

SERIES **THREE**

PROGRAMMABLE CONTROLLER



SERIES THREE MANUAL

GENERAL  **ELECTRIC**

SERIESTHREE

PROGRAMMABLE CONTROLLER

SERIES THREE MANUAL

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GENERAL  **ELECTRIC**

WARNING, CAUTION, AND NOTES AS USED IN THIS PUBLICATION

WARNING

Warning notices are used in this publication to emphasize that hazardous voltages, currents, and temperatures that could cause personal injury exist in this equipment.

CAUTION

Caution notices are used where equipment might be damaged if care is not taken.

In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.

NOTE

Notes merely call attention to information that is especially significant in understanding and operating the equipment.

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PREFACE

This is an updated issue of the manual describing the operation of the Series Three Programmable Controller. Improvements are expected based upon reader comments and additional features to be added. To obtain latest information, revised manuals, and maintenance bulletins, please return the registration card at the rear of this manual. Data relative to your application will assist us in planning new options and help to produce the best programmable controller at a price you can afford.

After a program or major portions of a program have been entered, or after extensive changes have been made, it is recommended that a record of that program be made on magnetic tape. When you are satisfied with the operation of the programs, two copies on separate tapes should be made as well as a print-out of its logic for future reference. The program and the Series Three hardware should be exercised through all possible modes of operation to ensure proper and expected response of the system to all configurations of inputs.

It is extremely important to observe all possible precautions before beginning operation of a system in order to preclude the possibility of damage to equipment or personnel injury. Since it is impossible to anticipate all applications in which a Series Three Programmable Controller may be used, the user must assume responsibility for proper use of the programming capabilities of the system.

Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company, Programmable Control Department, P. O. Box 8106, Charlottesville, Virginia 22906.

The Series Three and its associated modules have been tested and found to meet or exceed the requirements of FCC Rule, Part 15, Subpart J. The following note is required to be published by the FCC.

NOTE

This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. It has been tested and found to comply with the limits of a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

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CHAPTER 1
INTRODUCTION

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CHAPTER 1 INTRODUCTION

In today's control system environment, automation is made possible through the use of electronics. Rapid development of electronic devices has made the concept of the factory with a future a reality for modern technology. The factory with a future provides the automation required by industry in order to be dynamic and competitive in the marketplace today and in the future. It can provide improved system reliability, product quality, information flow, reduced costs, efficiency, and flexibility. A basic building block of an automated factory is an electronic device called a Programmable Controller (PC). The PC was introduced to the industrial environment in 1970. Since the industrial environment can contain many problem areas such as electrical noise, unreliable AC power, high temperatures, contaminated air and mechanical shock, the PC is ideally suited since it was designed specifically for the industrial environment. The design of PC's has been updated every few years to include the latest technology. Today's PC's incorporate the latest microprocessor design and associated electronic circuitry.

ADVANTAGES OF A PC

Programmable Controllers have many advantages over other control devices used commonly in the past such as relays, electrical timers and counters, and drum type mechanical controllers. The PC should be considered when selecting any control device because of certain advantages which typically are:

- Improved reliability
- Easier maintainability
- Less space required
- Programmable as requirements change
- Less expensive than equivalent hard-wired systems
- More flexible (can perform more functions)

SERIES THREE PROGRAMMABLE CONTROLLER

The General Electric Series Three Programmable Controller is a PC incorporating the latest design using microprocessor technology. The SERIES THREE provides up to 400 I/O points with 4K (4096 sixteen-bit words) of user logic memory. A maximum configuration uses only three base units to contain a CPU/Programmer and the I/O modules required for that configuration. The small physical space used by the base units provides a compact medium PC requiring a minimum of space.

The base units can be purchased to contain either 4, 6 or 8 I/O module units. I/O modules are available with either 8, 16 or 32 I/O points per module, depending on the type. The CPU/Programmer unit is compact and can be hand-held or attached to the primary base unit. Programming is easily accomplished by entering programs using a relay ladder diagram language. The instruction set is made up of 57 functions, including a four function BCD arithmetic capability and a software shift register. Table 1.1 lists some of the features of the Series Three. Table 1.2 provides a summary of Series Three specifications.

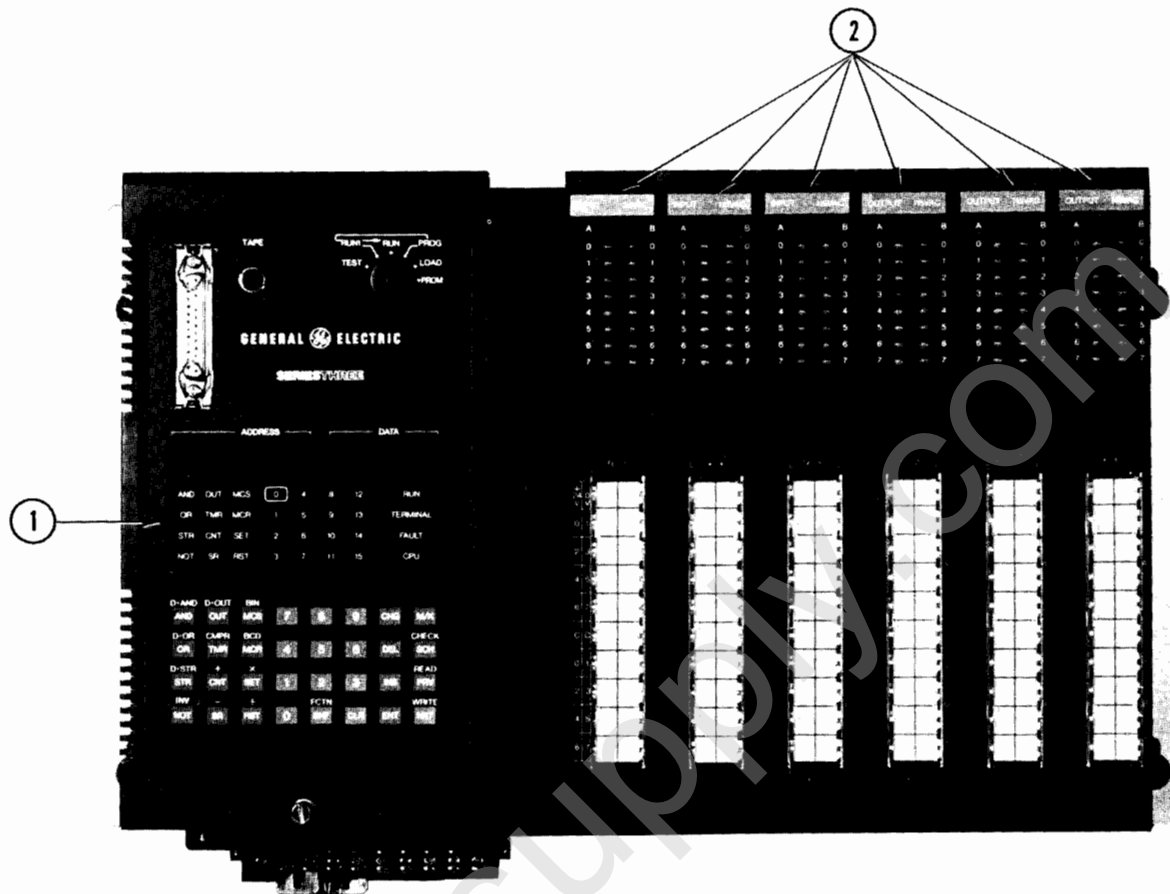
Table 1.1
FEATURES

Feature	Advantage or Description
● User Logic Memory	4096 sixteen-bit words, CMOS RAM or optional EPROM
● Lithium Battery	Retains CMOS memory on power-down condition
● I/O Points	400 Maximum
● Internal Relays	368 (64 are Latching Relays)
● Timers/Counters	128-Any mix (Maximum preset, 999.9 sec for Timer and 9999 for counter)
● Shift Registers	128
● Data Registers	128
● Programming Language	Relay Ladder Diagram
● Four Function BCD Math	Powerful Programming Tool
● I/O Modules	8 or 16 points per Module with LED indicators. 32 points per Module with no indicators.
● Number of Modules	Expandible from 8 Modules (1 base unit) to 24 Modules on three base Units.
● Flexible I/O	Any Mix in Groups of 8, 16 or 32
● Peripheral Devices	Cassette Tape Unit, Printer, PROM Loader.

Table 1.2
GENERAL SPECIFICATIONS

Power Supply	
Required AC Power	115 or 230 Vac, <u>±</u> 15% (Jumper Selectable)
Frequency	48-63 Hz
Maximum Load	60 VA Maximum each Base Unit
Humidity	5-95% (Non-Condensing)
Operating Temperature	0 to 60°C (32-140°F)
Storage Temperature	-10 to 70°C (14-158°F)
Battery Life (Depends on Operating Temperature)	2 years (under load)
Shelf Life	8 - 10 years (no load)
Memory Size	4096 Sixteen-bit words
Memory Type	CMOS RAM or EPROM
Scan Rate (Typical)	28.5 ms
Maximum I/O	400 (Any mix of Input and/or Output)
Internal Relays	
Non-Retentive	304
Retentive (Latching)	64
Timers and/or Counters	128
Shift Registers	128
Data Registers	128
Programming Functions	57
(Includes Four Function Math)	

Figure 1.1 shows the Series Three primary base unit with the CPU/Programmer mounted in place. The base unit pictured will accommodate 6 I/O modules.



① CPU/Programmer

② I/O Modules (4, 6 or 8 slots)

Figure 1.1
 SERIES THREE PROGRAMMABLE CONTROLLER

BASIC PC SYSTEM

Figure 1.2 illustrates a general block diagram of a Programmable Controller.

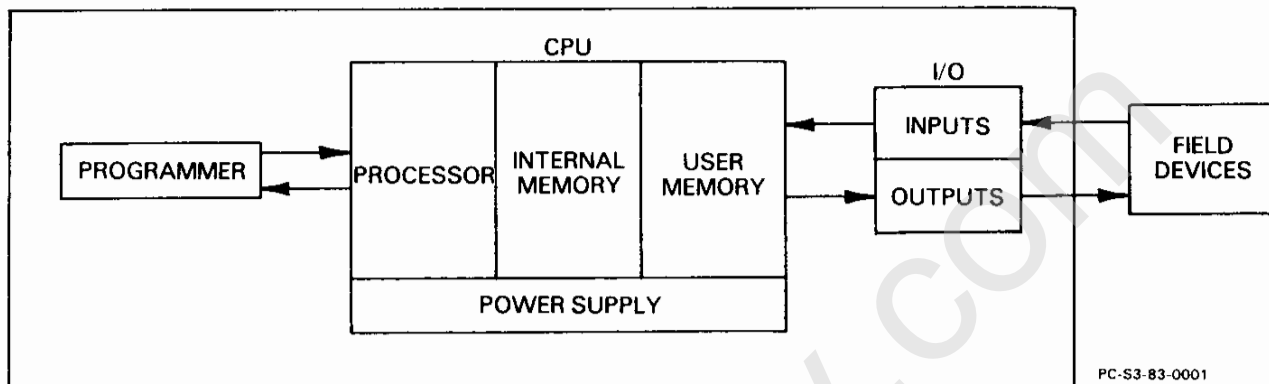


Figure 1.2
PROGRAMMABLE CONTROLLER BLOCK DIAGRAM

A Programmable Controller is defined as a solid-state industrial control system using microprocessor technology. Inputs from user supplied control devices such as switches and sensors are read in by the PC and implemented in logical patterns determined by instructions programmed by the user and stored in user memory. The results of these logical decisions are then used to drive outputs for control of user devices such as relays and motor starters.

PROGRAMMER

The programmer is a keyboard/display device used to enter functions in a line-by-line sequence which tells the PC how and in what sequence to perform its control operations. The programmer is also used to display any previously entered logic, edit (change or delete) portions of the logic, display the accumulated value of internal timers or counters, monitor the operation of any coil or contact in the program and make certain changes during program execution.

CPU

The Central Processor Unit (CPU) contains a microprocessor and is the part of the system that does the logical decision making. It reads the status of input devices in the control system, makes logical decisions using this information and the instructions which have been entered by the user and based on those decisions provides control to the actuating portion of the control system. The CPU performs its operation in a repetitive sequence called scanning. In the scanning process each line of logic is examined and solved one at a time in numerical sequence from the first to the last. In the Series Three, as each line of logic is solved, its output is updated. The scan time is variable dependent on the size of the program. Figure 1.3 illustrates the scanning sequence of the Series Three.

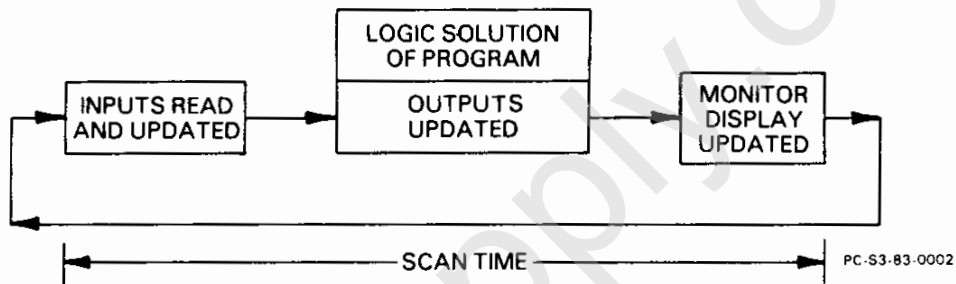


Figure 1.3
SCANNING SEQUENCE

MEMORY

The programs (logic) entered by the programmer are stored in the CPU in the user memory portion of the storage system. Other memory is provided for internal coils, timers, counters, shift registers, and data registers. User memory is 4096 sixteen-bit words. This is usually referred to as 4K words, where K is an abbreviation for Kilo or 1024. Instructions entered into the Series Three memory use either one or two words of memory, depending on the type of instruction.

MEMORY TYPES

Two types of memory are used to store logic and data in the PC; CMOS RAM and PROM. CMOS memory is commonly used as the name for a semiconductor type of memory, CMOS RAM which in turn is an acronym for Complimentary-Metal-Oxide Semiconductor, Random Access Memory. CMOS RAM is a fast, low cost, low power consuming memory that can be both read from and written into. This memory is; however, volatile - which means it can lose its memory contents if power is removed. To avoid losing the contents of this type of memory it is provided with a back-up battery to retain its contents during a power-down condition. The Series Three uses a Lithium battery for this purpose. A new Lithium battery can maintain the contents of memory under no-power conditions for a period of 1 to 5 years. When power is applied to the system, the battery is not used. Storage life of a Lithium battery is typically from five to 10 years.

The other type of memory used for storage of the user program is EPROM, Erasable Programmable Read Only Memory. This is a fast, low cost memory that will retain the contents of memory with loss of power. EPROM memory is easily read; however, the contents cannot be changed without special action by the user. A Series Three PC requires 2 EPROMs, one to contain the lower 8 bits of each word and the second to contain the upper 8 bits of each word. A program is initially entered into an EPROM by entering a program in the PC's CMOS memory, then transferred or written into EPROM by using a peripheral device called a PROM Writer. The EPROM is then removed from the writer and inserted into a socket in the CPU. If the contents of the program in EPROM are to be changed, the EPROM must be cleared (erased) of all previous contents. This is done by subjecting the EPROM to an intense ultraviolet light.

INPUT/OUTPUT SYSTEM

The Input/Output (I/O) system receives status signals from field devices connected to input modules. These signals are filtered and incoming voltages converted to signal levels compatible with the CPU. Logic decisions are made in the controller and the proper information is sent out through the output modules to control machines or processes. The output modules convert signal levels within the PC to the proper levels required for control of those field devices. Input and output modules are optically isolated from the internal circuitry of the PC. This isolation protects the PC from electrical noise on the power lines, inductive kick-back from loads or interference picked up by field wiring.

The I/O system is modular in design and is capable of handling a variety of signals. The type of module used is determined by the field device to be connected to the system. Modules are available for the Series Three to accommodate 115/230 Vac or 24 Vdc. Modules are available with either 8, 16

or 32 I/O points per module. Field wiring is made to a socket type terminal board on the front of each module. This board is easily removable, thereby allowing an I/O module to be easily removed or changed without disturbing field wiring.

Base units are available to accommodate either 4, 6 or 8 I/O modules. Three base units are required for a maximum I/O configuration of 400 I/O points. A primary base unit contains the CPU/Programmer and is daisy chained to a second base unit by an I/O expander cable. If a third base unit is required it connects to the second base unit by another I/O expander cable. The I/O system is explained in more detail in Chapter 2. Figure 1.4 is an illustration of an I/O system connected to accommodate a maximum I/O system.

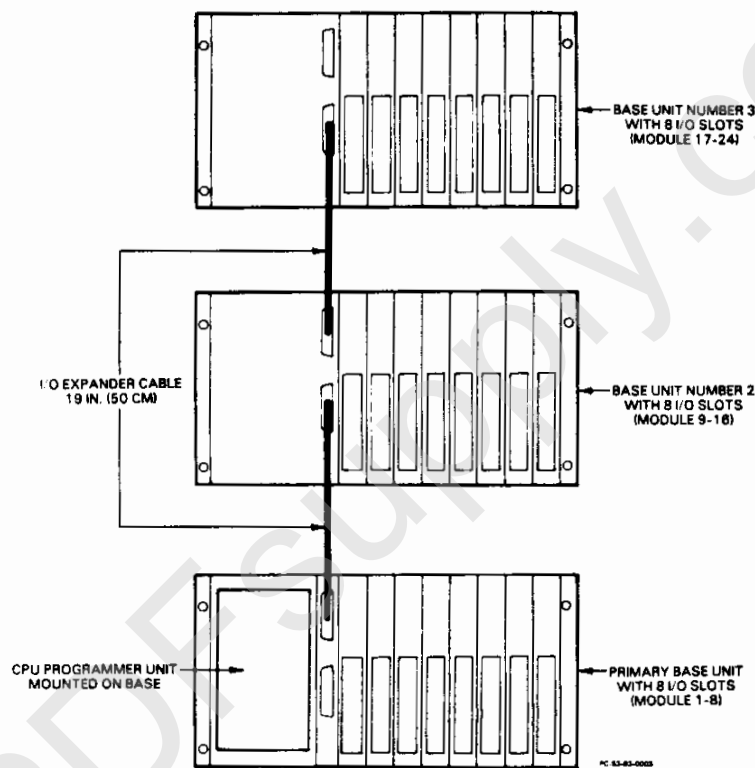


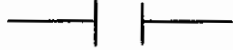
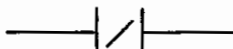


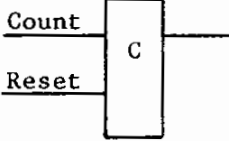
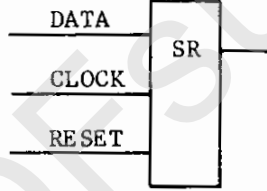
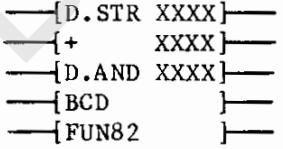
Figure 1.4
I/O SYSTEM BASE UNIT INTERCONNECTION

Each base unit has a power supply mounted on the left side. The CPU/Programmer mounts on top of the power supply on the primary base unit.

PROGRAMMING

Programming of the Series Three is accomplished by using a simple relay ladder representation based upon standard Boolean functions (AND, OR, and NOT). These functions are entered using the programmer unit. They are entered as lines of logic using normally open and normally closed contacts, output coils, timers, counters, shift registers and arithmetic functions. There is no limit internally on the number of contacts that can be placed in series or parallel. As a practical limit for programming and system documentation, it is recommended that a horizontal line be limited to nine contacts and the number of vertical rungs be limited to seven parallel lines. Table 1.3 shows the symbols for programming elements and functions of the Series Three. A complete list of programming functions can be found in Chapter 4. Chapter 5 describes how to physically enter each of the functions by using the programmer unit.

Table 1.3
BASIC PROGRAMMING ELEMENTS AND FUNCTIONS

Element	Symbol	Comment
Normally Open Contact		Basic relay contact used in ladder logic diagrams. Controlled by a discrete input reference number or a coil reference number.
Normally Closed Contact		Controlled same as a normally open contact.
Coil		Represents the discrete output of a rung of ladder logic. Provides a control signal for an external discrete device or can be used as an internal contact.
Timer		Requires one rung of logic. Accumulates time in seconds to tenths of seconds (0.1 sec. to 999.9 sec). Times down from preset.
Counter		Retentive. Requires two rungs of logic. Top rung enables, bottom rung resets the counter. Count can be preset from 0 to 9999. Counts down from preset.
Shift Register		Retentive. Requires three rungs of logic (Data, Clock, and Reset) and specifying of the first and last coils of the Shift Register. Shifts in forward or reverse direction.
Data, Arithmetic, Logic, Convert and Special Functions		Examples of the programming format for some functions is shown. Refer to Chapter 5 for a complete list of available functions.

When programs are written and entered into a PC, they must include reference numbers. The reference numbers specify which Function is to be used and are required by the CPU for keeping track of the program. In the Series Three the reference numbers are octal based; i.e., they start at zero and go up to seven, then ten to seventeen, twenty to twenty-seven, etc. When 77 is reached, the next value is 100. In this numbering system, the numbers are similar to decimal numbers, except that the digits 8 and 9 are not used. Table 1.4 lists the various references used in the Series Three. All discrete references can also be referenced in groups (8 bits) by using the first three digits of the discrete reference.

Table 1.4
SERIES THREE REFERENCES

Reference Type	Group Reference (octal)	Discrete Reference (octal)	Discrete Quantity (decimal)
I/O Points	000-061	0000-0617	400
Timer/Counter	200-377 (Accumulate Register)	000-177 Timer/Counter I.D. Number	128
Internal Relays (Non-Retentive)	400-445	4000-4457	304
Internal Relays (Retentive)	700-707	7000-7077	64
Shift Register Coils (Retentive)	900-917	9000-9177	128
Data Registers (8-bit)	500-677		128

In addition to the above list, several internal relays are used for specific functions. These are listed and described in Chapter 4.

I/O reference numbers have been preassigned to each of the 24 available I/O slots. Each slot will accept either an 8 point, a 16 point or a 32 point Input or Output module. The reference points assigned to a module are therefore established by the physical placement of the module. Referring to Figure 1.5, note that the primary base unit contains module number 1, which is to the right of the power supply. An 8 I/O slot base unit would contain

modules 1-8, while a 6 I/O slot base unit would contain modules 1-6. I/O reference numbers begin with the first I/O slot and continue upward until the last I/O slot is reached (24 possible). The example below shows I/O references assigned to modules (either 8 or 16 point) placed in I/O slots in the primary base unit.

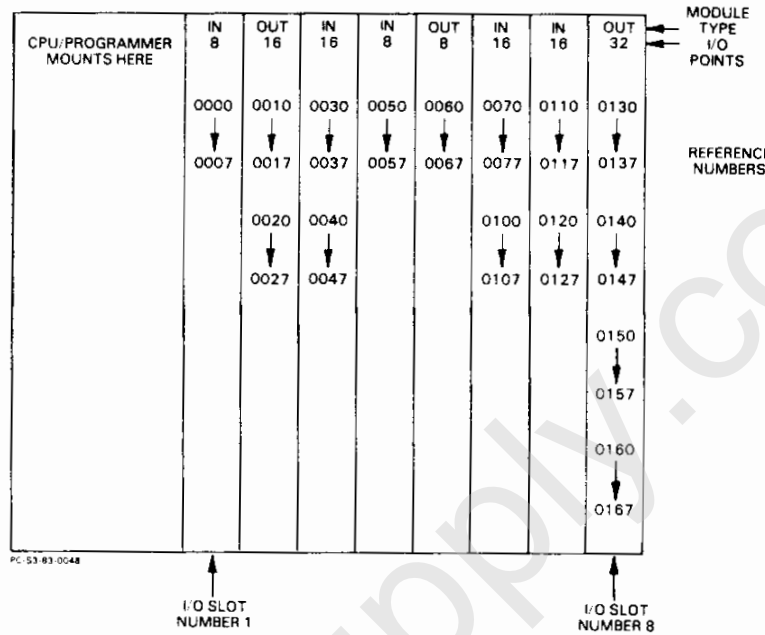


Figure 1.5
EXAMPLE OF I/O REFERENCES

In the example slot 1 contains an 8 point Input module with Input references 0000 to 0007; slot 2 contains a 16 point Output module with Output references 0010 to 0017 and 0020 to 0027.

When a system is initially configured, the number of I/O points and type of module assigned to each I/O slot (determined by the number of I/O points in the module placed in that slot) is stored in the CPU. Each time the system is powered up and when switching from Program mode to Run, the CPU checks the validity of each module in each slot. If there is a discrepancy between the I/O configuration stored and actually mounted an error condition is generated and displayed on the CPU/Programmer. If a slot does not contain an I/O module, that address is assumed to be a 16-point output.

PERIPHERALS

Peripherals are optional devices that can be used with the Series Three and include a cassette tape unit, a PROM Writer, and a printer. Any standard audio-type cassette deck such as a General Electric model 3-5158A or equivalent can be used to record (write) programs that have been entered into the PC memory or to playback (read) programs previously recorded. A high quality cassette tape should be used for recording programs. Programs can be entered in a system, recorded and then entered into a system at a different location. More than one program can be recorded on a tape and each program can be given a four digit identification number.

A back-up to a program is also convenient in the unlikely event that a CPU should fail, it can be replaced and the program read in from tape with a minimum of system downtime.

As mentioned earlier, a PROM Writer is a device that provides a means of writing a program entered into the CMOS memory to a PROM. The PROM, which is a non-volatile device will then contain the program. If the program entered into the PROM is to be changed, the PROM contents must be cleared by subjecting the PROM to an intense ultraviolet light.

The optional printer provides a method of obtaining a printed record of the program entered into user memory.

CHAPTER 2
EQUIPMENT CONFIGURATION

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CHAPTER 2 EQUIPMENT CONFIGURATION

This chapter contains a general description of the physical equipment configuration of a Series Three PC. Included are descriptions of the base units, CPU/Programmer and I/O structure.

BASE UNITS

The Series Three is provided as a family of base units into which I/O modules can be inserted. Base units are available to contain either 4, 6 or 8 I/O modules. Each base unit requires a power supply, which is mounted on the left side of each base unit. Figure 2.1 shows the 6 slot and 8 slot base units.

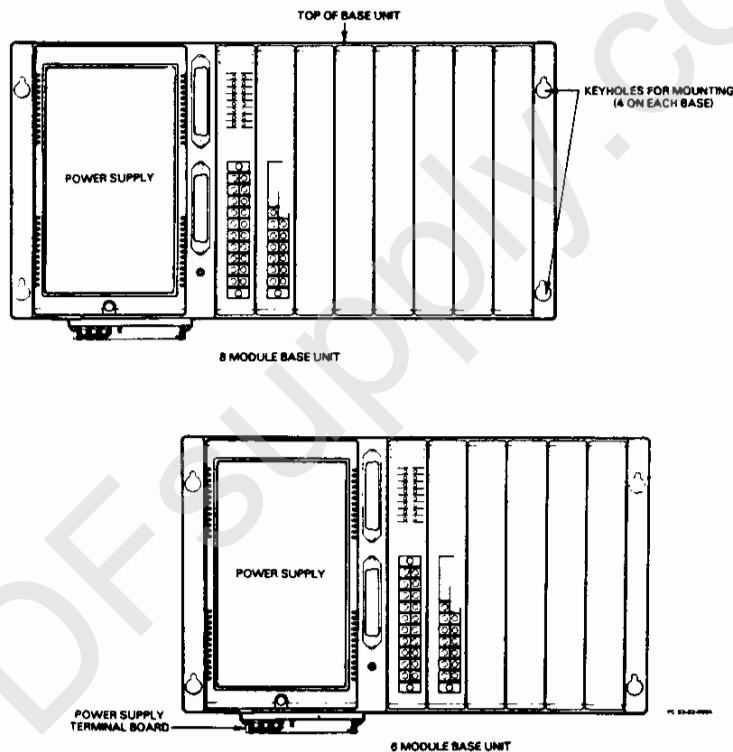


Figure 2.1
BASE UNITS

The power supply is jumper selectable for either 115 or 230 Vac operation and supplies +5 and +12 Vdc to the modules inserted into the base unit. Wiring to the power supply is made to a terminal board mounted at the bottom of the supply. Mounting of the base units is provided by four keyholes, one on each corner of the base unit frame.

Table 2.1 lists the power supply specifications.

Table 2.1
SPECIFICATIONS, POWER SUPPLY

Input	
Voltage	115 Vac/230 Vac, <u>+15%</u>
Frequency	50/60 Hz.
Normal Load	60 VA (maximum per base unit)
Fuse Rating	1 A
Output	
Voltage	+5 Vdc, <u>+5%</u>
Current	2.5 A Continuous 3.0 A Maximum
Voltage	+12 Vdc, <u>+15%</u>
Current	1.0 A Continuous 1.5 A Maximum
Fault and Run Contacts	Maximum load rating of external device: 4A resistive load, 0.5A inductive load at 230 Vac

Each base unit has two connectors mounted on the right side of the power supply. The lower (CPU) connector on the primary base unit connects to the CPU/Programmer. The top connector (EXPANDER) is used when a second base unit is required, connection is by a cable 19 inches (.5m) or a cable 3 feet (1m) in length (I/O Expander Cable). Refer to Figure 1.4, which shows connections to a maximum configuration of three base units.

The CPU/Programmer unit mounts directly on top of the power supply on the primary base unit. When more than one base unit is used in a system, the CPU/Programmer must be mounted on the first or primary base unit. The CPU contains the microprocessor and CMOS or EPROM devices required for memory storage. The I/O slots in a base unit can contain Input or Output modules in any mix of inputs or outputs or voltage levels as required for a particular application. The I/O modules are secured to the base unit by two screws, one at the top and one at the bottom of each module. The CPU/Programmer is secured to the base unit by a captive screw fastener at the bottom of the unit.

The base unit and modules are designed to dissipate internal heat by convection cooling and do not require a fan for forced air cooling. When mounting the base units, the flow of air should not be inhibited at the top and bottom of the unit. The base units should be panel or rack mounted in a position as shown in Figure 2.1 (when looking directly at the unit). A minimum of 3 inches (75 mm) at the top and 4 inches (100 mm) at the bottom of a base unit is recommended as the space required for proper air flow. When more than one base unit is required, 6 inches (150 mm)(minimum) is recommended between bases. Both sides should be free of obstacles to allow easy installation or removal of a unit, approximately 1 inch (25 mm) from each side is recommended.

For reliable operation, the ambient temperature of the air entering the bottom of the base should not be higher than 60°C (140°F). Field wiring to I/O modules and power supplies should be placed so as to avoid blocking air flow. A suitable service loop should be provided to allow easy removal of a module with wiring attached. Wires should be tied neatly to maintain their order in the event they need to be disconnected for any reason. As a convenience field wiring is made to terminals on a socket type terminal board on the front of each module. The terminal board attaches to a board edge connector on each I/O circuit board. This terminal board is easily removed, allowing an I/O module to be removed or changed without disturbing the field wiring. As a safety precaution a clear plastic cover is placed over the terminals. This cover snaps into place and is removed by squeezing in the top and bottom of the connector while pulling the cover towards you. See Figure 2.2. Some of the high-density I/O modules (32 points) are connected to field devices through an I/O Interface cable. This cable has a connector on one end which mates with a connector mounted on the faceplate. Each module requires two of these cables.

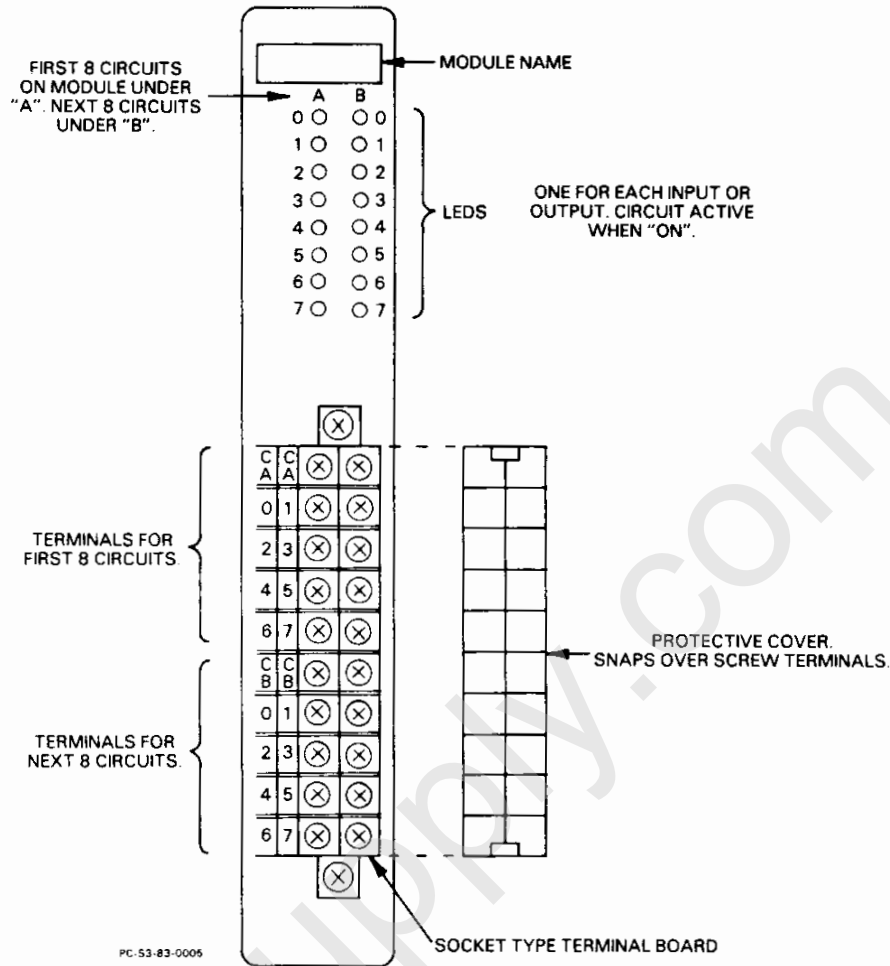


Figure 2.2
EXAMPLE OF I/O MODULE FACEPLATE

POWER SUPPLY

The power supply can be readily removed and replaced if necessary. It is secured in place on the base unit by 2 captive screw fasteners. The power supply is identical on each base unit. Figure 2.3 shows the features of a Series Three power supply. 115 or 230 Vac operation of the power supply is selected by configuring the jumper straps on the terminal board as shown in the figure. If the I/O expander connector is not used, a dust cover is available to protect the contacts.

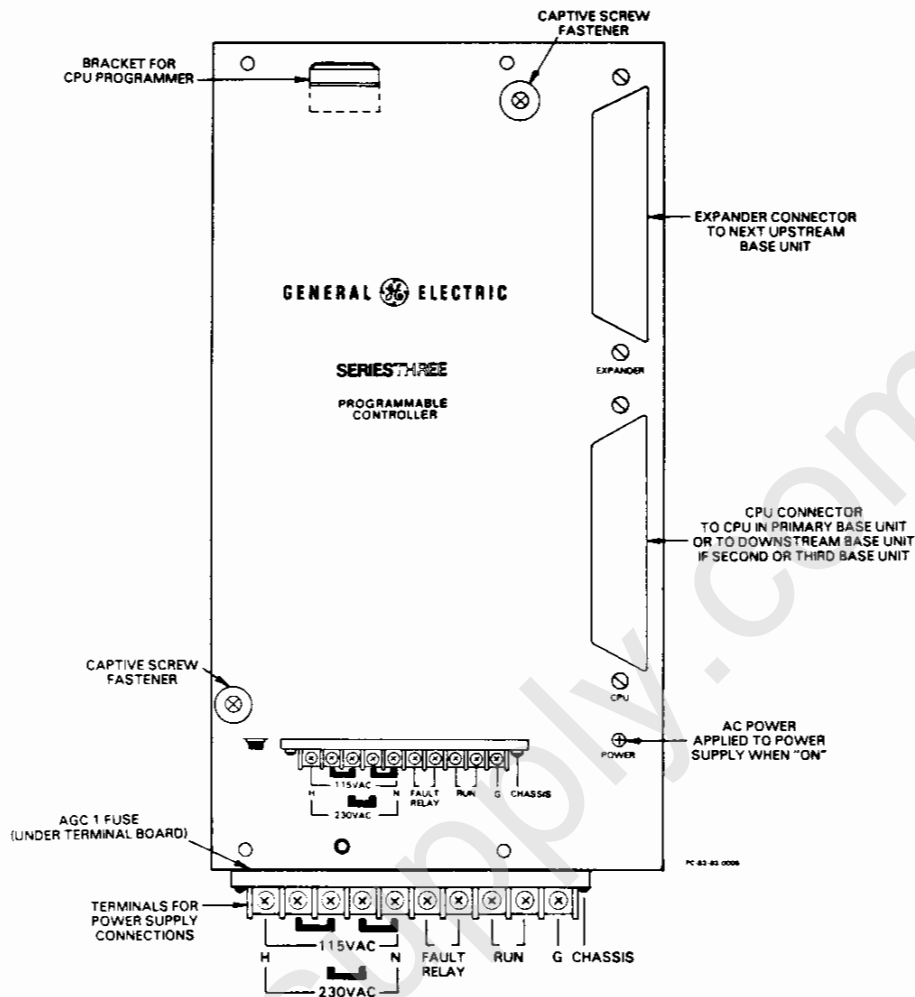


Figure 2.3
POWER SUPPLY

The FAULT RELAY contacts on the terminal board can be used to activate an alarm condition caused by an external device. The two terminals are connected to a pair of normally open contacts. The RUN terminals are also connected internally to a pair of normally open contacts. This contact output is made (ON) when in the RUN, RUN 1, or TEST position of the mode select switch. If an error condition is detected while in one of these modes, the RUN contacts will open.

CPU/PROGRAMMER

The CPU/Programmer can be secured to the primary base unit or detached for hand-held operation. In either case the 5 foot (1.5 m) cable wired to the CPU/Programmer unit must be connected to the CPU connector on the power supply on the primary base unit. The CPU/Programmer allows the user to:

- Enter ladder diagram programs
- Edit existing programs
- Change preset values of Timers and Counters when in the RUN 1 mode
- Monitor accumulated value of timers and counters
- Monitor individual coils and contacts
- Start and stop program execution
- Access peripheral devices such as an audio cassette unit, PROM Writer or Printer.

After programs have been entered and verified, they can be recorded on an audio-type cassette recorder such as a General Electric model 3-5158A . The recorded tape can then be read into any Series Three PC. This provides a convenient method of permanent storage for user programs. A connector on the CPU/Programmer provides a link to a PROM Writer for transferring programs to a PROM. The connector also provides access to a printer. This provides a way of obtaining a printed copy of the program entered into memory. The CPU/Programmer also displays error codes which can be used to interpret various system problems. Figure 2.4 shows the CPU/Programmer.

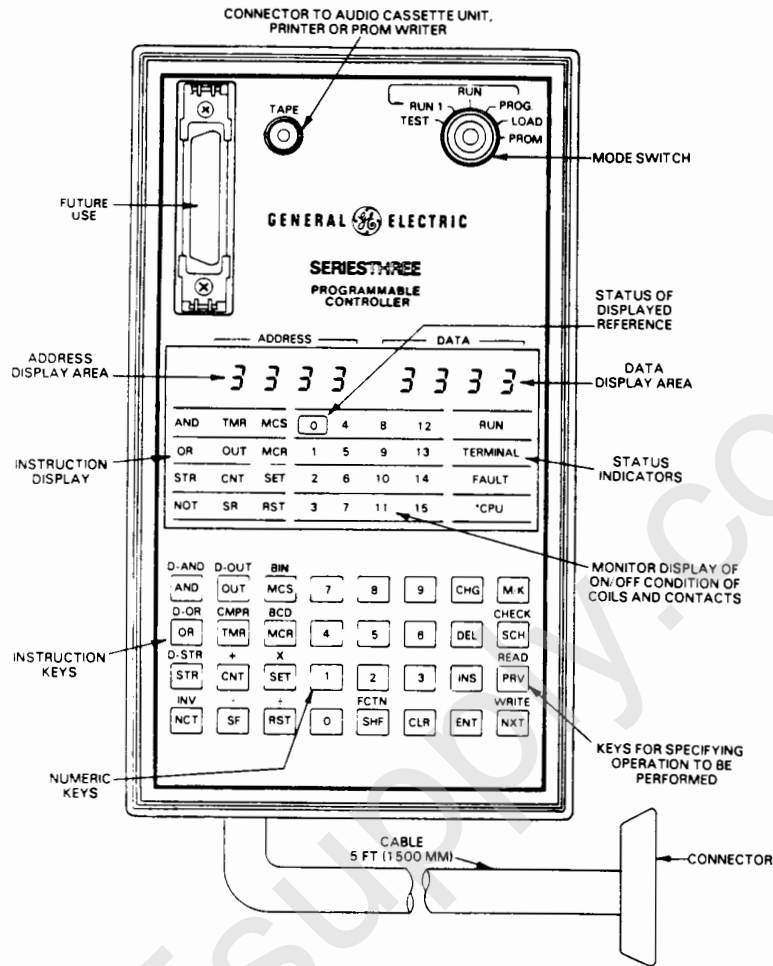


Figure 2.4
CPU/PROGRAMMER UNIT

A description of the operation and features of the CPU/Programmer is found in Chapter 4.

The bottom of the CPU/Programmer has a removable plastic cover which provides access to the Lithium battery used for retention of information in the CMOS memory.

I/O SYSTEM

An I/O system is made up of base units, Input modules, Output modules, input devices, output loads or actuating devices, field wiring to the I/O modules and power sources for the I/O modules on the user side of the system.

DETERMINING QUANTITY OF BASE UNITS AND I/O MODULES

The base units were described in the previous section. Selection of a base unit or units is determined by the number of I/O points required by the system. The following steps are suggested;

- Layout on paper the design of the inputs and outputs for the system.
- Add the total number of inputs and outputs. Separate by type and voltage required (e.g. (36) 115 Vac and (45) 24 Vdc inputs plus (27) 115 Vac and (9) 24 Vdc outputs).
- Divide each category by either 8, 16 or 32 as required by type of module (i.e. either 8, 16 or 32 inputs or outputs).
- Add total of I/O modules as determined from the above calculation.
- The number of base units required is determined by the total number of I/O modules to be used. A 6 module base unit can contain a maximum of 192 I/O points (6 modules x 32 points), while an 8 module base unit can contain a maximum of 256 I/O points (8 modules x 32 points).

If more than one base unit is required, an I/O Expander cable for each additional base unit is also required (maximum of 2 I/O Expander cables).

The base unit or units should be rack or panel mounted using the 4 keyholes to secure the base unit(s). Recommended spacing and orientation of base units should be maintained for proper air flow through the units. Figure 2.5 is an outline drawing of a base unit. A 9 inch (229 mm) deep panel is recommended for mounting the base units.

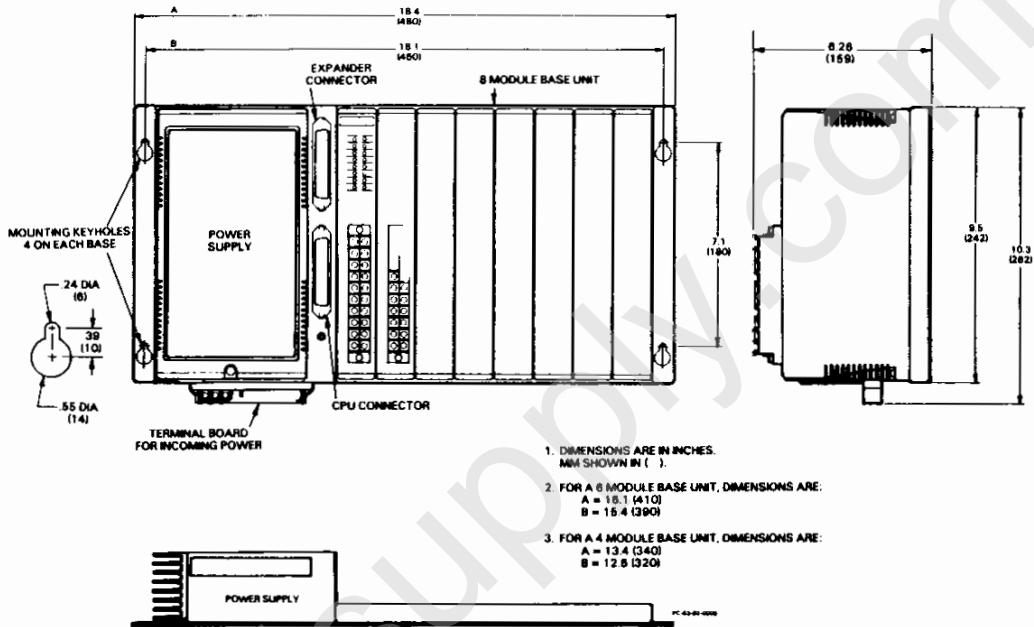


Figure 2.5
BASE MODULE OUTLINE DRAWING

Catalog numbers are listed for base units and the power supply. Each base unit ordered requires a power supply.

<u>Description</u>	<u>Catalog Number</u>
Base Unit, 4 Module	IC630CHS304A
Base Unit, 6 Module	IC630CHS306A
Base Unit, 8 Module	IC630CHS308A
Power Supply Unit	IC630PWR300A

CHAPTER 3
INSTALLATION

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CHAPTER 3 INSTALLATION

This chapter contains the information required to install a Series Three PC system. Included are instructions for mounting base units, power supply connections and mounting the CPU/Programmer.

INSPECTION

All shipping containers should be visually inspected for damage when your system is received. If any damage is noted, notify the carrier immediately. Save any damaged shipping containers as evidence for inspection by the carrier. It is the responsibility of the consignee to register a claim with the carrier for damage incurred during shipment.

After unpacking the Series Three system including base units, power supplies, CPU/Programmer, cables, Input modules and Output modules, it is recommended that any serial numbers on the equipment be recorded. The serial numbers may be required if Programmable Control Customer Service should need to be contacted for any reason during the warranty period of the equipment.

Verify that the system components received agree with your order. If any problems are noted at this time call Programmable Control Product Service in Charlottesville, Virginia at (804) 978-5624. A Customer Service representative will be available to help with your problem.

MOUNTING A BASE UNIT

The following procedures are recommended when mounting a base unit. A base unit can be easily rack, panel or wall mounted. For reference, Figure 2.5 shows a typical base unit with dimensions noted. Since base units can contain either 4, 6 or 8 I/O modules, the difference in the center to center dimensions for mounting (on the horizontal plane) should be taken into consideration. Mounting depth of a panel should be 9 inches (229 mm) or deeper.

