to external devices. Table 7-3 lists the pin definitions for connector J2. Figure 7-3 shows typical connections for the module. Figure 7-4 shows the internal configuration of Home and Limit inputs.

Table 7-3. Command Generator/Translator Connector Pin Definitions

J2 Pin	Name	Definition
1,2	+Vx	External power supply (+) input
3	-CW	Active low clockwise signal output
4	-CCW	Active low counterclockwise signal output
5	DIR	Direction output
6	-PULSES	Active low pulse output
7,8	Vx GND	External power supply (-) input
9	CHASSIS GROUND	Chassis ground from ac power input
10	HOME	Active high home input
11	+LIMIT	Active high (+) limit input
12	-LIMIT	Active high (-) limit input

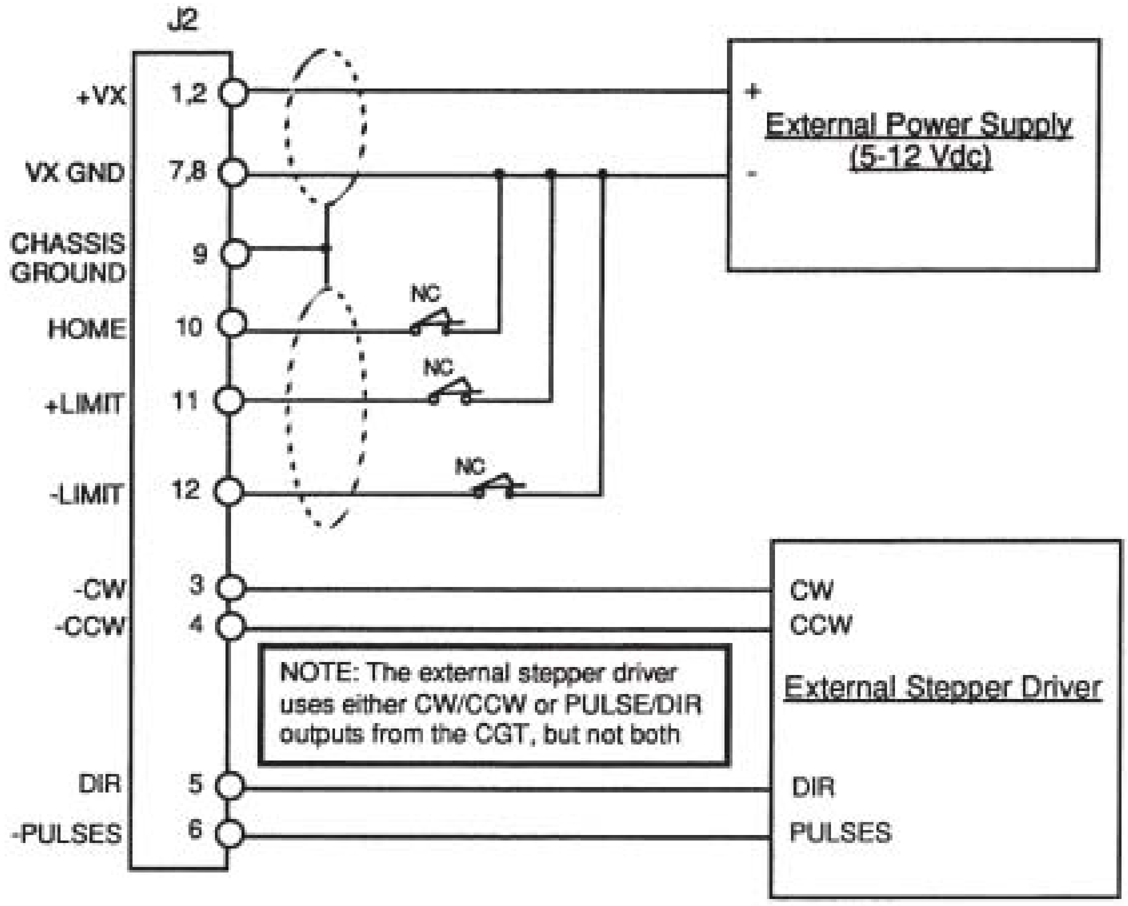


Figure 7-3. Command Generator/Translator Connections

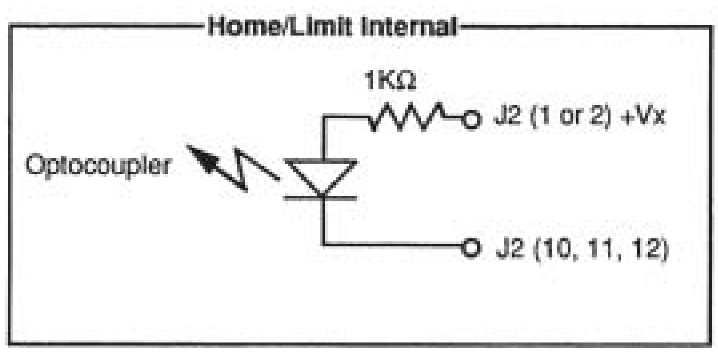


Figure 7-4. Home/Limit Inputs—Internal Configuration

Installing the Command Generator/Translator

The Command Generator/Translator requires one slot in the chassis.

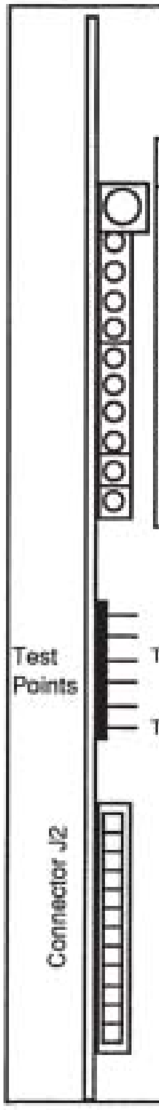
⚠ CAUTION

Make sure chassis power is OFF before installing the Command Generator/Translator.

LEDs

LEDs are provided the Command Generator/Translator cards for both fault and status indication. The designated label assigned to each LED is marked on the module next to the LED. The status LEDs for the Command Generator/Translator are described in Table 7-4 (includes eleven LEDs).

Table 7-4. Command Generator/Translator Status LEDs



Label	Name	Description
DS1	Fault	Indicates fault condition
S2	Status bit 2	Status indicator*
S1	Status bit 1	Status indicator*
S0	Status bit 0	Status indicator*
INT	Internal	ON = command direction set internally OFF = set by ENCODER DIR
HLT	Halt	ON = command halt OFF = command go
ACC	Acceleration	ON = accelerate OFF = decelerate
DIR	Direction	ON = clockwise OFF = counterclockwise
HME	Home	ON = at home OFF = not at home
+LM	+Limit	ON = on + limit
-LM	-Limit	ON = on - limit

*Decoding of Status Indicators:

○ S2 ○ S1 ○ S0	Stopped
○ S2 ○ S1 ● S0	Moving in profile
○ S2 ● S1 ○ S0	Ramping in Run mode
● S2 ○ S1 ○ S0	DSTOP in progress

● = ON
○ = OFF

You can use the Fault and Status indicators on the Command Generator/Translator to help in troubleshooting problems which occur when installing the Command Generator/Translator. The status LEDs are in known states during the following operations:

- Normal power-up
- Ramp execution*
- Profile execution*
- DSTOP execution*

  * This operation can only take place in response to an INCOL86 program. Refer to the INCOL86 System Programming Manual for an explanation of how to program this operation.

Status Indicators During Normal Power-Up

After power-up and before the System Processor has issued any commands to the Command Generator/Translator, the status LEDs are in the following state:

INT	ON
HLT	ON
ACC	ON

All other LEDs are off.

Status Indicators During Ramp Execution

While the system is executing a ramp motion, the status LEDs are in the following state:

S1	ON
INT	ON
ACC	ON if the command is accelerating or has just accelerated to a higher velocity, or
ACC	OFF if the command is decelerating or has just decelerated to a lower velocity.
DIR	ON if + direction is commanded, or
DIR	OFF if - direction is commanded

All other LEDs are off.

Status Indicators During Profile Execution

While the system is executing a motion profile, the status LEDs are in the following state:

S0	ON
INT	ON
ACC	ON if the command is accelerating or has just accelerated to a higher velocity.
ACC	OFF if command is decelerating or has just decelerated to a lower velocity.
DIR	ON if + direction is commanded
DIR	OFF if - direction is commanded

All other LEDs are off.

Status Indicators During DSTOP Execution

While the system is executing a DSTOP motion, the status LEDs are in the following state:

S2	ON
INT	ON
DIR	ON if + direction is commanded
DIR	OFF if - direction is commanded

All other LEDs are off.

⚠ CAUTION

Make sure chassis power is OFF before removing or installing the Command Generator/Translator.

Troubleshooting the Command Generator/Translator

Problem	Flashing Fault LED or all LEDs flashing on Command Generator/Translator. Possible causes are bad RAM or other component failure on Command Generator/Translator.
Steps	Replace Command Generator/Translator
Problem	Large fault LED lights on the Command Generator/Translator. The possible cause is an open limit switch.
Steps	1. Fault has occurred when trying to move the axis. Look for open limits on the Command Generator/Translator. 2. Check address switch on the Command Generator/Translator to make sure that it is addressed correctly. If the fault occurs without trying to move the axis

the Command Generator/Translator may have a component failure. Contact your supplier for information on replacement.

Problem

No fault indicated, but axis not moving. Possible causes include the following:

- Command Generator/Translator not addressed correctly.
- External stepper driver not wired correctly, or the Command Generator/Translator is not set to provide the output required by the stepper driver.
- Power supply problem.
- The program is not correct.

Steps

1. Check that the Command Generator/Translator is addressed correctly.
2. Check the stepper driver manufacturer's specifications against the setup of the Command Generator/Translator. Possible items to check include:
   a. Pulse width requirement
   b. Current sinking outputs from the Command Generator/Translator
   c. Active low output from the Command Generator/Translator
3. Check the power supply wiring. The standard setup is for external power supply. To change this to internal power supply, jumpers X4 and X5 must be set for 1-2.
4. Check whether the stepper drive needs CW/CCW pulses or pulse-and-direction output.
5. Check that jumpers X6 and X7 are set to provide the pulse width needed by the stepper driver.
6. Insure that the stepper drive needs active low outputs and current sinking outputs
7. The program may not be correct. The program must correctly initialize the Command Generator/Translator. Check the INCOL86 software manual for more detailed programming information.

Problem

Ratio axis is not working correctly. Possible causes include the following:

- Jumpers set wrong
- Program is not correct

Steps

1. Ratioing is a combination of software and hardware. Check that all of the jumpers are set correctly on the Command Generator/Translator and the translator for your

application. Ratioing may require changing some of the jumpers from factory settings.

2. Software is not correct. Refer to the INCOL86 software manual for more information on programming ratio axes.

Troubleshooting the Command Generator/Translator when used with an additional translator

Problem

Large fault LED lights on the Command Generator/Translator. Possible causes include the following:

- Open limit switch
- Address switches set wrong
- Jumpers wrong
- The program is not correct.

Steps

1. If the fault has occurred when trying to move the axis, look for open limits on the axis or faults on the translator (drive fault or excess error). The limits on the Command Generator/Translator must also be satisfied.

2. Check the address switch on the Command Generator/Translator to make sure that it is addressed correctly. **When the Command Generator/Translator is used as a command generator alone, the translator address must be different from the command generator address.** This is because the Command Generator/Translator takes the place of a translator plus a command generator. Any additional translator must use a different address. For example, the Command Generator/Translator could be addressed as translator number 1 and the associated translator as translator number 2.

3. For this configuration jumpers X8 and X9 must be connected 1-2.

4. The program may not be correct. The program must correctly initialize the Command Generator/Translator and the translator. Check the INCOL86 software manual for more detailed programming information.

Problem

No fault indicated, but axis not moving. Possible causes include the following:

- Address switches set wrong
- The Command Generator/Translator and the translator are not in the correct slots.
- Jumpers wrong
- The program is not correct.

Steps	1. Check the address switch on the Command Generator/Translator to make sure that it is addressed correctly. **When the Command Generator/Translator is used as a command generator alone, the translator address must be different from the command generator address.** This is because the Command Generator/Translator takes the place of a translator plus a command generator. Any additional translator must use a different address. For example, the Command Generator/Translator could be addressed as translator number 1 and the associated translator as translator number 2. 2. Check that the Command Generator/Translator and its associated translator are in the correct slots. In a system that has multiple axes, two lines on the backplane are separated between axis pairs. An axis pair consists of a command generator and its associated translator. The lines on the backplane are the command clock and the command direction. 3. For this configuration jumpers X8 and X9 must be connected 1-2. 4. The program may not be correct. The program must correctly initialize the Command Generator/Translator and the translator. Check the INCOL86 software manual for more detailed programming information.
Problem	Ratio axis not working correctly. Possible causes include the following: • Jumpers set wrong • Program is not correct
Steps	1. Ratioing is a combination of software and hardware. Check to see that all of the jumpers are set correctly on the command generator and the translator for your application. Ratioing may require that some of the jumpers need to be changed from factory settings. 2. The program may not be correct. Refer to the INCOL86 software manual for more information on programming ratio axes.

Specifications

Parameter	Specification
Microprocessor	Intel 8085A-2 8-bit microprocessor
On-board memory:	
ROM capacity	8 K bytes of EPROM
RAM capacity	8 K bytes standard (2K bytes dual-port, plus 6K bytes internal)
Command clock frequency	2.5 MHz max
Velocity resolution	1 part in 65536 (nominal)
CW, CCW outputs	1.0 Vdc (low-max), 11.0 Vdc (high-min) Up to 2 kHz at 150 mA max output current $T_{rise} = T_{fall} = 2\ \mu s$ (max)
Pulse/direction outputs	1.0 Vdc (low-max), 11.0 Vdc (high-min) Up to 500 kHz $T_{rise} = T_{fall} = 100$ ns (max)
Pulse widths	500 ns -0, +250 ns 1000 ns -0, +250 ns 15 µs -0, +5 µs (default) 30 µs -0, +12 µs
Home, ±Limit inputs	10 mA at 0 Vdc
System requirements	Requires one card slot in Motion Plus/473 chassis
Power requirements	+5 Vdc ±0.25 V at 1.40 A max +12 Vdc ±1.2 V at 0.022 A max -12 Vdc (no requirements)
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing

8 Model 473.70c Analog Input/Output Processor

Introduction

The model 473.70C Analog Input/Output Processor is a microcomputer-based data acquisition and distribution board. Firmware on the processor allows you to manipulate the I/O data at the card level, using special INCOL86 instructions to configure the processor. Standard features of the Analog I/O Processor include the following:

- 8 MHz Intel 80188 CPU
- Four individually configurable differential analog inputs
- Two individually configurable analog outputs
- Four optically isolated digital inputs
- Four optically isolated digital outputs
- A 16-bit up/down counter for counting command generator pulses
- Eight card-edge mounted status LEDs plus one fault LED

Standard Configuration

Table 8-1 shows the standard configuration for the Analog Input/Output Processor.

Table 8-1. Standard Configuration

Function	Name	Setting
Analog Inputs	AIN1 to AIN4	-10 V to +10 V
Analog Outputs	AOUT1 to AOUT2	-10V to +10 V differential
1 kHz Low Pass Filter	--	ON
Digital Outputs	DOUT1 to DOUT4	Current sourcing
Power Supplies		Internal

Software Configurations

The firmware functions on the Analog I/O Processor can be linked together as if they were hardware modules. This allows you to tailor the card configuration to a specific application. The functions include:

- AND, OR, and NOT gates
- offsetting and scaling of analog inputs
- offsetting and scaling of analog outputs
- PID control algorithms
- minimum, maximum, and window monitoring
- data collection

Refer to the INCOL86 manual for more information on software configuration.

Figure 8-1 shows the location of important components on the Analog I/O Processor.

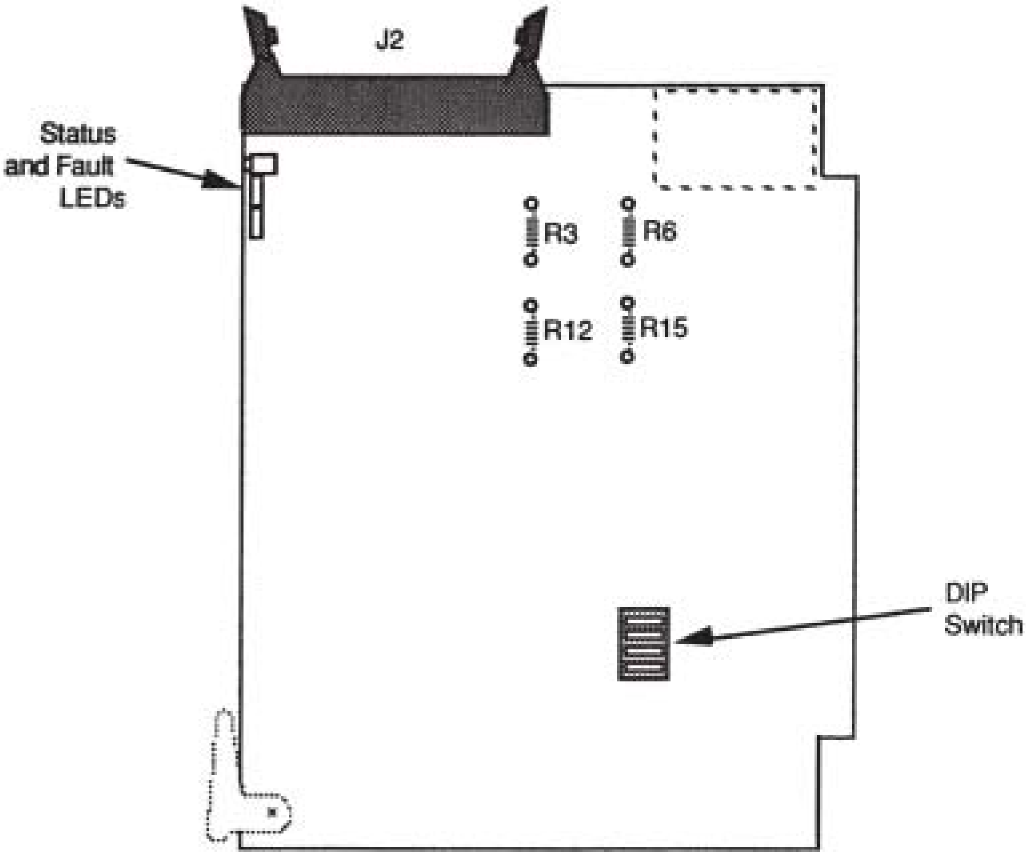


Figure 8-1. Model 473.70c Analog I/O Processor

Jumpers

Check or change jumper settings according to Tables 8-2 to 8-9. The standard connection is noted. Optional settings may require extra hardware.

In all of the following jumper selection charts, an asterisk (*) indicates the factory set position. Figure 8-2 shows a map of the Analog I/O Processor with all jumpers and test points labeled. Table 8-2 shows the factory settings for all jumpers.

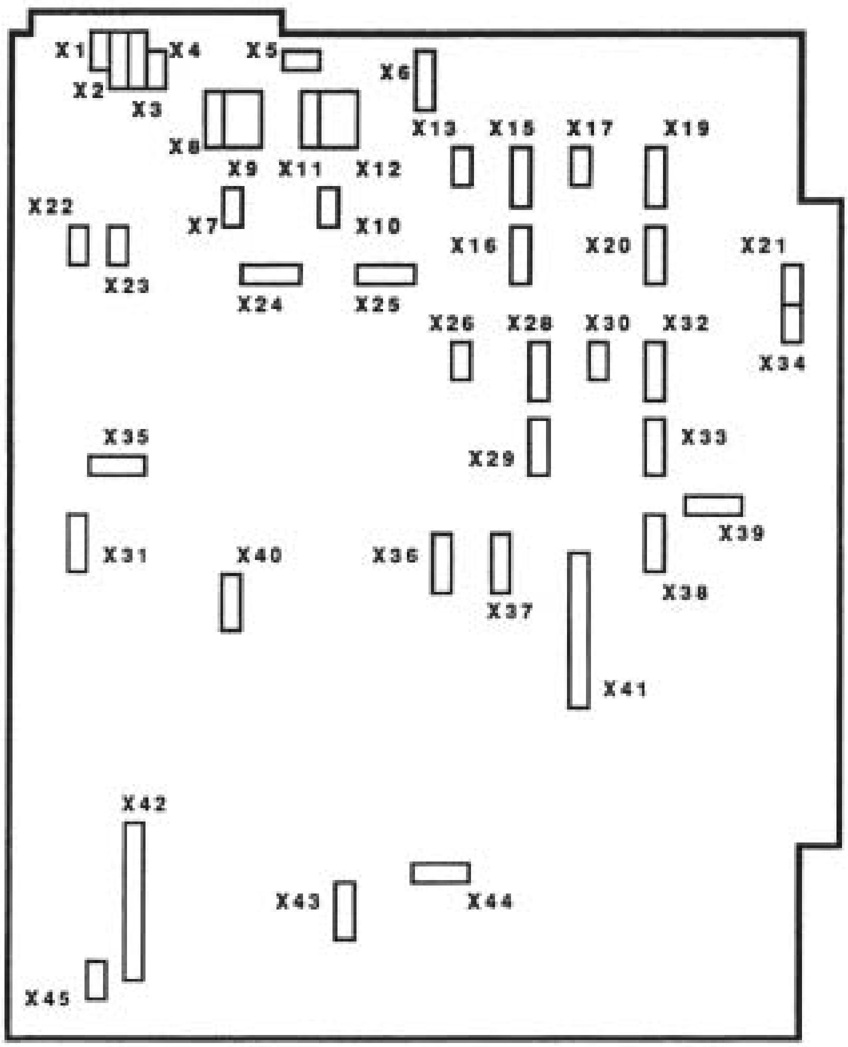


Figure 8-2. Jumper Map for the Analog I/O Processor

Jumpers—Default Jumper Positions

Table 8-2. Analog I/O Processor Jumper Connections

Jumper	Connection	Jumper	Connection	Jumper	Connection
X1	1-2	X16	2-3	X32	NC
X2	1-2	X17	NC	X33	2-3
X3	2-3	X19	NC	X34	1-2
X4	1-2	X20	2-3	X35	2-3
X5	1-2	X21	1-2	X36	2-3
X6	NC	X22	NC	X37	2-3
X7	NC	X23	1-2	X38	2-3
X8	1-2	X24	1-2	X39	1-2
X9	3-4	X25	1-2	X40	1-2
X10	NC	X26	NC	X41	6-7
X11	1-2	X28	NC	X42	NC
X12	3-4	X29	2-3	X43	1-2
X13	NC	X30	NC	X44	1-2
X15	NC	X31	2-3	X45	NC

Jumpers—DOUT1 Output Types

Jumpers X22 and X23 allow the DOUT1 output to adapt to various enable inputs: current source, current sink, or contact closure. Table 8-3 shows the jumper positions for each DOUT1 output type.

Table 8-3. Jumper Settings for DOUT1 Output Types

Jumper	Connection	Description
X22 X23	NC* 1-2*	DOUT1 current source
X22 X23	1-2 NC	DOUT1 current sink
X22 X23	NC NC	DOUT1 contact closure

Jumpers—Analog Inputs

Table 8-4 shows the jumper positions for analog input ranges.

Table 8-4. Jumper Settings for Analog Input Ranges

Range	Channel 1		Channel 2		Channel 3		Channel 4		Every Chan.	
	X13	X15	X26	X28	X17	X19	X30	X32	X38	X39
-10 to +10V*	NC*	NC*	NC*	NC*	NC*	NC*	NC*	NC*	2-3*	1-2*
-1 to +1 V	NC	1-2	NC	1-2	NC	1-2	NC	1-2		
-100 to +100 mV	NC	2-3	NC	2-3	NC	2-3	NC	2-3		
-10/G to +10/G V	NC	NC	NC	NC	NC	NC	NC	NC		
4 to 20 mA†	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2		
-5 to +5 V	NC	NC	NC	NC	NC	NC	NC	NC	1-2	1-2
-500 to +500 mV	NC	1-2	NC	1-2	NC	1-2	NC	1-2		
-50 to + 50 mV	NC	2-3	NC	2-3	NC	2-3	NC	2-3		
0 to +10 V	NC	NC	NC	NC	NC	NC	NC	NC	1-2	2-3
0 to +1 V	NC	1-2	NC	1-2	NC	1-2	NC	1-2		
0 to +100 mV	NC	2-3	NC	2-3	NC	2-3	NC	2-3		
4 to 20 mA	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2		
0 to +10/G V	NC	NC	NC	NC	NC	NC	NC	NC		

Notice that some ranges are incompatible with each other, because X38 and X39 are common to all channels.

† This range with reduced resolution is available to allow the use of 4-20 mA and bipolar voltage inputs at the same time.

Table 8-5 shows the jumper positions for the filter mode.

Table 8-5. Jumper Settings for Filter Mode

Filter Mode	Channel 1 X16	Channel 2 X29	Channel 3 X20	Channel 4 X33
Filter ON	2-3*	2-3*	2-3*	2-3*
Filter OFF	1-2	1-2	1-2	1-2

Jumpers—Analog Outputs

Table 8-6 shows the jumper positions for the output range for both D/A channels.

Table 8-6. Jumper Settings for Output Ranges

Output Range	Channel 1					Channel 2				
	X36	X24	X7	X9	X8	X37	X25	X10	X12	X11
-10 to +10V Differential	2-3*	1-2*	NC*	3-4*	1-2*	2-3*	1-2*	NC*	3-4*	1-2*
0 to +10V Single-ended	1-2	2-3	NC	2-5	2-3	1-2	2-3	NC	2-5	2-3
0 to +5V Single-ended	2-3	2-3	NC	2-5	2-3	2-3	2-3	NC	2-5	2-3
-10 to +10V Single-ended	1-2	2-3	NC	3-4	2-3	1-2	2-3	NC	3-4	2-3
-5 to +5V Single-ended	2-3	2-3	NC	3-4	2-3	2-3	2-3	NC	3-4	2-3
4 to 20 mA Single-ended	1-2	2-3	1-2	1-6	2-3	1-2	2-3	1-2	1-6	2-3

*Factory setting

Jumpers—Power Supplies

External power can be connected to the following parts of the Analog I/O Processor:

- Digital output opto-couplers and output drivers
- 4 to 20 mA current loop outputs
- DC-to-DC converter

Table 8-7 shows jumper settings for external power supplies.

⚠ CAUTION

Turn off all power to the chassis and the Processor before setting any jumpers. Setting jumpers with power connected can damage the card.

Table 8-7. Jumper Settings for External Power Supplies

Jumper	Connection	Description
X1 X4	1-2* 1-2*	Internal +12 V for digital outputs
X1 X4	NC NC	External +12 V for digital outputs
X5	1-2*	Internal +15 V for voltage-to-current converters
X5	NC	External +15 V to +30 V for voltage-to-current converters
X21 X34	1-2* 1-2*	Internal 12 V for DC-to-DC converter
X21 X34	NC NC	External 12 V for DC-to-DC converter

Non-Selectable Jumpers

Some jumpers must be kept in their factory set positions. Table 8-8 shows the factory settings of these non-selectable jumpers.

Table 8-8. Non-Selectable Jumpers

Jumper	Factory Setting
X2	1-2
X3	2-3
X6	NC
X35	2-3
X40	1-2
X41	6-7
X42	NC
X43	1-2
X44	1-2
X45	NC

Jumpers—DIN1/DOUT1 Interconnection

Jumper X31 links the DIN1 input internally to the DOUT1 output. This allows an enable output to be turned off in response to a fault input. Table 8-9 shows the jumper position for hardware connection.

Table 8-9. Jumper Settings for DIN1/DOUT1 Interconnection.

Jumper	Connection	Description
X31	2-3*	No linkage between DIN1 and DOUT1
X31	1-2	DIN1 linked to DOUT1

DIP Switch Addressing

Up to sixteen Analog I/O Processors can be used in a system. The address for each Processor is defined by means of a 4-segment DIP switch on the card.

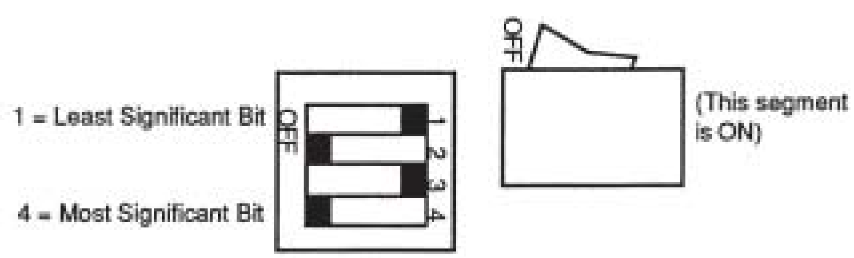
Table 8-11 lists the settings for the DIP switch S1 and corresponding card numbers.

Table 8-11. DIP Switch Settings

Switch Settings:

1 = ON
0 = OFF

Example:



bit pattern = 0101
Axis No. = 5

Axis No.	Setting 4321	Axis No.	Setting 4321
1	0001	9	1001
2	0010	10	1010
3	0011	11	1011
4	0100	12	1100
5	0101	13	1101
6	0110	14	1110
7	0111	15	1111
8	1000	16	0000

Wiring

Table 8-10 shows the pinout of the J2 connector on the Analog I/O Processor. When wiring external signals to the terminal board, keep in mind good grounding and shielding practices (Refer to Appendix B of this manual, "Grounding and Shielding Considerations" for helpful suggestions).

Table 8-10. J2 Pin Definitions

Pin	Name	Description
1	DIN2(+)	Positive input terminal of digital input 2
2	DIN2(-)	Negative input terminal of digital input 2
3	DIN3(+)	Positive input terminal of digital input 3
4	DIN3(-)	Negative input terminal of digital input 3
5	DIN4(+)	Positive input terminal of digital input 4
6	DIN4(-)	Negative input terminal of digital input 4
7	DOUT2	Signal source of digital output 2
8	VY GND	Ground return for digital output 2
9	DOUT3	Signal source of digital output 3
10	VY GND	Ground return for digital output 3
11	DOUT4	Signal source of digital output 4
12	VY GND	Ground return for digital output 4
13	DIN1(+)	Positive input terminal of digital input 1
14	DIN1(-)	Negative input terminal of digital input 1
15	DOUT1(+)	Positive output terminal of digital output 1
16	DOUT1(-)	Negative output terminal of digital output 1
17	CHASSIS GND	Motion Bus chassis ground
18	CHASSIS GND	Motion Bus chassis ground
19	VY	+12 V supply for digital I/O
20	VY GROUND	Supply return for digital I/O
21	VZ	Supply for 4-20 mA current loops
22	VZ GROUND	Ground reference for VZ supply
23	VX(+)	Positive input for DC-to-DC converter
24	VX(-)	Negative input for DC-to-DC converter
25	CHASSIS GND	Motion Bus chassis ground
26	CHASSIS GND	Motion Bus chassis ground
27	CHASSIS GND	Motion Bus chassis ground
28	CHASSIS GND	Motion Bus chassis ground
29	AOUT1(+)	Positive output terminal of analog output 1
30	AOUT1(-)	Negative output terminal of analog output 1
31	AOUT2(+)	Positive output terminal of analog output 2
32	AOUT2(-)	Negative output terminal of analog output 2
33	AIN1(+)	Positive input terminal of analog input 1
34	AIN1(-)	Negative input terminal of analog input 1
35	AIN2(+)	Positive input terminal of analog input 2
36	AIN2(-)	Negative input terminal of analog input 2
37	AIN3(+)	Positive input terminal of analog input 3
38	AIN3(-)	Negative input terminal of analog input 3
39	AIN4(+)	Positive input terminal of analog input 4
40	AIN4(-)	Negative input terminal of analog input 4

Cabling

Custom Servo Motors Cable Assembly

The Custom Servo Motors cable assembly, Model 473.50c-36A-300, (Custom Servo Motors part number 453850-01) is available for use with the Analog I/O Processor. The assembly includes a 5-ft ribbon cable and a 40 terminal board, with screw terminals for field wiring, which can be rail mounted.

Other Cable Recommendations

The Analog I/O Processor output connections have been designed for use with a twisted pair flat cable to run from the card edge to a rail-mounted terminal board. (A universal foot allows the terminal board to be snapped onto all available DIN EN mounting rails.) The header on the Processor has a notch for keying to avoid misorientation. The connector interfaced to the header should be 3M P/N 3417-6640 (P/N 118655-88) or equivalent. (Refer to Table 8-10 for part numbers.)

The twisted pair flat cable to be used is not shielded. For this reason, it must not be longer than 5 ft. A recommended cable is Belden P/N 9V28040 (Custom Servo Motors P/N 114477-08) or 3M P/N 1700/40 or equivalent.

Terminal Board

A recommended terminal board is the Phoenix Contact P/N FLKM 40 (Custom Servo Motors P/N 111453-17) or equivalent. This terminal board has a header that interfaces to the connector described above. The terminal board is suitable for DIN rail mounting (DIN EN 50022, 35 mm x 7.5 mm). The mounting dimensions of the terminal board are:

Height:	2.3 in. (58 mm)
Length:	4.4 in. (112.5 mm)
Width:	3 in. (77 mm)

Table 8-10. Cable Part Numbers

	Mfr Part No.	Custom Servo Motors Part No.
Custom Servo Motors Cable Assembly	–	453850-01
Connector interface with header	3M 3417-6640	118655-88
Cable	Belden 9V28040 or 3M 1700/40	114477-08
Terminal board	Phoenix FLKM 40	111453-17

Figure 8-3 shows a typical application configuration. Note the shield terminations on the terminal board.

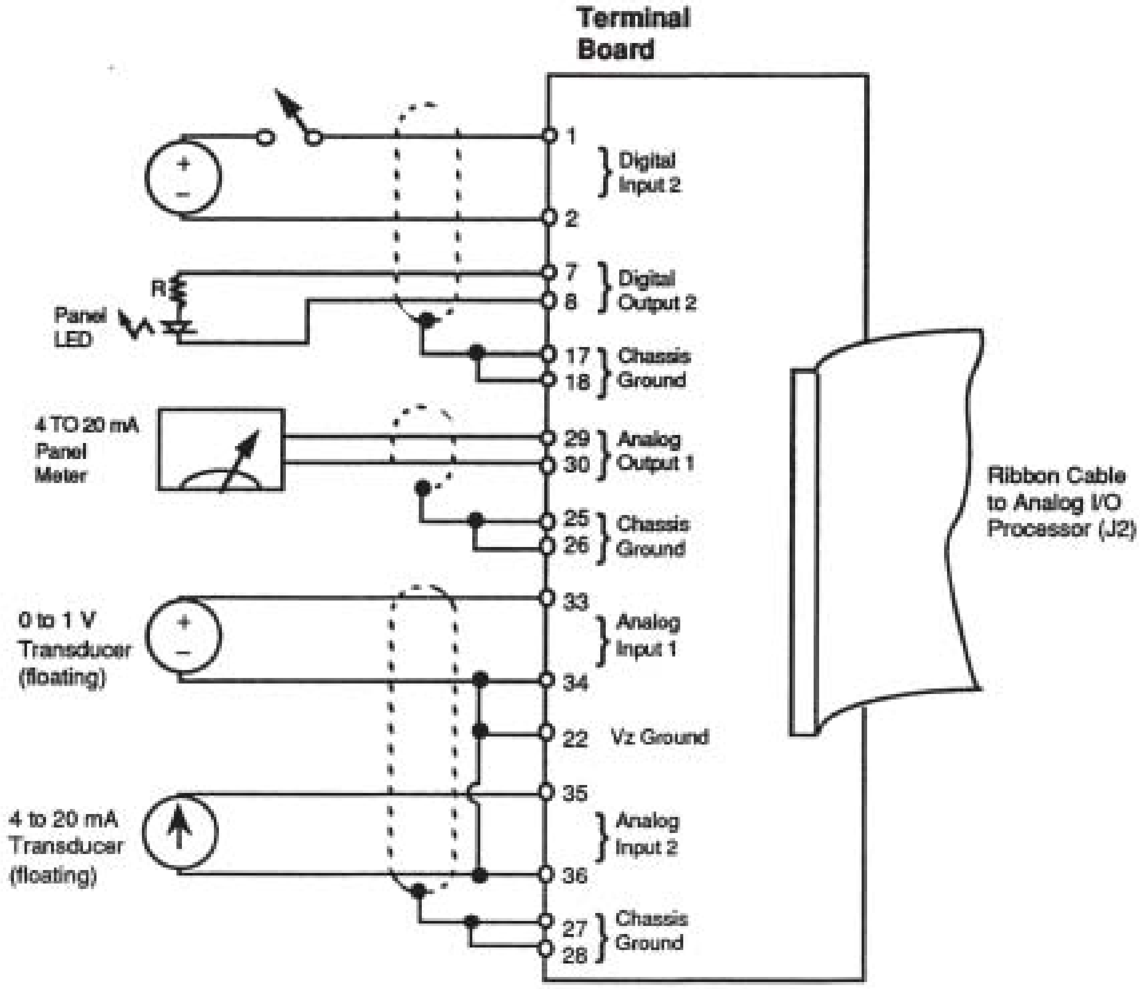


Figure 8-3. Typical Wiring Configuration for the Analog I/O Processor

Options

To use an external power supply for the DC to DC converter on the Analog I/O Processor, take the following steps:

1. Remove jumper X21.
2. Remove jumper X34.
3. Connect an external power supply from Vx(+) to Vx(–) as shown in Figure 8-3A. The voltage measured from Vx(+) to Vx(–) should be 12 Vdc (±5%).

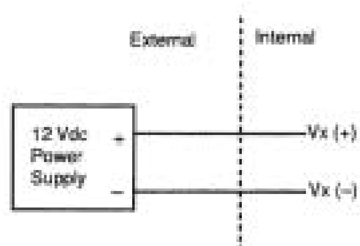


Figure 8-3A. External Power Supply for DC to DC Converter

Installing the Analog I/O Processor

The Analog I/O Processor requires one slot in the chassis.

Analog Inputs

Analog Inputs—General Considerations

IMPORTANT

The instrumentation amplifier inputs are effectively op amp inputs. For this reason, it is essential to always have a DC path to ground from both inputs. (If there are no DC paths to ground, bias currents can charge stray capacitances, resulting in unpredictable operation.) When measuring floating sources, Figure 8-4 shows methods for providing DC paths for the input bias currents, depending on how the input to the Analog I/O Processor is coupled to the source.

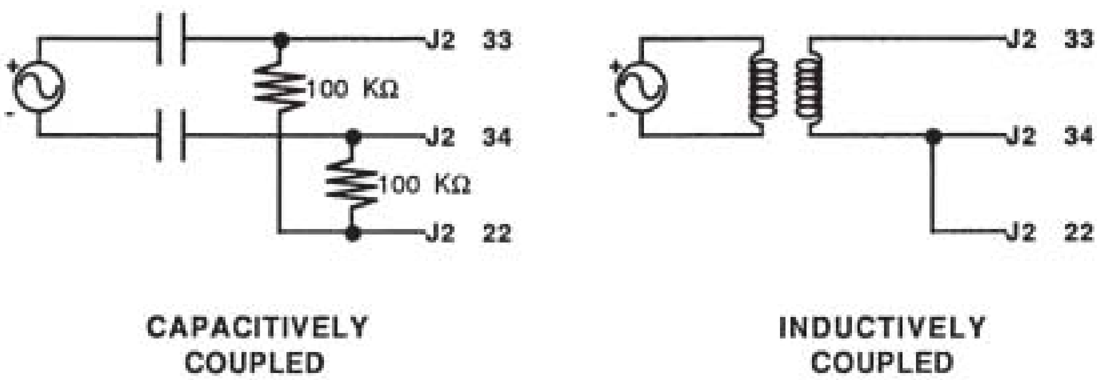


Figure 8-4. Providing a DC Path for Input Bias Currents (Channel 1)

Since the analog inputs of the Analog I/O Processor are differential, the instrumentation amplifier amplifies the *difference* in voltage between the (+) and (-) inputs. This allows the input voltages to be independent of the card's internal ground reference. However, there are two types of voltage limitations on the inputs: differential input voltage and common-mode input voltage. Differential input voltage, Vd, is defined as the voltage difference between the two inputs, and can be a maximum of ±10 V. Common-mode input voltage is defined as the voltage difference between the card's internal ground (at J2-22) and the input with the voltage level nearest the internal ground. The common-mode input voltage limit is dependent on the differential voltage, and the gain of the instrumentation amplifier, as given by the formula:

$$Vcm = \pm (10 - (\frac{G}{2} \cdot \left| Vd \right|)$$

For the 4-20 mA current loop input, this is translated into a maximum voltage difference of +5 V between the (-) input and the card's internal ground.

⚠ CAUTION

The differential and common-mode voltage limits must not be exceeded or damage to the Analog I/O Processor may result.

Analog Inputs—User-Defined Gain Setting

Jumpers X15, X28, X19, and X32 control the gain of the instrumentation amplifier. Removing the jumper configures the gain to be unity. Position 1-2 corresponds to a gain of 10, while 2-3 corresponds to a gain of 100. If other gains are required, an external resistor may be added to provide any gain in the range 1 - 1000. These optional resistors are labeled R3, R12, R6, and R15 (these correspond to channels 1,2,3, and 4 respectively). To provide the required gain (G) set the gain setting jumper to unity gain, and insert the resistor to satisfy the following formula:

$$Rg\ (\Omega) = \frac{40000}{G - 1} \quad \text{where } G > 1$$

Due to the 20% absolute tolerance of the instrumentation amplifiers internal resistors, this value of Rg produces a gain tolerance of 20%. The configuration shown in Figure 8-5 can be used to determine the actual value needed for Rg. For best results, Rg should be a low tolerance, low temperature coefficient resistor (0.1% tolerance, 10 ppm/°C is suggested) to minimize accuracy errors.

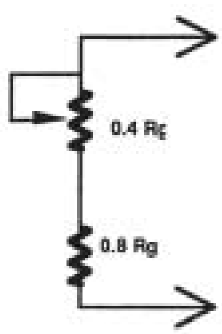


Figure 8-5. Circuit used to find the exact value of Rg

Analog Inputs—Current Loop Measurement

The instrumentation amplifier can also be used to measure current in a 4 to 20 mA current loop. This is done by passing the current through a precision 50Ω resistor (R4, R13, R7, and R16) and measuring the resultant voltage across the resistor. A 4 mA current produces a drop of 0.2 V, while a 20 mA current produces a drop of 1 V. With the gain setting jumper set for a gain of 10, this produces a range of 2 V to 10 V to be converted to digital form. The resistor is shorted across the input by connecting the current shunt jumper (X13, X26, X17, and X30). When using an input in a current loop, the current must flow into the (+) terminal and out of the (-) terminal of the Analog I/O Processor.

Digital Inputs

All digital inputs can be individually configured to be active high, current sinking, or active low, current sourcing, with a maximum draw of 10 mA. Table 8-12 shows the threshold voltages for the logic high and logic low input levels.

Table 8-12. Logic Thresholds for the Digital Inputs.

	Minimum	Maximum
Input = High	10 V	16.5 V
Input = Low	-2 V	2 V

Figure 8-6 shows how all of the digital inputs look to the user. Both the anode and the cathode are available, allowing you to configure the input as desired.

The +12 V power supply from the motion bus is available on J2-19 and J2-20. This supply can be used to power the digital inputs, if isolation is not necessary.

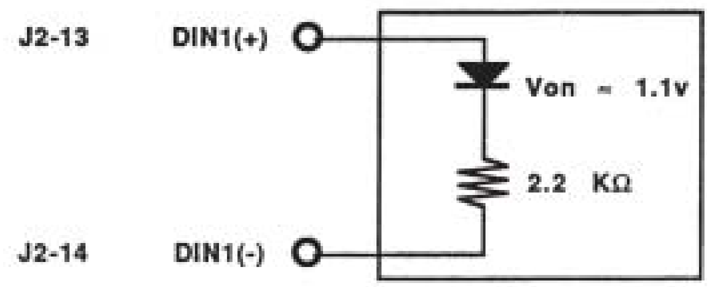


Figure 8-6. Equivalent Digital Input Circuitry.

Figure 8-7 shows all four inputs used in a typical configuration (without isolation). Here, DIN1, DIN2, DIN3, and DIN4 are all used as active high, current sinking inputs.

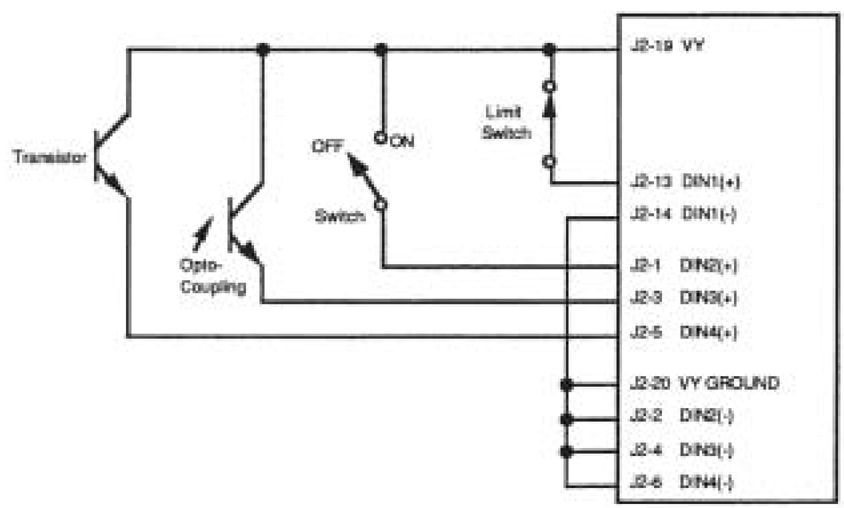


Figure 8-7. Examples of Digital Input Configurations.

Digital Outputs

Digital outputs DOUT2, DOUT3, AND DOUT4 are active high, current sourcing, with a maximum drive capability of 100 mA/channel. When the output is ON, the voltage level is high (approximately 10.5 V). When the output is OFF, the level is low (approximately 0 V). Each output can be thought of as a switch connecting the output to a 10.5 V source when ON, and disconnecting it when OFF. Figure 8-8 shows three common output configurations.

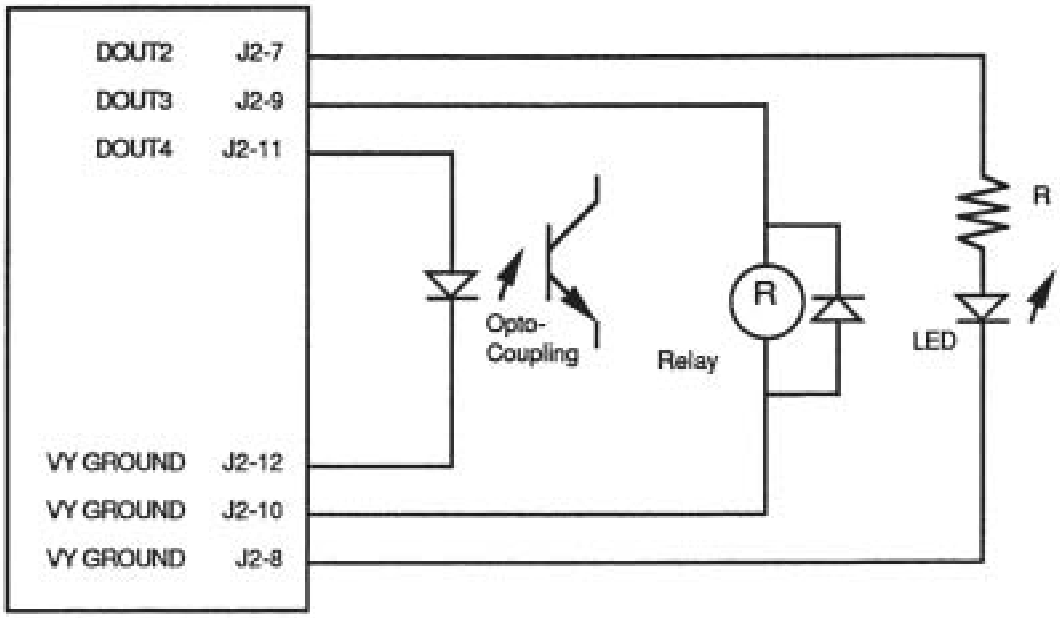


Figure 8-8. Examples of Digital Output Configurations

CAUTION

DOUT1 current must be limited to 75 mA. Shorting this or any other digital output can damage the Analog I/O Processor.

Digital output DOUT1 is different from the other outputs in that it may be connected as current sourcing, current sinking, or as a contact closure output. Figure 8-9 shows three possible DOUT1 configurations: current source, current sink, and contact closure.

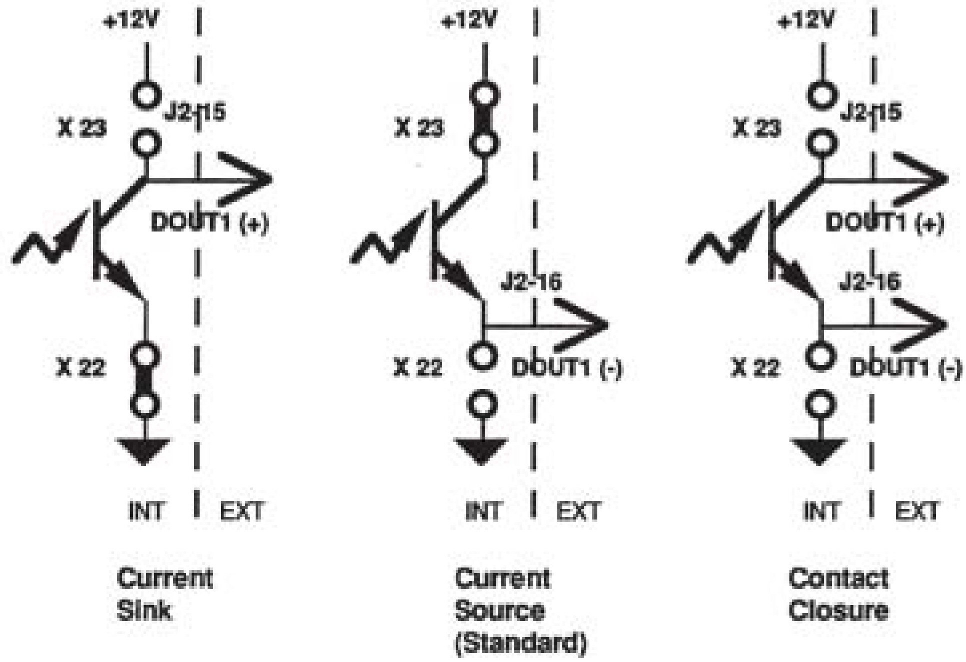


Figure 8-9. Examples of DOUT1 Output Configurations. Current sourcing is standard.

DIN1/DOUT1 Linkage

The DIN1 input can be connected by hardware to the DOUT1 output and the Fault LED by a jumper setting. When this linkage is used, the interruption of current at the DIN1 input will turn OFF the DOUT1 output and turn ON the large Fault LED. This is useful in applications where an enable output (DOUT1) must be turned OFF in response to an emergency stop, limit, or other fault input(DIN1).

Analog Outputs—Current Loop Driving

The current loop outputs are specified to drive up to a 500Ω load, which is another way of saying that the *compliance voltage* of the loop is 10 V. This compliance voltage can be increased to a maximum of 25 volts, (or a 1250Ω load can be driven), if the voltage-to-current converters are powered by an external 30 V power supply. An external power supply can be input to the Processor on pins J2-21 and J2-22, after removing the jumper on X5. Notice that the supply input must be floating with reference to the analog ground of the Analog I/O Processor.

Figure 8-10 shows a plot of the maximum load resistance versus the current loop power supply.

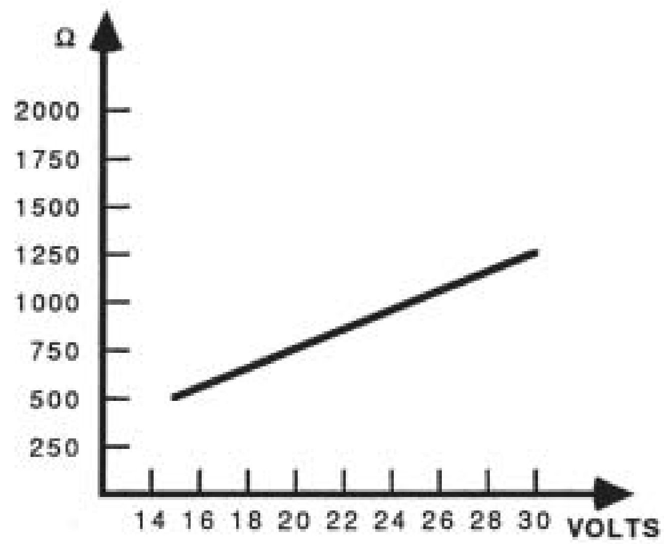


Figure 8-10. Maximum Load Resistance vs. Current Loop Power Supply Voltage.

LED Functions

All nine LED indicators on the Analog I/O Processor are user-definable. You can use INCOL86 instructions to define any of these indicators (including the large Fault LED). LED indications at power-up are described later in the Troubleshooting section of this chapter.

Troubleshooting the Analog I/O Processor

Normal Power-Up

At power up the Analog I/O Processor performs a number of self-tests. When it has passed these tests, the LED indicators display the firmware version number (in binary form) as shown in the example in Figure 8-11.

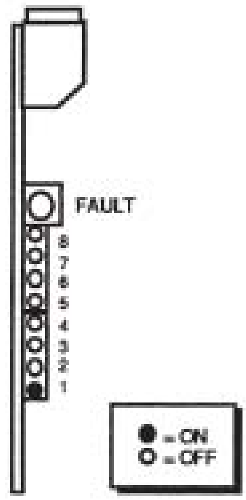


Figure 8-11. LEDs after Normal Power-up (Version 1 Firmware)

If the Analog I/O Processor fails a self-test, the Fault LED is on, and a status LED (1 to 4) indicates the test that has been failed, as shown in Figure 8-12. If the Fault LED is on but no status LEDs are on, this also indicates an EPROM failure.

If the Analog I/O Processor has failed a self-test, it does not respond to any commands until serviced. Contact Custom Servo Motors for replacement procedures.

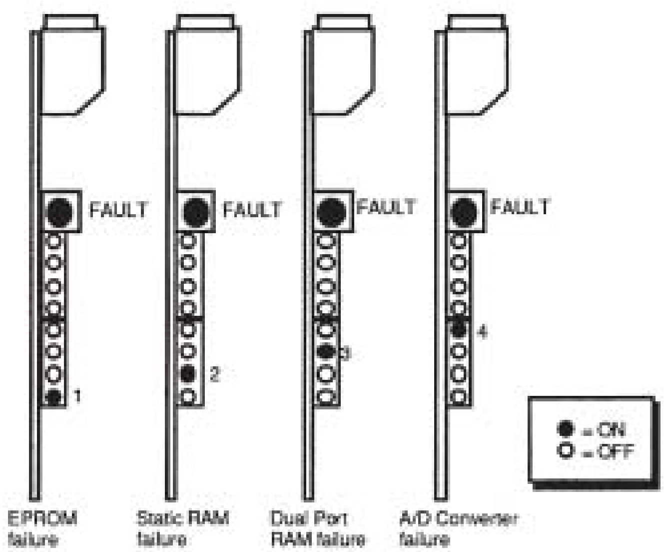


Figure 8-12. LED Fault Indications at Power-up

Self-Tests for the Analog I/O Processor

A number of diagnostics have been built into the Analog I/O processor firmware to help you verify the functioning of critical parts of the Processor. Each test may require special wiring and jumper settings. You can then use INCOL86 instructions to start the self diagnostic test. The following tests are available:

- full EPROM checksum
- full static RAM test
- full dual port RAM test
- analog loop-back test
- digital loop-back test.

⚠ CAUTION

Disconnect all other parts of the system affected by the Analog I/O Processor before running these tests. Self diagnostic tests may require special jumper settings, or modify RAM locations, which can cause system malfunction.

Test—Full EPROM Checksum

This test performs an addition of all bytes in the 32K byte EPROM. The 16-bit result is stored in the dual port RAM diagnostic word, which can be read using the INCOL86. Use the following INCOL86 instruction to run the checksum test:

```
APARAM Card, 43 ON
```

where `Card` is the number of the card being tested (1-16). Notice that there may be up to a 1 second delay before the checksum is completed, so the diagnostic word is not valid for 1 second after the INCOL86 instruction is executed. During this test, the only valid dual port RAM operation is reading the diagnostic word. Read the diagnostic word using the INCOL86 instruction:

```
Rn = ASOURCE Card,41
```

where `Rn` is a numeric register, and `Card` is the number of the card being tested (1-16). The 16-bit result is also sent to the 8 card-edge LEDs, one byte at a time. The Fault LED is on for the least significant byte, and is off for the most significant byte.

To stop running the test, you must use the following INCOL86 instruction:

```
APARAM Card, 43 OFF
```

where `Card` is the number of the card being tested (1-16).

Test—Full Static RAM

This test executes several algorithms that check for faults in the static RAM circuitry. If any memory address is not read properly, the Fault LED is turned on and the failing RAM address is put into the dual port RAM. Note that some failure modes will turn on card-edge LEDs. If all memory addresses are read properly, the Fault LED flickers, and the diagnostic word in the dual port RAM contains all ones. For Custom Servo Motors Customer

Service use, it is important to make a note of the status of the diagnostic word and the LEDs if the test fails.

Use the following INCOL86 instruction to run the static RAM test:

```
APARAM Card, 44 ON
```

where `Card` is the number of the card being tested (1-16). To read the diagnostic word result of the RAM test (after 6 seconds) use the following INCOL86 instruction:

```
Rn = ASOURCE Card, 41
```

where `Rn` is a numeric register, and `Card` is the number of the card being tested (1-16). Notice that there may be up to a 6-second delay before the test is completed, so the diagnostic word is not valid for 6 seconds after the INCOL86 instruction is executed. During this test, the only valid dual port RAM operation is reading the diagnostic word.

Use the following INCOL86 instruction to exit this test:

```
APARAM Card, 44 OFF
```

where `Card` is the number of the card being tested (1-16). Since all memory addresses are altered, when exiting this test the Processor resets itself. It then returns to the default power-up state in 1 second.

Test—Full Dual Port RAM

This test writes every possible data byte to a dual port RAM address, and reads each byte back from the address. It performs these operations at all dual port RAM addresses. If any dual port RAM address is not read properly, the Fault LED is turned on and the failing address is put in the dual port RAM diagnostic word. If all memory addresses are read properly, the Fault LED flickers, and the diagnostic word in the dual port RAM contains all ones. It is important to remember that if the dual port RAM is not functioning properly, the diagnostic word may or may not be valid. Thus it is recommended to use the fault LED condition to determine validity of the dual port RAM.

Use the following INCOL86 instruction to run the dual port RAM test:

```
APARAM Card, 45 ON
```

where `Card` is the number of the card being tested (1-16). To read the diagnostic word result of the dual port RAM test (after 2 seconds) use the following INCOL86 instruction:

```
Rn = ASOURCE Card, 41
```

where `Rn` is a numeric register, and `Card` is the number of the card being tested (1-16). Use the following INCOL86 instruction to exit this test:

```
APARAM Card, 45 OFF
```

where `Card` is the number of the card being tested (1-16). Since all dual port memory addresses are altered, it is important that no INCOL86 instructions involving the Processor are executed until the Processor has been taken out of this test.

Test—Analog Loop-back

Use this test to check if the analog inputs and outputs are functioning properly. The two analog outputs are fed back into the four analog inputs, and a number of conversions are attempted. Before doing this, it is critical that the analog outputs are set to the -10 V to +10 V differential scale, and the analog inputs are set for the -10 V to +10 V scale. Table 8-13 shows the required settings for the loop-back test. Notice that these are the standard configuration for these jumpers.

Table 8-13. Settings of the Analog Inputs and Outputs for the Analog Loop-back Test.

Jumper	Setting	Jumper	Setting	Jumper	Setting
X36	2-3	X8	1-2	X19	NC
X37	2-3	X11	1-2	X32	NC
X24	1-2	X13	NC	X16	2-3
X25	1-2	X26	NC	X29	2-3
X7	NC	X17	NC	X20	2-3
X10	NC	X30	NC	X33	2-3
X9	3-4	X15	NC	X38	2-3
X12	3-4	X28	NC	X39	1-2

The test also requires the proper connections between the analog outputs and the analog inputs, shown in Figure 8-13.

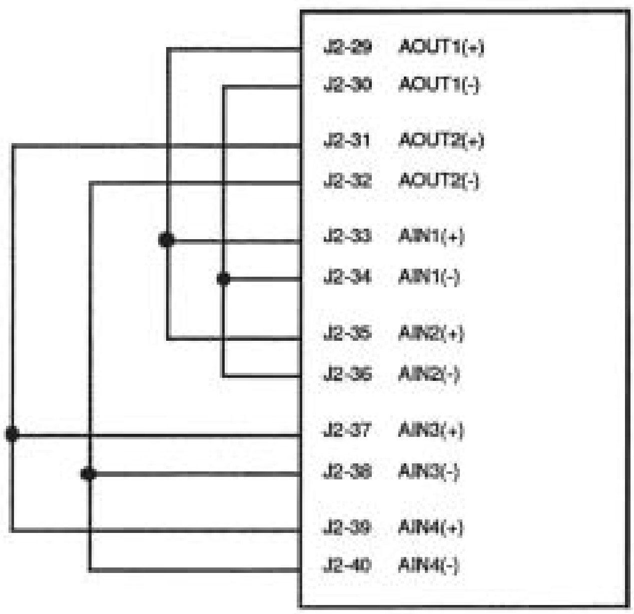


Figure 8-13. Connections for the Analog Loop-back Test

Use the following INCOL86 instruction to run the analog loop-back test:

```
APARAM Card, 46 ON
```

where `Card` is the number of the card being tested (1-16).

To read the diagnostic word result of the test, use the following INCOL86 instruction:

```
Rn = ASOURCE Card, 41
```

where Rn is a numeric register, and Card is the number of the card being tested (1-16). Use the following INCOL86 instruction to exit this test:

```
APARAM Card, 46 OFF
```

where Card is the number of the card being tested (1-16). When the analog loop-back test is begun, the diagnostic word in the dual port RAM and the 8 card-edge LEDs present the same results. Notice that this test runs continuously until instructed to stop. The Fault LED flickers when the test is in progress and is turned on when an error is detected. Because the Fault LED turns off again if the error is cleared, reading the dual port RAM diagnostic word is better suited to detecting random failures than observing the card edge.

Often, incorrect jumper placement or interconnection is the cause of a failure; It is critical that all jumpers are set correctly and all interconnections made correctly, for the analog loop-back test to function properly.

When the Fault LED is on, the 8 card-edge LEDs displays the firmware's diagnosis of the error. (As with any loop-back test, this diagnosis is subject to error, as is described later.) Figure 8-14 shows the card-edge LEDs failure indications, while Figure 8-15 shows the corresponding diagnostic word.

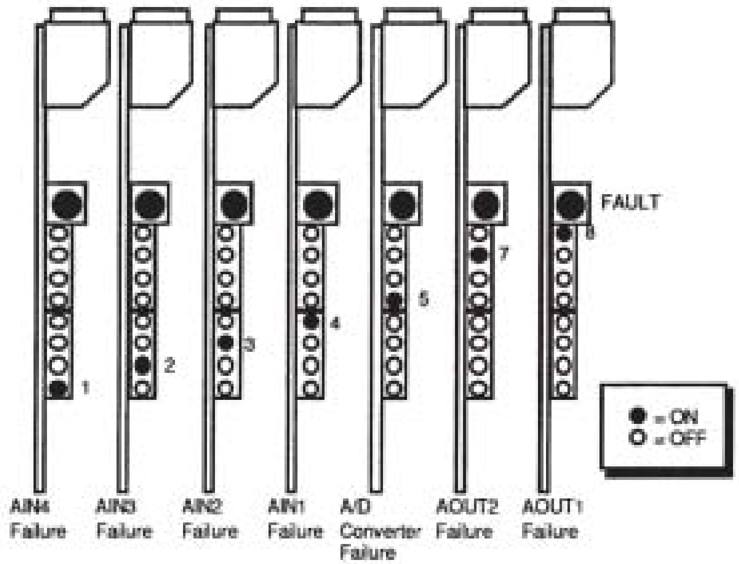


Figure 8-14. LED Indications for the Analog Loop-back Test

DIAGNOSTIC WORD

0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1
not used	not used	not used	not used	not used	not used	not used	not used	AOUT1 FAILURE	AOUT2 FAILURE	not used	A/D FAILURE	AIN1 FAILURE	AIN2 FAILURE	AIN3 FAILURE	AIN4 FAILURE

Figure 8-15. Diagnostic Word for the Analog Loop-back Test

Notice that if AOUT1 is diagnosed as failing, AIN1 and AIN2 cannot be judged to be functioning properly. Similarly, if AIN1 and AIN2 both are diagnosed as failing, a decision as to AOUT1s validity cannot be made. An A/D converter failure invalidates all other data. The CPUs diagnosis of a failure should only be used to alert the user to a problem, since it is only an educated guess. However, the identification of a possible problem is often useful in debugging a system problem.

Digital Loop-back Test

Use this test to check the digital outputs and digital inputs. Table 8-14 shows the proper jumper settings for the digital loop-back test to function properly. Notice that this is the standard configuration of the card.

Table 8-14. Proper Jumper Settings for the Digital Loop-back Test

Jumper	Setting
X31	2-3
X22	NC
X23	1-2
X40	1-2

Use the following INCOL86 instruction to run the digital loop-back test:

```
APARAM Card, 47 ON
```

where `Card` is the number of the card being tested (1-16).

To read the diagnostic word result of the test, use the following INCOL86 instruction:

```
Rn = ASOURCE Card, 41
```

Use the following INCOL86 instruction to exit this test:

```
APARAM Card, 47 OFF
```

Figure 8-16 shows how the digital outputs are connected to the digital inputs.

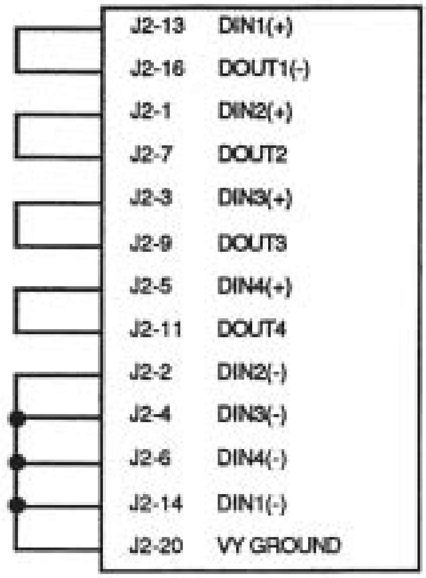


Figure 8-16. Connections for the Digital Loop-back Test

When the digital loop-back test is begun, the diagnostic word in the dual port RAM and the eight card-edge LEDs present the same results. As with the analog loop-back test, this test runs continuously until instructed to stop. The Fault LED flickers when the test is in progress and is turned on when an error is detected. Since it turns off again if the error is not detected, reading the dual port RAM diagnostic word is better suited to detecting random failures than observing the card edge.

Figure 8-17 shows the card edge LED failure indication, and Figure 8-18 shows the corresponding diagnostic word. Since each digital output is connected to one digital input, the CPU cannot make a decision where the fault occurred, other than to say that DIN1 or DOUT1 is failing, for example.

Often, incorrect jumper placement or interconnection is the cause of a failure; It is critical that all jumpers are set correctly and all interconnections made correctly, for the digital loop-back test to function properly.

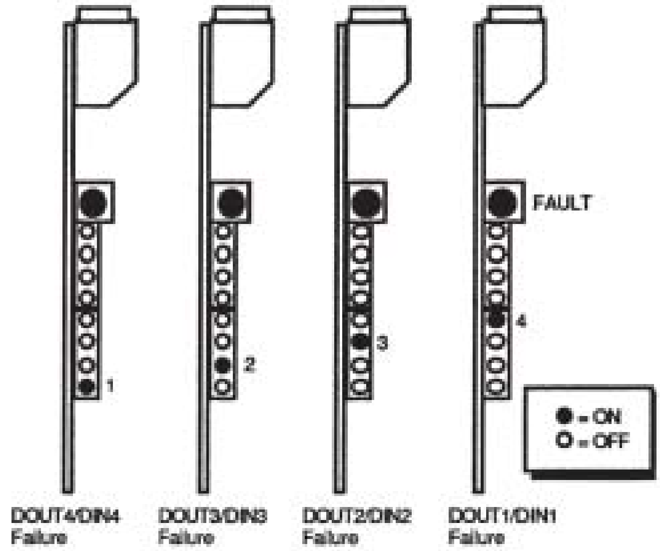


Figure 8-17.LED Indications for the Digital Loop-back Test

DIAGNOSTIC WORD

0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
not used	not used	not used	not used	not used	not used	not used	not used	not used	not used	not used	not used	DOUT1/DIN1 FAILURE	DOUT2/DIN2 FAILURE	DOUT3/DIN3 FAILURE	DOUT4/DIN4 FAILURE

Figure 8-18. Diagnostic Word for the Digital Loop-back Test

Analog I/O Processor Fault Conditions

Problem

An analog voltage input to the card does not yield the expected value. Possible causes include the following:

- Analog input module offset and gain are not properly set in INCOL86.
- Connections are incorrect.
- Jumper settings incorrect.
- Jumper settings for one channel are incompatible with those for another channel.
- No dc return path is available for input bias currents.
- The common-mode or differential voltage limit has been exceeded.

Steps

1. Check the INCOL86 program.
2. Check the wiring for the analog inputs.
3. Check the jumper settings.
4. Check that the input source has a dc path to the Analog Processor internal ground. If no path exists, provide one (as shown in Figure 8-5.
5. Make sure that the common-mode and differential voltage limits have not been exceeded. (Those limits are shown in the specifications table at the end of this chapter)
6. Run the analog loop-back self-test (described earlier in this chapter).

Problem

A 4-20 mA current loop passed through the analog input does not yield the expected value. Possible causes include the following:

- INCOL86 program is incorrect.
- Connections are incorrect.
- Jumper settings incorrect.
- Jumper settings for one channel are incompatible with those for another channel.
- No dc return path is available for input bias currents.
- Input current overload.

Steps

1. Check the INCOL86 program.
2. Check the wiring for the analog input.
3. Check the jumper settings.
4. Check that the input source has a dc path to the internal ground of the Analog Processor. If no path exists, provide one as shown in Figure 8-5.

5. Verify that the voltage at the (-) terminal is within 5 V of the Analog Processor internal ground (at J2-22).

6. With power removed from the card, check the input impedance (4-20 mA) against that given in the specifications at the end of this chapter.

7. Run the analog loop-back self-test (described earlier in this chapter). If the Analog I/O Processor fails a self-test, contact Custom Servo Motors for replacement procedures.

Problem

An analog output, used as a voltage source, is not providing the required value. Possible causes include the following:

- Analog output module offset and gain are not properly set in INCOL86.
- Connections are incorrect.
- Jumper settings incorrect.
- Load drawing too much current.

Steps

1. Check the INCOL86 program.
2. Check the wiring for the analog output.
4. Check the jumper settings.
5. Verify that the load is drawing less than 5 mA.
6. Run the analog loop-back self-test (described earlier in this chapter). If the Analog I/O Processor fails a self-test, contact Custom Servo Motors for replacement procedures.

Problem

An analog output, used as a 4-20 mA current source, is not providing the required value. Possible causes include the following:

- Analog output module offset and gain are not properly set in INCOL86.
- Connections are incorrect.
- Jumper settings incorrect.
- Voltage drop of load exceeds the compliance voltage.
- External supply not floating.

Steps

1. Check the INCOL86 program.

2. Check the wiring for the analog output.

3. Check the jumper settings.

4. Verify that the load resistance does not exceed specifications. (Refer to the earlier figure showing "Maximum Load Resistance vs. Current Loop Power Supply Voltage", or refer to the specifications at the end of this chapter.)

5. If an external supply is used to power the current loop outputs, verify that it is a floating type, that is, referenced to the ground at J2-22.

6. Run the analog loop-back self-test (described earlier in this chapter). If the Analog I/O Processor fails a self-test, contact Custom Servo Motors for replacement procedures.

Problem

The digital inputs are not working properly. Possible causes include the following:

- The INCOL86 program is incorrect.
- Connections are incorrect.
- Input voltage is not in the required range.

Steps

1. Check the INCOL86 program.

2. Check the wiring for the digital inputs. Refer to the discussion and examples of digital inputs earlier in this chapter.

3. Verify that the input voltage meets the requirements listed in the specifications at the end of this chapter.

4. Run the digital loop-back self-test (described earlier in this chapter). If the Analog I/O Processor fails a self-test, contact Custom Servo Motors for replacement procedures.

Problem

The digital outputs are not working properly. Possible causes include the following:

- The INCOL86 program is incorrect.
- Jumper settings incorrect.
- Load resistance limit has been exceeded.
- Connections are incorrect.

Steps

1. Check the INCOL86 program.

2. Check the wiring for the digital outputs. Refer to the discussion and examples of digital outputs earlier in this chapter.

3. Check the jumper settings.

4. Verify that the loads are not drawing more current than allowed by the specifications at the end of this chapter. Notice that DOUT1 has lower power-handling capabilities than the other digital outputs.

4. Run the digital loop-back self-test (described earlier in this chapter). If the Analog I/O Processor fails a self-test, contact Custom Servo Motors for replacement procedures.

Problem

The Analog I/O Processor is not responding to INCOL86 instructions. Possible causes include the following:

- Analog I/O Processor has failed a power-up self-test.
- The INCOL86 program is incorrect.
- The address DIP switch is set incorrectly.
- The System Processor RTI has not been upgraded to compatibility with the Analog I/O Processor.
- Connections are incorrect.

Steps

1. Check the INCOL86 program.
2. Check the wiring.
3. If the Fault LED remains on after power-up, one of the self-tests has failed. Refer to "Normal Power-up" earlier in this chapter for an explanation of the LEDs at power-up. If the Analog I/O Processor fails a self-test, contact Custom Servo Motors for replacement procedures.
4. Check that the address DIP switch is set correctly. Refer to the table of DIP switch settings earlier in this chapter.
5. Verify that the System Processor or High Speed System Processor RTI is compatible with the Analog I/O Processor. (Refer to the System Processor or High Speed System Processor chapter of this manual to identify the RTI). The System Processor RTI must be version BSYS0012 or later to work with the Analog I/O Processor. The High Speed System Processor RTI must be version BHSSS0012 or later to work with the Analog I/O Processor.

Specifications

Parameter	Specification Min	Typ	Max	Units
Analog Inputs				
Differential Input Voltage (Vd)	-10		+10	V
Common-mode input voltage	G*Vd/2-10		10-G*Vd/2	V
Common-mode rejection up to 60 Hz (assuming 1 kΩ source imbalance)	70			dB
Input impedance (except 4 to 20 mA)	10			MΩ
Input impedance (4 to 20 mA)		50		Ω
Rise/fall time (without filter)			20	µs
Filter cutoff frequency		1		kHz
Filter rise time		1		ms
Filter rolloff (per decade)		20		dB
Resolution (except 4 to 20 mA)	12			bits
Resolution (4 to 20 mA)	11.6			bits
Offset error (at 25 °C)				
G = 1		2	16	mV
G = 10		3	21	mV
G = 100		10	112	mV
4 to 20 mA		20	50	µA
Gain error (at 25°C [77°F])				
G = 1		0.03	0.07	%FS
G = 10		0.15	0.28	%FS
G = 100		0.3	0.55	%FS
4 to 20 mA		0.15	0.3	%FS
Analog Outputs				
Resolution	12			bits
Offset error (at 25°C [77°F])				
0 to +10 V single-ended		1	4	mV
0 to +5 V single-ended		1	4	mV
-10 to +10 V single-ended		5	17	mV
-5 to +5 V single-ended		3	9	mV
-10 to +10 V differential		8	18	mV
4 to 20 mA		12	90	µA
Gain error (at 25°C [77°F])				
0 to +10 V single-ended		0.05	0.15	%FS
0 to +5 V single-ended		0.07	0.2	%FS
-10 to +10 V single-ended		0.1	0.25	%FS
-5 to +5 V single-ended		0.2	0.25	%FS
-10 to +10 V differential		0.1	0.25	%FS
4 to 20 mA		0.25	0.75	%FS
Rise/fall time (except 4 to 20 mA)		2	5	µs
Rise/fall time (4 to 20 mA)		15	25	µs
Load current (except 4 to 20 mA)			5	mA
Load resistance (4 to 20 mA with internal +15 V supply)			500	Ω
Load resistance (4 to 20 mA with external +30 V supply)			1250	Ω

Specifications (Continued)

Parameter	Specification Min	Typ	Max	Units
Digital Inputs				
Input current (Vin = 12 V)			10	mA
Input low voltage	-2		+2	V
Input high voltage	+10		+16.5	V
Propagation delay (Vin = 12 V)		30		µs
Optical isolation	1000			V
Digital Outputs				
Output ON voltage		10.5		V
Load resistance (except DOUT1)	125			Ω
DOUT1 load resistance	160			Ω
Propagation delay (at full load)		75		µs
Optical isolation	1000			V
DIN1 input/DOUT1 output				
DIN1 pulse width (no current flow)	3			ms
Propagation delay			3	ms
Power requirements (optional external supplies)				
Supply voltage for output current loop	15		30	V
Supply current for output current loop		50	60	mA
Supply ripple for output current loop			50	mV
Supply voltage for digital outputs	11.4		12.6	V
Supply current for digital outputs			425	mA
Supply ripple for digital outputs			100	mV
Supply voltage for DC-to-DC converter	11.4		12.6	V
Supply current for DC-to-DC converter		320	620	mA
Supply ripple for DC-to-DC converter			50	mV
Power requirements (Motion Bus)†				
+5 V supply current		1200		mA
+12 V supply current (with internal power for digital I/O)			425	mA
+12 V supply current (with external power for digital I/O)			0	mA
-12 V supply current (with internal power for DC-to-DC converter)		320†		mA
-12 V supply current (with external power for DC-to-DC converter)			0	mA
Environmental				
Temperature	0		50	°C
	32		122	°F
Humidity (non-condensing)	10		90	%

†The absolute maximum number of Analog I/O Processor cards that can be used with internal Motion Bus power is four cards. The practical maximum may be fewer cards, depending on the system configuration.

9 Model 473.04c RS232 Interface

Introduction

The Model 473.04c RS232 Interface provides the Motion Plus™/473 family of controllers with an additional serial port for communication with an external microcomputer or other RS232 compatible device.

Standard features of the RS232 Interface include the following:

- Single RS232c interface channel (COM 1 or COM 2)
- nine LEDs for fault and status indication

PWA Part Number	COM Number
353747-02	1
353747-03	2

Figure 9-1 shows the location of important components on the RS232 Interface.

