D320 PLC
User's Manual

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TRADEMARKS

Catalog Number D320SA100

P/N 01-00408-02

Preface

Welcome to Cutler-Hammer’s D320 PLC User's Manual. This preface describes the contents of this manual and provides information on Support Services.

About This Manual

Purpose

This manual focuses on describing the D320 Programmable Logic Controller (PLC).

What's Inside

This manual is organized in the following way:

Preface
Chapter 1: Introduction
Chapter 2: System Configuration
Chapter 3: Product Specification
Chapter 4: Installation and Wiring
Chapter 5: CPU Operation and Memory
Chapter 6: Instructions
Chapter 7: Testing and Troubleshooting
Chapter 8: Troubleshooting Noise Problems
Chapter 9: External Dimensions
Appendix A: D320 PLC Communication Protocol
Appendix B: PID Loop Control
Appendix C: COM2 UDCP Specification

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3. Product assistance and product price information.
4. Product returns other than warranty returns.

For information on your local distributor or sales office, call the Cutler-Hammer Tech Line at 1-800-809-2772.

Correspondence Address **Cutler-Hammer**
173 Heatherdown Drive
Westerville, OH 43081

Table of Contents

Introduction

1

Welcome to the D320 PLC User's Manual. The D320 Programmable Logic Controller (PLC) is a versatile and dependable industrial controller, designed to handle a wide range of application. This manual will give you a complete understanding of how to install and program the D320 PLC. It also includes complete product specifications, and a description of the various products that work with the D320 PLC.

This chapter contains:

- *An overview of this manual*
- *The features of the D320 PLC*
- *System installation considerations*

Overview of the Manual

This manual contains the following information:

- Chapter 1 introduces the D320 PLC by describing its features and discussing installation considerations.
- Chapter 2 discusses various system configurations and products that can be used with the D320 PLC.
- Chapter 3 gives performance specifications and operating ranges of the CPU and the D320 series products.
- Chapter 4 describes installation and wiring guidelines and procedures including system design considerations, wiring the power supply, and connecting the PLC to a PC.
- Chapter 5 introduces many concepts you need to know to program the D320 PLC including terminology, how the registers are used, different types of address designations, and the CPU processing procedure.
- Chapter 6 presents detailed information on the Instruction Set that is used by the D320 PLC.
- Chapter 7 discusses testing and troubleshooting procedures.
- Chapter 8 describes electrical interference or noise and the ways you can reduce its influence.
- Chapter 9 details the external dimensions of the D320 PLC system modules.
- Appendix A gives rules and procedures for D320 PLC communication.
- Appendix B details the configuration and operation of PID Loop Control on the D320 PLC.
- Appendix C describes the enhanced operation of the CPU’s second program loader port .

Features of the D320 PLC

The D320 Programmable Logic Controller (PLC) is a versatile and dependable industrial controller, designed to handle a wide range of control applications to improve productivity and reduce operating costs. This small-to-medium sized PLC provides high-speed processing of user control programs. It comes with a complete line of I/O and special function modules, including digital, analog, communications, and networking. These features combine to provide the right solution for a multitude of applications.

- The D320 PLC is designed for medium-sized control applications that require from 100 to 1000 control points, high-speed processing capability, PID loop control, and advanced functionality.
- High-speed data communications capability is available through the use of dedicated peer-to-peer link modules.
- Built-in dual program loader ports provide flexibility in design to accommodate simultaneous programming, monitoring, networking, and operator interface requirements.
- Intelligent communications units from remote I/O to communications modules allow for both distributed or centralized control schemes.

- The D320 PLC is built to simplify operation, maintenance, and repair with its modular design and removable terminal.
- I/O flexibility is achieved through the wide variety of available digital and analog modules, covering a broad range of voltage and current ratings.

The D320 PLC has many additional features that combine to make it the ideal choice for many control applications.

Self Diagnostics

While in the Run mode, the D320 PLC provides continuous self-diagnostics and error-checking on the processor, control program, and I/O system. Built-in diagnostics also perform error-checking during program download and system initialization. Error status information is stored internally, providing for quick and easy troubleshooting of system and programming errors.

PID Loop Control

A built-in 8-loop PID processor easily handles demanding analog process control requirements, such as temperature and/or position control.

Real-time Clock

A real-time clock (RTC) function enables time and date related programming tasks, including alarm recording, process scheduling, and product serialization.

Large Program Memory

Sufficient program capacity is furnished for even the most demanding applications. Internal program memory handles up to 24K separate control steps.

NOVRAM Battery-Backup

An easily-replaceable lithium battery provides up to 10 years of program and data backup..

I/O and Special Function Module Support

The D320 PLC I/O module line includes complete coverage of all major standard I/O requirements. Digital input modules include 24 VDC in both 16 and 32 points, and 16 point 5-12 VDC, 115 VAC and 230 VAC modules. Digital output modules include 24 VDC transistor and relay types in 16 and 32 points, and 16 point 115/230 VAC triac type. Analog support is available for voltage and current A/D and D/A, as well as RTD and thermocouple inputs. Special function modules include high-speed counter and serial data communications modules. Finally, wire-link network modules can provide peer-to-peer networking for loops of up to 32 PLC's each.

Peripheral Support

The D320 PLC has two program loader software packages available for use on standard PCs: the DOS-based GPC5, and the Windows-based WinGPC. These packages provide advanced programming, monitoring, editing, and troubleshooting for the D320 PLC. A dedicated hand-held programmer is also available for harsh environments. Cutler-Hammer also offers a complete line of Operator Interface products and HMI software packages compatible with the D320 PLC. Through the use of the dual program loader ports, the D320 PLC can be connected to any combination of two peripheral products without additional hardware.

Note: When this manual uses the term GPC, either GPC5 or WinGPC can be used.

System Installation Considerations

Environmental Considerations

The D320 PLC system should **never** be installed under the following environmental conditions:

1. Ambient temperature outside the range of 0 to 55°C (32 to 131°F).
2. Direct sunlight.
3. Humidity outside the range of 30% to 85%.
4. Altitudes greater than 10,000 ft. (3,000 m).
5. Corrosive or dusty air.
6. High voltage, high magnetics, or high electromagnetic waves.
7. Locations subject to direct impact greater than 5G or vibrations greater than 1G @ 57-2000 Hz.

Installing Modules on the System

1. Turn off the main PLC power and the I/O module power.
2. Follow the instructions provided with the I/O module to mount and wire the module.
3. Turn on the power to the I/O module.
4. Turn on the main PLC power.

Removing Modules from the System

1. Turn off the main PLC power.
2. Turn off the power to the I/O module.
3. Disconnect the wiring to the I/O module.

Preventing PLC System Malfunctions

1. Use an isolation transformer and line filter on the incoming power to the PLC when in the vicinity of equipment using or producing high current, high voltage, or large magnetic fields.
2. Separate the main PLC power line ground from all other power grounds. Always use triple-grounding.
3. Do not exceed the current and power rating of the external 24 VDC provided by the D320 power supply.
4. Avoid system faults due to programming errors by reading and fully understanding this system manual and the PLC instruction set.
5. Perform regular preventive maintenance on installed systems, checking devices and wiring for potential breakdowns and failures.

System Configuration

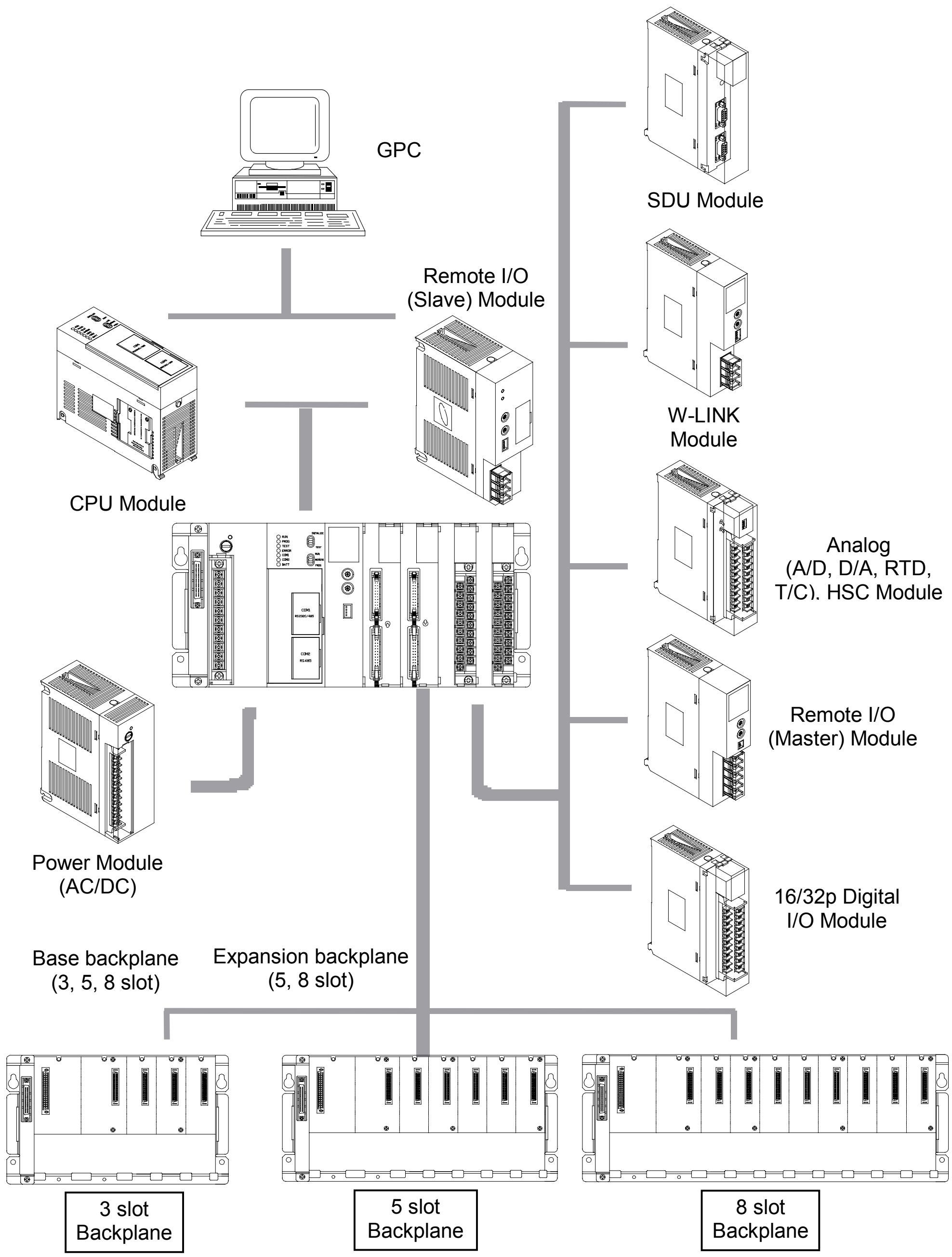
2

This chapter provides information on the various products that are available for the D320 PLC. It includes a diagram that shows the D320 PLC system components, I/O configurations, and backplane configurations.

This chapter contains:

- *Information about the D320 PLC system components*
- *Descriptions of the line of D320 PLC products*
- *The D320 PLC I/O configurations*
- *The D320 PLC backplane configurations*

D320 PLC System Components



D320 PLC Product List

CPU

Name	Catalog #	Product Description	Remarks
CPU	D320CPU320	24K Words, 0.2 µs/instruction, 8 loop PID, Realtime Clock, 2 communications ports	

Backplanes

Name	Catalog #	Product Description	Remarks
Base Backplane	D320RAK03B	3-slot type	
	D320RAK05B	5-slot type	
	D320RAK08B	8-slot type	
Expansion Backplane	D320RAK05E	5-slot type	
	D320RAK08E	8-slot type	

Power Supplies

Name	Catalog #	Product Description	Remarks
Power Supply	D320PSU230	110/220 VAC input, (5 V 4.0 A), (24 V 0.8 A)	
	D320PSU24DC	24 VDC input, (5 V 6.0 A)	

I/O Modules

Name		Catalog #	Product Description	Remarks
Input Module	16 point	D320DIM1605D	5 to 12 VDC, 8 points/common, sink or source	
		D320DIM1624D	12 to 24 VDC, 8 points/common, sink or source	
		D320DIM1615A	100 to 120 VAC, 8 points/common	
		D320DIM1623A	200 to 240 VAC, 8 points/common	
	32 point	D320DIM3224D	12 to 24 VDC, 20 pin connector × 2, 16 points/common, sink or source	*Requires Adapter Cables
Output Module	16 point	D320DOM1600R	RELAY output, 250 V, 3 A, 8 points (5 A)/common	
		D320DOM1600V	RELAY output, 250 V, 3 A, 8 points (5 A)/common, varistor protection	
		D320DOM1624D	TR output, NPN, 12 to 24 VDC, 0.6 A, 8 points (4 A)/common	
		D320DOM1615A	SSR output, 100 to 220 VAC, 0.5 A, 8 points (2 A)/common	
	32 point	D320DOM3200R	RELAY output, 250 V, 1 A, 20 pin connector × 2, 16 points/common	*Requires Adapter Cables
		D320DOM3224D	TR output, NPN, 12 to 24 VDC, 0.4 A, 20 pin connector × 2, 16 points/common	*Requires Adapter Cables

Note: 32-point modules require 20-pin cable connection for breakout to standard screw terminals. Refer to Accessories Table for additional information.

Analog and Intelligent Modules

Name	Catalog #	Product Description	Remarks
Analog Input (8 Ch)	D320AIM810V	8 Ch, 16 bit A/D converter, ±10 V, 0 to 5 V Conversion speed: 1.25 ms/Ch Resolution: 1/20,000, 1 mV	
Analog Input (8 Ch)	D320AIM820C	8 Ch, 16 bit A/D converter, ±20 mA, 0 to 20 mA Conversion speed: 1.25 ms/Ch Resolution: 1/10,000, 4 µA	
Analog Output (4 Ch)	D320AOM410V	4 Ch, voltage output, 14 bit D/A converter ±10 V, ±5 V, 0 to 10 V, 0 to 5 V Resolution: 1 mV/1 bit	
Analog Output (4 Ch)	D320AOM420C	4 Ch, current output, 14 bit D/A converter, 4 to 20 mA Conversion speed: 2.5 ms/Ch Resolution: 4 µA/1 bit	
RTD Input	D320RTD800	8 Ch, 24 bit Σ–Δ, A/D converter, 3-wire , 0.1°C, Pt 100, JPt 100, 60 ms/Ch	
Thermocouple Input	D320TC800	8 Ch, 24 bit Σ–Δ, A/D converter, 0.1°C, type B/R/S/N/K/E/J/T, 80 ms/Ch	
High-speed Counter	D320HSC100	1 Ch, 100 kHz, 24 bit counter, up/down/encoder, 2 pulse outputs (40 kHz), 2 control outputs	

PLC Communication Module

Name	Catalog #	Product Description	Remarks
Serial Data Unit (SDU)	D320SDU100	RS-232C × 2 Ch (serial input and output enabled by ladder command) Provides data communication to various RS-232C devices	

PLC Link Module

Name	Catalog #	Product Description	Remarks
Wire Link Module	D320LNKW	Install on backplane. Can install maximum of three. Function: PLC Link, data transmission, remote programming 32 units/loop, 3 loops, transfer speed: 0.5 Mbps Transfer distance: total 800 m, interface: RS-485 multidrop	Refer to Wire Link Module Manual for installation and operation.

Remote I/O System

Name	Catalog #	Product Description	Remarks
Remote I/O Master Module	D320RMU300	Master Unit installed on main rack with CPU.	
Remote I/O Slave Module	D320RSU300	Replaces CPU on remote backplanes	
Remote I/O Drops with Interface	D320RIM1624D	16 points, DC IN, terminal type	
	D320RIM1615A	16 points, AC IN, terminal type	
	D320RIM3224D	32 points, DC IN, connector type	
	D320ROM800R	8 points, RELAY OUT, terminal type (4 points/common)	
	D320ROM1600R	16 points, RELAY OUT, terminal type (8 points/common)	
	D320ROM1624D	16 points, TR OUT, terminal type	
	D320ROM1615A	16 points, AC OUT, terminal type	
	D320ROM3224D	32 points, TR OUT, connector type	
	D320RIO3224D	32 points, DC IN/TR OUT mixed, connector type	

Programming Equipment

Name	Catalog #	Product Description	Remarks
Handheld Program Loader	D320PGM500	Write, edit, monitor program (mnemonic only) Memory BACK-UP function Backlit LCD screen Supports RS-232C/485 communication	Does not include cable

Name	Catalog #	Product Description	Remarks
GPC5 (DOS)	D50CCS35	Software for computer which provides programming, monitoring, uploading, downloading, online editing, error checking, PLC status monitoring, and other troubleshooting and diagnostic features.	For MS-DOS
WinGPC (Windows)	D50WINCS35		For Windows 3.1, 95, 98, NT

Note: When this manual uses the term GPC, either GPC5 or WinGPC can be used.

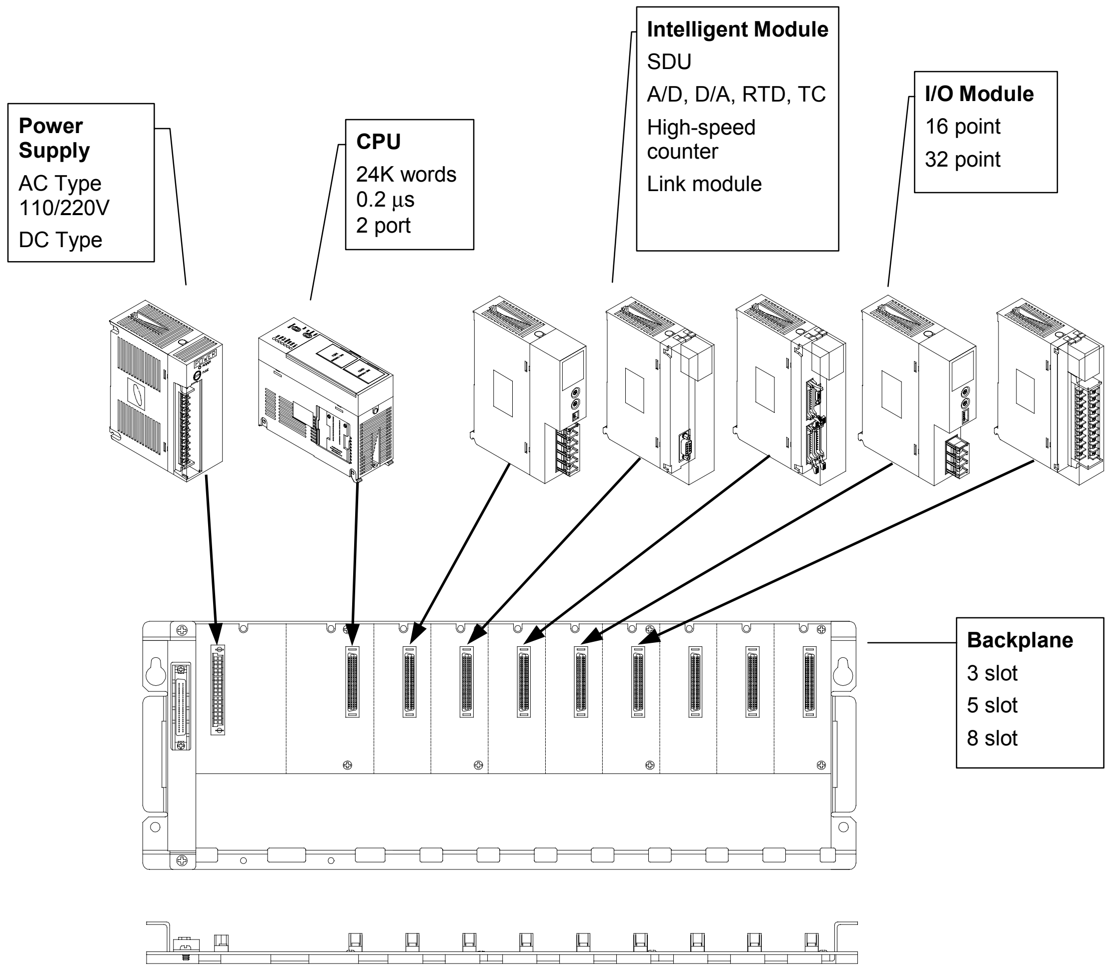
Programming Cables

Name	Catalog #	Product Description	Remarks
RS232C/485 Cable	D320CBL20	Handheld Program Loader (PGM500) For IBM-PC communication (GPC)	6 ft (2 m)
RS232C Cable	D320CBL50	For IBM-PC communication (GPC)	15 ft (5 m)

Accessories

Name	Catalog #	Product Description	Remarks
Dummy Module	D320BNK300	Blank module for D320 backplane empty slot.	
32pt. I/O Cable Harnesses	D320CBL32IN	DC IN 32 points connector harness 5 ft (1.5 m)	For D320DIM3224D
	D320CBL32TO	TR OUT 32 points connector harness 5 ft (1.5 m)	For D320DOM3224D
	D320CBL32RO	Relay OUT 32 points connector harness 5 ft (1.5 m)	For D320DOM3200R

D320 PLC I/O Configuration



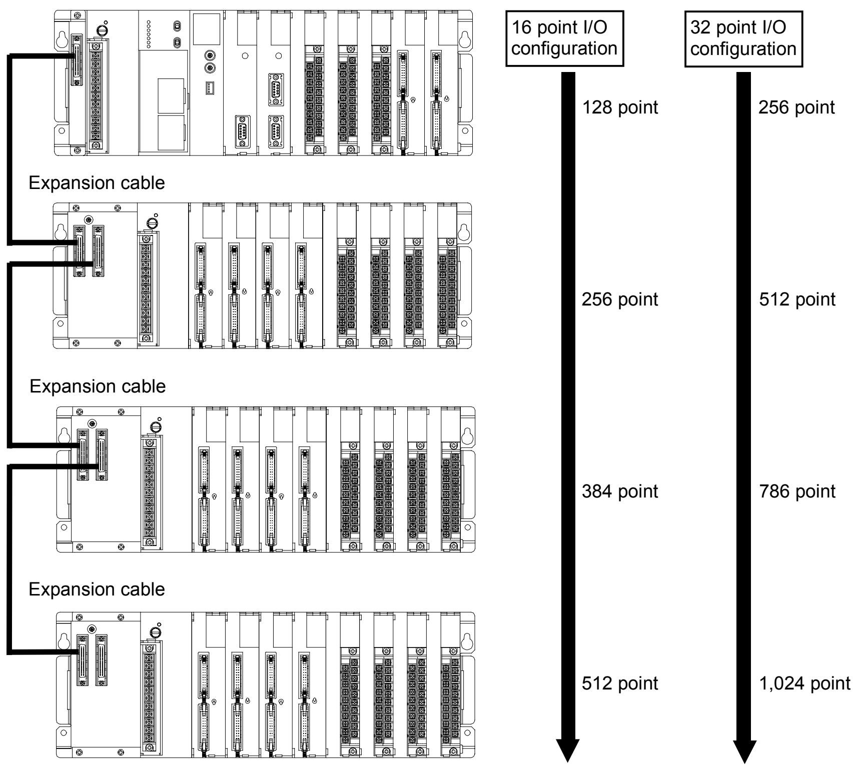
Module Placement Requirements

The power supply and CPU modules have assigned slots. Most other modules may be installed in any available slot in any order, but there are certain restrictions that may apply. The following table gives those limitations.

Module Type	Position of Installation/Base System
Power Supply	Slot to extreme left.
CPU Module	Second slot from left.
I/O Module	Any slot to right of CPU.
Serial Data Unit (SDU)	Any slot to right of CPU.
Remote I/O (Slave)	Install in the CPU module position (second slot from left).
Wire Link Module	Any slot to right of CPU in the base rack. Limit three modules/system.

D320 PLC Backplane Configurations

- A general I/O module has two point types: 16 point and 32 point. The diagram below shows the two types of control.
- The base backplane has three different slot types: 3 slot, 5 slot, and 8 slot.
- A maximum of 256 control points are available with one backplane. This is achieved by using 32-point I/O modules with an 8-slot backplane.
- The expansion backplane has two different slot types: 5 slot and 8 slot.
- A maximum of three expansion backplanes can be installed in addition to the base backplane.
- A maximum of 1,024 local control points are available. This is achieved by using four 8-slot backplanes consisting entirely of 32-point I/O modules.
- An additional 1,024 control points (2,048 total maximum) are available by using a remote I/O system. The remote I/O is connected with two-wire twisted pair cables.



Product Specification

3

This chapter outlines the environmental conditions for D320 PLC operation and the performance specifications and component functions of the CPU.

This chapter discusses:

- *The environmental operating ranges for the D320 Series products*
- *The performance specifications of the CPU*
- *The name and function of CPU components*

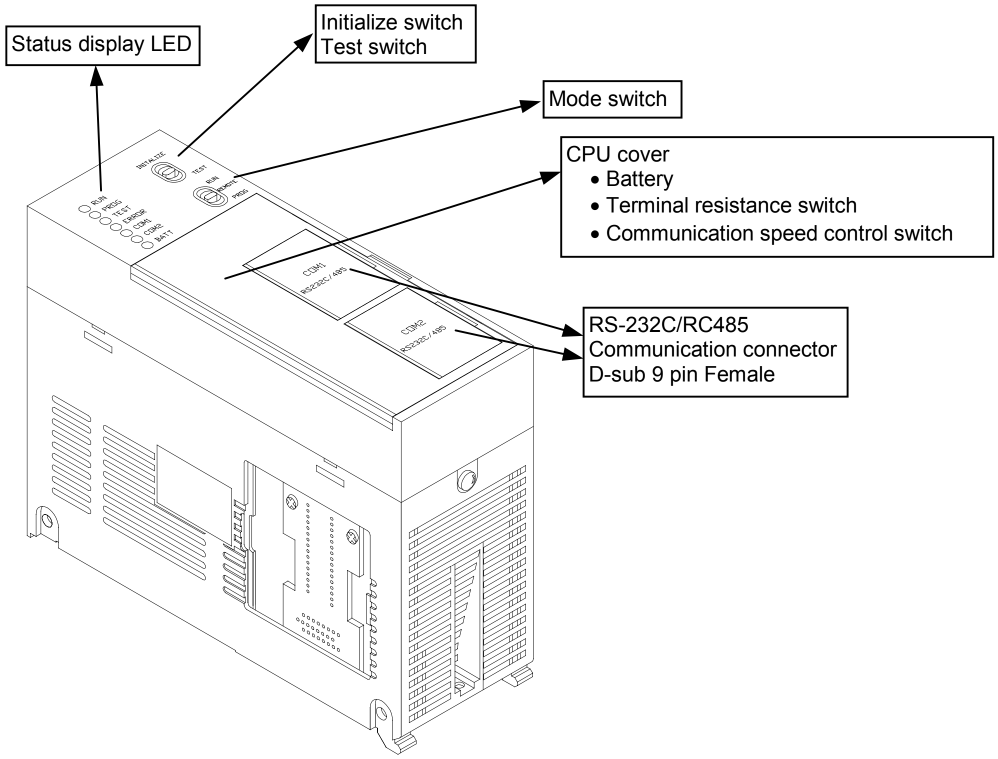
Environmental Operating Ranges

Item		Specifications
Ambient temperature	Operating temp.	0 to 55°C (32 to 131°F)
	Storage temp.	-20 to 70°C (-4.0 to 158°F)
Ambient humidity	Operating	30% to 85% RH (Non-condensing)
	Storage	30% to 85% RH (Non-condensing)
Breakdown voltage		Between AC external terminal and earth, AC 1500 V for 1 min.
		Between DC external terminal and earth, AC 500 V for 1 min.
Insulation resistance		Between AC external terminal and earth, AC 1500 V for 1 min.
Vibration resistance		10 to 55 Hz/1 min., amplitude 0.75 mm, each direction of X, Y, Z for 10 min.
Insulation resistance		Over 98 m/S^2, X, Y, Z each direction 4 times.
Noise resistance		1500 Vp-p pulse width 50 ns, 1 µs (according to noise simulator method)
Usage condition		No corrosive gas or severe dust conditions.