- Using the base unit as a template, mark where mounting holes are to be drilled.
- Drill the four mounting holes (1/4 inch (6 mm)) if using pass through bolts, or 3/16 inch (5 mm) if using tapped holes.

- Insert top two bolts (3/16 inch x 1 1/2 inch or 5 mm by 40 mm), put unit in place and loosely secure with washers, lock-washers and nuts.

or

Tap holes and insert top two bolts. Place unit onto mounting bolts and loosely secure.

- Complete installation of the bottom two bolts and tighten all mounting hardware.
- If additional base units are required, repeat the above steps.
- If additional base units are installed, the I/O expander cable or cables should now be connected.

POWER SUPPLY INSTALLATION

After installing a base unit or units, install a power supply on each base unit. To install a power supply, note the position of the power supply connector on the base unit and the mating connector on the bottom of the power supply. Set the power supply in position on the base unit, pushing it down gently until the connectors are secure. Secure the power supply to the base unit by fastening the 2 captive screw fasteners. The location of the screw fasteners is shown in Figure 2.3

From one to three base units can be used in a system, depending on the total number of I/O points required by the system. Refer to the previous chapter for instruction on calculating the number of I/O points and modules. If more than one base unit is to be used each one should be mounted adjacent to the other as shown in Figure 3.1.

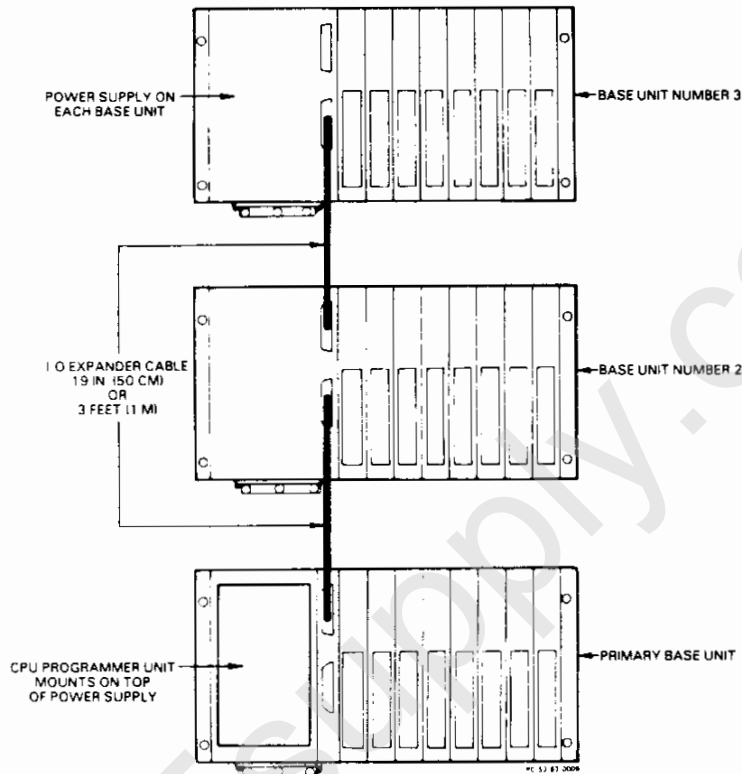
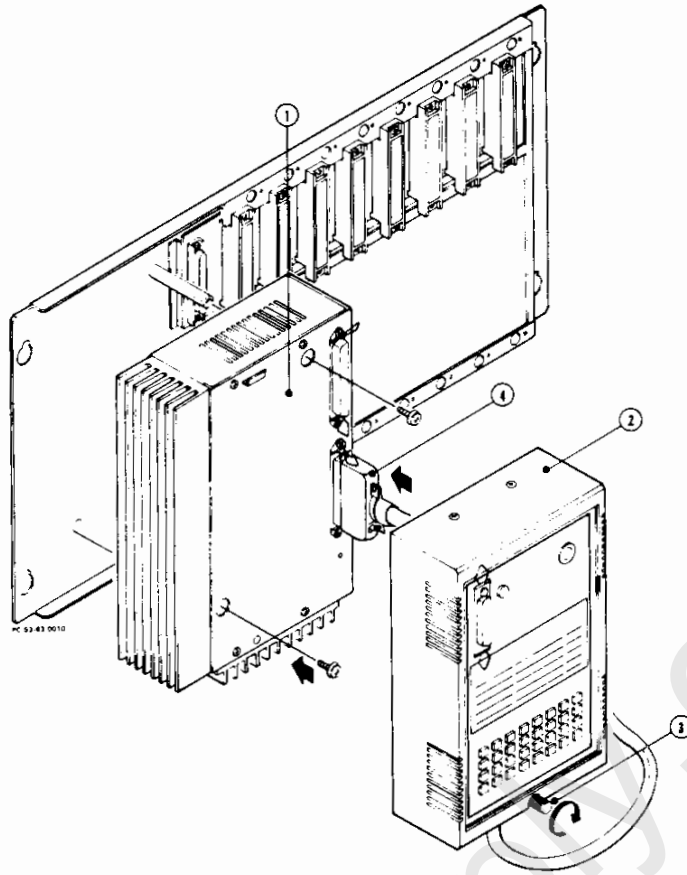


Figure 3.1
BASE UNIT MOUNTING CONFIGURATION

CPU/PROGRAMMER INSTALLATION

Install the CPU/Programmer by affixing it to the bracket at the top of the power supply. The CPU/Programmer will then fit flush to the power supply. Figure 3.2 shows this mounting procedure. Tighten the captive screw on the bottom front of the CPU/Programmer to secure the unit to the base.



- ① Position power supply over stand-offs, push down, making sure connector on power supply is secure with connector on base. Tighten 2 screws as shown.
- ② Position CPU/Programmer over power supply. Place cutout on back over hook on power supply.
- ③ Tighten captive screw fastener.
- ④ Plug CPU/Programmer cable into lower connector on power supply (labeled CPU).

Figure 3.2
CPU/PROGRAMMER AND POWER SUPPLY INSTALLATION

NOTE

If a system contains more than one base unit, the CPU Programmer must be installed on the first or primary base unit.

The CPU Programmer can easily be removed from its mounted position for hand-held operation by loosening the captive screw and lifting up on the unit; however, once connected to the CPU Programmer connector it should not be removed. Improper system operation could result if the connector is detached.

I/O MODULE INSTALLATION

After mounting the power supply on a base unit, the I/O modules should be installed. Each module position on a base unit has a 28 pin connector mounted at the top of the unit. Position the I/O module directly over the selected position and push down firmly on the module, the edge connector on the circuit board in the module should mate securely with the connector. Tighten the 2 captive screws on each module to secure the module in place. When all modules have been installed, the base units can be mounted. Refer to Chapter 6 for field wiring of I/O modules.

BASE UNIT SPACING

When installing a base unit or units in a rack or panel, sufficient space should be left around the units to provide proper ventilation and working room for wiring, maintenance or inspection. Figure 3.3 shows the recommended space between units and the mounting enclosure. Minimum depth of a rack or panel should be 9 inches.

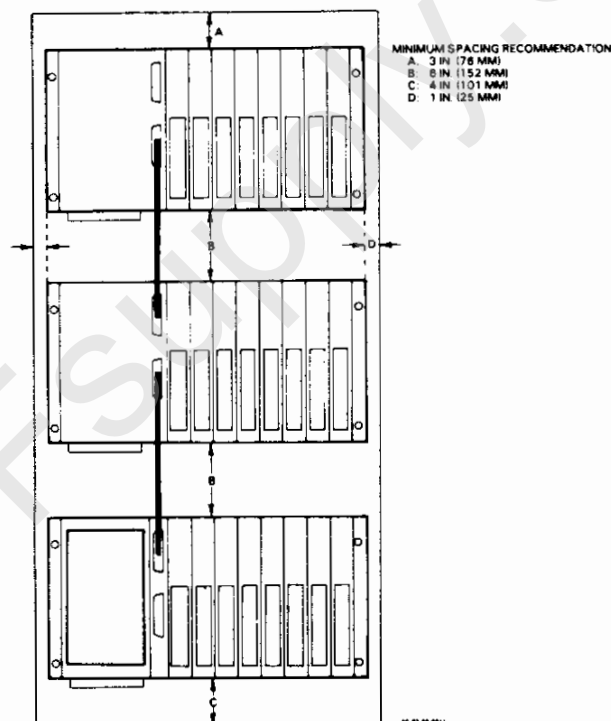


Figure 3.3
SPACING OF BASE UNITS

POWER SUPPLY CONNECTION

The power supply has a terminal board located on the bottom of the power supply case. AC power wiring should be run in conduit separate from signal wiring to the I/O modules. This will help to minimize any effects of electrical interference from the power lines. The power supply provides +5 and +12 Vdc to the I/O modules through the backplane in the base unit. Figure 3.4 shows the power supply terminal board with each terminal connection labeled.

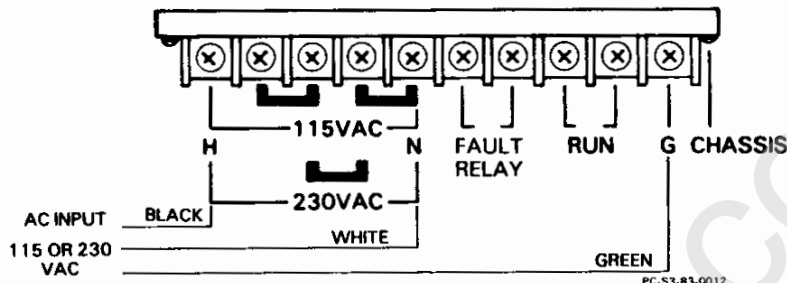


Figure 3.4
POWER SUPPLY TERMINAL BOARD

- Select either 115 Vac or 230 Vac input to the power supply by connecting the jumper straps as shown in the figure.
- The 2 FAULT RELAY terminals are connected internally to the normally open contacts of a relay. These terminals can be connected to an external alarm device.

CAUTION

The user device connected to the monitor contacts should present a resistive load of no more than 4A or an inductive load at no more than 0.5A at 230 Vac.

- The 2 RUN terminals are also connected internally to a pair or normally open contacts. This set of contacts is closed during normal operation in the RUN, RUN 1 or TEST mode of operation. These terminals can be connected to an external device (light, alarm indicator, etc.) to sense that the PC for some reason has gone out of the normal operating mode when errors specified by the check function are detected. The same caution as above should be observed.

- Connect the ground wire (green) of the AC power source to the screw labeled G.
- Connect a short jumper wire between the point marked CHASSIS and G on the terminal board on the first base unit only.

CAUTION

Do not connect the jumper wire between CHASSIS and G on the second or third base units. If this is done, a difference in potential between units could cause damage to the circuit boards.

I/O EXPANDER CABLE

If more than one base unit is to be connected in a system, the I/O expansion cables must be connected as shown below.

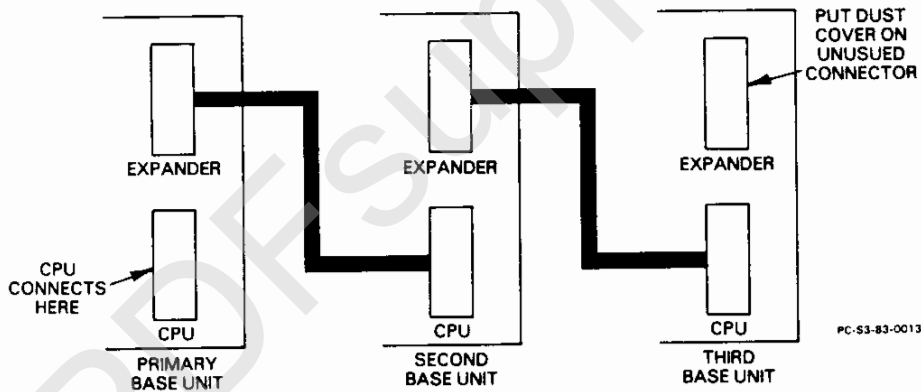


Figure 3.5
I/O EXPANDER CABLE CONNECTION

I/O POWER SUPPLY

When 24 Vdc I/O modules are required for a system a 5 to 12 Vdc or 24 Vdc power supply should be connected to the corresponding +V and 0V or +24V and 0V terminals on each of the modules. A single supply with sufficient current carrying capacity can be used. Figure 3.6 illustrates the suggested AC/DC and cabling for a maximum system.

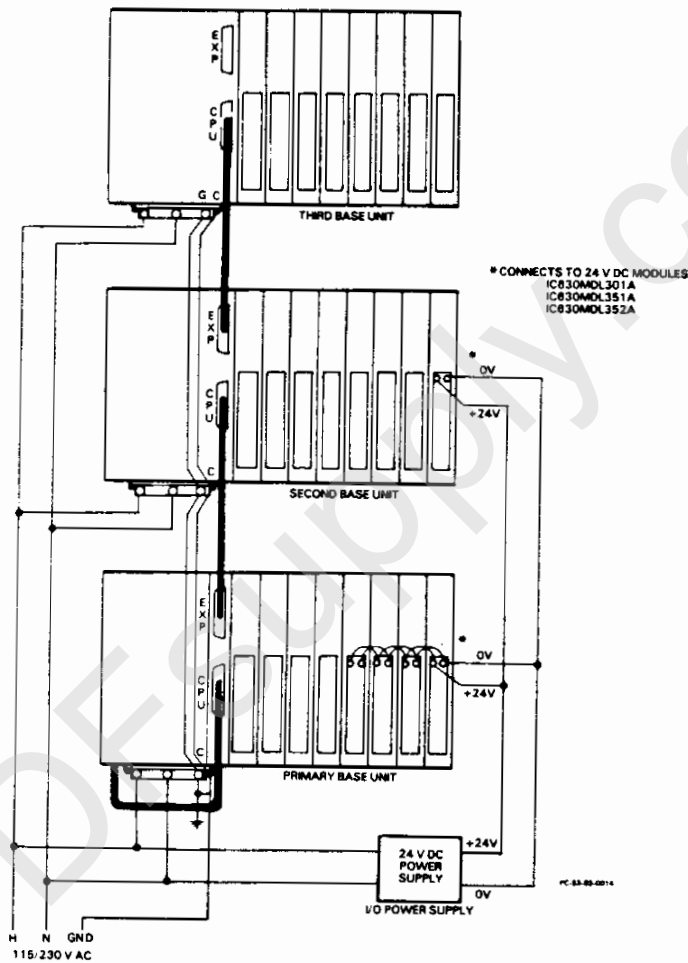


Figure 3.6
SYSTEM WIRING CONFIGURATION

I/O MODULE WIRING

After all base units have been mounted and I/O modules installed in their selected slots in each base unit, field wiring should be connected to each module. Most field wiring to each module is made to the removable socket type terminal located on the front of the module. Up to one number 12 AWG or two number 14 AWG wires can be connected to each terminal. Wiring to Input modules is from devices such as limit switches, relay contacts, TTL or CMOS circuitry etc. and wiring from Output modules is to the devices to be controlled; solenoids, motor starters, TTL or CMOS circuitry, etc.

Certain high density modules (5-12 Vdc) are connected to inputs or outputs through two 40-pin connectors mounted on the faceplate. The module connects to input or output devices through a 10-foot (3 cm) cable.

WARNING

Voltages from user field devices may be present on the module screw terminals, even though power to a base unit is off. Care should be taken when handling the terminal board or any wires connected to it.

SAFETY CONSIDERATIONS

When planning the layout of a system, safety should be a prime consideration. System planning should include procedures and methods to ensure the physical safety of personnel, the Series Three system and the equipment or process being controlled. Those personnel who are involved in the planning and installation of a system should be familiar with all local and national electrical codes as well as installation instructions in this manual.

All practices should be followed that are specified by the IEEE (Institute of Electrical and Electronic Engineers) Standard 510 which includes tray and conduit spacing and wiring procedures. A copy of this standard can be obtained by writing:

Institute of Electrical and Electronic Engineers
345 East 47th Street
New York, NY 10017

FIELD WIRING

The following procedures are recommended when running field wiring:

- Low-level signal wires should be separated from other field wiring.
- AC power wiring should be separated from DC field wiring.
- Wiring should not be routed near devices causing electrical interference.
- If severe noise problems are present, additional power supply filtering or an isolation transformer may be required. Contact your General Electric Sales Representative if assistance is required.
- Proper grounding should be provided to minimize hazards to personnel.
- Label all I/O wires. Circuit numbers or other identification can also be marked on the cover over the wire terminals on each I/O module.
- I/O wires should be no larger than No. 12 AWG.

WARNING

The user should calculate the maximum current for each wire and observe proper wiring practices. Failure to do so can cause injury to personnel or damage to equipment.

CHAPTER 4
OPERATION

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CHAPTER 4 OPERATION

This chapter describes the operation of a Series Three PC. An understanding of the features is required to effectively use the programming unit. An illustration of the CPU/Programmer is shown, followed by descriptions of the mode switch, keys, displays and connectors. The basic steps required for building a ladder diagram logic program are shown in a keystroke-by-keystroke sequence. Detailed programming sequences for each function can be found in Chapter 5, Programming.

Figure 4.1 is an illustration of the CPU/Programmer.

NOTE

As each key on the programmer is depressed, a tone is generated. This is an audible operator aid indicating that the keystroke has been entered.

After most keystrokes, the ENTER (ENT) key must be depressed. This puts the required key or keys in program memory. When a value such as a timer or counter preset is required a prompt is given by the programmer. This prompt is a long tone and indicates a two-word instruction.

Certain operations, such as a Delete or Insert, require an additional keystroke as a verification that the action is to be completed.

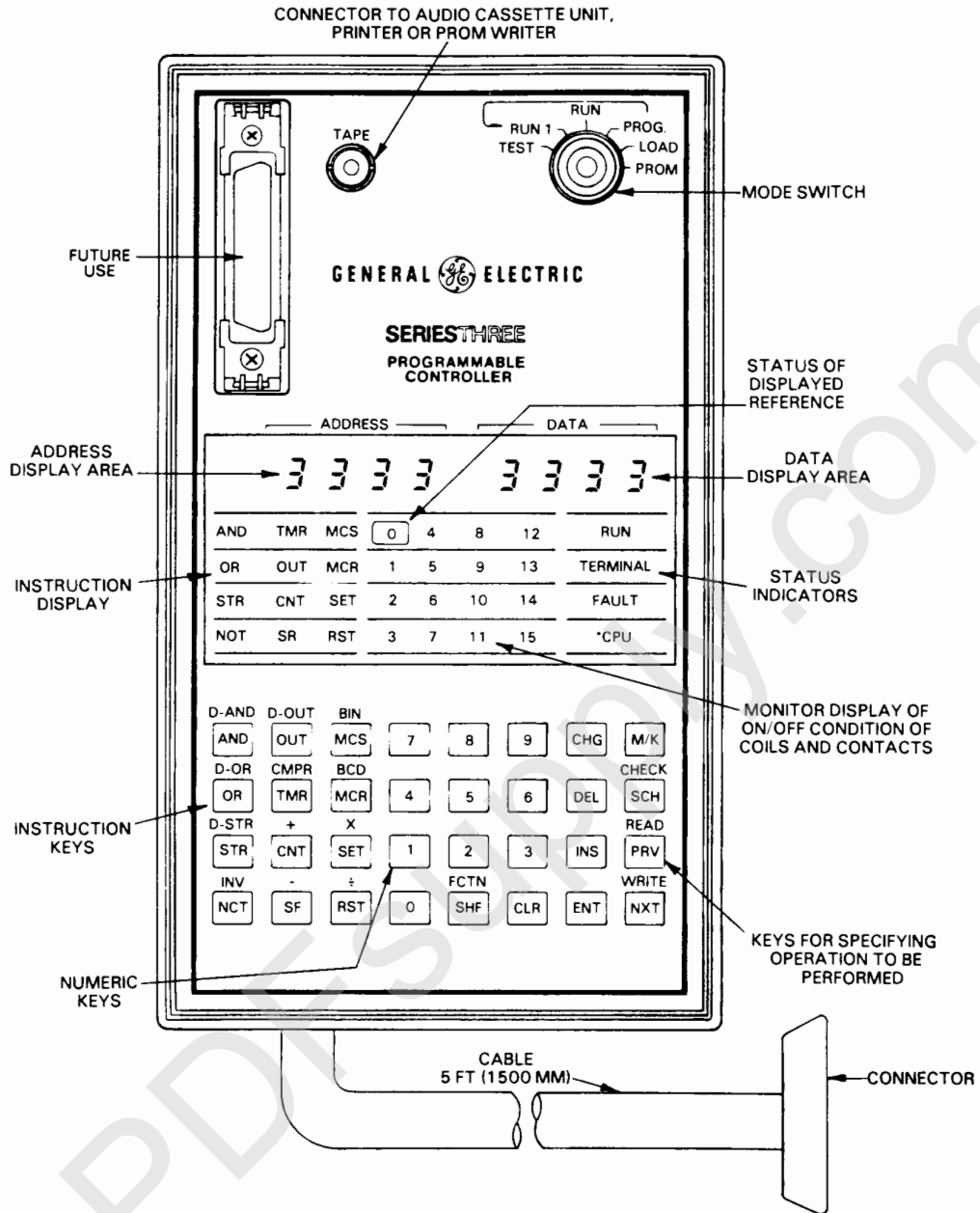


Figure 4.1
CPU/PROGRAMMER FEATURES

MODE SELECT KEYSWITCH

This is a 6 position keyswitch for selection of the PC operating mode. The 6 positions are shown in Figure 4.1 and include; TEST, RUN 1, RUN, PROG, LOAD, and PROM. The functions of each operating mode are listed below.

TEST

- Stops execution of program while in this position. Outputs are disabled.
- Allows a one-scan execution of program.
- Individual rung execution can be monitored by assigning coils or contacts to the 16 monitor LEDs.
- Most programming functions allowed.

RUN 1

- Program execution with outputs enabled.
- Timer and Counter preset values can be changed.
- Monitor display can be observed.
- Program can be read using address and data display.
- Allows entering I/O configuration into memory if the configuration has changed since the previous power-up condition.

RUN

- Program execution with outputs enabled.
- Monitor display can be observed.
- Program can be read using address and data display.
- No program changes can be made.
- Key removable in this position.

PROG

- Stops execution of program.
- Allows all of the program entered into memory to be erased.
- Programs can be entered and edited (changed).

LOAD

- Stops execution of program.
- Allows operation (reading, writing and verifying) with a cassette tape unit.
- Allows operation with a logic printer unit.
- Key can be removed.
- Allows operation with PROM writer

PROM

- Stops execution of program.
- Allows the contents of a PROM to be transferred to the CMOS RAM memory in the PC.
- Allows the transferred contents from PROM to CMOS RAM to be verified.

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The following table lists the keys on the programmer and their functions.

Table 4.1
KEY DEFINITIONS

KEY	DEFINITION	DESCRIPTION
M/K	M MONITOR	Causes PC to enter the Monitor mode.
	K CONSTANT	Value entered after this key will be a constant
CHECK	CHECK	Shifted function (depress SHF SCH), used with cassette recorder and PROM writer to check validity of data transfer.
SCH	SCH SEARCH	Search for specified information
READ	READ	Shifted function, Causes data to be read into the PC from peripherals such as a cassette recorder.
PRV	PRV PREVIOUS	Scrolls back to previous program memory address.
WRITE	WRITE	Shifted function causes program memory contents to be outputted to a peripheral.
NXT	NXT NEXT	Scrolls ahead to the next program memory address.
CHG	CHANGE	Used with SET or RST to force the state of a coil/contact ON or OFF. Also used to change a reference number.
DEL	DELETE	Causes the displayed instruction to be deleted. All instructions at a higher program memory address will move back one address.
INS	INSERT	Adds an instruction at program memory address displayed, all instructions from that address up move one address higher.
ENT	ENTER	Used after instruction keys are depressed to enter the information into program memory.
CLR	CLEAR	Clears displayed data information when depressed one time and displayed address when depressed two times.

Table 4.1
KEY DEFINITIONS (Continued)

KEY	DEFINITION	DESCRIPTION
FCTN	FCTN FUNCTION	When depressed before a two-digit value, causes a Function (F20, F81, etc.) instruction assigned to that value to be specified.
<input type="checkbox"/> SHF	SHIFT	When depressed before another key, the shifted function of that key will be executed.
0 - 9	NUMERIC KEYS	Used to specify numeric values for entry into program. Also to specify a program memory address
BIN	BIN BINARY	Shifted function used to convert a BCD value stored in the accumulator to a binary value.
<input type="checkbox"/> MCS	MCS MASTER CONTROL START	Specifies start of a Master Control Relay function.
BCD	BCD BINARY CODED DECIMAL	Shifted function used to convert a binary value stored in the accumulator to a BCD value.
<input type="checkbox"/> MCR	MCR MASTER CONTROL RESET	Specifies end of a Master Control Relay function.
<input type="checkbox"/> ×	× MULTIPLY	Arithmetic function used when specifying multiplication.
<input type="checkbox"/> SET	SET	Used to turn a coil ON. Also, when forcing a coil or contact to the ON state.
<input type="checkbox"/> ÷	÷ DIVIDE	Shifted function used when specifying division in an arithmetic operation.
<input type="checkbox"/> RST	RST RESET	Used to turn a coil OFF. Also, when forcing a coil or contact to the OFF state.
D•OUT	D•OUT DATA OUT	Used in a data instruction sequence to move data from the accumulator to a specified location.
<input type="checkbox"/> OUT	OUT	Used before a numeric value to assign an output coil to a rung of ladder diagram logic.

Table 4.1
KEY DEFINITIONS (Continued)

KEY	DEFINITION	DESCRIPTION
CMPR	CMPR COMPARE	Shifted function use to specify a compare operation (> = <)
TMR	TMR TIMER	When used before a numeric value, assigns a Timer function to a line of logic.
+	+	ADD
CNT	CNT COUNTER	Shifted function used to specify addition in an arithmetic operation.
-	-	SUBTRACT
SR	SR SHIFT REGISTER	Used to assign a Counter function to a line of logic.
D•AND	D•AND DATA AND	Shifted function used to specify subtraction in an arithmetic operation.
AND	AND	Assigns a Shift Register function to a line of logic.
D•OR	D•OR DATA OR	Specifies a logical AND operation.
OR	OR	Adds referenced status to previously entered logic in series.
D•STR	D•STR DATA STORE	Specifies a logical OR operation.
STR	STR START	Adds referenced status to previously entered logic in parallel.
INV	INV INVERT	Used in a data instruction sequence to move data into the accumulator from a specified location or as a constant value. Always used to start a data operation sequence.
NOT	NOT	Used with a reference to begin a rung of ladder diagram logic.
		Used to invert the 16 bits of the accumulator. Use after the D.STR instruction to invert before performing a data operation or immediately before D.OUT to invert before outputting data.
		Specifies a contact reference to be normally closed.

In order to enter programs and for other operations of the PC, an understanding of the use of each key is required. Table 4.2 lists the various operations, the keystrokes required and the mode or modes in which the operation can be performed. The mode abbreviations used in the table heading are:

T = TEST
R1 = RUN 1
R = RUN
P = PROGRAM
L = LOAD
PM = PROM

Table 4.2
PC OPERATION SEQUENCES (Continued)

OPERATION	KEYSTROKES OR OPERATION SEQUENCE	MODE					
		T	RI	R	P	L	PM
<ul style="list-style-type: none"> Data Register contents - looks at 16 consecutive bits 	CLR CLR M \nearrow XXX NXT Lower Byte Number	X	X	X	X		
<ul style="list-style-type: none"> Accumulated value of Timer of Counter 	CLR CLR M \nearrow XXX NXT 200 + T/C Number	X	X	X	X		
Monitor Display <ul style="list-style-type: none"> Display contact or coil status at a specified monitor point. 	CLR XX M \nearrow [Reference] NXT Monitor Display LED (0-15)	X	X	X	X		
<ul style="list-style-type: none"> Advance display to next monitor point 	CLR XX M [Reference] NXT NXT (After reaching 15, display will wrap-around to 00).	X	X	X	X		
	NOTE When in Monitor Display Mode, all instruction keys except TMR and CNT are disabled.						
<ul style="list-style-type: none"> Leave Monitor display mode 	CLR CLR	X	X	X	X		
Forced setting and resetting <ul style="list-style-type: none"> Turn ON (Input, Output, Internal Relay) 	CLR [I/O Reference Number] CHG SET	X	X		X		
<ul style="list-style-type: none"> Turn OFF (Input, Output, Internal Relay) 	CLR [I/O Reference Number] CHG RST	X	X		X		

Table 4.2
PC OPERATION SEQUENCES (Continued)


OPERATION	KEYSTROKES OR OPERATION SEQUENCE	MODE						
		T	RI	R	P	L	PM	
<ul style="list-style-type: none"> • Turn Timer/Counter ON 	TMR or CNT XXX SCH CHG SET	X	X		X			
<ul style="list-style-type: none"> • Turn Timer/Counter OFF 	TMR or CNT XXX SCH CHG RST	X	X		X			
<ul style="list-style-type: none"> • Turn Shift Register or Retentive Relay ON 	CLR [SR or Relay Number] CHG SET	X	X		X			
<ul style="list-style-type: none"> • Turn Shift Register or Retentive Relay OFF 	CLR [SR or Relay Number] CHG RST	X	X		X			
One-Scan Program Execution	[Program Address] SET OUT NXT <ul style="list-style-type: none"> • Each time the SET OUT NXT sequence is entered, the next scan will be executed. ON/OFF status of coils or contacts can be observed by assigning them to Monitor Display LEDs and observing the LEDs. 	X						
Cassette Recorder Operation <ul style="list-style-type: none"> • Write to Tape • Read From Tape • Compare Read or Write Operation 	Program Number CLR SHF WRITE  NXT CLR SHF READ XXXX NXT CLR SHF CHECK XXXX NXT <ul style="list-style-type: none"> • Compare should be done immediately after a Read or Write Refer to Chapter 6 for further details.					X	X	X

Table 4.2
PC OPERATION SEQUENCES (Continued)

OPERATION	KEYSTROKES OR OPERATION SEQUENCE	MODE					
		T	RI	R	P	L	PM
PROM Writer Operation	Refer to Chapter 6 for this operation.					X	
Printer Operation	Refer to Chapter 6 for this operation.					X	
Transfer Contents of PROM to CMOS RAM	CLR SHF READ NXT						X
Verify PROM to CMOS RAM	CLR SHF CHECK NXT						X

PROGRAMMING REFERENCES

Programming references for the Series Three are listed in the following tables. These references are fixed internally and must be assigned as shown for proper system operation.

Table 4.3
DISCRETE I/O POINTS (400)

GROUP	000	001	002	003	004	005	006	007	010	011	012	013	014	015	016	017
I/O Number	0000	0010	0020	0030	0040	0050	0060	0070	0100	0110	0120	0130	0140	0150	0160	0170
	0001	0011	0021	0031	0041	0051	0061	0071	0101	0111	0121	0131	0141	0151	0161	0171
	0002	0012	0022	0032	0042	0052	0062	0072	0102	0112	0122	0132	0142	0152	0162	0172
	0003	0013	0023	0033	0043	0053	0063	0073	0103	0113	0123	0133	0143	0153	0163	0173
	0004	0014	0024	0034	0044	0054	0064	0074	0104	0114	0124	0134	0144	0154	0164	0174
	0005	0015	0025	0035	0045	0055	0065	0075	0105	0115	0125	0135	0145	0155	0165	0175
	0006	0016	0026	0036	0046	0056	0066	0076	0106	0116	0126	0136	0146	0156	0166	0176
	0007	0017	0027	0037	0007	0057	0067	0077	0107	0117	0127	0137	0157	0157	0167	0177

GROUP	020	021	022	023	024	025	026	027	030	031	032	033	034	035	036	037
I/O Number	0200	0210	0220	0230	0240	0250	0260	0270	0300	0310	0320	0330	0340	0350	0360	0370
	0201	0211	0221	0231	0241	0251	0261	0271	0301	0311	0321	0331	0341	0351	0361	0371
	0202	0212	0222	0232	0242	0252	0262	0272	0302	0312	0322	0332	0342	0352	0362	0372
	0203	0213	0223	0233	0243	0253	0263	0273	0303	0313	0323	0333	0343	0353	0363	0373
	0204	0214	0224	0234	0244	0254	0264	0274	0304	0314	0324	0334	0344	0354	0364	0374
	0205	0215	0225	0235	0245	0255	0265	0275	0305	0315	0325	0335	0345	0355	0365	0375
	0206	0216	0226	0236	0246	0256	0266	0276	0306	0316	0326	0336	0346	0356	0366	0376
	0207	0217	0227	0237	0247	0257	0267	0277	0307	0317	0327	0337	0347	0357	0367	0377

GROUP	040	041	042	043	044	045	046	047	050	051	052	053	054	055	056	057
I/O Number	0400	0410	0420	0430	0440	0450	0460	0470	0500	0510	0520	0530	0540	0550	0560	0570
	0401	0411	0421	0431	0441	0451	0461	0471	0501	0511	0521	0531	0541	0551	0561	0571
	0402	0412	0422	0432	0442	0452	0462	0472	0502	0512	0522	0532	0542	0552	0562	0572
	0403	0413	0423	0433	0443	0453	0463	0473	0503	0513	0523	0533	0543	0553	0563	0573
	0404	0414	0424	0434	0444	0454	0464	0474	0504	0514	0524	0534	0544	0554	0564	0574
	0405	0415	0425	0435	0445	0455	0465	0475	0505	0515	0525	0535	0545	0555	0565	0575
	0406	0416	0426	0436	0446	0456	0466	0476	0506	0516	0526	0536	0546	0556	0566	0576
	0407	0417	0427	0437	0447	0457	0467	0477	0507	0517	0527	0537	0547	0557	0567	0577

GROUP	060	061
I/O Number	0600	0610
	0601	0611
	0602	0612
	0603	0613
	0604	0614
	0605	0615
	0606	0616
	0607	0617

Table 4.4
INTERNAL RELAYS (298 PLUS 6 SPECIAL)

GROUP	400	401	402	403	404	405	406	407	410	411	412	413	414	415	416	417
Bit Number	4000	4010	4020	4030	4040	4050	4060	4070	4100	4110	4120	4130	4140	4150	4160	4170
	4001	4011	4021	4031	4041	4051	4061	4071	4101	4111	4121	4131	4141	4151	4161	4171
	4002	4012	4022	4032	4042	4052	4062	4072	4102	4112	4122	4132	4142	4152	4162	4172
	4003	4013	4023	4033	4043	4053	4063	4073	4103	4113	4123	4133	4143	4153	4163	4173
	4004	4014	4024	4034	4044	4054	4064	4074	4104	4114	4124	4134	4144	4154	4164	4174
	4005	4015	4025	4035	4045	4055	4065	4075	4105	4115	4125	4135	4145	4155	4165	4175
	4006	4016	4026	4036	4046	4056	4066	4076	4106	4116	4126	4136	4146	4156	4166	4176
	4007	4017	4027	4037	4047	4057	4067	4077	4107	4117	4127	4137	4147	4157	4167	4177

GROUP	420	421	422	423	424	425	426	427	430	431	432	433	434	435	436	437
Bit Number	4200	4210	4220	4230	4240	4250	4260	4270	4300	4310	4320	4330	4340	4350	4360	4370
	4201	4211	4221	4231	4241	4251	4261	4271	4301	4311	4321	4331	4341	4351	4361	4371
	4202	4212	4222	4232	4242	4252	4262	4272	4302	4312	4322	4332	4342	4352	4362	4372
	4203	4213	4223	4233	4243	4253	4263	4273	4303	4313	4323	4333	4343	4353	4363	4373
	4204	4214	4224	4234	4244	4254	4264	4274	4304	4314	4324	4334	4344	4354	4364	4374
	4205	4215	4225	4235	4245	4255	4265	4275	4305	4315	4325	4335	4345	4355	4365	4375
	4206	4216	4226	4236	4246	4256	4266	4276	4306	4316	4326	4336	4346	4356	4366	4376
	4207	4217	4227	4237	4247	4257	4267	4277	4307	4317	4327	4337	4347	4357	4367	4377

GROUP	440	441	442	443	444	445
Bit Number	4400	4410	4420	4430	4440	4450
	4401	4411	4421	4431	4441	4451
	4402	4412	4422	4432	4442	4452
	4403	4413	4423	4433	4443	4453
	4404	4414	4424	4434	4444	4454
	4405	4415	4425	4435	4445	4455
	4406	4416	4426	4436	4446	4456
	4407	4417	4427	4437	4447	4457

Special purpose coils. Used as flags for certain conditions as a result of a computation.

- 4452 Compare > (greater than)
- 4453 Compare = (equal to)
- 4454 Compare < (less than)
- 4455 Carry or Borrow
- 4456 Zero
- 4457 Overflow

Arithmetic Computations

Table 4.5
RETENTIVE RELAYS (64)

GROUP	700	701	702	703	704	705	706	707
Bit	7000	7010	7020	7030	7040	7050	7060	7070
Number	7001	7011	7021	7031	7041	7051	7061	7071
	7002	7012	7022	7032	7042	7052	7062	7072
	7003	7013	7023	7033	7043	7053	7063	7073
	7004	7014	7024	7034	7044	7054	7064	7074
	7005	7015	7025	7035	7045	7055	7065	7075
	7006	7016	7026	7036	7046	7056	7066	7076
	7007	7017	7027	7037	7047	7057	7067	7077

These are internal coils that will retain last ON or OFF state under power-down condition.

} Special purpose
(See below)

- 7076 Turns on when voltage of Lithium back-up battery drops below 2.7 Vdc.
- 7077 When on, indicates an error during a data transfer between CPU and peripheral equipment.

Table 4.6
SHIFT REGISTERS (128)
(RETENTIVE)

GROUP	900	901	902	903	904	905	906	907	910	911	912	913	914	915	916	917
Bit Number	9000	9010	9020	9030	9040	9050	9060	9070	9100	9110	9120	9130	9140	9150	9160	9170
	9001	9011	9021	9031	9041	9051	9061	9071	9101	9111	9121	9131	9141	9151	9161	9171
	9002	9012	9022	9032	9042	9052	9062	9072	9102	9112	9122	9132	9142	9152	9162	9172
	9003	9013	9023	9033	9043	9053	9063	9073	9103	9113	9123	9133	9143	9153	9163	9173
	9004	9014	9024	9034	9044	9054	9064	9074	9104	9114	9124	9134	9144	9154	9164	9174
	9005	9015	9025	9035	9045	9055	9065	9075	9105	9115	9125	9135	9145	9155	9165	9175
	9006	9016	9026	9036	9046	9056	9066	9076	9106	9116	9126	9136	9146	9156	9166	9176
	9007	9017	9027	9037	9047	9057	9067	9077	9107	9117	9127	9137	9147	9157	9167	9177

Table 4.7
DATA REGISTERS, 8-BIT (128)

Number	500	501	502	503	504	505	506	507	510	511	512	513	514	515	516	517
	520	521	522	523	524	525	526	527	530	531	532	533	534	535	536	537
	540	541	542	543	544	545	546	547	550	551	552	553	554	555	556	557
	560	561	562	563	564	565	566	567	570	571	572	573	574	575	576	577
	600	601	602	603	604	605	606	607	610	611	612	613	614	615	616	617
	620	621	622	623	624	625	626	627	630	631	632	633	634	635	636	637
	640	641	642	643	644	645	646	647	650	651	652	653	654	655	656	657
	660	661	662	663	664	665	666	667	670	671	672	673	674	675	676	677

see below

Register 674 Fault diagnosis, error condition storage.
 Register 675 Fault diagnosis, error condition storage.
 Register 676 Auxiliary accumulator, lower byte.
 Register 677 Auxiliary accumulator, upper byte.

Table 4.8
TIMER OR COUNTER NUMBERS AND REGISTERS (128)

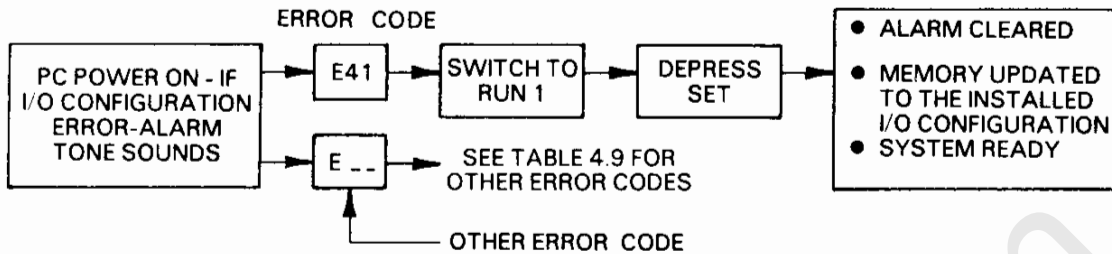
The T/C Numbers are not I/O points, they are only Timer or Counter identification numbers.

T/C Number	000	001	002	003	004	005	006	007	010	011	012	013	014	015	016	017
Accumulate Reg.	200	201	202	203	204	205	206	207	210	211	212	213	214	215	216	217
T/C Number	020	021	022	023	024	025	026	027	030	031	032	033	034	035	036	037
Accumulate Reg.	220	221	222	223	224	225	226	227	230	231	232	233	234	235	236	237
T/C Number	040	041	042	043	044	045	046	047	050	051	052	053	054	055	056	057
Accumulate Reg.	240	241	242	243	244	245	246	247	250	251	252	253	254	255	256	257
T/C Number	060	061	062	063	064	065	066	067	070	071	072	073	074	075	076	077
Accumulate Reg.	260	261	262	263	264	265	266	267	270	271	272	273	274	275	276	277
T/C Number	100	101	102	103	104	105	106	107	110	111	112	113	114	115	116	117
Accumulate Reg.	300	301	302	303	304	305	306	307	310	311	312	313	314	315	316	317
T/C Number	120	121	122	123	124	125	126	127	130	131	132	133	134	135	136	137
Accumulate Reg.	320	321	322	323	324	325	326	327	330	331	332	333	334	335	336	337
T/C Number	140	141	142	143	144	145	146	147	150	151	152	153	154	155	156	157
Accumulate Reg.	340	341	342	343	344	345	346	347	350	351	352	353	354	355	356	357
T/C Number	160	161	162	163	164	165	166	167	170	171	172	173	174	175	176	177
Accumulate Reg.	360	361	362	363	364	365	366	367	370	371	372	373	374	375	376	377

The top number in each row (000-177) is the number assigned to a Timer or Counter. The number (200-377) under the Timer or Counter number is the 16-bit register that stores the accumulated value of that Timer or Counter.

POWER-UP SEQUENCE

When power is turned on, the CPU performs a self-check diagnostic, including checking the I/O configuration installed and comparing it to the configuration previously entered in a portion of internal memory reserved for that data. The type of I/O module (Input or Output) and number of I/O points are checked. If a change in the configuration is detected, an alarm will sound and an error code will be displayed. This sequence is shown below.



An I/O slot that does not have a module installed is interpreted as being a 16 point Output module. This must be considered when assigning I/O references. The I/O configuration as stored in memory is retained by the lithium back-up battery.

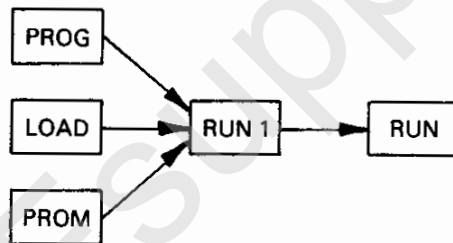
Several other diagnostics are performed during the self-check portion of the power-up sequence. If an error is detected, an alarm is sounded and an error code is displayed. The alarm tone and error code are present until cleared by the operator. The error codes and their definitions are listed in Table 4.9. A complete list of system error codes can be found in Table 4.13.

Table 4.9
SELF-CHECK ERROR CODES

Error Code	Definition
E13	Instantaneous power failure.
E21	Program memory parity error.
E22	Memory back-up battery has dropped below 2.7 Vdc. Will not retain memory.
E31	CPU watchdog timer timed out (> 300 ms).
E41	Change in I/O module configuration.
	or
E50	I/O to CPU data transfer error. Error in data transfer to peripheral device.

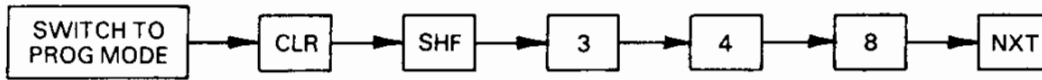
SWITCHING TO RUN MODE

Insertion of the key in the keyswitch slot allows switching between modes. However; a specific sequence must be followed when switching to the RUN mode. When switching directly to RUN from PROG, LOAD or PROM, all operations are disabled. You must first switch to RUN 1, then RUN as shown below.



CLEARING PROGRAM MEMORY

Before entering a program initially or if all of the contents of program memory are to be cleared, use the following procedure. This will clear all program memory addresses of any instructions and data previously entered.



When the above procedure is executed parts of the CPU's internal memory are also cleared, while other parts are retained.

Memory cleared

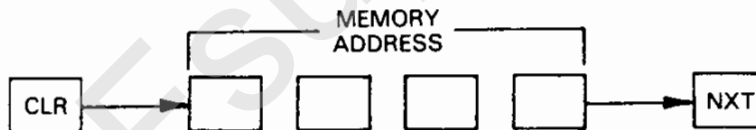
- User program memory
- Contents of 16-bit monitor display
- Operating state of internal retentive relays
- Operating state of shift registers

Memory not cleared

- I/O configuration
- Data registers
- Timers, Counters and their accumulated value registers

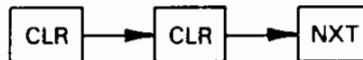
SELECTING A PROGRAM MEMORY ADDRESS

To display a particular program memory address, use the following key sequence. The address will be displayed along with the data entered at that address.



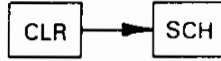
START OF MEMORY

To access the start of program memory (Address 0000), use the following key sequence.



SEARCH FOR NEXT UNUSED ADDRESS

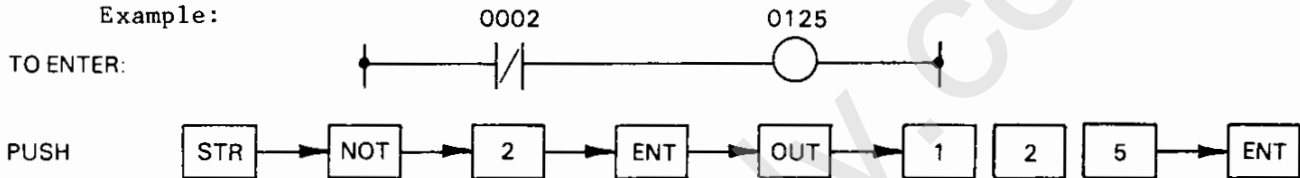
To access and have displayed the next unused program memory address without stepping through a program one address at a time, enter the following key sequence. The CPU will search for the next available address and display that address.