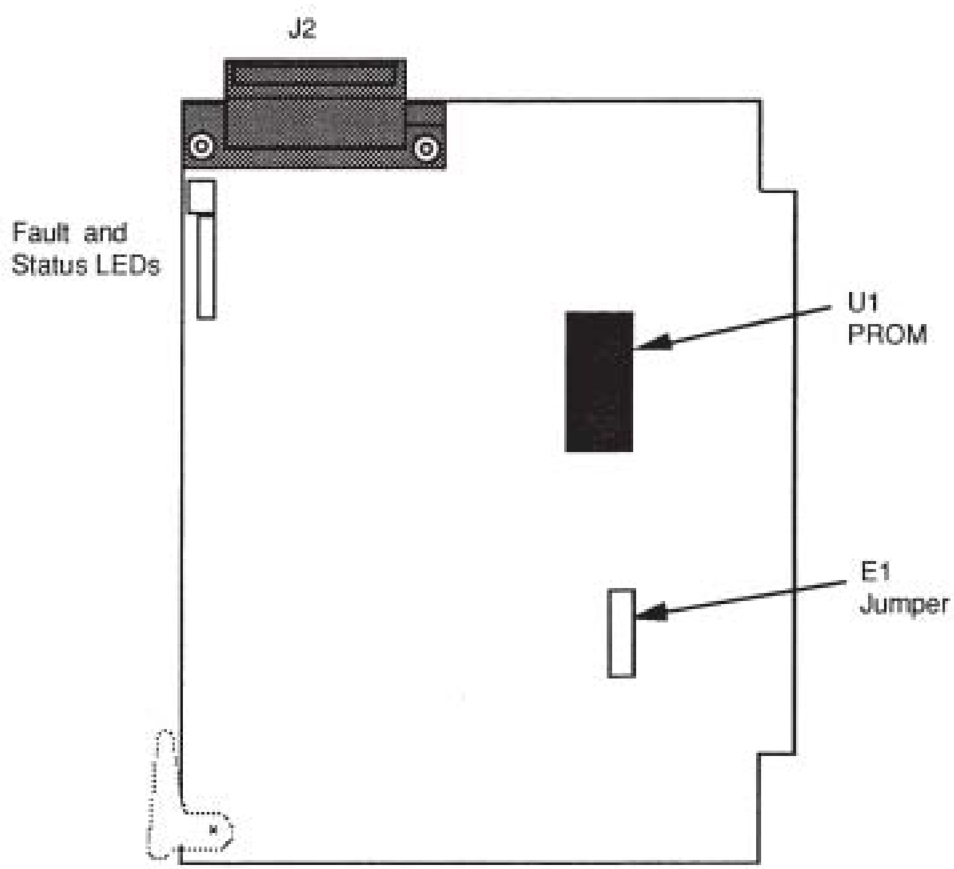


Figure 9-1. Model 473.04c RS232 Interface Component Location

Jumpers

Check or change jumper settings according to Figure 9-2. The standard connection is noted. Optional settings require an extra power supply.

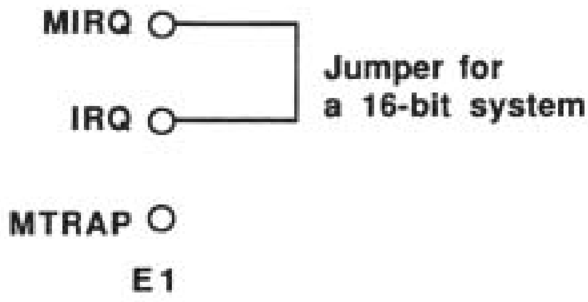


Figure 9-2. E1 Jumper Setting

PROMs

The U1 PROM determines whether the RS232 Interface is set for COM 1 or COM 2, as shown in Table 9-1.

Table 9-1. U1 PROMs for Port Address

COM Number	U1 PROM Part Number
1	371533-09
2	371533-11

Wiring

The J2 connector (AMP part number 206584-1) provides signal connections as shown in Table 9-3.

Table 9-3. J2 Pin Definitions

J2 Pin	Name	Direction	Description
1	Chassis ground		Chassis ground
2	RXD	In	Receive data
3	TXD	In	Transmit data
5	CTS	In	Clear to send
6	DSR	In	Data set ready
7	Signal ground		Analog ground
8	DCD	In	Data carrier detect

Installing the RS232 Interface

The RS232 Interface requires one slot in the chassis.

LED Functions

One fault LED and eight status LEDs are provided. Figure 9-3 shows the functions for these LEDs.

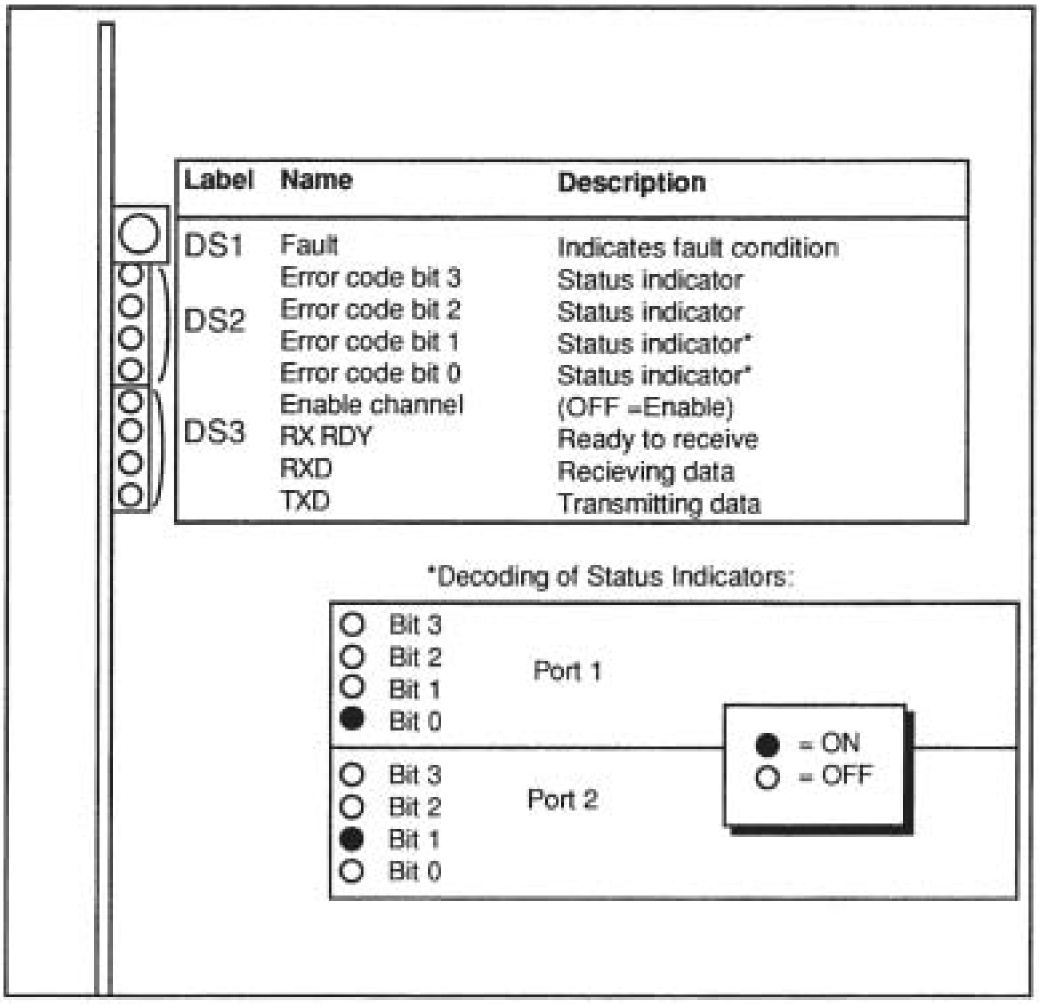


Figure 9-3. Fault and Status Indicator LEDs on the RS232 Interface

Troubleshooting the RS232 Interface

Problem	No communication.
Steps	1. Make sure that the RS-232 Interface is addressed correctly. The address PROM in socket U1 determines the address as COM 1 or COM 2 When the card is addressed as COM 1, the error code bit 0 is turned on. When the card is addressed as COM 2, the error code bit 1 is turned on. 2. Check that jumper E1 is set to the MIRQ1-to-IRQ position. 3. Check the RXD and the TXD LED on the RS-232 Interface. These LEDs should flash while communication is being attempted. If neither LED flashes, check your computer to make sure that it is transmitting properly. 4. Check that your cable is correct for the RS-232 Interface. The cable is different from the cable that is used with the System Processor. 5. Check the program that you are running. The RS-232 Interface requires a program (running on the System Processor) that handles all of the input and output communications. Refer to the INCOL86 software manual for more information.
Problem	RS232 Interface seems to communicate but is sending garbage.
Steps	Check that the receiving device is set for the proper baud rate. The baud rate for the RS232 Interface is set through the INCOL86 application program. The receiving device must be set to the same rate.

Specifications

Parameter	Specification
Baud rate	150 to 19200 baud, software selectable
Serial Communications	8 bits per character no parity 1 stop bit
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing
Power Inputs (PWA only)	+5 V ±0.25 V at 0.25 A +12 V ±0.6 V at 0.05 A -12 V ±0.6 V at 0.05 A

10 Model 473.10c 32 I/O Interface

Introduction

The Model 473.10c Optically Coupled 32 I/O Interface provides the Motion Plus™/473 family of controllers with a low-level dc interface to external machine-level components such as relays, LEDs, LCDs, switches, keyboards, thumbwheel switches, and sensors.

Standard features of the 32 I/O Interface include the following:

- 32 discrete bidirectional I/O points with LED indicators
- internal power supply for I/O
- I/O state is software verifiable
- nine LEDs for status indication
- active low outputs and inputs

Options include the following:

- external power supply at +5 V, +12 V, or +24 V*
- Optical isolation for each I/O point

* Requires jumper removal. May also require component change.

Figure 10-1 shows the location of important components on the 32 I/O Interface.

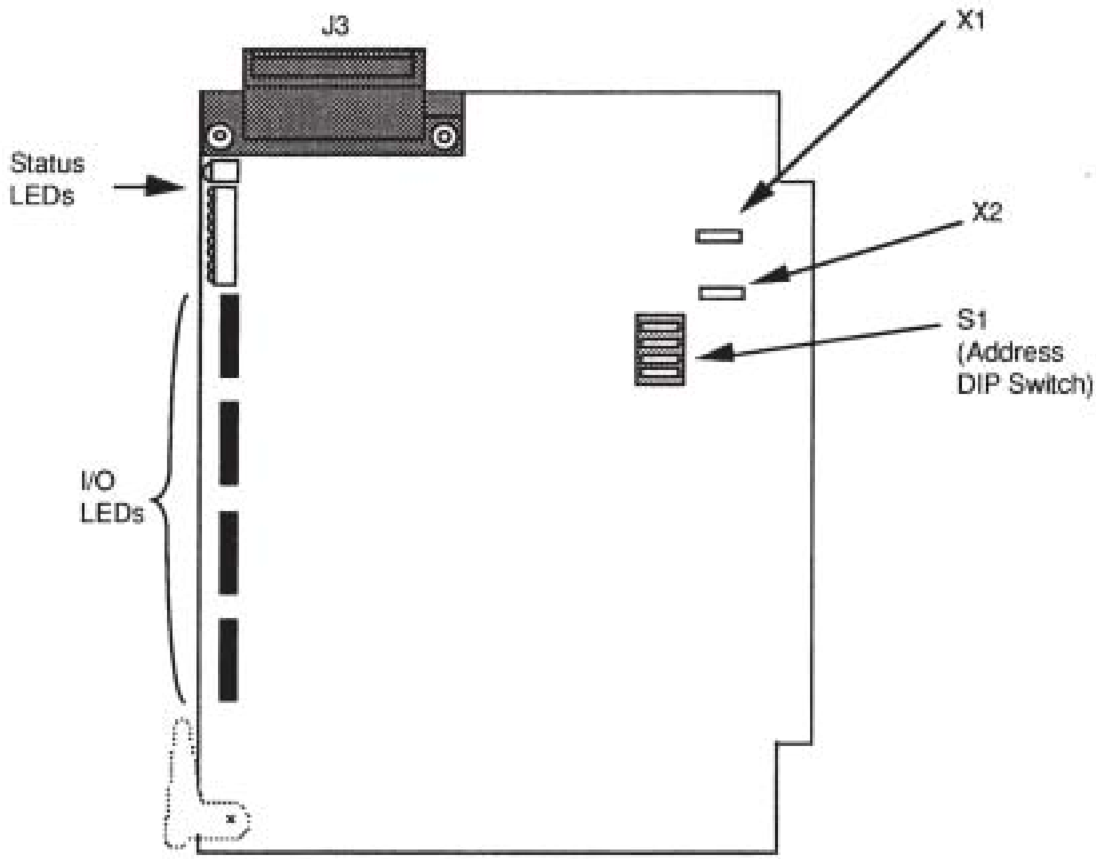


Figure 10-1. Model 473.10c 32 I/O Interface Component Location

Jumpers

Check or change jumper settings according to Table 10-1. The standard connection is noted. Optional settings require an extra power supply.

Table 10-1. 32 I/O Interface Jumper Connections

Jumper	Connection	Description
X1	IN OUT	Internal +12 V supply* External power supply +V
X2	IN OUT	Internal 12 V common* External power supply common
*Standard Connection		

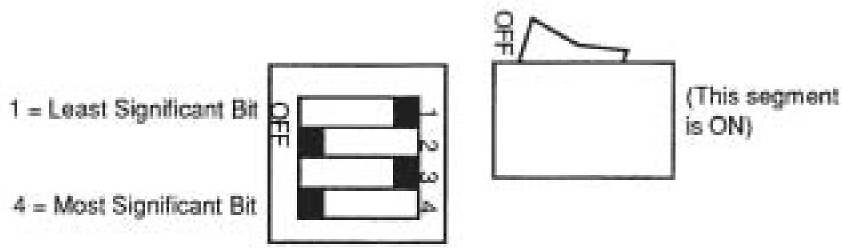
Address DIP Switch or PROM

Up to eight I/O Interface cards can be used in a system. Cards with serial number 2902 or higher define addresses by means of a PAL (part number 442055-01) and a 4-segment DIP switch on each card. Table 10-2 shows the settings for the DIP switch S1, and corresponding I/O line assignments for each address.

Table 10-2. DIP Switch settings (Serial Numbers 2902 or Higher)

Switch Settings: 1 = ON
0 = OFF

Example:



bit pattern = 0101
I/O Card No. = 5

I/O Card Number	Setting 4321	I/O Line Assignments
1	0001	1 to 32
2	0010	33 to 64
3	0011	65 to 96
4	0100	97 to 128
5	0101	129 to 160
6	0110	161 to 192
7	0111	193 to 224
8	1000	225 to 255

Older cards (those with serial numbers less than 2902) define addresses by means of a PROM on each card. I/O line assignments are also defined by the PROM, as shown in Table 10-3.

Table 10-3. Standard I/O Address PROMs (Serial Numbers Less than 2902)

PROM Part Number	I/O Card Number	I/O Line Assignments
371526-01	1	1 to 32
371526-02	2	33 to 64
371526-03	3	65 to 96
371526-04	4	97 to 128
371526-05	5	129 to 160
371526-06	6	161 to 192
371526-07	7	193 to 224
371526-08	8	225 to 255

Wiring

Table 10-4 shows pin definitions for the J3 Connector.

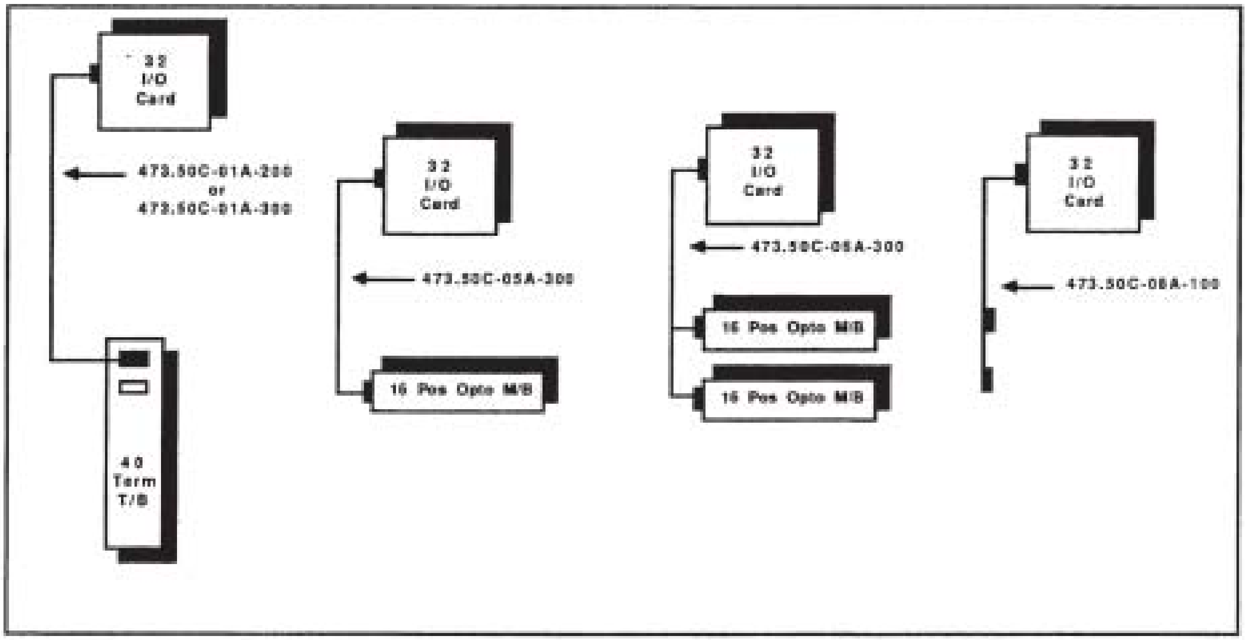
Table 10-4. J3 Pin Definitions

J3 Pin	Name	Remote Terminal Board
1	I/O 0	1
2	I/O 2	3
3	I/O 4	5
4	I/O 6	7
5	I/O 8	9
6	I/O 10	11
7	I/O 12	13
8	I/O 14	15
9	I/O 16	17
10	I/O 18	19
11	I/O 20	21
12	I/O 22	23
13	I/O 24	25
14	I/O 26	27
15	I/O 28	29
16	I/O 30	31
17	+Vx	37–40
18	Vx common	33–36
19	I/O 1	2
20	I/O 3	4
21	I/O 5	6
22	I/O 7	8
23	I/O 9	10
24	I/O 11	12
25	I/O 13	14
26	I/O 15	16
27	I/O 17	18
28	I/O 19	20
29	I/O 21	22
30	I/O 23	24
32	I/O 25	26
32	I/O 27	28
33	I/O 29	30
34	I/O 31	32
35	+Vx	37–40
36	Vx common	33–36
* When used with cable 387316-xx		
+Vx and Vx common depend upon the power supply configuration		

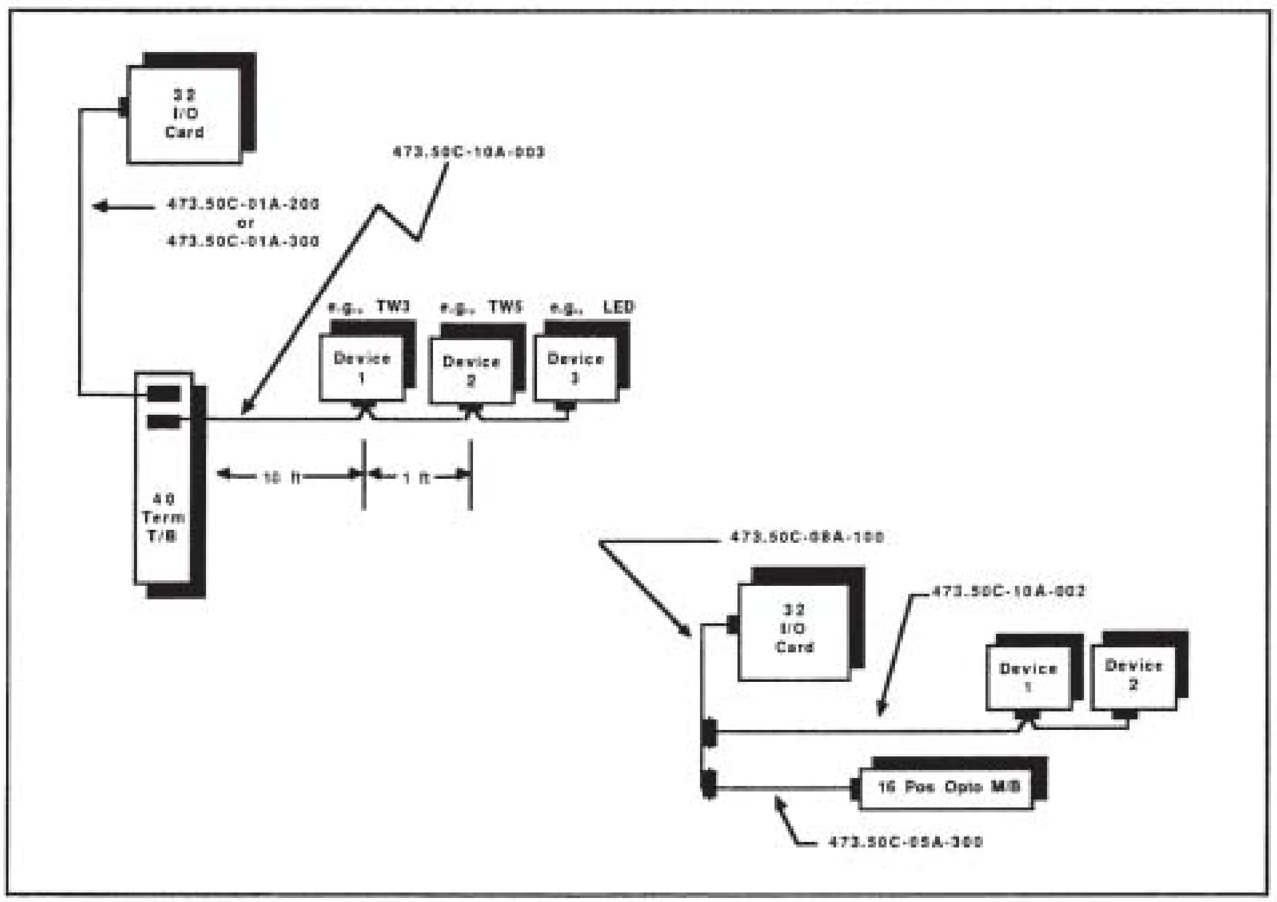
Cabling

Various cabling configurations are available from the 32 I/O Interface (refer to Figures 10-2 and 10-3). Up to 20 lines of the 32 I/O Interface may be reserved as the "Remote Data Bus" for two-way data communication to selected circuit modules (keypads, thumbwheels, LCDs, LEDs). These are supported only by I/O Interface #8. In systems requiring a Remote Data Bus and 16 or fewer I/O lines, a single card is installed as Card #8. That is, either the DIP switch segments are set for card #8, or (in older cards with serial numbers less than 2902), the single card is installed with address PROM part number 371526-08.

For further information on the Remote Data Bus, refer to Chapter 3 of this manual.



32 I/O to Remote Terminal Board | 32 I/O to One Opto 22 Motherboard | 32 I/O to Two Opto 22 Motherboards | Adapter Cable



32 I/O to Remote Terminal Board and Remote Data Bus

Figure 10-2. Cable Configurations for the 32 I/O Interface

Connect the 32 I/O card to the 473.36c Motherboard using one of the following cables: The 473.50c-05A-300 Cable connects one Opto Motherboard. The 473.50c-06A-300 Cable connects two Opto Motherboards.

The Model 473.50c-05A-300 32 I/O Cable is designed to connect the Model 473.10c 32 I/O Interface to a single Model 473-36c-02A-000 16-position Opto Motherboard. A 50-pin edge connector is provided for the motherboard, and a 36-pin "D" male connector plugs into the I/O interface. Figure 10-2a shows the configuration for these connectors. Connects I/O points 1-16 to the 32 I/O Card.

OPTO 22 → 32 I/O Interface

Pin #				Signal
47	A24	BLUE/WHITE	1	I/O 0
45	A23	ORANGE/WHITE	19	I/O 1
43	A22	GREEN/WHITE	2	I/O 2
41	A21	BROWN/WHITE	20	I/O 3
39	A20	GRAY/WHITE	3	I/O 4
37	A19	BLUE/RED	21	I/O 5
35	A18	ORANGE/RED	4	I/O 6
33	A17	GREEN/RED	22	I/O 7
31	A16	BROWN/RED	5	I/O 8
29	A15	GRAY/RED	23	I/O 9
27	A14	BLUE/BLACK	6	I/O 10
25	A13	ORANGE/BLACK	24	I/O 11
23	A12	GREEN/BLACK	7	I/O 12
21	A11	BROWN/BLACK	25	I/O 13
19	A10	GRAY/BLACK	8	I/O 14
17	A9	BLUE/YELLOW	26	I/O 15
49	A25	YELLOW/ORANGE	17	+Vx
50	B25	RED/GREEN	18	Vx Common

Figure 10-2a. Connecting 32 I/O Card to One Opto Motherboard

The Model 473.50c-06A-300 32 I/O Cable is designed to connect the Model 473.10c 32 I/O Interface to two Model 473.36c-02A-000 16-position Opto Motherboards. A 50-pin edge connector is provided for each motherboard, and a 36-pin "D" male connector plugs into the I/O interface. Figure 10-2b shows the configuration for these connectors.

	Pin #		Wire	32 I/O Interface	Signal
OPTO 22 Lower I/O (1 TO 16)	47	A24	BLUE/WHITE	1	I/O 0
	45	A23	ORANGE/WHITE	19	I/O 1
	43	A22	GREEN/WHITE	2	I/O 2
	41	A21	BROWN/WHITE	20	I/O 3
	39	A20	GRAY/WHITE	3	I/O 4
	37	A19	BLUE/RED	21	I/O 5
	35	A18	ORANGE/RED	4	I/O 6
	33	A17	GREEN/RED	22	I/O 7
	31	A16	BROWN/RED	5	I/O 8
	29	A15	GRAY/RED	23	I/O 9
	27	A14	BLUE/BLACK	6	I/O 10
	25	A13	ORANGE/BLACK	24	I/O 11
	23	A12	GREEN/BLACK	7	I/O 12
	21	A11	BROWN/BLACK	25	I/O 13
	19	A10	GRAY/BLACK	8	I/O 14
	17	A9	BLUE/YELLOW	26	I/O 15
	49	A25	YELLOW/ORANGE	17	+Vx
	50	B25	RED/GREEN	18	Vx Common
OPTO 22 Upper I/O (17 TO 32)	47	A24	ORANGE/YELLOW	9	I/O 16
	45	A23	GREEN/YELLOW	27	I/O 17
	43	A22	BROWN/YELLOW	10	I/O 18
	41	A21	GRAY/YELLOW	28	I/O 19
	39	A20	BLUE/VIOLET	11	I/O 20
	37	A19	ORANGE/VIOLET	29	I/O 21
	35	A18	GREEN/VIOLET	12	I/O 22
	33	A17	BROWN/VIOLET	30	I/O 23
	31	A16	GRAY/VIOLET	13	I/O 24
	29	A15	WHITE/BLUE	31	I/O 25
	27	A14	WHITE/ORANGE	14	I/O 26
	25	A13	WHITE/GREEN	32	I/O 27
	23	A12	WHITE/BROWN	15	I/O 28
	21	A11	WHITE/GRAY	33	I/O 29
	19	A10	RED/BLUE	16	I/O 30
	17	A9	RED/ORANGE	34	I/O 31
	49	A25	YELLOW/GREEN	35	+Vx
	50	B25	RED/BROWN	36	Vx Common

Figure 10-2b. Connecting 32 I/O Card to Two Opto Motherboards

Connect the 32 I/O card to J2 of the 473.38c Remote Terminal Board. Two cables are available: 473.50c-01A-200 - 4 ft (1.2 m) ribbon cable, and 473.50c-01A-300 - 10 ft (3 m) round cable. The Terminal Board provides screw-terminal connections for up to 32 I/O points, plus an external power supply. Refer to Figure 10- 3.

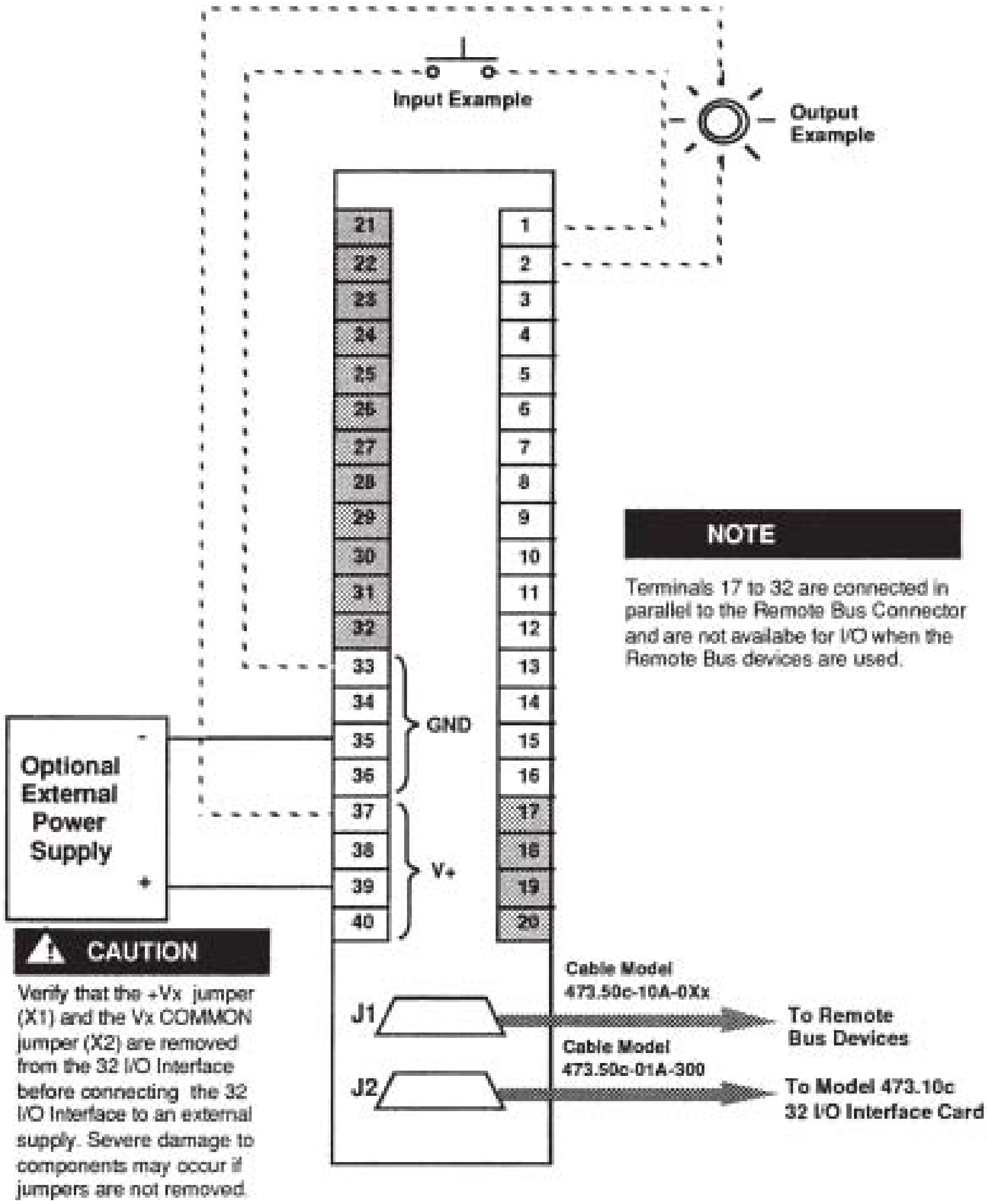


Figure 10-3. Remote Terminal Board to 32 I/O Card

The Model 473.50c-10A-0XX Remote Data Bus Cable connects up to 32 devices such as thumbwheels, LCDs, LEDs, and keypads to the I/O Interface card. It is a 20-conductor ribbon cable terminated with a 36-pin "D" male connector and supplied with a separate connector for each Remote Data Bus device. When this cable is connected directly to an I/O Interface card, other I/O connections are not supported by the cable, and +12 Vdc chassis power is provided via the I/O Interface jumpers. As shown in Figure 10-3, the Remote Data

Bus Cable can also be plugged into J1 of the Terminal Board, with terminals remaining for 16 additional I/O points plus an external power supply.

The Model 473.50c-08A-100 Adapter Cable, a 1 ft (30 cm) cable with one 36-pin "D" male and two female connectors, allows two cables to be connected to one I/O Interface. The Model 473.50c-00A-300 32 I/O Cable is unterminated at one end for connection to a user configured I/O and power supply. This cable is supplied with a 36-pin "D" type male connector, which mates to the I/O Interface card. Refer to the cabling chapter of this manual for the cable pin-outs.

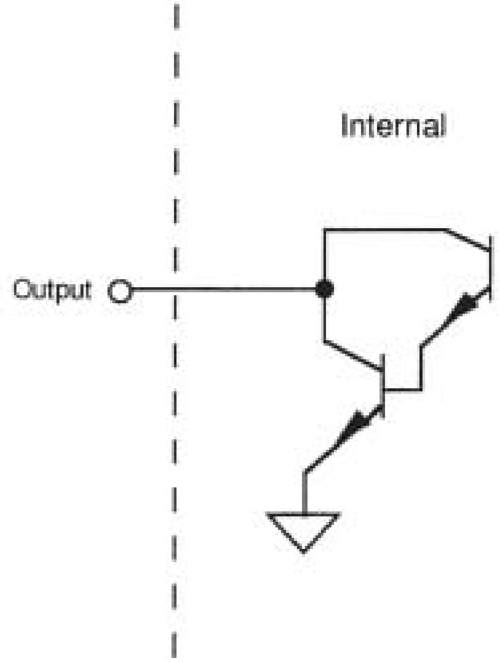


Figure 10-4. Typical Output

Figure 10-4 shows a typical output. Outputs are active low (that is, the card acts as a current sink). External output devices are electrically connected between the +Vx line and the I/O point for each output line. When an output driver is on, the total driver current consists of the output current plus 10 mA of current supplied through its own input circuitry. <u>Both current sources must be considered when calculating total current per output line.</u>

CAUTION

Operation beyond recommended output current limits can cause permanent damage to the output driver ICs.

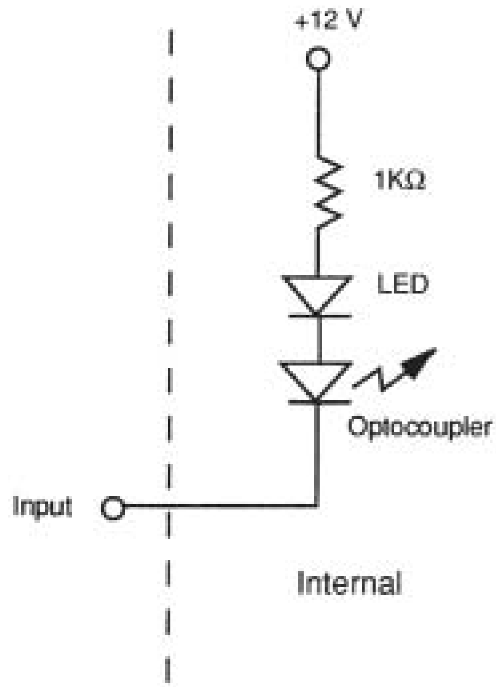


Figure 10-5. Typical Input

Figure 10-5 shows a typical input. Inputs are active low (that is, the card acts as a current source). An input line can be activated externally (for example, by switch or relay closure), provided the output driver for that line is kept in an off state. External input devices are connected between the line I/O point and the Vx COMMON line. When an input is pulled low, it requires 10 mA from the supply. For most installations, I/O cards controlling external devices should be powered with an external dc supply.

Options

External Power Supply

CAUTION

Verify that the +Vx jumper (X1) and the Vx COMMON jumper (X2) are *removed* from on the 32 I/O Interface before connecting the 32 I/O Interface to an external supply. Severe damage to components may occur if jumpers are not removed.

It is recommended that you use a separate power supply for I/O devices . The total load for all devices connected to the I/O Interface must be calculated before selecting a power supply.

The following power supplies are available from Custom Servo Motors :

Model Number	Part Number	Voltage	Current
473.32c-01A-000	111777-25	+12 Vdc	1A
473.32c-12A-000	111777-37	+12 Vdc	3A
External power supplies for +5 Vdc or +24 Vdc operation must be provided by the user.			

Circuit Card

Operation with a +5 Vdc or +24 Vdc power supply requires a modified card. These cards require component changes from the standard configuration, and are not compatible with Remote Data Bus devices.

Model Number	Part Number	Description
473.10c-01A-002	353750-02	Requires +24 Vdc external supply
473.10c-01A-001	353750-03	Requires +5 Vdc external supply

Installing the 32 I/O Interface

⚠ CAUTION

Make sure chassis power is OFF before installing this module.

The 32 I/O Interface requires one slot in the chassis.

LED Functions

Refer to Figure 10-6 for LED functions.

LED Description

The first small LED at the top indicates proper operation:

OFF = card enabled

ON = card disabled

The four LEDs marked DS3 indicate the card address, as determined by the DIP switch setting (or PROM on older cards). These four LEDs show a binary representation of the card address (1 to 8).

The 32 LEDs marked DS4 to DS11 indicate the logic state of the 32 I/O lines. When an LED is ON, the corresponding I/O voltage level is low. If the corresponding line is configured as an output, this indicates that the output drive is active. If the corresponding line is configured as an input, this indicates that the input signal is active.

● = ON
○ = OFF

FAULT — ON= card disabled

DS3

	Card #1	Card #2	Card #3	Card #4	Card #5	Card #6	Card #7	Card #8
DS3	○	○	○	○	○	○	○	●
	○	○	○	●	●	●	●	○
	○	●	●	○	○	●	●	○
	●	○	●	○	●	○	●	○

LED Numbers — INCOL I/O Numbers — Remote Data Bus (Card #8, 255–241)

LED Numbers		Card #1	Card #2	Card #3	Card #4	Card #5	Card #6	Card #7	Card #8
31	DS4	32	64	96	128	160	192	224	N/A
30	DS4	31	63	95	127	159	191	223	255
29	DS4	30	62	94	126	158	190	222	254
28	DS4	29	61	93	125	157	189	221	253
27	DS5	28	60	92	124	156	188	220	252
26	DS5	27	59	91	123	155	187	219	251
25	DS5	26	58	90	122	154	186	218	250
24	DS5	25	57	89	121	153	185	217	249
23	DS6	24	56	88	120	152	184	216	248
22	DS6	23	55	87	119	151	183	215	247
21	DS6	22	54	86	118	150	182	214	246
20	DS6	21	53	85	117	149	181	213	245
19	DS7	20	52	84	116	148	180	212	244
18	DS7	19	51	83	115	147	179	211	243
17	DS7	18	50	82	114	146	178	210	242
16	DS7	17	49	81	113	145	177	209	241
15	DS8	16	48	80	112	144	176	208	240
14	DS8	15	47	79	111	143	175	207	239
13	DS8	14	46	78	110	142	174	206	238
12	DS8	13	45	77	109	141	173	205	237
11	DS9	12	44	76	108	140	172	204	236
10	DS9	11	43	75	107	139	171	203	235
9	DS9	10	42	74	106	138	170	202	234
8	DS9	9	41	73	105	137	169	201	233
7	DS10	8	40	72	104	136	168	200	232
6	DS10	7	39	71	103	135	167	199	231
5	DS10	6	38	70	102	134	166	198	230
4	DS10	5	37	69	101	133	165	197	229
3	DS11	4	36	68	100	132	164	196	228
2	DS11	3	35	67	99	131	163	195	227
1	DS11	2	34	66	98	130	162	194	226
0	DS11	1	33	65	97	129	161	193	225

Figure 10-6. Fault and Status Indicator LEDs on the 32 I/O Interface Card

The LED indicators described earlier (9 status LEDs plus 32 input/output LEDs) can be used to help troubleshoot the card.

Normal Powerup Sequence

On power-up the disable LED is on until the System Processor initializes the 32 I/O Interface. After initialization the disable LED is off and the card address is displayed in binary form on status LEDs DS3. The card addressed as 32 I/O Interface number 8 is used as the remote data bus. On that card the I/O points 16-31 flash, indicating that the System Processor has reset the remote data bus devices.

If you do not see this sequence on powerup, check the following.

⚠ CAUTION

Be sure to turn off the chassis power before installing or removing any circuit card from the chassis. Installing or removing cards with the power on can damage the system.

1. Make sure that the card address DIP switch is set to the desired address (or that the address PROM is correct).
2. Check that the power supply jumpers are correct in your application.
3. Check external power supply (if used).

Troubleshooting the 32 I/O Interface

Problem	A single input not working.
Steps	To test an input point, connect a wire from the suspect point to 12 V common and the associated LED indicator on the card edge should turn on. The controller recognizes an input point as on when the point is pulled low to 12 V common. Refer to earlier Figure 10-5). If this does not occur, take the following steps: 1. Make sure that the wiring connecting the 32 I/O interface to the desired external connection is correct. 2. Check that the power supply jumpers are correct in your application. 3. Check external power supply if one is being used on the 32 I/O Interface card.

If the LED turns on but the input is not recognized by the application program, take the following steps:

1. Check address switch or address prom is correct.
2. Check application program.

Problem

All inputs not working

Possible Causes

If all of the inputs are not working this is usually a power supply problem or an address problem.

Steps

1. Make sure that the card address DIP switch is set to the desired address (or that the address PROM is correct).
2. Check that the power supply jumpers are correct in your application.
3. Check external power supply (if used).

Problem

A single output not working.

Steps

1. Check application software. Use a simple INCOL86 application program such as the following to turn on the output point:

```
LOGIC:
OUT n ON
END
```

   Where n is the desired output point.

   The controller turns on an output when directed to by an INCOL86 application program. The 32 I/O interface card pulls the point towards Vx common when it is turning on an output point.

2. Make sure that the wiring connecting the 32 I/O interface to the desired external connection is correct.
3. Check that the power supply jumpers are correct in your application.
4. Check external power supply (if used).

Problem

All outputs not working. This is usually a power supply problem or an address problem.

Steps

1. Make sure that the card address DIP switch is set to the desired address (or that the address PROM is correct).

2. Check that the power supply jumpers are correct in your application.

3. Check external power supply (if used).

Specifications

Parameter	Specification
Model 473.10c 32 I/O	
Outputs	390 mA at 1.7 Vdc (only one output on) max 168 mA at 1.2 Vdc (all outputs on) max
Input	10 mA at V1 = 0 V
Logic isolation between I/O	1500 V
Power requirements–PWA only	+5 Vdc ± 0.25 V at 0.70 A +12 Vdc ±1.2 V at 0.32 A (all outputs on, no external load)
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing
Model 473.32c Power Supply	
Input power	115 Vac, 1 phase, 50/60 Hz
Output power:	
473.32c-01A-000	12 Vdc at 1 A
473.32c-12A-000	12 Vdc at 3 A

11 Model 473.38c-02A Remote Terminal Board

Introduction

The Model 473.38c-02A Remote Terminal Board provides a convenient method of connecting remote devices to the Motion Plus™/473 controller.

Standard features of the Remote Terminal Board include the following:

- 40 screw terminals for external connections
- two 36-pin connectors for cable connection to Motion Plus/473 controller circuit cards.
- external panel mounting

Figure 11-1 shows the location of connections on the Remote Terminal Board.

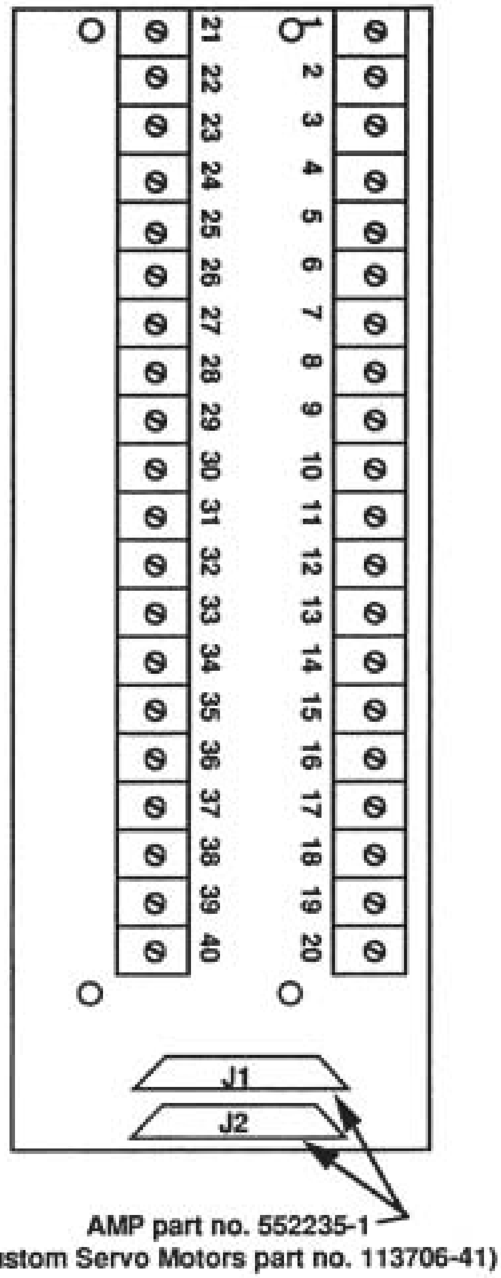


Figure 11-1. 473.38c-02A Remote Terminal Board

Installing the Remote Terminal Board

Figure 11-2 shows the mounting dimensions of the Remote Terminal Board.

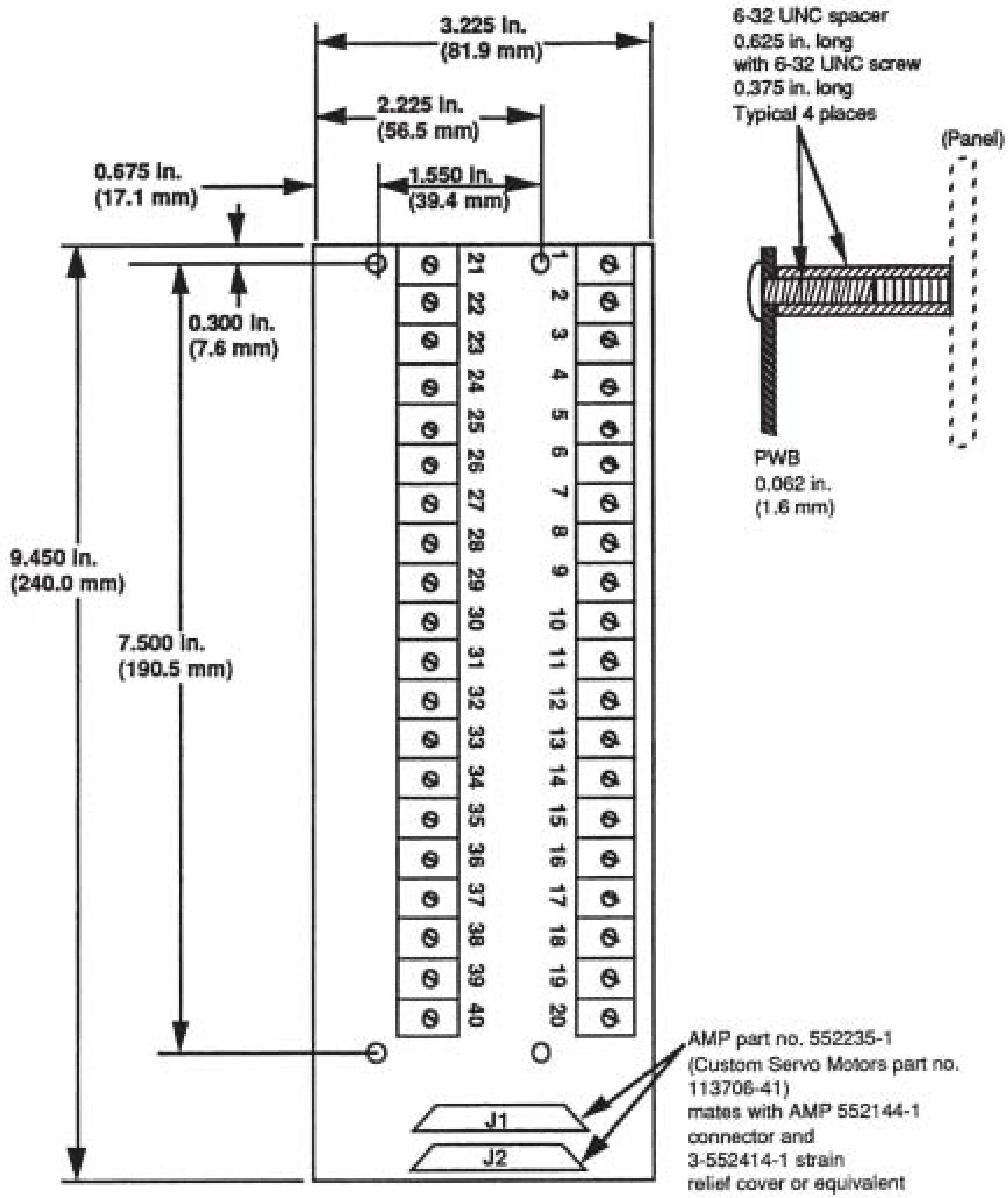


Figure 11-2. 473.38c-02A Remote Terminal Board Mounting Dimensions

The Remote Terminal Board comes with four 6-32 UNC spacers, 5/8 in. long and four 6-32 UNC screws 3/8 in. long, for panel mounting.

Connections

Figure 11-3 shows the internal electrical connections between J1, J2, and the 40 screw terminals of the Remote Terminal Board.

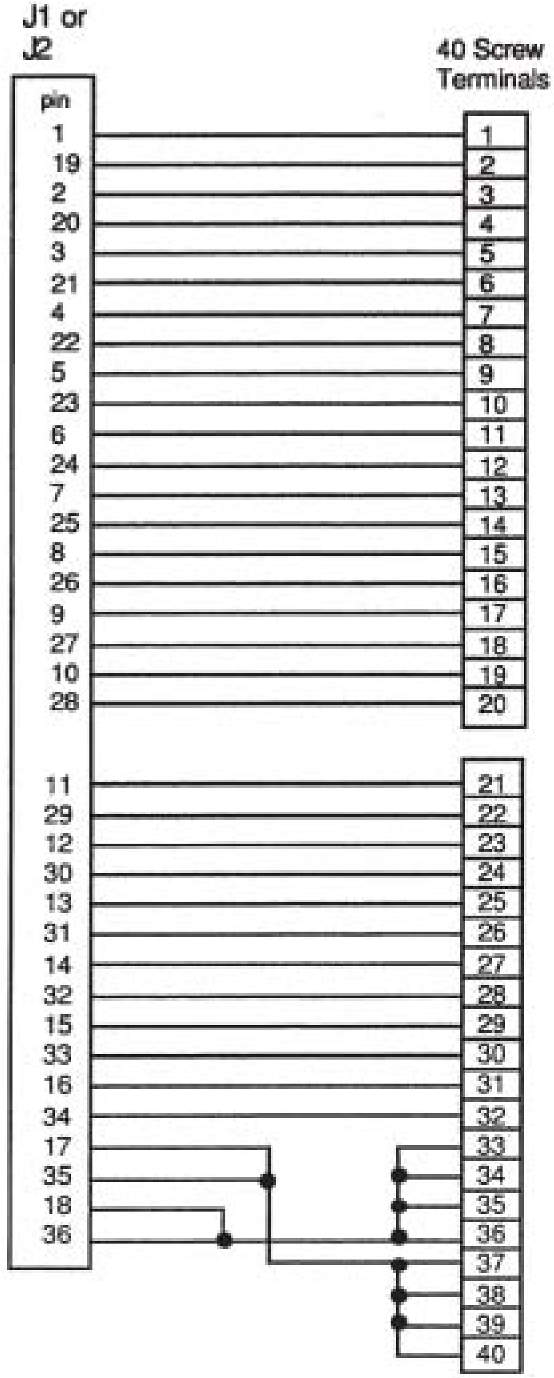


Figure 11-3. Remote Terminal Board Internal Connections

Wiring and Cabling

The Remote Terminal Board can be used in various cabling configurations with other Motion Plus/473 circuit modules. For wiring and cabling details, refer to cabling for specific circuit modules in other chapters of this manual.

Specifications

Parameter	Specification
Current limit (J1 or J2)	1 A per contact maximum
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing

12 Model 473.36c-0X, 473.11c-0X, and 473.12c-0X Modular I/O Interface Equipment

Introduction

The Model 473.36c-0X Motherboard plus 473.11c-0X Input Modules and 473.12c-0X Output Modules provide a reliable and flexible signal interface to various external devices. The Motherboard and Modules are OPTO22 devices with the following features:

- Compatible with the Model 473.10c I/O Interface
- Plug-in color-coded I/O modules
- Screw terminal strip accommodates up to 16 AWG wire.
- Rack mounting
- Individual fuses and status LEDs for each I/O module
- Keyed card-edge connector for signal connection
- External power supply operation
- Operation up to 50 ft from the Motion Plus/473 controller

Options include a variety of I/O modules such as models with higher voltage and higher speed options.

Standard Modules:

Model Number	Part Number	Description
473.36c-02	113791-01	Opto PB16A 16-Position Motherboard
473.11c-01	113791-14	OPTO IDC-15 dc Input Module
473.11c-02	113791-09	OPTO IAC-15 ac Input Module
473.12c-01	113791-13	OPTO ODC-15 dc Output Module
473.12c-03	113791-08	OPTO OAC-15 ac Output Module

Figure 12-1 shows the location of connections on the Remote Terminal Board.

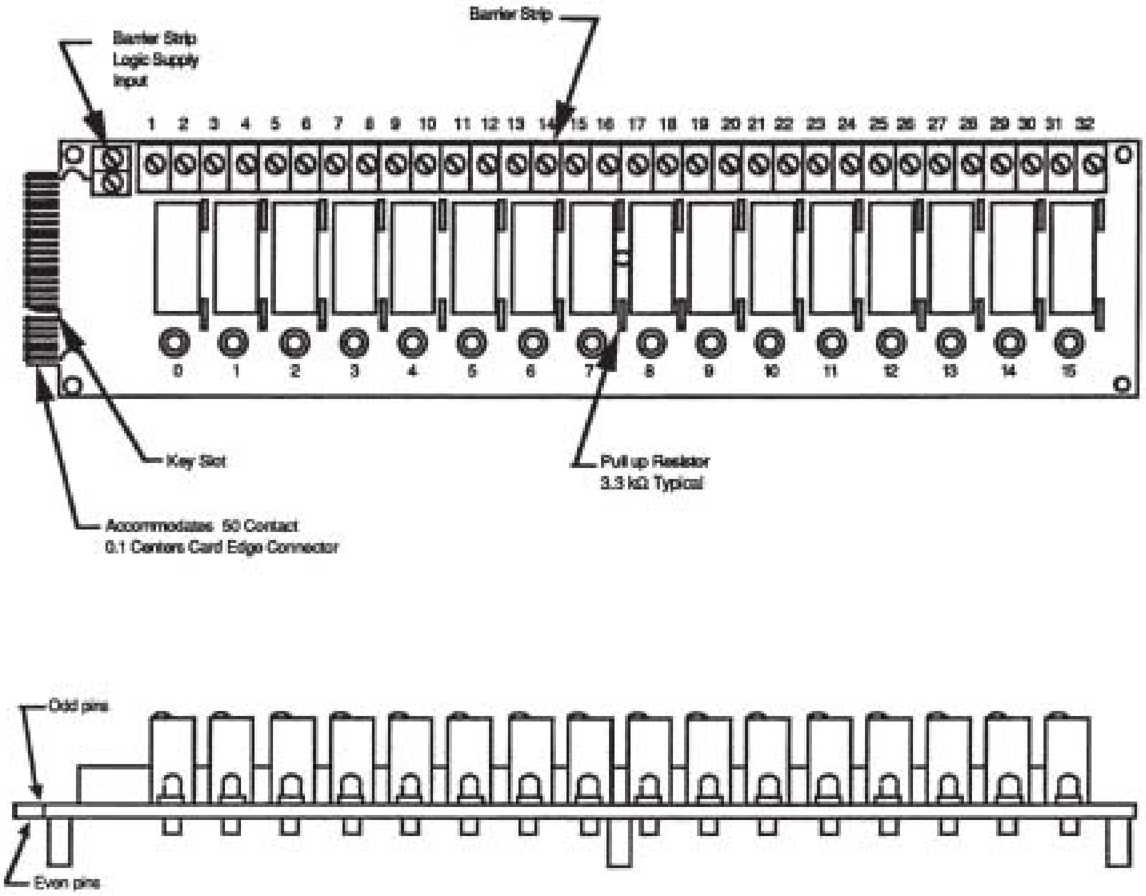


Figure 12-1. 473.36c-02 Motherboard

Jumpers

Two jumpers are available on the Motherboard, for the use of external power. To use these jumpers, you must:

- solder wire in place at both locations (refer to Figure 12-2)
- remove jumpers X1 and X2 on the 473.10c 32 I/O Interface
- provide an external power supply to the barrier strip logic supply input

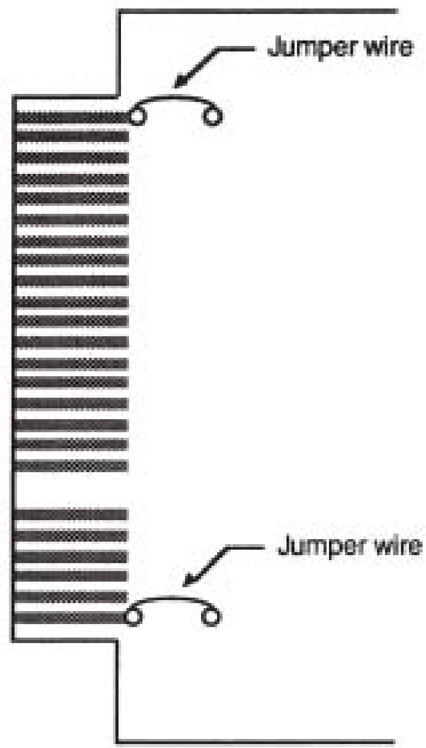


Figure 12-2. Jumpers on the 473.36c-02 Motherboard

Wiring and Cabling

The Motherboard can be used in various cabling configurations with other Motion Plus/473 circuit modules, as shown in Figure 12-3.

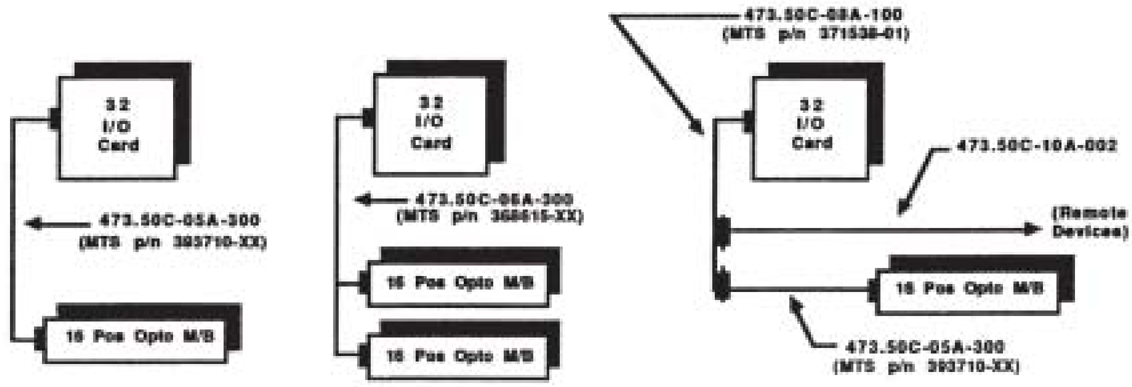


Figure 12-3. Cabling for the Motherboard

Installing the Motherboard

Figure 12-4 shows the mounting dimensions of the Motherboard. Figure 12-5 shows the mounting dimensions of the 473.11c-0X Input Modules and 473.12c-0X Output Modules.

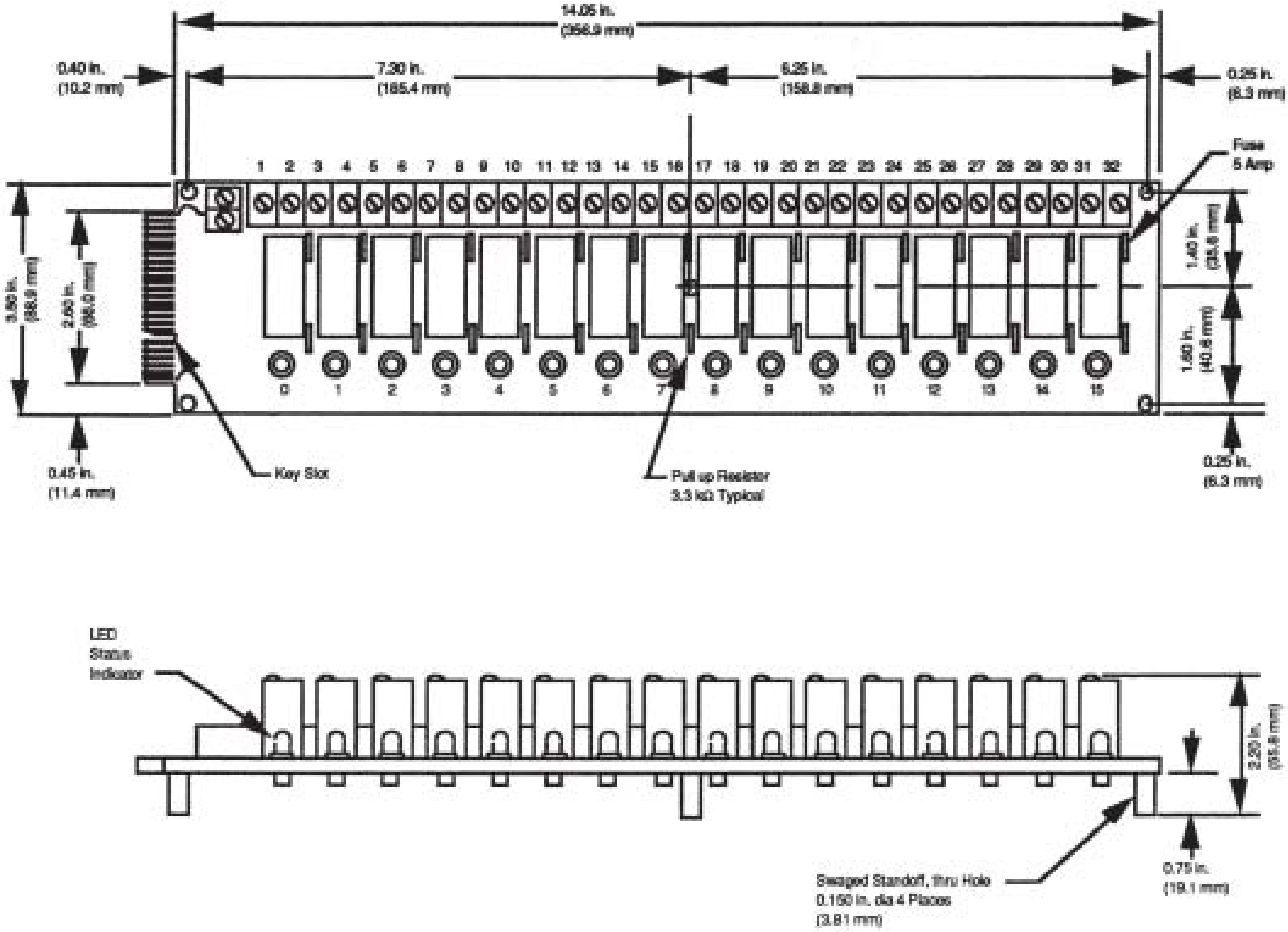


Figure 12-4. 473.36c-0X Motherboard Mounting Dimensions

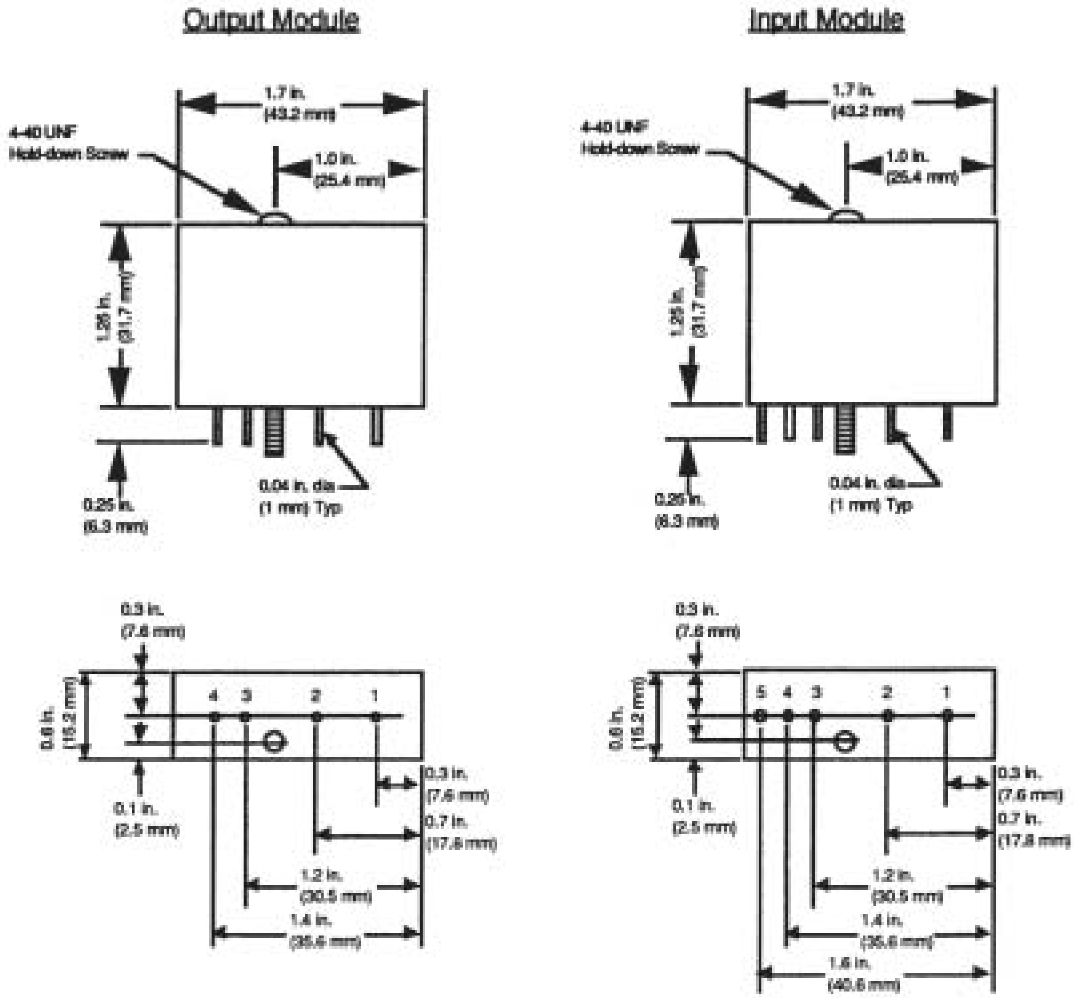


Figure 12-5. 473.11c-0X Input Modules and 473.12c-0X Output Modules Mounting Dimensions

LED Functions

A status LED is provided on the Motherboard for each I/O Module. The LED is ON if the input or output is ON. The LED is OFF if the input or output is OFF.

Connections

Figure 12-6 shows the internal electrical connections of the Motherboard Figures 12-7 to 12-10 show the internal connections for the Modules.

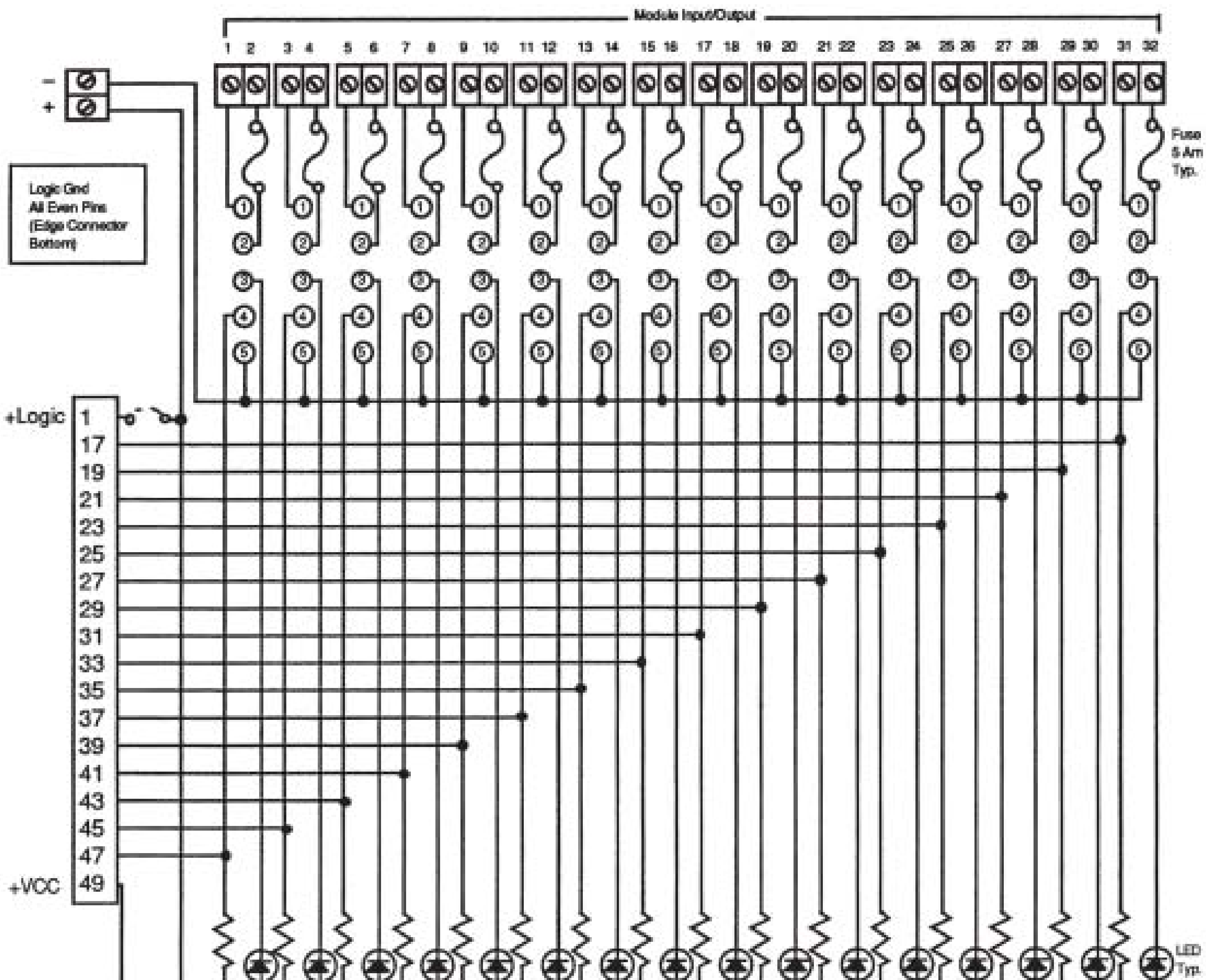


Figure 12-5. Motherboard Internal Connections

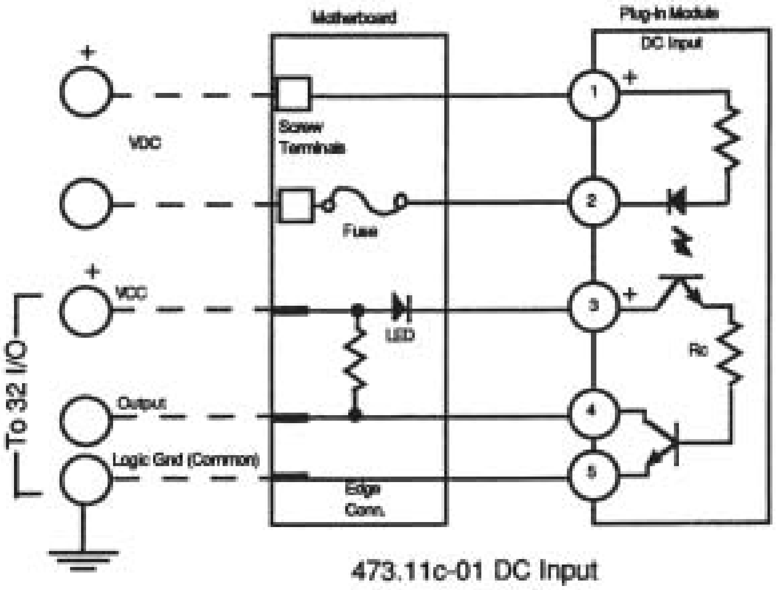


Figure 12-7. DC Input Module Internal Connections

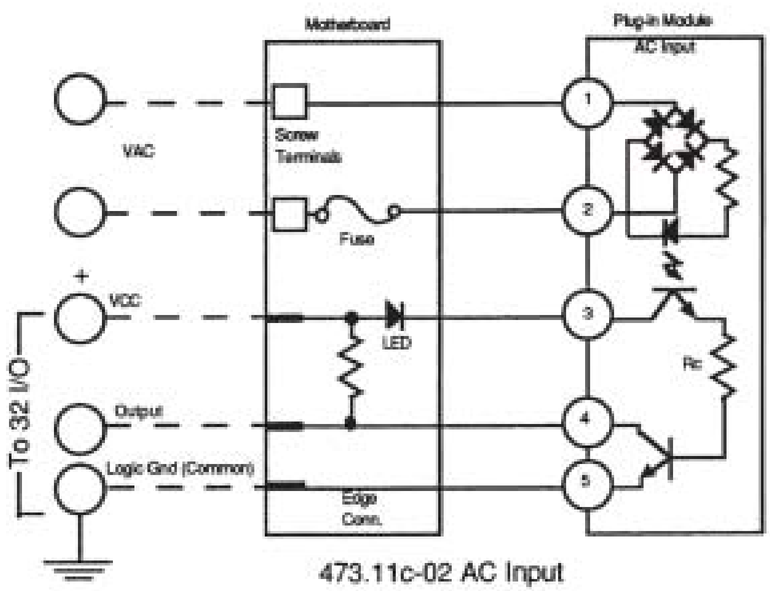
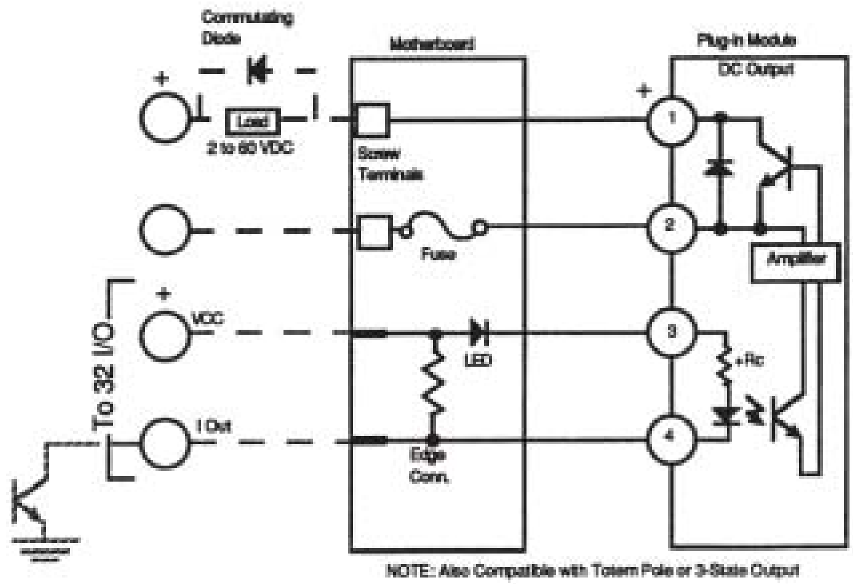
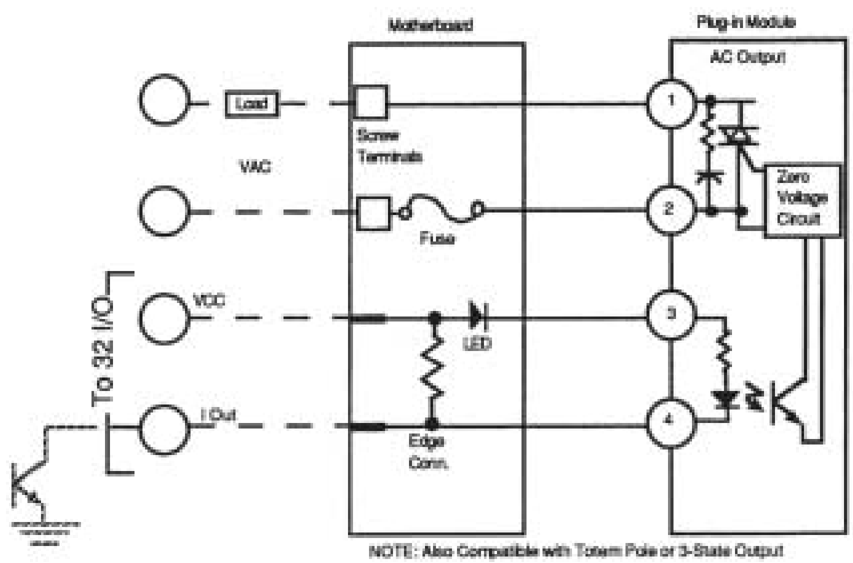


Figure 12-8. AC Input Module Internal Connections



473.12c-01 DC Output

Figure 12-9. DC Output Module Internal Connections



473.12c-03 AC Output

Figure 12-10. AC Output Module Internal Connections

Setup

Take the following steps to set up the Modular I/O Interface:

1. Add jumpers for external power on the Motherboard. Refer to the section "Jumpers" earlier in this chapter.
2. Remove jumpers X1 and X2 from the Model 473.10c 32 I/O Interface card # 8.
3. Connect an external power supply.
4. Connect a cable between the 32 I/O Interface and the Motherboard.
5. Connect inputs and outputs to the Motherboard.

