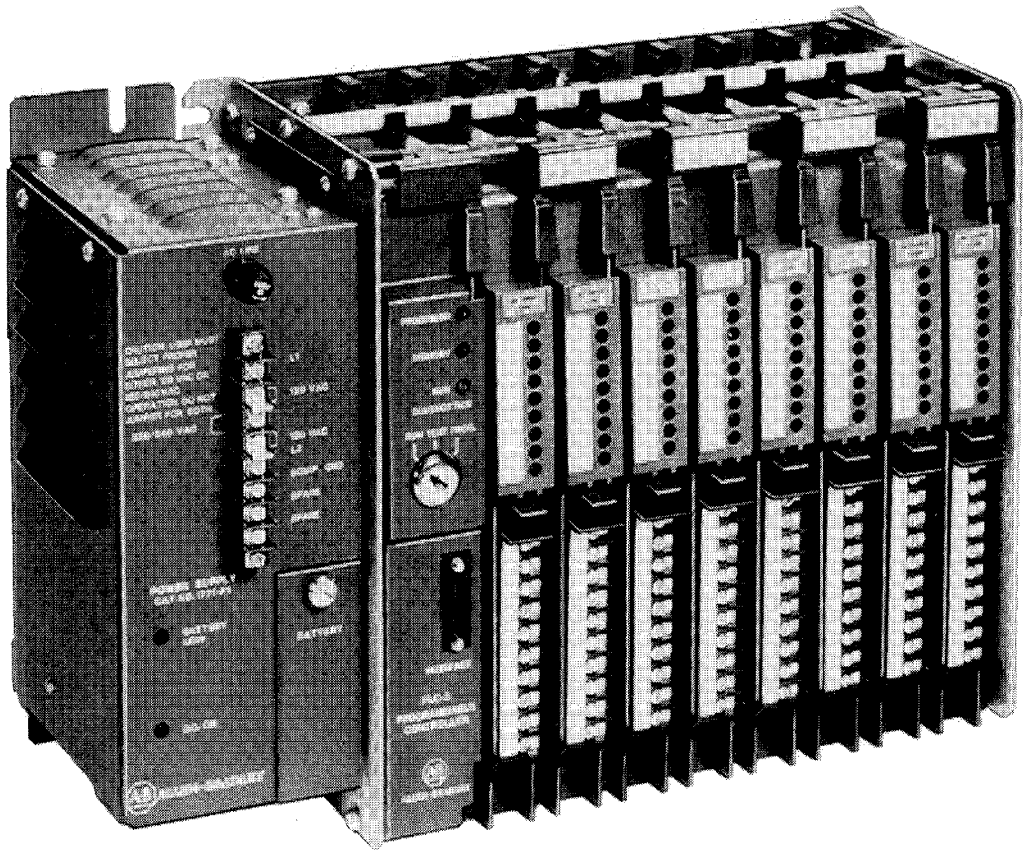
1772-6.6.3

Bulletin 1772

MINI-PLC-2 PROGRAMMABLE CONTROLLER

Assembly and Installation Manual



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Cleveland, Ohio 44143

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Section 1
INTRODUCTION

1.0 General – The Bulletin 1772 Mini-PLC-2 programmable controller is a microprocessor-based controller for industrial applications. Adaptable in size and configuration, it can monitor and control up to 128 input and output (I/O) devices. (Refer to Figure 1.1)

The controller has a central control logic unit – the Mini-Processor Module, and a number of user-selected I/O Modules, chosen for the number and types of I/O devices in the application. By selecting the appropriate modules, a user assembles his Mini-PLC-2 controller around the requirements of his application.

The selected I/O modules and the Mini-Processor Module are all housed in a single Chassis which can be mounted within an enclosure of 8-inch working depth.

1.1 PC Definition – A programmable controller (PC) is a solid-state logic control device for industrial applications. As the term "programmable" indicates, the controller has an essential difference from hard-wired controls. Its logic function is determined by a user-entered program, which specifies how output devices operate in response to input devices. Because the program is stored in a read/write memory, a change in a controlled process is accomplished by reprogramming rather than by extensive rewiring, as hard-wired control systems require.

The controller continuously monitors the status of devices connected as inputs. Based on user program instructions, the controller then controls the devices connected as outputs. Input and output devices may be of several types, with various voltage and current ranges. These devices may include any of the following:

- Limit, float, selector, and pressure switches
- Thumbwheel switches
- Push buttons
- Alarms, indicators, and annunciator panels
- Solenoids
- Motors and motor starters
- Transducers
- Various solid-state devices, including TTL-compatible instrumentation

The controller stores all I/O device status data in a central read/write memory. This allows the controller full access to the latest status data in the application. Operations which can be performed based on this data include the following:

- Timing (1.0-, and 0.1- and 0.01-second time bases)
- Counting
- Arithmetic operations
- Comparison
- Data manipulation

The Mini-PLC-2 controller program uses readily understandable symbols in a simple format – the ladder diagram. Manual entry of the ladder-diagram program is done through a Program Panel. This device is also used to edit the program and monitor I/O device status. In addition, Program Panels can be used to interface the Mini-PLC-2 controller with a peripheral data terminal. Data terminals include tape punches/readers, keyboard/printers, and the Digital Cassette Recorder (Cat. No. 1770-SA). These data terminals allow a variety of additional capabilities, including:

- Loading/storing the program on magnetic or punched tape
- Generating a hard-copy printout of program
- Generation of various kinds of reports, in a user-programmed format

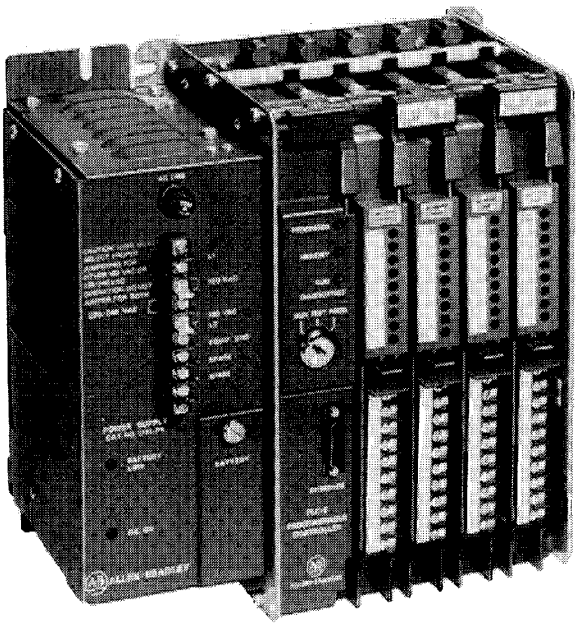


Figure 1.1 – Mini-PLC-2 Programmable Controller

On the various controller components themselves, indicators show I/O device, Mini-Processor, and Power Supply status. These indicators aid in providing quick diagnosis of a fault situation thus enabling troubleshooting by plant maintenance personnel, without the need for specialized equipment or programming knowledge.

1.2 Organization of Manual — This Manual is organized in sections. Each section deals with a specific topic of concern to the installer of the Mini-PLC-2 controller and its associated equipment. A brief outline of the contents follows:

Section 2 gives a description of the components of the Mini-PLC-2 controller.

Section 3 gives the recommendations for layout and assembly of the controller.

Section 4 gives the recommended procedures for controller start-up.

Section 5 explains controller diagnostic indicators and gives an approach to troubleshooting procedures.

Section 6 lists the system specifications.

Section 7 describes supplementary documentation which is available for the Mini-PLC-2 controller user.

1.3 PC Installation and Start-Up — Read this entire manual before any installation is begun. It is strongly recommended that hardware and installation personnel work closely with the Mini-PLC-2 programmer at start-up. The proper operation of a programmable controller is as much a function of the user program as it is a function of proper installation.

Since programmable controllers often perform relay-equivalent functions, there is much in common between the programmable controller and relays. However, many aspects of the programmable controller may be new to individuals. For this reason, Publication SGI-1.1, "Application Considerations for Solid-State Controls," is included in the Support Documentation for the Mini-PLC-2 Programmable Controller. This Publication gives general background information on solid-state control.

1.4 Support Documentation — A separate Publication is provided with this Manual. This Publication, Support Documentation for the Mini-PLC-2 Programmable Controller, Publication 1772-820-1, contains Product and Application Data Sheets on the various Mini-PLC-2 controller components. This Publication is essential for the installer of the controller, with information on wiring, module keying, and use of the various controller components.

Section 2
CONTROLLER DESCRIPTION

2.0 Components — The Mini-PLC-2 programmable controller is made up of the following major components:

- 1 I/O Chassis Assembly (Cat. No. 1771-A1, -A2, or -A4)
- 1 Mini-Processor Module (Cat. No. 1772-LN1 or -LN2)
- A number of I/O modules, as determined by application needs
- 1 System Power Supply (Cat. No. 1771-P1)
- 1 I/O Power Cable (Cat. No. 1771-CL or -CM)

These components, and units shipped with them, are shown in Figure 2.1. The following Paragraphs briefly describe each of these components and their function in the controller.

In addition to these units, the Program Panels are described. Although portable and not usually installed as a part of a programmable controller, the Program Panel is the tool for program entry, editing and monitoring functions, as well as a necessary component for report generation.

This Section also lists various user-supplied devices which may be installed as part of the overall controller system.

2.1 I/O Chassis Assembly — A single Bulletin 1771 I/O Chassis houses all of the modules which make up the Mini-PLC-2 programmable controller. In each I/O Chassis, the left-most slot is used for the Mini-Processor Module. The remaining slots in the Chassis are used for I/O modules.

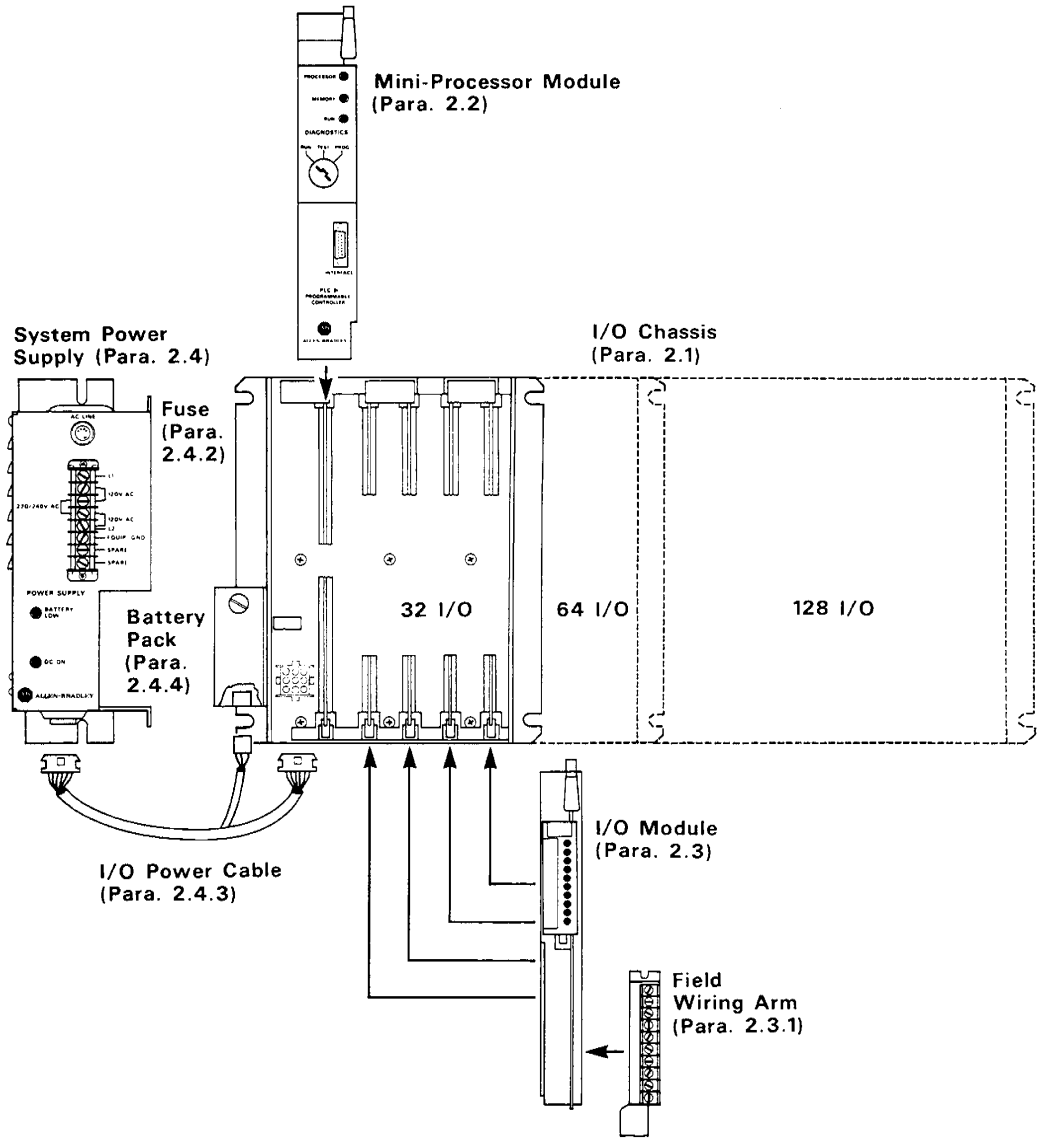


Figure 2.1 — Components of Mini-PLC-2 Controller

There are 3 I/O Chassis sizes, based on I/O module capacity. These sizes are:

- 32 I/O – Cat. No. 1771-A1 contains 4 I/O module slots
- 64 I/O – Cat. No. 1771-A2 contains 8 I/O module slots
- 128 I/O – Cat. No. 1771-A4 contains 16 I/O module slots

Chassis dimensions for any of these sizes allow mounting of the controller within an enclosure of 8-inch working depth.

Chassis design permits convenient controller expansion. If a 32- or 64-I/O Chassis is used and, subsequently, more interfacing capacity is needed, a larger Chassis may be installed. Rewiring of devices is not necessary, since Field Wiring Arms, with all wiring intact, can be removed from the smaller Chassis and snapped onto corresponding positions on the larger Chassis. In addition, when Wiring Arms and I/O modules are placed in exactly corresponding slots, the original programming addresses of user I/O devices need not be changed.

The backplane of the Chassis has connectors for each module, a socket for Power Supply connection and a Switch Group Assembly. Latches on the top of the Chassis snap down to hold modules securely in place and provide labeling for ease of module identification.

The Mini-PLC-2 controller shown in Figure 1.1 uses a 32 I/O Chassis.

Included as standard with each I/O Chassis Assembly are a number of Field Wiring Arms (Cat. No. 1771-WA), one for each I/O module slot. In addition, an I/O Rack Keying Bands package (Cat. No. 1777-RK) is shipped with each I/O Chassis Assembly. Use of keying bands helps to assure that only a user-designated module is placed in a particular keyed slot.

2.2 Mini-Processor Module – The Mini-Processor Module is the control processing unit and memory of the Mini-PLC-2 controller. (Refer to Figure 2.2.) It performs the scan of input and output (I/O) devices, timing and counting functions, data comparison and transfers, arithmetic operations, and self-checking diagnostic routines.

The Mini-Processor Module has the capability to monitor and control up to a maximum of 128 I/O devices which can be connected to I/O modules in the Chassis. It is available with two user-memory sizes:

- 1/2K (512 words) Cat. No. 1772-LN1
- 1K (1024 words) Cat. No. 1772-LN2

The single difference between the Cat. No. 1772-LN1 and -LN2 modules is memory capacity. The memory capacity of the Cat. No. 1772-LN1 Mini-Processor Module may be increased to 1024 words. To do this, the user may order the optional Memory Expansion (Cat. No. 1772-MH). Memory Expansion procedures are described in Publication 1772-703.

The Mini-Processor Module is inserted into the left-most I/O Chassis slot. Keying Bands, provided with the Chassis, can be used to allow insertion of only the Mini-Processor in this slot. (Keying band placement for the Mini-Processor is described in Publication 1772-701.)

By means of built-in diagnostics, the Mini-Processor monitors the status of its own operation, of data in memory, and of power from the System Power Supply. Orderly shutdown is provided if a malfunction from any of these points is detected. Visual indicators on the front of the module illuminate to show that the controller is operating normally or a malfunction is detected. These indicators are:

- PROCESSOR – This indicator illuminates when the Mini-Processor detects a fault in its own operation. It is normally OFF.
- MEMORY – This indicator illuminates when the Mini-Processor detects memory data with the wrong form, or parity. It is normally OFF.
- RUN – This indicator illuminates when the controller is in operation in the RUN mode.

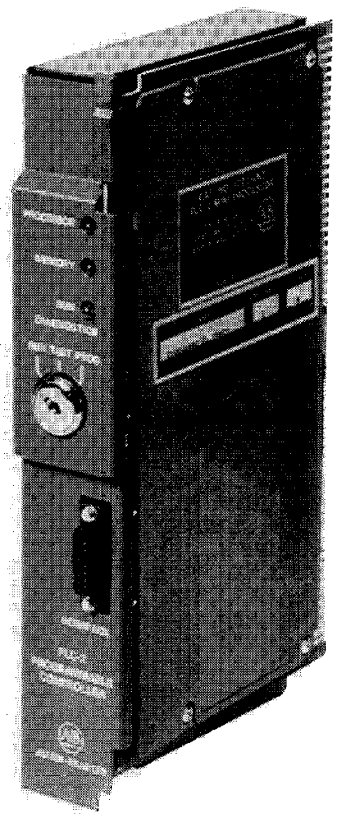


Figure 2.2 – Mini-Processor Module

The significance of these indicators for troubleshooting is explained in Section 5.

Beneath these diagnostic indicators is the Mode Select Switch. By means of this 3-position keylock switch, the user selects the operating mode of the Mini-Processor. These modes are:

- RUN – The RUN switch position enables the Mini-Processor to control outputs as instructed in the program.
- TEST – The TEST switch position allows the program to be thoroughly examined without energizing outputs.
- PROG – The PROGRAM switch position allows the user's program to be entered or edited.

Controller behavior for each of these modes is described in Section 5.

Also on the front of the module is a socket labeled INTERFACE. Program Panels are connected to this socket for programming, troubleshooting, or report generation functions.

2.3 I/O Modules – Through Bulletin 1771 I/O modules, the Mini-Processor Module monitors and controls the various devices in the user's application.

There are 2 general I/O module types:

- Input modules, which sense the voltage levels of input devices and provide the Mini-Processor with logic-level status information on these devices. Inputs may include limit, float and selector switches, push buttons, transducers and many other sensing and switching devices.
- Output modules, which control output devices, based on logic-level commands from the Mini-Processor. Outputs may include various types of motor starters, solenoids, alarms, displays, and indicators.

Figure 2.3 shows two I/O modules, one of each type.

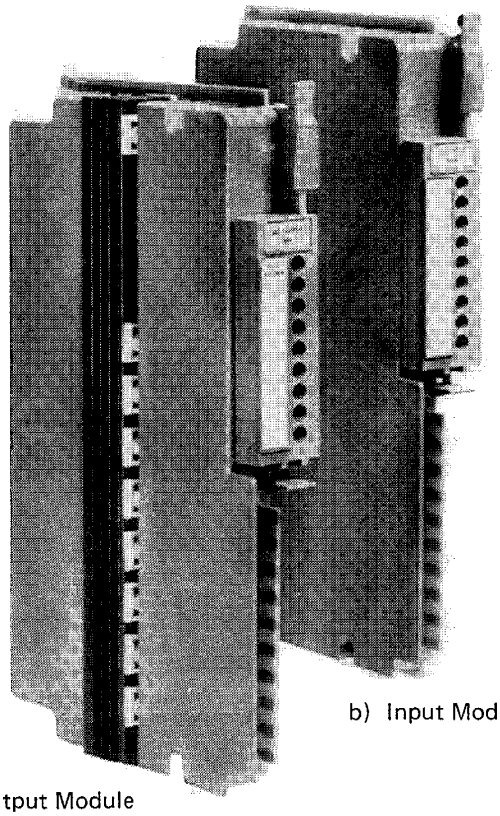
I/O modules are available for devices with different voltage levels and characteristics. Table 2.A lists I/O modules available as of the date of this Publication. Details, specifications, and connection diagrams for I/O modules are listed on various Product Data Sheets. These Data Sheets also give keying information for each type of I/O module. (Refer to Publication 1772-820-1, Support Documentation.)

AC and DC I/O modules have indicators to show the ON/OFF status of each connected input or output device. These indicators are useful in start-up, monitoring, and troubleshooting of the controller. An additional indicator on output modules illuminates if a fuse on the module has blown.

On each I/O circuit, optical isolation separates controller logic circuitry from the voltage levels in the user's application. This also guards against the possibility of damage to controller logic circuitry from high-voltage transients along the user's line.

A color-coded label on each I/O module identifies the general module type and voltage range. This label, on the front of the module, can be seen when the module is positioned in the Chassis. Table 2.A lists color-coding for modules.

2.3.1 Wiring Arms – Wiring to and from user I/O devices connects to a separate Field Wiring Arm for each I/O module. The Wiring Arm, acting as a terminal strip, pivots up to allow quick and easy insertion or removal of modules for start-up and troubleshooting. (Refer to Figure 2.4.)



b) Input Module

a) Output Module

Figure 2.3 – Input and Output Modules (typical)

The Cat. No. 1771-WA Field Wiring Arm is shipped with the I/O Chassis. This Wiring Arm is used with most AC and DC I/O modules. Certain modules, however, may re-

Table 2.A

MODULE REFERENCE CHART

MODULE	Cat. No.	SYSTEM POWER SUPPLY +5.1V CURRENT REQUIREMENT	KEYING BAND POSITIONS BETWEEN NOS.	FIELD WIRING ARM (Cat. No. 1771-)	COLOR-CODED LABEL
DC (12-24V) Input	1771-IB	74 mA	4-6, 14-16	-WA	Blue
DC (48V) Input	1771-IC	74 mA	4-6, 16-18	-WA	Blue
DC (24-48V) Input	1771-IH	74 mA	4-6, 16-18	-WA	Blue
AC/DC (120V) Input	1771-IA	74 mA	4-6, 10-12	-WA	Red
DC (12-24V) Output	1771-OB	165 mA	4-6, 18-20	-WA	Green
DC (48V) Output	1771-OC	165 mA	4-6, 20-22	-WA	Green
AC (120V) Output	1771-OA	210 mA	4-6, 12-14	-WA	Orange
Analog (8 bit) Input	1771-IE	400 mA	4-6, 26-28	-WB	Pink
TTL Input	1771-IG	122 mA	4-6, 34-36	-WC	Pink
TTL Output	1771-OG	168 mA	6-8, 10-12	-WC	Gray
Mini-Processor	1772-LN1 LN2	1.5 A 1.5A	40-42, 54-56	N/A	N/A

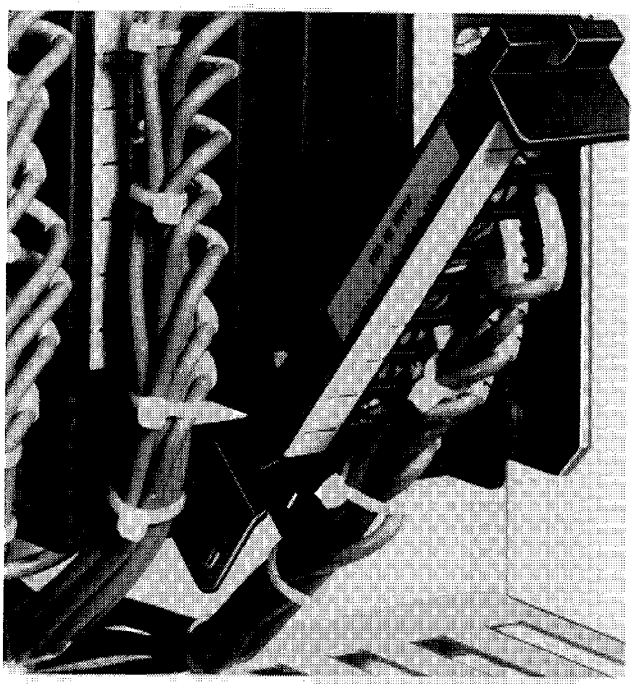


Figure 2.4 — Field Wiring Arms

quire a different Wiring Arm. If a special-purpose Wiring Arm is required for a module, it is shipped as standard with that module. Use only the Wiring Arm that comes with the module in these cases.

2.3.2 5-Digit Address — Each I/O terminal of the Mini-PLC-2 controller is identified by a unique 5-digit address:

- The first digit of the address is either 0 or 1. 0 designates an output. 1 designates an input.
- The second digit of the address is always 1.
- The third digit of the address refers to the Module Group No. (0 thru 7). Labels on Chassis latches identify the Module Group No. of each pair of I/O slots.
- The fourth and fifth digits of the address refer to the Terminal Designation within the Module Group (00-07, 10-17).

Refer to Figure 2.5.

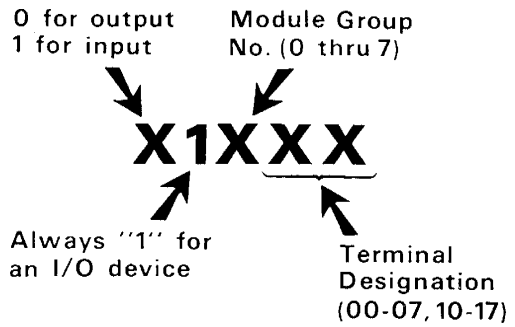


Figure 2.5 — Five-Digit Address

The 5-digit address is a key concept of Mini-PLC-2 programming. Note that the actual physical location of an I/O module and terminal determines its specific programming address. The programmer must be familiar with recommendations for I/O module placement, as given in Paragraph 3.1.1.2 and must provide the installer with a list showing I/O module slot positions and I/O device addresses.

For further information on I/O addressing, refer to the Programming and Operations Manual, Publication 1772-821.

2.3.3 Output Fuses — Each output module driver circuit is fused to protect the user's power supply and output devices. For replacement, fuses are easily accessed by removal of the module's front component-side cover.

Replacement fuses for output modules are listed in Table 5.B. The user can order the optional Fuse Package (Cat. No. 1771-FC), which contains 5 replacement fuses.

Note that a blown-fuse condition is not considered a "fault" for the purpose of disabling Mini-Processor operation.

2.3.4 Bulletin 1777/1778 Compatibility — In some applications it may be useful to interface I/O modules of the Mini-PLC-2 controller with the I/O modules of either the Bulletin 1772 PLC-2 or the Bulletin 1774 PLC controllers. This arrangement can be used to sense the status of devices which are important to the operation of both programmable controllers. This configuration might also be used to coordinate closely-related functions between two controllers.

To use Bulletin 1771 I/O circuits as inputs or outputs with Bulletin 1777 or 1778 I/O circuits, observe individual module voltage and current requirements. Product Data Sheets list these specifications for each I/O module.

2.4 System Power Supply — The required power source for the Mini-PLC-2 programmable controller is the System Power Supply (Cat. No. 1771-P1). (Refer to Figure 2.6.) It powers the logic circuitry of both Mini-Processor and I/O modules, powers the Mini-Processor memory, and provides battery backup to maintain memory contents during AC power loss, removal or replacement of the Supply, or controller shutdown.

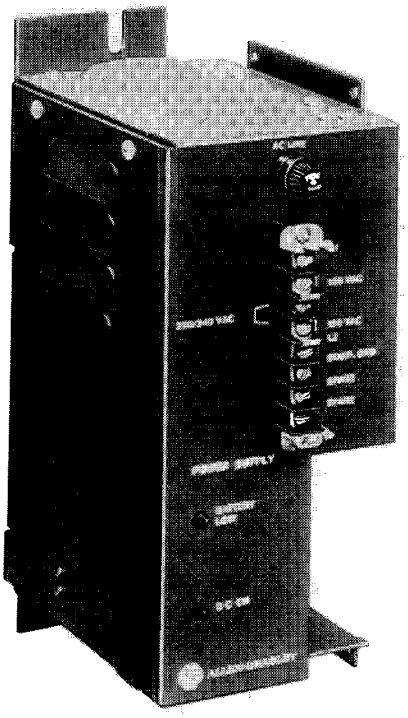


Figure 2.6 — System Power Supply

The maximum current of the System Power Supply 5.1V output is 6.5 amperes. This is sufficient for the largest controller configuration – one Mini-Processor Module and a 128 I/O Chassis holding as many as 16 I/O modules. The Power Supply current requirements for these modules are shown in Table 2.A.

The Power Supply can be operated from 120V AC, 220/240V AC, or 24V DC. [1]

The front face of the Supply provides a terminal strip for user input power connections and a fuseholder for ease of fuse replacement. In addition, there are two status indicators. These are labeled:

- DC ON
- BATTERY LOW

The significance of these status indicators is described in Section 5.

2.4.1 Input-Line Monitoring – The System Power Supply continuously senses the input voltage on the user's AC line. When it detects abnormally low line voltage, the System Supply signals the Mini-Processor. This signal alerts the Mini-Processor to stop receiving input data and to turn outputs OFF.

The value of this input-line monitoring is twofold: it guards against the entry of incorrect input data into controller memory, and it helps to provide consistent output shutdown when the user line fails or a "brownout" occurs.

The System Power Supply **normal** operating range, when jumpered for 120V AC operation, is between 98V and 132V AC. When jumpered for 220/240V AC operation, the normal range is between 196 and 250V AC.

The Power Supply allows some margin for variation from this normal voltage range. However, there is a **minimum** voltage of approximately 92V for 120V AC operation or approximately 184V for 220/240V AC operation. Should the AC line fall below normal range, to this minimum voltage for more than one-half cycle, the Power Supply signals the Mini-Processor Module to stop communication with its I/O modules.

When the Mini-Processor receives this signal, it stops receiving input module data. At the same time, it turns all controller outputs OFF. However, no special steps need be taken to restart the controller. The System Power Supply signals the Mini-Processor to restart when line voltage has recovered to the **normal** operating range.

In order to take full advantage of this input-line monitoring capability, the user should observe the layout recommendations given in Paragraph 3.1.4.

2.4.2 Fuse – The AC line fuseholder is on the front of the System Power Supply. The Supply is shipped with a 1-ampere fuse installed in the holder. This fuse is required for 120V AC operation.

A 0.5-ampere fuse is also shipped with the Supply for 220/240V AC operation **only**. Replace the 1-ampere fuse with this 0.5-ampere fuse if the System Power Supply is connected for 220/240V operation. Otherwise, do **not** place the 0.5-ampere fuse where it might mistakenly be used to replace a 1-ampere fuse.

Table 5.B lists the manufacturer's number for replacement fuses. The user may order the optional Fuse Package (Cat. No. 1771-FP). This contains 5 fuses each of both 1- and 0.5-ampere types.

When replacing fuses, use **only** the fuse of proper rating for the line voltage.

2.4.3 Power Cable – The I/O Power Cable is used to connect the System Power Supply and Battery Pack with the I/O Chassis. This Cable is available in two lengths. These are:

- Cat. No. 1771-CL I/O Power Cable (1 ft./30.5 cm)
- Cat. No. 1771-CM I/O Power Cable (5 ft./1.5 m)

The choice of Cable is based on the mounting arrangement for the System Power Supply.

2.4.4 Battery Pack – The System Power Supply is shipped with a Battery Pack as a standard item. The Battery Pack provides convenient, inexpensive memory backup power. Its batteries are used to maintain controller memory contents during AC power loss, removal or replacement of the Supply, or Supply shutdown.

One of two Battery Packs may be included with the System Supply. These are:

- Cat. No. 1771-BB Battery Pack
- Cat. No. 1771-BP Battery Pack

General information applicable to both these units is included in this Paragraph. Specific information on each of these Battery Packs is given in Paragraphs 2.4.4.1 and 2.4.4.2.

The Battery Pack makes backup power available to the user memory only as long as the Mini-Processor Module is seated in the left-most slot of the I/O Chassis. Therefore, it is recommended that a copy of the user's program be stored on punched or magnetic tape. If the Mini-Processor Module must be removed from the I/O Chassis, there will be a quick, convenient means of reloading the program.