ENTERING INSTRUCTIONS

Instructions for a ladder diagram program are entered by pushing an instruction key or a combination of up to 3 instruction keys, up to 4 numerical keys and ENT.

Example:

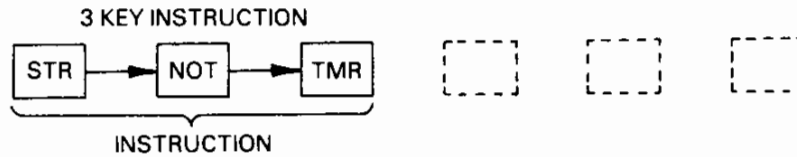


There are 24 Instruction keys (12 plus 12 shifted) as shown in Figure 4.1. Additional instructions are entered by pushing these keys as the second or third key of a combined sequence of keys. Table 4.10 shows the key legends and their allowable locations in a combined key sequence. Combinations of the keys allow 50 instructions to be entered.

Table 4.10
INSTRUCTION KEY SEQUENCE POSITIONS

Key	Position			Key	Position		
	1	2	3		1	2	3
STR	0	0		D•STR	0		
AND	0			D•AND	0		
OR	0			D•OR	0		
NOT		0		COM	0		
OUT	0	0		D•OUT	0		
TMR	0	0	0	>=<	0		
CNT	0	0	0	+	0		
SR	0			-	0		
MCS	0	0		BIN	0		
MCR	0	0		BCD	0		
SET	0			X	0		
RST	0		0	÷	0		

Example:



Notice that STR is pushed first, then NOT, and finally TMR. The Keys are in positions as shown in the table. This instruction would specify the first contact in a rung of logic as a closed contact referencing a Timer coil for the contact.

If keys are pushed in an invalid sequence, an alarm tone will sound and an error code will be displayed on the programmer. When this happens, push CLR, then enter the correct sequence.

In addition to the keys in Table 4.10, there are 7 instructions which can be entered using the FCTN (Function) key and a two-digit numeric sequence. For example, to specify Function 20, the following key sequence is pushed.



The data display will display F20 as those keys are pushed. When ENT is pushed, a long tone will sound, the data display clears and then displays 0.0.0.0.; simultaneously the program memory address display will advance one address. This is a CPU prompt indicating that a second entry must be made to complete the instruction since it is a two-word instruction.

Using the above described key sequences, a total of 57 instructions are available for programming a Series Three PC system. Chapter 5 lists and describes all of the programming instructions.

ENTERING DATA

After entering an instruction, the required data is entered using the numerical keys 0-9. The value entered with the numerical keys is displayed on the data display, with digits shifting left as they are entered. If more than four numerical keys are pushed, the left digit(s) are lost and the four remaining are considered valid data. Leading zeros can be omitted from a sequence; i.e. to enter 123, you only need to push 1, 2, 3 and not 0, 1, 2, 3. Table 4.11 lists the instructions requiring numerical entries and the ranges of those entries.

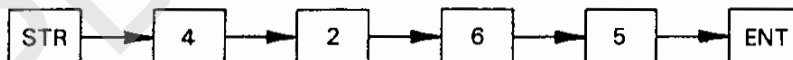
Table 4.11
VALID NUMERICAL RANGES

INSTRUCTION	NUMERICAL LIMITS
STR, AND, OR, OUT, SR SET, RST, SET.OUT, SET.OUT.RST	0000-0617 4000-4457 7000-7077 9000-9177
D • STR, D • OUT > = < , +, -, x, ÷ D • AND, D • OR	000-061 400-445 700-707 900-917 500-677 200-377
Timer Preset	0000-999.9
Counter Preset	0000-9999
Timer and Counter Reference Numbers	000-177
FUN 80, FUN 81 (Instructions For Data Shifts)	1-15
FUN 20 (Fault Diagnosis)	Fault Identification Number 0000-9999

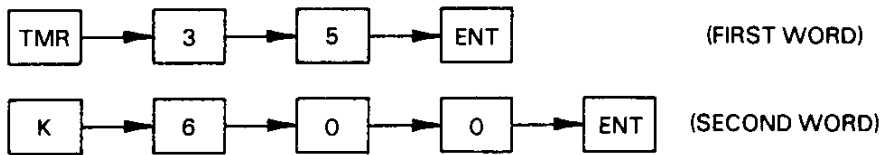
If a numerical entry is attempted, but is out of range for the Instruction an alarm will sound and an error code (E01) will be displayed. Push CLR, the data display will clear, then enter the correct data.

Examples of numerical entries:

- Instruction referencing an internal relay, STR 4265.



- Instruction specifying a Timer number (35) with a constant preset value of 60.0 seconds.

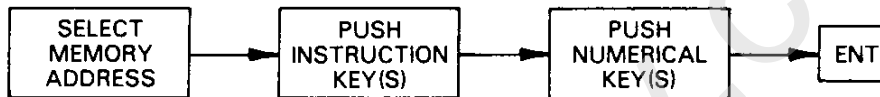


PROGRAMMING PROCEDURES

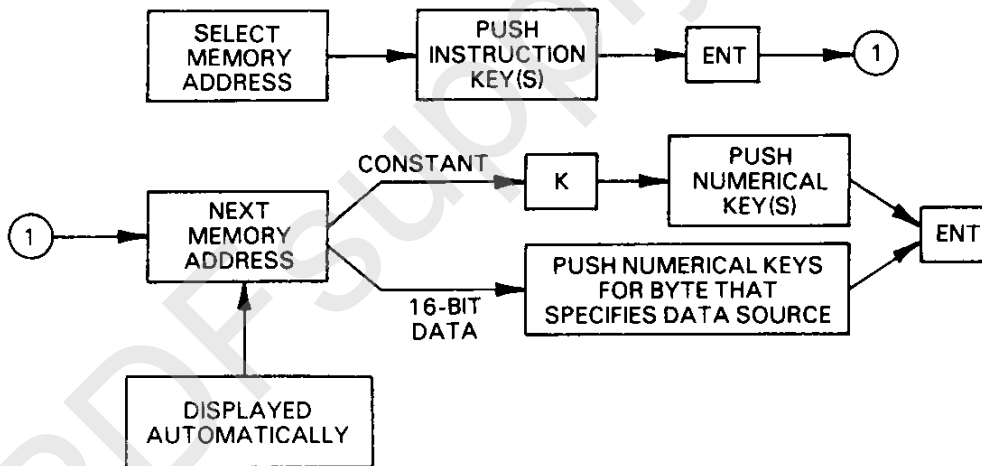
Some general information required for entering ladder diagram programs is as follows:

- Instructions are written (entered) in program memory when the ENT key is pushed.
- Instructions use either 1 or 2 words of memory.

1. Entering a one-word instruction.



2. Entering a two-word instruction.



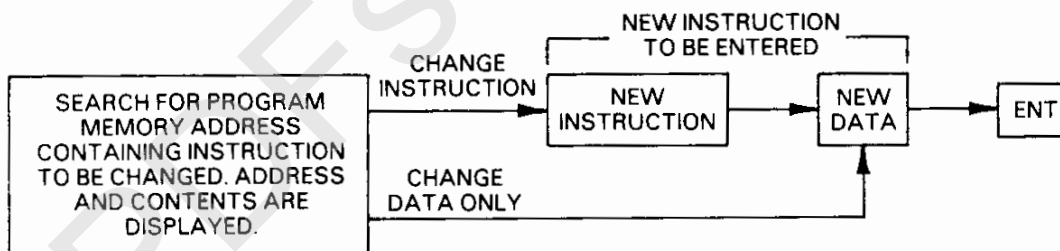
- The program memory address must be displayed for an instruction to be entered; otherwise, the ENT key has no effect.
- When entering a two-word instruction, the program memory address advances 1 address when the ENT key is pushed after the instruction key(s).
- Invalid ENT key operation
 1. ENT key does not respond.
 - Program memory address not displayed.
 - ENT key pushed before instruction key
 - ENT key pushed before numerical key (instruction key has been pushed) - except for a two-word instruction.
 - Keys other than numerical pushed for second word of a two-word instruction.
 2. ENT key responds, but alarm sounds and entry is invalid (error code E01 or E02).
 - Only numerical keys pushed (except two-word commands).
 - Data entry exceeds the legal limits.

In any of the above examples, push CLR and re-enter the instruction.

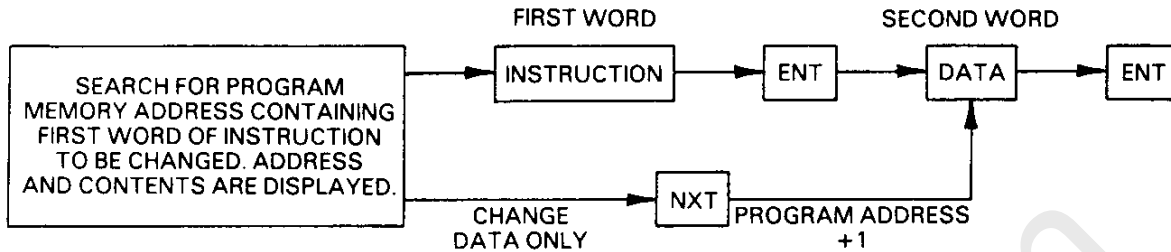
EDITING A PROGRAM

Editing a program previously entered in program memory is a relatively easy procedure requiring a minimum of keystrokes. The two following block diagrams show the general steps for editing a one-word or a two-word instruction.

1. Editing a one-word instruction



2. Editing a 2-word instruction



If a one-word instruction is changed to a two-word instruction, the program memory address advances for the second word; all following instructions are shifted ahead one address. Conversely, if a two-word instruction is changed to a one-word instruction the data contained in the second word is deleted and all following instructions are shifted back one address.

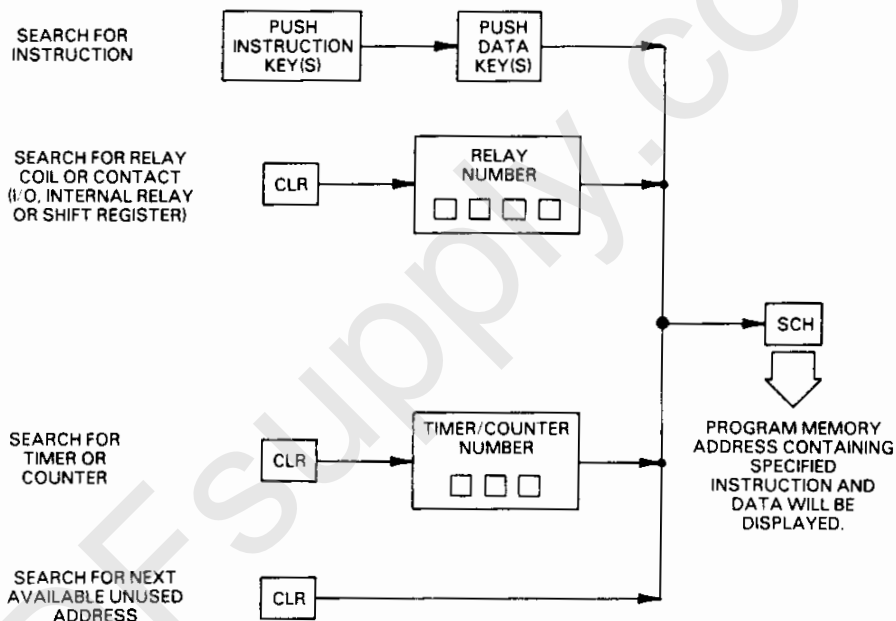
USING THE OPERATION KEYS

Most of the Keys in the Operation Key group are used when editing. The use of these Keys when making changes in a program are described in this paragraph.

- CLR** CLEAR. An instruction can be rewritten by pushing the CLR key and re-entering the instruction; however, the instruction can be written over simply by entering the new instruction without pushing CLR.
- ENT** ENTER. Pushing the ENT key after the instruction and numeric keys will cause the specified instruction to be entered at the displayed address in program memory.
- PRV** PREVIOUS. When reading the contents of program memory, pushing the PRV Key will allow the program memory address to be displayed which precedes the one currently displayed. The contents of that address will also be displayed.
- NXT** NEXT. Pushing the NXT Key will advance the displayed program memory address to the next higher address. The program memory address and its contents will be displayed.

SCH

SEARCH. The SCH key is used to find an instruction, or a coil, contact, Timer or Counter reference in a program. The specified item will be displayed with its program memory address. The keys specifying the item to be searched for are pushed, then the SCH key. The address will be displayed containing the instruction and the instruction is read by observing the LEDs on the instruction display and the data display. If the instruction or reference is used more than one time in a program, the display will show the first time it is used. Pushing SCH again will advance the program memory address and display the information at its next location. If the instruction or reference is not used again, the address displayed will not change. A block diagram of the SCH key operation is shown below.

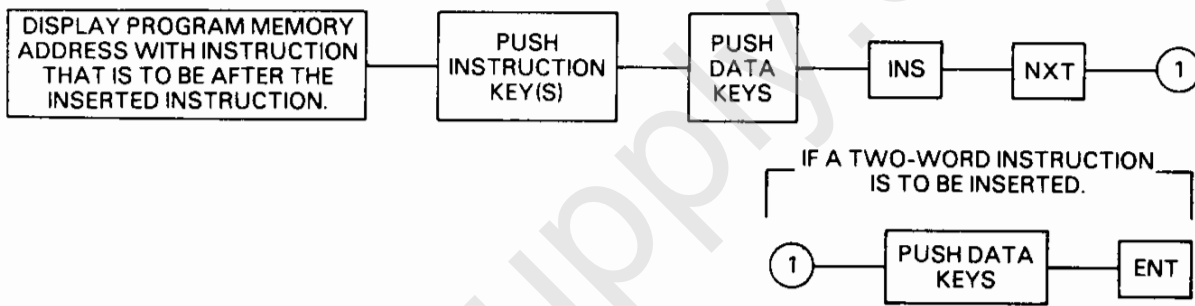


If the reference numbers pushed before the SCH key are out of range, error code E01 will be displayed. If the specified instruction or data is not found, error code E99 (instruction or data not found) will be displayed.

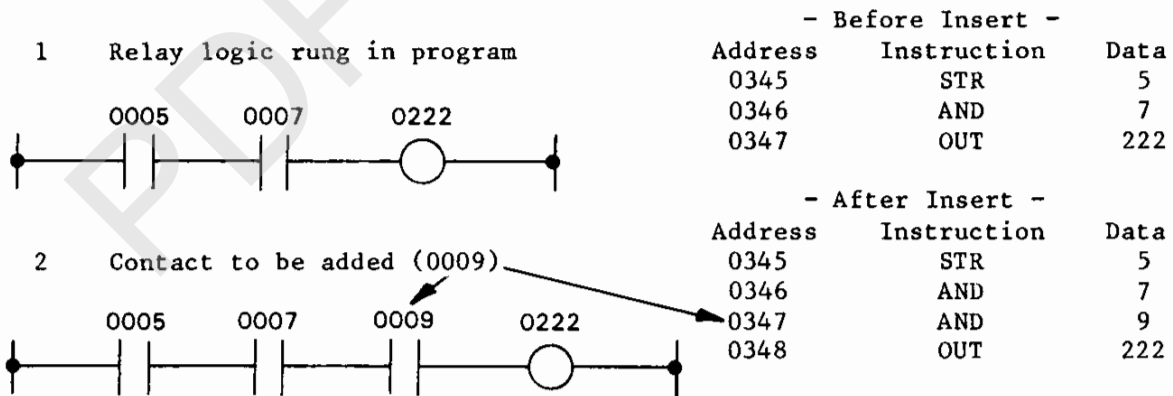
INS

INSERT. The INS key provides a method of adding a new instruction or any number of instructions to an existing program. To insert an instruction, first search for and display the program memory address containing the instruction that will be after the instruction to be inserted. Push the keys for the instruction and data to be added, then push INS. The display will alternate On and Off with a tone, then push NXT (this is a two key operation as a precaution against accidental insertion of an instruction). The added instruction and data will be inserted in the program at the displayed address. All instructions following will advance one address. If the new instruction is a two-word instruction, the existing program will advance two addresses.

The mode switch must be in the PROG or TEST position to do an insert operation. An insert operation sequence is shown in block diagram form.

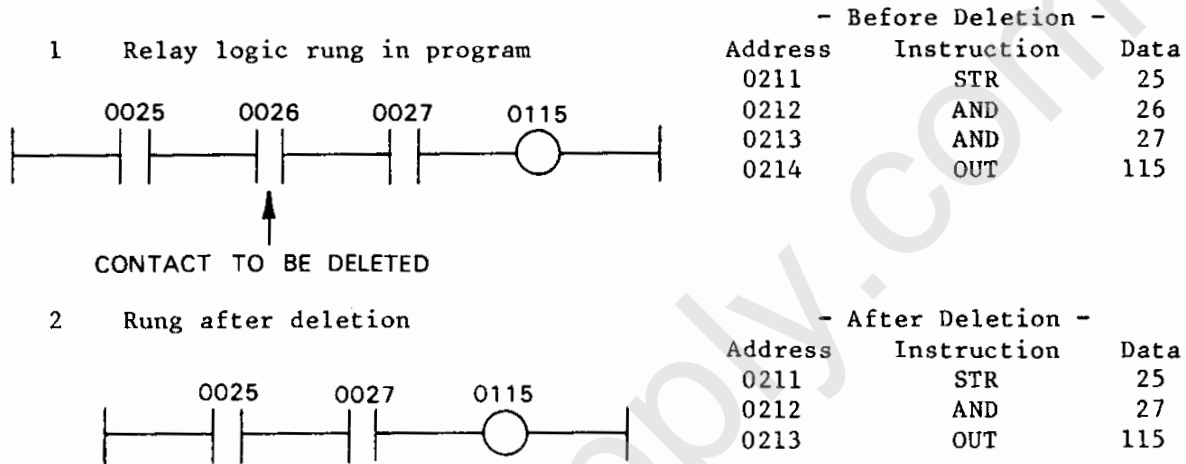


Example of the results of an insert operation:



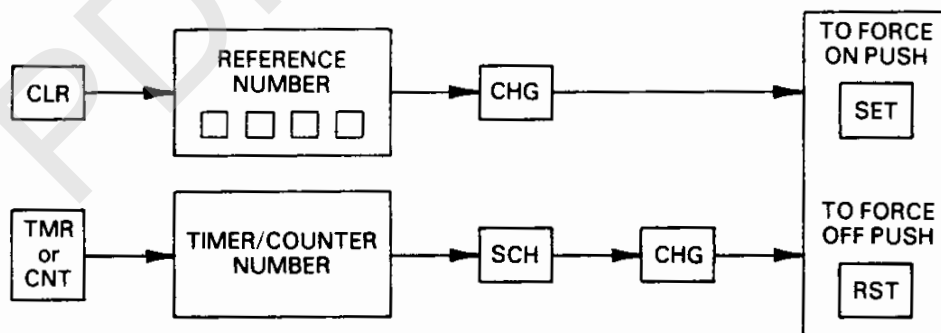
DEL DELETE. The DEL key provides a method of removing an instruction from a relay ladder logic program. Display the program memory address containing the instruction to be deleted, then push the DEL key. The display will alternate On and Off with a tone, then push PRV (this is a two key operation to prevent accidental deletions). The instruction located at that address will be deleted and all instructions that had been after the one deleted will move back one address.

Example of the results of a delete operation:



If the instruction to be deleted is a two-word instruction, all following instructions will move back two addresses.

CHG CHANGE. The CHG key is used in a key sequence when forcibly turning Inputs, Outputs, Timer or Counter coils, Shift Register coils or Internal coils ON or OFF. This key is used with the SET key when forcing to the ON condition and with the RST key when forcing to the OFF condition. Examples of these key sequences are shown below.

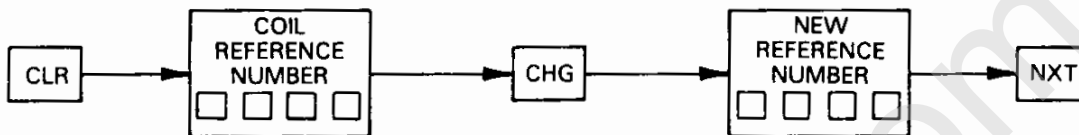


The forcing ON or OFF of contacts or coils provides a convenient way of testing the operation of system devices and debugging a program. Table 4.12 shows the operation of contacts and coils when they are forced either ON or OFF.

Table 4.12
RESULTS OF FORCED SET OR RESET

Contact or Relay Type	Operation when forced by SET	Operation when forced by RST
Input Contact	Normally - open contact is closed for 1 scan.	Normally - closed contact is opened for 1 scan.
Output or Internal Relay	When the normal operating condition is OFF, the Output or Internal Relay is turned ON. During the next program execution, the Output or Relay will turn OFF.	If the normal operating condition is ON, the Output or Internal Relay is turned OFF. During the next program execution, the Output or Relay will turn back ON.
Shift Register	If OFF, is forced to ON.	If ON, is forced to OFF.
Timer	Timer is forced to begin timing. If the timer was running it would continue. If the timer had not been running, it would reset on the next scan.	Timer is reset to the preset value.
Counter	Counter will count up.	If the counter is counting, it will reset.

The CHG key can also be used in a sequence to change the reference number of a coil (output or internal) and all subsequent contact references to that coil. For instance, consider an output coil reference as 0122 with several contacts in the program referenced to that coil. If, using the CHG key, that output coil reference is changed to 0132, all of the contact references will automatically change to 0132. The sequence to change a coil reference is shown in the following block diagram. To do this, the mode switch must be in the PROG position.



PROGRAM CHECK AND ERROR CODES

As a program is being entered, the CPU automatically performs a check for the validity of each entry. Instructions are checked for proper key sequence, range of numerical data, etc. If an error is detected, an error code will be generated and a tone will sound. When this happens, pushing CLR will remove the tone and error code. Refer to the error code listing in Table 4.13 and correct the program step.

A program check can also be made at any time while in the TEST, RUN 1, RUN or PROG mode by using the following key sequence.



The CPU will perform a program error check. If a program error is found, the address containing the error will be displayed, a tone will sound, and an error code will be displayed alternately with the address and its contents. If no errors are found when the CLR, SCH sequence is pushed, the next available unused program memory address will be displayed.

The CPU also automatically performs the program error check any time that the system is switched to the RUN mode. Error codes are also generated for system problems such as watch-dog timer timing out, back-up battery voltage low, etc. These error codes are also listed in Table 4.13.

Table 4.13
ERROR CODE DEFINITIONS

ERROR CODE	WHEN DETECTED				CAUSE OF ERROR	ACTION TO CLEAR ALARM
	LOAD MODE	PROG. CHECK	SWITCH TO RUN	POWER UP		
E 01	0				Incorrect entry of instruction or data.	CLR (Push CLR key)
E 02		0			Instruction and I/O data wrong. Input programmed as an Output.	CLR Change reference
E 03		0			Instructions that can be stacked (MCS, MCR, etc.) exceed 8 levels.	CLR
E 05		0			Output coil, Internal relay, timer or Counter reference already used.	CLR Use new reference
E 06		0			Number of MCR instructions greater than number of MCS instructions.	CLR
E 07		0			Timer, Counter or Shift Register required condition incomplete.	CLR Check program
E 08		0	0		No Timer or Counter preset value	CLR
E 09		0			Incomplete rung	CLR Check program entered
E 10	0				Two-word instruction written to last program memory address (4095), no room for second word.	CLR
E 11		0			All program memory locations used.	CLR
E 13	●	●	●	●	Momentary power failure.	CLR
E 21		●	●	●	Program memory parity error	Switch to PROG, push CLR
E 22			●	●	Lithium back-up battery <2.7 V dc.	CLR Change battery
E 25	0				Contents of cassette tape and PC memory not equal.	CLR and Clear relay 7066 with forced RST
E 28	0				Improper level of recorder volume control.	CLR Adjust volume control to about mid-range
E 31	●	●	●	●	Watch-dog timer >300 msec (timed out).	CLR Switch to PROG, push CLR
E 41				0	I/O module configuration change since last power-up.	Switch to RUN 1, push SET then CLR (Updates I/O map)
E 50	0				Invalid I/O → CPU transfer	Switch to RUN 1 → RST → CLR
E 50	0				Invalid data to or from peripheral device.	CLR, then clear relay 7077 with forced RST.
E 75	0				Contents of PROM and CMOS RAM are not equal.	CLR
E 76	0				PROM to CMOS RAM data transfer invalid or defective CMOS RAM.	CLR
E 99	0				Instruction or data not found when a SEARCH operation is initiated.	CLR

1. 0 indicates an improper programming operation.
2. ● indicates a system problem.

MONITORING OPERATION

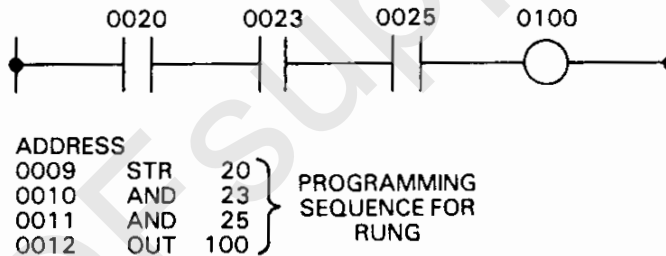
There are several ways to monitor the operation of a Series Three PC system. The monitoring operations are convenient in that that not only provide a means of checking system operation; but they are also a useful tool for debugging and troubleshooting. The items that can be easily monitored are:

- The ON or OFF state of contacts and coils while stepping through a program.
- The operating state (ON or OFF) of any 16 contacts or coils can be observed simultaneously on the monitor display.
- The accumulated value of Timers and Counters.
- Fault condition identification numbers.
- The contents of two consecutive bytes of data. This is an advanced capability of the system. The procedure for this can be found in Appendix A.

ON/OFF STATE OF CONTACTS OR COILS

Any time that a program memory address is displayed, the state (ON or OFF) of the referenced contact or coil is displayed on LED 0 of the monitor display.

Example:



When program memory address 0012 is displayed by using the NXT or PRV keys or the SCH key sequence, the data display will contain 0100, which is the output coil for the rung. The 0 position on the 0-15 LED display will reflect the state of the coil or contact on the data display. The LED will be ON for an ON condition and OFF for an OFF condition.

MONITOR DISPLAY

The monitor display area on the CPU/Programmer is the center section with the numerals 0 to 15; each number having an LED directly behind it. The reference number of a relay coil or contact or a Timer/Counter reference number can be assigned to one of the monitor display numbers. A bit in an internal register will then be ON or OFF to reflect the ON or OFF status of the coil or contact assigned to that point. The associated LED will turn ON or OFF to give a visual display of that status. Since there are 16 monitor points, any 16 coils, contacts or Timer/Counter references can be assigned to the 16 points. It is recommended that monitor points 1 through 16 be used for the monitor display since the 0 position always reflects the ON/OFF state of the coil or contact whose address is displayed on the programmer. These assignments can be random or in consecutive order. This provides a convenient way of observing all of the contacts and the output coil of a rung of logic, and is helpful when debugging or troubleshooting a ladder diagram program.

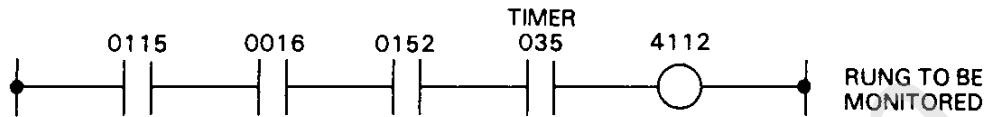
The monitor display can be accessed when in the TEST, RUN 1, RUN or PROG mode. While in the Monitor mode, the LED assignments can be made.

NOTE

While in the Monitor mode all other key operations are disabled.

Normally, when assigning the LEDs, the first contact, coil, Timer or Counter reference should be assigned to the 1 position. Once the assignments have been made and the Monitor mode is left, the LEDs will continue to show the status of the assigned reference number. The status of the monitor display is retained during power failure. The references for the monitor display can be changed as required. The contents of the monitor display register can be totally cleared only by totally erasing program memory, or by individually clearing the contact or coil assigned to each LED.

- The following sequence shows how a rung of logic can be monitored for power flow by assigning all of the contacts and the output coil to consecutive monitor LEDs. Assigning the references consecutively is not necessary; however it is easier to monitor a series of contacts or coils grouped together if they are assigned in this manner.



MONITOR DISPLAY ASSIGNMENT	CONTACT OR COIL REFERENCE
01	0015
02	0016
03	0152
04	TMR 035
05	4112

MONITOR DISPLAY ASSIGNMENT CHART

It is suggested that a record of monitor LED assignments for each program be kept for future reference. A sample form can be found in Appendix B.

Keystroke	Address Display	Data Display	
CLR	0134	----	
1	0134	1	Specifies Monitor Display LED 1
M/K	01	----	
1 5	01	15	Assigns contact 0015 to LED 1
NXT	01	15	
NXT	02	----	Advances to next LED
1 6	02	16	
NXT	02	16	
NXT	03	----	
1 5 2	03	152	
NXT	03	152	
NXT	04	----	
TMR	04	----	Assigns Timer 035 to monitor LED 04
3 5	04	35	
NXT	04	35	
NXT	05	----	
4 1 1 2	05	4112	
NXT	05	4112	

- The operating state of the assigned references can now be monitored by observing the ON or OFF condition of LEDs 1 through 5 on the monitor display.

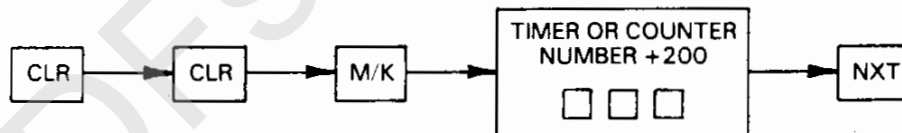
While in the monitor display mode, the contents of each position (0 - 15) can be checked by displaying the monitor position LED number. Pushing the NXT key advances to the next position, i.e., 00, 01, 02, 03, etc. Pushing the PRV key will display the previous position, i.e., 03, 02, 01, etc. When advancing the display forward and 15 is displayed, depressing the NXT key will cause the display to wrap around to 00. Conversely, when going in the reverse direction with the PRV key; when 00 is reached, the display will next go to 15.

- To change a reference assigned to a monitor LED, display the LED number, enter the new reference and push NXT. That position will now contain the new reference to be monitored.
- To clear a reference assigned to a monitor LED, display the LED number push the CLR key, then NXT, NXT. All of the monitor references can be cleared by repeating this procedure for each monitor position.
- To leave the Monitor mode, push the CLR key two times; i.e.
CLR → CLR.

ACCUMULATED VALUE, TIMERS AND COUNTERS

The accumulated value of any Timer or Counter in a program can be monitored by entering the Timer/Counter number and observing the LED display under Address and Data on the CPU/Programmer. The Timer/Counter number can be specified while in the TEST, RUN 1, RUN or PROG mode. The changing of the accumulated value can be monitored during system operation in the RUN 1 or RUN mode.

The sequence for specifying a Timer or Counter accumulated value register and displaying the contents for monitoring purposes is shown below.

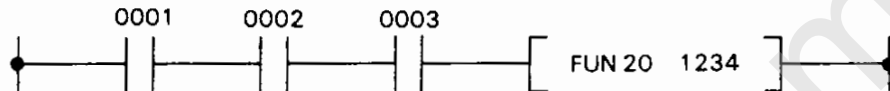


- The register reference for the accumulated value of a Timer or Counter is always the Timer or Counter number (0 to 177) plus 200. The accumulate register references are then 200 to 377 (see Table 4.8).

EXTERNAL DEVICE CHECK FAULT DETECTION DISPLAY

One of the special functions in the Series Three is a Function 20 instruction, which allows external devices to be monitored for a fault condition. This provides an easy way of monitoring 2 or more limit switches (for example) that should not be made at the same time without using complex ladder diagram logic. This function is described in more detail in Chapter 5. This paragraph will describe only the display generated as the result of a fault detection.

Example:



- The references 0001, 0002 and 0003 are for 3 switches that should not be closed at the same time. They are programmed in a rung of logic with a FUN20. FUN20 is a two-word instruction, the second word is a 4 digit BCD value (0000 to 9999) which when displayed indicates that the specified fault condition has occurred. The normally-open FAULT contacts on the power supply terminal board will close when a fault condition is detected by using the FUN20.

If the 3 switches in the example were closed at the same time, the fault would be detected and the fault identification number would be displayed as shown below. The FAULT LED on the CPU/Programmer will also turn on



Two data registers, 674 and 675 are used to store the fault identification number when a fault condition occurs. These registers can then be programmed to turn on an audible or visual alarm.

Any number of fault conditions can be detected by using the FUN20 with different identification numbers for each FUN20. If more than one fault occurs, the identification number of the last one to occur will be displayed. When a fault condition occurs all key operations are disabled except CLR. The display can be cleared by pushing the CLR key.

HALTING PROGRAM EXECUTION

Program execution can be temporarily stopped by switching from RUN or RUN 1 to the TEST mode. The PC scan is stopped, the condition of the program execution up to that time is retained and outputs programmed with an OUT instruction are inhibited. Outputs programmed with SET, SET OUT or D*OUT are not inhibited, inputs are updated by one scan and program execution using those commands is enabled.

SINGLE SCAN PROGRAM EXECUTION

While in the TEST mode programs can be executed one scan at a time. This is a convenient feature for testing and debugging of programs. The operation of contacts, outputs using the OUT instruction, Internal coils, Timer, Counter and SR coils can be monitored by assigning their reference numbers to the 16 point monitor display. As the program is stepped through one scan at a time, the monitor display LEDs will then reflect the state of the coils assigned to them.

CHAPTER 5
PROGRAMMING

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CHAPTER 5 PROGRAMMING

This chapter contains the information required for developing and programming the relay ladder diagram programs for a Series Three PC system. Each of the instructions and functions are described, along with the step-by-step sequences required for entering the instructions.

When developing a PC system, the first step should be to define the system by writing a description of the functional requirements for that system. A description would usually consist of block diagrams and written descriptions of the various parts of the system. Input devices should be defined along with the process or machines to be controlled.

The next step would be to develop the program required to control the system. A sample of forms that can be used for documenting a program are provided. On the first sheet, each rung of ladder diagram logic can be drawn. The second sheet is for writing the program in mnemonic form. An area is also provided for comments which could include defining inputs and outputs, etc. Formats for these forms are shown in Figures 5.2 and 5.3. Sample of these forms are provided in Appendix B of this manual. A typical rung of relay ladder diagram logic is shown below.

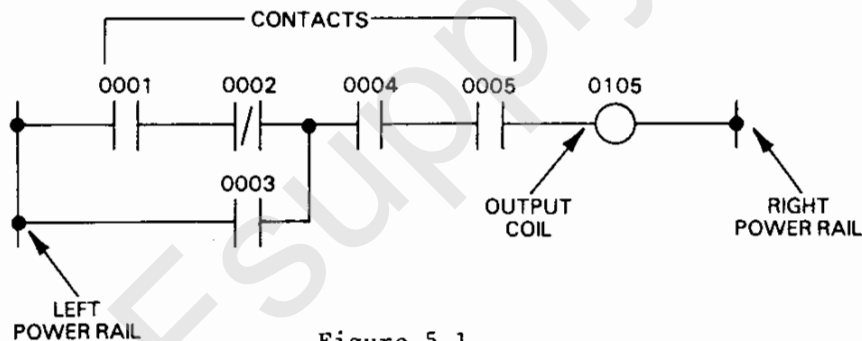


Figure 5.1
TYPICAL LADDER DIAGRAM RUNG

One key feature of PCs is power flow. This is a conceptual flow of electrons used to visualize the operation of coils, timers, counters, etc. Referring to Figure 5.1, the left hand power rail can be envisioned as "hot" (connected to 115 Vac or + 24 Vdc) and the right rail to its associated "neutral" (connected to 115 Vac return or - 24 Vdc). The coil will be energized if there is a path for electrons to flow from the left leg to the coil placing the full potential across the coil. If there is no power (electron) flow, the coil will be de-energized (OFF). Power flows always from left towards the right and will

pass through normally open contacts if their references are energized (ON) or normally closed with de-energized (OFF) references. Power flow is also allowed vertically either up or down between adjacent lines where parallel connections are programmed. However, power can NOT flow from right to left at any time through contacts or horizontal shunts. This feature simplifies programming and prevents undesired sneak paths. However, if hard wired relays are replaced by a Series Three, it is possible some adjustments may be necessary to the logic to either simplify the programming or to add sneak paths that may be a basis for the relays functioning.

Another difference between PC programming and hardwired relays is that any reference such as an input or coil can be used on relay contacts as often as necessary. Since references are merely a unique series of bits in a word of memory, they can be programmed wherever and whenever necessary. With PCs, there is no need to count relay contacts and try to limit individual references to four or less contacts; no need to plan to use form C configurations to squeeze two contacts from one pole. Any reference can be envisioned as a relay controlling many poles providing both normally open and normally closed contacts that operate without any time delay from pole 1 (closest to the coil) to pole 1,000 (further away from coil).

Sample program documentation sheets are shown below in Figure 5.2 and 5.3. As examples of the entries that can be made on the forms, the rung of logic in Figure 5.1 is documented.

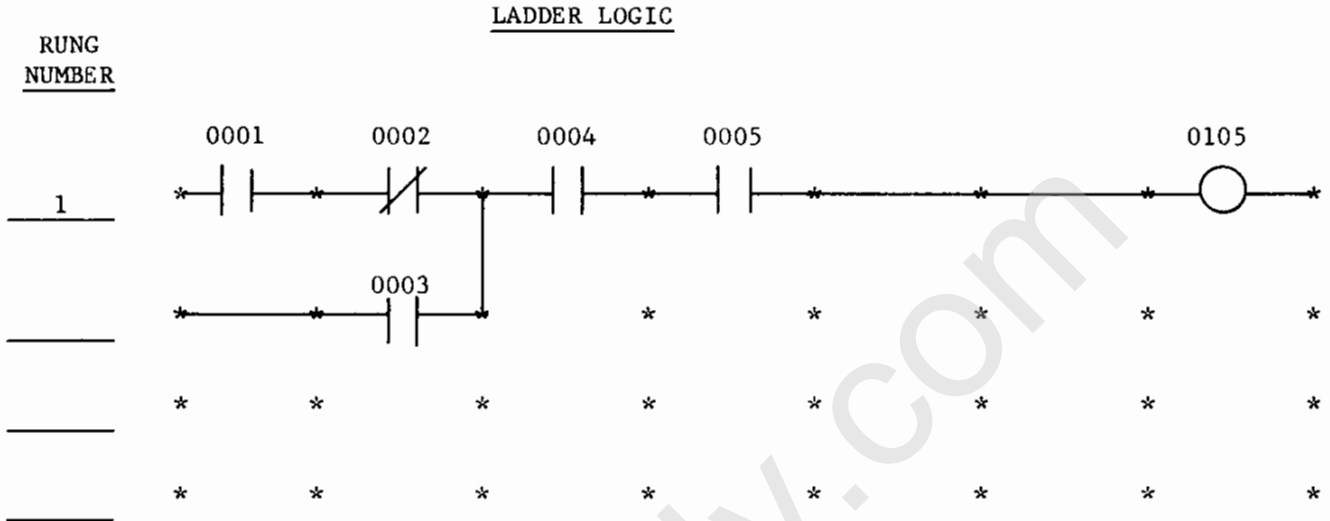


Figure 5.2
EXAMPLE, LADDER DIAGRAM DOCUMENTATION FORM

MNEMONICS

<u>RUNG</u>	<u>INSTRUCTION</u>	<u>COMMENTS</u>
1	STR 1	Start pushbutton
	AND NOT 2	{ Additional Input Devices
	OR 3	
	AND 4	
	AND 5	
	OUT 105	

Figure 5.3
EXAMPLE, PROGRAM MNEMONIC DOCUMENTATION FORM

Table 5.1 lists the 57 instructions for the Series Three. A more detailed explanation of each instruction can be found later in this chapter.

Table 5.1
SERIES THREE INSTRUCTIONS

Instruction	Definition	Memory Words	Execution Time (microseconds)
STR	START. Start rung with a N.O. (Normally Open) contact.	1	4.8 μ s ↓
STR TMR	START TIMER. Start rung with a N.O. contact referencing a timer	1	
STR CNT	START COUNTER. Start rung with a N.O. contact referencing a counter.	1	
STR NOT	START NOT. Start rung with a N.C. (Normally Closed) contact.	1	
STR NOT TMR	START NOT TIMER. Start rung with a N.C. timer contact.	1	
STR NOT CNT	START NOT COUNTER. Start rung with a N.C. counter contact.	1	
AND	Add a N.O. contact in series with the previous contact.	1	
AND TMR	AND TIMER. Add a N.O. timer contact in series with the previous contact.	1	
AND CNT	AND COUNTER. Add a N.O. counter contact in series with the previous contact.	1	
AND NOT	Add a N.C. contact in series with the previous contact.	1	
AND NOT TMR	AND NOT TIMER. Add a N.C. timer contact in series with the previous contact.	1	
AND NOT CNT	AND NOT COUNTER. Add a N.C. counter contact in series with the previous contact.	1	
OR	Add a N.O. contact in parallel with the previous contact.	1	
OR TMR	OR TIMER. Add a N.O. timer contact in parallel with the previous contact.	1	
OR CNT	OR COUNTER. Add a N.O. counter contact in parallel with the previous contact	1	

Table 5.1
SERIES THREE INSTRUCTIONS (Continued)

Instruction	Definition	Memory Words	Execution Time (microseconds)
OR NOT	Add a N.C. contact in parallel with the previous contact.	1	4.8 μ s ↓
OR NOT TMR	OR NOT TIMER. Add a N.C. timer contact in parallel with the previous contact.	1	
OR NOT CNT	OR NOT COUNTER. Add a N.C. counter contact in parallel with the previous contact.	1	
AND STR	AND STORE. Connects a logic group in series with the logic group preceeding it.	1	
OR STR	OR STORE. Connects a logic group in parallel with the logic group preceeding it.	1	
MCS	MASTER CONTROL START. Begin control of a block of logic with a master control relay.	1	40 μ s
MCR	MASTER CONTROL RESET. Ends control of a block of logic with a master control relay.	1	20 μ s
OUT MCS	OUT MASTER CONTROL START. Controls as block of logic and inhibits Outputs. References to the Outputs using SET, RST, SET OUT and D OUT are not affected.	1	50 μ s
OUT MCR	OUT MASTER CONTROL RESET. Ends control of an OUT MCS instruction.	1	40 μ s
OUT	Defines a coil for a rung of logic, either an external output or an internal coil.	1	5 μ s
SET	Defines a coil as being latched, the coil will remain on until turned off by RST.	1	30 μ s

Table 5.1
SERIES THREE INSTRUCTIONS (Continued)

Instruction	Definition	Memory Words	Execution Time (microseconds)										
SET OUT	IF ON, the coil will remain ON even under control of OUT MCS or when in the TEST mode.	1	30 μ s										
RST	RESET. Causes a coil that had been latched (SET) to be unlatched (Reset).	1	20 μ s										
SET OUT RST	SET OUT RESET. Defines a coil as being a one-shot (ON for one scan).	1	90 μ s										
TMR	TIMER. Programs a Timer operation. Times down to zero from a preset value. Elapsed time stored in an accumulate register. Self resetting. Preset time range is 0.1 seconds to 999.9 seconds.	2	<table style="border: none;"> <tr> <td></td> <td style="text-align: center;"><u>Data</u></td> </tr> <tr> <td>140 μs</td> <td rowspan="3" style="font-size: 2em; vertical-align: middle;">}</td> <td>Constant</td> </tr> <tr> <td>300 μs</td> <td>Data Register</td> </tr> <tr> <td>500 μs</td> <td>External</td> </tr> </table>		<u>Data</u>	140 μ s	}	Constant	300 μ s	Data Register	500 μ s	External	
	<u>Data</u>												
140 μ s	}	Constant											
300 μ s		Data Register											
500 μ s		External											
CNT	COUNTER. Programs a down counter. Counts down to zero from a preset value which can be 0 to 9999. The current count is stored in an accumulate register. Counters are retentive. Requires 2 rungs of logic; first rung enables the counter, the second rung resets the counter.	2	<table style="border: none;"> <tr> <td></td> <td style="text-align: center;"><u>Data</u></td> </tr> <tr> <td>140 μs</td> <td rowspan="3" style="font-size: 2em; vertical-align: middle;">}</td> <td>Constant</td> </tr> <tr> <td>300 μs</td> <td>Data Register</td> </tr> <tr> <td>500 μs</td> <td>External</td> </tr> </table>		<u>Data</u>	140 μ s	}	Constant	300 μ s	Data Register	500 μ s	External	
	<u>Data</u>												
140 μ s	}	Constant											
300 μ s		Data Register											
500 μ s		External											
SR	SHIFT REGISTER. Programs a shift register which can be 128 steps in length or a number of shift registers of varying lengths (128 bits total). Retentive. Requires 3 rungs of logic; (1) data, (2) clock, (3) reset. Can be programmed to shift forward or backward.	2	<table style="border: none;"> <tr> <td>90 μs</td> <td style="text-align: center;"><u>Inactive</u></td> </tr> <tr> <td></td> <td style="text-align: center;"><u>No. of Steps</u></td> </tr> <tr> <td>260 μs</td> <td style="text-align: center;">8</td> </tr> <tr> <td>340 μs</td> <td style="text-align: center;">16</td> </tr> <tr> <td>500 μs</td> <td style="text-align: center;">32</td> </tr> </table>	90 μ s	<u>Inactive</u>		<u>No. of Steps</u>	260 μ s	8	340 μ s	16	500 μ s	32
90 μ s	<u>Inactive</u>												
	<u>No. of Steps</u>												
260 μ s	8												
340 μ s	16												
500 μ s	32												

Table 5.1
SERIES THREE INSTRUCTIONS (Continued)

Instruction	Definition	Memory Words	Execution Time (microseconds)	
FUN 90	FUNCTION 90. Interrupt Input. Allows checking a specified input for a change of state more often than one time per scan. A block of logic is executed up to a FUN 91 if a change has occurred in the input since it was last checked. Acts as a high speed interrupt. Multiple FUN 90s can reference the same input.	2	300 μ s	
FUN 91	FUNCTION 91. Specifies the end of the logic block initiated by FUN 90. When reaching the FUN 91, the program jumps to the address immediately after that particular FUN 90 which initiated the interrupt.	2	80 μ s	
D • STR	DATA STORE. Loads accumulator with a BCD value which can be a 4 digit constant or the contents of a specified 2 byte reference.	2	Inactive 100 μ s	Active 150 μ s
D • STR1	DATA STORE1. Loads the lower byte (least significant) of the accumulator with the contents of a specified 1 byte reference.	2	100 μ s	150 μ s
D • STR2	DATA STORE2. Loads the lower 4 bits of the accumulator with the upper 4 bits of a specified 1 byte reference.	2	100 μ s	150 μ s
D • STR3	DATA STORE3. Loads the lower 4 bits of the accumulator with the lower 4 bits of a specified 1 byte reference.	2	100 μ s	150 μ s
D • OUT	DATA OUT. The contents of the accumulator (2 bytes) are written to a specified 2 byte reference (Output, Internal Relay, Shift Register Coils, Data Register or T/C Accumulate Register).	2	100 μ s	150 μ s

Table 5.1
SERIES THREE INSTRUCTIONS (Continued)

Instruction	Definition	Memory Words	Execution Time (microseconds)	
			Inactive	Active
D • OUT1	DATA OUT1. The contents of the lower byte of the accumulator are written to a specified 1 byte reference (Output, Internal Relay, Shift Register or Data Register).	2	100 μ s	150 μ s
D • OUT2	DATA OUT2. The contents of the lower 4 bits of the accumulator are written to the upper 4 bits of a specified 1 byte reference (Output, Internal Relay, Shift Register or Data Register).	2	100 μ s	150 μ s
D • OUT3	DATA OUT3. The contents of the lower 4 bits of the accumulator are written to the lower 4 bits of a specified 1 byte reference (Output, Internal Relay, Shift Register or Data Register).	2	100 μ s	150 μ s
+	ADDITION (BCD). The contents of the accumulator are added to a 4 digit constant or the contents of a specified 2 byte reference (Input, Internal Relay, Shift Register or Data Registers).	2	100 μ s	250 μ s
—	SUBTRACTION (BCD). The contents of a specified 2 byte reference (Input, Internal Relays, Shift Register, or Data Registers) or a 4 digit BCD constant are subtracted from the contents of the accumulator.	2	100 μ s	250 μ s
×	MULTIPLICATION (BCD). The contents of the accumulator are multiplied by the contents of a specified 2 byte reference (Input, Internal Relays, Shift Register, or Data Registers) or a 4 digit BCD constant. The lower 4 digits of the result remain in the accumulator, the upper 4 digits are stored in registers 676 and 677 which are the auxiliary accumulator.	2	100 μ s	1000 to 1500 μ s

Table 5.1
SERIES THREE INSTRUCTIONS (Continued)

Instruction	Definition	Memory Words	Execution Time (microseconds)	
			Inactive	Active
\div	DIVISION (BCD). The contents of the accumulator are divided by the contents of a specified 2 byte reference (I, IR, SR, or DR) or a 4 digit BCD constant. The first 4 digits of the answer are stored in the accumulator and the remainder is stored in the auxiliary accumulator (registers 676 and 677).	2	100 μ s	1000 μ s to 3000 μ s
D • AND	DATA AND (Logic product). The contents of the accumulator are logically AND-ed with the contents of a specified 2 byte reference (I, IR, SR, or DR) or a 4 digit BCD constant. The result is stored in the accumulator.	2	100 μ s	250 μ s
D • OR	DATA OR (Logic Sum). The contents of the accumulator are logically OR-ed with the contents of a specified 2 byte reference (I, IR, SR, or DR) or a 4 digit BCD constant. The result is stored in the accumulator.	2	100 μ s	250 μ s
$>=<$	COMPARE. The contents of the accumulator are compared to the contents of a specified 2 byte reference (I, IR, SR, or DR) or a 4 digit BCD constant. Internal coils turn on to reflect the result of the comparison. Acc Data } 4452 On Acc = Data } 4453 On Acc Data } 4454 On	2	100 μ s	250 μ s

Table 5.1
SERIES THREE INSTRUCTIONS (Continued)

Instruction	Definition	Memory Words	Execution Time (microseconds)					
			Inactive	Active				
INV	INVERT. The 16 bits of the accumulator are inverted; i.e. 1 to 0 and 0 to 1. Example: <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>1101 1001</td> <td>0110 0111</td> </tr> </table> inverted to <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>0010 0110</td> <td>1001 1000</td> </tr> </table>	1101 1001	0110 0111	0010 0110	1001 1000	1	100 μ s	150 μ s
1101 1001	0110 0111							
0010 0110	1001 1000							
BIN	BINARY. Converts a BCD value in the accumulator to a binary code.	1	100 μ s	300 μ s				
BCD	BINARY CODED DECIMAL. Converts a binary code in the accumulator to a BCD value.	1	100 μ s	300 μ s				
F80	FUNCTION 80, SHIFT RIGHT N BITS. Contents of the accumulator are shifted to the right by the specified number of bits (1-15). Positions from which bits were shifted are filled with zeros.	2	100 μ s	200 μ s 1 bit shift				
F81	FUNCTION 81, SHIFT LEFT N BITS. Contents of the accumulator are shifted to the left by the specified number of bits (1-15). Positions from which bits were shifted are filled with zeros.	2		350 μ s 7 bit shift 500 μ s 15 bit shift				
F82	FUNCTION 82, DECODE. Decodes the lower 4 bits of the accumulator to a decimal number from 0 to 15 and places a 1 in the bit position in the accumulator which corresponds to that decimal number.	1	100 μ s	250 μ s				

Table 5.1
SERIES THREE INSTRUCTIONS (Continued)

Instruction	Definition	Memory Words	Execution Time (microseconds)	
			Inactive	Active
F83	FUNCTION 83, ENCODE. Encodes a bit in the accumulator; to a binary code representing the position number (0 - 15) and places the binary code in the lower four bits of the accumulator.	1	100 μ s	250 μ s
F20	FUNCTION 20, EXTERNAL FAULT DIAGNOSIS. Allows external devices to be monitored for unwanted conditions. If a fault occurs a preassigned 4 digit BCD number is displayed on the programmer data display and the FAULT relay contacts on the power supply terminal board are closed. Multiple fault conditions can be monitored.	2	100 μ s	300 μ s

BUILDING A PROGRAM

This section provides a guide for entering and using each of the instructions. The format used is as follows:

- Instruction mnemonic (name).
- Description of how the instruction is used.
- Valid References.
- Step-by-step keystrokes required to enter the instruction in a rung of ladder logic.
- Illustration of how the instruction fits into a rung of logic.
- Combining the instruction with others to form a complete rung.