CPU Performance Specifications

CPU Name		D320CPU320
Control method		Program storage, Repeat calculation method
External I/O	Digital	1,024 points local, 1,024 points remote, 2,048 total
Instruction	Basic instruction	28 types
	Application instruction	About 150 types
Process speed	Basic instruction	0.2 to 0.4 µS/step
	Application instruction	1.0 to 60 µS/step
Program capacity		24k steps (1 step = 1 word) (1k step = 1,024 steps)
Memory capacity	Local I/O (R)	R000.0 to R063.15 (1,024 points, 64 words)
	Remote I/O (R)	R064.0 to R127.15 (1,024 points, 64 words)
	Link contact (L)	L000.0 to L063.15 (1,024 points, 64 words, loop 0) M000.0 to M063.15 (1,024 points, 64 words, loop 1)
	Internal contact (M)	M000.0 to M127.15 (2,048 points, 128 words)
	Retentive internal contact (K)	K000.0 to K127.15 (2,048 points, 128 words)
	System flags (F)	F000.0 to F015.15 (256 points)
	Timer/Counter (TC or TIM)	256 channels (timer + counter), set point: 0 to 65,535 Timer: 0.01 second: TC000 to TC063 (64 channels) 0.1 second: TC064 to TC255 (192 channels) counter: TC000 to TC255 (256 channels)
	Link word (W)	W0000 to W0127 (128 words, loop 0) W0128 to W0255 (128 words, loop 1)
	Data word (W)	W0000 to W2047 (2,048 words)
	System registers (W, SR)	W2560 (= SR000) to W3071 (= SR511) (512 words)
Clock function (RTC)		year, month, day, hour, min., sec., day
Comm. function	Port 1	Port 1: RS232C/RS485 compatible, 9600/19200 bps.
	Port 2	Port 2: RS232C/RS485 compatible, 4800/9600/19200/38400 bps User defined communication protocol available.

Name and Function of CPU Components



The initialize switch clears CPU errors. The switch is only active when the CPU is in the Stop/Program mode.

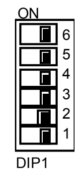
The mode conversion switch has the following settings:

State	Function
RUN	CPU set in Run mode.
REMOTE	CPU set in Run or Stop/Program mode.
PROG.	CPU set in Stop/Program mode.

The status display LEDs provide the following information:

LED	Color	Function
RUN	Green	On when CPU is in Run mode.
PROG.	Green	On when program is in Stop/Program mode.
TEST	Green	On when CPU is in Test mode.
ERROR	Red	On when CPU has an error.
COM1	Green	Flickers when CPU is communicating (COM1, COM2).
COM2	Green	
BATT.	Red	On when the battery voltage is low or is not installed.

The DIP switch located on the front of the CPU is used as a selecting switch for communication. The DIP switches function as follows:

Switch Number		Switch Position		Function	Diagram
1		Off		COM1, 9,600 bps	
		On		COM1, 19,200 bps	
2	3	Off	Off	COM2, 9,600 bps	
		On	Off	COM2, 19,200 bps	
		Off	On	COM2, 38,400 bps	
		On	On	COM2, 4,800 bps	
4				Not used.	
5	6	Off	Off	Terminating resistors for RS485 communications not connected.	
		On	On	Terminating resistors for RS485 communications connected.	

CAUTION:

- The communication port can be used for an RS232 or RS485 connection. It will automatically select between the two.
- The terminating resistors are connected to the end of the communication line to help remove communication interference and signal distortion when it occurs between the PLC and other PLCs or peripherals. The terminating resistors are typically used with long communication distances and the RS485 communication protocol.

Installation and Wiring

4

This chapter provides considerations and information on installing and wiring the D320 PLC. Diagrams are included to illustrate the installation procedures.

This chapter contains:

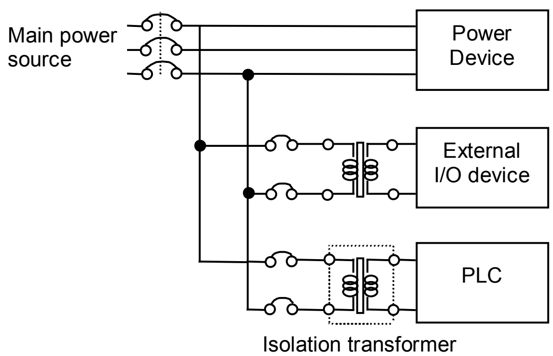
- *System design considerations*
- *System installation guidelines*
- *System wiring and installation procedures*

System Design Considerations

Power Supply Wiring

Physical and Electrical Isolation of Power Supplies

When wiring the PLC, external control I/O, and large power equipment such as motors, each system should be electrically separated as shown:



Interlock Circuit and Emergency Stop Circuit (Safety measures in system design)

In any PLC application, abnormal and potentially dangerous operation can occur. These system malfunctions may result from power surges, brownouts, blackouts, shorted or opened I/O devices, or any type of system component failure. Any errors of the PLC, the external power source, and/or external devices can cause a system malfunction. The potentially dangerous effects of these errors on the whole system can be prevented with proper safety precautions. The use of properly designed safety circuits external to the PLC will protect against both equipment damage and human injury.

Interlock Circuit

An interlock circuit can control and prevent problems such as those caused by unexpected or reversed operation of a motor. Install the interlock circuit external to the PLC control wiring and circuitry.

Emergency Stop Circuit

Every industrial control application involving electrical or moving parts should be wired with an emergency stop circuit. The emergency stop circuit turns off the power immediately to all output devices in the system. The emergency stop circuit should provide independent power cutoff from the PLC system.

Power-Up Sequence

In a properly designed control system, the default Off state of the system is the safe state, in which no machinery is operating. Before the PLC is powered-up, line power and control power are applied to the system. Once the system is powered up in the safe/default state, the PLC is powered up and begins system control. As necessary, the control system should be modified to ensure the proper delayed startup to prevent problems on power-up.

For example: 1) Run the PLC after turning on the power
2) Use an external or internal timer to delay the operation of the PLC.

Momentary Power Failure and Voltage Drop

Momentary Power Failure

The D320 PLC will ride through momentary power failures of 10 msec or less. The PLC will stop and turn off its outputs if a momentary power failure greater than 20 msec occurs. For momentary power failures between 10 msec and 20 msec, the PLC's operation depends on circumstances at that time, and is not defined. The control system should be designed specifically to ensure safe operation for these potential power-loss conditions.

Voltage Drop (Brownouts)

The PLC will stop and turn off its outputs if the PLC 's power supply voltage drops below the allowable fluctuating voltage range (see specifications for power supply units).

CAUTION: Steps should be taken to prevent damage to the PLC system through fluctuating voltages, brownouts, blackouts, shorts, ground faults, or other power supply failures. For example, you may need to apply an isolation transformer before the incoming PLC power supply and/or I/O control wiring.

System Installation Guidelines

Environmental Usage Conditions

Avoid the Following Environments:

- Ambient temperature outside the range of 0 to 55°C (32 to 131°F).
- Humidity levels outside the range of 30% to 85%.
- Abrupt temperature variations which lead to the formation of dew.
- Presence of corrosive or flammable gases.
- Presence of dense dust, salt, and iron concentrations.
- Presence of corrosive solutions such as benzene, thinner, alcohol, ammonia and caustic soda.

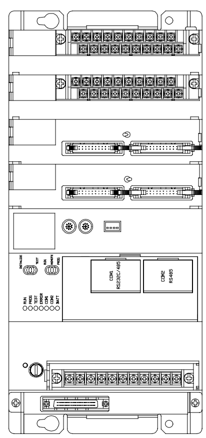
- Locations subject to direct impact greater than 5 G or vibrations greater than 1 G @ 57-2000 Hz.
- Direct sunlight.
- Presence of water, oil, and other chemicals.

Electrical Noise Considerations

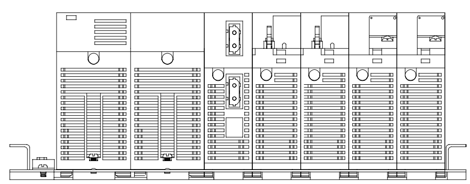
- Do not install near high-tension wires, high-voltage devices, power cables, power devices, and other devices which generate large power surges or electromagnetic fields when starting and stopping.
- Do not place near wireless communications devices with transceivers, such as walkie talkies, cellular phones, or shortwave radios.

Control Panel Installation

- Leave enough space at the top of unit from other devices or wiring ducts to allow ventilation space and easy replacement and wiring of the unit (see the following diagrams).
- Do not mount the PLC system vertically, or facing up or down. This will prevent proper air cooling of the PLC CPU, which will cause abnormal overheating inside the PLC (see the following diagrams).

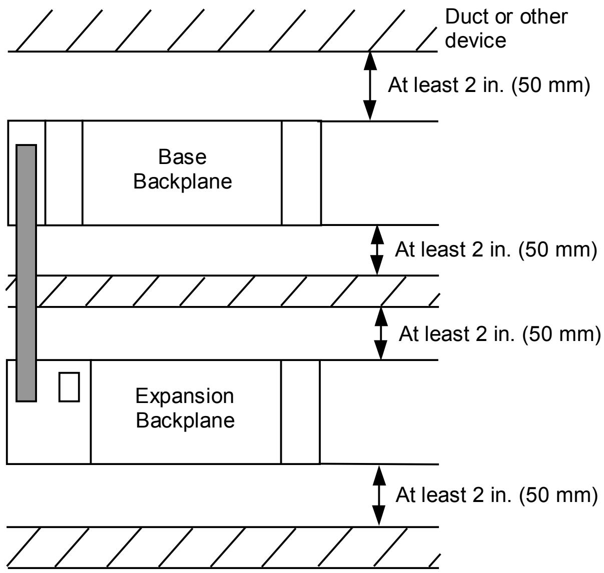


Unacceptable: Vertical mounting



Unacceptable: Horizontal mounting

- Avoid installation over heat generating equipment such as heaters, transformers, and power resistors.
- Avoid radiation noise by leaving a minimum distance of 4 inches (100 mm) from the surface of each unit to the power cable, and the noise-generating device (motor starter, solenoid, etc.).



Leave at least 2 inches (50 mm) from the duct or other devices:

- To prevent overheating.
- For easy replacement and wiring of the unit.

When using a link module, leave additional space at the bottom of the unit:

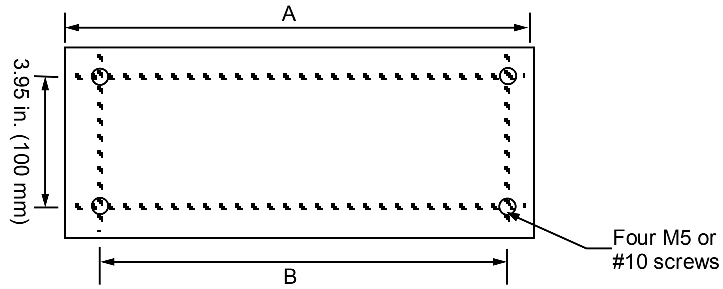
- Leave 3 inches (80 mm) or more for the optical link module.
- Leave 4 inches (100 mm) or more for the wire link module.
- This allows for extra ventilation space and reduces noise interference.

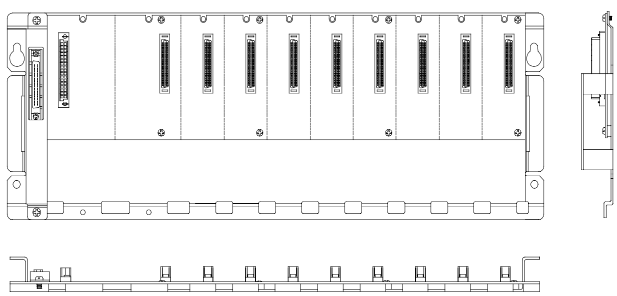
When installing the PLC in a cabinet or enclosure:

- Leave 4 inches (100 mm) or more from the front surface of unit.
- This area in front of the PLC helps to avoid the effects of emission, noise, and heat.

System Wiring and Installation Procedures

Installation Dimensions





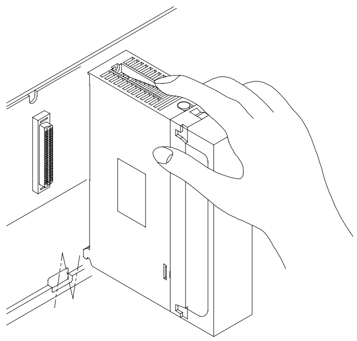
Type	Slot	Product Number	Size (A) in.* (mm)	Size (B) in.* (mm)
Base Backplane	3	D320RAK03B	10.25 (260)	9.65 (254)
	5	D320RAK05B	13.0 (330)	12.4 (315)
	8	D320RAK08B	17.15 (435)	16.55 (420)
Expansion Backplane	5	D320RAK05E	13.0 (330)	12.4 (315)
	8	D320RAK08E	17.15 (435)	16.55 (420)

*values are rounded to the nearest 0.05 in.

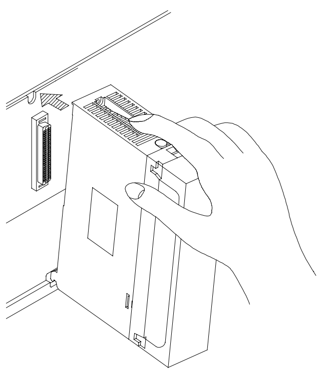
Module Installation

Mounting

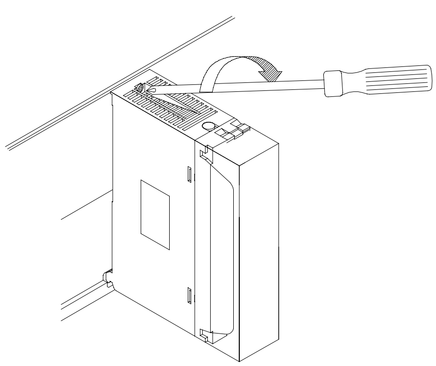
1. Insert the flanges at the base of the module into the slots at the bottom of the I/O backplane.



2. Swing the I/O module up onto the backplane, pressing firmly onto the backplane connector.

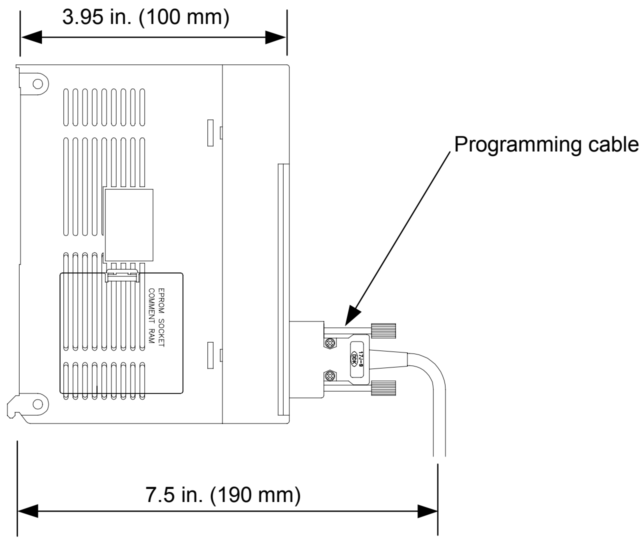


3. Tighten the screw at top of module to establish a solid connection between the module and backplane.



Unit Installation Height

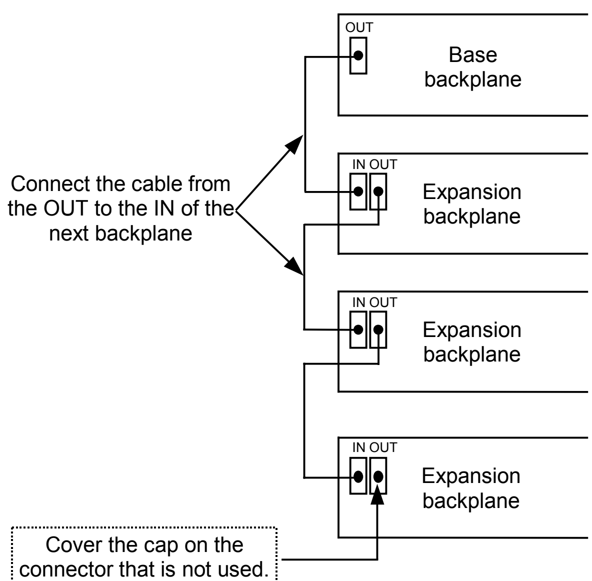
The depth of the D320 PLC is 5 inches (120 mm) when the unit is installed on the backplane. When the communication cable is connected and the unit is installed in an enclosure, additional space is required. The minimum installation sizes are given in the following diagram.



Expansion Cable Connection

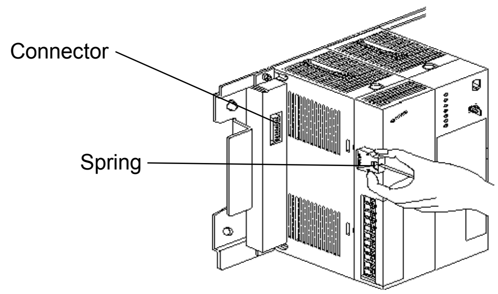
Connecting the Expansion Cable

- The expansion cable is connected between the connectors marked IN and OUT on the backplane.
- The expansion cable should not be run in the same wiring duct as the power, control or communications wiring



Fastening the Connector

- Push the expansion cable connector onto the backplane connector firmly until it clicks into place. (See the following diagram.)
- To remove the expansion cable from the backplane, release the locking device by pressing the spring on the expansion cable connector.



Power Supply Wiring

Power wiring

- For the 120/240 VAC power supply, the power conversion terminal must be shorted for 110 to 120 VAC, and left open for 220 to 240 VAC.

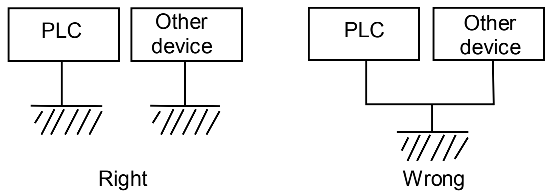
  ⚠ **CAUTION:** Connecting 220 V to power supply with the power conversion terminal shorted (120 VAC mode) will damage the PLC equipment and generate excessive heat.

- When connecting the power cable:
  To reduce power loss in the wiring, use at least 14 AWG (2 mm) cable.
  To reduce the effect of noise, use twisted, shielded cable.
- An isolation transformer can be used to further reduce noise and to prevent failures from power problems such as ground faults.
- Use the same power source for both base and expansion backplane power supplies.

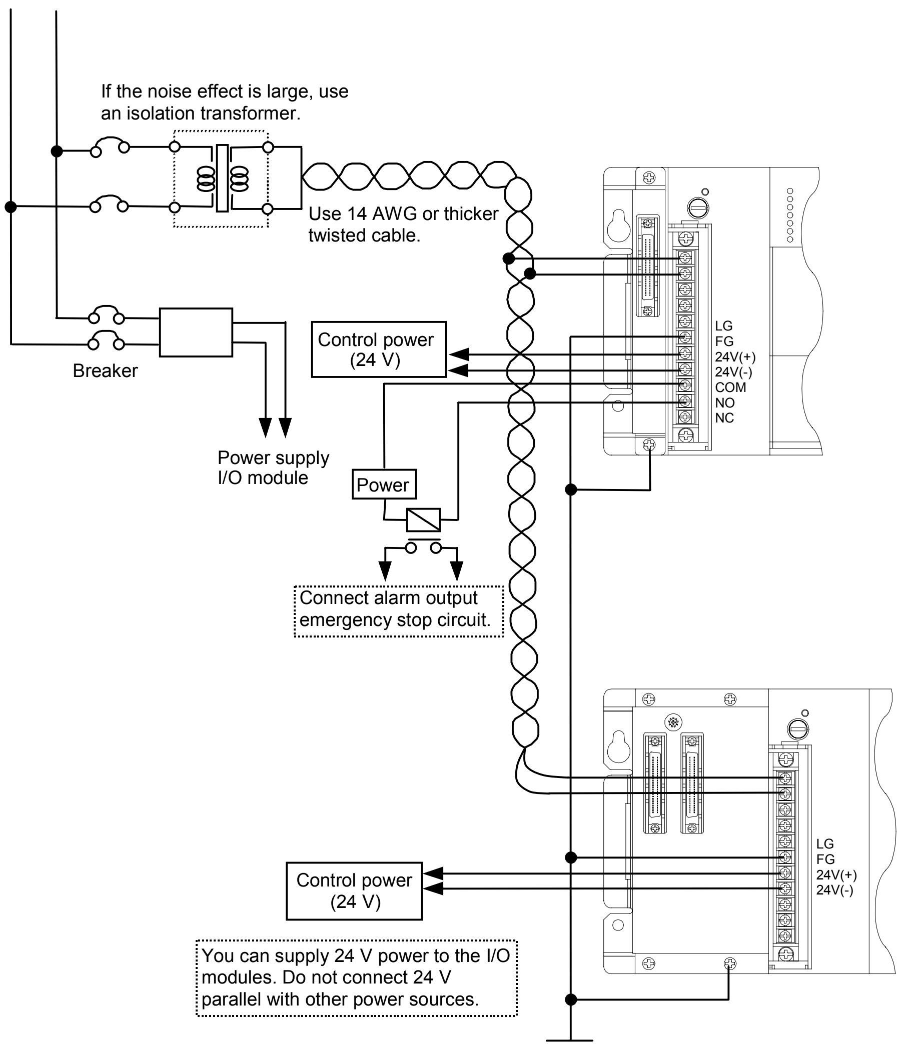
Grounding

- In normal low-noise environments such as closed-room control cabinets, it is possible to operate the PLC without frame grounding. However, it is necessary to ground the PLC for noisy environments, and is recommended for all installations regardless of electronic noise levels.
- For the frame ground, use a cable of at least 14 AWG (2 mm) in size. The ground should be exclusive to the PLC. Sharing the ground connection with other devices can cause problems due to ground loops and current feedback.

- The line ground (LG) terminal has electric potential. When the frame ground (FG) is connected to a solid earth ground, you must also earth ground the LG terminal to prevent electric shock from the electric potential difference between the two grounds.
- If the PLC system is not earth grounded, the LG and FG terminals must be kept separate to prevent ground loops in the power supply system.



120/240 VAC Power Supply Wiring Diagram



I/O Module Wiring

Digital Input Module Wiring

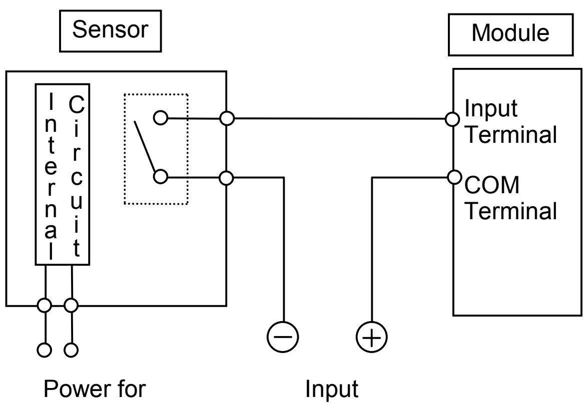
Check Points

- Refer to the instruction leaflet for the individual modules for specific limitations regarding the particular type of input sensor used.
- The input device connection methods are shown in the following graphics for the various types of digital input devices.

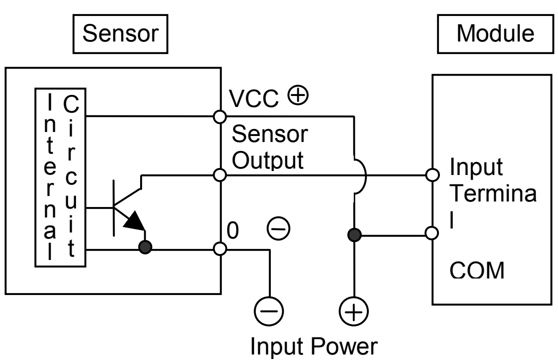
DC Sensor

The following diagrams show the input device in connection with a DC sensor.

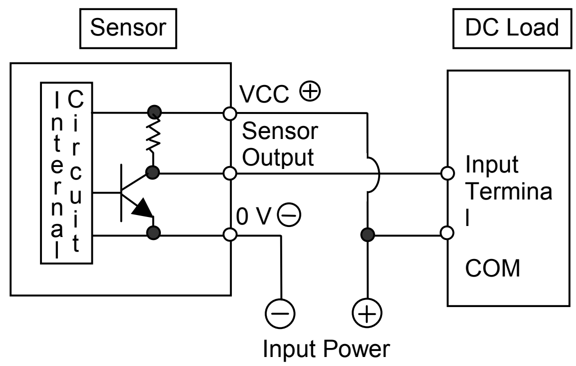
1. Relay Type



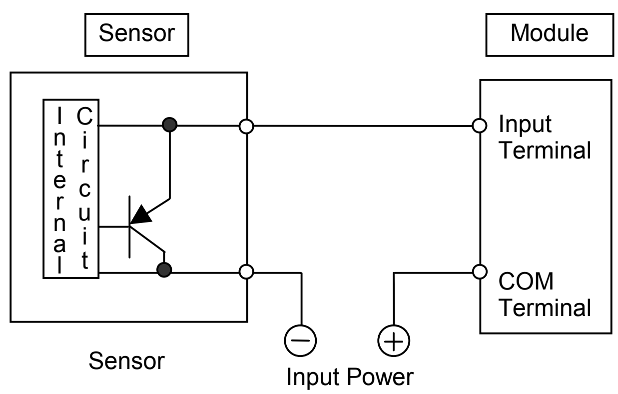
2. Sinking NPN Type



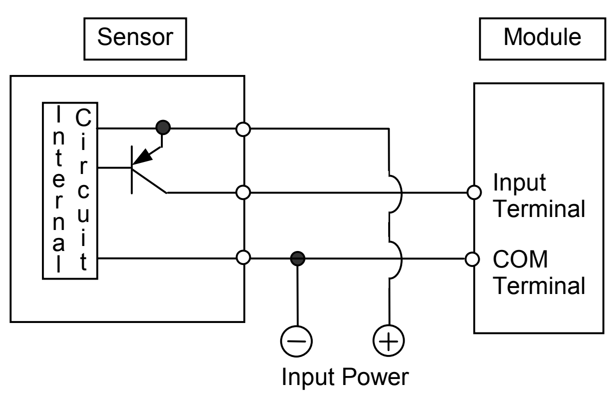
3. Universal Type



4. 2-Wire Sensor



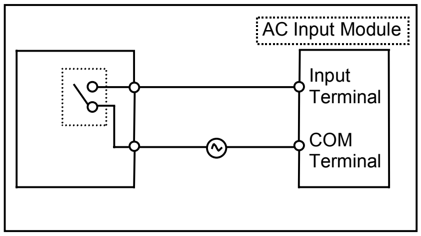
5. Sourcing PNP Type



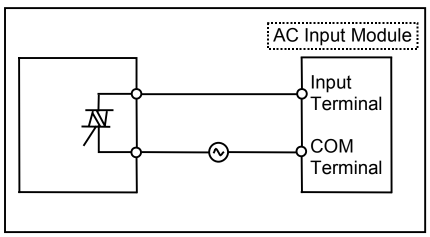
AC Sensor

The following diagrams show the input device in connection with an AC sensor.

1. Contact Type



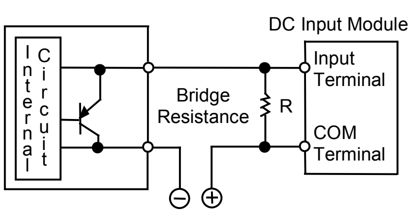
2. SSR/Triac Type



2-Wire Sensor

When using a 2-wire type photoelectric switch or a proximity sensor, the sensor may draw such a low level of current that the input may not be turned off due to the effect of leakage current. To avoid this leakage current, connect the bridge resistance as shown in the below figure.