Troubleshooting the Modular I/O Interface (Opto 22)

Modular I/O Interface Faults

Problem:	The LEDs on the 32 I/O interface glow faintly and the LEDs on the Motherboard glow faintly until four or five of the I/O points are turned on.
Steps:	Check the jumpers on the Motherboard. These jumpers must be in place in all configurations. (Refer to the jumper section of this chapter.)
Problem:	A single input is not working
Steps:	1. Check that the LED associated with this input on the Motherboard goes on when the input is activated. If not, check the wiring to the Motherboard for this input or replace the input module. 2. If the LED goes on correctly, check the wiring between the Motherboard and the 32 Input/Output Interface. 3. Check the 32 Input/Output Interface.
Problem:	All inputs are not working
Steps:	1. Check the External power supply going to the Motherboard. 2. Check the wiring between the Motherboard and the 32 Input/Output Interface. 3. Check the 32 Input/Output Interface.
Problem:	A single output is not working
Steps:	1. Check that the associated LED on the 32 Input/Output Interface goes on when the output is activated. If not, check the 32 I/O Interface. 2. Check that the LED associated with this output on the Motherboard goes on when the output is activated. If not, check wiring to the Motherboard for this output or replace the output module.
Problem:	All outputs are not working
Steps:	1. Check the External power supply going to the Motherboard. 2. Check the wiring going to the Motherboard and the 32 Input/Output Interface.

Specifications

Parameter	Specification
Model 473.36c-0X Motherboard	
Operating temperature	0° to 70° C (32° to 158°F)
Operating Humidity	Up to 95%, noncondensing
Model 473.11c-01 (IDC-15)*	
Input line voltage	12 to 32 Vdc
Input current	25 mA at 32 Vdc
Isolation, I/O	4000 V rms
Input allowed for no output	1 mA or 3 V
Turn-on time	5 ms max
Turn-off time	5 ms max
Output transistor	30 V breakdown
Output current	50 mA
Output leakage at 30 Vdc, no input	100 µA max
Output voltage drop	0.4 V at 50 mA
Logic supply voltage dc	12 to 18 V
Logic supply current	15 mA at 15 V logic supply
Model 473.11c-02 (IAC-15)*	
AC input line voltage	90 to 140 Vac
Input current at max line voltage	11 mA
Isolation, I/O	4000 V rms
Input allowed for no output	3 mA or 45 V
Turn-on time	20 ms max
Turn-off time	20 ms max
Output transistor	30 V breakdown
Output current	50 mA
Output leakage at 30 Vdc, no input	100 µA max
Output voltage drop	0.4 V at 50 mA
Logic supply voltage dc	12 to 18 Vdc
Logic supply current	15 mA at 15 V logic supply
Model 473.12c-01 (ODC-15)*	
Load voltage rating	60 Vdc max
Output current rating	3 A¶
Isolation, I/O	4000 V rms
Signal pickup voltage	9 V
Signal dropout voltage	1 V
Signal input resistance	1 KΩ
1-second surge	5A
Turn-on time	100 µs max
Turn-off time	750 µs max
Logic supply voltage DC	9 to 16 Vdc

*Opto 22 model numbers are shown in parentheses.
¶Operating ambient: -30° to +70°C (-22° to 158°F); 3 A at 45°C (113°F); 2A at 70°C (158°F)

Specifications (Continued)

Parameter	Specification
Model 473.12c-03 (OAC-15)*	
Line voltage	12 to 140, 120 Vac nominal
Current rating	3 A¶
Signal pickup voltage	9 V
Signal dropout voltage	1 Vdc
Signal input resistance	1 KΩ
Peak repetitive voltage	500 V
Maximum contact drop	1.6 V
Off state leakage	5 mA rms at 120 Vac
Minimum load current	20 mA
Isolation, I/O	4000 V rms
Static DV/DT	200 V/µs minimum
Commutating DV/DT	0.5 power factor loads§
Turn-on time	1/2 cycle max —zero voltage
Turn-off time	1/2 cycle max—zero current
Output leakage at 30 Vdc, no input	100 µA max
Logic supply voltage	9 to 16 Vdc
Logic supply current	15 mA at 15 Vdc

*Opto 22 model numbers are shown in parentheses.
¶Operating ambient: -35° to +70°C (-31° to 158°F); 3 A at 45°C (113°F); 2A at 70°C (158°F)
†Derate 0.018 A per °C from 45°C ambient (0.01 A per °F from 113°F ambient)
§Built-in snubber

13 Model 473.06c Remote Keypad

Introduction

The Model 473.06c Remote Keypad is designed for use in an industrial environment as an operator interface device. It provides a flexible means of parameter entry on Motion Plus/473 controllers.

Standard features of the Remote Keypad include the following:

- 14 defined keys for numeric data entry
- 6 user-defined function keys
- Remote Data Bus compatibility
- Can be mounted up to 100 ft from the controller

An optional panel allows the Keypad to be mounted at a remote location or on the Model 473.40c and 473.41c chassis.

Figure 13-1 shows the location of important components on the Remote Keypad.

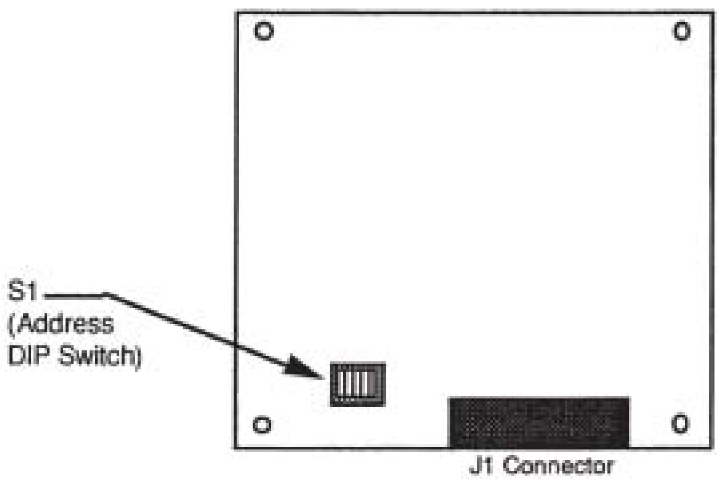


Figure 13-1. Model 473.06c Remote Keypad Component Location

Address DIP Switch

The 5-segment DIP switch must be set with all segments in the OFF position. Only one Remote Keypad can be used on the Remote Data Bus. Figure 13-2 shows a the switch setting.

Switch Settings: 1 = ON
0 = OFF

Segment	1	2	3	4	5
Setting	0	0	0	0	0

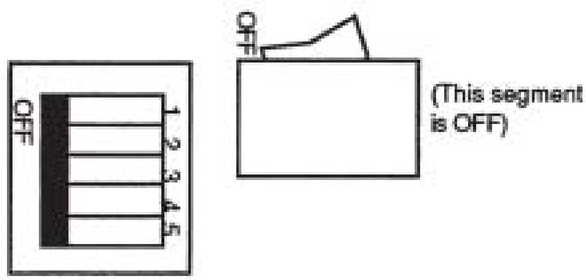


Figure 13-2. DIP Switch Setting

Wiring

NOTE

The Remote Keypad is used only with the Model 473.10c 32 I/O Interface Card #8.

Connector J1 (3M part number 3428-2302) on the Remote Keypad provides connection to the Remote Data Bus. This connector is keyed to prevent misorientation of the mating connector.

Cabling

The Remote Keypad is connected to 32 I/O Interface Card #8 using the Model 473.50c-10A-00X Remote Data Bus Cable (Custom Servo Motors part number 393709-xx).

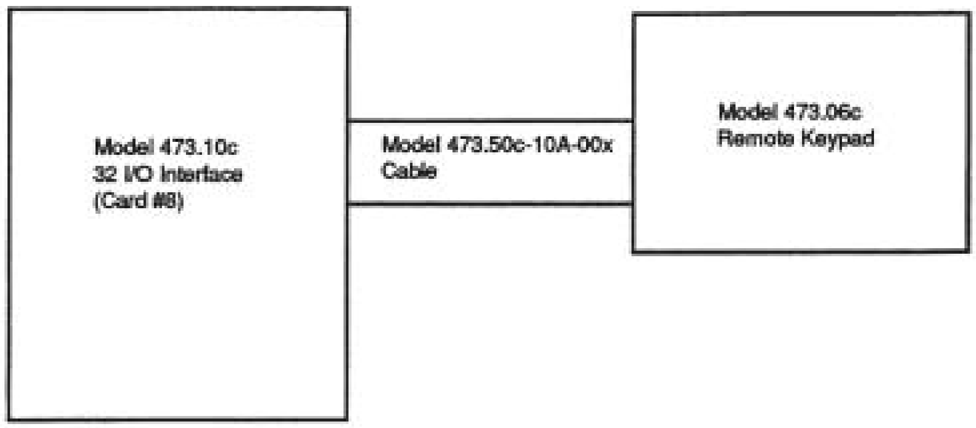


Figure 13-3. Cable Configuration for the Remote Keypad

Setup

Take the following steps to set up the Remote Keypad:

1. Remove power from the controller.
2. Connect the Remote Keypad to the Remote Data Bus cable
3. Verify that the Remote Data Bus Cable is connected to 32 I/O Interface Card #8.
4. Verify that all DIP switch segments on the Remote Keypad are set to the OFF position.

Installing the Remote Keypad

⚠ CAUTION

When mounting a Keypad on a surface other than a Motion Plus chassis, take the following precautions to make sure the Keypad is properly grounded:

- If mounting to a metal surface, connect the metal surface to chassis ground. The Keypad support plate is then attached to the surface in such a way to ensure proper grounding.
- If mounting to a non-metallic surface, the Keypad support plate must be connected to chassis ground.

Figure 13-4 shows mounting dimensions for the Remote Keypad. A metal plate is placed between the keypad and the circuit card to provide mechanical support for mounting the Keypad to the control panel.

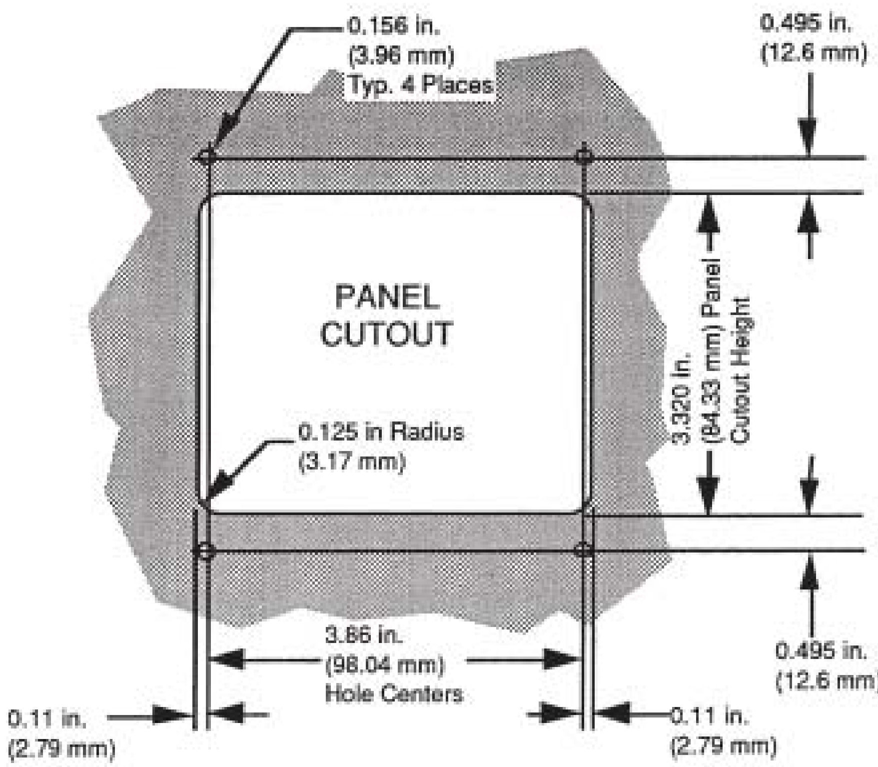


Figure 13-4. 473.06c Keypad Mounting Dimensions

Optional Installation

The Model 473.83-01A-000 Assembly (Custom Servo Motors part number 395214-01) includes the Remote Keypad, the Model 473.13c Remote LCD, and a mounting plate with gaskets. This assembly can be mounted on optional versions of the Model 473.40c 6-slot Chassis and Model 473.41c 12-slot Chassis. Those chassis versions are equipped with optional panels.

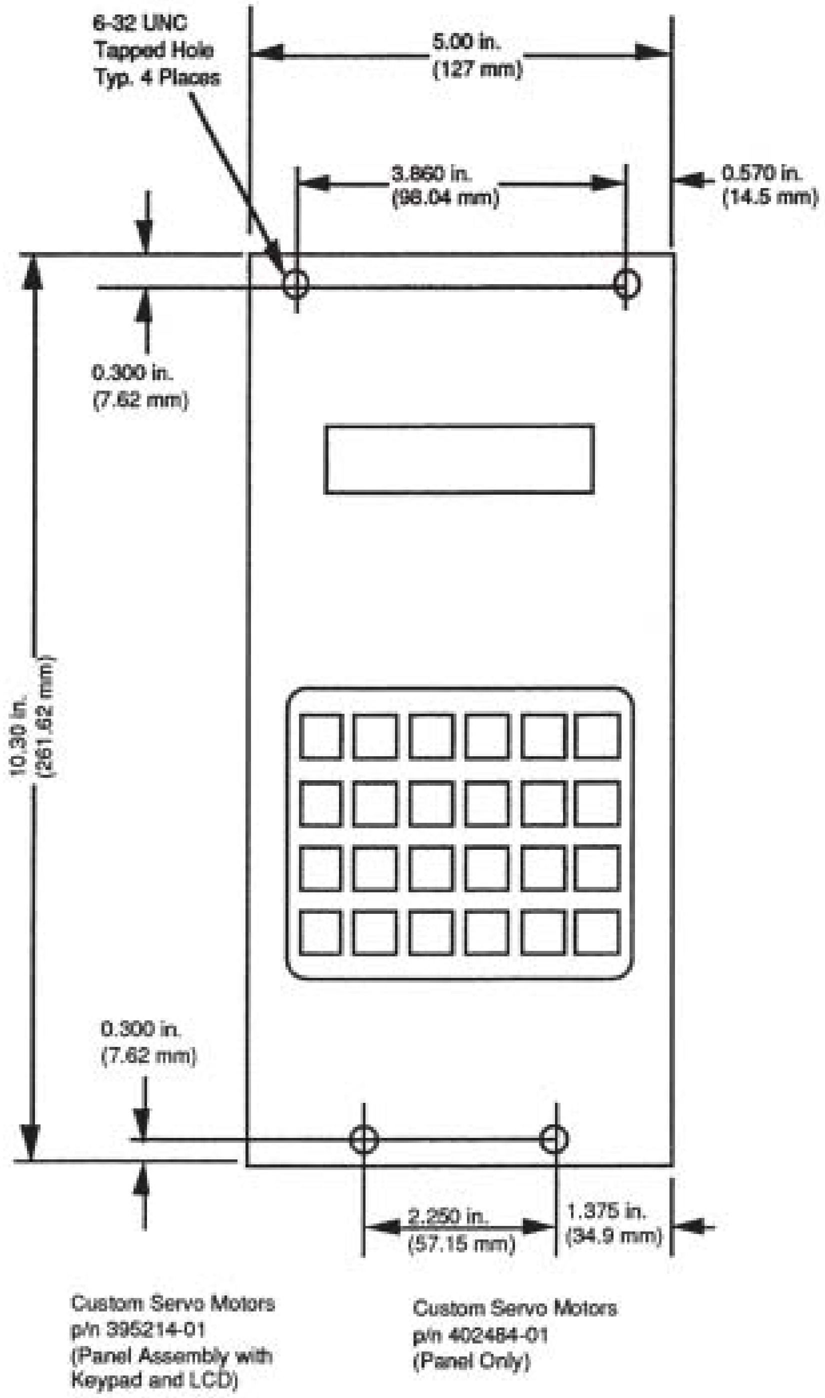


Figure 13-5. Optional Mounting Panel Dimensions

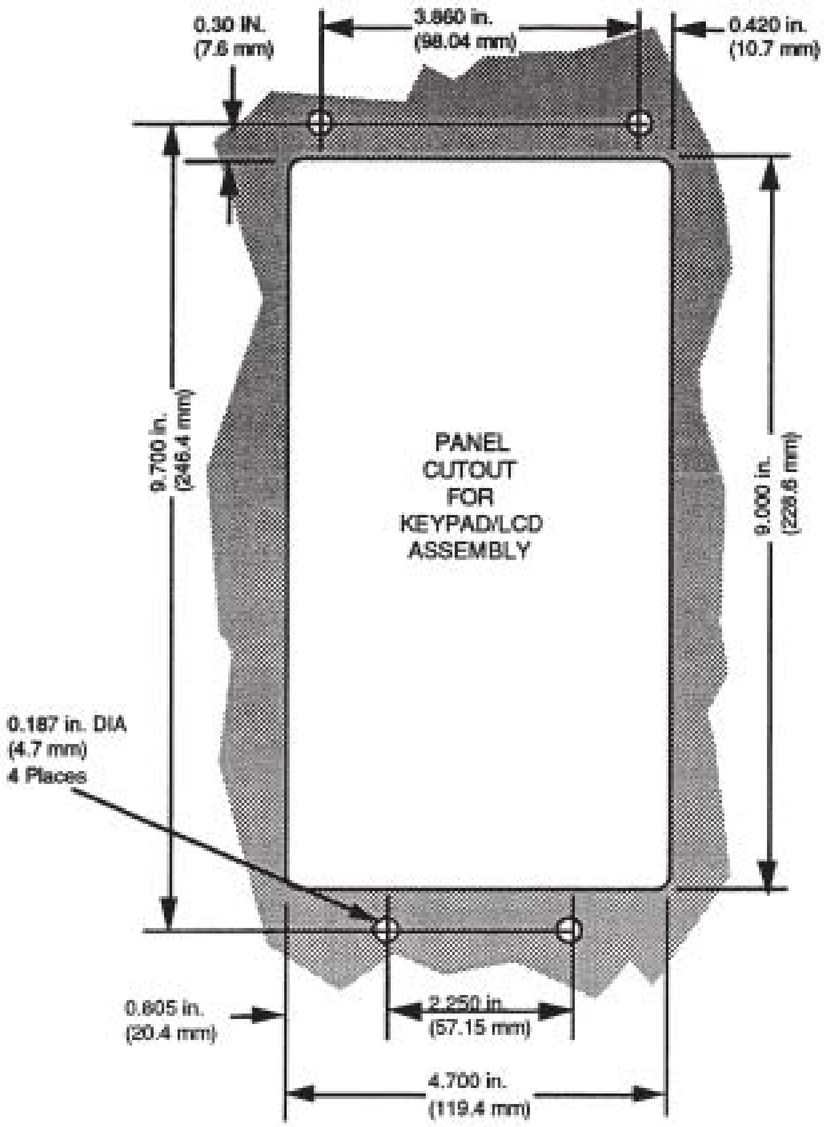


Figure 13-6. Panel Cutout for Optional Mounting

CAUTION

Do not press keys with sharp objects such as pens or screwdrivers, as this may damage the keys.

Troubleshooting the Keypad

Problem	Nothing can be entered from the Keypad.
Steps	1. Check the address DIP switch on the Keypad to see if it is set correctly. All of the address switches must be set to the off position. 2. Check that the cable going to the Keypad is connected to the correct 32 Input/Output Interface (card number 8). 3. Check for correct setting of the power supply jumpers on the 32 I/O card number 8. 4. Check the cable from the 32 I/O card number 8 to the Keypad. 5. Replace the Keypad.
Problem	Data is incorrect when entered from the Keypad
Steps	1. Check the cable from the 32 I/O card to the Keypad. 2. Check the address DIP switch on the Keypad to see if it is set correctly. All of the address switches must be set to the off position. 3. Check the INCOL86 application program. 4. Replace the Keypad

Specifications

Parameter	Specification
Key dimensions	0.5 in. x 0.5 in. on centers 0.75 in. apart (12.7 mm x 12.7 mm on centers 19.05 mm apart)
Overlay material	Oil-resistant Mylar
Keyboard or switch matrix:	
Keyboard type	4 x 5 matrix (maximum)
Number of switches	20 (maximum)
Switch type	spst
Switch ON resistance	50 kΩ (maximum)
Terminals	9-pin single row on 0.1 in. (2.5 mm) centers
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing
Power requirements	+12 Vdc at 2 mA

14 Model 473.07c Remote Thumbwheel

Introduction

The Model 473.07c Remote Thumbwheel is designed for use in an industrial environment as an operator interface device. It provides a convenient means of parameter entry on Motion Plus/473 controllers.

Standard features of the Remote Thumbwheel include the following:

- Remote Data Bus compatibility
- Can be mounted up to 100 ft from the controller

Options include:

- Up to 32 thumbwheel assemblies on a single Remote Data Bus cable.
- Up to 6 characters of numeric input on a single thumbwheel assembly

Figure 14-1 shows the location of important components on the Remote Thumbwheel.

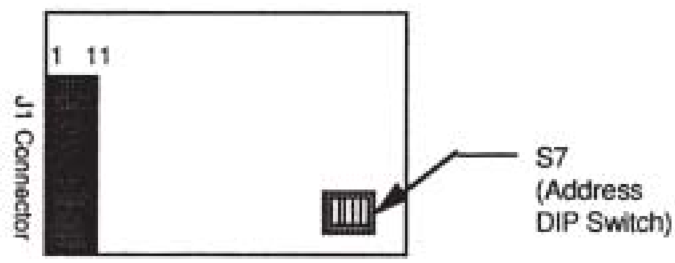


Figure 14-1. Model 473.07c Remote Thumbwheel Component Location

Address DIP Switch

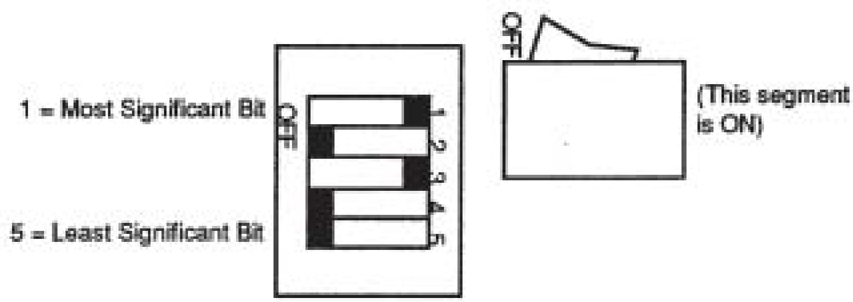
The 5-segment DIP switch is used to set the address for any of 32 different modules on a single Remote Data Bus. No two devices on a Remote Data Bus can be set to the same address. Table 14-1 shows the possible switch settings.

Table 14-1. Address Switch Setting for Remote Thumbwheel

Switch Settings:

1 = ON
0 = OFF

Example:



bit pattern = 10100
Thumbwheel No. = 21

Thumbwheel Number	Setting 12345	Thumbwheel Number	Setting 12345
1	00001	17	10001
2	00010	18	10010
3	00011	19	10011
4	00100	20	10100
5	00101	21	10101
6	00110	22	10110
7	00111	23	10111
8	01000	24	11000
9	01001	25	11001
10	01010	26	11010
11	01011	27	11011
12	01100	28	11100
13	01101	29	11101
14	01110	30	11110
15	01111	31	11111
16	10000	32	00000

Wiring

NOTE

The Remote Thumbwheel is used only with the Model 473.10c 32 I/O Interface Card #8.

Connector J1 (3M part number 3428-2302) on the Remote Thumbwheel provides connection to the Remote Data Bus. This connector is keyed to prevent misorientation of the mating connector.

Cabling

The Remote Thumbwheel is connected to 32 I/O Interface Card #8 using The Model 473.50c-10A-00X Remote Data Bus Cable (Custom Servo Motors part number 393709-xx).

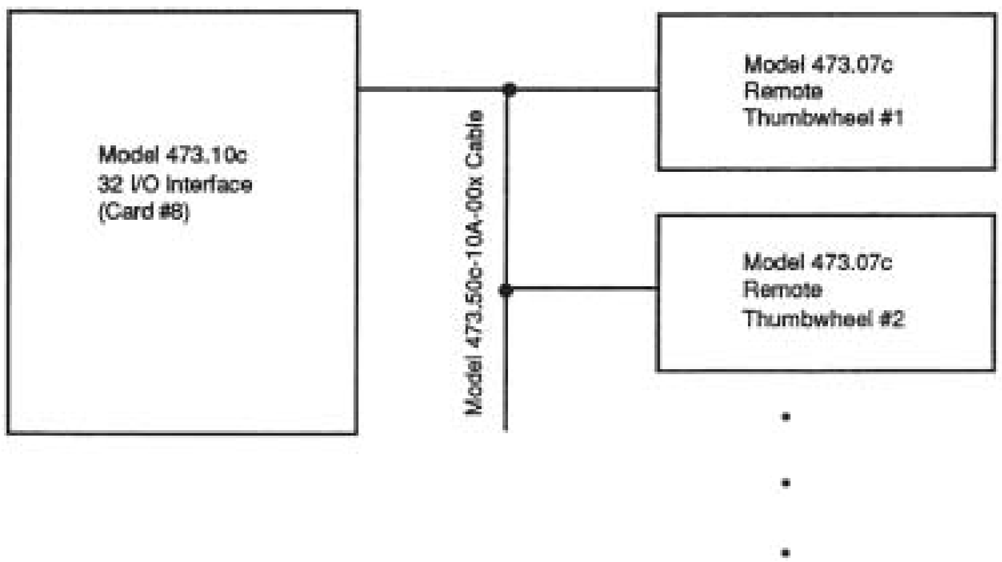


Figure 14-2. Cable Configuration for the Remote Thumbwheel

Setup

Take the following steps to set up the Remote Thumbwheel:

1. Remove power from the controller.
2. Connect the Remote Thumbwheel to the Remote Data Bus cable
3. Verify that the Remote Data Bus Cable is connected to 32 I/O Interface Card #8.
4. Verify that the DIP switch on the Remote Thumbwheel is set to the required address.

Installing the Remote Thumbwheel

Figure 14-4 shows mounting dimensions for the Remote Thumbwheel.

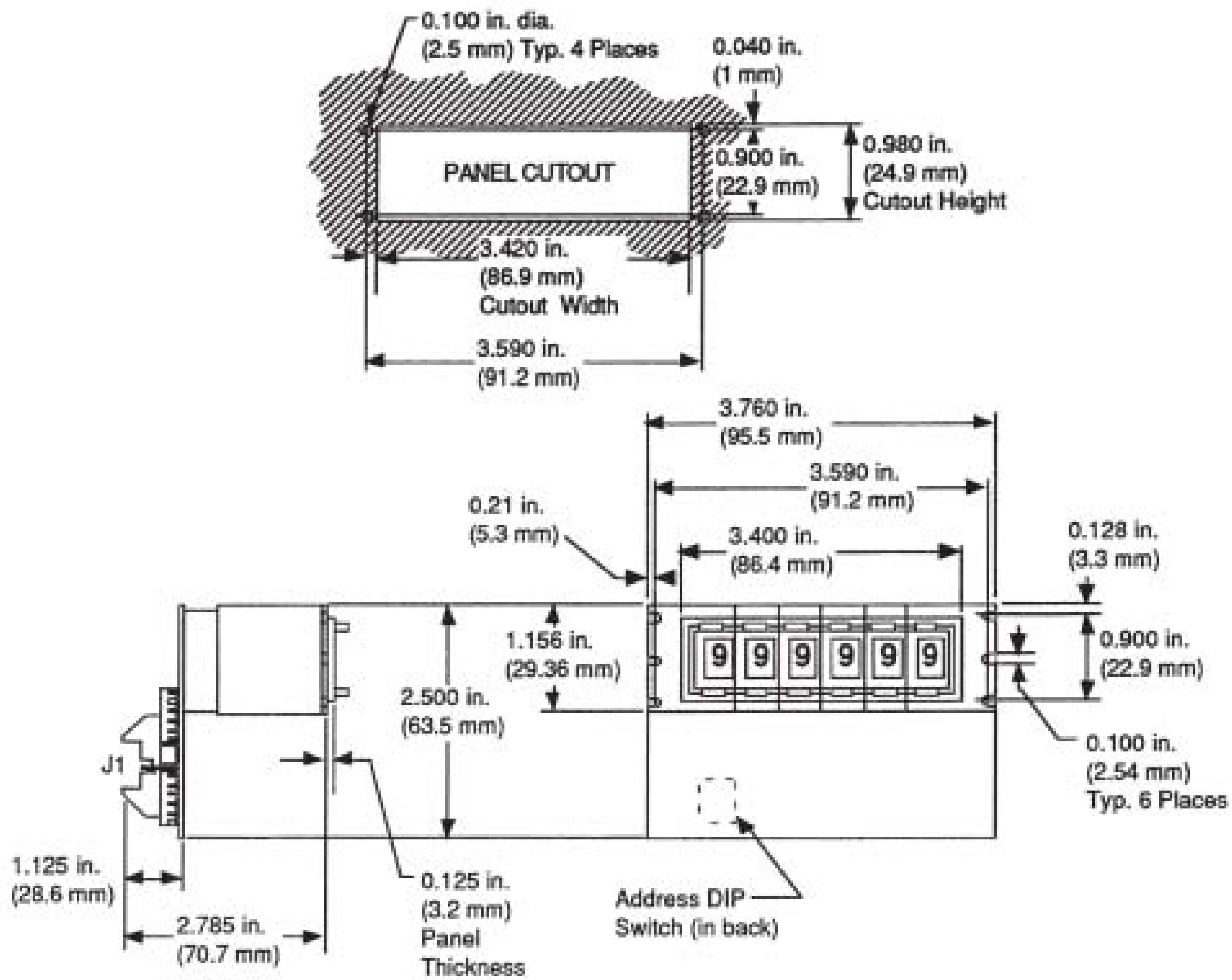


Figure 14-4. 473.07c Thumbwheel Mounting Dimensions

Troubleshooting the Thumbwheel Assembly

Problem	Nothing can be entered from the Thumbwheel.
Steps	1. Check the address DIP switch on the Thumbwheel to see if it is set correctly. 2. Check that the cable going to the Thumbwheel is connected to the correct 32 Input/Output Interface (card number 8). 3. Check for correct setting of the power supply jumpers on the 32 I/O card number 8. 4. Check the cable from the 32 I/O card number 8 to the Thumbwheel. 5. Check the INCOL86 application program. 6. Replace the Thumbwheel Assembly.
Problem	Data is incorrect when entered from the Thumbwheel
Steps	1. Check the cable from the 32 I/O card to the Thumbwheel. 2. Check the address DIP switch on the Thumbwheel to see if it is set correctly. 3. Check the INCOL86 application program. 4. Replace the Thumbwheel Assembly.

Specifications

Parameter	Specification
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing
Power requirements	+12 Vdc ±1.2 V at 10 mA

15 Model 473.09c Numeric LED Display

Introduction

The Model 473.09c Numeric LED Display is designed for use in an industrial environment as an operator interface device. It provides a convenient means of displaying numeric parameters from Motion Plus/473 controllers.

Standard features of the Numeric LED Display include the following:

- Remote Data Bus compatibility
- Can be mounted up to 100 ft from the controller
- 7 digits of display including 6 numeric and 1 overflow (±)
- 0.40 in. numeral height
- Integral bezel and display filter (Panel Graphic Scarlet 65 or equivalent)

Options include:

- Up to 16 LED Displays on a single Remote Data Bus cable
- External power supply connector

Figure 15-1 shows the location of important components on the Numeric LED Display.

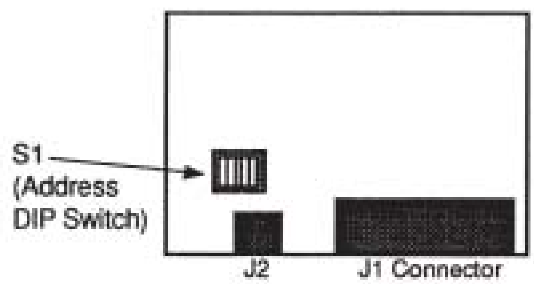


Figure 15-1. Model 473.09c Numeric LED Display Component Location

Address DIP Switch

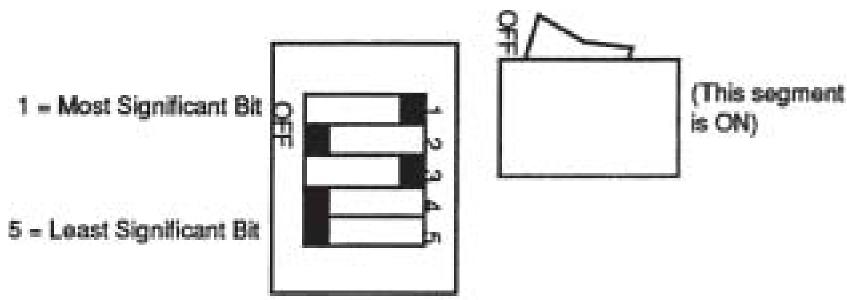
The 5-segment DIP switch is used to set the address for any of 32 different modules on a single Remote Data Bus. No two devices on a Remote Data Bus can be set to the same address. Table 15-1 shows the possible switch settings.

Table 15-1. Address Switch Setting for Numeric LED Display

Switch Settings:

1 = ON
0 = OFF

Example:



bit pattern = 10100
LED Display No. = 20

LED Display. Number	Setting 12345	LED Display. Number	Setting 12345
2	00010	18	10010
4	00100	20	10100
6	00110	22	10110
8	01000	24	11000
10	01010	26	11010
12	01100	28	11100
14	01110	30	11110
16	10000	32	00000

Wiring

NOTE

The Numeric LED Display is used only with the Model 473.10c 32 I/O Interface Card #8.

Connector J1 (3M part number 3428-2302) on the Numeric LED Display provides connection to the Remote Data Bus. This connector is keyed to prevent misorientation of the mating connector.

Cabling

The Numeric LED Display is connected to 32 I/O Interface Card #8 using the Model 473.50c-10A-00X Remote Data Bus Cable (Custom Servo Motors part number 393709-xx).

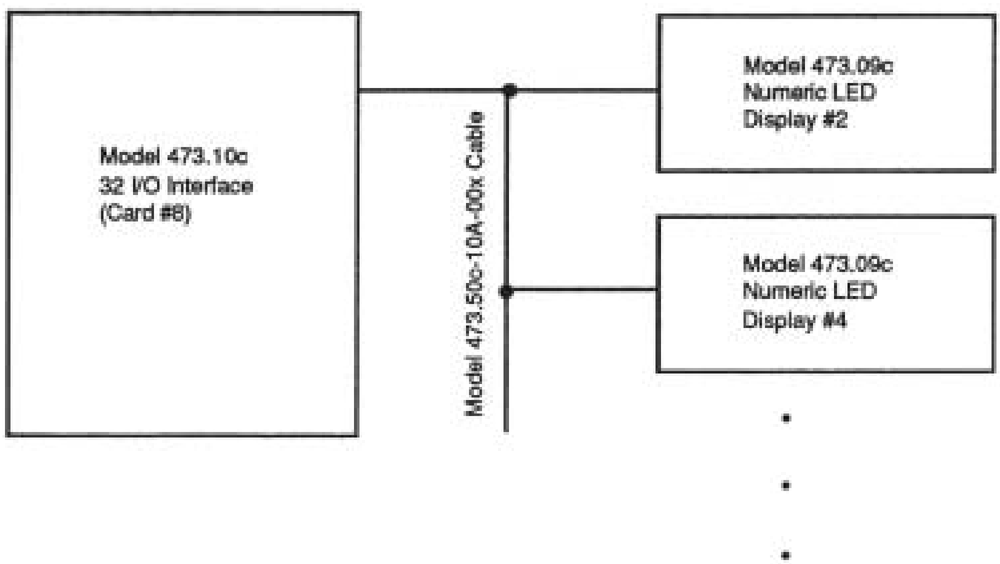


Figure 15-2. Cable Configuration for the Numeric LED Display

External Power Supply Option

NOTE

If an external power supply is used as shown, all devices on the Remote Data Bus will be tied to that external supply. You must remove jumpers X1 and X2 from the 32 I/O Interface before connecting an external supply.

CAUTION

No more than 5 Numeric LED Displays can use the internal +12 Vdc power supply on the Remote Data Bus. Systems requiring more than 5 Numeric LED Displays must use an external +12 Vdc power supply.

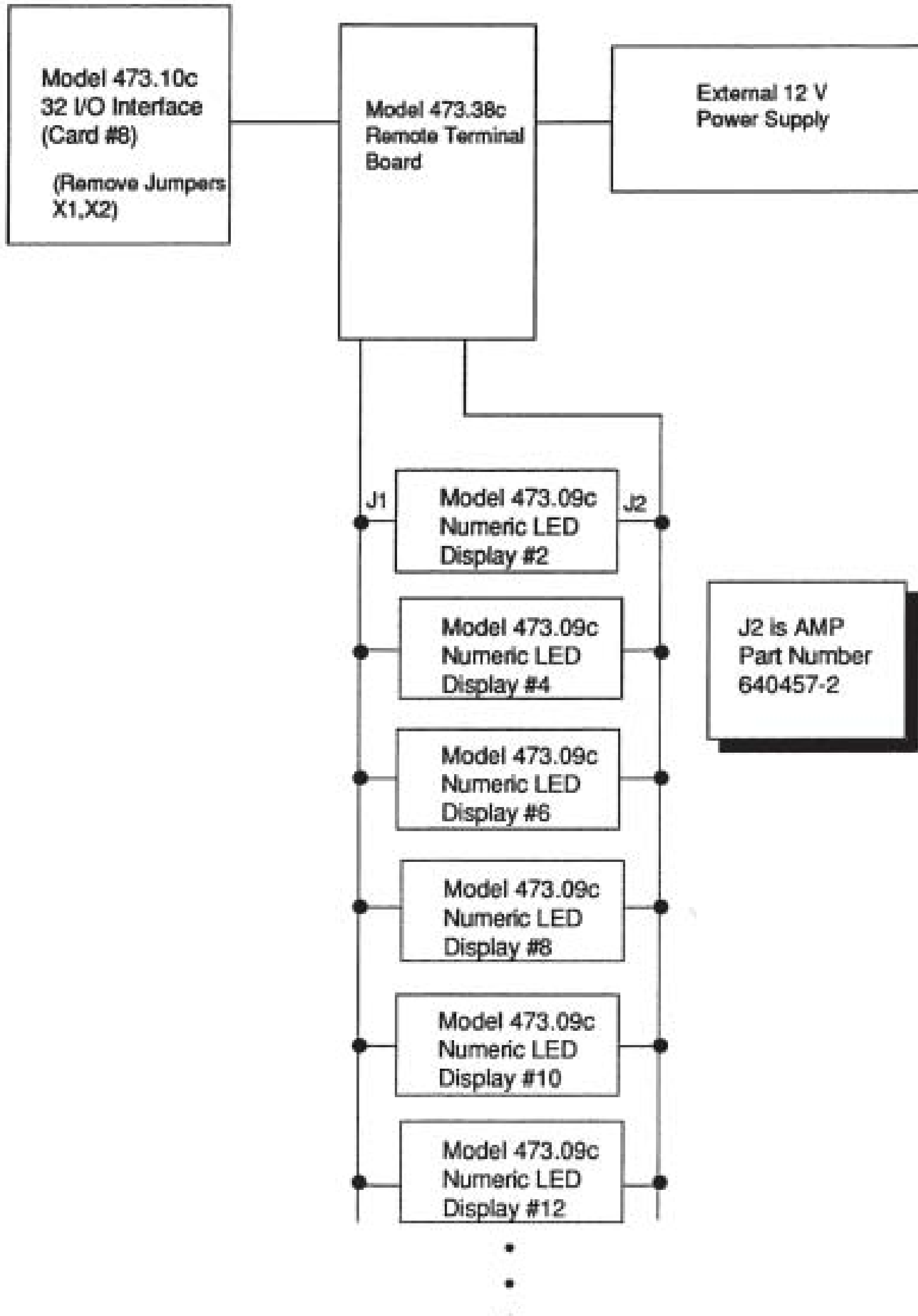


Figure 15-3. Cable Configuration for the Optional External Power Supply With More Than Five Numeric LED Displays

Setup

Take the following steps to set up the Numeric LED Display:

1. Remove power from the controller.
2. Connect the Numeric LED Display to the Remote Data Bus cable
3. Verify that the Remote Data Bus Cable is connected to 32 I/O Interface Card #8.
4. Verify that the DIP switch on the Numeric LED Display is set to the required address.

Installing the Numeric LED Display

Figure 15-4 shows mounting dimensions for the Numeric LED Display.

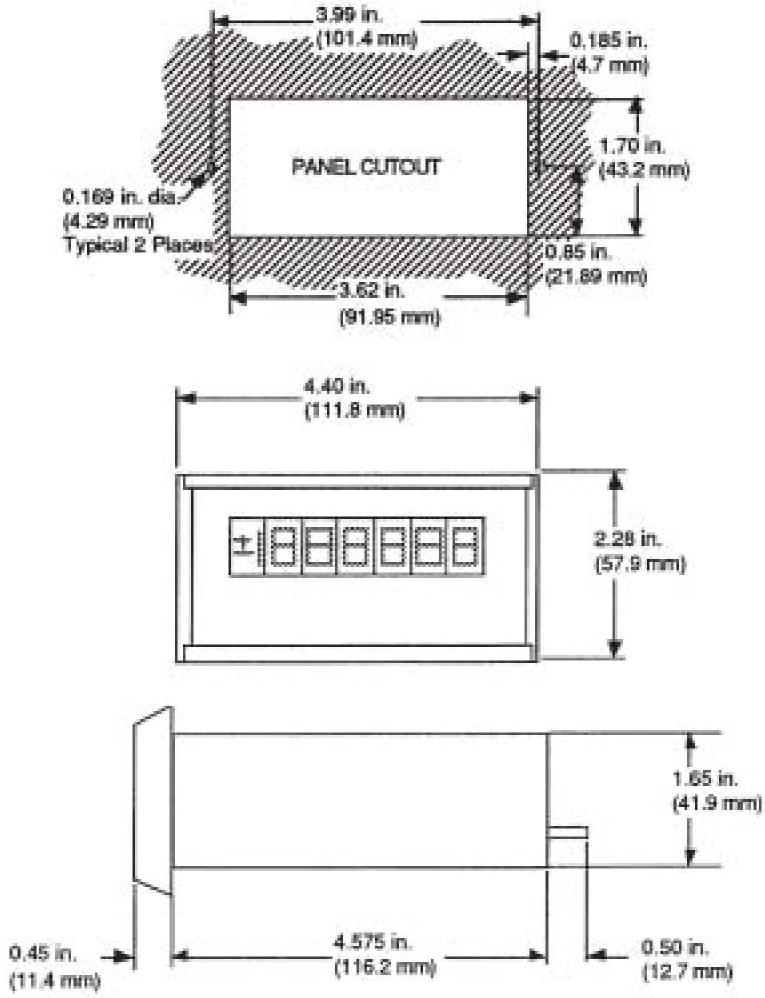


Figure 15-4. Numeric LED Display Mounting Dimensions

Troubleshooting the LED Display

Problem	Data is not displayed on the LED Display.
Steps	1. Check the address DIP switch on the LED Display to see if it is set correctly. Remember that only even numbers from 2 to 32 can be used. 2. Check that the cable going to the LED Display is connected to the correct 32 Input/Output Interface (card number 8). 3. Check for correct setting of the power supply jumpers on the 32 I/O card number 8. 4. Check the cable from the 32 I/O card number 8 to the LED Display. 5. Check the INCOL86 application program. 6. Replace the LED Display.

Problem	Data is incorrect when displayed on the LED Display
Steps	1. Check the cable from the 32 I/O card to the LED Display. 2. Check the address DIP switch on the LED Display to see if it is set correctly. Every LED Display module must have a unique even-numbered address in the range 2 to 32. 3. Check the INCOL86 application program. 4. Replace the LED Display.

Specifications

Parameter	Specification
Character size	0.25 in. x 0.40 in. (6.35 mm x 10.16 mm)
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing
Power requirements	+12 Vdc ±1.2 V at 0.275 A

16 Model 473.13c Remote LCD Display

Introduction

The Model 473.13c Remote LCD Alphanumeric Display provides Motion Plus/473 controllers with a means of displaying alphanumeric parameters .

Standard features of the Remote LCD Display include the following:

- Remote Data Bus compatibility
- 2 row by 20 column alphanumeric display
- Viewing angle adjustment
- Can be mounted up to 100 ft from the controller

An optional panel allows the LCD Display to be mounted at a remote location or on an optional Model 473.40c and 473.41c chassis.

Figure 16-1 shows the location of important components on the Remote LCD Display.

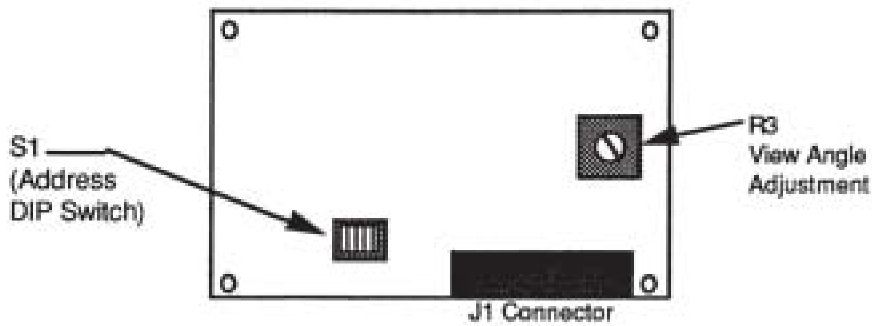


Figure 16-1. Model 473.13c Remote LCD Display Component Location

Address DIP Switch

The 5-segment DIP switch must be set with all segments in the ON position. Only one Remote LCD Display can be used on the Remote Data Bus. Figure 16-2 shows a the switch setting.

Switch Settings: 1 = ON
0 = OFF

Segment	1	2	3	4	5
Setting	1	1	1	1	1

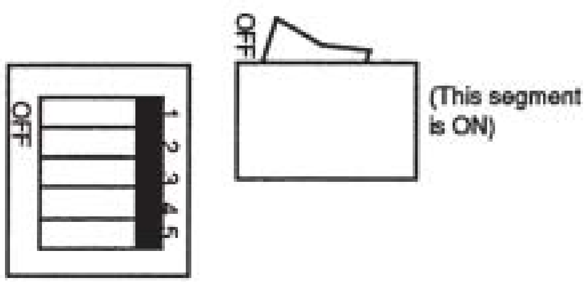


Figure 16-2. DIP Switch Setting

Wiring

NOTE

The Remote LCD Display is used only with the Model 473.10c 32 I/O Interface Card #8.

Connector J1 (3M part number 3428-2302) on the Remote LCD Display provides connection to the Remote Data Bus. This connector is keyed to prevent misorientation of the mating connector.

Cabling

The Remote LCD Display is connected to 32 I/O Interface Card #8 using The Model 473.50c-10A-00X Remote Data Bus Cable (Custom Servo Motors part number 393709-xx).

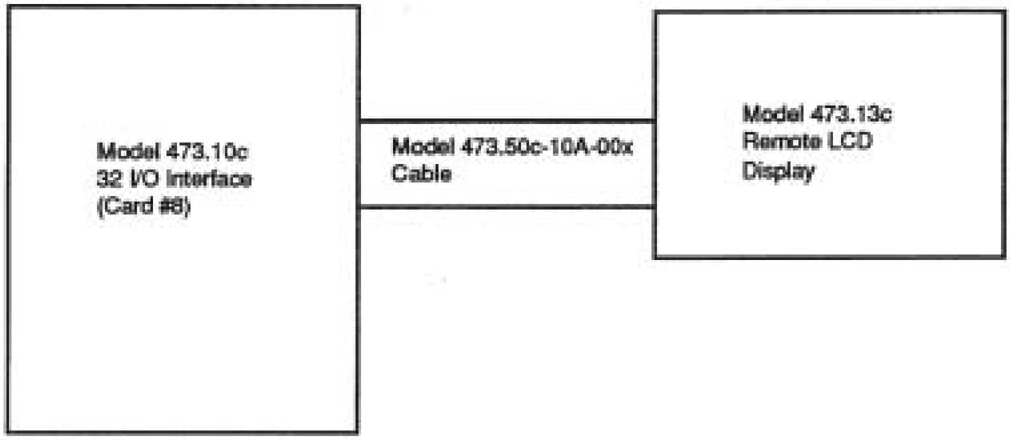


Figure 16-3. Cable Configuration for the Remote LCD Display

Setup

Take the following steps to set up the Remote LCD Display:

1. Remove power from the controller.
2. Connect the Remote LCD Display to the Remote Data Bus cable
3. Verify that the Remote Data Bus Cable is connected to 32 I/O Interface Card #8.
4. Verify that all DIP switch segments on the Remote LCD Display are set to the ON position.

Installing the Remote LCD Display

Figure 16-4 shows mounting dimensions for the Remote LCD Display.

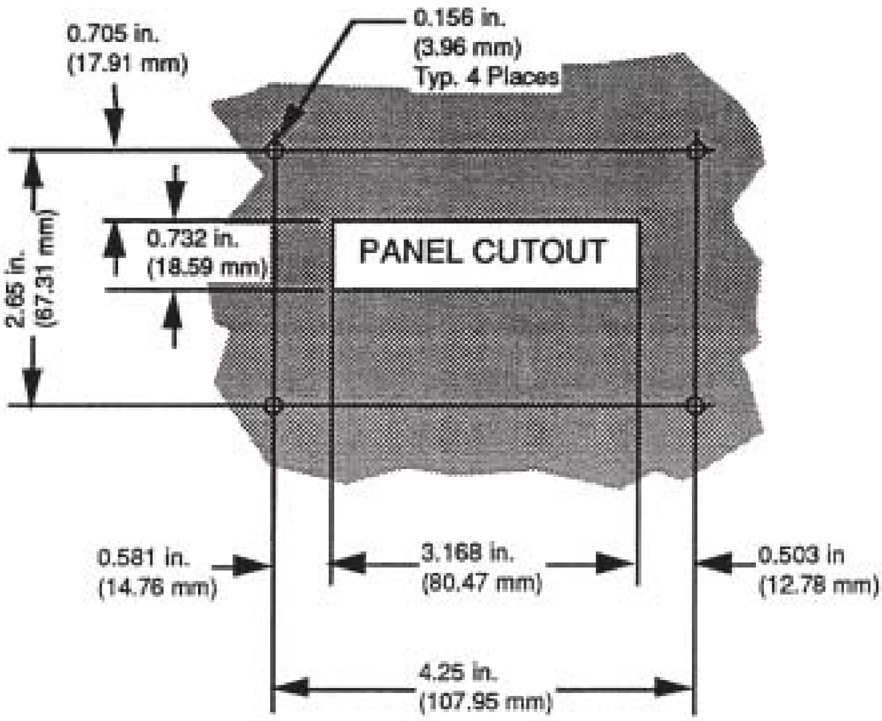


Figure 16-4. 473.13c LCD Display Mounting Dimensions

Optional Installation

The Model 473.83-01A-000 Assembly (Custom Servo Motors part number 395214-01) includes the Remote LCD Display, the Model 473.06c Remote Keypad, and a mounting plate with gaskets. This assembly can be mounted on optional versions of the Model 473.40c 6-slot Chassis and Model 473.41c 12-slot Chassis. Those chassis versions are equipped with optional panels.

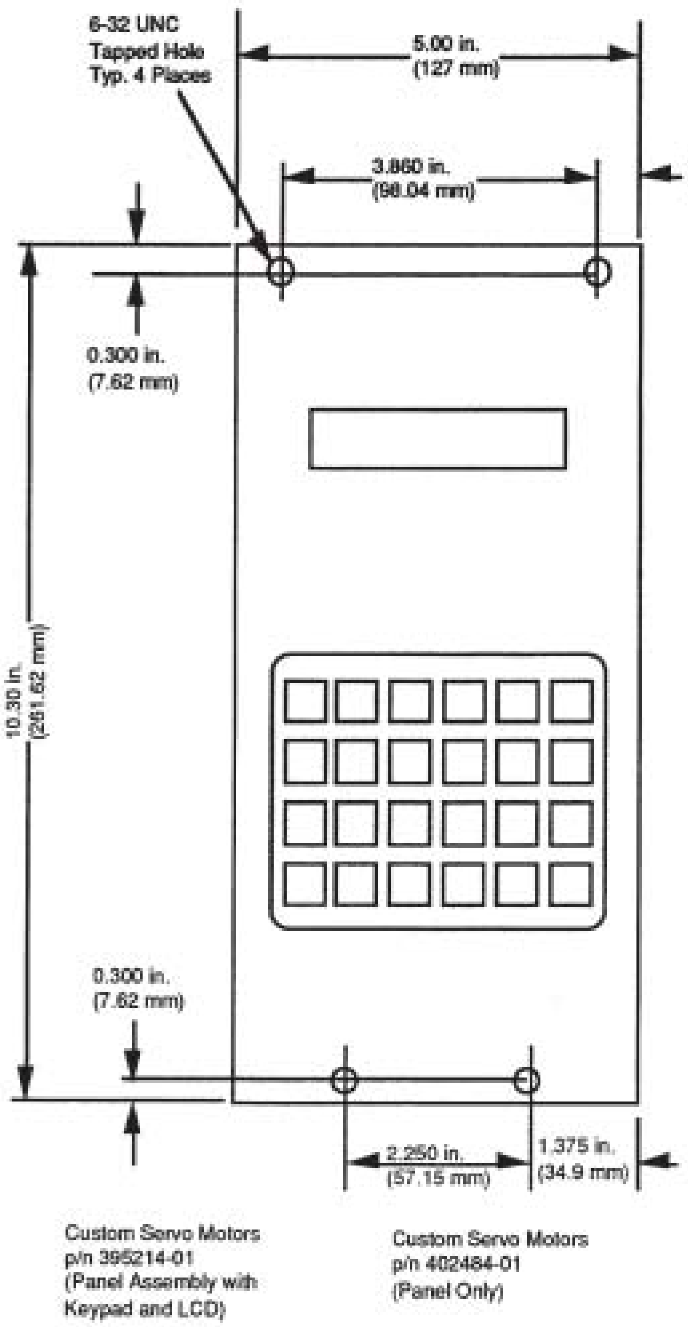


Figure 16-5. Optional Mounting Panel Dimensions

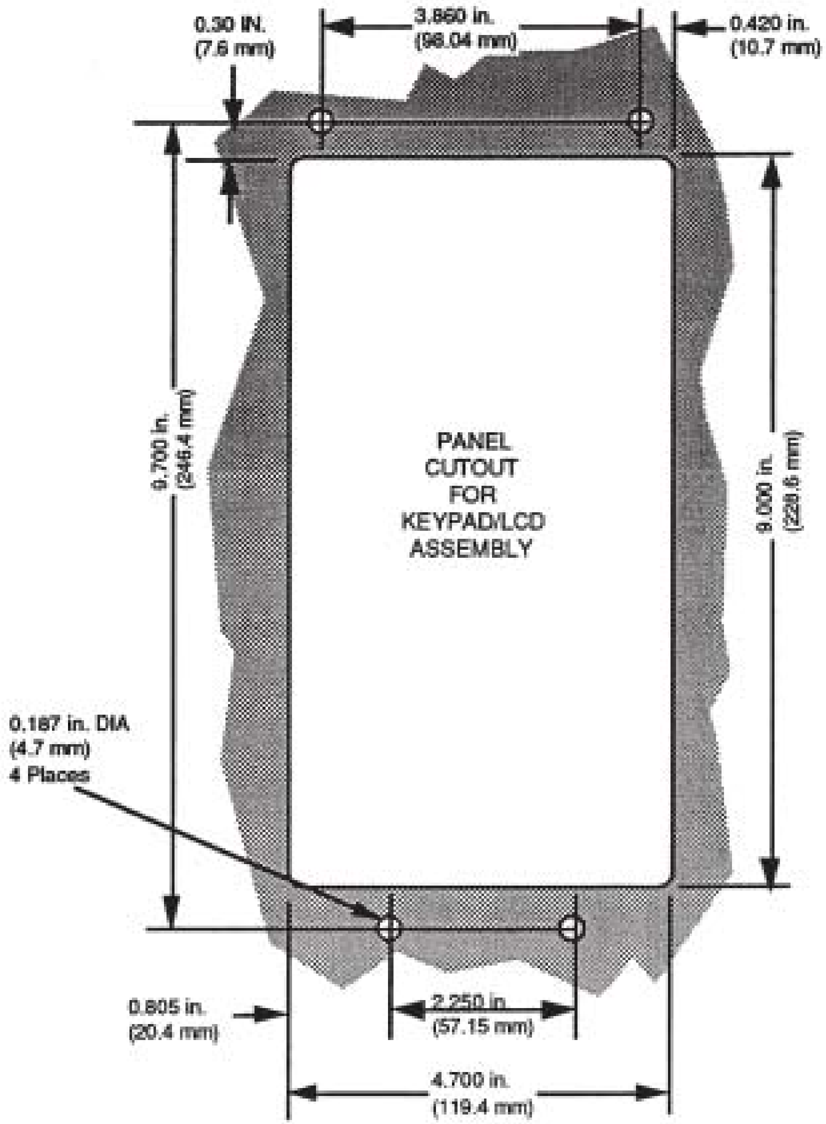


Figure 16-6. Panel Cutout for Optional Mounting

Adjustments

A single turn potentiometer, R3, is provided on the circuit board for adjusting the viewing angle.

⚠ CAUTION

Do not use a metal screwdriver to adjust the LCD viewing angle potentiometer. A plastic adjustment tool is recommended. Using a metal screwdriver can cause a short-circuit and damage the LCD Display.

Troubleshooting the LCD Display

Problem	Nothing displayed on the LCD Display except black squares on the top row.
Steps	1. Check the address DIP switch on the LCD Display to see if it is set correctly. All of the address switches must be set to the ON position. 2. Check that the cable going to the Keypad is connected to the correct 32 Input/Output Interface (card number 8). 3. Check for correct setting of the power supply jumpers on the 32 I/O card that is addressed to number 8. 4. Check the cable from the 32 I/O card number 8 to the LCD Display. 5. Replace the LCD Display.
Problem	Display clears the top row but can not print any data on the LCD Display.
Steps	1. Check the cable from the 32 I/O card to the LCD display. 3. Check for correct setting of the power supply jumpers on the 32 I/O card number 8. 3. Check the INCOL86 application program.
Problem	Data is incorrectly displayed on the LCD Display
Steps	1. Check the cable from the 32 I/O card to the LCD Display.

2. 1. Check the address DIP switch on the LCD Display to see if it is set correctly. All of the address switches must be set to the ON position.
3. Check the INCOL86 application program.
4. Replace the LCD Display

Specifications

Parameter	Specification
Display configuration	2 rows by 20 columns
Character type	5 x 7 dot matrix LCD
Character size (4.9 mm x 3.2 mm)	0.191 in. high x 0.126 in. wide
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing
Power requirements	+12 Vdc ±1.2 Vdc at 7 mA

17 Model 473.08c CRT Interface

Introduction

The Model 473.08c CRT Interface provides a composite video signal for use with appropriate CRT monitors or a TTL video output compatible with an IBM PC monochrome display.

Standard features of the CRT Interface include the following:

- 7 x 9 dot characters on a 9 x 11 dot field
- 16 line by 64 column display format
- EIA RS170 compatibility (composite video output) OR IBM PC monochrome compatibility
- ASCII character generator
- Reverse video and cursor operation
- Monitor operation up to 100 feet (for composite output only)

Figure 17-1 shows the location of important components on the CRT Interface.

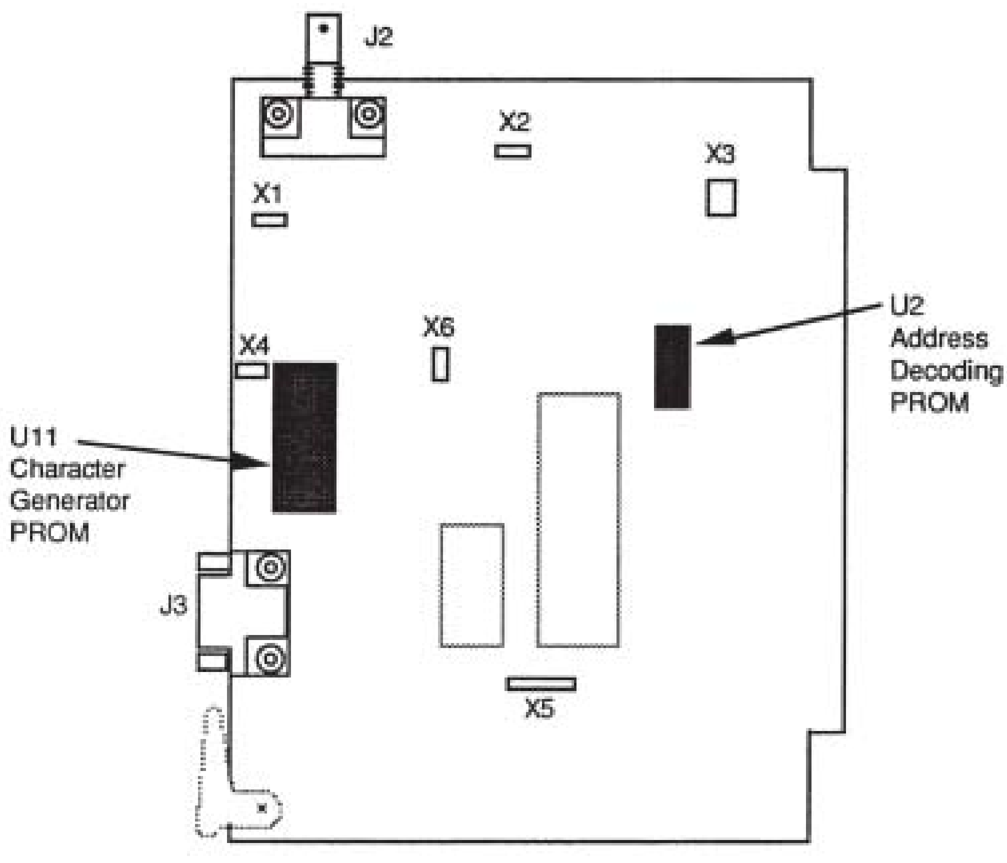


Figure 17-1. Model 473.08c CRT Interface Component Location

Jumpers

Set the jumpers on the CRT Interface using Table 17-1. The standard connection for all jumpers is listed under Type 0. jumper is noted in the table. Refer to Figure 17-1 for jumper locations. (The numbered types at the top of the table must be set by the INCOL86 instruction CRTTYPE.)

Table 17-1. Model 473.08c CRT Interface Jumper Settings

INCOL86 CRTTYPE	Type 0 (standard)	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
Rows	16	25	16	8	8	16	25	16
Columns	64	80	32	32	16	64	80	64
Monitor Type	Composite	Composite	Composite	Composite	Composite	Composite	Composite	IBM Mono
Jumper X1	1–2	1–2	1–2	1–2	1–2	1–2	1–2	2–3
Jumper X2	1–2	1–2	1–2	1–2	1–2	1–2	1–2	1–2
Jumper X3	1–6	1–6	1–6	1–6	1–6	1–6	1–6	1–6
Jumper X4	1–2	1–2	1–2	2–3	2–3	1–2	1–2	1–2
Jumper X5	1–2, 4–5	1–2, 4–5	1–2, 4–5	1–2, 3–4	2–3, 4–5	1–2, 4–5	1–2, 4–5	1–2, 4–5
Jumper X6	1–2	1–2	1–2	1–2	1–2	1–2	1–2	1–2
Custom modifica-tions	None	None	Change Y1 6.5536 Mhz	Change Y1 6.5536 Mhz	Change Y1 3.2768 Mhz	Change Y1 16.0000 Mhz	Change Y1 16.0000 Mhz	None

INCOL86 CRTTYPE	Type 8	Type 9	Type 10	Type 11	Type 12	Type 13	Type 14	Type 15
Rows	25	20	16	8	8	20	10	10
Columns	80	64	32	32	16	32	32	16
Monitor Type	IBM Mono	IBM Mono	IBM Mono	IBM Mono	IBM Mono	IBM Mono	IBM Mono	IBM Mono
Jumper X1	2–3	2–3	2–3	2–3	2–3	2–3	2–3	2–3
Jumper X2	2–3	1–2	1–2	1–2	1–2	1–2	1–2	1–2
Jumper X3	1–6	1–6	2–5	2–5	3–4	2–5	2–5	3–4
Jumper X4	1–2	1–2	1–2	2–3	2–3	1–2	2–3	2–3
Jumper X5	1–2, 4–5	1–2, 4–5	1–2, 4–5	1–2, 3–4	2–3, 4–5	1–2, 4–5	1–2, 3–4	2–3, 4–5
Jumper X6	1–2	1–2	1–2	1–2	1–2	1–2	1–2	1–2
Custom modifica-tions	None	None	None	None	None	None	None	None

INCOL86 CRTTYPE	Type 16	Type 17	Type 18	Type 19	Type 20	Type 21	Type 22
Rows	16	25	20	16	8	8	20
Columns	64	80	64	32	32	16	32
Monitor Type	Composite	Composite	Composite	Composite	Composite	Composite	Composite
Jumper X1	1–2	1–2	1–2	1–2	1–2	1–2	1–2
Jumper X2	1–2	2–3	1–2	1–2	1–2	1–2	1–2
Jumper X3	1–6	1–6	1–6	2–5	2–5	3–4	2–5
Jumper X4	1–2	1–2	1–2	1–2	2–3	2–3	1–2
Jumper X5	1–2, 4–5	1–2, 4–5	1–2, 4–5	1–2, 4–5	1–2, 3–4	2–3, 4–5	1–2, 4–5
Jumper X6	1–2	1–2	1–2	1–2	1–2	1–2	1–2
Custom modifica-tions	None	None	None	None	None	None	None

PROMs

Two standard PROMs are used on the Model 473.08c CRT Interface: an 8K x 8 EPROM is used for character generation, and a 32 x 8 PROM is used for address decoding.

Character generator	Custom Servo Motors part no. 474268-01
Address decoder	Custom Servo Motors part no. 371536-01

Wiring

Connector J2 on the CRT Interface is a BNC connector, AMP part no. 226978-1. Table 17-2 shows pin definitions for this connector.

Table 17-2. J2 Pin Definitions

J2 Pin	Name
1	Composite video output
2	Signal ground

Connector J3 on the CRT Interface is a 9-pin D connector, AMP part no. 745131-2. Table 17-3 shows pin definitions for this connector.

Table 17-3. J3 Pin Definitions

J3 Pin	Name
1	Ground
2	Shield
6	Highlight (Intensity)
7	Video
8	Horizontal
9	Vertical

Cabling

The standard cable used with the CRT Interface is Model 473.50c-13A-300 (Custom Servo Motors part number 384976-xx). This cable connects the CRT Interface J2 to the CRT Monitor, as shown in Figure 17-2.

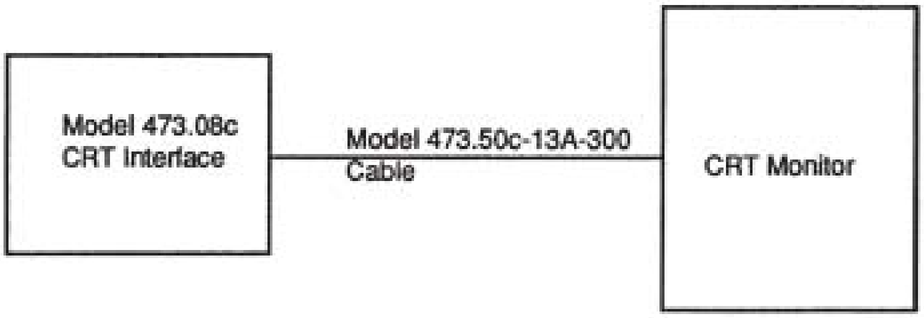


Figure 17-2. Cable Configuration for the CRT Interface

The standard cable used with the IBM compatible output (J3) is normally supplied with the monitor.

Installing the CRT Interface

CAUTION

Make sure chassis power is OFF before installing the CRT Interface.

The CRT Interface requires one slot in the chassis. Only one CRT interface can be installed in a chassis.

Troubleshooting the CRT Interface

Problem	No display or incorrect display.
Steps	1. Check the ac power wiring to the monitor. 2. Check the cable from the CRT Interface to the CRT Monitor. 3. Check the address PROM on the CRT Interface. It must be part number 371536-01. 4. Check that the brightness and contrast adjustments on the monitor are set to a proper viewing level. These adjustments are factory-set. You can turn up the brightness control until the raster of the monitor is visible. If the raster is not visible, replace the CRT Monitor. 5. Make sure the jumpers are set correctly for the monitor used. 6. Make sure that the CRT type selected in software (using CRTTYPE) is correct for the monitor used.
Problem	CRT has "noise" in the display.
Steps	1. Make sure that the cable from the CRT Interface to the CRT display has a good connection on the ground terminals.

Specifications

Parameter	Specification
Video output	EIA RS170 composite video or TTL positive video
Impedance	75 Ω (J2 only)
Character format	7 x 9 dot character on 9 x 11 dot field (standard)
Display format	16 line by 64 column (standard)
Power requirements	+5 Vdc at 0.6 A (PWA only)
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing

18 Model 473.91c CRT Display Monitors

Introduction

The Model 473.91c CRT Display Monitors provide a method of displaying alphanumeric data from Motion Plus/473 Control systems. Two CRT Display Monitors are available:

Model Number	Custom Servo Motors Part Number	Description
473.91c-09A-003	457570-01	9-inch diagonal open chassis (Kristel)
473.91c-09A-004	475635-01	12-inch diagonal enclosed chassis

Standard features of the CRT Display Monitors include the following:

- Either a 9-inch open chassis or 12-inch enclosed chassis
- Amber phosphor display
- RS170 composite video input or IBM PC compatible positive TTL video

Figures 18-1 and 18-2 show the location of important components on the Monitors.

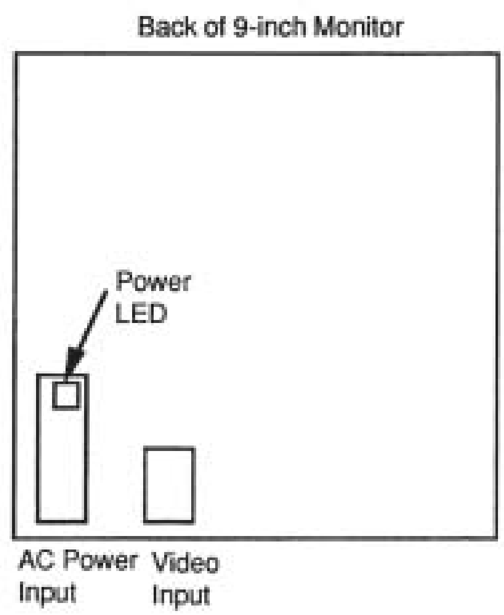


Figure 18-1. Model 473.91c-003 CRT Display Monitor Component Location (9-inch Monitor)

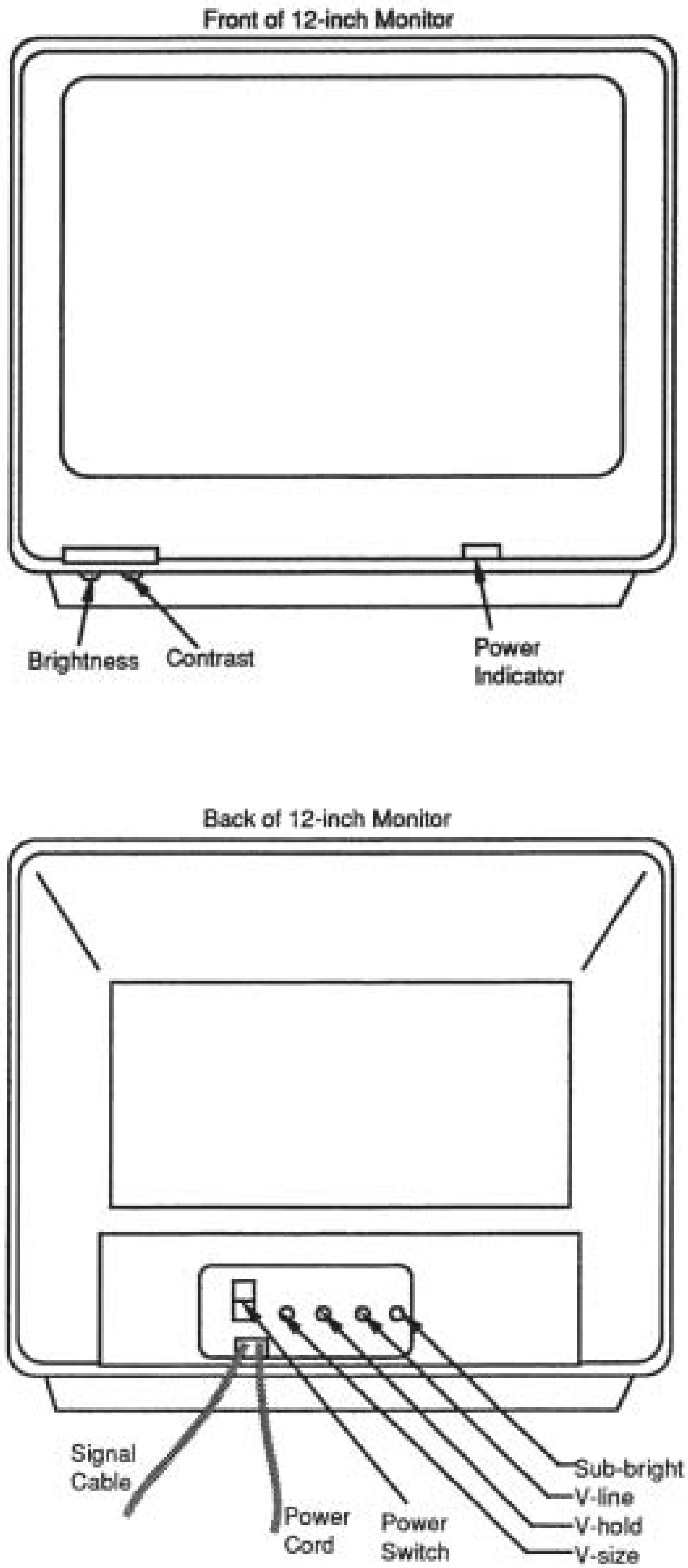


Figure 18-2. Model 473.91c-004 CRT Display Monitor Component Location (12-inch Monitor)

Cabling

The standard cable used with the 9-inch CRT Display Monitor is Model 473.50c-13A-300 (Custom Servo Motors part number 384976-xx). This cable connects the CRT Monitor to the Model 473.08c CRT Interface, as shown in Figure 18-3.

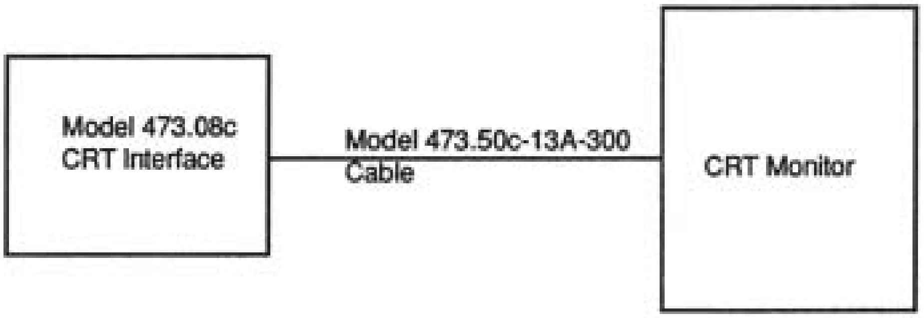


Figure 18-3. Cable Configuration for the 9-inch CRT Display Monitor

The standard cable used with the 12-inch CRT Display Monitor is provided with the Monitor.

Installing the CRT Display Monitor

Mounting dimensions for the 9-inch CRT monitor are shown in Figure 18-3.

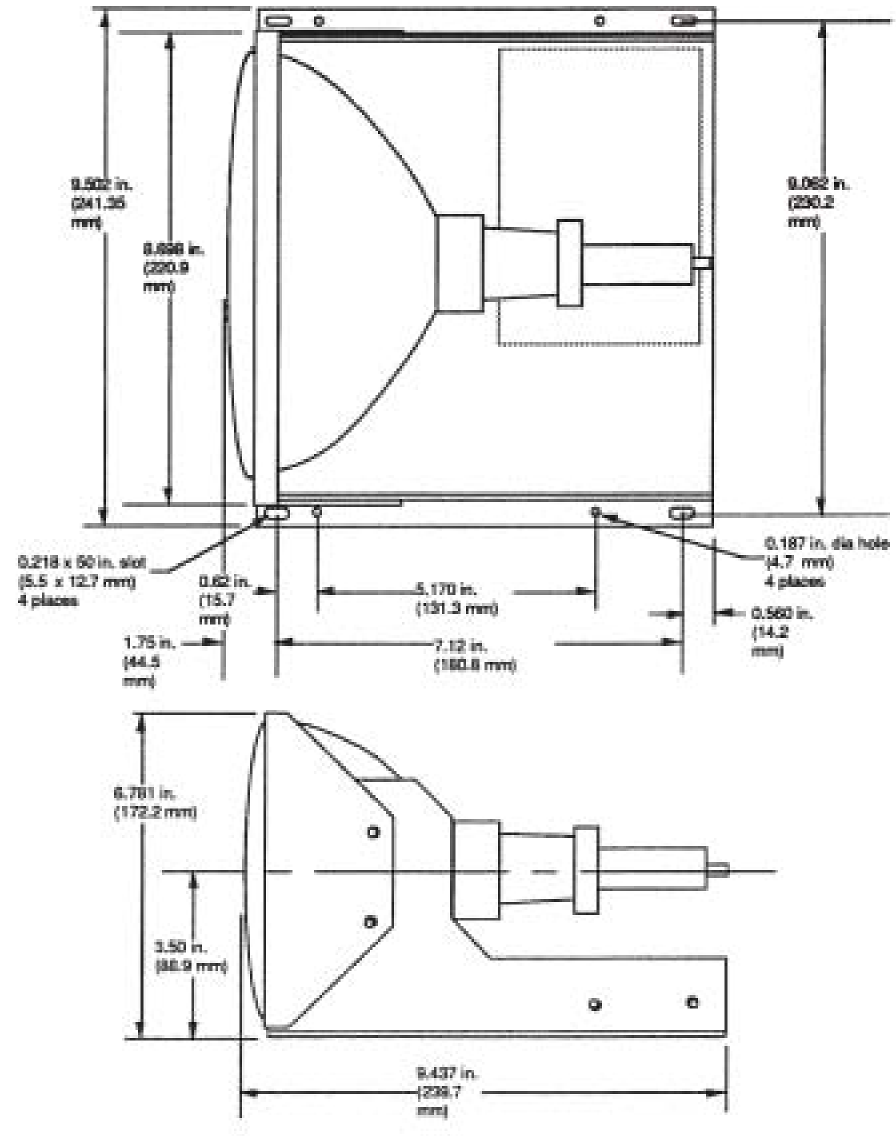


Figure 18-3. Mounting Dimensions, 9-inch CRT Display Monitor

Overall dimensions for the 12-inch Monitor are

Height	10.5 in. (267 mm)
Width	12 in. (305 mm)
Depth	12.3 in. (312 mm)

Setting Up the 9-inch Monitor

⚠ WARNING

This procedure is dangerous. It must be performed only by qualified personnel, taking reasonable precautions against high voltage shock hazard.