The instructions are listed in groups that correspond to their functionality. Table 5.2 lists the instructions grouped in this manner.

Table 5.2
SERIES THREE INSTRUCTION GROUPS

BASIC	STR, STR TMR, STR CNT, STR NOT, STR NOT TMR, STR NOT CNT AND, AND TMR, AND CNT, AND NOT, AND NOT TMR, AND NOT CNT OR, OR TMR, OR CNT, OR NOT, OR NOT TMR, OR NOT CNT AND STR, OR STR MCS, MCR, OUT MCS, OUT MCR OUT, SET, SET OUT, RST, SET OUT RST TMR, CNT, SR
MOVE	D • STR, D • STR1, D • STR2, D • STR3 D • OUT, D • OUT1, D • OUT2, D • OUT3
ARITHMETIC	+, -, X, ÷, >=<
LOGICAL	D • AND, D • OR, INV
CONVERT	BIN, BCD, FUN 80, FUN 81, FUN 82, FUN 83
SPECIAL	FUN 90, FUN 91, FUN 20

BASIC INSTRUCTIONS

This group can be considered as the basic building blocks for a relay ladder diagram. The instructions reference discrete bits that are to be part of an operation; i.e., a conditional contact or the end of a rung, which could be an output or an internal relay.

STR

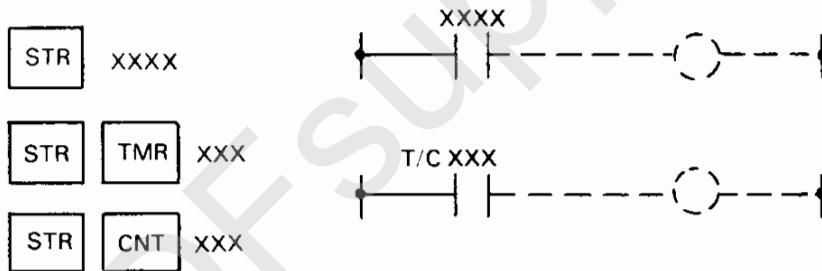
STR TMR

STR CNT

Starts a rung of logic with a N.O. (Normally Open) contact.

Valid References

0000-0617	}	STR
4000-4457		
7000-7077		
9000-9177		
000-177		STR TMR, STR CNT



STR NOT

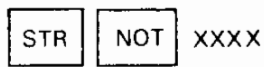
STR NOT TMR

STR NOT CNT

Starts a rung of logic with a N.C. (Normally Closed) contact.

Valid References

0000-0617	}	STR NOT
4000-4457		
7000-7077		
9000-9177		
000-177		STR NOT TMR, STR NOT CNT



AND

AND TMR

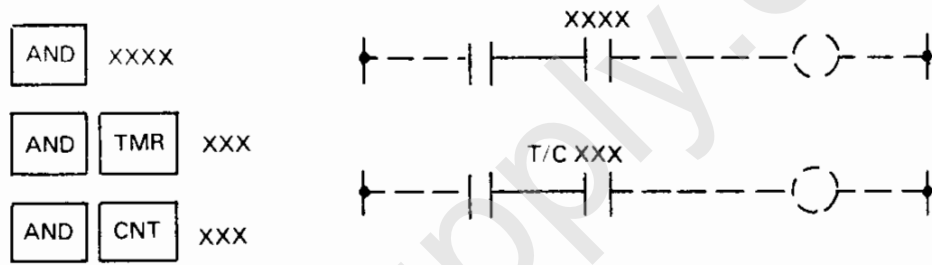
AND CNT

Enters a N.O. contact in series with the previous condition (logic product).

Valid References

0000-0617 }
 4000-4457 } AND
 7000-7077 }
 9000-9177 }

000-177 AND TMR, AND CNT



AND NOT

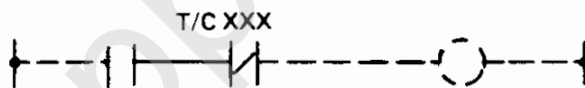
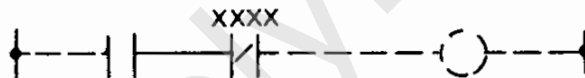
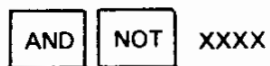
AND NOT TMR

AND NOT CNT

Enters a N.C. contact in series with the previous condition (logic product).

Valid References

0000-0617	}	AND NOT
4000-4457		
7000-7077		
9000-9177		
000-177		AND NOT TMR, AND NOT CNT



OR

OR TMR

OR CNT

Enters a N.O. contact in parallel with the previous condition (logic sum).

Valid References

0000-0617

4000-4457

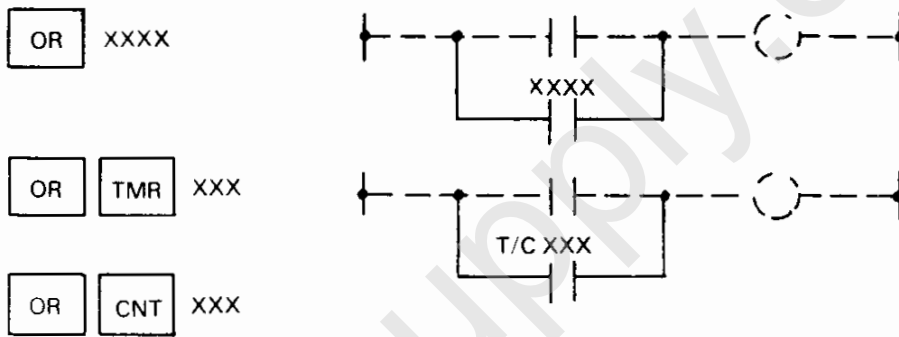
7000-7077

9000-9177

000-177

OR

OR TMR, OR CNT



OR NOT

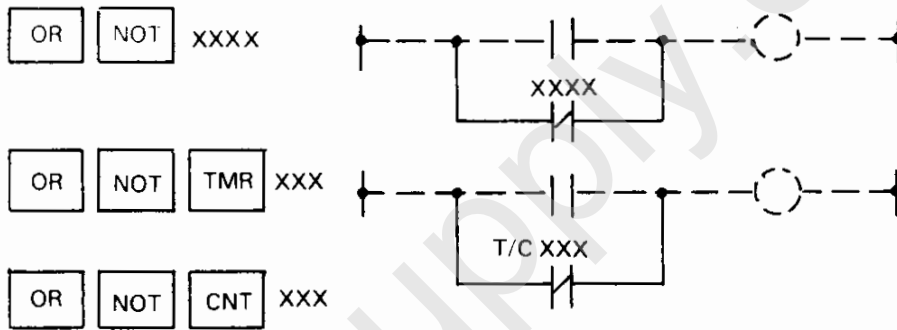
OR NOT TMR

OR NOT CNT

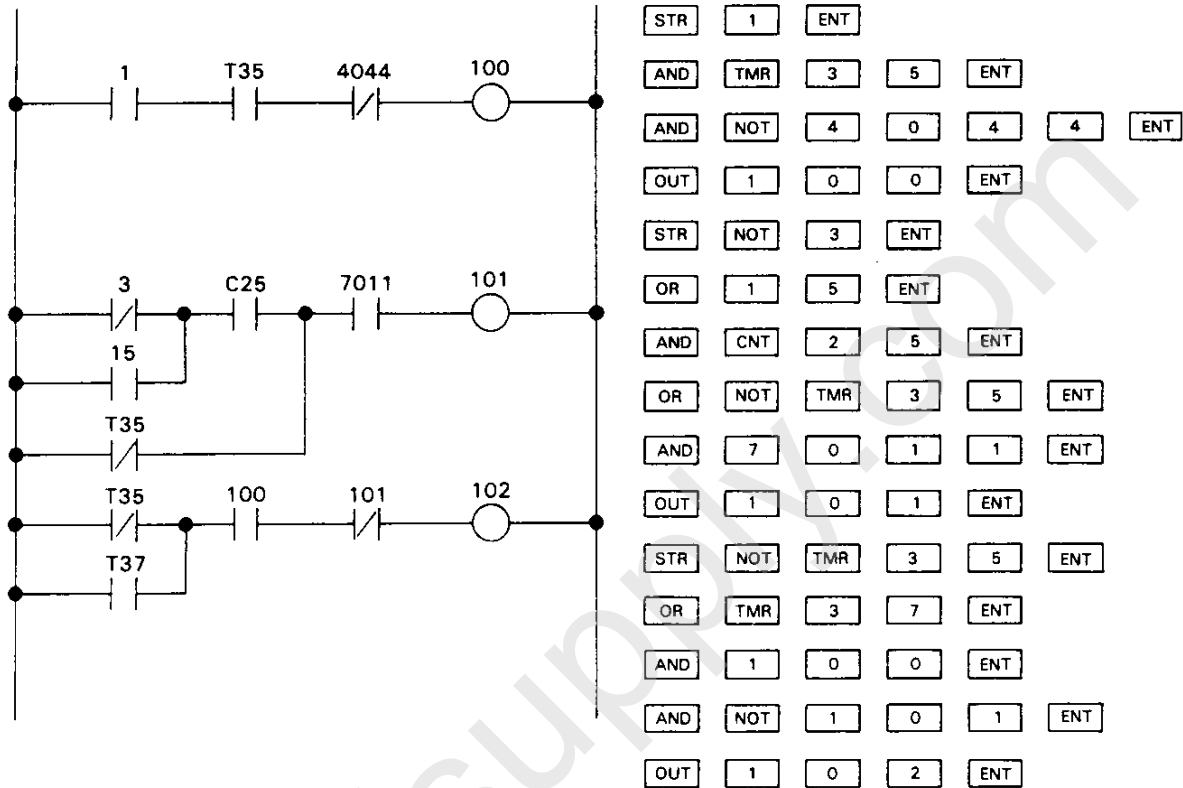
Enters a N.C. contact in parallel with the previous condition (logic sum).

Valid References

0000-0617	}	OR NOT
4000-4457		
7000-7077		
9000-9177		
000-177		OR NOT TMR, OR NOT CNT

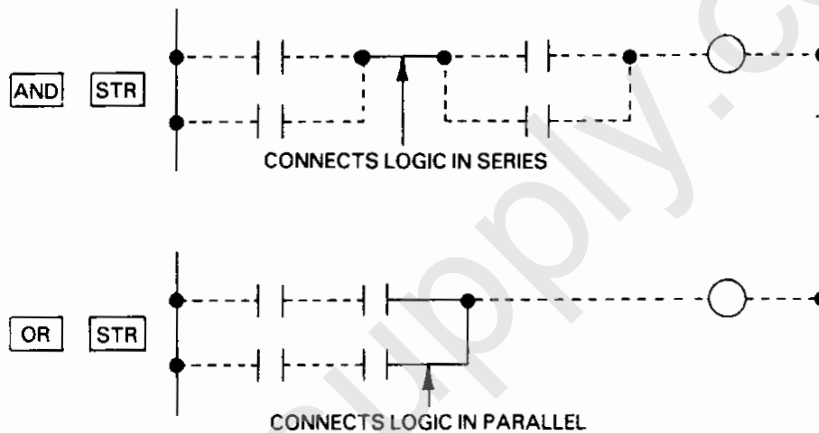


The following example of a ladder diagram uses many of the instructions listed up to this point. The key sequence shows how to enter the rung.



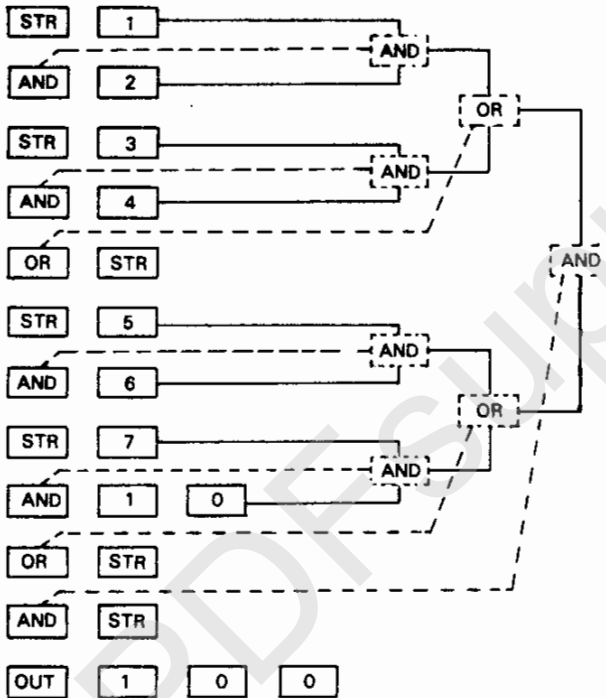
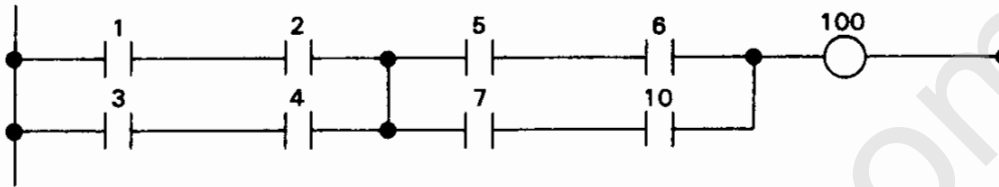
*AND STR**OR STR*

The AND STR provides a common series connection between a block of logic and the OR STR provides a common parallel connection for a block of logic. These instructions provide the connecting links not allowed with any of the previously mentioned instructions. The logic used with this type of operation is referred to as a push-down stack. The push-down stack can accommodate up to eight levels (groups) of logic. A push-down stack can be thought of as a temporary storage area to allow the combining of elements in series (AND) or parallel (OR) connections.



An example of a more complex rung of logic illustrates how logic is connected using the AND STR and OR STR in the same rung. The keystroke sequence for entering the logic is shown. The connecting lines and blocks to the right show how the contacts are connected by the AND STR and OR STR.

- Example of programming the AND STR and OR STR instructions.



NOTE

Dotted lines and squares illustrate how the AND, OR, AND STR and OR STR keystrokes tie the logic together. The dotted squares are not additional keystrokes.

*MCS**MCR*

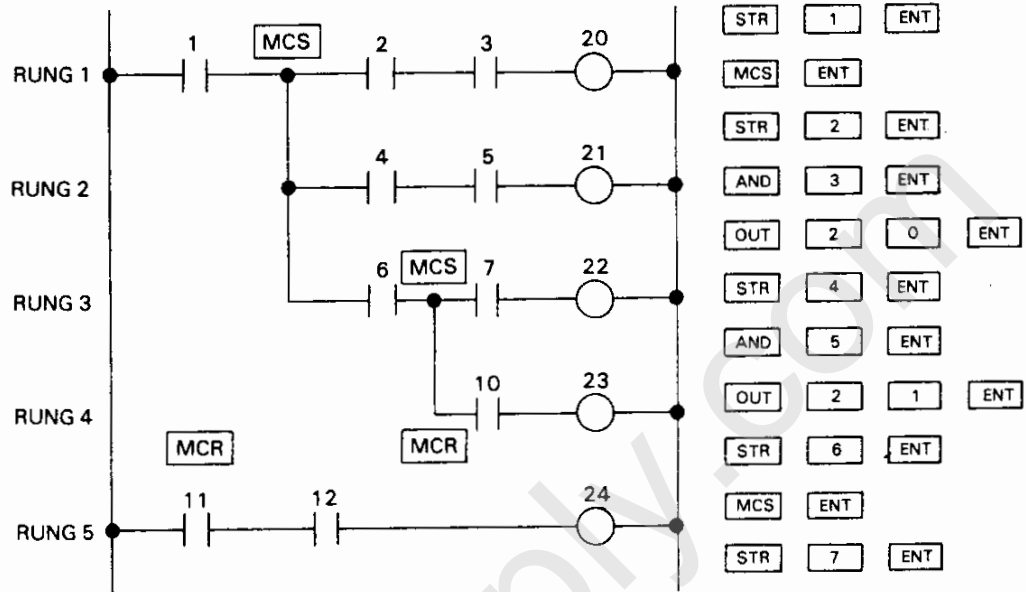
The MCS (Master Control Start) and MCR (Master Control Reset) instructions are used to implement and end a Master Control relay function. This provides a method of efficient programming for turning off large quantities of coils if a specific permissive condition is not satisfied. When programming an MCS, the permissive logic is built starting with the power rail (left side of the ladder diagram). Then an MCS is entered, followed by the logic it is to control, and finally, ending with an MCR instruction.

When power flows to the MCS, the logic after it will operate normally. When the MCS is de-energized (no power flow to it), the coils under its control will be forced to the OFF state regardless of the logic conditions controlling each coil. The logic that can be controlled by an MCS is limited only by the quantity of program memory available.

In the following example of programming an MCS, it may help to understand how the MCS/MCR works by viewing the MCS instruction as defining a new left power rail whose connection to the main power rail is dependent on the preceding logic.

Multiple Master Control relay functions can be used in any program. They can also be nested in a program; i.e., MCS/MCR under the control of a previous MCS/MCR. This is shown in the example. In order to operate properly, each MCS must end with an MCR. Up to 8 levels of MCS control can be nested.

- Example of programming the MCS/MCR instructions to control a group of coils.



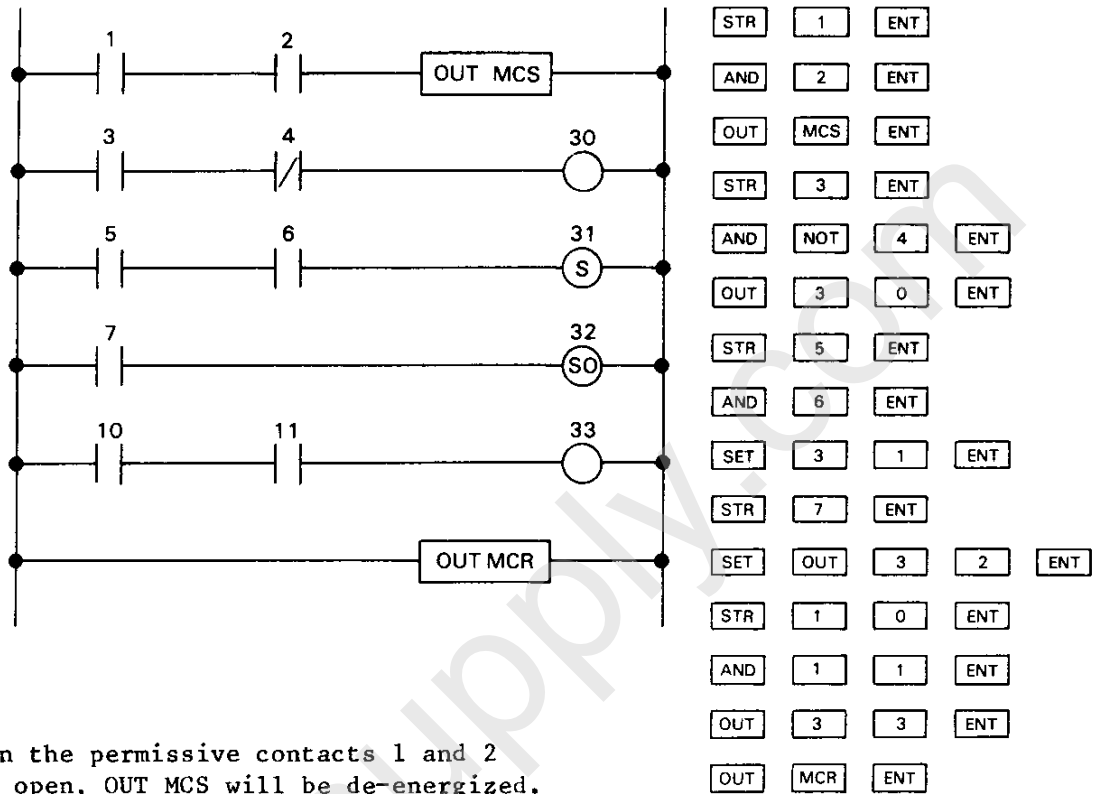
- If the MCS in rung 1 is de-energized (no power flow to it), coils 20, 21, 22 and 23 will always be OFF.
- If the MCS in rung 1 is energized and the MCS in rung 3 is de-energized, coils 22 and 23 will always be OFF. In this case coils 20 and 21 would be controlled normally by the logic preceding it.
- The first MCR ends control of the second MCS, the second MCR ends control of the first MCS.

*OUTMCS**OUTMCR*

The OUT MCS and OUT MCR instructions are used to implement and end a Master Control relay function that inhibits external outputs using the OUT instruction. All external coils between the OUT MCS and OUT MCR are affected. External outputs referenced by the SET, RST, SET OUT and D OUT instructions are not inhibited. If an output referenced by the SET, SET OUT or D OUT is turned ON, it will remain on when switching to the TEST mode.

The OUT MCS and OUT MCR instructions can be nested in a program the same as the MCS and MCR. Each OUT MCS must end with an OUT MCR. The OUT MCS controls the logic following it when it is de-energized (no power flow from preceding logic).

- Example of programming OUT MCS and OUT MCR to inhibit external outputs.



- When the permissive contacts 1 and 2 are open, OUT MCS will be de-energized.
- Outputs 30 and 33 will be inhibited, regardless of the state of the conditional contacts preceding those outputs.
- When contacts 1 and 2 are closed, OUT MCS will be energized and logic operation between OUT MCS and OUT MCR will be normal.

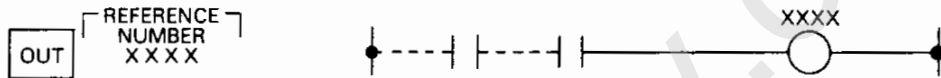
OUT

The OUT instruction is used to assign a coil to a rung of logic. The coil can be defined as an external output or an internal relay. Power flow to the coil will cause it to turn ON, with no power flow, it will be OFF. When ON, it will remain ON as long as the conditional logic preceeding it provides power flow.

If the coil is assigned an external output number, its output control function will be inhibited if an OUT MCS instruction is implemented.

Valid References

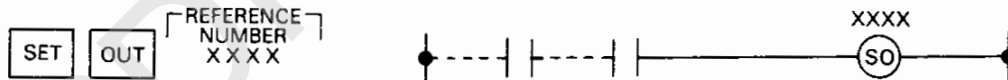
0000-0617	} External Outputs
4000-4457	
7000-7077	} Internal Relay Coils
9000-9177	



Outputs can be paralleled by entering additional OUT instructions at the end of a rung of logic; i.e. OUT 120, OUT 121, OUT 122, etc.

SET OUT

The SET OUT instruction assigns a coil to a rung of logic and uses the same reference numbers as the OUT instruction. SET OUT operation is the same as operation using the OUT instruction, except that an output referenced by SET OUT will not be inhibited when the OUT MCS instruction is executed. An output referenced by SET OUT will also remain ON when the mode switch is turned to the TEST position.



SET OUT RST

When a coil is defined by the SET OUT RST instruction, that coil will operate as a one-shot. A one-shot coil when turned ON, will remain on for only 1 scan. It turns on when power flow to it makes an OFF to ON transition. Power flow is usually completed to the one-shot coil by the closing of a momentary pushbutton or contact.

Valid References

- | | | |
|-----------|---|----------------------|
| 0000-0617 | } | External Outputs |
| 4000-4457 | | Internal Relay Coils |
| 7000-7077 | | |
| 9000-9177 | | |

- Example of using a one-shot.

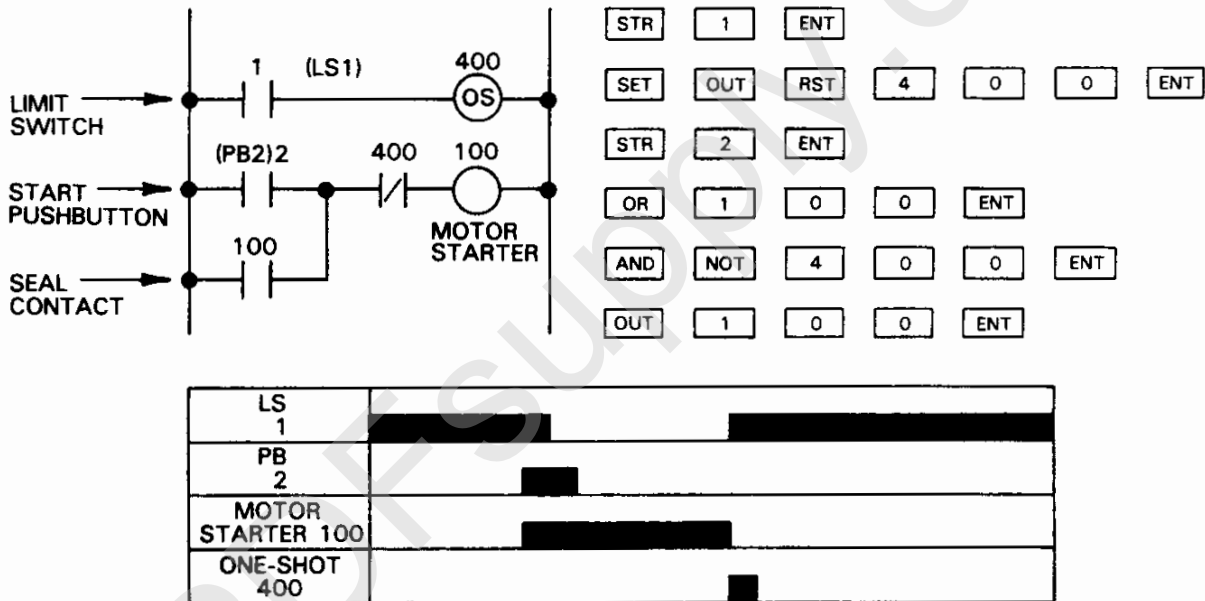


Figure 5.4
TIMING CHART, ONE-SHOT OPERATION

- When start pushbutton 2 is depressed, motor starter output coil 100 turns on and remains on when seal contact 100 closes. LSI detects 1 revolution and is made momentarily, turning the one-shot (Output 400) ON for 1 scan. The one-shot contact in rung 2 opens, turning off output 100.

TIMERS AND COUNTERS

Two of the most commonly used non-relay functions are timing and counting. Both of these functions are easily programmed in the Series Three and are standard features. Both timers and counters use special internal coils using references 000-177. A total of 128 coils are available for timers or counters. Either 128 timers or 128 counters or a combination of timers and counters up to 128 can be programmed. Both timers and counters are two-word instructions, T/C number and preset.

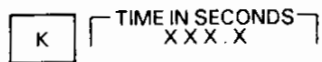
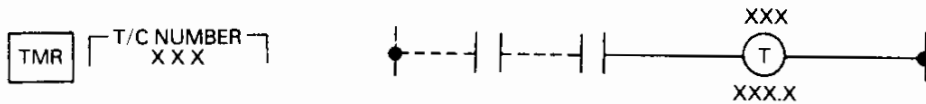
Timers are non-retentive and time down from a preset value of 0.1 seconds to 999.9 seconds. The timers are not self resetting. When the timer preset reaches zero, it's coil turns on. The preset value can be a constant or can be entered by specifying a group (8 bit) reference that can be an Input, Internal coil, Shift Register or Data Register. The basic clock that drives the timers derives its accuracy from a crystal in the CPU.

The elapsed value of a timer or counter is stored in a group of 16-bit registers referred to as timer or counter accumulated value registers. To monitor the timing or counting functions, the accumulated value register contents are displayed. Refer to Table 4.8 for a complete listing of the timer or counter numbers and their corresponding accumulated value register. The accumulated value register is the timer or counter number plus 200.

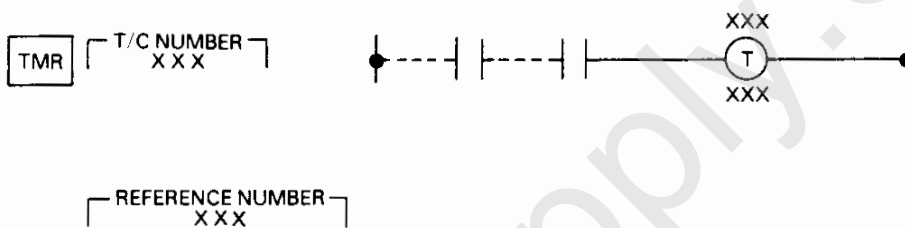
Counters are retentive and count down from a preset value (1 to 9999) to zero. Counters require two rungs of logic. The top rung controls decrementing of the counter. Each time the rung changes from no power flow (OFF) to power flow (ON) the counter decrements by one count. The lower rung of logic causes the counter to be reset to zero whenever the rung has power flow. If both rungs supply power flow to the counter, no counts are recorded and the counter is forced to zero.

TMR

- Programming a timer by specifying a constant value as the preset.

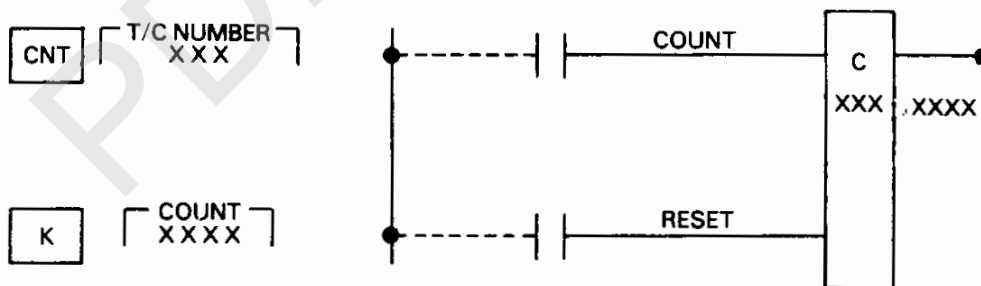


- Programming a timer by specifying a preset value from a group reference. A group reference is the first three digits of 8 consecutive I/O points, internal coils, etc.; e.g., group reference 440 refers to internal coils 4400 to 4407.

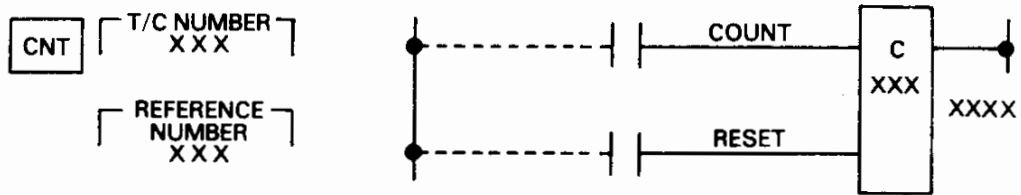


CNT

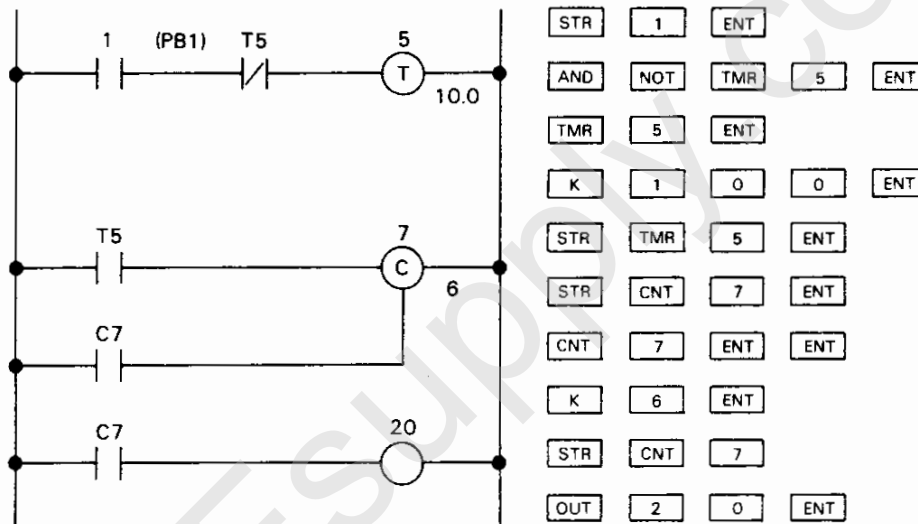
- Programming a counter by specifying a constant value as the preset.



- Programming a counter by specifying a preset value from a group reference.



- Example of programming a timer and using the timer coil reference as the count input for a counter.



- When PB1 is closed Timer 5 will begin timing (preset is 10 seconds). Each time the timer preset reaches zero, the time contact T5 will close, decrementing the counter, C7, one count. When the counter counts down to zero from its preset (6), 60 seconds will have elapsed. Contact C7 resets the counter. The counter contact, C7 will turn on output coil 20 at one minute intervals.

SHIFT REGISTERS

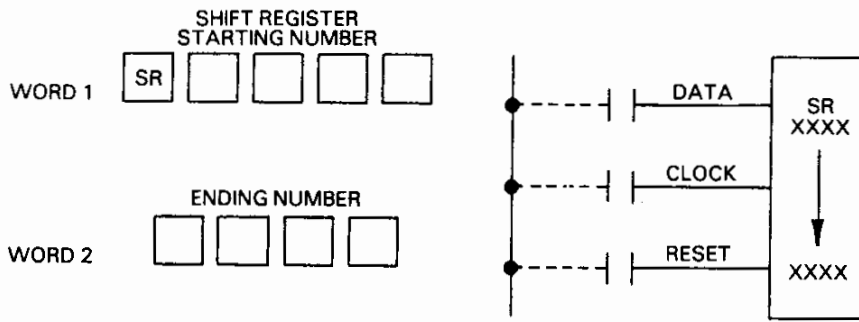
Another feature of the Series Three is the capability of easily programming shift registers. The built in shift register function can be programmed to shift up to 128 steps. A group of internal coils (references 9000 to 9177) are available to use when building a shift register. This group of coils allows one shift register to have 128 steps or a number of shift registers can be programmed with a total maximum number of 128 steps for all shift registers.

A shift register is retentive and requires 3 rungs of logic.

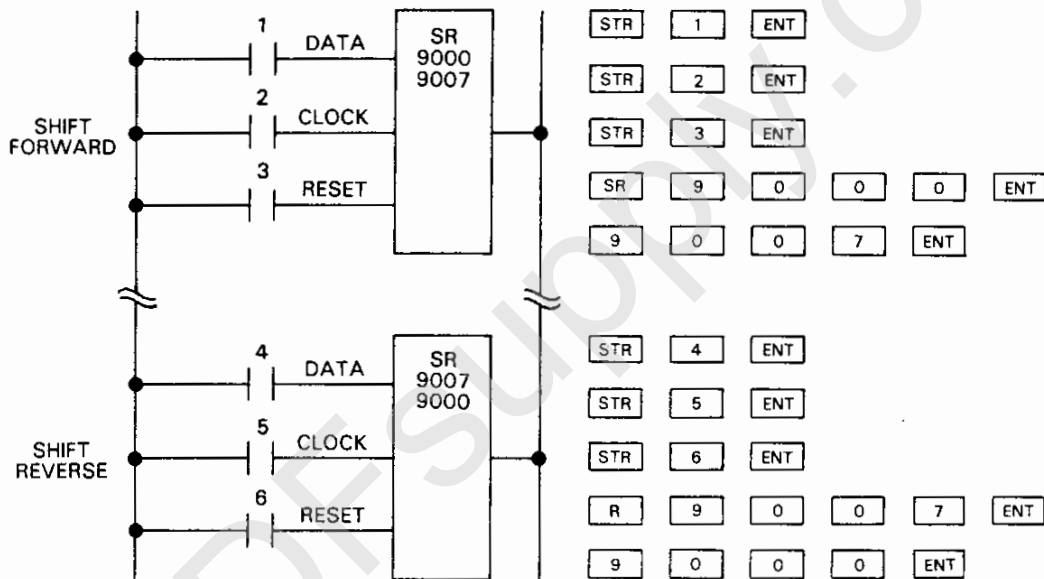
1. DATA. Information to be shifted. ON (1) or OFF (0) status can be shifted.
2. CLOCK. For each transition (rise) of the clock input, the information into DATA will shift one step.
3. RESET. Resets the shift register when an OFF to ON transition occurs.

When a shift register is built, the first coil (step 1) and the last coil must be specified. If the lower number coil is specified first the shift register will step forward. If the higher number coil is specified first, the shift register will step in the reverse direction.

When specifying a shift register, 2 words of program memory are used. The first word specifies a shift register and the starting coil, the second word specifies the ending coil. This is shown in the following example.



- Example of the programming sequences for forward and reverse shifting shift registers.



*FUN 90**FUN 91*

The FUN 90 (Function 90) and FUN 91 (Function 91) instructions are used to begin and end control of a high speed interrupt which will allow checking an input for a change in status (ON to OFF or OFF to ON) more than one time per scan. If a change in the input is detected (since it was last checked) a subroutine (which must be located at the beginning of user memory) which can be a rung or several rungs of logic is initiated. If there had been no change in the input, the logic flow would continue in the normal sequence.

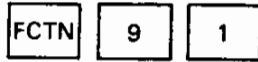
More than one FUN 90 can be entered in a program; one input can be checked several times or more than one input can be checked. Use of this instruction allows a real time update of an input.

NOTE

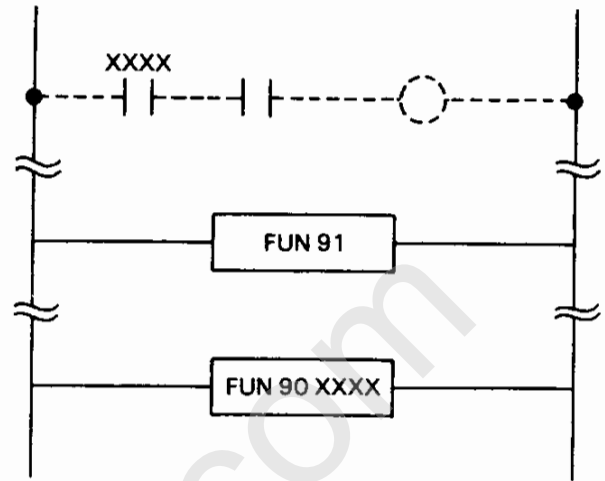
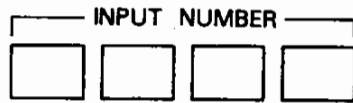
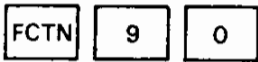
When programming the subroutine sequence, consideration must be given to the total scan time. If a number of F90s are programmed in a program using a lot of program memory locations, it would be possible to exceed the time of the system watch-dog timer. This would cause the CPU to stop scanning.

• Programming FUN 90, FUN 91

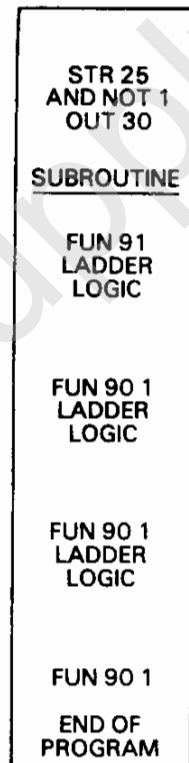
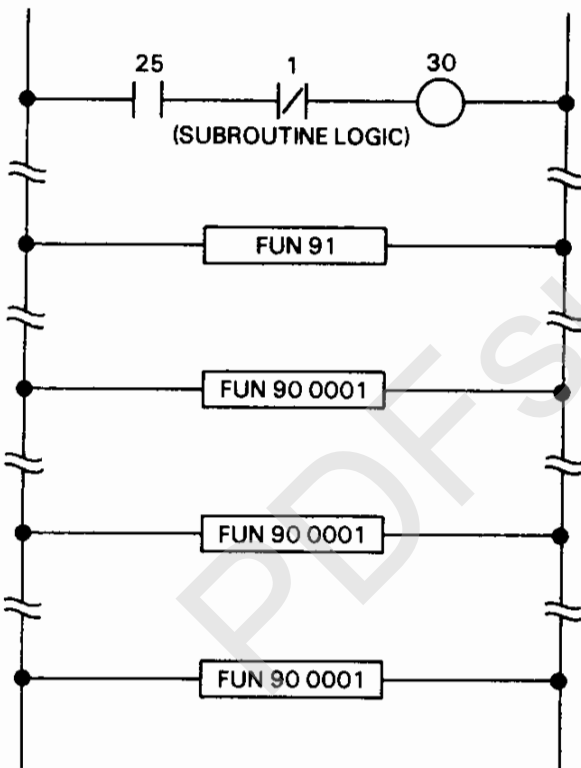
Enter after subroutine logic



Initiates Input Check when encountered in program



• Example of subroutine execution



Start of Program

Input 1, will be checked for change of state since last time checked. Assume Input 1 initially closed.

