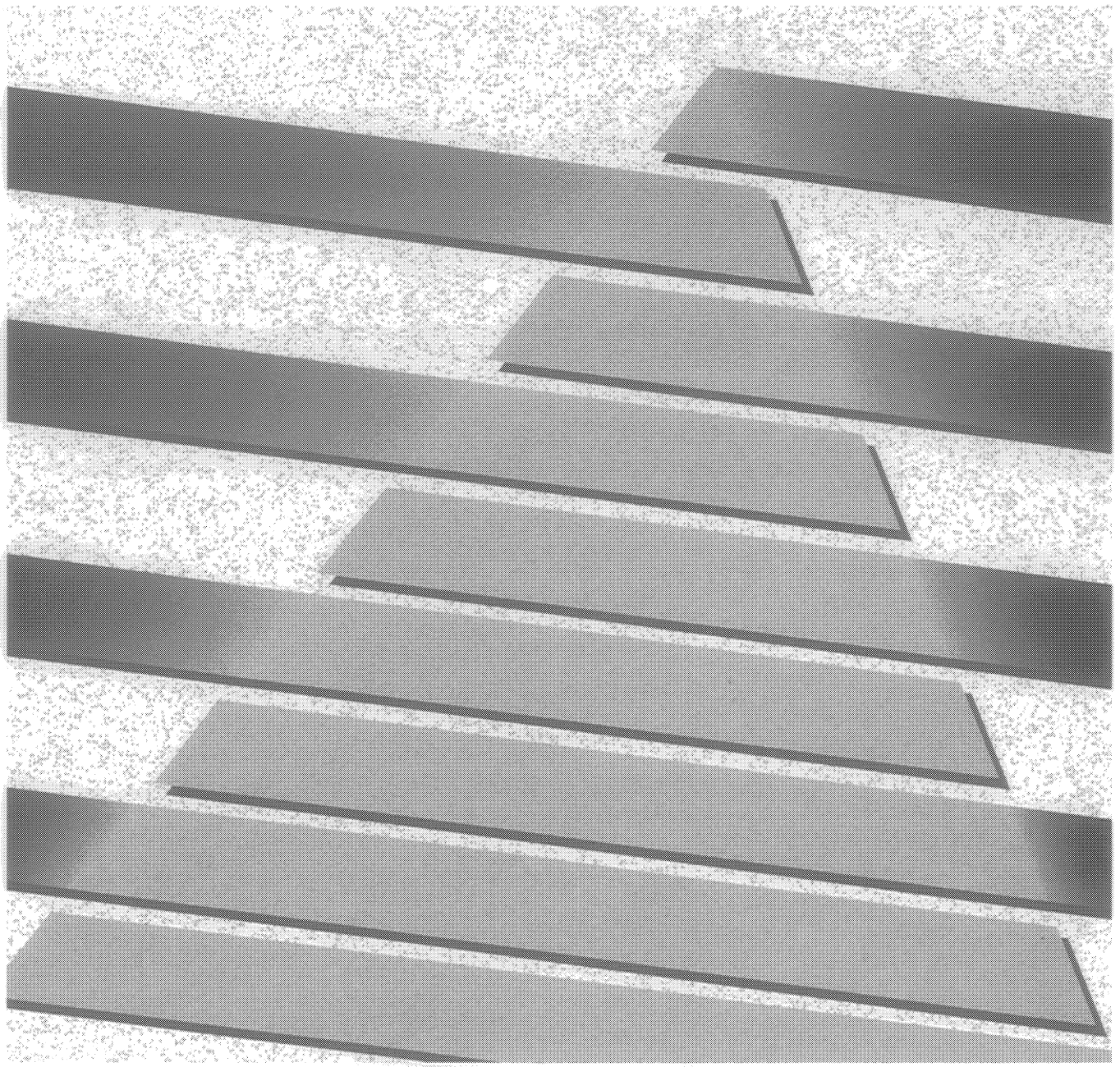
ALLEN-BRADLEY

IMC 110 Motion Control System

(Cat. No. 1746-HS)

Installation Manual



Important User Information

Because of the variety of uses for this product and because of the differences between solid state products and electromechanical products, those responsible for applying and using this product must satisfy themselves as to the acceptability of each application and use of this product. For more information, refer to publication SGI–1.1 (Safety Guidelines For The Application, Installation and Maintenance of Solid State Control).

The illustrations, charts, and layout examples shown in this manual are intended solely to illustrate the text of this manual. Because of the many variables and requirements associated with any particular installation, Allen–Bradley Company cannot assume responsibility or liability for actual use based upon the illustrative uses and applications.

No patent liability is assumed by Allen-Bradley Company with respect to use of information, circuits, equipment or software described in this text.

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Throughout this manual we make notes to alert you to possible injury to people or damage to equipment under specific circumstances.

WARNING: Tells readers where people may be hurt if procedures are not followed properly.

CAUTION: Tells readers where machinery may be damaged or economic loss can occur if procedures are not followed properly.

Warnings and Cautions:

- Identify a possible trouble spot.
- Tell what causes the trouble.
- Give the result of improper action.
- Tell the reader how to avoid trouble.

Important: We recommend you frequently backup your application programs on appropriate storage medium to avoid possible data loss.

Using This Manual

Manual Objective

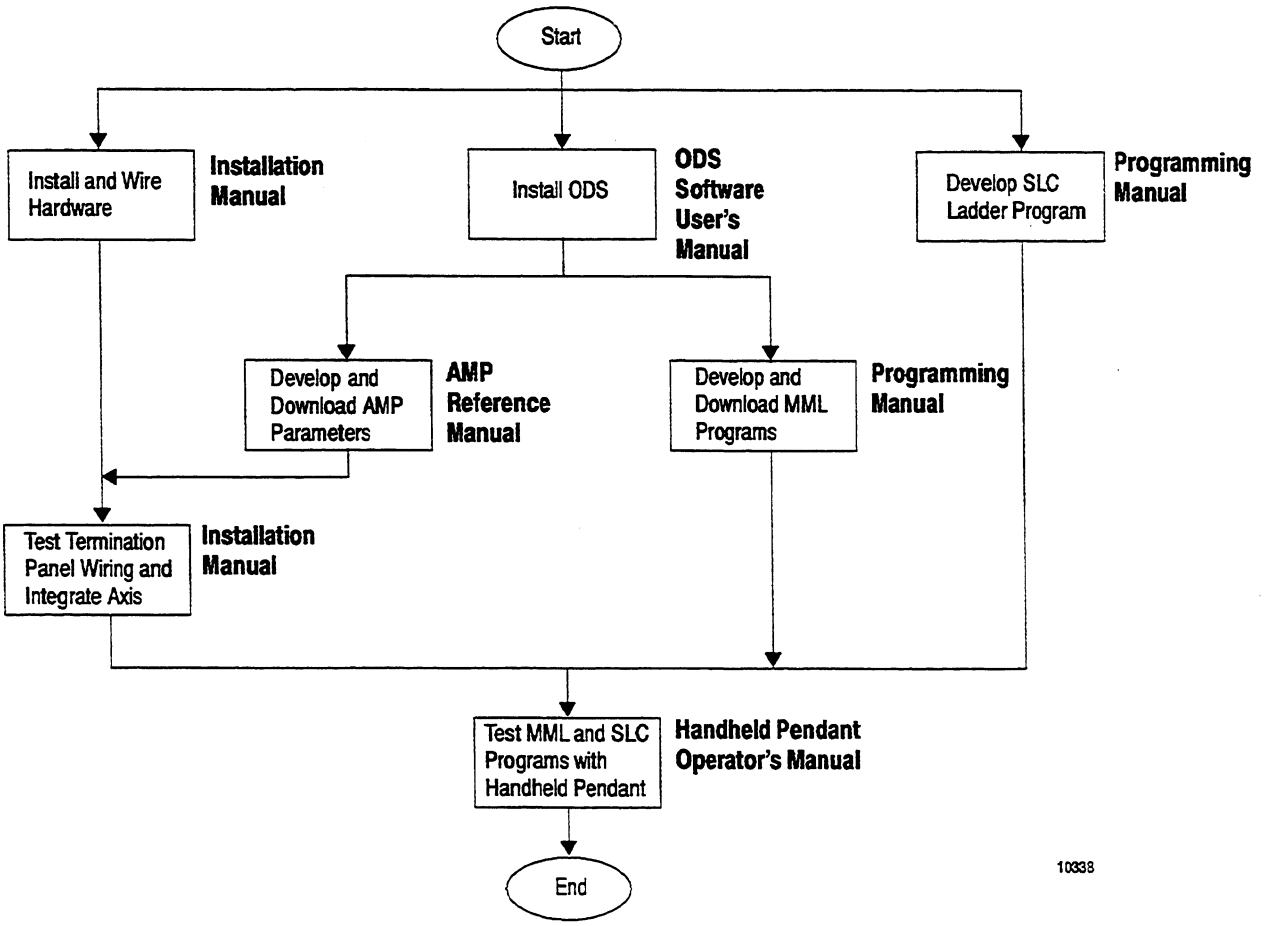
This manual shows you how to install the IMC 110 hardware. We assume that if you are using this manual, you know or are familiar with:

- servo systems
- reading wiring diagrams
- installing power supplies, encoders and drives

Using IMC 110 Documentation

Figure 1.1 shows you the tasks for setting up an IMC 110 system and the manual that discusses each task.

Figure 1.1
Task Flowchart for Setting Up an IMC 110 System



What this Manual Contains

Use Table A to find information in this manual.

Table A
What This Manual Contains

If you want to know how to :	Refer to :	Title
select power supplies, encoders and drives	Chapter 1	Selecting Power Supplies, Encoders and Drives
route wires, classify conductors, use general wiring practices, place modules in the chassis	Chapter 2	Planning Hardware Installation
insert the controller into the chassis, mount the termination panel, connect the handheld pendant, connect the ODS terminal	Chapter 3	Installing the IMC 110 System
wire fast inputs and outputs, hardware overtravels, home limit switches, and E-stop for single and multi-axis systems	Chapter 4	Wiring Fast I/O and E-stop
wire power supplies, wire differential encoders, wire Allen-Bradley 1386, 1388, 1389, 1391, 1392 drives	Chapter 5	Wiring Power Supplies, Encoders and Drives
power up, test E-Stop wiring; testing fast I/O; integrating the axis; testing homing	Chapter 6	Testing the IMC 110 Hardware
make a 1746-HCA cable	Appendix A	Cable Specifications
wire an IMC 110 system without a termination panel	Appendix B	Wiring Without the Termination Panel
recover from an error message	Appendix C	Error Messages and Diagnosis

Warnings, Cautions and Important Information

Information that is especially important to note is identified by three labels:

WARNING: informs you of circumstances or practices that can lead to personal injury as well as to damage to the control, the machine, or other equipment.

CAUTION: informs you of circumstances or practices that can lead to damage to the control, your machine, or other equipment.

Important: provides you with information that is important for successful application of the control.

Terms That We Use

In this manual, we use these terms:

Term	Refers to
the control module	IMC 110 Motion Control Module
AMP	Adjustable Machine Parameters
AWG	American Wire Gage
EGND	Earth Ground
E-stop	Emergency Stop
ODS	Offline Development System
MML	Motion Management Language
SLC	Small (Programmable) Logic Controller

Finding More Information

For more information on the IMC 110 motion control system refer to Table B. For information on SLC 500 products that are used with the IMC 110 refer to Table C.

Table B
Publications About IMC 110 Products

Title	Publication Number
IMC 110 System Overview	1746-2.30
IMC 110 Termination Panel	1746-2.31
IMC 110 Handheld Pendant Operator's Manual	1746-ND002
IMC 110 AMP Reference Manual	1746-ND003
IMC 110 Programming Manual	1746-ND004

Table C
Publications About SLC 500 Products

Title	Publication Number
SLC 500 Programmable Controllers	1746-1.1
Bulletin 1746 & 1747 Modular Hardware Style Programmable Controllers Installation and Operation Manual	1747-804
Hand-held Terminal Programming Manual	1747-809

Table of Contents

Chapter 1

Selecting Power Supplies, Encoders and Drives

Chapter Objectives

In this chapter we discuss how to select the hardware you need to support an IMC 110 system. We discuss:

- selecting a power supply for the backplane
- selecting a power supply for the user-side
- using fast inputs and fast outputs
- selecting an encoder
- selecting a drive

The amount of hardware you need depends on how many axes your application uses. Consult your local Allen-Bradley sales engineer or distributor to help you select the equipment for your application.

Selecting a Power Supply for the Backplane

Before you select a power supply you must calculate the current requirements for your backplane. Table 1.A lists the backplane current requirements for the control module.

Table 1.A
Current Requirements for the Control Module

Voltage	Current Requirement
+5	.300 A
+24V	.104 A (when using handheld pendant)

In your calculations you must include the current requirements of the I/O modules in your chassis. Refer to your SLC 500 documentation.

Example of Calculations for Backplane Current Requirements

Our example system includes:

- one 7-slot modular rack
- one 1747-L511 CPU module
- one 1746-IB8 dc input module with 8 inputs @ +24 V
- one 1746-OV8 dc output module with 8 outputs @ +24 V
- one 1747-PIC interface module
- an IMC 110 system which includes:
  - 2 control modules
  - 2 termination panels
  - 2 Allen-Bradley 845H encoders
  - 6 fast inputs
  - 2 fast outputs

Table 1.B lists the current requirements of the devices that use backplane power. Those devices that are not included in the backplane calculations are included in the user-side example calculations.

Table 1.B
Current Requirements for the Backplane of the Example System

Device	+5V	+ 24V
1747-L511	.350 A	.104 A (when using handheld pendant)
control module	.300 A	.104 A (when using interface module)
control module	.300 A	0
1746-IB8	.040 A	0
1746-OV8	.125 A	0
	Total +5V	**Total +24V**
	1.115 A	.208 A

Given the current requirements of this system, you can use the power supply included in the fixed-style SLC 500, the 1746-P1 or the 1746-P2 to power the backplane. Table 1.C lists the power supplies Allen-Bradley recommends for the backplane.

Table 1.C
Recommended Power Supplies for Backplane Current Requirements

Power Supply	Output Capacity	AC Line Input Capacity
included with the fixed-style SLC 500 chassis	5V dc @ 2A; 24V @ .2A	85-130, 170-265 V ac or 19.2-28.8 V dc
1746-P1	5V dc @ 2A; 24V @ .2 A	85-130, 170-265 V ac
1746-P2	5V dc @ 5A; 24V @ .2 A	85-130, 170-265 V ac
1746-P3	5V dc @ 3.6A; 24V @ .2 A	19.2-28.8 V dc

Selecting a Power Supply for the User-Side

You must provide a power supply that will meet the user-side requirements of your system. These devices require user-side power:

- the control module
- encoders
- I/O modules
- E-stop circuitry
- fast inputs and fast outputs

The power supply you select must meet the specifications of a NEC Class 2 power supply. The power supply must have +5V, ±15V capacity, and +24V capacity for E-stop circuitry and fast I/O. We recommend that you **do not** use the +24V included with the 1770-P1, P2, or P3 to power your E-stop and/or fast I/O.

Before you select a power supply, you must calculate the user-side current requirements for the system.

Example of Calculations for User-Side Current Requirements

Our example system includes:

- one 7-slot modular rack
- one 1747-L511 CPU module
- one 1746-IB8 dc input module with 8 inputs @ +24 V
- one 1746-OV8 dc output module with 8 outputs @ +24 V
- an IMC 110 system which includes:
  - 2 control modules
  - 2 termination panels
  - 2 Allen-Bradley 845H encoders
  - 6 fast inputs
  - 2 fast outputs

Table 1.D lists the current requirements of the devices that draw user-side power.

Table 1.D
Current Requirements for User-Side of the Example System

Device	+5V	+15V	–15V	+24V
1746-IB8	0	0	0	.064 A
1746-OV8	0	0	0	.800 A
control module	.150 A	.030 A	.200 A	0
control module	.150 A	.030 A	.200 A	0
E-stop circuitry	0	0	0	.100 A
6 fast inputs	0	0	0	.015 A
2 fast outputs	0	0	0	.100 A
A-B 845H encoder	.200 A	0	0	0
A-B 845H encoder	.200 A	0	0	0
	Total +5V	**Total +15V**	**Total –15V**	**Total +24V**
	.700 A	.060 A	.400 A	1.079 A

Using Fast Inputs and Outputs

The fast I/O (FIN1-FIN3, and FOUT1) are 24V dc compatible and are designed to be used in conjunction with a customer supplied +24V power supply. Potential 24V dc I/O devices should be reviewed for compatibility with the electrical specifications in Table 1.E.

Table 1.E
Electrical Specifications for Fast I/O

Outputs (source drivers)	
Specification	**Rating**
V_{oh} (high-level, on-state output voltage)	Refer to the specifications for your user-side power supply
I_{oh} (high-level, on-state output current for each output)	+ 24V @ .20 A (for resistive and inductive loads +24 V @ .10 A (for capacitive roads)
Turn on time	500 µs
Turn off time	500 µs
Inputs	
Specification	**Rating**
V_T (input low/high trip threshold)	10.51V (min) 12.5V (typ) 14.61V (max)
V_T (input high/low trip threshold)	6.4V (min) 8.3V (typ) 10.3V (max)
V_{HYST}	1.9V (min) 4.1V (typ) 6.5V (max)
I_{IN} @ 27V	2.5 mA (max)
T_{PD+} (input low/high debounce filter)	.2msec (typ)
T_{PD-} (input low/high debounce filter)	.2msec (typ)
V_{IN} (absolute max.)	+ 75V (max)

Selecting an Encoder

The IMC 110 system supports Allen-Bradley AB-845H differential encoders. Other encoders may be compatible if they comply with the specifications listed in Table 1.F.

Table 1.F
Encoder Specifications

Specification	Rating
Maximum channel frequency	Incoming quadrature frequency is limited by the following relationship: F_{QUAD} (HZ) = (3334)(90°-E_Q) where: E_Q = quadrature error (degrees, electrical) Example: For an AB-845H encoder with 22° quadrature error, what would the maximum frequency be? F_{QUAD} (HZ) = (3334)(90°-22° quadrature error) = 226,712 Hz **Important:** The maximum quadrature error is a limit, and system design should include acceptable margins.
Maximum Axis Speed	The IMC 110 decodes the incoming encoder feedback in quadrature to extract the maximum resolution with 4 counts per electrical cycle. The maximum number of encoder counts per second can be determined by : Maximum # of counts/second = 4 counts/cycle × F_{QUAD} The maximum axis speed as limited by the encoder feedback would be: $\frac{(\text{maximum \# of counts/second})(60)}{(4E)(N)}$ where: E = the number of encoder lines per revolution N = number of revolutions of the encoder per inch or millimeter of axis travel. (For a rotary axis, N = number of revolutions of the encoder per revolution of the axis.) For a linear axis the units are inches or millimeters per minute, for a rotary axis the units are revolutions per minute
Input signal	Encoder feedback must be differential with 5V compatible output signals, open-collector outputs are not supported. (i.e. channels A, B, and Z must have source and sink current capability, 8830 line driver outputs or equivalent)
Input sink current	7mA (max)
Marker channel	Gated markers
Cable length	Depends on the power supply for the user-side. Power at the encoder must be greater than or equal to the power requirement specified by the manufacturer. The minimum power requirement for the A-B 845H is 4.75V, and the maximum limit is 5.25 V. In order to meet the power requirement of the encoder and still attain maximum cable length, you can: • raise the voltage of the power supply to meet the encoder requirement, but you cannot exceed the 5.25V limit of the control • increase the gage of the wire from the termination panel to the encoder (12 AWG maximum)

Selecting a Drive

The IMC 110 supports Allen-Bradley Series 1386, 1388, 1389, 1391, and 1392 servo drive systems. Table 1.G lists references that help you select a suitable drive system.

Table 1.G
A–B Drives Selection Guide References

A–B Drive	Publication Number	Title
1386	1386-2.0	DC Servo Drive Product Data Sheet
1388	1388-2.0	DC PWM Servo Drive Product Data Series B
1389	1389-2.0	AC Servo Amplifier System Product Data Sheet
1391	1391-2.0	AC PWM Servo Controller Product Data Sheet
1392	1392-2.1	High Performance AC Drive (460V and 230V) Product Data

The control module provides a ±10V analog output to one drive amplifier for a velocity command. This analog voltage is 11 bits plus an additional sign bit (12 bits total) and interfaces to drive amplifiers with a 2K-20K ohm range. Table 1.H shows servo drive signal ANALOG OUT specifications.