Example: D320DIM1624D—12 to 24 VDC type input module (Off voltage 2.5 V, input impedance 3 kΩ)



I = Leakage current of the sensor
R = Bridge resistance value

If the Off voltage of the input is 2.5 V, set R so that the voltage between the input terminal is below 2.5 V. Input impedance is 3 kΩ. The leakage current I for a given sensor will be provided by the manufacturer of the sensor. Using the specification for the sensor, R can be calculated from the following equations:

$$I \times 3R/(3 + R) \leq 2.5$$
$$R \leq 7.5/(3I - 2.5)(k\Omega)$$

The power rating W required for the bridge resistor R can be calculated as follows:

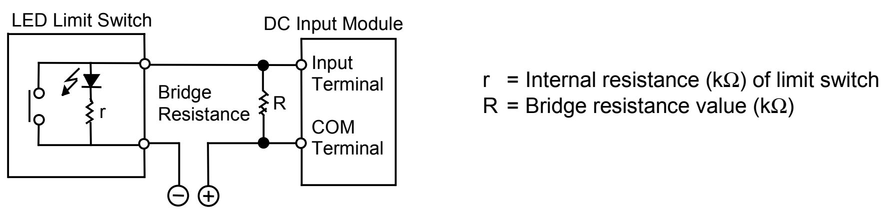
$$W = (\text{Power Voltage})^2/R$$

When specifying the resistor, set it within 3 to 5 times of this value.

LED Limit Switch

When using a limit switch with internal LED On/Off indication, the input may not be turned off due to the effect of leakage current, or the LED may be incorrectly illuminated. Connecting the bridge resistance as shown in the figure below may help solve these problems.

Example: D320DIM1624D—12-24 VDC type input module (Off voltage 2.5V, input impedance 3kΩ)



For many sensors, the manufacturer will provide the value of the internal resistance r, in which case the leakage current I can be directly calculated in the following equation (the Off voltage of the input is 2.5 V, and power voltage is 24 V):

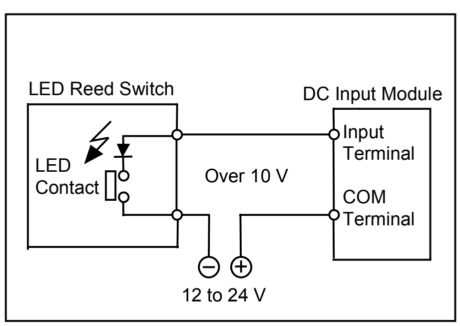
$$I = (24 - 2.5)/r$$

Alternatively, the value of I can be experimentally calculated by simply measuring the current draw of the sensor during use. Once I is calculated, the bridging resistor specification can again be calculated using the following equations:

$$R \leq 7.5/(3I - 2.5)(k\Omega)$$
$$W = (\text{Power Voltage})^2/R \times (3 \text{ to } 5 \text{ times})$$

LED Reed Switch

When using a reed switch with an LED On/Off indication, the voltage going into the input terminal should not exceed the On voltage under normal Off conditions. No type of bridging resistor is required.



Digital Output Module Wiring

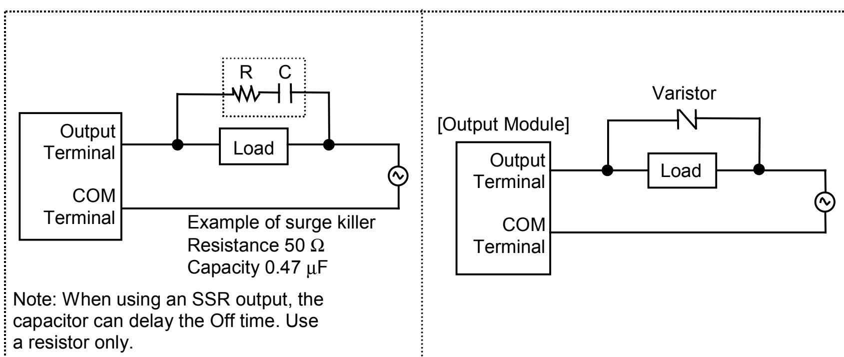
Check Points

- Refer to the instruction leaflet for the individual modules for specific limitations regarding the particular output ratings for that module, particularly with regard to load current limitations. Additionally, installation of the modules in high temperature environments can further limit the acceptable load ratings of the outputs.
- For inductive and capacitive type loads, a protective circuit can be installed to prevent damage to the module through feedback/discharge on Open/Close. (See the below diagrams.)
- Use the output modules only within the specified ranges of operation.

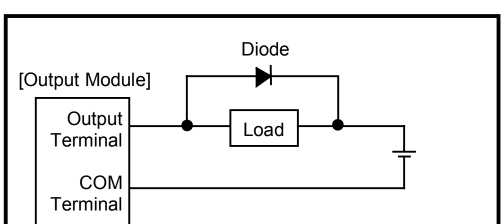
Inductive Loads

- For an inductive load, connect the protective circuit in parallel with the load.
- When opening or closing a DC inductive load using a relay output, the addition of a protective circuit will significantly extend the life of the output contact. Install a diode in parallel with the load.

1. AC load



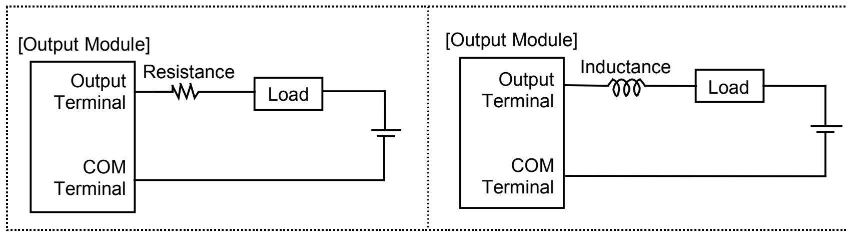
2. DC load



Rated diode	Voltage within band	More than 3 times the load voltage
	Average rated current	Over the load current

Capacitive Load

When using a capacitive load, to reduce the effect of an inrush current, connect the protective circuit in series with the load as shown in the figure below.

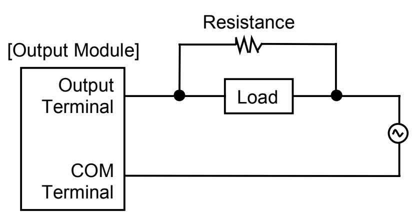


External Fuse

An external fuse can be used for overload protection. The fuse within the module is provided to prevent damage in case of a short circuit on the output. However, the module fuse is not designed to protect the terminal in case of an overload. It is recommended to attach an external fuse for each output point, based on the particular application. Short circuits in certain types of loads can damage the output module before the internal fuse blows. Be certain to provide the proper level of short circuit protection for a given output type.

Leakage Current

When using an SSR output to a load that draws a very low level of current, leakage current in the SSR output may cause a load not to turn Off. To prevent this problem, connect a properly rated resistance in parallel with the load.



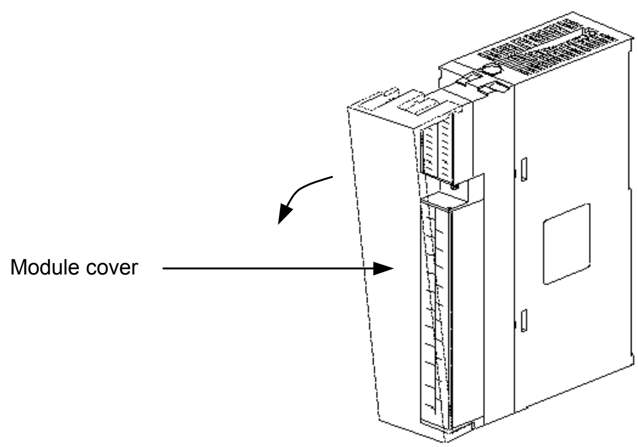
Installation Precautions for I/O Modules

I/O and Power Cables

- Separate the wiring of the I/O cable and the power cable as far as possible. Do not put the two cables through the same duct.
- Leave 4 inches (100 mm) or more between the following:
  - I/O wiring
  - Power cable
  - High voltage cable

Module Cover

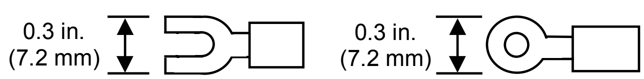
- Remove module cover of I/O module as shown in the picture below.
- With the connector type unit (for example, the 32-point digital I/O modules), the connector hood may be used in place of the module cover.



Terminal Strip Wiring

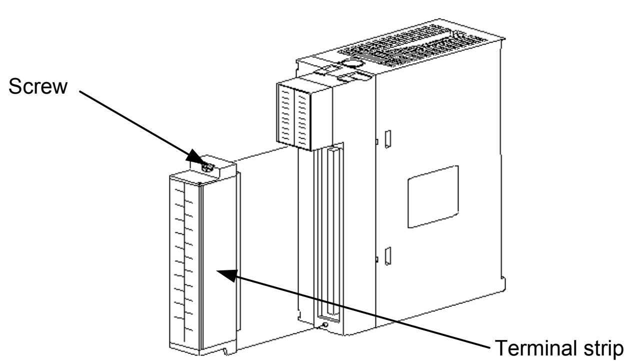
Compressed Terminal, M3.5

- The removable terminal strips on the I/O modules for the D320 PLC use an M3.5 metric screw. Either open or circular type connectors may be used for attaching the control wiring to the terminal strip.



Removing Terminal Strip

The terminal strip is removed by releasing the screws located at the top and bottom of the terminal strip. Be certain to tighten these mounting screws firmly when reattaching the terminal strip after wiring, or replacing the I/O module.



Connector Module Wiring

Connection

For the 32-point input and output modules (D320DIM3224D, D320DOM3224D) of the D320 PLC, use a 20-pin MIL connector. Use the correct Cutler-Hammer supplied cable for the type of I/O module used.

Harness Connection

Use flat ribbon cable connector. Harness cables are available for the following modules:

- D320DIM3224D (DC In 32 point)
- D320DOM3224D (TR Out 32 point)
- D320DOM3200R (Relay 32 point)

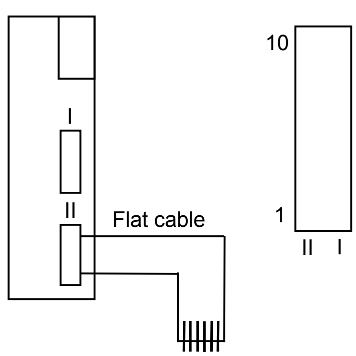
The harness cable consists of a 20-pin connector at one end for connection to the I/O module, and 20 separate open type screw connectors at the other for connecting the field devices. The cable is 5 feet in length.

Product Name	Product Code	Product Specification
Cable ASS'Y	D320CBL32IN	DC In 32 point connector harness cable 5 feet (1.5 m)
	D320CBL32TO	TR Out 32 point connector harness cable 5 feet (1.5 m)
	D320CBL32RO	Relay Out 32 point connector harness cable 5 feet (1.5 m)

Connector Module Wiring

Fit Cable Connector

When using the I/O ribbon cables (D320CBL32xx) for wiring field devices, pay careful attention to the I/O addressing associated with the given terminal on the cable. Refer to the tables below for I/O addressing by connector.



I/O Address Cross-reference Table (D320DIM3224D, D320DOM3224D, 0320DOM3200R)

Connector (I)

I/O Point	D320DIM3224D	D320DOM3224D	D320DOM3200R
I 1	R0.0	R0.0	R0.0
I 2	R0.1	R0.1	R0.1
I 3	R0.2	R0.2	R0.2
I 4	R0.3	R0.3	R0.3
I 5	R0.4	R0.4	R0.4
I 6	R0.5	R0.5	R0.5
I 7	R0.6	R0.6	R0.6
I 8	R0.7	R0.7	R0.7
I 9	R0.8	R0.8	R0.8
I 10	R0.9	R0.9	R0.9
I 11	R0.10	R0.10	R0.10
I 12	R0.11	R0.11	R0.11
I 13	R0.12	R0.12	R0.12
I 14	R0.13	R0.13	R0.13
I 15	R0.14	R0.14	R0.14
I 16	R0.15	R0.15	R0.15
I 17	COM1	+	COM
I 18	COM1	+	COM
I 19	COM2	COM	+24VDC
I 20	COM2	COM	-24VDC

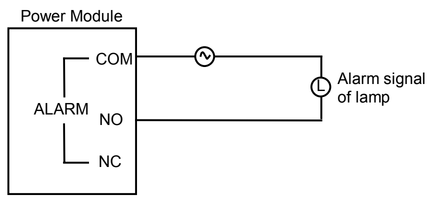
Connector (II)

I/O Point	D320DIM3224D	D320DOM3224D	D320DOM3200R
I 1	R1.0	R1.0	R1.0
I 2	R1.1	R1.1	R1.1
I 3	R1.2	R1.2	R1.2
I 4	R1.3	R1.3	R1.3
I 5	R1.4	R1.4	R1.4
I 6	R1.5	R1.5	R1.5
I 7	R1.6	R1.6	R1.6
I 8	R1.7	R1.7	R1.7
I 9	R1.8	R1.8	R1.8
I 10	R1.9	R1.9	R1.9
I 11	R1.10	R1.10	R1.10
I 12	R1.11	R1.11	R1.11
I 13	R1.12	R1.12	R1.12
I 14	R1.13	R1.13	R1.13
I 15	R1.14	R1.14	R1.14
I 16	R1.15	R1.15	R1.15
I 17	COM1	+	COM
I 18	COM1	+	COM
I 19	COM2	COM	+24VDC
I 20	COM2	COM	-24VDC

Alarm Output of Power Supply

Alarm Output (Power Supply)

- The alarm output on the power supply turns On when the PLC is in Error mode.
- The alarm output terminal has two relay contacts. These contacts are the NO (Normally Open) contact, and the NC (Normally Closed) contact. They are located on the terminal strip of the power supply. These contacts are provided for use as either an external alarm indication for system fault, or for wiring as part of the emergency stop circuit for the system. They provide a PLC-independent method of indication that the system is in fault.



Watchdog Timer

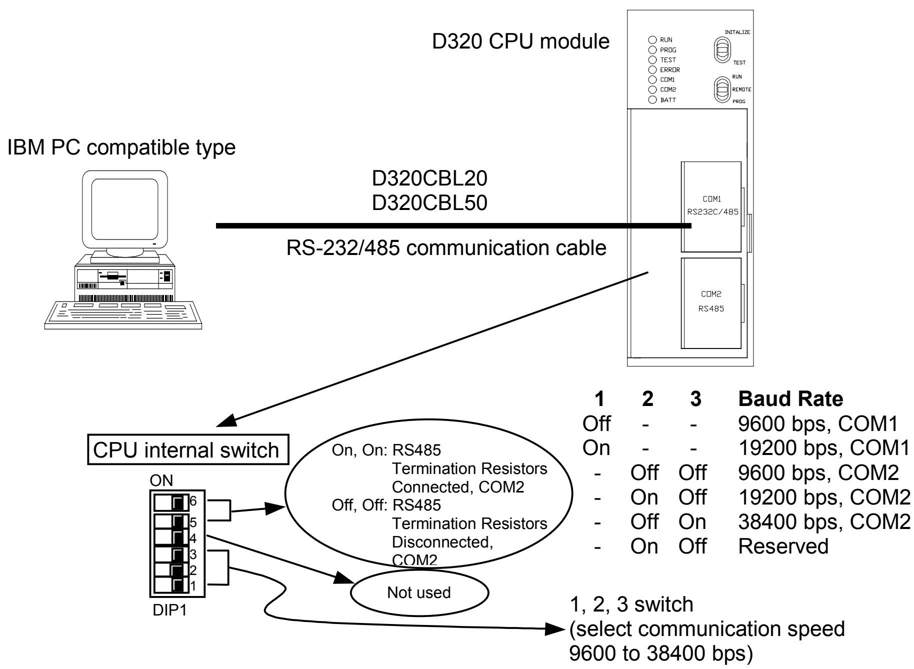
- The watchdog timer detects program errors or hardware errors. The timer is On when the scan time exceeds a user-defined time limit of up to 3 seconds.
- When the watchdog timer detects a fault, the Error LED is lit, and the alarm contact of the power supply turns On.

PLC Communications Wiring

Connecting the PLC to a PC

The D320 PLC communication ports (COM1, COM2) support both RS-232C and RS-485 communications.

The diagram below shows local communications connections for the D320 PLC.



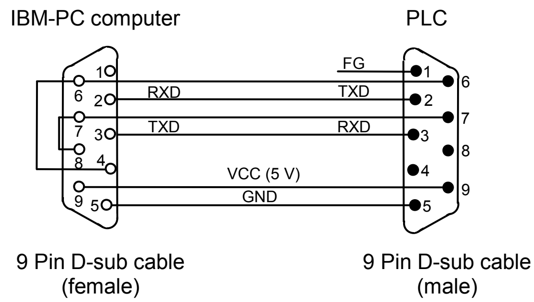
D320 CPU Module Communication Specification

Connection Specification	**RS-485**	**RS-232C**	**Remarks**
Transfer distance (max.)	4000 ft (1.2 km)	50 ft (15 m)	
Transfer speed	38400, 19200, 9600		Dip switch setting COM1: 9600, 19200 COM2: 9600, 19200, 38400
Protocol	Half duplex asynchronous polling		
Parity	No parity		
Stop bit	1 Stop bit		
Cable type	Twisted pair cable		Use Shielded cable.
Program Loaders	D320PGM500	GPC5, WinGPC, D320PGM500	

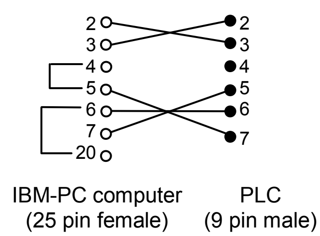
Reference

- RS232C/RS485 common cable diagram (D320CBL20, 6 feet (2 m))
- RS232C shared cable wiring diagram (D320CBL50, 15 feet (5 m))

D320CBL20



D320CBL50



CPU Operation and Memory

5

This chapter provides you with information about memory addresses and the CPU operation. It includes a terminology section and an overview of registers.

This chapter discusses:

- *The terminology used in the D320 PLC manual*
- *CPU operation and processing*
- *Internal/external address designation*
- *Special function internal addresses*

Terminology

This section introduces some terminology you should know.

1. **Address (register)**
   Address refers to the location of memory being used. It can refer to the external input/output module or internal memory. An address is categorized into 1 bit, 16 bit (word), or 32 bit (double word).
2. **Bit**
   A bit is the minimum unit required for calculation. It can be either On (1) or Off (0).
3. **Byte**
   A byte is made up of 8 bits. It can hold data values from 0 to 255. In base 16, or hexadecimal, a byte can be expressed as 0 to FF. You cannot have a value greater than 255 when using one byte.
4. **Word**
   A word is made of 16 bits. It can hold data values from 0 to 65,535. In base 16 a word can be expressed as 0 to FFFF.
5. **Double Word**
   A double word is made of 32 bits. It can hold data values from 0 to 4,294,976,295. In base 16 a double word can be expressed as 0 to FFFFFFFF. In the D320, a double word is made up of two consecutive word addresses.
6. **Scan Time**
   The CPU follows a procedure in which it 1) reads the inputs, 2) processes the ladder program, and 3) updates the outputs. It continually repeats this process. This 3-step process is called a "scan," and the time it takes to complete this process is the "scan time." In a typical PLC application, most of the scan time is used to process the program. When programming, keep in mind that the scan time will increase as you increase the number of inputs and outputs and/or the size of the program.
7. **Edge**
   An edge is defined as the point when an input changes state. For example, a rising edge occurs during the very first scan after the input has changed from Off to On. A falling edge occurs after the input has changed from On to Off.
8. **Hex (Hexadecimal)**
   A hexadecimal number is a value expressed in Base 16. Base 16 values consist of digits from 0 to F. In a byte, word, or double word, each set of 4 bits corresponds to a single hex digit. For example, the binary value 01001111 would correspond to the hex value 4F, and a decimal value of 79. A hex value is designated by the use of the symbol "$" in front of the value (i.e. $4F is the hex value 4F).

8. **BCD (Binary Coded Decimal)**
   BCD is used to express a decimal digit (0 to 9) using 4 bits. Conversion of BCD values can be done in hexadecimal calculations. For example, the BCD representation of decimal 27 would be two sets of 4 bits: 0010 0111.

9. **NOVRAM**
   NOVRAM (non-volatile RAM) is programmable memory that retains its data even through loss of power through the use of a backup battery. The PLC program and retentive memory is stored in NOVRAM and will be retained when power is off. The battery supplied will provide up to 10 years of backup power under normal use.

10. **GPC**
    Graphic Programming Console. Cutler-Hammer offers two program loader software packages for programming, monitoring, and configuring the D320 PLC. The DOS-based package is GPC5, the Windows™-based package is WinGPC. In this manual, GPC is used to refer to either of these programs.

Overview of CPU Operation Mode

What Is the CPU Operation Mode?

The CPU has an external RUN/REMOTE/PROG switch. The PLC performs a system check that determines the position of the switch. The switch position determines which operating mode the PLC is in. It can be in Run, Stop, Remote, or Error mode.

Run Mode (operating)

The D320 PLC reads the external input signals and executes the user program stored in RAM. The external outputs are updated every scan according to program results.

Stop Mode

The user program is stopped and the external outputs are turned Off. In the Stop mode, you can correct, delete, and transfer the program.

Remote Mode

The Remote mode allows the user to switch between the Run and Stop modes using the GPC software instead of the mode switch. It is a convenient tool for program debugging. The Remote/Stop (or Pause) mode is similar to the Stop mode using the switch, but it does not initialize data.

Error Mode

The Error mode occurs when the D320 PLC finds an error after running the self-diagnostics. When an error occurs, the CPU stops program operation and turns off all external outputs. When the Error mode occurs, do one of the following:

- Check the error code and take appropriate measures, then change power from Off to On.
- Put the mode conversion switch in PROG. status and press the Initialize Key to clear the Error.

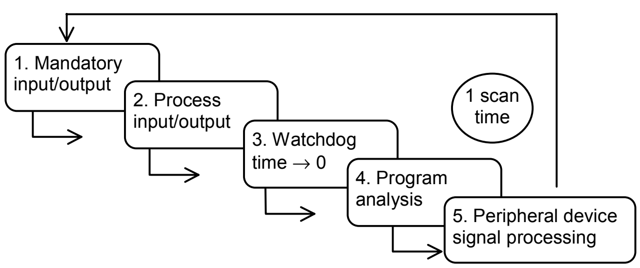
Operation mode and function according to CPU mode switch

Mode Change Switch	Operation Mode	LED Display Run	LED Display Prog.	Program Change	Data Change	Initialize Switch	Mode after Power-Cycle
Run	Run	☼	●	Disabled	Enabled	×	Run
	Stop	●	☼	Enabled	Enabled	×	Run
Remote	Run	☼	☼	Enabled	Enabled	×	Run
	Pause	◑	☼	Enabled	Enabled	×	Pause
Prog	Stop	●	☼	Enabled	Enabled	○	Stop

- When the Prog. LED is on, you can change the user program.
- The Initialize switch clears errors when the mode switch is set to Prog.
- When the mode switch is set to Remote and power is switched from Off to On, the previous mode of operation is restored.
- When debugging the user program, the mode switch should be set to Remote.

CPU Processing Procedure

Program Processing Procedure

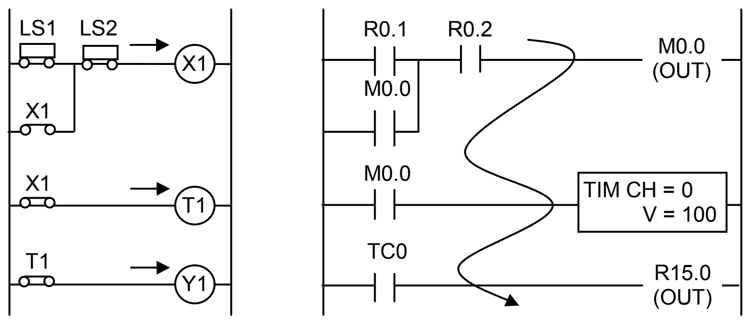


The diagram indicates the PLC program processing procedure. The CPU regularly repeats procedure 1 through 5. This cycle is called 1 scan time.

1. **Mandatory input/output processing**
   The internal force table is applied to internal/external I/O, turning forced I/O On or Off.
2. **Input/output processing**
   Preserves the On/Off state of the external I/O and uses it as input in the next scan. (For accurate processing, input should continue for more than 1 scan time.) The processed program outputs are sent from the internal memory to the external modules.
3. **Watchdog time initialization**
   The watchdog elapsed time value is set to 0. This value is the watchdog calculation point until the next scan.

4. **Program analysis**
   Executes the program from its first step to its final step and stores the internal/external output in the working RAM.
5. **Peripheral device signal processing**
   Stores data from communications module or peripheral device in the internal memory.

The following illustration shows the difference between the relay board and PLC sequence processing. The relay carries out all sequences simultaneously while the PLC processes sequentially throughout the program.



Processing of relay sequence (parallel process)

Processing of PLC program (serial process)

Introduction to Registers

The D320 PLC has a series of registers for storing data. Different registers store different types of data.

1. R (Relay) register (Can be bit, word or double word)
   Indicates the internal memory address which is directly linked with the real-world external input/output module. The address and number of R registers used by the I/O module is determined by the type of module and its location on the I/O backplane.
2. M (Memory) register (Can be bit, word, or double word)
   An internal bit memory address which supports relay logic operations. Can also be used as a word or double-word variable for general calculations and programs. M Registers are non-retentive—when the power of the PLC is Off or the CPU has stopped, the register value is reset to 0.
3. W (Word) register (Can be word or double word)
   Used for general calculations, data storage, and recipe values. Values are preserved after the power is turned off, but can be cleared by program downloads or special command words.
4. K (Keep) register (Can be bit, word, or double word)
   Same usage as M registers. The K Registers are retentive—the value is preserved when the power is turned off.
5. F (Flag) register (Only process bit)
   These bit registers provide special application specific functions to the programmer of the PLC. They are also used as diagnostic and system control bits, providing Run/Stop control of the PLC and other system conditions.

6. L (Link) register (Can be bit, word, or double word)
A special memory area which holds shared data when the D320 PLC is on a Link Network with other D320 PLC's. Refer to the D320 Link Network User's Manual for detailed information on the L registers.

Each type of register is used for a variety of purposes. The register used will be determined by the type of function being performed.

1. When a calculation or input value exceeds 65,535 ($FFFF), use double word instructions which can store and calculate values over 65,535 in the K, M, R, and W registers. When a double word instruction is used, it can represent values up to 4,294,967,295 (2^{32}).
2. When a value needs to be stored even through a loss of system power, use the K or W area. The K and W areas are preserved unless specifically erased. The W area is erased by program downloads or special commands.
3. For bit operations, such as setting, resetting, shifting, or rotating use the M, K, or R registers. You cannot perform bit operations on W registers.
4. The Set Value of timers and counters is stored in a special area of the W registers, W2048 to W2303. These values can also be addressed using register type SV. The Set Values are then referenced as SV000 to SV255.
5. The Present Value of timers and counters is stored above the Set Values in the W registers, from W2304 to W2559. These values can also be addressed using the PV designation, PV000 to PV255. The Present Value is maintained in the Stop state. It is also retentive—the value is maintained through loss of power.

Internal/External Address Designation

- The memory address designation types are R, L, M, K, F, W, SV, PV, SR, and TC.
  - Types F and TC can only be used to designate bits.
  - Types W, SV, PV, and SR can only be used to designate words.
  - Types R, L, M, and K can be used for either bits or words.
- A bit address is composed of a character (R, L, M, K, F), a three digit word address (000 to 127), a decimal point, and a bit address (0 to 15). The timer/counter contact is represented by the TC label followed by three digits. The three digits indicate the channel number of the timer/counter (TC000 to TC255).
- A word address is composed of a character (R, L, M, K, W) and a four digit number (i.e. W0000 to W2047). Special areas of word memory have alternate designations. For example, words W2560 to W3071 are also referred to as the System Registers, and can be represented as SR0000 to SR0511.
- The bit address indicates an On (1) or Off (0) state. The word address is composed of 16 bits that holds data values of 0 to 65,535. The double word address is composed of 32 bits that holds data values of 0 to 4,294,967,295.