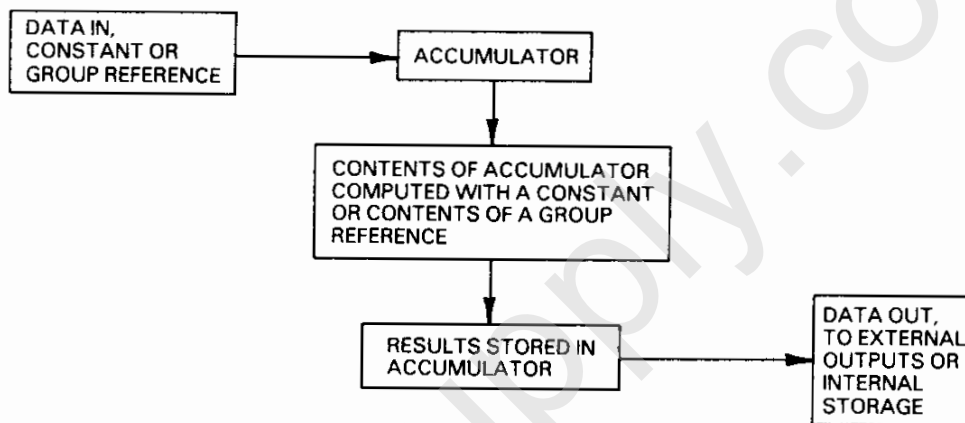
Input 1 checked, no change of state detected at (a). Logic flow continues to next FUN 90.

At (b), Input 1 checked, now OPEN. Subroutine logic is executed to the FUN 91. Program then jumps back to (b) and continues.

DATA OPERATIONS

The Series Three has a group of instructions that include data moves, math functions, logical operations, and conversion. These instructions provide the capability of performing various data operations. These instructions operate on multiple bits rather than one bit at a time.

All of these instructions require that the data to be operated on be loaded (stored) into a 16-bit register called the accumulator. When an operation is performed with the contents of the accumulator, the result of the operation is stored in the accumulator. This data can then be transferred to external outputs or stored internally to be used as needed.

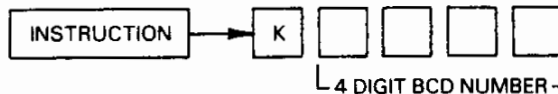


The contents of the accumulator do not change until new data is loaded into it or a computation takes place and the result is stored in the accumulator.

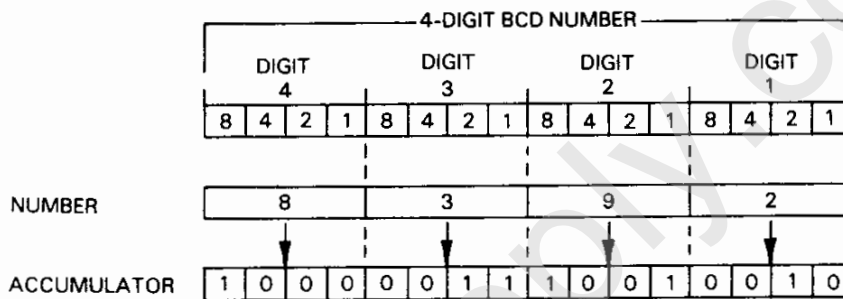
SPECIFYING DATA

When entering an instruction for a data operation, the instruction is specified, then the data. The data can be a constant value or a group reference that contains the data to be used.

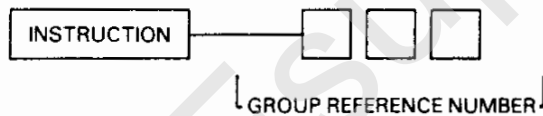
- Constant value



When a constant (4-digit BCD number) is entered as the data value, the bits of the BCD numbers will be stored in the corresponding position in the accumulator.



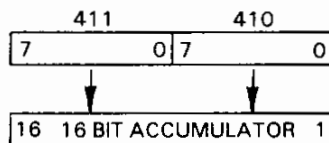
- Group reference



The group reference number is the first three digits of the discrete reference for each 8-bit group (T/C accumulated value register is 16-bits).

When the group reference is specified, that reference and the next higher reference are used.

- Example: Reference specified is 410



Contents of 410 and 411 (16 bits) are loaded into the accumulator

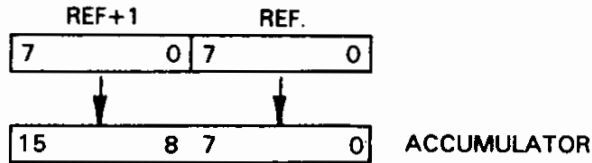
Discrete bit 4100 will be stored in the first position of the accumulator; discrete bit 4117 will be stored in the last position (16) of the accumulator.

When a program is entered to perform any of the data operations, the first instruction must have a conditional contact entered immediately preceding it. When entering any of the data operation instructions, the SHF key must first be pushed, then the key directly beneath the instruction. When the ENT key is pushed the data display will display a function number, F50, F51, etc. These numbers are assigned internally to each of the data instructions and are listed below. The function number will be displayed for an instant, then the address will advance 1 step and 500 will be displayed. The second word (data entry) should now be entered. If no entry is made and the ENT key is pushed, 500 is entered as the default value. 500 is the first Data Register.

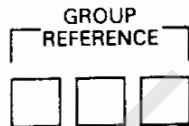
Instruction	Display	Instruction	Display
D • STR	F50	X	F73
D • STR1	F51	÷	F74
D • STR2	F52	D • AND	F75
D • STR3	F53	D • OR	F76
D • OUT	F60	INV	F84
D • OUT1	F61	BIN	F85
D • OUT2	F62	BCD	F86
D • OUT3	F63	F80	F80
CMPR	F70	F81	F81
+	F71	F82	F82
-	F72	F83	F83
		F90	F90
		F91	F91
		F20	F20

D-STR

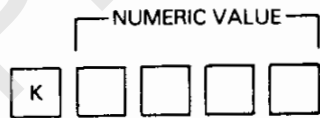
D • STR (Data Store) is a 2 word instruction which, when executed, loads the accumulator with a 4 digit BCD constant or the contents of a specified 2 byte reference.



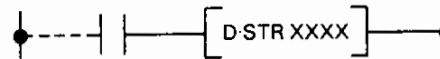
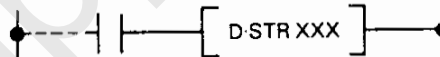
Valid References	
0000 - 0617	I/O System
4000 - 4451	
7000 - 7075	
9000 - 9177	Internal Coils
500 - 673	Shift Register Coils
200 - 377	Data Registers (8-bit)
	Timer/Counter Accumulate Value Registers (16-bit)



4 DIGIT CONSTANT VALUE

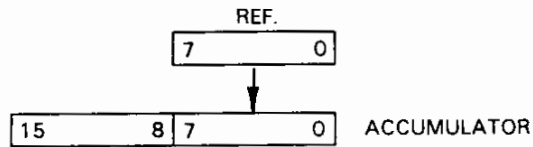


CONDITIONAL CONTACT

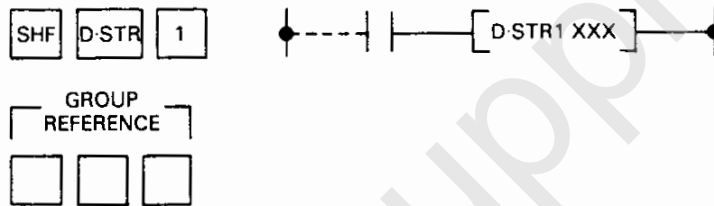


D-STR1

This is a 2 word instruction which, when executed loads the lower 8 bits of the accumulator with the contents of a specified 1 byte reference. The upper 8 bits (8-15) will be zeros.

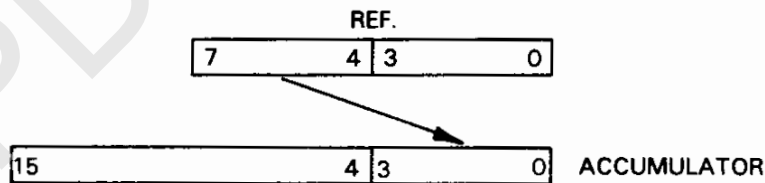


Valid References	
0000 - 0617	I/O System
4000 - 4451	Internal Coils
7000 - 7075	
9000 - 9177	Shift Register Coils
500 - 673	Data Registers

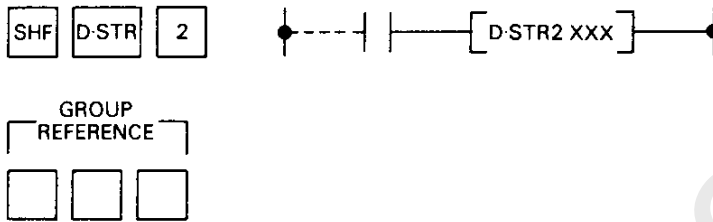


D-STR2

This is a 2 word instruction which, when executed loads the lower 4 bits of the accumulator with the upper 4 bits of a specified 1 byte reference.

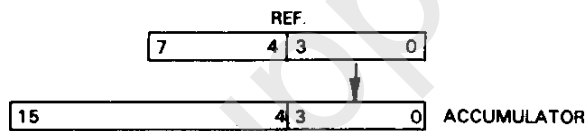


Valid References	
0000 - 0617	I/O System
4000 - 4451	Internal Coils
7000 - 7075	
9000 - 9177	Shift Register Coils
500 - 673	Data Registers

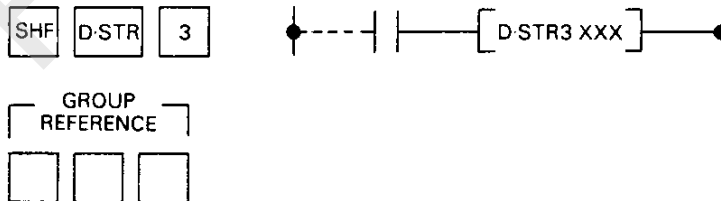


D-STR3

This is a 2 word instruction which, when executed loads the lower 4 bits of the accumulator with the lower 4 bits of a specified 1 byte reference.

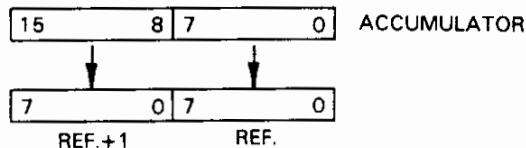


Valid References	
0000 - 0617	I/O System
4000 - 4451	Internal Coils
7000 - 7075	
9000 - 9177	Shift Register Coils
500 - 673	Data Registers



D-OUT

D • OUT (Data Out) is a 2 word instruction, which when executed transfers the contents of the accumulator (16 bits) to a specified 2 byte (group) reference (Output, Internal Relay, Shift Register coils, Data Registers or Timer/Counter accumulate value register).

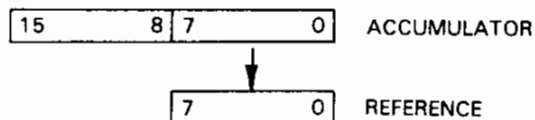


Valid References	
0000 - 0617	} I/O System Internal Coils
4000 - 4451	
7000 - 7075	
9000 - 9177	Shift Register Coils
500 - 673	Data Registers
200 - 377	Timer/Counter Accumulate Value Registers



D-OUT1

D • OUT1 is a 2 word instruction which, when executed will write the contents of the first 8 bits (0-7) of the accumulator to a specified reference.

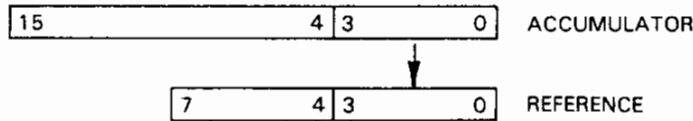


Valid References	
0000 - 0617	I/O System
4000 - 4451	Internal Coils
7000 - 7075	
9000 - 9177	Shift Register Coils
500 - 673	Data Registers



D-OUT3

D • OUT3 is a 2 word instruction, which when executed will write the contents of the lower 4 bits of the accumulator to the lower 4 bits of a specified reference.



Valid References	
0000 - 0617	I/O System
4000 - 4451	
7000 - 7075	
9000 - 9177	Shift Register Coils
500 - 673	Data Registers

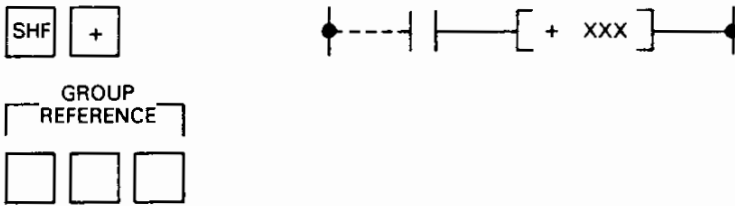


ADDITION (+), BCD 4 DIGIT

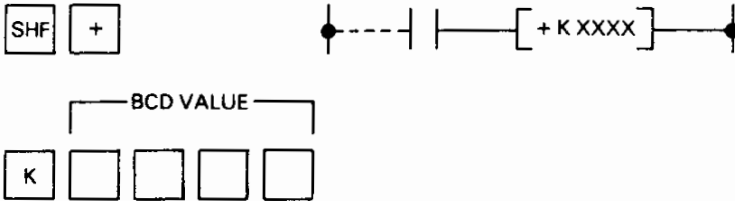
The contents of a 4 digit constant or a specified 2 group reference are added to the contents of the accumulator. The result of the addition is stored in the accumulator as a 4 digit BCD number. If the answer is >9999, the carry flag (Internal coil, 4455) will turn on. If the answer is zero, the zero flag (4456) will turn on. The flag coils can be used in a program as references for contacts to turn on an output connected to a light or other device to provide an indicator of the flag conditions.

Valid References	
0000 - 0617	I/O System
4000 - 4451	
7000 - 7075	
9000 - 9177	Shift Register Coils
500 - 673	Data Registers
200 - 377	T/C Accumulated Value registers

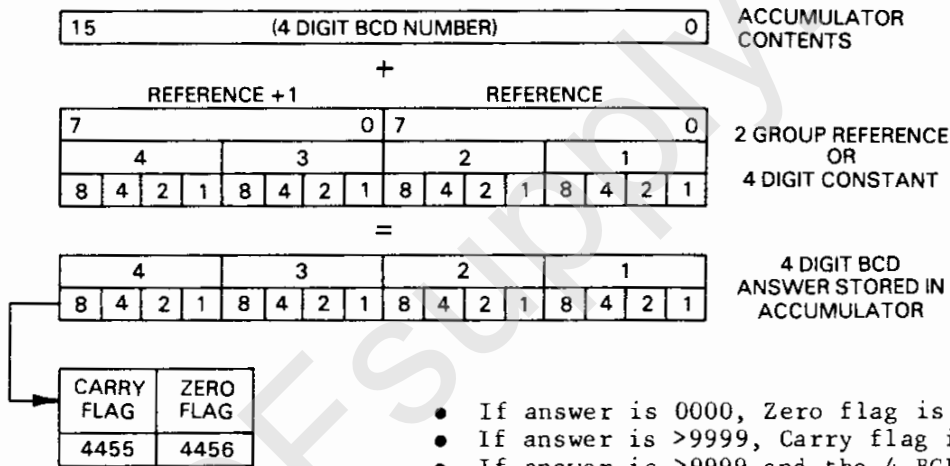
FLAGS	
CARRY	ZERO
4455	4456



4 DIGIT CONSTANT VALUE

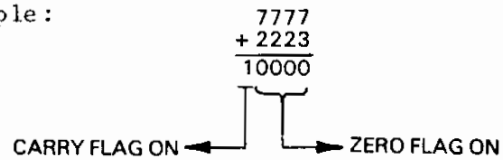


• Addition sequence



- If answer is 0000, Zero flag is ON
- If answer is >9999, Carry flag is ON
- If answer is >9999 and the 4 BCD digits are 0000, both the Carry and Zero flags will turn ON.

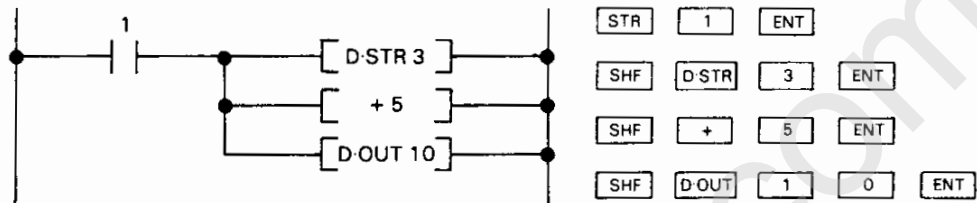
Example :



- Addition Programming Example

Example 1

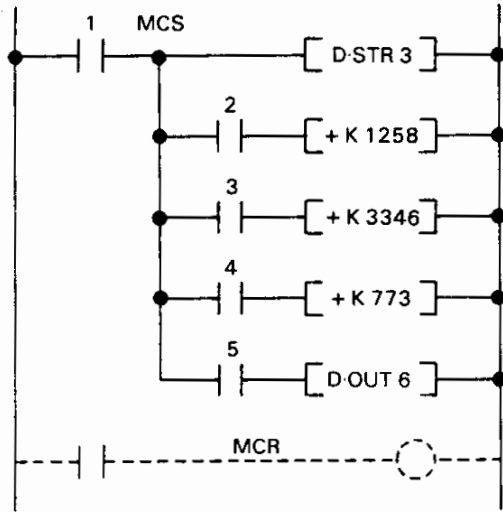
4 BCD digits are loaded in accumulator from Inputs 0030-0047.



- The contents of the accumulator are added to data from Inputs 0050-0067.
- The answer is stored in the accumulator and also written to Outputs 0100 - 0117. If D* OUT is specified as a Data Register, Internal coil, etc.; the answer would be stored at that location for further use in the program.

Example 2

This example shows more than one constant value entered in the program. By closing the respective contact, a different number can be selected to be added to the contents of the accumulator



```

STR 1 ENT
MCS ENT
SHF D-STR ENT 3 ENT
STR 2 ENT
SHF + ENT
K 1 2 5 8 ENT
STR 3 ENT
SHF + ENT
K 3 3 4 6 ENT
STR 4 ENT
SHF + ENT
K 7 7 3 ENT
STR 5 ENT
SHF D-OUT ENT 6 ENT
MCR ENT
    
```

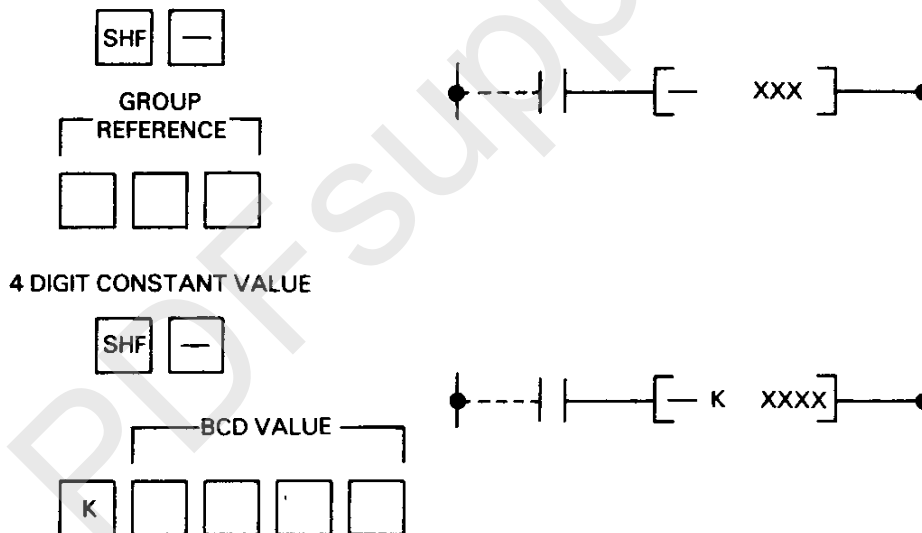
When I1 is closed, MCS is energized and does not control the logic following it. The number selected by closing one of the contacts, I2, I3, or I4 is added to the contents of the accumulator (read from Inputs 0030-0047). When I5 is closed, the answer will be written to Outputs 0060-0077.

SUBTRACTION (-), BCD 4 DIGIT

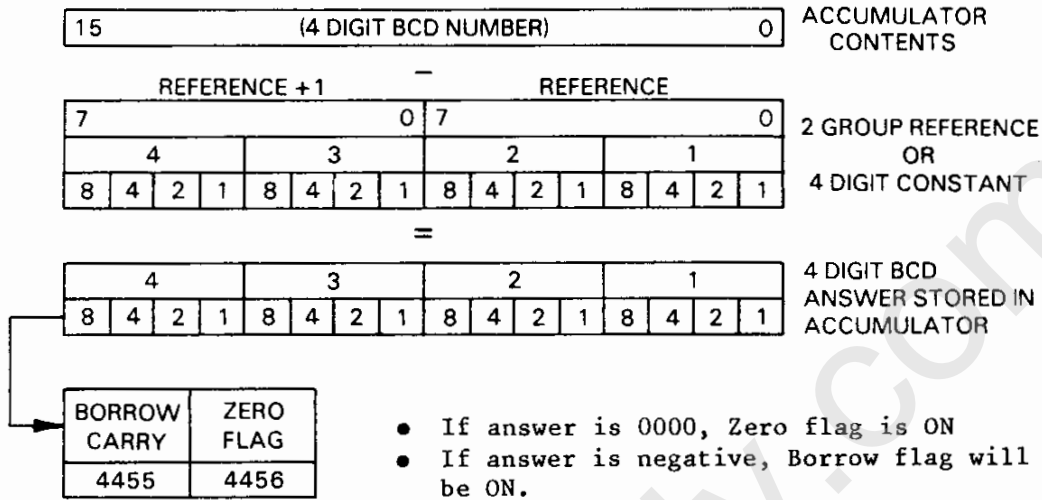
The contents of a specified 2 group reference or a 4 digit BCD constant value are subtracted from the contents (BCD) of the accumulator. If the answer after the subtraction is positive, it is written directly to the accumulator. If the answer is negative, the Borrow Flag (4455) turns ON, the absolute value is subtracted from 10000 and the resulting value is written to the accumulator. If the answer after subtraction is zero, the Zero flag (4456) turns ON.

Valid References	
0000 - 0617	I/O System
4000 - 4451	Internal Coils
7000 - 7075	
9000 - 9177	
500 - 673	Shift Register Coils
200 - 377	Data Registers
	T/C Accumulated
	Value registers

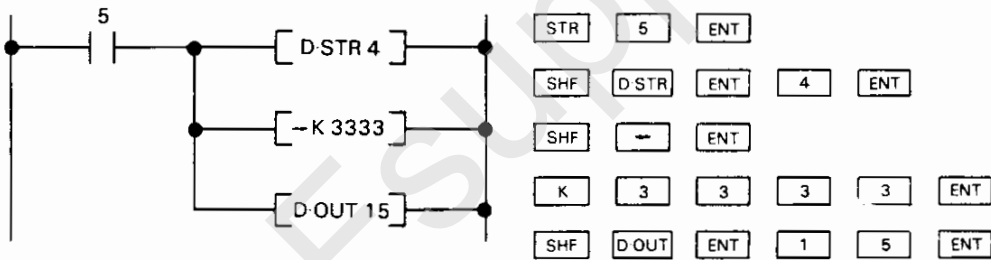
FLAGS	
CARRY OR BORROW	ZERO
4455	4456



• Subtraction sequence



• Subtraction programming example



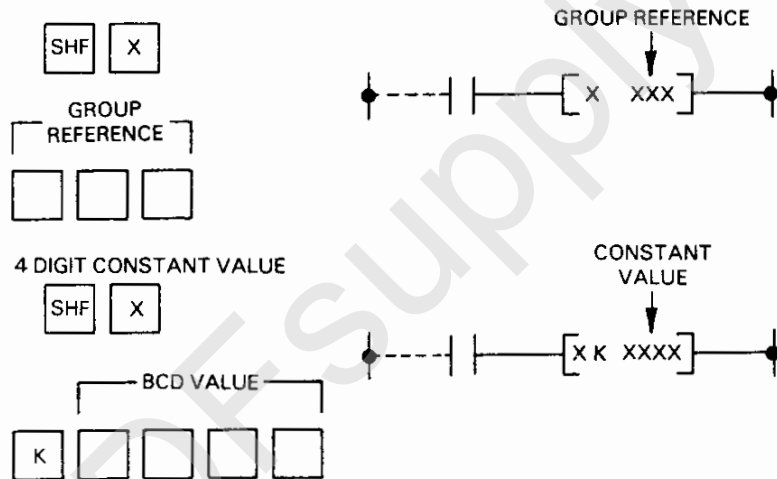
- Data is entered into the accumulator from Inputs 0040 - 0057.
- A constant value (3333) is subtracted from the contents of the accumulator.
- The answer is stored in the accumulator and is written to outputs 0150 - 0167.

MULTIPLICATION (X), BCD 4 DIGIT

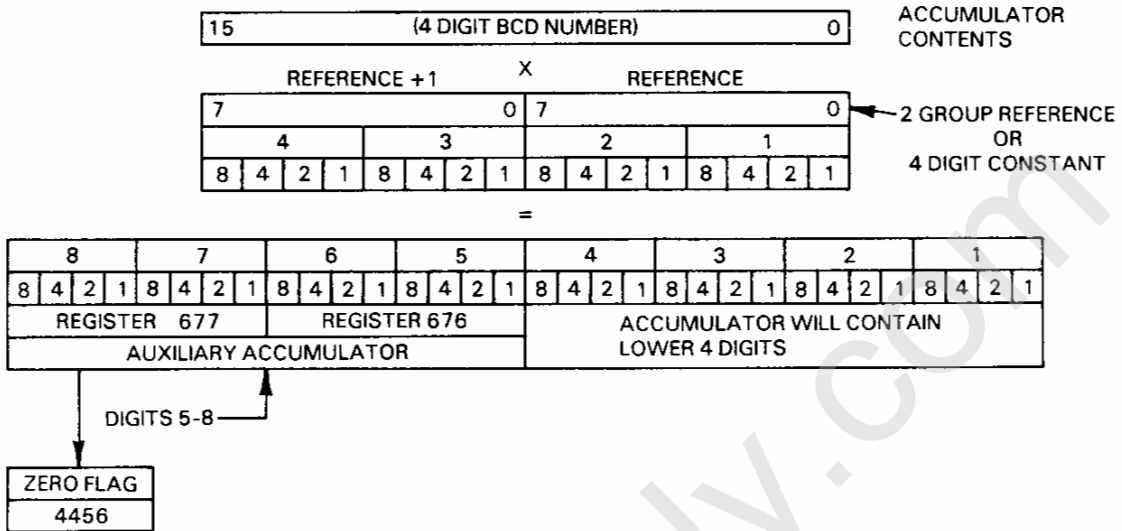
The contents of the accumulator are multiplied by the contents of a specified 2 group reference or a 4 digit BCD constant. The answer can be from 1 to 8 digits. The lower 4 digits of the answer are stored in the accumulator and digits 5-8 are stored in data registers 676 and 677, which are the auxiliary accumulator. If the answer is zero, the Zero flag (4456) will turn ON.

Valid References	
0000 - 0617	I/O System
4000 - 4451	Internal Coils
7000 - 7075	
9000 - 9177	Shift Register Coils
500 - 673	Data Registers
200 - 377	T/C Accumulated Value registers

FLAGS
ZERO
4456



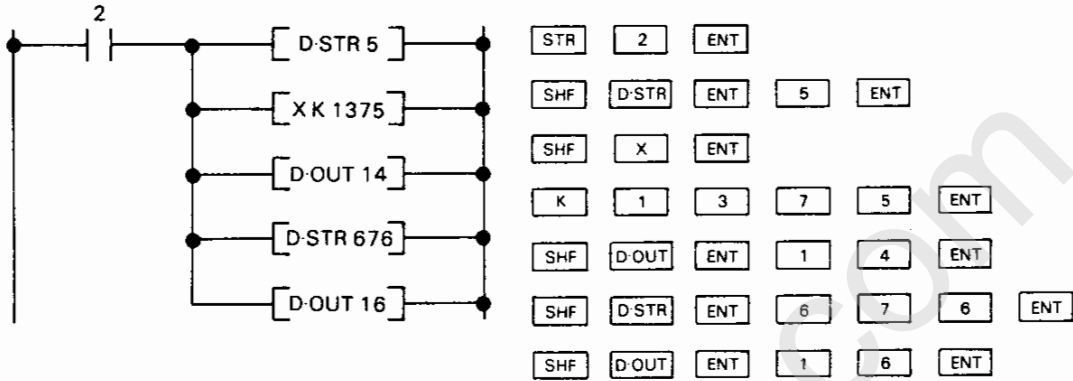
- Multiplication sequence



- The lower 4 digits (1, 2, 3, 4) of the answer will be stored in the accumulator. The upper 4 digits (5, 6, 7, 8) will be stored in the auxiliary accumulator (Data Registers 676 and 677).
- If the answer is 00000000, Zero flag is ON.

- Multiplication programming example

Multiplying 4 digits by 4 digits with an answer containing 8 digits.



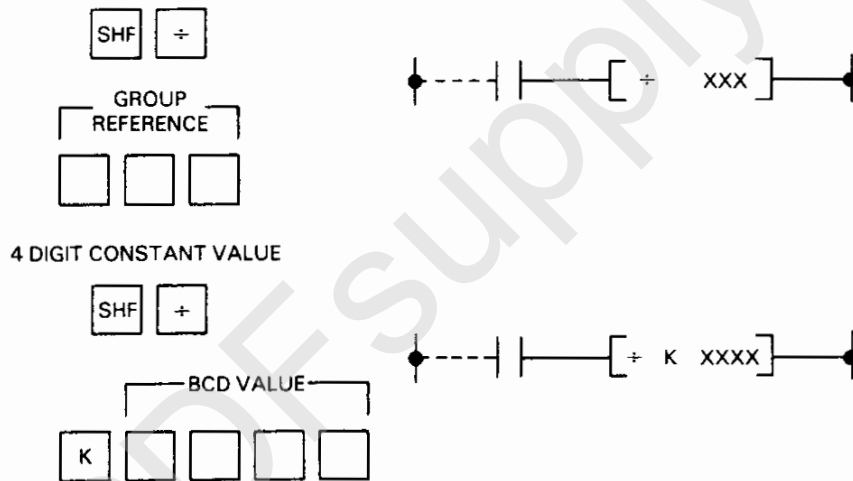
- A 4 digit BCD value is entered into the accumulator from Inputs 0050-0067.
- A constant value (1375) is entered as the multiplier.
- Assume that the answer is an 8 digit BCD number. The lower 4 digits are stored in the accumulator and transferred to Outputs 0140-0157. The upper 4 digits are stored in the auxiliary accumulator (Data Registers 676, 677) and transferred to Outputs 0160-0177.

DIVISION (-), BCD 4 DIGIT

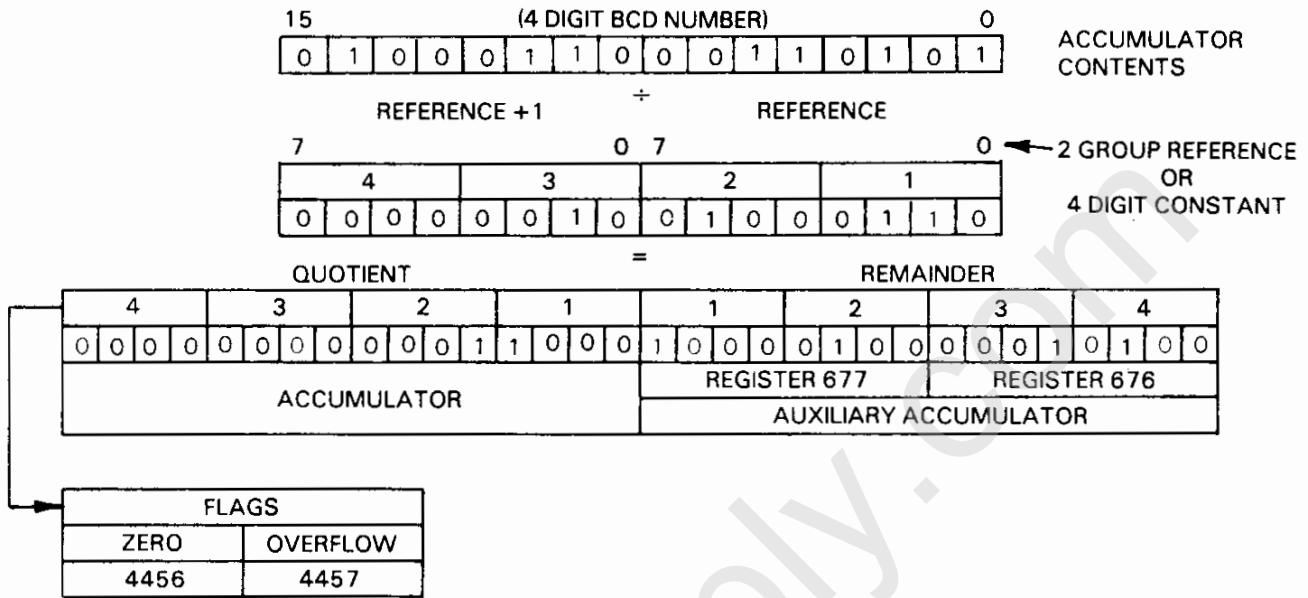
The contents of the accumulator are divided by the contents of a specified 2 group reference or a 4 digit BCD constant. The 4 digits of the quotient are stored in the accumulator and the 4 digits of the remainder are stored in the auxiliary accumulator (Data Registers 676, 677). If either the dividend or divisor are zero, the Zero flag (4456) will turn ON. If the divisor is zero, the Overflow flag (4457) will also turn ON.

Valid References	
0000 - 0617	I/O System
4000 - 4451	
7000 - 7075	
9000 - 9177	Internal Coils
500 - 673	Shift Register Coils
200 - 377	Data Registers
	T/C Accumulated
	Value registers

FLAGS	
ZERO	OVERFLOW
4456	4457



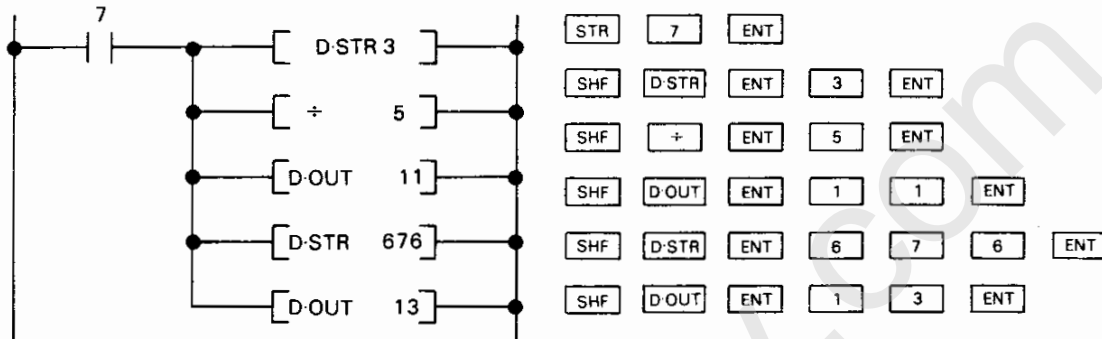
• Division sequence



- The quotient (0 - 4 digits) will be stored in the accumulator as shown. the remainder (0 - 4 digits) will be stored in the auxiliary accumulator (Data Registers 677, 676) as shown.

- Division programming example

Division of a 4 digit number by another 4 digit number showing how the quotient and remainder can be written to Outputs.



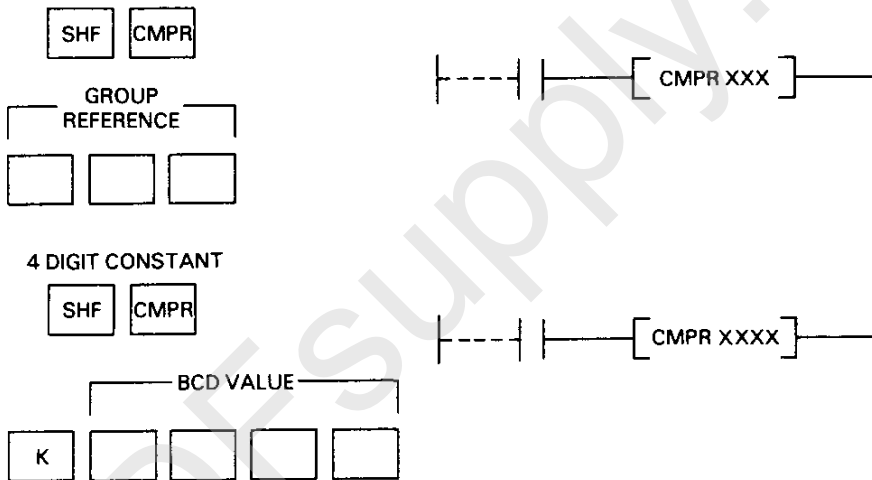
- A 4 digit number is entered into the accumulator from Inputs 0030 - 0047.
- That number is divided by a number specified by Inputs 0050 - 0067.
- The 4 digits of the quotient are stored in the accumulator and are also written to Outputs 0110 - 0127.
- The 4 digits of the remainder are stored in the auxiliary accumulator (Data Registers 677, 676) and are written to Outputs 0130 - 0147.

CMPR

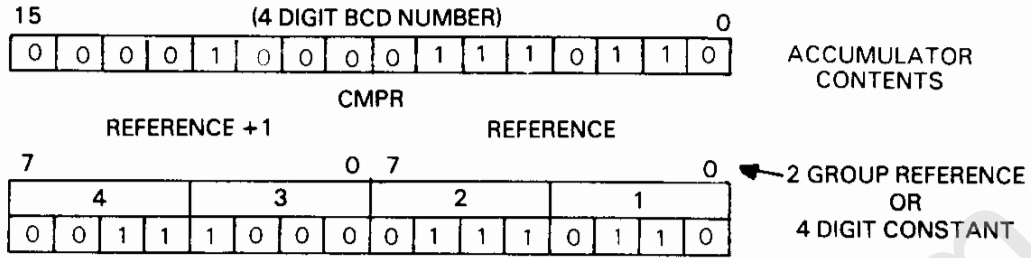
The contents of a specified 2 group reference or a 4 digit BCD constant are compared to the contents of the accumulator. The result of the comparison will cause one of three special purpose internal coils to turn on, depending on whether the accumulator value is greater than (>), equal to (=) or less than (<) the value specified by the reference or constant.

Valid References	
0000 - 0617	I/O System
4000 - 4451	Internal Coils
7000 - 7075	
9000 - 9177	Shift Register Coils
500 - 673	Data Registers
200 - 377	T/C Accumulated Value registers

FLAGS		
>	=	<
4452	4453	4454

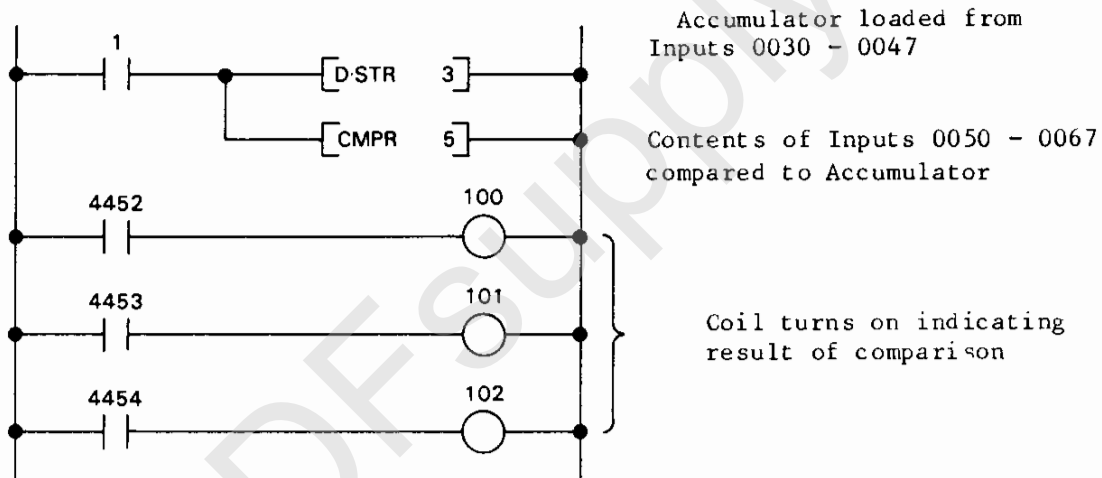


• Compare sequence



- If Accumulator > Reference, then 4452 turns ON.
- If Accumulator = Reference, then 4453 turns ON.
- If Accumulator < Reference, then 4454 turns ON.

• Programming example, Compare

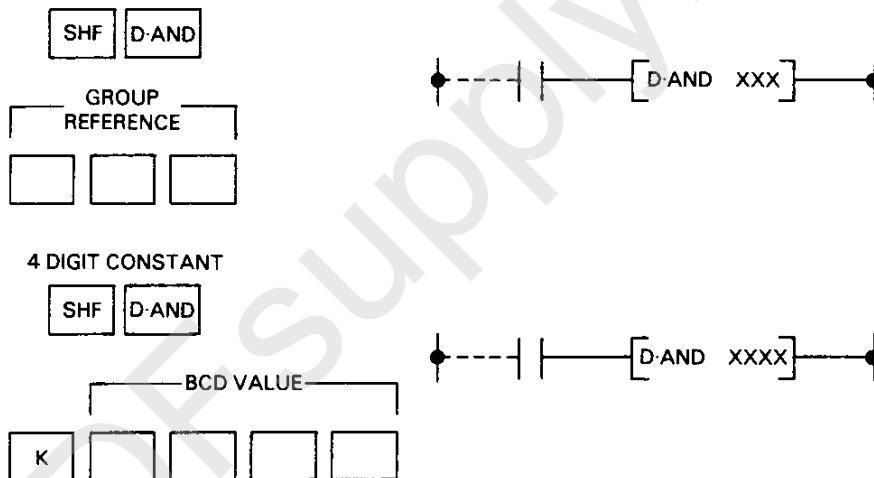


D-AND (DATA AND)

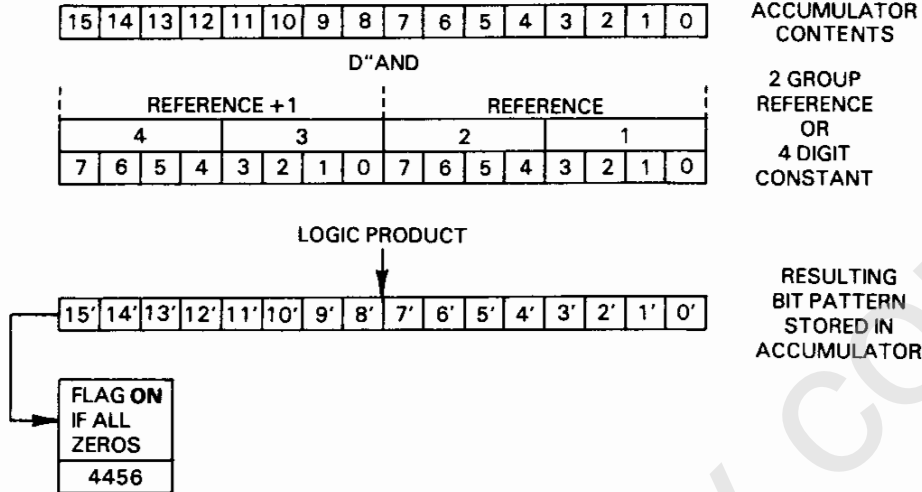
The contents of the accumulator are logically bit AND-ed with the contents of a specified 2 group reference or a 4 digit BCD constant. The result is stored in the accumulator. If the answer is 0000, the Zero flag (4456) will turn ON.

Valid References	
0000 - 0617	I/O System
4000 - 4451	Internal Coils
7000 - 7077	
9000 - 9177	
500 - 673	Shift Register Coils
200 - 377	Data Registers
	T/C Accumulated
	Value registers

FLAGS
ZERO
4456



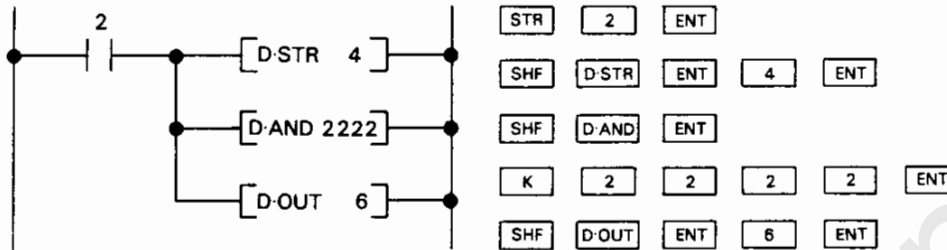
• D • AND Sequence



- Truth table for D • AND operation.
 A = Accumulator contents
 D = Contents of reference or constant

A	D	RESULT
0	0	0
0	1	0
1	0	0
1	1	1

- Programming example, D*AND



- Assume the data entered into the accumulator from Inputs 0040 - 0057 = 1234
- Is logically AND-ed with 2222
- The resulting answer stored in the accumulator would be 0220
- 0220 is written to Outputs 0060 - 0077
- Accumulator and reference contents for above operation are shown below

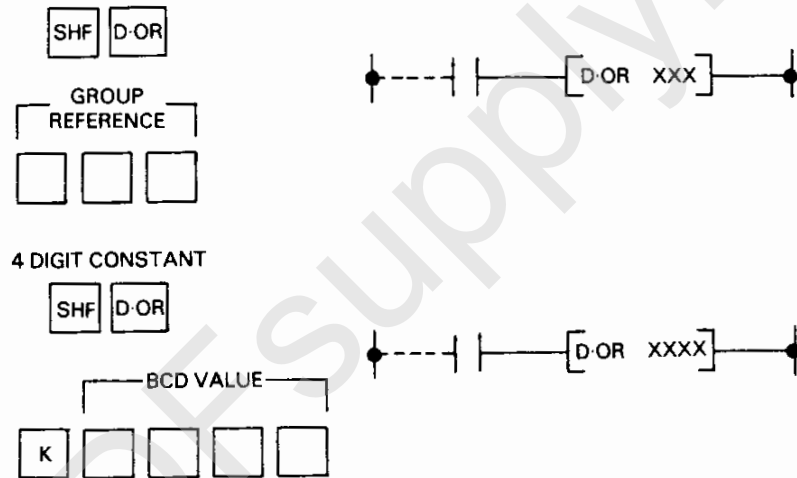
15	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	0	Accumulator Contents	
7	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	Reference or Constant
15	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	Accumulator contents After operation

D-OR (DATA OR)

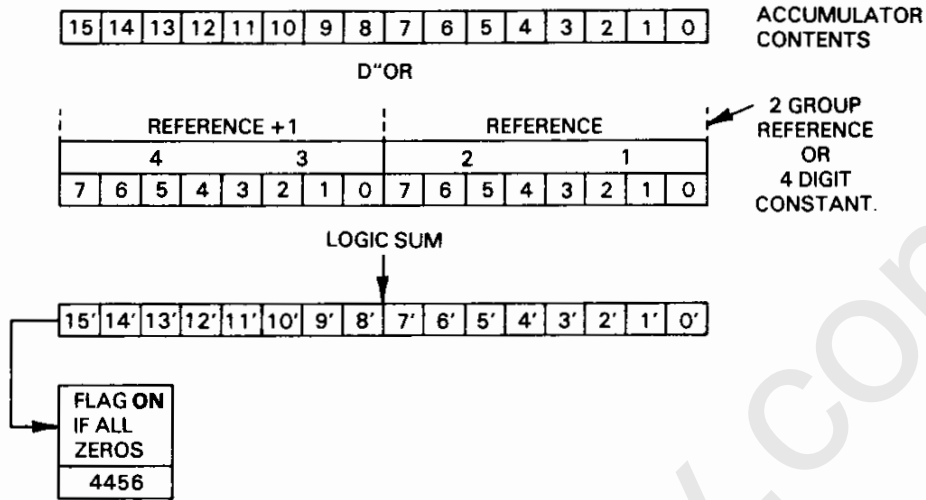
The contents of the accumulator are logically bit OR-ed with the contents of a specified 2 group reference or a 4 digit BCD constant. The result is stored in the accumulator. If the answer is 0000, the Zero flag (4456) will turn ON.