Take the following steps to set up the 9-inch Monitor:

1. Remove the plastic power supply safety cover by prying gently at the edges.
2. Connect the AC power cable. (Do not apply power.)
3. Replace the plastic power supply safety cover.
4. Plug in the video cable from the CRT Interface.
5. Apply power to the unit. Verify that the green power LED is ON.

Setting Up the 12-inch Monitor

Take the following steps to set up the 12-inch Monitor:

1. Plug in the video cable to the CRT Interface.
2. Plug in the power cable.
3. Turn the power switch ON.

NOTE

The pedestal base can be removed from the 12-inch Monitor.

Troubleshooting the CRT Display Monitor

Problem	No Display
Steps	1. Check the AC power wiring to the monitor. For each monitor, the power LED should be on when the power is on. • The power LED for the 9-inch CRT Display Monitor is green. It is located on the back of the monitor. • The power LED for the 12-inch CRT Display Monitor is green. It is located on the front of the monitor. 2. Check the cable from the CRT Interface to the CRT Monitor. 3. Check the address PROM on the CRT Interface. It must be part number 371536-01. 4. Check that the brightness and contrast adjustments on the monitor are set to a proper viewing level. These adjustments are factory set. 5. After the CRT Display Monitor is correctly connected to power and to the CRT Interface, check that the Monitor screen flashes when the Motion Plus chassis is powered up and initialized. If not, and you have checked all of the above, replace the CRT Interface card.

Specifications

Parameter	473.91c-09A-004	473.91c-09A-003
CRT	12-inch diagonal measure, non-glare amber phosphor	9-inch diagonal measure, amber phosphor
Viewable area	47.66 square inches (307.5 square cm)	44 square inches (284 square cm)
Deflection	90°	90°
Input type	TTL level positive	1.5 V p-p Composite video (RS170)
Impedance	–	75Ω
Resolution	720 x 350 lines at center	800 lines at center (horizontal)
Power requirements	120 Vac, 60 Hz, 35 W	120 Vac (85-132 V) 50/60 Hz Nominal 25 W
Overall dimensions	12 in. wide (30.5 cm) 10.5 in. high (26.7 cm) 12.3 in. deep (31.2 cm)	9.5 in. wide (24.1 cm) 6.8 in. high (17.4 cm 9.5 in. deep (24.1 cm)
Weight	16.4 lb (7.5 kg)	7 lb (3.2 kg)
Connector	9-pin D-sub miniature	S0-239
Operating environment:		
Temperature	0 to 40 °C (32 to 104 °F)	0 to 50 °C (32 to 122 °F)
Humidity	20 to 80% noncondensing	10 to 90% noncondensing
Altitude	up to 9900 ft (3017 m)	up to 10,000 ft (3048 m)
Display Control	Brightness/contrast	–

19 Model 473.20c Stepper Translator

Introduction

The Model 473.20c Stepper Translator provides an interface between the Motion Plus™/473 family of controllers and electric or electrohydraulic stepper motors.

Standard features of the Stepper Translator include the following:

- Half-step operation (400 pulses per revolution)
- Direct drive of fractional horsepower four-phase permanent magnet dc stepper motors
- overtravel limit and home inputs
- eight LEDs for fault and status indication
- metal shroud for EMI shielding and heat dissipation
- removable terminal strip connector
- calibrated for use with MO62 and MO91 stepper motors
- requires external +48 Vdc power supply

As an option, the Stepper Translator can be factory-calibrated for use with MO92 and MO93 stepper motors.

Figure 19-1 shows the location of important components on the Stepper Translator.

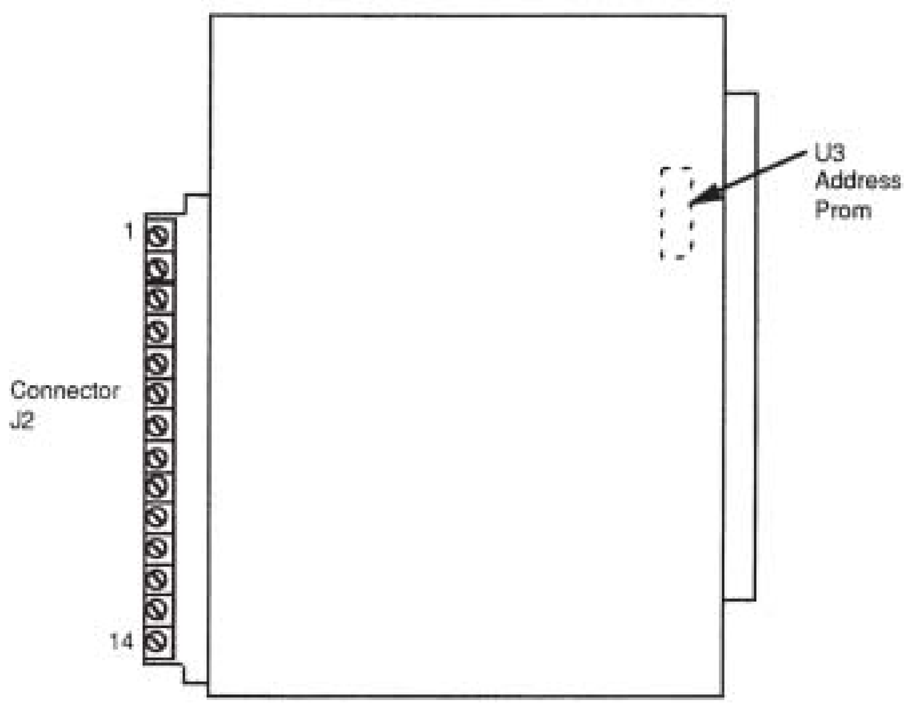
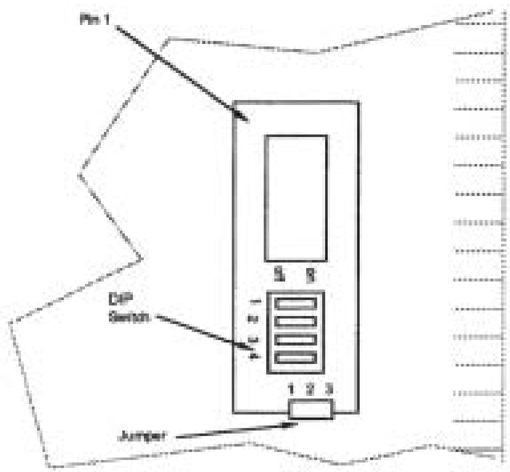


Figure 19-1. Model 473.20c Stepper Translator Component Location

Address DIP Switch

The Address DIP Switch Assembly replaces the address PROM used on each circuit card to identify it to the System Processor. The Assembly mounts in the socket provided for the address PROM and is compatible with all circuit card assemblies that require unique addressing.



Set the jumper and the DIP switch on the Assembly as required. When the jumper is connected 2–3, it addresses any of the translators as follows:

DIP Switch Setting 1234	Function
1000	Axis 1
0100	Axis 2
1100	Axis 3
0010	Axis 4
1010	Axis 5
0110	Axis 6
1110	Axis 7
0001	Axis 8

DIP Switch Setting 1234	Function
1001	Axis 9
0101	Axis 10
1101	Axis 11
0011	Axis 12
1011	Axis 13
0111	Axis 14
1111	Axis 15
0000	Axis 16

1 = ON 0 = OFF

Older Stepper Translator cards do not use a DIP switch. Instead the address is defined by a PROM on each card, as shown in table 19-1. PROM U3 determines the axis number of the Stepper Translator.

Table 19-1. Axis Numbers and PROM Part Numbers

Stepper Translator Axis Number	U3 PROM Part Number
1	371529-01
2	371529-02
3	371529-03
4	371529-04
5	371529-05
6	371529-06
7	371529-07
8	371529-08
9	371529-09
10	371529-10
11	371529-11
12	371529-12
13	371529-13
14	371529-14
15	371529-15
16	371529-16

Wiring

⚠ CAUTION

Circuit cards should be handled only at an anti-static work station. Anti-static wrist or ankle bands should be attached before touching circuit cards to avoid static discharge, which can damage circuit components.

Avoid touching components or conductive paths on the circuit cards. Cards should be handled similar to handling a photograph, using the edges. The card ejectors should be used if possible.

Some connection points on connector J2 are static-sensitive. Observe the above anti-static precautions when wiring connections at J2.

Connector J2 on the front of the Stepper Translator provides signal connections to external devices. Table 19-2 lists the signal definitions for connector J2.

Table 19-2. J2 Pin Definitions

J2 Pin	Name	Description
1	+12 V	+12 Vdc from the chassis power supply
2	12 V COM	12 V common from the chassis power supply
3	+Limit	+Limit active high input
4	-Limit	-Limit active high input
5	Home	Home active high input
6	Shield	Chassis ground conner leads
10	D	-
11	E	-
12	F	-
13	48 V COM	External power supply common
14	+48 V	External power supply +48 Vdc input

Terminal strip J2 at the front of the Stepper Translator provides connections to a motor, a 48 Vdc power supply, limit and home switches, and a 12 Vdc supply. The strip can be removed, allowing the Stepper Translator to be moved or serviced without rewiring.

CAUTION

To avoid equipment damage, ensure that all power is off before installing or removing the terminal strip. The strip must be installed as shown in Figure 19-2 (not rotated 180°) so that the screws are facing their labels on the Stepper Translator.

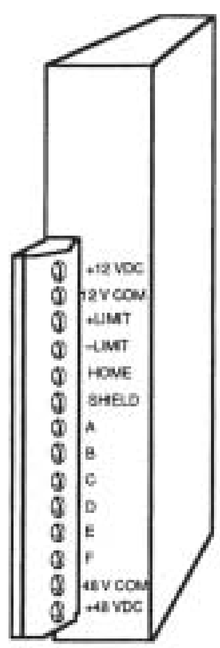


Figure 19-2. Terminal Strip Orientation

Cabling

Figure 19-3 shows connections for the stepper motor and the sensor switches. The following restrictions apply to the stepper motor cable:

- The maximum cable length is 100 ft (30 m)
- The wire gauge for the cable (refer to Table 19-3) must be selected so that the total resistance over the entire length of the cable does not exceed one-half the motor winding resistance.
- The stepper motor cable leads should be bundled together at the terminal strip to cut down stray electromagnetic emission.

Unused home or limit inputs must be tied to 12 V COM.

Table 19-3. Motor Cable Length vs. Wire Gauge

Cable Length	Wire Gauge (AWG)
50 to 100 ft (15 to 30 m)	12-gauge
25 to 50 ft (7.5 to 15 m)	14-gauge
0 to 25 ft (0 to 7.5 m)	16-gauge

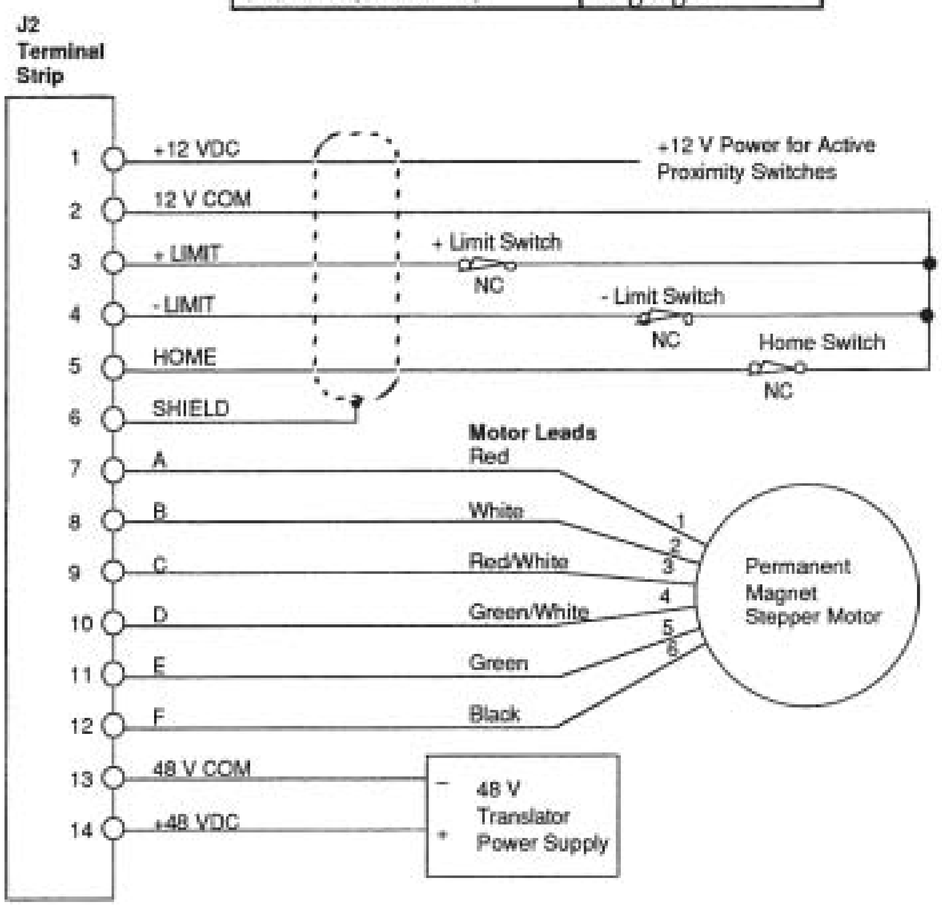


Figure 19-3. Typical Cabling Connections for the Model 473.20c Stepper Translator

Installing the Stepper Translator

⚠ CAUTION

Make sure chassis power is OFF before installing the Stepper Translator .

The Stepper Translator requires two slots in the chassis.

Setup

⚠ CAUTION

Do not apply power until all wiring has been verified. Applying power with incorrect wiring can damage the Stepper Translator components.

⚠ CAUTION

Circuit cards should be handled only at an anti-static work station. Anti-static wrist or ankle bands should be attached before touching circuit cards to avoid static discharge, which can damage circuit components.

Avoid touching components or conductive paths on the circuit cards. Cards should be handled similar to handling a photograph, using the edges. The card ejectors should be used if possible.

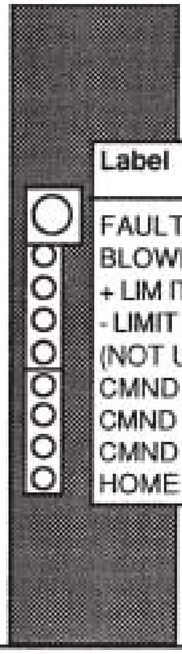
Some connection points on connector J2 are static-sensitive. Observe the above anti-static precautions when wiring connections at J2.

Take the following steps to set up the Stepper Translator:

1. Connect the stepper motor to connector J2 (refer to wiring and cabling information in this chapter and to the motor manufacturer's specifications).
2. Connect the home and limit switches.
3. Connect the 48 Vdc power supply.

LED Functions

One fault LED and seven status LEDs are provided. Figure 19-4 shows the functions for these LEDs.



Label	Description
FAULT	Indicates fault condition
BLOWN FUSE	Indicates loss of +48 Vdc power supply
+ LIM IT	Active high + limit
- LIMIT	Active high - limit
(NOT USED)	(not used)
CMND DISABLED	ON = Command disabled, OFF = enabled
CMND DIR	ON = clockwise OFF = counterclockwise
CMND CLK	Intensity directly proportional to pulse output
HOME	ON = home OFF = not home

Figure 19-4. Fault and Status Indicator LEDs on the Stepper Translator

Troubleshooting the Stepper Translator

Problem

Large Fault LED is lit on the Translator or on the Command Generator.

There are three types of problems that will turn on this LED.

1. Hitting the + over travel limit
2. Hitting the – over travel limit
3. Lack of power from the + 48 volt power supply to the translator.

Steps

1. Check the +limit and –limit switches.
2. Check the wiring to the limit switches. The limit switch must make contact with the 12 V common. The limit LED may be on due to a possible debounce problem on the limit switch.

3. For the loss of the 48 volt power, check that the blown fuse LED is on. This will tell you if the translator is receiving the voltage from the external power supply.

4. Check the wiring to the translator from the external 48 volt power supply.

5. Check the external 48 volt power supply.

Problem

No faults but no motion and Cmnd Disabled LED on

Steps

1. Make sure the address PROM has the correct part number. Also check the Command Generator for proper addressing.

2. Check the application program. The application program must properly initialize the axis. The following program will turn off the Cmnd Disabled LED (n = the number of the axis under test):

```
LOGIC:
AXIS Xn = STEPPER     ;declare axis type
HALT Xn               ;reset faults on translator
XLATOR Xn ON          ;enable translator
END
```

3. If Cmnd Disabled LED is still on, replace the Stepper Translator.

Problem

No motion and no faults and cmnd Disabled LED off

Steps

1. Check the wiring to the motor. With the translator powered up there should be holding torque on the motor.

2. Check that there is no mechanical binding that could stop the stepping motor.

3. Check the application program. The following program will move a stepper motor 1 revolution (n = the number of the axis under test):

```
LOGIC:
AXIS Xn = STEPPER  ;define axis type
HALT Xn            ;reset translator
SCALE Xn = 400     ;set scale to motor revs
VMAX Xn = 25.25    ;set to 10 % more then needed
AVD Xn = 1,1,1     ;1 rev/sec/sec and 1 rev/sec
DIST Xn = 1        ;distance of 1 motor rev
XLATOR Xn ON       ;enable translator
MOVE Xn            ;move motor
MWAIT Xn           ;wait for motion to stop
END
```

4. Replace the Stepper Translator.

Problem

Jerky motion.

Steps

1. Check the wiring to the stepping motor.
2. Check there is no mechanical reason for the jerky motion.
3. Replace the Stepper Translator.

Specifications

Parameter	Specification
Phase current	3.5 A maximum per phase
Output current vs. motor common	8 A maximum
Output voltage vs. motor common	41 V maximum
Step rate (half step)	15 kHz maximum
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing
Power Inputs	
PWA only	+5 Vdc ±0.25 V at 0.25A +12 Vdc ±1.2 V at 30 mA
External power supply	+48 Vdc ± 4 Vdc at 2 A (for MO91-FC401 motor under full load at 1200 rpm)

20 Model 473.31c Stepper Translator Power Supply

Introduction

The Model 473.31c Stepper Translator Power Supply provides 48 Vdc unregulated power for up to three 473.20c Stepper Translators.

Standard features of the Stepper Translator Power Supply include the following:

- Fused primary power input
- 48 Vdc unregulated power output
- metal case for RFI shielding
- flanges for external mounting

Figure 20-1 shows the location of important components on the Stepper Translator Power Supply.

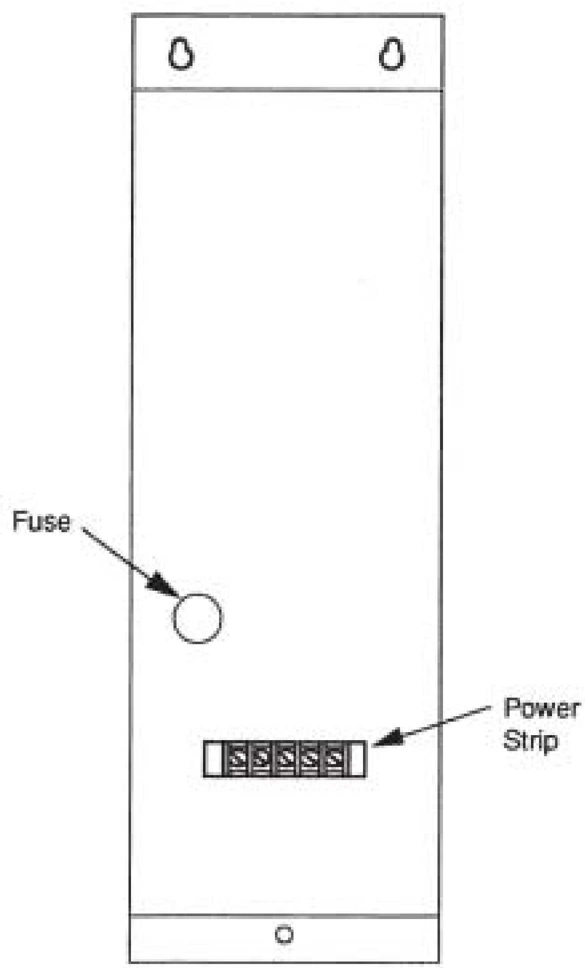


Figure 20-1. Model 473.31c Stepper Translator Power Supply Component Location

Wiring

Figure 20-2 shows wiring connections for the Stepper Translator Power Supply.

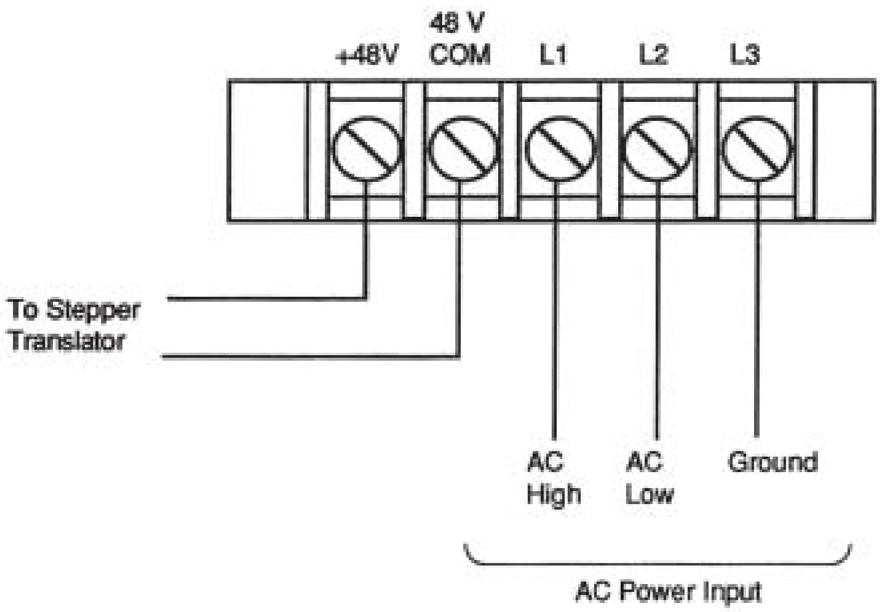


Figure 20-2. Wiring Connections

Mounting

Figure 20-3 shows mounting dimensions for the Stepper Translator Power Supply.

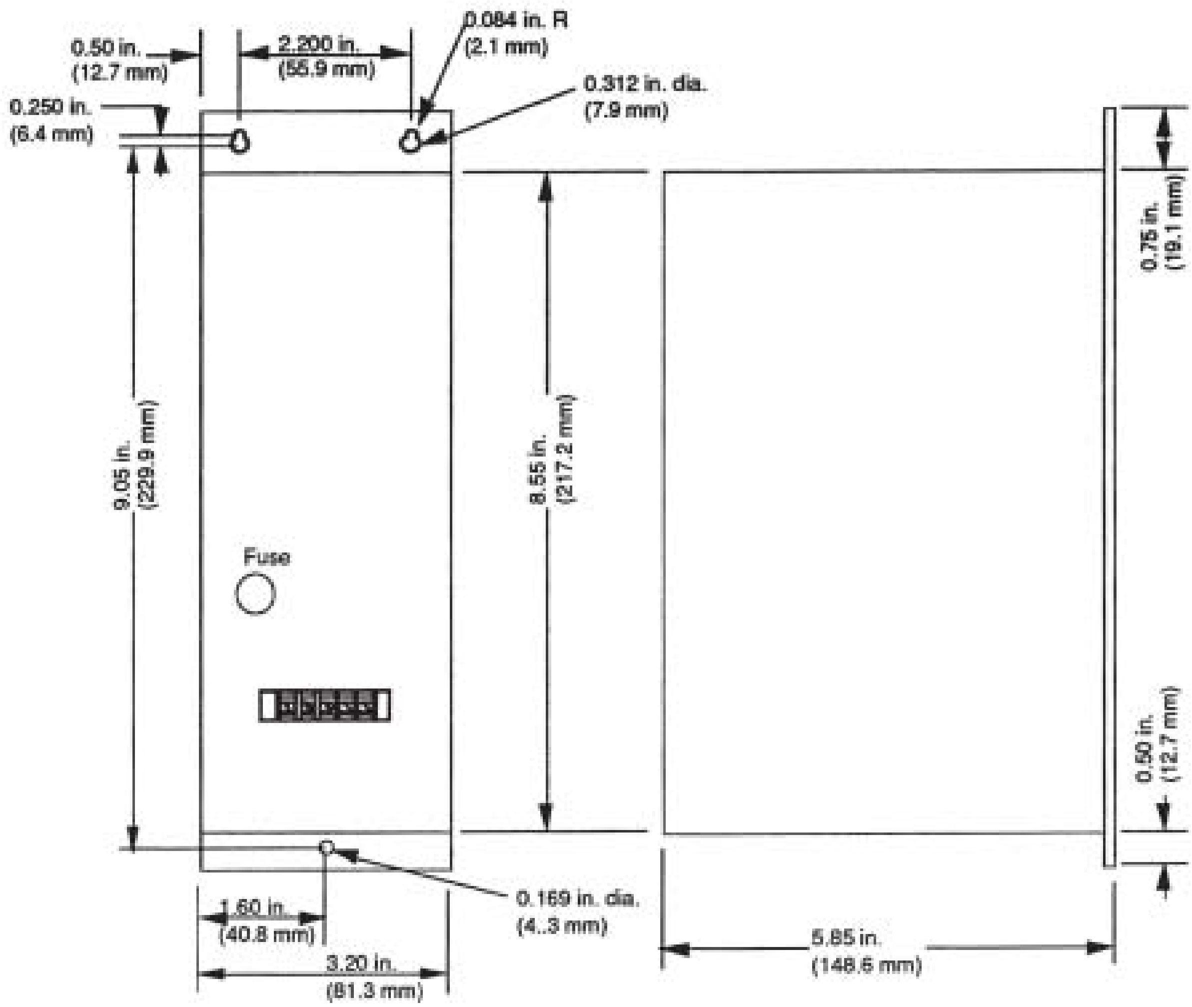


Figure 20-3. Mounting Dimensions

Troubleshooting the Stepper Translator Power Supply

⚠ WARNING

This equipment is dangerous. Testing must be performed only by qualified and experienced personnel.

Problem	Blown fuse indication on Stepper Translator
Steps	1. Check the voltage coming from the power supply. If no voltage, then: A. Check input AC voltage to the power supply B. Check the fuse on the power supply 2. If voltage is present on the power supply, then check the wiring from the power supply to the translator.

Specifications

Parameter	Specification
AC Power Input	105–125 Vac
AC Frequency Input	50–60Hz
DC Power Output	48 Vdc unregulated
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing

21 Model 473.23c Four-Phase Stepper Translator Interface

Introduction

The Model 473.23c Four-Phase Stepper Translator Interface provides an interface between the Motion Plus™/473 family of controllers and the stepper motor drivers of other manufacturers.

Standard features of the Four-Phase Stepper Translator Interface include the following:

- Half-step operation (400 pulses per revolution)
- overtravel limit and home inputs
- eight LEDs for fault and status indication
- metal shroud for EMI shielding and heat dissipation
- removable terminal strip connector
- requires external power supply

Figure 21-1 shows the location of important components on the Four-Phase Stepper Translator Interface.

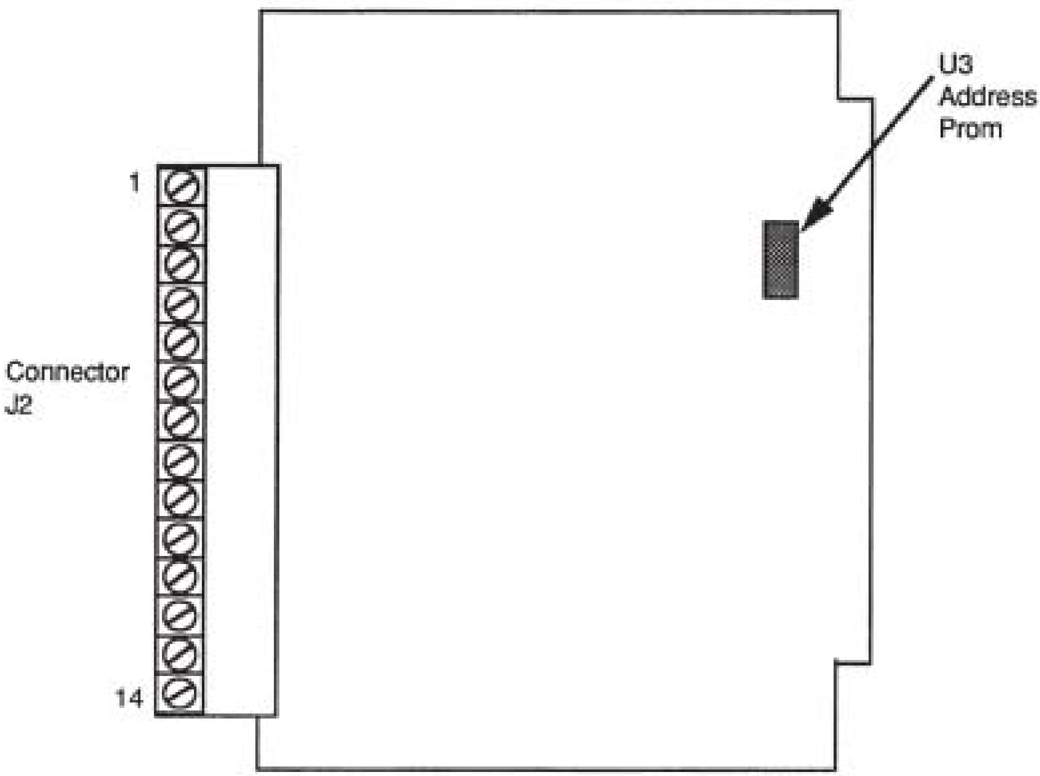


Figure 21-1. Model 473.23c Four-Phase Stepper Translator Interface Component Location

Address PROM

The Four-Phase Stepper Translator Interface axis number is defined by an address PROM, U3, as shown in Table 21-1.

Table 21-1. Axis Numbers and PROM Part Numbers

Four-Phase Stepper Translator Interface Axis Number	U3 PROM Part Number
1	371529-01
2	371529-02
3	371529-03
4	371529-04
5	371529-05
6	371529-06
7	371529-07
8	371529-08
9	371529-09
10	371529-10
11	371529-11
12	371529-12
13	371529-13
14	371529-14
15	371529-15
16	371529-16

Wiring

Connector J2 on the front of the Four-Phase Stepper Translator Interface provides signal connections to external devices. Table 21-2 lists the signal definitions for connector J2.

Table 21-2. J2 Pin Definitions

J2 Pin	Name	Description
1	+12 V	+12 Vdc from the chassis power supply
2	12 V COM	12 V common from the chassis power supply
3	+Limit	+Limit active high input
4	-Limit	-Limit active high input
5	Home	Home active high input
6	Shield	Chassis ground connection
7	-Phase 1	Active Low Pulse Outputs to Stepper Driver
8	-Phase 2	
9	-Phase 3	
10	-Phase 4	
11	Unused	-
12	+5 Vx	+5 Vdc derived from external power supply (requires +12 to +15 Vdc at J2-14)
13	Ext COM	External power supply common
14	Ext +V	External power supply + input (5 to 15 Vdc)

CAUTION

To avoid equipment damage, ensure that all power is off before installing or removing the terminal strip. The strip must be installed as shown in Figure 21-1 (not rotated 180°)

Cabling

Figure 21-3 shows cabling connections for the Four-Phase Stepper Translator Interface. Unused home or limit inputs must be tied to 12 V COM. Pins 7 through 10 require an external pull-up resistor for proper operation.

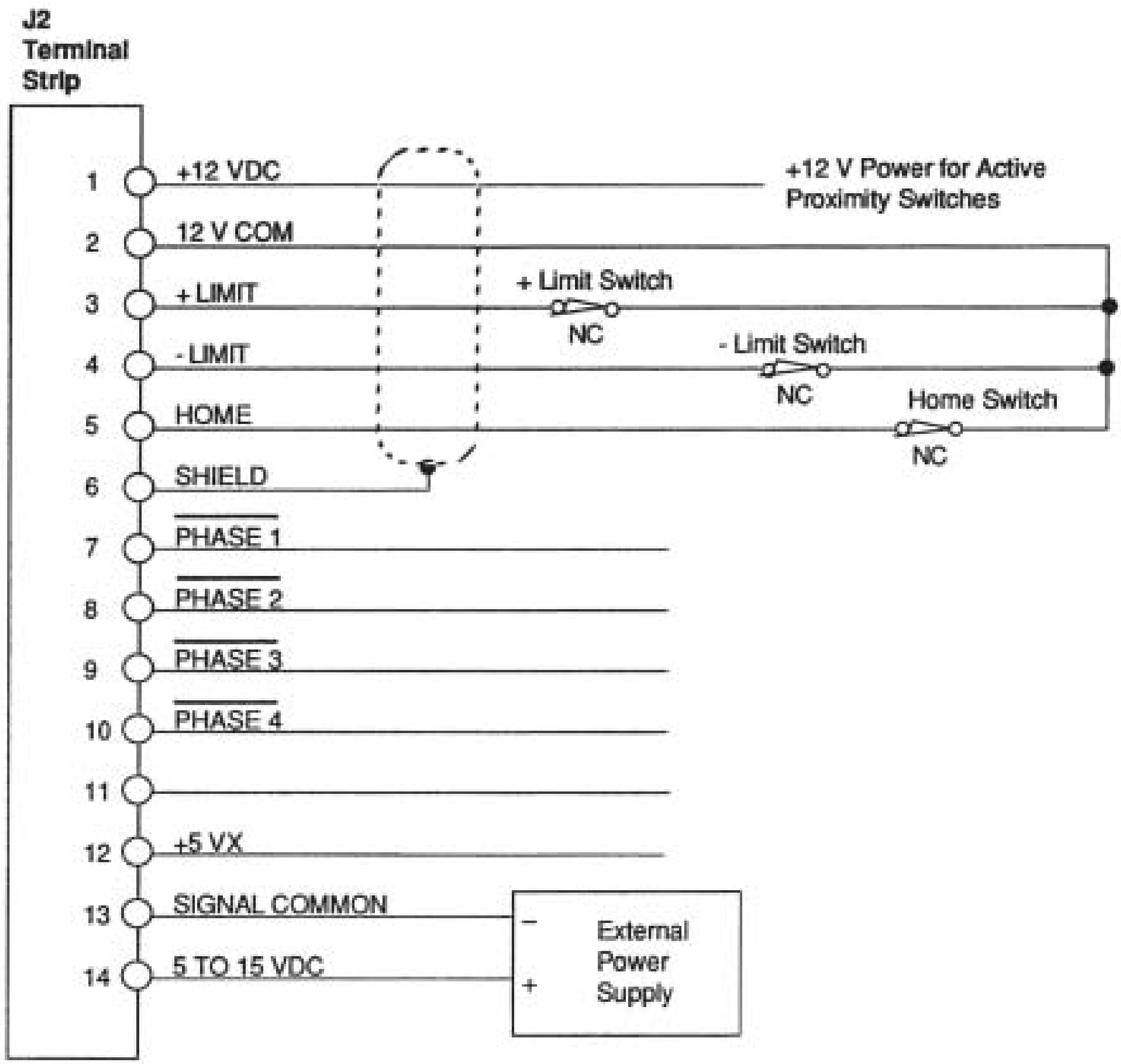


Figure 21-3. Typical Cabling Connections for the Model 473.23c Four-Phase Stepper Translator Interface

Installing the Four-Phase Stepper Translator Interface

⚠ CAUTION

Make sure chassis power is OFF before installing the Four-Phase Stepper Translator Interface .

The Four-Phase Stepper Translator Interface requires ONE slot in the chassis.

Setup

⚠ CAUTION

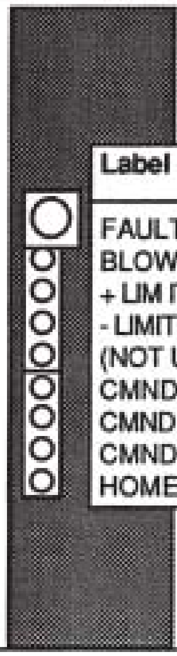
Do not apply power until all wiring has been verified. Applying power with incorrect wiring can damage the Four-Phase Stepper Translator Interface components.

Take the following steps to set up the Four-Phase Stepper Translator Interface:

1. Connect the stepper driver to connector J2 (refer to wiring and cabling information in this chapter and to the driver manufacturer's specifications).
2. Connect the home and limit switches.
3. Connect the external +5 to +15 Vdc power supply.

LED Functions

One fault LED and seven status LEDs are provided. Figure 21-4 shows the functions for these LEDs.



Label	Description
FAULT	Indicates fault condition
BLOWN FUSE	ON indicates loss of power supply
+ LIMIT	Active high + limit
- LIMIT	Active high - limit
(NOT USED)	(not used)
CMND DISABLED	ON = Command disabled, OFF = enabled
CMND DIR	ON = clockwise OFF = counterclockwise
CMND CLK	Intensity directly proportional to pulse output
HOME	ON = home OFF = not home

Figure 21-4. Fault and Status Indicator LEDs on the Four-Phase Stepper Translator Interface

Troubleshooting the Four-Phase Stepper Translator Interface

Problem

Large Fault LED is lit on the Translator Interface or the Command Generator

There are three types of problems that will turn on this LED.

- Hitting the + overtravel limit
- Hitting the - overtravel limit
- Failure of the external power supply to reach the translator.

Steps

1. For the ± overtravel limits check the limit switches.
2. Check the wiring to the limit switches. The limit switch must make contact to the 12 V common. (The limit LED may be on due to a possible debounce problem on the limit switch.)

3. Check the wiring to the translator from the external power supply.

4. Check the external power supply.

Problem

No faults but no motion and Cmnd Disabled LED on

Steps

1. Check the address PROM for the correct part number. Also check the Command Generator for proper addressing.

2. Check the application program. The application program must properly initialize the axis. The following program will turn off the Cmnd Disabled LED:

```
LOGIC:
AXIS Xn = STEPPER                ;declare axis type
HALT Xn                          ;reset faults on translator
XLATOR Xn ON                     ;enable translator
END
```

Where n is the number of the axis under test

3. If Cmnd Disabled LED is still on, replace the Four- Phase Stepper Translator.

Problem

No motion and no faults and Cmnd Disabled LED off

Steps

1. Check the wiring to the external translator.

2. Check the wiring to the motor. With the external translator powered up there should be holding torque on the motor.

3. Check that there is no mechanical binding that could stop the stepping motor.

4. Verify that the external translator is working within the manufacturer's specifications.

5. Check the application program. The following program will move a stepper motor 1 revolution:

```
LOGIC:
AXIS Xn = STEPPER             ;define axis type
HALT Xn                       ;reset translator
SCALE Xn = 400                ;set scale to motor revolutions
VMAX Xn = 25.25               ;set to 10 % more then needed
AVD Xn = 1,1,1                ;1 rev/sec/sec and 1 rev/sec
DIST Xn = 1                   ;distance of 1 motor revolution
XLATOR Xn ON                  ;enable translator
MOVE Xn                       ;move motor
MWAIT Xn                      ;wait for motion to stop
END
```

Where n = axis under test

6. Replace the Four- Phase Stepper Translator.

Problem	Jerky motion
Steps	1. Check the wiring to the stepping motor. 2. Verify that there is no mechanical reason for the jerky motion. 3. Verify that the external translator is working within the manufacturer's specifications. 4. Replace the Four- Phase Stepper Translator.

Specifications

Parameter	Specification
Step rate	50 kHz maximum
Phase output driver	Vmax = 30 Vdc Imax = 30 mA
External power supply	+5 Vdc to +15 Vdc, 200 mA
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing

22 Model 473.19c Servo Translator

Introduction

The Model 473.19c Servo Translator provides an interface between the Motion Plus/473 controllers and various closed-loop servo drivers.

Standard features of the Servo Translator include the following:

- ±10 Vdc full scale analog output
- Adjustable loop gain
- Uses 12 V shaft encoder (sine wave or digital)
- Overtravel limit and home inputs—active high
- Thirteen fault and status LEDs
- X2 multiplication of feedback pulses
- Requires an encoder with complementary outputs

Figure 22-1 shows the location of important components on the Servo Translator.

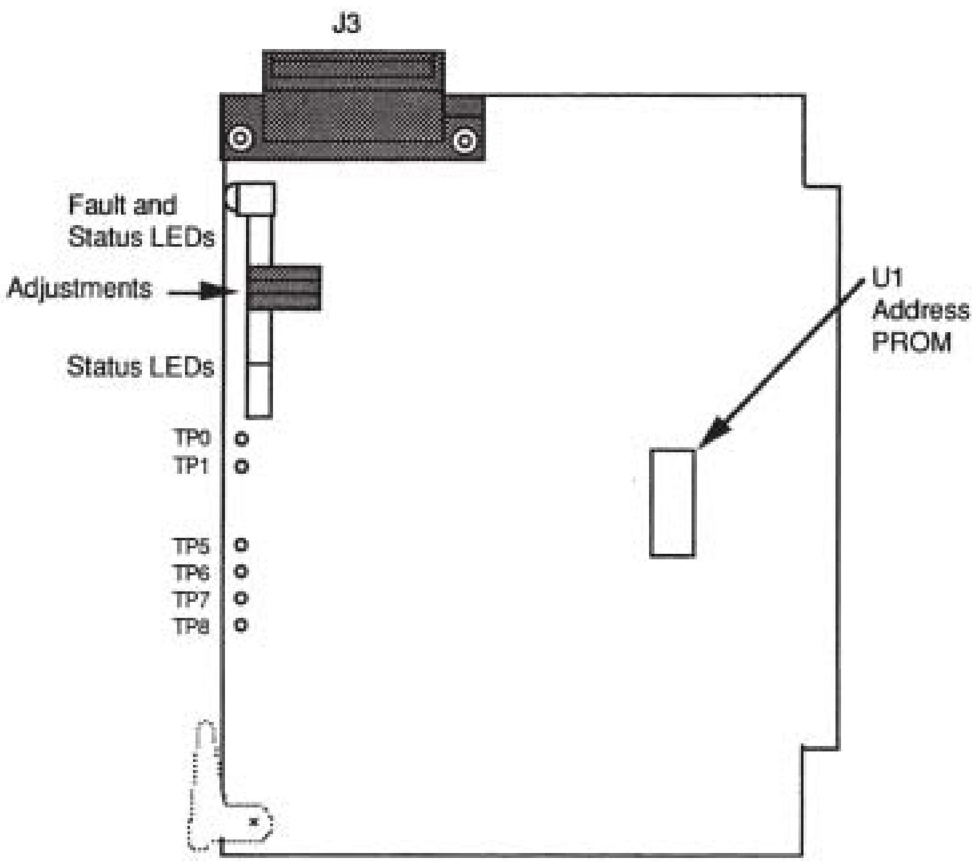
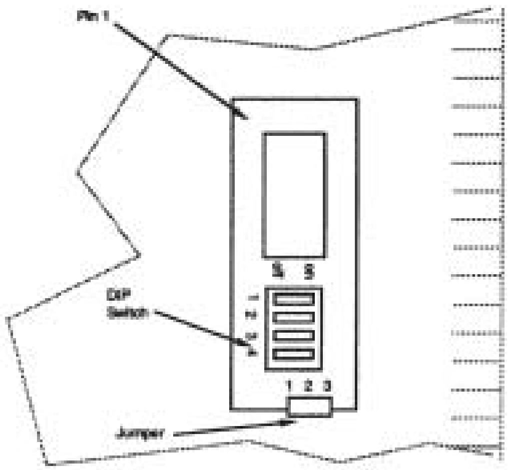


Figure 22-1. Model 473.19c Servo Translator Component Location

Address DIP Switch

The Address DIP Switch Assembly replaces the address PROM used on each circuit card to identify it to the System Processor. The Assembly mounts in the socket provided for the address PROM and is compatible with all circuit card assemblies that require unique addressing.



Set the jumper and the DIP switch on the Assembly as required. When the jumper is connected 2–3, it addresses any of the translators as follows:

DIP Switch Setting 1234	Function
1000	Axis 1
0100	Axis 2
1100	Axis 3
0010	Axis 4
1010	Axis 5
0110	Axis 6
1110	Axis 7
0001	Axis 8

DIP Switch Setting 1234	Function
1001	Axis 9
0101	Axis 10
1101	Axis 11
0011	Axis 12
1011	Axis 13
0111	Axis 14
1111	Axis 15
0000	Axis 16

1 = ON 0 = OFF

Older Servo Translator cards do not use a DIP switch. Instead the address is defined by a PROM on each card, as shown in table 22-1. PROM U1 determines the axis number of the Servo Translator.

Table 22-1. Address PROMs

Axis No.	PROM Part No.
1	371529-01
2	371529-02
3	371529-03
4	371529-04
5	371529-05
6	371529-06
7	371529-07
8	371529-08
9	371529-09
10	371529-10
11	371529-11
12	371529-12
13	371529-13
14	371529-14
15	371529-15
16	371529-16

Wiring

Connector J3 (AMP part number 552740-01) on the Servo Translator provides external connections. Table 22-22 shows pin definitions for this connector.

Table 22-2. J3 Pin Definitions

J3 Pin	Name	Description	Remote Terminal Board*
1	+12 V	+12 Vdc from chassis power supply	1
2	-12 V	-12 Vdc from chassis power supply	
3	12 V COM	12 V common from chassis power supply	2
4	A-	Encoder phase A complement input	4
5	A+	Encoder phase A input	3
6	Z-	Encoder marker complement input	8
7	Z+	Encoder marker input	7
8	Vel Cmnd	±10 V full scale velocity command	16
9	Enab	Active low drive enable	18
10	Drive Fault	Active high drive fault input	19
11	+Limit	Active high + limit input	12
12	+12 V	+12 Vdc from chassis power supply	10
13	+12 V	+12 Vdc from chassis power supply	37–40
14	-12 V	-12 Vdc from chassis power supply	
15	12 V COM	12 V common from chassis power supply	33–36
16	B-	Encoder phase B complement input	6
17	B+	Encoder phase B input	5
18	Shield	Chassis ground	9
19	Shield	Chassis ground	15
20	Vel Com	Velocity command common	17
21	Shield	Chassis ground	20
22	Home	Active high home input	14
23	-Limit	Active high - limit input	13
24	12 V COM	12 V common from chassis power supply	11
* When used with cable 382012-XX			

Cabling

The standard cable used with the Servo Translator is Model 473.50c-31A-200 (Custom Servo Motors part number 382012-xx). This cable connects the Servo Translator to the Remote Terminal Board. Refer to the cabling chapter of this manual for the cable pinout. Figure 22-2 shows cabling connections.

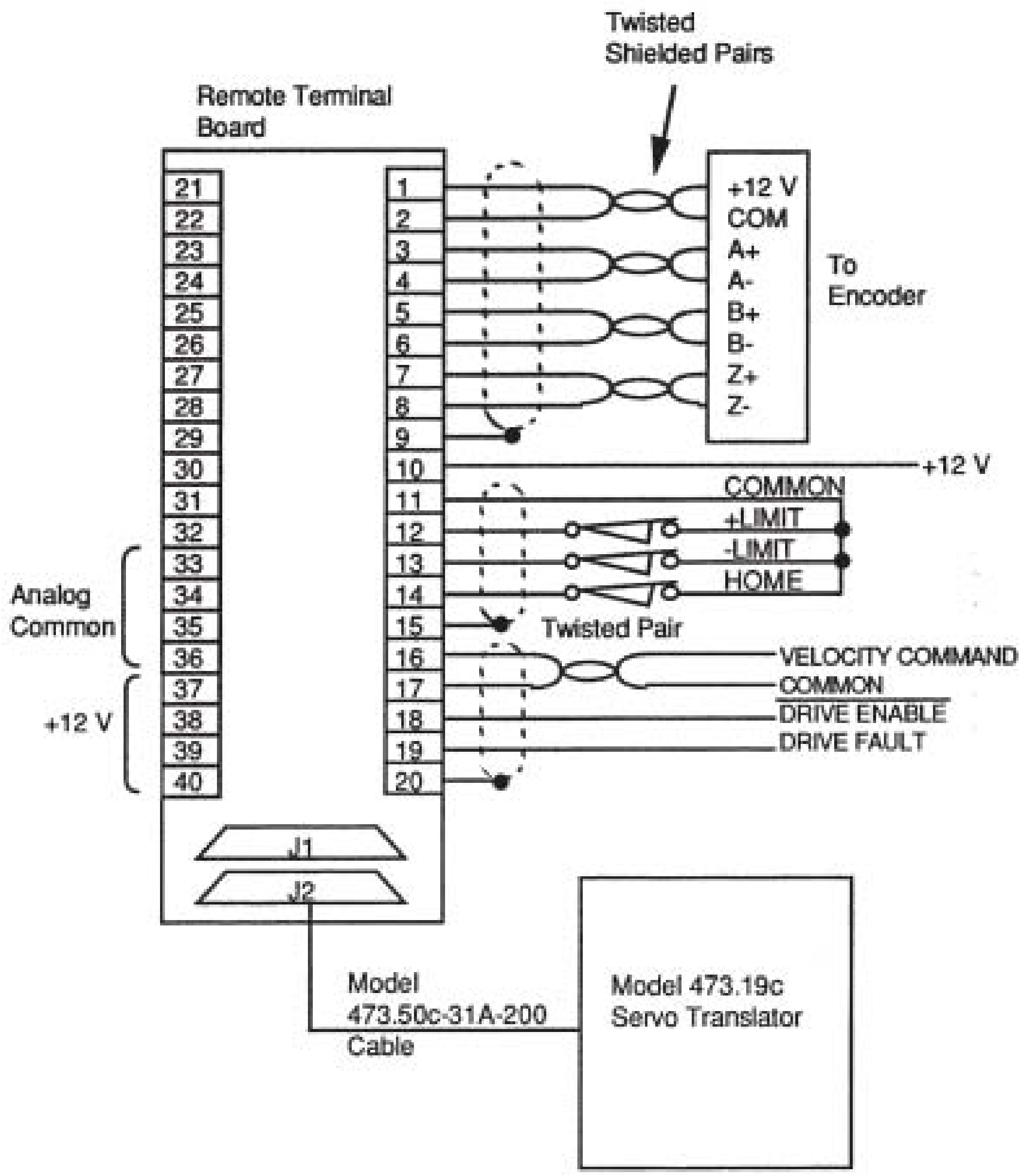


Figure 22-2. Cable Connections for the Servo Translator

Optional Cabling

The Servo Translator can be connected directly to interface devices. Figure 22-3 shows a direct cabling example.

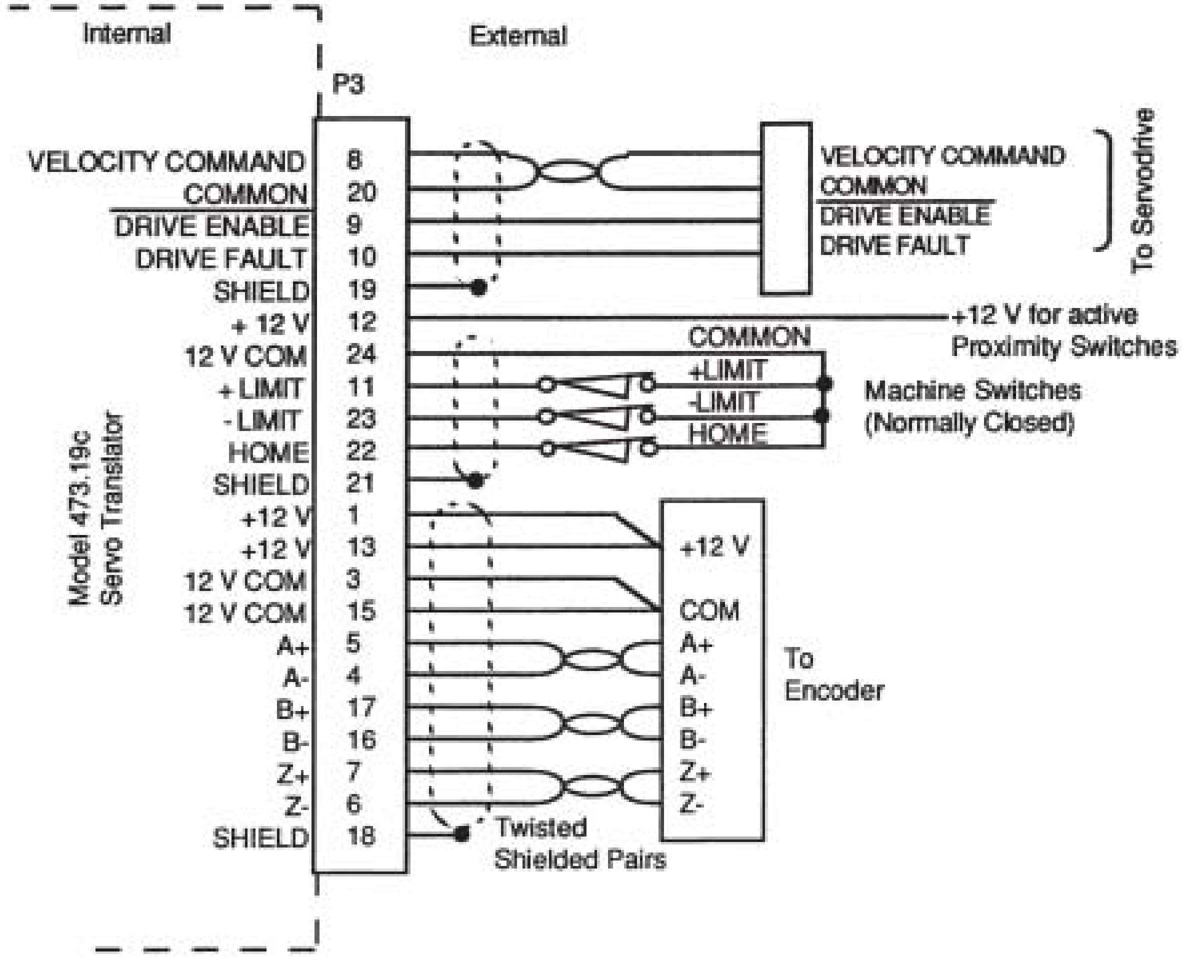


Figure 22-3. Direct Cabling Connections (Optional)

Limits, Home, and Drive Fault Inputs

Before connecting limits, home, or drive faults, refer to Figure 22-4 for the internal configuration of these inputs. Any of these inputs that is not used must be tied to 12 V common.

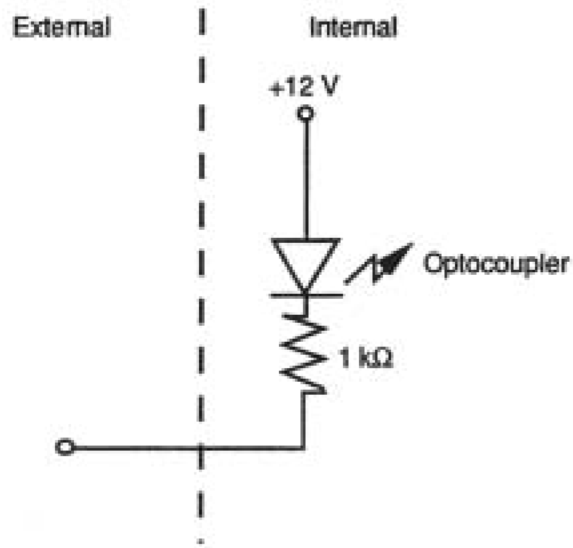


Figure 22-4. Limit, Home, or Drive Fault Input

Installing the Servo Translator

⚠ CAUTION

Make sure chassis power is OFF before installing this module.

The Servo Translator requires one slot in the chassis.

Setup

Take the following steps to set up the Servo Translator:

1. Verify that the address PROM (U1) on the Servo Translator is correct for the axis number you are using.
2. Verify that the Command Generator is set for the correct axis number.
3. Verify that the cabling between the Servo Translator and its interface devices is correct.
4. Calibrate the Servo Translator as described later in this chapter.

LED Functions

Thirteen LEDs are provided on the Servo Translator for fault and status indication. Figure 22-5 lists the fault and status LEDs and the test points on the Servo Translator.

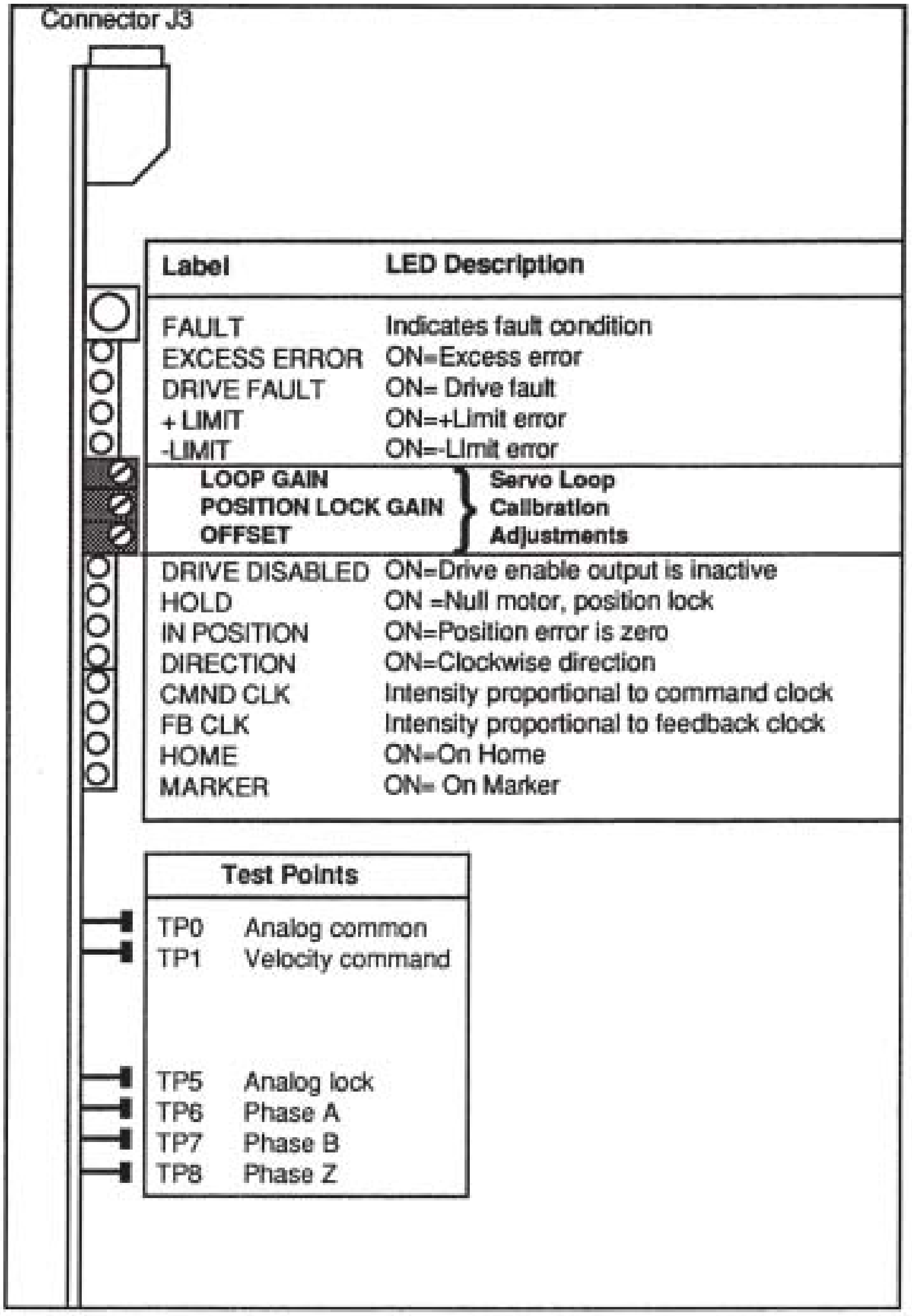


Figure 22-5. LEDs and Test Points

Calibrating the Servo Translator

Calibrate the Servo Translator using the following procedures:

- velocity loop (servo amplifier) calibration
- analog lock adjustment
- offset adjustment
- encoder phasing
- position loop (servo translator) calibration
- motor direction

These procedures contain frequent references to fault and status LEDs, adjustment pots (potentiometers), and test points on the Servo Translator card. Refer to Figure 22-1 for the location of these components.

In addition to ordinary tools, you will require a DVM (digital voltmeter) to perform these procedures.

NOTE

Before starting calibration, remove all command generators and translators from the chassis except the translator you are setting up and the command generator that drives it.

Software-controlled functions, such as maximum following error, must be set by the INCOL86 application program for proper operation.

⚠ WARNING

The following procedure involves uncontrolled actuator movement. Before starting, uncouple the actuator from any machinery that could be damaged or cause a safety hazard.

Velocity Loop

Velocity loop calibration ensures that the amplifier produces the desired range of motor speeds. Take the following steps:

1. Decouple the servo motor from the machine. Disconnect the Servo Translator from the servo amplifier.

2. Refer to the servo amplifier manufacturer's user manual to calibrate the velocity loop.

NOTE

During the offset adjustment portion of calibration, the velocity command input of the servo amplifier must be grounded. Connect a jumper between that input and its common.

3. Verify that the servo amplifier drives the motor over the desired range of velocities. Adjust the input scaling of the velocity command signal so that the maximum signal input voltage corresponds to the maximum desired motor velocity.

4. Reconnect the Servo Translator to the servo amplifier. This completes the velocity loop adjustment.

Analog Lock

Take the following steps to adjust the analog lock:

1. Disconnect the Motion Plus system from ac input power.

2. Set the DVM to measure resistance. Connect it between TP0 and TP4 at the front edge of the Servo Translator.

3. Adjust the Position Lock Gain pot until the resistance reading of the DVM is 115 ohms between TP0 (common) and TP4.

4. Disconnect the DVM. Reconnect input power to the system. This completes the analog lock adjustment.

Encoder Phasing

Encoder phasing ensures that the encoder output provides feedback to the position loop. Take the following steps to calibrate this phasing:

1. With the system completely connected, turn on power. If the motor breaks into violent oscillation or runs away, turn off power at once. The encoder channels are reversed.

2. Exchange encoder leads A+ with A-. Repeat Step 1. When the encoder is properly phased, the motor remains stationary.

Offset

Take the following steps to adjust the offset:

1. Remove power from the amplifier.

2. Power up the Motion Plus chassis but do not execute a program.

3. Connect the DVM between TP0 and TP1.

4. With the velocity command and common connected to the amplifier, adjust the offset pot so that 0.00 V is read between TP0 and TP1.

5. Disconnect the DVM. This completes the offset adjustment.

Position Loop

Follow one of the following two procedures to calibrate the position loop of the translator. The first procedure requires an oscilloscope. Take the following steps:

1. Turn the Loop Gain pot fully CCW (counterclockwise) before power up.

2. Program the controller to repeatedly send small step commands to the Servo Translator. The following is an example program:

```
LOGIC:
   AXIS X1 = SERVO              ;define the axis type as servo
   SCALE X1 = 2048              :use your own scale value
   VMAX X1 = 50.5               ;vmax is 10% more than needed
   XLATOR X1,4 = 1              ;sets excess error limit
   HALT X1                      ;reset translator
   XLATOR X1 ON                 ;enable translator
   AVD X1 = 200,200,200         ;use fast accel and velocity
   START BACK_AND_FORTH
   END

BACK_AND FORTH:
   DIST X1 = .05                ;small incremental move
   MOVE X1                      ;start move
   MWAIT X1                     ;wait for motion to stop
   DELAY .15                    ;delay for easier observation
   DIST X1 = -.05               ;small negative incremental move
   MOVE X1                      ;start move
   MWAIT X1                     ;wait for motion to stop
   DELAY .15                    ;delay for easier observation
   START BACK_AND_FORTH         ;loop on this test
   END
```

3. While observing the command signal on an oscilloscope, adjust the Loop Gain pot CW (clockwise) until fast response is achieved with little or no overshoot. Loop gain adjustment is now complete.

To use the second position loop calibration procedure, take the following steps:

1. Turn the Loop Gain pot fully counter-clockwise.

2. Remove ac power from the amplifier.

3. Program the controller to move close to the excess error limit. The following is an example program:

```
LOGIC:
   AXIS X1 = SERVO              ;define the axis type as servo
   SCALE X1 = 1                 ;set scale to command pulses
   VMAX X1 = 100000             ;set vmax to a high number
   XLATOR X1,4 = 2040           ;set excess error limit to max
   HALT X1                      ;reset translator
   XLATOR X1 ON                 ;enable translator
   AVD X1 = 1000,1000,1000      ;set accel, vel, decel
   DIST X1 = 2000               ;dist almost to error limit
```

```
MOVE X1                     ;start move
MWAIT X1                    ;wait for motion to stop
END
```

4. Connect the DVM between TP0 and TP1.

5. Adjust the Loop Gain pot until the DVM reads 9.745 V between TP0 and TP1. This completes the position lock gain adjustment.

Motor Direction

If the rotation of the motor shaft is opposite to the desired direction, reverse the motor rotation:

1. Exchange the tachometer leads.

2. Exchange the armature leads.

3. Exchange the A+ and A- leads to the encoder, or exchange the B+ and B- leads on the encoder.

Troubleshooting the Servo Translator

Problem	Large Fault LED on Servo Translator is lit.
Steps	1. Check the ± overtravel limits and the drive fault input from the servo amplifier. 2. Check wiring to the ± overtravel limits and the drive fault. If the error condition still exists, then the associated LED on the front of the circuit card will be on. 3. Replace the Servo Translator.
Problem	Large Fault LED on the associated Command Generator is lit. This condition exists when an excess following error fault has occurred on the Servo Translator. The fault must be cleared from the Servo Translator for continued operation, but is set on the Command Generator for troubleshooting purposes.
Steps	1. Using the manufacturer's procedures, make sure that the servo amplifier and motor are fully operational and capable of achieving desired speeds. 2. Using INCOL86 software and your application program, make sure that the following error limit is set to a usable value. The default value is set to zero. 3. The position loop gain pot must be adjusted to the proper level. Start by adjusting the loop gain pot fully CCW (20 turns). Turn the pot CW until minor oscillations occur and then turn the pot CCW until they disappear. 4. Replace the Servo Translator.
Problem	No faults but no motion.
Steps	1. Check the address PROM on the Servo Translator. 2. Check the address switch on the associated Command Generator. 3. If the system has more then one axis of motion, make sure that the Servo Translator and its Command Generator are in the correct slots. (Cuts on the backplane prevent signals from one axis of motion interfering with another axis of motion.)

4. Check the wiring from the Servo Translator to the servo amplifier.
5. Using manufacturer's procedures make sure that the servo amplifier and motor are fully operational.
6. Check the application program.

⚠ WARNING

The following procedure involves uncontrolled actuator movement. Before starting, uncouple the actuator from any machinery that could be damaged or cause a safety hazard.

The following sample program will move the motor. This test should be performed only after the amplifier and motor have been verified and the encoder has been verified.

```
LOGIC:
   AXIS Xn = SERVO            ;define axis type as servo
   SCALE Xn = 2048            ;scale = 2 x encoder resolution
   VMAX Xn = 50.5             ;vmax = 10% more then needed
   XLATOR Xn,4 = 1            ;set excess error limit
   HALT Xn                    ;reset translator
   XLATOR Xn ON               ;enable translator
   AVD Xn = 1,1,1             ;1 rev/sec/sec, 1 rev/sec
   DIST Xn = 1                ;distance will be 1 revolution
   MOVE Xn                    ;start motion
   MWAIT Xn                   ;wait for motion to stop
   END
```

In this test, n stands for the number of the axis under test, the scale is set to your encoder resolution, and the excess error limit has max value of 2040.

7. If you have more than one Servo Translator swap the translators and repeat the test in Step 6. When swapping Servo Translators remember to change the address PROMs.
8. If you have more than one Command Generator swap the Command Generators and repeat the test in Step 6. When swapping Command Generators remember to change the address switch settings.
9. Replace Servo Translator.

Problem	Motor runs away.

Steps

1. Using manufacturer's procedures make sure that the servo amplifier and motor are fully operational.

2. If the amplifier and motor are fully operational, then the motor is running away because the encoder feedback is not correctly phased or if there is no encoder feedback. Perform the following test to make sure that you getting feedback from the encoder. This test will display the following error on the computer screen. To test for encoder feedback start this test and turn the shaft on the motor by hand. The value displayed is the encoder feedback. The maximum value that can be displayed is 2040 before an excess error fault will occur. When the fault occurs, the value displayed resets to zero.

```
LOGIC:
   AXIS Xn = SERVO              ;define axis type as servo
   SCALE Xn = 1                 ;set scale to pulses
   XLATOR Xn,4 = 2040           ;set excess error limit
   HALT Xn                      ;reset translator
   START LOOP                   ;start next task
   END
LOOP:
   R1 = XLATOR Xn, 2            ;read following error
   PRINT 0,R1                   ;display value on computer
   START LOOP                   ;restart task
   END
```

3. If you are getting feedback using the test in Step 2, then the encoder is not phased correctly. To change the encoder phasing swap the A+ with the A- encoder lead.

Problem

Motor oscillates violently.

Steps

1. Using manufacturer's procedures make sure that the servo amplifier and motor are fully operational.

2. The violent could be due to incorrect encoder phasing. See the procedure above for verification of encoder phasing.

3. If the encoder phasing is correct then the problem is probably due to excess position loop gain. Adjust the loop gain pot fully CCW (20 turns). Turn the pot CW until minor oscillations occur and then turn the pot CCW until they disappear.

Specifications

Parameter	Specification
Command output voltage	±10 V Analog
Command output current	5 mA maximum
Optical shaft encoder:	
Type	Dual channel quadrature
Marker	Optional
Voltage	+12 Vdc
Quadrature phase	±45° maximum mismatch
quadrature amplitude	25% maximum mismatch
Drive enable current	100 mA maximum
Encoder interface (PWA)	
Common mode voltage	±8 V maximum
Differential amplitude	100 mV / 2 V p-p
Power (PWA only)	+12 Vdc at 325 mA -12 Vdc at 325 mA
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing

23 Model 473.24c Incremental Optical Shaft Encoder Interface

Introduction

The Model 473.24c Incremental Optical Shaft Encoder Interface provides an interface between the Motion Plus/473 controllers and optical encoders. The Encoder Interface is designed to work with an optical encoder having dual channel quadrature outputs and an index marker.

Standard features of the Encoder Interface include the following:

- Uses 5 V or 12 V optical encoders having dual channel quadrature outputs
- Internal pulse rate multiplication of X 4
- Index marker channel input (not required)
- Five fault and status LEDs
- Differential receivers for improved noise immunity
- Onboard test points for phase and marker inputs

Figure 23-1 shows the location of important components on the Encoder Interface.

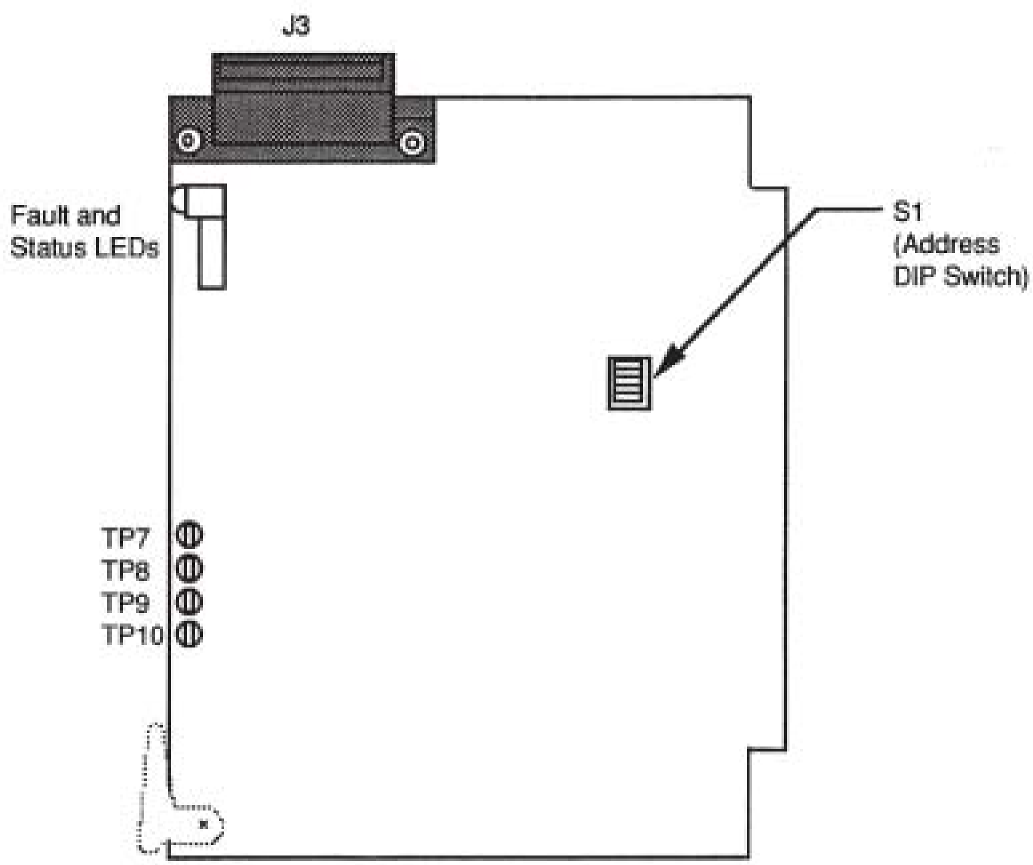
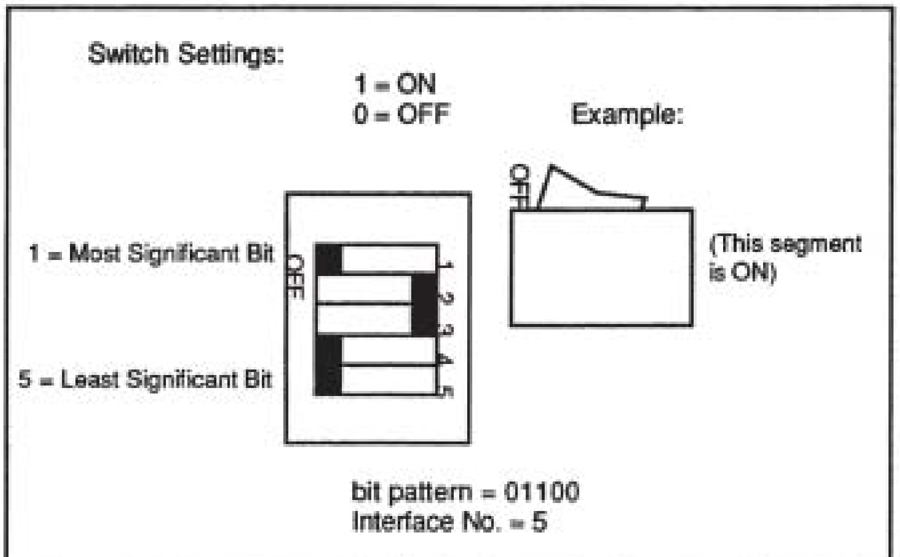


Figure 23-1. Model 473.24c Encoder Interface Component Location

Address DIP Switch

Set the 5-segment DIP switch S1 with the required address, using Table 23-1. Table 23-1 applies only to cards with serial numbers of 1466 or higher, and only to systems using a 16-bit CPU. For 8-bit CPUs, contact Custom Servo Motors Inc.

Table 23-1. DIP Switch Settings



Encoder Interface Number	Setting 12345
1	01000
2	01001
3	01010
4	01011
5	01100

Older Encoder Interface cards (with serial numbers below 1466) do not use a DIP switch. Instead, the address is defined by a PROM on each card, as shown in Table 23-2.

Table 23-2. Address PROMs (Serial Numbers below 1466)

PROM Part No.	Encoder Interface No.
371530-11	1
371530-12	2
371530-13	3
371530-14	4
371530-15	5

Wiring

Connector J3 (AMP part number 552740-01) on the Encoder Interface provides external connections. Table 23-3 shows pin definitions for this connector.

Table 23-3. J3 Pin Definitions

J3 Pin	Name	Remote Terminal Board*
1	+12 V	1
2	-12 V	
3	12 V COM	
4	Reserved	
5	Reserved	
6	Z-	8
7	Z+	7
8	A-	4
9	A+	3
10	Spare	
11	Spare	
12	+12 V	
13	+12 V	
14	-12 V	
15	12 V COM	2
16	Reserved	
17	Reserved	
18	Shield	
19	Shield	9
20	B-	6
21	B+	5
22	Spare	
23	Spare	
24	Reserved	

* When used with cable 418158-xx

Cabling

The standard cable used with the Encoder Interface is Model 473.50c-33A-001 (Custom Servo Motors part number 418158-xx). This cable connects the Encoder Interface J3 to the Remote Terminal Board. Refer to the cabling chapter of this manual for the cable pinout.

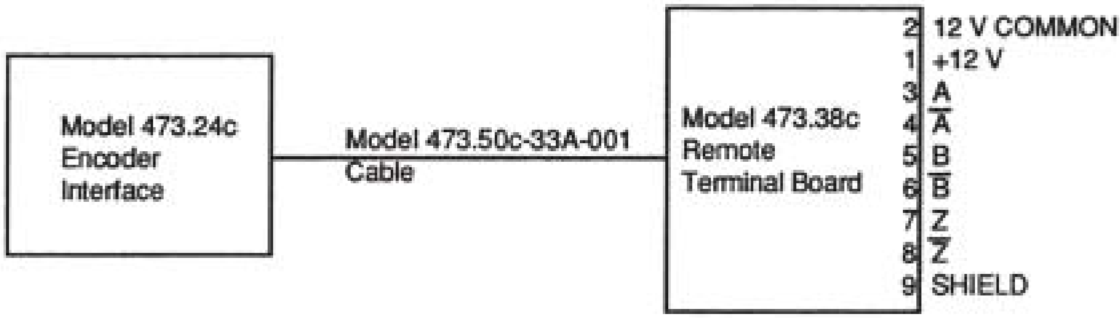


Figure 23-2. Cable Configuration for the Encoder Interface

Figure 23-3 shows a typical wiring example. Each signal and power pair must be a twisted, shielded pair. The shields must all be tied at the controller end only.