D320 Memory Addresses

Type	Scope	Features
External I/O Area	R000.0 to R127.15	Local I/O memory area. Remote I/O memory area. 2048 points, 128 words
Link Area	L000.0 to L063.15	Link memory area. 1024 points, 64 words
	M000.0 to M063.15	Link memory area for second loop. 1024 points, 64 words
Internal Contact	M000.0 to M127.15	Internal auxiliary contact memory area. 2048 points, 128 words
Retentive Contact	K000.0 to K127.15	Retentive internal auxiliary contact memory area. 2048 points, 128 words
System Flag	F000.0 to F015.15	Special internal contact memory area. 256 points, 16 words
Timer/Counter	TC000 to TC255 Set Value: W2048 (SV000) to W2303 (SV255) Present Value: W2304 (PV000) to W2559 (PV255)	256 channel common use. TC is contact signal or “Done” bit. SV is Set Value, PV is Present Value. SV can hold values from 0 to 65535.
Data Word	W0000 to W2047	Word value memory area. Used for tables, data storage, and math operations. Cannot be designated with a bit.
System Register	SR000 to SR511	Special internal data area for CPU status and RTC.

Expression Example

M 123 . 12

Bit number
- 2 digits, range is 0 to 15.

Word number
- When used with bit number, 3 digits (000 to 127) are used.
- When used for word number only, express in 4 digits (0000 to 3071).

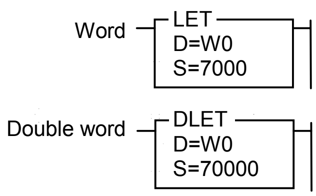
Register Type
- R, L, M, K, F, or W indicates address type.
- The W memory contains the character area (W0000 to W2047), the timer Set Value area (W2048 to W2303 = SV000 to SV255), the timer Present Value area (W2304 to W2559 = PV000 to PV255), and the System Register area (W2560 to W3071 = SR000 to SR511).

Note: The basic contact and coil instructions require a bit designation and use the 3.2 bit address format. Comparison and application instructions most often use word parameters, and are expressed using the 4 digit word address.

Double Word Address Designation

- Double words are composed of two words put together. The designation for a double word follows the word number designation method, consisting of a one character register type and a 4 digit word address. Double words can hold 32 bits of data.
- The type of instruction used determines whether the register is processed as a single word or a double word. For comparison instructions (>, <, ==, etc.), the programmer must be in “Double Mode” to enter a double-word comparison (refer to program loader manual for details). For application instructions, those instructions that start with a D in front of the related word instruction are double word instructions, and process the data as 32-bit double words.

Example 1:



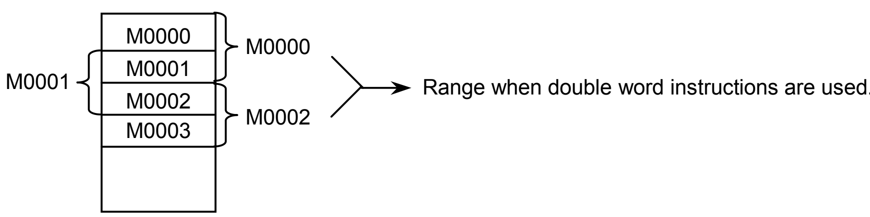
W0 is processed as 16 bit (1 word) data (0 to 65,535).
S is processed from 0 to 65,535.

Double word W0 is composed of W0 and W1.
W0 is the low word. W1 is the high word.
W0000 is:

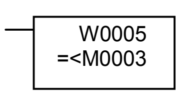
2^{31}	2^{30}	…	2^{17}	2^{16}	2^{15}	2^{14}	…	2^{2}	2^{1}	2^{0}
15	14	…	1	0	15	14	…	2	1	0
		—					—			

W0001 W0000

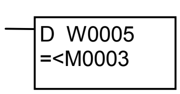
Example 2:



Example 3: Comparison Instruction



The example shows comparison instructions being used in the single mode of GPC. The parameters W0005 and M0003 represent 16 bits of data.



In this example, GPC is in double mode and comparison instructions are used. W5 is made up of W5 and W6. M3 is made up of M3 and M4. The comparison is performed on 32 bits of data.

Absolute Address Designation

In LDR, DLDR, STO, DSTO instructions, the absolute address is used to perform indirect memory operations using pointers. The absolute address is also used by the D320 program loader port protocol for reading and writing memory areas.

	Register Address	Absolute Address	
		Dec.	Hex.
External I/O	R0000	0	0000
	R0001	1	0001
	R0002	2	0002
	:	:	:
	R0126	126	007E
	R0127	127	007F
Link Area	L0000	128	0080
	L0001	129	0081
	L0002	130	0082
	:	:	:
	L0062	190	00BE
	L0063	191	00BF
Internal Contact	M0000	192	00C0
	M0001	192	00C1
	M0002	194	00C2
	M0003	195	00C3
	:	:	:
	M0126	318	013E
	M0127	319	013F
Internal Keep Contact	K0000	320	0140
	K0001	321	0141
	K0002	322	0142
	K0000	323	0143
	:	:	:
	K0126	446	01BE
	K0127	447	01BF

	Register Address	Absolute Address	
		Dec.	Hex.
System Flags	F0000	448	01C0
	F0001	449	01C1
	F0002	450	01C2
	:	:	:
	F0014	462	01CE
	F0015	463	01CF
Data Area	W0000	512	0200
	W0001	513	0201
	W0002	514	0202
	:	:	:
	W2046	2558	09FE
	W2047	2559	09FF
T/C Set Value	W2048	2560	0A00
	W2049	2561	0A01
	:	:	:
	W2303	2815	0AFF
T/C Present Value	W2304	2816	0B00
	W2305	2817	0B01
	:	:	:
	W2559	3071	0BFF
System Registers	SR0	3072	0C00
	SR1	3073	0C01
	:	:	:
	SR511	3583	0DFF

When accessing a bit absolute address using the program loader port communications protocol, the bit address (0 to 15) is kept separate from the word address (as shown below).

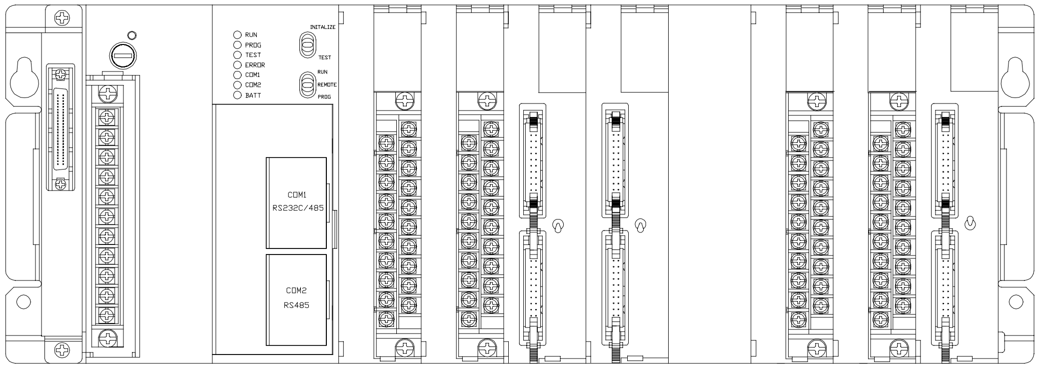
	15 … 4	3 … 0
1 word display	Word absolute address	bit number

For example, the absolute bit address for K127.12 internal contact is $1BFC (hex).
(word absolute address = $01BF + bit number = $C = $1BFC)

Refer to the appendix for a detailed explanation of the communications protocol.

I/O Address Designation

(8-slot backplane)



Example I/O Addressing Configuration

Slot No		**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**
I/O Points		16	16	32	32	0	16	16	32
Word No		R0	R1	R2, R3	R4, R5	-	R6	R7	R8, R9
Bit No	CPU Unit	R000.0 R000.1 R000.2 : R000.15	R001.0 R001.1 R001.2 : R001.15	R002.0 R002.1 R002.2 : R003.15	R004.0 R004.1 R004.2 : R005.15		R006.0 R006.1 R006.2 : R006.15	R007.0 R007.1 R007.2 : R007.15	R008.0 R008.1 R008.2 : R009.15

Note: I/O Address Designation

- The CPU assigns addresses in sequential order to the I/O modules on the backplane, starting at address 0.
- The CPU automatically determines whether the register data from the modules is of type input or output.
- The 16-point I/O modules use one word of register memory. The 32-point I/O modules require 2 words of register memory. Analog and Intelligent function modules can require from 1 to 4 words of register memory.
- The combination I/O module consisting of both inputs and outputs is separated into a one word input and a one word output. On a 16 point mixed I/O module, the eight input or output points will use up the lower 8 bits (00 to 07) of their respective words.
- When a slot is empty, a blank (D320BNK300) module can be installed. When addresses are automatically assigned by the CPU, no address is assigned to a blank module.

Special Internal Addresses

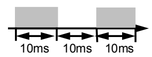
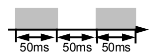
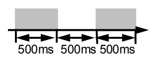
F000 to F015 System Flags

Address	Function	Details	Remarks
F0 register	System check/control	System self check/program checking, operation control.	
F1 register	System check/clock	0.02/0.1/1.0 s timer output, operation results, carry flag	
F2 register	Link control	Link installation and operation mode setting.	Loop #0
F3 register	Link control	Link installation and operation mode setting.	Loop #1
F4 register	Link status flag	Link participating station information.	Loop #0
F5 register	Link status flag	Link participating station information.	Loop #1
F6 register	Link status flag	Link data receiving information flag.	Loop #0
F7 register	Link status flag	Link data receiving information flag.	Loop #1
F8 register	Remote control flag	Remote operation control flag.	Loop #0
F9 register	Remote control flag	Remote operation control flag.	Loop #1
F10 register	Remote control flag	Remote operation control flag.	Loop #2
F11 register	User defined communication protocol	For port COM2 User defined communication control flag.	
F12 register	Realtime Clock	RTC installation, remote I/O setting, etc.	
F13 register	System reserved		
F14 register	PID control	PID operation mode and operation/stop control flag.	Channel 0, 1, 2, 3
F15 register	PID control	PID operation mode and operation/stop control flag.	Channel 4, 5, 6, 7

F0.0 to F0.15 (F0 word register) System/Diagnostic Functions

Address	Function	Details	Remarks
F0.0	System check	When power is applied, the system runs self-diagnostics. Should any fault exist, the error lamp is turned on. Output and operation are halted.	Normal: Off
F0.1	CPU ROM check	When power is applied, the system self-checks the ROM. Should any faults exist, the error lamp is turned on. Output and operation are halted.	Normal: Off
F0.2	CPU RAM check	When the power is applied, the system self-checks the RAM. Should any faults exist, the error lamp is turned on. Output and operation are halted.	Normal: Off
F0.3	User program memory error	If the user program memory is damaged or the program is faulty, the error lamp is turned on. Output and operation are halted.	Normal: Off
F0.4	Program check	The CPU initially runs and checks the user program's syntax. In the case of an error, the error lamp is turned on. Output and operation are halted.	Normal: Off
F0.5	Module range error	Indicates an invalid R address (>127) used.	Normal: Off
F0.6	Module change error	On when an I/O module is removed/added/fails while the system is running. The error lamp is on and the CPU keeps running. Turned off when the error is corrected.	Normal: Off
F0.7	Module type error	On when module information that is stored in the CPU and module that is installed are different types. The error lamp is turned on and operation stops.	Normal: Off
F0.8	Input data control	Off when the running CPU input module's data is not updated. (Input update is turned Off.)	Normal: On
F0.9	Output data control	Off to suspend updating of the output modules while the CPU is in the run state. (Output update is turned Off.) The outputs are maintained in their last valid state prior to update being disabled.	Normal: On
F0.10	All outputs OFF	Turns all outputs off while CPU is in the run state. (Outputs are disabled.)	Normal: On
F0.11	Constant cycle interrupt	On when constant cycle interrupt instructions are used. See the INT instruction. The cycle time is defined by the user.	Normal: Off
F0.12	Watchdog error	On when a scan time exceeds the watchdog set time.	Normal: Off
F0.13	Disable module type checking	On when the CPU starts the initial run, and the program is checked without performing input/output module type verification.	Normal: Off
F0.14	Program changes during run	On when error-checking the program while in run mode. If there are syntax errors, the CPU is stopped.	Normal: Off
F0.15	Run state control	On when the CPU is in the run state. Off when stopped or paused.	Normal: On

F1.0 to F1.15 (F1 word register) Special Application Functions

Address	Function	Details	Note
F1.0	First single scan	Maintain On state for first single-scan period, when the CPU changes its status from Stop to Run.	
F1.1	Scan clock	Cycle On/Off state for each scan during the program. (1Scan On, 1Scan Off)	
F1.2	0.02 sec. Clock	10 ms: On, 10 ms: Off 	
F1.3	0.1 sec. Clock	50 ms: On, 50 ms: Off 	
F1.4	1 sec. Clock	500 ms: On, 500 ms: Off 	
F1.5	Instantaneous interrupt	On when power is off for over 20 ms.	Maintained
F1.6	Execute status	On when the CPU is in the run state.	
F1.7	Keep error display	On when the K retentive data is destroyed and/or changed.	
F1.8	Carry Flag	On in the event of carry when performing math instructions (ADD, SUB, etc.)	
F1.9	Division by zero error	On when the denominator of division commands is zero.	
F1.10	Range designation error	On when the absolute address exceeds the specified range.	
F1.11	Reserved	System use.	Do not use.
F1.12	Reserved	System use.	Do not use.
F1.13	Reserved	System use.	Do not use.
F1.14	Reserved	System use.	Do not use.
F1.15	Reserved	System use.	Do not use.

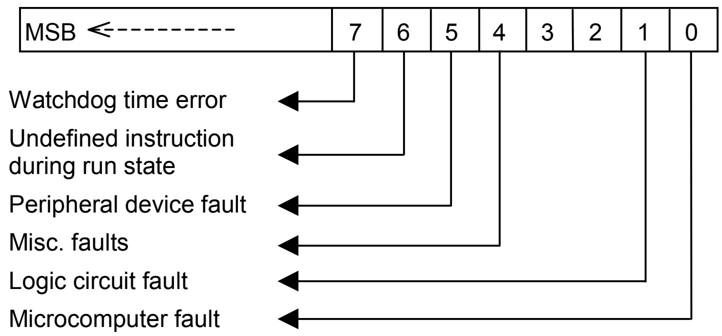
Note: The 16 bits in the F1 address provide the CPU's special function and self diagnosis result. They are used for status contacts only, and are not used to modify or control the PLC. Only the F1.5 instantaneous interrupt display contact should be used as an output contact by the user, to be turned off after power loss indication.

F12.0 to F12.15 (F12 word register) Realtime Clock Functions

Address	Function	Details	Note
F12.0	RTC check	On when the RTC is enabled.	Output
F12.3	Flash	On when the Flash ROM is enabled.	Output
F12.10	RTC set error	On when there is an error setting the RTC.	Output
F12.13	RTC set 1	On when changing the year, month, or date. Off when the data set is normal.	I/O
F12.14	RTC set 2	On when changing time, min., or sec. Off when the data set is normal.	I/O

System Registers SR0 to SR511

Address	Function	Detail
SR000	CPU address	Indicates the CPU ID number in the lower 8 bits. 0 to 223 are the valid user-defined values, 255 is the default value.
SR001	CPU status	Indicates current CPU information state. (stop/remote control mode/run mode/error) MSB ← | 03 | 02 | 01 | 00 Error = 1 (bit 03) Run control (same as F15) (bit 02) CPU switch remote control (REM) = 1 (bit 01) CPU switch RUN = 1 (bit 00) CPU switch STOP = 0 (bit 00)
SR002	User watchdog	Indicates the user program watchdog time. (unit: msec)
SR003	Scan time	Indicates the scan time when executing a program. (unit: msec)
SR004	Max. scan time	Indicates maximum value of scan time when executing a program. Initialized as zero when the program mode changes from the stop state to the run state.
SR005 to 7	Link unit number	Unit address as set by the link module.
SR008	PID table	PID register block start address.
SR009 to 16	Remote info.	Remote I/O configuration information.

Address	Function	Detail
SR017	System error information	Gives result of self-check by CPU. Indicates error content when F0.0 turns On. 
SR018	Location of undefined instruction	Indicates the location of the instruction (the step number) that caused an undefined instruction error during program execution.
SR019	Reserved	System use.
SR020	Multiplication	Stores high order 8 bit values upon executing 16 bit multiplication instructions.
SR022	Remainder	Stores the remainder after a division instruction has been executed (high order 16 bits).
SR024 to 27	Reserved	System use.
SR028 to 29	Error I/O module	Sets bit position at error in I/O module.
SR030 to 047	Reserved	System use.
SR048 to 111	Slot information	Stores slot information for I/O modules.
SR112 to SR239	Remote	Contains remote I/O configuration data.
SR289 to SR297	RTC	Contains real time clock information.
SR298 to SR373	User defined comm. protocol	User defined communication protocol information for COM2.
SR374 to SR379	Link error	Link error information data.
SR380 to SR511	Reserved	System use.

Syntax Check Data (16 bits of SR30)

Indicates the result of the automatic check on user program syntax when the programmer or GPC executes a syntax check, and when operation mode is switched from the Stop state to the Run state. If the value of SR30 is not zero, F0.4 turns On. The error lamp also turns On.

There are two error correction methods:

Method 1: Find the error in the CPU online mode, then correct the program.
Method 2: Use the syntax checking function, then correct the program.

Word	Bit	Detail
SR30	0	On if the I/O number range of bit process instruction is beyond the specified range or designates an external contact/output module which is not installed.
	1	On if the channel number of the timer or the counter exceeds 255 or is duplicated.
	2	On if the bit or word number in the application program is beyond the specified range or if it designates a module which is not installed.
	3	On if a word number in the refresh instruction (INPR, OUTR) is beyond the specified range, or if it designates a module which is not installed.
	4	On if an undefined instruction exists.
	5	On in the event of a user program memory error.
	6	On in the event of miscellaneous errors.
	7	On if the user program memory is destroyed.
	8	On if an external I/O module register address is improperly used within the program. For example, the first slot is set with an input module and OUT R00001 is designated.
	9	On if the label numbers of the JMP or CALL instructions exceed 63, the corresponding instruction (LBL, SBR) does not exist, and/or the corresponding LBL/SBR instructions exist prior to JMP/CALL instructions.
	10	On if the label number of the LBL instruction exceeds 63 and/or is duplicated.
	11	On if the JMPS/JMP instructions are mistakenly combined and/or used.
	12	On if the FOR/NEXT instructions are mistakenly combined and/or used more than four times. (Loop)
	13	On if SBR/RET instructions are not combined and/or used and/or the SBR instructions overlap or exceed 63.
	14	On if INT/RETII instructions are not combined and/or used, and/or more than two sets of INT instructions are used.
	15	On if no END instruction exists.

SR290 to SR297 (W2849 to W2857) Realtime Clock Functions

Sets the time of the built-in clock (RTC) and stores and displays the current time. Data is stored in BCD format.

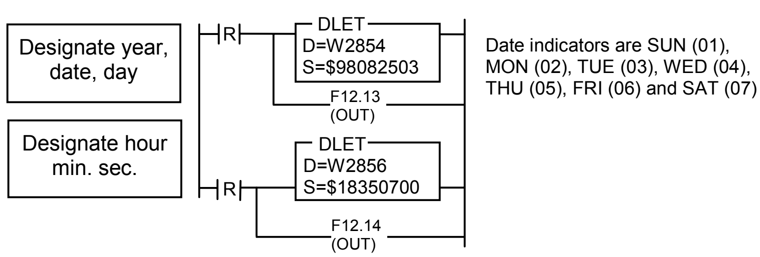
	Address	Control display	Bit Control Contents															
			15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	SR289	This year (4 BCD)	Example: $1998, $2000															
Current Time	SR290	Date: day	○	○	×	×	×	×	×	×	○	○	○	○	○	×	×	×
	SR291	Year: month	○	×	×	×	×	×	×	×	○	○	○	×	×	×	×	×
	SR292	Second: 00	○	○	×	×	×	×	×	×	○	○	○	○	○	○	○	○
	SR293	Time: minute	○	○	×	×	×	×	×	×	○	×	×	×	×	×	×	×
Set Time	SR294	Date: day	○	○	×	×	×	×	×	×	○	○	○	○	○	×	×	×
	SR295	Year: month	○	×	×	×	×	×	×	×	○	○	○	×	×	×	×	×
	SR296	Second: 00	○	○	×	×	×	×	×	×	○	○	○	○	○	○	○	○
	SR297	Hour: minute	○	○	×	×	×	×	×	×	○	×	×	×	×	×	×	×

○: bit = 0; ×: bit change

Note:

1. Set the range as follows:
   - Year: 00 to 99
   - Month: 01 to 12
   - Date: 01 to 31
   - Day: 01 to 07 (Sun. to Sat.)
   - Hour: 00 to 23
   - Minute: 00 to 59
   - Second: 00 to 59

2. Ladder setting method:
   - For example, current date and time are: Tuesday, August 25, 1998, 18:35:07.



3. When changing the year, month, date, or day, new data is input in W2855 and W2854, then the F12.14 bit is turned On. The F12.10 bit is kept Off.

4. When changing the hour, minute, and second, the new data is input in W2857 and W2856 then the F12.14 bit is turned on. If the new data is not set correctly, the F12.10 bit turns on.
5. The display date and set date are expressed in BCD so it is convenient to input as hex($).
6. The year, month, and day are changed automatically.
7. The RTC can be set using GPC5 as follows:
    - In the online menu choose System Control then select F1(System Control).
    - Using the direction key enter in the date in the yy-mm-dd format. Use the direction key to select the year then enter 98.
    - Move using the direction key to select the month, day, and week and enter the current information.
    - Tab the cursor to Done and press Enter to set the entered information.
    - Use the same procedure for setting the hour, minutes, and seconds.
8. The RTC can be set using WinGPC as follows:
    - Go online with the D320 by clicking on the Online button on the toolbar, or by selecting Online from the Online menu.
    - Enter the PLC ID (or 255 for direct connection) and password, and click the OK button to go online.
    - Once connected to the D320 PLC, select Status Monitoring from the Monitoring menu.
    - Click on the RTC Date button to open the Date window. Enter the current year, month, and day, and select the day of the week. Click the OK button to accept the values and change the data in the PLC.
    - Click on the RTC Time button to open the Time window. Enter the current time in 24-hour HH:MM:SS format. Click the OK button to accept the values and change the data in the PLC.
9. The D320 PLC realtime clock is completely year 2000 compliant. However, as the year is designated by a two-digit representation, it is the responsibility of the programmer to accurately account for the proper calculation of dates using the two-digit value. Register SR289 is provided as a convenience for holding a four-digit representation of the year.

Timer/Counter (TC0-255)

The table below gives the timer/counter Set Value and Present Value for each inherent address

Ch	SV	PV	Ch	SV	PV	Ch	SV	PV
0	W2048	W2304	40	W2088	W2344	80	W2128	W2384
1	W2049	W2305	41	W2089	W2345	81	W2129	W2385
2	W2050	W2306	42	W2090	W2346	82	W2130	W2386
3	W2051	W2307	43	W2091	W2347	83	W2131	W2387
4	W2052	W2308	44	W2092	W2348	84	W2132	W2388
5	W2053	W2309	45	W2093	W2349	85	W2133	W2389
6	W2054	W2310	46	W2094	W2350	86	W2134	W2390
7	W2055	W2311	47	W2095	W2351	87	W2135	W2391
8	W2056	W2312	48	W2096	W2352	88	W2136	W2392
9	W2057	W2313	49	W2097	W2353	89	W2137	W2393
10	W2058	W2314	50	W2098	W2354	90	W2138	W2394
11	W2059	W2315	51	W2099	W2355	91	W2139	W2395
12	W2060	W2316	52	W2100	W2356	92	W2140	W2396
13	W2061	W2317	53	W2101	W2357	93	W2141	W2397
14	W2062	W2318	54	W2102	W2358	94	W2142	W2398
15	W2063	W2319	55	W2103	W2359	95	W2143	W2399
16	W2064	W2320	56	W2104	W2360	96	W2144	W2400
17	W2065	W2321	57	W2105	W2361	97	W2145	W2401
18	W2066	W2322	58	W2106	W2362	98	W2146	W2402
19	W2067	W2323	59	W2107	W2363	99	W2147	W2403
20	W2068	W2324	60	W2108	W2364	100	W2148	W2404
21	W2069	W2325	61	W2109	W2365	101	W2149	W2405
22	W2070	W2326	62	W2110	W2366	102	W2150	W2406
23	W2071	W2327	63	W2111	W2367	103	W2151	W2407
24	W2072	W2328	64	W2112	W2368	104	W2152	W2408
25	W2073	W2329	65	W2113	W2369	105	W2153	W2409
26	W2074	W2330	66	W2114	W2370	106	W2154	W2410
27	W2075	W2331	67	W2115	W2371	107	W2155	W2411
28	W2076	W2332	68	W2116	W2372	108	W2156	W2412
29	W2077	W2333	69	W2117	W2373	109	W2157	W2413
30	W2078	W2334	70	W2118	W2374	110	W2158	W2414
31	W2079	W2335	71	W2119	W2375	111	W2159	W2415
32	W2080	W2336	72	W2120	W2376	112	W2160	W2416
33	W2081	W2337	73	W2121	W2377	113	W2161	W2417
34	W2082	W2338	74	W2122	W2378	114	W2162	W2418
35	W2083	W2339	75	W2123	W2379	115	W2163	W2419
36	W2084	W2340	76	W2124	W2380	116	W2164	W2420
37	W2085	W2341	77	W2125	W2381	117	W2165	W2421
38	W2086	W2342	78	W2126	W2382	118	W2166	W2422
39	W2087	W2343	79	W2127	W2383	119	W2167	W2423

Internal/external address designation.