The Battery Pack voltage level is continuously monitored by the System Supply. When this level drops beneath a certain threshold voltage, the BATTERY LOW indicator begins to flash. At this threshold voltage, batteries can continue to maintain memory contents for approximately one week. [2] This allows ample time for battery replacement.

In addition to this indicator, a battery-low condition is also signaled to the Mini-Processor Module. Memory bit 02700 is turned alternately ON and OFF when the Mini-Processor receives this signal. Thus, through the user's program, an annunciator, warning light, or other device can be used to warn of a battery-low condition.

Replacement alkaline batteries may be ordered using Cat. No. 1771-BA. A fresh supply of these replacement cells should be kept on hand. Store these batteries in a cool, dry environment.

Batteries may be replaced without loss of memory contents, provided that AC power to the Supply is ON. Battery replacement is described in Paragraph 5.2.4.

2.4.4.1 Cat. No. 1771-BB Battery Pack – The Cat. No. 1771-BB Battery Pack has a metal battery housing. The following additional parts are shipped as standard with this Pack:

- Mounting Hardware Set (Cat. No. 1771-BX), consisting of 2 metal brackets
- 2 alkaline D-size batteries (Cat. No. 1771-BA)

Assembly and mounting procedures for the Cat. No. 1771-BB Battery Pack are given in Paragraph 3.2.1.1.

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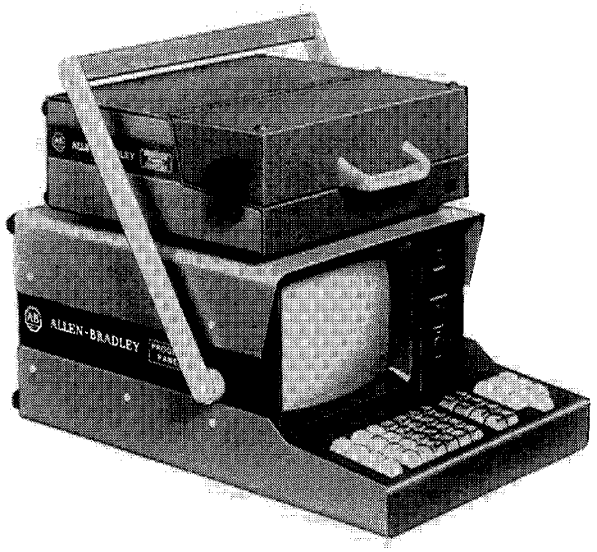
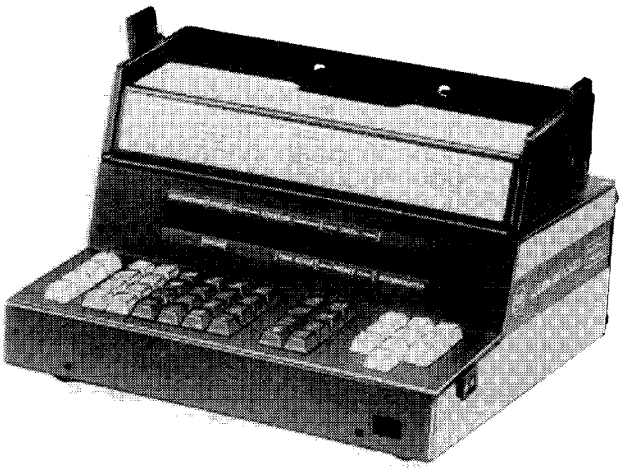
[1] Note that 24V DC operation is not described in this Publication. Consult factory for information on 24V DC operation.

[2] This one-week approximation applies whether the 512- or 1024- word memory is used.



(a) PLC Program Panel and Adapter



(b) PLC-2 Program Panel

Figure 2.7 — Compatible Program Panels

2.4.4.2 Cat. No. 1771-BP Battery Pack — The Cat. No. 1771-BP Battery Pack has a plastic battery housing. The following additional parts are shipped as standard when this Battery Pack is ordered as part of the System Power Supply:

- Outer mounting shell, for Chassis attachment
- 2 alkaline D-size batteries (Cat. No. 1771-BA) [1]

An optional lithium battery (Cat. No. 1771-BL) can be ordered for use with the Cat. No. 1771-BP Battery Pack. [2]

The assembly and mounting procedures for the Cat. No. 1771-BP Battery Pack are given in Paragraph 3.2.1.2.

2.5 Program Panels — Program Panels are used to enter the user's program to the Mini-Processor Module. In addition, the Program Panel can be used to edit the program, monitor or alter the ON/OFF status of a user device, or change a value in the user's application. The Program Panel also provides interfacing with several RS-232-C compatible data terminals for recording/loading a copy of the user's program on punched or magnetic tape, for Report Generation, or for producing a ladder diagram printout of the user's program.

There are 2 different Program Panels compatible with the Mini-Processor Module. These devices are:

- Bulletin 1772 PLC-2 Program Panel System (Cat. No. 1772-T1)
- Bulletin 1774 PLC Program Panel (Cat. No. 1774-TA) which must be used with the PLC/PLC-2 Program Panel Adapter (Cat. No. 1772-T4)

Refer to Figure 2.7.

The PLC/PLC-2 Program Panel Adapter is shipped with a Keyhead Conversion Kit (Cat. No. 1774-KH), to make the Bulletin 1774 PLC Program Panel compatible with the Bulletin 1772 Mini-PLC-2 instruction set.

Program Panels are portable and not usually left connected to the Mini-Processor when not in use. However, for applications using Report Generation, some users may prefer to set up some form of station for temporary or permanent Program Panel installation. Cable length limits the distance between the Mini-Processor Module and the PLC-2 Program Panel to 10 feet. This 10-foot distance also applies when the PLC/PLC-2 Program Panel Adapter is connected to the Mini-Processor. However, the user can make up a cable to mount the PLC Program Panel up to 50 cable-feet from the Adapter. (Refer to Paragraph 3.2.8.)

NOTE: Print pockets on the inside of an 8-inch enclosure door may prevent closing of the door while the Program Panel is connected to the Mini-Processor.

2.6 User-Supplied Equipment — In addition to the Mini-PLC-2 controller components described in this Section, the user supplies other equipment for controller installation. This may include any or all of the following devices:

- An enclosure, for mounting the controller and shielding from noise and airborne contaminants
- Emergency-Stop switches, variable in type and number
- Master Control Relay, to enable and disable I/O power by manual control
- Disconnects, normally a part of any electrical installation
- Isolation transformers or constant voltage transformers, as application needs dictate
- User power supplies, for I/O devices not powered directly from the AC line
- Suppression devices, for noise-generating equipment, including inductive loads in series with hard contacts

This equipment may vary widely between applications. Refer to Section 3 for recommendations concerning the use of these devices in conjunction with the controller.

[1] If the Cat. No. 1771-BP Battery Pack is ordered separately as a replacement unit, the 2 alkaline batteries are not supplied.

[2] The System Power Supply must be Series B, or later Series, for lithium battery use. (Series level is marked on the side label of the Supply.) Consult the factory for lithium battery availability and Supply update information.

Section 3
ASSEMBLY AND INSTALLATION

3.0 General — This Section outlines rules and recommendations for planning, layout, assembly, and installation of the Mini-PLC-2 programmable controller. A working understanding of these guidelines, in advance of installation, is necessary in the interest of safety and minimum down-time.

CAUTION: To avoid equipment damage, read and understand this entire Manual before attempting to install or operate the Mini-PLC-2 controller.

A primary consideration in programmable controller installation and operation is safety. The guidelines in this Section are presented with consideration for the safety of the operator, of controlled equipment and of the controller itself. As such, these guidelines are intended to **supplement** all applicable codes and ordinances which govern wiring and installation practices. The persons installing the controller should be familiar with local codes **and** these guidelines.

Essential for installation of the Mini-PLC-2 programmable controller is a well-planned layout. Paragraph 3.1 outlines the various considerations necessary for planning a controller installation. This Paragraph also describes various devices which are commonly supplied by the user for a programmable controller.

Once the layout of the controller is planned, the installation of its components can be done. Procedures for controller mounting, assembly and connections are given in Paragraph 3.2.

3.1 Recommendations for System Layout — This Paragraph describes the general recommendations for layout of the controller system. These recommendations are the result of both product testing and Allen-Bradley's cumulative experience with solid-state industrial controls. As such, they provide useful guidelines for most Mini-PLC-2 installations.

Overall recommendations concerning user-supplied equipment and wiring are also given in this Paragraph. These recommendations are intended to aid in making the controller an integral part of the user's manufacturing facility. Necessarily some of the installation recommendations for user-supplied equipment are general in nature. Environmental conditions, the individual application, and local codes and ordinances dictate the specific types, layout, and wiring of user-supplied installation equipment.

Particular industrial environments may contain one or more conditions adverse to solid-state control. The user's plant may include other equipment which produces excessive heat or electrical noise. Line-voltage variations may also occur in some locations. There are various measures which may be taken to limit the effect of any of these conditions. These are described in Paragraph 3.1.6.

3.1.1 Enclosure Considerations — An enclosure is usually provided by the user for the Mini-PLC-2 controller.

The enclosure is the chief protection of the controller from atmospheric contaminants. These may include oils, moisture, conductive dust or particles, or any corrosive or otherwise harmful airborne substance. Standards established by the National Electrical Manufacturer's Association (NEMA) define enclosure types, based on the degree of protection an enclosure is designed to provide. [1] In general, an enclosure which conforms to the NEMA standard for Type 12 enclosures is preferred for solid-state control devices.

The enclosure should be mounted in a position which allows doors to be opened fully and allows access to wiring and components for testing or troubleshooting. Also important is the accessibility of an emergency disconnect device in the enclosure, as noted in Paragraph 3.1.3.

The Mini-PLC-2 programmable controller requires a minimum enclosure working depth of 8 inches. "Working depth" is defined as the distance from the front mounting surface of the back panel to the inside rear of the door.

In some cases, back panels may be fixed on, or very close to, the inside rear wall of the enclosure. In other cases, back panels are mounted on standoffs which decreases the working depth available. Door-mounted print pockets may also use up valuable space. When specifying an enclosure for the Mini-PLC-2 controller, carefully examine the vendor's data sheets for print-pocket and standoff measurements; then calculate the "working depth" available.

3.1.1.1 Component Spacing — Mini-PLC-2 controller components must be spaced sufficiently from other equipment and the enclosure walls to allow convection cooling.

Convection cooling draws a vertical column of air upward, over the controller module surfaces. To keep the controller modules within the specified temperature limits, this cooling air, drawn at the base of the controller must not exceed 60°C (140°F). Because the flow of air is in the vertical direction, the unobstructed vertical spacing above and below controller components is especially important.

Vertical spacing is application-dependent, based on these factors:

- Average number of controller inputs and outputs ON at any one time. I/O modules must dissipate more heat when I/O devices are in the energized (ON) state.
- Average current supplied by output terminals to output devices. The greater the current draw, the more heat is generated.
- Heat from other equipment in or near the controller enclosure.

Because applications vary widely with regard to these factors, the vertical spacing will also vary. For this reason, two possible cases are described:

- Typical Condition, in Paragraph 3.1.1.1.1.
- Worst-Case Condition, in Paragraph 3.1.1.1.2.

The various factors of controller environment and use in individual applications can be compared with these cases. This allows the installer to judge the amount of unobstructed space required for his controller.

Note that these recommended spacing allowances refer to "unobstructed" space. This implies that no other device which might impede or prevent a steady vertical air flow should occupy this space. However, wiring or plastic wire-

[1] National Electrical Manufacturer's Association
2101 L Street NW
Washington, D.C. 20037

ways or wiring ducts can be routed through this space since they are not considered "obstructions" for this purpose.

Because the controller components are cooled by convection, the controller is to be mounted against a vertical panel and in an upright position, so that all modules present a vertical surface to convection flow.

3.1.1.1.1 Typical Condition – In a typical Mini-PLC-2 controller installation, the following conditions of use and environment may exist:

- On an average, 60% of inputs are energized (ON) at any one time.
- On an average, 30% of outputs are energized (ON) at any one time.
- Each output terminal, in the ON state, supplies an average 250 mA current to its load.
- Air temperature outside the enclosure is not more than 40°C (104°F).

For a controller with these operating conditions, the following spacing allowances, as shown in Figure 3-1, are recommended:

- Allow 6 vertical inches (15.2 cm) above and below all controller components. When more than one controller is mounted within an enclosure, allow 6 vertical inches between controllers.
- Allow 4 horizontal inches (10.2 cm) on the side of each controller component. (When the Power Supply is Chassis mounted, allow 4 inches from the left side of the Supply.)
- Allow 6 horizontal inches (15.2 cm) between 2 controllers mounted in the same horizontal plane within the same enclosure.

3.1.1.1.2 Worst-Case Condition – A Mini-PLC-2 controller may be considered to be operating under worst-case conditions when **either** of the following statements is true:

- Equipment near the controller produces large amounts of heat.
- Almost all controller inputs and outputs are continuously energized (ON). Output modules are supplying the maximum allowable current to output devices.

Under these conditions, spacing of controller components within the enclosure becomes more critical. Where these conditions exist, the following minimum spacing dimensions are recommended:

- Allow 10 vertical inches (25.4 cm) from the base of the I/O Chassis or Power Supply to the inside bottom of the enclosure.
- Allow 12 vertical inches (30.5 cm) above each controller component. When more than one controller is mounted in an enclosure, allow 12 vertical inches between controllers.
- Allow 4 horizontal inches (10.2 cm) on the side of each controller component. (Where the Power Supply is Chassis-mounted, allow 4 inches from the left side of the Supply.)
- Allow 6 horizontal inches (15.2 cm) between 2 controllers if mounted in the same horizontal plane within the same enclosure.

Component spacing for a worst-case installation is indicated in Figure 3.1.

Note that the input ambient temperature, (the temperature of the air at the base of the controller) must not exceed 60°C (140°F). In some applications, additional cooling means may be required to keep the input ambient temperature within specifications. (Refer to Paragraph 3.1.6.1.)

3.1.1.2 Wiring Layout – Careful wire routing within the enclosure helps to minimize any electrical noise due to "crosstalk" between I/O lines. Follow these rules for routing user wiring:

- **Rule No. 1** – Route AC input power into the enclosure by a separate path from wiring to I/O modules.
- **Rule No. 2** – Do not mount I/O wiring ducts closer than 2 inches (5 cm) from the I/O Chassis. If terminal strips are used for I/O wiring, these must not be mounted within 2 inches of the Chassis.

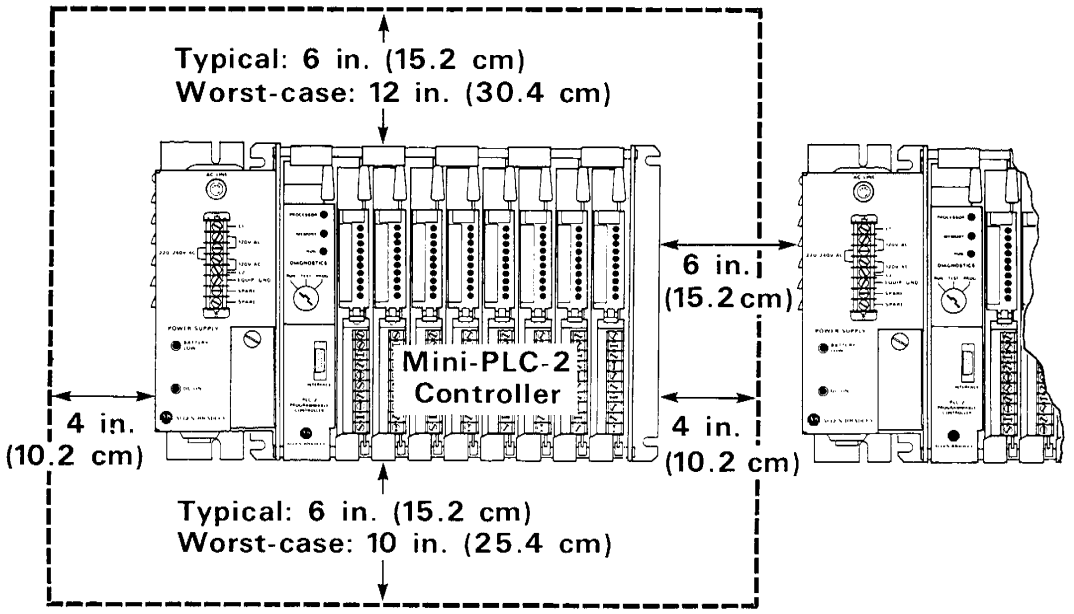


Figure 3.1 – Unobstructed Space Requirements

- **Rule No. 3** – Segregate I/O wiring by signal type. Bundle wiring with similar electrical characteristics together. Wiring with different signal characteristics should be routed into the enclosure by separate paths, whenever possible.

  Following this rule, for example, AC I/O wiring is bundled together and routed physically separate from DC I/O, analog, TTL, or other wiring. It is preferable to use separate ducts for AC and DC I/O wiring. Alternately, one duct may be used, with AC and DC I/O wiring entering the enclosure from different directions.

Figure 3.2 shows these rules used in a typical controller configuration.

I/O wiring is facilitated when I/O modules in the Chassis are grouped together by type. Figure 3.2 for example, shows AC I/O modules placed to the right in the Chassis, DC I/O modules to the left. (Since slot positions in the I/O Chassis directly correspond to programming addresses, the actual designation of an I/O module to a specific slot is the concern of the programmer.)

I/O wiring practices may vary, depending upon the nature of the application and types of I/O modules used. Where a high level of electrical noise exists in an application, I/O wiring with different signal characteristics must be routed along different paths and in separate ducts within the enclosure whenever possible. In addition, noise suppression might be needed for some applications. (These are listed in Paragraph 3.1.6.2.)

Specific I/O modules may require other wiring practices to limit electrical noise. Refer to product data sheets on individual I/O modules for this information.

3.1.1.3 Layout Examples – Representative layouts for both typical and worst-case conditions are shown in Figures 3.3 thru 3.5. All dimensions shown are based on standard sizes for 8- and 10-inch depth enclosures.

Note that the Power Supply may be mounted up to 5 cable-feet from the I/O Chassis as shown in Figure 3.4. This allows the user flexibility in enclosure sizing.

3.1.2 Grounding – Grounding is an important safety measure in electrical installations. With solid-state control systems, grounding has added value because it helps to limit the effects of noise due to electromagnetic induction.

WARNING: The Mini-PLC-2 programmable controller, controller enclosure, and controlled devices must all be properly grounded. All applicable codes and ordinances should be observed when wiring the controller system.

The grounding path for the controller and its enclosure is provided by the equipment-grounding conductor. This conductor provides a permanent, continuous, low-impedance path to ground for any possible fault current in the system.

The exact configuration of the equipment grounding conductor varies between installations. An equipment grounding conductor is identifiable by its green insulation. Normally, the grounding conductor is routed into the enclosure along with the current-carrying conductors in the user's line and connected to a suitable mounting lug on the enclosure back panel. It is often necessary, however, to provide an additional grounding conductor connection with the enclosure. A separate connection

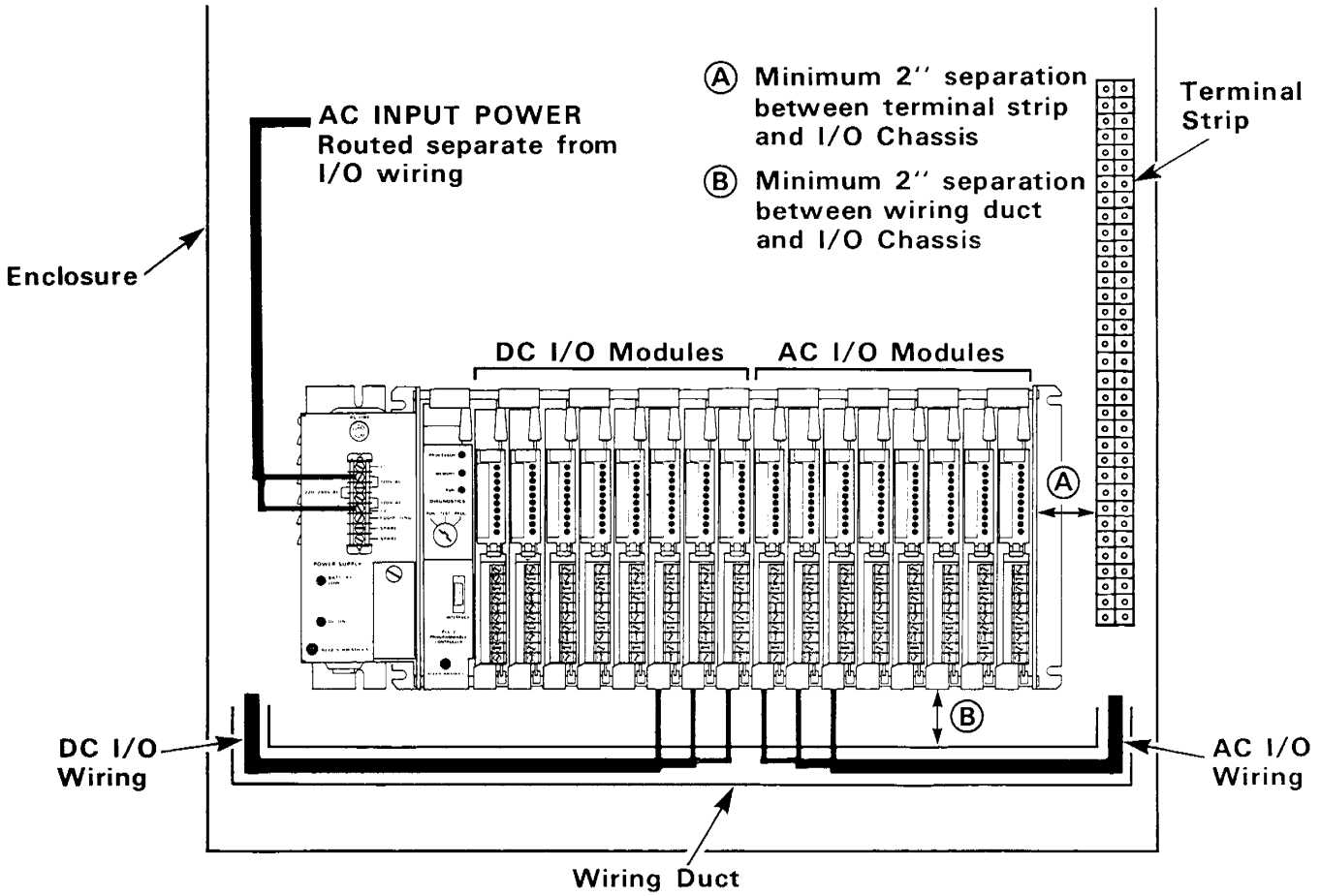
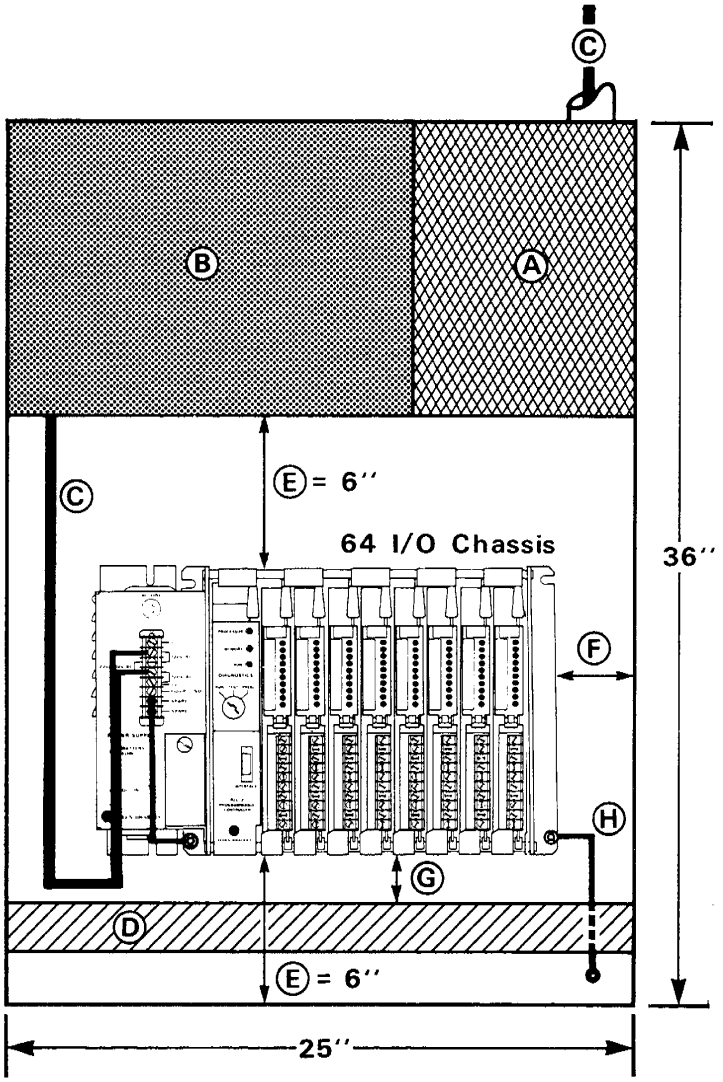


Figure 3.2 – Example Wiring and Duct Layout



Legend:

(Figures 3.3, 3.4, and 3.5)

Ⓐ This 9 x 12 in. area reserved for disconnecting means.

Ⓑ Area available for fuses, control relay, transformers, or other user devices.

Ⓒ AC input line. Routed separately from I/O wiring.

Ⓓ Wiring duct for I/O wiring within enclosure.

Ⓔ Unobstructed minimum vertical space required.

Above the controller:

Typical – 6 in.

Worst Case – 12 in.

Below the controller:

Typical – 6 in.

Worst Case – 10 in.

Between 2 controllers:

Typical – 6 in.

Worst Case – 12 in.

Ⓕ Unobstructed horizontal space required: 4 in. (minimum)

Ⓖ Minimum 2 in. between I/O wiring duct or terminal strip and I/O Chassis.

Ⓗ 8-gauge wire or 1-inch braid for bonding purposes. (Refer to Paragraph 3.1.2.)

Figure 3.3 – Example Layout – Typical Spacing

from a lug on the enclosure to the nearest reliable ground is made in this instance. Local codes and ordinances dictate which grounding means are acceptable.

The equipment grounding conductor connects to the Power Supply terminal labeled EQUIP. GND. In addition, this conductor also is used to ground other controller components and the enclosure itself. The connection of the controller components and the enclosure in this way effectively "bonds" them together for grounding purposes. (A bonding connection is made when two metallic parts of electrical equipment, not intended in normal operation to conduct current, are solidly joined to provide a conductive path for fault current.)

To provide good electrical contact between controller components and the enclosure, bare-metal contact is required. Paint or other non-conductive finish must be scraped from the back panel where it comes in contact with a controller mounting bolt, nut, or stud. Non-conductive finishes must also be scraped from the mounting slot of the System Power Supply. Mounting procedure is described in Paragraph 3.2.2.

In addition to scraping the mounting areas, additional bonding means should be used. An 8-gauge wire or 1-inch metal braid should be used to connect each controller component to the enclosure. Connections should be made at mounting bolts or studs.

Grounding connections for the Mini-PLC-2 programmable controller are shown in Figure 3.6. Exact connections will differ between applications.

An authoritative source for grounding requirements for most installations is the National Electrical Code.[1] Article 250 of the Code provides such data as the size and types of conductors and connections necessary for safe grounding of electrical components. As defined in the Code, a grounding path must be permanent and continuous, and be able to conduct safely the ground-fault current possible in the system, with minimal impedance. This implies that any connection to a grounding conductor must also be of a permanent nature. Thus, solder does **not** provide an acceptable connection for bonding and grounding purposes.

In addition to the grounding required for the programmable controller and its enclosure, the user must also provide proper grounding for all controlled devices in his

[1] National Electrical Code, published by the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210 (Publication NFPA 70-1978).

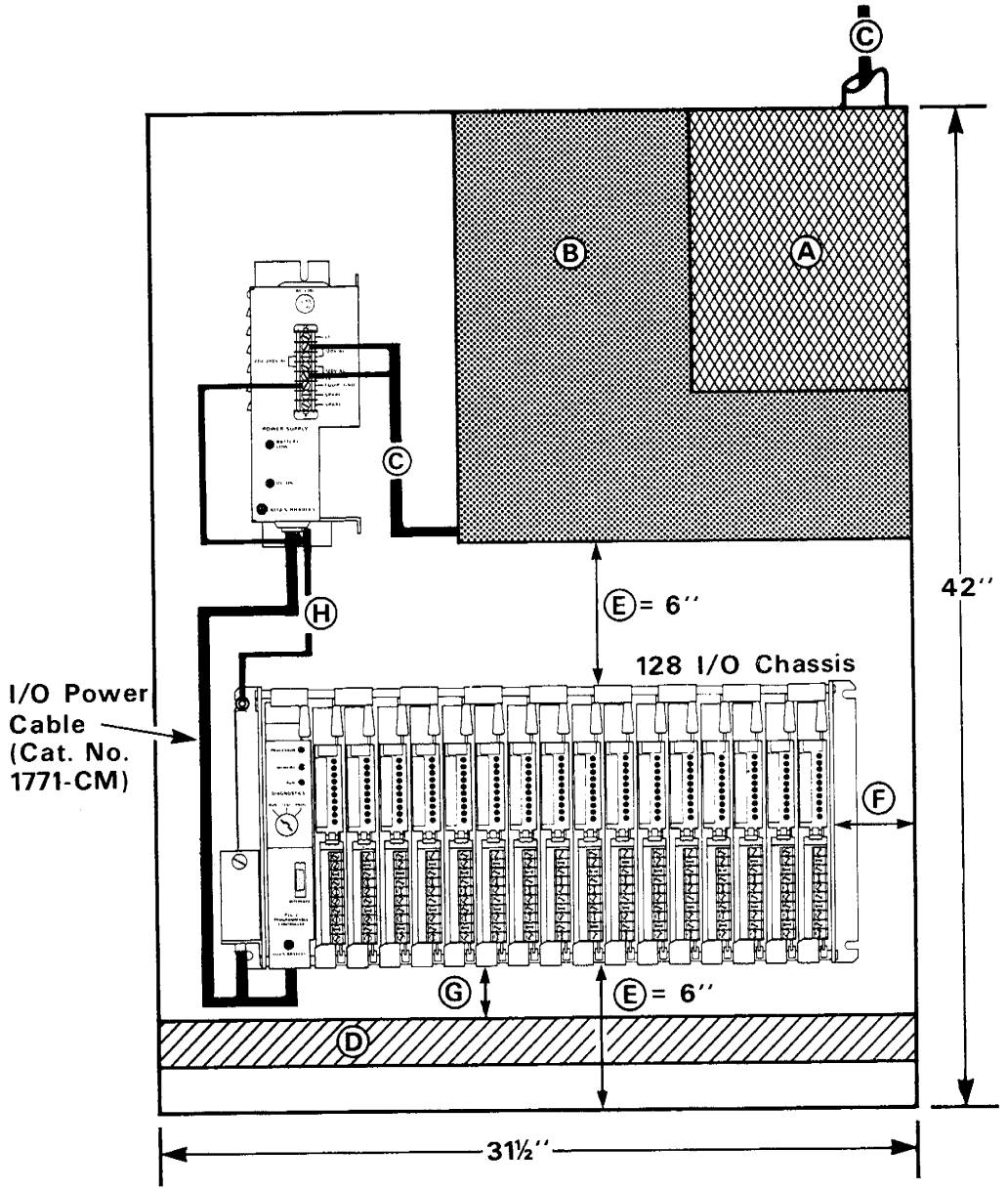


Figure 3.4 — Example Layout — Separately Mounted Supply

application. Care must be taken to provide each device with an acceptable grounding path. This helps prevent the possible occurrence of ground loops, that is, erroneous connection of grounds in series, which causes undesirable voltage potentials.