Table 1.H
Control Module Drive Reference Signal Specifications

Specification	Rating
Resolution	12 bits or 4.88 mV/bit
Output Voltage Swing	± 10V
Load Range	2K-20K ohms
Conversion Time	100µs
Output Step Response (20V swing)	
rise time	110µs typical
overshoot	5% typical
settling time	60µs typical
Differential Linearity	± 1 LSB Max. (Monotonic over the entire temperature range)
Output Offset Voltage	500µV (max)
Gain Error Drift	7 LSB (max)

Chapter 2

Planning Hardware Installation

Chapter Objectives

Now that you have selected your system, you should plan your system layout. In this chapter we discuss:

- general wiring practices
- routing wires
- classifying your conductors
- placing your modules in the modular chassis

When you plan the installation of the hardware you must also consider:

- noise suppression
- environment
- grounding
- space requirements

Refer to your SLC 500 documentation for more information on these topics.

General Wiring Practices

In this section we discuss:

- connecting different level power conductors to terminals
- using shielded cables

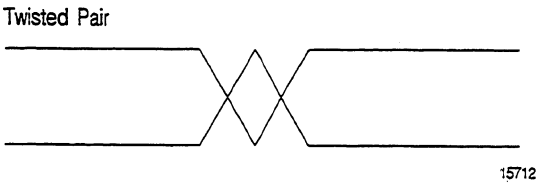
Using Shielded Cables

For many connections, we tell you to use shielded cable. Using shielded cables and properly connecting their shields to ground protects against electromagnetic noise interfering with the signals transmitted through the cables.

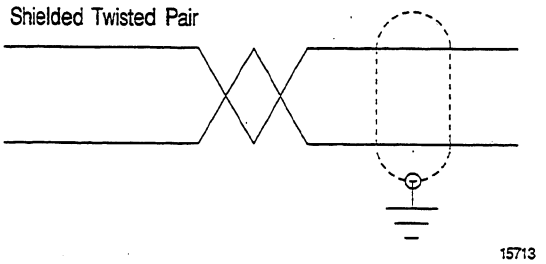
WARNING: Use shielded cable as directed in this manual. If you do not, the axis motion in your system could be unpredictable. This could result in damage to equipment and/or injury to personnel.

Within a cable, pairs of wires are twisted together. Using a twisted pair for a signal and its return path provides further protection against noise.

We show a twisted pair like this:



We show a shielded twisted pair like this:



Shield wires, in general, should connect to ground at one and only one end. The termination panel provides a convenient place to connect all shield wires while providing the necessary ground connection, EGND.

At the other end, cut the shield foil and drain wire short and cover them with tape to protect against their accidentally touching ground. Keep the length of leads extending beyond the shield as short as possible.

In high noise environments, the user may want to connect shield wires at both ends of the cable in an attempt to improve the noise immunity of the system. If this must be done, terminate one end of the shield to ground through a 0.1 μf capacitor to avoid ground loops in the system.

Routing Wires

When planning your wire routing, you must classify all wires and cables connecting your IMC 110 system.

Table 2.A tells you how to classify conductors and route cables. Remember to keep low-level signal conductors separate from high-level power conductors. This is particularly important for cable connections to encoders.

Follow the practices outlined in publication 1770-4.1, entitled "Programmable Controller Wiring and Grounding Guidelines" to learn how to route other conductor categories.

Table 2.A lists:

- the categories
- the cables included in each category
- guidelines for routing the wires and cables

Table 2.A
Categories for Classifying Wires and Cables

These wires and cables:	Are in this category:	Follow these guidleines for routing: (inside or outside an enclosure)
• ac power lines • High-power ac I/O lines — Connect to ac I/O modules that are rated for high power and high noise immunity. • High-power dc I/O lines — Connect to dc I/O modules that are rated for high power or have input circuits with long time constant filters for high noise rejection. They typically connect to devices such as hard-contact switches, relays, and solenoids.	1	• Route with machine power conductors of up to 600V ac (feeding up to 100 hp devices) if this does not violate local codes. • Article 300-3 of the National Electrical Code requires that all conductors (AC and/or DC) in the same raceway must be insulated for the highest voltage applied to any one of the conductors in the raceway.
• IMC 110 cable (1746-HCA) and termination panel wiring • Serial communication cables — Connect to programming terminals, data terminals, and from the scanner to remote I/O adapter modules, or PLC processors. • Low-power ac/dc I/O lines — Connect to I/O modules that are rated for low power such as low-power contact-output modules. • Low-power dc I/O lines — Connect to dc I/O modules that are rated for low power and have input circuits with short time constant filters to detect short pulses. They typically connect to devices such as proximity switches, photo-electric sensors, TTL devices, encoders, motion control devices, analog devices.	2	• Properly shield conductors, where applicable, and route them in separate raceways. If conductors must cross power feed lines, they should do so at a right angle. • Route at least 1 foot from 110V ac power lines, 2 feet from 240V ac power lines, and 3 feet from 480V ac power lines. • Route at least 3 feet from any electric motors, transformers, rectifiers, generators, arc welders, induction furnaces, or sources of microwave radiation. • If conductor is in a metal raceway or conduit, that raceway or conduit must be well grounded along its entire length.

Module Placement

Your control module should be kept as far away as possible from all dc and ac I/O modules. Place the control module on the left side of the chassis along with other intelligent I/O modules and the CPU. Then place any dc and ac I/O modules on the right side of the chassis, leaving any empty slots between these two groups. This placement protects the intelligent (CPU based) modules from the heat and electrical noise of the dc and ac I/O modules.

When planning your module placement you must:

- Classify the modules that you are using into their conductor categories and follow the guidelines stated in Table 2.A.

- You should divide modules, as much as possible, into the following types:
  - ac
  - high level dc
  - low level digital dc (TTL, encoder, pulse output)
  - analog I/O
  - intelligent I/O modules (i.e. the IMC 110 control module)

If a complete I/O chassis cannot be reserved for one of these types of modules, one end of an I/O chassis can be reserved for one type of modules, and the other end for another type. If there is to be a blank I/O slot, choose a slot between two groups of different types of modules to further separate them.

Chapter 3

Installing the IMC 110 System

Chapter Overview

Now that you have planned your installation, you can install the components of your system. In this chapter we discuss:

- unpacking and inspecting your system
- installing the control module
- mounting the termination panel
- connecting the termination panel
- connecting the handheld pendant
- connecting an ODS terminal

Unpacking and Inspecting the IMC 110 System

To make sure that you receive what you ordered, first check the label on each shipping carton with your order.

CAUTION: Electrostatic discharge can degrade performance or damage the module. Observe the following precautions to guard against such damage:

- Touch a grounded object to eliminate static charge from your body before handling the module. It is also recommended practice to wear a wrist strap (such as cat. no. 8000-XESD) that provides a high resistance path to ground.
- Keep the module in its static-shield bag when not in use.

For more information about electrostatic discharge and how to guard against it, refer to publication 8000-4.5.2, Guarding Against Electrostatic Damage — Using the ESD Kit.

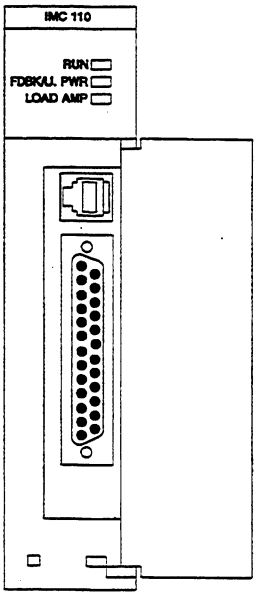
Remove the contents from the shipping carton. Check the items received against the bill of lading to assure that the equipment nameplate description matches the material ordered.

Important: All claims for breakage and damage, whether concealed or obvious, must be made to the carrier by the buyer as soon as possible after receipt of the shipment. Allen-Bradley will be glad to render the buyer reasonable assistance in the securing of adjustment for such damage claims.

IMC 110 Motion Control Module

To familiarize yourself with the control module, see Figure 3.1. It shows the control module (with door open) and its LED's and connectors.

Figure 3.1
Motion Control Module with Door Open



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Inserting a Control Module

The first component you need to install is the control module. Once you install the control module, you can connect the other components.

WARNING: Remove backplane power from the chassis and disconnect the 1746-HCA cable before installing or removing a module.

- Failure to remove power from the backplane or to disconnect cabling could cause module damage, degradation of performance, or personal injury.
- Failure to remove power from the backplane could cause injury or equipment damage due to possible unexpected operation.

CAUTION: Do not force a module into a backplane connector. Forcing a module can damage the backplane connector or the module.

To insert a module into an I/O chassis, follow these steps:

1. Remove backplane and user side power from the I/O chassis before inserting or removing a module.

2. Align the larger of the two boards of the control module with the card-edge guide at the bottom of the chassis

3. Slide the module into the chassis and press firmly to seat the module into the backplane connector.

4. Check to make sure that the locking latches on the top and bottom of the chassis hold the module in place.

Replacing a Control Module

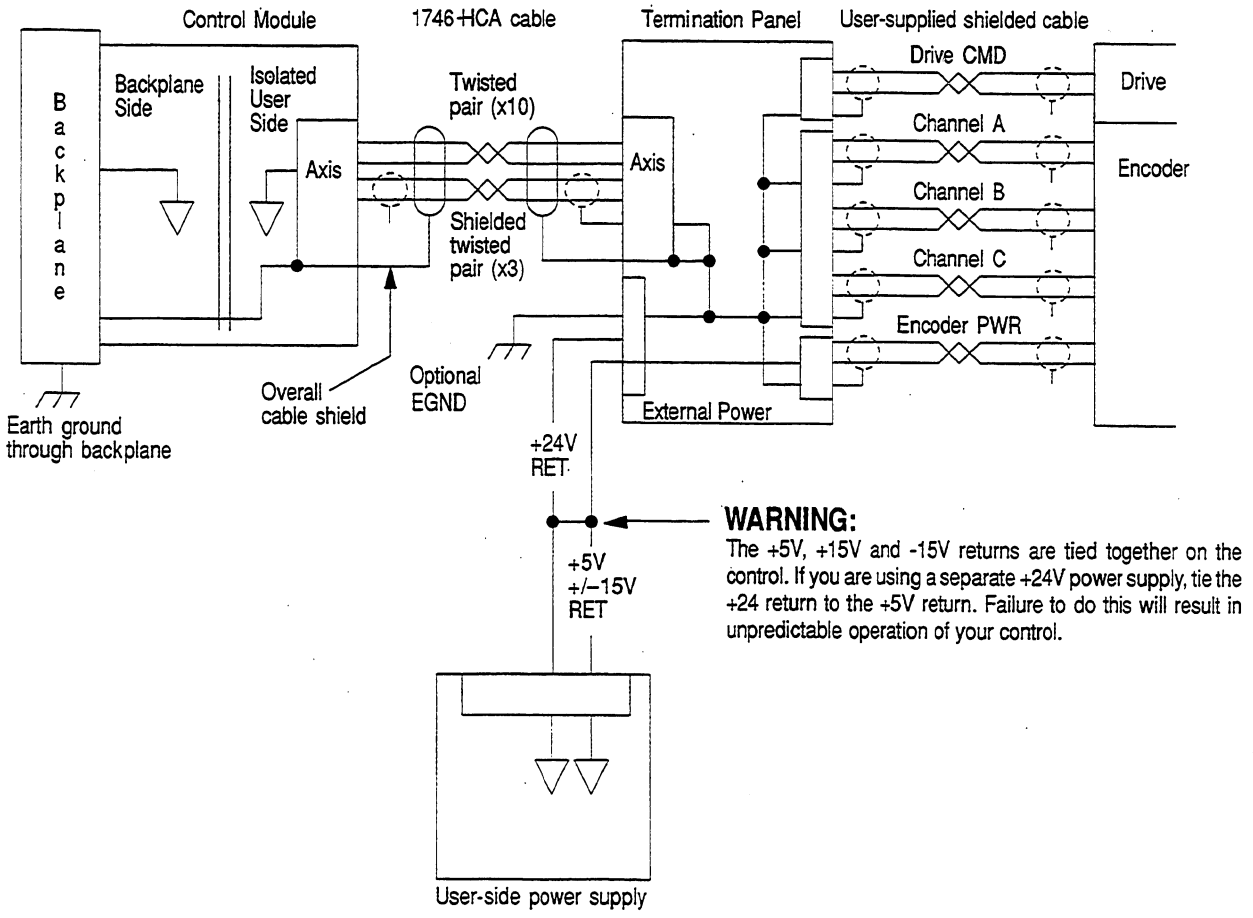
To replace a control follow the previous procedure. You must then download your AMP parameter and MML programs. For the specific procedure on downloading AMP parameters, refer to the AMP Reference Manual (Publication 1746-ND003). For the specific procedure on downloading your MML programs, refer to the Programming Manual (Publication 1746-ND004)

Grounding the Control Module

Before you install the rest of the system, you should first ground the control module. Figure 3.2 shows a typical grounding and shielding block diagram for an IMC 110 system. All of the shields and signal commons (normally floating) are tied to earth ground at a single point. The EGND terminal has been provided on the termination panel for this purpose.

The practice of connecting shields to earth ground at both ends should be avoided since it may result in circuit loops that are susceptible to both radiated and coupled noise.

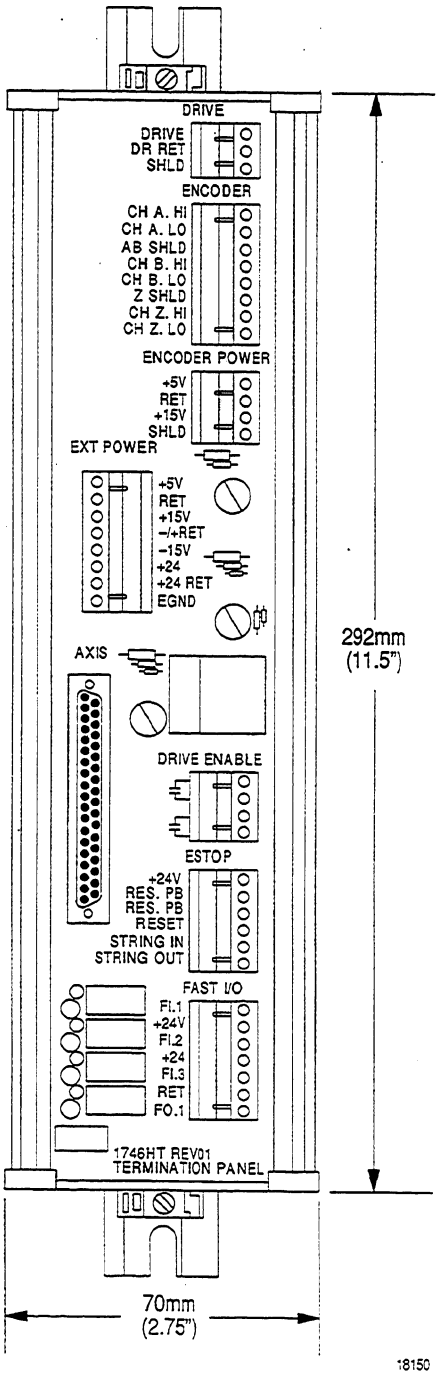
Figure 3.2
Typical Grounding and Shielding for the IMC 110 System



IMC 110 Termination Panel

To familiarize yourself with the termination panel, see Figure 3.3. It shows the termination panel and gives its dimensions.

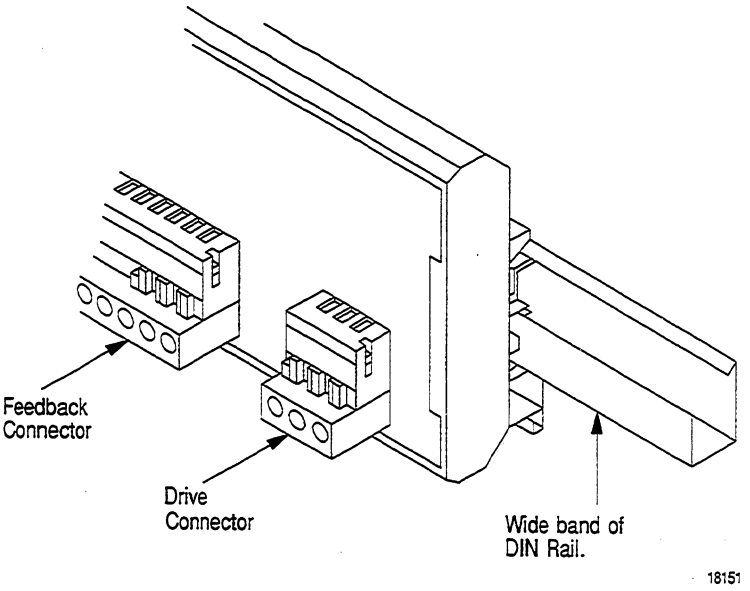
Figure 3.3
Termination Panel and Its Dimensions



Mounting the Termination Panel

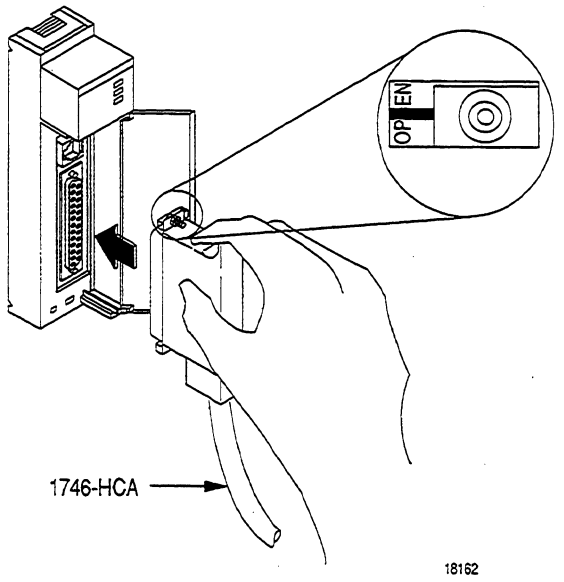
Before you make any connections to the termination panel you must first mount it securely. You mount the termination panel to a DIN-type rail (#46277-1) as shown in Figure 3.4.

Figure 3.4
Mounting the Termination Panel

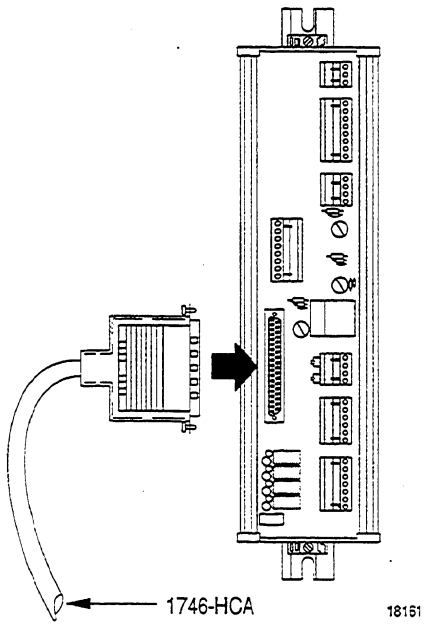


Connecting the Termination Panel

Once the termination panel has been mounted, you connect it to the control module with the 1746-HCA cable. Connect the termination panel to the control module as shown here.

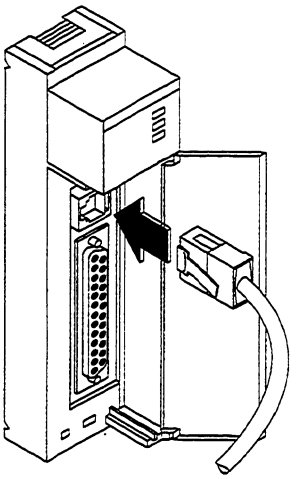


1. Make sure the locking latches above and below the connector are set so the latch reads OPEN.
2. Open the module door.
3. Hold the connector as shown and insert it into the D-sub connnector on the module until the connector is seated.
4. Take a small, flat-edge screwdriver and carefully insert it next to the locking latch (between the module door and connector).
5. Use the screwdriver to slide the locking latch to the right.
6. Repeat steps 4 and 5 for the locking latch on the bottom of the connector.
7. Connect the other end of the cable to the termination panel as shown here.



Connecting the Handheld Pendant

Before you connect the handheld pendant you should install the IMC 110 keyboard overlay. For this procedure, refer to the Handheld Pendant Operator's Manual (publication 1746-ND002). Once you have inserted the keyboard overlay, you can connect the handheld pendant to the control module as shown here. The cable is included with the handheld pendant.