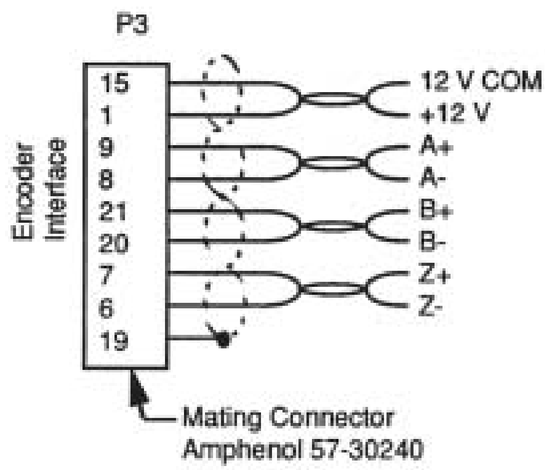


Figure 23-3. Wiring Example

Installing the Encoder Interface

The Encoder Interface requires one slot in the chassis.

Setup

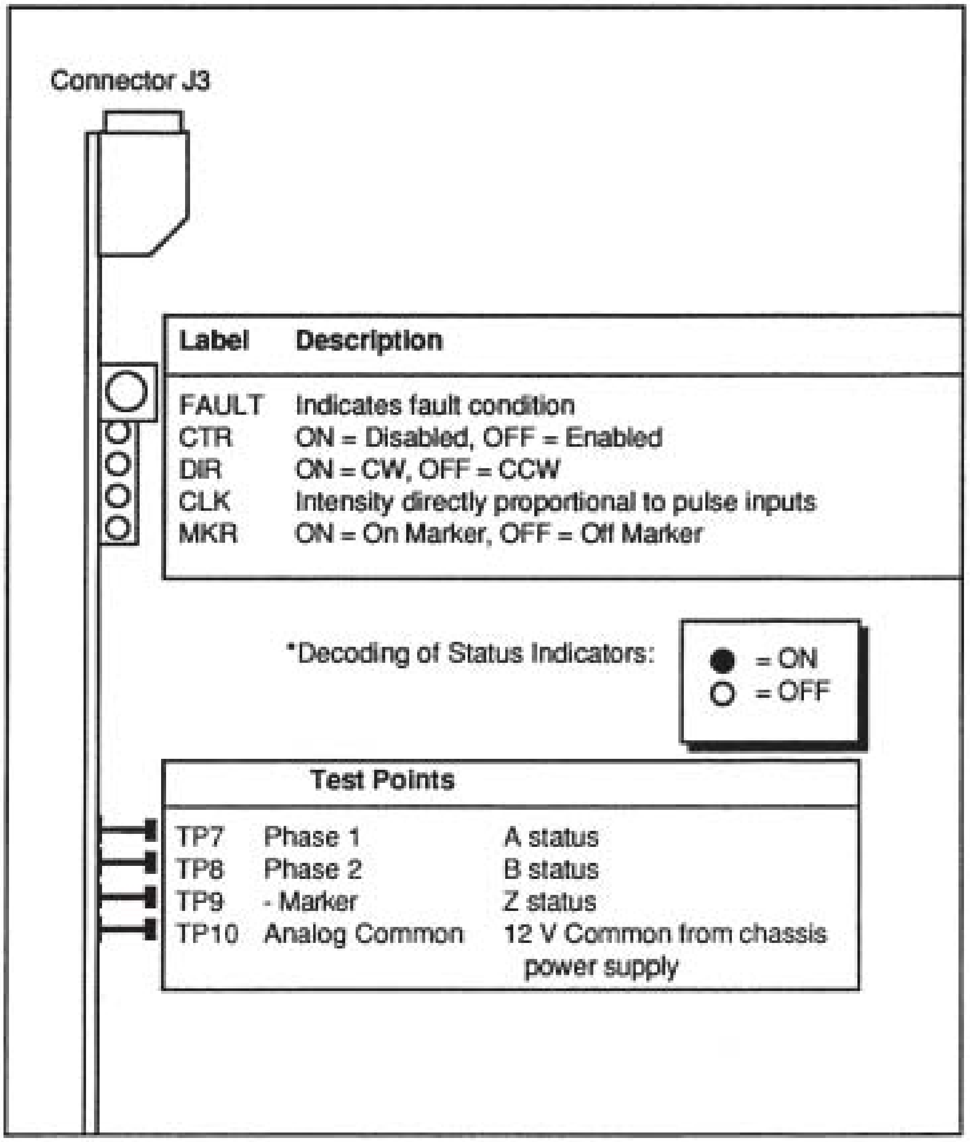
Take the following steps to set up the Encoder Interface:

1. Verify that the DIP switch segments on the Encoder Interface are set to the correct number.
2. Verify that the encoder provides the correct type output for the Encoder Interface.
3. Verify that the cabling is correct for the type of encoder used.

LED Functions

Five LEDs are provided on the Encoder Interface for fault and status indication. The function of each status LED is marked on the card next to it. Table 23-4 lists the fault and status LEDs and the test points on the Encoder Interface.

Table 23-4. LEDs and Test Points



Label	Description
FAULT	Indicates fault condition
CTR	ON = Disabled, OFF = Enabled
DIR	ON = CW, OFF = CCW
CLK	Intensity directly proportional to pulse inputs
MKR	ON = On Marker, OFF = Off Marker

Test Points		
TP7	Phase 1	A status
TP8	Phase 2	B status
TP9	- Marker	Z status
TP10	Analog Common	12 V Common from chassis power supply

Troubleshooting the Encoder Interface

Problem	No change in the Encoder Interface count value.
Steps	1. Check the encoder (refer to the manufacturer's specifications). 2. Check the wiring between the encoder and the Encoder Interface. 3. Rotate the encoder. Check that the Clk LED on the Encoder interface comes on when the encoder is rotated. The faster the encoder is rotated the brighter the LED will glow. 4. Check the address switch on the Encoder Interface (or the address PROM). 5. Run the following test program. The program will display the value coming from the encoder on the computers display. The count that you get will be in encoder counts x 4.

```
LOGIC:
   ESCALE n = 1
   ZERO ENCODER n
   START LOOP
   END

LOOP:
   R1 = ENCODER n
; n is the Encoder Interface number
   PRINT 0, R1
   START LOOP
   END
```

Problem	Wrong count
Steps	1. Check the wiring and shielding. 2. Check the encoder. 3. Check software and run the test program above.

Specifications

Parameter	Specification
Input power for encoder	+12 Vdc
Maximum input frequency	100 kHz
Digital Receiver:	
Maximum common mode voltage	±15 V
Minimum differential channel amplitude	1 V p-p
Differential input impedance	180 Ω
Power requirements (PWA only)	+5 Vdc ± 0.25 V at 0.5 A +12 Vdc ±1.2 Vdc at 0.035 A -12 Vdc ±1.2 V at 0.002 A
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing

24 Model 473.21c Temposonics Servo Translator

Introduction

The Model 473.21c Temposonics Servo Translator provides closed-loop servo control of hydraulic actuators or electric drives using Temposonics™ feedback transducers.

Standard features of the Temposonics Servo Translator include the following:

- Internal transducer power supply at +12 Vdc, -12 Vdc and +5 Vdc.
- Internal servo output supply at +12 Vdc and -12 Vdc.
- 25 mA full scale servo output current.
- Drive Enable output active low.
- +Limit, -Limit, and Home inputs active high.
- Interface to ±12 Vdc digital Temposonics transducer with external interrogation.
- 13 fault and status LEDs

Options include the following:

- External transducer power supply at +12 Vdc, -12 Vdc and +5 Vdc or +15 Vdc, -15 Vdc, and +5 Vdc.*
- External servo output supply at +12 Vdc to +26 Vdc and -12 Vdc to -26 Vdc.*
- 50 mA or 100 mA full scale servo output current.†
- ±10 V full scale voltage servo output.†
- Drive Enable output active high.*

* Requires jumper changes.
† Requires component changes.

Many models are available:

Model No.	Custom Servo Motors Part No.	Description
473.21c-01A-005	381861-05	±25 mA full scale servo output*
473.21c-01A-006	381861-06	±25 mA full scale servo output and 56 MHz crystal
473.21c-01A-007	381861-07	±50 mA full scale servo output and 28 MHz crystal
473.21c-01A-008	381861-08	±10 V full scale servo output and 28 MHz crystal
473.21c-01A-009	381861-09	±100 mA full scale servo output and 28 MHz crystal
473.21c-01A-010	381861-10	±10 V full scale servo output and 56 MHz crystal
473.21c-01A-011	381861-11	±50 mA full scale servo output and 56 MHz crystal

* Standard stocked assembly.

Figure 24-1 shows the location of important components on the Temposonics Servo Translator.

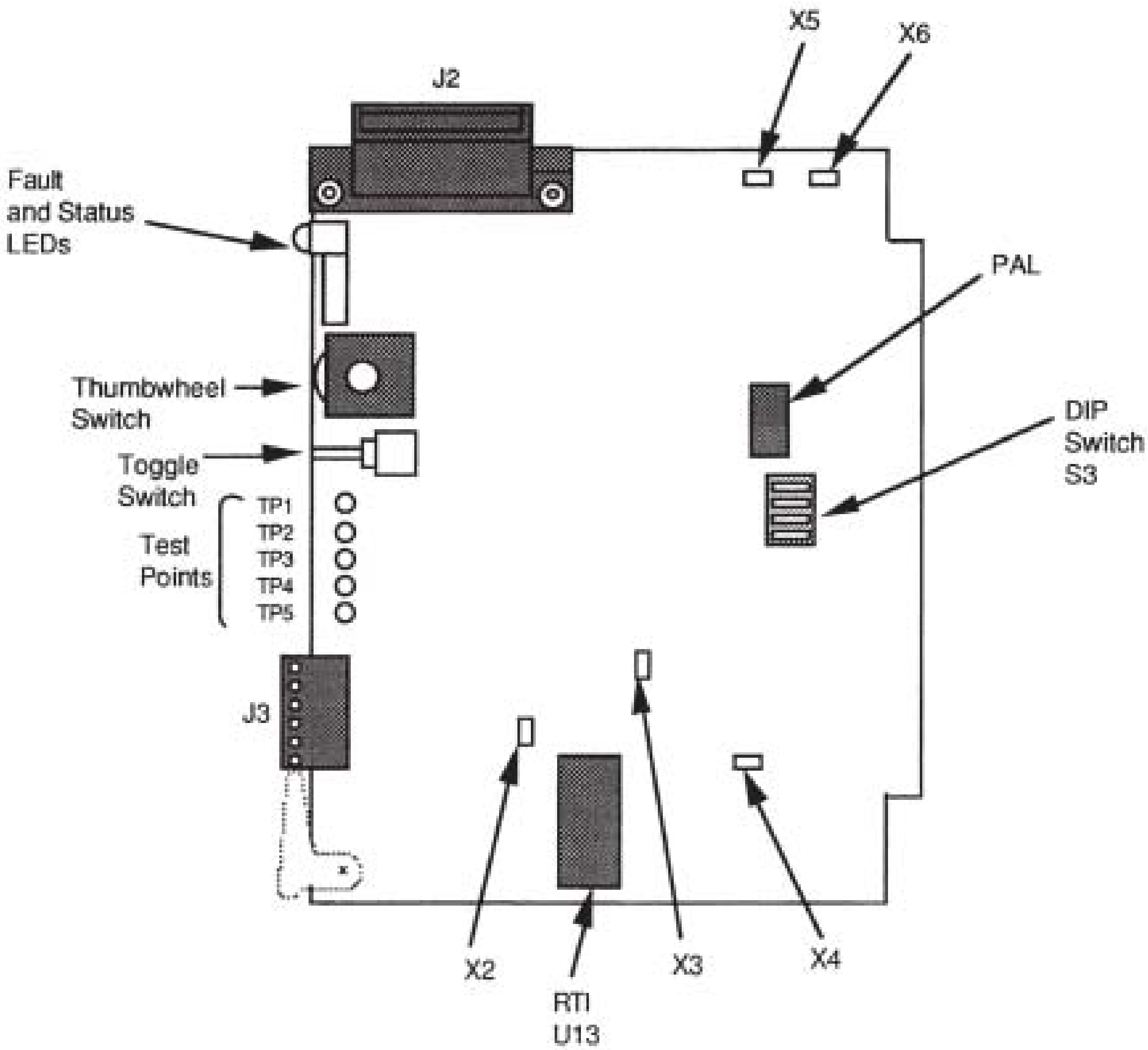


Figure 24-1. Model 473.21c Temposonics Servo Translator Component Location

Jumpers

Set the jumpers on the Temposonics Servo Translator card using Table 24-1. The standard connection for each jumper is also noted in the table. Refer to Figure 24-1 for the jumper locations.

Table 24-1. 473.21c Temposonics Servo Translator Jumper Connections

Jumper	Connection	Description
X2	2-3*	1K x 8 RAM
X2	1-2	8K x 8 RAM
X3	2-3*	512 x 8 EEPROM
X3	1-2	8K x 8 EEPROM
X4	1-2*	8031 Microcomputer
X4	NC	8751 Microcomputer
X5	1-8*	Internal +12 Vdc transducer power supply
X5	2-7*	Internal -12 Vdc transducer power supply
X5	3-6*	Internal +5 Vdc transducer power supply
X5	4-5*	Internal supply analog common
X5	NC	External power supply for transducers and circuit card optocouplers
X6	1-8*	Internal +12 Vdc for servo output power supply
X6	3-6*	Internal -12 Vdc for servo output power supply
X6	2-7	External +12 Vdc to +26 Vdc for servo output power supply
X6	4-5	External -12 Vdc to -26 Vdc for servo output power supply
X7	1-2*	Drive enable active low
X7	2-3	Drive enable active high
X8	1-2*	Drive enable active low
X8	2-3	Drive enable active high
*	Standard connection	

NOTES

You must use an external transducer supply if more than two Temposonics control axes are present in a single chassis.

External servo amplifier output supplies are used in high current applications.

Address DIP Switch

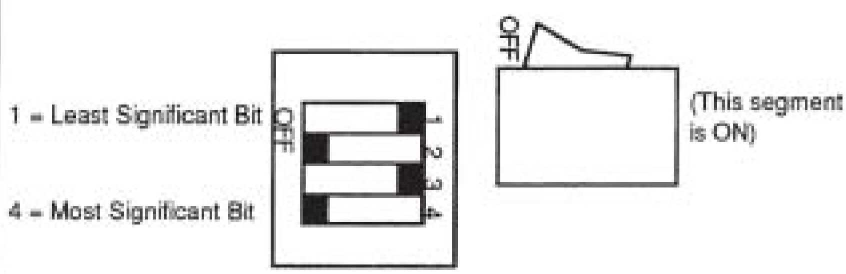
Up to 16 Temposonics Servo Translators can be used in a system. Cards with serial numbers of 1523 or higher define addresses by a PAL (part number 442055-01) and a 4-segment DIP switch on each card. Set the 4-segment DIP switch S3 with the required address, using Table 24-2.

Table 24-2. DIP Switch Settings(4-segment DIP switch only)

Switch Settings:

1 = ON
0 = OFF

Example:



bit pattern = 0101
Translator No. = 5

Temposonics Servo Translator Number	Setting 4321
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111
16	0000

Older Temposonics Servo Translator cards (with serial numbers below 1523) do not use a DIP switch. Instead, the address is defined by a PROM on each card, as shown in Table 24-3.

Table 24-3. Address PROM (Serial Numbers below 1523)

Axis No.	PROM Part No.
1	371529-01
2	371529-02
3	371529-03
4	371529-04
5	371529-05
6	371529-06
7	371529-07
8	371529-08
9	371529-09
10	371529-10
11	371529-11
12	371529-12
13	371529-13
14	371529-14
15	371529-15
16	371529-16

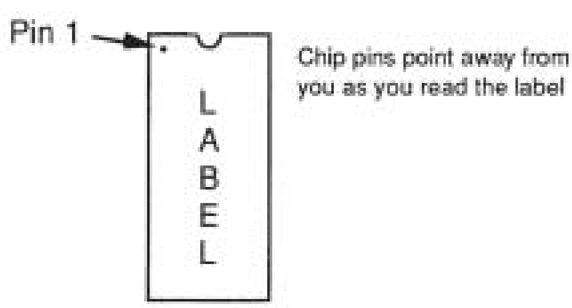
Replacing the RTI EPROM

EPROM U13 contains the RTI (Run Time Interpreter). This is the firmware used by the Temposonics Servo Translator to interpret INCOL86 instructions at run time. In some cases (using custom firmware) this EPROM must be replaced.

CAUTION

Make sure chassis power is OFF before removing the Temposonics Servo Translator to replace this EPROM.

Carefully remove the existing EPROM at site U13 (using a tool such as a flat-bladed screwdriver). Install the new EPROM at U13. Do not plug in this chip upside down. Use pin 1 of this chip as a reference point:



Plug pin 1 of the chip into pin 1 of the socket (pin 1 is in the upper left hand corner of the socket if you position the card with J2 facing up).

Wiring

Connector J2 and J3 on the Temposonics Servo Translator provide external connections. Tables 24-4 and 24-5 show pin definitions for these connectors.

Table 24-4. J2 Pin Definitions

J2 Pin	Name	Description	Remote Terminal Board* Screw Terminals
1	+Vx	+12 Vdc or +15 Vdc	15
2	–Vx	–12 Vdc or –15 Vdc	16
3	Vx COM	12 V or 15 V common	18
4	INTERROGATE–	Pulse output to transducer	13
5	INTERROGATE+	Pulse output to transducer	12
6	AUX SERVO POWER+	External servo power	1
7	AUX SERVO POWER+	External servo power	
8	OUTPUT SOURCE	Command output	5
9	DRIVE ENABLE	Drive enable output	7
10	AUX SERVO POWER COM	Auxiliary power supply common	3
11	+5 VX	+ 5 V transducer supply	17
12	+5 VX	+ 5 V transducer supply	
13	+Vx	+12 Vdc or +15 Vdc	
14	–Vx	–12 Vdc or –15 Vdc	
15	Vx COM	12 V or 15 V common	
16	GATE–	Feedback pulse from transducer	11
17	GATE+	Feedback pulse from transducer	10
18	AUX SERVO POWER–	External – servo power –12 V to –26 V	2
19	AUX SERVO POWER–	External – servo power –12 V to –26 V	
20	OUTPUT RETURN	Command return	6
21	CHASSIS COMMON	Internal chassis ground	9
22	AUX SERVO POWER COM	Auxiliary power supply common	
23	Vx COM	12 V or 15 V common	8
24	Vx COM	12 V or 15 V common	
* When used with cable 389186-XX			

Table 24-5. J3 Pin Definitions

J3 Pin	Name	Description
1	+12 V	+12 Vdc internal
2	ANALOG COMMON	Internal analog common
3	+LIMIT	Active high +limit input
4	–LIMIT	Active high –limit input
5	HOME	Active high home input
6	CHASSIS COMMON	Internal chassis ground

Cabling

The standard cable used with the Temposonics Servo Translator is Model 473.50c-35A-200 (Custom Servo Motors part number 389186-xx). This cable connects the Temposonics Servo Translator J2 to the Remote Terminal Board. Refer to the cabling chapter of this manual for the cable pinout. If limits, or home inputs are not used, they must be tied to analog ground.

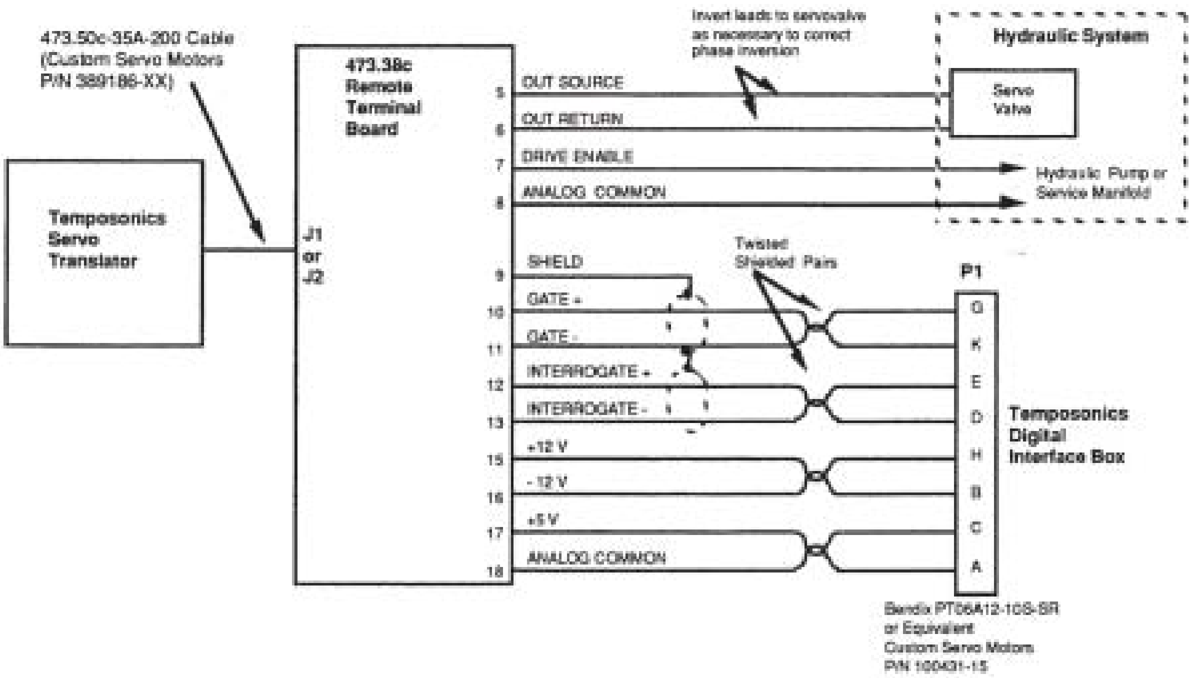


Figure 24-2. Cable Configuration for the Temposonics Servo Translator When Using an Analog *Current* Velocity Command

Cabling to Temposonics II Transducer

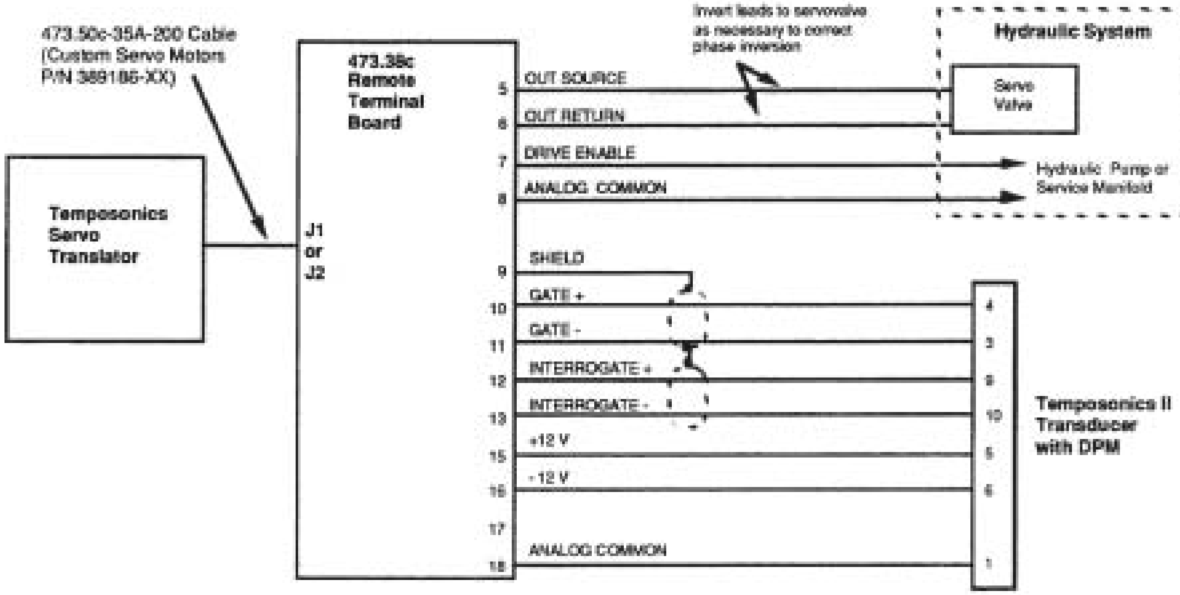


Figure 24-2a. Cable Configuration for the Temposonics II Transducer

Older systems may use cables with different color coding. The following table compares previous and present cables.

Table 24-5a. Cable Colors for Previous and Present Temposonics II Transducer Connections

Tranducer Pin Number	Previous Cable Color	Present Cable Color
1	White/Blue	White
2	Blue/White	Brown
3	White/Orange	Gray
4	Orange/White	Pink
5	White/Green	Red
6	Green/White	Blue
7	White/Brown	Black
8	Brown/White	Violet
9	White/Gray	Yellow
10	Gray/White	Green

Optional Cabling for J2

Connect the Temposonics Translator direct to the Temposonics transducer and the hydraulic system as shown in Figure 24-3.

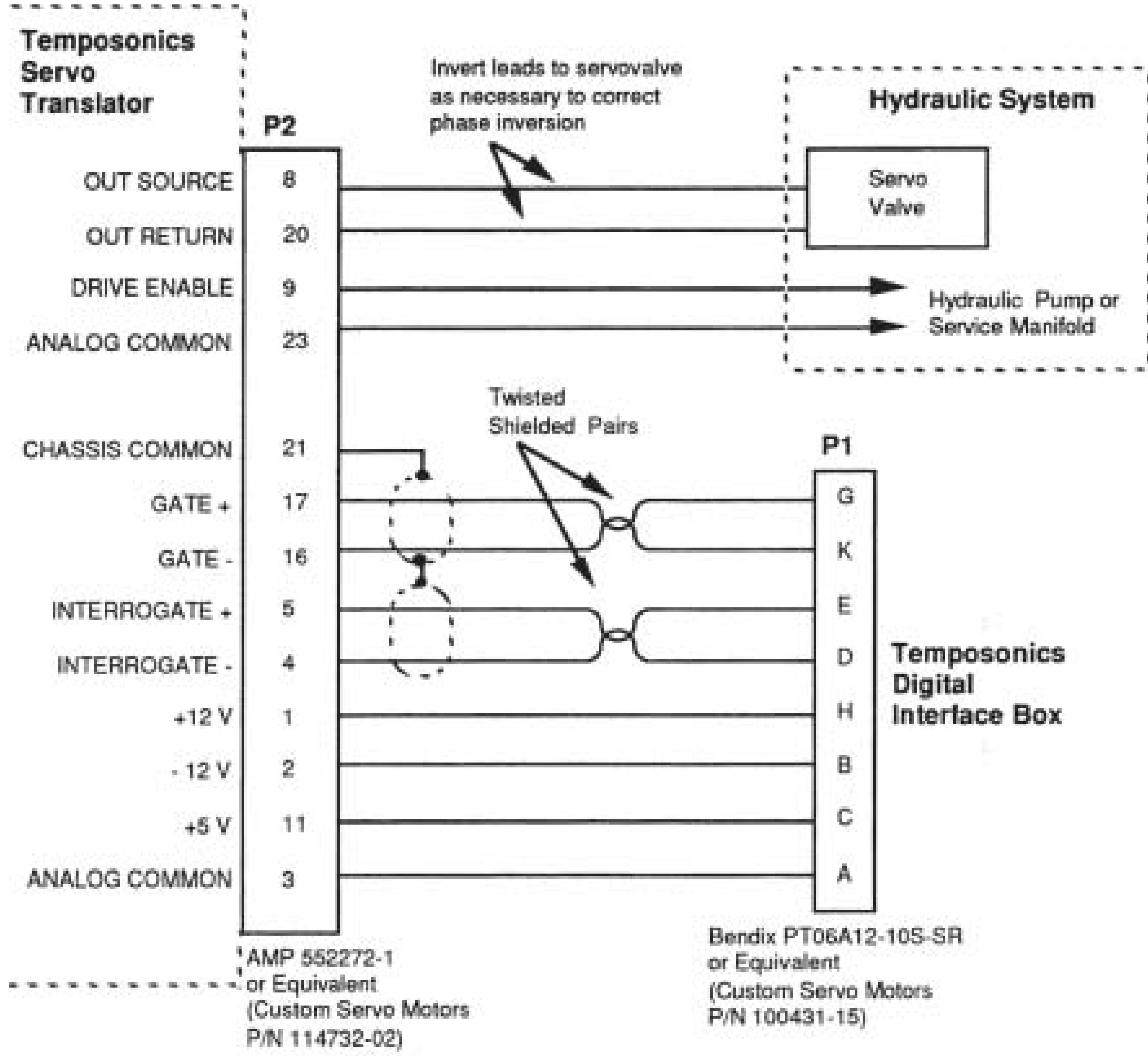


Figure 24-3. Optional Cabling Example When Using an Analog *Current* Velocity Command

Connect the Temposonics Translator direct to the Temposonics II transducer and the hydraulic system as shown in Figure 24-3a.

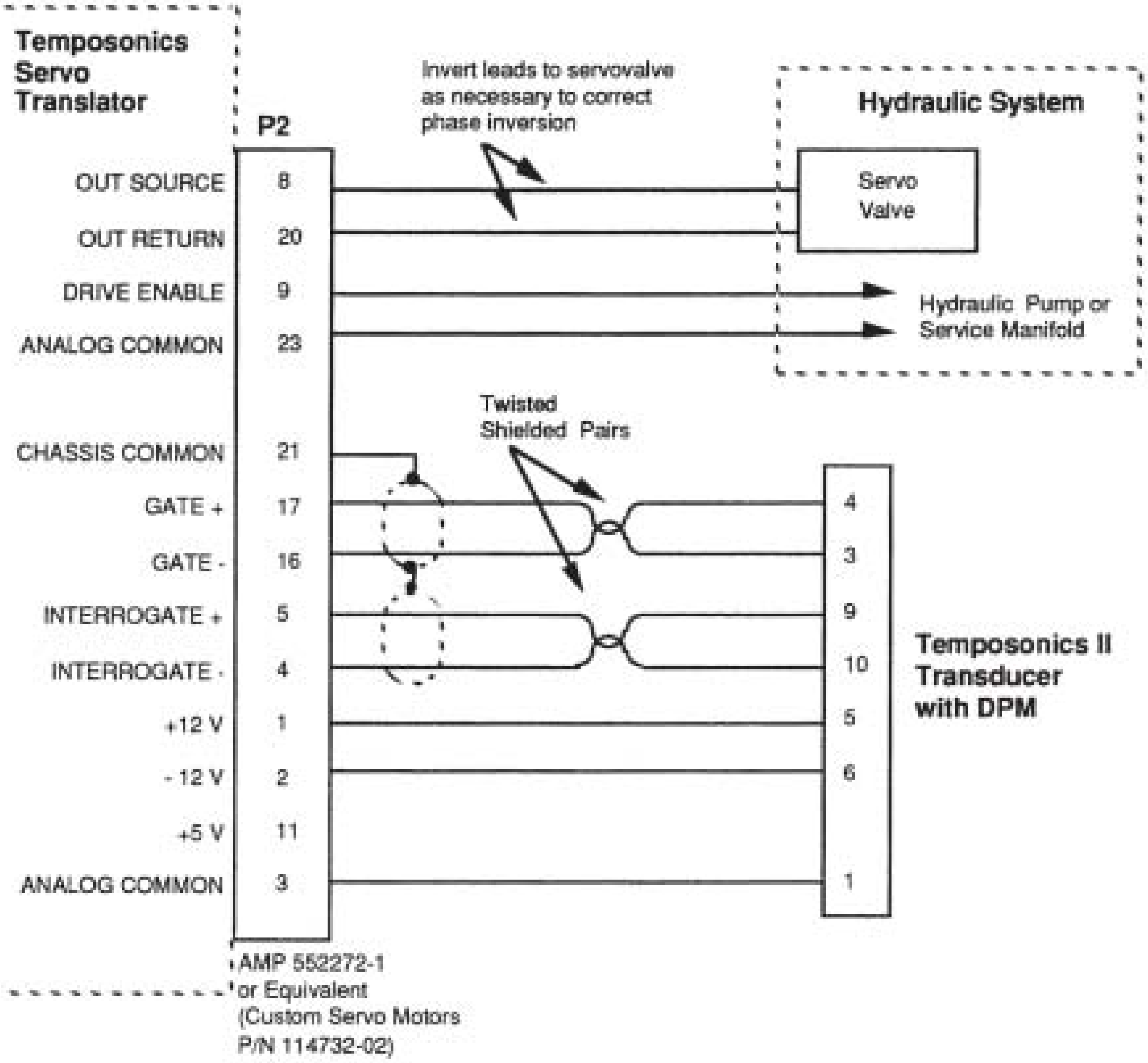


Figure 24-3a. Optional Cabling Example for Temposonics II Transducer When Using an Analog *Current* Velocity Command

Refer to Figure 24-4 for optional cabling when using the *voltage* servo amplifier mode.

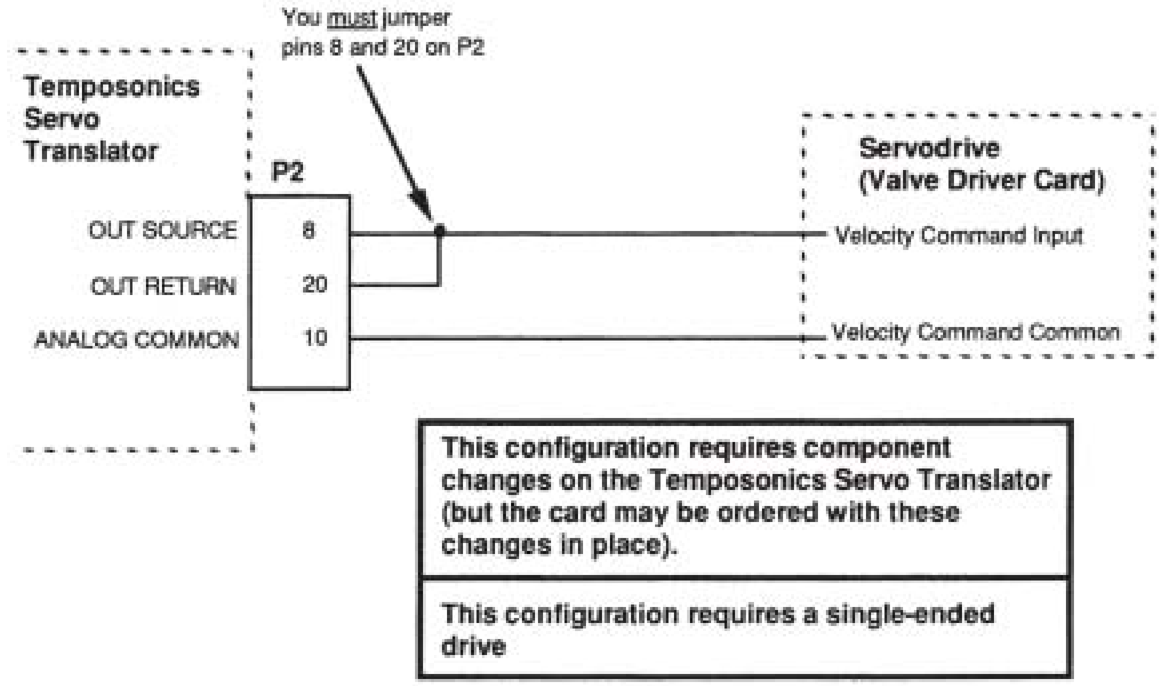


Figure 24-4. Optional Cable: Translator to DC Servo Drive

Refer to Figure 24-5 for optional cabling when using the *voltage* servo amplifier mode with a Remote Terminal Board.

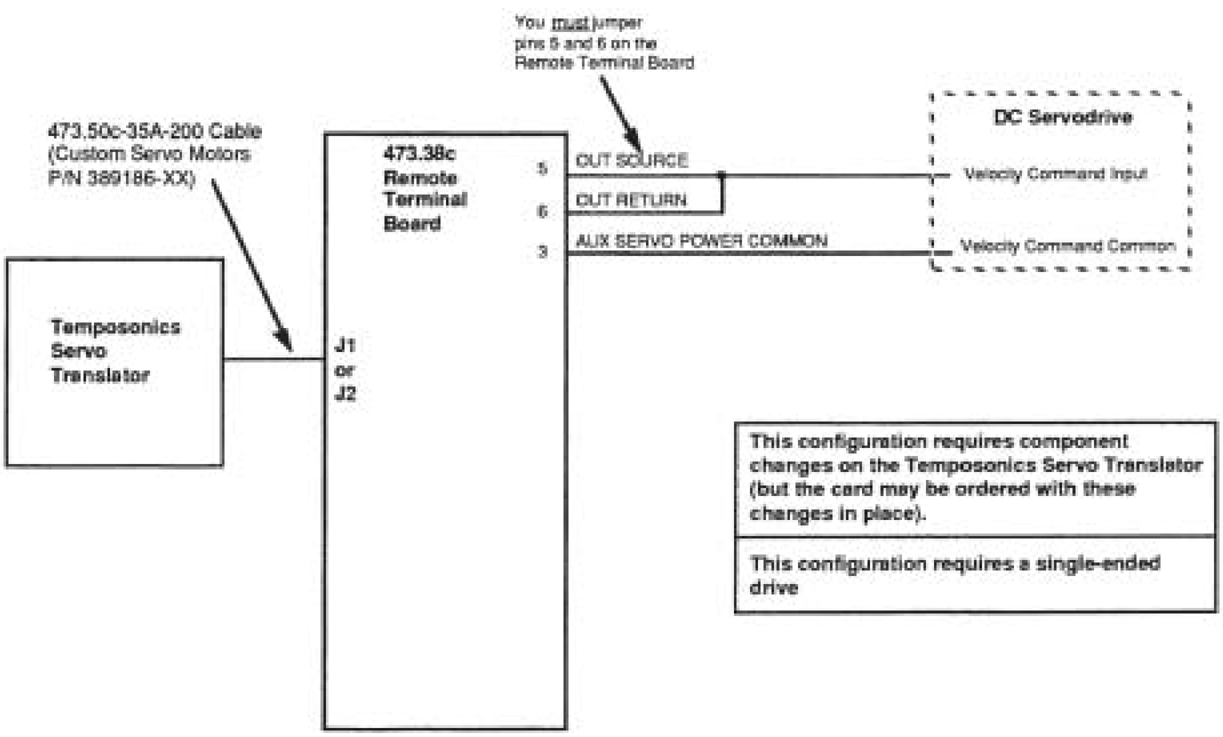


Figure 24-5. Optional Cable: Servo Drive with Remote Terminal Board

Refer to Figure 24-6 for optional cabling when using an external transducer supply.

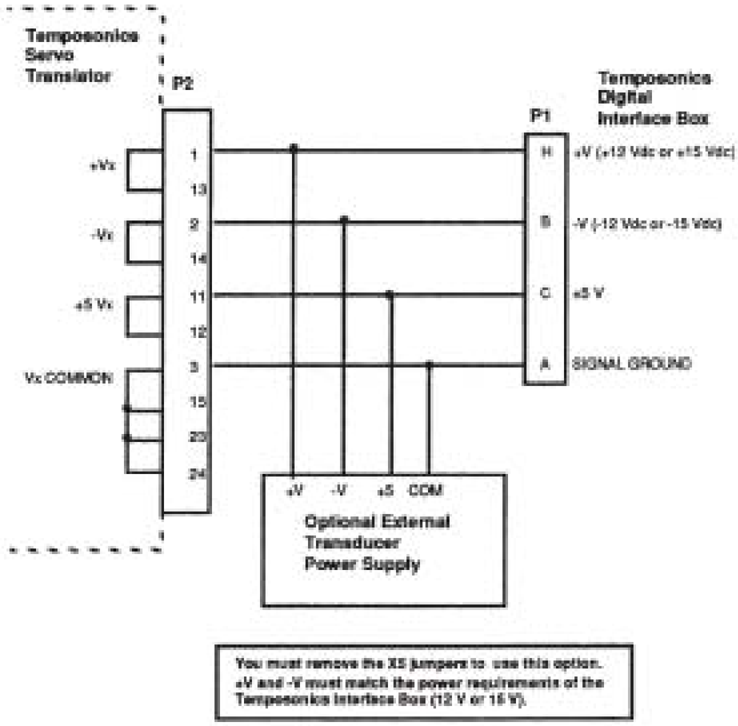


Figure 24-6. Optional Cable: External Power Supply for Transducer

Refer to Figure 24-7 for optional cabling when using an external transducer supply with a Remote Terminal Board.

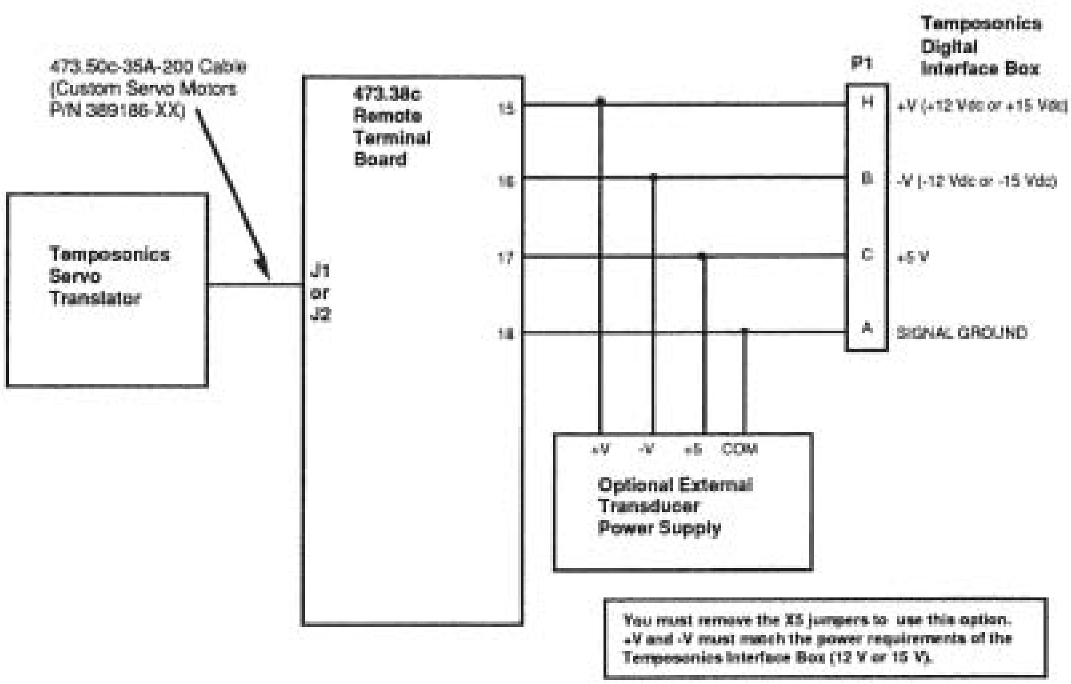


Figure 24-7. Optional Cable: External Power Supply for Transducer with Remote Terminal Board

Refer to Figure 24-8 for optional cabling when using an external servo output supply.

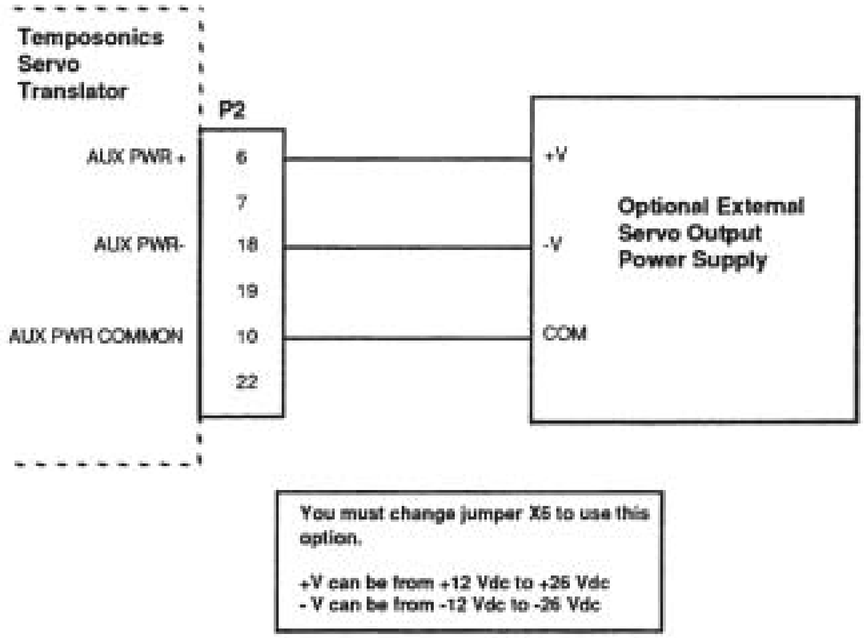


Figure 24-8. Optional Cable: External Power Supply for DC Servo Output

Refer to Figure 24-9 for optional cabling when using an external servo output supply with a Remote Terminal Board.

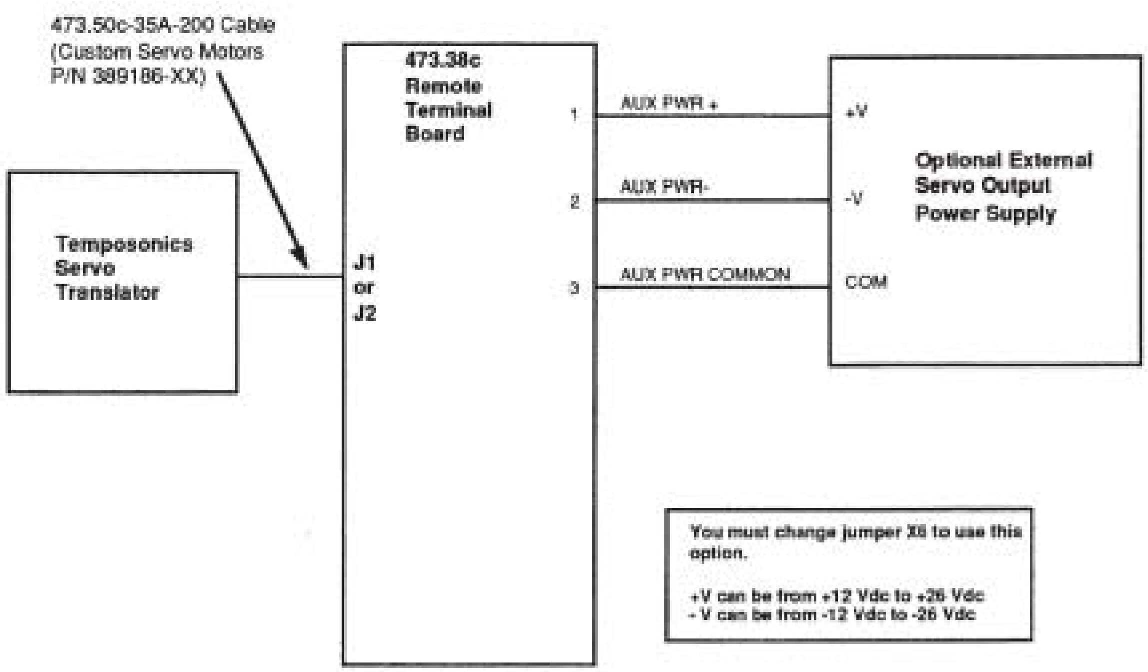


Figure 24-9. Optional Cable: External Power Supply for DC Servo Output with Remote Terminal Board

Standard Cabling for J3

Limit and home switches are connected to connector J3 of the Temposonics Servo Translator. Refer to Figure 24-10. Limit and Home inputs are active when the switches are open. If the Limits and Home are not used, they should be tied direct to analog common.

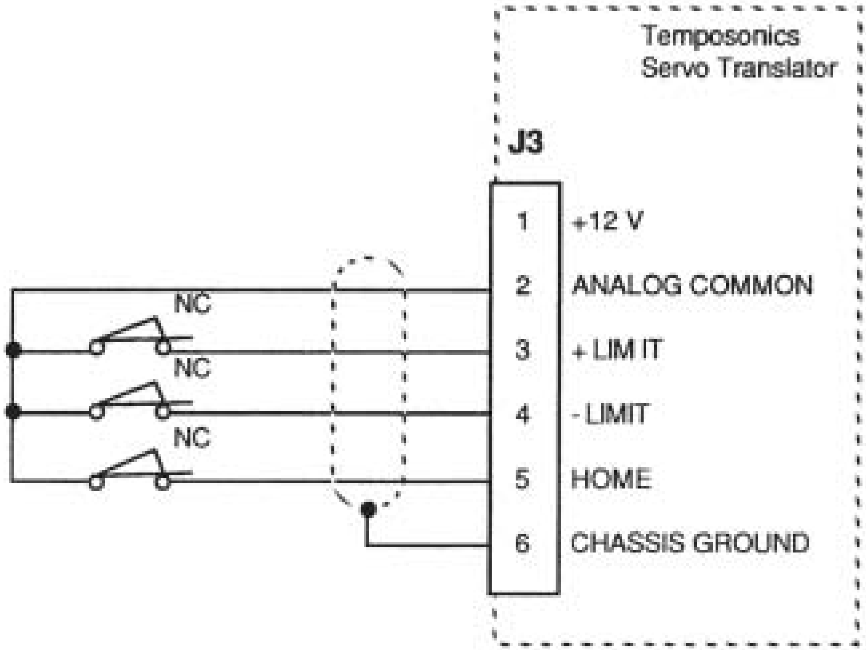


Figure 24-10. Cabling for J3

Drive Enable Output

The drive enable output is normally configured for active low output. Optionally, Jumpers X7 and X8 can be used to configure the drive enable sense as active high (refer to the jumper table earlier in this chapter). The drive enable configuration is illustrated in Figure 24-11. The maximum drive enable output current is 100 mA.

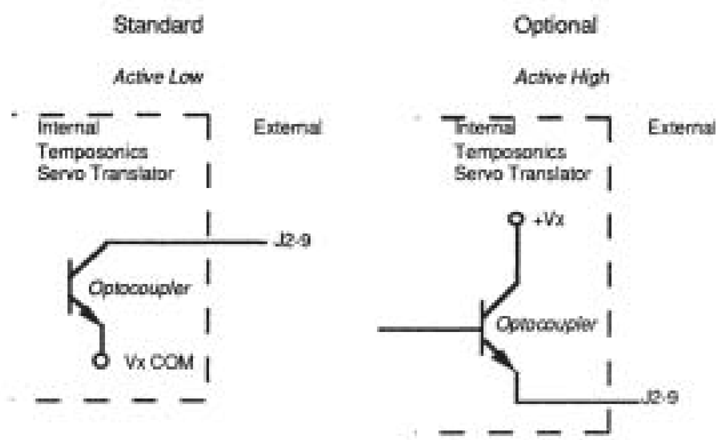


Figure 24-11. Enable Circuit Configurations Changing the Enable Sense

WARNING

If you are not using the drive enable output, you must provide separate shutdown protection to be used in case of controller malfunction or unanticipated movement. Uncontrolled movement can cause personal injury and damage to equipment.

Limit and Home Inputs

Figure 24-12 shows the typical internal configuration for both the home and limit inputs.

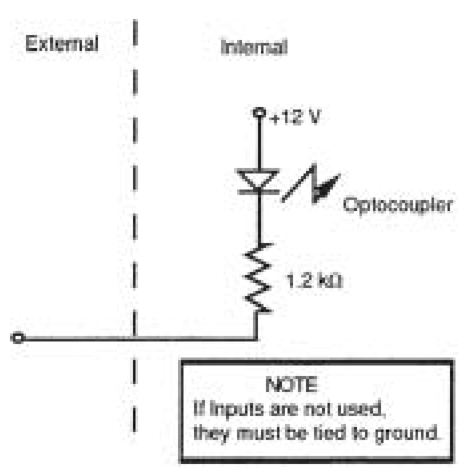


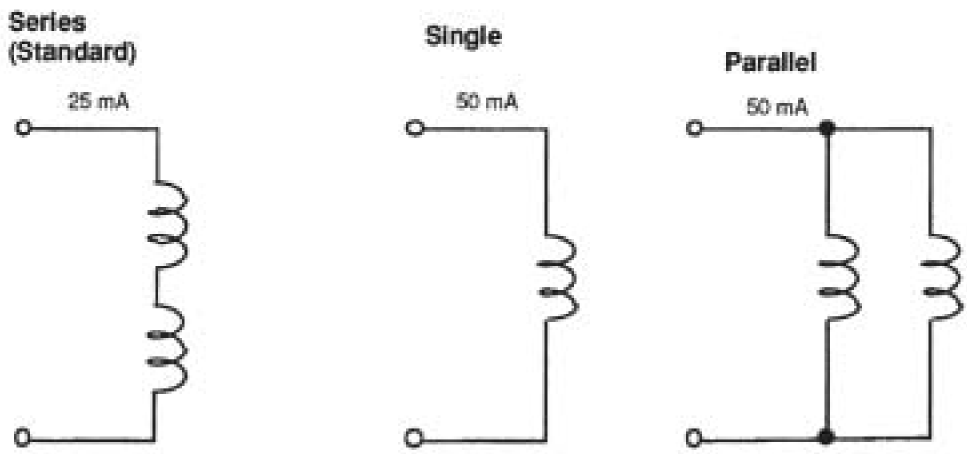
Figure 24-12. Internal Configuration of Limit and Home Inputs

Servovalve Configurations

NOTE

Refer to servovalve manufacturer's specifications to determine the configuration of your servovalve.

Coils on a servovalve can be configured as series, single, or parallel (Refer to Figure 24-13). Using standard Custom Servo Motors coils that have 80 ohms resistance per coil, the specifications for rated full flow input signal current are shown in Table 24-6.



All configurations except the standard (Series) configuration require component changes on the Temposonics Servo Translator

Figure 24-13. Servo Valve Configurations

Table 24-6. Current Specifications for Servo Value Configurations for 80 Ω Coils

Configuration	Current
Series Coils	25 mA *
Single Coil	50 mA
Parallel Coils	50 mA
*Standard Temposonics Servo Translator Configuration	

Servo Output Amplifiers

The servo output amplifier full scale output is set for 25 mA standard. The full scale output can be reconfigured as shown in Table 24-7. The final column of the table shows Custom Servo Motors part numbers for Temposonics Servo Translators which have already been configured for the outputs shown.

Table 24-7. Servo Output Full Scale Configurations

Full Scale Output	Resistors			Custom Servo Motors Part No.
	R43	R44	R18	
25 mA *	15	15	100(0.5W)	381861-05 ①
50 mA	10	10	47 (0.5W)	381861-07
100 mA	4.7	4.7	24 (1W)	381861-09 ③

*Standard Temposonics Servo Translator Configuration
¶All Values are in Ohms. Use 0.25W resistors unless otherwise indicated.
R16 = 3.3 kΩ and R48=2.4 kΩ for all current ranges

The servo output amplifier can also be configured for voltage output instead of current (used on servo drives and valve driver cards). Reconfigure as shown in Table 24-8:

Table 24-8. Servo Output Voltage Configurations

Function	R43	R44	R18	R16	R48	Custom Servo Motors Part No.
Voltage Buffer	4.7Ω	4.7Ω	(remove)	(remove)	10KΩ	381861-08 ②

NOTE

The voltage buffer configuration requires a cabling configuration that is different from the current configuration.

① 381861-06 similar to -05 except it uses 56 Mhz oscillator.
② 381861-10 similar to -08 except it uses 56 Mhz oscillator.
③ 381861-11 similar to -07 except it uses 56 Mhz oscillator.

Installing the Temposonics Servo Translator

⚠ CAUTION

Make sure chassis power is OFF before installing this module.

The Temposonics Servo Translator requires one slot in the chassis.

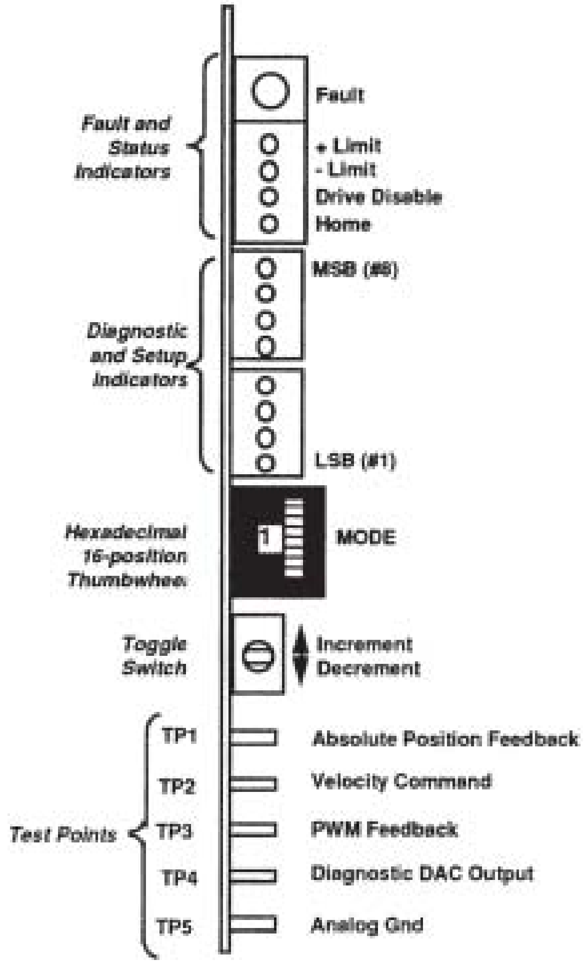
Setup

Take the following steps to set up the Temposonics Servo Translator:

1. Verify that the DIP switch segments on the Temposonics Servo Translator are set to the correct number.
2. Check that the Translator is set for the correct full scale output (current or voltage).
3. Set the drive enable jumpers for the correct configuration.
4. Set the jumpers for the type of transducer power supply.
5. Set the jumpers for the type of servo output power supply.
6. Check the cabling for the feedback and valve or drive configuration used.
7. Check limit and home wiring.
8. Use the front panel thumbwheel and toggle switch to tune the servo loop.
9. Calculate feedback update time.

Thumbwheel, LEDs, and Toggle Switch

Parameters can be adjusted by the set-up controls shown in Figure 9-12. The thumbwheel switch selects the parameters to be displayed on the LEDs, and the toggle switch adjusts these parameters. Thumbwheel position 0 allows the operator to monitor an 8-bit fault and status display.



LEDs		
Label	Name	Description
DS1	Fault	ON = fault
+L	+Limit	ON = on + limit
–L	–Limit	ON = on –limit
DD	Drive Disable	ON = drive disabled
H	Home	ON = at home

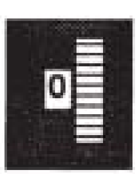
MODE (Thumbwheel Position)	Displayed Parameter
0	Fault/Status Word*
1	Proportional Gain
2	Integral Gain
3	Dither Amplitude
4	Loop Bias
5	EEPROM Recall
6	EEPROM Save
7	Loop Time
8	Diagnostic DAC Output Selection
9	Diagnostic DAC Scaling
A	Derivative
B	Double Derivative
C	Feedforward Fraction
D	Feedforward Units
E	(Not Used)
F	(Not Used)

*The top LED represents the MSB of an 8-bit word

Figure 9-12. Temposonics Module Thumbwheel, Toggle Switch, and LEDs

Functions can be set via the front panel controls or by the applications program. To use the front panel controls, set the thumbwheel switch to position 0 and verify that LED #8 (MSB) is lit. If LED #8 is not lit, you must enable it using INCOL86. If it is lit, you can change system parameters by first placing the thumbwheel switch to the desired function number and then pushing the toggle switch up or down to increase or decrease the setting of the particular function.

Thumbwheel Position Versus Displayed Parameter



Reading the Fault and Status Word. Thumbwheel position 0 allows the operator to monitor an 8-bit fault and status LED display. Table 24-8 describes the condition associated with each LED of the display.

Table 24-9. Fault and Status Word Indications

LED	Description
8	ON = Toggle switch operation enabled. OFF = Toggle switch disabled for setup.
7	ON = EEPROM save in progress.
6	ON = Feedback loss is due to feedback stuck high or low, or incorrect update time.
5	ON = Command direction is positive (retraction).
4	ON = Hold/Not Go. The Translator holds its current position.
3	ON = In position. Command equals feedback.
2	Hard excess position error. Motion stops and fault LED lights.
1	Soft excess position error. A flag is set to allow software decisions.

Proportional Gain Adjustment. Selecting thumbwheel position 1 allows the operator to monitor and adjust the proportional gain setting. Pushing the toggle switch up increases the proportional gain. Pushing the toggle switch down decreases the proportional gain. The proportional gain range is 0.25 to 63.75 in 0.25 increments. The diagnostic/setup LED display shows a binary representation of the proportional gain value. For example, with all LEDs lit, the value represented would be calculated as follows:

displayed value = 11111111 (binary) = 255 (decimal)

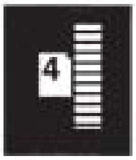
gain value = 255 x 0.25 = 63.75

Reset Time Constant Divider Adjustment. Selecting thumbwheel position 2 allows the operator to monitor and adjust the reset time constant divider (D) used when the reset integrator is enabled. Pushing the toggle switch up increments the reset time constant divider. Pushing the toggle switch down decrements the rest time constant divider. The LEDs show a binary representation of the time constant value in the range 1 to 255 (0 means off), which is calculated as follows:

$$Rtc = 4096 \times \frac{T}{D}$$

where Rtc is the reset time constant (seconds)
T is the loop update time in milliseconds
D is the time constant divider

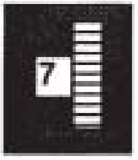
Dither Amplitude Adjustment. Selecting thumbwheel position 3 allows the operator to monitor and adjust the servovalve dither signal amplitude. Pushing the toggle switch up causes the dither amplitude to increase in 0.048% steps. Pressing the toggle switch down causes the dither amplitude to decrease in 0.048% steps. The maximum allowed dither amplitude is 12% of the full-scale valve current. The LED display shows the binary representation of the dither amplitude.



Inserting Loop Bias. Selecting thumbwheel position 4 allows the operator to remove simple dc offsets from the loop without the use of the reset integrator. This is accomplished by finding the loop bias and compensating the translator output command accordingly. Pushing the toggle switch up finds and inserts the loop bias value. Pressing the toggle switch down clears an existing loop bias value. The LED display shows the binary representation of the absolute value of the offset up to a maximum value of 12% of the full-scale valve current. The offset polarity is not indicated.

Recalling Setup Parameters from Memory. Selecting thumbwheel position 5 allows the operator to recall setup parameters saved in EEPROM. The recalled parameters include proportional gain, reset time constant, dither amplitude, loop bias, loop time, feedback loss, diagnostic DAC scaling, rate/acceleration gain, and feed forward. Pushing the toggle switch up or down recalls the parameters.

Saving Setup Parameters in Memory. Selecting thumbwheel position 6 allows the operator to save current setup parameters in EEPROM. Pushing the toggle switch up or down saves the current setup parameters. All LEDs in the display are on while the save process is in progress.



Loop Time Adjustment. Selecting thumbwheel position 7 allows the operator to adjust the time between servo loop updates. The loop time must be greater than or equal to the feedback update time, which is computed according to the following formula:

$$T = P \times N\,(D + L) \text{ microseconds}$$

where:

T = minimum update time in µs

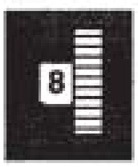
P = propagation time in µs/in.

N = number of circulations (set on transducer interface box)

D = dead space (at end of transducer) in inches

L = active stroke of transducer in inches

Pushing the toggle switch up increases the loop time by .25 ms Pressing the toggle switch down decreases the loop time by .25 ms. The value shown on the LED display is in 0.25 ms increments. The minimum loop time is 1.25 ms (decimal 5 or binary 00000101). The maximum loop time is 3 ms (decimal 12 or binary 00001100).



Diagnostic DAC Output Selection. Selecting thumbwheel position 8 allows the operator to select a parameter to be monitored at the diagnostic DAC output. Pushing the toggle switch up or down increases or decreases the LED display (respectively) to select a parameter according to:

1 = position error

2 = feedback

3 = command

Diagnostic DAC Scaling. Selecting thumbwheel position 9 allows the operator to select a desired scaling of the diagnostic DAC output. DAC scaling actually selects an 8-bit window of a 16-bit word for digital-to-analog conversion. If the parameter to be measured is low in amplitude, the lower bits of the 16-bit word should be in the window to allow higher output resolution. The window must be moved toward the upper bits of the 16-bit word to output higher amplitude levels without saturation of the DAC. It is desirable to select the scaling that produces the highest resolution (the lowest window of the 16-bit word), however the lower the window position, the greater the chances are of encountering saturation.

Pushing the toggle switch up or down increases or decreases the LED display value (respectively) to select the DAC scaling window as follows:

1 = bits 8 through 15 (lowest resolution)

2 = bits 7 through 14

3 = bits 6 through 13

4 = bits 5 through 12

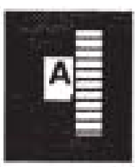
5 = bits 4 through 11

6 = bits 3 through 10

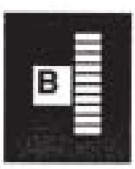
7 = bits 2 through 9

8 = bits 1 through 8

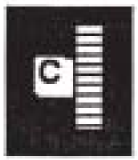
9 = bits 0 through 7 (highest resolution)



Derivative Adjustment. Selecting thumbwheel position A allows the operator to monitor and adjust the rate stabilization setting. Pushing the toggle switch up increases the rate gain. Pushing the toggle switch down decreases the rate gain. The rate gain range is 0 to 255.



Double Derivative Adjustment. Selecting thumbwheel position B allows the operator to monitor and adjust the acceleration stabilization setting. Pushing the toggle switch up increases the acceleration gain. Pushing the toggle switch down decreases the acceleration gain. The acceleration stabilization adjustment range is 0 to 255.

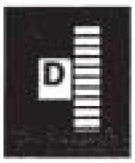


Feedforward Fraction Adjustment. Selecting thumbwheel position C allows the operator to monitor the feedforward fraction and adjust the feedforward. Raising the toggle switch increases the feedforward setting. Lowering the toggle switch decreases the feedforward setting. The diagnostic LED display shows a binary representation of the fractional part of the feedforward setting. For example, with all LEDs lit, the value represented would be calculated as follows:

displayed value = 1111 1111 (binary) = 255 (decimal)

reset fraction = .003906 x 255 = .996094

The adjustment will overflow or underflow, causing the unit value to increment or decrement.



Feedforward Units Adjustment. Selecting thumbwheel position D allows the operator to view and adjust the units part of the feedforward setting. Raising the toggle switch increases the feedforward setting. Lowering the switch decreases the setting. The maximum feedforward units setting is 127.

Test Points

The translator circuit card contains edge-mounted test points for monitoring certain parameters. These test points are typically used for readout and diagnostic purposes. Table 24-9 lists the test points and the parameters associated with them.

Table 24-9. Edge-Mounted Test Points

Test Point	Parameter
TP1 (ANA FB)	Analog feedback voltage proportional to the absolute position as measured by the transducer
TP2 (OUT)	Analog output command applied to the servovalve
TP3 (PWM FB)	Digital signal that follows the output of the transducer interface box
TP4 (DIAG OUT)	Analog signal (the output of an 8-bit digital-to-analog converter) that represents the parameter selected by the thumbwheel switch
TP5 (ANA GND)	Analog ground

Setting Recirculations

For certain applications it may be necessary to set the number of circulations in your Temposonics Transducer Interface Box to a different value. Refer to Appendix C.

Troubleshooting the Temposonics Servo Translator

Problem	Large Fault LED lit on Temposonics Servo Translator
Steps	1. Check the Fault and Status indicators to see which fault occurred. Set the 16 position thumbwheel switch to position 0 and refer to Table 24-8. One or more of the following conditions will be indicated: a. + limit or - limit error b. loss of feedback c. hard excess error If a fault occurs after power-up, set the thumbwheel to position 0 and push the toggle switch up. If this does not clear the fault read the LEDs and take the appropriate action as shown in the following procedures.
Problem	+ limit or – limit error
Steps	1. Check the wiring to ± overtravel limits. 2. Check the limit switches. 3. Replace the Temposonics Servo Translator
Problem	Loss of Feedback If LED 6 is lit then the fault is caused by loss of feedback. Loss of feedback is a condition that exists when the Temposonics transducer is not functioning or when the magnet is too far away from the transducer head for the loop update time.
Steps	1. Check wiring to the transducer. 2. Check the jumper settings on the Temposonics Servo Translator. The translator has jumpers for selecting external power supplies. The factory setting is for internal power supply. If using external power supply, check the power supply and wiring to the Temposonics Servo Translator. 3. Check the loop update time on the translator. With the thumbwheel switch set to position 7, the loop update time is displayed. For troubleshooting purposes, set the loop update time to the maximum setting of 3 ms. If you calculate that the loop update time will need to be larger than 3 ms, the number of recirculations in the transducer must be changed. Refer to the Temposonics transducer documentation for information on setting the number of recirculations.

4. Check compatibility of the Temposonics transducer and digital interface box with the Temposonics Servo Translator. Verify the model numbers of the transducer and digital interface box. Things to check are:

   - The transducer must use external interrogation.
   - The transducer must be a ±12V version when using internal supply.
   - The recirculation setting.
   - Positive or negative pulses for length of transducer.

5. If you have more than one Temposonics transducer and digital interface box, swap the transducer and digital interface box to determine if the transducer or digital interface box is at fault.

6. If you have more then one Temposonics Servo Translator, swap the cards to isolate the problem to a circuit card.

7. Use an oscilloscope to check the transducer interface of the Temposonics Servo Translator, as follows: The Temposonics Servo Translator sends out + and – interrogation pulses to the transducer and receives gate pulses from it. Disconnect the Temposonics Servo Translator from the transducer and measure from the ANALOG GND test point to the + INTERROGATE pin on connector J2 or on the 40 terminal board. You should see a positive going pulse (pulse width 1 µs, to approximately 4.5 V) once every loop update time (every 3 ms). The – interrogate is identical but it is a pulse from approximately 4.5 volts to common. If you have these pulses then the Temposonics Servo Translator is functioning properly.

Problem

Hard Excess Position Error .

This condition exists when the programmed following error fault has occurred on the Temposonics Servo Translator. This is caused by the following error exceeding the programmed limit. (The following error is the difference between the commanded position and the feedback position.)

Steps

1. Using the manufacturer's procedures, make sure that the servo amplifier and motor are fully operational and capable of achieving desired speeds. If using a servovalve and hydraulic cylinder make sure that they operate properly according to manufacturer's specifications.

2. Using INCOL86 software and your application program make sure that the hard excess error limit is set to a usable value. The default value is set to zero. Typical settings

would be in the 2000 count range. Translator function 4 in INCOL86 sets the following error limit.

3. Adjust the proportional loop gain. The proportional loop gain adjustment is set by INCOL86 software or by setting the thumbwheel to position 1 and moving the toggle switch up to increase the proportional gain and down to decrease the proportional gain. Start by adjusting the proportional gain to its lowest setting. Increase the gain until minor oscillations occur, and then decrease the gain until they disappear.

4. Check that the drive enable jumper and wiring are set correctly for your application. The enable output must match the enable input of the actuator.

5. Replace the Temposonics Servo Translator.

Problem No faults, but no motion

⚠ CAUTION

Make sure chassis power is OFF before removing this module.

Steps

1. Check the address switch (or the address PROM) on the Temposonics Servo Translator.

2. Check the address switch on the associated Command Generator.

3. Check that the drive enable jumper and wiring are set correctly for your application. The enable output must match the enable input of the actuator.

4. If the system has more then one axis of motion, make sure that the Temposonics Servo Translator and its Command Generator are in the correct slots. The backplane is cut to prevent signals from one axis of motion interfering with another axis of motion. Refer to your system block diagram for the correct card placement.

5. Check the wiring from the Temposonics Servo Translator to the servo amplifier or servovalve.

6. Using the manufacturer's procedures, make sure that the servo amplifier and motor or the servovalve and hydraulic cylinder are fully operational.

⚠ WARNING

The following procedure involves uncontrolled actuator movement. Before starting, uncouple the actuator from any machinery that could be damaged or cause a safety hazard.

7. Check the application program. The following sample program will move the motor or cylinder. Before trying this test make sure that motion will not cause personal injuries or damage equipment. This test should be done only after the amplifier and motor, or servovalve and cylinder, have been verified. This program initializes the Temposonics Servo Translator and moves the motor or cylinder 1012 counts or approximately 1 inch. (With 4 recirculations you should get approximately 1012 counts per inch.) If you are working with a different axis use that axis number instead of X1.

```
LOGIC:
AXIS X1 = DDC SERVO          ;IDENTIFY TRANSLATOR TYPE
SCALE X1 = 1012.             ;SET SCALE 1012 APPROX = 1 INCH
XLATOR X1,2 OFF              ;TURN DRIVE ENABLE OFF
XLATOR X1,4 = 2              ;SET EXCESS ERROR TO LARGE VALUE FOR SETUP
XLATOR X1,5 = 2              ;SOFT EXCESS ERROR NOT REQUIRED
XLATOR X1,6 = 4.             ;SET PROPORTIONAL GAIN TO 1
XLATOR X1,7 = 0.             ;INTEGRATOR OFF
XLATOR X1,8 = 0.             ;DITHER OFF
XLATOR X1,9 = 5.             ;SETS FEEDBACK LOSS VALUE ON TEMPO XLATORS
XLATOR X1,10 = 0.            ;OFFSET SET TO 0
XLATOR X1,11 = 0.            ;DERIVATIVE SET TO 0
XLATOR X1,12 = 0.            ;DOUBLE DERIVATIVE SET TO 0
XLATOR X1,13 = 0.            ;FEED FORWARD SET TO 0
XLATOR X1,14 = 0.            ;SET RANGE OR FEEDBACK SCALING TO 0
XLATOR X1,15 = 0.            ;SET SOFTWARE COUNTERS TO 0
XLATOR X1,16 = 12.           ;SET UPDATE TIME TO 3 ms
HALT X1                      ;RESET TRANSLATOR
VMAX X1 = 50.5               ;SET VMAX TO A HIGH VALUE FOR TEST
AVD X1 = 1,1,1               ;ACCEL,DECEL = 1 IN/SEC/SEC VEL = 1 IN/SEC
DIST X1 = 1                  ;MOVE 1012 COUNTS APPROX 1 INCH
XLATOR X1 ON                 ;ENABLE TRANSLATOR
MOVE X1                      ;START MOVE
MWAIT X1                     ;WAIT FOR MOTION TO STOP
END
```

8. Replace Temposonics Servo Translator

Problem

Motor or cylinder runs away

Steps

1. Using manufacturer's procedures, make sure that the servo amplifier and motor, or servovalve and hydraulic cylinder, are fully operational.

	2. Make sure that the power supply for the command output is working properly. 3. If the amplifier and motor or the servovalve and cylinder are fully operational, then the motor or cylinder could be running away because the command is not correctly phased. To change the command phasing, swap the velocity command with the velocity command common. 4. Swap or replace the Temposonics Servo Translator.
Problem	Motor or cylinder oscillates violently
Steps	1. Using manufacturer's procedures, make sure that the servo amplifier and motor or the servovalve and cylinder are fully operational. 2. If the command phasing is correct, then the problem may be due to excess position loop gain. Adjust the loop gain down until the oscillation goes away.

Specifications

Parameter	Specification
Operating Environment	0° to 50° C (32° to 122° F) Up to 95% relative humidity, noncondensing
Power requirements—PWA only	+12 Vdc (±1.2 V), 0.15 A (max) -12 Vdc (±1.2 V), 0.04 A (max) +5 Vdc (±0.25 V), 1.075 A (max)
Optional external output amp supply	+12 to +26 Vdc, 0.12A (max) -12 to -26 Vdc, 0.12A (max)
Optional external transducer supply	+12 (±0.6) Vdc to +15 (±0.75) Vdc, 100 mA (max) -12 (±0.6) Vdc to -15 (±0.75) Vdc, 100 mA (max) +5 Vdc (±0.25 V), 0.35 A (max)
Transducer:	
Type	Temposonics linear displacement transducer with digital output
Power Requirements	±12 Vdc or ±15 Vdc (±15 Vdc requires external supply)
Transducer Conditioner:	
Type	Pulse-width measurement
Resolution	Up to one part in 65,535
Update time (application dependent	T = P x N x (D+L) where: T = minimum update time in µs P = propagation time in µs/in. N = number of recirculations (set on transducer interface box) D = dead space (at end of transducer) in inches L = active stroke of transducer in inches
Temp coefficient of reading	±0.0001 % per degree C
Servo Controller:	
Type	Direct digital, proportional plus integral
Incremental position command input	100,000 pulses per second
Feedback input	5 V differential pulse-width modulated signal
Frequency response	Limited by transducer feedback update time
Proportional gain range	0.25 to 63.75
Reset integrator time constant range	20 ms to 15 s
Dither frequency	400 Hz nominal
Dither amplitude	0 to ±12% of full-scale output current
Rate/Acceleration stabilization range	0 to 255
Feedforward gain range	0 to 128
Output amplifier	Up to ±100 mA output current
Machine Status Interface:	
± Limit inputs; home switch input	Active high; input source current 10 mA at 0 V
Drive enable output	Active low; output sink current 100 mA at 0.2 V

25 Model 473.65c Resolver Servo Translator

Introduction

The Model 473.65c Resolver Servo Translator provides closed-loop servo control of electric or hydraulic servo motors using resolver feedback.

Standard features of the Resolver Servo Translator include the following:

- Uses resolver transducer (such as Clifton 11-BHW-31F or Harowe 11BRCX-300-J10)
- Internal resolver reference oscillator
- Fifteen fault and status LEDs
- ±10 V full scale single-ended analog output
- Active high overtravel limit, drive fault, and home inputs
- Active low drive enable
- Multiplexed coarse/fine resolver inputs

Options include the following:

- External resolver excitation input
- Drive enable active high or contact closure

Figure 25-1 shows the location of important components on the Resolver Servo Translator.