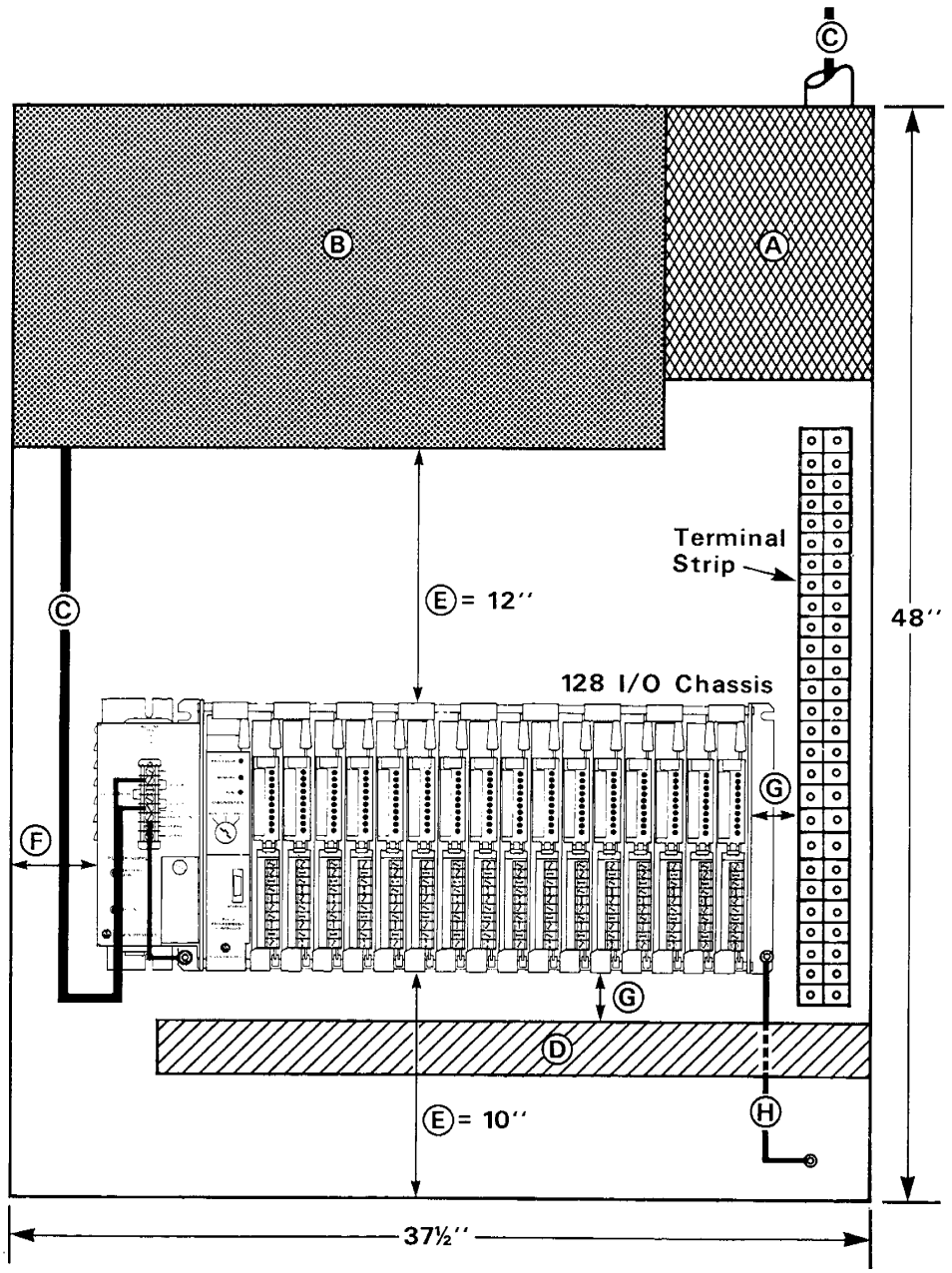
3.1.3 Master Control Relay — A hard-wired master control relay, to be supplied by the user, provides a convenient means for controller shutdown. Since the master control relay allows the placement of several Emergency Stop switches in different locations, its installation is strongly recommended. When used as outlined in this Paragraph, the master relay also provides distinct troubleshooting advantages.

Wiring of the control relay in a grounded system is shown in Figure 3.7. [1] When any of the Emergency Stop switches are opened, power to input and output devices is removed. However, power continues to be supplied to the System Power Supply. Thus, the controller itself continues operation, even though all of its inputs and outputs are disabled. This allows the inspection of diagnostic indicators on the Mini-Processor Module and System Power Supply.

Note that the master control relay is **not** a substitute for a disconnect to the controller. It is intended for any situation where the operator must quickly de-energize I/O devices **only**. When replacing any module, replacing output module fuses, or working on equipment within the enclosure, the disconnect must be used to shut off power to the controller system.

The master control relay must **not** be controlled by the Mini-PLC-2 controller. The operator must be provided with the additional safety of a direct connection between an Emergency Stop switch and the master control relay.

[1] An ungrounded system requires ground detector lights, fuses, and CRM contacts on both sides of the transformer secondary.



Legend:

(Figures 3.3, 3.4, and 3.5)

Ⓐ This 9 x 12 in. area reserved for disconnecting means.

Ⓑ Area available for fuses, control relay, transformers, or other user devices.

Ⓒ AC input line. Routed separately from I/O wiring.

Ⓓ Wiring duct for I/O wiring within enclosure.

Ⓔ Unobstructed minimum vertical space required.

Above the controller:

Typical – 6 in.

Worst Case – 12 in.

Below the controller:

Typical – 6 in.

Worst Case – 10 in.

Between 2 controllers:

Typical – 6 in.

Worst Case – 12 in.

Ⓕ Unobstructed horizontal space required: 4 in. (minimum)

Ⓖ Minimum 2 in. between I/O wiring duct or terminal strip and I/O Chassis.

Ⓗ 8-gauge wire or 1-inch braid for bonding purposes. (Refer to Paragraph 3.1.2.)

Figure 3.5 – Example Layout – Worst-Case Spacing

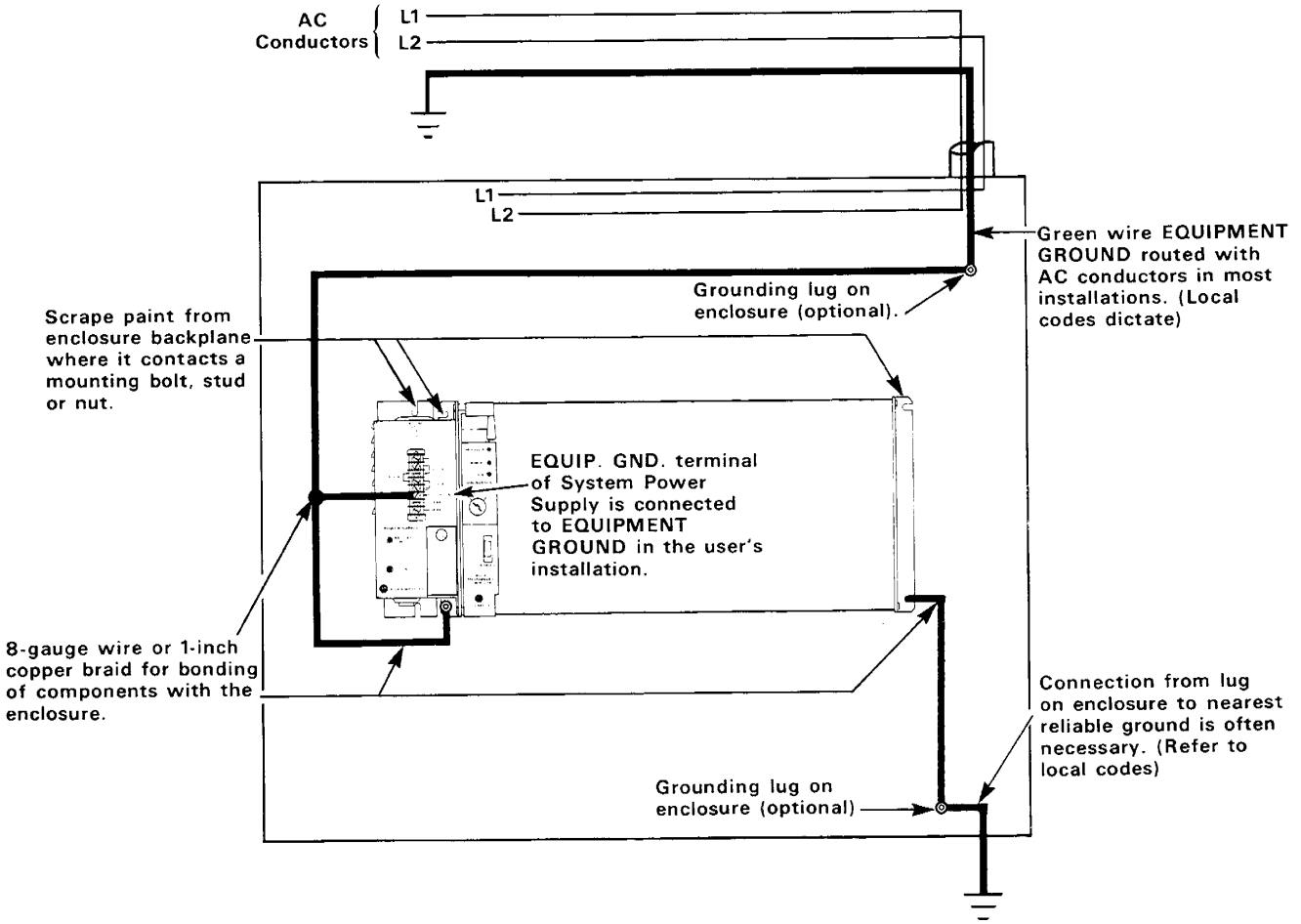


Figure 3.6 — Controller Grounding Connections

WARNING: Do not program Emergency Stop switches in the controller program. Any Emergency Stop switch should turn off all machine power, by turning off the master control relay.

Observe all applicable local codes concerning placement and labeling of Emergency Stop switches.

CAUTION: It is the user's responsibility to install Emergency Stop switches and the master relay. The user must make certain that relay contacts have sufficient rating for his application. Emergency Stop switches must be located in a place which gives quick access to operator or maintenance personnel. Of course, multiple Emergency Stop switches can be wired in series, as required.

Once a fault is corrected, the controller can be restarted by placing the Mode Select Switch on the Mini-Processor in TEST, pressing the START switch, as shown in Figure 3.7, and then turning the Mode Select Switch to RUN.

3.1.4 Common AC Source — It is strongly recommended that the System Power Supply have the same AC source as input and output devices. This relationship is depicted in Figure 3.7.

As Paragraph 2.4.1 states, the System Power Supply monitors its input voltage. When it detects abnormally low line voltage, the Supply signals the Mini-Processor to stop receiving input data; at the same time, the controller turns all outputs off.

To take fullest advantage of the Supply's input-line monitoring, therefore, the same AC source powering the Supply should be used for I/O devices. As Figure 3.7 illustrates, it is also recommended that any DC supply for I/O devices be derived from the common AC source.

3.1.5 Transformer Rating — A user-supplied isolation transformer is often used along the AC line to the controller. (Refer to Figure 3.7.) This type of transformer provides isolation from the user's power distribution system and is often used as a "step down" transformer to reduce line voltage to desired levels. Any transformer used with the Mini-PLC-2 controller must have a sufficient power rating for its load. This power rating is generally expressed in units of volt-amperes, VA.

To size a transformer for its load, the worst-case power requirement of the load must be considered. Often, this worst-case power requirement is several times the nominal power requirement for a specific unit of electrical equipment. For some motors, for instance, the power required during start-up is several times the power needed for continuing operation.

The System Power Supply has a nominal power rating of 75 VA. To supply the worst-case power to the System Power Supply, an isolation transformer should have at least **3 times** this rating, that is, 225 VA. This allows ample power to be delivered to the Power Supply

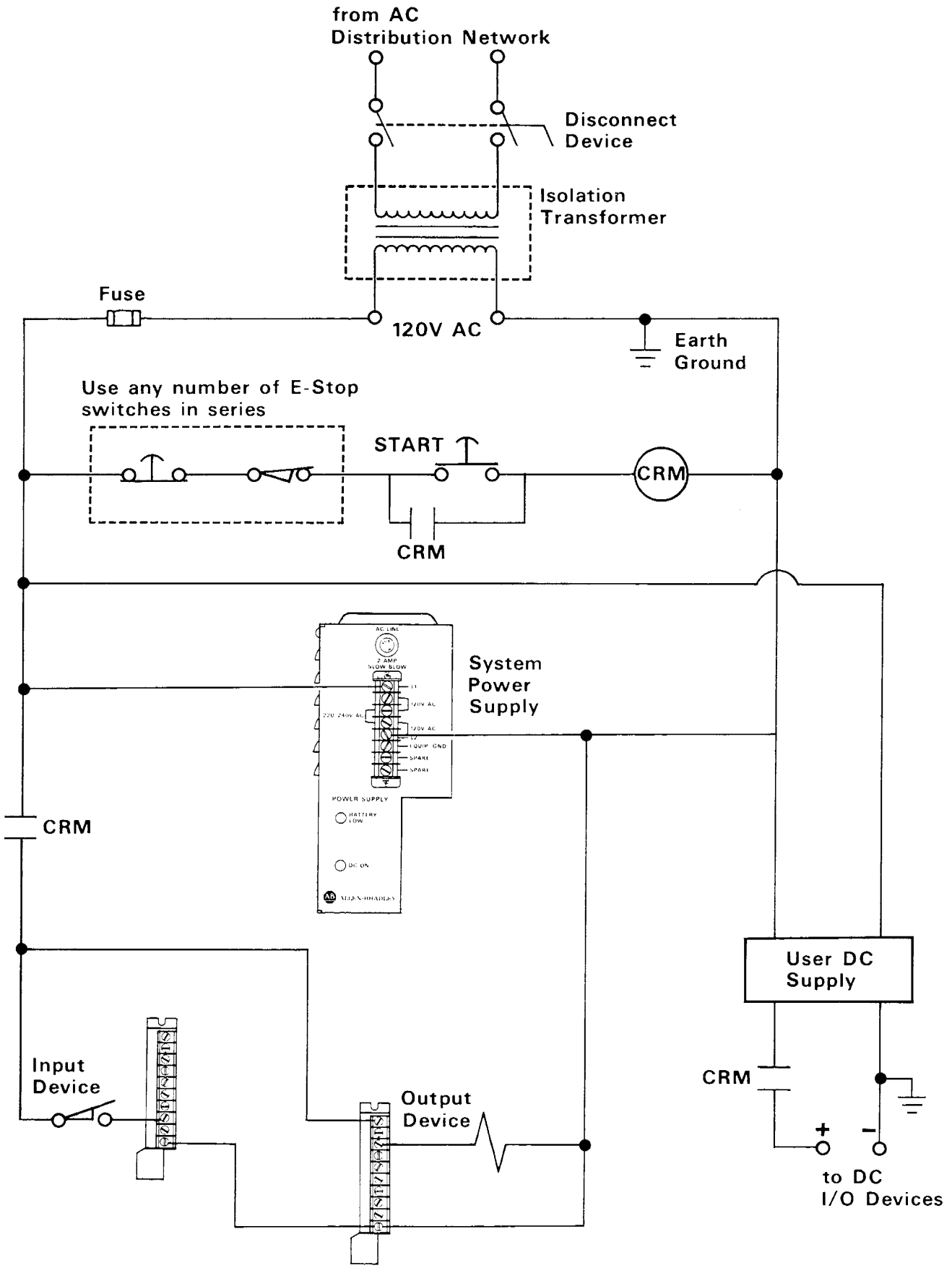


Figure 3.7 — Master Control Relay Configuration

throughout the AC cycle. This also allows sufficient power for most types of input devices. (Input devices, such as switches, generally consume little power.)

Where other devices, such as controlled output equipment, also load this same transformer, the VA-rating required for these devices must be added to that required for the controller itself.

This same sizing consideration also applies when selecting a constant voltage transformer. (Refer to Paragraph 3.1.6.3.)

3.1.6 Special Considerations – The recommendations given in the preceding paragraphs are sufficient to provide favorable operating conditions in the majority of controller installations. However, individual applications may contain one or more adverse conditions of heat, electrical noise, or line-voltage variation. This Paragraph describes steps which can be taken to minimize the effect of these conditions.

3.1.6.1 Excessive Heat – For most applications, normal convection cooling keeps controller components within the 0° to 60°C operating range. Thus, the proper spacing of components within the enclosure is usually sufficient for heat dissipation. (Spacing recommendations are given in Paragraph 3.1.1.1.) However, in some applications, a substantial amount of heat is produced by other equipment inside or outside the enclosure. In this case, blower fans may be placed inside the enclosure to assist air circulation and to reduce "hot spots" near the controller. However, do not bring in outside air; it may introduce harmful contaminants or dirt.

In extreme cases, air conditioning may be required to protect against heat build-up within the enclosure.

3.1.6.2 Excessive Noise – When the Mini-PLC-2 controller is operating in a "noise-polluted" industrial environment, special consideration should be given to possible electrical interference. The effect of electrical interference is reduced by the design of the Mini-PLC-2 controller, by its proper mounting within an enclosure, and by the routing of wiring as recommended in Paragraph 3.1.1.2. However, to increase the operating margin in noise-filled environments, it is recommended that suppression of noise generators be provided.

Potential noise generators include inductive loads, such as relays, solenoids, and motors and motor starters when they are operated by "hard contacts," such as push buttons and selector switches. In the case of reversing motor starters, hard contacts are wired in to make each starter electrically as well as mechanically interlocked. With this case, suppression is needed at the device because of the hard contacts in the circuit with the load.

Suppression for noise generators may be necessary when these types of loads are connected as output devices or when connected along the same AC line which powers the Mini-PLC-2 controller.

Suggested electrical noise suppression for small AC devices (i.e. relays, solenoids, and starters up to Size 1) is given in Figure 3.8. Larger contactors of Size 2 and above need, in addition to the RC network, a parallel varistor for transient voltage limitation. (Refer to Figure 3.9.) Three-phase motors are transient-suppressed by providing discharge networks across all phases. (Refer to Figure 3.10.) DC relays are suppressed by free-wheeling diodes. (Refer to Figure 3.11.) However, resistors or zener diodes can be substituted under special conditions.

Some applications present a heavily noise-polluted environment, with such noise sources as high-frequency welding equipment, large AC motors, DC commutation machines, etc. In these applications, all possible sources of noise should be suppressed. Best results are achieved when

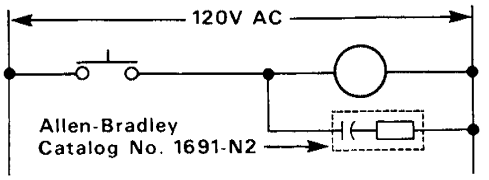


Figure 3.8 – Typical Interference Suppression for Small Apparatus

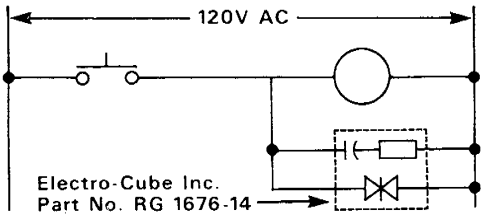


Figure 3.9 – Typical Interference Suppression for Large Apparatus

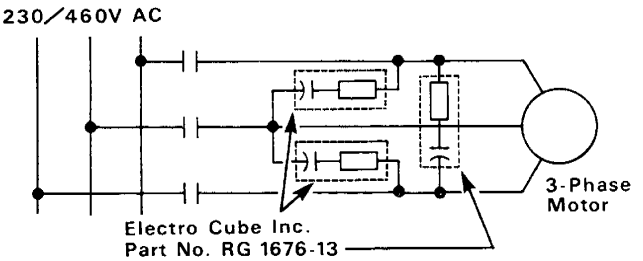


Figure 3.10 – Typical Interference Suppression for 3-Phase Apparatus

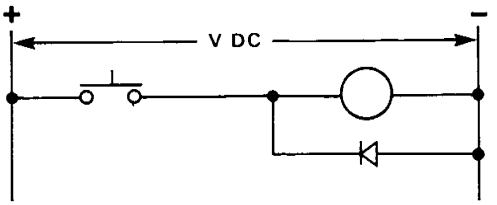


Figure 3.11 – Typical Interference Suppression for DC Relays

the noise-suppressing networks are connected as closely as possible to the device.

Keep high-power AC and DC wiring separate from input and output device wiring, as this will reduce the electrical interference in the controller system. Where I/O wiring must cross AC power lines, it should do so only at right angles.

3.1.6.3 Constant Voltage Transformer – In applications where the AC line is especially unstable and subject to unusual variation, a constant voltage transformer can be used to stabilize the input voltage to the Power Supply as well as the input voltage to user devices.

As stated in Paragraph 2.4.1, the System Power Supply has a normal operating voltage range, which allows some margin for line variation. As long as input voltage is within normal range, the Supply provides the necessary logic voltage at its outputs and enables the Mini-Processor Module. However, if a significant drop below normal

range is detected, the Supply signals the Mini-Processor to stop I/O data communication .

The best solution to line variation is to correct any feeder problems in the user's line power distribution. Where this does not solve the line variation problem, or in certain critical applications, a constant voltage transformer can be used.

A constant voltage transformer compensates for voltage changes at its input, or primary, to maintain a steady voltage value at its output, or secondary. If a constant voltage transformer is required, it must be connected to the System Power Supply **and** all input devices connected to the Mini-PLC-2 programmable controller. Output devices should be connected on the same AC line, but their connection along the AC line is normally made before the constant voltage transformer.

A constant voltage transformer must have sufficient power rating for its load. As stated in Paragraph 3.1.5, the transformer power rating for the System Power Supply itself should be at least 225 VA. This rating is sufficient when the Power Supply and **input** devices are connected along the transformer secondary. However, if any **output** device is connected thru the constant voltage transformer, a higher rating is required.

The Sola CVS, Solatron series, or equivalent constant voltage transformers, are suitable for use with the Mini-PLC-2 programmable controller. [1] These transformers incorporate line filtering which removes high harmonic content and provides a sinusoidal output. However, other types of constant voltage transformers, such as the Sola CVN, are **not** recommended for use with the System Power Supply. (Line filtering of high harmonics is not provided by transformers of this type.)

3.2 Procedures for Installation – This Paragraph describes the assembly and installation procedures for Mini-PLC-2 controller components. For ease of controller set-up, the installer should carry out these procedures in the order which follows.

3.2.1 Battery Pack – The first step in Mini-PLC-2 installation is assembly and mounting of the Battery Pack to the I/O Chassis.

As stated in Paragraph 2.4.4, there are two different Battery Packs. These Battery Packs differ significantly with respect to polarity and mounting method. Thus, the installer should refer **only** to the subsequent Paragraph which applies to the Pack shipped with his Power Supply.

3.2.1.1 Cat. No. 1771-BB Battery Pack – The Cat. No. 1771-BB Battery Pack has a metal battery housing. This Battery Pack is shipped with the Mounting Hardware Set (Cat. No. 1771-BX) consisting of a set of 2 mounting brackets with screws. These brackets are mounted by the user on the left side-plate of the I/O Chassis. Mounting of these brackets is shown in Figure 3.12.

Standard with the Cat. No. 1771-BB Battery Pack are 2 D-size alkaline batteries (Cat. No. 1771-BA). These batteries are positioned in the battery housing with the polarity shown in Figure 3.13. It is most advantageous to align each battery so that the seam of the battery case faces downwards in the Pack. Should one (or both) of the batteries leak, the drip tray will collect the effluence.

The Battery Pack slides into position along the mounting bracket tracks. A thumbscrew then retains the Pack in the bracket.

3.2.1.2 Cat. No. 1771-BP Battery Pack – The assembled Cat. No. 1771-BP Battery Pack consists of two plastic units: an inner tray to hold the batteries and an outer shell in which the assembled inner tray is to be mounted.

The Battery Pack and alkaline D-size batteries are shipped

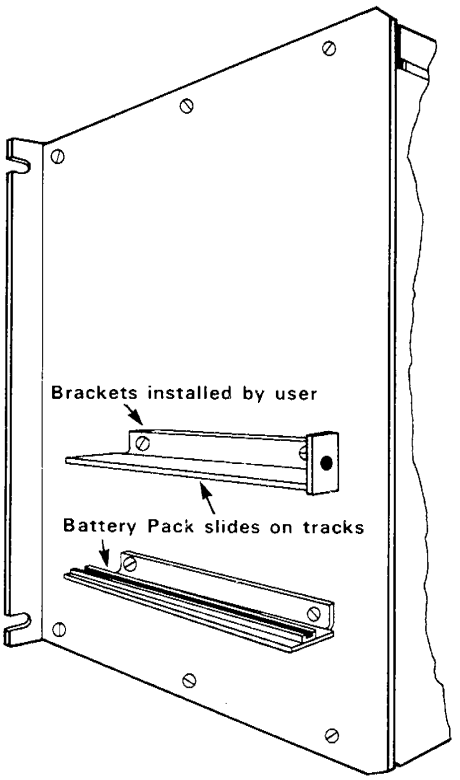


Figure 3.12 – Mounting Hardware Set (Cat. No. 1771-BX)

as standard with the System Power Supply (Cat. No. 1771-P1). The batteries are to be installed in the inner tray with the polarity shown in Figure 3.14. It is most advantageous to align each battery so that the seam of the battery case faces downwards in the Pack. Should one (or both) of the batteries leak, the effluence will be contained.

As Figure 3.14 shows, a removable separator and two gaskets are fitted between the two batteries upon installation. These devices aid in protection against possible leakage of the alkaline cells. Note the positioning of the plastic separator in the center slot of the battery tray.

The Cat. No. 1771-BP Battery Pack also permits the use of an optional Lithium Battery (Cat. No. 1771-BL). To use the single D-sized Lithium Battery, the user must move the plastic spring holder and its gasket forward in the tray. This is shown in Figure 3.15. (The polarity of the Lithium Battery is the same as that for the alkaline cells.) [2]

The plastic separator and its gaskets are not used with the Lithium Battery. They should be stored in the rear of the tray.

To attach the Cat. No. 1771-BP Battery Pack, the installer should first screw the outer plastic mounting shell onto the Chassis. (This is shown in Figure 3.16.) The assembled

[1] Sola Basic Industries
1717 Busse Road
Elk Grove Village, IL 60007

[2] The System Power Supply must be Series B, or later Series, for lithium battery use. (Series level is marked on the side label of the Supply.) Consult the factory for lithium battery availability and Supply update information.

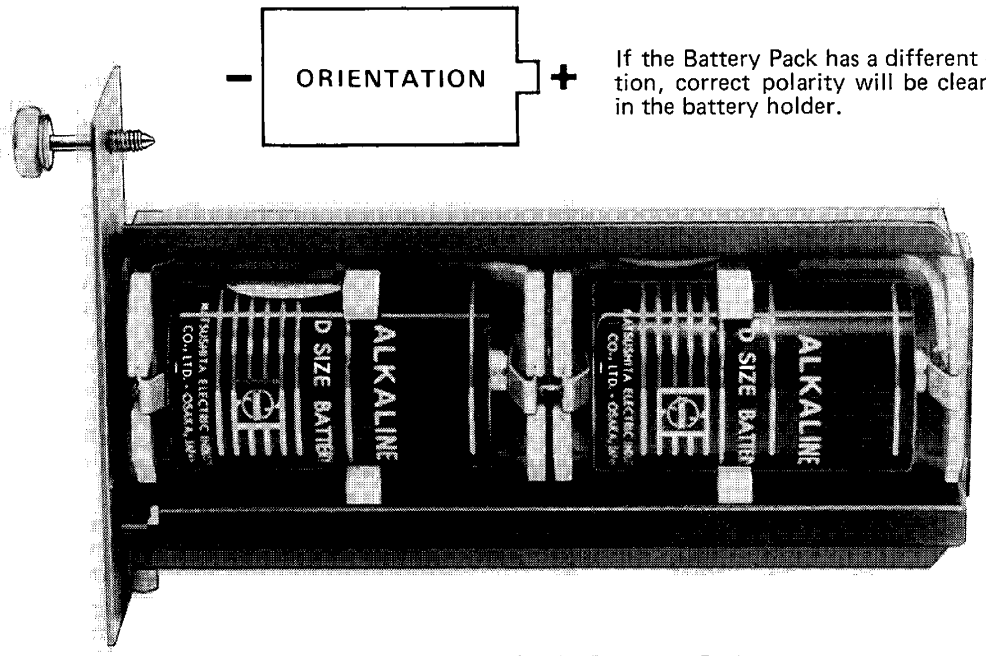


Figure 3.13 – Cat. No. 1771-BB Battery Pack

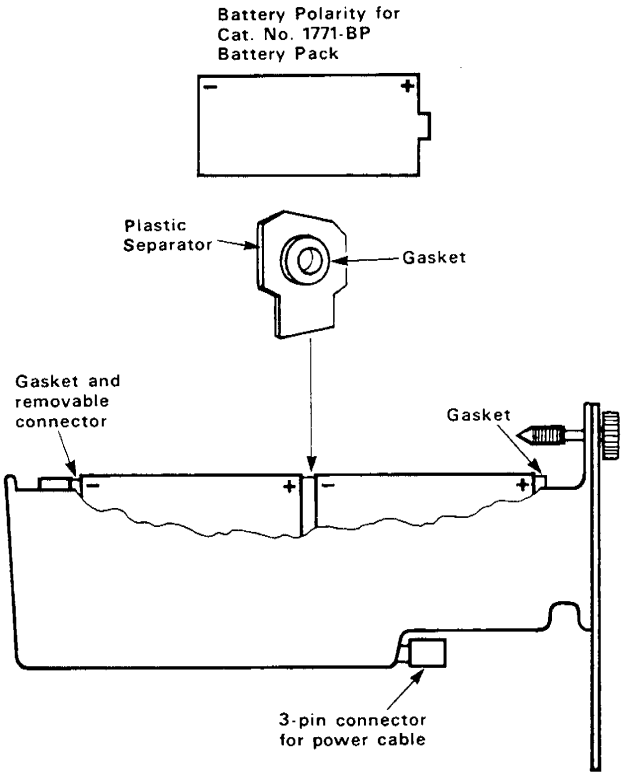


Figure 3.14 – Cat. No. 1771-BP Battery Pack

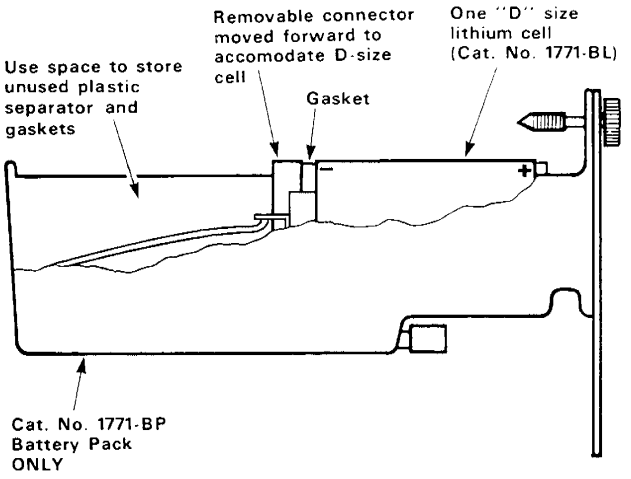


Figure 3.15 – Lithium Battery Placement

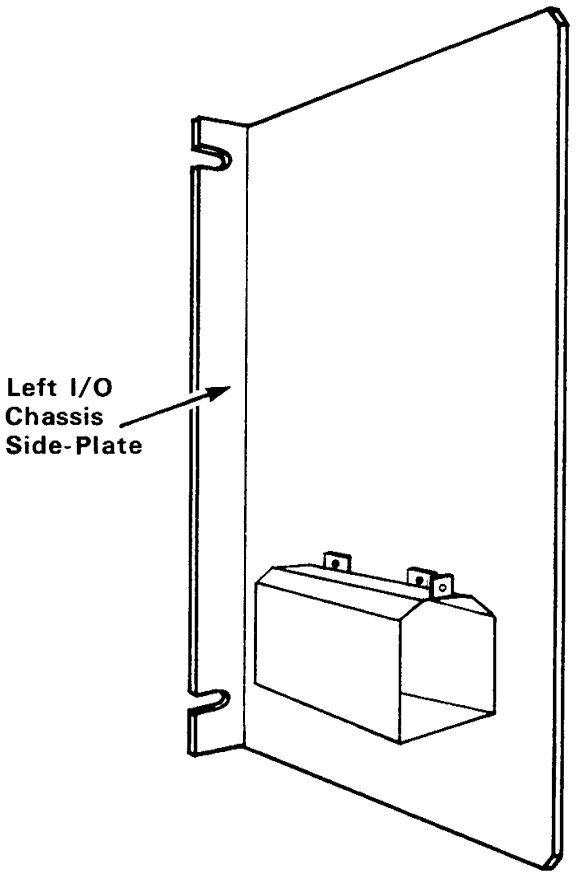


Figure 3.16 – Mounted Plastic Battery Shell

inner tray can then be slid into position in the shell. A thumbscrew then retains the Pack in place.