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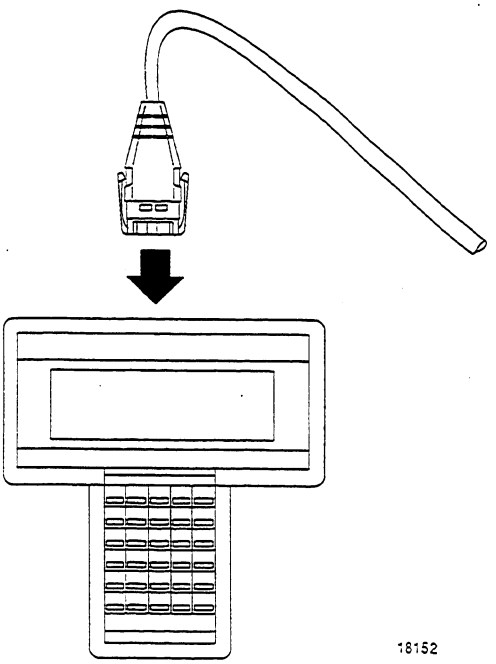


18152

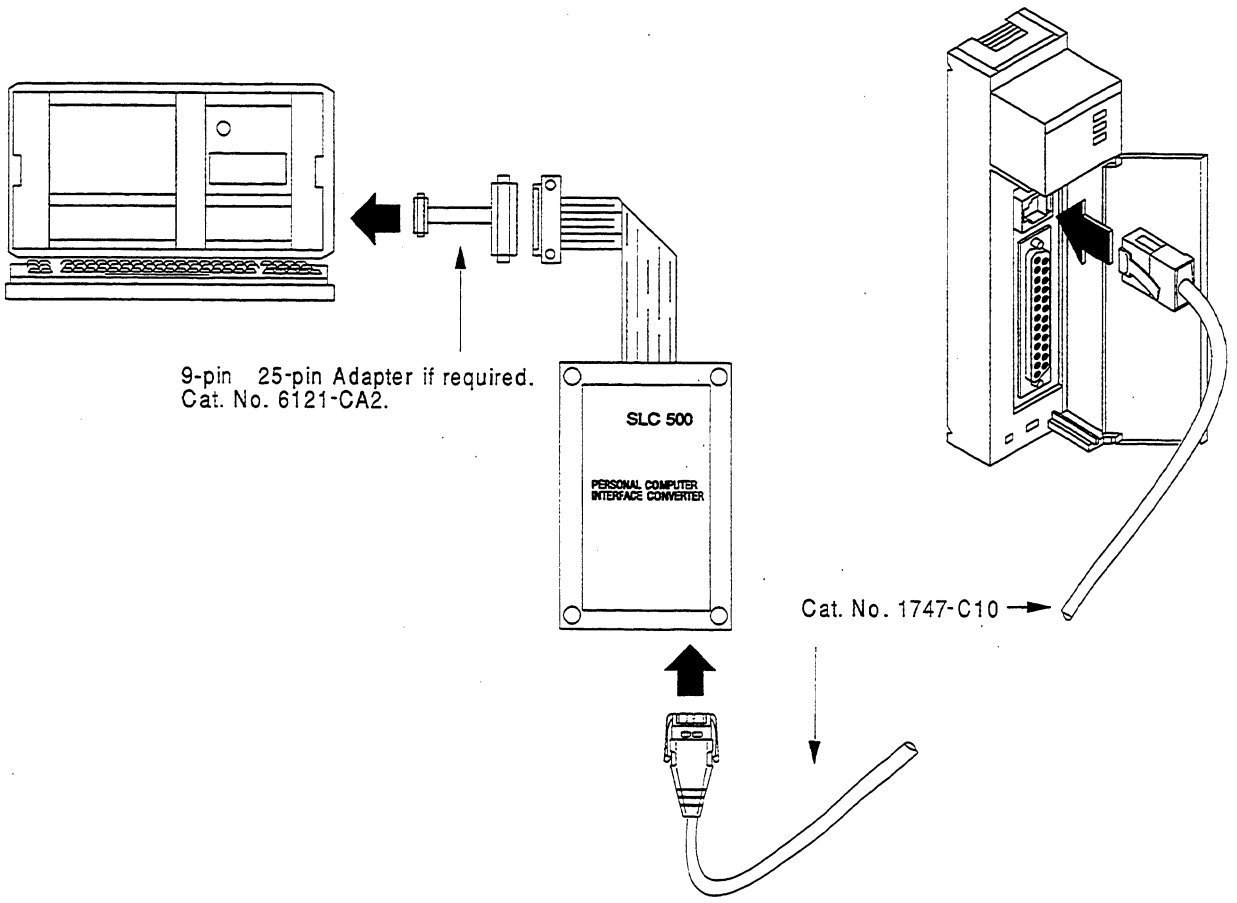
Connecting the ODS Terminal

To upload and download programs, you need to connect your ODS terminal to the control module. Table 3.A lists the components you need and Figure 3.5 shows you how to connect the terminal.

Table 3.A
Components You Need to Connect the ODS Terminal to the Control Module

Component	Catalog Number
SLC 500 RS-232 to RS-485 Interface Converter	1747-PIC
Interface Cable (included with handheld terminal)	1747-C10
9-pin to 25-pin Adapter (required only if your terminal uses a 9-pin connector for a RS-232 port)	6121-CA2

Figure 3.5
Connecting the ODS Terminal to the Control Module



Chapter 4

Wiring Fast I/O and E-stop

Chapter Overview

Now that you have mounted and connected the termination panel you can wire your fast inputs and outputs and your E-stop string to the termination panel. This chapter discusses:

- wiring fast inputs and outputs
- wiring E-stop connections

Wiring Fast Inputs and Outputs

On the termination panel, the +24V dc fast inputs and outputs of the control module are routed from its connector (37 pin D-shell) to the FAST I/O connector (7 pin pluggable) on the termination panel.

The fast I/O consists of:

- fast inputs FI1-FI3
- fast output FO.1
- +24V dc and +24V dc return signals

We recommend 18 AWG wire for wiring fast I/O. This allows 2 wires for each connection point. The termination panel accepts 12 AWG wire, but this allows only one wire per point.

Figure 4.1 shows a diagram of typical fast I/O connections. Figure 4.2 shows equivalent fast input and fast output circuits.

Important: All fast inputs are +24V dc referenced (i.e. the input device always connects between +24V dc and the appropriate fast input). The fast output is ground-referenced (i.e. the output load always connects between the fast output and ground).

Figure 4.1
Typical Fast I/O Connections

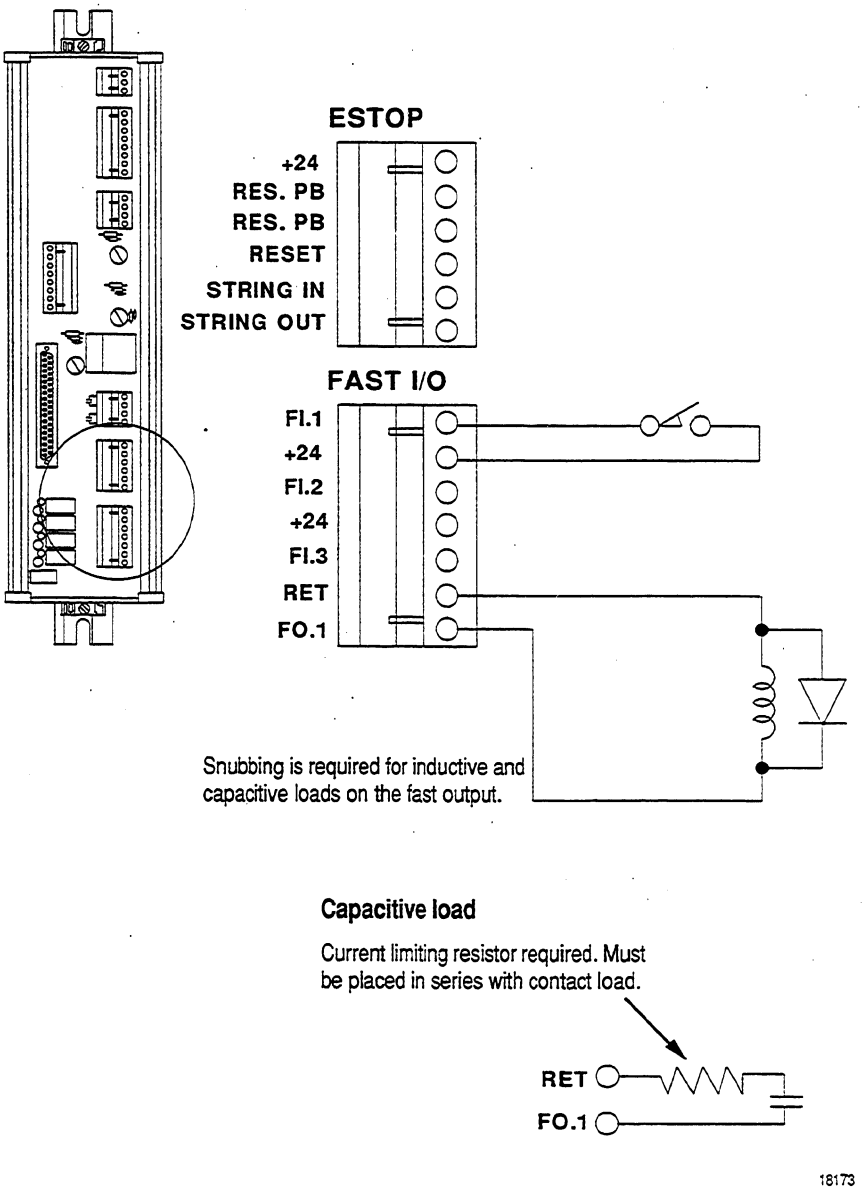
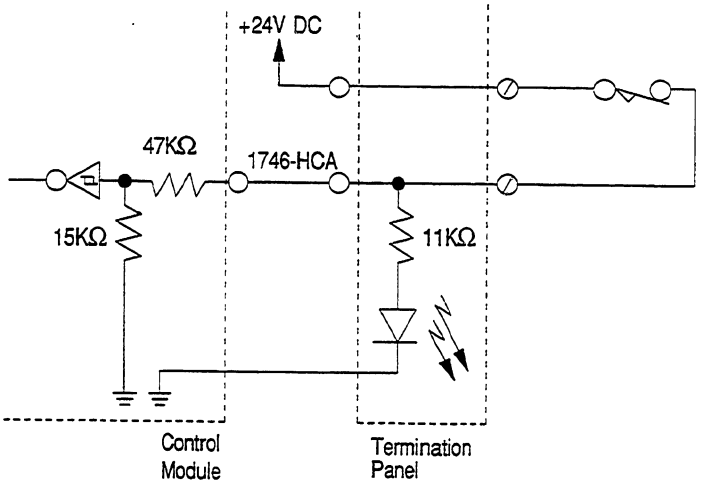
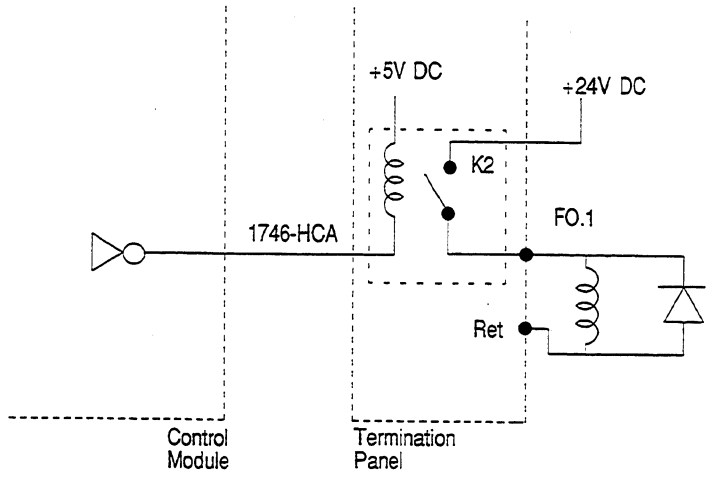


Figure 4.2
Equivalent Fast Input and Output Circuits

Equivalent Fast Input Circuit



Equivalent Fast Output Circuit



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Wiring Hardware Overtravels

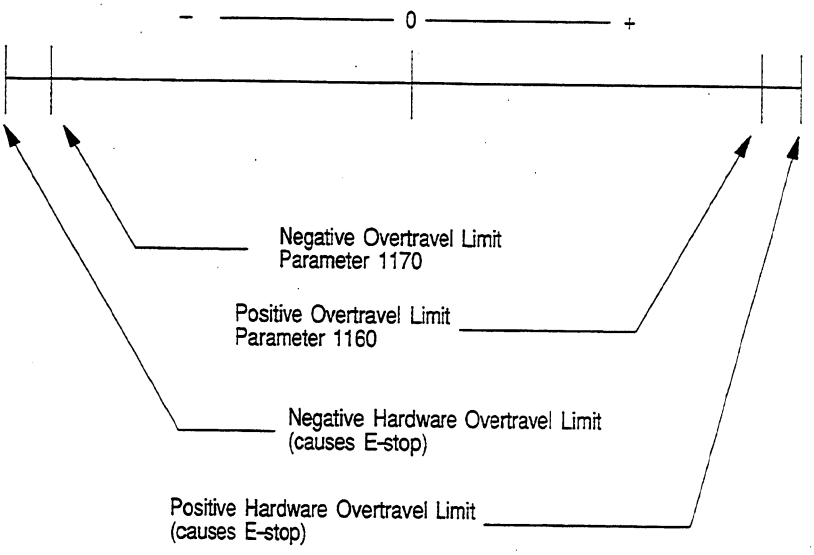
Hardware overtravel limit switches for each axis should be:

- wired into the customer E-stop string
- positioned outside software overtravels as shown in Figure 4.3.

The system should go into E-stop when a hardware overtravel is tripped.

Refer to the AMP Reference Manual (publication 1746-ND003) to read more about software overtravels.

Figure 4.3
Overtravel Limits



NOTE:

Positive and negative software overtravel limits are checked only if Software Overtravels Used (parameter 2250) is set at YES.

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Connecting Home Limit Switch as a Fast Input

You can establish any one of the fast inputs as the home limit switch through AMP parameter 2360, SOURCE OF SWITCH INPUT. Refer to the AMP Reference Manual (Publication 1746-ND003) to read more about this AMP parameter.

The exact position of home is not important. It is important that the home position is:

- a repeatable resting place for the axis when it is not in use
- free of obstruction from any other axis that is in motion

To connect a home limit switch, follow these steps:

1. Place the limit switch near the approximate desired home position.

2. Adjust the encoder so that the marker is about 1/2 revolution from the limit switch closure.

If step 2 is not done, home may occasionally be off by one revolution of the encoder.

E-stop Operation

The control module detects and controls E-stop conditions. Each control module has a separate and independent E-stop circuit. Refer to customer wiring documentation for recommendations on how to correctly wire your external E-stop string.

The following events cause a hardware E-stop to occur:

- broken wire in the user power cable
- powerfail (signal from chassis backplane)
- watch-dog time out on control module
- software E-stop conditions
- a contact in the external E-stop string or a broken/missing wire opens the string (someone pushes the E-stop pushbutton)

Table 4.A shows the specifications for E-stop relay on the control module.

Table 4.A
Specifications for the E-stop Relay on the Control Module

Specification	Rating
Max. Contact Voltage Rating	80V dc max
Operate time	500µs average
Contact bounce	less than 200µs average
Contact resistance	150 milliohms average
Contact rating	5.0 VA @ 0.35 A max

Wiring the E-stop for a One Axis System

Wiring the E-stop for one axis system consists of connecting:

- Drive Enable
- E-stop Reset pushbutton (RES PB, RES PB, and RESET)
- customer E-stop string (STRING IN and STRING OUT)

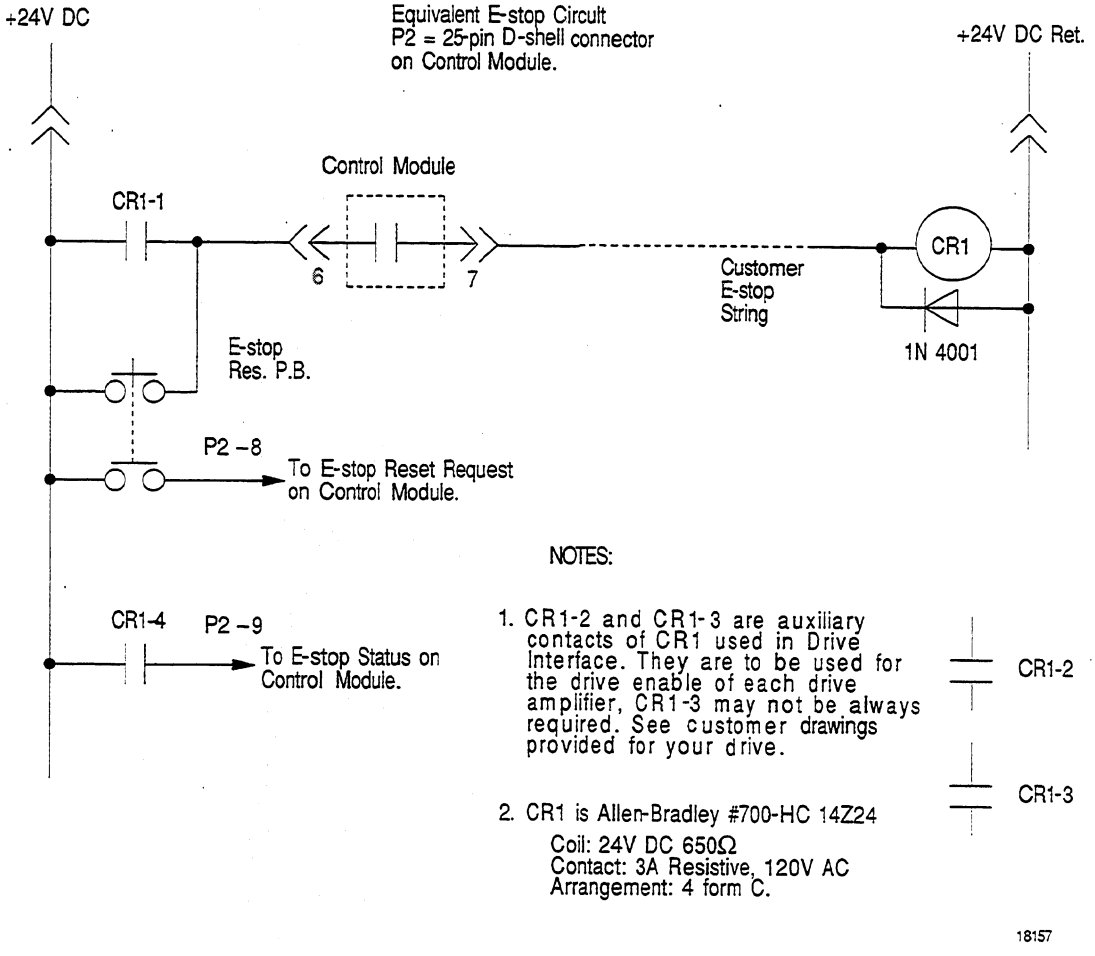
WARNING: It is responsibility of the user to develop a failsafe wiring design for his customer E-stop string. You must wire a remote E-stop pushbutton near where the handheld pendant is connected to the control module.