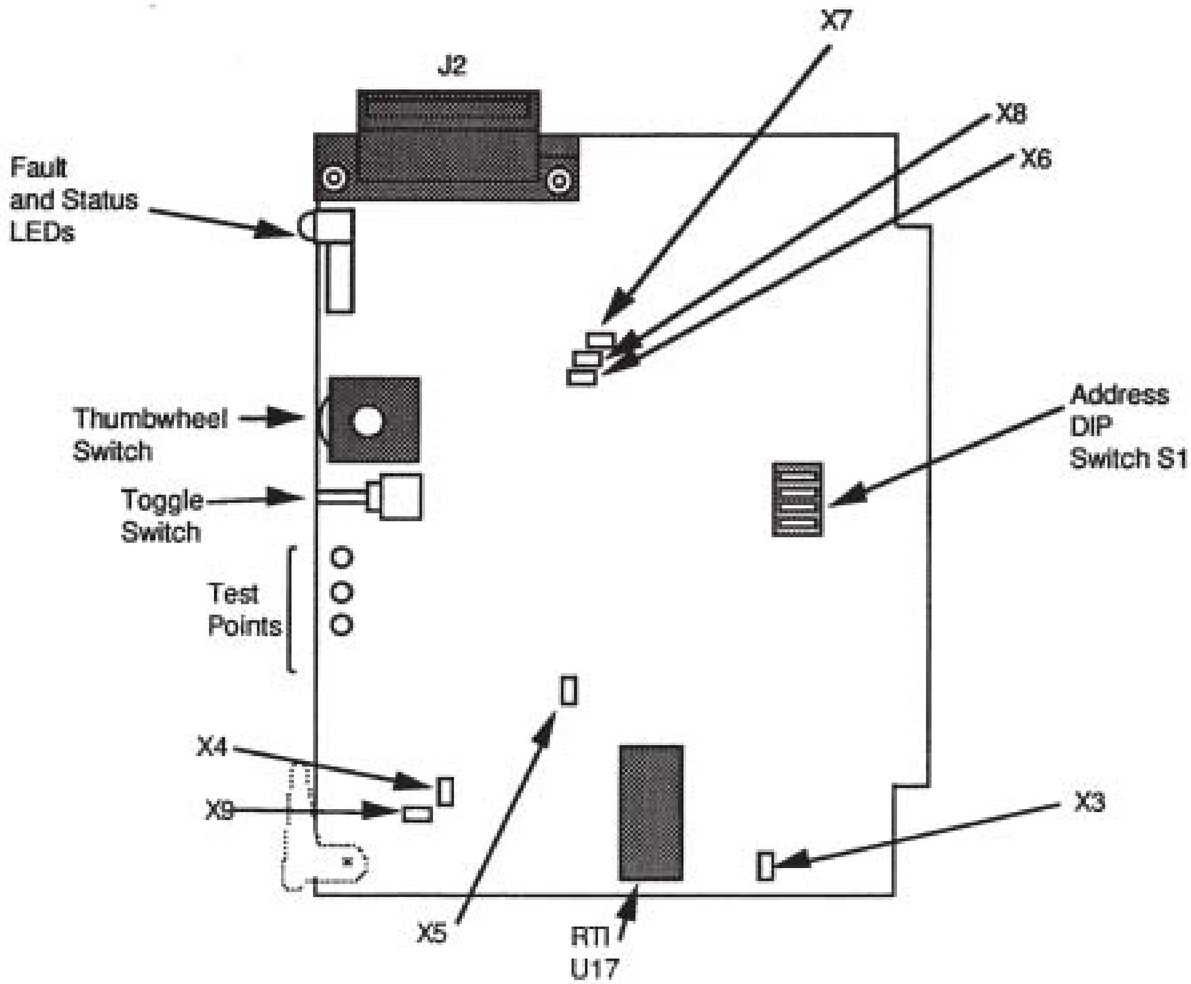


Figure 25-1. Model 473.65c Resolver Servo Translator Component Location

Jumpers

Set the jumpers on the Resolver Servo Translator card using Table 25-1. The standard connection for each jumper is also noted in the table. Refer to Figure 25-1 for the jumper locations.

Table 25-1. 473.65c Resolver Servo Translator Jumper Connections

Jumper	Connection	Description
X3	2-3*	2K x 8 RAM
X3	1-2	8K x 8 RAM
X4	1-2*	8031 Microcomputer
X4	1	8751 Microcomputer
X5	1-2	Connects ENCODER CLK to the motion bus
X5	OUT*†	Disconnects signal from the motion bus
X5	3-4	Connects ENCODER DIR to the motion bus
X5	OUT*†	Disconnects signal from the motion bus
X6§	2-3*	Enabled = current flow
X6	1-2	Enabled = no current flow
X7§	1†*	Drive enable active low or contact closure
X7	1-2	Drive enable active high
X8§	1-2*	Drive enable active low
X8	1†	Drive enable active high or contact closure
X9	1-2*	Drive fault active high
X9	2-3	Drive fault active low

* Standard connection

† Remove jumper plug and connect to pin 1 only.

§ The drive enable can be configured for active high, active low, or contact closure, using jumpers X7 and X8

Address DIP Switch

A 5-segment DIP switch (S1) located on the Translator card, designates the module address (refer to Figure 25-1 for the switch location). Table 25-2 lists the switch settings for addressing up to 16 Resolver Servo Translators in a system.

Table 25-2. DIP Switch Settings

Translator Number	Address (Hex)	MA15 S1-1	MA14 S1-2	MA13 S1-3	MA12 S1-4	MA11 S1-5
1	68-6F	off	ON	ON	off	ON
2	70-77	off	ON	ON	ON	off
3	78-7F	off	ON	ON	ON	ON
4	80-87	ON	off	off	off	off
5	88-8F	ON	off	off	off	ON
6	90-97	ON	off	off	ON	off
7	98-9F	ON	off	off	ON	ON
8	A0-A7	ON	off	ON	off	off
9	A8-AF	ON	off	ON	off	ON
10	B0-B7	ON	off	ON	ON	off
11	B8-BF	ON	off	ON	ON	ON
12	C0-C7	ON	ON	off	off	off
13	C8-CF	ON	ON	off	off	ON
14	D0-D7	ON	ON	off	ON	off
15	D8-DF	ON	ON	off	ON	ON
16	E0-E7	ON	ON	ON	off	off

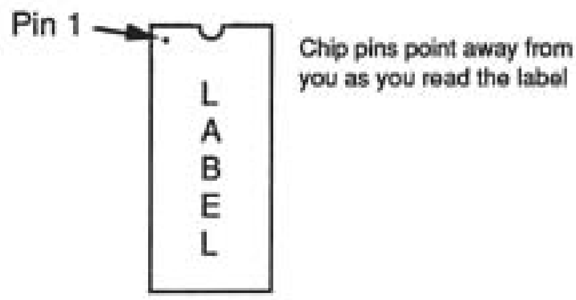
Replacing the RTI EPROM

EPROM U17 contains the RTI (Run Time Interpreter). This is the firmware used by the Resolver Servo Translator to interpret INCOL86 instructions at run time. In some cases (using custom firmware) this EPROM must be replaced.

⚠ CAUTION

Make sure chassis power is OFF before removing the Resolver Servo Translator to replace this EPROM.

Carefully remove the existing EPROM at site U17 (using a tool such as a flat-bladed screwdriver). Install the new EPROM at U17. Do not plug in this chip upside down. Use pin 1 of this chip as a reference point:



Plug pin 1 of the chip into pin 1 of the socket (pin 1 is in the upper left hand corner of the socket if you position the card with J2 facing up).

Wiring

Connector J2 on the Resolver Servo Translator provides external connections. Table 25-5 shows pin definitions for this connector.

Table 25-5. J2 Pin Definitions

J2 Pin	Name	Description	Remote Terminal Board* Screw Terminals
1	Sin A	Fine resolver S1 input	1
2	Shield	Chassis ground	3
3	ANALOG GND	Internal 12 V common	5
4	Shield	Chassis ground	7
5	Ref Osc Out	Internal reference oscillator (5 kHz, 2.5 V rms)	9
6	ANALOG GND	Internal 12 V common	11
7	Sin B	Coarse resolver S1 input	13
8	Shield	Chassis ground	15
9	ANALOG GND	Internal 12 V common	17
10	ENAB OUT –	Enable source output	19
11	VEL CMND	Velocity command output	21
12	Shield	Chassis ground	23
13	ANALOG GND	Internal 12 V common	25
14	ANALOG GND	Internal 12 V common	27
15	+LIMIT	Active high +limit input	29
16	DRIVE FAULT	Active high drive fault input	31
17	+12 V	Internal chassis +12 Vdc power supply	37–40
18	ANALOG GND	Internal 12 V common	33–36
19	ANALOG GND	Internal 12 V common	2
20	Cos A	Fine resolver S2 input	4
21	Shield	Chassis ground	6
22	ANALOG GND	Internal 12 V common	8
23	Shield	Chassis ground	10
24	Ref Osc In	Reference oscillator input to R/D converter	12
25	ANALOG GND	Internal 12 V common	14
26	Cos B	Coarse resolver S2 input	16
27	Shield	Chassis ground	18
28	(spare)		20
29	ANALOG GND	Internal 12 V common	22
30	(spare)		24
31	ENAB OUT+	Enable sink input	26
32	–LIMIT	Active high –limit input	28
33	HOME	Active high home input	30
34	–12 V	Internal chassis –12 Vdc power supply	32
35	+12 V	Internal chassis +12 Vdc power supply	37–40
36	ANALOG GND	Internal 12 V common	33–36

* When used with cable 387316-XX

Cabling

The standard cable used with the Resolver Servo Translator is Model 473.50c-01A-200 (Custom Servo Motors part number 387316-xx). This cable connects the Resolver Servo Translator J2 to the Remote Terminal Board. Refer to the cabling chapter of this manual for the cable pinout. If limits, home, or drive fault inputs are not used, they must be tied to analog ground.

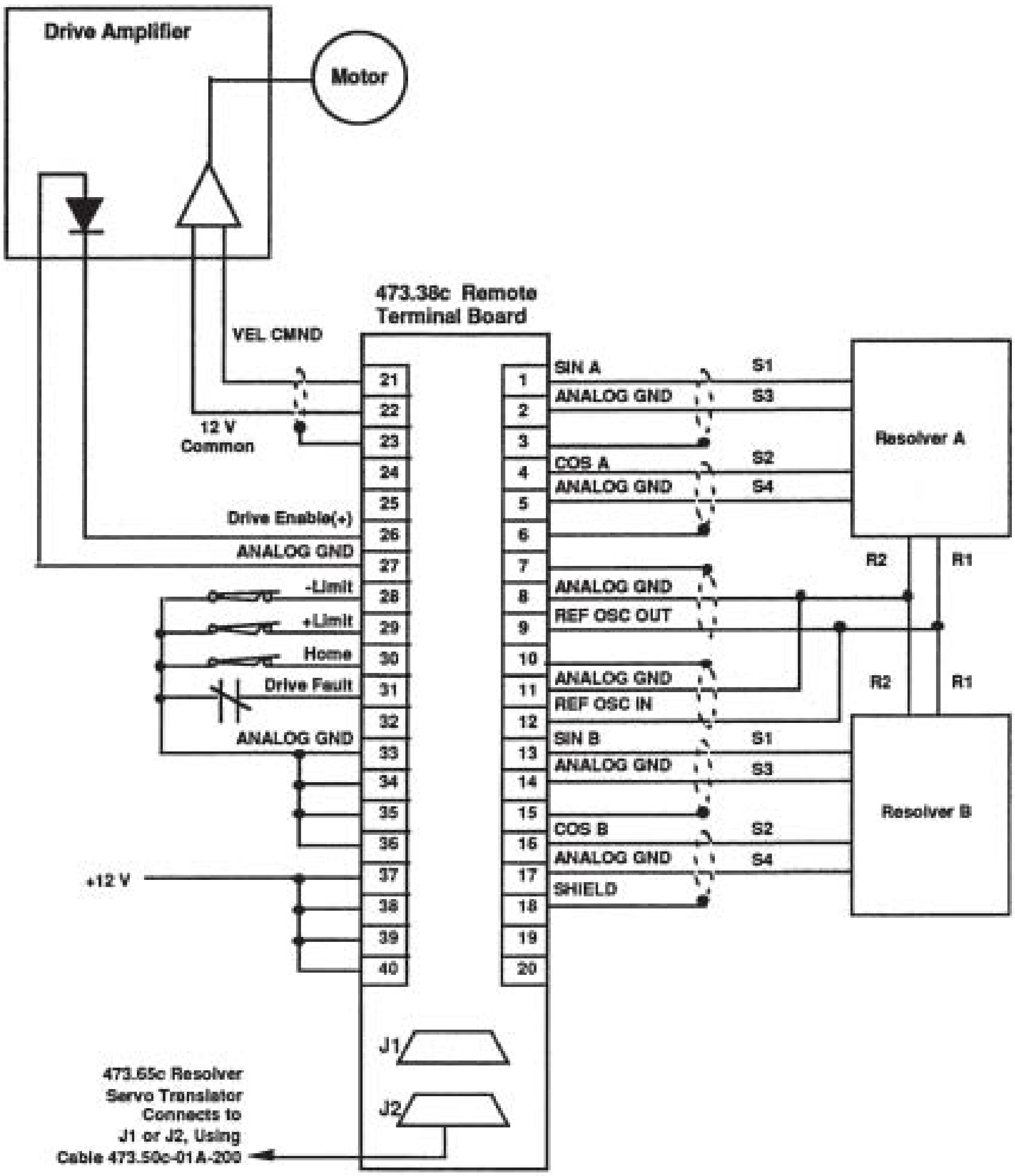


Figure 25-2. Cable Configuration for the Resolver Servo Translator

Optional Cabling

Connect the Resolver Translator directly to the DC drive, the resolver transducer, and the machine switches, as shown in Figure 25-3.

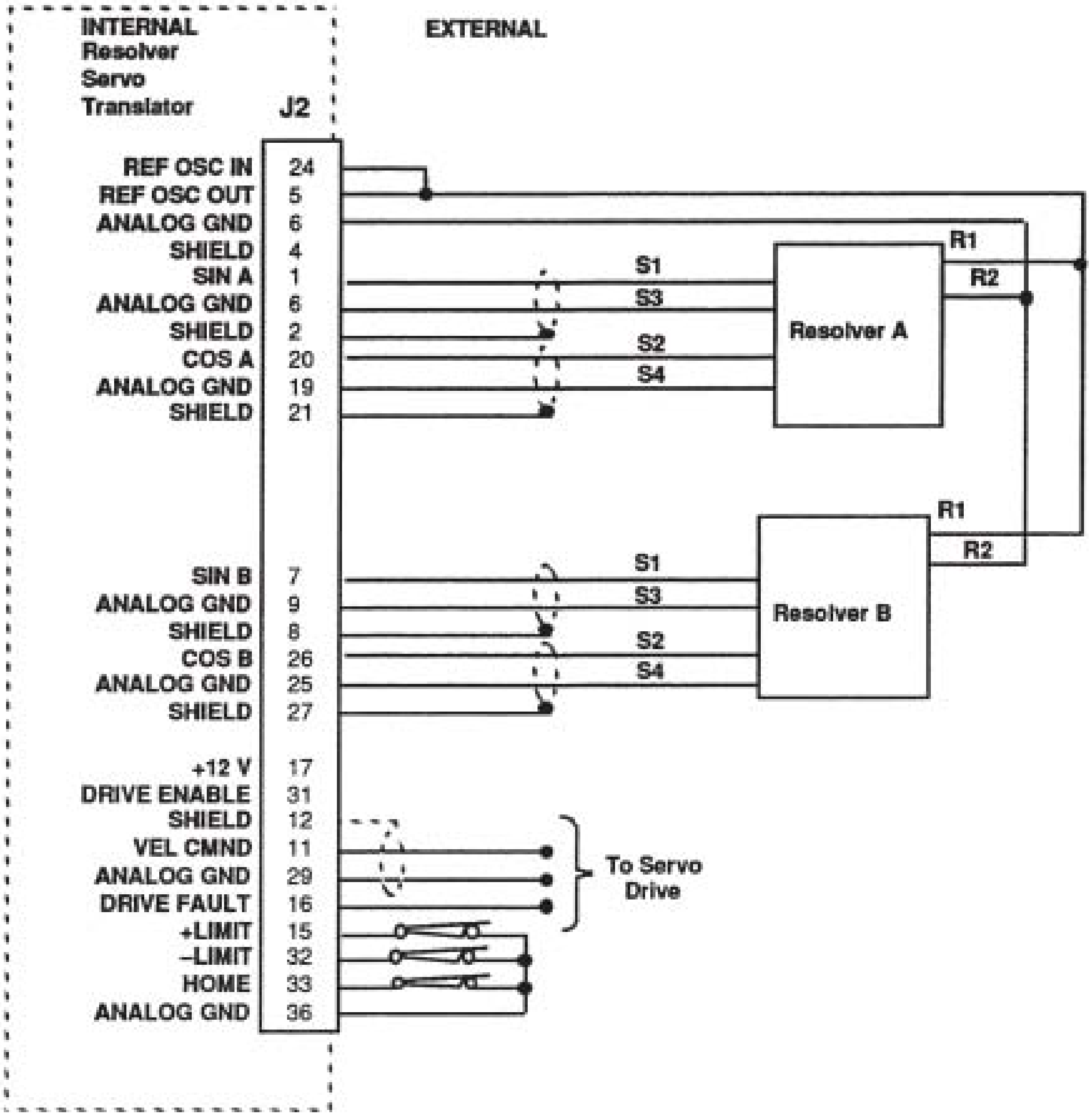


Figure 25-3. Wiring Example

External Reference Oscillator

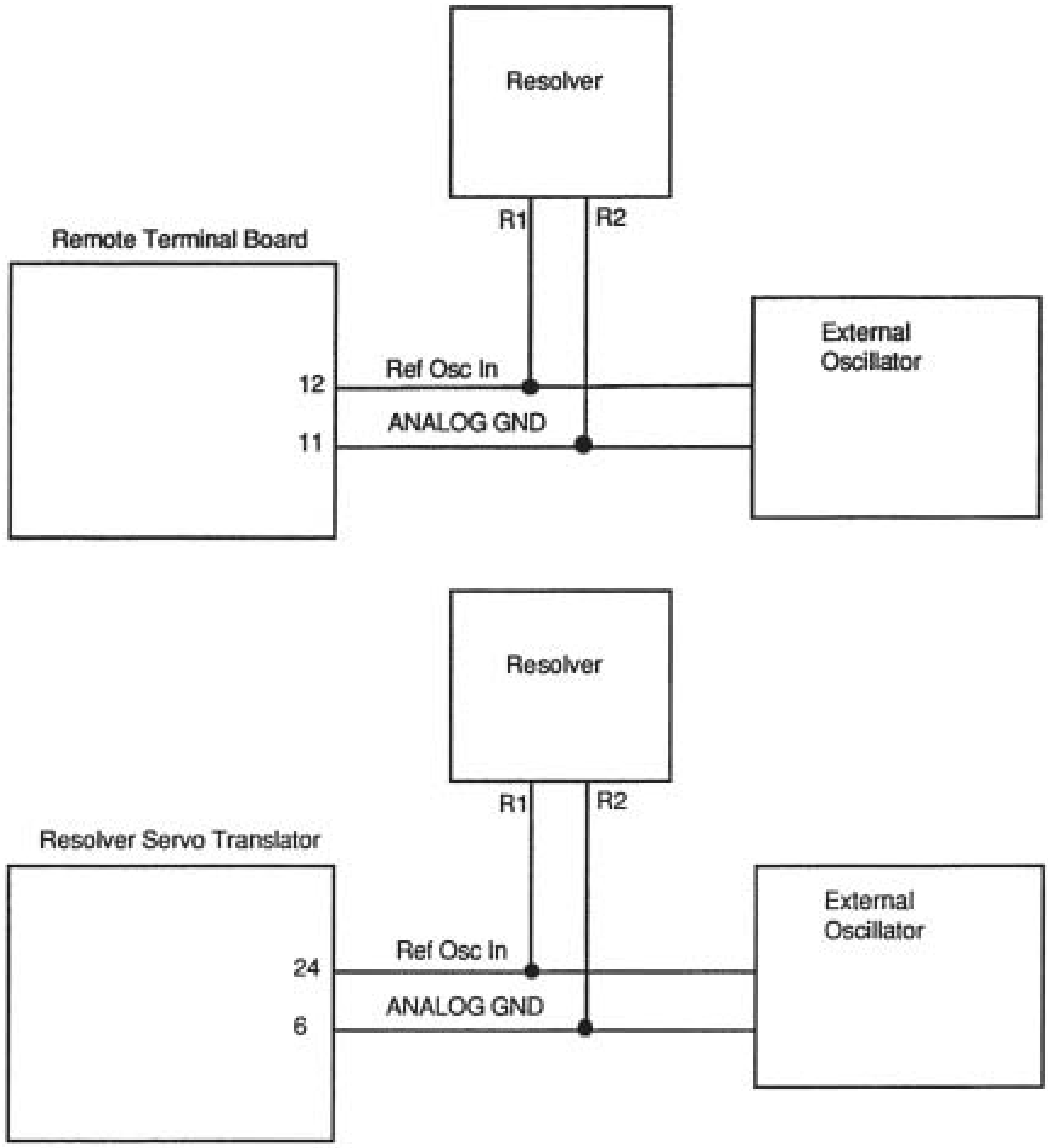


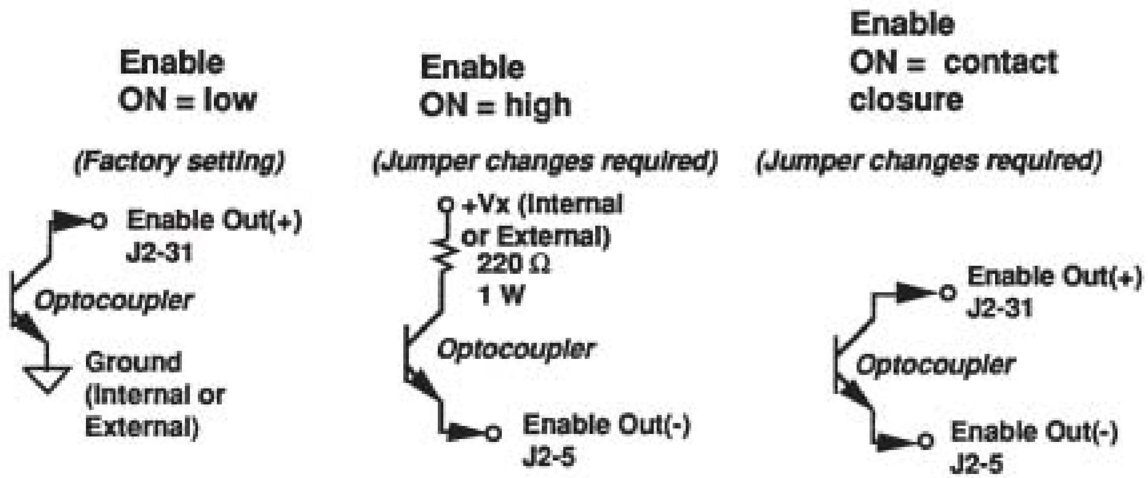
Figure 25-4. External Reference Oscillator Connections

NOTE

When using an external oscillator, do not jumper Reference Oscillator In to Reference Oscillator Out. In this case, jumpering those two lines together can damage equipment.

Drive Enable Output

Jumper X6 changes the sense of the enable. In the normal configuration, enabled allows current flow, disabled means no current flow. Jumpers X7 and X8 are used to configure the drive enable sense as active high, active low, or contact closure. These configurations are illustrated in Figure 25-5.



NOTE

Enable active high current is limited to 50 mA maximum. Enable active low and contact closure currents are limited to 75 mA maximum.

Figure 25-5. Enable Circuit Configurations Changing the Enable Sense

Limit, Home, and Drive Fault Inputs

Figure 25-6 shows the typical internal electrical configuration for limit, home, and drive fault inputs.

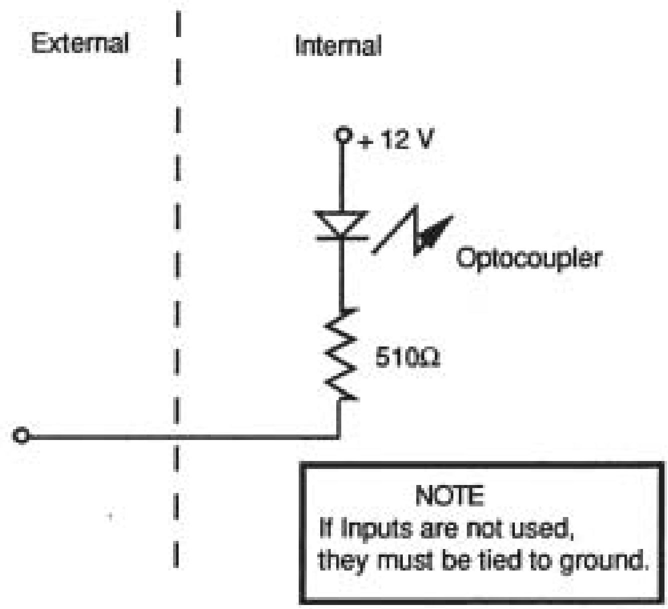


Figure 25-6. Internal Configuration of Limit, Home, and Drive Fault Inputs

Installing the Resolver Servo Translator

CAUTION

Make sure chassis power is OFF before installing this module.

The Resolver Servo Translator requires one slot in the chassis.

Setup

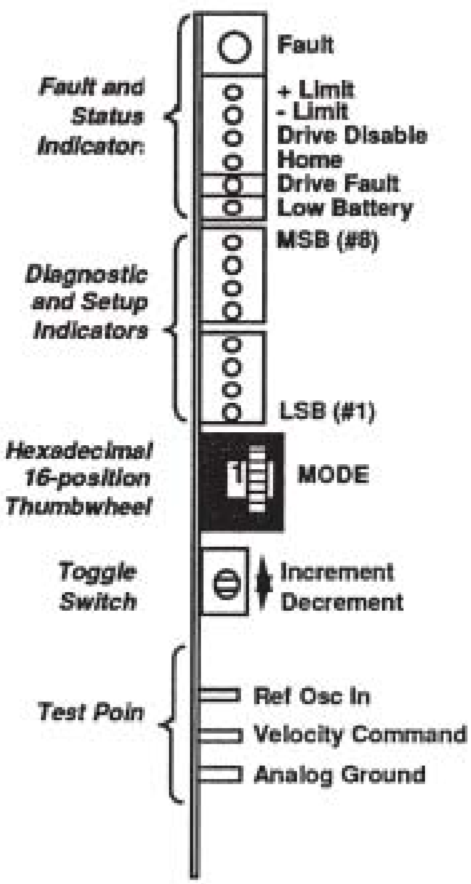
Take the following steps to set up the Resolver Servo Translator:

1. Verify that the DIP switch segments on the Resolver Servo Translator are set to the correct number.
2. Set the drive enable jumpers for the correct configuration.
3. Check the reference oscillator power supply configuration.
4. Check the resolver cabling.
5. Verify resolver compatibility.
6. Check limit, home, and drive fault wiring.
7. Use the front panel thumbwheel and toggle switch to tune the servo loop.

Thumbwheel, LEDs, and Toggle Switch

Setup Controls and Indicators

The diagnostic/setup controls and indicators consist of a 16- position thumbwheel switch, a spring-loaded 3-position toggle switch, and an 8-bit LED display. The thumbwheel switch selects the parameters to be displayed on the LEDs. (Thumbwheel positions 8, 9, E, and F are not used.) The toggle switch adjusts the parameter selected by the thumbwheel switch. Figure 25-7 shows the location of these components, and lists the parameters selected by each thumbwheel position.



LEDs		
Label	Name	Description
DS4	Fault	ON = fault
+L	+Limit	ON = on + limit
–L	–Limit	ON = on –limit
DD	Drive Disable	ON = drive disabled
H	Home	ON = at home
DF	Drive Fault	ON = drive fault
LB	Low Battery	ON = replace battery

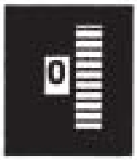
MODE (Thumbwheel Position)	Displayed Parameter
0	Fault/Status Word*
1	Proportional Gain
2	Integral Gain
3	Dither Amplitude
4	Loop Bias
5	NVRAM Recall
6	NVRAM Save
7	Loop Time
8	(Not Used)
9	(Not Used)
A	Derivative
B	Double Derivative
C	Feedforward Fraction
D	Feedforward Units
E	(Not Used)
F	(Not Used)

*The top LED represents the MSB of an 8-bit word.

Figure 25-7. Edge-Mounted Switches, Indicators, and Test Points

Functions can be set via the front panel controls or by the applications program. To use the front panel controls, set the thumbwheel switch to position 0 and verify that LED #8 (MSB) is lit. If LED #8 is not lit, you must enable it using INCOL86. If it is lit, you can change system parameters by first placing the thumbwheel switch to the desired function number and then pushing the toggle switch up or down to increase or decrease the setting of the particular function.

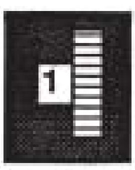
Thumbwheel Position Versus Displayed Parameter



Thumbwheel position 0 monitors an 8-bit LED display. Table 25-6 describes the condition associated with each LED.

Table 25-6. Fault and Status LED Display

LED	Description
8	ON = Toggle switch operation enabled. OFF = Toggle switch disabled for setup.
7	ON = NVRAM save in progress.
6	ON = Feedback loss due to open sine/cosine inputs or a bad connection to reference oscillator.
5	ON = Command direction is positive (retraction).
4	ON = Hold/Not Go. The Translator holds its current position.
3	ON = In position. Command equals feedback.
2	Hard excess position error. Motion stops and fault LED lights.
1	Soft excess position error. A flag is set to allow software decisions.



Proportional Gain Adjustment. Selecting thumbwheel position 1 allows the operator to monitor and adjust the proportional gain setting. Pushing the toggle switch up increases the proportional gain. Pushing the toggle switch down decreases the proportional gain. The proportional gain range is 0.25 to 63.75 in 0.25 increments. The diagnostic/setup LED display shows a binary representation of the proportional gain value. For example, with all LEDs lit, the value represented would be calculated as follows:

displayed value = 11111111 (binary) = 255 (decimal)

gain value = 255 x 0.25 = 63.75

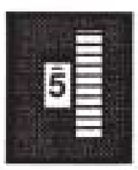
Reset Time Constant Divider Adjustment. Selecting thumbwheel position 2 allows the operator to monitor and adjust the reset time constant divider (D) used when the reset integrator is enabled. Pushing the toggle switch up increments the reset time constant divider. Pushing the toggle switch down decrements the rest time constant divider. The LEDs show a binary representation of the time constant value in the range 1 to 255 (0 means off), which is calculated as follows:

$$Rtc = 4096 \times \frac{T}{D}$$

where	Rtc	is the reset time constant (seconds)
	T	is the loop update time in milliseconds
	D	is the time constant divider

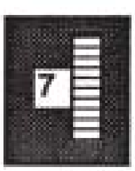
Dither Amplitude Adjustment. Selecting thumbwheel position 3 allows the operator to monitor and adjust the dither signal amplitude. Pushing the toggle switch up causes the dither amplitude to increase in 0.048% steps. Pressing the toggle switch down causes the dither amplitude to decrease in 0.048% steps. The maximum allowed dither amplitude is 12% of the full scale. The LED display shows the binary representation of the dither amplitude.

Inserting Loop Bias. Selecting thumbwheel position 4 allows the operator to remove simple dc offsets from the loop without the use of the reset integrator. This is accomplished by finding the loop bias and compensating the translator output command accordingly. Pushing the toggle switch up finds and inserts the loop bias value. Pressing the toggle switch down clears an existing loop bias value. The LED display shows the binary representation of the absolute value of the offset up to a maximum value of 12% of the full-scale. The offset polarity is not indicated.

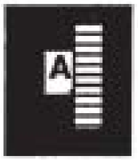


Recalling Setup Parameters from Memory. Selecting thumbwheel position 5 allows the operator to recall setup parameters saved in NVRAM. The recalled parameters include proportional gain, reset time constant, dither amplitude, loop bias, loop time, feedback loss, diagnostic DAC scaling, rate/acceleration gain, and feed forward. Pushing the toggle switch up or down recalls the parameters.

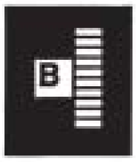
Saving Setup Parameters in Memory. Selecting thumbwheel position 6 allows the operator to save current setup parameters in NVRAM. Pushing the toggle switch up or down saves the current setup parameters. All LEDs in the display are on while the save process is in progress.



Loop Time Adjustment. Selecting thumbwheel position 7 allows the operator to read the time between servo loop updates. The value shown on the LED display is in 0.25 ms increments. This value is 1.25 ms standard and is not adjustable.



Derivative Adjustment. Selecting thumbwheel position A allows the operator to monitor and adjust the rate stabilization setting. Pushing the toggle switch up increases the rate gain. Pushing the toggle switch down decreases the rate gain. The rate gain range is 0 to 255.



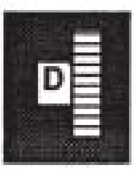
Double Derivative Adjustment. Selecting thumbwheel position B allows the operator to monitor and adjust the acceleration stabilization setting. Pushing the toggle switch up increases the acceleration gain. Pushing the toggle switch down decreases the acceleration gain. The acceleration stabilization adjustment range is 0 to 255.

Feedforward Fraction Adjustment. Selecting thumbwheel position C allows the operator to monitor the feedforward fraction and adjust the feedforward. Raising the toggle switch increases the feedforward setting. Lowering the toggle switch decreases the feedforward setting. The diagnostic LED display shows a binary representation of the fractional part of the feedforward setting. For example, with all LEDs lit, the value represented would be calculated as follows:

displayed value = 1111 1111 (binary) = 255 (decimal)

reset fraction = .003906 x 255 = .996094

The adjustment will overflow or underflow, causing the unit value to increment or decrement.



Feedforward Units Adjustment. Selecting thumbwheel position D allows the operator to view and adjust the units part of the feedforward setting. Raising the toggle switch increases the feedforward setting. Lowering the switch decreases the setting. The maximum feedforward units setting is 127.

Test Points

The translator circuit card contains edge-mounted test points for monitoring certain parameters. These test points are typically used for readout and diagnostic purposes. Table 25-9 lists the test points and the parameters associated with them.

Table 25-9. Edge-Mounted Test Points

Test Point	Parameter
TP1 (REF OSC IN)	Reference oscillator signal for resolver excitation.
TP2 (VEL CMND)	Analog output command applied to the dc motor command input.
TP3 (ANA GND)	Analog ground.

Troubleshooting the Resolver Servo Translator

Problem	Large Fault LED lit on Resolver Servo Translator
Steps	1. Check the Fault and Status indicators to see which fault occurred. Set the 16 position thumbwheel switch to position 0 and refer to Table 25-6. One or more of the following conditions will be indicated: a. + limit or - limit error b. excess error c. drive fault If a fault occurs after power-up, set the thumbwheel to position 0 and push the toggle switch up. If this does not clear the fault read the LEDs and take the appropriate action as shown in the following procedures.
Problem	+ limit or – limit error
Steps	1. Check the wiring to ± overtravel limits. 2. Check the limit switches. 3. Replace the Resolver Servo Translator
Problem	Drive fault error
Steps	1. Verify operation of amplifier. The amplifier may be in a fault condition. 2. Check drive fault jumper X9 for correct setting for your application. 3. Check wiring from the amplifier to the Resolver Servo Translator. 4. Replace Resolver Servo Translator.
Problem	Hard Excess Position Error . This condition exists when an excess following error fault has occurred on the Resolver Servo Translator. This is caused by the following error exceeding programmed limit. (The following error is the difference between the commanded position and the feedback position.)
Steps	1. Using the manufacturer's procedures, make sure that the servo amplifier and motor are fully operational and capable of achieving desired speeds.

2. Using INCOL86 software and your application program make sure that the hard excess error limit is set to a usable value. The default value is set to zero. Typical settings would be in the 4096 count range. Translator function 4 in INCOL86 sets the following error limit.

3. Adjust the proportional loop gain. The proportional loop gain adjustment is set by INCOL86 software or by putting the thumbwheel to position to 1 and moving the toggle switch up to increase the proportional gain and down to decrease the proportional gain. Start by adjusting the proportional gain to its lowest setting. Increase the gain until minor oscillations occur and then decrease the gain until they disappear.

4. Check that the drive enable jumper and wiring are set correctly for your application. The enable output must match enable input required by your amplifier.

5. Replace the Resolver Servo Translator.

Problem No faults, but no motion

⚠ CAUTION

Make sure chassis power is OFF before removing this module.

Steps

1. Check the address switch on the Resolver Servo translator.

2. Check the address switch on the associated Command Generator.

3. Check that the drive enable jumper and wiring are set correctly for your application. The enable output must match enable input required by your amplifier.

4. If the system has more then one axis of motion, make sure that the Resolver Servo Translator and its Command Generator are in the correct slots. The backplane is cut to prevent signals from one axis of motion interfering with another axis of motion. Refer to your system block diagram for correct card placement.

5. Check the wiring from the Resolver Servo Translator to the servo amplifier.

6. Using manufacturer's procedures make sure that the servo amplifier and motor are fully operational.

⚠ WARNING

The following procedure involves uncontrolled actuator movement. Before starting, uncouple the actuator from any machinery that could be damaged or cause a safety hazard.

7. Check the application program. The following sample program will move the motor. Before trying this test make sure that motion will cause personal injuries or damage equipment. This test should be done only after the amplifier and motor have been verified. This program initializes the Resolver Servo Translator and moves the motor 1 revolution. If you are working with a different axis, use that axis number instead of X1. Scale should be set to match the range scaling (XLATOR X1,14).

```
LOGIC:
AXIS X1 = DDC SERVO        ;IDENTIFY TRANSLATOR TYPE
SCALE X1 = 4096.           ;SET SCALE
XLATOR X1,2 OFF            ;TURN DRIVE ENABLE OFF
XLATOR X1,4 = 2.           ;SET EXCESS ERROR TO LARGE VALUE FOR SETUP
XLATOR X1,5 = 2.           ;SOFT EXCESS ERROR NOT REQUIRED
XLATOR X1,6 = 4.           ;SET PROPORTIONAL GAIN TO 1
XLATOR X1,7 = 0.           ;INTEGRATOR OFF
XLATOR X1,8 = 0.           ;DITHER OFF
XLATOR X1,10 = 0.          ;OFFSET SET TO 0
XLATOR X1,11 = 0.          ;DERIVATIVE SET TO 0
XLATOR X1,12 = 0.          ;DOUBLE DERIVATIVE SET TO 0
XLATOR X1,13 = 0.          ;FEED FORWARD SET TO 0
XLATOR X1,14 = 4.          ;SET RANGE OR FEEDBACK SCALING TO 4096
XLATOR X1,15 = 0.          ;SET SOFTWARE COUNTERS TO 0
HALT X1                    ;RESET TRANSLATOR
VMAX X1 = 50.5             ;SET VMAX TO A HIGH VALUE FOR TEST
AVD X1 = 1,1,1             ;ACCEL,DECEL = 1 REV/SEC/SEC VEL = 1 REV/SEC
DIST X1 = 1                ;SET DISTANCE TO MOVE 1 REV
XLATOR X1 ON               ;ENABLE TRANSLATOR
MOVE X1                    ;START MOTION
MWAIT X1                   ;WAIT FOR MOTION TO STOP
END
```

8. If your system uses more than one Resolver Servo Translator, swap the translators and try the test in Step 6 again. When swapping Resolver Servo Translators remember to change the address switch settings.

8. If your system uses more than one Command Generator, swap the Command Generators and try this test again. When swapping Command Generators remember to change the address switch settings.

9. Replace the Resolver Servo Translator

Problem

Motor runs away

Steps

1. Using manufacturer's procedures make sure that the servo amplifier and motor are fully operational.
2. If the amplifier and motor are fully operational, then the motor is running away because the resolver feedback is not correctly phased or there is no resolver feedback. Perform the following test program to make sure there is feedback from the resolver. This test will display the following error on the computer screen. To test for resolver feedback, start the program and turn the shaft on the motor by hand. The value displayed is the resolver feedback. The maximum value that can be displayed (before an excess error fault occurs) is 16276 . When the fault occurs then the value displayed resets to zero.

```
LOGIC:
AXIS X1 = DDC SERVO         ;IDENTIFY TRANSLATOR TYPE
SCALE X1 = 1.               ;SET SCALE TO ENCODER PULSES
HALT X1                     ;RESET TRANSLATOR
XLATOR X1,2 OFF             ;TURN DRIVE ENABLE OFF
XLATOR X1,4 = 16276.        ;SET EXCESS ERROR TO LARGE VALUE FOR SETUP
XLATOR X1,5 = 16276.        ;SOFT EXCESS ERROR NOT REQUIRED
XLATOR X1,6 = 4.            ;SET PROPORTIONAL GAIN TO 1
XLATOR X1,7 = 0.            ;INTEGRATOR OFF
XLATOR X1,8 = 0.            ;DITHER OFF
XLATOR X1,10 = 0.           ;OFFSET SET TO 0
XLATOR X1,11 = 0.           ;DERIVATIVE SET TO 0
XLATOR X1,12 = 0.           ;DOUBLE DERIVATIVE SET TO 0
XLATOR X1,13 = 0.           ;FEED FORWARD SET TO 0
XLATOR X1,14 = 4.           ;SET RANGE OR FEEDBACK SCALING TO 4096
XLATOR X1,15 = 0.           ;SET SOFTWARE COUNTERS TO 0
START DISPLAY               ;START DISPLAY TASK
END

DISPLAY:
R1 = XLATOR X1,2            ;READ FOLLOWING ERROR
PRINT 0,R1                  ;PRINT TO COMPUTER SCREEN
START DISPLAY               ;LOOP ON TASK
END
```

3. If you are getting feedback using the above test, then the resolver is not phased correctly. To change the resolver phasing swap the SIN A with the COS A resolver leads.

Problem

Motor oscillates violently

Steps

1. Using manufacturer's procedures, make sure that the servo amplifier and motor are fully operational.

2. The violent movement could be due to incorrect resolver phasing. Refer to the procedure above for verification of resolver phasing.

3. If the resolver phasing is correct then the problem is probably due to excess position loop gain. Adjust the loop gain down until the oscillation goes away.

Specifications

Parameter	Specification
Resolver Interface:	
Type	Brushless (Clifton, 11-BHW-31F or equivalent)
Signal voltage input	2.5 V rms ±5%
Reference voltage input (external oscillator)	2.5 to 7 V rms
Signal/reference input frequency (external oscillator)	5 kHz standard
Signal input impedance	10 MΩ (min)
Reference input impedance	50 kΩ
Allowable phase shift (signal to reference)	±10°
Internal Reference Oscillator Output:	
Frequency	5 kHz
Signal level	2.5 V rms
Current	100 mA max
Digital Servo Controller:	
Incremental position command input	400,000 pps (max)
Feedback input	SIN/COS at 2.5 V rms
Compensation types	proportional, integral, derivative, double-derivative, and feedforward
Loop update period	1.25 ms
Dither amplitude	nominal 0 to 12% of full scale
Output buffer	Up to 10 mA output current ±10 Vdc full scale
Machine Status Interface	
Input source current	20 mA at 0 V (overtravel limit, drive fault, home inputs)
Output sink current	75 mA at 0.2 V (drive enable output)
Power requirements (PWA only)†	+5 Vdc ± 0.25 V at 900 mA +12 Vdc ±1.2 Vdc at 120 mA -12 Vdc ±1.2 V at 90 mA
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing
System Requirements	1 chassis slot

26 Model 473.66c Encoder Servo Translator

Introduction

The Model 473.66c Encoder Servo Translator provides closed-loop servo control of electric or hydraulic servo motors using digital encoder feedback.

Standard features of the Encoder Servo Translator include the following:

- Uses digital encoder with quadrature outputs
- Index marker channel input
- X4 multiplication of feedback pulses
- Fifteen fault and status LEDs
- Uses +5 Vdc or +12 Vdc encoders
- ±10 V full scale single-ended analog output
- Active high overtravel limit and home inputs
- Active low drive enable
- Interfaces with encoders that use driver integrated circuits such as 88C30 and 26LS31

Options include the following:

- Non-complementary encoder input
- Drive enable active high or contact closure

Figure 26-1 shows the location of important components on the Encoder Servo Translator.

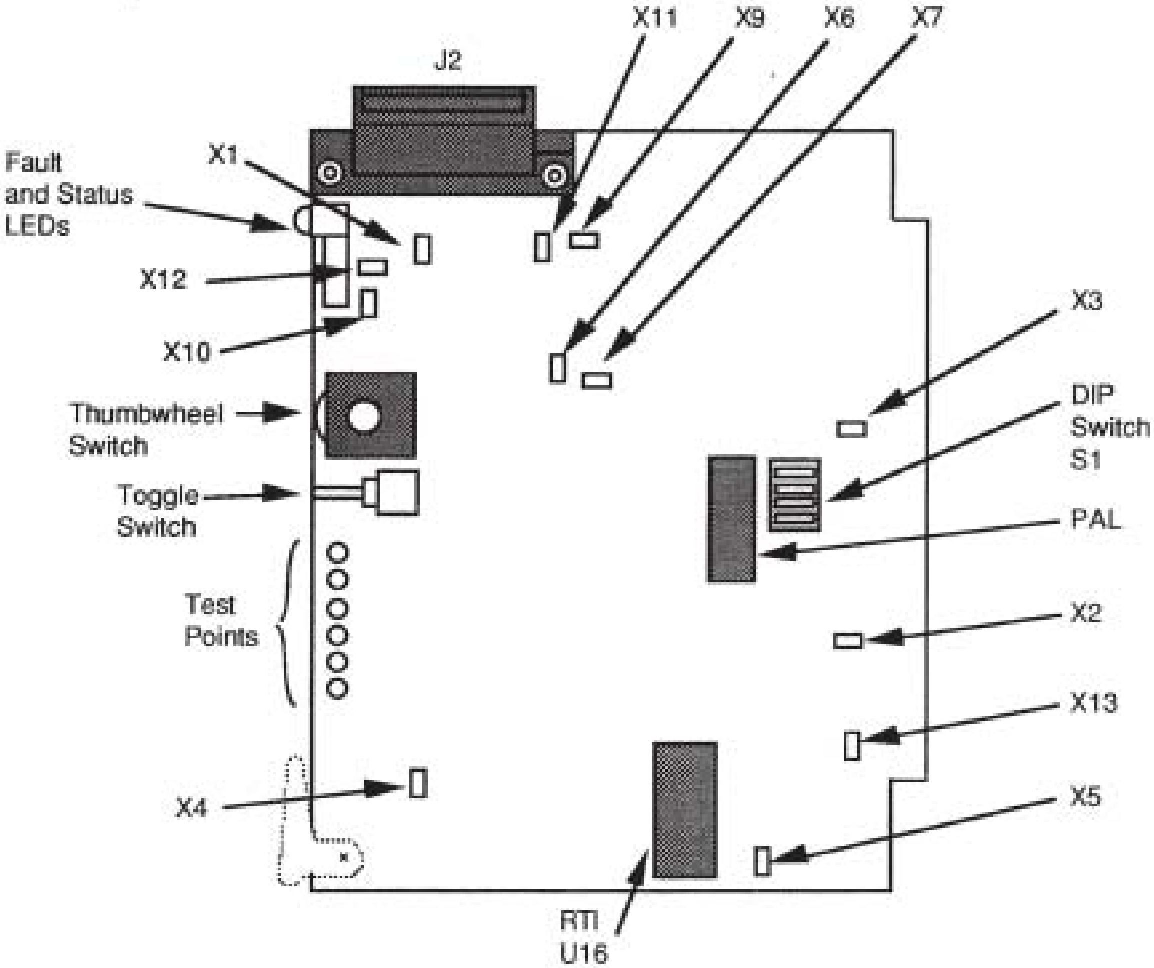


Figure 26-1. Model 473.66c Encoder Servo Translator Component Location

Jumpers

Set the jumpers on the Encoder Servo Translator card using Table 26-1. The standard connection for each jumper is also noted in the table. Refer to Figure 26-1 for the jumper locations.

Table 26-1. 473.66c Encoder Servo Translator Jumper Connections

Jumper	Connection	Description
X1	2-3* 5-6* 9-10*	A B Differential operation Z
	1-2 4-5 10-11	A B TTL operation Z
X2	2*† 1-2	Disconnects ENCODER CLK from bus Connects ENCODER CLK to bus
X3	2*† 1-2	Disconnects ENCODER DIR from bus Connects ENCODER DIR to bus
X4	1-2* 2†	8031 CPU 8751 CPU
X5	1-2* 2-3	8K x 8 RAM 2K X 8 RAM
X6‡	2-3* 1-2	Enabled = current flow Enabled = no current flow
X7‡	2*† 1-2	Drive enable active low or contact closure Drive enable active high
X9‡	1-2* 2†	Drive enable active low Drive enable active high or contact closure
X10	2-3* 1-2	Drive fault active high Drive fault active low
X11¶	1-2* NC	Internal +12 Vdc External 5 to 12 Vdc
X12¶	1-2* NC	Internal Analog Ground External Ground
X13	1-2* 2-3	8K x 8 RAM 2K X 8 RAM

*Standard connection.
†Remove jumper plug and connect to pin 2 only.
‡The drive enable can be configured for active high, active low, or contact closure output using jumpers X7 and X9.
¶ Removing X11 and X12 allows limit, home, drive fault and drive enable circuits to be powered by an external supply, (5 to 12 Vdc) using optical isolation.

Address DIP Switch

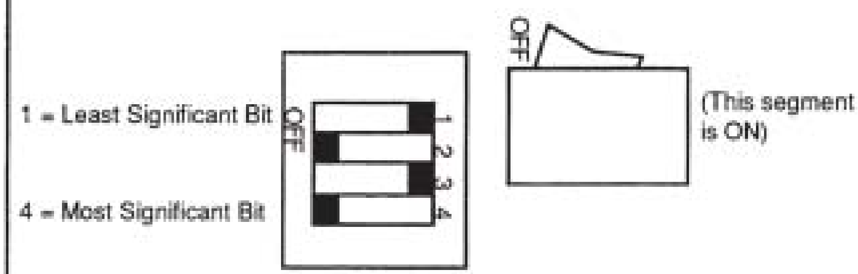
Up to 16 Encoder Servo Translators can be used in a system. Cards with serial numbers of 1700 or higher define addresses by a PAL (part number 442055-01) and a 4-segment DIP switch on each card. Set the 4-segment DIP switch S1 with the required address, using Table 26-2.

Table 26-2. DIP Switch Settings(4-segment DIP switch only)

Switch Settings:

1 = ON
0 = OFF

Example:



bit pattern = 0101
Translator No. = 5

Encoder Servo Translator Number	Setting 4321
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111
16	0000

Older Encoder Servo Translator cards (with serial numbers below 1700) do not use a PAL. Instead, the address is defined by a 5-segment DIP switch on each card, as shown in Table 26-3.

Table 26-3. Switch Settings for Translator Address Selection (5-Segment Switch Only. Serial No. Less than 1700)

Translator Number	Address (Hex)	(MSB) MA15 S1-1	MA14 S1-2	MA13 S1-3	MA12 S1-4	(LSB) MA11 S1-5
1	68-6F	off	ON	ON	off	ON
2	70-77	off	ON	ON	ON	off
3	78-7F	off	ON	ON	ON	ON
4	80-87	ON	off	off	off	off
5	88-8F	ON	off	off	off	ON
6	90-97	ON	off	off	ON	off
7	98-9F	ON	off	off	ON	ON
8	A0-A7	ON	off	ON	off	off
9	A8-AF	ON	off	ON	off	ON
10	B0-B7	ON	off	ON	ON	off
11	B8-BF	ON	off	ON	ON	ON
12	C0-C7	ON	ON	off	off	off
13	C8-CF	ON	ON	off	off	ON
14	D0-D7	ON	ON	off	ON	off
15	D8-DF	ON	ON	off	ON	ON
16	E0-E7	ON	ON	ON	off	off

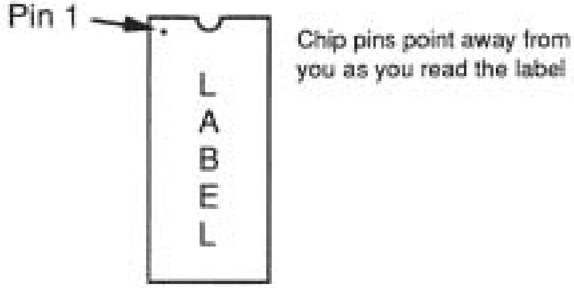
Replacing the RTI EPROM

EPROM U16 contains the RTI (Run Time Interpreter). This is the firmware used by the Encoder Servo Translator to interpret INCOL86 instructions at run time. In some cases (using custom firmware) this EPROM must be replaced.

⚠ CAUTION

Make sure chassis power is OFF before removing the Encoder Translator to replace this EPROM.

Carefully remove the existing EPROM at site U16 (using a tool such as a flat-bladed screwdriver). Install the new EPROM at U16. Do not plug in this chip upside down. Use pin 1 of this chip as a reference point:



Plug pin 1 of the chip into pin 1 of the socket (pin 1 is in the upper left hand corner of the socket if you position the card with J2 facing up).

Wiring

Connector J2 on the Encoder Servo Translator provides external connections. Table 26-5 shows pin definitions for this connector.

Table 26-5. J2 Pin Definitions

J2 Pin	Name	Description	Remote Terminal Board* Screw Terminals
1	A+	Encoder Phase A input	1
2	Shield	Chassis ground	3
3	A–	Encoder Phase A complement input	5
4	Shield	Chassis ground	7
5	Enab Out –	Enable source output	9
6	+5 V User	+ 5 Vdc power for encoder	11
7	B+	Encoder Phase B input	13
8	Shield	Chassis ground	15
9	B–	Encoder Phase B complement input	17
10	+Vx	Internal +12 Vdc or external +5 V to + 12 Vdc	19
11	VEL CMND	Velocity command output	21
12	Shield	Chassis ground	23
13	Spare		25
14	Vx GND	Internal 12 V common or external 5 V to 12 V common	27
15	+LIMIT	Active high +limit input	29
16	DRIVE FAULT	Active high drive fault input	31
17	+Vx	Internal +12 Vdc or external +5 V to + 12 Vdc	37–40
18	Vx GND	Internal 12 V common or external 5 V to 12 V common	33–36
19	Vx GND	Internal 12 V common or external 5 V to 12 V common	2
20	Z+	Encoder marker input	4
21	Shield	Chassis ground	6
22	Z–	Encoder marker complement input	8
23	Shield	Chassis ground	10
24	Vx GND	Internal 12 V common or external 5 V to 12 V common	12
25	Vx GND	Internal 12 V common or external 5 V to 12 V common	14
26	–12 V	Internal –12 Vdc	16
27	Shield	Chassis ground	18
28	ANALOG GND	Internal 12 V common	20
29	ANALOG GND	Internal 12 V common	22
30	Vx GND	Internal 12 V common or external 5 V to 12 V common	24
31	ENAB OUT+	Enable sink input	26
32	–LIMIT	Active high –limit input	28
33	HOME	Active high home input	30
34	–12 V	Internal –12 Vdc	32
35	+Vx	Internal +12 Vdc or external +5 V to + 12 Vdc	37–40
36	Vx GND	Internal 12 V common or external 5 V to 12 V common	33–36

NOTE: Vx is normally connected through jumper X11 to the internal power supply +12 Vdc.
Vx GND is normally connected through jumper X12 to the analog ground
* When used with cable 387316-xx

Cabling

The standard cable used with the Encoder Servo Translator is Model 473.50c-01A-200 (Custom Servo Motors part number 387316-xx). This cable connects the Encoder Servo Translator J2 to the Remote Terminal Board. Refer to the cabling chapter of this manual for the cable pinout.

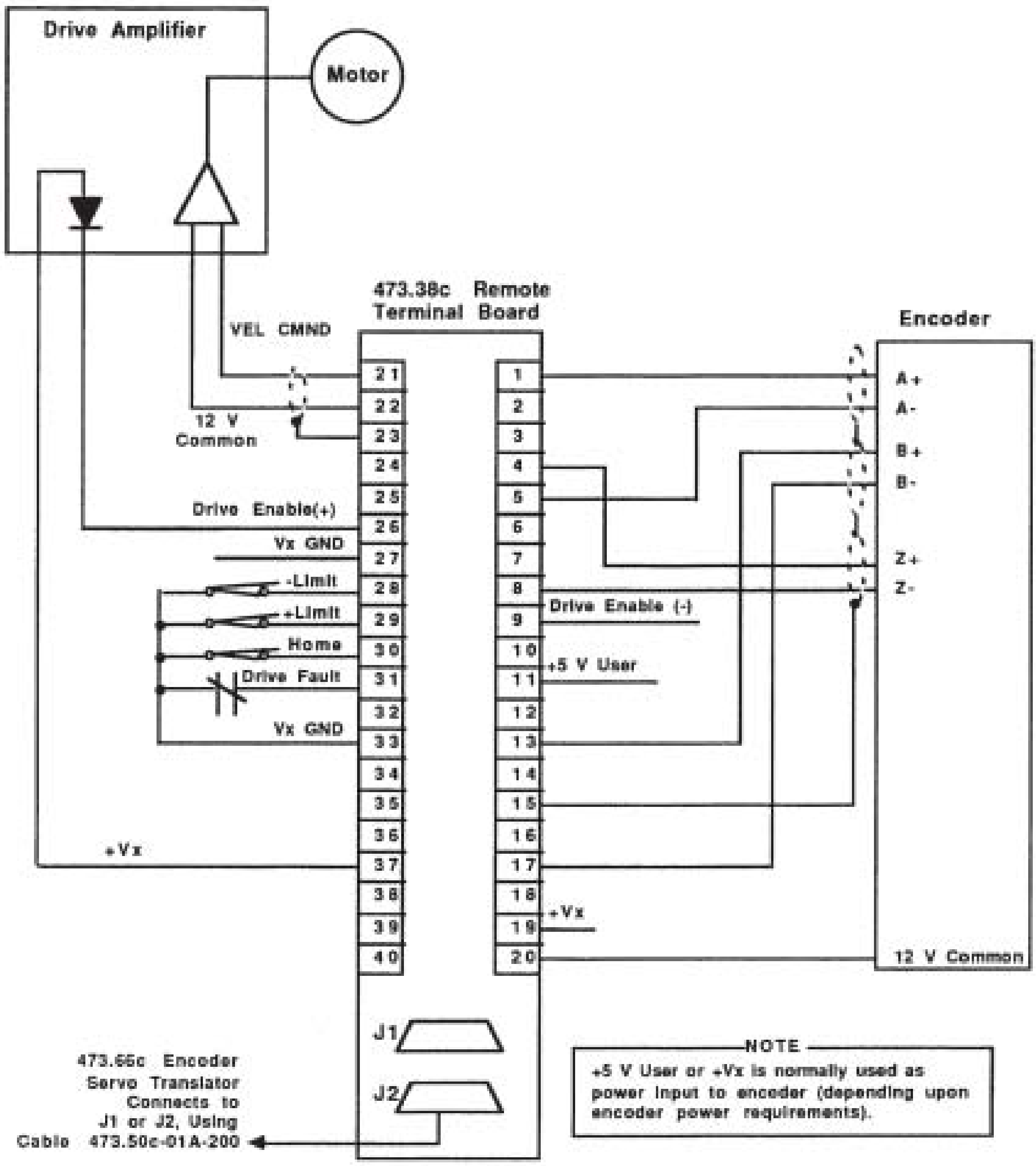


Figure 26-2. Cable Configuration for the Encoder Servo Translator

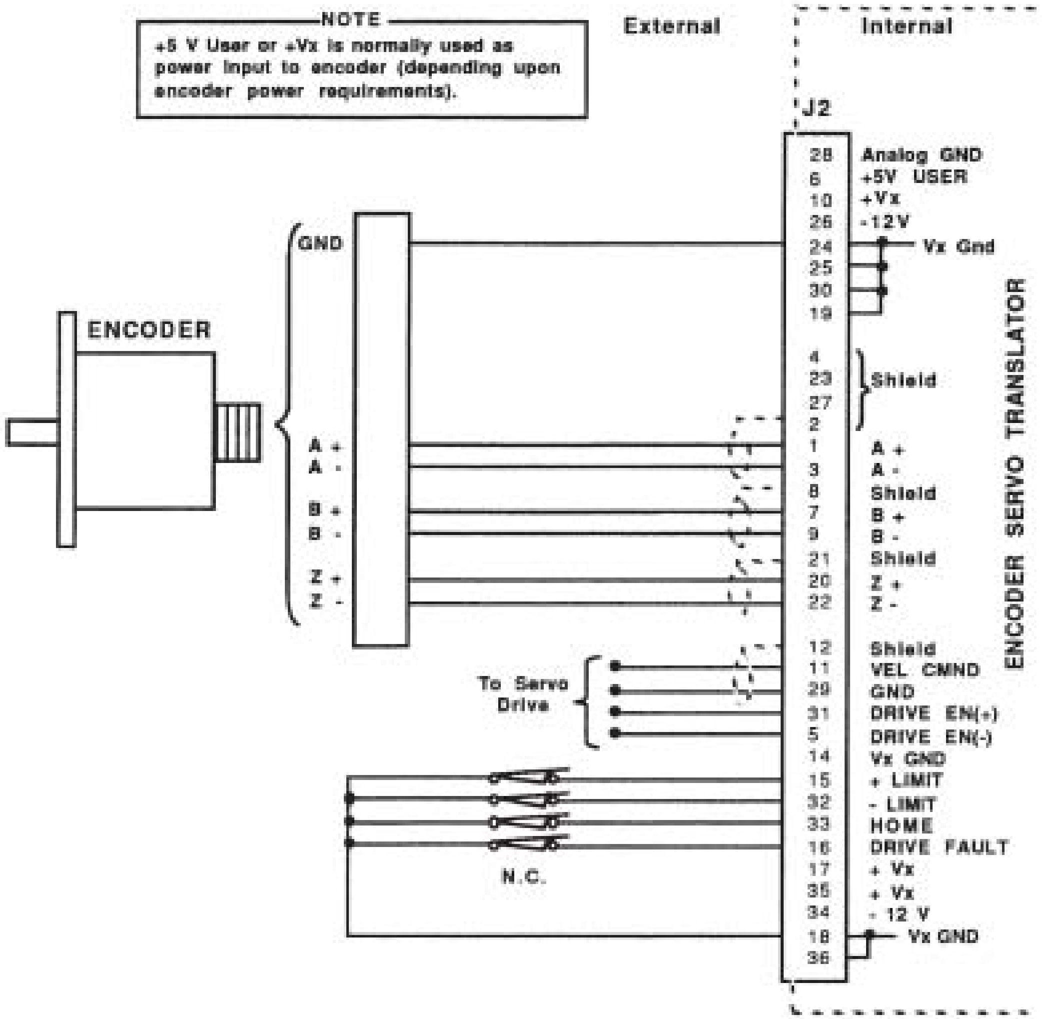


Figure 26-3. Wiring Example

External Power

External power can be used to optically isolate input signals such as limits, home, and drive fault. Figure 26-4 shows the connections for an external power supply, using either the Remote Terminal Board or direct connections to the Encoder Servo Translator J2 connector.

> NOTE
> Jumpers X11 and X12 must be removed before using external power.

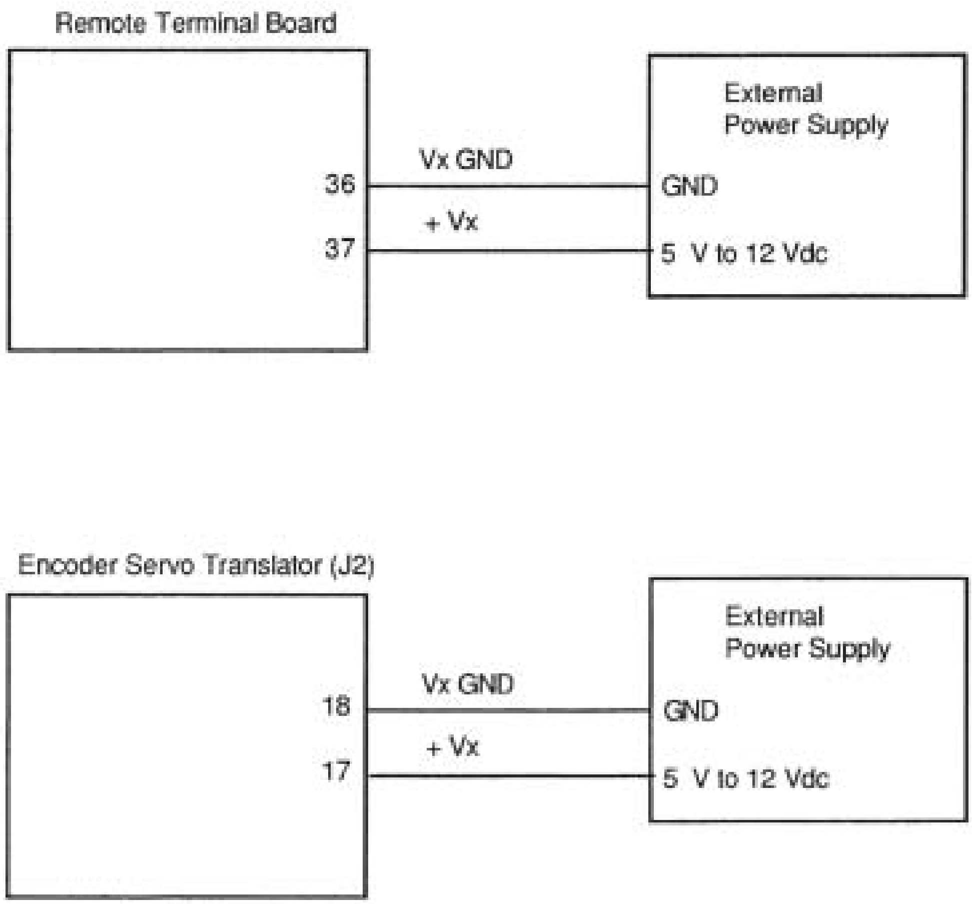


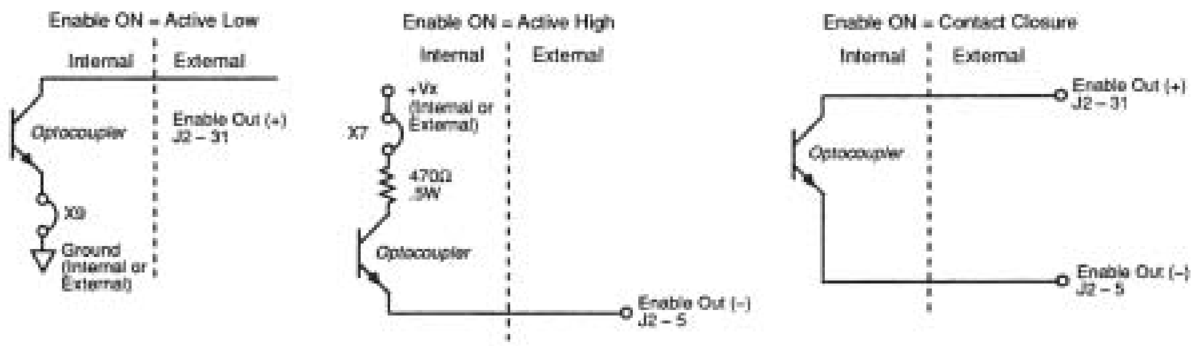
Figure 26-4. External Power Connections

Drive Enable Output

Jumper X6 changes the sense of the enable. In the normal configuration, enabled allows current flow, disabled means no current flow. Jumpers X7 and X9 are used to configure the drive enable sense as active high, active low, or contact closure. These configurations are illustrated in Figure 26-5.

Description	Jumper X7	Jumper X9
Active High	1-2	NC
Active Low	NC	1-2 *
Contact Closure	NC	NC

NC = No Connect * = Standard Connection



Jumpers	
X7	NC
X9	1-2

Jumpers	
X7	1-2
X9	NC

Jumpers	
X7	NC
X9	NC

> NOTE
>
> Enable active high current is limited to 25 mA maximum. Enable active low and contact closure currents are limited to 75 mA maximum.

Figure 26-5. Enable Circuit Configurations Changing the Enable Sense

Limit, Home, and Drive Fault Inputs

Figure 26-6 shows the typical internal electrical configuration for limit, home, and drive fault inputs.

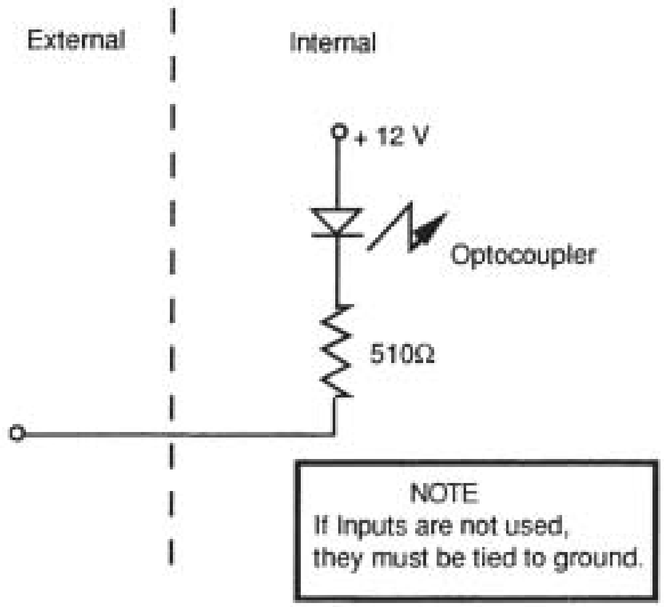


Figure 26-6. Internal Configuration of Limit, Home, and Drive Fault Inputs

Installing the Encoder Servo Translator

⚠ CAUTION

Make sure chassis power is OFF before installing this module.

The Encoder Servo Translator requires one slot in the chassis.

Setup

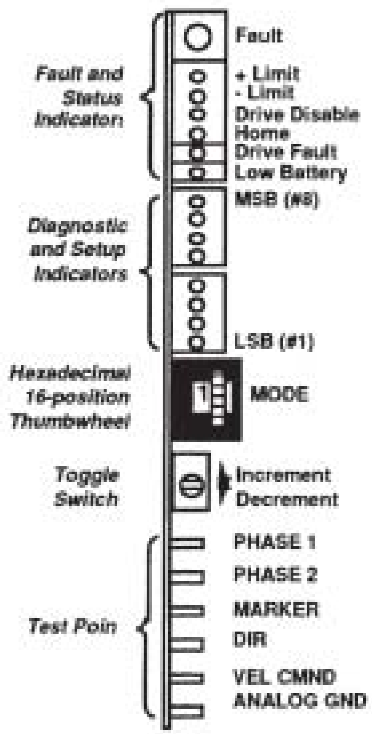
Take the following steps to set up the Encoder Servo Translator:

1. Verify that the DIP switch segments on the Encoder Servo Translator are set to the correct number.
2. Verify that the encoder provides the correct type output for the Encoder Servo Translator.
3. Verify that the cabling is correct for the type of encoder used.
4. Check the limit, home, and drive fault wiring.
5. Verify that the drive enable jumpers are set correctly.
6. Use the front panel thumbwheel and toggle switch to tune the servo loop.

Thumbwheel, LEDs, and Toggle Switch

Setup Controls and Indicators

The diagnostic/setup controls and indicators consist of a 16- position thumbwheel switch, a spring-loaded 3-position toggle switch, and an 8-bit LED display. The thumbwheel switch selects the parameters to be displayed on the LEDs. (Thumbwheel positions 8, 9, E, and F are not used.) The toggle switch adjusts the parameter selected by the thumbwheel switch. Figure 26-7 shows the location of these components, and lists the parameters selected by each thumbwheel position.



LEDs		
Label	Name	Description
DS4	Fault	ON = fault
+L	+Limit	ON = on + limit
–L	–Limit	ON = on –limit
DD	Drive Disable	ON = drive disabled
H	Home	ON = at home
DF	Drive Fault	ON = drive fault
LB	Low Battery	ON = replace battery

MODE (Thumbwheel Position)	Displayed Parameter
0	Fault/Status Word*
1	Proportional Gain
2	Integral Gain
3	Dither Amplitude
4	Loop Bias
5	NVRAM Recall
6	NVRAM Save
7	Loop Time
8	(Not Used)
9	(Not Used)
A	Derivative
B	Double Derivative
C	Feedforward Fraction
D	Feedforward Units
E	(Not Used)
F	(Not Used)

*The top LED represents the MSB of an 8-bit word.

Figure 26-7. Edge-Mounted Switches, Indicators, and Test Points

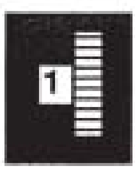
Thumbwheel position 0 monitors an 8-bit LED display. Table 26-6 describes the condition associated with each LED.

Table 26-6. Fault and Status LED Display

LED	Description
8	ON = Toggle switch operation enabled. OFF = Toggle switch disabled for setup.
7	ON = NVRAM save in progress.
6	Marker pulse
5	ON = Command direction is positive (retraction).
4	ON = Hold/Not Go. The Translator holds its current position.
3	ON = In position. Command equals feedback.
2	Hard excess position error. Motion stops and fault LED lights.
1	Soft excess position error. A flag is set to allow software decisions.

Functions can be set via the front panel controls or by the applications program. To use the front panel controls, set the thumbwheel switch to position 0 and verify that LED #8 (MSB) is lit. If LED #8 is not lit, you must enable it using INCOL86. If it is lit, you can change system parameters by first placing the thumbwheel switch to the desired function number and then pushing the toggle switch up or down to increase or decrease the setting of the particular function.

Thumbwheel Position Versus Displayed Parameter



Proportional Gain Adjustment. Selecting thumbwheel position 1 allows the operator to monitor and adjust the proportional gain setting. Pushing the toggle switch up increases the proportional gain. Pushing the toggle switch down decreases the proportional gain. The proportional gain range is 0.25 to 63.75 in 0.25 increments. The diagnostic/setup LED display shows a binary representation of the proportional gain value. For example, with all LEDs lit, the value represented would be calculated as follows:

displayed value = 11111111 (binary) = 255 (decimal)

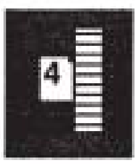
gain value = 255 x 0.25 = 63.75

Reset Time Constant Divider Adjustment. Selecting thumbwheel position 2 allows the operator to monitor and adjust the reset time constant divider (D) used when the reset integrator is enabled. Pushing the toggle switch up increments the reset time constant divider. Pushing the toggle switch down decrements the rest time constant divider. The LEDs show a binary representation of the time constant value in the range 1 to 255 (0 means off), which is calculated as follows:

$$Rtc = 4096 \times \frac{T}{D}$$

where Rtc is the reset time constant (seconds)
T is the loop update time in milliseconds
D is the time constant divider

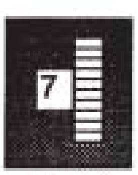
Dither Amplitude Adjustment. Selecting thumbwheel position 3 allows the operator to monitor and adjust the dither signal amplitude. Pushing the toggle switch up causes the dither amplitude to increase in 0.048% steps. Pressing the toggle switch down causes the dither amplitude to decrease in 0.048% steps. The maximum allowed dither amplitude is 12% of the full scale. The LED display shows the binary representation of the dither amplitude.



Inserting Loop Bias. Selecting thumbwheel position 4 allows the operator to remove simple dc offsets from the loop without the use of the reset integrator. This is accomplished by finding the loop bias and compensating the translator output command accordingly. Pushing the toggle switch up finds and inserts the loop bias value. Pressing the toggle switch down clears an existing loop bias value. The LED display shows the binary representation of the absolute value of the offset up to a maximum value of 12% of the full scale. The offset polarity is not indicated.

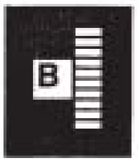
Recalling Setup Parameters from Memory. Selecting thumbwheel position 5 allows the operator to recall setup parameters saved in NVRAM. The recalled parameters include proportional gain, reset time constant, dither amplitude, loop bias, loop time, feedback loss, diagnostic DAC scaling, rate/acceleration gain, and feed forward. Pushing the toggle switch up or down recalls the parameters.

Saving Setup Parameters in Memory. Selecting thumbwheel position 6 allows the operator to save current setup parameters in NVRAM. Pushing the toggle switch up or down saves the current setup parameters. All LEDs in the display are on while the save process is in progress.

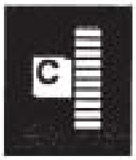


Loop Time Adjustment. Selecting thumbwheel position 7 allows the operator to read the time between servo loop updates. The value shown on the LED display is in 0.25 ms increments. This value is 1.25 ms standard and is not adjustable.

Derivative Adjustment. Selecting thumbwheel position A allows the operator to monitor and adjust the rate stabilization setting. Pushing the toggle switch up increases the rate gain. Pushing the toggle switch down decreases the rate gain. The rate gain range is 0 to 255.



Double Derivative Adjustment. Selecting thumbwheel position B allows the operator to monitor and adjust the acceleration stabilization setting. Pushing the toggle switch up increases the acceleration gain. Pushing the toggle switch down decreases the acceleration gain. The acceleration stabilization adjustment range is 0 to 255.



Feedforward Fraction Adjustment. Selecting thumbwheel position C allows the operator to monitor the feedforward fraction and adjust the feedforward. Raising the toggle switch increases the feedforward setting. Lowering the toggle switch decreases the feedforward setting. The diagnostic LED display shows a binary representation of the fractional part of the feedforward setting. For example, with all LEDs lit, the value represented would be calculated as follows:

displayed value = 1111 1111 (binary) = 255 (decimal)

reset fraction = .003906 x 255 = .996094

The adjustment will overflow or underflow, causing the unit value to increment or decrement.

Feedforward Units Adjustment. Selecting thumbwheel position D allows the operator to view and adjust the units part of the feedforward setting. Raising the toggle switch increases the feedforward setting. Lowering the switch decreases the setting. The maximum feedforward units setting is 127.

Test Points

The translator circuit card contains edge-mounted test points for monitoring certain parameters. These test points are typically used for readout and diagnostic purposes. Table 26-9 lists the test points and the parameters associated with them.

Table 26-9. Edge-Mounted Test Points

Test Point	Parameter
TP1 (PHASE 1)	Phase 1 output of the differential receiver.
TP2 (PHASE 2)	Phase 2 output of the differential receiver.
TP3 (MARKER)	Marker signal of the differential receiver.
TP4 (DIR)	Direction signal input to the accumulation counter.
TP5 (VEL CMND)	Analog output command applied to the dc motor command input.
TP6 (ANALOG GND)	Analog ground.

Troubleshooting the Encoder Servo Translator

Problem	Large Fault LED lit on Encoder Servo Translator
Steps	1. Check the Fault and Status indicators to see which fault occurred. Set the 16 position thumbwheel switch to position 0 and refer to Table 26-6. One or more of the following conditions will be indicated: a. + limit or - limit error b. drive fault c. hard excess error If a fault occurs after power-up, set the thumbwheel to position 0 and push the toggle switch up. If this does not clear the fault read the LEDs and take the appropriate action as shown in the following procedures.
Problem	+ limit or – limit error
Steps	1. Check the wiring to ±overtravel limits. 2. Check the limit switches. 3. Check jumper setting for external power supply. 4. Replace the Encoder Servo Translator
Problem	Drive fault error
Steps	1. Verify operation of amplifier. The amplifier may be in a fault condition. 2. Check drive fault jumper X10 for correct setting for your application. 3. Check wiring from the amplifier to the Encoder Servo Translator. 4. Replace Encoder Servo Translator.
Problem	Hard Excess Position Error . This condition exists when an excess following error fault has occurred on the Encoder Servo Translator. It is caused by excess following error exceeding the programmed limit. (The following error is the difference between the commanded position and the feedback position.)

Steps

1. Using the manufacturer's procedures, make sure that the servo amplifier and motor are fully operational and capable of achieving desired speeds.

2. Using INCOL86 software and your application program make sure that the hard excess error limit is set to a usable value. The default value is set to zero. Typical settings would be in the 4096 count range. Translator function 4 in INCOL86 sets the hard excess error limit.