3.2.2 Mounting – Mini-PLC-2 controller components are designed for back panel mounting using either 1/4-inch bolts or welded studs. Mounting procedures for the installer are given in this Paragraph. Dimensions for the different Chassis sizes and configurations are given in Figures 3.17 thru 3.19.

Prior to mounting on the back panel the Battery Pack should be attached to the I/O Chassis side-plate as described in Paragraph 3.2.1. In addition, if the side-mounting configuration is used, the Power Supply is most easily attached to the I/O Chassis **before** panel mounting.

The controller components must have solid electrical contact with the enclosure for grounding purposes. Scrape paint or other non-conductive finish from the enclosure back panel surface or Power Supply mounting bracket where it joins the bolt or stud. This allows Keps[TM] nuts [1] to dig into the metal for electrical contact.

A side view of one section of a bolt-mounted unit is shown in Figure 3.20. A stud-mounted unit is shown in Figure 3.21. Care must be taken with stud-mounted units not to break the weld when tightening the nuts.

When the Chassis and Power Supply are being mounted, the installer should also attach the 8-gauge wire or 1-inch metal braid for bonding purposes, as specified in Paragraph 3.1.2.

Note: Care must be taken not to allow warping of the mounted I/O Chassis. (This may occur if the back panel is slightly curved.) Chassis distortion can introduce stress into the printed circuit board of the Chassis backplane. Poor connection of modules with backplane connectors may result.

[1] Keps is a registered trademark of Illinois Tool Works, Inc.

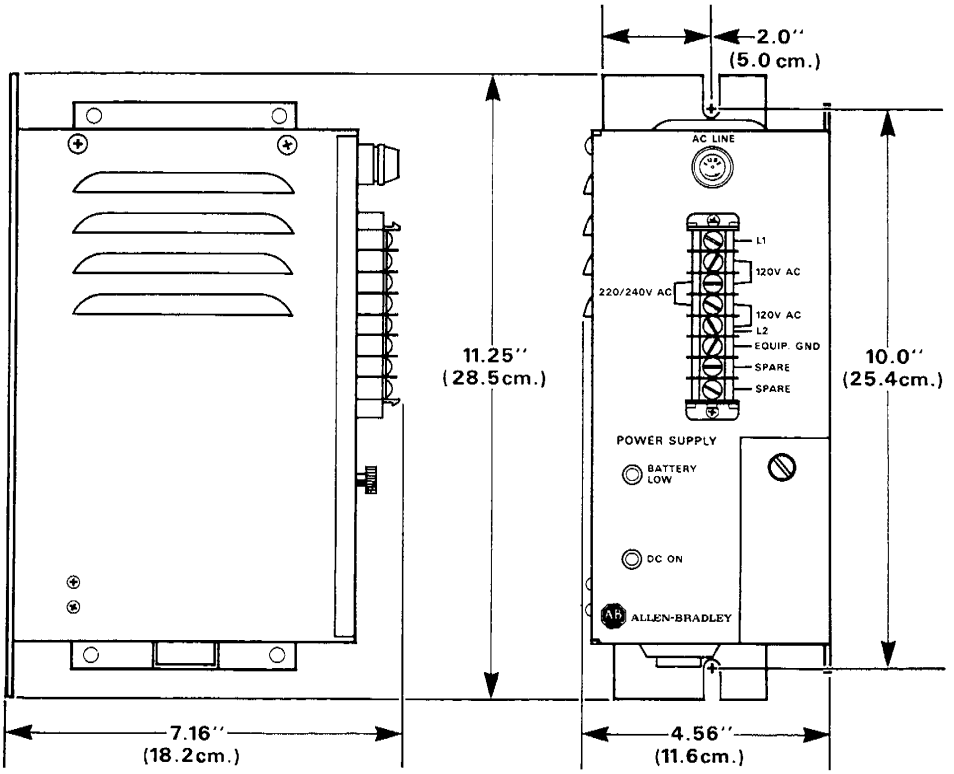


Figure 3.17 – System Power Supply Dimensions

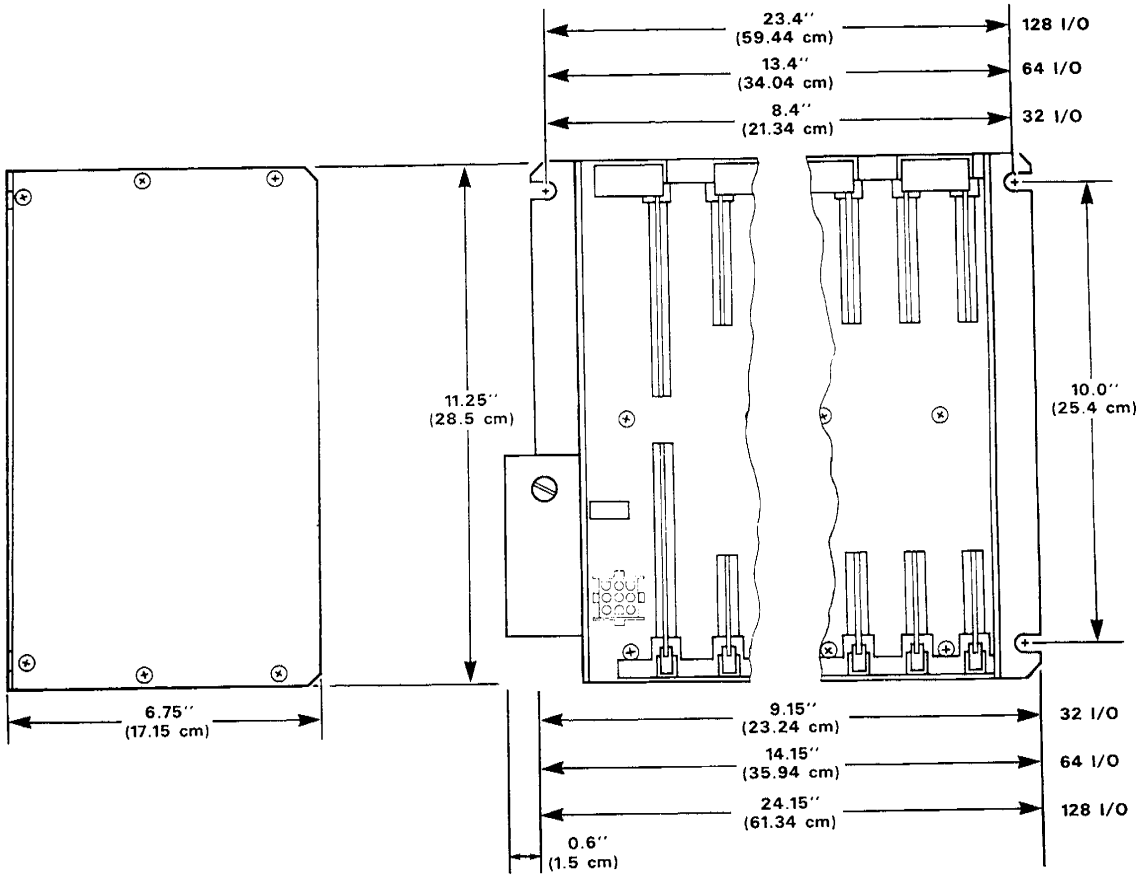
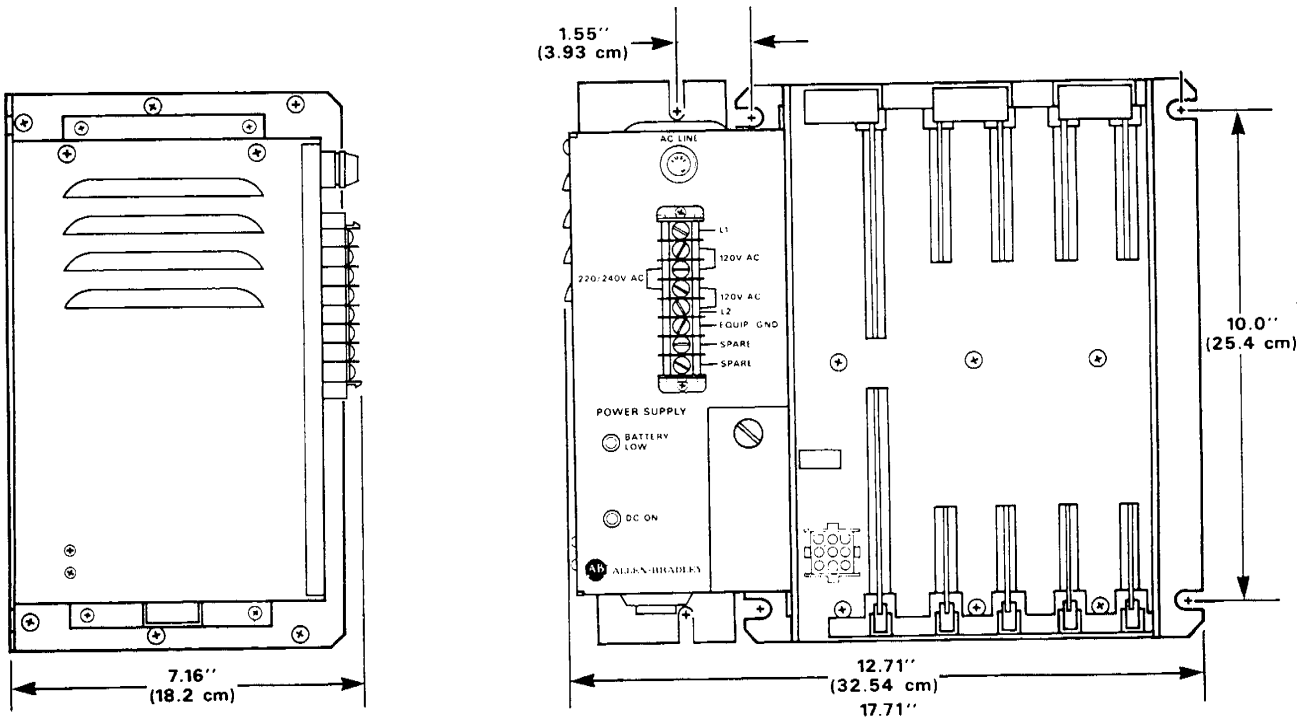


Figure 3.18 — I/O Chassis Dimensions (Power Supply Separate)



Note: For ease of assembly, Power Supply and I/O Chassis should be assembled as a unit before mounting.

Figure 3.19 — I/O Chassis Dimensions (Mounted Power Supply)

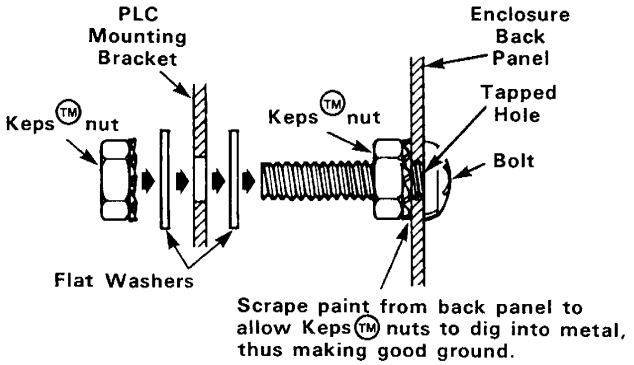


Figure 3.20 — Bolt Mounting Assembly

To avoid this problem, carefully inspect spacing between the Chassis mounting brackets and the enclosure back panel with the mounting nuts hand-tightened. If spaces are uneven, insert flat washers onto the mounting stud or bolt as needed. Then wrench-tighten the mounting nuts.

Once the Chassis and Power Supply are suitably mounted, wiring ducts and terminal strips may be installed as needed.

3.2.3 Input Power Connection — AC line connection is made to the terminal strip on the front face of the System Power Supply. (Refer to Figure 3.22.) Before making this connection, however, the user must make certain that the Supply is appropriately jumpered for the supplied line voltage.

The Supply is factory-shipped for 120V AC operation. Two metal jumpers are installed on this terminal strip at the positions indicated 120V AC. For 220/240V AC operation, **both** metal jumpers on the terminal strip must be removed from their original 120V positions. **One** of these jumpers must then be installed at the terminals labeled 220/240V AC.

CAUTION: Incorrect jumpering on the terminal strip may cause improper operation or damage to the Supply. The user must make certain that the Power Supply is correctly jumpered for **either** 120V **or** 220/240V AC.

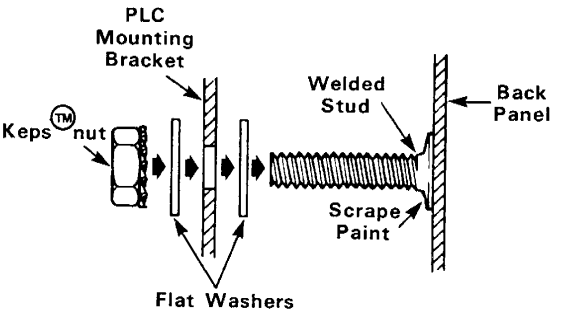


Figure 3.21 — Stud Mounting Assembly

The Power Supply is shipped with a 1 ampere slow-blow fuse installed, which is appropriate for 120V operation. A 0.5-ampere fuse is shipped separately with the Supply for replacement where 220/240V operation is required. Discard the unused fuse so that it will not be used as a replacement. Replace a blown fuse only with a fuse of the correct rating, selected from Table 5.B.

AC input line connections for either 120V or 220/240V AC are made to the terminals marked L1 and L2. (L1 is the high side of the AC line; L2 the low side.) The green-wire ground is connected to the terminal labeled EQUIP. GND.

3.2.4 Power Cable Connection — The Power Cable (Cat. No. 1771-CL or -CM) has 3 connectors: two 9-pin plugs and one 3-pin plug. Cable plugs are configured for connection to the correct sockets only. A label on each plug identifies its proper connection.

Side snap-locks hold the mating connectors together once a snug connection is made. To disconnect a Cable, squeeze in on the two snap-lock levers and pull the connector gently but firmly.

Connection to the Mini-PLC-2 programmable controller is made at the 9-pin socket on the I/O Chassis backplane. (Refer to Figure 3.23.) To make this connection, the Mini-Processor Module and left-most I/O module must be removed from the I/O Chassis. The Power Cable is run up

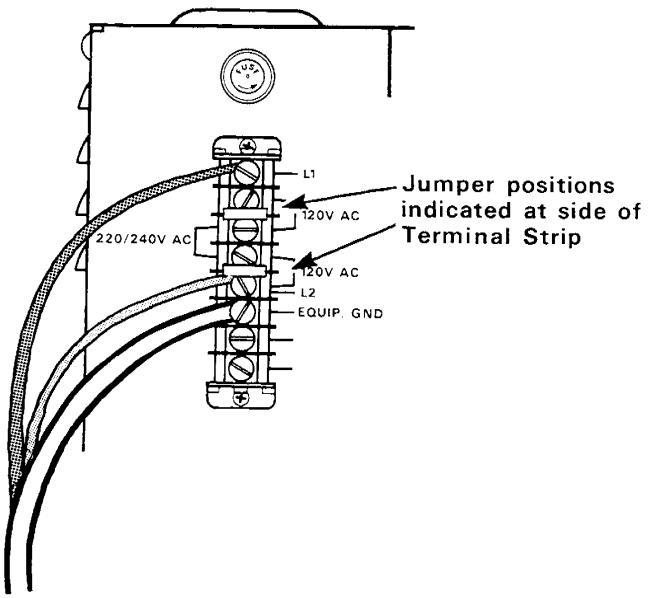


Figure 3.22 — Power Supply Input Connections

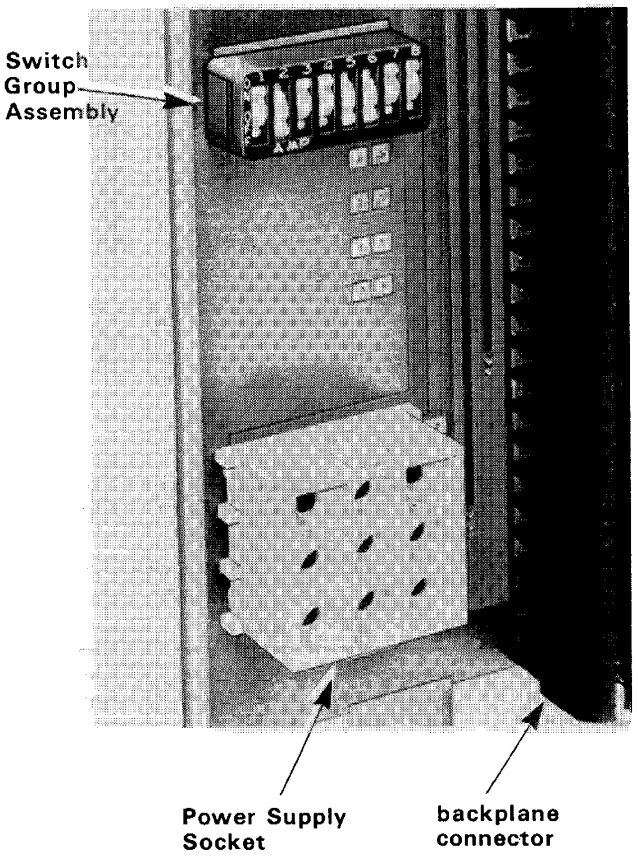


Figure 3.23 — I/O Chassis Backplane

through the bottom of the I/O Chassis, so that it does not interfere with insertion of the Mini-Processor Module.

Power Cable connection to the main body of the Power Supply is made to the 9-pin socket on its base. The 3-pin plug connects to the socket at the base of the Battery Pack. (The Battery Pack must be in its mounting bracket for this connection.)

Figure 3.24 illustrates Power Cable connection for a side-mounted System Power Supply. Connection with the 5-foot I/O Power Cable (Cat. No. 1771-CM) is made in similar fashion.

3.2.5 Last-State Switch — There is a Switch Group Assembly on the left side of the I/O Chassis backplane. (Refer to Figure 3.25.) Switch No. 1 must be set by the user to determine output response to a faulted condition detected by the Mini-Processor Module. These are the switch settings:

- ON — Outputs remain in their last state, energized or de-energized, when a fault is detected.
- OFF — Outputs are de-energized when a fault is detected.

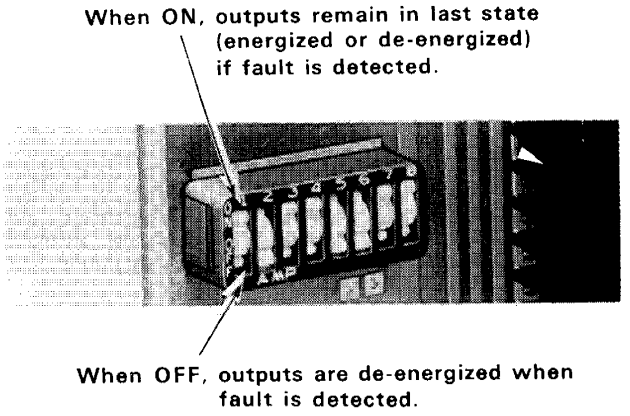


Figure 3.25 — Switch Group Assembly

WARNING: For reasons of personal safety, Switch No. 1 should be set to the OFF position in most applications. This allows the Mini-Processor to turn controlled devices OFF when a fault is detected. If this switch is set to ON, machine motion can continue after fault detection and personnel or equipment may be endangered.

It should be noted that Switch No. 1 does **not** determine the response of controller outputs if user AC line power fails. The Mini-Processor turns all outputs OFF as soon as user's line power drops below a minimum rated voltage. (Refer to Paragraph 2.4.1.)

Switch No. 1 does **not** determine the response of controller outputs when the Mode Select Switch is changed from the RUN position. Outputs are turned OFF when the Mode Select Switch is turned to TEST or PROGRAM positions.

Switches No. 2 thru 8 have no significance with the current Mini-PLC-2 programmable controller. These switches may have any setting.

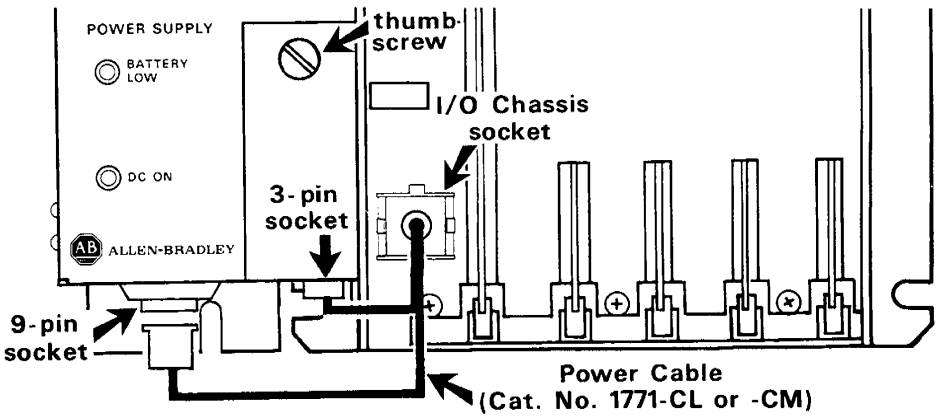


Figure 3.24 — Power Cable Connection

3.2.6 I/O Module Installation and Wiring – The installation of I/O modules, including connection from I/O devices to Field Wiring Arms can now begin. This Paragraph outlines the general installation procedures which may be followed for I/O modules. Specific installation and wiring practices for each type of I/O module are given in Product Data Sheets. The Support Documentation, provided with this Manual, includes Product Data Sheets for I/O modules available as of the date of publication.

For modules which require shielded cable, refer to the instructions of Paragraph 3.2.6.3.

3.2.6.1 Preparation – There are several considerations which help to allow orderly module installation. These include:

- **Correct slot placement of I/O modules** – The program address of each I/O device directly relates to module slot placement and terminal wiring. Therefore, the system programmer should provide a list showing module placement in the Chassis and device connection to Wiring Arm terminals.
- **Acceptable wire gauge** – Field Wiring Arms are not designed for wire larger than 14 AWG (stranded).

> **CAUTION:** It is the user's responsibility to calculate the maximum possible current in each power and common wire. Observe all local electrical codes which dictate the maximum current allowable for each wire size. Current above these maximum ratings may cause wiring to overheat, which may damage equipment.

- **Wire labeling** – Each wire which connects to an I/O device, power source, or common should be appropriately labeled. Tape, shrink-tubing, or other dependable means can be used for labeling purposes. The 5-digit address provides a convenient label for I/O wiring.

  In addition to labeling, insulation color may be used to distinguish wiring based on signal characteristics. Thus, for example, DC I/O wiring may be blue in color; AC I/O wiring red. Local electrical codes may also specify insulation colors for various types of signals.

- **Wire bundling** – Wiring for each I/O module should be bundled together within the wiring duct. (Refer to the wire-routing practices outlined in Paragraph 3.1.1.2.)

  Power and common wires, of appropriate gauge, may be jumpered from one Wiring Arm to the next. (Refer to the instructions of Paragraph 3.2.6.2)

- **Field Wiring Arm labeling** – Space is available on each Field Wiring Arm for labeling. This can be used for the 5-digit address of connected devices, or for any user designation for each device. (Refer to Figure 3.26.)

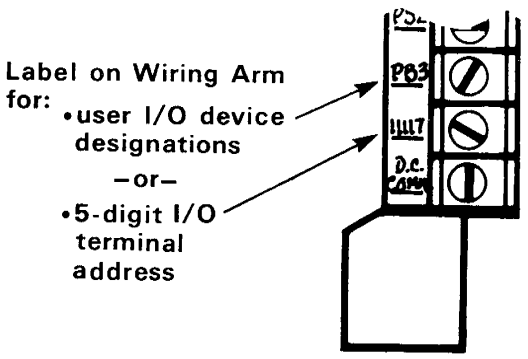


Figure 3.26 – Wiring Arm Labeling

- **Indicator labeling** – A space to the left of I/O module status indicators can also be used for labeling purposes. (Refer to Figure 3.27.)

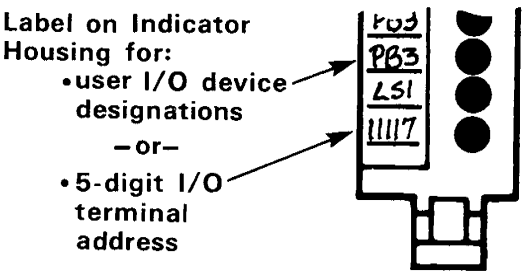


Figure 3.27 – Indicator Labeling

3.2.6.2 Procedures – Once preparatory steps are completed, the actual installation and wiring of I/O modules can be done.

For installation and wiring of all modules, power must be disconnected from **both** the System Power Supply and any user source to I/O devices.

> **WARNING:** To avoid injury to personnel and damage to equipment, disconnect AC power from the controller before module installation and wiring.

Follow these steps for I/O module installation:

- **Step No. 1** – Key the backplane connector for each I/O module. Plastic keying bands are shipped with the I/O Chassis. These keying bands help to prevent insertion of the wrong module into a particular Chassis slot.

  Each type of I/O module has 2 slots along its backplane edge. Keying bands are positioned on the backplane connectors to correspond to these slots. (Refer to Figure 3.28.) Correct key placement is specified in the Product Data Sheets for each module, reproduced in the Support Documentation, Publication 1772-820-1. A summary of keying band positions is given in Table 2.A.

  Keying bands may be placed on the backplane connectors by means of needle-nose pliers. These bands can be easily re-positioned as subsequent system needs require.

- **Step No. 2** – Insert each I/O module into its designated slot in the Chassis.

  On the top and bottom of each slot, plastic guides permit the module to be easily slid into the Chassis. Do not force the module into its backplane connectors. Rather, apply a firm, even pressure to seat each module firmly in these connectors.

  Once each pair of I/O modules, or Module Group, is inserted, latches on the top of the I/O Chassis can be snapped down to hold the modules in place. (Refer to Figure 3.29.)

- **Step No. 3** – Loosen the terminals on each Field Wiring Arm.

- **Step No. 4** – For each I/O module, fasten the bundled wiring to the base of the Field Wiring Arm.

  To do this, hold the Wiring Arm close to the base of the Chassis, near the front of its corresponding I/O module. Use nylon cable tie or other means to attach the wire bundle to the Wiring Arm. The base of the Wiring Arm is slotted for this purpose. (Refer to Figure 3.30.)

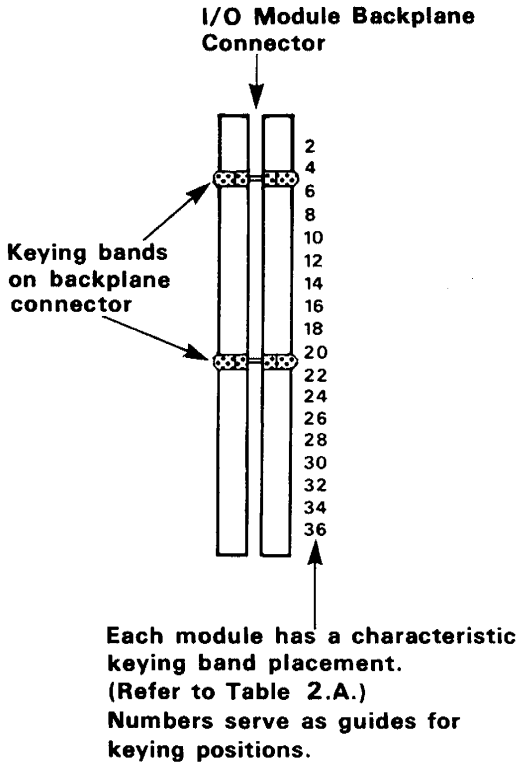


Figure 3.28 — Module Keying Bands

Leave sufficient slack so that wiring comes out loosely from the duct to each Wiring Arm.

- **Step No. 5** — Snap each Field Wiring Arm into place on the Chassis. The lower end of the Wiring Arm forms a C-shaped connector which clamps onto the horizontal bar of the I/O Chassis.

  To position the Arm, snap its plastic connector onto the bar from below the Chassis. This is shown in Figure 3.31. When in place, the Field Wiring Arm pivots on the lower cross-bar of the I/O Chassis.

- **Step No. 6** — Pivot each Wiring Arm to make connection with its corresponding I/O module.

  When the Wiring Arm is pivoted into vertical position, it makes contact with I/O module terminals. Complete contact is made when the Arm snaps into position against the front of the module.

- **Step No. 7** — From the bundled wiring of the first Wiring Arm, locate the wire which connects to the **lowest** terminal. (This is the terminal labeled "B" on the Cat. No. 1771-WA Wiring Arms.)

  The lowest terminal connection is to be made **first.**

- **Step No. 8** — At the point where this wire is at the vertical height of the terminal screw, bend it to the right at approximately a 90° angle. (Refer to Figure 3.32.)

- **Step No. 9** — Cut the wire where it extends approximately 1/4 inch beyond the edge of the Field Wiring Arm. Strip approximately 3/8 inch of insulation from the wire. (Refer to Figure 3.32.)

- **Step No. 10** — Bend the end of the wire inward and slip it beneath the pressure plate of the terminal. Tighten the terminal screw securely. The wiring of this terminal is now complete. (Refer to Figure 3.33.)

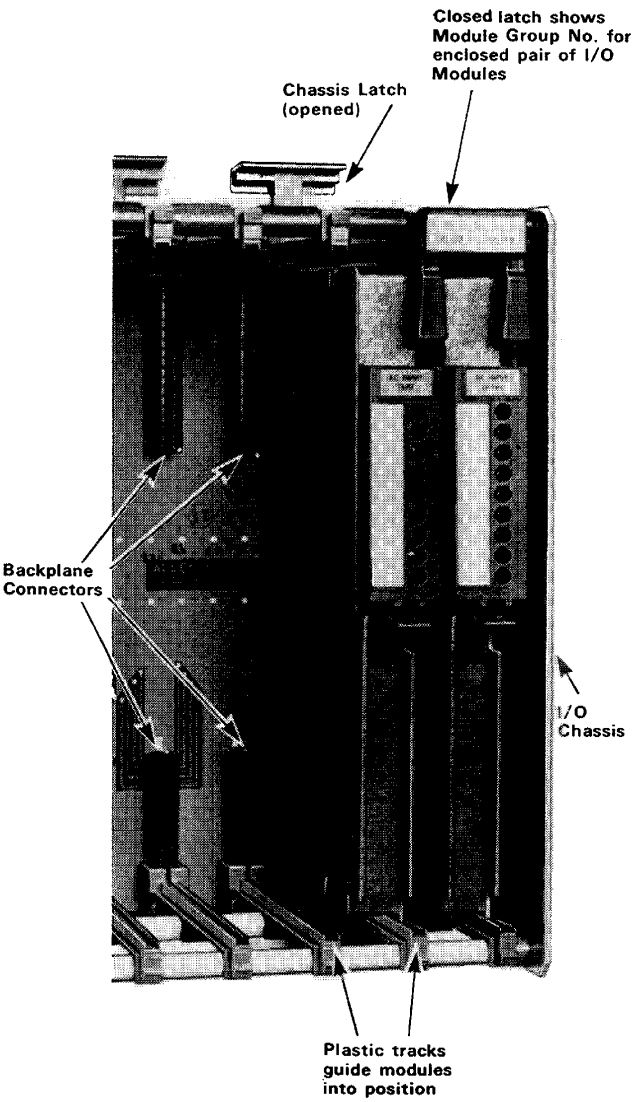


Figure 3.29 — I/O Module Insertion

Repeat Steps No. 8 thru 10 for each terminal. For best results, move **up** the Wiring Arm, one terminal at a time.