Ch	SV	PV
120	W2168	W2424
121	W2169	W2425
122	W2170	W2426
123	W2171	W2427
124	W2172	W2428
125	W2173	W2429
126	W2174	W2430
127	W2175	W2431
128	W2176	W2432
129	W2177	W2433
130	W2178	W2434
131	W2179	W2435
132	W2180	W2436
133	W2181	W2437
134	W2182	W2438
135	W2183	W2439
136	W2184	W2440
137	W2185	W2441
138	W2186	W2442
139	W2187	W2443
140	W2188	W2444
141	W2189	W2445
142	W2190	W2446
143	W2191	W2447
144	W2192	W2448
145	W2193	W2449
146	W2194	W2450
147	W2195	W2451
148	W2196	W2452
149	W2197	W2453
150	W2198	W2454
151	W2199	W2455
152	W2200	W2456
153	W2201	W2457
154	W2202	W2458
155	W2203	W2459
156	W2204	W2460
157	W2205	W2461
158	W2206	W2462
159	W2207	W2463
160	W2208	W2464
161	W2209	W2465
162	W2210	W2466
163	W2211	W2467
164	W2212	W2468
165	W2213	W2469

Ch	SV	PV
166	W2214	W2470
167	W2215	W2471
168	W2216	W2472
169	W2217	W2473
170	W2218	W2474
171	W2219	W2475
172	W2220	W2476
173	W2221	W2477
174	W2222	W2478
175	W2223	W2479
176	W2224	W2480
177	W2225	W2481
178	W2226	W2482
179	W2227	W2483
180	W2228	W2484
181	W2229	W2485
182	W2230	W2486
183	W2231	W2487
184	W2232	W2488
185	W2233	W2489
186	W2234	W2490
187	W2235	W2491
188	W2236	W2492
189	W2237	W2493
190	W2238	W2494
191	W2239	W2495
192	W2240	W2496
193	W2241	W2497
194	W2242	W2498
195	W2243	W2499
196	W2244	W2500
197	W2245	W2501
198	W2246	W2502
199	W2247	W2503
200	W2248	W2504
201	W2249	W2505
202	W2250	W2506
203	W2251	W2507
204	W2252	W2508
205	W2253	W2509
206	W2254	W2510
207	W2255	W2511
208	W2256	W2512
209	W2257	W2513
210	W2258	W2514
211	W2259	W2515

Ch	SV	PV
212	W2260	W2516
213	W2261	W2517
214	W2262	W2518
215	W2263	W2519
216	W2264	W2520
217	W2265	W2521
218	W2266	W2522
219	W2267	W2523
220	W2268	W2524
221	W2269	W2525
222	W2270	W2526
223	W2271	W2527
224	W2272	W2528
225	W2273	W2529
226	W2274	W2530
227	W2275	W2531
228	W2276	W2532
229	W2277	W2533
230	W2278	W2534
231	W2279	W2535
232	W2280	W2536
233	W2281	W2537
234	W2282	W2538
235	W2283	W2539
236	W2284	W2540
237	W2285	W2541
238	W2286	W2542
239	W2287	W2543
240	W2288	W2544
241	W2289	W2545
242	W2290	W2546
243	W2291	W2547
244	W2292	W2548
245	W2293	W2549
246	W2294	W2550
247	W2295	W2551
248	W2296	W2552
249	W2297	W2553
250	W2298	W2554
251	W2299	W2555
252	W2300	W2556
253	W2301	W2557
254	W2302	W2558
255	W2303	W2559

Note: Channel: The inherent number of the timer and the counter.

Set Value (SV): The designated value for the timer (to turn On) and the counter (number of times On) to start operation.

Present Value (PV): Current processing value of the timer (elapsed time) and the counter (number of counts).

Note: When using GPC software, the above W registers can be represented as follows.

Ch	Set Value (SV)	Present Value (PV)
0	W2048 = SV0	W2304 = PV0
1	W2049 = SV1	W2305 = PV1
:	:	:
255	W2303 = SV255	W2559 = PV255

Where SV is Set Value and PV is Present Value.

CAUTION: Be sure you understand the programming of the timer/counter thoroughly. If you change the above registers while the program is running or program them incorrectly, errors or damage may occur.

Instructions

6

This chapter contains all of the instructions that are used with the D320 PLC. The instructions are grouped by function, and then explained in detail.

This chapter discusses:

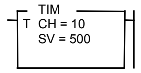
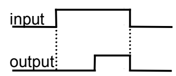
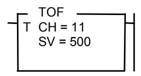
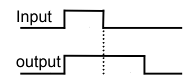
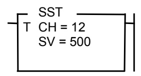
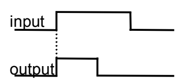
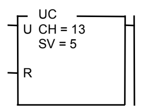
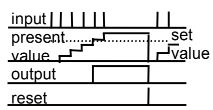
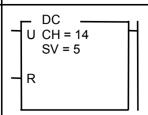
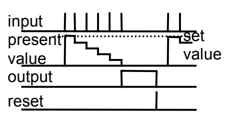
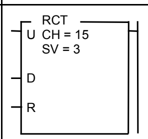
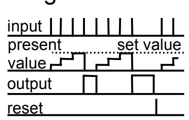
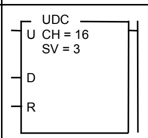
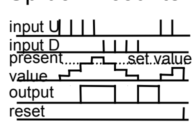
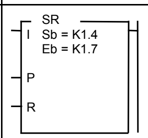
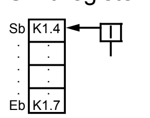
- *The instructions that are used with the D320 PLC*
- *How to read the descriptions of the instructions*
- *Detailed information concerning the usage of the instructions*

Basic Instructions

Mnemonic	Command	Ladder Symbol	Description
STR	Start	|—| |—	Start NO contact.
STN	Start Not	|—|/|—	Start NC contact.
AND	And	—| |—	NO contact series circuit.
ANN (ADN)	And Not	—|/|—	NC contact series circuit.
OR	Or	└—| |—┘	NO contact parallel circuit.
ORN	Or Not	└—|/|—┘	NC contact parallel circuit.
OUT	Out	—(OUT)—|	Relay output.
SET	Set	—(SET)—|	Turn On output.
RST	Reset	—(RST)—|	Turn Off output.
NOT	Not	—/—	Invert logic result.
STR DIF	Start Differential	|—|R|—	Start rising edge contact (_|‾).
STR DFN	Start Dif. Not	|—|F|—	Start falling edge contact (‾|_).
AND DIF	And Dif.	—|R|—	Rising edge series connection (_|‾).
AND DFN	And Dif. Not	—|F|—	Falling edge series connection (‾|_).
OR DIF	Or Dif	└—|R|—┘	Rising edge parallel connection (_|‾).
OR DFN	Or Dif. Not	└—|F|—┘	Falling edge parallel connection (‾|_).
ANB	And Block		Circuit block series connection.
ORB	Or Block		Circuit block parallel connection.
MCS	Master Control Set	—(MCS)—|	Start batch processing block.
MCR	Master Control Reset	—(MCR)—|	End batch processing block.

Note: NO = Normally Open
NC = Normally Closed

Timer/Counter/SR Instructions

Mnemonic	Command	Ladder Symbol	Description	Remarks
TIM	On Delay Timer		Turn on after set delay time from input on. 	Time Base: Ch 0-63: 0.01s Ch 64-255: 0.1s Setting range: SV = 0-65535 Done Contact: TC + channel no.
TOF	Off Delay Timer		Turn off after set delay time from input off. 	Time Base: Ch 0-63: 0.01s Ch 64-255: 0.1s Setting range: SV = 0-65535 Done Contact: TC + channel no.
SST	Single Shot Timer		Turn off after set delay time from input on. 	Time Base: Ch 0-63: 0.01s Ch 64-255: 0.1s Setting range: SV = 0-65535 Done Contact: TC + channel no.
UC	Up Counter		Up counter 	Range of channel: Ch 0 to 255 (Shared with timer) Setting range: SV = 0-65535 Done Contact: TC + channel no.
DC	Down Counter		Down counter 	Range of channel: Ch 0 to 255 (Shared with timer) Setting range: SV = 0-65535 Done Contact: TC + channel no.
RCT	Ring Counter		Ring counter 	Range of channel: Ch 0 to 255 (Shared with timer) Setting range: SV = 0-65535 Done Contact: TC + channel no.
UDC	Up-Down Counter		Up/down counter 	Range of channel: Ch 0 to 255 (Shared with timer) Setting range: SV = 0-65535 Done Contact: TC + channel no.
SR	Shift Register		Shift register 	Sb, Eb: M, K bit address 1 bit shift by each p input Max. # of bits: 256

Comparison Instructions

Mnemonic	Command	Word	Double Word	Description
STR = AND = OR =	START = AND = OR =	A = B	D C = D	On if A(C) value and B(D) value are the same.
STR <> AND <> OR <>	START <> AND <> OR <>	A <>B	D C <>D	On if A(C) value and B(D) value are different. <> means the same as ≠.
STR > AND > OR >	START > AND > OR >	A > B	D C > D	On if A(C) value is greater than B(D) value.
STR >= AND >= OR >=	START >= AND >= OR >=	A >=B	D C >=D	On if A(C) value is greater than or equal to B(D) value.
STR <= AND <= OR <=	START <= AND <= OR <=	A <=B	D C <=D	On if A(C) value is less than or equal to B(D) value.
STR < AND < OR <	START < AND < OR <	A < B	D C < D	On if A(C) value is less than B(D) value.

Substitution, Increment/Decrement Instructions

Note: Application instructions that operate on double words (32-bit) are designated with a "D" in front of the single word instruction. For example, DINC refers to double word decimal increment, DDEC refers to double word decimal decrement, etc.

Mnemonic	Command	Word	Double Word	Description
LET (DLET)	Let (Substitution)	LET D = S =	DLET D = S =	Store value of designated register S into D.
INC (DINC)	Decimal increment	INC D =	DINC D =	D value increased by 1 whenever input is On.
DEC (DDEC)	Decimal decrement	DEC D =	DDEC D =	D value decreased by 1 whenever input is On.
INCB (DINCB)	BCD increment	INCB D =	DINCB D =	D value increased by 1 (BCD) whenever input is On.
DECB (DDECB)	BCD decrement	DECB D =	DDECB D =	D value decreased by 1 (BCD) whenever input is On.

Arithmetic Instructions

Mnemonic	Command	Word	Double Word	Description
ADD (DADD)	Decimal addition	ADD D = S1 = S2 =	DADD D = S1 = S2 =	D = S1 + S2 (Decimal operation)
SUB (DSUB)	Decimal subtraction	SUB D = S1 = S2 =	DSUB D = S1 = S2 =	D = S1 - S2 (Decimal operation)
MUL (DMUL)	Decimal multiplication	MUL D = S1 = S2 =	DMUL D = S1 = S2 =	D = S1 × S2 (Decimal operation)
DIV (DDIV)	Decimal division	DIV D = S1 = S2 =	DDIV D = S1 = S2 =	D = S1/S2 (Decimal operation)
ADDB (DADDB)	BCD addition	ADDB D = S1 = S2 =	DADDB D = S1 = S2 =	D = S1 + S2 (BCD operation)
SUBB (DSUBB)	BCD subtraction	SUBB D = S1 = S2 =	DSUBB D = S1 = S2 =	D = S1 - S2 (BCD operation)
MULB (DMULB)	BCD multiplication	MULB D = S1 = S2 =	DMULB D = S1 = S2 =	D = S1 × S2 (BCD operation)
DIVB (DDIVB)	BCD division	DIVB D = S1 = S2 =	DDIVB D = S1 = S2 =	D = S1/S2 (BCD operation)
ADC (DADC)	Decimal addition w/carry	ADC D = S1 = S2 =	DADC D = S1 = S2 =	D = S1 + S2 + CY (Decimal operation, include carry)
SBC (DSBC)	Decimal subtraction w/carry	SBC D = S1 = S2 =	DSBC D = S1 = S2 =	D = S1 - S2 - CY (Decimal operation, include carry)
ADCB (DADCB)	BCD addition w/carry	ADCB D = S1 = S2 =	DADCB D = S1 = S2 =	D = S1 + S2 + CY (BCD operation, include carry)
SBCB (DSBCB)	BCD subtraction w/carry	SBCB D = S1 = S2 =	DSBCB D = S1 = S2 =	D = S1 - S2 - CY (BCD operation, include carry)
ABS (DABS)	Absolute value	ABS D =	DABS D =	D = |D| (Absolute value operation)
NEG (DNEG)	Negative (2's complement)	NEG D =	DNEG D =	Store the 2's complement of D in D (1's complement + 1).
NOT (DNOT)	NOT (1's complement)	NOT D =	DNOT D =	Store the 1's complement of D in D.

Logic Instructions

Mnemonic	Command	Word	Double Word	Description
AND (DAND)	AND (logic multiply)	AND D = S1 = S2 =	DAND D = S1 = S2 =	Store AND of S1 and S2 in D. S1 0 0 1 1 S2 0 1 0 1 D 0 0 0 1
OR (DOR)	OR (logic sum)	OR D = S1 = S2 =	DOR D = S1 = S2 =	Store OR of S1 and S2 in D. S1 0 0 1 1 S2 0 1 0 1 D 0 1 1 1
XOR (DXOR)	Exclusive OR	XOR D = S1 = S2 =	DXOR D = S1 = S2 =	Store exclusive OR of S1 and S2 in D. S1 0 0 1 1 S2 0 1 0 1 D 0 1 1 0
XNR (DXNR)	Exclusive OR NOT (equal circuit)	XNR D = S1 = S2 =	DXNR D = S1 = S2 =	Store exclusive OR NOT of S1 and S2 in D. S1 0 0 1 1 S2 0 1 0 1 D 1 0 0 1

Rotation Instructions

Mnemonic	Command	Word	Double Word	Description
RLC (DRLC)	Rotate left without carry	RLC D = N =	DRLC D = N =	Rotate contents of designated register D to the left N times. (lower→higher) F1.8 ← 15 ...D... 0 ←
RRC (DRRC)	Rotate right without carry	RRC D = N =	DRRC D = N =	Rotate contents of designated register D to the right N times. (higher→lower) → 15 ...D... 0 → F1.8
ROL (DROL)	Rotate left	ROL D = N =	DROL D = N =	Rotate (shift) to the left N times. (lower→higher) (Input F1.8 value for low bit) ← 15 ...D... 0 ← F1.8
ROR (DROR)	Rotate right	ROR D = N =	DROR D = N =	Rotate (shift) to the right N times. (higher→lower) (Input F1.8 value for high bit) → 15 ...D... 0 → F1.8
SHL (DSHL)	Shift left	SHL D = N =	DSHL D = N =	Shift value of designated register D to the left N times. (Input 0 for low bit) F1.8 ← 15 ...D... 0 ← 0
SHR (DSHR)	Shift right	SHR D = N =	DSHR D = N =	Shift value of designated register D to the right N times. (Input 0 for high bit) 0 → 15 ...D... 0 → F1.8

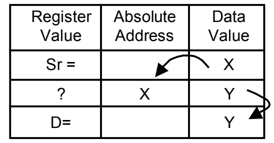
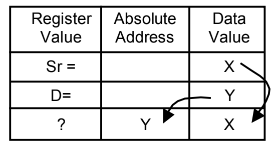
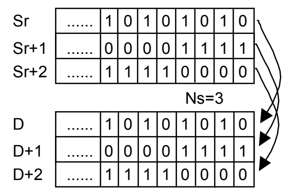
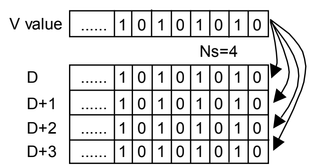
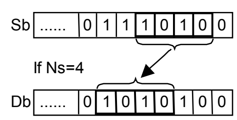
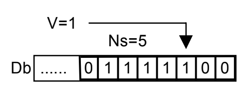
Word Conversion Instructions

Mnemonic	Command	Word	Double Word	Description
BCD (DBCD)	Binary Coded Decimal	BCD D = S =	DBCD D = S =	Convert binary number of S to BCD and store in D. S ...... 0 0 1 1 1 1 1 1 =63 D ...... 0 1 1 0 0 0 1 1 =$63
BIN (DBIN)	Binary	BIN D = S =	DBIN D = S =	Convert BCD of S to binary number and store in D. S ...... 0 1 0 1 1 0 0 1 =$39 D ...... 0 0 1 0 0 1 1 1 =39
XCHG (DXCHG)	Exchange	XCHG D1 = D2 =	DXCHG D1 = D2 =	Exchange D1 and D2. D1 .. 0 1 0 1 D1 .. 0 0 1 1 D2 .. 0 0 1 1 D2 .. 0 1 0 1
SEG	Segment	SEG D = S =	——	Convert the low-order 4 bit value of S to 7-segment display pattern and store in D. =5 S ... 0 0 0 0 0 1 0 1 D ... 0 1 1 0 1 1 0 1 g f e d c b a a b c d e f g
ENCO	Encode	ENCO D = S =	——	Store the location of the highest set bit in S in D. 15..8 7 6 5 4 3 2 1 0 S 0..0 0 1 1 1 0 0 0 0 D invariable 0 0 0 0 0 1 1 1 6+1=7
DECO	Decode	DECO D = S =	——	Convert the low-order 4 bit value of S to a power of 2 (2^S) and store in D. S ..... x x x x 0 1 0 1 =5 D 0..0 0 0 1 0 0 0 0 0 15..8 7 6 5 4 3 2 1 0
DIS	Dissemble	DIS D = Nd = Sr =	——	Separate Sr into Nd+1 units of 4 bits each, and store in the low 4 bits of words starting at D. (N = 0-3) Sr $ 7 4 1 1 1 0 0 1 0 1 Nd+1 / Nd=3 D $0000 0 1 0 1 D+1 $0000 1 1 1 0 D+2 $0000 0 1 0 0 4 D+3 $0000 0 1 1 1 7
UNI	Unify	UNI D = Sr = Nd =	——	Combine the low 4 bits of Nd+1 words starting at Sr, and store in D. (Nd = 0-3) Nd+1 / Nd=3 Sr $ 0 1 0 1 S+1 $ 1 1 1 1 S+2 $ 1 0 1 0 S+3 $ 0 1 0 0 D $ 4 1 1 1 1 0 1 0 1

Bit Conversion Instructions

Mnemonic	Command	Word	Double Word	Description
BSET	Bit Set	BSET D = N =	——	Set Nth bit of D to 1. D ...... 0 1 1 1 1 1 0 0 N=5 → 1
BRST	Bit Reset	BRST D = N =	——	Reset Nth bit of D to 0. D ...... 0 1 0 1 0 1 0 0 N=3 → 0
BNOT	Bit Not	BNOT D = N =	——	Reverse state of Nth bit of D. D ...... 0 1 1 1 0 1 0 0 N=4 D 0 1 1 0 0 1 0 0
BTST	Bit Test	BTST D = N =	——	Set carry bit F1.8 to the state of the Nth bit of D. D ...... 0 1 1 1 0 1 0 0 N=6 → F1.8
SUM	Sum	SUM D = S =	——	Store the number of bits in S that are 1 in D. S $00 0 1 1 1 0 1 0 0 4 ON(=1)s D 0..0 0 0 0 0 0 1 0 0 D=4
SC	Set Carry	SC	——	Set carry bit (F1.8) to 1. 1 → F1.8
RC	Reset Carry	RC	——	Reset carry bit (F1.8) to 0. 0 → F1.8
CC	Complement Carry	CC	——	Reverse carry bit (F1.8). F1.8 → F1.8 1 → 0 0 → 1

Transfer Instructions

Mnemonic	Command	Word	Double Word	Description
LDR (DLDR)	Load D←(Sr)	LDR D = Sr =	DLDR D = Sr =	Store value at absolute address Sr in D. 
STO (DSTO)	Store (D)←Sr	STO Sr = D =	DSTO Sr = D =	Store Sr in register at absolute address D. 
MOV	Move	MOV D = Sr = Ns =	———	Copy Ns words from Sr to D. 
FMOV	Fill Move	FMOV D = Ns = V =	———	Repeatedly copy the value V, Ns times to words starting at D. 
BMOV	Bit Move	BMOV Db = Sb = Ns =	———	Move Ns bits from bit address Sb to bit address Db. 
BFMV	Bit Fill Move	BFMV Db = Ns = V =	———	Repeatedly copy the bit value V, N times to bit address Db. (V = 0,1) (Ns = 0, 1,…, 15). 

Block Processing Instructions

Mnemonic	Command	Word	Double Word	Description
FOR (DFOR)	For Loop	FOR D =	DFOR D =	Begin execution of instructions between FOR and corresponding NEXT. Repeat execution D times.
NEXT	Next	NEXT	———	Decrease D of FOR instruction by 1. If not zero, repeat from FOR Instruction.
JMP	Jump	JMP L =	———	Jump to LBL instruction L. (L = 0 to 63)
LBL	Label	LBL L =	———	Position jumped to by JMP instruction. (L = 0 to 63)
JMPS	Jump Start	JMPS	———	Jump to JMPE instruction.
JMPE	Jump End	JMPE	———	Position jumped to by JMPS instruction.
CALL	Call Subroutine	CALL Sb =	———	Call subroutine Sb. (Sb = 0 to 63)
SBR	Subroutine Start	SBR Sb =	———	Start subroutine. (Sb = 0 to 63)
RET	Subroutine Return	RET	———	End subroutine. Returns execution to instruction after CALL.
INT	Interrupt	INT Ni =	———	Begin block of constant cycle scan instructions. Ni = 1 to 999 (20 msec - 10 sec) Constant cycle time = (Ni+1) $\times$ 0.01 sec
RETI	Return Interrupt	RETI	———	End block of constant cycle scan instructions.

Special Instructions

Mnemonic	Command	Word	Double Word	Description
INPR	Input Refresh	INPR Ch =	—	Refresh external input (get input signal during execution of program). Ch is external input word address.
OUTR	Output Refresh	OUTR Ch =	—	Refresh external output (send output signal during execution of program). Ch is external output word address.
WAT	Watchdog Timer	WAT	—	Clear watchdog elapsed value.
END	END	END	—	End program. This instruction is automatically added by GPC.
READ	Read data, intelligent I/O unit, shared memory	READ To = RR1 Sz = NR3 Fr = NN5:NR6	—	Read NR3 words from slot NN5, module memory address NR6, and store in words starting at RR1.
WRITE	Write data, intelligent I/O unit, shared memory	WRITE To = NN1:NR2 Sz = NR3 Fr = NR5	—	Read NR3 words from NR5, and write them to slot NN1, module memory address NR2.
RMRD	Read data, remote I/O, intelligent I/O unit, shared memory	RMRD To = NR1:RR2 Nt = NN3:NN4 Fr = NN5:NR6	—	Read NR1 words from remote I/O loop NN3, station NN4, slot NN5, module memory address NR6, and store in words starting at RR2.
RMWR	Write data, remote I/O, intelligent I/O unit, shared memory	RMWR Nt = NN1:NN2 To = NN3:NR4 Fr = NR5:NR6	—	Read NR5 words from NR6, and write them to remote I/O loop NN1, station NN2, slot NN3, module memory address NR4.
RECV	Receive data (Link Network)	RECV To = NR1:RR2 Nt = NN3:NN4 Fr = NN5:NR6	—	Read NR1 words from link network NN3, station NN4, register type NN5, address NR6, and write them to words starting at RR2.
SEND	Send data (Link Network)	SEND Nt = NN1:NN2 To = NN3:NR4 Fr = NR5:NR6	—	Read NR5 words from NR6, and write them to link network NN1, station NN2, register type NN3, address NR4.
RECVB	Receive data (Link Network)	RECVB To = BR1 Nt = NN3:NN4 Fr = NN5:NR6	—	Read the bit value from link network NN3, station NN4, register type NN5, bit address NR6, and store to bit address BR1.
SENDB	Send data (Link Network)	SENDB Nt = NN1:NN2 To = NN3:NR4 Fr = NB5	—	Read the bit value of NB5, and write it to link network NN1, station NN2, register type NN3, bit address NR4.

How to Read the Description of Instructions

Each instruction is explained in three parts: the instruction itself, its ladder diagram, and a description. This section explains how to read the instructions.

Sample Instruction

Mnemonic	Substitution Formula (Assignment expression)	Range
LET DLET	Direct substitution of number (direct output of number)	☐ Bit
		■ Word
		■ Double words

Explanation of Codes

☐ = unavailable option

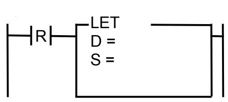
■ = available option

$xx indicates a hexadecimal number.

Explanation of Table

- Mnemonic—A word instruction, D designates double word instruction.
- Assignment expression—Description of the instruction.
- Range—Size of data that can be used by this instruction.

Sample Ladder



D: Destination

S: Source

Example: S = M0, and M0 is 123
D = R3, and R3 is 456

Before execution: M0 = 123, R3 = 456

After execution: M0 = 123, R3 = 123

Explanation of Ladder

The ladder diagram shows the structure of the instruction as it is displayed. Additional text typically gives an example and explains the processing structure.

Sample Description

Range: LET: 0 to 65,535
DLET: 0 to 4,294,976,295

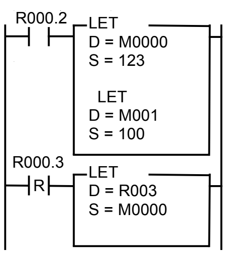
1. Either a register (R, M, K, L, or W) address or a constant number can be assigned for S.
2. When S is a register address, copy the data of the register to D.
3. When S is a constant number, copy the value to D.
4. This operation occurs on every scan for which the input condition to the instruction is true.

Explanation of Description

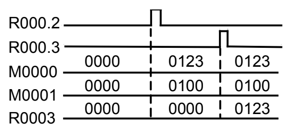
The description provides details of the instruction.

Sample Example

Program Expression



Time Chart



Explanation of Example

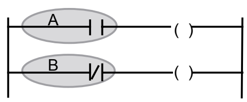
The example shows an application of an instruction as programmed in GPC. The time chart demonstrates how the instruction operates with respect to time and the changing input conditions for the example. The results of the operation may also be shown as part of the example.

Basic Instruction Details

Instruction

Mnemonic	Start of the Circuit	Range
STR	Start rung with NO contact	■ Bit
STN	Start rung with NC contact	☐ Word
		☐ Double words

Ladder



Used for the start of a circuit.

STR: Start NO (normally open) contact

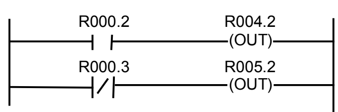
STN: Start NC (normally closed) contact (STR NOT)

A: Circuit started with NO contact→STR

B: Circuit started with NC contact→STN

Description

1. Every rung in the ladder program begins with either a STR or STN.
2. Every rung will contain one or more contacts.
3. Every rung will end in one or more output coils or application instructions.
4. When programming a ladder with NO and NC contacts, GPC will automatically use the proper contact instruction (STR, STN, AND, ANN, OR, ORN).

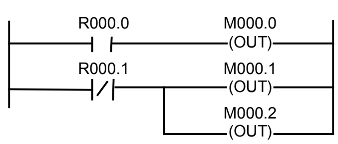


Start of circuit: R000.2, R000.3

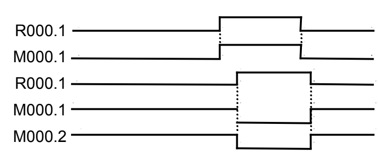
End of circuit: R004.2, R005.2

Example

Program Expression



Time Chart



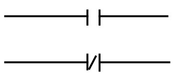
M000.0 has the same logic as R000.0

M000.1, M000.2 have the opposite logic as R000.1

Instruction

Mnemonic	Series Connection	Range
AND ANN (ADN)	Series connection	■ Bit ☐ Word ☐ Double words

Ladder

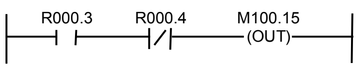


AND: NO (normally open) contact series connection.

ANN: NC (normally closed) contact series connection.

Description

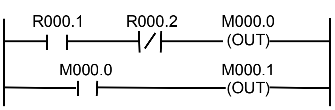
1. AND and ADN (AND NOT) indicate a series connection of each contact.
2. The number of ANDs and ADNs used within one branch (rung) is unlimited.



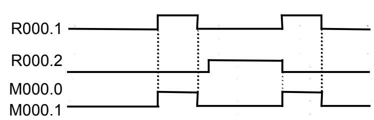
3. M100.15 is On only when contact R000.3 is On and contact R000.4 is Off. M100.15 is Off for all other cases.

Example

Program Expression



Time Chart

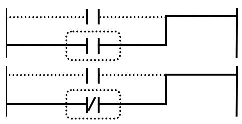


Contact M000.0 is On only when R000.1 is On and R000.2 is Off. M000.0 is Off for all other cases.

Instruction

Mnemonic	Parallel Circuit	Range
OR ORN	Parallel connection	■ Bit
		☐ Word
		☐ Double words

Ladder

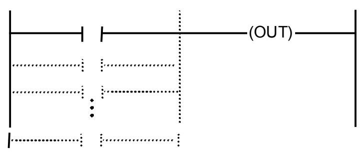


← OR: NO (normally open) contact parallel connection.

← ORN: NC (normally closed) contact parallel connection.

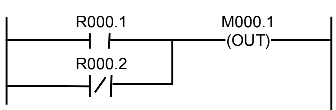
Description

1. OR and ORN (OR NOT) indicate parallel connection of each contact.
2. The number of ORs and ORNs used within a branch is unlimited.