3. Adjust the proportional loop gain. The proportional loop gain adjustment is set by INCOL86 software or by putting the thumbwheel to position to 1 and moving the toggle switch up to increase the proportional gain and down to decrease the proportional gain. Start by adjusting the proportional gain to its lowest setting. Increase the gain until minor oscillations occur and then decrease the gain until they disappear.

4. Check that the drive enable jumper and wiring are set correctly for your application. The enable output must match the enable input required by your amplifier.

5. Replace the Encoder Servo Translator.

Problem

No faults, but no motion.

⚠ CAUTION

Make sure chassis power is OFF before removing this module.

Steps

1. Check the address switch on the Encoder Servo Translator

2. Check the address switch on the associated Command Generator

3. Check that the drive enable jumper and wiring are set correctly for your application. The enable output must match the enable input required by your amplifier.

4. If the system has more then one axis of motion, make sure that the Encoder Servo Translator and its Command Generator are in the correct slots. The backplane is cut to prevent signals from one axis of motion interfering with another axis of motion. Refer to your system block diagram for the correct card placement.

5. Check the wiring from the Encoder Servo Translator to the servo amplifier.

6. Using manufacturer's procedures, make sure that the servo amplifier and motor are fully operational.

⚠ WARNING

The following procedure involves uncontrolled actuator movement. Before starting, uncouple the actuator from any machinery that could be damaged or cause a safety hazard.

7. Check the application program. The following sample program will move the motor. Before trying this test make sure that motion will not cause personal injuries or damage equipment. This test should be done only after the amplifier and motor have been verified. This program initializes the Encoder Servo Translator and moves the motor 1 revolution. If you are working with a different axis. use that axis number instead of X1. Set the appropriate scale value for the encoder used.

```
LOGIC:
AXIS X1 = DDC SERVO          ;IDENTIFY TRANSLATOR TYPE
SCALE X1 = 4096.             ;SET SCALE 1024 LINE ENCODER X 4
XLATOR X1,2 OFF              ;TURN DRIVE ENABLE OFF
XLATOR X1,4 = 2.             ;SET EXCESS ERROR TO LARGE VALUE FOR SETUP
XLATOR X1,5 = 2.             ;SOFT EXCESS ERROR NOT REQUIRED
XLATOR X1,6 = 4.             ;SET PROPORTIONAL GAIN TO 1
XLATOR X1,7 = 0.             ;INTEGRATOR OFF
XLATOR X1,8 = 0.             ;DITHER OFF
XLATOR X1,10 = 0.            ;OFFSET SET TO 0
XLATOR X1,11 = 0.            ;DERIVATIVE SET TO 0
XLATOR X1,12 = 0.            ;DOUBLE DERIVATIVE SET TO 0
XLATOR X1,13 = 0.            ;FEED FORWARD SET TO 0
XLATOR X1,14 = 0.            ;SET FEEDBACK SCALING TO DIVIDE BY 1
XLATOR X1,15 = 0.            ;SET SOFTWARE COUNTERS TO 0
HALT X1                      ;RESET TRANSLATOR
VMAX X1 = 50.5               ;SET VMAX TO A HIGH VALUE FOR TEST
AVD X1 = 1,1,1               ;ACCEL,DECEL = 1 REV/SEC/SEC VEL = 1 REV/SEC
DIST X1 = 1                  ;SET DISTANCE TO MOVE 1 REV
XLATOR X1 ON                 ;ENABLE TRANSLATOR
MOVE X1                      ;START MOTION
MWAIT X1                     ;WAIT FOR MOTION TO STOP
END
```

8. If your system uses more than one Encoder Servo Translator, swap the translators and try the test in Step 6 again. When swapping Encoder Servo Translators remember to change the address switch settings.

9. If your system uses more than one Command Generator, swap the Command Generators and try this test again. When swapping Command Generators remember to change the address switch settings.

10. Replace the Encoder Servo Translator

Problem

Motor runs away.

Steps

1. Using manufacturer's procedures make sure that the servo amplifier and motor are fully operational.

2. If the amplifier and motor are fully operational, then the motor is running away because the encoder feedback is not correctly phased or there is no encoder feedback. Perform the following test program to make sure there is feedback from the encoder. This test will display the following error on the computer screen. To test for encoder feedback, start the program and turn the shaft on the motor by hand. The value displayed is the encoder feedback. The maximum value that can be displayed (before an excess error fault occurs) will be 16276 . When the fault occurs then the value displayed resets to zero.

```
LOGIC:
AXIS X1 = DDC SERVO          ;IDENTIFY TRANSLATOR TYPE
SCALE X1 = 1    .            ;SET SCALE TO ENCODER PULSES
XLATOR X1,2 OFF              ;TURN DRIVE ENABLE OFF
XLATOR X1,4 = 16276.         ;SET EXCESS ERROR TO LARGE VALUE FOR SETUP
XLATOR X1,5 = 16276.         ;SOFT EXCESS ERROR NOT REQUIRED
XLATOR X1,6 = 4.             ;SET PROPORTIONAL GAIN TO 1
XLATOR X1,7 = 0.             ;INTEGRATOR OFF
XLATOR X1,8 = 0.             ;DITHER OFF
XLATOR X1,10 = 0.            ;OFFSET SET TO 0
XLATOR X1,11 = 0.            ;DERIVATIVE SET TO 0
XLATOR X1,12 = 0.            ;DOUBLE DERIVATIVE SET TO 0
XLATOR X1,13 = 0.            ;FEED FORWARD SET TO 0
XLATOR X1,14 = 0.            ;SET FEEDBACK SCALING TO DIVIDE BY 1
XLATOR X1,15 = 0.            ;SET SOFTWARE COUNTERS TO 0
START DISPLAY                ;START DISPLAY TASK
END

DISPLAY:
R1 = XLATOR X1,2             ;READ FOLLOWING ERROR
PRINT 0,R1                   ;PRINT TO COMPUTER SCREEN
START DISPLAY                ;LOOP ON TASK
END
```

3. If you are getting feedback using the above test then the encoder is not phased correctly. To change the encoder phasing swap the A+ encoder lead with the A– encoder lead.

Problem	Motor oscillates violently
Steps	1. Using manufacturer's procedures, make sure that the servo amplifier and motor are fully operational. 2. The violent movement could be due to incorrect encoder phasing, phasing. Refer to the procedure above for verification of encoder phasing. 3. If the encoder phasing is correct, then the problem is probably due to excess position loop gain. Adjust the loop gain down until the oscillation goes away.

Specifications

Parameter	Specification
Encoder Interface:	
Type	Rotary or linear quadrature
Signal voltage input	Differential or single-ended
Input frequency	100 kHz (max)
Differential input impedance	180Ω
Common mode voltage	±15 V (max)
Differential channel amplitude	1 V p-p (min)
5 V and 12 V encoder supply current	350 mA (max)*
Digital Servo Controller:	
Incremental position command input	325,000 pps (max)
Feedback input	quadrature
Compensation types	proportional, integral, derivative, double-derivative, and feedforward
Loop update period	1.25 ms
Dither amplitude	nominal 0 to 12% of full scale
Output buffer	Up to 10 mA output current
Machine Status Interface	
Input source current	20 mA at 0 V (overtravel limit, drive fault, home inputs)
Output sink current	75 mA at 0.2 V (drive enable output)
Power requirements (PWA only)†	+5 Vdc ± 0.25 V at 900 mA +12 Vdc ±1.2 Vdc at 100 mA -12 Vdc ±1.2 V at 30 mA
Operating Environment:	0° to 50°C (32° to 122°F) ambient operating temperature Up to 95% humidity, noncondensing
System Requirements	1 chassis slot

* +5 V user encoder supply current derived from +12 V supply.

† Assumes internal +12 V used for optocoupler power.

27 Model 475.71c Command Enable Module

Introduction

The Model 475.71c Command Enable Module provides a control interface between INCOL86/Motion Plus™ control system command outputs and drive/actuator command inputs.

Standard features of the Command Enable Module include the following:

- +15 Vdc power input
- Enable control of output signals for two separate axes
- Panel or DIN rail mounting

Options include the following:

- +12 Vdc power input*
- Optional power input*¶

  * Requires jumper change.
  ¶ Requires additional component.

Figure 27-1 shows the location of important components on the Command Enable Module.

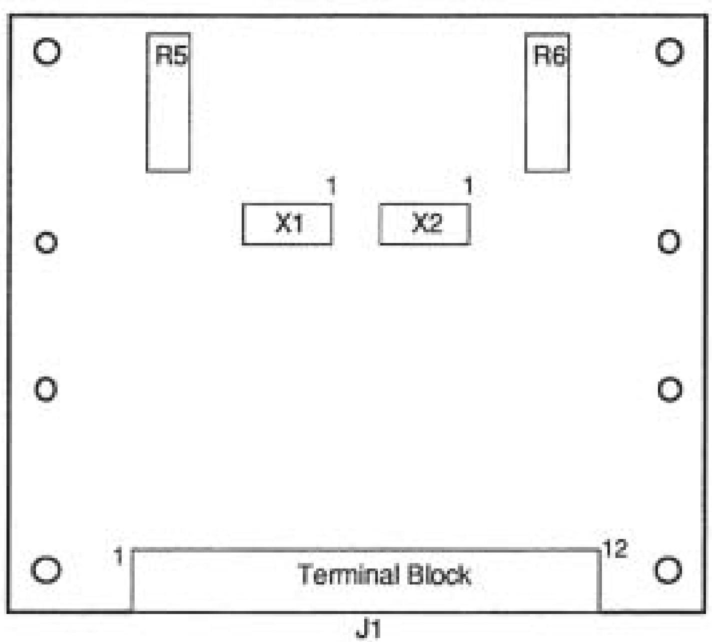


Figure 27-1. Model 475.71c Command Enable Module

Jumpers

Check or change jumper settings according to Table 27-1. The standard connection is noted. Optional settings may require extra hardware.

Table 27-1. Command Enable Module Jumper Connections

Power Supply	X Axis Jumper X1	Y Axis Jumper X2
+15 VDC	1-6*	1-6*
+12VDC	2-5	2-5
+Vx	3-4**	3-4**

*Standard Configuration
**Requires Resistor Selection:
X Axis
R5=(Vx/0.025) - 200
Y Axis
R6=(Vx/0.025) - 200

The table shows formulas for selecting the resistors, which must be changed for Vx voltages other than +15 V or +12 V. Resistor R5 affects the X axis only. Resistor R6 affects the Y axis only. The formula is applied as shown in the following example, to select a resistor and power requirement for the X axis.

Example:

$+Vx = +24$ VDC
$R5 = (+Vx / I) - 200$ where I is the normal current (0.025 A)
$200\ \Omega$ is the normal coil resistance.
$R5 = (24 / 0.025) - 200$
$= 760\ \Omega$ (Select $750\ \Omega$)

Power required $= I^2 \times R \times 2$ where I is 0.025 A
R is $750\ \Omega$
2 is a safety factor
$= 0.938$ W (Select 1 W)

Wiring

Table 27-2. Pin Definitions (J1)

Pin	Signal Name	Description
1	+Vx	+ Power supply input
2	SHIELD	Shield connection point
3	X CMND + IN	X Axis +Velocity Command Input
4	X CMND - IN	X Axis -Velocity Command Input
5	Y CMND + IN	Y Axis +Velocity Command Input
6	Y CMND - IN	Y Axis -Velocity Command Input
7	X ENAB IN	X Axis Active Low Enable Input
8	Y ENAB IN	Y Axis Active Low Enable Input
9	X CMND + OUT	X Axis +Velocity Command Output
10	X CMND - OUT	X Axis -Velocity Command Output
11	Y CMND + OUT	Y Axis +Velocity Command Output
12	Y CMND - OUT	Y Axis -Velocity Command Output

Cabling

Figure 27-2 shows cable configurations for connecting the Command Enable Module to various Motion Plus/473 axis cards. The Command Enable Module card must be mounted within 10 ft of the controller. Refer to Appendix B of this manual for grounding and shielding considerations.

A shield connection point is provided at J1 pin 2. Shield connection to chassis ground is tied at the controller end. Twisted shielded pairs are recommended for routing signals between the Command Enable Module and the drive/actuator.

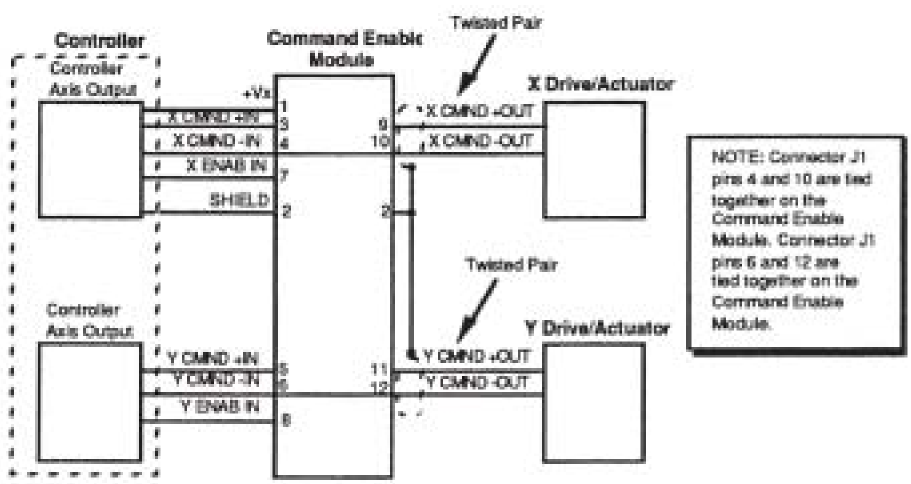


Figure 27-2. Cable Configurations

Installing the Command Enable Module

The Command Enable Module comes with a hardware mounting kit consisting of plastic mounting feet with self-starting screws for DIN rail mounting (DIN EN 50022, 35 mm x 7.5 mm) and nylon spacers (1/2 in. long) with 6-32 UNC mounting screws (3/4 in. long) for panel mounting. Mounting dimensions are shown in Figure 27-3.

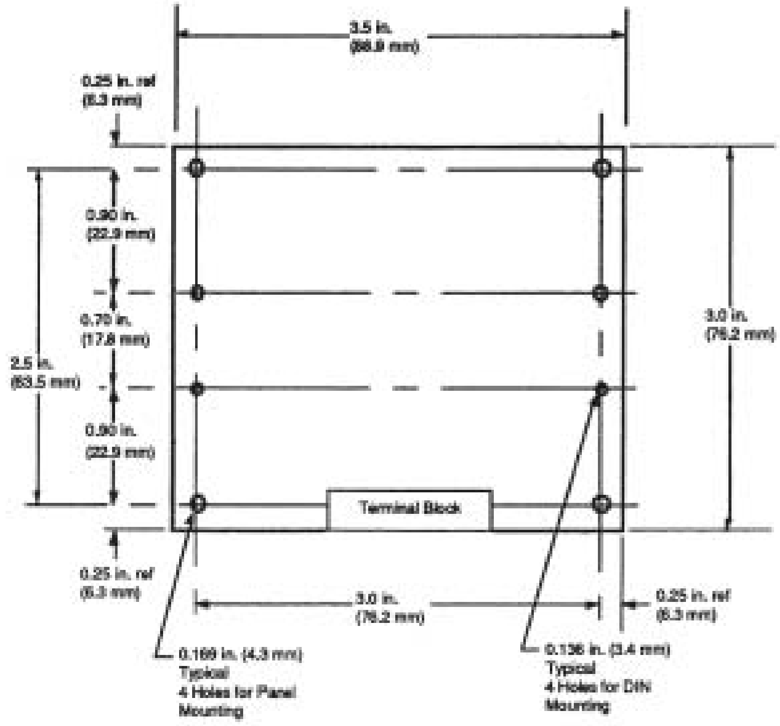


Figure 27-3. Mounting Dimensions

Troubleshooting the Command Enable Module

Problem	System drifts and does not respond to command input.
Possible Causes	• Incorrect wiring • Incorrect module configuration • Enable inactive
Steps	1. Check the wiring between the axis card and the Command Enable module. 2. Verify that the jumpers X1 and X2 are in the correct position for the input voltage used. If using the selectable output range, you must install the correct values for R5 and R6. 3. Verify that the enable signal from the axis card is active low.

Specifications

Parameter	Specification
Power Requirements:	
+Vx	+11 to +24 Vdc at 25 mA per axis
Command Inputs	±10 Vdc or ±100 mA max
Reed Relay	200 Ω coil nominal resistance at 25 °C operating time 1 ms max internal diode protection dry contacts
Operating Environment	
Temperature Humidity	0° to 50°C (32 to 122 °F) up to 90% noncondensing

28 Model 475.70c Voltage-to-Current Converter Module

Introduction

The Model 475.70c Voltage-to-Current Converter provides an interface between INCOL86/Motion Plus™ control systems and hydraulic servo valves requiring a current command.

Standard features of the Voltage-to-Current Converter include the following:

- 50 mA full scale current output
- Enable control of the output signal
- Panel or DIN rail mounting

Options include the following:

- 25 mA full scale current output*
- 100 mA full scale current output*
- Selectable full scale current output*¶

* Requires jumper change.
¶ Requires additional component.

Figure 28-1 shows the location of important components on the Voltage-to-Current Converter.

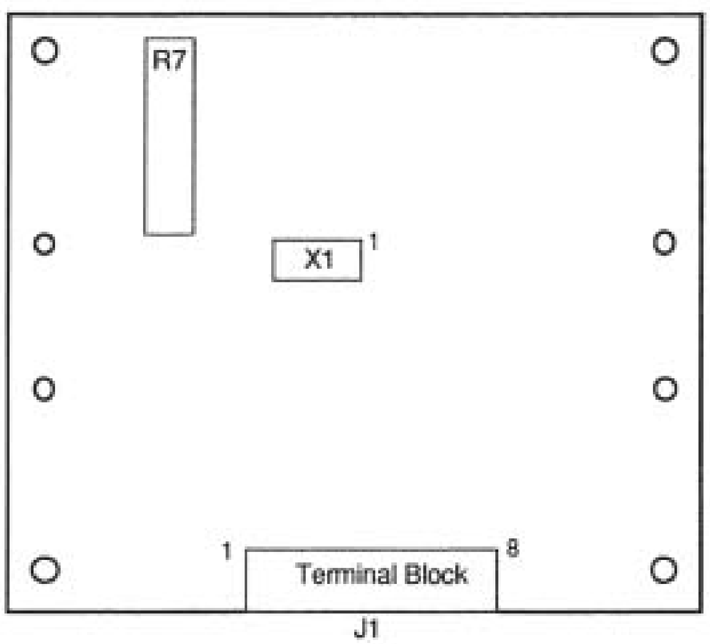


Figure 28-1. Model 475.70c Voltage-to-Current Converter

Jumpers

Check or change jumper settings according to Table 28-1. The standard connection is noted. Optional settings may require extra hardware.

Table 28-1. Voltage-to-Current Converter Jumper Connections

Jumper	Connection	Description
X1	1-8* 2-7 3-6 4-5¶	50 mA full scale current output 25 mA full scale current output 100 mA full scale current output Selectable full scale current output
* Standard connection ¶ Resistor selection required (R7)		

Resistor R7 must be selected for full scale values other than those listed. The calculation is as follows:

$$R7 = 1/I_{fs}$$

where I_{fs} is the full scale current desired, in amps
$R7$ is the required resistance for the current limiting resistor (R7), in ohms.

Example:

The desired full scale current is 40 mA

$$R = 1 / 0.04 = 25 \text{ ohms}$$

$$\begin{aligned} \text{Power} &= I_{fs} \times I_{fs} \times R7 \times 2 \text{ (where 2 is a safety factor)} \\ &= 0.04 \times 0.04 \times 25 \times 2 \\ &= 0.08 \text{ watts} \end{aligned}$$

Use a 0.1 watt resistor

Wiring

Table 28-2. Pin Definitions (J1)

J1 Pin	Name	Description
1	VEL CMND	±10 Vdc full scale velocity command
2	+12V	+12 V power supply input
3	12V COM	12 V common power supply input
4	-12V	-12 V power supply input
5	SHIELD	Shield connection point
6	-ENABLE	Active low enable input
7	CURR SRC	Current source to valve
8	CURR RET	Current return from valve

Cabling

Table 28-3 and Figure 28-2 show cable configurations for connecting the Voltage-to-Current Converter to various Motion Plus/473 axis cards. The Voltage-to-Current Converter card must be mounted within 10 ft of the controller. Refer to Appendix B of this manual for grounding and shielding considerations.

Table 28-3. Cable Configurations

Voltage-to-Current Converter (J1 Pins)	Name	473.66c Encoder Translator or 473.65c Resolver Translator		473.70c Analog I/O Processor	473.19c Servo Translator
		Direct (J2)	Via Remote Term. Bd.		
1	VEL CMND	11	21	29 (CH0) or 31 (CH1)	8
2	+12V	17 or 35	37-40	19	13
3	12V COM	18 or 36	33-36	20	20
4	-12V	34	32	24	14
5	SHIELD	12	23	18 or 25	18 or 19
6	ENABLE	31	26	15	9

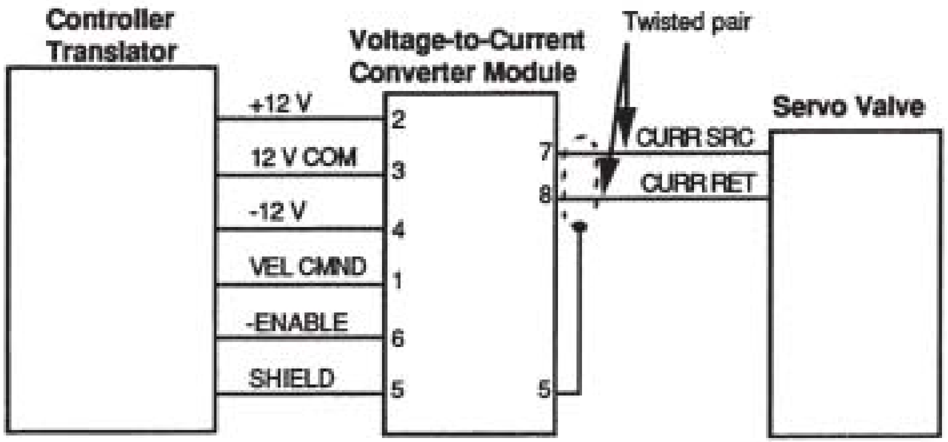


Figure 28-2. Cable Configurations

IMPORTANT

Observe general signal precautions for cable routing. Mount the Voltage-to-Current Converter Module within 10 ft of the controller. Cable routing should be physically isolated from high frequency or high power conductors.

A shield connection point is provided at J1-5. Shield connection to chassis ground is tied at the controller end. Twisted pairs with shields are recommended for signal routing between the Voltage-to-Current Converter Module and the servo valve.

Installing the Voltage-to-Current Converter

The Voltage-to-Current Converter Module comes with a hardware mounting kit consisting of plastic mounting feet with self-starting screws for DIN rail mounting (DIN EN 50022, 35 mm x 7.5 mm) and nylon spacers (1/2 in. long) with 6-32 UNC mounting screws (3/4 in. long) for panel mounting. Mounting dimensions are shown in Figure 28-3.

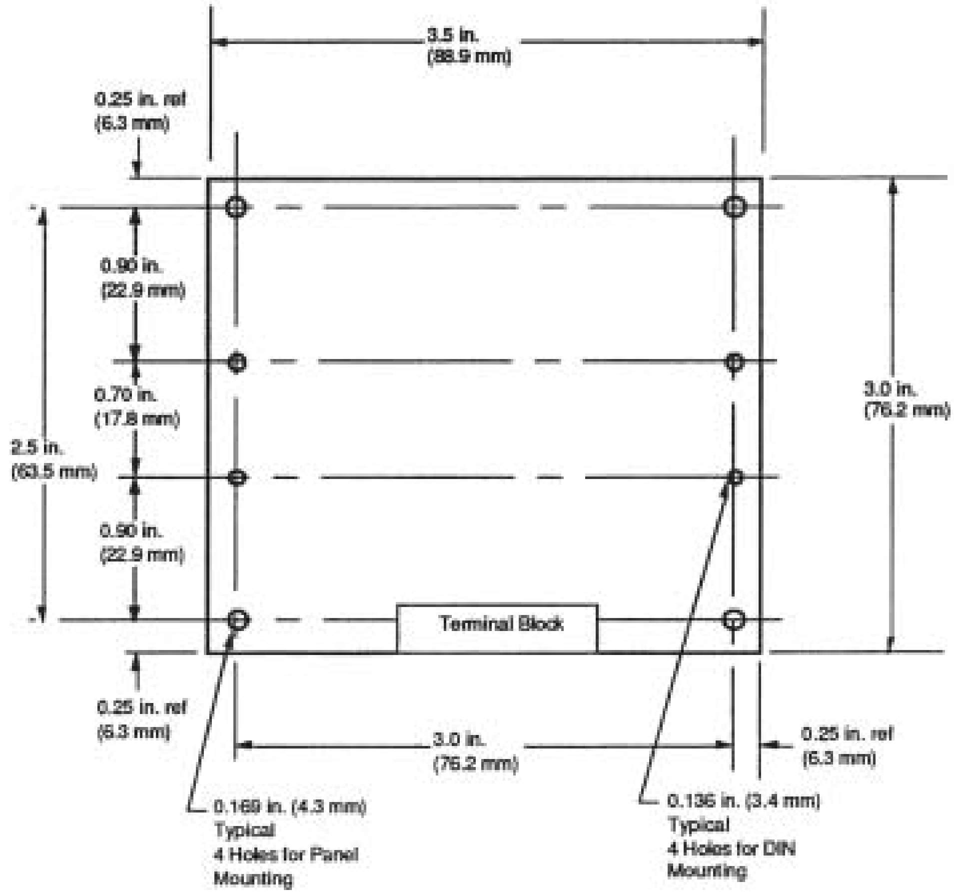
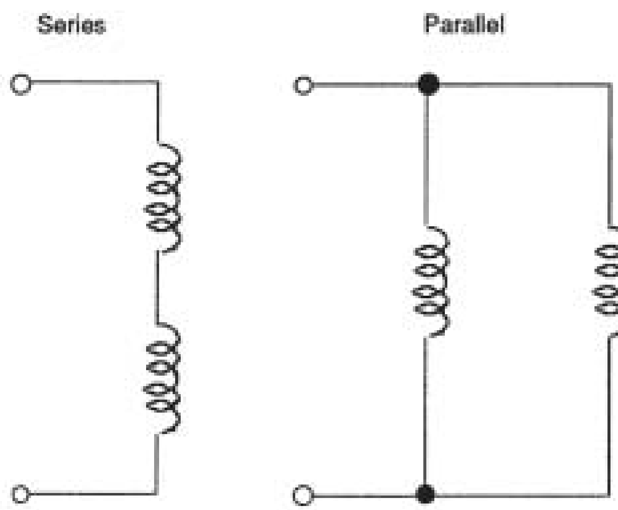


Figure 28-3. Mounting Dimensions

Troubleshooting the Voltage-to-Current Converter

Problem	System drifts and valve does not respond to command input.
Possible Causes	• Incorrect wiring • Incorrect module configuration • Enable inactive
Steps	1. Check the wiring between the axis card and the Voltage-to-Current Converter. 2. Verify that jumper X1 is in the correct position for your application. If using the Selectable output range, you must install the correct resistor at R7. 3. Verify that the enable signal from the axis card is active low.
Problem	Incorrect system response
Possible Causes	• Incorrect full scale output
Steps	1. Verify that jumper X1 is in the correct position for your application. If using the Selectable output range, you must install the correct resistor at R7. 2. Verify that the servo valve is configured correctly. Typical valve configurations are shown below. 

Specifications

Parameter	Specification
Power requirements	+12 V at 150 mA maximum -12 V at 150 mA maximum
Command input	±10 Vdc analog maximum
Current output	±100 mA maximum (85Ω max resistance at 100 mA)
Operating temperature	0 to 50°C(32 to 122°F)
Operating humidity	Up to 90%, noncondensing

29 Model 475.50c Cables

Introduction

Cables designed for connecting components of the Motion Plus system have model numbers beginning 473.50c-. Pinout and configuration details are included in this subsection. Series 473.50- cables are listed in Table 29-1.

Table 29-1. Series 473.50 Cables

Model Number	Custom Servo Motors Part No.	Connects this	To this
473.50c-00A-300	383629-XX	32 I/O Interface	(Unterminated at one end for connection to customer terminal board)
473.50c-01A-200	387316-XX	32 I/O Interface or Encoder Servo Translator or Resolver Servo Translator	Remote Terminal Board
473.50c-01A-300	368625-XX	32 I/O Interface	Remote Terminal Board
473.50c-05A-200	393710-XX	32 I/O Interface	(one) 16-position Opto motherboard
473.50c-06A-300	368615-XX	32 I/O Interface	(two) 16-position Opto motherboards
473.50c-08A-100	371538-XX	(adapter cable, connects two cables to one 32 I/O Interface)	
473.50c-10A-0XX	393709-XX	32 I/O Interface or Remote Terminal Board	Remote data devices
473.50c-13A-300	384976-XX	CRT Interface	Composite CRT Monitor
473.50c-25A-300	408344-XX	System Processor or High Speed System Processor	IBM PC
473.50c-25B-300	426488-XX	System Processor or High Speed System Processor	IBM AT
473.50c-26A-300	426487-XX	GTEK EPROM Programmer	IBM PC
473.50c-26B-300	426489-XX	GTEK EPROM Programmer	IBM AT
473.50c-31A-200	382012-XX	Remote Terminal Board	Servo Translator
473.50c-33A-001	418158-XX	Remote Terminal Board	Encoder Interface
473.50c-35A-200	389186-XX	Remote Terminal Board	Temposonics Servo Translator
473.50C-36A-300	453850-XX	Analog I/O	Phoenix type remote t.b.

473.50c-00A-300 Unterminated I/O Cable

The Model 473.50c-00A-300 Unterminated I/O Cable is used to connect the Model 473.10c 32 I/O Interface to external I/O and power supply. This 10-ft round cable is unterminated at one end for connection to a customer terminal board. The other end is terminated with a 36-pin "D" type male connector (AMP part no. 552144-1, Custom Servo Motors part no. 113706-47) which mates to the 32 I/O Interface card. Table 29-2 lists the pin numbers and INCOL86 I/O numbers of this cable for Card 1.

Table 29-2. Cable Configuration (473.50c-00A-300)

Connector Number	INCOL86 I/O No.	Color Code
1	1	BLUE/WHITE
2	3	GREEN/WHITE
3	5	GRAY/WHITE
4	7	ORANGE/RED
5	9	BROWN/RED
6	11	BLUE/BLACK
7	13	GREEN/BLACK
8	15	GRAY/BLACK
9	17	ORANGE/YELLOW
10	19	BROWN/YELLOW
11	21	BLUE/VIOLET
12	23	GREEN/VIOLET
13	25	GRAY/VIOLET
14	27	WHITE/ORANGE
15	29	WHITE/BROWN
16	31	RED/BLUE
17	+Vdc	YELLOW/ORANGE
18	-Vdc	RED/GREEN
19	2	ORANGE/WHITE
20	4	BROWN/WHITE
21	6	BLUE/RED
22	8	GREEN/RED
23	10	GRAY/RED
24	12	ORANGE/BLACK
25	14	BROWN/BLACK
26	16	BLUE/YELLOW
27	18	GREEN/YELLOW
28	20	GRAY/YELLOW
29	22	ORANGE/VIOLET
30	24	BROWN/VIOLET
31	26	WHITE/BLUE
32	28	WHITE/GREEN
33	30	WHITE/GRAY
34	32	RED/ORANGE
35	+Vdc	YELLOW/GREEN
36	-Vdc	RED/BROWN

Model 473.50c-01A-200 Cable

The Model 473.50c-01A-200 Cable is a 4-ft ribbon cable terminated at both ends with 36-pin "D" male connectors (AMP part number 554084-1, Custom Servo Motors part number 113706-61). The cable is designed to connect the Model 473.10c 32 I/O Interface to the Model 473.38c-02A-000 Remote Terminal Board. The Remote Terminal Board provides screw-terminal connections for up to 32 I/O points plus an external power supply.

The cable also connects Models 473.65c Resolver Servo Translator and 473.66c Encoder Servo Translator to the Remote Terminal Board.

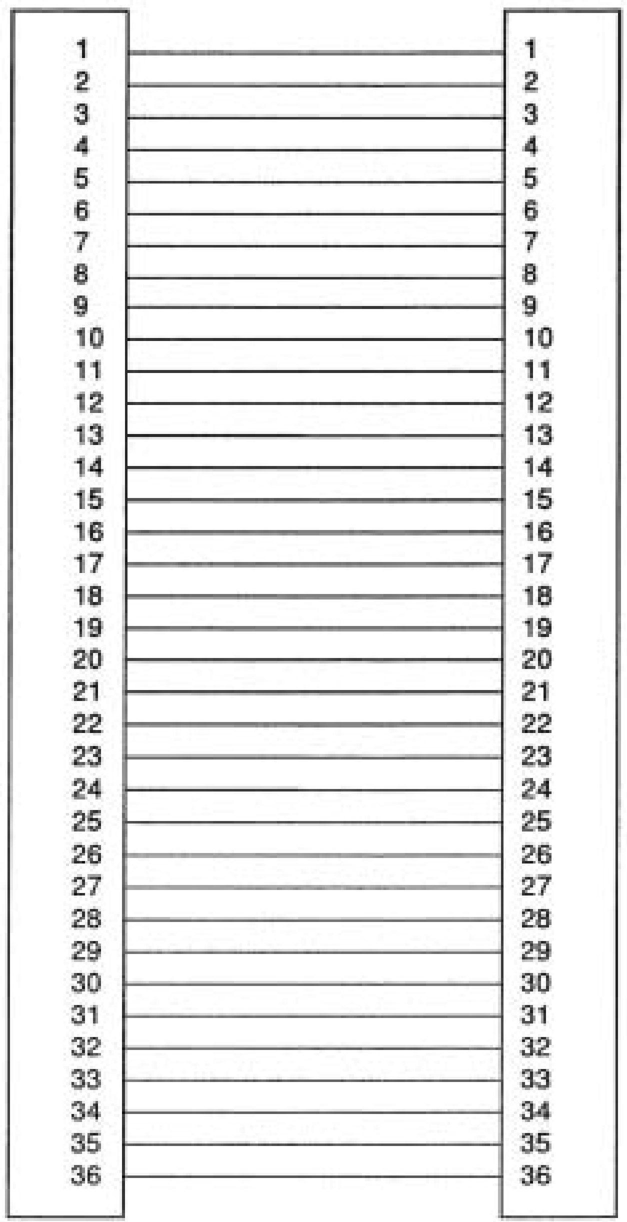


Figure 29-1. Cable Configuration (473.50c-01A-200)

Model 473.50c-01A-300 Cable

The Model 473.50c-01A-300 Cable is a 10-ft round cable terminated at both ends with 36-pin "D" male connectors (AMP part number 552144-1, Custom Servo Motors part number 113706-47). The cable is designed to connect the Model 473.10c 32 I/O Interface to the Model 473.38c-02A-000 Remote Terminal Board. The Remote Terminal Board provides screw-terminal connections for up to 32 I/O points plus an external power supply.

1	BLUE/WHITE	1
2	GREEN/WHITE	2
3	GRAY/WHITE	3
4	ORANGE/RED	4
5	BROWN/RED	5
6	BLUE/BLACK	6
7	GREEN/BLACK	7
8	GRAY/BLACK	8
9	ORANGE/YELLOW	9
10	BROWN/YELLOW	10
11	BLUE/VIOLET	11
12	GREEN/VIOLET	12
13	GRAY/VIOLET	13
14	WHITE/ORANGE	14
15	WHITE/BROWN	15
16	RED/BLUE	16
17	YELLOW/ORANGE	17
18	RED/GREEN	18
19	ORANGE/WHITE	19
20	BROWN/WHITE	20
21	BLUE/RED	21
22	GREEN/RED	22
23	GRAY/RED	23
24	ORANGE/BLACK	24
25	BROWN/BLACK	25
26	BLUE/YELLOW	26
27	GREEN/YELLOW	27
28	GRAY/YELLOW	28
29	ORANGE/VIOLET	29
30	BROWN/VIOLET	30
31	WHITE/BLUE	31
32	WHITE/GREEN	32
33	WHITE/GRAY	33
34	RED/ORANGE	34
35	YELLOW/GREEN	35
36	RED/BROWN	36

Figure 29-2. Cable Configuration (473.50c-01A-300)

473.50c-05A-300 Cable

The Model 473.50c-05A-300 32 I/O Cable is a 10-ft round cable designed to connect the Model 473.10c 32 I/O Interface to a single Model 473.36c-02A-000 16-position Opto Motherboard. A 50-pin edge connector is provided for the motherboard, and a 36-pin "D" male connector plugs into the I/O interface. Figure 29-3 shows the configuration for these connectors. Connects I/O points 1-16 to the 32 I/O Card.

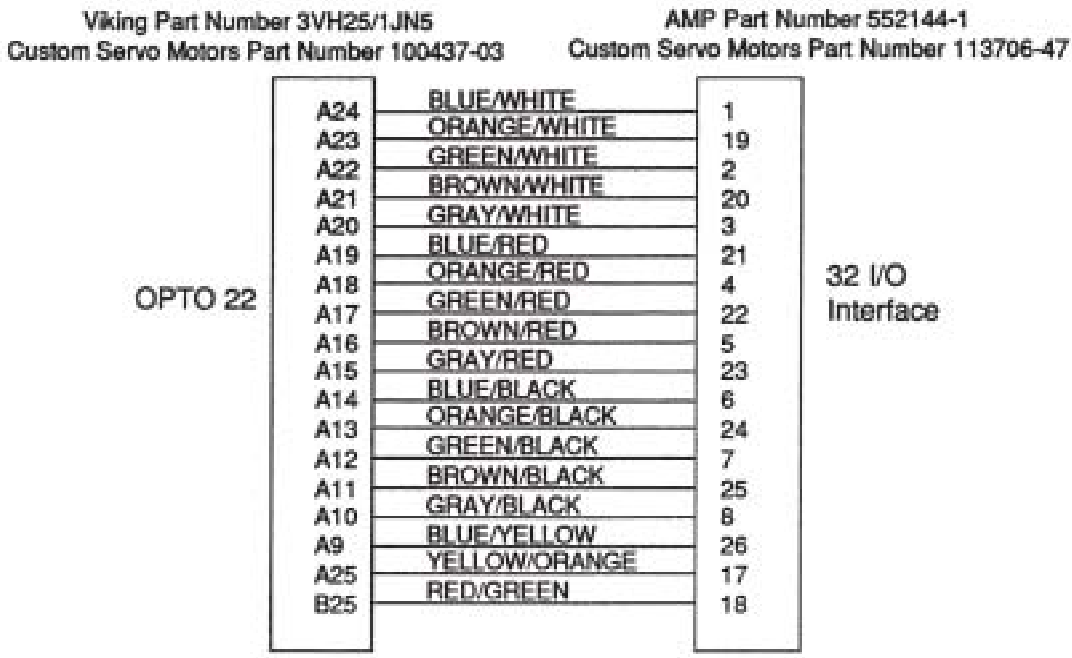


Figure 29-3. Cable Configuration (473.50c-05A-300)

473.50c-06A-300 Cable

The Model 473.50c-06A-300 32 I/O Cable is a 10-ft cable designed to connect the Model 473.10c 32 I/O Interface to two Model 473.36c- 02A-000 16-position Opto Motherboards. A 50-pin edge connector is provided for each motherboard, and a 36-pin "D" male connector plugs into the I/O interface. Figure 29-4 shows the configuration for these connectors.

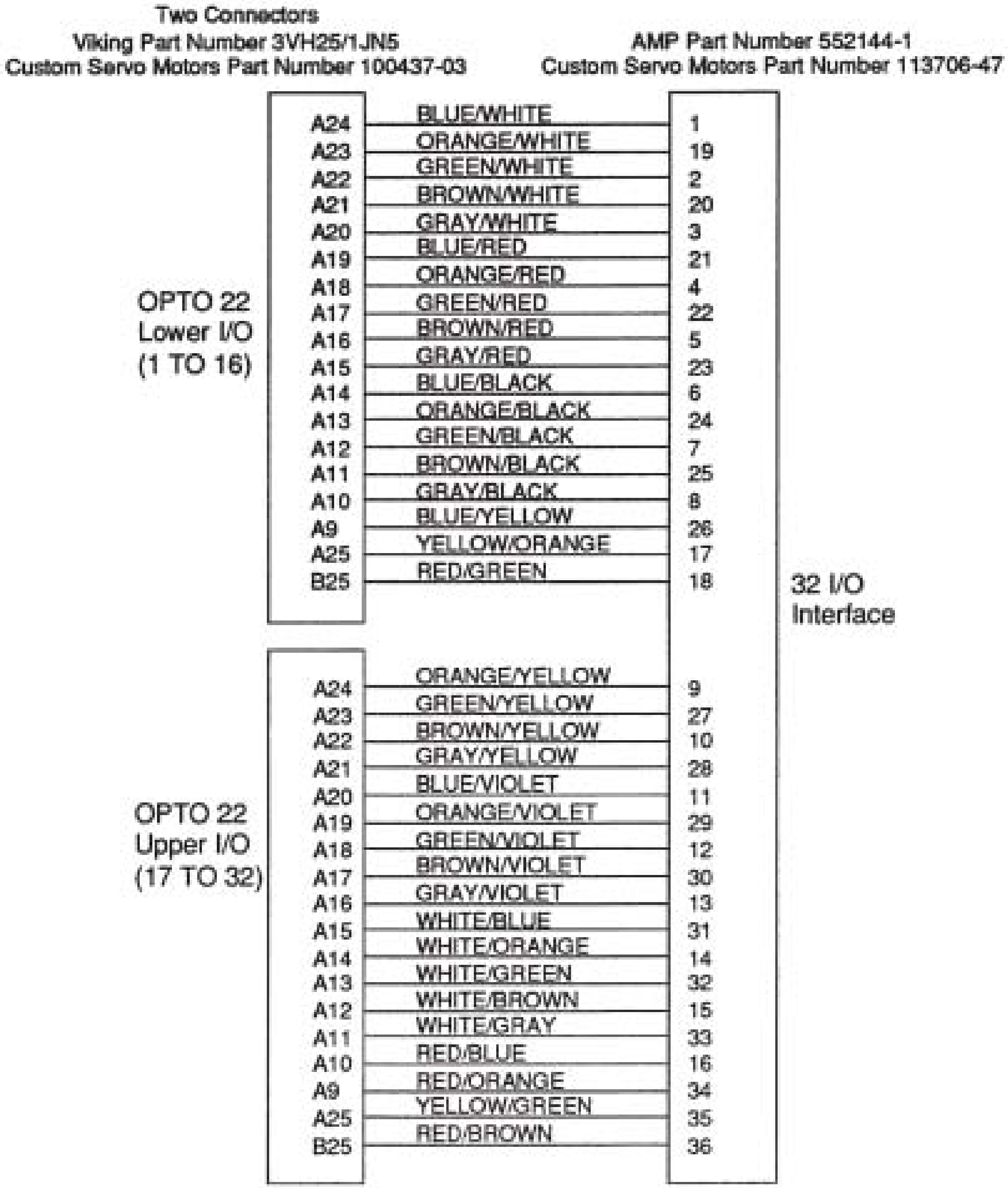


Figure 29-4. Cable Configuration (473.50c-06A-300)

473.50c-08A-300 Adapter Cable

The Model 473.50c-08A-100 Adapter Cable is a 1-ft RIBBON cable that allows two cables to be connected to one Model 473.10c 32 I/O Interface. The cable is terminated with one 36-pin "D" male connector (AMP part number 554084-1, Custom Servo Motors part number 113706-61) which plugs into the 32 I/O Interface, and two 36- pin "D" female connectors (AMP part number 553601-1, Custom Servo Motors part number 113706-62, one at the end, and one 3 inches from the end) for connection to other cables. As shown in Figure 29-5, pin configurations are identical for all three connectors.

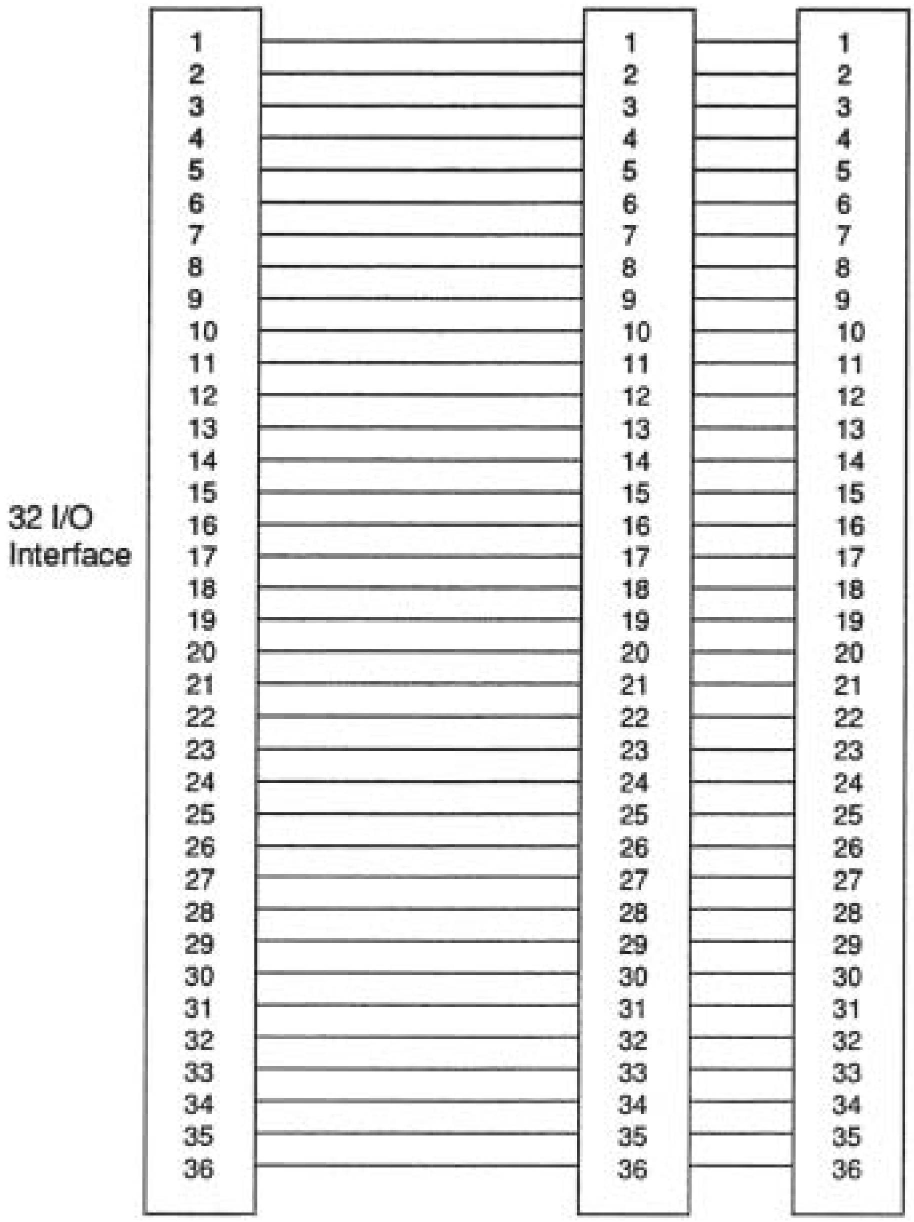


Figure 29-5. Cable Configuration (473.50c-08A-300)

473.50c-10A-0XX 32 I/O Remote Data Bus Cable

The Model 473.50c-10A-0XX 32 I/O Remote Data Bus Cable is used to connect Remote Data Bus devices such as thumbwheels, LCD or LED displays, and keypads to the 32 I/O Interface. The following devices are compatible with this cable:

- Model 473.06c Remote Keypad (one per cable)
- Model 473.07c Thumbwheel Switch (1 to 32 per cable)
- Model 473.09c LED Display (1 to 5 per cable, more than 5 requires a custom cable)
- Model 473.13c LCD Display (one per cable)

The Remote Data Bus Cable is a 20-conductor ribbon cable terminated with a 36-pin "D" male connector (AMP part number 554084-1, Custom Servo Motors part number 113706-61) and supplied with a separate connector (3M part number 3421-6020, Custom Servo Motors part number 100834-05) for each Remote Data Bus device. Refer to Figure 29-6. The cable length is 10 ft from the D connector to the first device connector, and 1 ft between device connectors. The number of device connectors provided with the cable is denoted by an extension to the model number. Model 473.50- 10A-001 has one device connector, while -002 has two device connectors, -003 has three, etc.

When the Remote Data Bus Cable is connected directly to an 32 I/O Interface card, other I/O connections are not supported by the card, and +12 Vdc power is provided via the 32 I/O Interface jumpers.

Alternatively, the Remote Data Bus Cable can be plugged into the Model 473.38c Remote Terminal Board, with terminals remaining for 16 additional I/O points plus an external power supply.

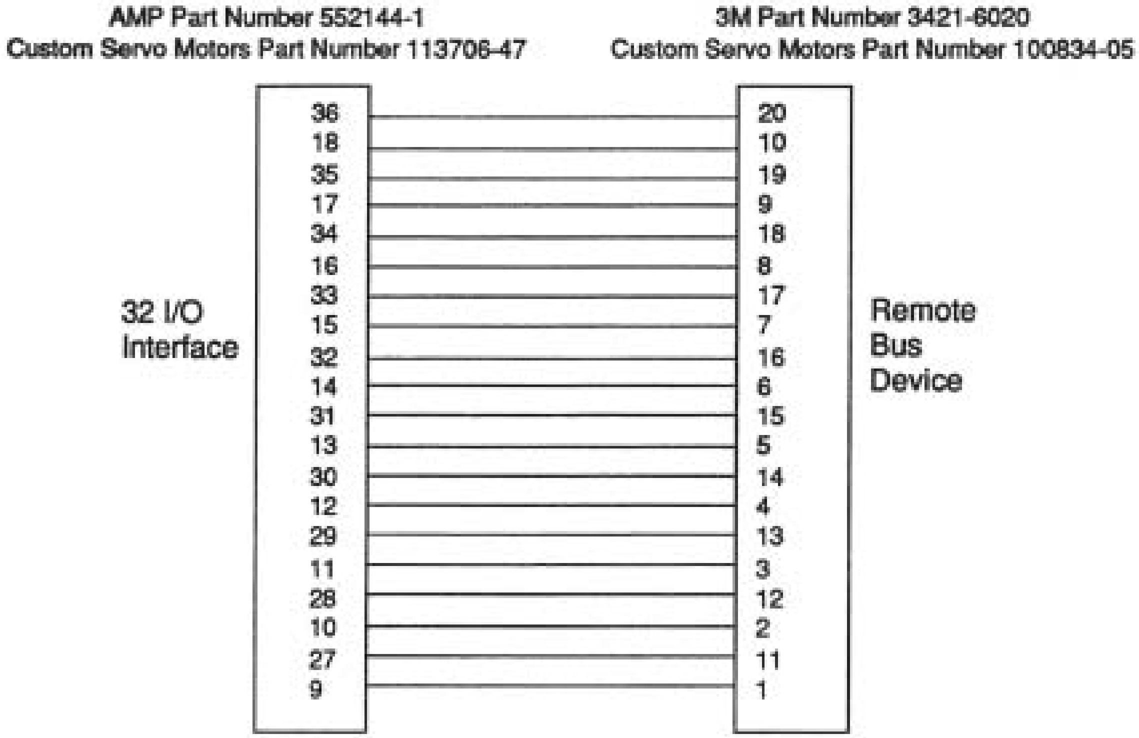


Figure 29-6. Cable Configuration (473.50c-10A-0XX Remote Data Bus Cable)

473.50c-13A-300

The Model 473.50c-13A-300 Cable is designed to connect the Model 473.08c CRT Interface to the a composite monitor, such as the Model 473.91c-09A-003 CRT Monitor. This is a 10-ft coaxial cable configured as shown in Figure 29-7. It includes a phono plug connector (Switchcraft part number 39F2159, Custom Servo Motors part number 111395-17) on one end and a BNC plug (AMP part number 227079-9, Custom Servo Motors part number 100446-01) on the other end.

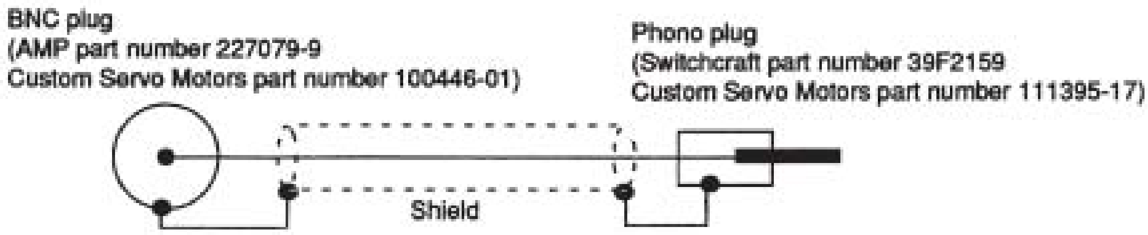


Figure 29-7. Cable Configuration (473.50c-13A-300)

473.50c-25A-300

The Model 473.50c-25A-300 Cable is designed to connect the Model 473.60c System Processor to the serial port of an IBM PC microcomputer. Both ends are terminated with 25-pin connectors. The male end (Cannon part number DBMA-25P, Custom Servo Motors part number 100441-10) connects to the System Processor module. The female end (Cannon part number DBMA-25S, Custom Servo Motors part number 100441-11) connects to the IBM PC serial port, as shown in Figure 29- 8.

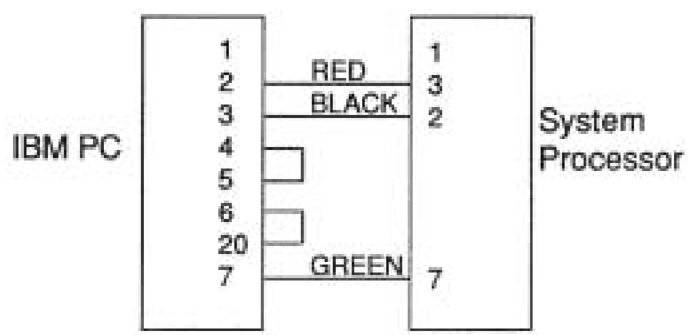


Figure 29-8. Cable Configuration (473.50c-25A-300)

473.50c-25B-300

The Model 473.50c-25B-300 Cable is designed to connect the Model 473.60c System Processor to the serial port of an IBM AT microcomputer. Both ends are terminated. The 25-pin male end (Cannon part number DBMA-25P, Custom Servo Motors part number 100441-10) connects to the System Processor module. The 9-pin female end (Cannon part number DEMA-9S, Custom Servo Motors part number 100441-70) connects to the IBM AT, as shown in Figure 29-9.

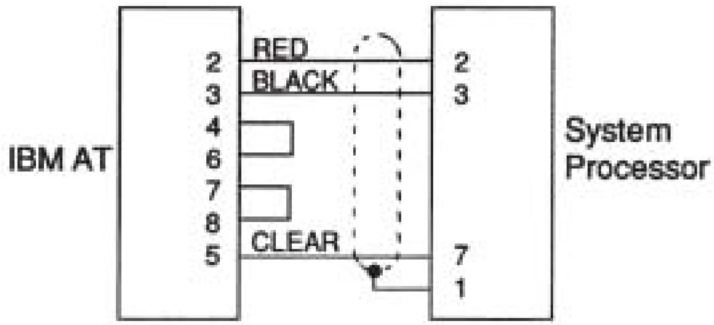


Figure 29-9. Cable Configuration (473.50c-25B-300)

473.50c-26A-300

The Model 473.50c-26A-300 Cable is designed to connect the GTEK EPROM Programmer to an IBM PC microcomputer, as shown in Figure 29-10. Both ends are terminated with female 25-pin connectors (Cannon part number DBMA-25S, Custom Servo Motors part number 100441-11).

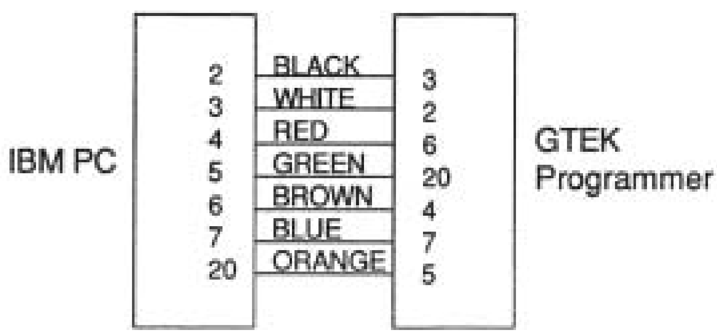


Figure 29-10. Cable Configurations (473.50c-26A-300)

473.50c-26B-300

The Model 473.50c-26B-300 Cable is designed to connect the GTEK EPROM Programmer to an IBM AT, as shown in Figure 29-11. The IBM AT end is terminated with a female 9-pin connector (Cannon part number DEMA-9S, Custom Servo Motors part number 100441-70). The GTEK end is terminated with a female 25-pin connector (Cannon part number DBMA-25S, Custom Servo Motors part number 100441-11).

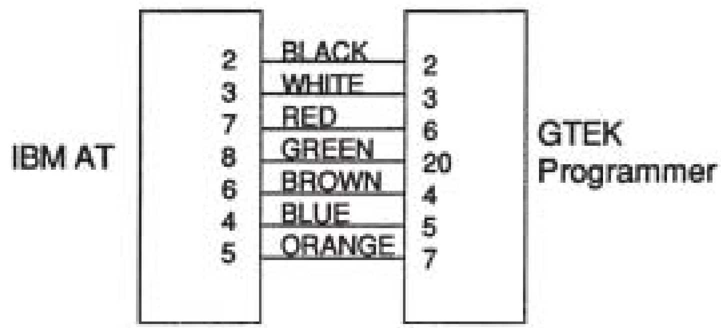


Figure 29-11. Cable Configurations (473.50c-26B-300)

473.50c-31A-200

The Model 473.50c-31A-200 Cable is designed to connect the Model 473.19c Servo Translator to the Model 473.38c Remote Terminal Board. One end is terminated with a 24-pin connector (AMP part number 552272-1, Custom Servo Motors part number 114732-02) which connects to the Servo Translator. The other end is terminated with a 36-pin "D" male connector (AMP part number 552274-1, Custom Servo Motors part number 114732-01) which connects to the Remote Terminal Board. Figure 29-12 shows the cable configuration.

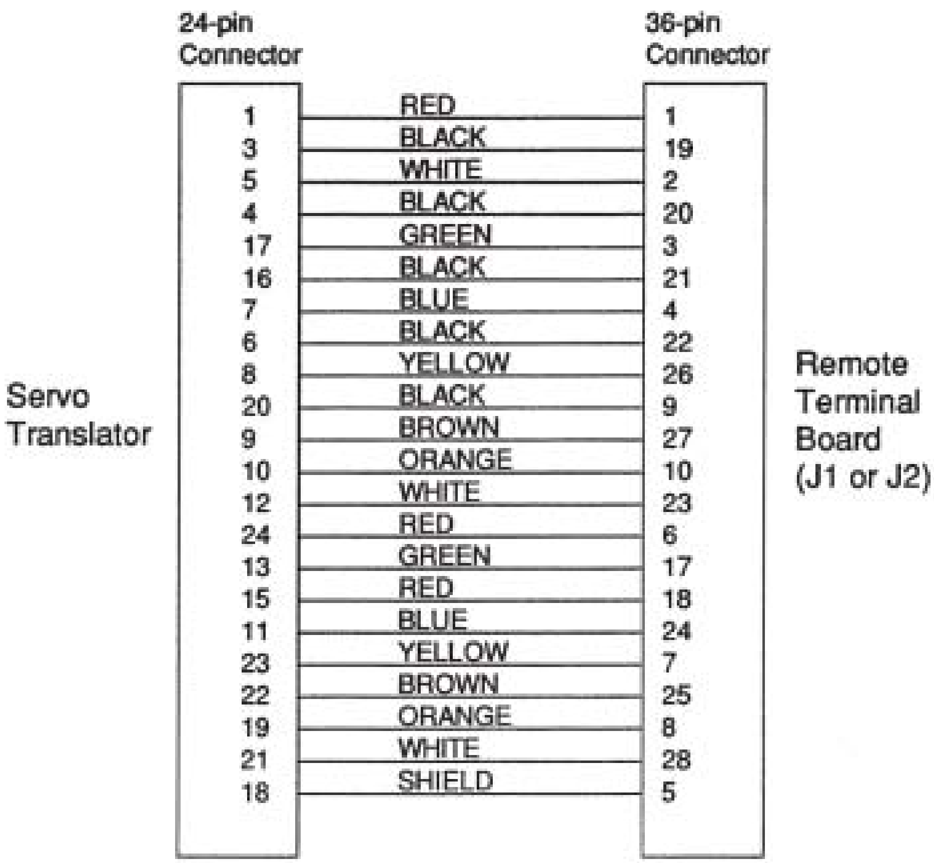


Figure 29-12. Cable Configuration (473.50c-31A-200)

473.50c-33A-001

The 473.50c-33A-001 Cable connects the Model 473.24c Encoder Interface card to the Model 473.38c Remote Terminal Board (RTB). One end is terminated with a 24-pin connector (Amphenol part number 57-30240, Custom Servo Motors part number 100440-04) which connects to the Encoder Interface. The other end is terminated with a 36-pin "D" male connector (AMP part number 552274-1, Custom Servo Motors part number 114732-01) which connects to the Remote Terminal Board. Figure 29-13 shows the cable configuration.

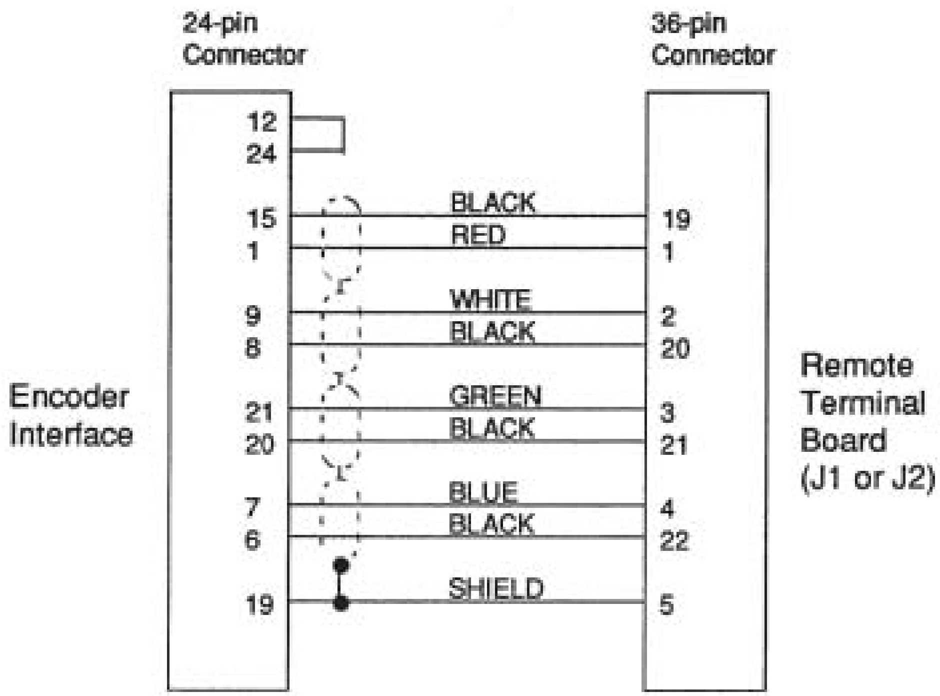


Figure 29-11. Cable Configuration (473.50c-33A-001)

473.50c-35A-200

The 473.50c-35A-200 Cable is designed to connect the Model 473.21c Temposonics Servo Translator to the Model 473.38c Remote Terminal Board. One end is terminated with a 24-pin connector (AMP part number 552272-1, Custom Servo Motors part number 114732-02)which connects to the Temposonics Servo Translator. The other end is terminated with a 36-pin "D" male connector (AMP part number 552274-1, Custom Servo Motors part number 114732-01) which connects to the RTB. Figure 29-12 shows the cable configuration.

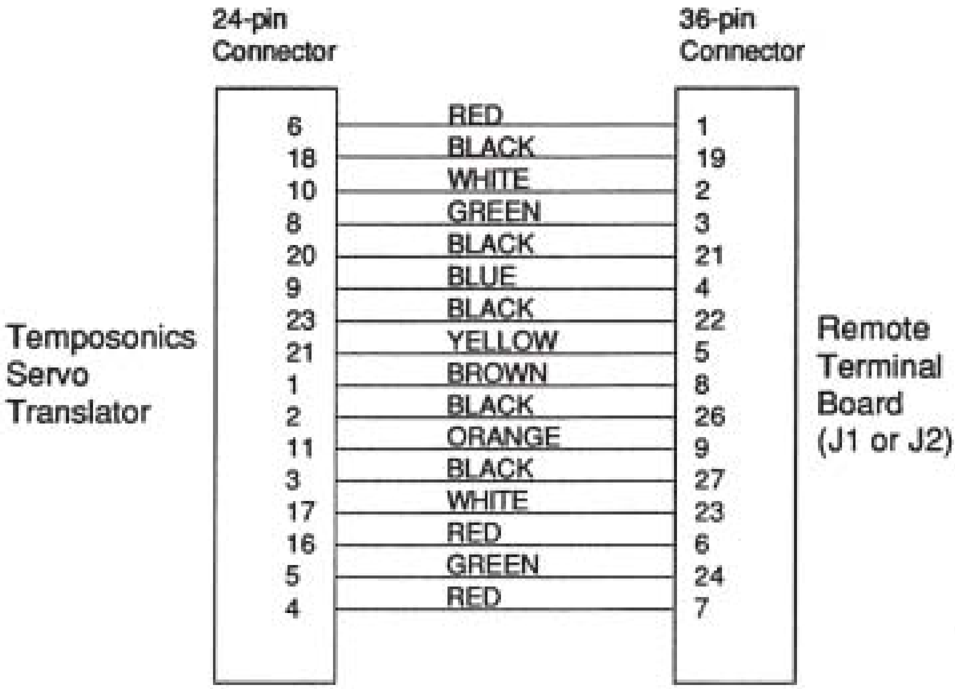


Figure 29-12. Cable Configuration (473.50c-35A-200)

473.50c-36A-300

The 473.50c-36A-300 Cable is designed to connect the Model 473.70c-01A-000 Analog I/O Processor through a 5-ft ribbon cable (consisting of 20 twisted pairs) to a Phoenix 40-connection terminal board. The cable is terminated at each end with a 40-pin connector (3M part number 3417-6640, Custom Servo Motors part number 118655-88). Figure 29-13 shows the cable configuration.

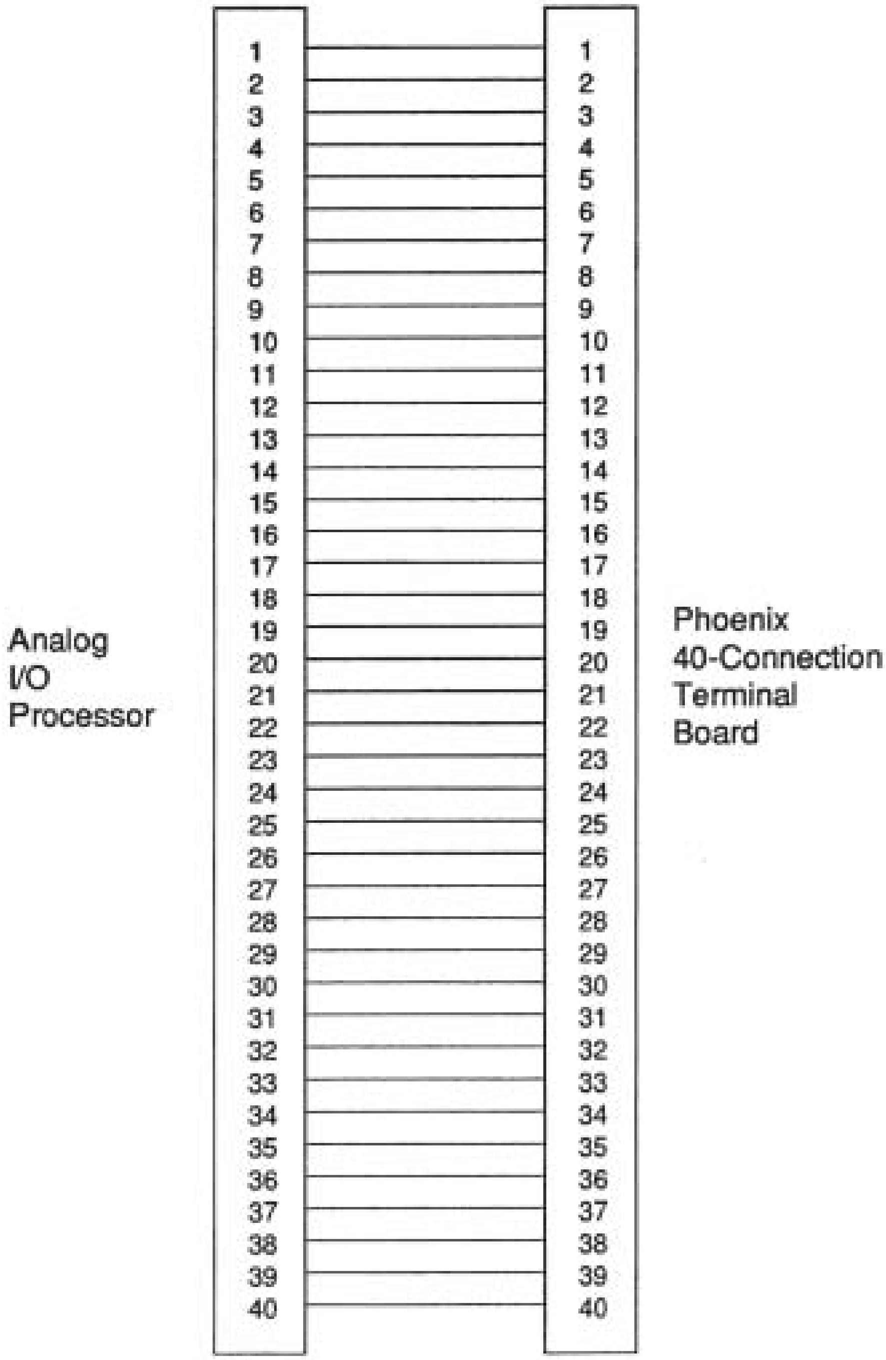


Figure 29-13. Cable Configuration (473.50c-36A-300)

A Tuning the Servo System

Introduction

This appendix contains general procedures for calibrating and tuning most servo systems using Motion Plus controllers. The following topics are included:

A.1 Quick Start Procedure provides a shortcut for experienced users.

A.2. Loop Description describes typical Motion Plus servo loops and characterizes velocity loops and position loops.

A.3. System Specification establishes the system parameters required for position loop calibration.

A.4. Position Loop Calibration provides a calibration procedure for the position loop.

A.5. Position Loop Tuning provides a tuning procedure for use in cases of loop instability.

A.6. Miscellaneous Adjustments describes the use of velocity feedforward and the integrator time constant.

A.1 Quick Start Procedure

For experienced users, who are familiar with servo systems, can use the following quick start procedure. A more detailed guide is provided in the remainder of this appendix (sections A.2 to A.6).

Specify the System Parameters:

1. Maximum velocity V = ________units/second
2. Maximum command C = ________volts
3. Maximum change in velocity ω = ________radians/second
4. Total system inertia J = ________pound-inch-second^2
5. Acceleration torque T = ________inch-pounds
6. Required resolution R = ________units
7. Maximum acceleration A = ________radians/second^2

Calculate the Loop Factors:

8. Velocity loop gain $K_V = V/C$ = __________(units/second)volt

9. Velocity loop time constant
   $T_C = (\omega \times J)/T$ = __________seconds

10. Position scale, $S \geq 2/R$ = __________counts/unit

11. Position loop gain
    $K_L = (K_V \times K_P \times S)/204.8$ = __________seconds^{-1}

12. Position loop time constant
    $TC_L = 204.8/(K_V \times K_P \times S)$ = __________seconds

13. Application time constant
    $TC_A = \omega/A$ = __________seconds

14. Minimum proportional gain
    $K_{pmin} = 204.8 / (TC_A \times K_V \times S)$ = __________

15. Maximum proportional gain K_{pmax} =
    $68.3 / (TC_V \times K_V \times S)$ = __________

16. Adjust ω, J,T, K_P, K_V, and S as required until $TC_L \geq 3 \times TC_V$.

Calibrate the Position Loop

17. Set up and tune the velocity loop according to the instructions provided by the servo amplifier manufacturer. (This step sets K_V.)

18. Set the
    SCALE S = __________counts/unit

19. Set the
    IN POSN = __________units

20. Set the
    EXCESS ERROR = $1.2 \times V / K_L$ = __________units

21. Set the
    proportional gain (Kp) = __________

Tune the Position Loop . Use this procedure if $TC_L < 3 \times TCv$, or if the position loop demonstrates instability.

22. Connect an oscilloscope to the tachometer or a test point on the servo amplifier that provides a velocity signal. Display velocity versus time.

23.. Program the system to provide a repeated step command and run this program.

24. Increase the proportional gain (K_P) until the response becomes underdamped.

25. Increase the double rate (K_{dd}) until the instability decays as quickly as possible.

26. Adjust the rate (K_d), until the overshoot is reduced to a minimum.

A.2 Loop Description

Definition

A *servo system* is a feedback system in which the output or some function of the output is fed back for comparison with the input. The difference between these quantities (the error) is used to control a source of power.

In Motion Plus applications, a servo system is used most often to control the position of a machine member and is referred to, therefore, as a *position loop*. A simplified position loop is illustrated in Figure A-1. The actual position is compared with the commanded position, and the difference (the position error) is used to control the machine.

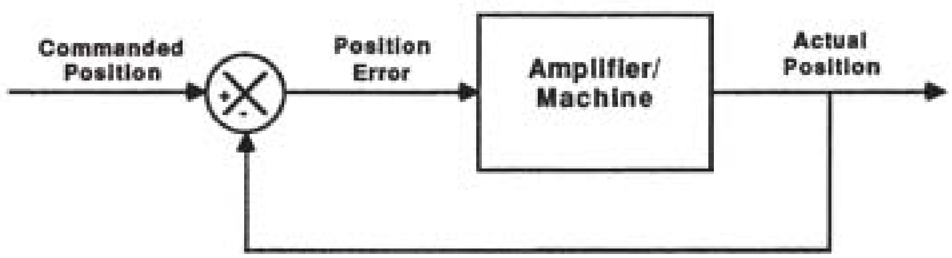


Figure A-1. Position Loop

The element that performs this comparison and generates the position error is the position controller. The position controller used here is a Motion Plus system. It will be referred to as the Controller.

The position error signal generated by the Controller is amplified to drive the servo actuator which propels the machine member. Servo actuators may be either electric or hydraulic, rotary or linear.

A position feedback transducer provides feedback of the actual position of the machine member to the Controller. Encoders, resolvers, and Temposonics transducers are used in Motion Plus systems as position feedback transducers.
Figure A-2 illustrates the interconnections of a typical position loop.

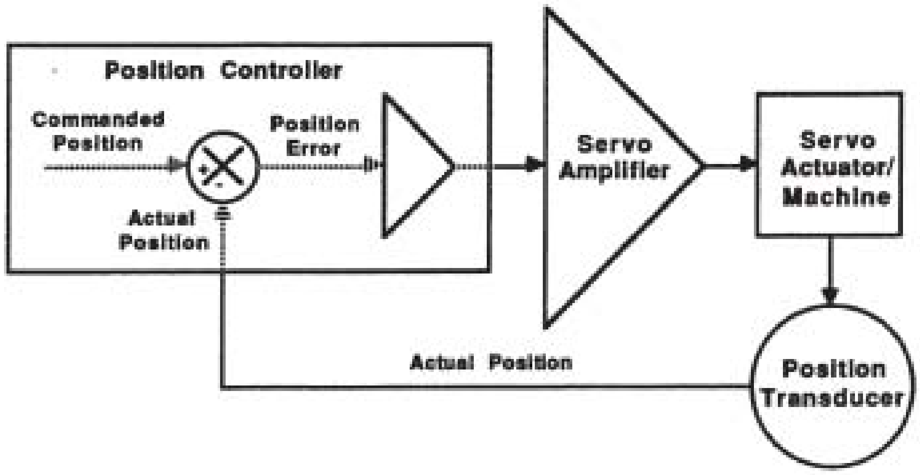


Figure A-2. Typical Position Loop

Calibration (as in section A.3) is always required to integrate the various elements properly in the position loop. In addition, tuning (as in section A.4) may be necessary to compensate for instability in the position loop.

In Motion Plus servo applications, the position loop is the major servo loop. This loop is controlled by a Motion Plus servo module: Encoder Servo Translator, Resolver Servo Translator, or Temposonics Servo Translator.

Electric Servo Loops

The diagrams on the following pages illustrate position loops with electric servo components, or electric servo loops. The elements of a position loop are:

- the Controller
- the servo amplifier and servo motor
- the drive train and connected load
- the position feedback transducer

The electric servo loop can be configured with the load outside the loop or inside the loop.

Load Outside. In the system illustrated in Figure A-3, the transducer is coupled directly to the servo motor. This tight coupling between motor and transducer translates into the highest dynamic performance capability of the position loop. Although the load inertia and load torque affect the performance of the position loop, the load is said to be dynamically "outside" the position loop.