The elements of the E-stop string consist of the following connections in series:

- axis hardware overtravels
- remote E-stop
- motor thermal switch
- transformer thermal switch
- drive fault

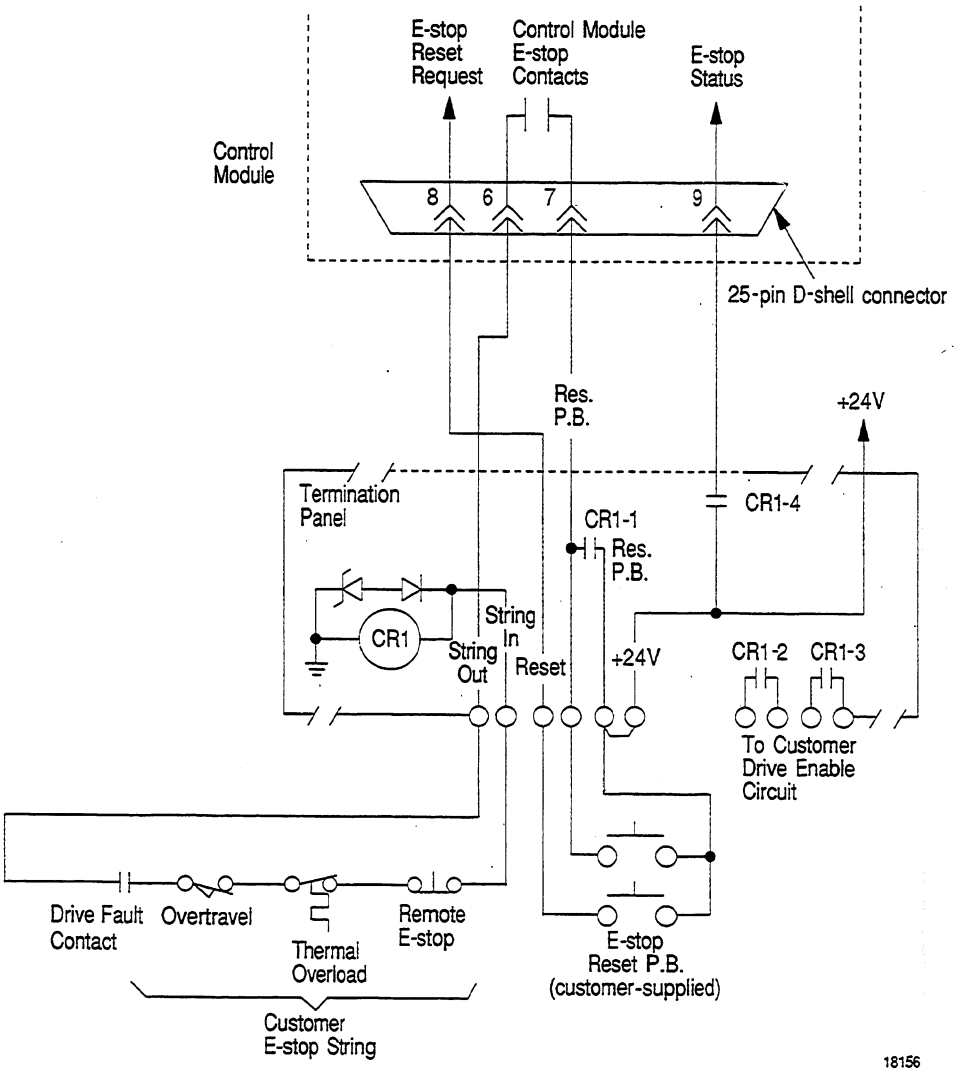
Figure 4.4 shows the ladder diagram for a system with one axis.
Figure 4.5 shows the E-stop diagram for a system with one axis.

Figure 4.4
Ladder Diagram for a One Axis System



CAUTION: If the above relay is not used, be sure that replacement relay has a coil resistance greater than or equal to 650Ω.

Figure 4.5
E-stop Circuitry Diagram for a One Axis System



To wire E-stop connections you must refer to wiring diagrams for the drive you are using. Table 4.B lists the figures that show wiring for four different Allen-Bradley compatible drives.

Table 4.B
Figure Numbers of the Wiring Diagrams for Compatible Allen-Bradley Drives

Figure	Wiring Diagram for
5.6	1386 DC Servo Drive
5.7	1388 DC PWM Servo Control
5.8	1389 AC Servo Amplifier
5.9	1391 AC Servo Control Module Amplifier
5.10	1392 AC Servo Amplifier
The 1389 servo drives requires a 115 V ac power contactor (K1) to supply main power to the drive amplifier. See the 1389 Servo Amplifier Installation Manual for details.	

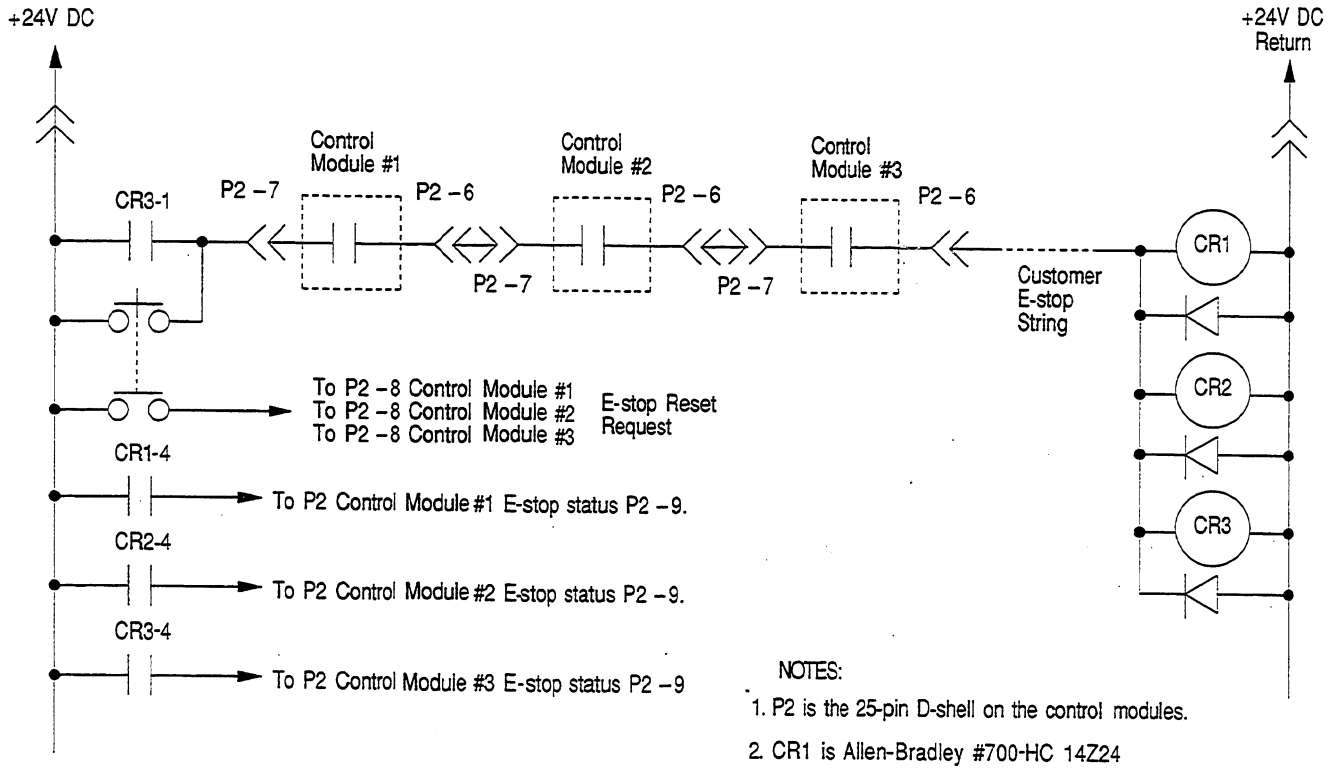
Wiring the E-stop for System with Two or More Axes

For a system with two or more axes you need a termination panel and a servo control module for each axis. Refer to Figure 4.6 and Figure 4.7 for the ladder diagram and E-stop circuitry diagram for a system with two or more axes. This type of system will have these E-stop characteristics:

- all of the control modules must be up and running before the system comes out of E-stop
- if any one axis drops into E-stop, the whole system drops into E-stop.

The number of axes on one E-stop String is determined by the power capacity of the user-supplied +24V dc power supply. Each E-stop String requires ~ 50 mA of current from the +24V supply.

Figure 4.6
Ladder Diagram for Two or Three Axis System



NOTES:

1. P2 is the 25-pin D-shell on the control modules.
2. CR1 is Allen-Bradley #700-HC 14Z24

   Coil: 24V DC 650Ω
   Contact: 3A Resistive, 120V AC
   Arrangement: 4 form C.
3. CR1, CR2, and CR3 auxiliary contacts to be used for drive enable of each drive amplifier. CR2 and CR3 may not always be required.

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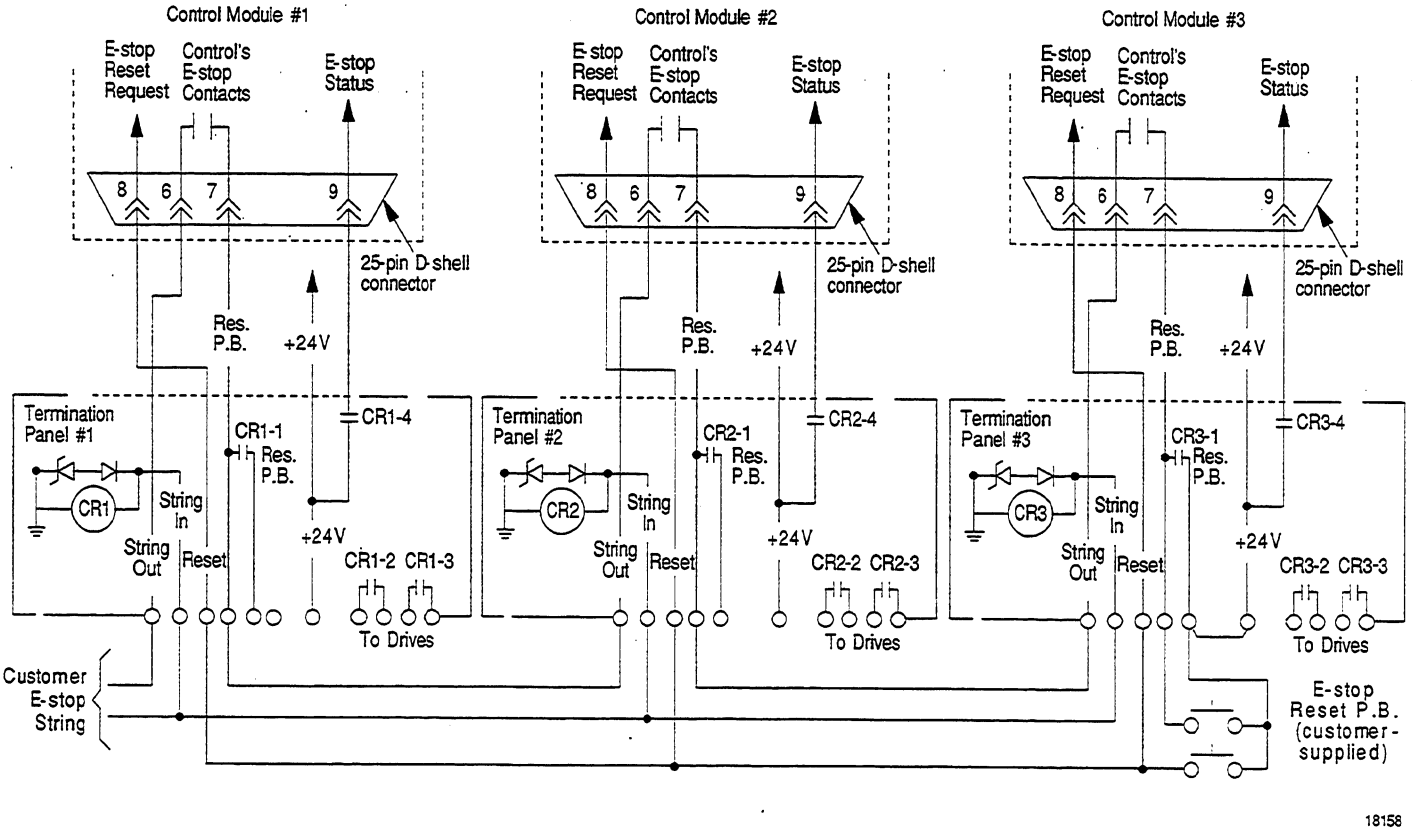
Figure 4.7
E-stop Circuitry Diagram for Two or Three Axis System



Chapter 5

Wiring Power Supplies, Encoders and Drives

Chapter Objectives

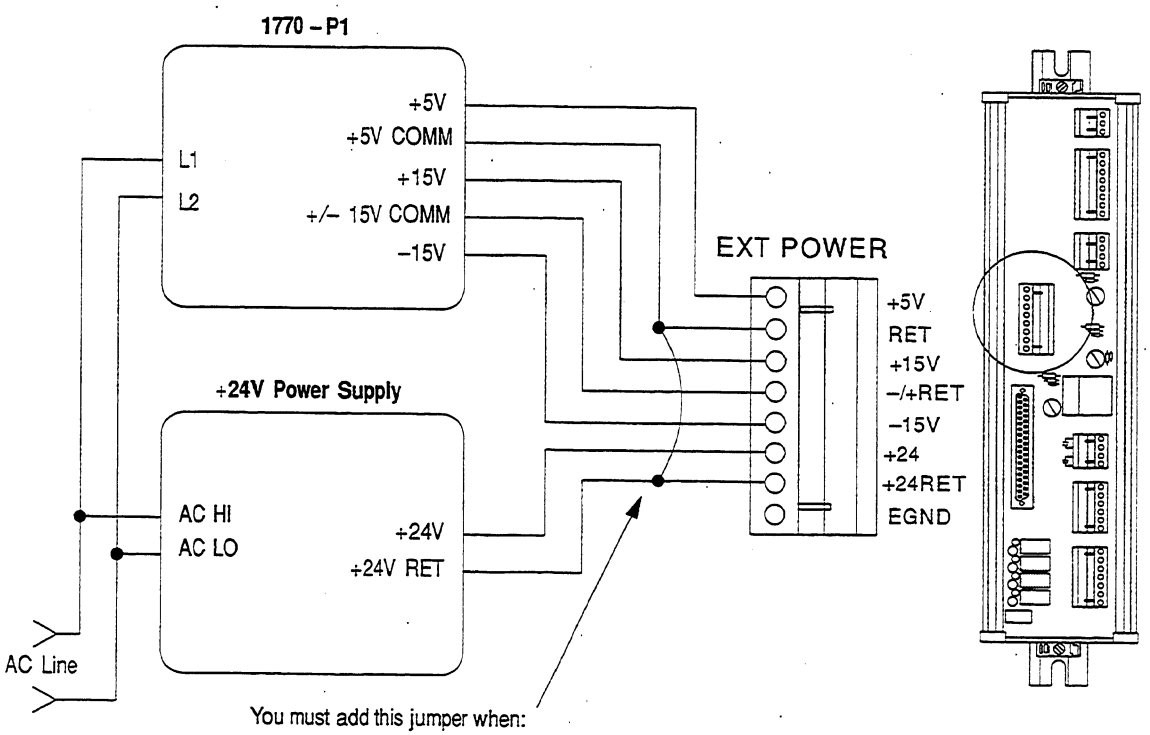
Now that you have wired the E-stop string and fast I/O, you can wire the system power supply(ies), encoders, and drives. This chapter discusses:

- wiring power supplies
- wiring encoders
- wiring A-B drive connections

Wiring Power Supplies

Figure 5.1 shows how to wire a 1770-P1 power supply (for backplane and user-side requirements) and a +24V power supply (for E-stop circuitry) to the termination panel.

Figure 5.1
Wiring a 1770-P1 Power Supply and a +24V Power Supply



WARNING: Failure to add this jumper when necessary will result in unpredictable operation of your control.

Wiring Encoders

When you wire encoders, use only a single, continuous, shielded cable segment. Wire the cable directly from the encoder to the termination panel.

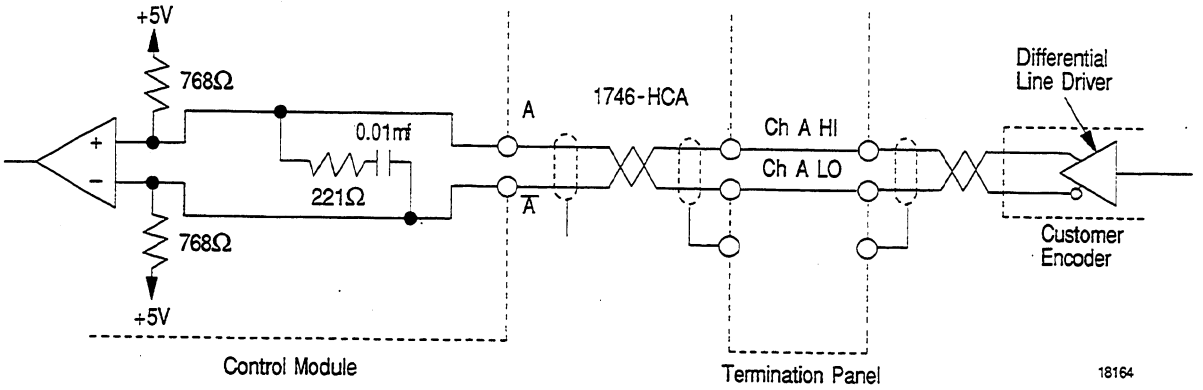
Cable length depends on the power supply for the user-side. Power at the encoder must be greater than or equal to the power requirement specified by the manufacturer. The minimum voltage requirement for the A-B 845H is 4.75V. The maximum voltage limit is 5.25V.

In order to meet the power requirement of the encoder and still attain maximum cable length, you can:

- raise the voltage of the power supply to meet the encoder requirement, but you cannot exceed the 5.25V limit of the control module
- increase the gage of the wire from the termination panel to the encoder (12 AWG maximum)

Figure 5.2 shows an encoder feedback equivalent circuit for channel A.

Figure 5.2
Encoder Feedback Equivalent Circuit



For proper operation of the control module, wire the encoder such that the marker Z is true at the same time that channels A & B are true. If you are using an AB845H encoder this requirement will already be met if you follow the wiring diagrams. If you are not using an AB845H encoder, then use the following wiring procedure:

1. Obtain the encoder output timing diagram from the vendors data sheets. A typical one is provided in Figure 5.3 as an example.

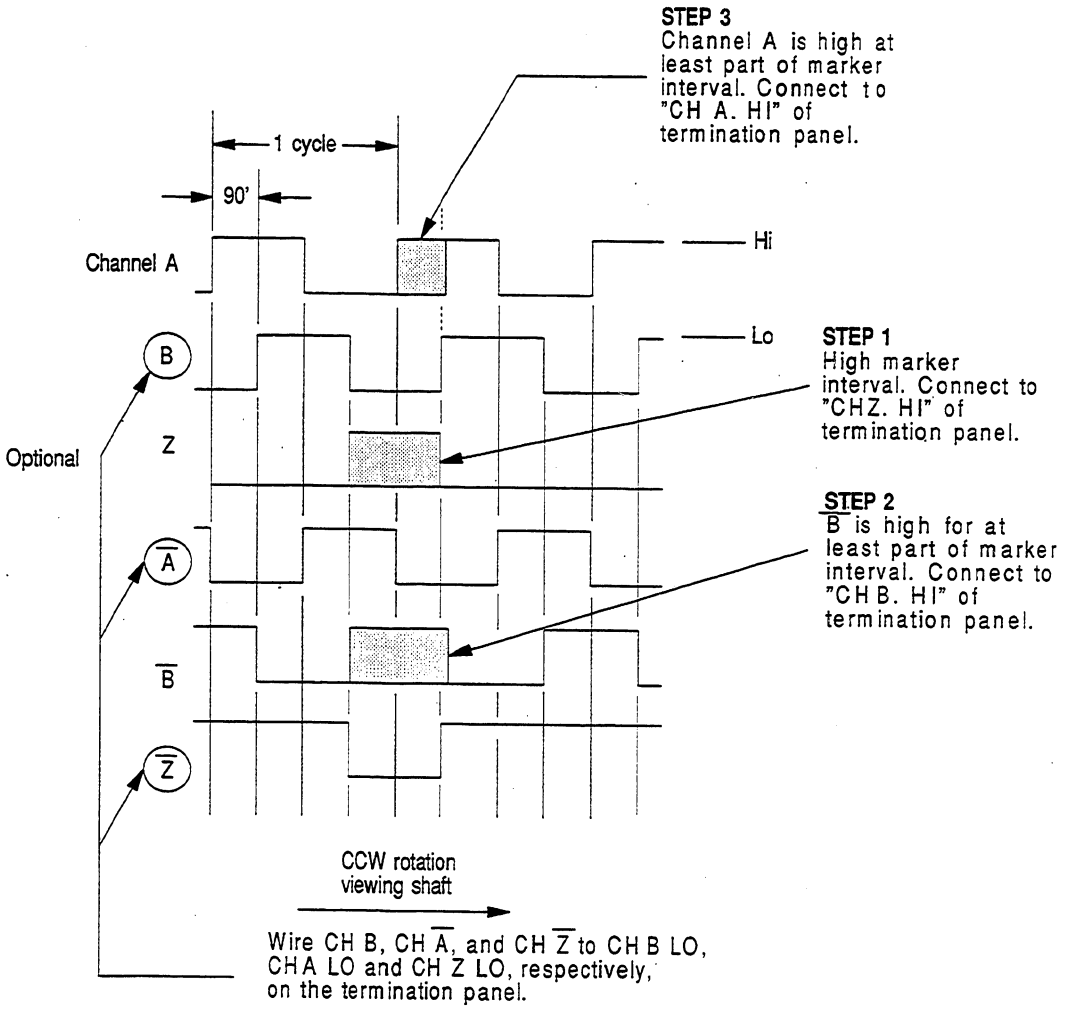
2. On the timing diagram, look at the marker Z and its complement, marker Z'. Whichever one is low for most of the encoder revolution and pulses high for the marker interval should be wired to "CH Z.HI" of the termination panel. Wire the other to "CH Z.LO" of the termination panel.