- **Step No. 11** — Determine that each wire is properly connected between its Wiring Arm terminal and input or output device.

  A simple continuity test is recommended for all I/O wiring. This test can be accomplished as follows: Temporarily jumper an I/O terminal to ground. Then check for very low resistance to ground at the other end of the I/O wire where it connects to its input or output device.

  Obviously, this quick test does not check for I/O components being shorted together or to ground. However, this type of complication can be detected in controller start-up procedures, described in Section 4.

Completed wiring should lie neatly, as close to the Field Wiring Arm as possible. (Refer to Figure 3.34.) At the same time, the bundled I/O wiring should have sufficient slack to the duct to allow the Wiring Arm to pivot easily on the Chassis. The pivoting action of a completed Wiring Arm is shown in Figure 3.35.

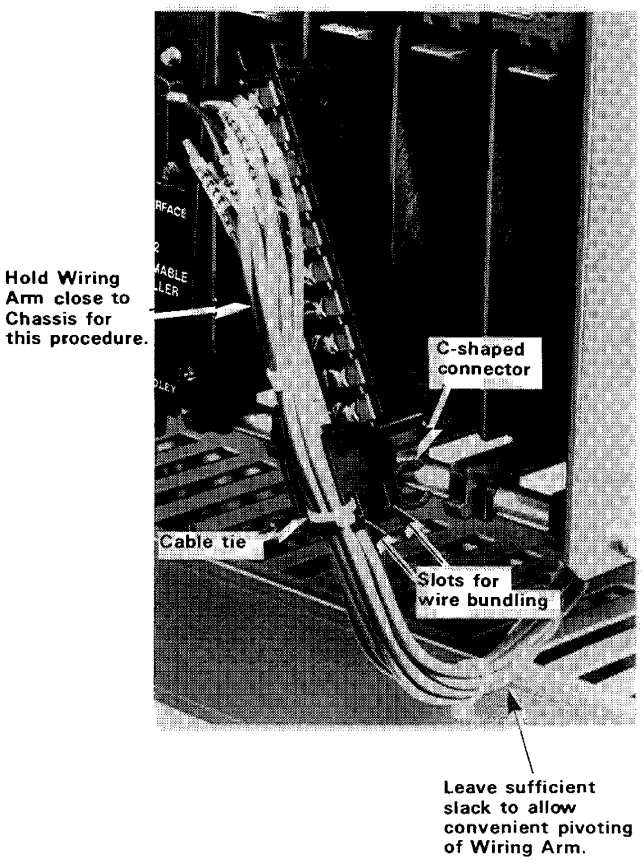


Figure 3.30 — Bundling Wire to the Arm

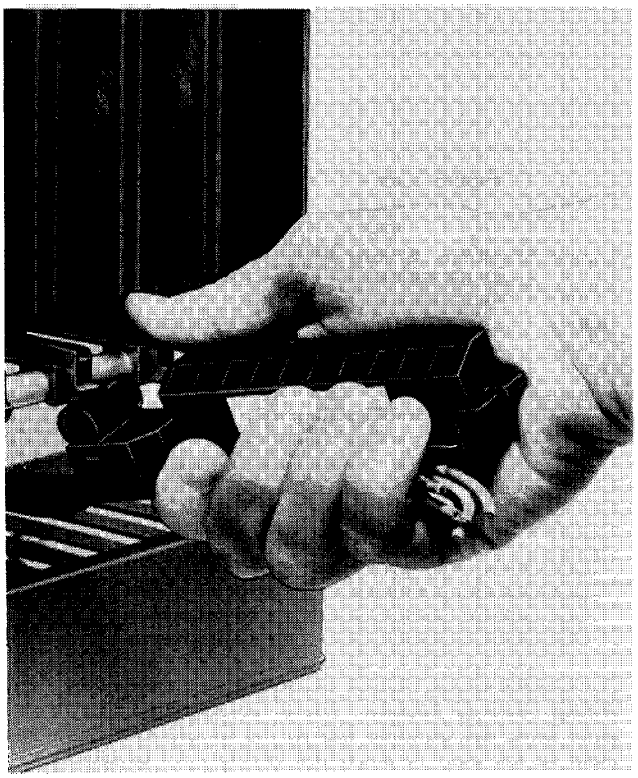


Figure 3.31 — Snapping Wiring Arm onto Chassis

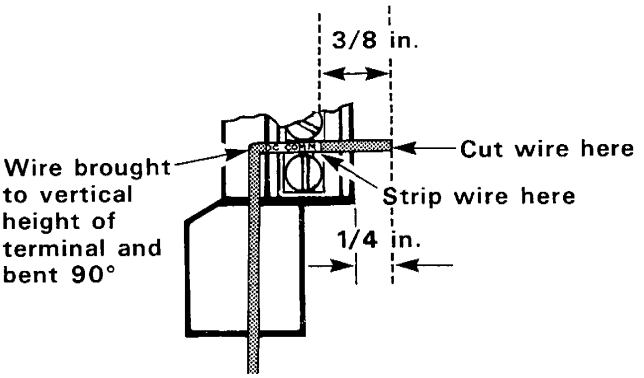


Figure 3.32 — Wiring a Terminal

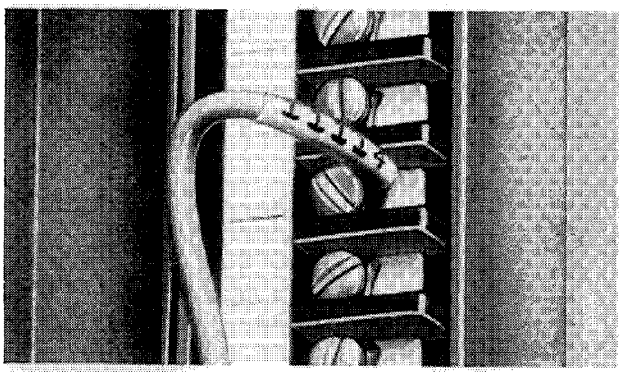


Figure 3.33 — Completed Terminal Wiring

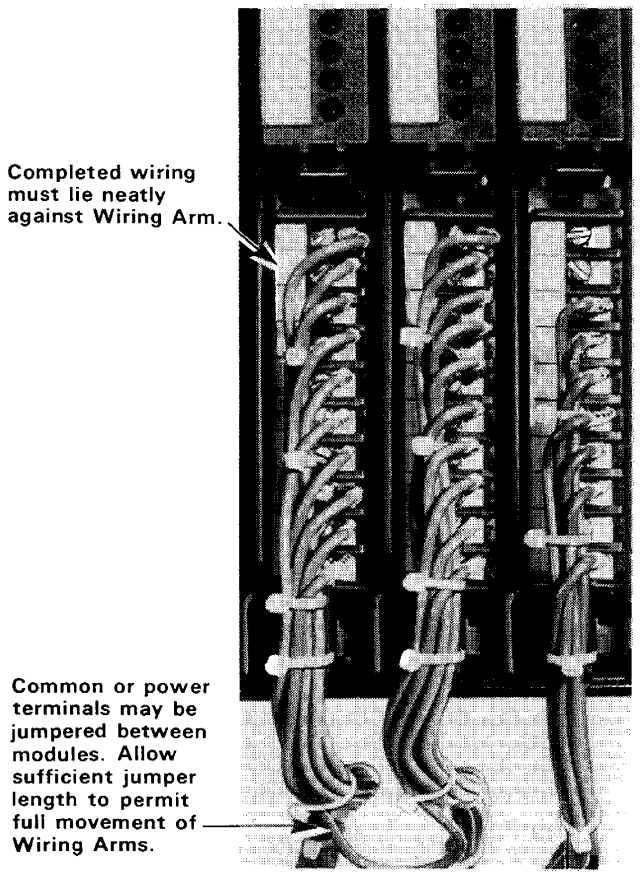


Figure 3.34 — Completed Module Wiring

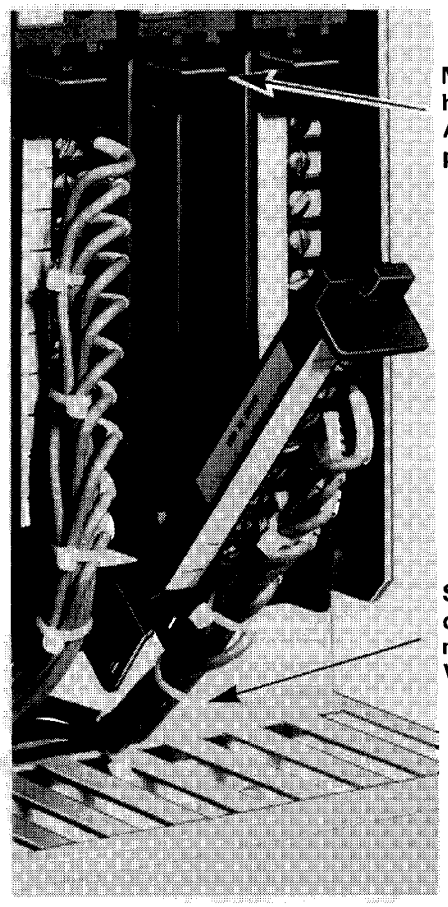


Figure 3.35 — Wiring Arm Pivoting

Where the same user power-source is shared by two or more modules, power wiring common to two or more Wiring Arms can be jumpered from one Arm to the next. When making connection in this manner, however, allow sufficient length for the jumper wire to be bundled with I/O wiring for each module. (Refer to Figure 3.34.) Allowing sufficient length for this jumpering wire permits each Wiring Arm to be pivoted separately.

All I/O module slots in the I/O Chassis need not be filled and unused Field Wiring Arms should **not** be attached to the Chassis. To avoid unnecessary exposure of the electrical contacts, keep unused Wiring Arms in the plastic bags in which they were shipped.

3.2.6.3 Shielded Cable — Certain Bulletin 1771 I/O modules require shielded cable for signal transmission. These modules are listed in Table 3.A. For these modules, the specified cable, Belden 8761 or equivalent, has a single insulated twisted-pair covered, along its total length, by a foil shield.

The twisted-pair consists of a signal wire and a signal return wire. The exact connection of these 2 insulated wires varies, depending on the type of module used. Data sheets for these modules give this twisted-pair wiring information. However, the connection of the foil **shield** for all of these modules is the same, as outlined in this Paragraph.

The function of a shield is to reduce the effect of induced noise at any point along the cable. In order to do this, the shield must cover the enclosed pair of wires as completely as possible. Most importantly, the shield must be properly grounded at one end **only**.

The recommended grounding point for the shield is at the controller Chassis. This is because the Chassis, through its

Table 3.A

I/O MODULES REQUIRING SHIELDED CABLE CONNECTIONS

I/O MODULE ASSEMBLY	Cat. No.
TTL Input	1771-IG
TTL Output	1771-OG
Analog (8 bit) Input	1771-IE

enclosure, is provided a solid connection to earth ground. (Refer to Paragraph 3.1.2.) Steps No. 1 thru 6 describe how this connection is to be made at the Chassis.

Step No. 7 describes the protection of the shield at the end of this cable which connects to the user device.

Follow these procedures with shielded cable:

- **Step No. 1** — At the Wiring Arm end of the cable, strip and remove about 30 inches of the cable jacket. Be careful not to cut the shield. (Refer to Figure 3.36.)

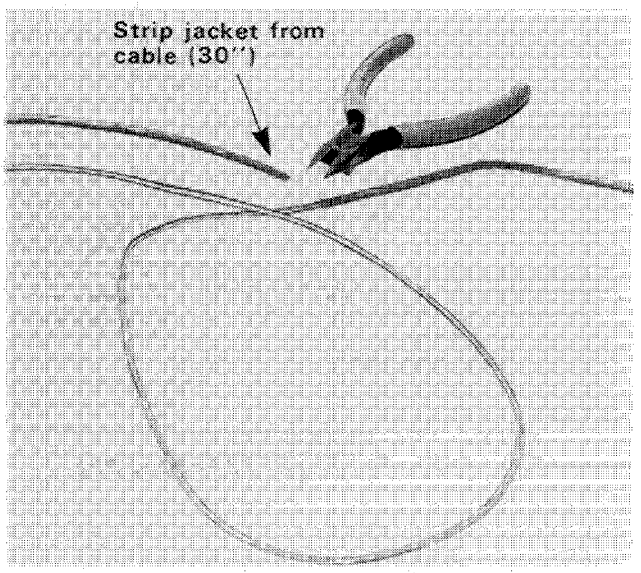


Figure 3.36 — Removing Cable Jacket

- **Step No. 2** — Peel the shield away from the two insulated wires. The Belden 8761 shield is composed of a strip of foil and a bare stranded wire. (Refer to Figure 3.37.)
- **Step No. 3** — Twist the shield foil and bare wire together, thereby forming a single strand. (Refer to Figure 3.38.)
- **Step No. 4** — Trim both insulated wires to 2-inch lengths. Then strip approximately 3/8 inch of insulation from the end of each wire. The shield strand is left at its full 30-inch length. (Refer to Figure 3.39.)
- **Step No. 5** — Connect the insulated wires at the Wiring Arm terminals specified in the individual I/O module data sheet.
- **Step No. 6** — Once the Wiring Arm connection of both insulated wires is made, fold back the shielded strand and route it to connection at the nearest convenient ground.

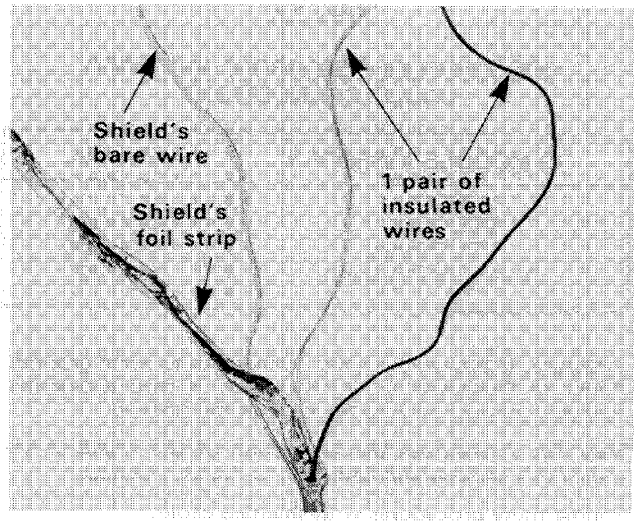


Figure 3.37 – Peeling Foil Shield

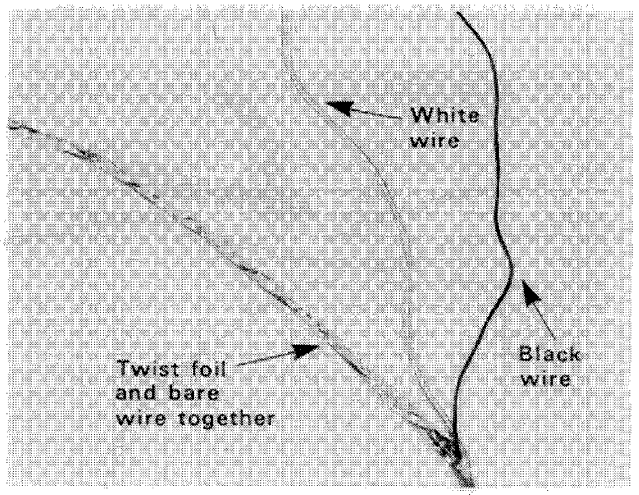


Figure 3.38 – Twisting Shield Foil and Wire

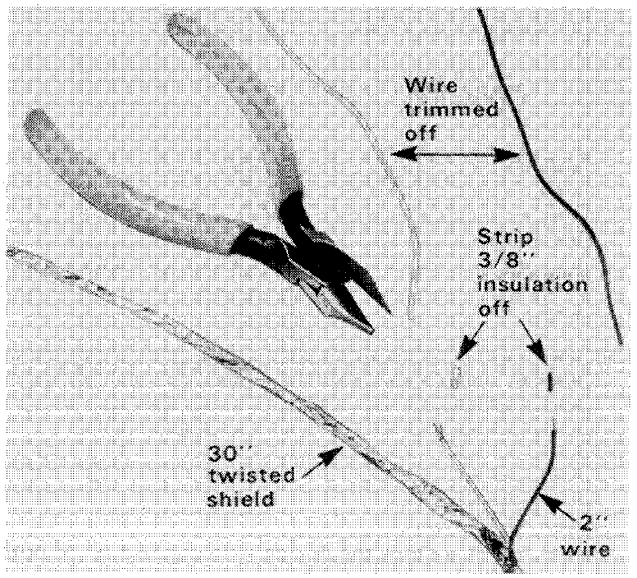


Figure 3.39 – Trim Unnecessary Insulated Wire

The recommended ground connection is at a mounting bolt of the I/O Chassis. Figure 3.40 shows the routing of the shield to this bolt. Note that the shield is carefully routed so as not to touch any terminal or make contact with other wiring.

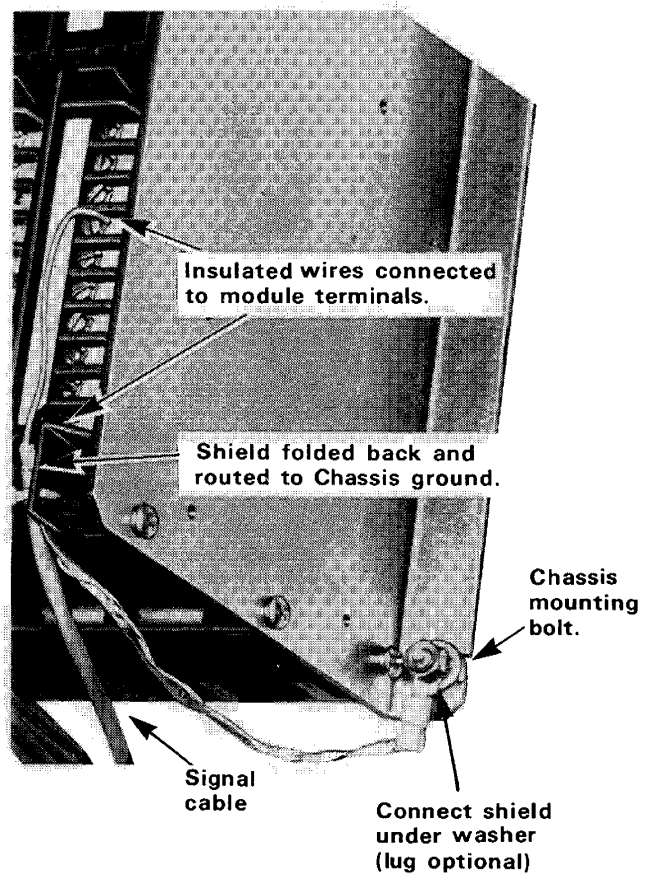


Figure 3.40 – Shielded Cable Connection

Where necessary, insulate all or part of the shield to prevent contact between the shield and other terminals. Shrink-tubing or electrical tape can be wrapped around the shield for this purpose.

Connection of the shielded cable at the **controller** end is now complete.

- **Step No. 7** – At the user device, cut the shield and bare stranded wire of the cable short. Tape the shield back to prevent contact with any other wiring or with any terminals. (Refer to Figure 3.41.)

  Note: Do not confuse the shield with the "signal ground return wire," which is a formal term for one of the insulated wires of the twisted-pair. This signal ground return is to be connected as specified in the appropriate I/O module data sheet.

3.2.7 Mini-Processor Installation – The Mini-Processor is installed in the left-most I/O Chassis slot. Before actual installation, however, there are two steps that must be accomplished. These are:

- Setting of the Last-State Switch (Refer to Paragraph 3.2.5.)
- Connection of the Power Cable to the Chassis backplane (Refer to Paragraph 3.2.4.)

To guard against insertion of any other module into the

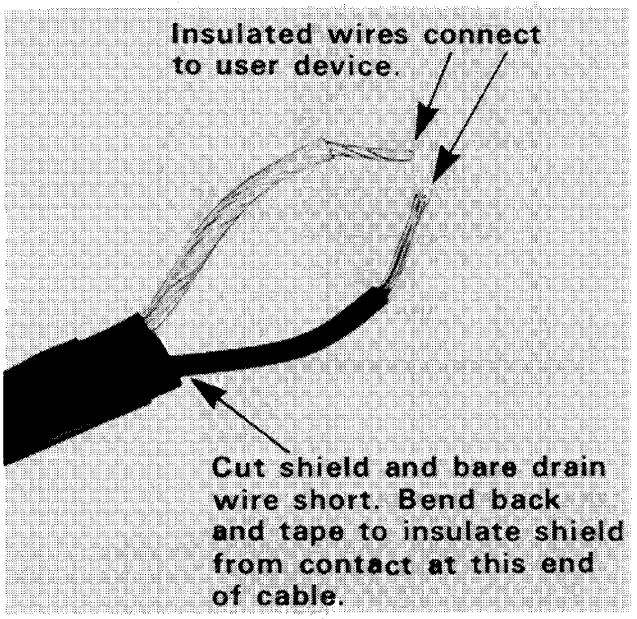


Figure 3.41 — Shield Protection at User Device

left-most Chassis slot, keying bands should be positioned onto the backplane connector. (Refer to Publication 1772-701, in the Support Documentation for the Mini-PLC-2 Programmable Controller.

CAUTION: Be certain that power is OFF before insertion or removal of the Mini-Processor Module or any Module from the I/O Chassis. Equipment damage or insertion of erroneous data into the controller memory could result if this caution is not observed.

The Mini-Processor Module is inserted into the Chassis and pressed gently and firmly into its backplane connectors. Once the Module is properly positioned, a latch on the top of the Chassis snaps down to hold the Mini-Processor securely in place.

3.2.8 Program Panel Connection — This Paragraph outlines the connections necessary when the Program Panels and Program Panel Adapter are being used. These devices are portable and not normally installed as a permanent unit of the controller.

All Cables necessary for the connection of the Program Panels and Adapter are supplied as standard when these units are shipped. For ease of Cable connection, sockets and plugs are configured to mate in the proper orientation only. Cable connections to the Mini-Processor Module can be made with power ON and the controller in any mode.

Grounding type AC line cords are standard with Program Panels and Adapters. Plug this line cord only into a grounded receptacle to minimize exposure to electrical hazard.

For cooling purposes, all Program Panels and Adapters draw in air through a filter at the rear of the unit. This filter should be checked and cleaned periodically. To clean this filter, first remove it from the Program Panel. Use air pressure [1] to remove any loose dust and wash the filter in soapy water. Make sure it is completely dry before placing it back on the Program Panel.

3.2.8.1 PLC-2 Program Panel Connection — The Bulletin 1772 PLC-2 Program Panel System is connected using the Program Panel Interconnect Cable (Cat. No. 1772-TC). This Cable connects to the Program Panel socket labeled PROCESSOR. This connection is shown in Figure 3.42.

The Cat. No. 1772-T1 Program Panel System is shipped for 120V AC operation. With user modification, this Program Panel can be operated from a 220/240V AC source.

For 220/240V AC operation the user must remove several screws on the rear panel; carefully slide this panel out. The standard jumpers are placed between terminals No. 1 and 2, and between 3 and 4. These should **both** be placed between terminals No. 2 and 3. (Figure 3.43 shows the connections needed for both voltages.)

[1] **WARNING:** Flying dirt and dust can cause injury to personnel. Use eye protection to guard against flying dirt and dust when using air pressure. Also, direct the air away from personnel.

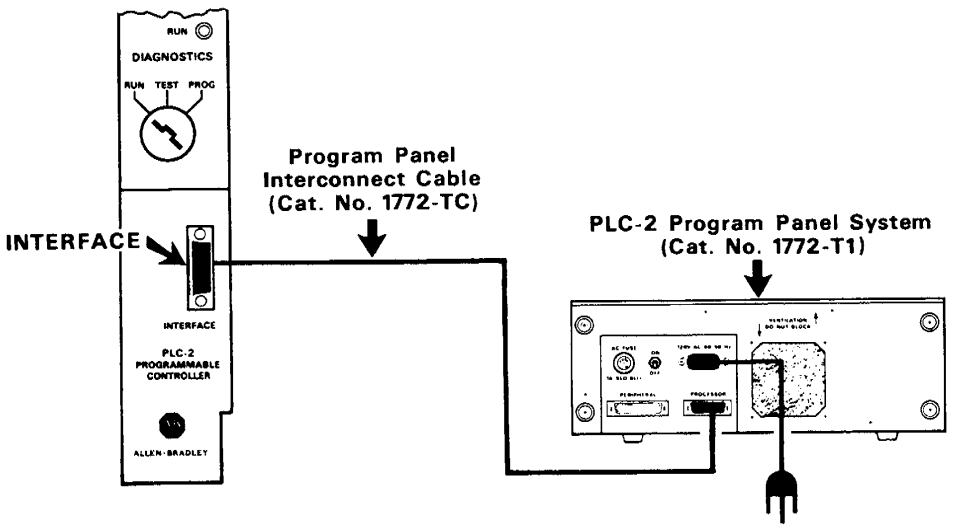


Figure 3.42 — PLC-2 Program Panel Connection

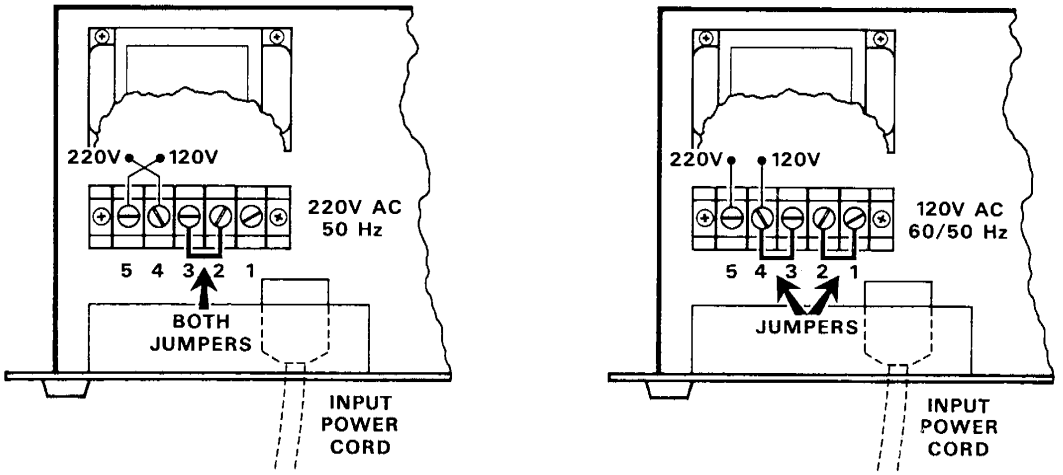


Figure 3.43 – Connecting for 120 or 220V Operation

Note: The same fuse is used for either 120V or 220/240V operation.

The PLC-2 Program Panel has an ON/OFF switch at the rear. Once power is turned ON, the PLC-2 Program Panel displays its Series and Revision Level for a few seconds, and then displays the first Instruction in the program. [1] (Should no program be present in the memory, the message END 0128 will appear.)

3.2.8.2 PLC Program Panel/Adapter Connection – The Bulletin 1774 PLC Program Panel is connected to the PLC/PLC-2 Program Panel Adapter, using the PLC/PLC-2 Program Panel Adapter Cable (Cat. No. 1772-TR). This Cable runs from the PROCESSOR socket on the back of the PLC Program Panel to the socket labeled PLC PROGRAM PANEL on the Program Panel Adapter. The Program Panel Interconnect Cable (Cat. No. 1772-TC) then connects from the socket labeled PROCESSOR on the PLC/PLC-2 Program Panel Adapter to the socket labeled INTERFACE on the Mini-Processor. These connections are shown in Figure 3.44.

The Cat. No. 1774-TA Program Panel is shipped for 120V AC operation. A special version of this Program Panel, with Cat. No. 1774-TH, operates from a 220/240V AC source.

The Program Panel Adapter is easily modified for 220/240V operation. Follow the procedure for modifying the PLC-2 Program Panel. (Refer to Paragraph 3.2.8.1 and Figure 3.43.)

[1] Series B or later PLC-2 Program Panels display a numerical equivalent for Series and Revision. A message, such as STA 2.1 appears upon power up. Here, 1 means A, 2 means B, etc. The Series A PLC-2 Program Panel does not display Series or Revision Level.

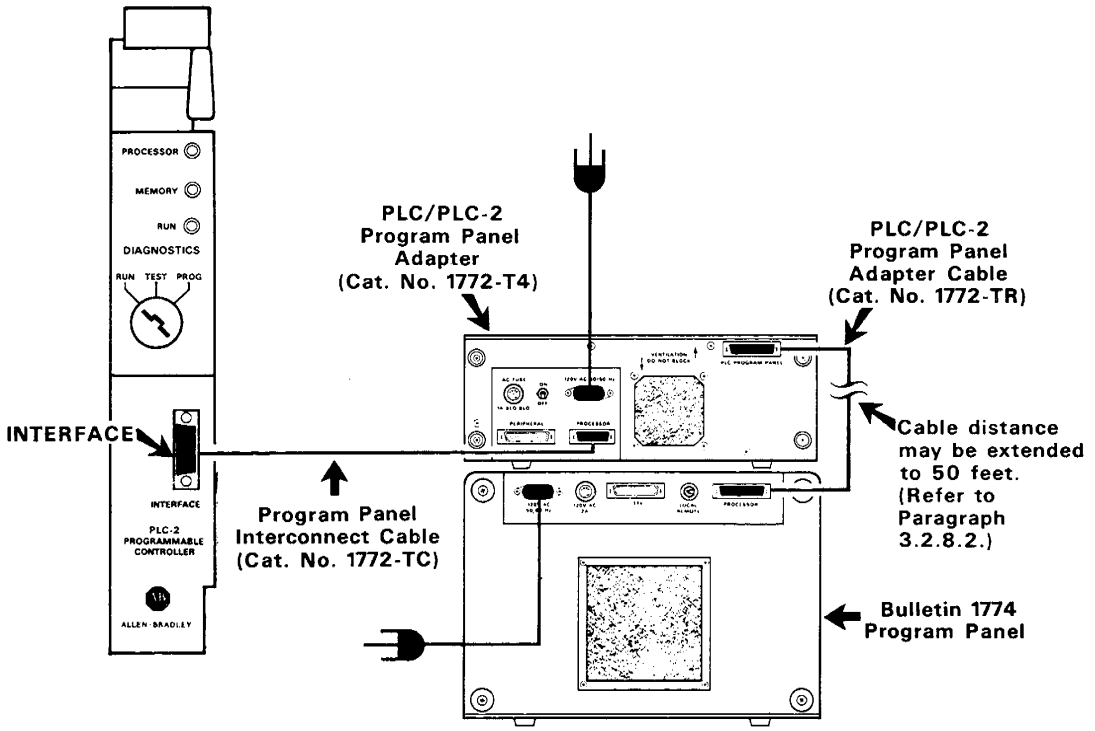


Figure 3.44 – PLC Program Panel Connection

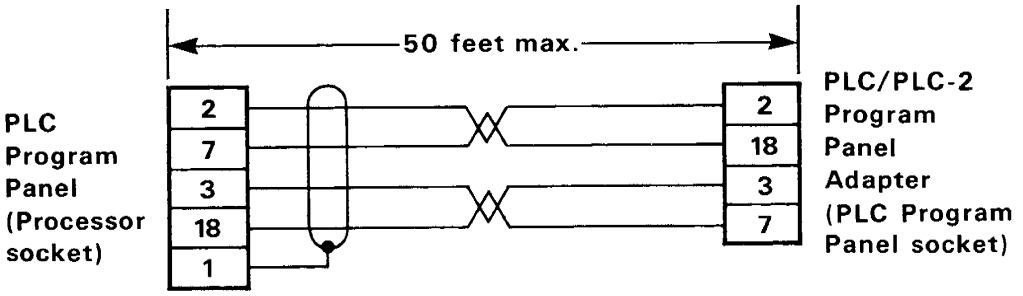


Figure 3.45 — Extended Cable Wiring Diagram

The PLC Program Panel has an ON/OFF switch on the front right side. The Adapter has an ON/OFF switch at the rear. Once power is turned ON, press this key sequence on the Program Panel:

[TTY] [CANCEL COMMAND]

The Program Panel will display Series and Revision Levels. [1]

To show the first program Instruction, press:

[DISPLAY]

The distance between the Mini-Processor and the Adapter is limited by the length of the Program Panel Interconnect Cable. This distance is 10 cable-feet.