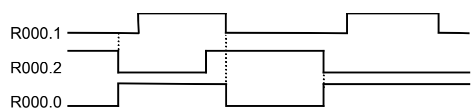


Example

Program Expression



Time Chart



Contact M000.1 is On if contact R000.1 is On or contact R000.2 is Off.

Instruction

Mnemonic	Output	Range
OUT	Relay output	■ Bit
SET	On output	□ Word
RST	Off output	□ Double words

Ladder

(OUT) OUT: Relay coil turns On or Off based on the state of the input conditions.

(SET) SET: Relay coil turns On when the input conditions are true.

(RST) RST: Relay coil turns Off when the input conditions are true.

Description

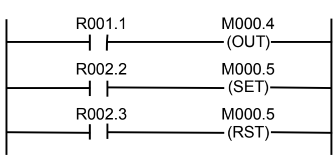
For an OUT instruction, you cannot use the same address twice.

OUT, SET, and RST instructions must be connected to the right bus and not in the middle of the circuit.

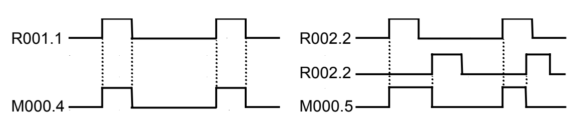
1. OUT—Use for external I/O (R), internal (M), and retentive (K) contacts. On or Off according to status of the input condition.
2. SET—Use for external I/O (R), internal (M), and retentive (K) contacts. The same address can be used more than once. When the input conditions are true, the coil is turned On and stays on unless turned off by a RST. The output is turned Off in the Stop mode.
3. RST—Use for external I/O (R), internal (M), and retentive (K) contacts. The same address can be used more than once. When the input conditions are true, the coil is turned Off and stays off unless turned on by a SET. The output is Off in the Stop mode.
4. When using retentive coils (K) in OUT, SET, or RST, the state is maintained. It will remain On or Off even after placed in the Stop mode and power is turned off.

Example

Program Expression



Time Chart



M000.4 follows contact logic for R001.1 input.

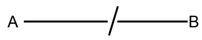
When R002.2 contact is On, M000.5 output is On.

When R002.3 contact is On, M000.5 output is Off.

Instruction

Mnemonic	Reverse	Range
NOT	Reverse the previous status of the logic.	■ Bit
		□ Word
		□ Double words

Ladder



Reverse the logic result of the input conditions before A at B.

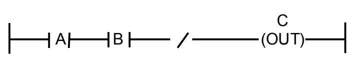
Reverse the previous On/Off state and transfer to the next input.

The results of the NOT execution:

Before	**After**
A (On)→	B (Off)
A (Off)→	B (On)

Description

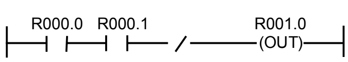
1. The instruction cannot be connected directly to the bus—it must come after a contact or set of contacts.
2. The instruction directly inverts the result of the input conditions before it. The instruction can be used for verification of the circuit or in the test stage.



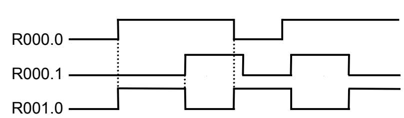
A	B	C
On	On	Off
Off	On	On
On	Off	On
Off	Off	On

Example

Program Expression



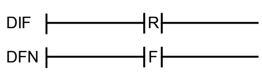
Time Chart



Instruction

Mnemonic	Edge Contact	Range
STR DIF STR DFN AND DIF AND DFN OR DIF OR DFN	Contact which is On for one scan at the up or down point of contact	■ Bit ☐ Word ☐ Double words

Ladder



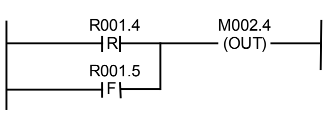
DIF: On at the rising edge ( ) (Off→On) for one scan.
DFN: On at the falling edge ( ) (On→Off) for one scan.

Description

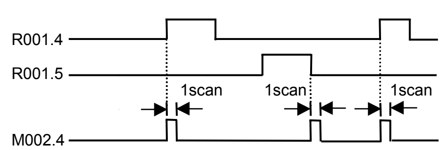
1. The DIF and DFN instructions may be used more than once in the ladder program for any of the bit addresses (R, L, M, K, F, and TC).
2. The DIF instruction is a contact which is On for the first scan after the signal has changed from Off→On. The contact is Off for all other scans, when the signal has not changed from Off or On.
3. The DFN instruction is a contact which is On for the first scan after the signal has changed from On→Off. The contact is Off for all other scans, when the signal has not changed from Off or On.
4. Both DIF and DFN can be used on the same bit address in a single scan.

Example

Program Expression



Time Chart

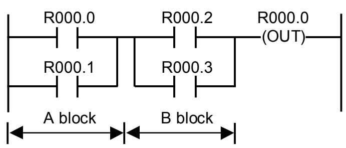


Contact M002.4 is On if contact R001.4 changes from Off→On or contact R001.5 changes from On→Off.

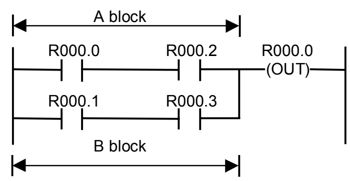
Instruction

Mnemonic	Block Circuit	Range
ANB ORB	Connect circuit by block	■ Bit ☐ Word ☐ Double words

Ladder



ANB: block in series



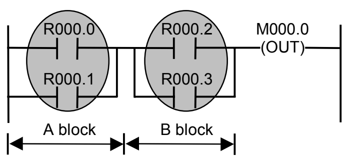
ORB: block in parallel

Description

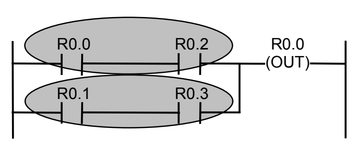
1. Block in series:
   - Series connection of more than two contacts.
   - Starts with STR or STN.
   - Ends with ANB.
2. Block in parallel:
   - Parallel connection of more than two contacts.
   - Starts with STR or STN.
   - Ends with ORB.
3. When programming in ladder, GPC will automatically add the proper ANB and ORB instructions as required by the contact connections.

Example

Program Expression (ANB)



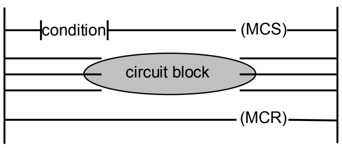
Program Expression (ORB)



Instruction

Mnemonic	Master Control Set (Reset)	Range
MCS MCR	Execute block circuit using the specified conditions.	☐ Bit
		☐ Word
		☐ Double words

Ladder

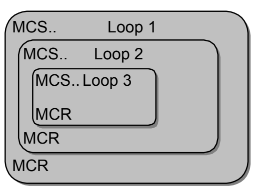


MCS: Enable processing of the following block of instructions.

MCR: End block of instructions enabled by MCS.

Description

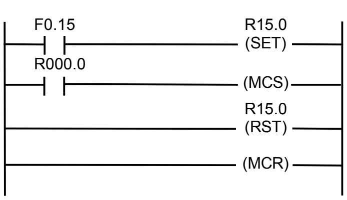
1. MCS (Master Control Set)—Marks the start of a conditional block of instructions. When the input conditions to the MCS are false, the block of instructions that follow are executed as false. Must be used with MCR.
2. MCR (Master Control Reset)—Marks the end of a conditional block of instructions. Must be used with MCS.
3. Up to seven MCS/MCR blocks can be nested.



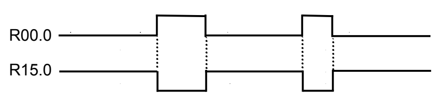
4. If you use eight or more MCS/MCR nested blocks, a syntax error will occur.

Example

Program Expression



Time Chart



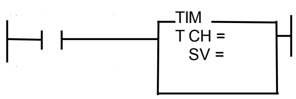
The circuit block R15.0 bit is reset (0) by R000.0.

Timer/Counter/SR Instruction Details

Instruction

Mnemonic	Timer	Range
TIM	On delay timer	■ Bit
SST	Single shot timer	□ Word
		□ Double words

Ladder



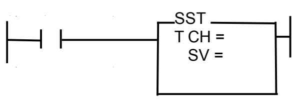
In t seconds (t = SV × time base) after the input is On, the output is On.

If the input is Off, the output is Off.

Valid channel numbers: Ch 0 through Ch 255 (256 channels)

Done contact: TC + channel number

SV set range: 0 to 65,535



For t seconds (t = SV × time base) after input is On, the output is On. At the end of t seconds, the output is Off.

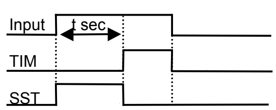
If the input is Off, the output is Off.

Valid channel numbers: Ch 0 through Ch 255 (256 channels)

Done contact: TC + channel number

Description

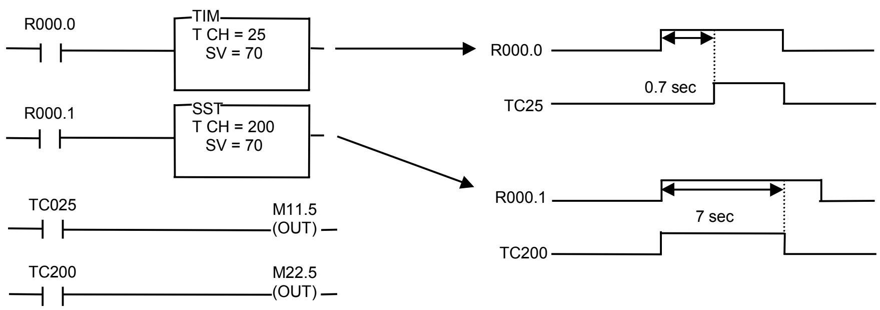
1. Ch 0 to Ch 63: Time base = 0.01 sec (10 msec)
   Ch 64 to Ch 255: Time base = 0.1 sec (100 msec)



2. The output done contact of the timer is TC + channel number.
3. The channel number can only be used once. It cannot be reused by other timer or counter instructions (TOF, UC, DC, RCT, UDC).
4. To change the Set Value or Present Value of the timer while the program is running, modify registers W2048 to W2559. In GPC, you may also reference these registers using the PV or SV designation.
5. The Present Value (PV) is reset to zero when the input is Off, in Stop mode, or when power is off.

Example

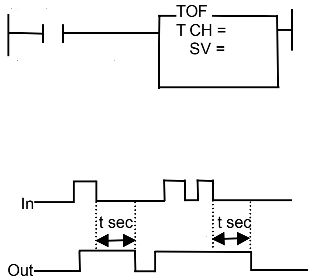
Program Expression **Time Chart**



Instruction

Mnemonic	Timer	Range
TOF	Off delay timer	■ Bit
		□ Word
		□ Double words

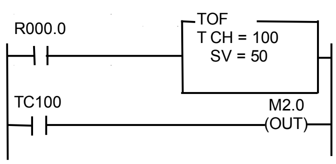
Ladder



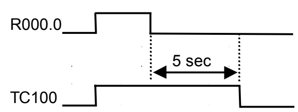
- While the input is On, the timer output is On. For t seconds (t = SV × time base) after the input turns Off, the output stays On.
- Unlike the TIM and SST instruction, in which the PV counts up from 0, the timer elapsed value (PV) decreases from SV when the input is turned Off until it reaches 0.
- If the input is turned On again before the output turns Off, the output is maintained On.
- Available channels are Ch 0 through Ch 255 (256 channels) and Set Value (SV) is from 0 to 65,535.

Example

Program Expression

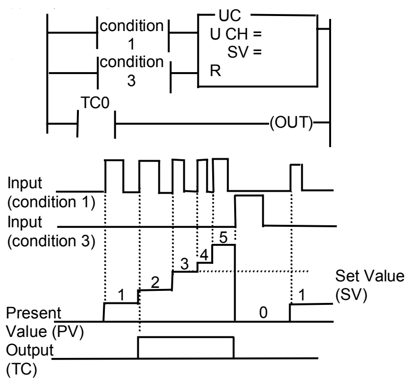


Time Chart



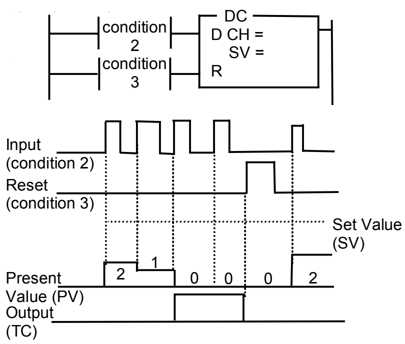
Instruction

Mnemonic	Timer (I)	Range
UC	Up counter	■ Bit
DC	Down counter	☐ Word
		☐ Double words



Example of UC with SV = 3.

- Whenever count input condition (U input) turns On, PV increases by 1. When PV and SV are the same, the output TC done contact is On. When the reset input condition (R input) is On, the output contact is Off.
- While the count input pulses On, the PV will continue to count up to a maximum of 65,535. When the reset input is On, the PV is reset to a value of 0.



Example of DC with SV = 3.

- Whenever count input condition (D input) turns On, PV decreases by 1. When PV is 0, the output TC done contact is On.
- When the reset input condition (R input) is turned On, the TC done contact is turned Off, and the PV is set to 0.

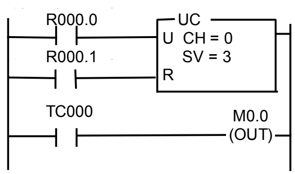
Description

1. The timer/counter channel can only be used once. It cannot be reused by other timer or counter instructions (TIM, SST, TOF, RCT, UDC). A maximum of 256 channels (Ch 0 to Ch 255) can be used.
2. The output done contact is displayed as TC + channel no. in the counter.
3. The elapsed value (PV) of the counter is maintained in case of a power failure and for retentive purposes.
4. When SV is 0, the output contact (TC) turns On if one pulse of input occurs.
5. SV can be specified from 0 to 65,535.

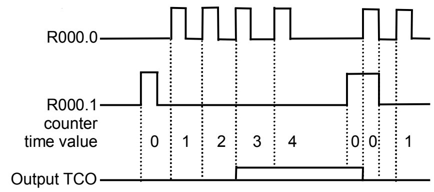
CAUTION: Each input condition to the counter should be on its own line of the rung. They should not share a common contact or be connected in any way.

Example

Program Expression



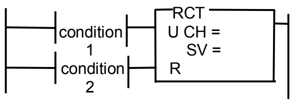
Time Chart

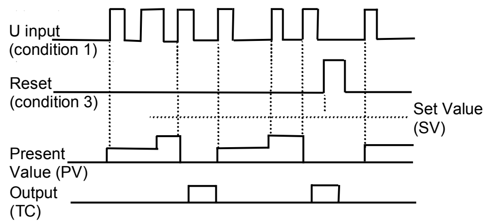


Instruction

Mnemonic	Rotation Counter	Range
RCT	Ring counter	■ Bit
		□ Word
		□ Double words

Ladder



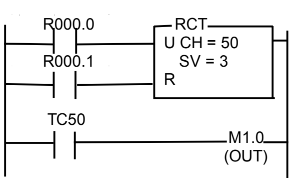


Description

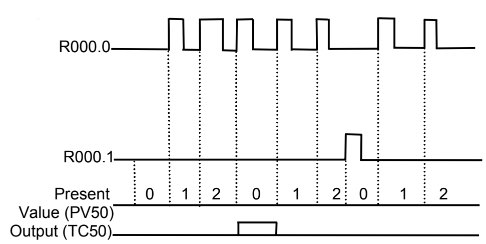
1. When the input count condition (U input) turns on, the Present Value (PV) is incremented by 1. When the PV reaches the Set Value (SV), it is reset to 0, the output done contact is turned On, and stays On until the next count input pulse is received.
2. When the reset input condition (R input) is On, the output done contact is turned Off. All count input pulses are ignored and the Present Value stays reset to 0.
3. When the SV of the counter is 0, the output done contact is On unless the reset input is On.
4. The timer/counter channel can only be used once. It cannot be reused by other timer or counter instructions (TIM, SST, TOF, UC, DC, UDC). The number of available channels is 256 (Ch 0 through Ch 255).
5. The counter can be set to a maximum value of 65,535.

Example

Program Expression



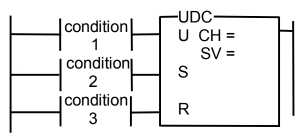
Time Chart



Instruction

Mnemonic	Up/Down Counter	Range
UDC	Up/Down counter	■ Bit
		□ Word
		□ Double words

Ladder



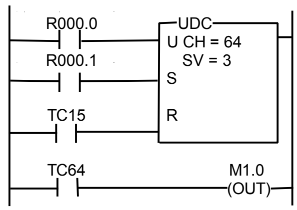
Description

1. When the up count input (U input) turns On, the Present Value (PV) increases by 1. When the down count input (D input) turns On, PV decreases by 1. When PV is greater than or equal to the Set Value (SV) or is reduced to 0, the output done contact turns On.
2. In the following cases, the output done contact changes from On to Off:
   - When the reset input is turned On.
   - When the PV is decreased below the SV by the down count pulse input.
   - When the PV increases from 0 to 1 by the up count pulse input.
3. If the reset input (R input) is On, the output is Off. In this state, the up/down counter input pulses are ignored and the Present Value stays reset to 0.
4. When the up count input pulse and the down count input pulse occur at the same time, the PV does not change.
5. When the PV is 0, if the down count pulse is input, the Present Value does not change, and the output is On. When the Present Value is 65,535, even if the up-counter pulse is input, the Present Value 65,535 is maintained.
6. When the counter Set Value is 0, if the reset input is On then the output is Off. If up or down is input while the reset input is Off, the output changes to On.
7. The timer/counter channel can only be used once. It cannot be reused by other timer or counter instructions (TIM, SST, TOF, UC, DC, RCT). The number of channels available is 256 (Ch 0 through Ch 255).
8. The SV can be set to a maximum value of 65,535.

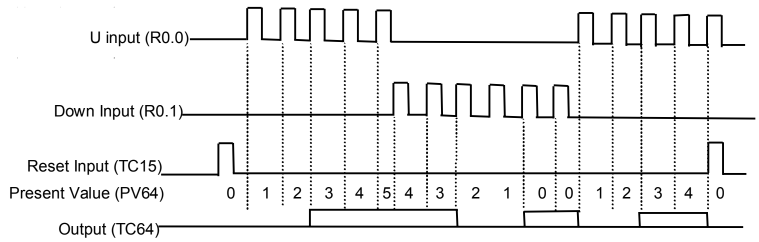
CAUTION: This instruction operates differently than the UDC instruction of the Cutler-Hammer D50/D300 PLC. Please read and understand the above information before using.

Example

Program Expression



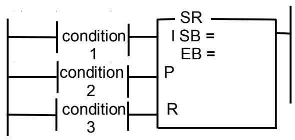
Time Chart

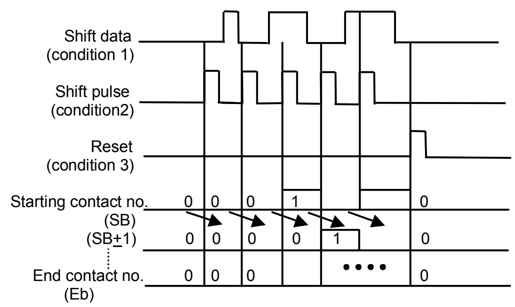


Instruction

Mnemonic	Shift Register	Range
SR	Shift Register	■ Bit
		☐ Word
		☐ Double words

Ladder





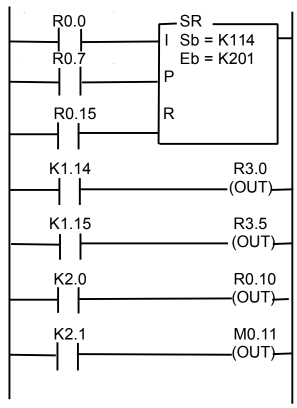
1. Condition 1 (Input Data): Condition (1 or 0) of the input data to the starting contact (Sb).
2. Condition 2 (Shift Pulse): Shift clock.
3. Condition 3 (Reset): Reset all the bits from the starting contact (Sb) to the end contact (Eb) to 0.

Description

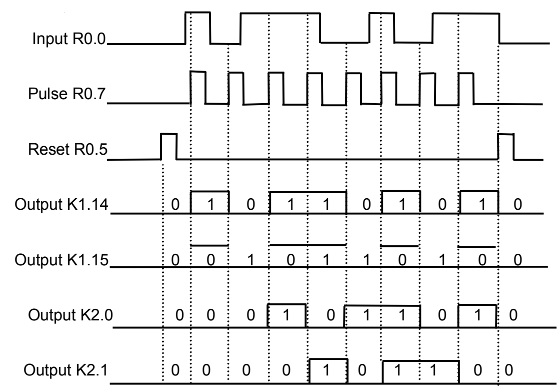
1. The SR instruction can be used in the M and K address areas. When the K address area is used, data is maintained in the event of a power failure.
2. The number of available SR commands is 256. The SR commands can be used independently of the timer/counter.
3. When the Shift Pulse input (P input) is turned on, the starting contact (Sb) is set to the state of the Input Data input (I input).
4. As each Shift Pulse occurs, data is shifted by 1 bit from the starting contact (Sb) to the end contact (Eb). If Sb is at a lower starting bit address than Eb, the data is shifted up from Sb to Eb. If Sb is at a higher starting bit address than Eb the data is shifted down from Sb to Eb.
5. The total number of bits from Sb to Eb is from a minimum of 2 bits to a maximum of 2,047 bits.
6. Sb and Eb may not be the same bit address (bit size of 1).
7. If the reset input is On, all of the bits from Sb to Eb are set to 0.

Examples

Program Expression



Time Chart

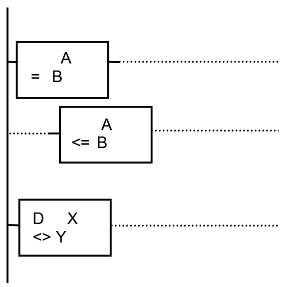


Comparison Instruction Details

Instruction

Mnemonic	Comparing the Value	Range
=	A = B (A is equal to B)	☐ Bit
<>	A <> B (A is not equal to B)	
>	A > B (A is greater than B)	■ Word
>=	A >= B (A is greater than or equal to B)	
<=	A <= B (A is less than or equal to B)	■ Double words
<	A < B (A is less than B)	

Ladder



A or B: Constant value 0 to 65,535 or a word address (R, L, M, K, W, PV, SV, SR).

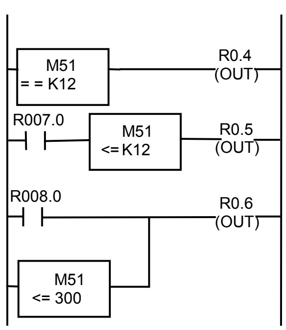
D is displayed when double words are input. When using GPC5 to program, change the mode to double (Ctrl+T) and then enter the comparison command.

Description

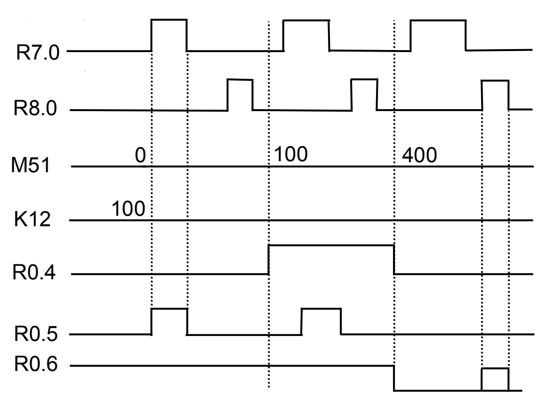
1. The comparison functions as a contact, whose On/Off state is determined by the result of the comparison of A and B. If the comparison is true, the state is On.
2. Each comparison instruction can be used with the STR, AND, and OR instructions (GPC will automatically use the correct instruction).
3. Double word comparison instructions can process up to 32 bits of data (0 to 4,294,295).

Example

Program Expression



Time Chart

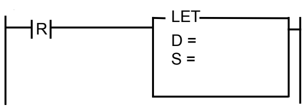


Substitution, Increment/Decrement Instruction Details

Instruction

Mnemonic	Substitution Formula	Range
LET DLET	Direct substitution of number (direct output of number)	☐ Bit
		■ Word
		■ Double words

Ladder



D: Destination

S: Source

Example: S = M0, and M0 is 123

D = R3, and R3 is 456

Before execution: M0 = 123, R3 = 456

After execution: M0 = 123, R3 = 123

Description

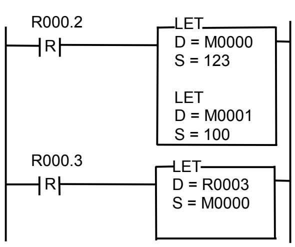
Range: LET: 0 to 65,535

DLET: 0 to 4,294,967,295

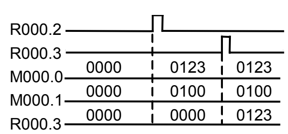
1. Either a register (R, M, K, L, or W) address or a constant number can be assigned for S.
2. When S is a register address, copy the data of the register to D.
3. When S is a constant number, copy the value to D.
4. This operation occurs on every scan for which the input condition to the instruction is true.

Example

Program Expression



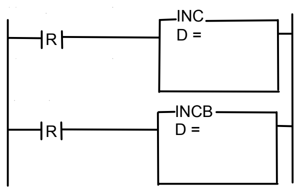
Time Chart



Instruction

Mnemonic	Increment	Range
INC DINC INCB DINCB	Increment (INC, DINC) BCD increment (INCB, DINCB)	□ Bit ■ Word ■ Double words

Ladder



D = D + 1: Decimal number increment

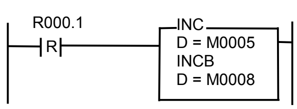
D = D + 1: BCD increment

Description

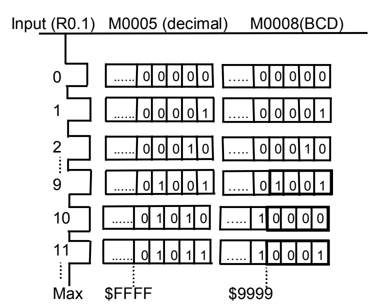
1. INC and DINC increase D in decimal by 1 when the input is On.
2. INCB and DINCB increase D in BCD (Binary Coded Decimal) by 1.
3. INC and INCB are word instructions for processing 16 bit data.
4. DINC and DINCB are double word instructions for processing 32 bit data.

Example

Program Expression



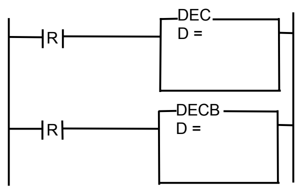
Time Chart



Instruction

Mnemonic	Decrement	Range
DEC DDEC DECB DDECB	Decrement (DEC, DDEC) BCD decrement (DECB, DDECB)	□ Bit ■ Word ■ Double words

Ladder



D = D - 1: Decimal decrement

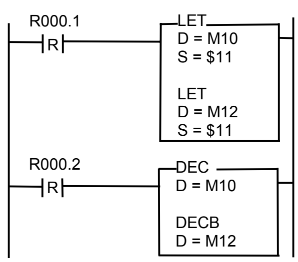
D = D - 1: BCD decrement

Description

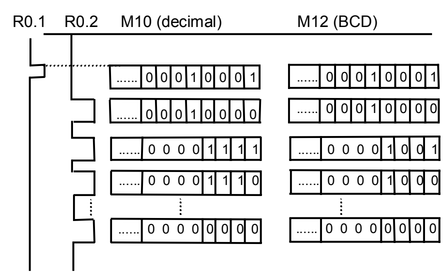
1. DEC and DDEC decrease D by 1 down to 0 when the input is On.
2. DECB and DDECB decrease D by 1 in BCD to 0 when the input is On.
3. Word instructions (DEC, DECB) process 16 bit data, double word instructions(DDEC, DDECB) process 32 bit data.