Valid References	
0000 - 0617	I/O System
4000 - 4451	Internal Coils
7000 - 7077	
9000 - 9177	
500 - 673	Shift Register Coils
200 - 377	Data Registers
	T/C Accumulated
	Value registers

FLAGS
ZERO
4456



• D • OR Sequence

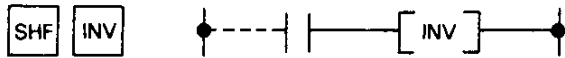


- Truth table for D • OR operation.
 A = Accumulator contents
 D = Contents of reference or constant

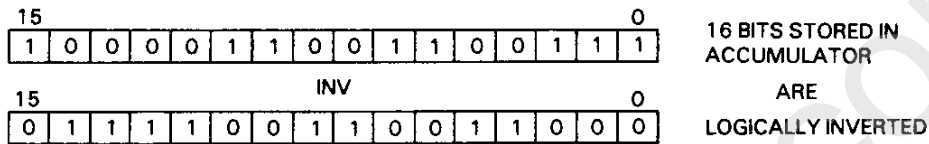
A	D	RESULT
0	0	0
0	1	1
1	0	1
1	1	1

INV

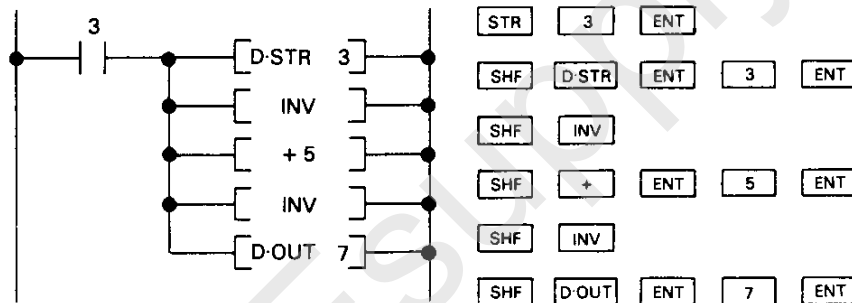
The 16 bits stored in the accumulator are logically inverted; i.e., 1 to 0 and 0 to 1.



- Invert sequence



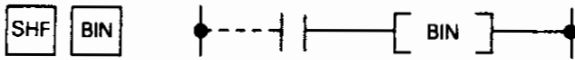
- Programming example, INV



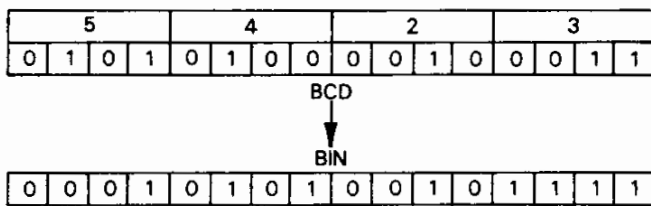
- Data entered into the accumulator from Inputs 0030 - 0047 is inverted.
- The inverted data is added to data from Inputs 0050 - 0067. The answer is stored in the accumulator, then inverted again.
- Data is written to Outputs 0070 - 0107

BIN (BCD TO BINARY)

The BCD value stored in the accumulator is converted to a binary code corresponding to that value.

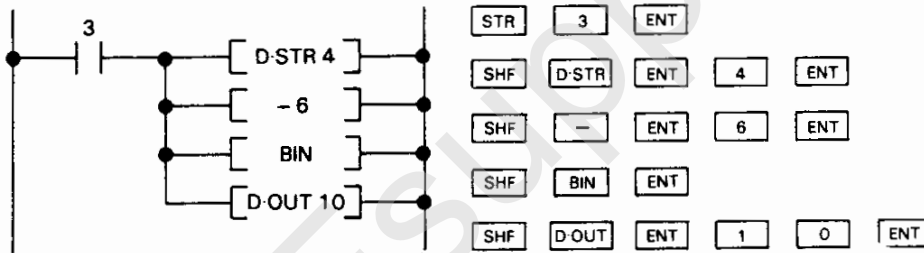


- Binary conversion sequence



4 BCD
NUMBERS
STORED IN
ACCUMULATOR
ARE
CONVERTED
TO A BINARY
CODE

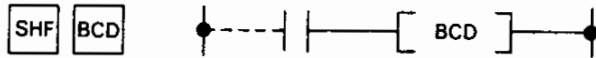
- Programming example, BIN



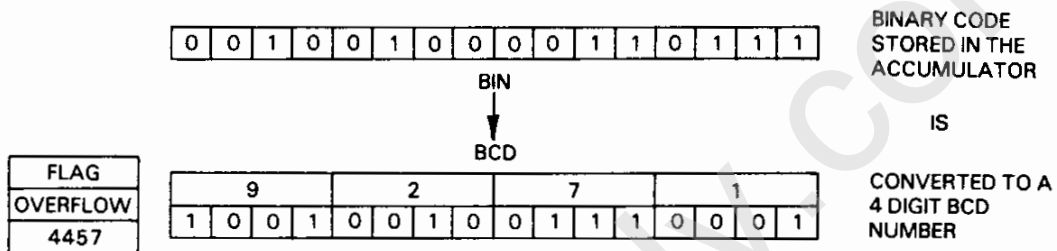
- Data is stored in the accumulator from Inputs 0040 - 0057.
- Data entered from Inputs 0060 - 0077 is subtracted from the value in the accumulator.
- The resulting answer is stored in the accumulator, then it is converted to a binary code.
- The binary code is written to Outputs 0100 - 0117.

BCD (BINARY TO BCD)

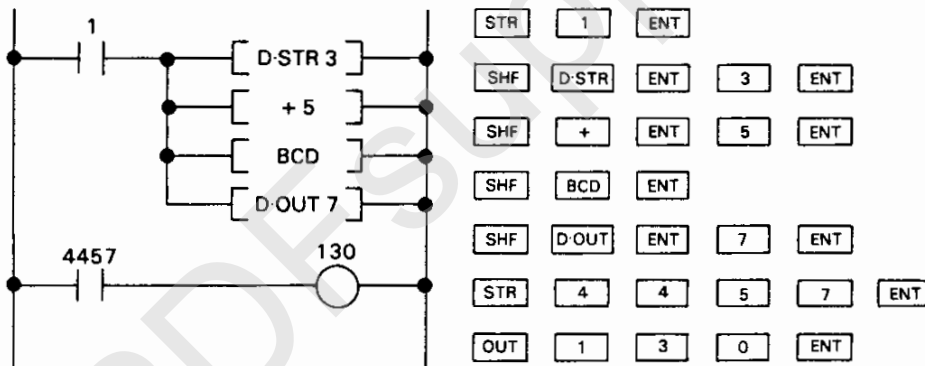
A binary code stored in the accumulator is converted to a 4 digit BCD value. If the resulting BCD value is >9999, the overflow flag (4457) will turn on. The flag coil can be used to turn on an output device as an indication of the overflow.



- BCD conversion sequence

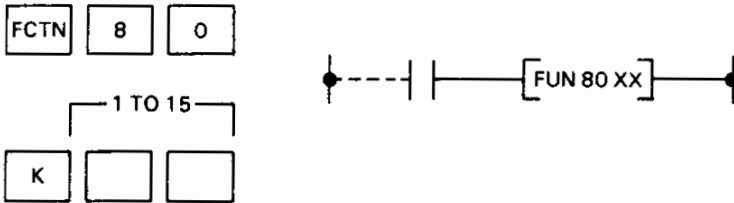


- Programming example, BCD

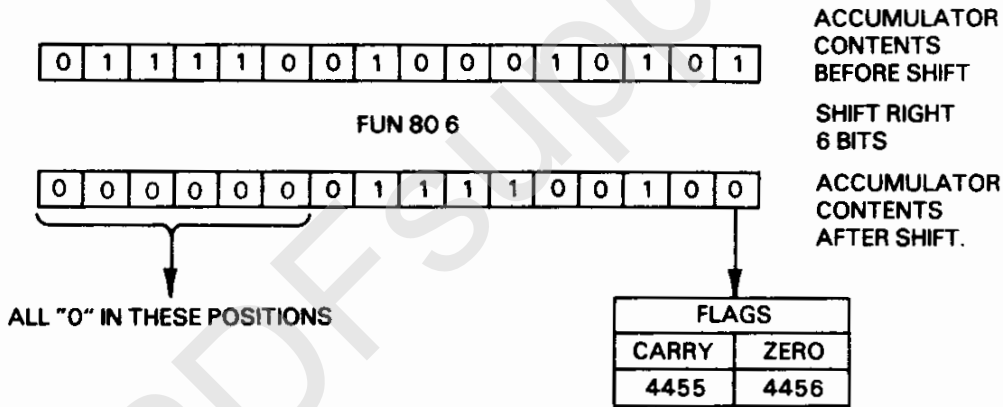


FUN 80 (SHIFT RIGHT)

The contents of the accumulator are shifted to the right by the number of shifts (bits) specified by the instruction. The number of bits shifted can be from 1 to 15. The bit positions of bits shifted from the left are filled with zeros. If a "1" is shifted out of the accumulator as a result of the shift, the Carry flag will turn on. If after the shift, the accumulator contains only zeros, the Zero flag will turn on.

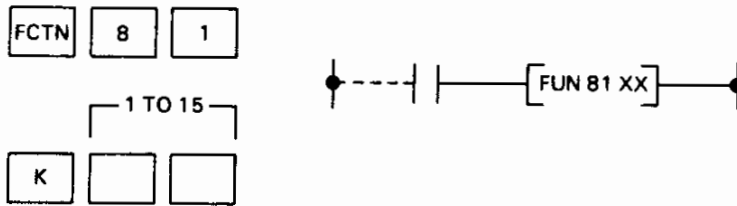


- FUN 80, Shift right sequence (6 shifts in example)

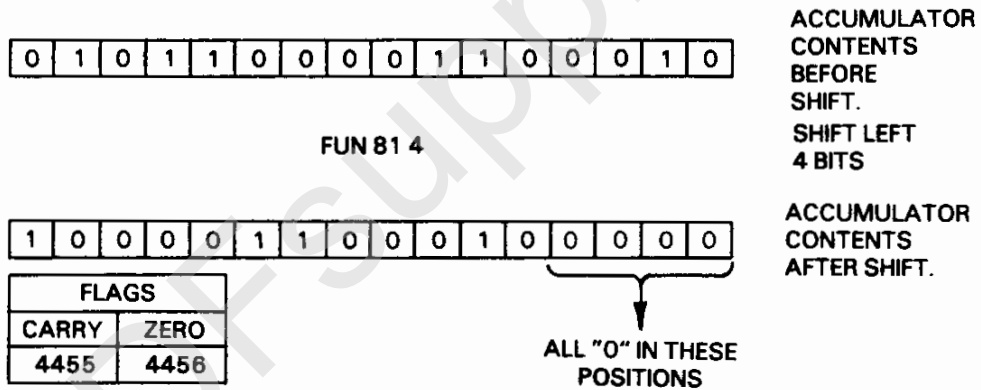


FUN 81 (SHIFT LEFT)

The contents of the accumulator are shifted to the left by the number of shifts (bits) specified by the instruction. The number of bits shifted can be from 1 to 15. The bit positions of bits shifted from the right are filled with zeros. If a "1" is shifted out of the accumulator as a result of the shift, the Carry flag will turn on. If after the shift, the accumulator contains only zeros, the Zero flag will turn on.

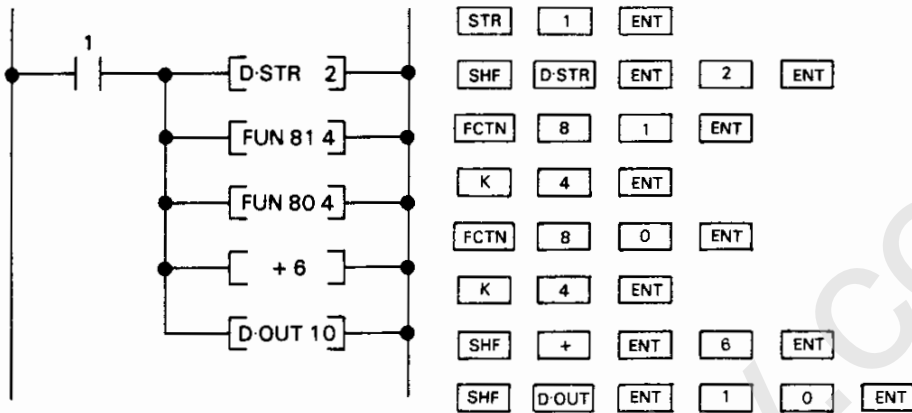


- FUN 81, Shift left sequence (4 shifts in example)



• Programming example using FUN 80 and FUN 81

This example shows a technique that can be used for deleting unnecessary data after it has been entered into the accumulator. In the example the fourth BCD digit will be deleted.



- Date entered into accumulator from Inputs 0020 - 0037.

5	3	6	2
---	---	---	---

- Shifted left, 4 bits.

3	6	2	0
---	---	---	---

- Shifted right, 4 bits.

0	3	6	2
---	---	---	---

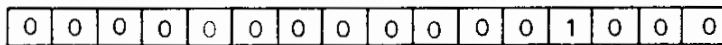
- The fourth digit (5) has been deleted.
- The remaining value is added to the contents of Inputs 0060 - 0077. The result is stored in the accumulator and written to Outputs 0100 - 0117.

FUN 82 (DECODE)

The lower 4 bits (least significant) of the accumulator are decoded to a decimal number from 0 to 15. A "1" is placed in the bit position in the accumulator that corresponds to the decoded decimal number. The upper 12 bits of the accumulator are disregarded for this operation.



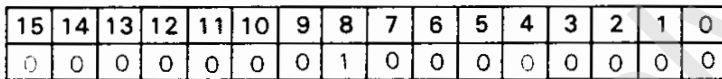
- FUN 82 Decode sequence



LOWER 4 BITS OF
ACCUMULATOR CONTAIN
1 BCD DIGIT.

FUN 82

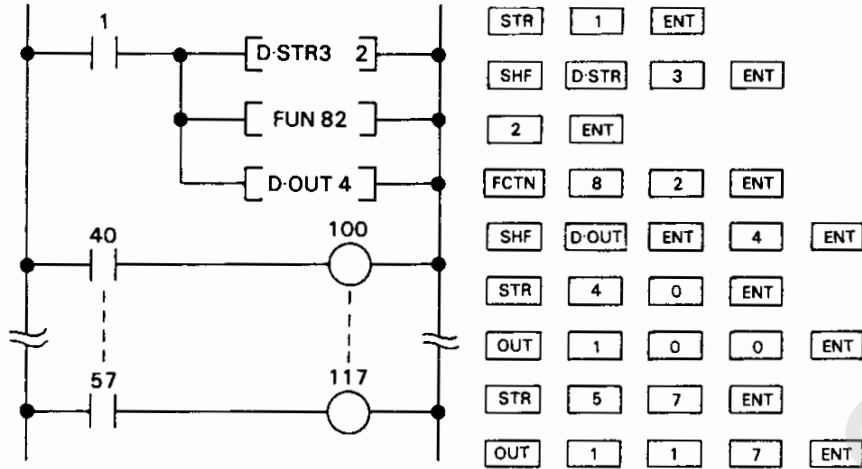
WHICH IS DECODED TO
A DECIMAL NUMBER.



A "1" WILL BE PLACED
IN THE ACCUMULATOR
POSITION CORRESPONDING
TO THAT DECIMAL NUMBER.
ALL OTHER POSITIONS WILL
CONTAIN ZEROS.

- If the BCD digit to be decoded is an 8, A "1" will be placed in the accumulator at that position as shown.

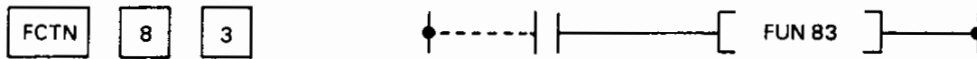
- Programming example, FUN 82



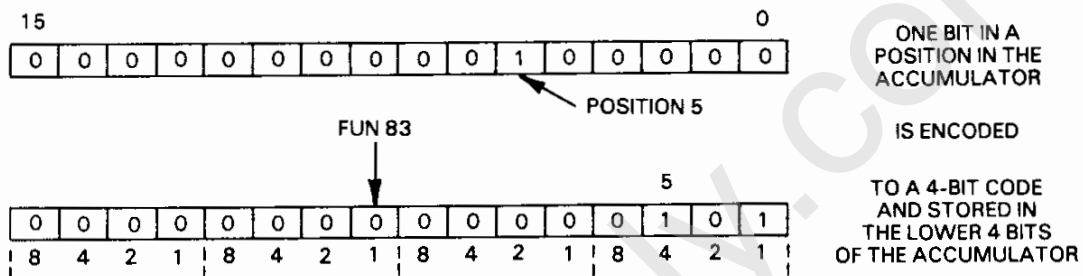
- A BCD digit (example; 6) is loaded into the accumulator (lower 4 bits) from the lower 4 bits of the reference, Inputs 20, 21, 22, and 23.
- The BCD digit is decoded to a decimal number between 0 - 15 (in this example 6).
- That number is stored in the corresponding bit position in the accumulator.
- Outputs 0040 to 0057 correspond to the 16 bits of the accumulator. One of the outputs will be enabled when the accumulator position has a "1" placed in it. When the contact corresponding to the output reference is closed, a coil 100 - 117 will turn on.

FUN 83 (ENCODE)

A bit in a position in the accumulator is encoded to a 4-bit code representing the position number (0-15) in the accumulator. The resulting 4-bit code is placed in the lower four bits of the accumulator.



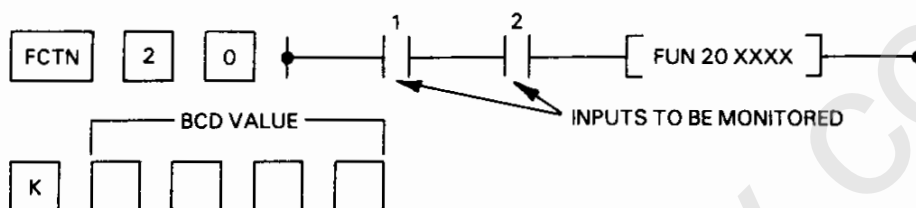
• FUN 83 Encode sequence (Example)



- The upper 12 bits of the accumulator will contain zeros after the FUN 83 has been executed.

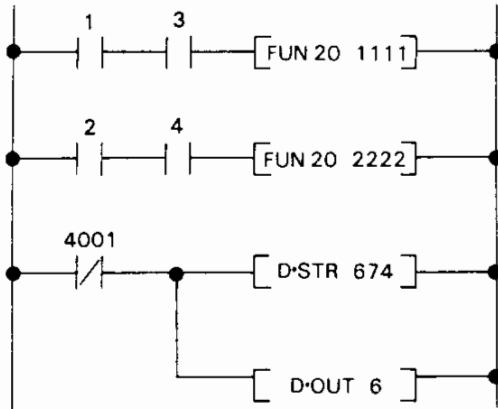
FUN 20 (EXTERNAL FAULT DIAGNOSIS)

This instruction provides a method of monitoring external devices for unwanted conditions such as switches that should not be on at the same time. When the instruction is programmed, a 4 digit BCD number is specified as a fault indication number. If the unwanted condition occurs, the 4 digit number will be displayed on the programmer data display. At the same time, the FAULT relay in the power supply will be energized and the FAULT relay contacts on the power supply terminal board will be closed. These contacts are available for connection to an external alarm indicator.



Multiple FUN 20 instructions can be used in a program for detection of multiple fault conditions. Each condition to be monitored is assigned a different 4 digit number. If multiple faults occur simultaneously, the number displayed will be the one assigned by the last FUN 20 in the program. Data Registers 674 and 675 will contain the fault indicator number.

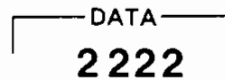
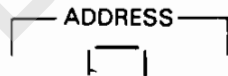
● Programming example, FUN 20



```

STR 1 ENT
AND 3 ENT
FCTN 2 0 ENT
K 1 1 1 1 ENT
STR 2 ENT
AND 4 ENT
FCTN 2 0 ENT
K 2 2 2 2 ENT
STR NOT 4 0 0 1 ENT
SHF D*STR ENT
6 7 4 ENT
SHF D*OUT ENT 6 ENT
    
```

- If devices connected to I1 and I3 are made at the same time, FUN 20 will be active, 1111 will be displayed on the data display on the programmer and the FAULT relay contacts will close.
- If devices connected to I2 and I4 are made at the same time the data display will display 2222.
- The indicator number will be stored in 674 and 675 and that number will be written to Outputs 0060-0077.
- Fault indicator number display



CHAPTER 6
I/O MODULES

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CHAPTER 6 I/O MODULES

I/O MODULES

The Input and Output modules available for use with a Series Three PC system are listed in Table 6.1. The modules can be placed in a base unit in any order and any mix. The address (I/O point reference) is determined by the slot into which the module is inserted (See Figure 1.5). Each module is secured to the base unit by fastening 2 captive screws on the module. LEDs on most modules provide a visual indication of the ON or OFF state of each circuit on the module.

Table 6.1
I/O MODULES

MODULE NAME	CATALOG NUMBER	I/O POINTS
115 VAC/DC INPUT	IC630MDL325A	16
ISOLATED AC INPUT	IC630MDL326A	8
115/230 VAC OUTPUT	IC630MDL375A	16
ISOLATED AC OUTPUT	IC630MDL376A	8
5-12 VDC INPUT	IC630MDL303A	32
5-12 VDC OUTPUT	IC630MDL354A	32
24 VDC INPUT	IC630MDL301A	16
24 VDC INPUT	IC630MDL302A	32
24 VDC OUTPUT	IC630MDL351A	8
24 VDC OUTPUT	IC630MDL352A	16
24 VDC OUTPUT	IC630MDL353A	32
24 VDC IN/OUT	IC630MDL304A	16/16
RELAY OUTPUT	IC630MDL380A	16
I/O SIMULATOR	IC630MDL324A	16

Most field wiring connections are made to screw terminals on socket type terminal boards. The terminal board is easily removable allowing modules to be readily removed or changed. A clear plastic cover snaps over the terminals as a safety precaution. The covers also have an insert to record circuit identification. The circuit boards are mounted in a lightweight Noryl plastic case. The following series of tables provide specifications and field wiring information for each of the Input and Output modules. The module name labels are color coded as a safety precaution. Low voltage (5-12 and 24 Vdc) module labels are blue; high voltage module labels are red.

Some of the high-density (32 I/O points) modules are connected to user supplied input devices or loads to be controlled through an I/O interface cable which is 10 feet (3 m) in length. One end of the cable has a 40-pin female connector which mates with a 40-pin male connector mounted on the faceplate of the I/O module. The wires on the opposite end are stripped and tinned for connection to user devices. Each module requires two of these cables. Each wire in the cable is color coded for easy identification.

I/O REFERENCES

When an I/O module is inserted in a base slot, the CPU senses the quantity of I/O points (8, 16, or 32) and assigns a consecutive number of I/O points to the module starting with the first reference for that slot. Refer to Figure 1.5.

Table 6.2 is a list of a specifications for use as an aid in selecting user supplied external power supplies for Series Three I/O modules.

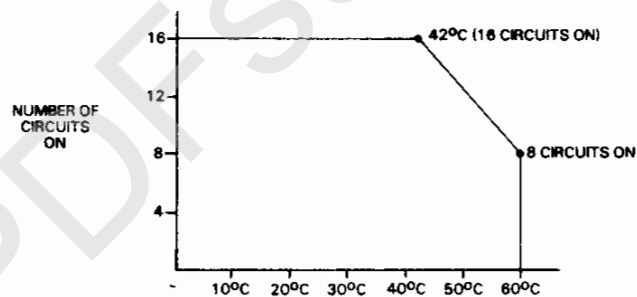
Table 6.2
EXTERNAL POWER SUPPLY SPECIFICATIONS

<u>I/O MODULE CATALOG NO.</u>	<u>I/O TYPE</u>	<u>VOLTAGE</u>	<u>CURRENT</u>
IC630MDL325A	INPUT	115 Vac, +15% 48-63 Hz.	TYP., 9.5 mA (60 Hz) per one input on
IC630MDL326A	INPUT	115 Vac, + 15% 48-63 Hz.	TYP., 7.9 mA (50 Hz) per one input on
IC630MDL303A	INPUT	+5 Vdc, + 5% Ripple < 1% rms	TYP., 9.5 mA (60 Hz) per one input on 130 mA maximum
IC630MDL354A	OUTPUT	or +12 Vdc, + 10% Ripple < 3% rms	400 mA maximum
		+5 Vdc, + 5% Ripple < 1% rms	160 mA maximum
IC630MDL301A	INPUT	or +12 Vdc, + 10% Ripple < 3% rms	400 mA maximum
		+24 Vdc, + 10% Ripple < 3% rms	280 mA maximum
IC630MDL302A	INPUT	+24 Vdc, + 10% Ripple < 3% rms	270 mA maximum
IC630MDL351A	OUTPUT	+24 Vdc, + 10% Ripple < 3% rms	50 mA maximum
IC630MDL352A	OUTPUT	+24 Vdc, + 10% Ripple < 3% rms	130 mA maximum
IC630MDL353A	OUTPUT	+24 Vdc, + 10% Ripple < 3% rms	50 mA maximum
IC630MDL304A	IN/OUT	+24 Vdc, + 10% Ripple < 3% rms	160 mA maximum

115 VAC/DC INPUT
IC630MDL325A

The 115 Vac Input module has 16 Inputs arranged in 2 groups with 8 Inputs in each group. An Ac/dc voltage source should be connected as shown; one side of the voltage source to C, the other side of the input device as shown. The voltage source can be 80 to 133 Vac or 80 to 150 Vdc. Note that the common connections are tied together internally. Specifications for this module are listed below.

Input Points	16 with LED Indicators	
User Power Supply	AC Input	DC Input
Voltage	97 - 132 Vac, 50-60 Hz	80 - 150 Vdc
Current	7.5 mA (80V, 50 Hz) 8.2 mA (80V, 60 Hz) 12.8 mA (133V, 50 Hz) 14.1 mA (133V, 60 Hz)	2.2 mA (80V) 4.2 mA (150V)
ON state	>80 Vac >7 mA (50 Hz) >8 mA (60 Hz)	>80 Vdc >2 mA
OFF state	<20 Vac <2 mA (50 Hz) <2.5 mA (60 Hz)	<30 Vdc <1 mA
ON delay	10 - 40 ms	6 - 30 ms
OFF delay	10 - 60 ms	15 - 70 ms
Internal Power Consumption	5 Vdc, 10 mA + 10 mA/point	



AMBIENT TEMPERATURE (°C)
I/O POINTS VS. TEMPERATURE CHART

PC-83-83-0024

Figure 6.1 provides user wiring information for the 115 Vac/dc input module.

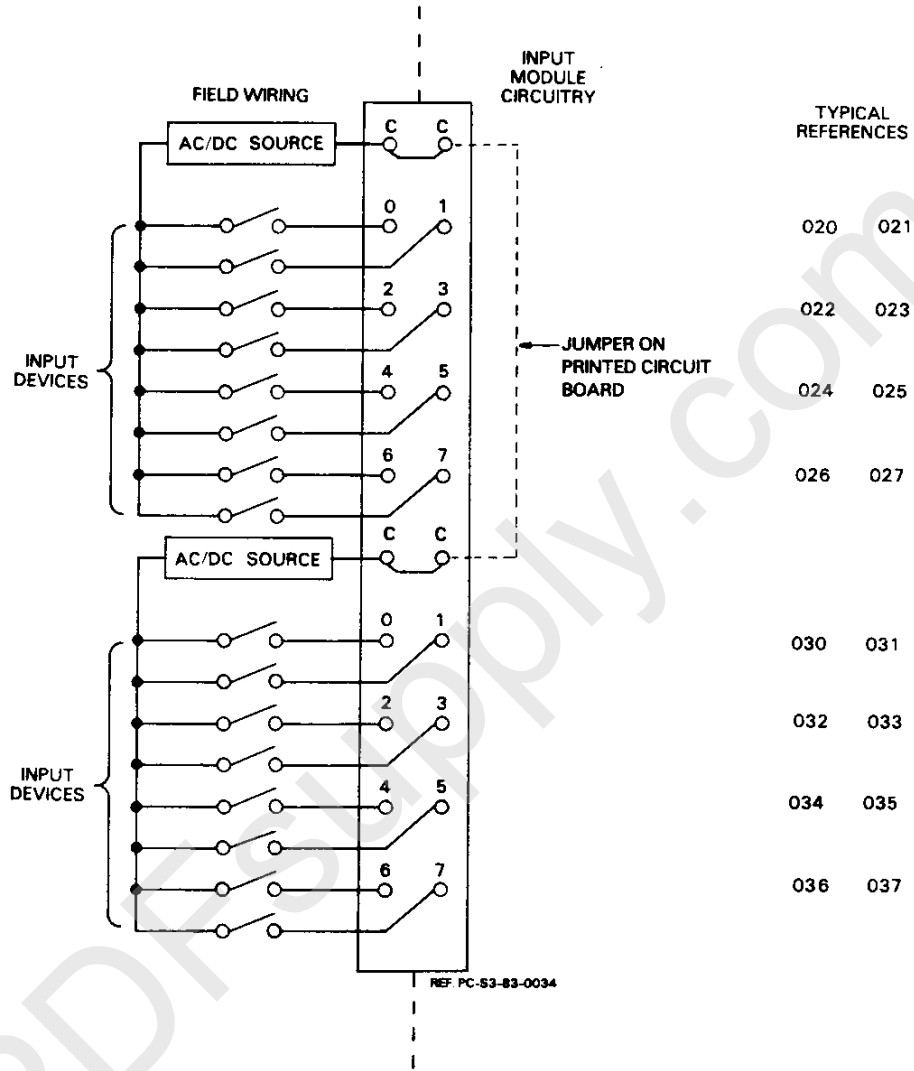
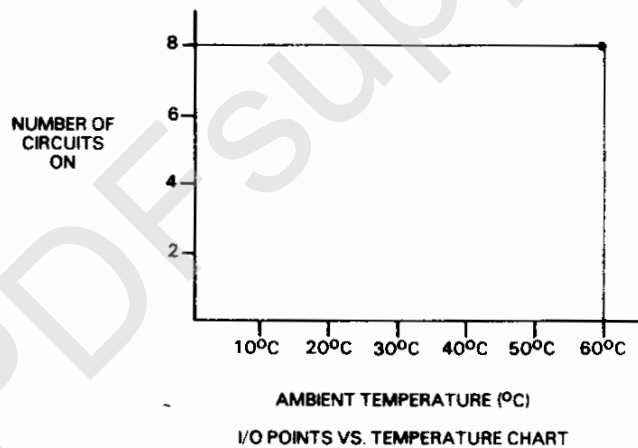


Figure 6.1
 115 VAC/DC INPUT, USER CONNECTIONS

ISOLATED AC INPUT
IC630MDL326A

This module provides eight circuits, each designed to receive a single discrete (ON/OFF) signal from user supplied devices. Typical input devices include limit switches, pushbuttons, selector switches, and relay contacts. Each of these circuits is "isolated" from the other circuits on this module relative to AC power source; the term "isolation" is not relative to optical-coupler noise/fault which all I/O modules have. Each input is provided with two field terminals allowing separate AC power sources (i.e. different phases) for each of the eight inputs. These power sources must be supplied by the user. Specifications for this module are listed below.

Input Points	8 With LED Indicators
User Power Voltage	97 - 132 Vac, 50/60 Hz
Input Current	19.5 mA Typical (115 Vac, 60 Hz) 11.0 mA Maximum (115 Vac, 60 Hz)
ON Voltage	80 Vac Minimum
OFF Voltage	20 Vac Maximum
ON Delay	10-40 ms Typical
OFF Delay	10-60 ms Typical
Internal Power Consumption	5 Vdc, 50 mA



PC-S3-83-0025

Figure 6.2 provides user wiring information for the isolated AC input module.

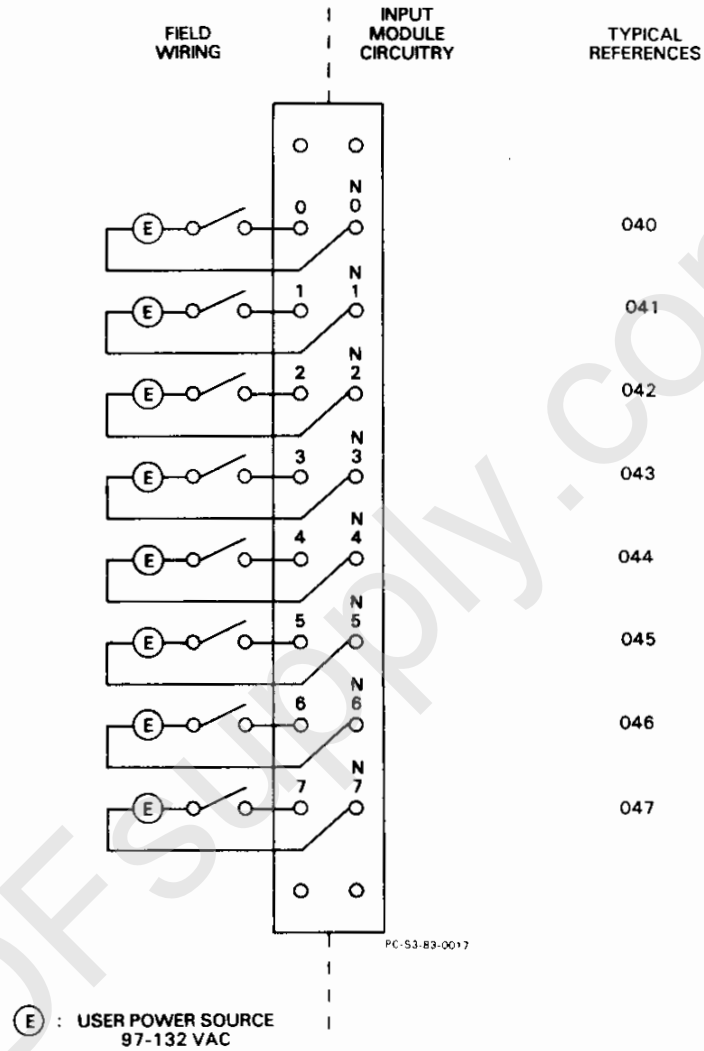


Figure 6.2
ISOLATED AC INPUT, USER CONNECTIONS

115/230 VAC OUTPUT (TRIAC)
IC630MDL375A

The 115/230 Vac Output module provides 16 circuits each capable of controlling user supplied discrete (ON/OFF) loads. Typical loads include relay coils, motor starters, solenoid valves and indicator lights. The 16 circuits are divided into two groups of 8 circuits, each having its own common. Each group can be supplied from a separate power source. Power to operate the field devices must be supplied by the user. Each group of 8 outputs is protected by a 5 amp fuse. Maximum switching capacity of the output circuits is 2 amps. Specifications for this module are listed below.

Output points	16 with LED Indicators
User Supplied Voltage	97 - 265 Vac
ON delay	< 0.1 ms
OFF delay	< 1/2 cycle
Output Current (ON)	
Minimum	25 mA
Maximum	2 A
Leakage (OFF)	2.7 mA (115V, 50 Hz) 3.3 mA (115V, 60 Hz) 5.5 mA (230V, 50 Hz) 6.6 mA (230V, 60 Hz)
Inrush Current	20A for 1 cycle
Fuse Rating	5A for each 8 circuits
Internal Power Consumption	5 Vdc, 35 mA 12 Vdc, 20 mA + 17.5 mA/point

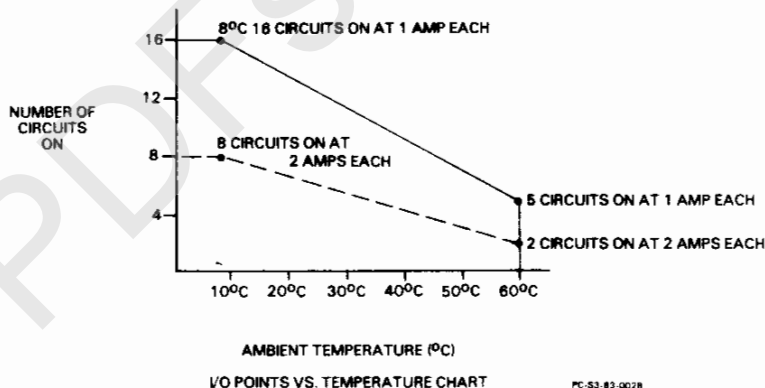


Figure 6.3 provides user wiring information for the 115/230 VAC output module.

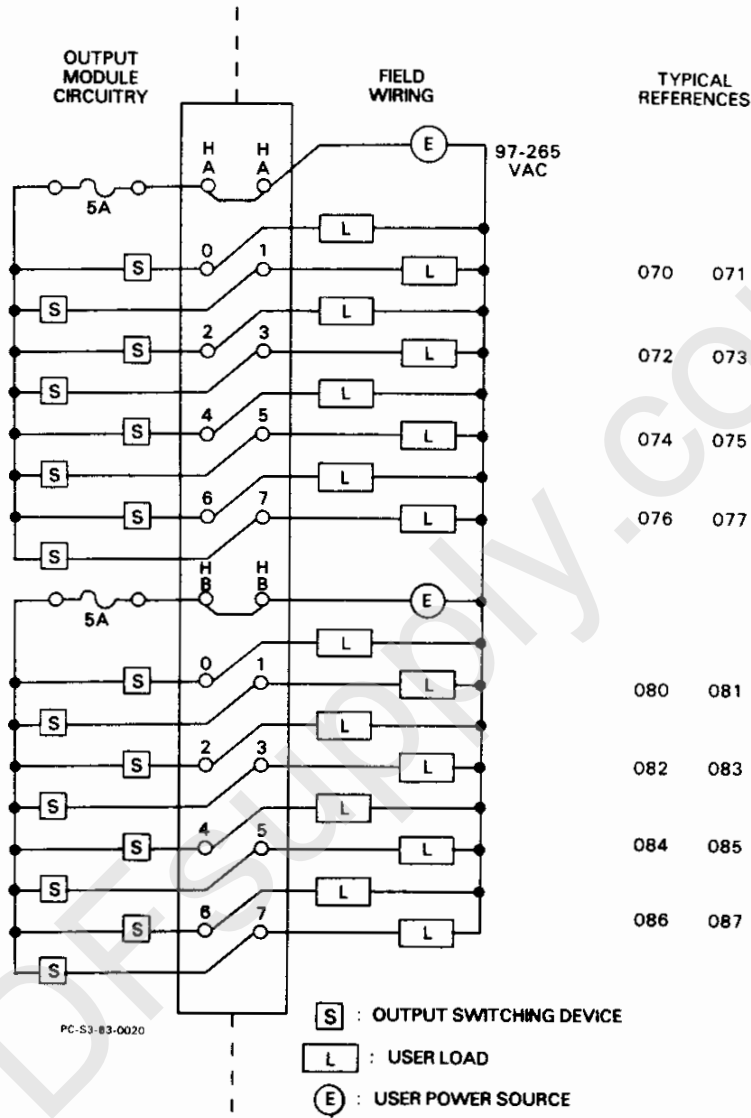
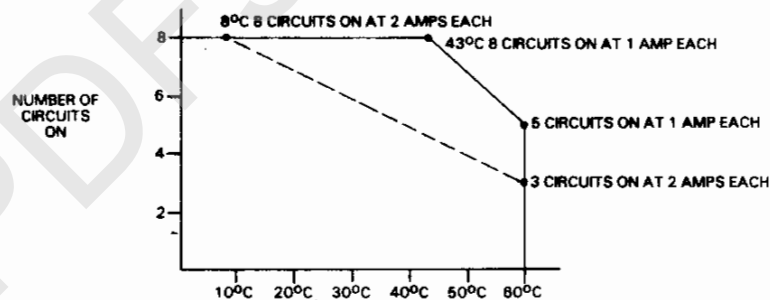


Figure 6.3
115/230 VAC OUTPUT, TYPICAL USER CONNECTIONS

ISOLATED AC OUTPUT
IC630MDL376A

This module provides eight circuits each capable of controlling user supplied discrete (ON/OFF) loads. Typical loads include relay coils, motor starters, solenoid valves, and indicator lights. Each of these circuits is "isolated" from the other circuits on this module relative to AC power source; the term "isolation" is not relative to optical-coupler noise/fault isolation which all I/O modules have. Each input is provided with two field terminals allowing separate AC power sources (i.e. different phases) for each of the eight outputs. These power sources must be supplied by the user. User supplied power sources to each circuit can be 97 to 265 Vac, with a maximum current of 2 amps for each circuit. Each output switching circuit is protected by a 3 amp fuse. Specifications for this module are listed below.

Output points	8 with LED Indicators
User Supplied Voltage	97 - 265 VAc
ON delay	< 0.1 ms
OFF delay	< 1/2 cycle
Output Current (ON)	
Minimum	25 mA
Maximum	2 A
Leakage (OFF)	2.7 mA (115V, 50 Hz) 3.3 mA (115V, 60 Hz) 5.5 mA (230V, 50 Hz) 6.6 mA (230V, 60 Hz)
Inrush Current	20A for 1 cycle
Fuse Rating	3A (each circuit)
Internal Power Consumption	5 Vdc, 20 mA 12 Vdc, 17.5 mA/point



I/O POINTS VS. TEMPERATURE CHART

PC-S3-83-0029

Figure 6.4 provides user wiring information for the 115/230 Vac Isolated Output module.

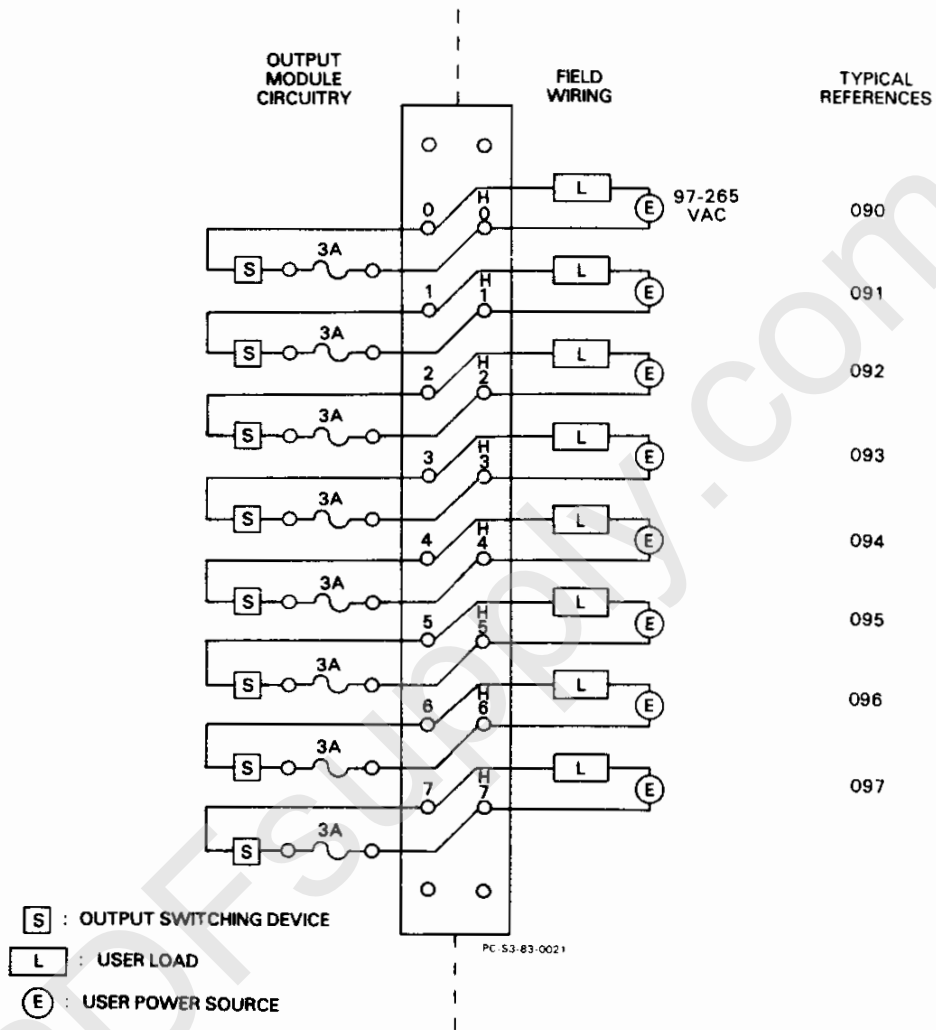


Figure 6.4
115/230 VAC ISOLATED OUTPUT, TYPICAL USER CONNECTIONS

5 TO 12 VDC INPUT (32 CIRCUITS)
IC630MDL303A

The 5-12 VDC Input module provides 32 circuits, each designed to receive a single discrete (ON/OFF) signal from user supplied devices. Typical input devices include TTL, and CMOS circuitry. An external power source in the range of 5 to 12 Vdc must be provided by the user for sensing the state of the inputs. All 32 Inputs are powered from a single source. User devices are connected to the inputs through two 40-pin connectors mounted on the faceplate.