The PLC/PLC-2 Program Panel Adapter Cable limits the distance between the Adapter and the PLC Program Panel to 3 cable-feet. However, by making up a cable for this connection, the user can extend this distance to 50 cable-feet.

Figure 3.44 shows the connection of this user-supplied cable. A wiring diagram for both connectors is given in Figure 3.45.

Parts needed to make this cable are listed in Table 3.B.

[1] The Series and Revision Levels are displayed upon power-up with Series B or later Program Panel Adapters.

Table 3.B

ADAPTER CABLE EXTENSION — PARTS LIST

PART	TYPE	MANUFACTURER'S DESIGNATION
Connectors	25-Pin-Male	Cannon Type DB-25P, or Equivalent
Hood	Plastic	AMP type 205718-1
Cable	2 twisted pair, 22 AWG, shielded (50 ft. max length)	Belden 8723, or Equivalent

Cannon 666 E. Dyer Santa Ana, CA 92702	AMP, Inc. P.O. Box 3608 Harrisburg, PA 17105	Belden Corp. P.O. Box 1327 Richmond, IN 47374

Section 4
SYSTEM START-UP

4.0 Start-Up Procedure — A careful start-up procedure is essential for proper Mini-PLC-2 controller operation. This Section describes orderly procedures for system start-up which can be followed in most applications. These procedures may be followed once the complete controller system is installed as described in Section 3, with user wiring in place and the Program Panel connected.

After assembly and installation of a new Mini-PLC-2 controller have been completed, a cautious approach must be taken toward the initial system start-up. Care and patience in following start-up procedures will isolate problems which might occur in the form of programming errors, wiring mistakes, or equipment malfunction. The procedures outlined here provide a means of uncovering such problems under controlled conditions, thereby not only making it easier to pinpoint any problems, but also minimizing any possibility of equipment damage or personal injury.

In general, certain checkout steps must be taken before power to the controller system is turned ON. Then, other steps may be taken with power ON to all devices **except** those that allow any machine motion. Finally, the system is checked out with the machine in motion. These 3 divisions of procedures form the basis for the following Paragraphs.

WARNING: Machine motion during system checkout can be hazardous to personnel. During the first stage of system checkout, as described in Paragraphs 4.1 and 4.2, disconnect any device which, when energized, might cause machine motion to occur.

Machine motion must be permitted only in the **final** stages of system checkout. (These stages are described in Paragraph 4.3.)

4.1 Checkout Before Power is Connected — The following checkout steps must be taken **before** AC power is connected to the controller:

- **Step No. 1** — Measure the incoming AC line voltage to be certain that it corresponds to the jumper-selected voltage of the System Power Supply. (Refer to Paragraph 3.2.3.) Also check that the line voltage is within tolerance. For 120V AC operation, the normal range is 98 - 132V AC. For 220/240V AC operation, the normal range is 196 - 250V AC.
- **Step No. 2** — Check the wiring of the main disconnect switch or circuit breaker connected on the AC line to the Power Supply. Also, check the wiring of the master control relay for the correct terminal connections. (Refer to Paragraph 3.1.3.)
- **Step No. 3** — Check the Power Cable connections to the I/O Chassis and Battery Pack. Make sure plugs are securely held in their sockets.
- **Step No. 4** — Make sure that all modules are securely held in the I/O Chassis. All latches on the top of the I/O Chassis must be snapped down. All Field Wiring Arms must be pivoted up against their appropriate modules.
- **Step No. 5** — Disconnect all motors from their starters, valves from their solenoids, etc., to insure that no power-driven machine motion occurs when power is first applied to the controller.

  In cases where this is not practical, the output device itself should be disconnected at a convenient terminal strip. If at all possible, disconnect the user wiring at some point other than the Wiring Arm terminal.

4.2 Hardware/Indicator Comparison — Each connected input and output device has status indicators in the controller. This Paragraph gives the technique for comparison of these indicators with the actual status of I/O devices. This technique is valuable both in initial checkout of the controller and in troubleshooting hardware-related faults.

Each input or output device has the two status indicators shown in Figure 4.1. One of these status indicators is on the I/O module itself; the other indicator is provided by the Program Panel.

The I/O module status indicator helps to isolate the source of a fault in the user's hardware. A hardware-related fault may originate from one of these sources:

- Improper I/O device operation
- Wiring error
- Loss of user-supplied power to I/O devices

The Program Panel status indicator helps to show the relation between I/O device status and the controller logic. By comparing this indicator to the actual I/O device status, specific aspects of controller behavior can be examined. These include the following:

- I/O module function
- Mini-Processor scan of inputs and outputs

The following Paragraphs describe the significance of these status indicators and their relation to user hardware devices. Paragraph 4.2.1 describes the I/O module indicators. Paragraph 4.2.2 describes the Program Panel indicators.

Once the significance of these status indicators is understood, the hardware/indicator comparison can be made. Step-by-step procedures for hardware/indicator comparison are described in Paragraph 4.2.3.

4.2.1 I/O Module Indicators — On the front of the basic AC and DC Input and Output Modules are status indicators. (Refer to Figure 4.2.) Each of these indicators corresponds to a terminal on the module's Wiring Arm. These indicators illuminate when the I/O device connected to the corresponding terminal is ON, or energized.

4.2.1.1 Input Modules — On the front of each input module, one indicator corresponds to each input terminal. When the module detects the connected input device as being ON, the indicator illuminates.

A comparison of this indicator with the actual status of an input is useful to check the following:

- User's power source for the device
- Wiring from the device
- Connection to the correct Wiring Arm terminal
- The input device itself
- The input module

4.2.1.2 Output Modules — On the front of each output module, one indicator corresponds to each output terminal. When the module turns an output ON, this indicator illuminates.

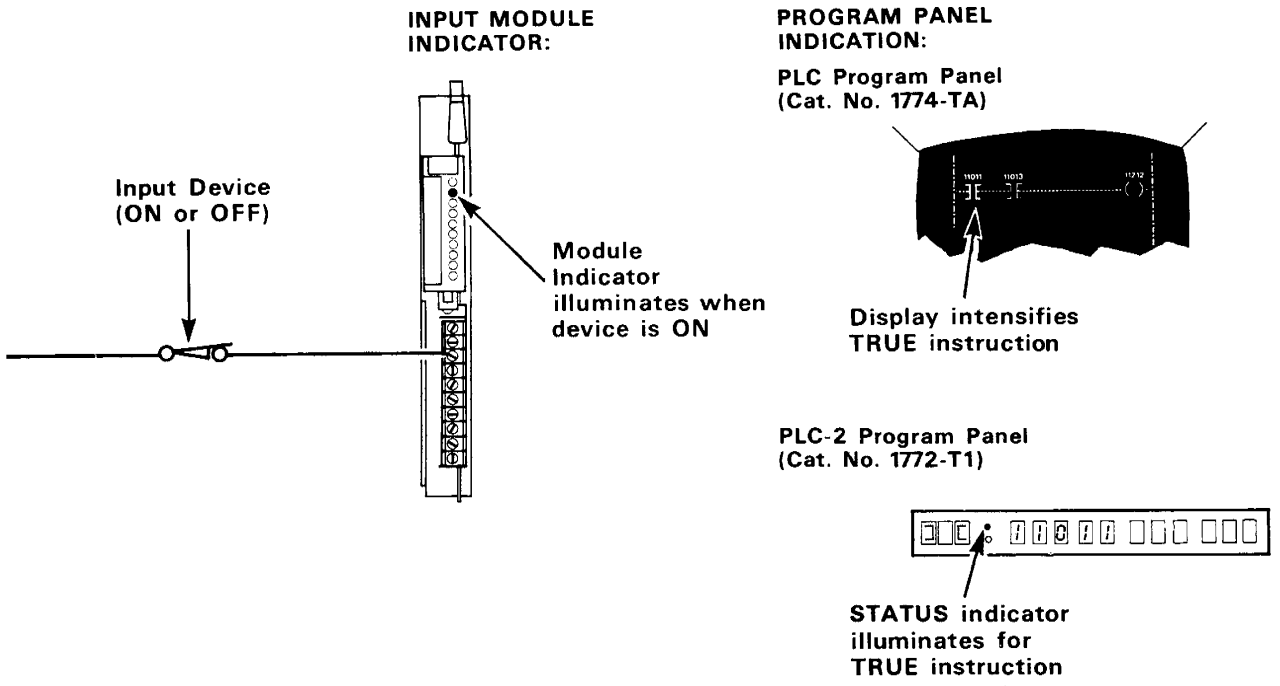


Figure 4.1 — I/O Device Status Indicators

A comparison of this indicator with the actual status of an output device is useful to check the following:

- User's power source for the output device
- Wiring to the output device
- Connection to the correct Wiring Arm terminal
- The output module fuse
- The output device
- The output module

Note: The output terminal need not be connected to the output device for the indicator to function. This makes the indicator useful for check-out of an output terminal which will be connected to any device causing machine motion. (Refer to Paragraph 4.2.3.3.)

4.2.2 Program Panel Indicators — The Program Panel indicates the status of each Instruction displayed. The status indicator of the Program Panel, however, has a different meaning from the ON/OFF status indicators of the I/O modules. The Program Panel shows the logical, or TRUE/FALSE, status of an **Instruction.**

An Instruction is logically TRUE, in this sense, if the condition it specifies is met. If the condition is not met, the Instruction is logically FALSE. For example:

- The Instruction —[xxxxx]— is logically TRUE when the input device corresponding to address xxxxx is ON (closed). The Instruction is otherwise FALSE.

- The Instruction —[/ yyyyy]— is TRUE when the input device corresponding to address yyyyy is OFF (open). The Instruction is otherwise FALSE.

Figure 4.1 shows the status indicators for both types of Program Panel. The PLC Program Panel (Cat. No. 1774-TA) **intensifies** each TRUE Instruction in its displayed rung. Normal intensity indicates a FALSE state for the Instruction.

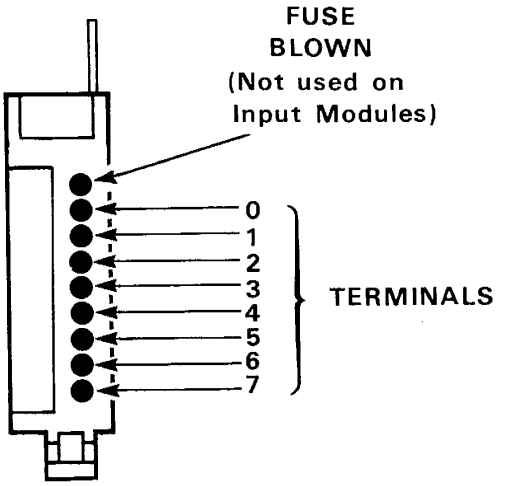


Figure 4.2 — I/O Module Status Indicators

The PLC-2 Program Panel (Cat. No. 1772-TA) has an LED indicator labeled STATUS. This indicator illuminates when the displayed Instruction is TRUE. Absence of this indicator shows a FALSE state for the Instruction.

Note that the "status of an Instruction" has a different connotation than the "status of an I/O device." Thus, the user should understand the relationship between Program Panel and I/O module indicators. A quick reference for decoding the logical TRUE/FALSE state into ON/OFF terms is given in Table 4.A.

Table 4.A

PROGRAM PANEL STATUS INDICATION

DISPLAYED INSTRUCTION	STATUS OF I/O DEVICE WHEN INSTRUCTION IS TRUE PLC-2 Program Panel: STATUS L.E.D. ON PLC Program Panel: display intensified	STATUS OF I/O DEVICE WHEN INSTRUCTION IS FALSE PLC-2 Program Panel: STATUS L.E.D. OFF PLC Program Panel: display normal intensity
–[ ]–	Energized (ON)	De-energized
–[/]–	De-energized (OFF)	Energized
–( )–	Energized	De-energized
–(L)– –(U)– [1]	Energized	De-energized
CTU CTD TON TOF RTO	Timer/Counter Rung Enabled	Timer/Counter Rung Disabled
–[=]–	Equal	Not Equal
–[<]–	Less than	Not less than

[1] The Unlatch Instruction is an exception to the general rule. Because it is normally paired with a Latch Instruction for the same address, the Unlatch Instruction will display the same TRUE/FALSE status as the Latch Instruction. Thus, **both** Latch and Unlatch Instructions will be intensified (or show STATUS as ON) when the output device is ON. Both Instructions will have normal intensity (or show no STATUS indicator) when the output device is OFF.

Program Panel status indicators operate in both TEST and RUN modes. When testing output devices, each mode allows certain advantages:

- TEST – The **logical** status of an output device Instruction is displayed in the TEST mode. However, in this mode, all outputs are disabled. Thus, displaying output devices in TEST allows safe monitoring of their controlled status. This mode is useful in checkout of the user's program.
- RUN – The **logical** status of an output device Instruction is displayed in the RUN mode. Outputs are enabled in this mode. Thus, the **logical** (TRUE/FALSE) status may be compared with the **actual** (energized/de-energized) status. This allows the user to troubleshoot a problem originating in an output module or in the user's hardware.

For testing **input** devices, the TEST mode is used.

Note: This Section describes Program Panel use for system start-up and troubleshooting purposes **only**. For more complete information on the Program Panels, refer to the Programming and Operations Manual, Publication 1772-821.

4.2.3 Comparison Procedures - This Paragraph outlines step-by-step procedures for hardware/indicator comparison. These procedures are to be followed upon initial controller system checkout.

CAUTION: Machine motion must not be permitted during the procedures outlined in this Paragraph. It is important for safety reasons to disconnect any device which might cause machine motion during this stage of controller checkout.

Besides inhibiting all machine motion, the user must make certain that no program has been entered into the controller memory. To clear the controller memory of both Instructions and Data Table, connect and initialize the Program Panel as described in Paragraph 3.2.8. Then perform the following steps:

- **Step No. 1** – Display the first program Instruction on the Program Panel. To do this, press these Program Panel keys:

  [SEARCH] [↑]

- **Step No. 2** – Turn the Mode Select Switch to PROGRAM.
- **Step No. 3** – Press these Program Panel keys, in this order:

  [CLEAR MEMORY] [9] [9]

The Program Panel displays EXC or EXECUTE while it clears the Mini-Processor memory. The END (of program) statement appears when the memory is cleared.

Only the rungs specifically noted in this Paragraph should be used for these checkout procedures. Only **one** rung should be in the memory at any one time for start-up procedures.

For these procedures, power is connected to both the System Power Supply and to most I/O devices. However, do **not** connect power to any device causing machine motion. (Refer to Paragraph 4.1, Step No. 5.)

4.2.3.1 Testing Inputs – Hardware/indicator comparison should begin with the testing of input devices and modules. Follow these steps for each input device:

- **Step No. 1** – On the Mini-Processor Module, turn the Mode Select Switch to TEST.
- **Step No. 2** – Compare the ON/OFF status of the input device to its corresponding input module indicator.

```
        Address each input                              Use a "dummy"
        in turn                                         output address

! 11100                                                  02000 !
+-] [---------------------------------------------------( )--+
!                                                              !
```

Figure 4.3 — Rung for Input Testing

> **WARNING:** Never reach into a machine to actuate a switch since unexpected machine motion can occur. Use a wooden stick or other non-conductive device to guard against electrical shock.

For this comparison, manually turn the input device ON and OFF. Observe that the input module indicator turns ON and OFF as the device is turned ON and OFF.

The indicator on the front of the module must illuminate when the input device is ON. If the indicator does not illuminate, check out the user hardware in the following order:

- User power source for the input device
- Wiring from the input device
- Connection to the correct Wiring Arm terminal
- The input device
- The input module

- **Step No. 3** – On the Mini-Processor Module, turn the Mode Select Switch to PROGRAM.
- **Step No. 4** – Program a "dummy" rung, examining the status of the input device. In this type of rung, a "storage bit" is to be energized, rather than any output device. Figure 4.3 shows a sample rung which can be used for this purpose. (Refer to the Programming and Operations Manual for additional information on using storage bits.)
- **Step No. 5** – On the Mini-Processor Module, turn the Mode Select Switch to TEST.
- **Step No. 6** – While displaying the input device address on the Program Panel, compare the Program Panel status indicator with the actual ON/OFF status of the device.

  To do this, manually turn the input device ON and OFF while observing the Program Panel status indication for the device. (Paragraph 4.2.2 describes the Program Panel status indicator.)

> **WARNING:** Never reach into a machine to actuate a switch, since unintended machine motion can occur. Use a wooden stick or other nonconductive device to guard against electrical shock.

Table 4.A lists the actual ON/OFF status, given the displayed Instruction on the Program Panel and its status indicator.

Should the Program Panel indicator fail to show device status correctly, check that procedures have been followed as outlined in this Paragraph.

If the correct procedure has been followed and it has been determined that no fault exists with the input device or wiring, the input module may require replacement. If this does not clear the fault, replace the Mini-Processor Module. Rules for module replacement are given in Paragraph 5.4.

Repeat Steps No. 1 thru 6 for each input device in the application. In Step No. 4, replace the input device address in the dummy rung. Do not program multiple rungs for checkout purposes.

4.2.3.2 Testing Outputs – Once all inputs have been tested, the user should test each output device in turn. Hardware/indicator comparison for output devices is described in this Paragraph.

> **CAUTION:** For reasons of safety, machine motion **must** be inhibited during the start-up procedures outlined in this Paragraph.

There are two different methods for output testing. The simpler method employs a convenient, readily accessible push button or similar normally-open/momentary-close device. (The push button may be part of an operator panel or may be specifically installed for start-up or troubleshooting purposes.) With this method, the push button is used to energize each output device, one at a time. This method is described in Paragraph 4.2.3.2.1.

Where the user does not have a push button or similar application device, he may use the FORCE function of the Program Panel to energize each output device, one at a time. This method is described in Paragraph 4.2.3.2.2.

4.2.3.2.1 Use of Push Button – A normally-open/momentary-close push button, connected as an input to the controller, may be used for testing outputs during start-up. To use this device, the user programs a single rung which examines the state of the push button and energizes each output device in turn.

To use this method, follow these steps:

- **Step No. 1** – Display the first program Instruction on the Program Panel. To do this, press these Program Panel keys:

  [SEARCH] [↑]

- **Step No. 2** – Clear the Mini-Processor memory. To do this, turn the Mode Select Switch to PROGRAM. Then, enter these Instructions from the Program Panel:

  [CLEAR MEMORY] [9] [9]

- **Step No. 3** – Enter the output control rung for the first output to be tested. This rung examines the push button for an ON (energized) condition and energizes the output device when the Instruction is TRUE. A sample rung is shown in Figure 4.4.

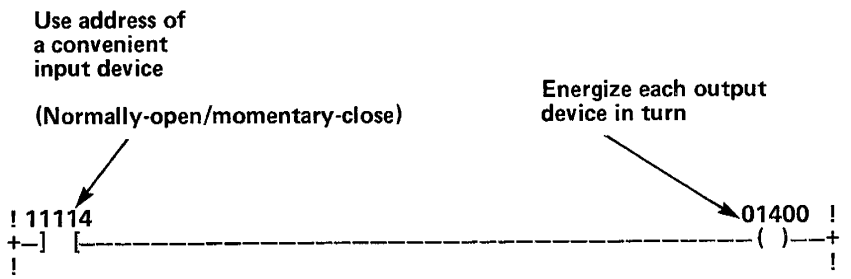


Figure 4.4 — Rung for Output Testing — Push Button Use

CAUTION: During this phase of controller checkout, **only** the one rung of user program used for trouble-shooting should be entered into the Mini-Processor memory. Do not program multiple rungs for start-up purposes, as unpredictable system behavior may result.

- **Step No. 4** — On the Mini-Processor Module, turn the Mode Select Switch to TEST.
- **Step No. 5** — Display the output device on the Program Panel. Close the push button and examine the output status indicator on the Program Panel. The output Instruction should be TRUE when the input Instruction is TRUE, that is, when the push button is closed.
- **Step No. 6** — Turn the Mode Select Switch to RUN.
- **Step No. 7** — Close the push button and check behavior of the output device.

  Should the output device fail to energize, the user should check the output module indicator for the device. This indicator aids in locating the source of the fault by its state, as follows:

  - ON — If the output module indicator is illuminated, the module has turned its output triac ON, supplying voltage at its output terminal. If the output device does **not** energize, check the following:
    - User wiring to the output device
    - Wiring of the device to the proper Field Wiring Arm terminal
    - The output device itself
  - OFF — If the output module indicator fails to illuminate, recheck the procedures of Steps No. 1 thru 7. If this does not isolate the problem, replace the output module.

    Rules for module replacement are given in Paragraph 5.4.
- **Step No. 8** — With the output device turned off, turn the Mode Select Switch to PROGRAM.
- **Step No. 9** — Remove the tested output address from the control rung and program the next output address in its place.

  It is important that the user's memory have only one rung at a time. Do **not** program more than one rung for these procedures.

Repeat Steps No. 3 thru 9 until each output device has been tested.

4.2.3.2.2 Use of FORCE Function — If a push button or similar device is not available in an application, the FORCE function can be used. With this function, a user can turn output devices ON and OFF directly from the Program Panel.

CAUTION: A fast means of shutting off power to output devices must be available when testing devices with the FORCE function. An alert, competent person should be stationed at the Emergency Stop switch during these procedures.

To use this method, follow these steps:

- **Step No. 1** — Display the first program Instruction on the Program Panel. To do this, press the Program Panel keys:

  [SEARCH] [↑]
- **Step No. 2** — Clear the Mini-Processor memory.

  To do this, turn the Mode Select Switch to PROGRAM. Then, enter these Instructions from the Program Panel:

  [CLEAR MEMORY] [9] [9]

  While the memory is being cleared, the Program Panels display EXC or EXECUTE. When this is complete, the END (of program) message is displayed.
- **Step No. 3** — Enter the output control rung for the first output to be tested. The rung to be used for these procedures is shown in Figure 4.5.

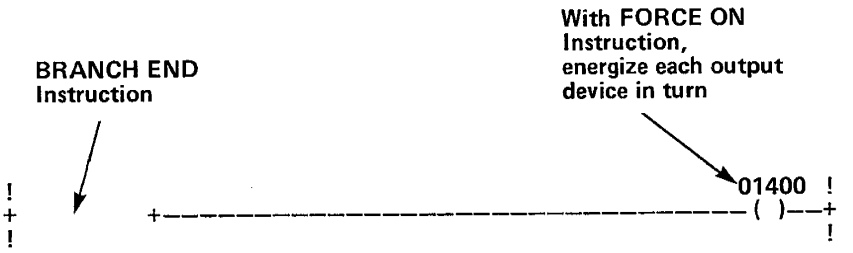


Figure 4.5 — Rung for Output Testing —FORCE Function Use

This rung begins with a BRANCH END Instruction. This is so that an output of this rung can never be energized by the program logic; a BRANCH END Instruction, by itself, is never TRUE. Thus, only the FORCE function can energize an output in this rung.

CAUTION: During this phase of controller checkout, **only** the one rung of user program used for troubleshooting should be entered into the Mini-Processor memory. Do not program multiple rungs for initial checkout purposes, as unpredictable system behavior may result.

- **Step No. 4** – On the Mini-Processor Module, turn the Mode Select Switch to TEST.
- **Step No. 5** – With the output Instruction displayed, enter the FORCE ON function by pressing these Program Panel keys:

  [SELECT] [FORCE ON] [INSERT]

  The Program Panels indicate TRUE state for the output device Instruction. In addition, a FORCED indication is given on the Program Panels. The Cat. No. 1772-TA Program Panel has an indicator labeled FORCED, directly beneath the status indicator. (Refer to Figure 4.1.) The Cat. No. 1774-TA Program Panel displays FORCED I/O for this type of Instruction.
- **Step No. 6** – To energize the output device, turn the Mode Select Switch to RUN.
- **Step No. 7** – Observe the behavior of the output device.

  Should the output device fail to energize, the user must check the output module indicator for the device. This indicator, by its state, aids in locating the source of the fault, as follows:

  - ON – If the output module indicator is illuminated, the module has turned its output triac on, supplying voltage at its output terminal. If the output device does **not** energize, check the following:
    - User wiring to the output device
    - Wiring of the device to the proper Field Wiring Arm terminal
    - The output device itself
  - OFF – If the output module indicator fails to illuminate, recheck the procedures of Steps No. 1 thru 7. If this does not isolate the problem, replace the output module.

    Rules for module replacement are given in Paragraph 5.4.
- **Step No. 8** – On the Mini-Processor Module, turn the Mode Select Switch to TEST.
- **Step No. 9** – Remove the FORCED ON condition. To do this, enter these Instructions from the Program Panel:

  [SELECT] [FORCE ON] [REMOVE]
- **Step No. 10** – Remove the output address from the control rung. In its place, program the next output address to be tested.

Repeat Steps No. 3 thru 10 until each output device has been tested.

- **Step No. 11** – Make sure all FORCE ON Instructions have been removed. To do this, press the following keys:

  [SELECT] [FORCE ON] [CLEAR MEMORY]

4.2.3.3 Testing Output Modules – Disconnected Devices – The procedures outlined in this Paragraph provide a check of output module behavior for those devices which cause machine motion. These devices must **not** be connected to Module terminals during these procedures. The purpose of this testing is to verify the proper operation of output modules for the disconnected devices. The devices themselves are checked as outlined in Paragraph 4.3.

When an output module indicator is ON, power is available at the corresponding output terminal. Thus, by observing this indicator, the user can check output module operation.

To check output module operation for each of the disconnected devices, follow these steps:

- **Step No. 1** – Display the first program Instruction on the Program Panel. To do this, press these Program Panel keys:

  [SEARCH] [↑]
- **Step No. 2** – Clear the Mini-Processor memory. To do this, turn the Mode Select Switch to PROGRAM. Then, enter these Instructions from the Program Panel:

  [CLEAR MEMORY] [9] [9]
- **Step No. 3** – Enter the output control rung for the first output to be tested. This rung uses either a normally-open/momentary-close push button as shown in Figure 4.4, or the FORCE ON/OFF function with a BRANCH END Instruction, as shown in Figure 4.5.

CAUTION: During this phase of controller checkout, **only** the one rung of user program used for troubleshooting should be entered into the Mini-Processor memory. Do not program multiple rungs for troubleshooting purposes, as unpredictable system behavior may result.

- **Step No. 4** – On the Mini-Processor Module, turn the Mode Select Switch to RUN.
- **Step No. 5** – Check the behavior of the output indicator. To do this, press the push button or use the FORCE ON/OFF function. The indicator should turn ON and OFF as controlled.

  If the output module indicator fails to turn ON, the user should first recheck his procedure and entry of the correct terminal address. Replace the output module if the indicator fails to turn ON.

  If the output module indicator is ON, but fails to turn OFF, module replacement is necessary.

Repeat Steps No. 3 thru 5 for each output terminal to be tested.

4.3 Checkout of Machine Motion – At this point the controller, connections, and most user hardware have been tested. This final procedure is to check out the machine motion or process as controlled by the actual user program.

All persons involved with the programming, installation layout design, machine or process design, and Mini-PLC-2 and machine maintenance should be involved in making decisions for determining the best and safest ways to test the total system. These procedures are general in nature. Individual conditions may warrant their modification.

The basic approach initiates testing with the least amount of machine motion; only some outputs are allowed to generate machine motion. Then additional machine motion can be added gradually, thereby allowing any problems to be detected more easily under controlled conditions.

Before this phase of system start-up is attempted, the user's program must be thoroughly reviewed. Only after this is done can the user complete final system checkout. The Programming and Operations Manual, Publication 1772-821, contains start-up information for the programmer. Refer to this Publication for information on program de-bugging and use of the partial program in start-up.

Follow these steps for final checkout:

> **WARNING:** During all phases of this checkout of machine motion, an alert, competent person must be ready to operate an Emergency Stop switch, which would de-energize the Master Relay, thereby removing all power from the machine. This circuit must be hard-wired only; it must never be programmed. (Refer to Paragraph 3.1.3.)

- **Step No. 1** – In the PROGRAM mode, clear the Mini-Processor memory, then enter the user's program.
- **Step No. 2** – On the Mini-Processor Module, turn the Mode Select Switch to TEST.
- **Step No. 3** – In the TEST mode, examine the program as entered. Double-check the programming of parallel branches and make certain that no output device is energized unconditionally.
- **Step No. 4** – Restore the connection from an output module to a single device which causes machine motion.
- **Step No. 5** – Check the behavior of the output device reconnected in Step 4. To do this, simulate the input conditions necessary to energize the output in the program. Then, turn the Mode Select Switch to RUN.
- **Step No. 6** – Disconnect this output device which had been connected in Step No. 4.
- **Step No. 7** – Restore the connection from an output module to the next single output device to be tested.
- **Step No. 8** – Repeat Steps 5 thru 7 until each output device has been tested singly.
- **Step No. 9** – Restore the connection from output modules to all devices causing machine motion. Restore power to any machine which had been disconnected for start-up or troubleshooting purposes.
- **Step No. 10** – After thoroughly checking out the controller system and program, a dry run of the application can be done, with all output devices enabled.
- **Step No. 11** – After the entire system has been checked out, it is recommended that the program be recorded with the optional Digital Cassette Recorder (Cat. No. 1770-SA). Make at least two cassette records and store them separately.

  Optionally, a copy of the user's program can be produced on a teletype or other RS-232-C compatible data terminal.

Section 5
TROUBLESHOOTING

5.0 General – The Mini-PLC-2 programmable controller is designed for convenient troubleshooting by maintenance personnel. Troubleshooting the majority of controller faults requires no special test equipment or programming techniques. Instead, status and diagnostic indicators in the controller help to isolate the source of a fault in user hardware or in the controller itself.

This Paragraph describes the significance of controller indicators for the troubleshooter. In addition, it describes basic troubleshooting procedures and replacement of controller components.

5.1 Mini-Processor Module – The front face of the Mini-Processor Module has three distinct functional areas. These areas include:

- Diagnostic Indicators
- Mode Select Switch
- INTERFACE socket

The significance of each of these for troubleshooting is described in the following Paragraphs.

5.1.1 Diagnostic Indicators – Indicators on the front of the Mini-Processor Module aid in analyzing controller status. (Refer to Figure 5.1.) During its operation in any mode, the Mini-Processor Module continuously monitors its own status, through checks on timing and data parity. In addition, the Mini-Processor receives a signal from the Power Supply if user line power goes low for longer than one-half cycle. (Refer to Paragraph 2.4.1.)

The indicators on the front of the Mini-Processor Module show the status of its various self-checking routines. These indicators are:

- PROCESSOR – This red indicator illuminates if the Processor is unable to scan the user's program and Data Tables in memory. It is normally OFF.

  If the Mini-Processor detects this type of fault, it stops communication with I/O modules. If this occurs, the Last State Switch determines the status of energized controller outputs. (Refer to Paragraph 3.2.5.)

  Reset may be attempted for this type of fault by changing the Mode Select Switch to the PROGRAM mode, then back to RUN. Reset may also be accomplished by recycling line power to the System Power Supply or by reloading the user program.

- MEMORY – This red indicator illuminates if the Mini-Processor detects loss of user program, a discrepancy in memory data, or a parity error. It is normally OFF.

  The Mini-Processor stops communication with I/O modules if this type of fault is detected. The Last State Switch determines the status of controller outputs if this fault occurs. (Refer to Paragraph 3.2.5.)

  This error may be reset by turning the Mode Select Switch to the PROGRAM mode, then back to RUN. Reset may also be accomplished by recycling line power to the System Power Supply.

  Reloading the user program may clear this fault in some instances.