3. Look at channel B and its complement, channel B'. Whichever one is high for at least part of the marker interval should be wired to "CH B.HI" of the termination panel. It is possible that both channels meet this requirement depending on the encoder manufacturer, in which case, use either one. Wire the remaining phase to "CH B.LO" of the termination panel.

4. Look at channel A and its complement channel A' and repeat as in step 3 using "CH A.HI" of the termination panel and the remaining wire to "CH A.LO".

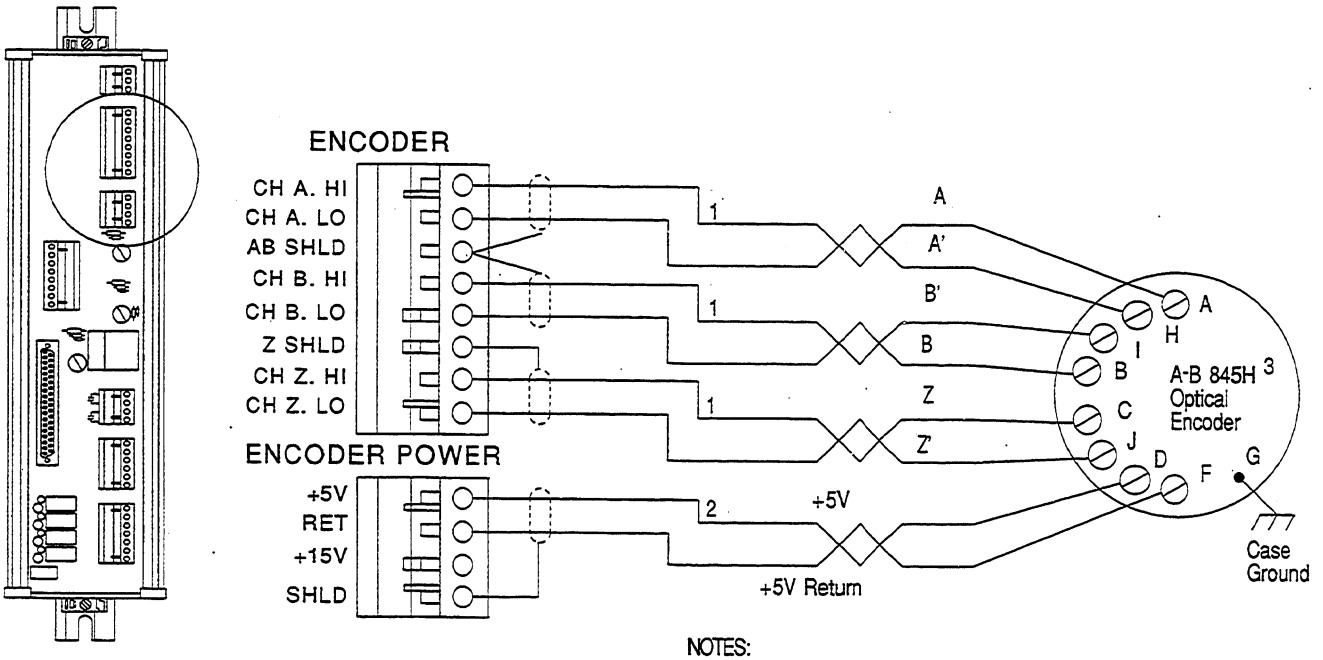
If the above wiring is not performed correctly, inconsistent homing of the axis may occur.

Figure 5.3
Typical Vendor Encoder Timing Diagram



Since an encoder may be mounted on either end of the ball screw, the encoder may spin CW or CCW for a given table direction. As a result, the direction (phasing) of the feedback may be backwards. If you switch Channel A wiring with Channel B wiring, you will change the direction of the feedback.

Figure 5.4
5V Encoder Feedback Connections



NOTES:

1 Use 3 pair 22 gauge individually twisted and shielded cable.

2 Use 1 pair 18 gauge twisted and shielded cable.

3 Encoders must have +5V compatible differential line drive outputs on channels A, B, & Z. (DS 8830 or equivalent.) (A-B 845H).

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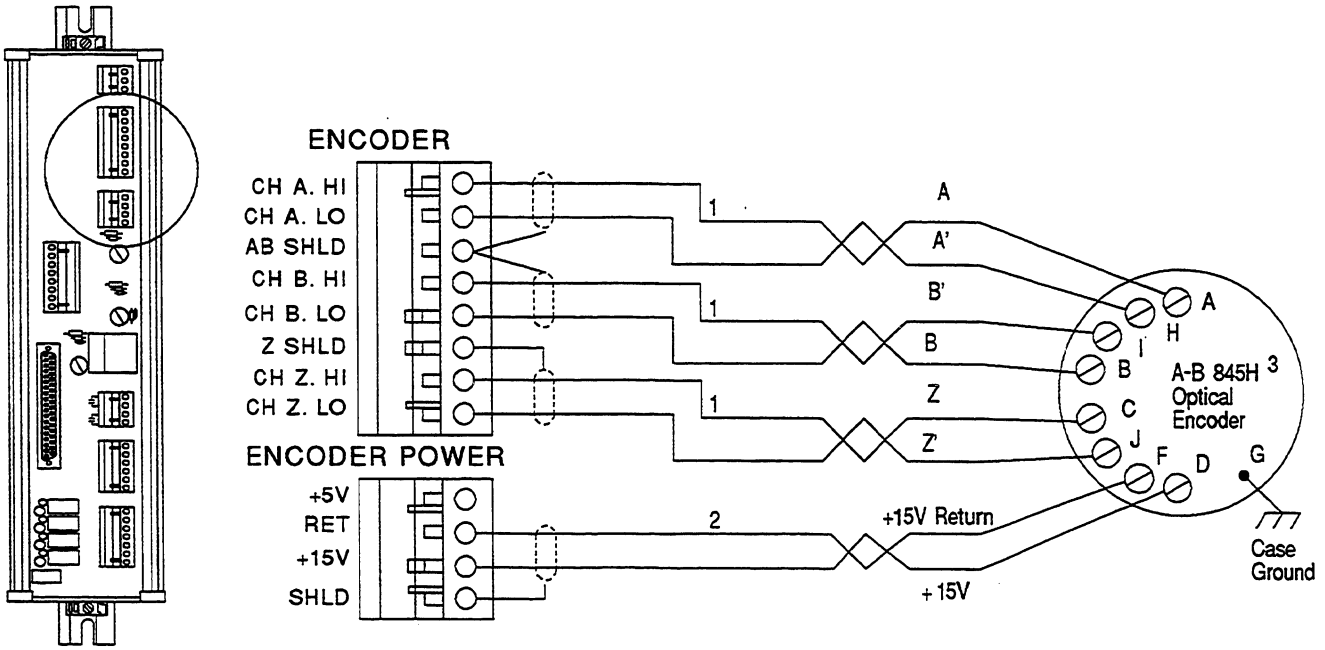
Figure 5.5
15V Encoder Feedback Connections



NOTES:

1 Use 3 pair 22 gauge individually twisted and shielded cable.

2 Use 1 pair 18 gauge twisted and shielded cable.

3 Encoders must have +5V compatible differential line drive outputs on channels A, B, & Z. (DS 8830 or equivalent.) (A-B 845H). 18170

Wiring A–B Drive Connections

The IMC 110 supports series 1386, 1388, 1389, 1391, and 1392 servo controllers (amplifiers).

Before you wire the drive to the termination panel, you must mount, set pre-startup adjustments, and wire your system.

Table 5.A lists installation references for each servo control system (amplifier) to enable you to do this.

Table 5.A
A–B Drives Installation References

A–B Drive	Catalog No.	Title
1386	1386-5.0	Bulletin 1386 DC Servo Drive Instruction Manual
1388	1388-5.1	Bulletin 1388 DC PWM Servo Controller Instruction Manual
1389	1389-5.0	Bulletin 1389 AC Servo Amplifier System Operator Instructions
1391	1391-5.0	Bulletin 1391 AC Servo Controller User Manual
1392	1392-5.1	Bulletin 1392 High Performance AC Drive Instruction Manual

These figures show the how to wire A-B drives to the termination panel:

Table 5.B
Figure References for Wiring Drives

Drive	Figure
1386	5.6
1388	5.7
1389	5.8
1391	5.9
1392	5.10

Figure 5.6
Wiring Diagram for Series 1386 Drives

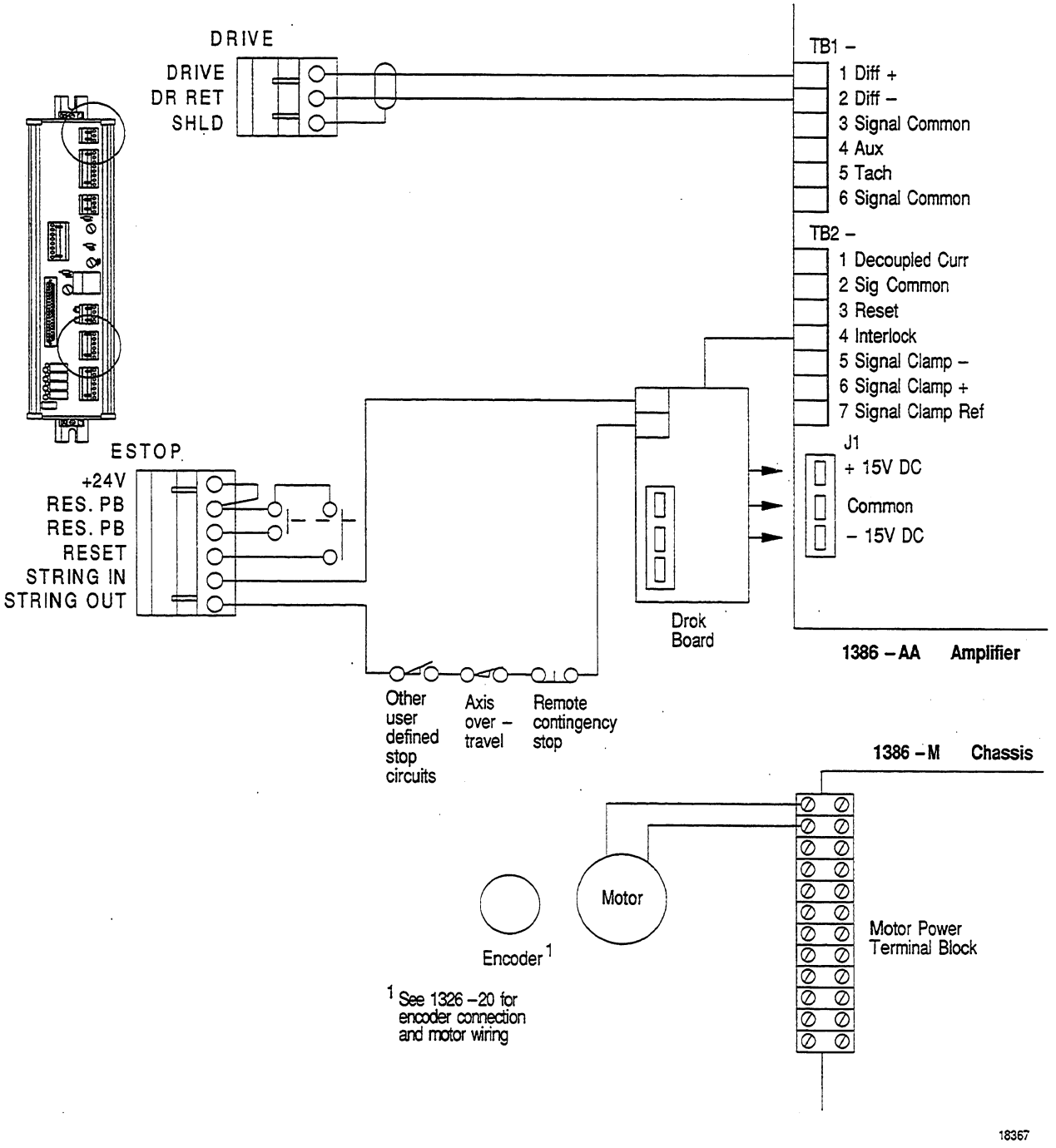


Figure 5.7
Wiring Diagram For Series 1388 Drives

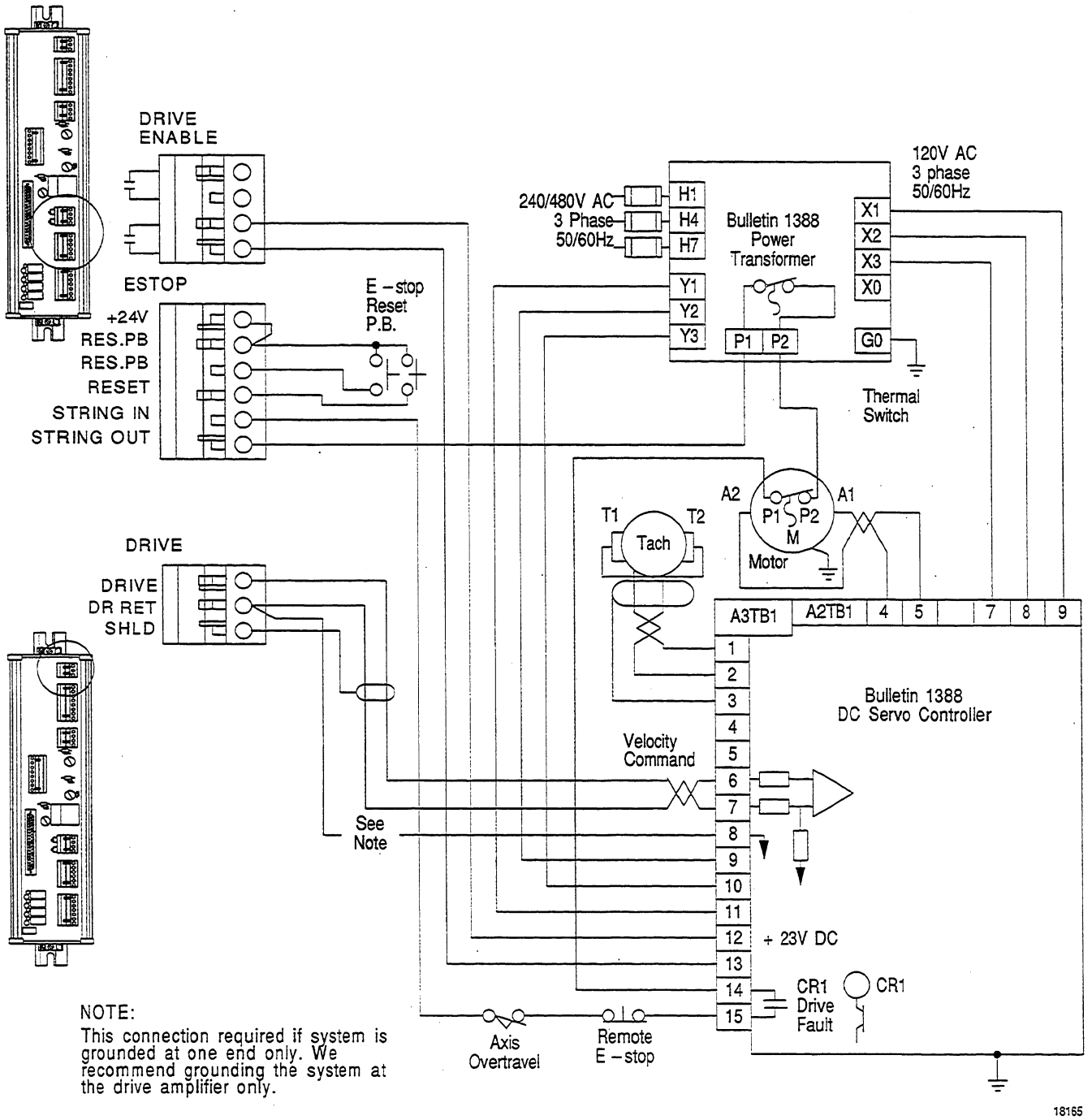


Figure 5.8
Wiring Diagram For Series 1389 Drives

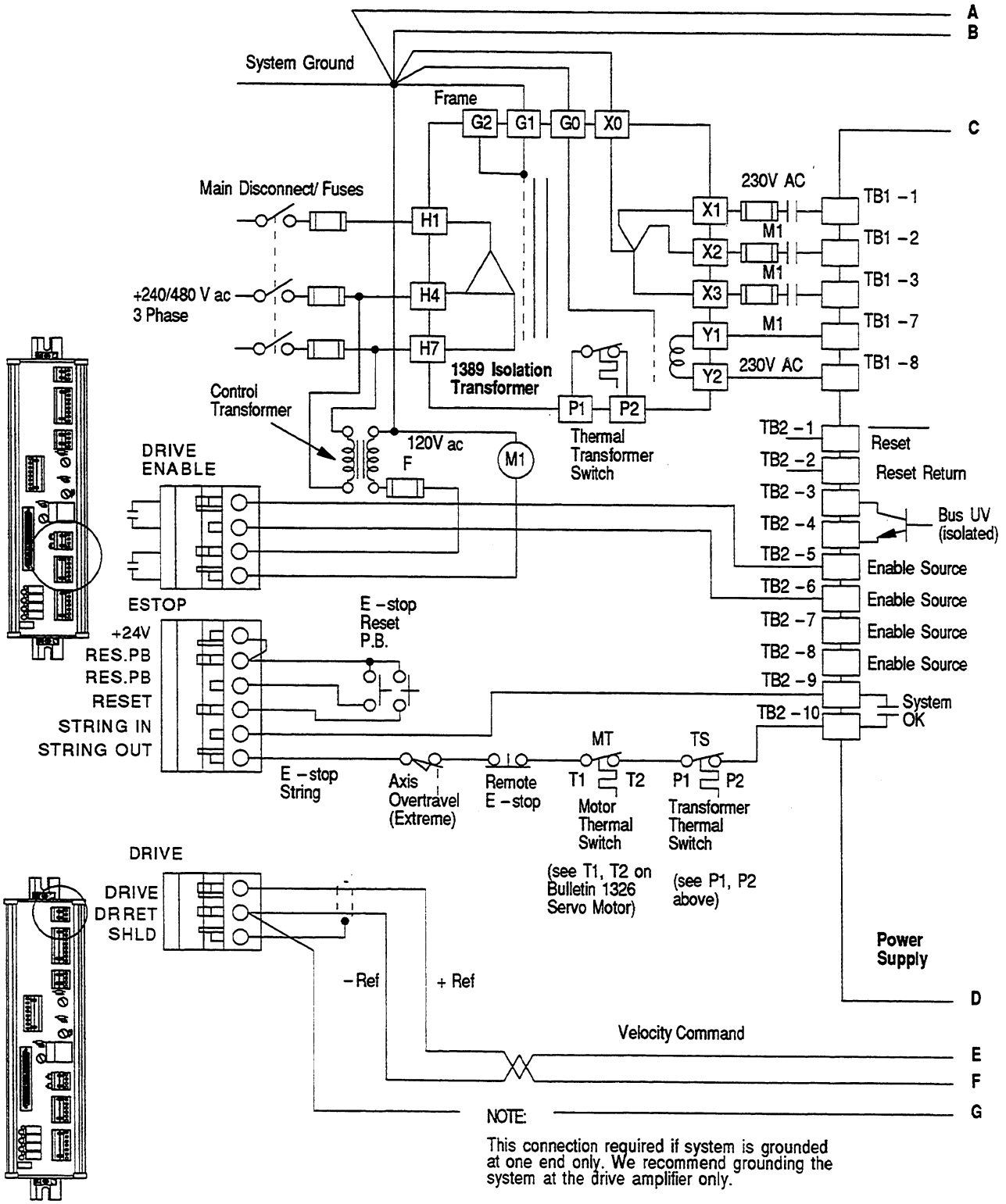


Figure 5.8 (continued)
Wiring Diagram For Series 1389 Drives

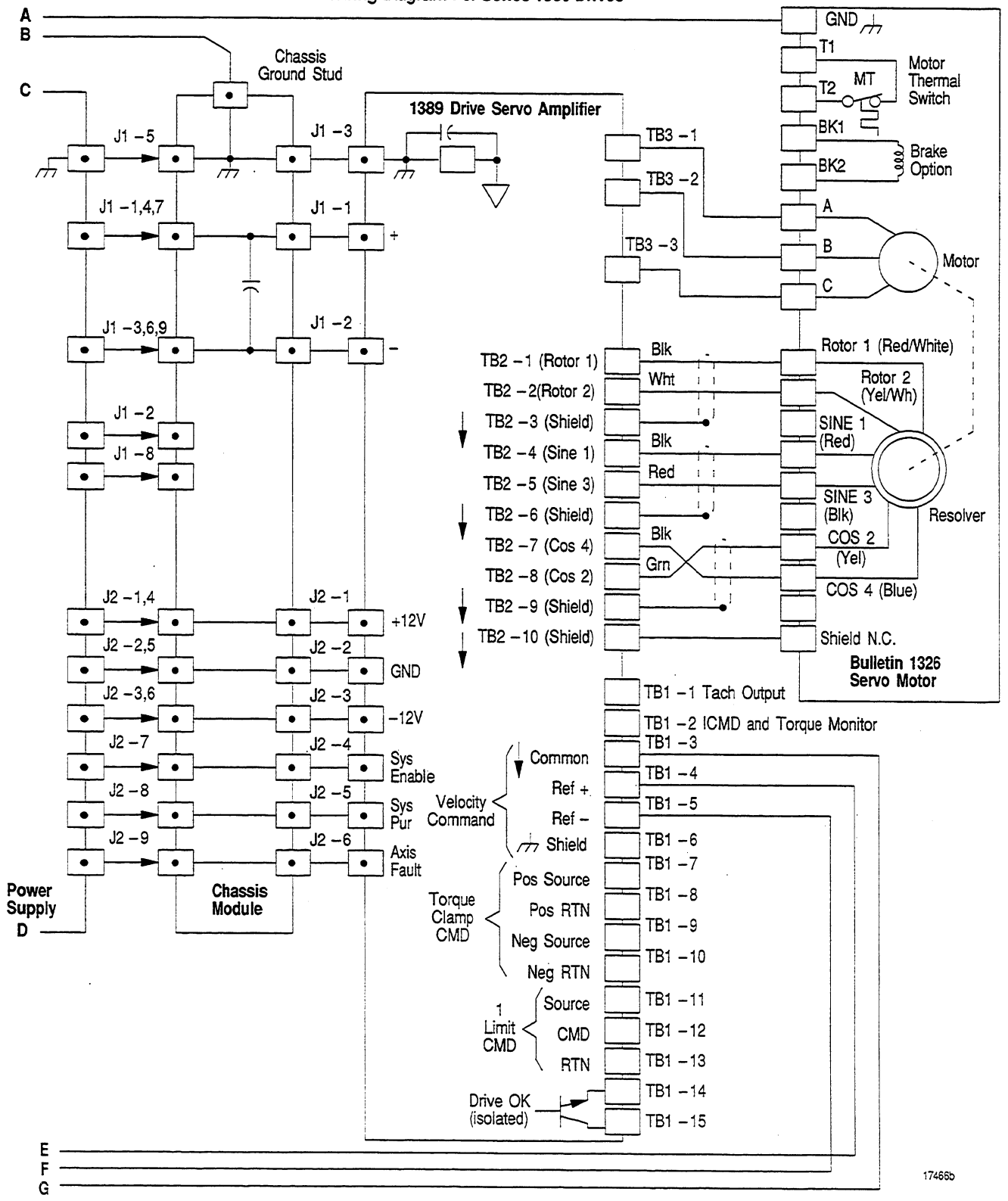


Figure 5.9
Wiring Diagram For Series 1391 Drives

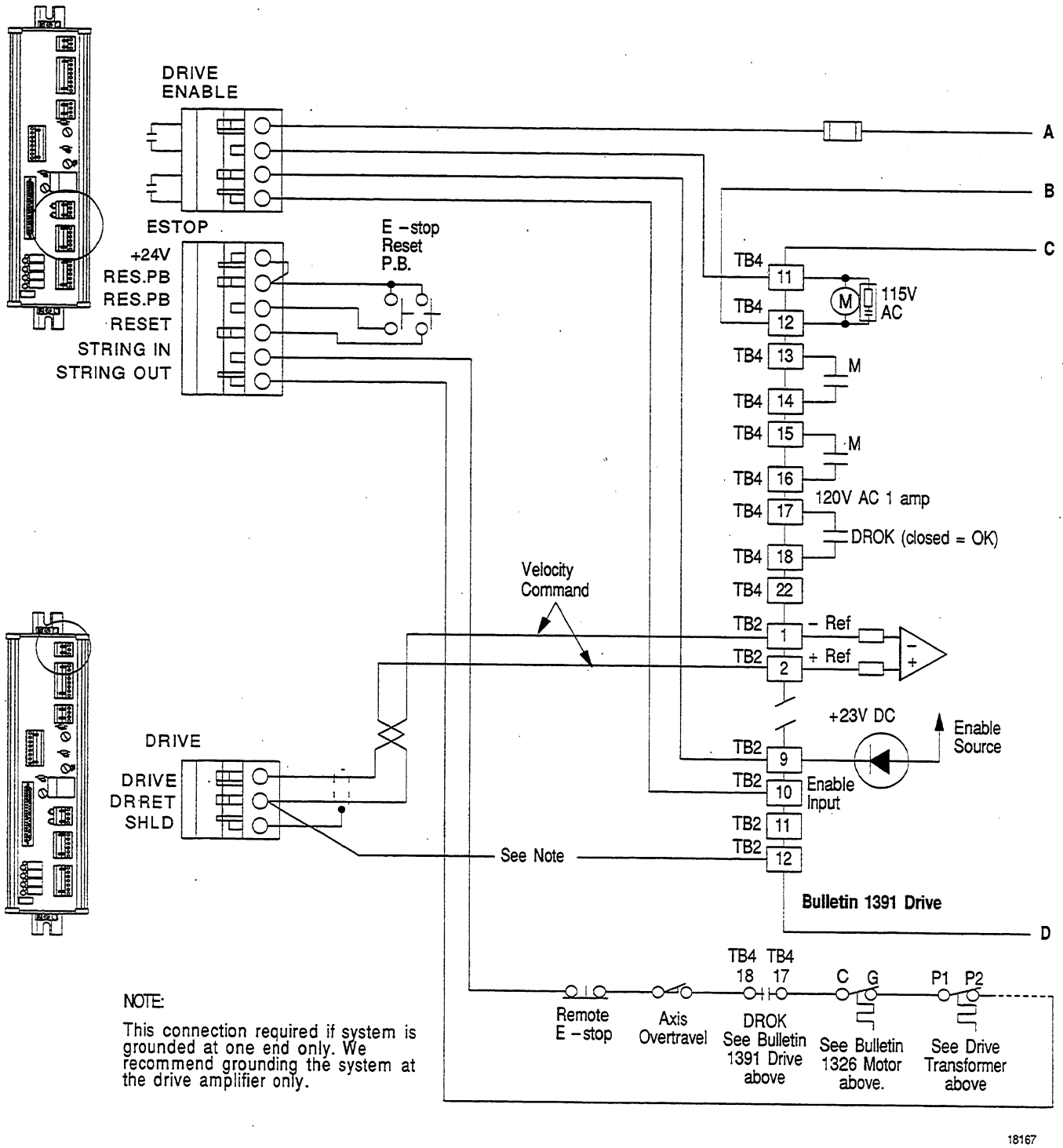


Figure 5.9 (continued)
Wiring Diagram For Series 1391 Drives

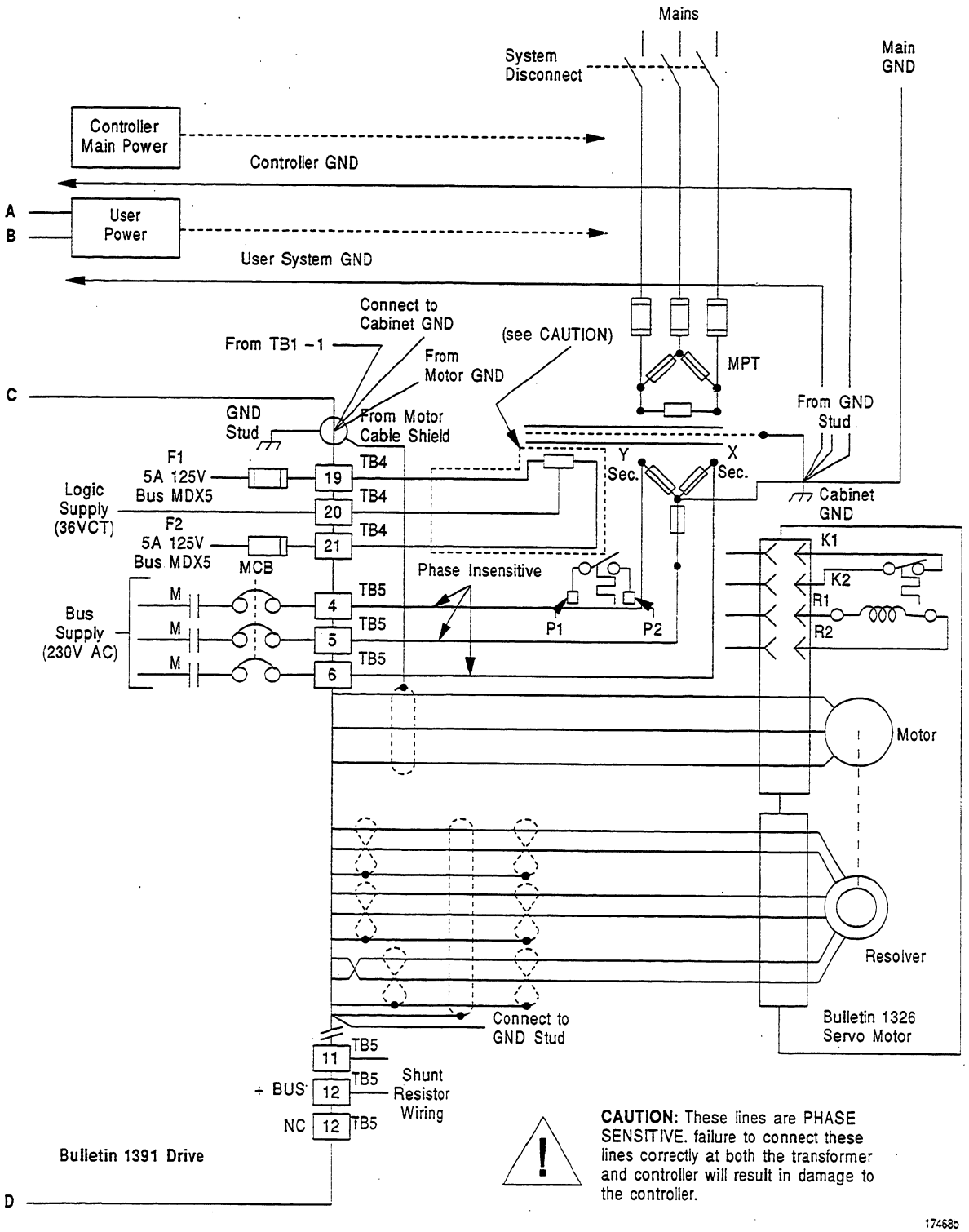
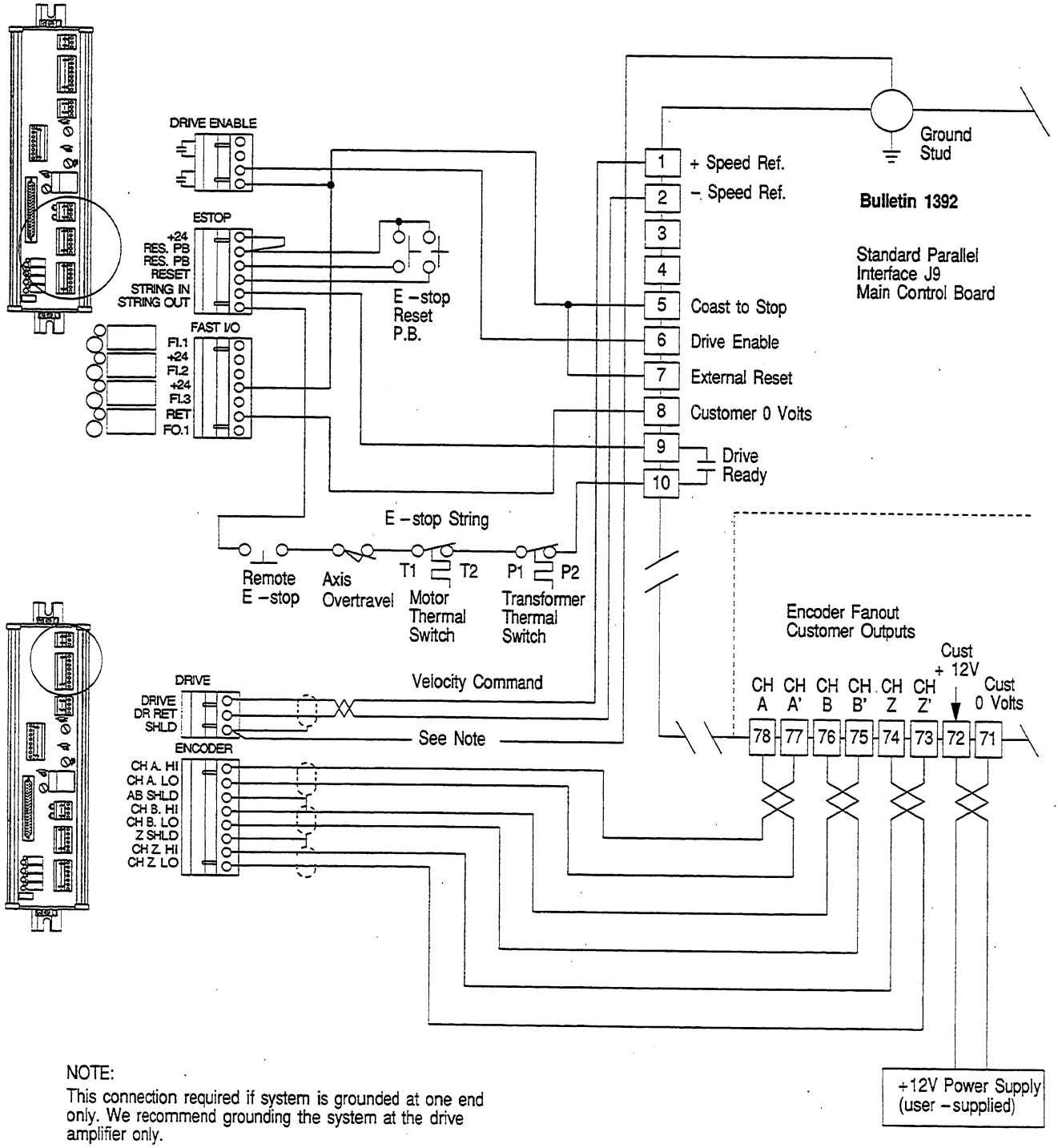


Figure 5.10
Wiring Diagram For Series 1392 Drives



NOTE:
This connection required if system is grounded at one end only. We recommend grounding the system at the drive amplifier only.

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Connecting the Velocity Command

Use 18-22 gauge shielded/twisted pair wire to connect the analog velocity command output signal (consisting of DRIVE and DR RET connections) from the DRIVE termination panel connector to the corresponding terminals of the various servo drives shown in Figure 5.6, Figure 5.7, Figure 5.8, Figure 5.9, and Figure 5.10. Connect this signal so that the direction of motion that results from it matches the correct direction of motion as you have defined it.

Reversing these connections reverses the direction the axis moves in response to a given polarity of the velocity command.

CAUTION: Some vendors drive amplifiers only provide a single-ended input for the velocity command. If you reverse the control module DRIVE OUT connections, you will short out the velocity command.

Chapter 6

Testing the IMC 110 Hardware

Chapter Objectives

This chapter discusses:

- powering up the IMC 110 system
- testing E-stop wiring
- testing fast I/O
- integrating the axes
- testing homing

Powering Up the IMC 110 System

Before you turn the power switch on, you should make sure:

- ac line is wired correctly on the power supply
- that the voltage is set correctly (120V or 240V)
- user power cables are connected and routed appropriately
- cable from the control module to the termination panel is connected
- wiring from the termination panel to drives, encoders, fast input and output devices, E-stop string and E-stop Reset button are connected

Use the following steps to power your IMC 110 system.

1. Turn the system power on.

2. After the control module initializes and performs its quick hardware diagnostics, its RUN led should be lit. If this is not the case refer to Table 6.A for a description of the LED pattern.

Table 6.A
LED Patterns on the Control Module

LED Pattern		Description
RUN	ON	System O.K.
FDBK/U.PWR	off	
LOAD AMP	off	
RUN	off	Power has not been applied or there has been a catastrophic failure.
FDBK/U.PWR	off	
LOAD AMP	off	
RUN	off	Hardware failure
FDBK/U.PWR	off	
LOAD AMP	ON	
RUN	off	Hardware failure
FDBK/U.PWR	ON	
LOAD AMP	off	
RUN	off	Power-up or RAM failure
FDBK/U.PWR	ON	
LOAD AMP	ON	
RUN	ON	AMP (Adjustable Machine Parameters) not loaded
FDBK/U.PWR	off	
LOAD AMP	ON	
RUN	ON	Feedback fault (broken wire, quadrature fault) or loss of user power.
FDBK/U.PWR	ON	
LOAD AMP	off	
RUN	ON	AMP not loaded and loss of user power
FDBK/U.PWR	ON	
LOAD AMP	ON	

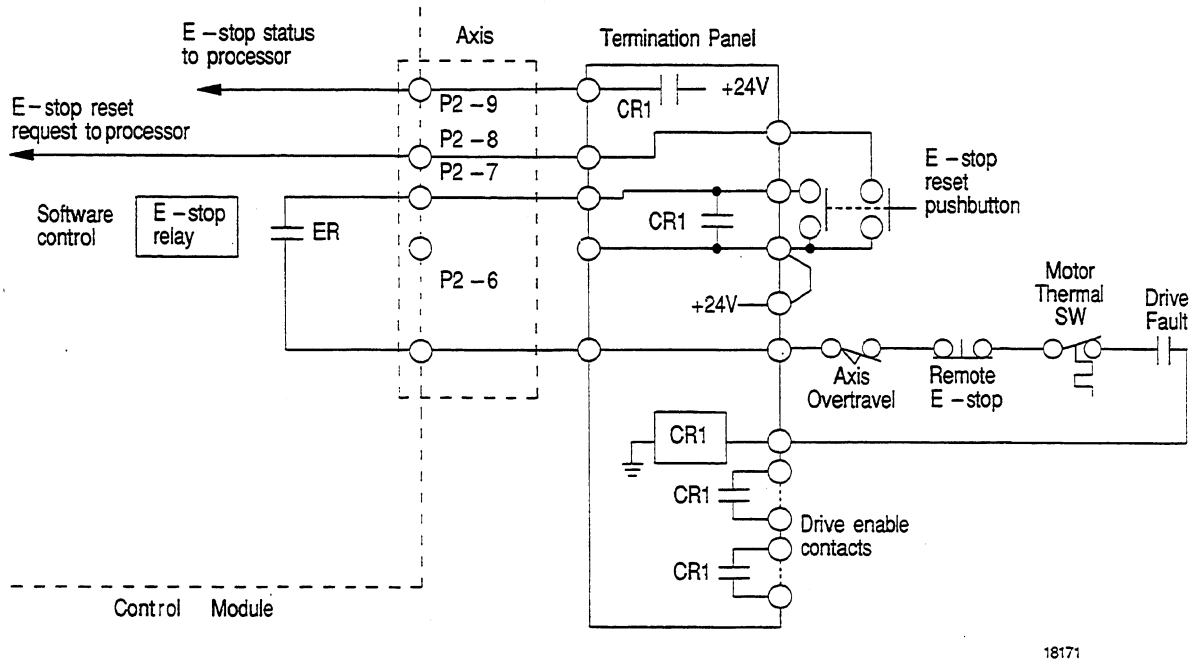
Testing E-stop Wiring

You should first test your E-stop wiring before you:

- test your fast I/O
- perform open and closed loop integration of drives and feedback devices

Figure 6.1 shows the wiring diagram for the E-stop circuit. Use this figure to first check the E-stop RESET pushbutton and then each contact on the E-stop string.

Figure 6.1
E-stop Circuitry



To check the E-stop RESET pushbutton, perform the following steps:

1. Disconnect the motor from its ball screw
2. Disconnect the drive enable contacts.
3. Disconnect the E-stop string at the termination panel
4. Short the (machine tool) hardware E-stop string.
5. Press the E-stop RESET pushbutton and hold it in.

The IMC 110 software detects an E-stop reset request and energizes the software controlled E-stop relay in the control module. Since the E-stop string is shorted, K1 seals the E-stop Reset pushbutton.

6. Release the E-stop Reset pushbutton and K1 will remain on. K1 may be verified to be on either visually or via a continuity check on one of the normally open drive enable contacts. Remove the string out/string in jumper and K1 should drop out indicating an E-stop condition.