Example

Program Expression



Time Chart

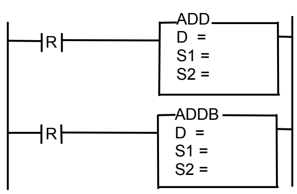


Arithmetic Instruction Details

Instruction

Mnemonic	Addition	Range
ADD DADD ADDB DADDB	Decimal addition (ADD, DADD) BCD addition (ADDB, DADDB)	☐ Bit ■ Word ■ Double words

Ladder



D = S1 + S2

Decimal: S1 = 21, and S2 = 22
Hexadecimal: S1 = $15 and S2 = $16

ADD Example:
Decimal: 21 + 22 = 43

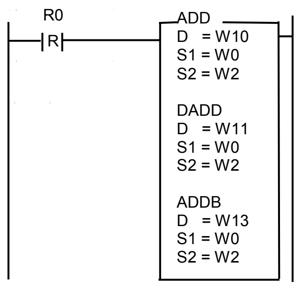
ADDB Example:
BCD: $15 + $16 = $31

Description

1. Add the data in the S1 and S2 addresses, then store the result in the D register.
2. When using ADD and ADDB, the calculation ranges are as follows:
   - S1: 0 to 65,535 ($0000 to $FFFF)
   - S2: 0 to 65,535 ($0000 to $FFFF)
   - D: 0 to 65,535 ($0000 to $FFFF)
3. When using DADD and DADDB, the calculation ranges are as follows:
   - S1: 0 to 4,294,976,295 (0 to $FFFFFFFF)
   - S2: 0 to 4,294,976,295 (0 to $FFFFFFFF)
   - D: 0 to 4,294,976,295 (0 to $FFFFFFFF)
4. If the result exceeds the range of calculation, a carry occurs. The carry flag (F1.8) is changed to On.
5. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



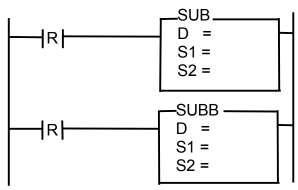
Operation Results

Initial conditions:	W0 = 00017 = $0011
	W1 = 00001 = $0001
	W2 = 00025 = $0019
	W3 = 00002 = $0002
Operation results:	W10 = 00042 = $002A
	W11 = 0000196650 = $0003002A
	W13 = 00048 = $0030

Instruction

Mnemonic	Subtraction	Range
SUB	Decimal subtraction (SUB, DSUB)	☐ Bit
DSUB	BCD subtraction (SUBB, DSUBB)	■ Word
SUBB		■ Double words
DSUBB		

Ladder



D = S1 - S2

Decimal: S1 = 34 and S2 = 19
Hexadecimal: S1 = $22 and S2 = $13

SUB Example:
Decimal: 34 - 19 = 15

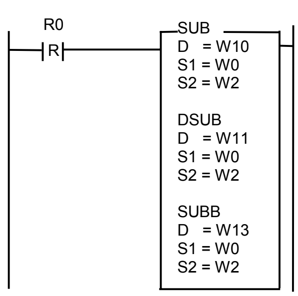
SUBB Example:
BCD: $22 - $13 = $09

Description

1. Subtract the data in S2 from S1, then store the result in the D register.
2. When using SUB and SUBB, the calculation ranges are as follows:
   - S1: 0 to 65,535 ($0000 to $FFFF)
   - S2: 0 to 65,535 ($0000 to $FFFF)
   - D: 0 to 65,535 ($0000 to $FFFF)
3. When using DSUB and DSUBB, the calculation ranges are as follows:
   - S1: 0 to 4,294,976,295 (0 to $FFFFFFFF)
   - S2: 0 to 4,294,976,295 (0 to $FFFFFFFF)
   - D: 0 to 4,294,976,295 (0 to $FFFFFFFF)
4. If the result exceeds the range of calculation, a carry occurs. The carry flag (F1.8) is changed to On.
5. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

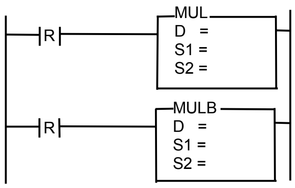
Initial conditions: W0 = 00016 = $0010
W1 = 00002 = $0002
W2 = 00007 = $0007
W3 = 00001 = $0001

Operation results: W10 = 00009 = $0009
W11 = 0000065545 = $00010009
W13 = 00003 = $0003

Instruction

Mnemonic	Multiplication	Range
MUL DMUL MULB DMULB	Decimal multiplication (MUL, DMUL) BCD multiplication (MULB, DMULB)	☐ Bit ■ Word ■ Double words

Ladder



D = S1 × S2
Decimal: S1 = 3 and S2 = 7
Hexadecimal: S1 = $03 and S2 = $07

MUL Example:
Decimal: 3 × 7 = 21

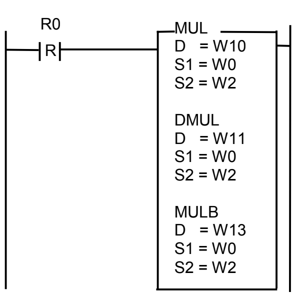
MULB Example:
BCD: $03 × $07 = $21

Description

1. Multiply the data in the S1 and S2 addresses, then store the result in the D register.
2. When using MUL and MULB, the calculation ranges are as follows:
   - S1: 0 to 65,535 ($0000 to $FFFF)
   - S2: 0 to 65,535 ($0000 to $FFFF)
   - D: 0 to 65,535 ($0000 to $FFFF)
3. When using DMUL and DMULB, the calculation ranges are as follows:
   - S1: 0 to 4,294,976,295 (0 to $FFFFFFFF)
   - S2: 0 to 4,294,976,295 (0 to $FFFFFFFF)
   - D: 0 to 4,294,976,295 (0 to $FFFFFFFF)
4. If the result exceeds the range of calculation, a carry occurs. The carry flag (F1.8) is changed to On. The high word of the result that exceeds the range of D is automatically stored in SR20.
5. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

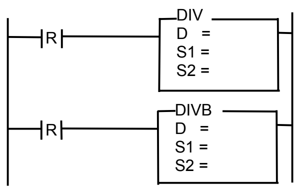
Initial conditions: W0 = 00002 = $0002
W1 = 00001 = $0001
W2 = 00006 = $0006
W3 = 00001 = $0001

Operation results: W10 = 00012 = $000C
W11 = 0000524300 = $0008000C
W13 = 00018 = $0012

Instruction

Mnemonic	Division	Range
DIV DDIV DIVB DDIVB	Decimal division (DIV, DDIV) BCD division (DIVB, DDIVB)	□ Bit ■ Word ■ Double words

Ladder



D = S1 ÷ S2

Decimal: S1 = 18 and S2 = 3
Hexadecimal: S1 = $12 and S2 = $03

DIV Example:
Decimal: 18 ÷ 3 = 6

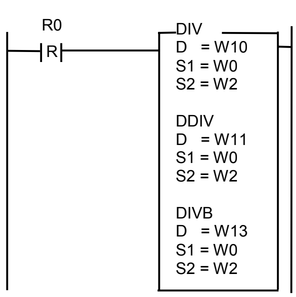
DIVB Example:
BCD: $12 ÷ $03 = $04

Description

1. Divide the data in S1 by S2, then store the result in the D register.
2. When using DIV and DIVB, the calculation ranges are as follows:
   - S1: 0 to 65,535 ($0000 to $FFFF)
   - S2: 0 to 65,535 ($0000 to $FFFF)
   - D: 0 to 65,535 ($0000 to $FFFF)
3. When using DDIV and DDIVB, the calculation ranges are as follows:
   - S1: 0 to 4,294,976,295 (0 to $FFFFFFFF)
   - S2: 0 to 4,294,976,295 (0 to $FFFFFFFF)
   - D: 0 to 4,294,976,295 (0 to $FFFFFFFF)
4. The quotient is stored in the D register, and the remainder in special register SR22.
5. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

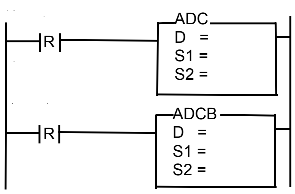
Initial conditions: W0 = 00024 = $0018
W1 = 00002 = $0002
W2 = 00004 = $0004
W3 = 00001 = $0001

Operation results: W10 = 00006 = $0006
W11 = 00002 = $0002
W13 = 00004 = $0004

Instruction

Command	Addition with Carry	Range
ADC DADC ADCB DADCB	Decimal addition with carry (ADC, DADC) BCD addition with carry (ADCB, DADCB)	□ Bit ■ Word ■ Double words

Ladder



D = S1 + S2 + carry

Decimal:	S1 = 21, and S2 = 22
Hexadecimal:	S1 = $15 and S2 = $16
Carry Flag:	F1.8 = On

ADC Example:

Decimal:	21 + 22 + 1 = 44

ADCB Example:

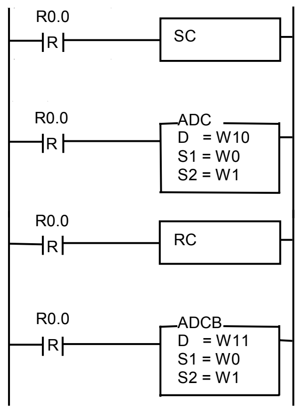
BCD:	$15 + $16 + $1 = $32

Description

1. Add the data in the S1 and S2 addresses. If the carry flag F1.8 is On, add 1, otherwise add 0. Then store the result in the D register.
2. When using ADC and ADCB, the calculation ranges are as follows:
   - S1: 0 to 65,535 ($0000 to $FFFF)
   - S2: 0 to 65,535 ($0000 to $FFFF)
   - D: 0 to 65,535 ($0000 to $FFFF)
3. When using DADD and DADDB, the calculation ranges are as follows:
   - S1: 0 to 4,294,976,295 (0 to $FFFFFFFF)
   - S2: 0 to 4,294,976,295 (0 to $FFFFFFFF)
   - D: 0 to 4,294,976,295 (0 to $FFFFFFFF)
4. If the result exceeds the range of calculation, a carry occurs. The carry flag (F1.8) is changed to On.
5. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



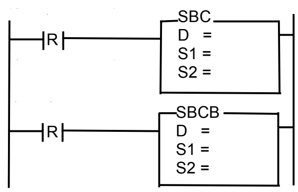
Operation Results

Initial conditions: W0 = 00017 = $0011
W1 = 00025 = $0019
Operation results: W10 = 00017 + 00025 +1 = 00043
W11 = $0011 + $0019 + 0 = $0030

Instruction

Command	Subtraction with Carry	Range
SBC DSBC SBCB DSBCB	Decimal subtraction with carry (SBC, DSBC) BCD subtraction with carry (SBCB, DSBCB)	☐ Bit ■ Word ■ Double word

Ladder



D = S1 - S2 - carry

Decimal:	S1 = 34 and S2 = 19
Hexadecimal:	S1 = $22 and S2 = $13
Carry Flag:	F1.8 = On

SBC Example:

Decimal:	34 - 19 - 1 = 14

SBCB Example:

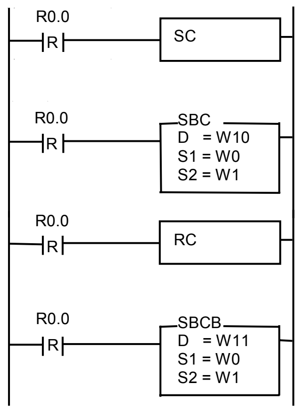
BCD:	$22 - $13 - $01 = $08

Description

1. Subtract the data in S2 from S1. If the carry flag F1.8 is On, subtract 1. Then store the result in the D register.
2. When using SBC and SBCB, the calculation ranges are as follows:
   - S1: 0 to 65,535 ($0000 to $FFFF)
   - S2: 0 to 65,535 ($0000 to $FFFF)
   - D: 0 to 65,535 ($0000 to $FFFF)
3. When using DSBC and DSBCB, the calculation ranges are as follows:
   - S1: 0 to 4,294,976,295 (0 to $FFFFFFFF)
   - S2: 0 to 4,294,976,295 (0 to $FFFFFFFF)
   - D: 0 to 4,294,976,295 (0 to $FFFFFFFF)
4. If the result exceeds the range of calculation, a carry occurs. The carry flag (F1.8) is changed to On.
5. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

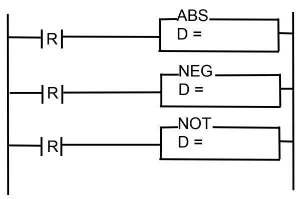
Initial conditions: W0 = 00016 = $0010
W1 = 00002 = $0002

Operation results: W10 = 00016 - 00002 - 1 = 00013
W11 = $0010 - $0002 - 0 = $0008

Instruction

Mnemonic	Absolute Value, NEG and NOT	Range
ABS	ABS: Absolute value	☐ Bit
DABS	NEG: 2's complement	■ Word
NEG	NOT: 1's complement	■ Double words
DNEG		
NOT		
DNOT		

Ladder



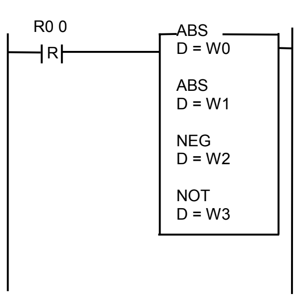
ABS: Take the absolute value of D, and store it in D.
NEG: Take the 2's complement and store it in D.
NOT: Take the 1's complement and store it in D.

Description

1. For the ABS (absolute value) instruction, if the highest bit (MSB) is 1, take the 2's complement. If the highest bit is 0, leave it as it is.
   - For example, the absolute value of $9A52 (=1001 1010 0101 0010) is $65AE (=0110 0101 1010 1110). The absolute value of $7A52 (=0111 1010 0101 0010) is $7A52.
2. The NEG (2's complement) instruction is expressed as the 1's complement + 1.
   - For example, NEG of $7A52 (=0111 1010 0101 0010) is $85AE (=1000 0101 1010 1110)
3. The NOT (1's complement) instruction is performed by reversing each bit.
   - For example, NOT of $7A52 (=0111 1010 0101 0010) is $85AD (=1000 0101 1010 1101)
4. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

Initial conditions: W0 = $9A52
W1 = $7A52
W2 = $7A52
W3 = $7A52

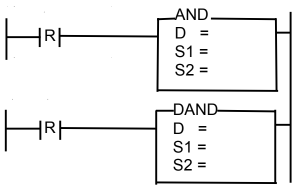
Operation results: W0 = $65AE
W1 = $7A52
W2 = $85AE
W3 = $85AD

Logic Instruction Details

Instruction

Mnemonic	Bit AND Operation	Range
AND DAND	Bit AND operation	☐ Bit ■ Word ■ Double words

Ladder



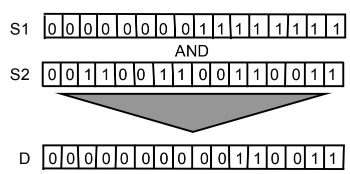
Process each bit of S1 and S2 in bit AND operation and store the result in D.

S1	S2	D
0	0	0
0	1	0
1	0	0
1	1	1

Description

1. Process the values of the S1 and S2 bits (word/double word) in bit AND operation and store the result in D.

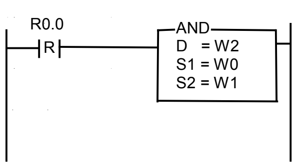
   For example: S1 = $00FF (hex)
   S2 = $3333 (hex)
   D = $0033 (hex)



2. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

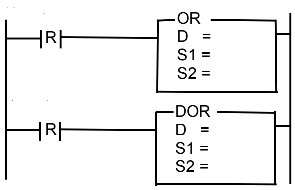
Initial conditions: W0 = $00FF
W1 = $3333
W2 = $XXXX

Operation results: W0 = $00FF
W1 = $3333
W2 = $0033

Instruction

Mnemonic	Bit OR Operation	Range
OR DOR	Bit OR operation	☐ Bit ■ Word ■ Double words

Ladder



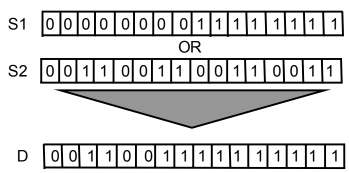
Process S1 and S2 in bit OR operation and store the result in D.

S1	S2	D
0	0	0
0	1	1
1	0	1
1	1	1

Description

1. Process S1 and S2 (word/double word) by bit OR operation and store the result in D.

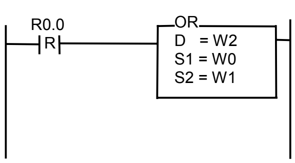
   For example: S1 = $00FF (hex)
   S2 = $3333 (hex)
   D = $33FF (hex)



2. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

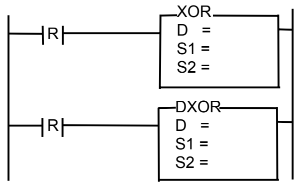
Initial conditions: W0 = $00FF
W1 = $3333
W2 = $XXXX

Operation results: W0 = $00FF
W1 = $3333
W2 = $33FF

Instruction

Mnemonic	Bit Exclusive OR Operation	Range
XOR DXOR	Bit exclusive OR operation	☐ Bit ■ Word ■ Double words

Ladder



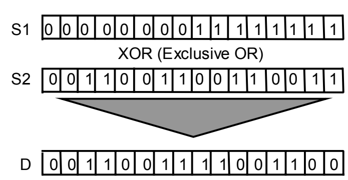
Process S1 and S2 in bit exclusive OR operation and store the result in D.

S1	S2	D
0	0	0
0	1	1
1	0	1
1	1	0

Description

1. Process S1 and S2 (word/double word) by bit exclusive OR operation and store the result in D.

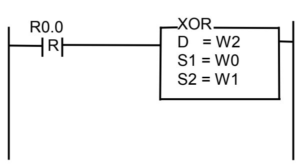
   For example: S1 = \$00FF (hex)
   S2 = \$3333 (hex)
   D = \$33CC (hex)



2. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

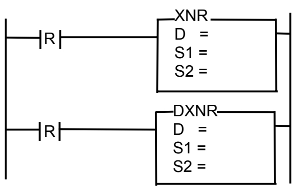
Initial conditions: W0 = \$00FF
W1 = \$3333
W2 = \$XXXX

Operation results: W0 = \$00FF
W1 = \$3333
W2 = \$33CC

Instruction

Mnemonic	Bit Exclusive NOR Operation	Range
XNR DXNR	Bit exclusive OR NOT operation	☐ Bit ■ Word ■ Double words

Ladder



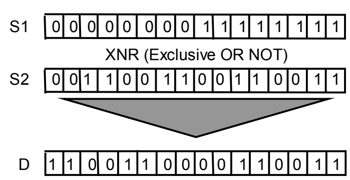
Process S1 and S2 in bit exclusive OR NOT operation and store the result in D.

S1	S2	D
0	0	1
0	1	0
1	0	0
1	1	1

Description

1. Process S1 and S2 (word/double word) by bit exclusive OR NOT operation and store the result in D.

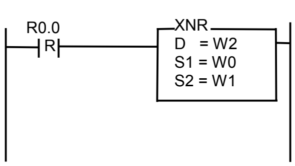
   For example: S1 = $00FF (hex)
   S2 = $3333 (hex)
   D = $CC33 (hex)



2. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

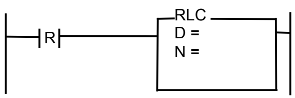
Initial conditions:	W0 = $00FF W1 = $3333 W2 = $XXXX
Operation results:	W0 = $00FF W1 = $3333 W2 = $CC33

Rotation Instruction Details

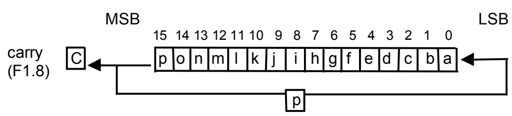
Instruction

Mnemonic	Rotate to the Left Without Carry	Range
RLC DRLC	Rotate specified address to the left (low to high)	☐ Bit ■ Word ■ Double words

Ladder



D = Register address
N = Number of bits to rotate

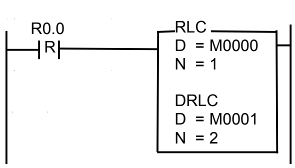


Description

1. Order:
   - Shift by N bits to the left (from low-order bit to high-order bit).
   - Fill the carry bit (F1.8) with the MSB (most significant bit).
   - Shift the MSB to the LSB (least significant bit).
2. Shift the register specified as D to the left by N bits. Each bit will move one bit position higher in the register.
3. The D register is either a word or a double word. For RLC (word), N = 0 to 15. For DRLC (double word), N = 0 to 31.
4. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

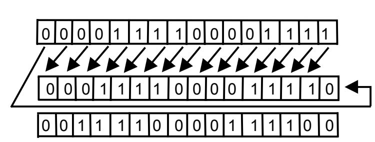
Program Expression



Operation Results

Initial condition: M0000 = \$0F0F
M0001 = \$0F0F
M0002 = \$0F0F

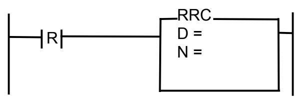
Operation results: M0 = \$1E1E
M1 = \$3C3C
M2 = \$3C3C



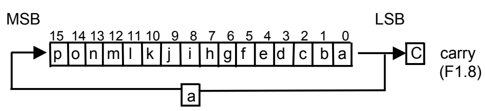
Instruction

Mnemonic	Rotate to the Right Without Carry	Range
RRC DRRC	Rotate the specified address to the right (high to low)	☐ Bit ■ Word ■ Double words

Ladder



D = Register address
N = Number of bits to rotate

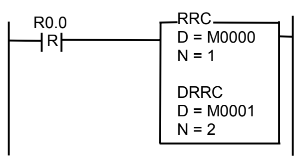


Description

1. Order:
   - Shift N bits to the right (from high-order bit to low-order bit).
   - Fill the carry bit (F1.8) with the LSB (least significant bit).
   - Shift the LSB to the MSB (most significant bit).
2. Shift the register specified as D to the right by N bits. Each bit will move one bit position lower in the register.
3. The D register is either a word or a double word. For RLC (word), N = 0 to 15. For DRLC (double word), N = 0 to 31.
4. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

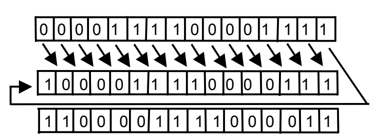
Program Expression



Operation Results

Initial condition: M0000 = $0F0F
M0001 = $0F0F
M0002 = $0F0F

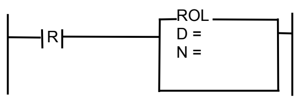
Operation results: M0 = $8787
M1 = $C3C3
M2 = $C3C3



Instruction

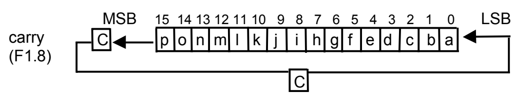
Mnemonic	Rotate to the Left	Range
ROL DROL	Rotate the specified address to the left with the carry flag	☐ Bit ■ Word ■ Double words

Ladder



D = Register address

N = Number of bits to rotate

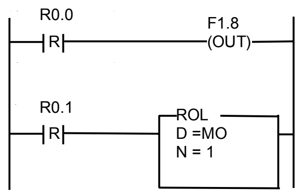


Description

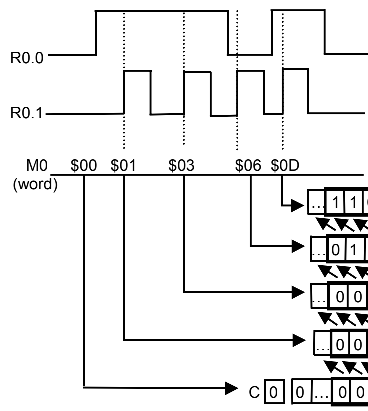
1. Order:
   - Shift N bits to the left (from low-order bit to high-order bit) including the carry bit.
   - The MSB (most significant bit) moves to the carry bit (F1.8).
   - Input F1.8 (carry bit) in the LSB (least significant bit).
2. This instruction is different from the RLC instruction because it sends the MSB to the carry bit and the carry bit moves to the LSB. The input to the LSB can be changed by setting or clearing the carry bit.
3. The D register is either a word or a double word. For ROL (word), N = 0 to 15. For DROL (double word), N = 0 to 31.
4. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

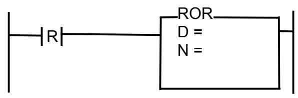


- If N = 1, the bits shift by one, and the LSB is always input from F1.8.
- If N = 2, the bits shift by two. The bits are shifted one position, and the first data input to the LSB is F1.8. The original MSB is stored in F1.8. The bits are again shifted one position, with the LSB being set by the new F1.8, and F1.8 being changed to the state of the last MSB.

Instruction

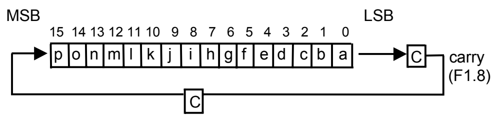
Mnemonic	Rotate to the Right	Range
ROR DROR	Rotate the specified address to the right with the carry flag	☐ Bit ■ Word ■ Double words

Ladder



D = Register address

N = Number of bits to rotate

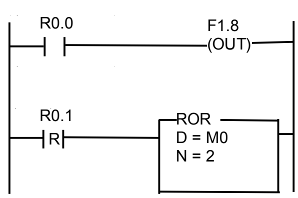


Description

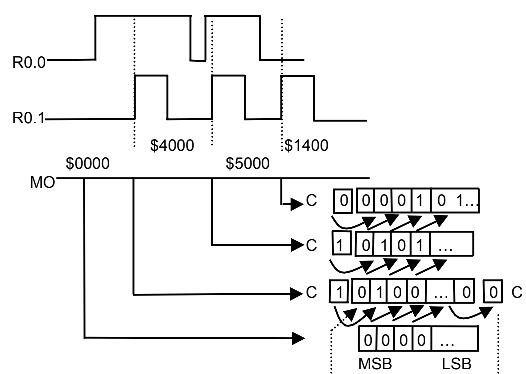
1. Order:
   - Shift N bits to the right (from high-order bit to low-order bit) including the carry bit.
   - Input the carry bit (F1.8) to the MSB (most significant bit).
   - The LSB (least significant bit) moves to the carry bit (F1.8).
2. This instruction is different from the RRC instruction because it sends the LSB to the carry bit, and the carry bit shifts to the MSB. The input to the MSB can be changed by setting or clearing the carry bit.
3. The D register is either a word or a double word. For ROR (word), N = 0 to 15. For DROR (double word), N = 0 to 31.
4. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



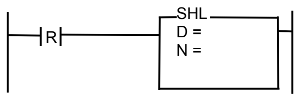
Operation Results



Instruction

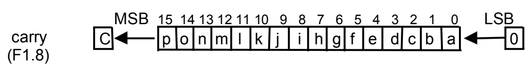
Mnemonic	Shift to Left	Range
SHL DSHL	Shift to left (high-order bit) by N bits Lowest bit becomes 0	■ Bit □ Word □ Double words

Ladder



D = Register address

N = Number of bits to rotate

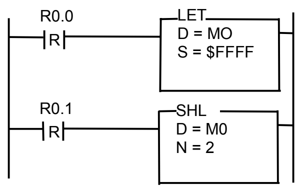


Description

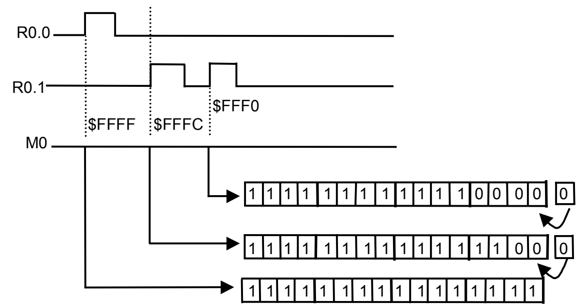
1. Order:
   - Shift N bits to the left (from low-order bit to high-order bit) including the carry bit.
   - The MSB (most significant bit) moves to the carry bit (F1.8).
   - The LSB (least significant bit) becomes 0.
2. Shift the register specified as D to the left by N bits. Each bit will move one position higher in the register.
3. The D register is either a word or a double word. For SHL (word), N = 0 to 15. For DSHL (double word), N = 0 to 31.
4. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

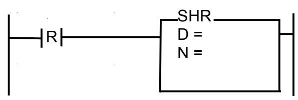


- Regardless of N, the MSB moves to the carry bit (F1.8) and the LSB always becomes 0.
- The R0.0 input is the initial condition, used to set the initial value of M0 to $FFFF.