- RUN – This green indicator illuminates when the Mini-Processor is operating with the Mode Select Switch in the RUN mode. When this indicator is ON, controller outputs are enabled. This also implies that no Mini-Processor-related fault has been detected.

  This indicator turns OFF in the RUN mode if the System Power Supply detects that voltage on the user's input line has dropped to unacceptable levels. In this event, the Mini-Processor disables all output devices and stops receiving input module data. This prevents the Mini-Processor from storing input data which might be inaccurate due to low voltage levels.

  In the event of user-line failure, reset of the Mini-Processor is automatic with recovery of the line to normal voltage range. (Refer to Paragraph 5.2.1.)

Note: Upon initial power-up of a newly-installed Mini-Processor, user memory circuitry is blank. Because of this, both PROCESSOR and MEMORY indicators may be illuminated while the Module is in the RUN mode. However, these indicators will turn OFF when the Mode Select Switch is changed to the PROG position.

5.1.2 Mode Select Switch – Beneath the Diagnostic Indicators on the front of the Mini-Processor, is the Mode Select Switch. (Refer to Figure 5.2.) By means of this 3-position keylock switch, the mode of controller operation is selected. Switch positions are:

- PROG – In the PROGRAM mode, the user enters program Instructions into the Mini-Processor Module. Instructions are entered either directly from the Program Panel keyboard or by means of a data terminal connected through the Program Panel. This data terminal may be a punched-tape reader or the Digital Cassette Recorder (Cat. No. 1770-SA). Outputs are disabled in this switch position.
- TEST – In the TEST mode, the user's program can be tested and controller behavior may be observed under simulated operating conditions. This allows preliminary de-bugging of a program without risking damage to controlled equipment or injury to personnel. The con-

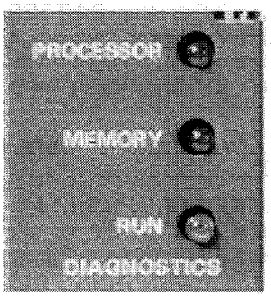


Figure 5.1 – Mini-Processor Diagnostic Indicators

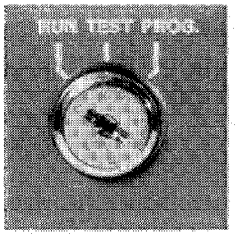


Figure 5.2 – Mode Select Switch

troller executes all programmed instructions in the TEST mode. However, outputs are disabled in this switch position.

- RUN – In the RUN mode, the Mini-Processor scans and executes the user's program. Outputs are energized according to the user's program.

  This is the only position that allows removal of the Mode Select Switch key.

When the Mode Select Switch is changed from the RUN mode to PROGRAM or TEST modes, all controller outputs are disabled.

5.1.3 INTERFACE Socket – The INTERFACE socket on the Mini-Processor Module is dedicated for Program Panel or Program Panel Adapter connection, as described in Paragraph 3.2.8.

The Program Panel is an invaluable troubleshooting tool with the Mini-PLC-2 programmable controller. Its basic use for this purpose is in performing hardware/indicator comparison as described in Paragraph 4.2.

5.1.3.1 Program Panel Messages – The Program Panel can also be used to detect certain types of faults in Mini-Processor operation. This is because diagnostic circuitry of the Program Panel monitors its communication with the Mini-Processor. If a data communication malfunction is detected, the Program Panel displays a message, indicating the possible source of the fault. When the Mini-Processor is the suspected fault source, the following messages may be displayed:

- ERR 8 – The ERROR 8 message is displayed when the Program Panel detects loss of the user program. It may also indicate that Mini-Processor memory data is "scrambled" or unintelligible to the Program Panel.

  If the ERROR 8 message is displayed, memory must be cleared and the user's program reloaded. Turning the Mode Select Switch to PROGRAM for a few seconds causes memory to be cleared when this message is shown. The message END 0128 indicates that the memory has been fully cleared.

- ERR 9 – The ERROR 9 message is displayed when a fault is detected in the Mini-Processor Module itself.

  If the ERROR 9 message is shown, attempt to reset the Mini-Processor Module. To do this, cycle line-power to the System Power Supply. If this action fails to reset the Mini-Processor, replace the Module. (Rules for module replacement are given in Paragraph 5.4.)

5.2 Power Supply – The System Power Supply aids controller troubleshooting by monitoring the various voltages at its inputs and outputs and at the Battery Pack. This Paragraph describes Power Supply indicators and output voltages.

5.2.1 Power Supply Indicators – The front face of the System Power Supply has 2 diagnostic indicators. (Refer to Figure 5.3.) These are labeled:

- DC ON
- BATTERY LOW

A brief description of each indicator follows.

5.2.1.1 DC ON – The DC ON indicator illuminates when the Power Supply outputs are within proper voltage and current tolerances. If this indicator fails to illuminate when the Supply is connected to the AC power line, check these possible fault sources:

- **Low input voltage** – Input AC voltage is wired to the Power Supply terminal strip. Specific terminal connections and terminal jumpering must be observed for proper Supply operation. These are described in Paragraph 3.2.3.

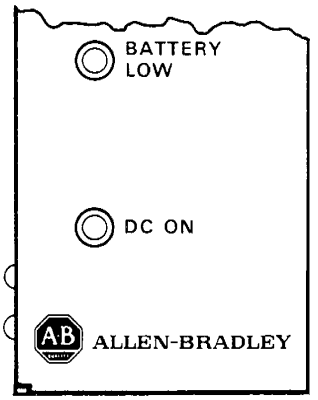


Figure 5.3 – Power Supply Indicators

- **Blown fuse** – Fuse replacement is described in Paragraph 5.2.5.
- **Output shutdown** – The System Power Supply may shut down its outputs for a number of reasons. Possible causes of output loss include overloading, tampering, or a shorted Power Supply load. Once such external conditions are removed, the Supply can be restarted by recycling its AC input power.

As was described in Paragraph 2.4.1, the System Power Supply monitors the user AC line and disables the Mini-Processor when AC voltage below the normal range is detected. Note that the DC ON indicator does **not** correspond to this disabling signal. This is because the System Supply may be able to maintain logic-level output voltage even when the input line voltage drops below the normal range.

In some "brownout" situations, therefore, it is possible that the DC ON indicator might be illuminated while the Mini-Processor Module is disabled. Observe the RUN indicator on the Mini-Processor Module to determine whether its operation has been enabled or disabled by the Supply. (Refer to Paragraph 5.1.1.)

5.2.1.2 BATTERY LOW – When the voltage level of the Battery Pack fails beneath a certain threshold voltage, the Power Supply flashes its BATTERY LOW indicator. This voltage threshold is set so that the batteries will still support memory contents for about one week after flashing begins. [1] This gives the user ample warning that replacement batteries are needed.

The BATTERY LOW indicator also flashes if batteries have been installed with incorrect polarity. If the BATTERY LOW indicator begins to flash upon system start-up, check battery polarity in the Pack. (Refer to Paragraph 3.2.1.)

A low-battery condition is also signaled to the Mini-Processor Module. Memory bit 02700 is turned alternately ON and OFF, in time with the BATTERY LOW indicator, when the Mini-Processor receives this signal. Thus, through the user's program, an annunciator, warning light, or other device can also be used to warn of a low-battery condition.

For BATTERY LOW indicator to flash, AC power to the Supply must be ON.

Batteries may be replaced without loss of memory contents, provided that AC power to the Supply is ON. Battery replacement is described in Paragraph 5.2.4.

[1] This one week back-up approximation applies whether the 512- or 1024-word memory is used.

5.2.2 Power Supply Replacement – The System Power Supply can be quickly replaced without the need to remove other controller components. As long as the Battery Pack connection is maintained, the Power Supply can be replaced without loss of power to the memory.

Follow these steps for Supply replacement:

> **WARNING:** AC line potentials may cause injury to personnel. Be certain that Step No. 1 is performed before proceeding.

- **Step No. 1** – Turn input power to the Supply OFF.
- **Step No. 2** – On the Mini-Processor Module, turn the Mode Select Switch to TEST.
- **Step No. 3** – Disconnect input AC wiring and ground connection from the Supply terminal strip.
- **Step No. 4** – Locate the Power Cable plug connected at the base of the Supply. Do **not** confuse this 9-pin plug with the smaller 3-pin plug connected to the Battery Pack. This Battery Pack connection to the Chassis backplane must remain intact to maintain Mini-PLC-2 memory contents.
- **Step No. 5** – Remove the 9-pin Power Cable plug from the connector on the base of the Supply. To do this, squeeze in on the levers on the side of the Cable plug. Gently but firmly ease the plug from the socket.
- **Step No. 6** – Remove the supply from its mounting connection.
- **Step No. 7** – Mount the replacement Supply.
- **Step No. 8** – Restore the Power Cable connection to the base of the replacement Supply.
- **Step No. 9** – Restore the input AC line connection and ground connection to the Supply's terminal strip.
- **Step No. 10** – Restart the controller. To do this, restore AC input power to the System Supply. Then, turn the Mode Select Switch on the Mini-Processor to RUN.

  Observe the controller for proper operation with the replacement Power Supply.

5.2.3 Power Supply Output – If the System Power Supply is the suspected source of a controller fault, output measurements can be made. While measurements in the field do not provide a complete diagnosis of Supply behavior, they may help to isolate problems during troubleshooting procedures. A voltmeter is necessary for these measurements.

Voltage measurements can be taken at the socket on the base of the System Power Supply. In order that socket numbering be readable, the Supply should be removed from the controller enclosure. By following Steps No. 1 thru 6 in Paragraph 5.2.2, the user can remove the Supply from the enclosure without loss of the Mini-PLC-2 memory.

Alternately, voltage measurements can be taken thru the Power Cable plug which connects to the I/O Chassis backplane. For this method, the Supply remains connected at its base and need not be removed from its mounting in the enclosure. Instead, the Power Cable must be removed only from its I/O Chassis backplane socket. However, when the Power Cable is disconnected from the I/O Chassis backplane, user memory will be lost. Thus, it is normally preferred to remove the Supply, while leaving Battery Pack and I/O connections intact.

The pins of the Power Supply socket are numbered 1 thru 9. The voltages at each pin are listed in Figure 5.4. (Note that pins numbered 6 and 9, designated "low true," cannot be measured directly with a voltmeter.)

5.2.4 Battery Replacement – The Mini-PLC-2 controller design allows battery replacement without interrupting normal controller operation. As long as AC line power is supplied to the System Power Supply, batteries may be removed and replaced without loss of power to the memory.

When replacing alkaline cells, it is strongly recommended that replacements be of the type supplied by Allen-Bradley under Cat. No. 1771-BA. However, in emergency situations, the user may **temporarily** substitute quality alkaline D-size batteries sold under these brand names:

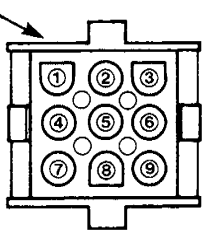
- National
- Eveready
- Ray-O-Vac

The use of ordinary carbon-zinc D-size batteries is **not** advised for this application.

To replace used batteries, follow these steps:

- **Step No. 1** – Loosen the thumbscrew on the front of the Battery Pack. (This screw is captive; it cannot be removed.)
- **Step No. 2** – Pull the Pack forward a few inches, but still within its brackets on the Chassis side-plate.
- **Step No. 3** – Locate the 3-pin Power Cable connector at the base of the Battery Pack. Squeeze in on the tabs along the sides of the plug and pull it gently down from the socket.

Socket at base of System Power Supply **or** at end of power cable which connects with I/O Chassis.



9-Pin Supply/Cable Connector

PIN NO.	FUNCTION
1, 2	Logic Voltage, +5.1V DC
3	Chassis Ground
4, 5	Common
6	Battery Fail (Low-True)
7	Battery (+) (2.7-3.7V DC) [1]
8	Memory Voltage, +5V DC
9	Processor Enable (Low-True)

[1] Battery voltage at Pin No. 7 is not measurable at base of Power Supply.

Figure 5.4 – System Power Supply Voltages

- **Step No. 4** – With the Cable plug disconnected, remove the Battery Pack from its mounting brackets.
- **Step No. 5** – Observe the polarity of the used cells in the Pack.

  There are 2 types of Battery Packs. As Paragraph 3.2.1 states, each type has a different polarity. Figures 3.13 and 3.14 show the polarity for each Battery Pack.
- **Step No. 6** – Remove the used batteries and insert the replacements. It may be useful to mark the replacement cells with the date of replacement. This may also be useful to help avoid mix-up during the replacement process. Position batteries so that seams face downward in the Pack. Should one (or both) of the batteries leak, the Battery Pack is designed to collect the effluence. When using the plastic Battery Pack (Cat. No. 1771-BP), pay close attention to the positioning of the plastic separator and gaskets. Their placement is shown in Figure 3.14.
- **Step No. 7** – When the replacement cells are positioned properly in the Battery Pack, install the Pack into its mounting bracket on the side of the I/O Chassis. Tighten the thumbscrew and restore the Power Cable plug connection.

5.2.5 Fuse Replacement – The fuseholder for the System Power Supply is located above its terminal strip. This allows the fuse to be readily examined and replaced during troubleshooting procedures.

Before replacing the Supply fuse, check the input terminal strip of the Supply. Jumper positions for the various AC operating voltages are marked at the side of the terminal strip. Make sure that these jumpers are properly placed. Connections from the input line are also marked near the terminal strip. Check for proper L1, L2, and EQUIPMENT GROUND connections.

The input line voltage may also be checked before replacing the Supply fuse.

To replace the System Power Supply fuse, follow these steps:

- **Step No. 1** – Remove AC power from the Supply inputs.
- **Step No. 2** – Remove the Supply fuse by pushing in slightly on the cap of the fuseholder. Twist it 1/4 turn counterclockwise and pull the fuseholder out of the socket.
- **Step No. 3** – Examine the fuse element inside the glass tube. A blown fuse element will be readily apparent.
- **Step No. 4** – Insert a replacement fuse into the holder and twist the holder back into its socket. Use only the replacement fuse recommended. (Refer to Table 5.B.)

The controller can be restarted once the replacement fuse is installed.

Note that each System Power Supply is shipped with a 1-ampere fuse installed for 120V use. An additional 0.5-ampere fuse is shipped with the Supply, to be used when the Supply is connected for 220/240V operation. Do not use either of these fuses as a replacement for the other.

Note that the Fuse Package (Cat. No. 1771-FP) contains replacement fuses of **both** 1- and 0.5-ampere ratings. Use only the fuse of the correct rating for the AC line voltage.

5.3 Troubleshooting – This Paragraph outlines the various possible sources of faults in the controller and user hardware and describes procedures for isolating and correcting faults.

5.3.1 Possible Fault Sources – A fault in system behavior may originate from the sources shown in Figure 5.5. These faults can be grouped into two broad categories:

- I/O Hardware
- Controller

The following Paragraphs describe faults possible from these sources.

5.3.1.1 I/O Hardware – The most likely source of a fault condition is hardware devices. Hardware-related faults may originate in the following:

- User input or output device
- Wiring between I/O devices and Wiring Arms
- User power to I/O devices
- An I/O module

If the controller continues to operate in the RUN mode, but some output devices do not turn ON or OFF as programmed, it can be assumed that the source of the fault is hardware-related.

To trace this type of fault, indicators on I/O modules and the Program Panel can be compared with I/O device status. These hardware/indicator comparison procedures for troubleshooting are described in Paragraph 5.3.3.

When a fault in user hardware is suspected, it is useful to have a copy of the user's program. This may be helpful to isolate I/O device conditions which affect the status of one or more outputs. For example, certain Instructions may be used to set up overriding conditions for a large block of program Instructions. These Instructions are:

Master Control Relay/Zone Control Logic

If specified conditions in the program are not met, these Instructions can be used to disable outputs of selected rungs. Refer to the Programming and Operations Manual, Publication 1772-821, for a full description of these Instructions.

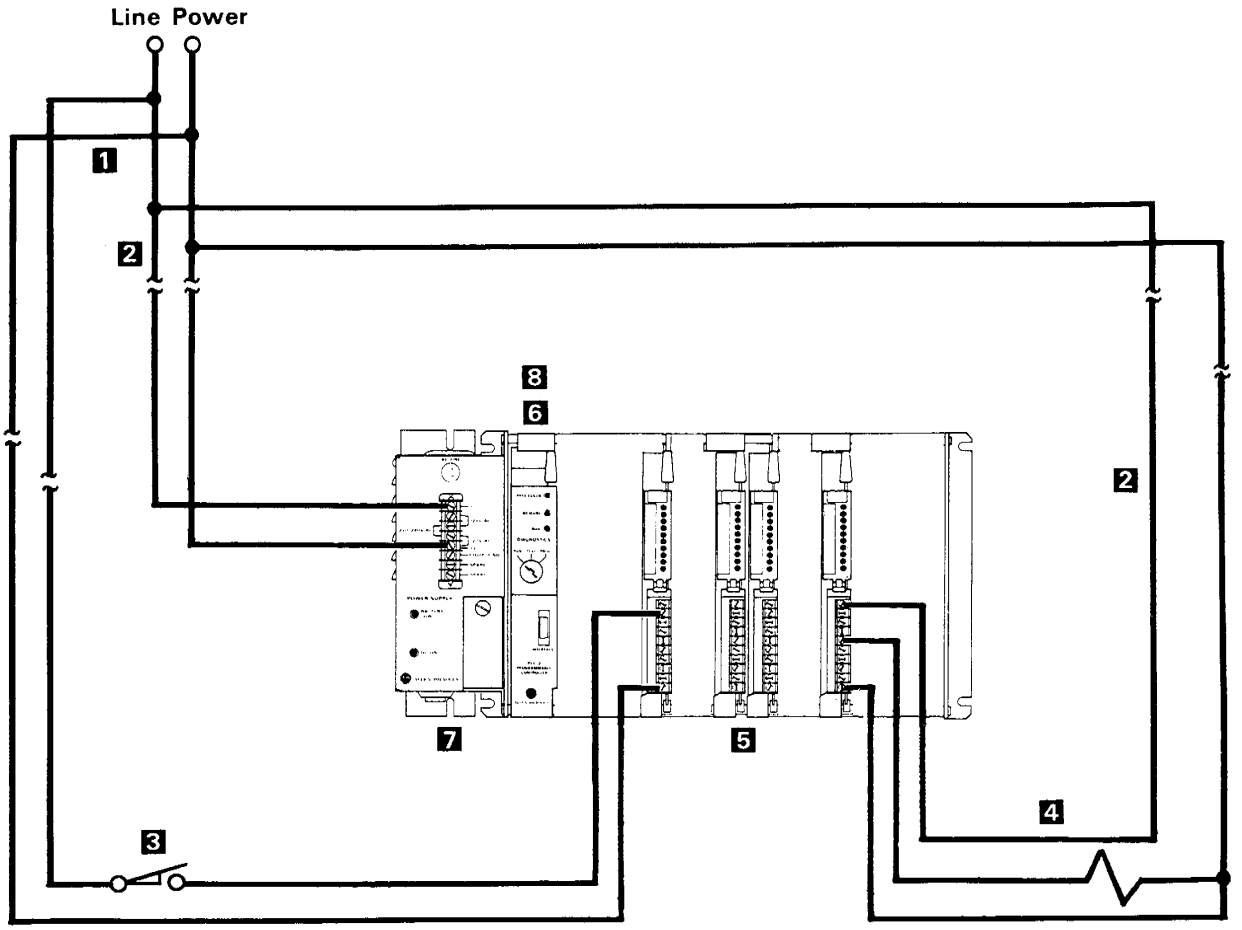
5.3.1.2 Controller – Controller-detected faults may originate in the following:

- User line-power to the System Power Supply
- I/O Power Cable
- System Power Supply operation
- Mini-Processor Module operation

Diagnostic and monitoring circuitry alert the Mini-Processor Module to a fault from any of these sources. The Mini-Processor provides consistent output behavior if one of these faults is detected. In most cases, this implies turning all outputs OFF. In the particular instance of a Mini-Processor fault, outputs may be held in their last state. (Refer to Paragraph 3.2.5.)

For any of these faults detected by the controller, diagnostic indicators are provided, both on the Mini-Processor Module and the System Power Supply. Paragraphs 5.1 and 5.2 describe the significance of these indicators for troubleshooting. Table 5.A gives a fault summary for comparison with the state of each of these controller indicators.

5.3.2 Troubleshooting Procedure – Troubleshooting involves a careful, systematic observation of controller indicators and behavior to narrow down the source of a fault to one component. The possible sources of a fault are shown in Figure 5.5. The many indicators of the Mini-PLC-2 programmable controller provide a quick means for isolating a fault to one of these sources.



LEGEND:

1 Power Source for:
- System Power Supply
- Input devices
- Output devices

2 Line-wiring to:
- System Power Supply
- Input devices
- Output devices

3 Input devices

4 Output devices

5 I/O Modules, including:
- User-wiring to correct terminal
- Output module fuses

6 Mini-Processor Module

7 System Power Supply, including:
- Blown Fuse
- Power Cable

8 User program

Figure 5.5 — Possible Controller Fault Sources

In many instances, troubleshooting must be performed by personnel with only minimal understanding of the controller and controlled operation. Or, the cause of faulted operation may not be readily apparent. The flow chart of Figure 5.6 gives an orderly approach when troubleshooting any type of controller fault. Using this approach, the general cause of a fault can be isolated by examining controller indicators.

In some applications, the comprehensive procedures outlined in Figure 5.6 may not be necessary. These may be applications where potentially hazardous machine motion is not involved. Or, there may be applications where it is beneficial, for troubleshooting purposes, to keep the controller in operation while examining input and output module indicators. For this type of troubleshooting, however, maintenance/operations personnel should be very familiar with controller indicators, the application program, and the controlled equipment.

In whatever method of troubleshooting used, hardware-related faults can be difficult to pinpoint. A hardware/indicator comparison, similar to the procedure used in controller start-up, is most useful in this case. This is described in Paragraph 5.3.3.

5.3.3 Hardware/Indicator Comparison for Troubleshooting — Once a hardware-related fault is suspected, the source of the problem can be isolated by comparing the actual status of a device with controller indicators. This

Table 5.A

FAULT SUMMARY

MINI-PROCESSOR DIAGNOSTIC INDICATOR			SYSTEM POWER SUPPLY INDICATOR		POSSIBLE FAULT SOURCE	ACTION TO CORRECT FAULT
PROCESSOR	MEMORY	RUN	DC ON	BATTERY LOW		
ON	ON	OFF	ON	OFF	Mini-Processor Module	A. Change Mode Select Switch to PROGRAM, then back to RUN. B. Recycle power to System Power Supply. C. Re-enter the user program. D. Replace the Mini-Processor Module.
ON	OFF	OFF	ON	OFF		
OFF	OFF	OFF (in RUN mode)	ON or OFF	OFF	Power Supply or Power Cable or Input-line Power	A. Check Power Cable connections. B. Check Power Supply fuse. C. Check input-line voltage for normal range. D. Replace Cable. E. Check Power Supply output. F. Replace Supply.
OFF	OFF	ON or OFF [1]	ON	FLASHING	Battery Pack	A. Check Cable connection to Battery Pack. B. With System Power Supply energized (to maintain memory contents), remove Battery Pack. Make sure batteries are inserted properly. C. Replace with 2 Cat. No. 1771-BA Alkaline Batteries or 1 Cat. No. 1771-BL Lithium Battery. [2]
ON	ON	ON	ON	OFF	Mini-Processor Module	Replace Mini-Processor Module
OFF	ON	OFF	ON	OFF		
ON	OFF	ON	ON	OFF		
OFF	ON	ON	ON	OFF		

[1] RUN indicator illuminates only in RUN mode.

[2] Lithium cell usable with Cat. No. 1771-BP Battery Pack only.

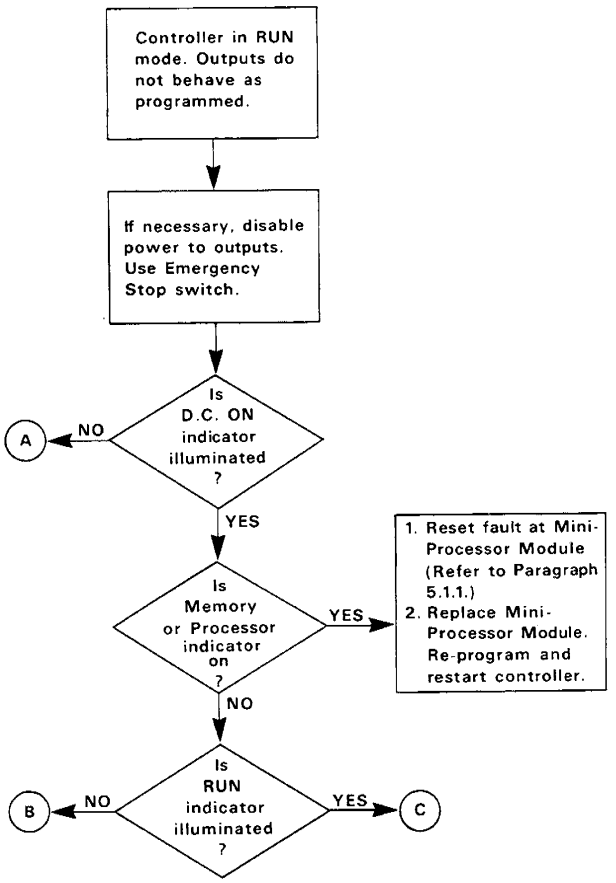


Figure 5.6 — Troubleshooting Flow Chart

procedure is similar to hardware/indicator comparison upon controller start-up, described in Section 4. However, the troubleshooting situation differs from controller start-up in one essential way: the user's program is in the controller memory. Because the program is to be kept intact, no programming is to be done for troubleshooting hardware faults.

CAUTION: Do **not** alter the user program for troubleshooting purposes. This can be a dangerous practice, since the program may no longer operate as had been intended.

The following Paragraphs describe I/O hardware troubleshooting. These Paragraphs assume a knowledge of the significance of I/O module and Program Panel status indicators. (An explanation of these indicators can be found in Paragraphs 4.2.1 and 4.2.2.)

5.3.3.1 Input Troubleshooting — To test input hardware during troubleshooting, follow these steps:

WARNING: Never reach into a machine to actuate a switch since unexpected machine motion can occur. Use a wooden stick or other nonconductive device to guard against electrical shock.

- **Step No. 1** — On the Mini-Processor Module, turn the Mode Select Switch to TEST.
- **Step No. 2** — Compare the ON/OFF status of each input device to its corresponding input module indicator.

  For this comparison, manually turn the input device ON and OFF. Observe the input module status indicator for the device. This indicator must turn ON and OFF as the device is turned ON and OFF.

  The indicator on the front of the module must illuminate when the input device is **ON**. If the indicator does not illuminate, check out the user hardware in the following order:
  - User power source for the input device
  - Wiring from the input device
  - Connection to the correct Wiring Arm terminal
  - The input device
  - The input module

  Repeat Step No. 2 for each input device.
- **Step No. 3** — Connect and initialize the Program Panel. (Refer to Paragraph 3.2.8.)
- **Step No. 4** — Display the first input device Instruction on the Program Panel. To do this, press the following keys:

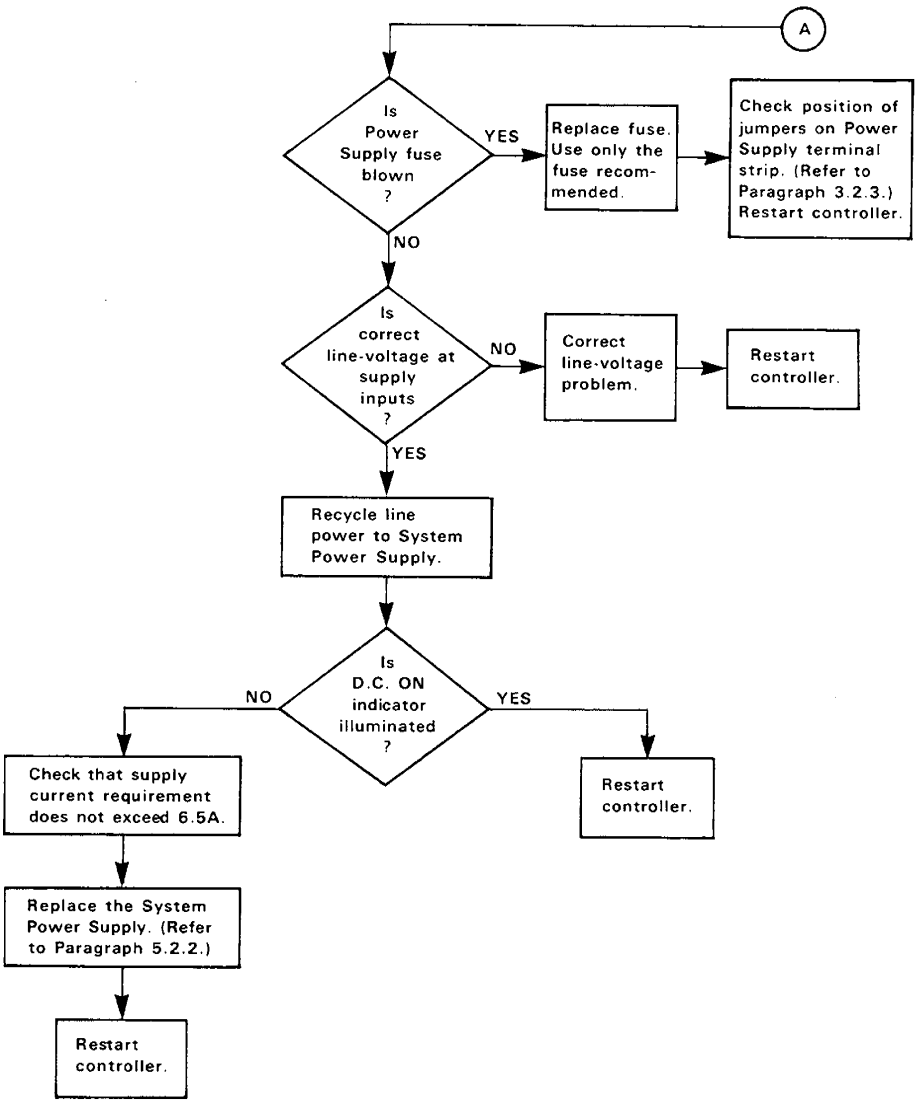


Figure 5.6 (continuous)

[SEARCH] [X] [Y] [Y] [Y] [Y] [Y]

Here [X] represents the device Instruction, ⊣⊢ or ⊣/⊢, and [Y] [Y] [Y] [Y] [Y] is the 5-digit address of the device.

- **Step No. 5** – With the input device address displayed on the Program Panel, compare the response of the Program Panel status indicator to the change in the actual ON/OFF status of the device. (Refer to Paragraph 4.2.2.)

  For this comparison, manually turn the input device ON and OFF.

  Table 4.A lists the actual ON/OFF status of an I/O device, given the displayed Instruction and its status indicator.

  Should the Program Panel status indicator fail to show the status of the Instruction, check that procedures have been followed as outlined in this Paragraph.

  If no fault was detected with the input device or wiring in Step 2, but the Program Panel status indicator does not show the status of the input device, replace the input module. Rules for module replacement are given in Paragraph 5.4.

- **Step No. 6** – Once the input Instruction has been checked, display the next address to be tested. To do this, press these keys on the Program Panel:

  [CANCEL COMMAND] [SEARCH]
  [X] [Z] [Z] [Z] [Z] [Z]

  Here [X] represents the next device Instruction, ⊣⊢ or ⊣/⊢, and [Z] [Z] [Z] [Z] [Z] is the 5-digit address of the next input device to be tested.

- **Step No. 7** – Repeat Steps No. 5 and 6 for each input device until all inputs have been checked.

5.3.3.2 Output Troubleshooting – Hardware/indicator comparison is a useful technique for the troubleshooting of output devices.

In output troubleshooting, machine motion must be permitted only under well-controlled circumstances. For this reason, the first part of the following procedure checks output devices which do **not** cause machine motion. Then, steps are taken to test output devices which cause machine motion.