7. Re-connect the E-stop string and drive enable to the termination panel to get the system up and running.

WARNING: Leave the motor disconnected from its ball screw.

Now that you know that the circuitry for the E-stop Reset pushbutton works, you can test each contact (i.e. the axis overtravel, remote E-stop, motor thermal switches) on your E-stop string. Since each element in the string is closed normally, open each contact on the string to ensure that the system goes into E-stop.

Testing Fast I/O

Input devices can be wired normally open or normally closed.

Testing Fast Inputs

Use the following steps to test fast inputs:

Fast input devices that are normally open:

1. Close the input device.

2. Check to see if the fast input LED on the termination panel lights.

Fast input devices that are normally closed:

1. Open the input device.

2. Check to see if the fast input LED on the termination panel goes off.

If not, then you know that there is a problem with the wiring between the termination panel and the input device.

3. Check the status of the fast input at the control module by using the handheld pendant:

Press This Key	To Select
<DEBUG>	Debug Menu
<F3>	Debug
<F4>	Variable

Enter variable name FIN [#] where # = 1 through 3 and view the value of that FIN # that you entered.

Testing Fast Output

Outputs are set by executing the MML program.

Use the handheld pendant to set and then test values for FO.1:

Press This Key	To Select
<DEBUG>	Debug Menu
<F3>	Debug
<F4>	Variable

Enter variable name FOUT [1] and set the value of FOUT [1]. Then check whether that LED (FO.1) on the termination panel lights. Next check the output device to see if it is activated.

Integrating the Axis

To integrate the axis you must first perform the open loop procedure and then the closed loop procedure. You must perform these procedures in conjunction with your servo drive manufacturers instructions.

Important: For these procedures to work, servo drive and motor must be capable of controlling axis motion according to your requirements. The control module cannot overcome inherent limitations of drives, motors, or axis mechanisms.

The Open Loop Procedure involves:

- supplying voltage to the drive input
- checking phasing of the drive input and axis feedback
- checking axis motion for smoothness and response.

The closed loop procedure involves closing the axis position loop and checking axis response to commands from the control module.

Before you begin axis integration, make sure that all system wiring has been completed:

- E-stop string is wired and functioning properly. Verify that the extreme overtravel limit switches cause E-stop and interrupt power to the drives.
- Encoder has been wired as shown in chapter 5.
- The velocity command connections have been made between the control module and the servo drive as described in chapter 5.
- Home limit switch is wired and verified to be functional.

Both the open and closed loop procedures use handheld pendant tasks. Table 6.B lists the key strokes of each task and the chapter in the Handheld Pendant Operator's Manual (publication 1746-ND002) to refer to if you want to learn more. Steps in the open and closed loop procedures refer to the task that needs to be performed.

Table 6.B
Handheld Pendant Tasks

Task #	Task	Press Key (s)	To Select	Refer to Chapter
1	Selecting Open Loop	[DEBUG] [F2] [ENTER]	Debug Menu Open/Close Loop Return to debug menu	5
2	Selecting Closed Loop	[DEBUG] [F2] [ENTER]	Debug menu Open/Close Loop Return to Debug Menu	5
3	Selecting the jog type	[JOGS] [F1] [F1], [F2], [F3] or[F4] [ENTER]	Jogs Menu Jog type Continuous/Incremental/Home/Return to Position Return to Jogs main menu	6
4	Selecting the jog speed	[JOGS] [F2] [F1]or [F2] [ENTER]	Jogs Menu View two jog speeds Choose a suitable speed (speeds are set in AMP) Return to Jogs Main menu	6
5	Monitoring Position, Following Error, Speed, Speed Override	[STATUS] [F3]	Status Menu Axis Status	4

Open Loop Procedure

Use the following steps to perform open loop integration.

1. Remove power to the control module and servo drive.

2. Remove servo drive fuses to ensure that the servo drives are disabled.

3. Disconnect the servo motor from the ball screw.

4. Replace the axis fuses, then re-apply power to the control module and the servo drive.

5. Use the handheld pendant to select the OPEN LOOP JOG mode (see task #1 in Table 6.B).

6. Press the E-stop Reset pushbutton and allow the system to come out of E-stop. At this point, the control module is not commanding motion (VELOCITY COMMAND = OV) and is not attempting to close the position loop.

7. If the motor rotates without acceleration, you may need to adjust the drive balance; refer to the servo drive manufacturers instructions.

If the motor starts to accelerate, the leads from the tachometer to the servo drive are reversed or disconnected.

If the motor is stationary or is moving very slowly, proceed to step 8.

8. As you watch the servo motor, command an open-loop jog in both directions ([JOG+] and [JOG–]) at a low speed. To set up jogging on the handheld pendant, perform these tasks in Table 6.B.

   - select open loop jog (see task #1)
   - select continuous jog type (see task #3)
   - select jog speed (see task #4)

   The motor should respond in both directions and return to a stationary position when the command is terminated.

WARNING: If sudden high speed rotation occurs, the velocity loop is not properly closed at the servo drive. Do not proceed until the problem has been corrected. See your drive manufacturers instructions for details.

9. Remove power to the control module and the servo drives.

10. Remove servo drive fuses to ensure that the servo drives are disabled.

11. Connect the servo motor to the ballscrew. Locate the axis near the midpoint of its travel.

12. Replace the axis fuses, then re-apply power to the control module and the servo drive.

13. Verify that the handheld pendant is still in the OPEN LOOP JOG mode.

CAUTION: Do not select NORMAL JOG mode (see task #1 in Table 6.B) during this procedure or sudden motion may occur. Keep all personnel away from the axis.

14. Press the E-stop Reset pushbutton to allow the system to come out of E-stop.

15. Check for correct phasing of the velocity command:

    - Pressing [JOG +] in OPEN LOOP JOG mode should cause axis motion in the direction that part programs will call positive (ignore the pendant position display).
    - Pressing [JOG –] in OPEN LOOP JOG mode should cause axis motion in the direction that part programs will call negative (ignore the pendant position display.)

CAUTION: Keep the axis near its center of travel. Running the axis into its mechanical stops could damage equipment.

If you inadvertently run an axis far enough to trip an overtravel limit switch, you will cause an E-stop and will shut off power to the drives. Manually back the axis off the limit switch and then press the E-stop Reset pushbutton to re-initialize the axis.

16. Run the axis at increasing speeds in both directions (see task #4 in Table 6.B to change speeds). Check for smooth axis motion. There should be no mechanical vibration or cogging. If there is, take appropriate corrective action.

17. Verify that 1/2 the maximum velocity command causes axis motion at approximately 1/2 the maximum axis speed. Check this for both directions of axis motion. You may need to adjust the servo drive. Refer to the servo drive manufacturers instructions.

18. Using the handheld pendant, monitor axis position feedback as you move the axis slowly in both directions (see task #5 in Table 6.B). When the axis moves in the positive direction (JOG+), axis position should increase in the positive direction. When the axis moves in the negative direction (JOG–), axis position should change in the negative direction.

19. If position feedback does not correspond to axis position, swap the wires to $\overline{A}$ and A with the wires that connect $\overline{B}$ and B.

Closed Loop Procedure

Follow this procedure to close the axis positioning loop. You MUST perform this procedure in conjunction with the servo drive manufacturer's instructions.

You must perform the open-loop procedure before you can perform the closed-loop procedure.

1. Make sure that the axis is at the approximate midpoint of its travel.

2. Power up the control module and the servo drive.

3. Using the handheld pendant, select the OPEN LOOP JOG mode (see task #1 in Table 6.B).

4. Press the E-stop Reset pushbutton to allow the system to come out of E-stop.

5. Using the handheld pendant, select the NORMAL JOG mode (see task #2 in Table 6.B). The control module is not commanding motion, but is closing the position loop.

   If the open loop procedure was performed correctly, no axis motion should occur.

WARNING: The operator should be prepared to hit the E-stop button in case unexpected motion occurs. If this happens, the open loop procedure was not performed correctly. Do not continue until the problem is corrected.

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6. Verify that there is no axis motion. If necessary, adjust the drive balance (at the servo drive) so that:

   - the axis following error (see task #5 in Table 6.B) is zero
   - no motion occurs, when the control module is not commanding motion (analog output voltage is zero).

7. Jog the axis in the positive direction <JOG+> at about 1/2 maximum traverse speed. Calculate to see if the following error is correct (see task #5 in Table 6.B to monitor the following error):

   If loop closure method = standard

   $$\text{Following error} = \frac{\text{velocity}}{\text{gain} * 1000}$$

   If loop closure method = velocity feed forward

   $$\text{Following error} = \frac{(\text{velocity})(1 - \text{feed forward const.})}{(\text{gain} * 1000)}$$

   where: following error is in thousandths of an inch and velocity is in inches/minute.

For more information on AMP parameters refer to the AMP Reference Manual (Publication 1746-ND003)

If necessary, adjust the gain of the drive to achieve the correct following error.

8. Jog the axis in the negative direction [JOG–] at the same rate used in Step 7. The following error should be the same. If not, lower one of the D/A voltage values (either parameter #2580, Output Voltage at + Max Speed or parameter #2590) in AMP to compensate.

9. Repeat steps 7 and 8 to verify the correction. The following error should be the same for both directions.

10. Jog the axis in both directions at various speeds and observe the following error. At each speed, the following error should be the same for axis motion in either direction.

11. Jog the axis back and forth within its range of travel. Use feedrate override to vary axis speed. Verify that axis motion is smooth and stable at all speeds, including rapid traverse, in both directions.

    If it is not, check the AMP parameters that affect motion (refer to the AMP Reference Manual, publication 1746-ND003). These parameters influence axis stability and positioning accuracy and may require minor adjustment at this point. If necessary, adjust the servo drive according to the manufacturers instructions to obtain the desired results. Repeat this closed-loop integration procedure for each axis.

Testing Home Using the Home Position Switch

To home an axis to the home position switch, follow this procedure:

1. Press [JOGS] to display the main menu.
2. Press [F1] to display the Jog Type menu.
3. Press [F3] to select the jog type: home.
4. Press [ENTER] to return to the Jogs menu.
5. Press [F2] to display the Jog Speed menu.
6. Press [F1] or [F2] to select the jog speed you want. Jog speeds are AMP values. For more information, refer to the AMP Reference Manual (publication 1746-ND003).
7. Press [ENTER] twice to return to the main menu.
8. Press [JOG +] or [JOG–] to jog to the home position switch.

When the control is homed the message HOME SUCCESSFUL will appear on the handheld pendant. With this procedure, it is possible for the control to miss the marker closest to the home position switch. The control will home to the next closest marker, and your home position will be off. There are two ways you can correct this:

- re-position your home position switch so that the distance between the edge of the switch and the closest marker is about half a revolution. Then change the AMP value for Speed of Move to Marker to the lowest speed possible and re-home.
- adjust the position of your encoder so that the marker is half a revolution from the point at which the home position switch deactivates. Then change the AMP value for the Speed of Move to Marker to the lowest speed possible and re-home.

Testing Home Using Encoder Marker

To home an axis to the nearest encoder marker follow this procedure:

1. Press [JOGS] to display the main menu.
2. Press [F1] to display the Jog Type menu.
3. Press [F3] to select the jog type: home.
4. Press [ENTER] to return to the main menu.
5. Press [JOG +] or [JOG–] to jog to the home position switch.

When the control is homed the message HOME SUCCESSFUL will appear on the handheld pendant.

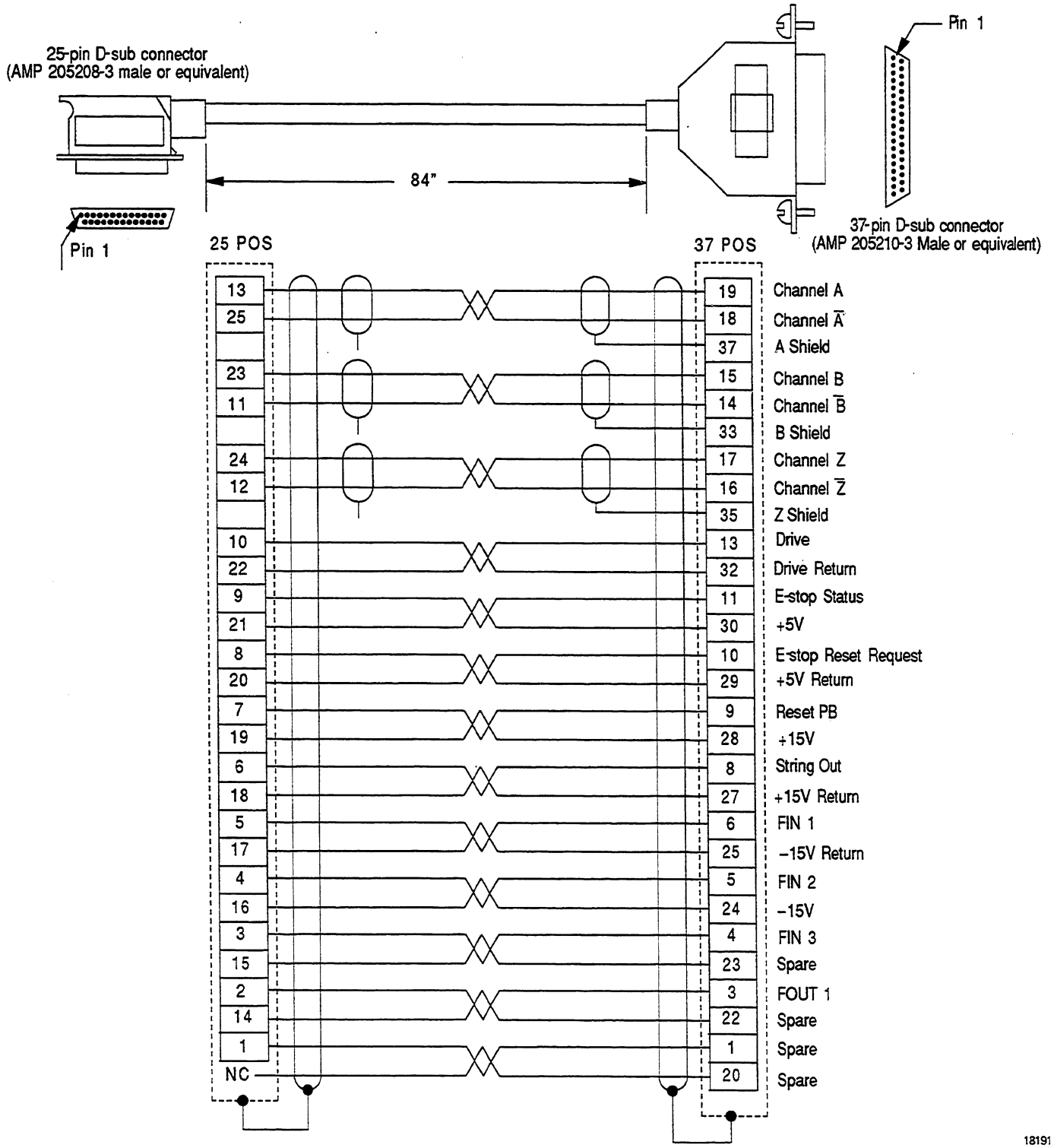
Appendix A

Cable Specifications

Appendix Overview

This appendix contains the specifications and wiring diagram for the 1746-HCA cable.

Figure A.1
1746-HCA Cable Specifications and Wiring Diagram



Appendix B

Wiring Without the Termination Panel

Appendix Overview

In this appendix, we discuss how you wire your IMC 110 system without a termination panel. If you don't use a termination panel, you will need to wire from the connectors on the control module to these user devices:

- fast inputs and outputs
- E-Stop Reset pushbutton, E-Stop string, and E-Stop relay
- power supplies
- encoders
- drives

Specifically we:

- list the pinout signals of the connector on the control module
- discuss how to use the wiring diagrams in this manual with the connector pinouts
- list the distance limitations for user devices

Using Fast Inputs and Outputs

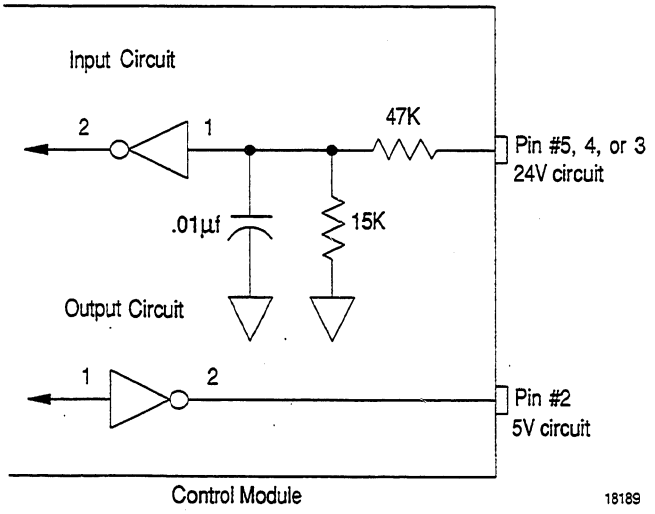
When using fast inputs you must snub all inductive and capacitive loads.

CAUTION: The fast output is a 5V circuit. Do not exceed the limit of this circuit. If you wire 24 V to the fast output you will damage your equipment.

The high-level, on-state output current for each output is maximum +5V @ ± 20.0 mA and minimum +0V @ ± 20.0mA.

Figure B.1 shows the circuitry in the control module for fast inputs and outputs.

Figure B.1
Circuitry in the Control Module for Fast Inputs and Outputs



Distances to User Devices

There are no distance limits for encoders or drives. Given the limits of your power supply, you must calculate the maximum distance at which the current requirements for the drive or encoder are met. In these calculations you must allow for voltage drops over the length of the cable. Refer to the cable manufacturer's specifications to determine the voltage drop in your cable.

Using the Wiring Diagrams in Chapters 4 and 5

Use the wiring diagrams in Chapters 4 and 5 to help wire your user devices to the control module. Match the connector signals from the control module with the signals on the connector blocks of the termination panel. There is a one-to-one connection relationship between these connectors (except for the E-Stop and drive enable signals). Then follow the signals from these connector blocks to the various user devices. Table B.A lists the following wiring diagrams in chapters 4 and 5.

Table B.A
Wiring Diagrams in Chapters 4 and 5

Description	Figure #
Typical Fast I/O connections	4.1
E-Stop circuitry for a One Axis System	4.5
E-Stop Circuitry for a Two or Three Axis System	4.7
5V Encoder Feedback Connections	5.4
15V Encoder Feedback Connections	5.5
Wiring Diagram For Series 1386 Drives	5.6
Wiring Diagram For Series 1388 Drives	5.7
Wiring Diagram For Series 1389 Drives	5.8
Wiring Diagram For Series 1391 Drives	5.9
Wiring Diagram For Series 1392 Drives	5.10

E-Stop Circuitry Drawings

Study the E-Stop Circuitry drawings and implement the equivalent circuit. You may not need the additional control relays (CR2 and CR3, etc.) if the drive amplifiers can be enabled at the same time. You will, however, have to purchase at least one control relay that is equivalent to the one used in our termination panel with the following specifications:

Allen-Bradley
700-HC 14Z24
Coil: 24V dc 650 ohms
Contact 3A Resistive 120 V ac
Arrangement: 4 Form C

Appendix C

Error Messages and Diagnosis

Appendix Overview

This appendix contains error messages displayed on the handheld pendant or sent to the SLC for handling during power up and testing of the IMC 110 hardware.

Messages Displayed on the Handheld Pendant

Table C.A lists error messages that are displayed on the handheld pendant and the causes of the messages and ways to correct them.

Table C.A
Types of Error Messages Displayed on the Handheld Pendant

Prompts	Name	Description
A:	Abort errors[1]	These errors will stop the execution of the program. By pressing [RUN], the program will restart at the beginning of the program and the message will be cleared from the screen.
E:	E-Stop errors	These errors will cause a system-wide emergency stop. You must clear the E–Stop using the user-supplied E-Stop reset circuit. Once the system is reset, the program will resume its operation and the message will be cleared from the screen.
N:	Nonrecoverable E-Stop	The program will not run because the watchdog jumper is still in place. Do not attempt to remove the watchdog jumper. Return to Allen–Bradley for removal.
P:	Pause errors[1]	These errors will stop the execution of the program. By pressing [RUN], the program will resume its operation and the message will be cleared from the screen.
W:	Warnings	Warnings provide information only. The message is cleared the screen as soon as it is displayed on the pendant screen. The program does not stop during a warning message.

Notes:
[1] The Abort and Pause errors can also be reset by setting the Resume bit (word 0, bit 0, SLC 500 to IMC 110 single transfer) through the computer terminal connected to the SLC 500.