When installed in an I/O slot, a 32 point I/O module uses 32 consecutive I/O references, i.e. the 16 references assigned to that slot and the next 16 references. A 32 point I/O module in slot 1 would use references 00-37. In this case, an I/O module installed in slot 2 would have a starting reference number of 40. If an 8-slot base was filled with 32 point I/O modules, that base would contain 256 I/O points (references 000-377, if first base unit).

Initial shipments of this module will include two connectors requiring user wiring. Eventually, a 10 foot (3m) I/O interface preassembled cable, with a connector wired on one end and stripped, tinned wires on the other end, will be available. Two of these cables will be required per module.

NOTE

The primary function of this module is intended to be as a TTL or CMOS logic interface.

A power source from 5 to 12 Vdc can be used for this module. Specifications for 5 and 12 Vdc power sources for each of the 32 circuits are as follows.

	<u>5 VDC</u>	<u>12 VDC</u>
External Power Voltage	5 Vdc, \pm 5%	12 Vdc, \pm 10%
Ripple	<3% rms, maximum	<3% rms, maximum
Current	130 mA, maximum	400 mA, maximum
Input Current ON	2-4 mA	2-13 mA
Input Current OFF	0.3 mA, maximum	0.3 mA, maximum
Input Voltage ON	0.75 Vdc, maximum	6.8 Vdc, maximum
Input Voltage OFF	4.25 Vdc, minimum	12.2 Vdc, minimum
ON delay	1-5 ms	1-5 ms
OFF delay	1.5-6 ms	1.5 - 6 ms
Input Signal	> 2 mA sink current and < .75 Vdc	>2 mA sink current and < 6.8 Vdc

Internal Power Consumption 5 Vdc @ 50 mA (Supplied by Series Three power supply).

Figure 6.5 provides user wiring information for the 5 to 12 Vdc Input module.

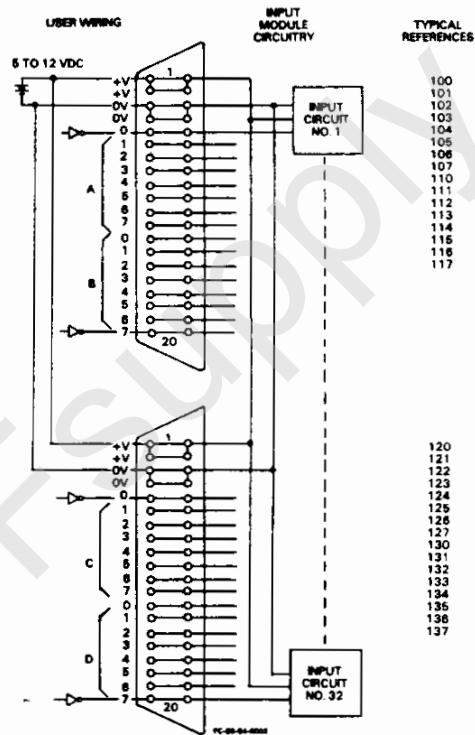
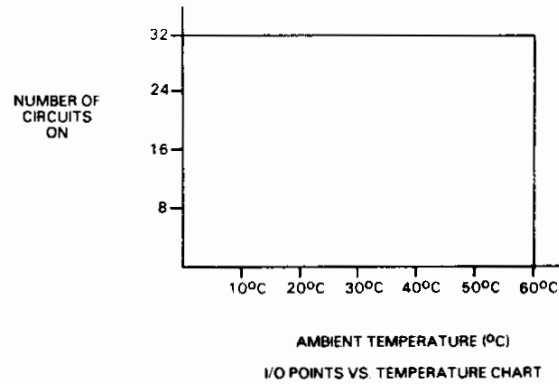


Figure 6.5
5 TO 12 VDC INPUT USER CONNECTIONS

5 TO 12 VDC OUTPUT (32 CIRCUITS)
IC630MDL354A

The 5-12 VDC Output module provides 32 circuits, each capable of controlling user supplied discrete (ON/OFF) loads. The 32 circuits are provided referenced to a 5 to 12 Vdc power source that must be supplied by the user. Typical loads include TTL or CMOS circuitry. The circuits are arranged on the module in two groups of 16 circuits. Each of the 16 circuit groups is connected to user loads through an I/O interface cable. Two cables are required for a module. Each cable has a 40-pin connector on one end which mates with a corresponding connector on the faceplate.

When installed in an I/O slot, a 32 point I/O module uses 32 consecutive I/O references, i.e. the 16 references assigned to that slot and the next 16 references. A 32 point I/O module in slot 1 would use references 00-37. In this case, an I/O module installed in slot 2 would have a starting reference number of 40. If an 8-slot base was filled with 32 point I/O modules, that base would contain 256 I/O points (references 000-377, if first base unit).

Initial shipments of this module will include two connectors requiring user wiring. Eventually, a 10 foot (3m) I/O interface preassembled cable, with a connector wired on one end, will be available. Two of these cables will be required per module.

NOTE

The primary function of this module is intended to be as a
TTL or CMOS logic interface.

A power source from 5 to 12 Vdc can be used for this module. Specifications for 5 and 12 Vdc power sources for each of the 32 circuits are as follows.

	<u>5 VDC</u>	<u>12 VDC</u>
External Power Voltage	5 Vdc, \pm 5%	12 Vdc, \pm 10%
Ripple	<3% rms, maximum	<3% rms, maximum
Current	160 mA, maximum (Excluding loads)	400 mA, maximum (Excluding loads)
ON State	0.15 mA @ 3.5 Vdc	2.5 mA @ 6 Vdc
OFF State	16 mA @ 0.4 Vdc	2.0 mA @ 0.4 Vdc
OFF delay	0.1 ms	0.1 ms
Input Signal	0.1 ms	0.1 ms

Internal Power Consumption 5 Vdc @ 160 mA (Supplied by Series Three power supply)

Figure 6.6 provides user wiring information for the 5 to 12 Vdc Output modules.

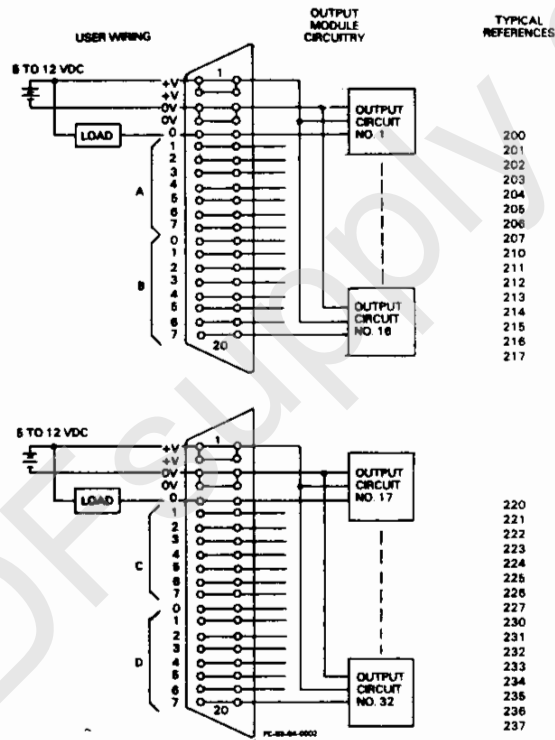
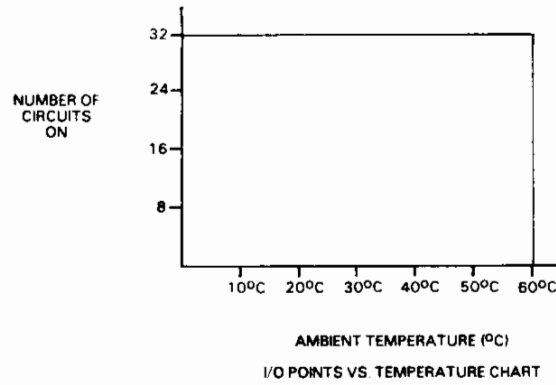
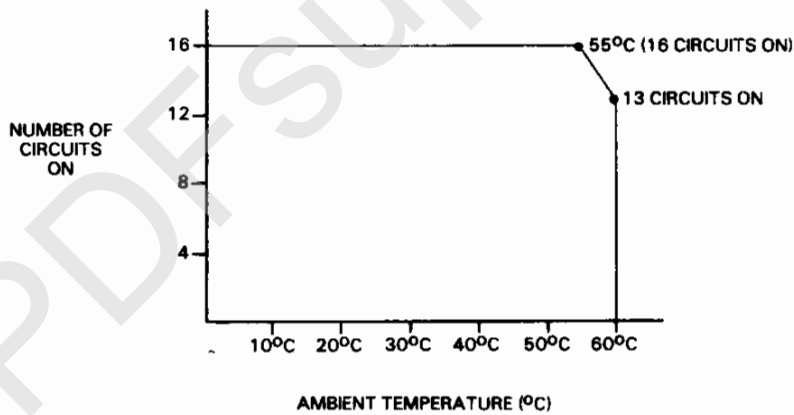


Figure 6.6
5 TO 12 VDC OUTPUT USER CONNECTIONS

24 VDC INPUT (16 CIRCUITS)
IC630MDL301A

This 24 Vdc Input module provides 16 circuits, each designed to receive a single discrete (ON/OFF) signal from user supplied devices. Typical input devices include pushbuttons, limit switches, and relay contacts. A 24 Vdc external power source must be supplied by the user for sensing the state of the inputs. All 16 inputs are powered from a single source. User devices are connected to the input circuits by connecting the field wiring to a connector mounted on the faceplate of the module. Recommended wire size for connection to the module is stranded No. 12 AWG wire. Two wires per terminal are possible with No. 14 AWG wire. The ON state of each circuit is indicated by a corresponding LED. Specifications for each of the 16 circuits are as follows.

Input Points	16 with LED Indicators
User power supply	Voltage 24 Vdc, +10% Ripple <3% rms Current 270 mA max. (16 Inputs On) 135 mA typ. (8 Inputs On)
ON state	<6.0 Vdc, >8.0 mA
OFF state	>18.0 Vdc, <4.0 mA
ON delay	3 - 12 ms
OFF delay	3 - 12 ms
Internal Power Consumption 5 Vdc, 30 mA + 5 mA/point	



I/O POINTS VS. TEMPERATURE CHART

PC-S3-83-0023

Figure 6.7 provides wiring information for this 24 Vdc Input module.

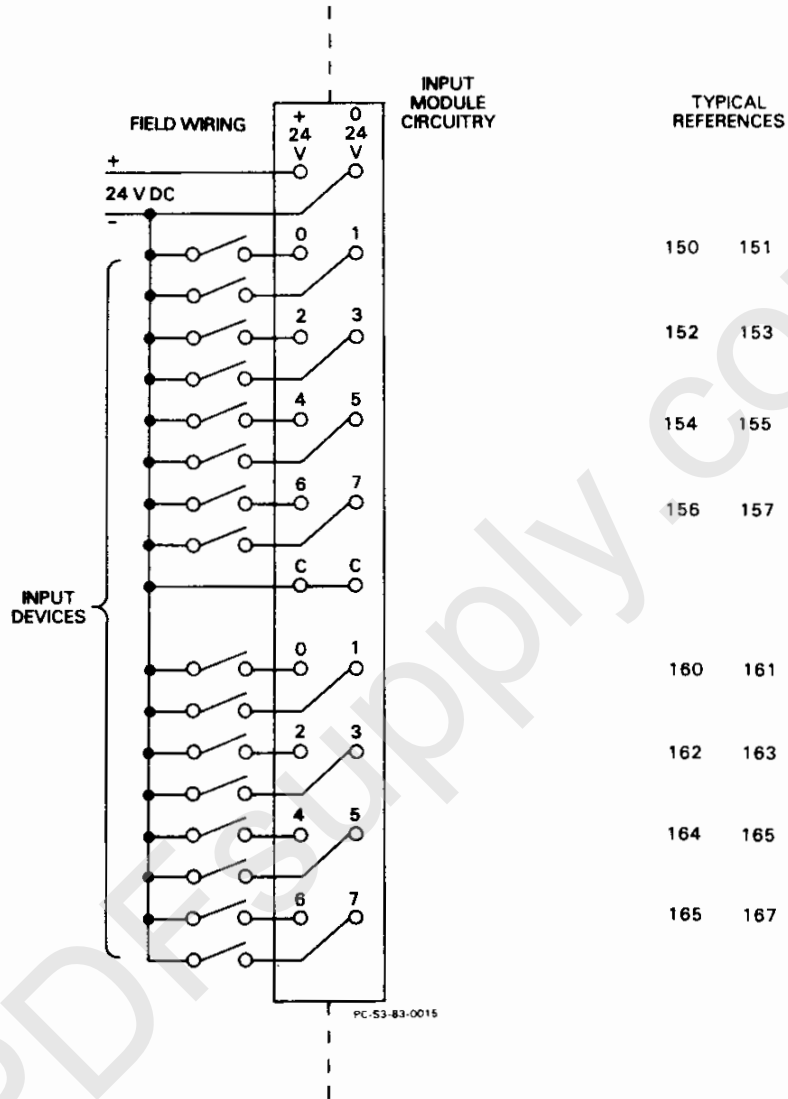


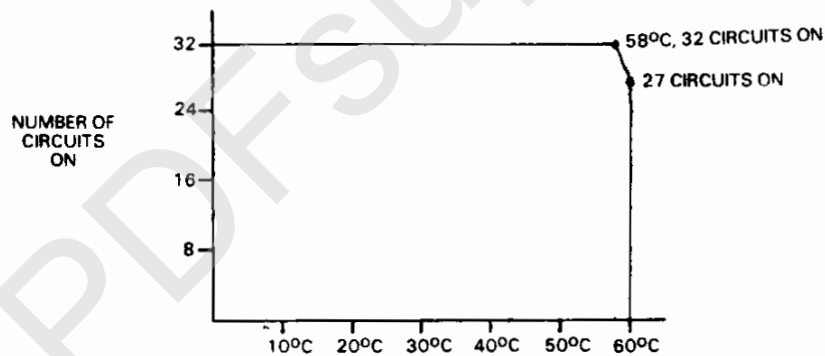
Figure 6.7
24 VDC INPUT, USER CONNECTIONS

24 VDC INPUT (32 CIRCUITS)

IC630MDL302A

This 24 Vdc Input module provides 32 circuits, each designed to receive a single discrete (ON/OFF) signal from user supplied devices. Typical input devices include pushbuttons, limit switches, and relay contacts. A 24 Vdc external power source must be provided by the user for sensing the state of the inputs. All 32 inputs are powered from a single source. User devices are connected to the input circuits by connecting the field wiring to screw terminals on a connector mounted on the faceplate of the module. Recommended wire size is one No. 12 AWG wire or two No. 14 AWG wires. Terminals are also provided on the connector for the user power source. Specifications for each of the 32 circuits are listed below.

External Power	
Voltage	24 Vdc, + 10%
Ripple	< 3% rms, maximum
Current	270 mA, maximum (32 Inputs ON)
	125 mA TYP. (16 Inputs ON)
Input Current	7 mA
ON Level	< 6.0 Vdc
OFF Level	> 18.0 Vdc
ON Current, Min.	5.0 mA
OFF Leakage, Max.	2.0 mA
ON Delay	3-12 ms
OFF Delay	3-12 ms
Internal Power Consumption	5 Vdc @ 50 mA



AMBIENT TEMPERATURE (°C)
I/O POINTS VS. TEMPERATURE CHART

Figure 6.8 provides wiring information for this 24 Vdc module.

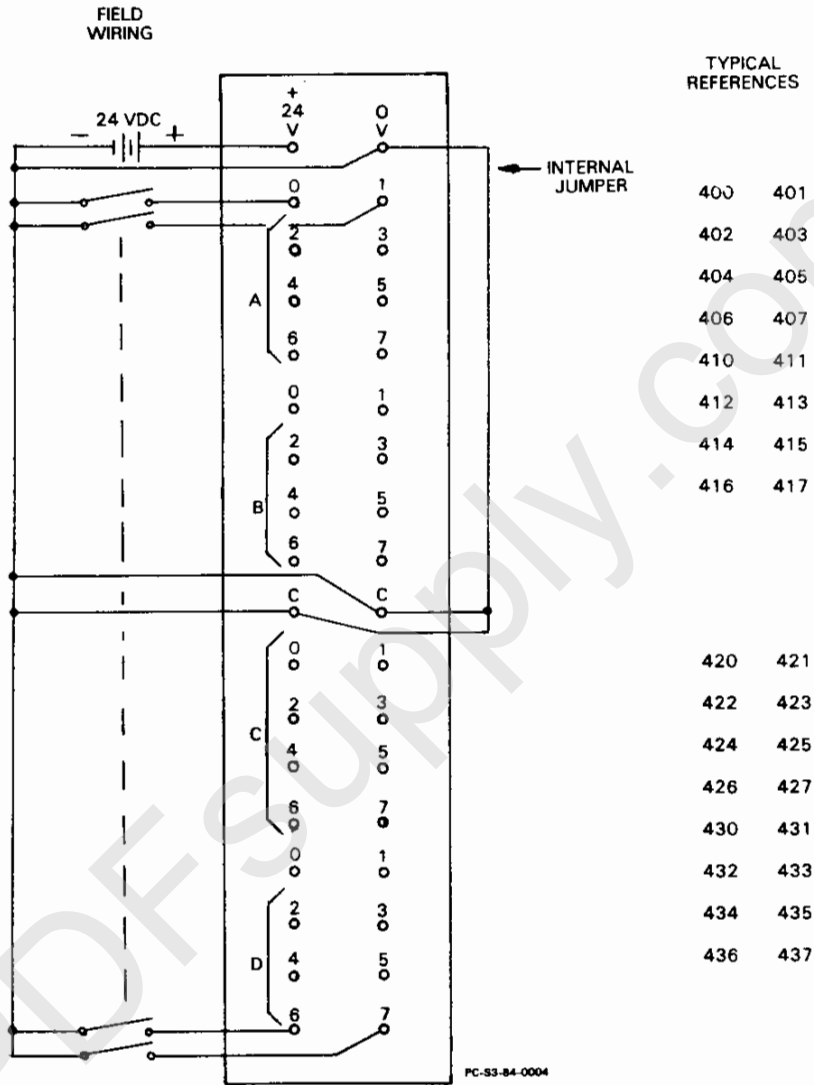
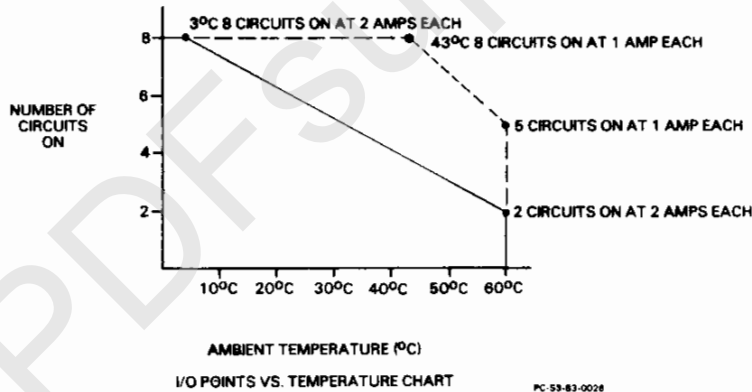


Figure 6.8
24 VDC INPUT CONNECTIONS

24 VDC OUTPUT (8 CIRCUITS)
IC630MDL351A

This 24 Vdc Output module provides 8 circuits, each capable of controlling user supplied discrete (ON/OFF) loads. Typical loads include motor starters, relay coils, and indicator lights. A 24 Vdc power supply must be provided by the user. This supply provides the power for the loads and also provides the DC power source for the output circuits. The output switching circuitry on the module is arranged in 4 groups of 2 circuits each. Each group is protected with a 5 amp fuse. Specifications for this module are listed below.

Output points	8 with LED Indicators
User Power Supply	Voltage 24 Vdc, $\pm 10\%$ Ripple <3% rms * Current 50 mA max (8 Outputs On) 25 mA typ. (4 Outputs On)
Fuse Rating	5A (for each 2 circuits)
Leakage Current	<200 nA
ON state Voltage drop	1.5 V maximum
ON delay	100 ns
OFF delay	100 ns
Max. switching capacity	24 Vdc, 2A
Internal Power Consumption	5 Vdc, 20 mA 12 Vdc, 12.5 mA/point



*Does not include current required by load device.

Figure 6.9 provides wiring information for this 24 Vdc Output module.

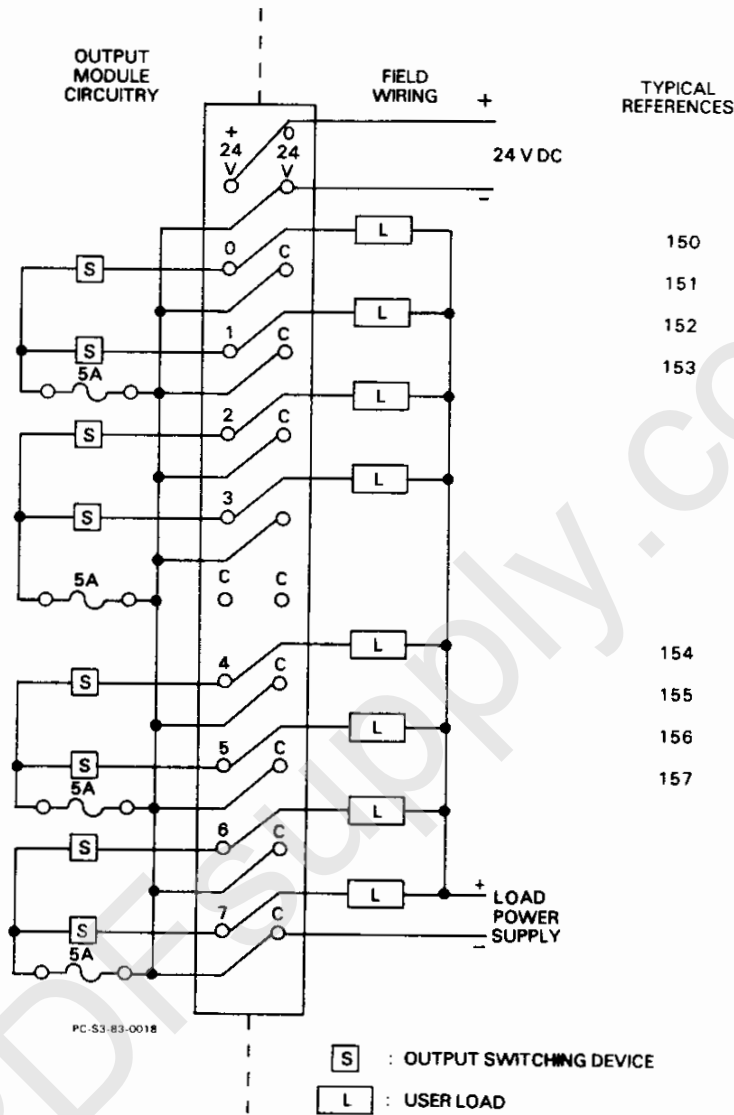
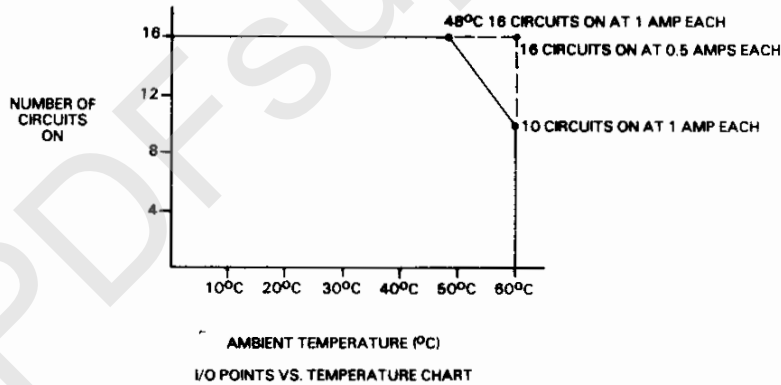


Figure 6.9
24 VDC (8 OUTPUTS), TYPICAL USER CONNECTIONS

24 VDC OUTPUT (16 CIRCUITS)
IC630MDL352A

This 24 Vdc Output module provides 16 circuits, each capable of controlling user supplied discrete (ON/OFF) loads. Typical loads include motor starters, relay coils, and indicators. A 24 Vdc power supply must be provided by the user. This supply provides power for the loads and also provides the DC power source for the output circuits on the module. The output switching circuitry on the module is arranged in 4 groups with 4 circuits in each group. Each group is protected by a 5 amp fuse. Specifications for this module are listed below.

Output points	16 with LED Indicators
User Power Supply	Voltage 24 Vdc, +10% Ripple <3% rms * Current 100 mA max (8 Outputs On) 50 mA typ. (4 Outputs On)
Fuse Rating	5A (for each 4 circuits)
Leakage Current	<100 μ A
ON state Voltage drop	.3 V maximum
ON delay	100 μ s
OFF delay	
Max. switching capacity	24 Vdc, 1A
Internal power consumption	5 Vdc, 35 mA 12 Vdc, 11 mA/point



PC-S3-83-0027

*Does not include current required by load device.

Figure 6.10 provides wiring information for this 24 Vdc Output module.

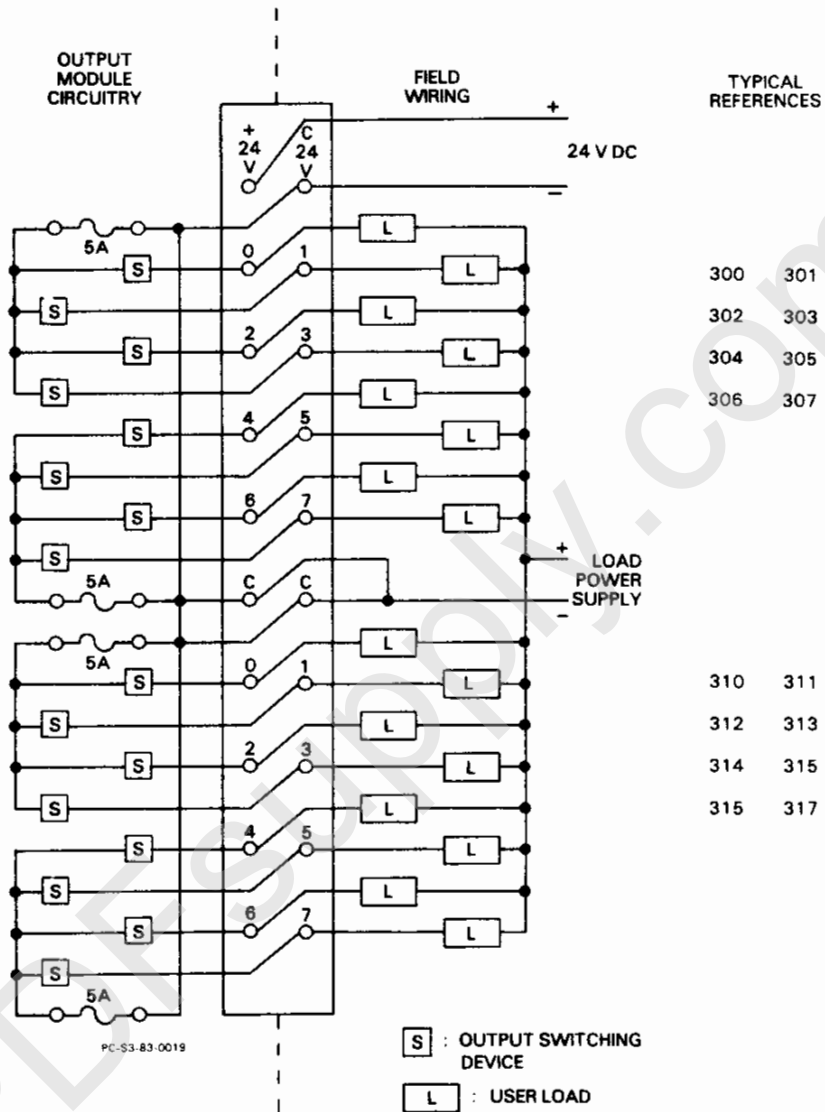
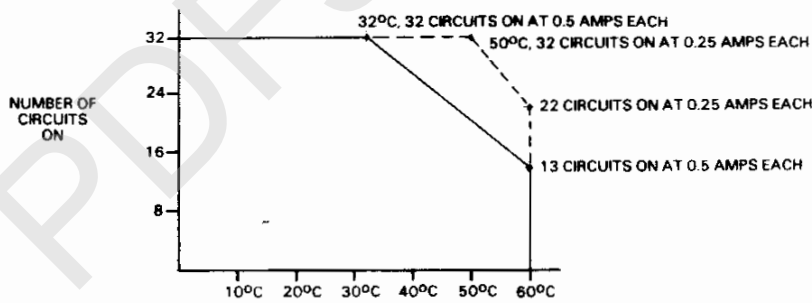


Figure 6.10
24 VDC (16 OUTPUTS), TYPICAL USER CONNECTIONS

24 VDC OUTPUT (32 CIRCUITS)
IC630MDL353A

This 24 Vdc Output module provides 32 circuits, each capable of controlling user supplied discrete (ON/OFF) loads. Typical loads include motor starters, relay coils, and indicators. A 24 Vdc power supply must be provided by the user. This supply provides power for the loads and also provides the DC power source for the output circuits on the module. The output switching circuitry on the module is arranged in 8 groups with 4 circuits in each group. Each group is protected by a 5 amp fuse. The 32 outputs are connected to user loads through field wiring to a 36 terminal connector mounted on the faceplate. Each terminal will accept one No. 12 AWG wire or two No. 14 AWG wires. Specifications for each of the 32 circuits are as follows.

External Power	
Voltage	24 Vdc, + 10%
Ripple	<3% rms, maximum
Current	100 mA, maximum (32 Inputs ON) 25 mA TYP. (16 Inputs ON)
Peak Voltage	45 Vdc
Maximum Current	0.5 amp
ON Voltage Drop	0.8 Vdc @ 0.5 amp 0.7 Vdc @ 0.25 amp
Leakage Current, max.	100 μ A
ON Delay	100 μ s
OFF Delay	100 μ s
Maximum Switching Capacity	24 Vdc @ 0.5A
Fuse (internal)	5 amp (In Output Common line, 1 for each 8 circuits.
Internal Power Consumption	5 Vdc, 40 mA + 1.9 mA per point



AMBIENT TEMPERATURE (°C)
I/O POINTS VS TEMPERATURE CHART

Figure 6.11 provides wiring information for this 24 Vdc Output module.

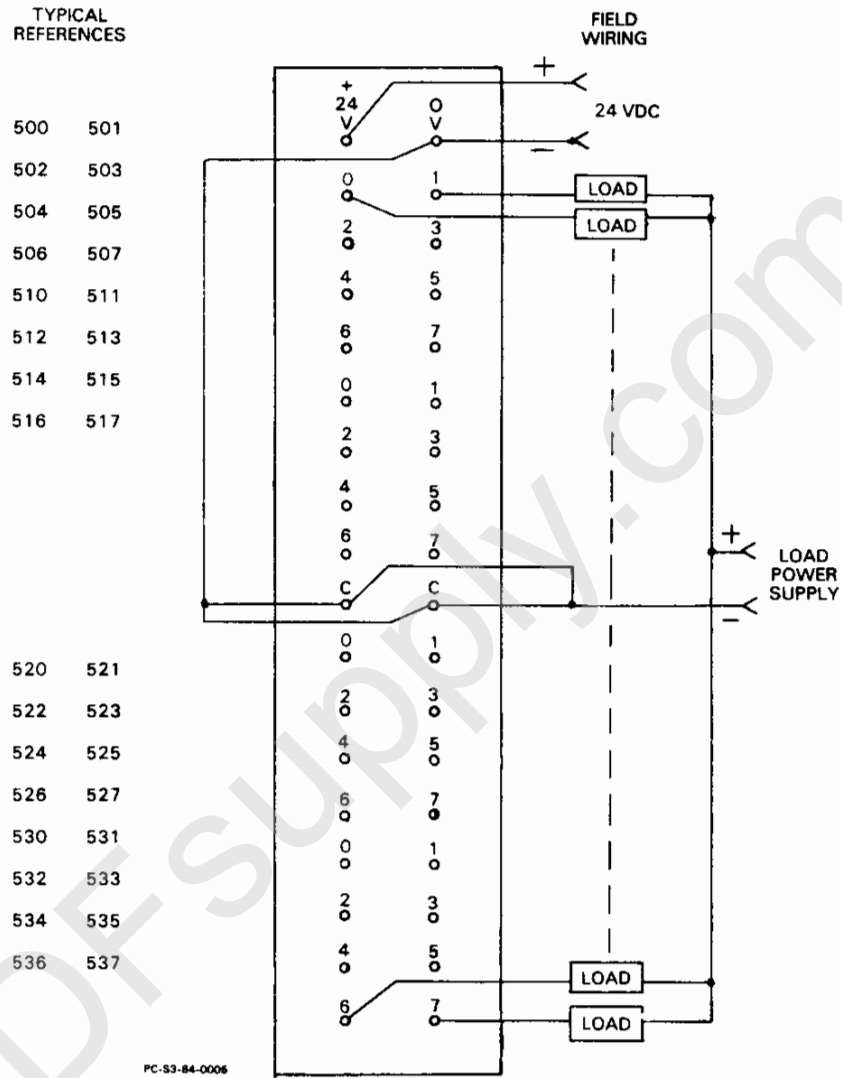


Figure 6.11
24 VDC OUTPUT USER CONNECTIONS

24 VDC INPUT/OUTPUT (16 INPUTS/16 OUTPUTS)
IC630MDL304A

This module provides a dual function in that it provides 16 input circuits and 16 output circuits on one module. The 16 input circuits are each designed to receive a single discrete (ON/OFF) signal from user supplied devices and the 16 output circuits are each capable of controlling user supplied discrete (ON/OFF) loads. Typical input devices include limit switches, pushbuttons, and relay contacts. Typical loads include motor starters, relay coils, and indicator lights. A 24 Vdc power supply must be provided by the user. This supply provides the power to sense the state of the inputs and also provides the DC power source for the output circuits.

The 16 input circuits and 16 output circuits are connected to the appropriate input devices or user loads through field wiring to a 36 screw-terminal connector mounted on the faceplate. Input and output terminals are each arranged in two groups with eight terminals in each group, numbered 0 to 7. The top 16 terminals are for inputs, the lower 16 terminals are for outputs. Each terminal will accept one No. 12 AWG or two No. 14 AWG wires.

When installed in an I/O slot, a 32 point I/O module uses 32 consecutive I/O references, i.e. the 16 references assigned to that slot and the next 16 references. A 32 point I/O module in slot 1 would use references 00-37. In this case, an I/O module installed in slot 2 would have a starting reference number of 40. If an 8-slot base was filled with 32 point I/O modules, that base would contain 256 I/O points (references 000-377, if first base unit).

Specifications for each of the 16 input and 16 output circuits are as follows.

INPUT CIRCUITS		OUTPUT CIRCUITS	
Input Current	7mA	Maximum Current	0.5 amp
ON Level	< 6.0 Vdc	ON Voltage Drop, Typical	0.8 Vdc @ 0.5 amp
OFF Level	> 18.0 Vdc	Leakage Current, Maximum	100 μ A
ON Current, Minimum	5.0 mA	Peak Voltage	45 Vdc
OFF Leakage, Maximum	2.0 mA	OFF to ON Response	100 μ s
OFF to ON Response	3-12 ms	ON to OFF Response	100 μ s
ON to OFF Response	3-12 ms	Maximum Switching Capacity	24 Vdc @ 0.5 amp
		Fuse (Internal)	5 amp (In output common line, 1 for each 8 circuits)
External Power			
Voltage	24 Vdc, 10%		
Ripple	<3% rms, Maximum		
Current	160 mA Maximum (32 Circuits ON) 80 mA Typical (16 Circuits ON)	Excluding loads	
Internal Power Consumption 5 Vdc @ 50 mA + .22 mA per Input ON (Supplied by Series Three power supply) + 2.25 mA per Output ON			

Figure 6.12 provides wiring information for the 24 Vdc Input/Output module.

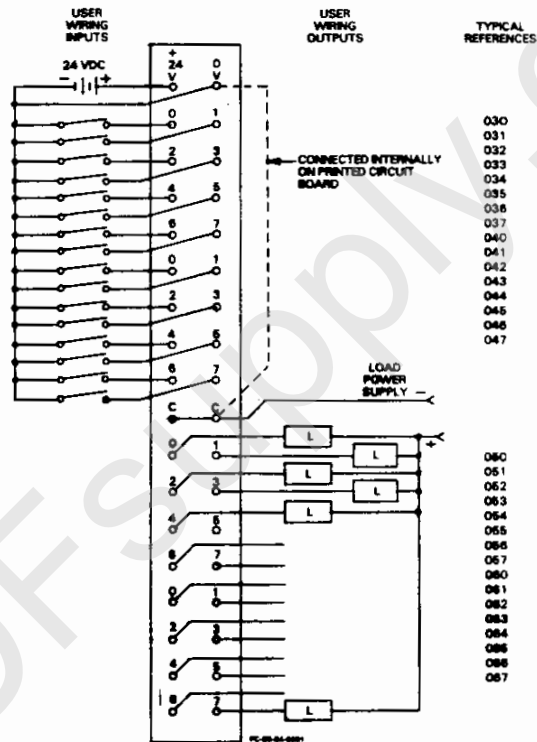
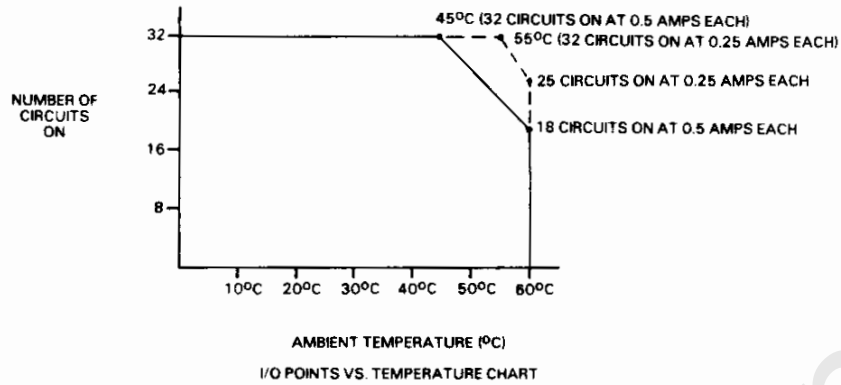


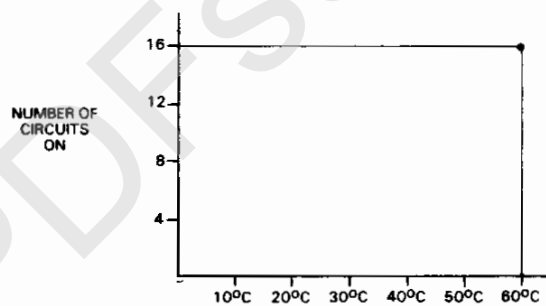
Figure 6.12
24 VDC INPUT/OUTPUT USER CONNECTIONS

RELAY OUTPUT
IC630MDL380A

The Relay Output module provides 16 circuits, each capable of controlling user supplied discrete (ON/OFF) loads. Typical loads include relay coils, motor starters, solenoid valves, and indicator lights. Since this module is not designed for a specific current type such as 24 Vdc or 115 Vac, it can be used for a wide variety of loads and signal types. The 16 circuits are arranged in two groups of 8 circuits each. Each group is protected by a 10 amp fuse. Each group can be supplied from a separate power source. Power to operate the field devices must also be supplied by the user. Specifications for this module are listed below.

Output points	16 with LED Indicators
Contact Type	Normally Open (N.O.)
User Supplied * Voltage Current	5 - 265 Vac/dc maximum 4A continous
ON delay OFF delay	5 ms 5 ms
Contact protection	RC network (100 Ω , .015 μ f)
Leakage current of contacts	1.3 mA (230V, 60 Hz) due to surge protection circuit
Fuse Rating	10A (each 8 circuits)
Internal Power Consumption	5 Vdc, 35 mA 12 Vdc, 40 mA/point

*Since non-solid state devices are used for power switching, the limitations listed in Table 6.3 must be observed for reliable operation.



AMBIENT TEMPERATURE (°C)
I/O POINTS VS. TEMPERATURE CHART

PC-S3-83-0030

Table 6.3
LOAD CURRENT LIMITATIONS

Operating Voltage	Maximum Current for Load Type			Typical Contact Life (Number of Operations)
	Resistive	Lamp	Solenoid	
220 Vac	4 Amp	0.5 Amp	0.5 Amp	100,000
220 Vac		0.05 Amp	0.05 Amp	800,000
110 Vac	4 Amp	0.5 Amp	0.5 Amp	100,000
110 Vac		0.1 Amp	0.1 Amp	650,000
24 Vdc	4 Amp	0.5 Amp		100,000

NOTE

Lamp loads are defined as having a X10 inrush with a power factor (PF) of 1.00 and when turned OFF represent a PF of 1.00. Solenoids are defined as having a X10 inrush with a PF of 0.65 and when turned OFF represent a PF of 0.35.

Figure 6.13 provides wiring information for the Relay Output module.

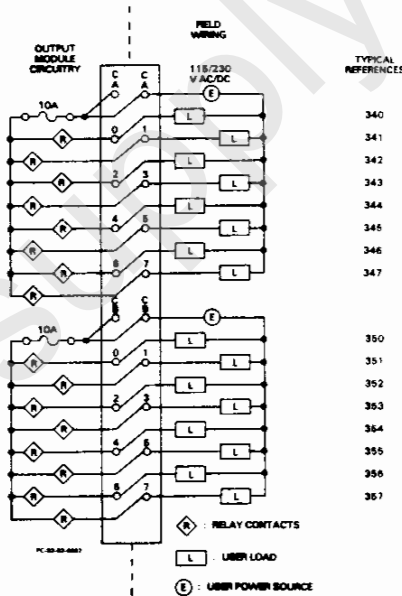


Figure 6.13
RELAY OUTPUT USER CONNECTIONS

I/O SIMULATOR MODULE
IC630MDL324A

The I/O simulator module for the Series Three has 16 two-position (ON-OFF) switches, each having an associated LED; i.e., if switch 1 is turned to the ON position, LED 1 will light. An I/O simulator module uses one I/O slot and the 16 I/O references for that slot. Each of the switches can be programmed as a discrete input device. An I/O simulator can also be used to program conditional input contacts for control of outputs. This module requires no field connections since its function is controlled by programming. An I/O simulator module can be a valuable tool in program development and troubleshooting. Internal power consumption by this module is 5 Vdc @ 30 mA + 5 mA/point. Figure 6.14 shows the switch and LED arrangement on the module faceplate.

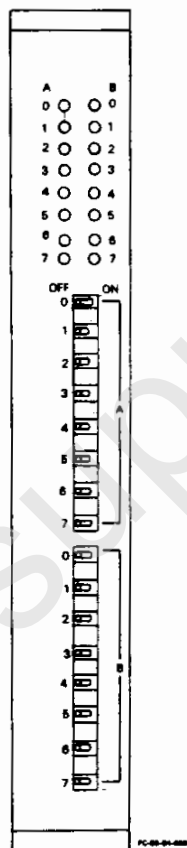


Figure 6.14
I/O SIMULATOR

CHAPTER 7
PERIPHERALS

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CHAPTER 7 PERIPHERALS

The CPU/Programmer allows operation via the tape port with various peripherals. This chapter describes the operations of these peripherals such as a tape loader, the logic printer, and the PROM writer. To operate these peripherals, the programmer's mode switch must be turned to the LOAD position. The 2.5 foot (0.75 meter) audio cable, gray with red tracer supplied with the CPU is used to connect only the tape loader to the tape port on the programmer. The solid gray cables supplied with the other peripheral device can be used with either the printer or the PROM Writer.

CASSETTE RECORDER OPERATION

Most audio tape recorders with auto-level control can be used with the Series Three. It is recommended that the recorder also be equipped with a counter to allow multiple programs to be recorded on tape. Units such as General Electric models 3-5158A or 3-5153A have been tested and found fully compatible with the Series Three. The tape recorder performs three functions: (1) record a program onto tape, (2) load a CPU from tape, and (3) verify the content of a tape. All of logic memory (4096 words) will be recorded on tape. The operation of each of these functions is described below in a step-by-step manner.

RECORD A PROGRAM

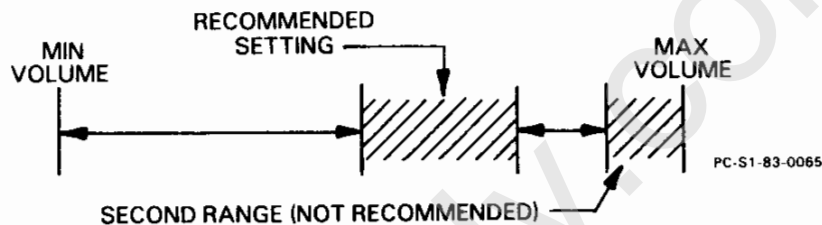
1. Turn the mode select switch on the programmer to LOAD.
2. Apply AC power to the tape recorder. Verify presence of write protect tab on cassette and insert cassette.
3. Adjust tone control to its highest position.
4. Connect Programmer (TAPE port) to the tape recorder (MIC input) with audio cable (Catalog Number IC630CBL151A).
5. Rewind tape to beginning or desired record position if multiple programs are to be recorded on one tape. Programs require a maximum of 9 minutes (4096 words) of tape per program.
6. Push CLR, SHF, and WRITE.

7. For identification of program if desired, enter a four digit number (0000-9999) on the Programmer. When tape is accessed later to load the CPU, this number can be used to verify program prior to altering CPU data. If program number is not as expected, operator can terminate load and obtain correct tape without loss of existing program nor delay incurred by loading wrong program. However, this identification is optional.
8. Begin tape recorder by depressing the RECORD button (and PLAY if required) on the recorder, then push NXT on the Programmer.
9. The record operation now commences and the Programmer display will read P-C. N.N.N.N. (N.N.N.N. is the four digit program number, if no number assigned display will be 0.0.0.0.).
10. When the record is complete, the Programmer will beep and display P-C End. Stop the recorder and note the counter position so that the amount of tape used for that program can be determined.
11. Either turn the mode select keyswitch to RUN 1 to start the CPU or check (verify) the recording.
12. It is recommended that the tape be rewound to where the record began and that the Verify operation described below be performed to ensure data integrity.

VERIFY A PROGRAM

1. Place Programmer in the LOAD mode.
2. Apply AC power to the tape recorder and insert cassette (if not already in the recorder).
3. Adjust volume and tone controls to their maximum setting.
4. Connect Programmer (TAPE port) to the tape recorder (EAR input) with audio cable (gray with red tracer).
5. Rewind tape to beginning of previously recorded program. Tape can also be on blank area prior to program, but not on another program. Enter the program identification number (if previously recorded).
6. Push CLR, SHE, and CHECK. The display will read C I P.