To test output devices and wiring, as well as output modules, follow these steps:

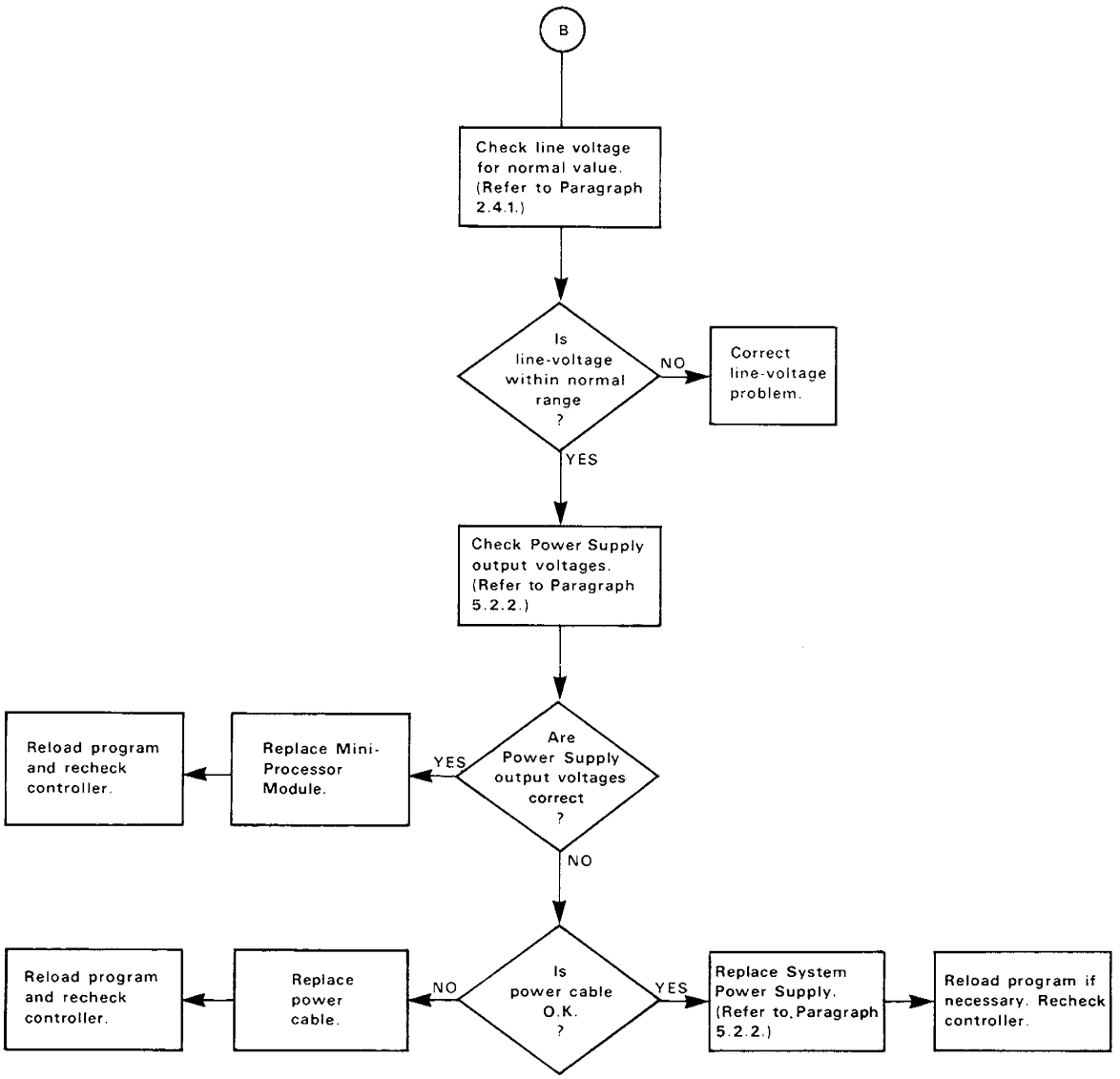


Figure 5.6 (continuous)

- **Step No. 1** — Disconnect power from all output devices which cause machine motion. To do this, shut OFF user power to the Wiring Arm terminals of each output module. Then disconnect wiring from the Wiring Arm to these output devices. It is normally preferable to disconnect the wiring at the output device itself or at an optional terminal strip. However, the wiring may be disconnected at the Field Wiring Arm terminal, if necessary.

- **Step No. 2** — Once devices causing machine motion are disconnected, reconnect user power to the Field Wiring Arm terminals.

- **Step No. 3** — Check the FUSE BLOWN indicator on each output module.

  If this indicator is illuminated, replace the blown output fuse. Instructions for fuse replacement are given in Paragraph 5.5.

- **Step No. 4** — On the Mini-Processor Module turn the Mode Select Switch to RUN.

- **Step No. 5** — Test each output device which remains connected.

  To do this, refer to a copy of the user program. For each output device which can be tested, simulate the input conditions needed to turn the device ON and OFF.

  If an output device fails to turn ON when required program conditions are met, observe the output module indicator which corresponds to the device. If the indicator is ON, go to Step No. 6. If the indicator is OFF, go to Step No. 7.

- **Step No. 6** — The output module indicator is ON for a device, but the device fails to turn ON.

  When the output module indicator is ON, power to the device is available at the output terminal. Thus, if the device fails to energize, check the following:

  - Wiring to the output device
  - The output device itself

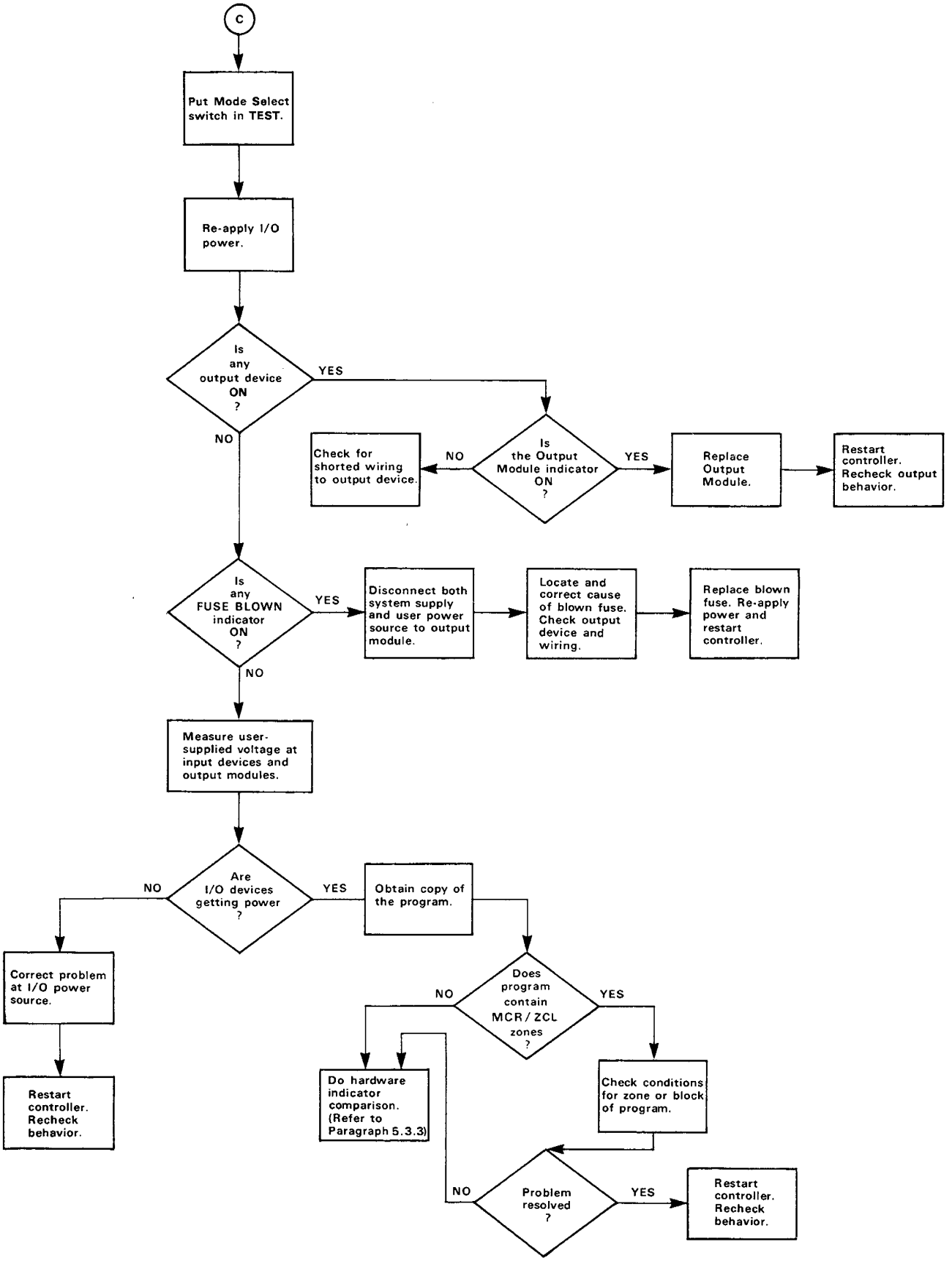


Figure 5.6 (continuous)

- **Step No. 7** — Input conditions have been met, but the output module indicator is OFF and the device fails to turn ON.

  All input devices may not be working properly. Check the input module indicators for each connected input device which is needed to turn the output device ON. (Refer to the procedures for input troubleshooting in Paragraph 5.3.3.1.)

  If all input devices operate as normal, replace the output module. Rules for module replacement are given in Paragraph 5.4.

Once all output devices which were left connected in Step No. 1 are tested, the outputs which had been disconnected are to be checked.

- **Step No. 8** — Test the output module **indicators** for each device causing machine motion. Leave these devices disconnected for this procedure.

  Observe the output module indicators for each device when input conditions have been met. If the output indicator fails to illuminate, assume that input hardware may be the source of the fault. Refer to the procedures for input troubleshooting in Paragraph 5.3.3.1.

  If all input hardware operates normally, but the indicator does not illuminate, replace the output module. Rules for module replacement are given in Paragraph 5.4.

- **Step No. 9** — Check each output causing machine motion, one device at a time.

  Note that to do this, power to the module's Wiring Arm must be shut down and the output device reconnected. Then, with power restored, simulate the input conditions necessary to energize the output.

- **Step No. 10** — Once an output device causing machine motion has been tested, **disconnect** it. Then, beginning with Step No. 8, test each remaining output device in turn.

5.4 Rules For Module Replacement — Once a controller fault has been narrowed down to one particular module, or type of module, it is often useful to replace the suspect module or modules, one at a time. The techniques for "module swapping" are described in this Paragraph.

In all cases, when removing modules from or inserting modules into the I/O Chassis, power must be OFF. This means that power must be removed from the System Power Supply during module replacement. Note when replacing I/O modules, that user I/O power sources must also be turned OFF.

A replacement module must be identical in type and compatible in series to the module replaced.

5.4.1 I/O Module Replacement — If an I/O module is the suspected source of a controller fault, replace the I/O module. Follow these steps:

> **WARNING:** Contact with AC line potentials may cause injury to personnel. Removing power from the System Power Supply does not remove power from the Field Wiring Arm. Failure to remove this external power source causes voltage to be present at Wiring Arm terminals.

- **Step No. 1** — Remove power from the module. Note that this means disconnection of power to **both** the System Power Supply **and** user power source for the I/O module.

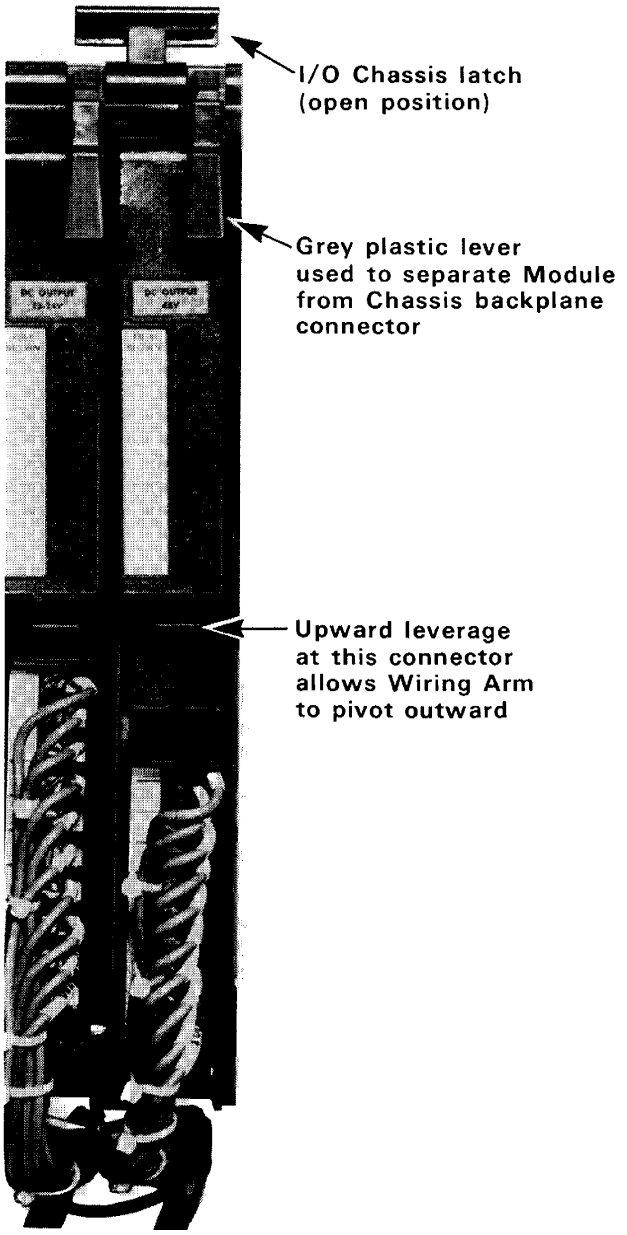


Figure 5.7 — Module Removal

- **Step No. 2** — Snap up the latch which holds the module in the I/O Chassis. (Refer to Figure 5.7.)
- **Step No. 3** — Pivot the Field Wiring Arm out from the module. A lever on the front of the module holds the Wiring Arm in place. With slight upward thumb pressure, this lever can be lifted to allow release of the Wiring Arm. (Refer to Figure 5.7.) The Wiring Arm can then be pivoted into horizontal position.
- **Step No. 4** — Pivot the grey plastic lever out on the top of the module. This partially separates the module from its backplane connectors.
- **Step No. 5** — Grasp the module firmly and slide it out from its I/O Chassis slot.
- **Step No. 6** — Insert the replacement module. Be certain that the replacement module is the same in type as the original module.

Note: Keying bands, placed on the backplane connector of the I/O module slot, will prevent insertion of a different type of module into the Chassis. Do **not** attempt to force a module into this backplane connector.

(Keying bands, however, may be removed if a controller is re-wired and a different type of module is required in an individual slot.)

- **Step No. 7** – Pivot the Wiring Arm into position on the Module. Snap down the I/O Chassis latch over the module.
- **Step No. 8** – Restore power to the System Power Supply of the controller. Restore power from the user I/O power source to the module.
- **Step No. 9** – Restart the controller in the RUN mode. If the fault does not reappear, it can be concluded that the source of the fault must have been with the replaced module. Put a descriptive tag on the faulty module and describe the symptoms of the fault you observed. Make immediate arrangements to return the faulty module to Allen-Bradley for repair.
- **Step No. 10** – If the fault reappears, put the original module back into the slot from which it was taken. Return to Step No. 1 and repeat the procedure to isolate the proper module.

CAUTION: Never replace more than one module at a time during troubleshooting. This prevents confusion that would result if two or more modules were replaced at one time.

5.4.2 Mini-Processor Replacement – This Paragraph outlines the procedures to be carried out when replacing the Mini-Processor Module.

Note that the user's program will be lost when the Mini-Processor is removed from the I/O Chassis. Therefore, replacement of this component should only be done if the behavior of the Mini-Processor warrants replacement. Before replacing this module, check all troubleshooting procedures carefully. Observe all status indicators on the controller and check Power Cable connection and the Mode Select Switch position. Only after all these checks have been made, and after reset of the faulted condition is attempted, should the Mini-Processor Module be replaced.

The Mini-Processor Module is available in two memory sizes. The Cat. No. on the side of the Module indicates its memory capacity:

- Cat. No. 1772-LN1, 512 words
- Cat. No. 1772-LN2, 1024 words

The user's program may require the larger, 1024-word memory. Care should be taken not to use the Cat. No. 1772-LN1 Module as a replacement in this instance.

Follow these procedures to replace the Mini-Processor Module:

CAUTION: Damage might occur to the module if it is removed with power applied. Power must always be disconnected when the Mini-Processor or any other module is either removed from or inserted into the I/O Chassis.

- **Step No. 1** – Remove power from the System Power Supply.
- **Step No. 2** – Snap up the latch which holds the module in the I/O Chassis. (Refer to Figure 5.7.)
- **Step No. 3** – On the top front of the Mini-Processor is a grey plastic lever. Pivot this lever out. This partially separates the Module from its backplane connectors.
- **Step No. 4** – Grasp the module firmly and slide it out from the I/O Chassis slot.
- **Step No. 5** – Insert the replacement module, sliding it into the Chassis. Gently but firmly, press the module into the backplane connectors. Snap the Chassis latch down over the Module.
- **Step No. 6** – Turn the Mode Select Switch to PROG.
- **Step No. 7** – Restore power to the System Power Supply.

  Note: Upon initial power-up of a newly-installed Mini-Processor, user memory circuitry is blank. Because of this, both PROCESSOR and MEMORY indicators may be illuminated while the Module is in the RUN mode. However, these indicators will turn OFF when the Mode Select Switch is changed to the PROG position.

- **Step No. 8** – Connect the Program Panel to the Mini-Processor Module. Re-enter the user program.

  A fast method for doing this uses the Digital Cassette Recorder System (Cat. No. 1770-SA) or a teletype punched-tape reader.

- **Step No. 9** – Once the program is entered and verified, test the controller in the RUN mode. Observe controller behavior. If the fault does not reappear, it can be concluded that the source of the fault must have been with the replaced Mini-Processor Module. Put a descriptive tag on the faulted module and describe the symptoms of the fault observed. Make immediate arrangements to return the faulted module to Allen-Bradley for repair.

- **Step No. 10** – Should the fault reappear, put the original module back in its I/O Chassis slot. Return to the troubleshooting procedures outlined in Paragraph 5.3.

5.5 Output Module Fuse Replacement – If a FUSE BLOWN indicator illuminates on an output module, the cause of the blown fuse must **first** be corrected. A blown fuse may be caused by the following conditions:

- Shorted load
- Shorted wiring
- Overheating of load
- Power variations

Once the condition causing a blown fuse is corrected, the fuse must be replaced.

To replace a blown output module fuse, follow these steps:

CAUTION: Use only replacement fuses of the proper type and rating. Use of the wrong fuse rating may result in damage to equipment or to module circuitry. Fuse specifications for Mini-PLC-2 controller components are listed in Table 5.B.

WARNING: Contact with AC line potentials may cause injury to personnel. Removing power from the System Power Supply does **not** remove power from the Field Wiring Arm. Power for each output circuit is supplied externally through the Field Wiring Arm. Failure to remove this external power source causes voltage to be present at Wiring Arm terminals.

Table 5.B

MINI-PLC-2 SPARE FUSE LIST

FUSE USED IN		FUSE INFORMATION	
Description	Cat. No.	Fuse Rating	Manufacturer's Part No.
DC (12-24V) Output Module DC (48V) Output Module AC (120V) Output Module	1771-OB 1771-OC 1771-OA	2A "Normal-Blo"	Littelfuse: 362002
System Power Supply	1771-P1	120V use: 1A slow-blow 220/240V use: 0.5A slow-blow	Bussmann: 3AG MDL Littelfuse: 313001 Bussmann: 3AG MDL Littelfuse: 313.500
PLC-2 Program Panel PLC/PLC-2 Program Panel Adapter	1772-TA 1772-T4	1A slow-blow	Bussmann: MDL-1A
PLC Program Panel (120V AC)	1774-TA	2A	MDL-2 3AG
PLC Program Panel (220/240V AC)	1774-TH	1A	AGC-1

- **Step No. 1** — Remove power from the module. Note that this means disconnection of power to **both** the System Power Supply **and** the user power source for the I/O module.
- **Step No. 2** — Snap up the latch which holds the module in the I/O Chassis. (Refer to Figure 5.7.)
- **Step No. 3** — Pivot the Field Wiring Arm out from the module. A lever on the front of the module holds the Wiring Arm in place. With slight upward thumb pressure, this lever can be lifted to allow release of the Wiring Arm. (Refer to Figure 5.7.) The Wiring Arm can then be pivoted into horizontal position.
- **Step No. 4** — On the top front edge of the module is a grey plastic lever. Pivot this lever out. This partially separates the module from its backplane connectors.
- **Step No. 5** — Grasp the module firmly and slide it out from the I/O Chassis slot.
- **Step No. 6** — Examine the side of the module that has labels for module type and terminal identification. The top and bottom screws on the front edge of the module hold the front cover onto the component side of the module. (Refer to Figure 5.8.) Do **not** remove the screws which hold the indicator housing to the module circuit board.
- **Step No. 7** — Carefully lift the front component-side cover from the module. Fuses are located underneath this cover. (Refer to Figure 5.9.)
- **Step No. 8** — Locate the blown fuse.
- **Step No. 9** — Remove the blown fuse. A fuse-pulling tool does this most easily.
- **Step No. 10** — Install the replacement fuse.
- **Step No. 11** — Fasten the front component-side cover back onto the module.
- **Step No. 12** — Insert the module back into the I/O Chassis. Gently but firmly press the module into its backplane connectors.

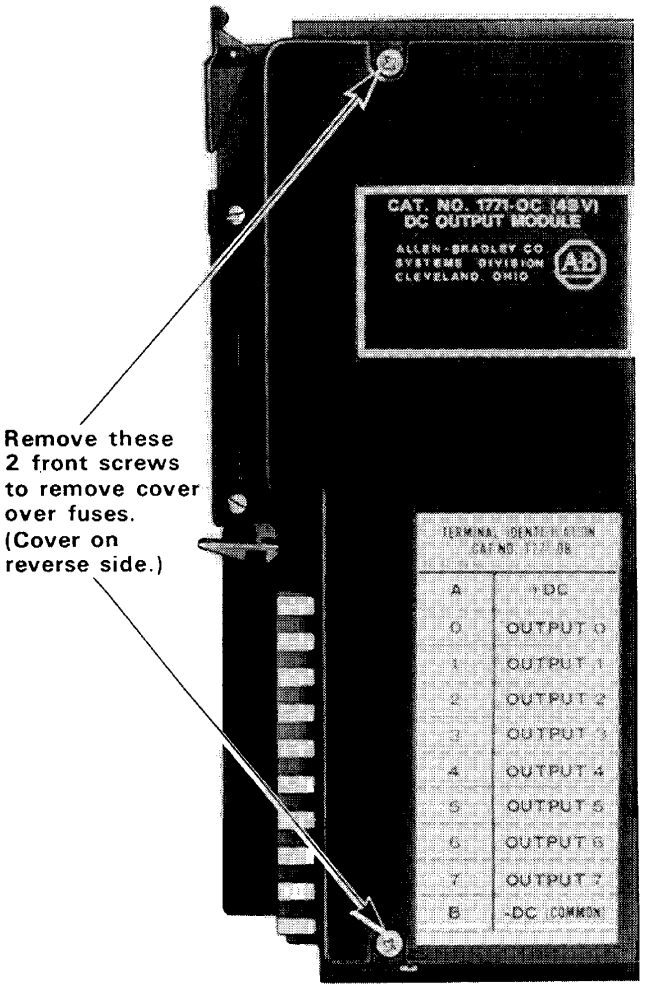


Figure 5.8 — Screws for Fuse Access

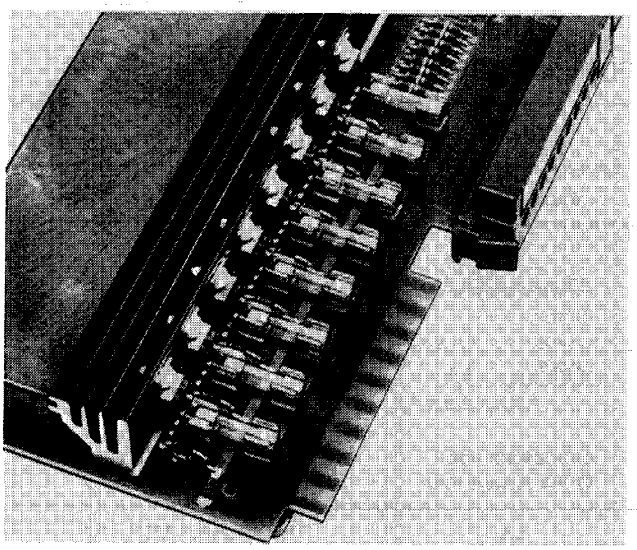


Figure 5.9 – Output Module Fuses

- **Step No. 13** – Snap the Chassis latch over the top of the module. Then, pivot the Wiring Arm back into position against the module.
- **Step No. 14** – Restore power to both the System Power Supply and the user output power source.
- **Step No. 15** – Restart the controller. Observe the behavior of the output device and make certain that the fuse does not blow. Should this replacement fuse blow, check both user output wiring and the output device for shorts or excessive current demand. Output current ratings for each output module are listed on Product Data Sheets, reproduced in the Support Documentation, provided with this Manual.

Section 6
SPECIFICATIONS

6.0 General — This Section contains physical, electrical, and functional information on each of the Mini-PLC-2 controller components. For the controller in operation, the following are overall specifications:

Ambient Temperature Rating:

Operational: 0° to 60°C (32° to 140°F)

Storage: -40° to 85°C (-40° to 185°F)
(Excluding memory battery)

Humidity Rating: 5 to 95% (without condensation)

Input Voltage (Nominal): 120V AC (50/60 Hz)
220/240V AC (50/60 Hz)
24V DC

6.1 Mini-Processor Module — The Mini-Processor Module has the following specifications:

Memory Size [1]:

Cat. No. 1772-LN1: 512 words (384-464 Instructions)

Cat. No. 1772-LN2: 1024 words (896-976 Instructions)

Data Table Size: 128 words (max.)

Memory Word Length:

16 data bits plus 2 parity bits

1 parity bit and 8 data bits per byte

Scan Time: 25 msec (nominal)

DC Input Voltage (supplied by System Power Supply):

5.1V DC (logic)

5V DC (memory)

Weight:

2 lb., 12 oz. (approx.)

1.25 kg.

6.2 System Power Supply — The following specifications apply to the System Power Supply (Cat. No. 1771-P1) including its Battery Pack:

Input Voltage Range:

98-132V AC (for 120V operation)

196-250V AC (for 220/240V operation)

Frequency Range: 60/50 Hz

Output Voltage:

5.1V DC (logic circuitry)

5V DC (memory)

Maximum Output Current: 6.5A

Input Power: 75 VA (approx.)

Power Capability:

1 PLC-2 Mini-Processor Module
and
1 Bulletin 1771 I/O Rack (equivalent of 128 I/O)

Location:

Side plate of Bulletin 1771 I/O Chassis
or
5 cable-feet from I/O Chassis

Battery Type:

2 Alkaline D-size 1.5V
or
1 Lithium D-size 3.7V

Ambient Temperature Rating:

0° to 60°C (operational)

-40° to 85°C (storage, without batteries)

Humidity Rating: 5 to 95% (without condensation)

Weight: 13 lbs (5.85 kg)

Dimensions (W x H x D):

4.56 x 11.25 x 7.16 inches

11.6 x 28.5 x 18.2 cm

Fuse:

120V use: 1A

Bussmann: 3AG MDL

Littelfuse: 313001

220/240V use: 0.5A

Bussmann: 3AG MDL

Littelfuse: 313.500

Battery Backup Time: 9 months at 60°C (Alkaline)

6.3 I/O Equipment — The following are summary specifications for Bulletin 1771 I/O Chassis and modules. (For specifications on individual I/O modules, refer to the product data sheets in Section 7.):

Chassis Dimensions: (W x H x D)

	Inches		
32 I/O:	9.15	11.25	6.75
64 I/O:	14.15	11.25	6.75
128 I/O:	24.15	11.25	6.75

	Centimeters		
32 I/O:	23.24	28.58	17.15
64 I/O:	35.94	28.58	17.15
128 I/O:	61.32	28.58	17.15

Chassis Sizes:

32 I/O, Cat. No. 1771-A1, contains 4 I/O slots

64 I/O, Cat. No. 1771-A2, contains 8 I/O slots

128 I/O, Cat. No. 1771-A4, contains 16 I/O slots

[1] The size of the data table in Mini-Processor memory can be altered by programming. When this is done, a program using less than 40 timers/counters can have increased capacity for Instructions. Refer to the Programming and Operations Manual, Publication 1772-821.

6.4 PLC-2 Program Panel – The Bulletin 1772 PLC-2 Program Panel has the following specifications:

Input Voltage (Nominal):

120V AC (50/60 Hz)

220/240V AC (50/60 Hz)

Input Voltage Range:

105 to 125V
or
210 to 250V

Frequency Range: 47 to 63 Hz

Input Power: 60 VA

Fuse:

120V or 220/240V use: 1A

Bussmann: MDL 1A

Ambient Temperature Rating:

0° to 60°C (operational)

-40° to +85°C (storage)

Humidity Rating: 5 to 95% (without condensation)

Weight: 17 lbs. (7.7 kg)

Dimensions: (W x H x D)

12.5 x 4.5 x 11.6 inches

31.8 x 10.4 x 29.5 cm

6.5 PLC Program Panel – The PLC Program Panel is used in conjunction with the PLC/PLC-2 Program Panel Adapter. (The Adapter has the same specifications as the PLC-2 Program Panel in Paragraph 6.4.) The PLC Program Panel, however, varies from the PLC-2 Program Panel in these specifications:

Ambient Temperature Rating: 0° to 40°C (32° to 105°F)

Humidity Rating: 5 to 80% (without condensation)

Weight: 35 lbs. (15.9 kg)

Dimensions: (W x H x D)

14 x 9.5 x 21 inches

35.6 x 24.1 x 53.5 cm

Section 7
SUPPLEMENTARY DOCUMENTATION

7.0 General — Types of documentation available for the Mini-PLC-2 controller user include:

- Product Data Sheets
- Manuals
- Block Diagrams

The Support Documentation for the Mini-PLC-2 Programmable Controller, provided with this Publication, includes Product Data Sheets of interest to the installer of the Mini-PLC-2 programmable controller. Information in these Data Sheets outlines the wiring, keying, and use of the various Mini-PLC-2 controller components.

The following Data Sheets are included in the Support Documentation:

- Mini-Processor Module (1772-701)
- The Organization and Structure of the Mini-PLC-2 Memory (1772-700)
- System Power Supply (1771-908)
- AC Line Voltage Stabilization with Constant Voltage Transformers (1771-910)
- Mounting Dimensions — Bulletin 1771 I/O Chassis and Power Supplies (1771-907)
- Configurations for Bulletin 1771 I/O Equipment (1771-912)
- AC/DC (120V) Input Module (1771-901)
- DC Output Driver Modules (1771-902)
- DC Input Modules (1771-903)
- AC (120V) Output Module (1771-904)
- DC (24-48V) Input Module (1771-911)

7.1 Manuals — At the time of Publication of this Manual, the following Mini-PLC-2 controller Manuals were either published, or expected to be available shortly.

- Assembly and Installation Manual, Publication 1772-820
- Programming and Operations Manual, Publication 1772-821

7.2 Block Diagrams — There are two other optional sets of block diagrams available from Allen-Bradley. These are:

- Block Diagrams (Cat. No. 1771-BD). This set of block diagrams documents such components as I/O modules, cables, and Power Supplies.
- Block Diagrams (Cat. No. 1771-ND). This set of block diagrams documents the Mini-Processor Module and selected I/O modules. A nondisclosure agreement must be signed prior to the sale of this set of block diagrams.

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Supersedes Publication 1772-820 Dated January, 1980

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