Error No.	Error Message	Cause(s)	Recovery Steps
1	W: NO PROGRAM SELECTED	RUN is pressed without ever selecting a program.	Select a program that is already downloaded in the control.
2	W: CAN'T SWITCH MODES	Operator attempted to change modes from auto to manual by pressing the JOGS key. Unfortunately, either the motion is not complete or a program is running. Given that one of these conditions is true, the operator can't change mode.	Operator must wait for motion to complete and the program status ($PGM_STATUS) is either not running or suspended. Then the mode can be changed with the JOGS key.
3	W: CAN'T RESET - NON-RECOVERABLE	Tried to exit estop after a non-recoverable estop has occurred.	Watchdog disable jumper must be removed. Call field service.
4	W: CAN'T RESET - AMP NOT LOADED	Tried to exit estop before AMP has been loaded, or after an unsuccessful AMP download.	Successfully download AMP, then perform the E-stop reset.
5	W: CAN'T RESET - RAM/PROM DIFFERENT REVISIONS	The AMP and/or major revision level in the system PROM does not match the corresponding revision level in user RAM.	Ensure that all software revision levels are compatible.
128	W: ILLEGAL BCD PRESET FROM SLC	The BCD PRESET from the SLC contained an illegal BCD digit, i.e., a digit with a value greater than 9.	Check ladder program and make sure program is converting value to BCD correctly.
129	W: ILLEGAL BCD OFFSET FROM SLC	The BCD OFFSET from the SLC contained an illegal BCD digit, i.e., a digit with a value greater than 9.	Check ladder program and make sure program is converting value to BCD correctly.
130	W: ILLEGAL BCD SPEED OVERRIDE FROM SLC	The BCD SPEED override from the SLC contained an illegal BCD digit, i.e., a digit with a value greater than 9.	Check ladder program and make sure program is converting value to BCD correctly.
131	W: ACTUAL POSITION BCD OUT OF RANGE	The axis actual position value exceeded 79,999,999.	Insure that the axis position stays within normal limits.
132	W: FOLLOWING ERROR BCD OUT OF RANGE	The following error value exceeded 79,999,999.	If Following Error has grown this big, there are severe system problems.
133	W: INITIALIZE HOME FAILED	An initialize home operation was attempted with either MOTION STACKED (MML STOP statement without a RESUME), or MOTION NOT COMPLETE.	Resume motion and wait for MOTION COMPLETE before attempting the INITIALIZE HOME operation.
134	W: PRESET FAILED	A PRESET operation was attempted with either MOTION STACKED (MML STOP statement without a RESUME), or MOTION NOT COMPLETE.	Resume motion an/or wait for MOTION COMPLETE before attempting the PRESET operation.
256	W: HOME OPERATION ABORTED	1. release JOG+ or JOG - button 2. broken or incorrectly wired home switch	1. n/a 2. replace or correctly wire home switch.
257	W: HOMED TOO FAST	Axis ran into the switch at too high velocity.	Slow down the speed at which the axis runs into the home switch.

Error No.	Error Message	Cause(s)	Recovery Steps
258	W: RETURN TO POSITION ABORTED	1. The Return To Posn has been aborted by the SLC or 2. by releasing the JOG+ JOG– key on the HHP during the operation.	1. Start the function from the SLC again. 2. Start the function from the HHP again by pressing either the JOG+ or JOG– key.
259	W: MOVE TO ALTERNATE HOME ABORTED	The Move to $ALT_HOME has been aborted by the SLC.	Start the function from the SLC again.
260	RETURN TO POSN SUCCESSFUL	Informational message saying the Return To Posn requested by the SLC or HHP was performed successfully.	
261	MOVE TO ALTERNATE HOME SUCCESSFUL	Informational message saying the Move To $ALT_HOME requested by the SLC was performed successfully.	
262	HOMED SUCCESSFULLY	Informational message saying the homing operation requested by the SLC or HHP was performed successfully.	
263	W: CAN'T HOME AXIS IN DRY RUN MODE	An attempt was made to home the axis when the control was in dry run mode. The operation is disallowed because homing requires the ability to detect markers in the feedback device. Since the feedback device is not moving, markers cannot be detected.	Place control in normal run mode, then perform the homing operation.
384	W: OVERTRAVEL	Jog or speed move encounters a software overtravel.	Push the "more" key.
385	W: OUTSIDE OVERTRAVEL – JOG AXIS MINUS	The current position of the axis is outside the positive software overtravel and a jog in the positive direction has been requested. The operation is disallowed because the positive overtravel would be further violated.	Continuously or incrementally jog the axis in the negative direction until the position of the axis is between the software overtravels.
386	W: OUTSIDE OVERTRAVEL – JOG AXIS PLUS	The current position of the axis is outside the negative software overtravel and a jog in the negative direction has been requested. The operation is disallowed because the negative overtravel would be further violated.	Continuously or incrementally jog the axis in the positive direction until the position of the axis is between the software overtravels.
512	W: FEEDBACK IS MARGINAL	Hardware detected a feedback failure on the feedback device.	If this message appears often, the feedback device should be checked.
768	ABORTING STATEMENT	In the MML program the ABORT statement got executed. Just an informational message.	The program can be run again. First determine why the ABORT statement got executed. Avoid any bad operation that caused the execution of the ABORT statement.
769	REACHED END OF PROGRAM	Just an informational message. Either an END statement or a RETURN statement was executed in MML main program.	The program can be run again just by pressing RUN.

Error No.	Error Message	Cause(s)	Recovery Steps
770	REACHED BREAKPOINT AT step–number	A programmed break point has been reached.	The program can be continued just by pressing RUN.
771	PAUSE STATEMENT DONE	In the MML program, the PAUSE statement got executed. Just an informational message.	The program can be continued just by pressing RUN.
772	BAD PROGRAM NUMBER	The specified program number is out of range for the requested operation	Ensure that the specified program number is within the range of 1 to 15.
773	CORRUPT MML PROGRAM	The selected MML file's checksum has does not match the newly calculated checksum for that file.	Re-download the MML file from ODS.
896	W: FILE COPY ERROR	1. Destination file already exists 2. Control out of memory	1. Rename the destination 2. Make room in memory
897	W: FILE DELETE ERROR	1. File does not exist. 2. File already open.	1. See if it exists or not. 2. If selected, abort the program; otherwise, stop any file operations on the file.
898	W: FILE RENAME ERROR	1. Source or destination file doesn't exist. 2. Destination file already exists.	1. Check the file names. 2. Rename the destination.
899	W: FILE OPEN ERROR	1. File could be locked. 2. Too many open files on system. 3. Attempt to read non-existent file. 4. Attempt to write to a file currently opened for read. 5. Attempt to write to a file currently opened for write.	1. Try again, file was being moved. 2. 6 max, close one and try again. 3. Make sure the file exists. 4. Close file and try again. 5. Close file and try again.
900	W: PROGRAM NOT FOUND	Any file management function that requires a source file will search the directory to verify that the source file entered exists.	Press MORE key. Choose a file that is in the directory.
901	W: STEP NUMBER NOT FOUND	Tried to set a breakpoint and a breakpoint could not be found as an executable statement in the current program.	Press the MORE key. Enter step number of executable statement.
902	W: INTERNAL ERROR CONTACT FIELD SERVICE	1. Could not find uninitialized variable within a program symbol table. 2. Pendant tables corrupt causing illegal menu or item selection.	1. This error is not fatal; the variable just won't be taught. 2. Unplug pendant and re-insert (this is fatal to the serial task; other tasks are not affected).
903	W: FILE WRITE ERROR	1. Out of RAM on control 2. Attempt to write to a nonexistent file 3. Attempt to write to an unopened file 4. Attempt to write to a file opened for read	1. Delete a file, try again. 2. Create the file. 3. Open the file. 4. Close the file. Open for write.
904	W: PROGRAM ACTIVE WARNING	Tried to select a program while a previously selected program is still active.	Press the MORE key. Press abort program. Now try selecting program.

Error No.	Error Message	Cause(s)	Recovery Steps
905	W: NO DEBUG INFORMATION FOUND	1. Tried to enter teach mode and no program symbols were found for the active program. Even though program is selected, symbol information is not valid until it begins to execute. 2. Tried to set a breakpoint while file header was set DEBUG_FLAG equals false, meaning the program was compiled without debug option specified.	1. Press MORE key, select a program and execute. 2. Press MORE key re-compile with debug switch.
906	W: CORRUPT FILE WAS DELETED	Control powered down in the midst of a sensitive file move routine.	Redownload the program.
907	W: INCORRECT ARRAY SIZE	In debug or teach mode, array size is out of range	Hit MORE key on HHP and enter this array with appropriate array element.
908	W: CONVERSION ERROR	1. Array index is not numeric when try to modify array 2. Value to modify an integer or a real variable is not entered as a numeric value 3. Value to modify a boolean variable is not entered as 1, 0, TRUE, or FALSE 4. Wrong data type has been detected or illegal value.	1. & 2. Hit MORE key on HHP and enter a numeric value. 3. Hit More key on HHP and enter value with 1, 0, TRUE, or FALSE 4. Enter correct data type or value.
909	W: ILLEGAL ARRAY LENGTH	1. In debug or teach mode, a variable which is not defined as an array is entered with [index]. 2. In debug or teach mode, a variable is entered with [index] followed by some character other than ENTER key.	1. Hit MORE key on HHP and enter the variable which is not defined as an array without [index] 2. Hit MORE key on HHP and enter the variable (if not an array, without [index] (if an array, type[index] after the variable name)
910	W: ILLEGAL NAME LENGTH	In debug or teach mode, the name length of the variable to change is more than 12.	Hit MORE key on HHP and enter the variable to change with right length.
911	W: VARIABLE NAME NOT FOUND	In debug or teach mode, the variable to change is not found in the MML program variable list, or system variable table, or special variable group.	Hit MORE key on HHP and enter another variable that is defined; an MML program variable, or system variable, or special variable (FIN, etc).
912	W: READ ONLY VARIABLE	In debug mode, a value is entered to change a variable that is a read only variable in the system variable table, DIN or FIN.	Hit MORE key on HHP and enter this variable name again. After the value is shown on HHP, just hit ENTER key again.
913	W: VALUE TOO LARGE OR SMALL FOR VARIABLE	In debug or teach mode, the value entered to change a variable is out of its range.	Hit MORE key in HHP and enter this variable with a value within the range.
914	W: NO PROGRAM ACTIVE	In debug mode, a variable to change is not found in system symbol table, nor in special symbol group and no program is selected.	Select the desired program and hit RUN key and then in debug mode enter the variable that is defined in the selected and active program.

Error No.	Error Message	Cause(s)	Recovery Steps
915	W: CAN'T RUN– CONTROL IN E–STOP	Attempt to start or resume a program while in estop.	Perform an E-stop Reset operation, then try to run the program again.
916	W: CAN'T RUN– TEACHING	Attempt to run a program while the control is "waiting" for a position or variable to be taught.	Abort the program and attempt to run it again or teach the position or variable.
917	W: CAN'T RUN– AXIS NOT HOMED	Attempt to run a program before the axis has been homed after power up.	Home the axis. Try to run the program again.
918	W: SORRY, YOUR PASSWORD IS INCORRECT	Password was incorrect.	Try again.
919	W: CAN'T CHANGE WHEN AXIS IS MOVING	The HHP attempted to change UNITS with motion active.	Wait until motion completes before changing the units of the system.
1024	P: OVERTRAVEL ERROR	The programmed position has exceeded an AMP specified positive or negative overtravel.	Programming error; program position somewhere within the overtravel limits or extend the limits.
1025	P: POSITION LIMIT ERROR	The programmed position is too large to fit into an internal position variable.	Programming error; position calculation in the MML program must be constrained to physical limits.
1026	P: SPEED LIMIT ERROR	The programmed speed ($SPEED) does not fall within the legal limits; 0 < speed < = MAX_SPEED, where MAX_SPEED is an AMP value.	Programming error; program $SPEED to be greater than 0, but less than or equal to MAX_SPEED.
1027	P: ACCELERATION LIMIT ERROR	The programmed accdec ($ACCDEC) does not fall within the legal limits; 0 < accdec < = 1.0; remember that $ACCDEC is a percentage of MAX_ACCEL (an AMP value).	Programming error; program $ACCDEC to be greater than 0, but less than or equal to 1.0.
1028	P: TERMTYPE OUT OF RANGE ERROR	$TERMTYPE has been given a value other than an enumerated value for NODECEL, NOSETTLE, COARSE, and FINE.	Programming error; $TERMTYPE enumerated value must represent either NODECEL, NOSETTLE, COARSE, or FINE.
1029	P: UNINITIALIZED STATIC VARIABLE	A static variable was not initialized before being used.	Teach the variable or abort program
1030	P: OUTSIDE OVERTRAVEL – MOVE AXIS MINUS	The current position of the axis is outside the positive software overtravel and a request to move the axis in the positive direction had been requested from a MML program. This operation has been disallowed because the positive overtravel would be further violated.	Place control in manual JOGS mode. Then, continuously or incrementally jog the axis in the negative direction until the position of the axis is between the software overtravels.

Error No.	Error Message	Cause(s)	Recovery Steps
1030	P: OUTSIDE OVERTRAVEL – MOVE AXIS PLUS	The current position of the axis is outside the negative software overtravel and a request to move the axis in the negative direction had been requested from a MML program. This operation has been disallowed because the negative overtravel would be further violated.	Place control in manual JOGS mode. Then, continuously or incrementally jog the axis in the positive direction until the position of the axis is between the software overtravels.
1280	P: SQUARE ROOT OF NEGATIVE NUMBER	The square root of negative number is being taken.	Correct MML program logic.
1281	P: ROUND OR TRUNC OUT OF RANGE	The real value supplied as an argument to a round or truncate function was greater than the maximum permissible integer in the MML program.	Correct MML program logic.
1408	P: SLC I/O RESET REQUEST	The SLC has gone into test or program mode; this causes a motion pause.	Change to Run mode. Press resume.
2048	A: REAL OVERFLOW	A MML program operation produced a result greater than the maximum permissible real value.	Correct MML program logic.
2049	A: REAL UNDERFLOW	A MML program operation produced a result less than the minimum permissible real value.	Correct MML program logic.
2050	A: INTEGER OVERFLOW	A MML program operation produced a result greater than the maximum permissible integer value of 80000000H (2, 147, 483, 648).	Correct MML program logic.
2051	A: DIVIDE BY ZERO	Divide by zero attempted.	Correct MML program logic.
2176	A: RUN – TIME STACK OVERFLOW	The MML stack has overflowed. The reasons are 1. The subroutine in the MML program is calling itself either directly or indirectly too many times. 2. The subroutine calls are nested too deep.	1. Correct program logic 2. Try to reduce number of variables, parameters, or nesting.
2177	A: MOTION QUEUE OVERFLOW	Too many programmed motions are being attempted; happens as result of many STOPped motions being RESUMEd all at once	Programming error; the program must be modified, recompiled, redownloaded, and re-executed.
2178	A: PLANNED MOTION QUEUE OVERFLOW	Too many motions have been planned.	Internal software error; if this happens there's nothing a user can do to fix it; there is a system software problem.
2179	A: MOTION STACK OVERFLOW	Too many STOPped motions without any of them being RESUMEd.	Programming error; the program must be modified, recompiled re-downloaded, and re-executed.

Error No.	Error Message	Cause(s)	Recovery Steps
2180	A: PROGRAM MOTION QUEUE OVERFLOW	The program motion queue is full when attempting a jog while the program is suspended.	The program will have to be ABORTed in order to clear the programmed motion queue; this error should actually never happen; it is only being checked as a precaution.
2181	A: TOO MANY EVENTS QUEUED	A cascade of events occurred. A maximum of ten events can be queued.	Correct the MML program logic.
2182	A: CONDITION HANDLER NESTING EXCEEDED	The maximum number of nesting allowed in calling condition handler routines has been exceeded.	Correct the MML program logic.
2183	A: PROGRAM EVENT QUEUE OVERFLOW	System Error	Call Field Service.
2184	A: PLANNING EVENT QUEUE OVERFLOW	System Error	Call Field Service.
2185	A: STATEMENT EVENT QUEUE 0 OVERFLOW	System Error	Call Field Service.
2186	A: STATEMENT EVENT QUEUE 1 OVERFLOW	System Error	Call Field Service.
2187	A: STATEMENT EVENT QUEUE 2 OVERFLOW	System Error	Call Field Service.
2188	A: STATEMENT EVENT QUEUE 3 OVERFLOW	System Error	Call Field Service.
2189	A: TOO MANY FAST I/O	More than 10 fout actions executed.	Correct MML program.
2190	A: TOO MANY CONDITION HANDLER ROUTINES	More than 10 condition handler routines called in condition handler(s).	Correct MML program.
2191	A: FILE OPEN FAILED	System Error	Call Field Service
2432	A: UNINITIALIZED LOCAL VARIABLE	A variable defined in a routine is being used before assigning any value to it.	Correct the MML program logic.
2433	A: BAD TIME VALUE	The time specified in an MML DELAY statement is negative or greater than 24 hours (86,400 seconds).	Correct the MML program logic.
2434	A: BAD DIGITAL I/O LINE NUMBER	The number specified for din or dout line is either less than one or more than the maximum supported.	Correct the MML program logic.
2435	A: ILLEGAL EVENT NUMBER	The event number specified in a SIGNAL statement or action or EVENT condition is not in the range of 1–1000.	Correct the MML program logic.
2436	A: ILLEGAL ERROR NUMBER	An illegal number was specified in an ERROR condition. Error numbers must be in range 1–64999.	Correct the MML program logic.

Error No.	Error Message	Cause(s)	Recovery Steps
2437	A: BAD FAST INPUT INDEX	The number specified for fin line is either less than one or more than the maximum supported.	Correct the MML program logic.
2438	A: BAD FAST OUTPUT INDEX	The number specified for fout line is either less than one or more than the maximum supported.	Correct the MML program logic.
2439	A: BAD CONDITION HANDLER INDEX	The number specified for condition handler is either less than one or more than the maximum supported.	Correct the MML program logic.
2440	A: ARRAY BOUNDARY EXCEEDED	Attempted to access a variable outside of the array.	Rewrite the MML program so as not access variables outside of the array this will cause the program to abort.
2560	A: FAST I/O CODE ERROR	Bad codes in fin or fout action.	Abort the program; run a "good" MML program
2688	A: LOCAL CONDITION HANDLER CODE ERROR	Bad codes in local condition handler action.	Abort the program; run a "good" MML program
2689	A: GLOBAL CONDITION HANDLER CODE ERROR	Bad codes in global condition handler action.	Abort the program; run a "good" MML program
2690	A: UNINITIALIZED VARIABLE IN CONDITION HANDLER OR FAST INPUT STATEMENT	Uninitialized variables have been used to monitor FIN/FOUT conditions or actions. This is illegal, the program aborts.	Either modify the variable or correct the MML program. Press the RUN key to start the program over from the beginning.
3072	E: QUADRATURE FAULT	Simultaneous transitions on the A and B channels of the encoder detected. This is an illegal condition. This error causes E-stop.	Reset from E-stop. If the problem persists, check the wiring to remove sources of noise. Also check the encoder, it may have failed.
3073	E: FEEDBACK FAILURE	Multiple feedback failures were detected on the feedback device.	Check the feedback device, then reset from E-stop.
3074	E: EXCESS FOLLOWING ERROR	1. The value of the axis following error exceeded the limit established in AMP. This can be caused by an obstruction to axis motion, servo wiring error, or loss of feedback channel. This error causes E-stop. 2. Having a reversal error greater than the maximum following error.	1. Reset from E-stop. If the problem persists, check axis mechanics, wiring, and feedback device. 2. Make reversal error smaller than maximum position following error.
3200	E: LOST SLC COMMUNICATIONS	No communication with the SLC has occurred within a reasonable period of time (approximately 5 seconds). This error causes E-stop.	Reset from estop. If the problem occurs again, check the SLC.
3328	E: USER POWER LOST	The user power supply has been shorted or disconnected. This error causes E-stop.	Check the user power and its connections to the SLC. After it is fixed, reset from E-stop.
3456	E: HARDWARE E–STOP	The user E-stop string has opened.	Insure that the device that opened the string is functioning properly, then reset from E-stop.

Error No.	Error Message	Cause(s)	Recovery Steps
3584	E: CAN'T SERVICE FAST INPUT	Too many fast input interrupts and the fin fout task is not able to respond fast enough or the fin/fout task is not created when no MML program is running.	Lower the frequency of fast inputs. Reset E-stop. Run MML program.
4096	N: WATCHDOG JUMPER MUST BE REMOVED	Watchdog disable jumper is installed.	Call Field Service.

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