7. Begin tape recorder by depressing the PLAY button, then push NXT on the Programmer. The verify operation now commences. The display will read C̄P-. N.N.N.N. The bar indicates that the volume control setting is correct. It should not be flickering on or off.
8. Error code E21 indicates the tape has an integral parity error; E25 indicates a mismatch between the content of the tape and the CPU logic memory. E28 indicates the play level is wrong and the verify should be stopped, volume adjusted, and the operation restarted (step 5 above).
9. The illustration below shows the available area of the volume control for a proper setting.



With some recorders, there are two ranges where the signal level appears to be acceptable, one near the middle and one near maximum volume. The setting near maximum volume should not be used. The CPU will indicate that it is acceptable; however, an unacceptable amount of clipping distortion may occur in this area with some recorders.

10. Find the correct position for the mid-range of the acceptable volume control during the beginning or "header" portion of the tape. Some experimenting may be necessary. The duration of time for the header is about 7 seconds. It is important to choose the lower of the two ranges for the volume control setting if they both exist (see 9 above). For the recommended General Electric recorder this is at about 80% of full maximum. Mark the proper setting with paint or other method.
11. During the verify (or load) operation, F.F.F.F. may appear in the display. This is most likely an indication that the tape was started after the beginning of a program. If this happens stop the tape, rewind it and restart the operation.

12. If an error code is displayed during a verify (or load) operation, the CLR key should be pushed two times in order to start over again. The first time CLR is pushed, the program address that did not match is displayed. The second CLR will allow the operation to be restarted.
13. If after following all instructions, reliable operation cannot be obtained, try operating the recorder with batteries.
14. When the verify is complete without error, the Programmer will display CIP-. End.
15. Stop the recorder and turn the mode switch to RUN 1 and re-enter the RUN mode.
16. The verify operation will require approximately the same time as the record (maximum of 9 minutes depending upon memory length used).

LOAD A PROGRAM

1. Place Programmer in the LOAD mode.
2. Apply AC power to the tape recorder and insert cassette.
3. Adjust volume control to the setting determined during the verify operation. Adjust tone control to its highest setting.
4. Connect Programmer (TAPE port) to the tape recorder (EAR input) with audio cable (gray with red tracer).
5. Rewind tape to beginning of previously recorded program. Tape can also be on blank area prior to program, but not on another program. Enter the program identification number (if previously recorded).
6. Push CLR, SHF, and READ on the Programmer to establish CPU load operation. Display will read C-P.

7. Begin tape recorder by depressing the PLAY button, then push NXT on the programmer. The load operation now commences. The display reads C-P. When the beginning of the program is reached the display will change to C-P-. If the bar after the P is off or flickering, the volume control should be adjusted until the flickering stops. Return to step 5 and proceed with the operation. The display will also eventually contain the program identification number. If the CPU detects a program number different than the one entered in step 5, the display will beep and show PA'7'7.
8. If the incorrect program has been selected, the load operation can be aborted by stopping the recorder or depressing the CLR (Clear) key on the Programmer.
9. Error code E21 indicates the tape has an internal parity error. E28 indicates the play level is wrong and the load should be stopped, volume adjusted, and the operation restarted (step 5 above).
10. When the load is complete without error, the Programmer will beep and display C-P-. End in the Address/Data display. Stop the recorder and depress the CLR (Clear) button on the Programmer to end the load operation.
11. The load operation will require approximately the same time as the record (maximum of about 9 minutes depending upon memory length used).



Figure 7.1
LOGIC PRINTER

LOGIC PRINTER OPERATION

In addition to the tape loader, the TAPE port on the Programmer can also support a Printer (Figure 7.1). This Printer is used to document the logic stored within a Series Three utilizing the same language or symbols as used to enter the program. Figure 7.2 is a sample printout; logic is documented from the beginning of memory (lower address) towards the higher addresses exactly as the CPU scans. The paper is heat sensitive and does not require ink or carbon paper. The printer has a buffer that is loaded from the Series Three and generates the print output from that buffer. An entire program can be printed out or just the logic contained in a 1K portion as controlled by the operator. On the lower right of the printer top are eight LED's and five pushbuttons. The function of each is as follows:

- LED 1 - On to indicate printer will document first 1024 words of logic space (addresses 0000-1023).
- LED 2 - On to indicate printer will document second 1024 words of logic space (addresses 1024-2047).
- LED 3 - On to indicate printer will document third 1024 words of logic space (addresses 2048-3071).
- LED 4 - On to indicate printer will document last 1024 words of logic space (addresses 3072-4095).
- POWER - On when power switch is in the ON position and power supply is providing proper DC voltages for internal operations.
- MEM SEL- Pushbutton used to change selected memory for printing. Each time it is depressed, LED's 1-4 will shift one position (1, 2, 3, 4, none, 1, 2, etc). When all LED's 1-4 are off, all of memory will be documented.
- READ - Pushbutton used to read CPU data into the Printer's buffer. Its associated LED will be ON when this operation is selected and other lower LED's will be extinguished.
- PRNT - Pushbutton used to begin print operation based upon data previously loaded into its buffer space. Its associated LED will be ON, and other adjacent LED's will be OFF, when this operation is selected.

CLR MEM- Pushbutton used to clear buffer memory within printer. Its associated LED will be ON when this operation is selected and other higher LED's will be extinguished.

RST - Pushbutton used to reset any printer operation. Functions such as reading CPU data, printing logic, and clearing memory will be terminated if this pushbutton is depressed.

To operate the Printer with the Series Three, install the Series Three Printer PROM (IC630ACC301A) with Printer power switch in the OFF position or AC power cord disconnected.

CAUTION

PROM must be installed with GE logo in the up position. Failure to correctly orient PROM may cause it to be damaged when power is applied.

This Printer can also be used to document Series One programs with Printer PROM IC610ACC101A (see Series One Manual, GEK-25375). Both PROM's are provided with the Printer. To document a Series Three program, perform the following actions:

1. Apply AC power to the Printer.
2. Put Printer power switch in the ON position. Verify that the POWER LED is On.
3. Depress CLR MEM pushbutton twice to clear memory. The first time the pushbutton is depressed the LED will turn ON and a tone will sound, the second time the LED will turn OFF.
4. Connect Programmer (TAPE port) to Printer (external terminal - on side) with audio cable that is totally gray (no red trace, Catalog Number IC630CBL150A).
5. Put Programmer in the LOAD mode.
6. Depress the READ pushbutton, the LED will flash ON and OFF.
7. At the Series Three Programmer, push the CLR, SHF, WRITE, NXT keys to cause a write to the printer to begin. The READ LED will turn ON, verifying that the printer is in READ mode. The Programmer displays P-C. indicating that data is being read.

8. The loading of the Printer buffer is complete when the Printer READ LED goes off and two quick tones sound and the Programmer displays P-C. End and generates a single tone. The time required to transfer the logic depends upon the amount of memory used. If a transmission error occurs, a constant beeping tone will sound.
9. At the Series Three, depress the CLR key to clear the display. The CPU can be disconnected from the audio cable and returned to normal operation if desired.
10. Select the memory to be documented by successive depressions of the MEM SEL pushbutton while observing LEDs 1-4. All LEDs off indicate that the total 4K of memory will be documented. Additional printouts can be obtained from this memory area or others without refreshing data from the CPU.
11. To begin the printing, depress the PRNT pushbutton, the PRNT LED will turn ON. The printer will begin to document the logic at the rate of one line per word or function. When Printing is complete a tone will sound and the PRNT LED will turn OFF.

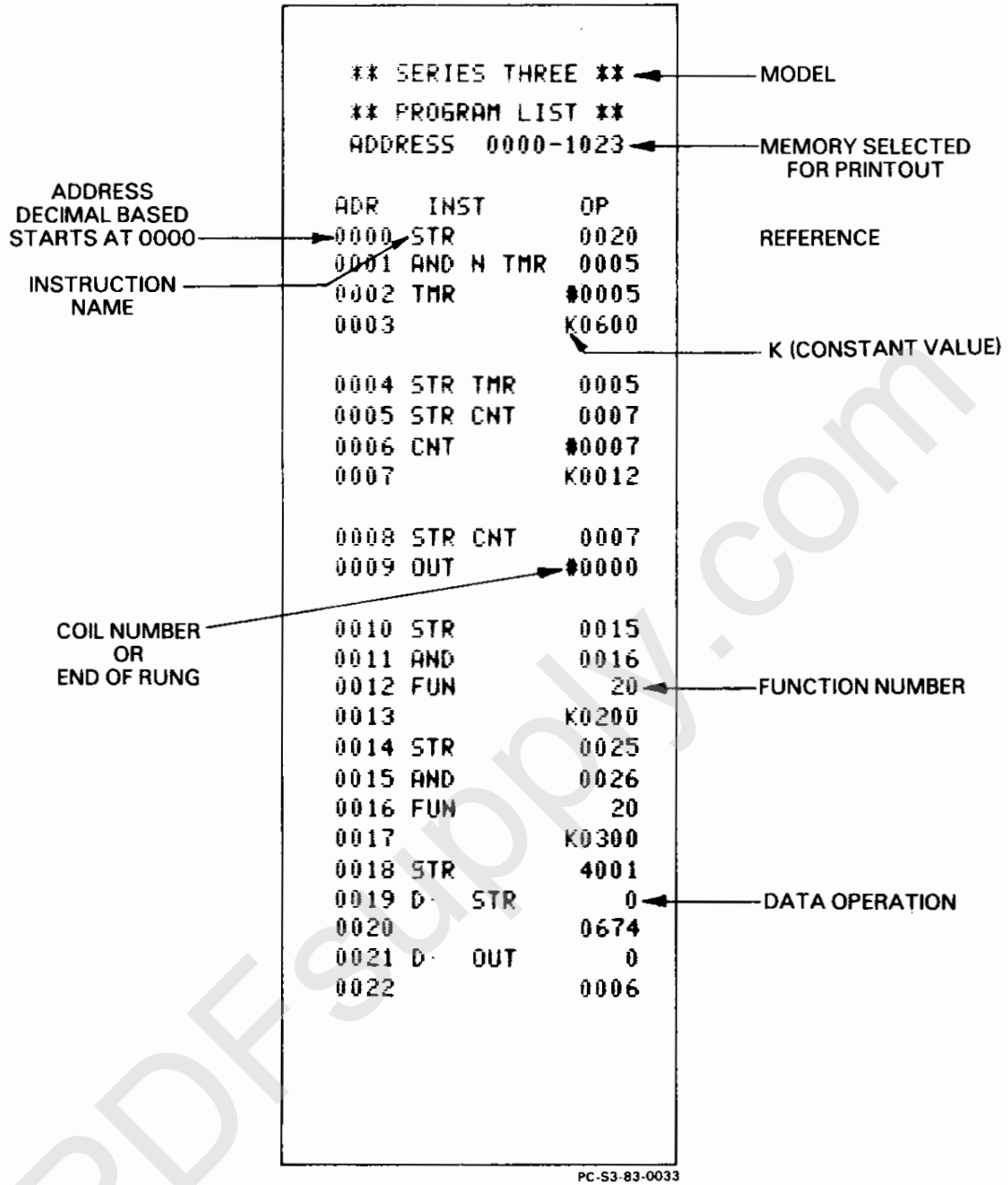


Figure 7.2
SAMPLE PRINTOUT

PROM WRITER OPERATION

The third peripheral available for use with the Tape port is the PROM writer (Figure 7.3). This device copies logic from the CPU's CMOS memory and writes it into a PROM for subsequent installation into any Series Three CPU. To operate with the Series Three, PROM Writer System PROM IC630ACC302A must be installed with Writer power switch in the OFF position or AC power cord disconnected.

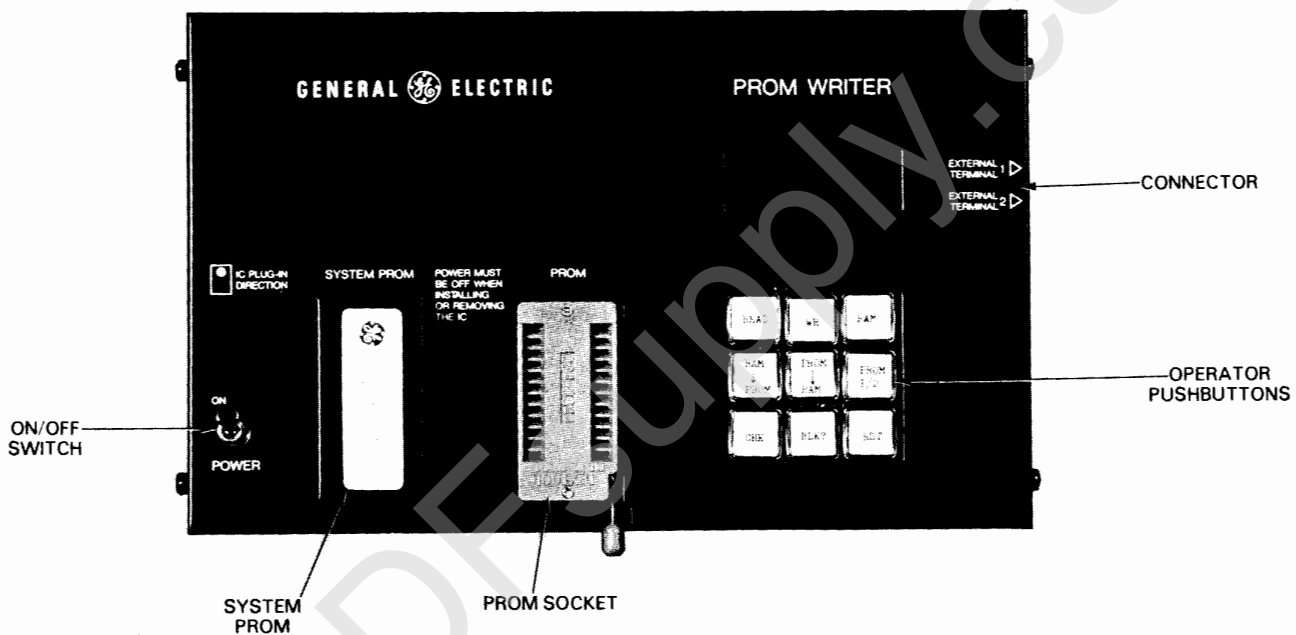


Figure 7.3
PROM WRITER

This Writer can also be used to transfer Series One programs with PROM Writer PROM IC630ACC102A (see Series One Manual GEK-25375). Both PROM's are provided with the PROM Writer. PROM memory can be written once by this Writer and not altered thereafter; their content is not lost when power is removed for long time periods (up to 8-10 years). To reuse a PROM it must be erased by long exposure (10-15 minutes) to an intense ultraviolet light in a special PROM eraser. Normal ambient ultraviolet light (e.g. sunlight) has virtually no effect on its content. There are many commercially available PROM erasers handling single PROM's or many PROM's at a time.

The nine pushbuttons to the lower right have the following functions:

- READ - Causes the Writer to receive data into its buffer memory from the Series Three.
- WR - Causes the Writer to write data from its buffer memory to the Series Three.
- RAM - Refers to the Writer's internal memory.
- RAM→PROM - Specifies loading the PROM from Writer's internal memory.
- PROM→RAM - Specifies loading the Writer's internal memory from the PROM.
- PROM 1/2 - Selects PROM 1 (lower 8 bits) or PROM 2 (upper 8 bits).
- CHK - Specifies a checking or verifying operation as contrasted to actual transfer of data.
- BLK? - Specifies testing for blank or erased PROM's.
- RST - Resets Writer's operation and obtains type of system PROM installed.

There are many functions possible with this Writer. The following steps should be used as appropriate for the functions desired.

1. Verify the following conditions before each function:
 - a. Apply AC power to the CPU base unit
 - b. Plug Writer's AC power cord into a source of power.

- c. Install the Series Three system PROM onto Writer with GE logo at top of PROM.
 - d. Place Writer's power switch to ON. Depress RST to reset the Writer. The display should read S3 if the Series Three System PROM is properly installed.
 - e. Place Programmer in the LOAD mode
2. To load the Writer's memory from the Series Three CPU:
 - a. Connect audio cable (solid gray) from the Programmer's TAPE port to the Writer's External Terminal 1 on its right side. Depress the RAM/RST buttons simultaneously to clear the Writer's RAM memory. The display will read CLR, a tone will sound, then when End is displayed memory has been cleared.
 - b. Depress the Writer's READ pushbutton. The display should read E-A.
 - c. On the Programmer push CLR, SHF, WRITE, NXT. The Writer's display will show P-C.
 - d. At the completion of the transfer, the Writer will display End and beep twice. The Programmer will also display End. If a transmission error occurs, a constant beeping tone will sound.
 - e. Select the CLR key on the Programmer to clear its operation.
 3. Verify Writer memory against Series Three memory.
 - a. Connect the audio cable (solid gray) from the Programmer's TAPE PORT to the Writer's External Terminal 1 on its right side.
 - b. Depress the Writer's RAM and CHK pushbuttons at the same time. Display will read E C P.
 - c. On the Programmer push the CLR, SHF, WRITE and NXT keys. The Programmer display will be P-C. If the verify proves both memories are identical, the Writer's display will show End and beep twice, the Programmer will also display End. The Verify will take about 4 minutes. To indicate an error, it will display (ErrU).

4. Loading PROM from Writer's memory
 - a. Place type 2732A-2 or equivalent PROM into blue-green socket. Insert with locking handle up and then lock in place by moving handle 90° to horizontal position. PROM should have notch at top to ensure pin 1 is at top left.
 - b. Depress RST pushbutton to reset the Writer. The display should be S 3 if the Series Three system PROM is properly installed.
 - c. Depress the RAM→PROM pushbutton to initiate the loading of the PROM. The display will read A-P1 for PROM 1 or A-P2 for PROM 2. The Writer will check that the PROM is erased, load it, and then verify the load automatically. The display will show Ers while checking if the PROM is erased or blank. The display ErrE indicates the PROM is not properly erased. The display $\square \square \square \square$, then End indicates satisfactory completion of the load which should take about 4 minutes.
 - d. Remove first PROM from socket, insert second PROM. Depress the 1/2 pushbutton to select PROM2, then repeat step c.
5. Verify Writer memory against PROM
 - a. Place type 2732A-2 or equivalent PROM into blue-green socket. Insert with locking handle up and then lock in place by moving handle 90° to horizontal position. PROM should have notch at top to ensure pin 1 is at top left.
 - b. Depress RST pushbutton to reset the Writer. The display should be S 3 if the Series Three system PROM is properly installed.
 - c. Depress the CHK pushbutton to initiate the checking of the PROM. The display will be $\square \square \square \square$ or $\square \square \square \square$. If differences are found, the checking halts at that location and Errc is displayed. Depressing the CHK pushbutton will display the first memory address with a miscompare, successive depressions of CHK will allow successive addresses with miscompares to be displayed. At the end of the check, the display will show End.
 - d. Remove PROM 1, insert second PROM, depress PROM 1/2 pushbutton and repeat step c.

6. Transfer from PROM to Writer's memory to Series Three CPU memory
 - a. Connect the audio cable (solid gray) from the Programmer's TAPE port to the Writer's External Terminal 2 on its right side.
 - b. Place type 2732A-2 or equivalent PROM into blue-green socket. Insert with locking handle up and then lock in place by moving handle 90° to horizontal position. PROM should have notch at top to ensure pin 1 is at top left.
 - c. Depress RST pushbutton to reset the Writer. The display should be 'E' if the Series Three system PROM is properly installed.
 - d. Depress the PROM → RAM pushbutton to initiate the loading of the Writer's memory. The Writer display will be P1-A, then [] while the transfer is taking place and End when the loading is complete.
 - e. On the Programmer, select the CLR, SHF, READ and NXT keys. The display will be C-P.
 - f. On the Writer, depress the WR pushbutton. The Writer will display A-E and the Programmer display will now be C-P. After a short delay 0.0.0.0. will appear under the Data display. When the transfer is complete, the Programmer will display C-P-. End and the Writer will display End. To terminate its operation, select the Programmer's CLR key.
 - g. Remove PROM, insert second PROM, depress PROM 1/2 pushbutton and repeat steps d to f.
 - h. To verify the accuracy of the transfer, select CLR, SHF, CHECK, NXT at the Programmer (display will be []) and depress the WR pushbutton on the Writer. The Writer will display A-E and the Programmer will display []-. After a short delay 0.0.0.0. will appear under the Data display. When the verify is complete, the Programmer will display []-. End. and the Writer will beep and display End.
7. To verify that a PROM is blank, insert it and depress the BLK? pushbutton. The Writer display of End indicates a blank PROM: display of ErrE indicates the PROM is not fully erased.

8. To clear the Writer's memory, depress the RAM and RST pushbuttons at the same time. A successful clearing results in the Writer's display of End; if for some reason (hardware failure) the clear is not successful, the display will be ErrM. The display will show CLE while erasing and End when complete.
9. Inserting PROM1 and PROM2 in CPU.
 - a. Turn off AC power to the CPU.
 - b. Remove cover on back of CPU.
 - c. Insert PROM1 in slot on right.
 - d. Insert PROM2 in slot on left.
 - e. To select PROM memory, move ROM/RAM switch to S (left position).
 - f. Replace cover on back of CPU.
 - g. Apply power to CPU.

CHAPTER 8
MAINTENANCE

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CHAPTER 8 MAINTENANCE

The Series Three PC is designed to provide trouble-free operating during its life. However, occasionally problems do occur and it is important to be able to quickly identify the source of the problem and correct it. Many times these problems originate outside of the Series Three. The advantage the Series Three design provides is indicators and built-in aids to troubleshoot not only the PC but also the overall control system. The main diagnostic tool is the CPU/Programmer. The programmer provides great insight to the status of the overall control system.

All major faults can be corrected by replacing modules. No special tools are required other than a screwdriver and voltmeter. The recommended screwdriver is a U.S. #2 Phillips. There is no requirement for an oscilloscope, highly accurate voltage measurements (digital to voltmeters), or specialized test programs.

Table 8.1 is a parts list for the Series Three. A spare parts kit is recommended so that a system can be returned to service with a minimum amount of down time in the event a problem should occur. If a failure should occur, some basic questions should be asked and appropriate corrective action taken to negative answers.

1. Is the POWER light on (located on power supply)? If not, measure the voltage at the AC terminals on the power supply (115 Vac or 230 Vac, $\pm 15\%$). If AC power is not present, locate the source of the problem external to the Series Three. If the AC power is adequate, but the POWER light is off, the power supply should be replaced.
2. Is the RUN light on? If not, ensure that the CPU cable is connected securely at the power supply. If it is, be sure that the mode switch is not in the PROG, LOAD, or PROM position. If those checks are all good, replace the CPU/Programmer.
3. Is the back-up battery O.K? If error code E22 is displayed on the programmer display, it is a warning that the battery voltage has dropped below 2.7 Vdc and will not retain memory if power is removed. The battery should be replaced. After replacing the battery, verify the program or test the Series Three operation. If a fault is discovered, reload the program from a tape recorded after initial system programming.

Table 8.1
SERIES THREE PARTS LIST

Catalog Number	Item Name
IC630CPU301A	CPU/Programmer Unit
IC630PWR300A	Power Supply Unit, 115/230 Vac
IC630CHS304A	Base Unit, 4 Modules
IC630CHS306A	Base Unit, 6 Modules
IC630CHS308A	Base Unit, 8 Modules
IC630MDL301A	24VDC Input Module (16 Inputs)
IC630MDL303A	5-12 VDC Input Module (32 Inputs)
IC630MDL304A	24 VDC In/Out (16 Inputs/16 Outputs)
IC630MDL324A	I/O Simulator Module
IC630MDL325A	115VAC Input Module (16 Inputs)
IC630MDL326A	Isolated 115VAC Input Module (8 Inputs)
IC630MDL351A	24VDC Output Module, 2 Amp (8 Outputs)
IC630MDL352A	24VDC Output Module, 1 Amp (16 Outputs)
IC630MDL354A	5-12 VDC Output Module (32 Outputs)
IC630MDL375A	115VAC Output Module (16 Outputs)
IC630MDL376A	Isolated 115VAC Output Module (8 Outputs)
IC630MDL380A	Relay Output Module (16 Outputs)
IC630MDL150A	Lithium Battery
IC630CBL304A	I/O Expander Cable

Additional troubleshooting procedures depend upon knowledge of the logic installed by the user. The following steps are general in nature and should be modified or adjusted to your specific application. The best troubleshooting tools are common sense and experience. Place the mode switch in the RUN mode, then follow these steps:

1. If the Series Three has stopped with some outputs energized or basically in mid-steady, locate the signal (input, timer, coil, etc.) that should cause the next operation to occur. The programmer will display ON/OFF condition of that signal (monitor display area, position 0).
2. If signal is an input, compare programmer state with LED on input module. If they are different, replace input module. If multiple modules in expander base are faulty, verify I/O cable and its connection before replacing module.

3. If input state and LED on Input module agree, compare LED status and input device (pushbutton, limit switch, etc.). If they are different, measure voltage at Input module (refer to Chapter 6 for typical I/O wiring). If voltage indicates a faulty I/O device replace it, or field wiring, or power source; otherwise; replace input module.
4. If the signal is a coil wired to a field device, compare its status to LED on output module. If they are different, verify source of field power to ensure that excitation voltage is available. If field power is not present, examine power source and its wiring. Otherwise, with field power available and wrong status at output module, replace output module.
5. If the signal is a coil and either there is no output module or output is same as coil state, examine logic driving output with programmer and hard copy of program. Proceeding from right towards left, locate first contact that is not passing power that is otherwise available to it from immediate left. Troubleshoot that signal per steps 2 and 3 above if it is an input, or 4 and 5 if it is a coil. Ensure that Master Control Relays are not impacting operation of the logic.
6. If the signal is a timer that has stopped at a non zero value below 999.9 replace CPU module.
7. If the signal is the control over a counter, examine logic controlling reset first and then the count signal. Follow steps 2-5 above.

The following procedures provide details on steps to be followed to replace various modules.

REPLACING POWER SUPPLY

1. Turn off AC power and remove CPU/Programmer (Refer to Figure 3.2).
2. Disconnect wiring from power supply terminal board.
3. Remove the power supply by loosening the two captive screw fasteners.
4. Install new power supply.
5. Reconnect wiring to terminal board.
6. Verify power wiring and connect AC power. Carefully check operation of entire system.

REPLACING CPU/PROGRAMMER

1. Remove AC power, then remove CPU/Programmer by loosening the captive screw fastener at bottom of unit.
2. Disconnect cable from mating connector on power supply.
3. Connect cable on new CPU/Programmer.
4. Install CPU/Programmer and tighten captive screw fastener.
5. Connect AC power and verify operation of system.

REPLACING I/O MODULES

1. Shut OFF power from both base unit and I/O system.
2. Remove plastic cover over terminals on I/O module. Only connector on faulty module needs to be removed. Loosen two screws holding socket-type terminal in place and remove terminal.
3. If the module is a high-density module with connectors, disconnect the two connectors from the faceplate.
4. Loosen two screws holding I/O module in place.
5. Pull module straight out.
6. Insert new I/O module. Place terminal over edge connector and firmly push down. Tighten screws on connector. Reconnect the I/O Interface cable connectors on high-density modules.
7. Replace plastic cover.
8. Reapply power to CPU then I/O system.

WARNING

Do not discard the Lithium battery in fire. Do not attempt to recharge the battery. Do not short the battery. The battery may burst or burn or release hazardous materials.

- ① Rear compartment screws.
- ② Battery compartment cover.
- ③ Battery connector.
- ④ ROM/RAM Switch.
M = RAM (Factory setting)
S = ROM (EPROM)

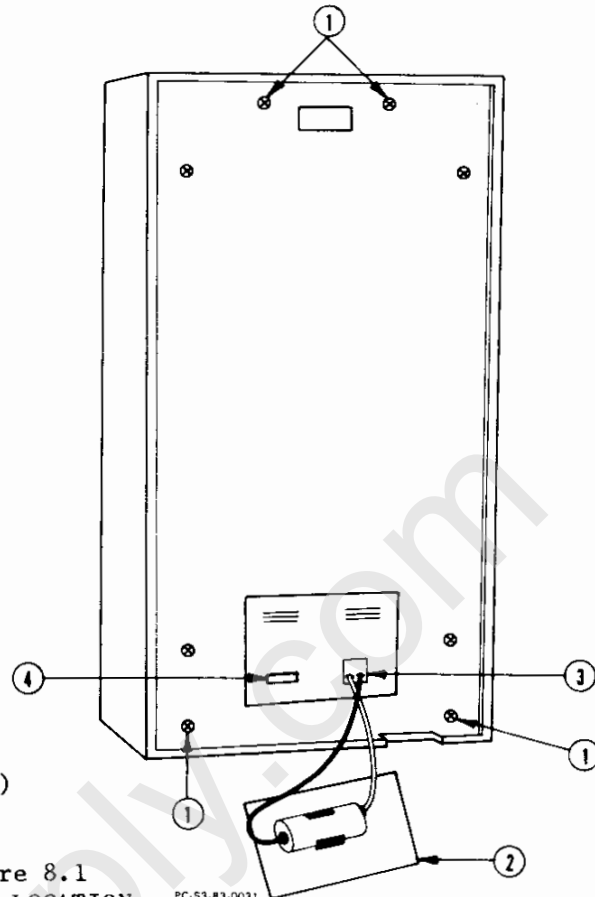


Figure 8.1
BATTERY LOCATION

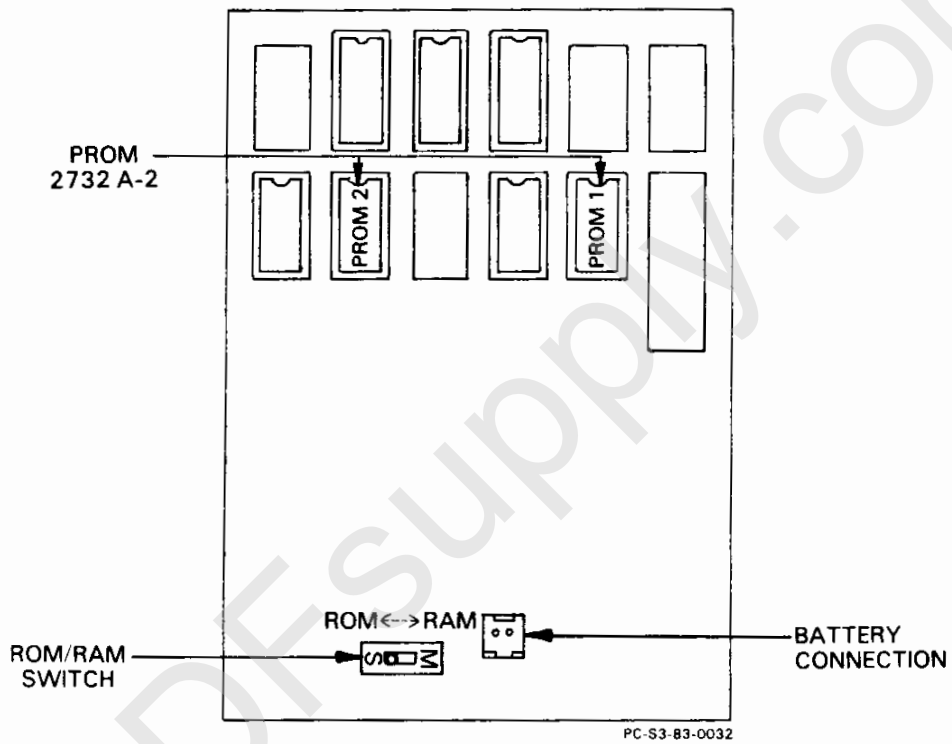
PC-S3-83-0031

REPLACE BATTERY (REFER TO FIGURE 8.1)

1. Remove CPU from base unit.
2. Remove plastic cover to compartment containing battery in rear of CPU.
3. Unplug battery. There is sufficient capacitance in the system to retain CMOS memory even without battery for 20 minutes.
4. Connect new battery.
5. Replace cover.
6. Reinstall CPU module.
7. Verify that Error code E22 has been cleared.

INSTALLING MEMORY (REFER TO FIGURE 8.2)

1. Turn off AC power and remove the CPU/Programmer from the base unit. Remove 4 screws from rear cover plate as shown in Figure 8.1.
2. Locate spare memory sockets on printed circuit board, they will be marked PROM 1 and PROM 2. Refer to Figure 8.2.



*Shown in ROM position.-

Figure 8.2
IC SOCKET LOCATION

3. Obtain memory ICs, (2732A-2 PROM). Refer to Chapter 7 for instructions on loading programs in PROM memory. A Series Three PC requires two PROMs, one for the lower 8 bits of memory and one for the upper 8 bits of memory.
4. Orient each IC so that notch at one end matches notch in memory socket.
5. Insert ICs into socket carefully and evenly so as not to bend any leads. Visually inspect to ensure that all leads are in place and then push down to firmly seat each IC.
6. Replace the cover plate.
7. Reinstall CPU module. Verify proper system operation.
8. When PROMs are installed and are to be the memory source, the ROM/RAM switch next to the battery connector must be pushed to the left (ROM).

FUSE LIST

Table 8.2 lists the fuses used in Series Three I/O modules.

Table 8.2
SERIES THREE FUSE LIST

MODULE NAME	CATALOG NUMBER	FUSE TYPE	SLOW/FAST BLOW	CURRENT RATING	REMOVABILITY	QUANTITY
Power Supply (AC Input)	IC630PWR300A	--	--	--	--	--
(5 Vdc Out)	↓	Midget	Slow	1A	●	1
(12 Vdc Out)	↓	Midget	Slow	5A	●	1
24 Vdc In/Out	IC630MDL304A	Midget	Slow	3A	●	1
24 Vdc Out	IC630MDL351A	Micro	Fast	5A	○	4
		Micro	Fast	5A	○	4
24 Vdc Out	IC630MDL352A	Micro	Fast	5A	○	4
115 Vac Out	IC630MDL375A	Midget	Fast	8A	●	2
Isolated 115 Vac Out	IC630MDL376A	Midget	Fast	3A	●	8
Relay Output	IC630MDL380A	Midget	Slow	10A	●	2

- = Mounted in fuse clips
- = Soldered connection

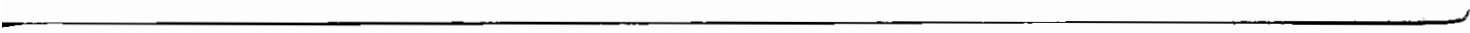
ACCESSORY KIT

To support the Series Three an accessory kit is available (IC630ACC320A). This kit includes commonly needed components that may get damaged or lost in the normal course of operation. Rather than attempting to order small parts such as fuses, audio cables, screws, etc., this kit can be ordered and provides sufficient material to support 3-5 CPUs depending upon their I/O count. Included in the kit are the following items.

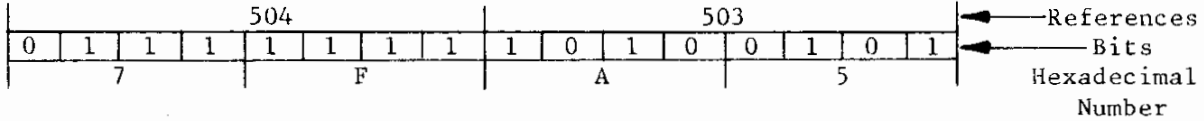
<u>COMPONENT</u>	<u>QUANTITY</u>
Key	1
Dust Cover for Connectors	3
I/O Terminal Cover (16 I/O)	3
I/O Terminal Cover (32 I/O)	2
Terminal (16 I/O)	1
Terminal (32 I/O)	1
Cable, CPU to Tape Recorder	1
Cable, CPU to Peripheral	1
Fuses (Slow Blow, 1 amp, 3 amp, 5 amp, 10 amp)	5 ea.
Fuses (Fast Blow, 3 amp, 8 amp)	5 ea.
Screws (M4 x 50)	2
(M3 x 6, pan-head)	5
(M3 x 6, counter sunk head)	5
(M3 x 6, binding head)	5
Washer (M3)	5

APPENDIX

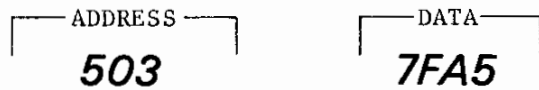
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For this example, assume that the contents of the referenced groups is as follows. The example refers to Data Registers. References can be any valid groups.



The display area of the CPU/Programmer would contain the following after the required key sequence has been pushed.



As a review, the following table lists the hexadecimal conversion from the data contained in the referenced groups. Each hexadecimal character is converted from 4 bits.

4 BIT DATA				HEXADECIMAL
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	A
1	0	1	1	B
1	1	0	0	C
1	1	0	1	D
1	1	1	0	E
1	1	1	1	F

APPENDIX B
SAMPLE PROGRAMMING AIDS

- B2 Ladder Logic Form
- B3 Program Mnemonics Form
- B4 I/O Record Form
- B5 Monitor Display Assignments

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LADDER LOGIC

RUNG NUMBER

_____	*	*	*	*	*	*	*	*
_____	*	*	*	*	*	*	*	*
_____	*	*	*	*	*	*	*	*
_____	*	*	*	*	*	*	*	*
_____	*	*	*	*	*	*	*	*
_____	*	*	*	*	*	*	*	*
_____	*	*	*	*	*	*	*	*
_____	*	*	*	*	*	*	*	*
_____	*	*	*	*	*	*	*	*
_____	*	*	*	*	*	*	*	*
_____	*	*	*	*	*	*	*	*

MONITOR DISPLAY ASSIGNMENTS			
MONITOR DISPLAY POSITION	CONTACT OR COIL REFERENCE		COMMENTS
	TYPE	NUMBER	
00			
01			
02			
03			
04			
05			
06			
07			
08			
09			
10			
11			
12			
13			
14			
15			

APPENDIX C

GLOSSARY OF TERMS

Address - A series of numbers from 0 to 4095 in the Series Three, assigned to specific program memory locations and used to access those locations.

AND (Logical) - A mathematical operation between bits whereby all bits must be a 1 in order for the result to be a 1.

BCD (Binary Coded Decimal) - A 4-bit system in which individual decimal digits (0 through 9) are represented by 4-bit binary numerals; e.g., the number 43 is represented by 0100(4) 0011(3) in the BCD notation.

CMOS - A read/write memory that requires a battery to retain content upon loss of power.

CPU (Central Processing Unit) - The central device or controller that interprets user instructions, makes decisions and executes the instructions based on the decisions.

Counter - A circuit internal to a PC which when controlled by a user programmed function controls other devices according to a preset number of on/off transitions.

Field Devices - User supplied devices typically providing information to the PC (Inputs: pushbutton, limit switches, relay contacts, etc.) or performing PC tasks (Outputs: motor starters, solenoids, indicator lights, etc.).

Group - A series of eight consecutive I/O points, internal coils, etc.

Inputs - A signal, typically ON or OFF, that provides information to the PC.

Instruction - A word, usually an acronym, or group of words and numerals that are part of a program entered into program memory.

I/O - Input/Output - that portion of the PC to which field devices are connected. Isolates the CPU from electrical noise.

I/O Scan - A method by which the CPU monitors all inputs and controls all outputs within a prescribed time.

K - An abbreviation for kilo or exactly 1024 in the world of electronics. Usually related to 1024 words of memory.

Ladder Diagram - A representation of control logic relay systems. The user programmed logic is expressed in relay equivalent symbology.

Latch - A PC operation that causes an output to stay on and remain on even if power or the input is removed. Referred to as a retentive function.

Logic - A fixed set of responses (outputs) to various external conditions (inputs). All possible situations for both synchronous and non-synchronous activity must be specified by the user. Also referred to as the program.

Memory - A physical place to store information such as programs and/or data.

Microsecond (μ s) - One millionth of a second. 1×10^{-6} or 0.000001 second.

Modules - A replaceable electronic subassembly usually plugged in and secured in place but easily removable in case of fault or system redesign.

Noise - Undesirable electrical disturbances to normal signals generally of high frequency content.

Non-Retentive Output - An output that will not remain in its last state when power is removed.

Optical Isolation - Use of a solid state device to isolate the user input and output devices from internal circuitry of an I/O module.

OR (Logical) - A mathematical operation between bits whereby if any bit is a 1, the result will be a 1.

Outputs - A signal typically ON or OFF, originates from the PC with user supplied power that controls external devices based upon commands from the CPU.

PC - See Programmable Controller.

Peripheral Equipment - External units that can communicate with a PC; e.g., cassette tape recorder, printer or PROM writer.

Preset - A numerical value specified in an instruction which establishes a limit for a counter or timer. A coil will energize when this value is reached.

Program - A sequence of instructions entered into a Programmable Controller to be executed by the CPU for the purpose of controlling a machine or process.

Programmable Controller - A solid-state industrial control system which receives inputs from user supplied control devices such as switches and sensors, implements them in a precise pattern determined by ladder diagram based programs stored in the user memory, and provides outputs for control of user supplied devices such as relays and motor starters.

Programmer - A device for entry, examination and alteration of the PC's memory including logic and storage areas.

PROM - A read only memory that requires a special method of loading, but is retentive upon power loss.

RAM - An acronym for Random Access Memory. A solid-state memory that allows individual bits to be stored and accessed. This type of memory is volatile; i.e., stored data is lost under no power conditions, therefore a battery backup is required.

Read - To have data entered into a PC from a peripheral unit.

Reference - A number used in a program that tells the CPU where data is coming from or where to transfer the data.

Retentive Output - An output that will remain in its last state, even though power has been removed.

Rung - A sequence or grouping of PC instructions that control one output. One or more rungs form a ladder diagram.

Scan - The technique of examining or solving all logic steps specified by the program in a sequential order from the first step to the last.

Thumbwheel Switch - A rotating numeric switch which can be used for inputting numeric data to a PC.

Unlatch - A PC function that causes an output previously turned on by a latch instruction to turn off no matter how briefly the function is enabled.

Word - A measurement of memory, in the Series Three 16 bits.

Write - To output or transfer data from the PC to a peripheral unit.

APPENDIX D OTHER PROGRAMMABLE CONTROLLERS

SERIES ONE

The Series One programmable controller is a low-cost compact PC designed to replace 4-100 relays and any combination of up to 64 timers, counters and sequencers. Its small mounting area of 54 square inches (348 sq. cm) allows 32 I/O in the same space as four 4 pole relays. It is expandable from 8 to 112 I/O points in groups of 4 or 8 circuits. Either CMOS RAM with battery back-up or EPROM memory can be selected and is available with 700 words (CMOS), expandable to 1724 words (CMOS or EPROM).

Modular plug-in construction allows any module to be easily changed without disturbing any other part of the PC. A hand-held programmer can be mounted on the CPU or can be easily removed and carried to the PC as needed. The programmer allows monitoring logic, timer and counter values and I/O points.

I/O MODULES

The following I/O modules are available for the Series One.

Table D.1
SERIES ONE I/O MODULES

MODULE NAME	I/O POINTS
24 Vdc Input	8
24 Vdc Input	16
115 Vac Input	8
Isolated AC Input	4
24 Vdc Output	8
24 Vdc Output	16
24 Vdc Input/Output	4/4
24 Vdc Input/Relay Output	4/4
115/230 Vac Output	8
115/230 Vac Isolated Output	4
Relay Output	8
Thumbwheel Interface	
I/O Simulator	

SERIES SIX

The Series Six is a family of programmable controllers consisting of three models, 60, 600 and 6000. The capacity for memory and Input/Output increases as the model number increases. Each model also has internal register storage in varying sizes. The family concept allows the use of common features between models. The common features are; the same programming language featuring a basic and an extended set, the same reference numbers, the same CRT programming device, the same I/O structure including modules, racks, cables, etc., most of the CPU modules, transportable programs from one model/size to another (upward or downward compatibility) and the same options. Memory and I/O capacity are listed in Table D.2

Table D.2
CPU CAPACITIES

MODEL	LOGIC MEMORY	I/O CAPACITY		REGISTER STORAGE
		INPUTS	OUTPUTS	
60	2K	256	256	256
60	4K	1000	1000	1024
600	8K	1000	1000	1024
6000	32K	2000	2000	1024

PROGRAMMING

Programs are entered with the Program Development Terminal. Programming logic is basically a relay ladder diagram language consisting of relay ladder logic (N.O. and N.C. contacts, counters, timers, one-shots and latches). Additional features in the Basic group include Arithmetic (Add, Subtract, Compare), data moves, binary and BCD conversion, a Master Control Relay function and communication requests. The extended Mnemonic group includes the following groups.

- Data Moves (Left 8, Right 8, Block)
- Signed Arithmetic (Double Precision Add and Subtract, Extended Add and Subtract, Multiply, Divide and Greater Than)
- Table Moves (Table-To-Destination, Source-To-Table and Move Table)
- List (Add-To-Top, Remove-From-Bottom, Remove-From-Top and Sort)
- Matrix (AND, OR, Exclusive OR, Invert and Compare)
- Bit Matrix (Bit Set, Bit Clear, Shift Right, Shift Left)
- Control (Do Subroutine, Return, Suspend I/O, Do I/O and Status)

I/O MODULES

I/O modules available for use with the Series Six PCs include the following:

- 115/230 Vac/dc, Inputs and Outputs
- 115/230 Vac Isolated Inputs and Outputs
- 12 Vac/dc Inputs
- 24-48 Vac/dc Inputs
- 12, 24, 48 Vdc Sink and Source Outputs
- High Density Inputs (32 Inputs)
- High Density Outputs (32 Outputs)
- Reed Relay Outputs
- Analog Inputs and Outputs
- Thermocouple Inputs
- Interrupt Inputs
- Axis Positioning
- I/O Receiver and Transmitter for operation up to 2000 feet (600 meters).
- Remote I/O Driver and Receiver for cable operation to 10,000 feet (3 Km) or unlimited distance over a modem link.
- Communications Control (provides a serial interface between a Series Six CPU and an intelligent device). Allows a Series Six to access the GENet data highway.

OPTIONAL EQUIPMENT

Optional equipment for use with a Series Six PC includes a Data Processor Unit (DPU), a Redundant Processor Unit (RPU) and an Operator Interface Unit (OIU).

The DPU provides the PC with access to large quantities of data storage (64K words) and message storage (64K words). Communications to external ASCII serial devices is provided by a Dual Serial Port module.

The RPU acts as a switch to transfer control from one Series Six CPU or I/O chain to a standby in the event that a failure occurs in the first. This provides a method of minimizing downtime in the event of a failure in the PC system.

The OIU is a hand-held micro-terminal that allows an operator to monitor or modify the register contents of a Series Six CPU. The OIU communicates with a CPU through the Communications Control module (version 2).