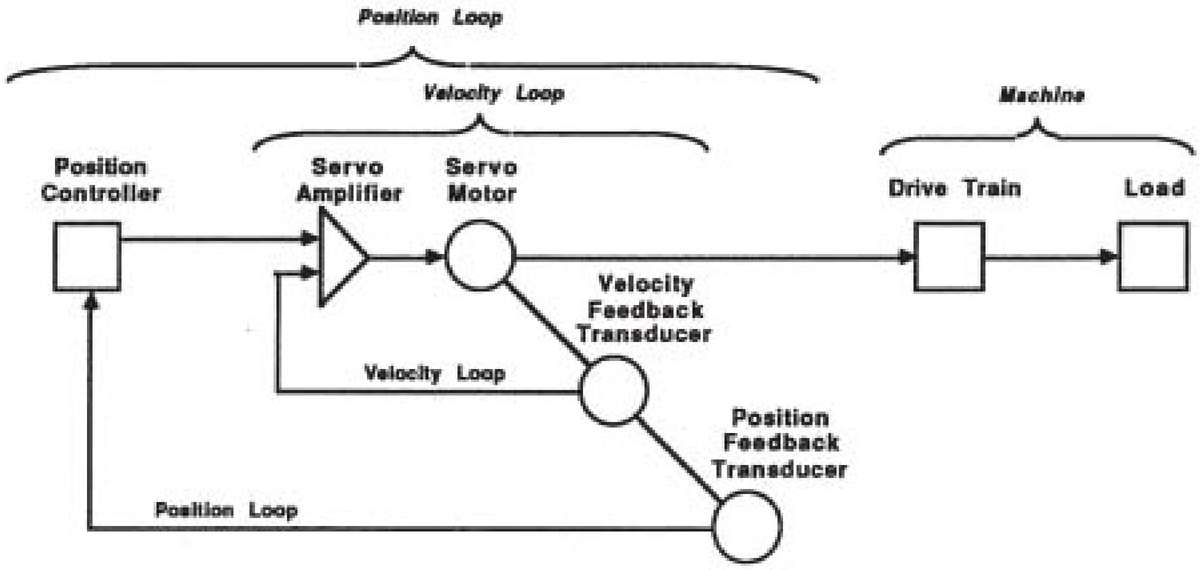


Figure A-3. Load Outside

Load Inside. In the system of Figure A-4, the transducer is coupled directly to the load. This provides the most accurate feedback of the load position. The disadvantage of this system is that the transducer is no longer tightly coupled to the motor, so that the position loop, in its dynamic response, must account for all of the compliance and lost motion of the drive train. In this case the load is said to be dynamically "inside" the position loop.

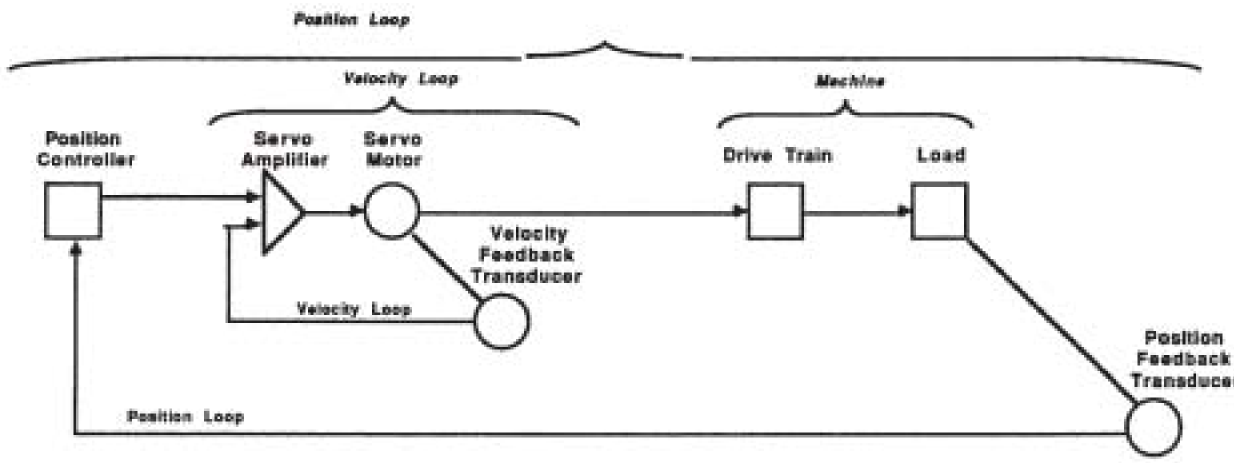


Figure A-4. Load Inside

The servo amplifier and servo motor are usually packaged with a velocity transducer in a velocity loop. The velocity loop is itself a servo loop that regulates motor speed. The servo amplifier acts as the velocity controller in the velocity loop. It compares the velocity command from the Controller with the actual velocity reported by the velocity transducer and applies a velocity correction to the servo motor if required. Whatever the drive train arrangement, the velocity loop is "inside" the position loop (and under its control) in all cases.

The typical electric servo loop will be configured as a position loop with an inner velocity loop. The position loop controls the positioning of the machine member by issuing real time velocity commands to the velocity loop. To better understand this interaction, it is helpful to begin with a discussion of the velocity loop.

Velocity Loop

A typical velocity loop with connected load is illustrated below in Figure A-5.

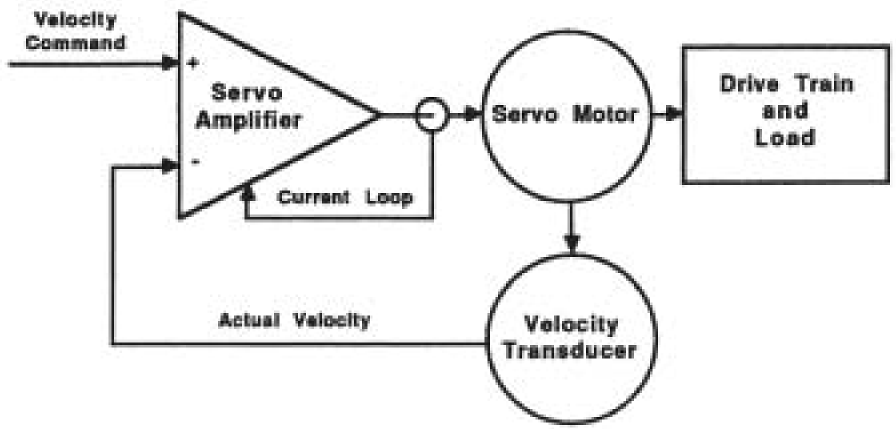


Figure A-5. Velocity Loop

The major components of the velocity loop are the servo amplifier, the servo motor, and the velocity transducer. Although the drive train and load are "outside" the velocity loop, their characteristics translate into speed and torque performance required of the servo motor, which is a component of the velocity loop.

Servo Amplifier and Current Loop. The servo amplifier compares the velocity command with the actual velocity and produces the current and voltage necessary to drive the servo motor at the commanded velocity.

The servo amplifier is equipped with a preamplifier that amplifies the difference between the velocity command and the actual velocity, and generates a velocity error. The velocity error becomes the input to an inner current loop which monitors and controls the current delivered to the servo motor. The frequency response, or bandwidth, of the current loop is typically five to ten times greater than that of the velocity loop, so the current loop responds to torque perturbations at the load by adjusting the current delivered to the motor before the velocity loop detects a change in actual velocity.

The preamplifier also provides adjustments for signal gain, velocity transducer gain, current limit, and lead/lag, to calibrate and stabilize the velocity loop with its connected drive train and load. The servo amplifier instructions include a procedure for calibrating and tuning the velocity loop, and this procedure is also the first step in calibrating and tuning the position loop. The tuning procedure optimizes the dynamic performance of the velocity loop and usually makes additional dynamic tuning in the position loop unnecessary.

Servo Motor. The servo motor transforms the current delivered by the servo amplifier into torque and speed at its output shaft. The motor torque accelerates and decelerates the system inertia, satisfies torque requirements of the load, and overcomes various torque losses in the system. The motor acceleration, velocity, and deceleration, track the velocity command issued by the Controller and drive the motor and connected load to the commanded position.

Velocity Transducer. The velocity transducer is coupled to the servo motor, and it provides a signal which is proportional to the actual velocity of the servo motor. This signal is fed back to the preamplifier where it is compared with the velocity command signal from the Controller. The velocity transducer supplies the signal that closes, or completes, the velocity loop.

Velocity Loop Performance. The purpose of the velocity loop is to transform accurately the velocity command signal into actual velocity at the servo motor shaft. Velocity loop components currently available (PWM servo amplifiers with responsive inner current loops; servo motors with high torque-to-inertia ratios; velocity transducers with 0.1% or better accuracy) make high performance velocity loops practical realities. In fact, the velocity loop can be thought of as a simple functional block with velocity command as the input and actual velocity as the output as shown in Figure A-6.

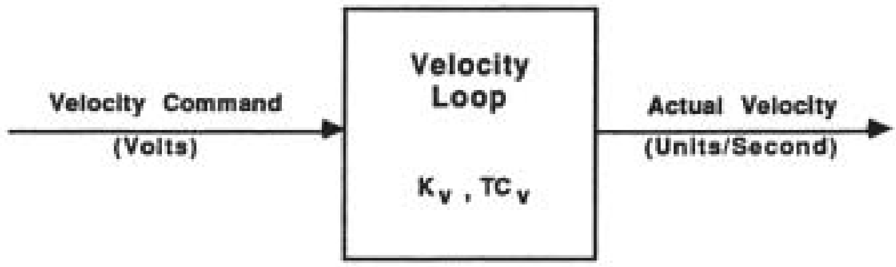


Figure A-6. Velocity Loop Simplified

Velocity Loop Gain (K_V)

$$K_V = \frac{V}{C} \text{ ((units/second)/volt)}$$

where	K_V	is the velocity loop gain in (units/second)/volt
	V	is the maximum velocity in units/second
	C	is the maximum command in volts

The velocity loop proportionality constant, K_V, relates the actual velocity to the velocity command. In response to the velocity command (in volts) the velocity loop produces actual velocity (in units/second). For example, if the velocity loop produces an actual velocity of 25 revs/second in response to a velocity command of 10 volts, then $K_V = 2.5$ ((revs/second)/volt). The actual value of K_V is established by adjusting the velocity scale on the servo amplifier.

Velocity Loop Time Constant (TC_V)

The velocity loop time constant, TC_V, is a second factor that characterizes the performance capability of the velocity loop. This time constant can be simply understood as the minimum time required for the velocity loop to accelerate the connected load over a specified change in velocity. TC_V is a function of the net change in velocity, the total system inertia, and the torque available for acceleration, as expressed in the relationship below:

$$TC_V = \frac{\omega \times J}{T} \text{ (seconds)}$$

where TC_V is the velocity loop time constant in seconds
ω is the maximum change in velocity in radians/second
J is the total system inertia in pound-inch-second^2
T is the torque available for acceleration in inch-pounds

It is important to note that J is the total system inertia, and that the motor inertia must be included in this total. T is the torque available for acceleration and does not include torque required to overcome any load or loss in the system. It is usually safe to assume that peak torque from the servo amplifier/motor combination is available during this period.

Example 1. If 60 inch-pounds of torque is available to accelerate a system inertia of 0.01 pound-inch-second^2 from rest to 25 revs/second, then:

$$TC_V = \frac{2\pi \times 25 \times 0.01}{60} = 0.0262 \text{ seconds}$$

In this example the minimum time required for the servo amplifier/motor combination to accelerate the connected load to 25 revs/second is 0.0262 seconds. This translates into a maximum acceleration rate capability of 25 / 0.0262 = 954 revs/second^2.

Position Loop

A position loop is shown in Figure A-7. The components of the position loop are the Controller, the velocity loop, and the drive train and load. The location of the position transducer determines how the drive train and load impact the dynamic response of the position loop. If the position transducer is tightly coupled to the servo motor, the impact is minimal. However, if the position transducer is coupled to the load, the compliance and lost motion in the drive train have a great impact on the dynamic performance of the position loop.

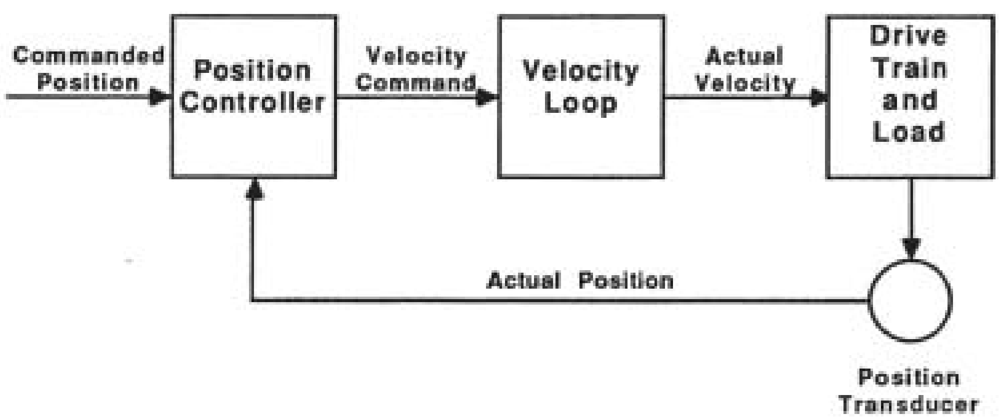


Figure A-7. Position Loop

The action of the position loop is monitored and controlled by the Controller. The Controller compares the commanded position with the actual position (from the position transducer) and generates the position error, which is the difference between these two inputs. The position error is amplified by K_p and applied to a digital-to-analog converter that provides the analog velocity command for the velocity loop. A functional diagram of the Controller is given below.

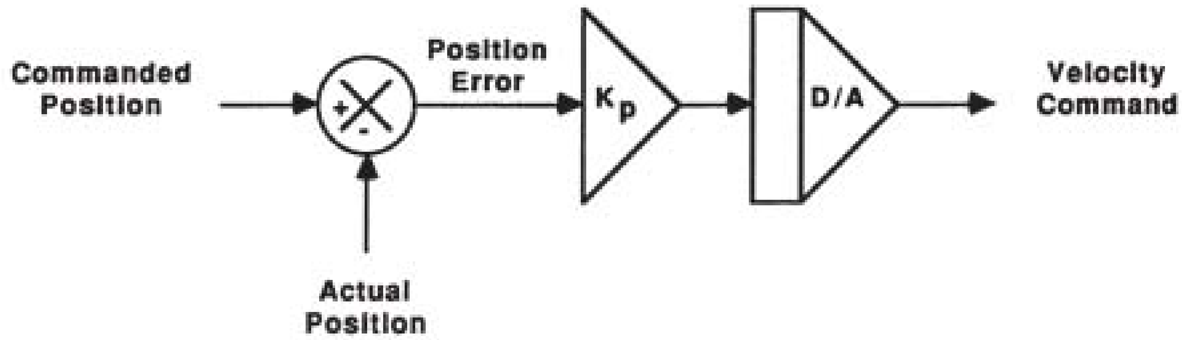


Figure A-8. Position Controller Functional Diagram

The proportional gain factor, denoted K_p, is the fundamental position loop gain parameter, and its value is set in the Controller. The value of K_p determines how the position loop responds to position error, both the sensitivity of the response and the rate of response.

Position Controller Gain (K_c). The Controller gain, K_c, is a function of the proportional gain, the digital-to-analog (D/A) converter gain, and the position scale, and is given by the following relationships:

$$K_c = \frac{C}{E} = \frac{S \times K_p \times 10}{2048} \text{ (volts/unit)}$$

where
K_c is the Controller gain in volts/unit
C is the velocity command in volts
E is the position error in units
S is the position scale in counts/unit
K_p is the proportional gain

The digital-to-analog converter in the Controller produces a velocity command of 10 volts with an input of 2048 counts.

Position Loop Gain (K_L). The position loop gain, K_L, is the product of the Controller gain, K_c, and the velocity loop gain, K_v. (In the machine tool industry, this factor is also called "NC gain," with units of inches per minute per mil.)

$$K_L = K_c \times K_v \text{ ((units/second)/unit)}$$

where
K_L is the position loop gain in (units/second)/unit
K_c is the Controller gain in volts/unit
K_v is the velocity loop gain in (units/second)/volt

The position loop bandwidth in radians/second is equivalent to the position loop gain, K_L.

Position Loop Time Constant (TC_L). The position loop time constant, TC_L, is the reciprocal of the position loop gain, K_L.

$$TC_L = \frac{1}{K_L} \text{ (seconds)}$$

The position loop time constant, TC_L, can be simply understood as the minimum time required for the position loop to drive the velocity command over a specified change in velocity. TC_L is also a function of the proportional gain, K_p, the velocity loop gain, K_v, the position scale, S, and the digital-to-analog converter gain, as expressed in the relationship below:

$$TC_L = \frac{204.8}{K_p \times K_v \times S} \text{ (seconds)}$$

where

	TC_L	is the position loop time constant in seconds
	K_p	is the proportional gain
	K_v	is the velocity loop gain in (units/second)/volt
	S	is the position scale in counts/unit

Position Loop Stability. In most cases, it will be possible to choose K_p, K_v, and S so that the position loop time constant is at least three times the velocity loop time constant:

$$TC_L \geq 3 \times TC_v$$

In those cases, the position loop is stabilized by the adjustments made on the servo amplifier during its setup procedure. No additional dynamic tuning adjustments are needed at the Controller.

Example 2. If 60 inch-pounds of torque is available to accelerate a system inertia of 0.01 pound-inch-second^2 from rest to 25 revs/second, then

$$TC_v = (2\pi \times 25 \times 0.01) / 60$$

$$= 0.0262 \text{ seconds}$$

$$K_v = \frac{25}{10} = 2.5 \text{ (revs/second)/volt.}$$

If we assume a scale of 1000 and $K_p = 1$, then

$$TC_L = \frac{204.8}{1 \times 2.5 \times 1000}$$

$$= 0.0819 \text{ seconds}$$

The position loop time constant is more than three times the velocity loop time constant:

$TC_L = 3.13 \times TC_V$

This means that in this example, the position loop will be stable, and no tuning adjustments for stability will be needed at the Controller.

A.3 System Specification

The following system parameters must be specified before you can calibrate the position loop:

- Maximum velocity, V (units/second)
- Maximum command, C (volts)
- Maximum change in velocity, ω (radians/second)
- Total system inertia, J (pound-inch-second squared)
- Torque available for acceleration, T (inch-pounds)
- Required Resolution, R (units)
- Maximum acceleration, A (radians/second^2)

(Note: "unit" refers to any convenient distance units - inches, revolutions, centimeters, etc.)

Once these parameters have been specified, the following position loop factors may be calculated:

- Velocity loop gain, K_V ((units/second)/volt)
- Velocity loop time constant, TC_V (seconds)
- Position scale, S (counts/unit)
- Position loop gain, K_L ((units/second)/unit) or (second^{-1})
- Position loop time constant, TC_L (seconds)
- Application time constant, TC_A (seconds)
- Proportional gain limits, K_{pmin} and K_{pmax}

Velocity Loop Gain (K_V)

$$K_V = \frac{V}{C} \frac{\text{(units/second)}}{\text{volt}}$$

where
- K_V is the velocity loop gain in (units/second)/volt
- V is the maximum velocity in units/second
- C is the maximum command in volts

Velocity Loop Time Constant (TC_V)

$$TC_V = \frac{\omega \times J}{T} \text{ (seconds)}$$

where
- TC_V is the velocity loop time constant in seconds
- ω is the maximum change in velocity in radians/second

J	is the total system inertia in pound-inch-second^2
T	is the torque available for acceleration in inch-pounds

Position Scale (S)

$$S \geq \frac{2}{R} \text{ (counts/unit)}$$

where

S	is the position scale in counts/unit
R	is the required resolution in units

Position Loop Gain (K_L)

$$K_L = \frac{K_p \times K_v \times S}{204.8} \qquad \text{((unit/sec)/unit)}$$

where

K_L	is the position loop gain in (units/second)/unit
K_p	is the proportional gain
K_v	is the velocity loop gain in (units/second)/volt
S	is the position scale in counts/unit

Position Loop Time Constant (TC_L)

$$TC_L = \frac{204.8}{K_p \times K_v \times S} \text{ (seconds)}$$

where

TC_L	is the position loop time constant in seconds;
K_p	is the proportional gain
K_v	is the velocity loop gain in (units/second)/volt
S	is the position scale in counts/unit

Application Time Constant(TC_A)

$$TC_A = \frac{\omega}{A}$$

where

ω	is the maximum change in velocity inradians/second
A	is the maximum acceleration in radians/second^2

Proportional Gain Limits (K_{pmin}, K_{pmax})

$$K_{pmin} = \frac{204.8}{TC_A \times K_v \times S}$$

$$K_{pmax} = \frac{68.3}{TC_v \times K_v \times S}$$

where K_{pmin} is the minimum value for K_p
K_{pmax} is the maximum value for K_p
TC_V is the velocity loop time constant in seconds
TC_A is the application time constant in seconds
K_V is the velocity loop gain in (units/second)volt
S is the position scale in counts/unit

Once the system parameters are gathered and the position loop factors calculated, the next step is to begin the calibration procedure.

A.4 Position Loop Calibration

Position loop calibration consists of two separate, but related, procedures - making adjustments at the servo amplifier, followed by setting parameters in the Controller. The procedures outlined in this section are sufficient to calibrate and tune systems where the position loop time constant, TC_L, is at least three times the velocity loop time constant, TC_V.

Servo Amplifier Adjustments

A setup and tuning procedure is included with the documentation supplied with the servo amplifier. The first step in position loop calibration is to follow the suggested procedure for making adjustments at the servo amplifier. These adjustments should be made with the load connected to the servo motor so that load dynamics are compensated for in the velocity loop. Adjustments made at the servo amplifier usually include the following parameters:

- command scale
- feedback scale
- current limit
- offset
- lead/lag or time constant

Command scale. This adjustment relates actual motor speed (unit/sec) to the velocity command (volts), and should be set so that maximum speed required in the application corresponds to maximum velocity command issued by the Controller. (The maximum velocity command chosen should be at least 0.5 volts less than the Controller specification for maximum velocity command.) This adjustment sets the value for K_V, the velocity loop gain parameter.

Feedback scale. This adjustment establishes the relationship between motor speed and the magnitude of the velocity feedback signal, and must be set so that the motor can reach maximum speed at the maximum velocity command. this adjustment does affect the gain and dynamic response of the velocity loop.

Current limit. This adjustment sets the maximum value for peak current in the servo amplifier. Peak current is called for when the motor is accelerating and decelerating, and this adjustment, therefore, limits the performance capability of the servo motor and directly effects the velocity loop time constant, TC_V. Since in Motion Plus applications acceleration and deceleration ramps are controlled by the Controller, this adjustment should be set to allow maximum peak current from the amplifier (or peak motor current if that is less than the peak amplifier current).

Offset. This adjustment should be set so that for a zero velocity command, there is no motion of the servo motor shaft. A good technique is to short the velocity command to the velocity common when making this adjustment.

Lead/lag or time constant. These adjustments set the dynamic response of the velocity loop, and it is important that the load be connected when making the adjustments. When the velocity loop has been stabilized with these adjustments, there is usually no need to make additional adjustments in the position loop for dynamic stability.

Controller Parameters

Once the servo amplifier adjustments have been made, the following parameters must be set in the Controller:

- Scale
- In Position
- Excess Error
- Proportional Gain (K_P)

Scale. This parameter sets the desired engineering units (inches, centimeters, revolutions, etc.) for motion in the application. Position scale can be calculated by multiplying the electronic resolution of the servo motor by the mechanical ratio of the drive train. The value set for position scale should be at least twice the required resolution (in parts/distance unit), but should not be larger than necessary since it affects the position loop time constant. Range or multiplier parameters can be set in the Controller to adjust the electronic resolution of the servo motor.

In Position. The In Position value is used by the Controller to determine when an actuator has reached its commanded position. The In Position value specifies a "window" around the commanded position. A feedback value satisfies a position instruction (such as WAIT TIL INPOS) when it falls within this window, and all commanded motion has ceased. The value for the In Position window should be set equal to the required resolution.

For example, if the In Position window is set to 0.005 inch, and the commanded position is 27 inches, then any value from 26.995 to 27.005 inches is in position. The In Position value is in the position units you have selected (for example, inches) and can be set to any value from 0 to 32767/scale.

The size of the In Position window depends upon the application. In general, it is good practice to use a small value which is also consistent with the accuracy and performance of the system configuration.

Excess error. This parameter sets an upper limit to the allowable position error, and an excess error status usually signals a catastrophic system failure. Excess error should be set to a value that is approximately 10% greater than the normal position error for the application. The normal position error at any time is simply the speed at that time divided by the position loop gain, K_L. the absolute maximum for position error in an application is the maximum velocity divided by K_L.

In applications where velocity feedforward is used to reduce position error, the value set for excess error would have to be reduced accordingly.

Proportional gain (K_p). This parameter relates directly to the overall performance of the position loop. High proportional gain translates into high position loop gain. In systems where the position loop time constant can be at least three times the velocity loop time constant, the upper bound of K_p (K_{pmax}) is the value that makes TC_L equal to three times TC_V.

The lower bound of Kp (Kpmin) is the value that makes TCl equal to the acceleration (or deceleration) period associated with the highest performance acceleration required in the application, which combines both the greatest acceleration rate with the greatest change in velocity.

Any value for proportional gain, Kp, that lies within these bounds is acceptable. Within the acceptable range, the major advantage of higher Kp is the corresponding lower position error.

A.5 Position Loop Tuning

In most Motion Plus applications the servo system can be designed so that tuning for the dynamic performance of the position loop is done entirely in the velocity loop by adjustments made during setup of the servo amplifier. In systems where the drive train and load are "inside" the position loop and have significant compliance or lost motion, or where the criteria discussed in section A.3 are not met, velocity loop tuning will not be sufficient for compensation of the position loop. In these cases it will be necessary to tune the position loop with appropriate adjustments at the Controller.

Parameters provided in Motion Plus Controllers for tuning the dynamic performance of the position loop are proportional gain (K_p), rate multiplier (K_d), and double rate (K_{dd}). The procedure for adjusting these parameters requires a step input command and the ability to observe the velocity feedback as a function of time. A common technique is to connect an oscilloscope to an analog tachometer coupled to the motor, or to a test point on the servo amplifier that provides an analog signal proportional to the actual velocity. The step input should be small enough to insure that the servo amplifier operates within its rated performance capability.

Take the following steps:

1. Set the proportional gain (K_p) to a low value so that the system response is overdamped (Figure A-9). A useful initial value for K_p is approximately 20 % of the theoretical minimum.

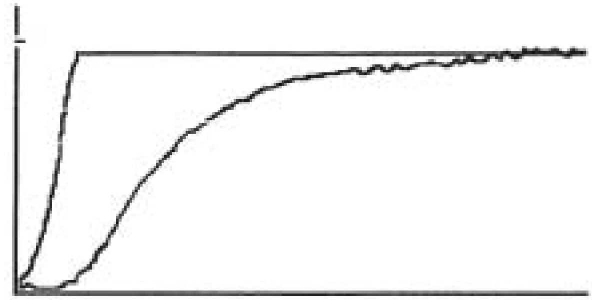


Figure A-9. K_p Set Low

2. Increase K_p until an under-damped overshoot response is observed (Figure A-10). The response is marked by successive overshoots and undershoots which gradually die out as the commanded velocity is reached. Increasing proportional gain decreases the stability margin, slightly increases the frequency of oscillation, and decreases response rise time.

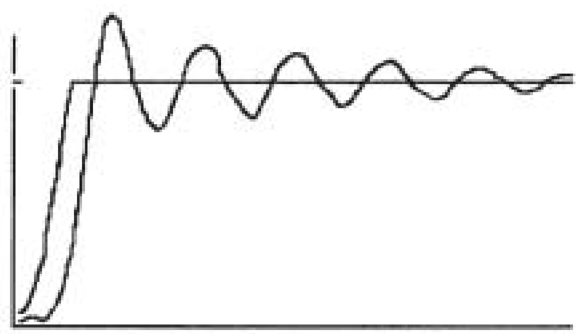


Figure A-10. K_p Set High

3. Adjust the double rate (K_{dd}) parameter to increase damping and decrease oscillatory frequency (Figure A-11). The introduction of double rate, which is the second derivative of the position feedback, increases the stability margin of the response, causes the overshoots and undershoots to die out quicker while the rise time is improved slightly.

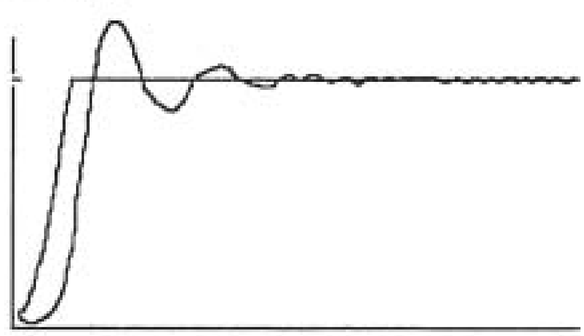


Figure A-11. Damping with K_{dd}

4. Adjust the rate multiplier (K_d), the first derivative of the position feedback, to decrease overshoot (Figure A-12). Increasing the rate multiplier causes a slight increase in rise time.

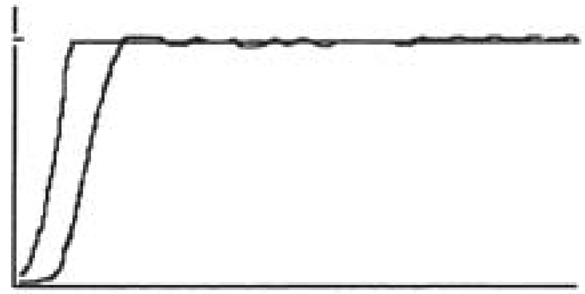


Figure A-12. Damping with K_d

A.6 Miscellaneous Adjustments

This section suggests procedures for adjusting the velocity feedforward (K_{ff}) and integrator multiplier (K_i) parameters on the Controller.

Feedforward (K_{ff})

The feedforward compensation, K_{ff}, is used to reduce position error while an axis is in motion. Typical Motion Plus position servo loops are characterized by position error that is proportional to motor velocity. As motor velocity increases, position error (the difference between commanded position and actual position) increases proportionally. In applications where this proportional position error is unacceptable, the following procedure can be used to reduce it to an acceptable level. This procedure requires that the position error be monitored and displayed while the motor is in motion.

1. Set the proportional gain (K_p) to a low value so that the system sensitivity to feedforward is increased. A value for K_p that is approximately 20 % of the minimum theoretical K_p would be a good initial setting.

2. Program the Controller to run at a typical application velocity . While the motor is running, monitor the position error.

3. Increase feedforward (K_{ff}) until the position error is reduced to an acceptable level. The maximum allowable value of K_{ff} will reduce position error to zero, and K_{ff} must not be increased to the point where the sign (+ or -) of the position error is reversed.

4. Restore K_p to its original value.

It is important that feedforward be used only for the purpose of reducing position error and not for dynamic tuning of the position loop. Feedforward has little or no effect on position loop dynamics.

Integrator Multiplier (K_i)

The integrator multiplier, K_i, is used to reduce to zero any residual position error after the command has expired. In applications characterized by high friction or heavy loads, the command signal may diminish as the load approaches its final destination to the point where it is not great enough, when multiplied by the gain of the servo amplifier, to drive the load into final position. A non-zero value for K_i causes the residual position error to be integrated over time until it is large enough to drive the load to its final position.

In Motion Plus controllers the integrator is not turned on until the command has expired, so it cannot be used for dynamic position loop compensation.

The value set for K_i actually determines the time constant of integration. K_i should be set so that the integration time constant is greater than the velocity loop time constant, TC_V.

B Grounding and Shielding

Introduction

This appendix on grounding and shielding is intended to help you understand the nature of interference problems, and to provide some basic guidelines for cabling and shielding to ensure greater system reliability. We recommend that you read it before connecting Custom Servo Motors motion control systems to external devices.

Interference is the name commonly given to any electrical disturbance that affects the reception of desired signals or produces undesirable responses in a circuit or system. It can be divided into two categories;

(1) Conducted Interference. This type of interference occurs when unwanted signals get into a circuit through a common conductor.

(2) *Radiated Interference.* This type of interference occurs when unwanted signals appear in a circuit due to the coupling of electromagnetic fields.

In many cases, a noise source can affect a circuit in both ways. For example, an arc welder can discharge large currents through a ground cable, which will affect other users of the same ground cable (conducted interference). The arc welder also acts as a broadcaster of electromagnetic waves which can then be coupled into a circuit, in the same way a transmission is received by an AM radio (radiated interference).

The following sections will explain the principles behind these two types of interference, and also provide some examples of noise problems with their associated solutions.

Conducted Interference

Many conducted interference problems can be avoided by realizing that *there is no such thing as a perfect conductor*. All cables, printed circuit traces, connectors, grounds, etc., have associated resistances, inductances, and capacitances. Most of the time these small impedances are neglected. While accounting for these small impedances in a circuit may complicate evaluation, they are essential to understanding why a circuit does not always work as it was intended to.

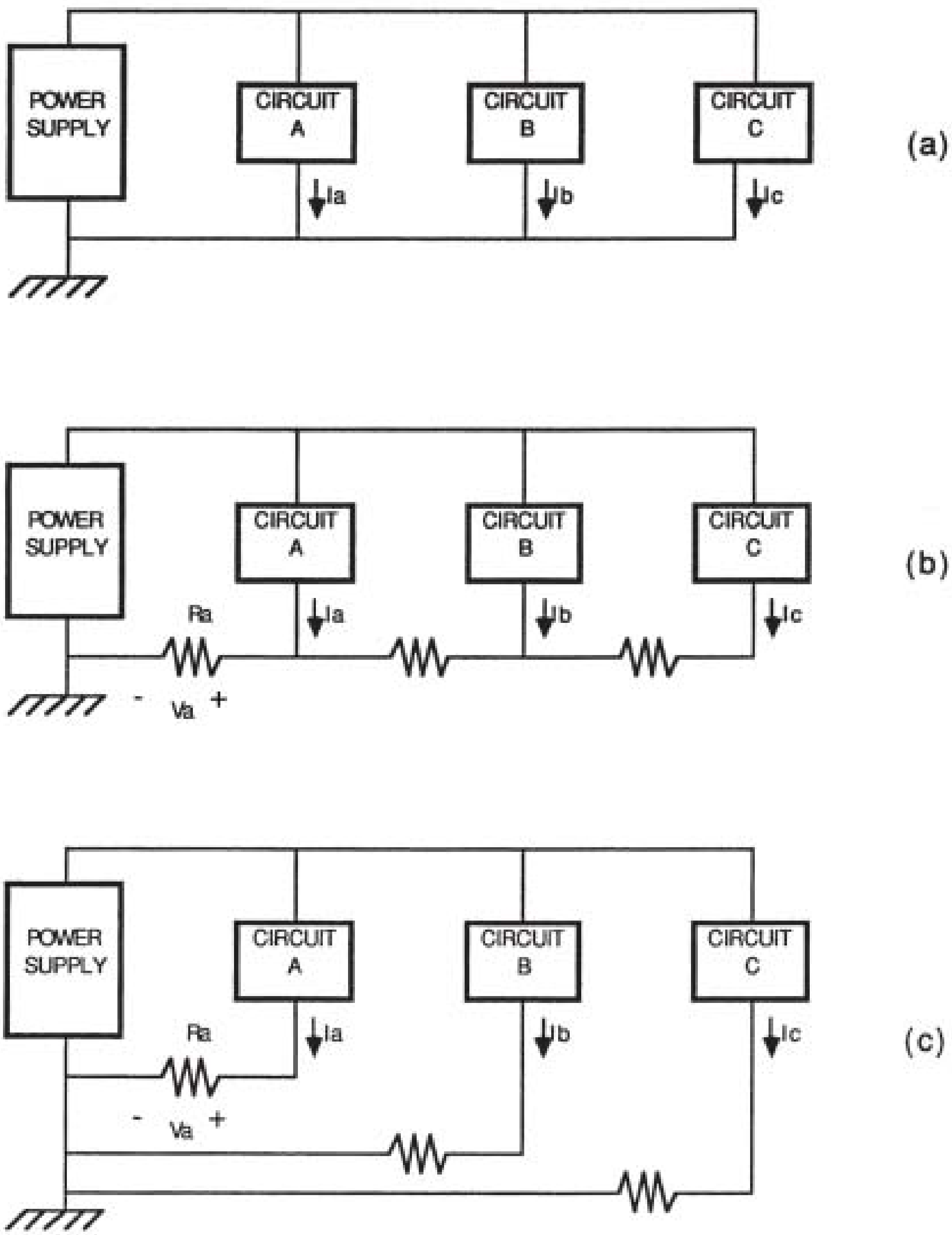


Figure B-1.

While Figure B-1(a) shows what we see on a schematic diagram, Figure B-1(b) shows the circuit as it really is. Here the impedance of the ground wiring has been included in the diagram for analysis. (To simplify the analysis, only resistance has been included, and only dc analysis will be done. The extension to ac is straightforward; the power supply could be a 5 volt TTL supply and circuits A, B, and C integrated circuits, or, the power supply could be the 120 volt ac input to a garage, with circuits A, B, and C appliances in the garage.) In Figure B-1(b) it can be seen that Ia, Ib, and Ic all go through resistance Ra. If

Ia = 10 milliamps
Ib = 800 milliamps
Ic = 300 milliamps
Ra = 15 milliohms

then the voltage produced across Ra would be

Va = (Ia + Ib + Ic)(Ra)
= (1.11)(0.015)
= 16.65 millivolts

In other words, the "ground" of circuit A has been raised 16.65 mV above the ground reference at the supply. This is more than 6 least significant bits of a 12-bit digital to analog converter operating on a 0-10 volt range. A solution to this problem is shown in Figure B-1(c). Here each circuit has its own return path to the supply reference. In this case, with only Ia flowing through Ra, the voltage drop is

Va = (Ia)(Ra)
= (0.01)(0.015)
= 0.15 millivolts

This example shows that circuits with large ground currents should have their own supply connections. This method of grounding is popularly referred to as a single point ground.

Often, currents flow in a circuit or system where we do not expect them (or want them). This is a good place to state an important point:

Mother Nature does not read schematics.

The circuit in Figure B-2 illustrates this problem.

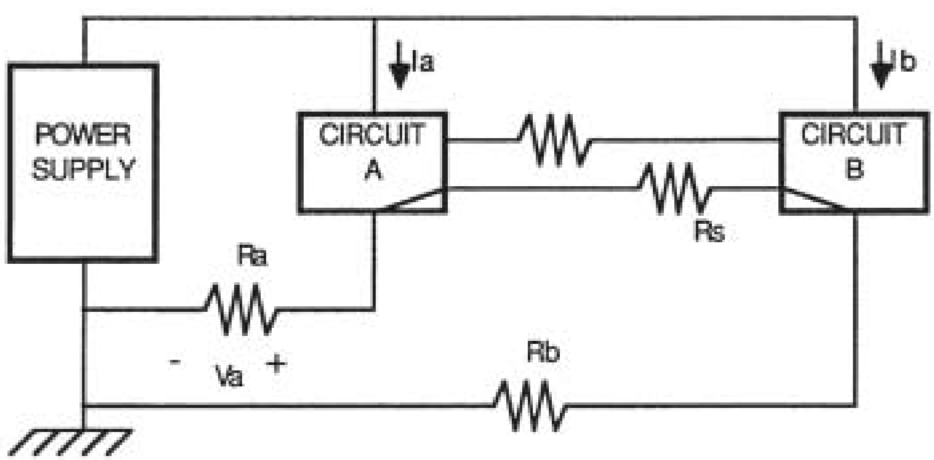


Figure B-2.

In this system, circuit A and circuit B have connections among themselves. (Note that the designer has correctly returned the grounds to a single point at the supply.) Since circuit B is driving an input of circuit A, they share a signal path and a return. (For example, circuit A may be a dc drive, circuit B may be a Custom Servo Motors servo controller, and the signal path and return may be a velocity output and return.) However, circuit B has 800 mA of return current that the designer thinks is going through Rb. If

Ra = 15 milliohms
Rs = 5 milliohms
Rb = 90 milliohms
Ia = 10 milliamps
Ib = 800 milliamps,

then only (Ra + Rs) / (Ra + Rs + Rb) = 18% of the 800 mA will be going through Rb, while Rb / (Ra + Rb + Rs) = 82% will be going through Ra and Rs. This will create a voltage drop across Ra of

Va = ((0.82)Ib + 0.86(Ia)(Ra)
Va = ((0.82)(0.8) + 0.0086)(0.015)
= 10 millivolts

One solution to this problem is to decrease the impedance in the supply return of circuit B. If circuit B is moved closer to the supply, and a heavier gauge wire used for the supply return path of circuit B, then the value of Rb can be reduced to 4 milliohms. In this case, only 17% of the 800 mA will flow through Ra and Rs. The new voltage drop is

Va = ((0.17)(Ib) + (0.38)(Ia))(Ra)
Va = ((0.17)(0.8) + 0.01)(0.015)
= 2 millivolts

This example has shown that currents often flow where they are not intended to. To simplify the explanation, only dc analysis was done, but the entire frequency range of the system must always be understood to get the complete picture. Remember that cables, connections, etc., are circuit elements and that you have control over their values. In general, we usually want to minimize all impedances that are not meant to be a part of the design (e.g. use a large diameter wire braid with good insulation). In many cases, cable manufacturers can suggest cables that have been designed to minimize a certain impedance.

Radiated Interference

This section will describe how magnetic and electric fields can induce unwanted signals on a circuit. A number of the field theory concepts have been simplified for presentation. A thorough knowledge of electromagnetic theory is not necessary for understanding, however it is highly recommended for those who have to deal quite often with "noise" problems.

Perhaps one of the most important things to keep in mind will be this:

All electrical energy is stored and transferred in electric and magnetic fields.

Wherever time-varying currents and voltages are involved, you can be certain that there is an associated electric and/or magnetic field. (From here on, electric fields will be known as E-fields, and magnetic fields will be known as H-fields.) A current traveling down a wire has an associated E-field and H-field, as does an electromagnetic wave propagating through the air.

There are two fundamental concepts that show how E-fields and H-fields are related to voltages and currents. Figure B-3 shows how a magnetic field induces a current on a wire loop. This loop may represent any closed loop in a circuit or system.

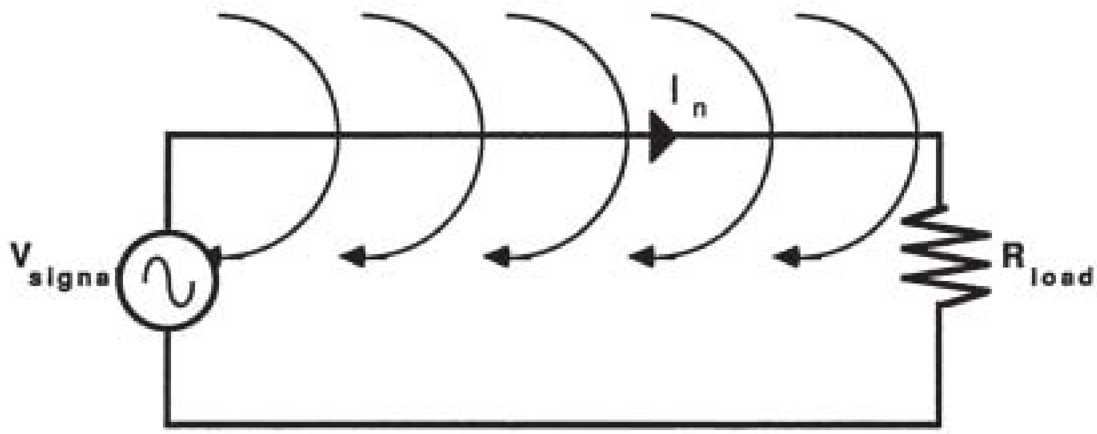


Figure B-3

The H-field is depicted in Figure B-3 using magnetic flux lines. The number of flux lines is proportional to the magnetic field strength. (A strong magnetic field corresponds to a high density of flux lines.) A current is induced to flow in the loop that is proportional to changes in the number of lines of flux that pass through the loop. Since magnetic fields are involved, this type of interference is often referred to as inductive coupling. The current induced is also proportional to the area of the loop. Now we can see two factors that affect the amount of current that will be induced in the loop:

(1) If the loop area is made smaller, fewer flux lines will be able to pass through the loop, and the resulting induced current will be smaller.

(2) If the magnetic field strength is reduced, fewer flux lines will pass through the loop, and again the induced current will be smaller. (Magnetic field strength decreases as you move away from the source.)

Now we will discuss the effects of an electric field. It is usually expressed as a potential difference per unit length, and is often written in units of volts/meter. Figure B-4 shows two voltmeters in the presence of an E-field, with the horizontal lines representing different potentials of the E-field. Voltmeter VM1 will measure V1 volts between its two probes, while VM2 will measure V2 volts. If a resistor, R, is inserted in place of VM2, a current will flow through R that is equal to V2/R.

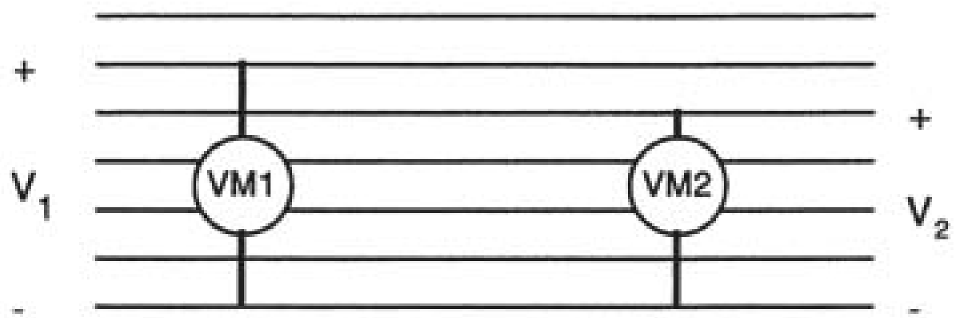


Figure B-4

If this resistor is thought of as being a cable, we can see how noise currents can flow in a circuit. This electric field interference is also referred to as capacitive coupling. Here again there are two factors which govern how much noise voltage will be induced in a circuit:

(1) If the circuit length is made shorter, the potential difference between the endpoints of the circuit will be lessened (the voltage will be decreased).

(2) If the electric field strength is reduced, again there will be less potential difference between the endpoints of the circuit. (The electric field decreases as you move away from the source.)

Before we see how these two phenomena come into play in an industrial environment we must go back to basics.

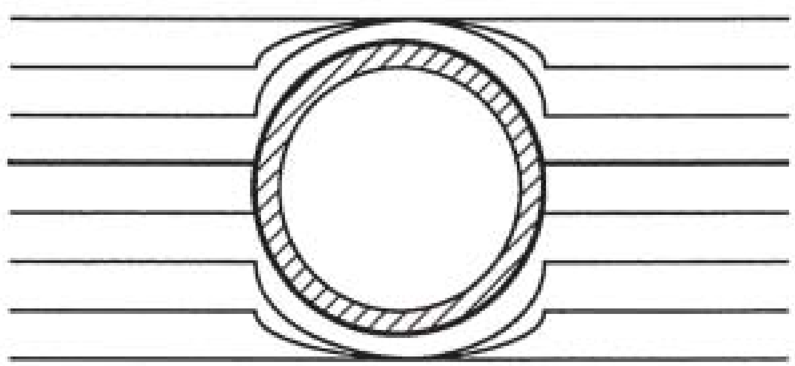


Figure B-5

Figure B-5 shows a hollow sphere made of a conductive material. An electromagnetic wave, upon reaching the outer surface, will not be able to pass through the conductor to the inside. Since the sphere is conductive, the electric field strength is constant at all points on the conductor. Therefore there cannot be any field strength inside the sphere from external sources. This is one of the important reasons for shielding enclosures and cabling. It should be noted that this is only true of electric fields, not magnetic fields—so shielding is only effective against capacitive coupling. Now that we have discussed some basic field theory, we can look at some problems and solutions.

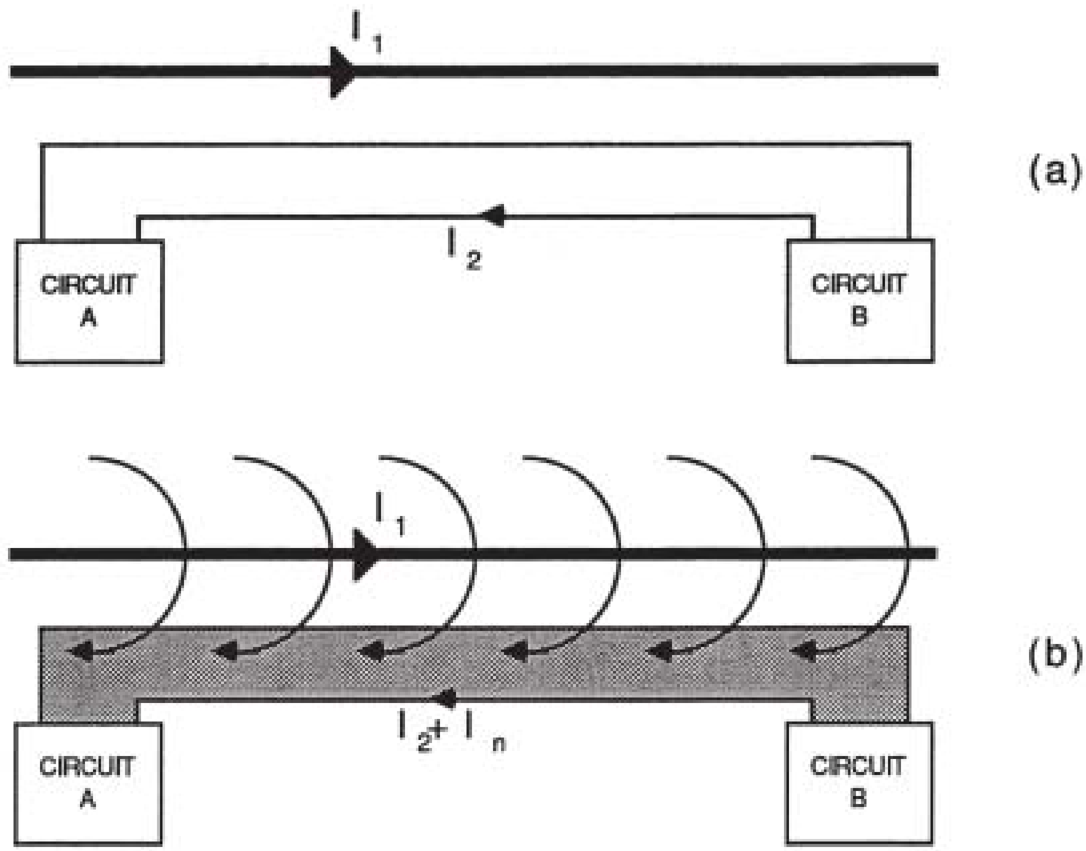


Figure B-6

Figure B-6 shows how a current-carrying wire can induce a current on another circuit or system. Figure B-6(a) shows the current I1 on the upper wire and current I2 on the 2 wire interface between circuit A and circuit B. Figure B-6(b) shows the magnetic field, produced by I1, passing through the shaded loop area of the "victim" circuits. I2 also produces a field that may affect the I1 circuit, but we shall assume that it is negligible. Circuits A and B may be low level analog, for example, and the wire containing I1 may be a power main. (Besides a magnetic field, I1 has an associated electric field, but for purposes of this discussion, we will assume the magnetic field is dominant.) The induced noise current, In, will be added to the normal current, I2. If the intensity of the field generated by I1 is high, and the shaded area is large enough, In may become large enough to cause some damage or a glitch in the data stream.

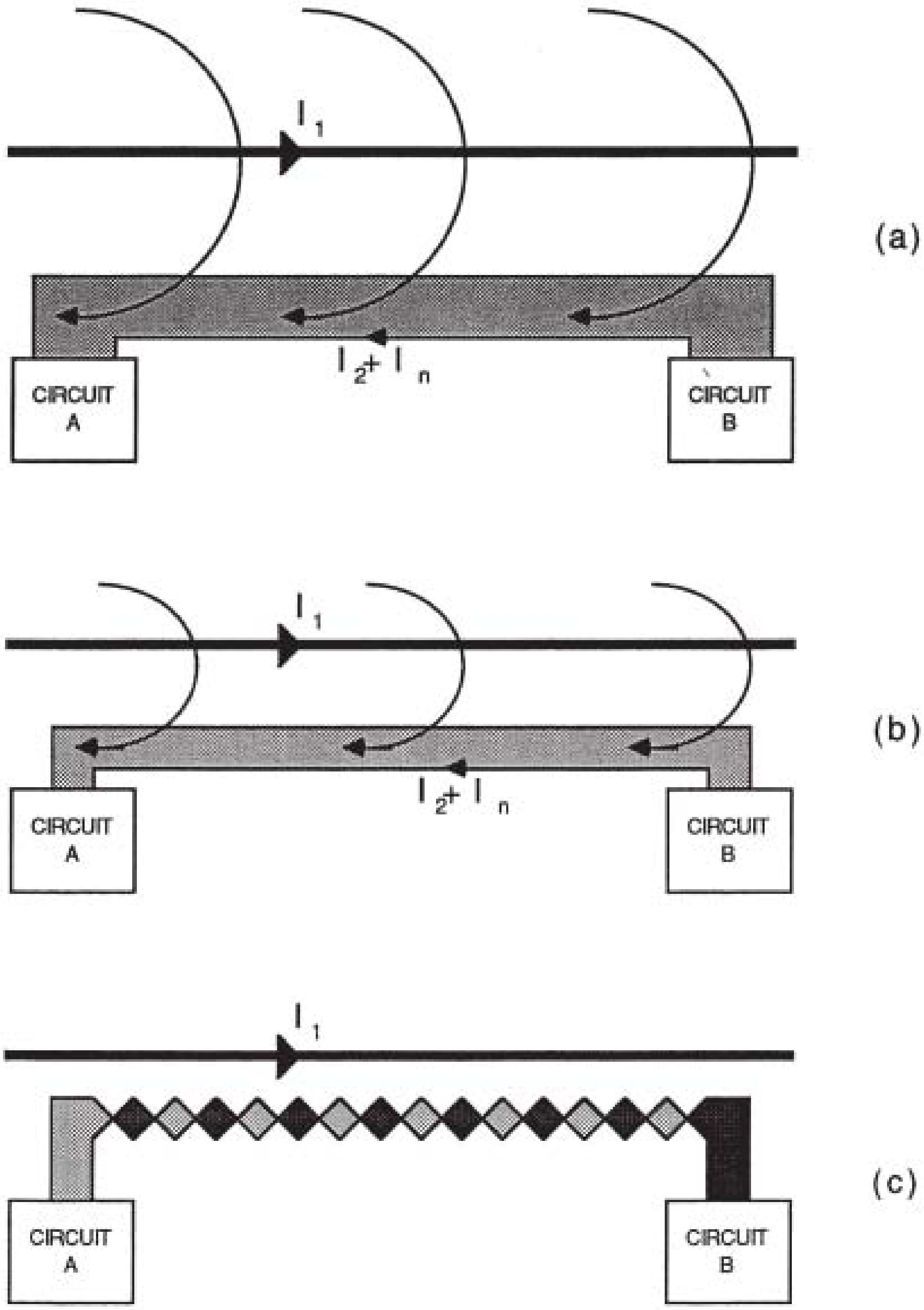
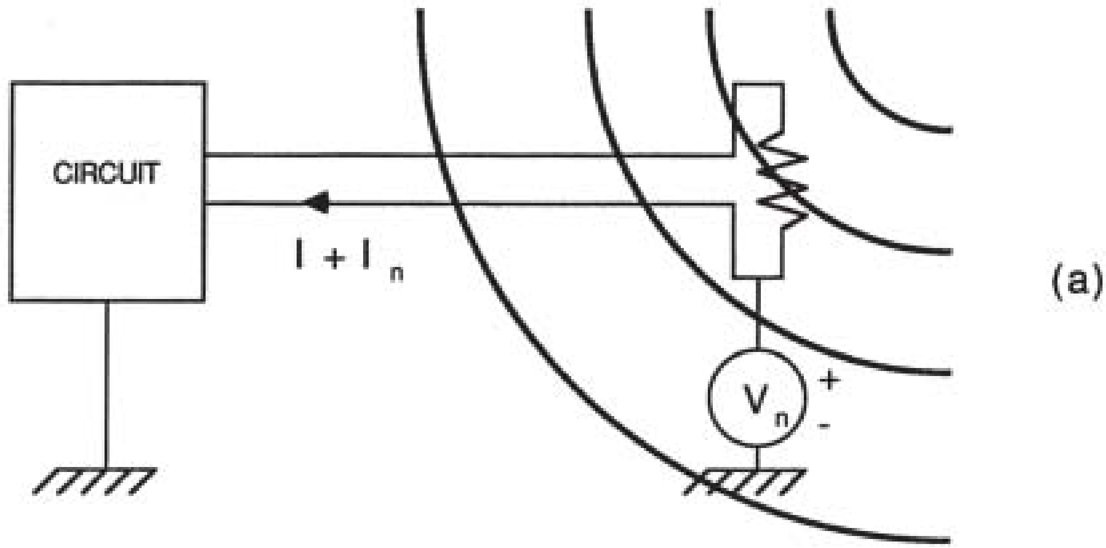


Figure B-7

Figures 7(a), (b), and (c) show three methods to reduce the induced noise current. In Figure B-7(a), the noisy wire has been moved away from the victim circuit, which means fewer flux lines through the loop area (since field strength decreases with distance). Figure B-

7(b) shows that the loop area has been reduced by running the signal and return wires closer together, again allowing fewer flux lines to pass through the loop. In Figure B-7(c), the popular method of using twisted pair wires has been used. In this configuration, the twists in the wires effectively force the lines of flux to cancel each other out. In practice, a combination of these methods is used to lessen the effect of noise sources.



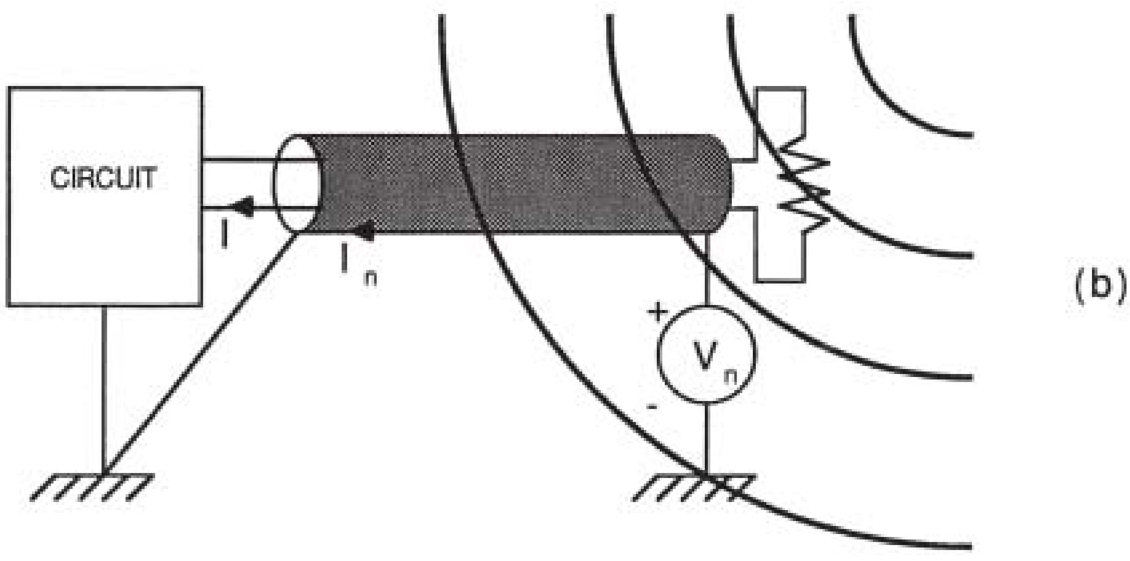


Figure B-8

Figure B-8(a) shows a circuit that is in the presence of a strong electric field. Due to the electric field, a noise voltage, Vn, will appear. (The noise voltage, Vn, is also shown in the figure as a noise current, In.) Figure B-8(b) shows a remedy to the problem in the form of a shielded cable. Here the noise voltage appears across the shield rather than the wire. The current will flow down the outside of the shield to the chassis ground.

This might be a good place to discuss the merits of different shielding practices. Figure B-9 shows three ill-fated shielding attempts.

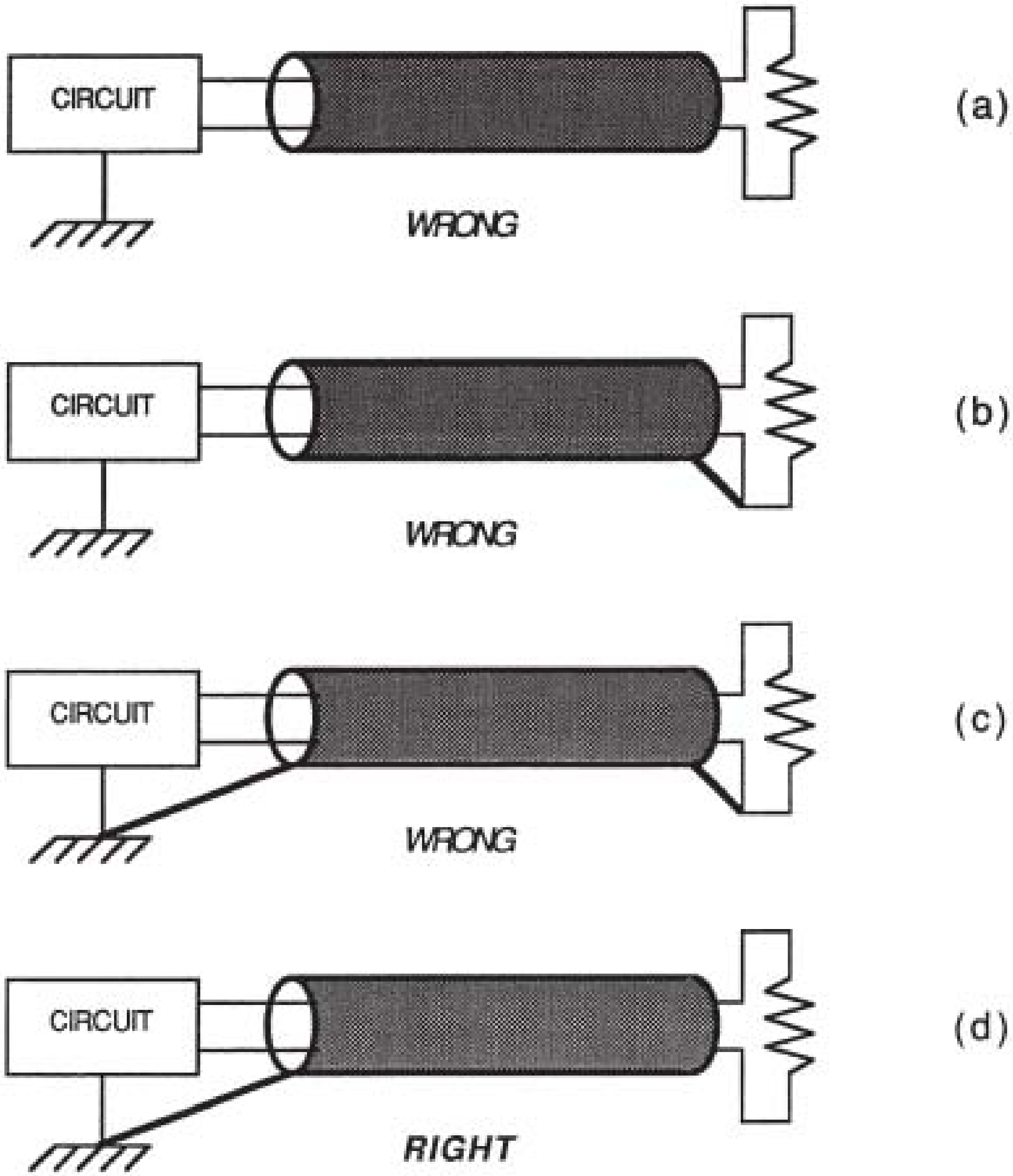


Figure B-9

Figure B-9(a) has a shield not connected at either end. In this case, the noise currents will form on the exterior of the shield, and also move to the interior. This will form E- and H-fields inside the shield which can then be coupled into the two wires.

Figure B-9(b) shows a shield connected at the wrong end. Here the noise currents on the shield will flow into the load return, an unwanted effect.

In Figure B-9(c) the shield is connected at both ends. Some noise current will flow through the shield directly to chassis ground, but we will also have the same effect observed in 9(b).

Figure B-9(d) shows a shield correctly connected to the chassis ground end only.

It is hoped that this section has provided you with some insight into how radiated interference becomes coupled into electronic systems. In many cases these fields will not visibly effect system operation, but steps should always be taken to reduce their influence.

Suggestions

This section summarizes some of the measures to reduce interference already presented, and also describes some additional ideas to yield greater system reliability. It should be noted that the use of these suggestions is very much system-dependent. However, if all of these ideas are kept in mind when laying out a system, headaches may be avoided.

All of the interference control suggestions have been divided into six categories:

(1) Physical Isolation.

- isolate high level signals from low level signals by increasing the separation distance
- isolate low frequency signals from high frequency ones (for example, keep digital cables away from analog cables)
- avoid long runs of cable parallel to primary power conductors, or any other conductor likely to be carrying high amplitude currents or voltages

(2) Shielding.

- use proper cable shielding techniques such as terminating the shield at one end only
- terminate the shield at a low impedance ground such as a chassis
- use a high quality shield (a heavy braid with an outer foil will yield a low transfer impedance, a good measure of shielding quality)
- shield <u>both</u> sources and receptors of radiated interference
- generally speaking, shielding is more effective against higher frequency fields - for low frequency (such as 60 Hz) other methods should be used in conjunction with shielding

(3) Ground Impedance Minimization.

- reducing cable length and using a large diameter stranded braid wire with good insulation are ways of minimizing impedance
- do not use corroded or oxidized wire or connectors (Aside from having poor impedance values, they will also show nonlinear characteristics.)

- keep in mind that one of the reasons for ground impedance minimization is preventing the source and load from being connected to points of a different potential

(4) Single Point Grounding.

- use single point grounding whenever possible, and know the reasons for doing so

- the two ideas of interference control and safety grounding are sometimes at odds with each other - both should be kept in mind when laying out a ground system (See the references at the end of this appendix to obtain a copy of the National Electrical Code.)

- in a multi-equipment system or facility, it can be difficult to implement and maintain a true single point ground, and often other methods of interference control must be used

(5) Filtering.

- filtering at the power mains input and/or the power supply output is often a good way to prevent conducted interference

- use an isolation transformer (preferably with Faraday shielding) at the ac power input

- filtering on I/O lines can be useful if the noise frequency is outside of the system frequency range

(6) Reduce Loop Areas.

- analyze the system in terms of how large the closed loops areas are, and work to reduce as many as possible

- keep cable lengths short and signal-to-return separation small to decrease loop area

- use twisted pair wiring to substantially reduce magnetic coupling

- use opto-isolation whenever possible to break ground loops. Opto-isolation also eases the restriction on cable impedance

Conclusion

Although a proper treatment of good grounding and shielding practices would take several volumes, we hope that this document has provided you with some useful information. Probably the two most important ideas covered were these:

> Always take into consideration the finite impedances in wiring, connections, etc., and know the effect that they will have in circuit operation.

> Remember that all circuits and systems are constantly being bombarded by external electromagnetic fields, and take steps to reduce their effect on your system.

References

Copies of the *National Electrical Code Handbook* can be obtained from the NFPA:

National Fire Protection Association
Batterymarch Park
Quincy, Massachusetts 02269
Telephone: 1-800-344-3555

A good book covering many aspects of grounding and shielding is:

Noise Reduction Techniques in Electronic Systems , by Henry W. Ott
New York: John Wiley & Sons, 1976
ISBN 0-471-65726-3

A consulting firm that publishes numerous books and teaches seminars on interference reduction, is ICT:

Interference Control Technologies
Don White Consultants Inc. Subsidiary
State Route 625, P. O. Box D
Gainesville, Virginia 022065
Telephone: 1-703-347-0030

C Modifying the Digital Interface Box (DIB)

The Temposonics transducer and digital interface box (DIB, sometimes called recirculation box) must be matched, and must be suitable for use with the Motion Plus/473 Controller. Suitable transducers and DIBs have the following characteristics:

- The DIB operates on ±12 Vdc power.
- The DIB is set for external interrogation.
- The transducer and DIB are a matched set. Both must be set for positive pulse or both must be set for negative pulse.
- The DIB is set for the required number of recirculations.

This appendix explains how to determine whether a given DIB and transducer set meet these requirements, and how to modify, if necessary, a DIB.

⚠ CAUTION

These modifications can damage the digital interface box (DIB). Modifications must be carried out only by qualified personnel, taking proper precautions to minimize the risk of damage to delicate electronic components. *Units under warranty must not be modified.— modifications void the warranty.*

Preliminary

The DIB characteristics are reflected in the 14-digit model number.

The 9th and 10th digits (XXXXXXXX40XXXX) indicate power requirements as follows:

40, 41, or 42:	±15 Vdc
43 or 44:	±12 Vdc (can be used with the Motion Plus/473 Controller)
Other values :	special voltage

The 12th digit (XXXXXXXXXXX1XX) indicates internal or external interrogation as follows:

0	internal
1	external (can be used with the Motion Plus/473 Controller)

The 13th digit (XXXXXXXXXXXX2X) indicates the number of recirculations as follows:

0	1 recirculation
1	2
2	4
3	8
4	16
5	32
6	64
7	128 recirculations

Before making modifications, take the following steps:

1. Remove all power from the system.

2. Disconnect cables from J1 and J2 on the DIB.

3. Remove the four Phillips screws from the top corners of the DIB.

4. Carefully lift off the top assembly, which includes the printed board and all components.

External Interrogation

Take the following steps to change the DIB from internal to external interrogation:

1. Open the DIB as described above.

2. Turn the top assembly upside down to view the components.

3. Remove the 555 timer from the lower side (notched end) of the 16-pin DIP socket (U1A position, pins 1–4 and 13–16). Refer to Figure D-1.

4. Install a 9637 integrated circuit into the upper side of the 16-pin DIP socket (U1B position, pins 5–8 and 9–12). Refer to Figure D-2.

5. Check connections from the 10-pin connector J1. J1, pin D connects to post E1, and J1, pin E connects to post E2 Refer to Figure D-3.

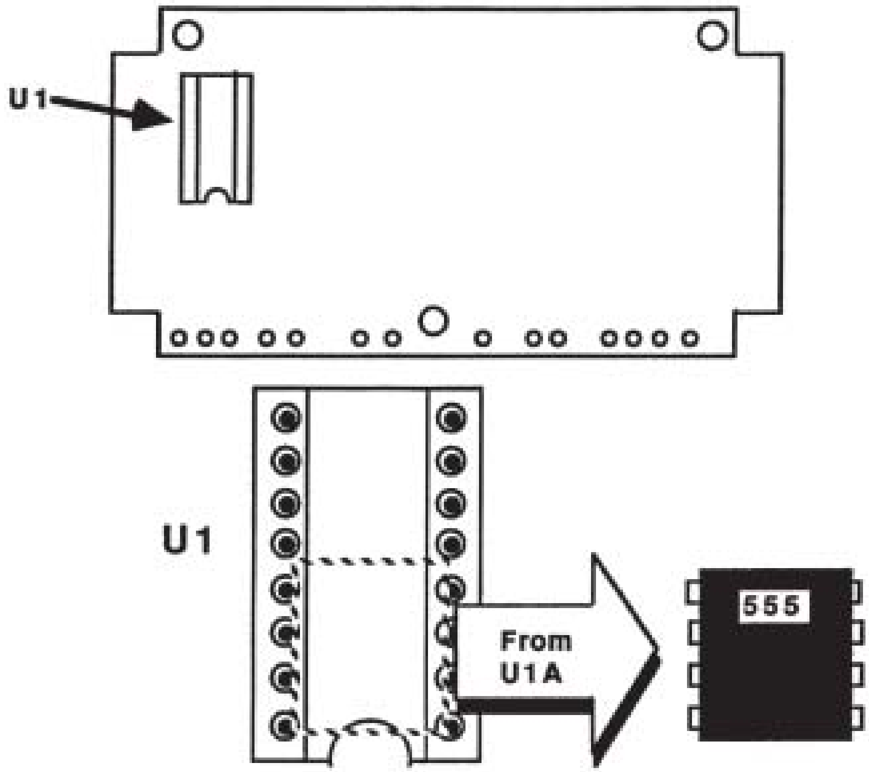


Figure D-1. U1A Position for Internal Interrogation

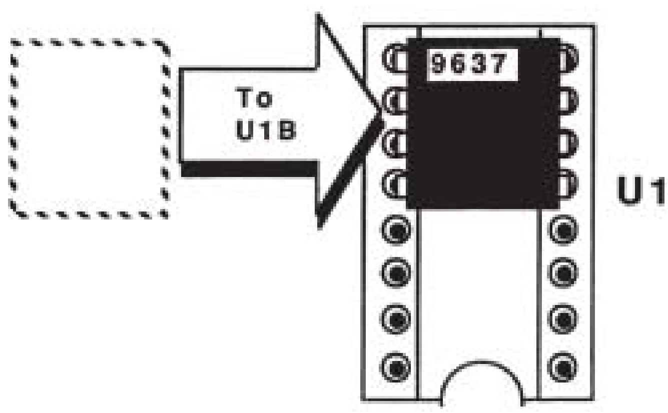


Figure D-2. U1B Position for External Interrogation

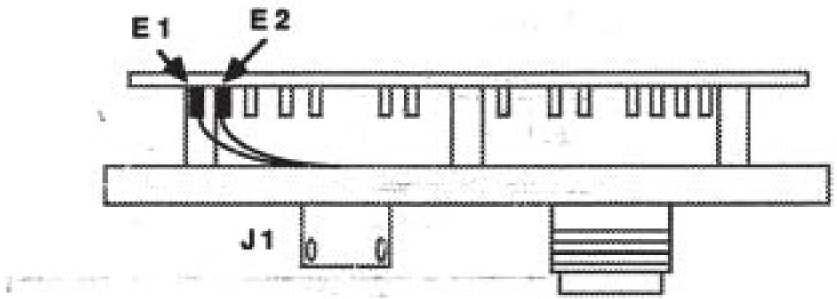


Figure D-3. DIB Internal Connections for External Interrogation.

Unmatched Transducers and Digital Interface Boxes

Two types of Temposonics transducers are available. Transducers with less than 12 inches of stroke use a negative pulse. Those with 12 inches or more of stroke use a positive pulse. Each type requires a matching digital interface box . Normally Temposonics transducers and DIBs are purchased as matched sets. If your application requires mixing and matching, you may need to verify that each DIB matches its transducer. First, compare the serial numbers of the DIB and the transducer:

a. If the transducer stroke is 12 inches or more, or if its serial number ends in P, it uses positive pulse. If the transducer stroke is less than 12 inches, or if its serial number ends in N, it uses negative pulse.

b. If the serial number of the DIB ends in P the DIB is suitable for use with positive pulse transducers. If the serial number ends in N, the DIB is suitable for use with negative pulse transducers.

In cases where the serial number information is not available, or where it is necessary to modify DIB, take the following steps:

1. Open the DIB as described above.

2. Turn the top assembly upside down, and orient it so that the row of terminal posts is near you. Observe the four posts at the right-hand side of the assembly.

3. If a wire is connected to the *first* (rightmost) post, as shown in Figure D-4, this is a *positive pulse* DIB, suitable for use only with transducers with 12 inches of stroke or more. (The wire connects this post to J2, pin E.)

4. If a wire is connected to the *second* post, as shown in Figure D-5, this is a *negative pulse* DIB, suitable for use only with transducers with less than 12 inches of stroke.(The wire connects this post to J2, pin E.)

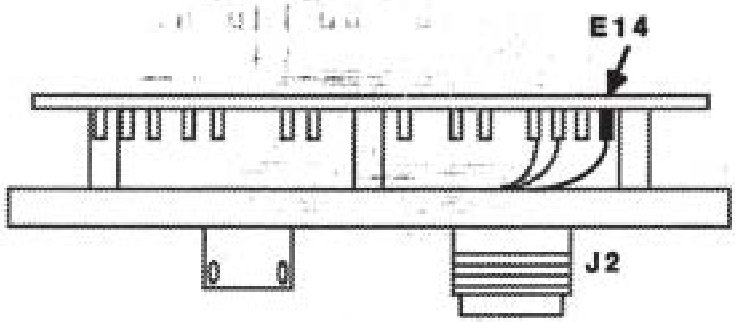


Figure D-4. DIB Internal Connection for Positive Pulse (Long) Transducer

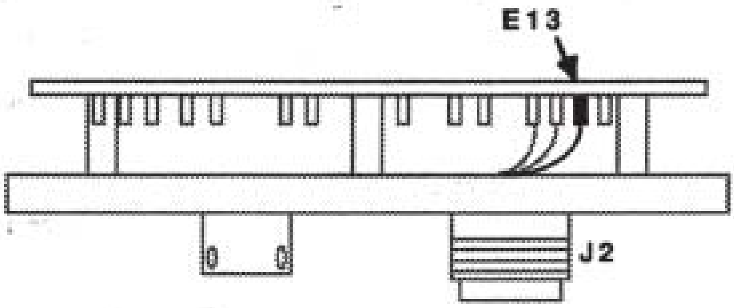


Figure D-5. DIB Internal Connection for Negative Pulse (Short) Transducer

Changing the Recirculation Number

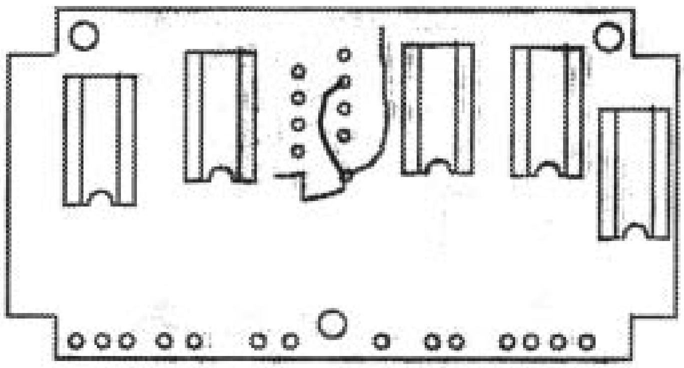
A DIB may have a recirculation number N from 1 to 128. If the DIB is set for N= 1 to 8, it cannot be reset for any N greater than 8. A DIB provided with N=16 TO N=128 can be set to any recirculation number. In general, it is always permissible to lower the number of recirculations; but raising the number may cause interrogation pulse timing problems.

Take the following steps to change the recirculation number:

1. Open the DIB as described above.

2. Turn the top assembly upside down, and inspect the set of numbered holes shown in Figure D-6. A jumper wire connects 0 to one of the other points (1–8). Table D-1 shows the recirculations associated with each hole:

3. Unsolder the jumper wire and connect it between 0 and the appropriate hole, using Table D-1. Resolder in position.



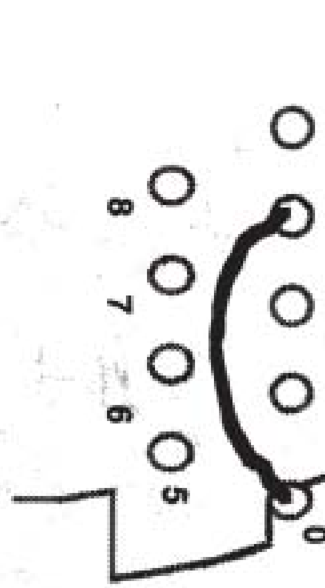


Figure D-6. Example of Recirculation Jumper Setting (0–3 for 4 Recirculations)

Table D-1. Jumper Positions and Recirculations

Jumper Position	Recirculations
1	1
2	2
3	4
4	8
5	16
6	32
7	64
8	128