Instruction

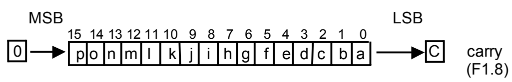
Mnemonic	Shift to Right	Range
SHR DSHR	Shift to right (low-order bit) by N bits The highest bit becomes 0	□ Bit ■ Word ■ Double words

Ladder



D = Register address

N = Number of bits to rotate

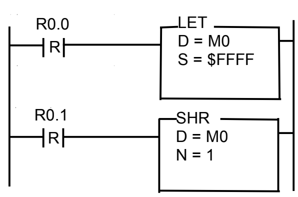


Description

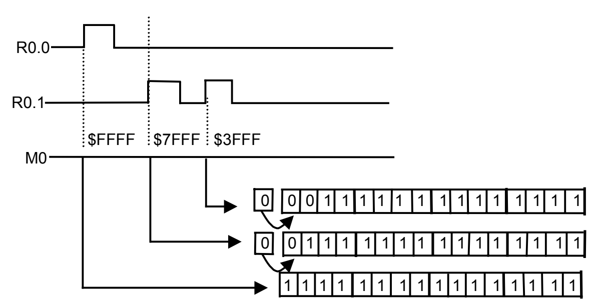
1. Order:
   - Shift N bits to the right (from high-order bit to low-order bit).
   - MSB (most significant bit) becomes 0.
   - Fill the carry bit (F1.8) with the LSB (least significant bit).
2. Shift the register specified as D to the right by N bits. Each bit will move one bit position lower in the register.
3. The D register is either a word or a double word. For SHR (word), N = 0 to 15. For DSHR (double word), N = 0 to 31.
4. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Time Chart



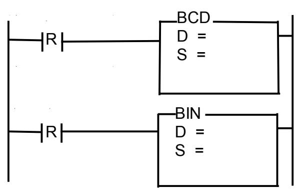
- Regardless of N, the MSB moves to the carry (F1.8) and the LSB always becomes 0.
- The R0.0 input is the initial condition, used to set the initial value of M0 to $FFFF.

Word Conversion Instruction Details

Instruction

Mnemonic	BCD Conversion, Binary Conversion	Range
BCD	BCD: Convert binary to BCD	☐ Bit
DBCD	BIN: Convert BCD to binary	■ Word
BIN		■ Double words
DBIN		

Ladder



BCD: Convert the S value from binary into BCD and store in D.

BIN: Convert the S value from BCD into binary and store in D.

Description

1. BCD: Convert S, which is expressed in binary (word /double word), into BCD and store in D. The range is as follows:

   Word conversion: S = 0 to $270F (hex) = 9999 (decimal)
   D = 0 to $9999 (hex) = 39321 (decimal)

   Double word conversion: S = 0 to $05F5E0FF (hex) = 99999999 (decimal)
   D = 0 to $99999999 (hex) = 2576980377 (decimal)

2. BIN: Convert S, which is expressed in BCD (word /double word), into binary (binary code) and store in D. The range is as follows:

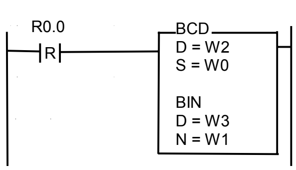
   Word conversion: S = 0 to $9999 (hex) = 39321 (decimal)
   D = 0 to $270F (hex) = 9999 (decimal)

   Double word conversion: S = 0 to $99999999 (hex) = 2576980377 (decimal)
   D = 0 to $05F5E0FF (hex) = 99999999 (decimal)

3. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

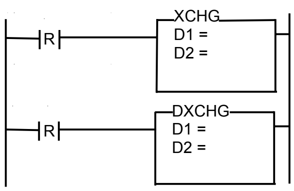
Initial conditions:
W0 = $07CC = 1996 (decimal)
W1 = $1996 = 6550 (decimal)
W2 = $XXXX
W3 = $XXXX

Operation results:
W0 = $07CC
W1 = $1996
W2 = $1996 = 6550 (decimal)
W3 = $07CC = 1996 (decimal)

Instruction

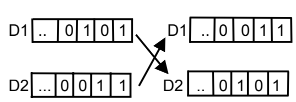
Mnemonic	Data Exchange	Range
XCHG DXCHG	Exchange registers of D1, D2 with each other	☐ Bit ■ Word ■ Double words

Ladder



Exchange registers D1 and D2 (word /double word) with each other.

D1 => D2, D2 => D1



Description

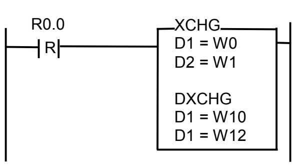
1. Exchange registers D1 and D2 with each other (word/double word). For example:

Word operation:	D1 = \$1234 (hex)	D2 = \$5678 (hex)
	D1 = \$5678 (hex)	D2 = \$1234 (hex)
Double word operation:	D1 = \$12345678 (hex)	D2 = \$9ABCDEF0 (hex)
	D1 = \$9ABCDEF0 (hex)	D2 = \$12345678 (hex)

2. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



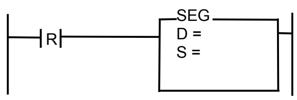
Operation Results

Initial conditions:	W0 = \$1234
	W1 = \$5678
	W10 = \$5678
	W11 = \$1234
	W12 = \$DEF0
	W13 = \$9ABC
Operation results:	W0 = \$5678
	W1 = \$1234
	W10 = \$DEF0
	W11 = \$9ABC
	W12 = \$5678
	W13 = \$1234

Instruction

Mnemonic	7-Segment Decoder	Range
SEG	Convert the low-order 4 bits of S into 7-segment display format and store in D	☐ Bit
		■ Word
		☐ Double words

Ladder

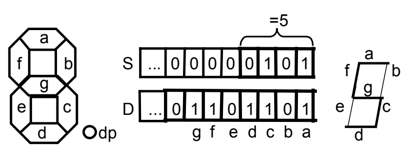


Convert the value in the low-order 4 bits of address S (0 to 15) into the proper format for display by a 7-segment display and store in D. In the converted format, if a bit is 1, the segment is illuminated (= active high output).

Description

1. Convert the value in the low-order 4 bits of address S into SEG display format, and store it in D. The high-order 8 bits of D do not change. The 8th bit of the D register, used with many 7-segment display cells as the decimal point, is not affected by this instruction.

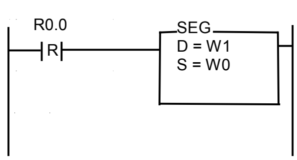
   For example: S = $XXX5 (hex)
   D = $XX6D (hex)



2. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

Initial conditions: W0 = $876**5** (hex)
W1 = $1234 (hex)

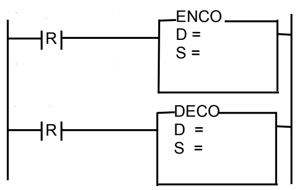
Operation results: W0 = $8765 (hex)
W1 = $12**6D** (hex)

The 8th bit of W1 does not change.

Instruction

Mnemonic	Decoder and Encoder with 8421	Range
ENCO	ENCO: 8421 encoder	☐ Bit
DECO	DECO: 8421 decoder	■ Word
		☐ Double words

Ladder

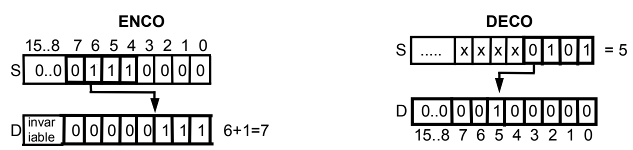


ENCO: Inspect the S register. If there is a bit in the On state, encode it (on bit n) and store it in the low-order 8 bits of D. If there are two or more bits in the S register that are in the On state, only the highest bit will be processed. The higher 8 bits of D do not change.

DECO: Interpret the lower 4 bits of the S register and store in D.

Description

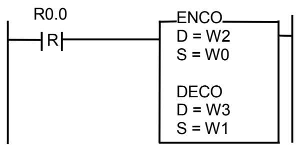
1. ENCO: Set D to the value of the bit number of highest bit in S that is On (0 to 16). If there are two or more On bits in S, use the location of the highest bit. The high-order 8 bits of D do not change.
2. DECO: Set the bit location (0 to 15) in D pointed to by the value in the low 4 bits of S. All other bits in D are reset to 0.



ENCO	\$0000→\$00	\$0020→\$06	\$0800→\$0C
	\$0001→\$01	\$0040→\$07	\$1000→\$0D
	\$0002→\$02	\$0080→\$08	\$2000→\$0E
	\$0004→\$03	\$0100→\$09	\$4000→\$0F
	\$0008→\$04	\$0200→\$0A	\$8000→\$10
	\$0010→\$05	\$0400→\$0B	
DECO	\$0→\$0001	\$6→\$0040	\$C→\$1000
	\$1→\$0002	\$7→\$0080	\$D→\$2000
	\$2→\$0004	\$8→\$0100	\$E→\$4000
	\$3→\$0008	\$9→\$0200	\$F→\$8000
	\$4→\$0010	\$A→\$0400	
	\$5→\$0020	\$B→\$0800	

Example

Program Expression



Operation Results

Initial conditions: W0 = $**0070** (hex)
W1 = $123**5** (hex)
W2 = $5678 (hex)
W3 = $9ABC (hex)

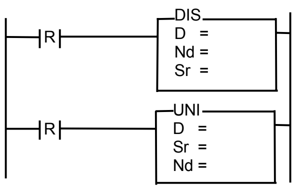
Operation results: W0 = $0070 (hex)
W1 = $1235 (hex)
W2 = $56**07** (hex)
W3 = $**0020** (hex)

The high-order 8 bits of W2 do not change.

Instruction

Mnemonic	Dissemble by 4 bit units/ Unify by 4 bit units	Range
DIS UNI	DIS: Dissemble by 4 bit units UNI: Unify by 4 bit units	☐ Bit
		■ Word
		☐ Double words

Ladder

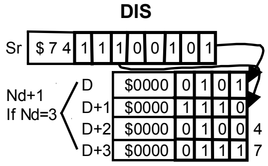


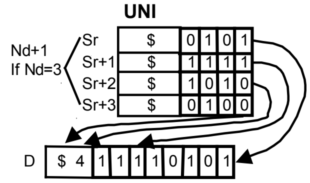
DIS: Separate Sr into Nd+1 units of 4 bits each, and store in the low 4 bits of words starting at D.

UNI: Combine the low 4 bits of Nd+1 words starting at Sr, and store in D.

Description

1. DIS: Separate the word value in register Sr into Nd+1 units of 4 bits each, and store these 4 bit units in sequence into registers starting at D. The 12 remaining high-order bits in each register become 0.
2. UNI: Combine the low-order 4 bit units from Nd+1 registers starting at Sr, and store in D.

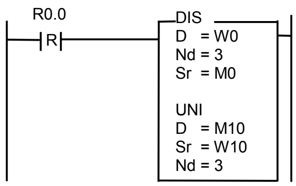




3. Nd + 1 represents the number of 4-bit segments to dissemble or unify. The range for Nd is Nd = 0 to 3.
4. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

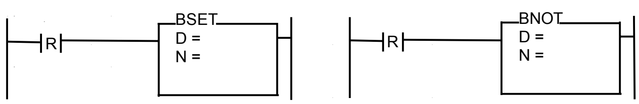
Initial conditions:	M0 = $**74E5** (hex)	W0 = $1111 (hex)
		W1 = $2222 (hex)
		W2 = $3333 (hex)
		W3 = $4444 (hex)
	W10 = $012**3** (hex)	M10 = $ABCD (hex)
	W11 = $456**F** (hex)	
	W12 = $789**A** (hex)	
	W13 = $765**4** (hex)	
Operation results:	M0 = $74E5 (hex)	W0 = $**0005** (hex)
		W1 = $**000E** (hex)
		W2 = $**0004** (hex)
		W3 = $**0007** (hex)
	W10 = $0123 (hex)	M10 = $**4AF3** (hex)
	W11 = $456F (hex)	
	W12 = $789A (hex)	
	W13 = $7654 (hex)	

Bit Conversion Instruction Details

Instruction

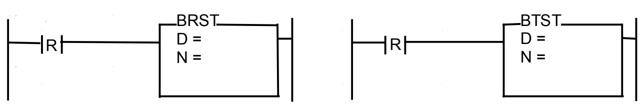
Instruction	Bit Set, Reset, Reverse, Test	Range
BSET	BSET: Nth bit set	☐ Bit
BRST	BRST: Nth bit reset	■ Word
BNOT	BNOT: Nth bit reverse	☐ Double words
BTST	BTST: Nth bit test	

Ladder



BSET: Set the Nth bit in the D register (X→1).

BNOT: Reverse the Nth bit in the D register (0→1, 1→0).

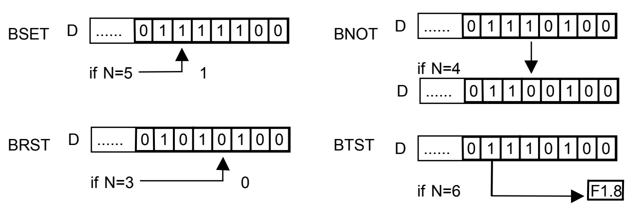


BRST: Reset the Nth bit in the D register (X→0).

BTST: Copy the Nth bit to the carry bit in the D register (X→F1.8).

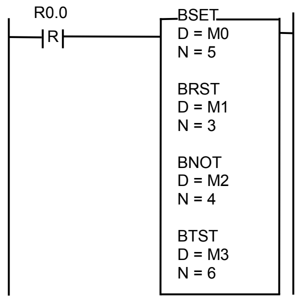
Description

1. BSET: Set the Nth bit of register D to 1.
2. BRST: Reset the Nth bit of register D to 0.
3. BNOT: Reverse the state of the Nth bit of register D.
4. BTST: Set the carry bit F1.8 to the state of the Nth bit of register D.
5. These instructions are useful when it is necessary to perform bit-level operations on word-only memory addresses, such as W, PV, SV, and SR.



Example

Program Expression



Operation Results

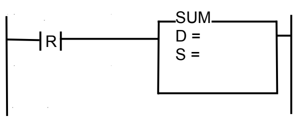
Initial conditions:
M0 = 0001 0010 00**0**1 1100 (binary)
M1 = 0011 0100 0101 **1**100 (binary)
M2 = 0101 0110 011**1** 0100 (binary)
M3 = 0111 1000 0**1**11 0100 (binary)
F1.8 = **0 (Off)**

Operation results:
M0 = 0001 0010 00**1**1 1100 (binary)
M1 = 0011 0100 0101 **0**100 (binary)
M2 = 0101 0110 011**0** 0100 (binary)
M3 = 0111 1000 0111 0100 (binary)
F1.8 = **1 (On)**

Instruction

Mnemonic	Count Number of On (= 1) Bits	Range
SUM	Count On (= 1) bits in the S register	☐ Bit ■ Word ☐ Double words

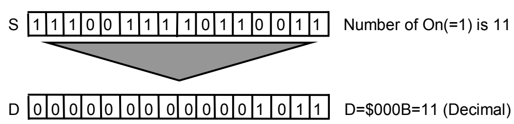
Ladder



SUM: Count the number of On (= 1) bits in the S register and store the result in the D register.

Description

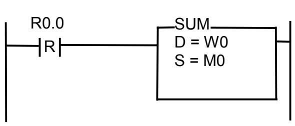
1. Count the number of On (= 1) bits in the S register and store the result in the D register.



2. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



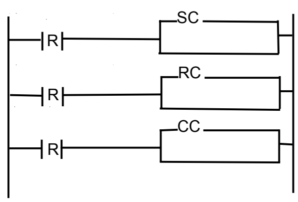
Operation Results

Initial conditions:	M0 = 1110 0111 1011 0011 (binary) W0 = $XXXX (hex)
Operation results:	M0 = 1110 0111 1011 0011 (binary) W0 = $000B (hex) = 11 (decimal)

Instruction

Mnemonic	Carry Bit (F1.8) Set, Reset, Reverse	Range
SC	SC: Set carry bit	☐ Bit
RC	RC: Reset carry bit	☐ Word
CC	CC: Reverse carry bit	☐ Double words

Ladder



SC: Carry bit set (F1.8: X→1).

RC: Carry bit reset (F1.8: X→0).

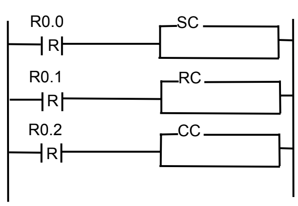
CC: Carry bit reverse (F1.8: 0→1, 1→ 0).

Description

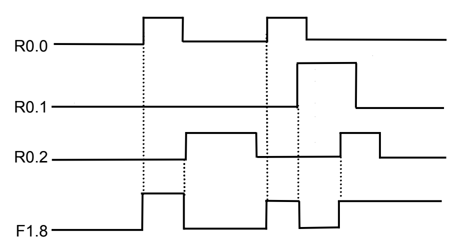
1. The carry bit (F1.8) is a special internal flag that holds the result of various types of mathematical and bit shift operations. When rotating, shifting, adding, or subtracting with a carry, the operation depends on the state of the carry flag, as well as changes the state of the carry flag. The above instructions are useful for setting the state of the carry flag as needed for these types of operations.
2. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

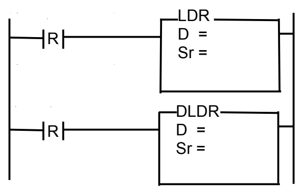


Transfer Instruction Details

Instruction

Mnemonic	Load Absolute Address	Range
LDR DLDR	Store value at absolute address Sr in D, D←(Sr)	☐ Bit ■ Word ■ Double words

Ladder



Store the value located at the absolute address pointed to by Sr into register D.

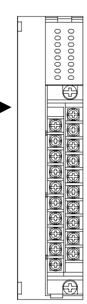
R0 word absolute address: 0
M0 word absolute address: 192
W0 word absolute address: 512

Description

1. This instruction is useful in transferring data patterns stored sequentially in memory, to a single output register location. For example, if the register addresses W100 through W199 contained a set of 100 control patterns (P0 to P99) that needed to be transferred to an output module located at address R002, the LDR instruction can be used to load the data from the absolute addresses of W100 to W199 (absolute addresses 612 to 711) into the destination register R002.
2. In the example below, register W0 is used as the Sr (source) register, which contains the absolute address of the data patterns to be loaded. Initially, W0 contains 612, which is the absolute memory address of register W100. As W0 is incremented, it successively points to the next higher W register to load data from.
3. See Chapter 5, Absolute Address Designation, for a complete table of absolute addresses.

Control Pattern	Register (Absolute Address)	Register Value
P0	W100 (612)	$22
P1	W101 (613)	$10
P2	W102 (614)	$33
…	…	…
…	…	…
P98	W198 (710)	$05
P99	W199 (711)	$85

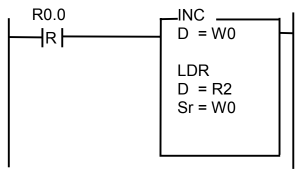
R002 Output Module



Transfer the data of W100-W199 ($22, $10, $33,..., $05, $85) registers in sequence into R002 output module. See the following example.

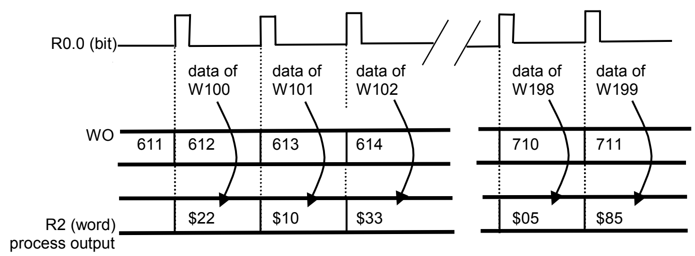
Example

Program Expression



Operation Results

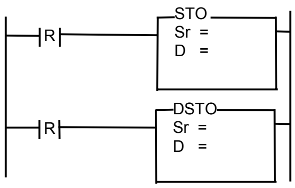
Initial conditions: W0 = 611



Instruction

Mnemonic	Store Absolute Address	Range
STO DSTO	Store Sr in register at absolute address D, (D)←Sr	□ Bit ■ Word ■ Double words

Ladder



Store the data contained in the Sr register into the register pointed to by the absolute address contained in register D.

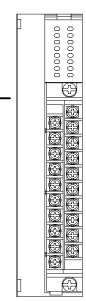
R0 word absolute address: 0 (decimal)
M0 word absolute address: 192 (decimal)
W0 word absolute address: 512 (decimal)

Description

1. This instruction is useful in storing data patterns from a single input register to a sequential table of registers in memory. For example, if the process measurements (D0 to D99) from an input module located at address R001 needed to be stored in register addresses W100 through W199. The STO instruction can be used to load the data from the source register R001 to the absolute addresses of W100 to W199 (absolute addresses 612 to 711).
2. In the example below, register W0 is used as the D (destination) register, which contains the absolute address of the locations to store the process measurements. Initially, W0 contains 612, which is the absolute memory address of register W100. As W0 is incremented, it successively points to the next higher W register to store data.
3. See Chapter 5, Absolute Address Designation, for a complete table of absolute addresses.

Process Measurement	Register (Absolute Address)	Register Value
D0	W100 (612)	$34
D1	W101 (613)	$25
D2	W102 (614)	$88
…	…	…
…	…	…
D98	W198 (710)	$17
D99	W199 (711)	$09

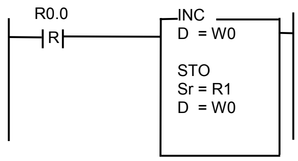
R001 Input Module



Store the process measurement data ($34, $25, $88,...,$17, $09) you get from input module R001 (word) in sequence into W100-W199. See the following example.

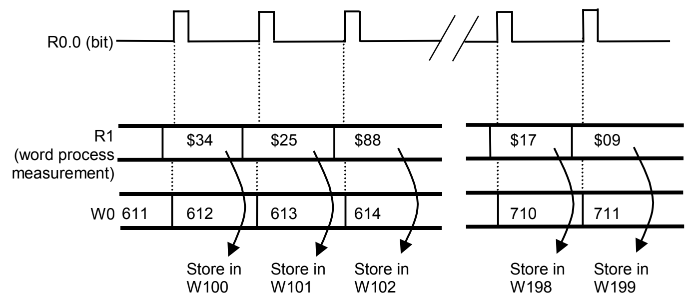
Example

Program Expression



Operation Results

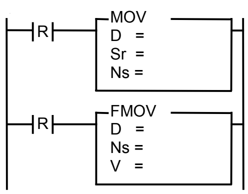
Initial conditions: W0 = 611



Instruction

Mnemonic	Duplicate Word, Duplicate the Same Word	Range
MOV FMOV	MOV: Copy a block of words FMOV: Fill a block of words with the same value	☐ Bit ■ Word ☐ Double words

Ladder



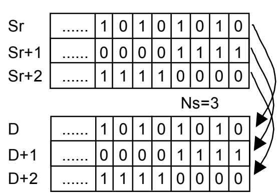
MOV: Copy Ns words from Sr to D.

FMOV: Repeatedly copy the value V, Ns times to words starting at register address D.

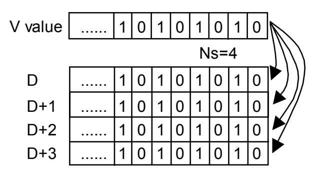
Description

1. MOV: Copy a total of Ns registers from registers starting at Sr word into registers starting at D. This instruction is used for mass duplication of blocks of registers.
2. FMOV: Copy the constant number V, Ns times into registers starting at D. This instruction is useful for initializing the internal and external memory of certain areas when initializing a program.

MOV



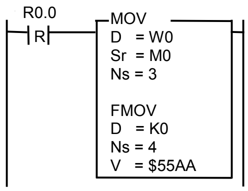
FMOV



3. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



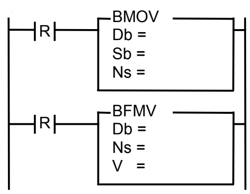
Operation Results

Initial conditions:	M0 = $12AA (hex)	W0 = $XXXX (hex)
	M1 = $340F (hex)	W1 = $XXXX (hex)
	M2 = $56F0 (hex)	W2 = $XXXX (hex)
	K0 = $XXXX (hex)	K2 = $XXXX (hex)
	K1 = $XXXX (hex)	K3 = $XXXX (hex)
Operation results:	M0 = $12AA (hex)	W0 = $12AA (hex)
	M1 = $340F (hex)	W1 = $340F (hex)
	M2 = $56F0 (hex)	W2 = $56F0 (hex)
	K0 = $55AA (hex)	K2 = $55AA (hex)
	K1 = $55AA (hex)	K3 = $55AA (hex)

Instruction

Mnemonic	Copy Bit, Copy the Same Bit	Range
BMOV BFMV	BMOV: Copy a block of bits BFMV: Fill a block of bits with the same bit value	■ Bit ☐ Word ☐ Double words

Ladder

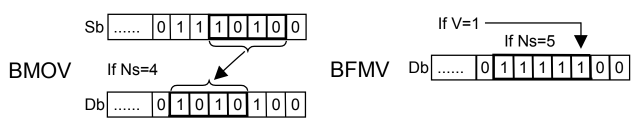


BMOV: Copy Ns bits from bit address Sb into bit address D.

BFMV: Copy the V bit (0 or 1) into bit address D, Ns times.

Description

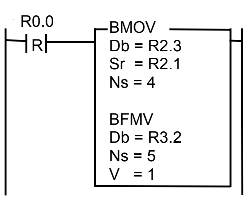
1. BMOV: Copy a block of Ns bits starting at bit address Sb to bit address D. This instruction is useful for moving large blocks of bits at one time, or for copying sections of bits within a word without copying the entire word.
2. BFMV: Fill a block of Ns bits starting at bit address D with the value of V (0 or 1). This instruction is useful for initializing a set of bits to 0 or 1 at the start of a program or process.



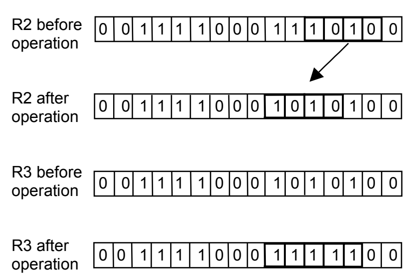
3. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

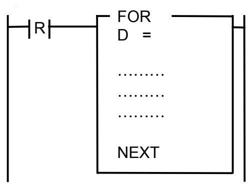


Block Processing Instruction Details

Instruction

Mnemonic	FOR-NEXT Loop	Range
FOR	FOR (DFOR): Start loop	☐ Bit
DFOR	NEXT: End loop	■ Word
NEXT		■ Double words

Ladder



FOR: Begin execution of instructions between (D)FOR and corresponding NEXT. Repeat execution D times.

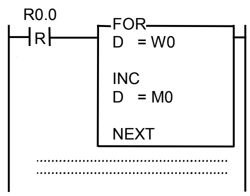
NEXT: Decrease D of FOR instruction by 1. If not zero, repeat from FOR instruction.

Description

1. The FOR/NEXT instructions are used to perform a block of instructions inside a ladder program repeatedly. The parameter D of the FOR instruction is a value indicating how many times the block of instructions is to be performed.
2. Branch instructions such as JMP and CALL can be made inside the FOR/NEXT loop.
3. The number of loops to execute (D value) can be changed inside of the FOR/NEXT loop. This can be used to dynamically increase or decrease the number of loops performed while processing the loops.
4. If the D register is 0 before the FOR instruction, the instructions between the FOR and NEXT instructions will NOT be executed. Instead, the program will jump directly to the instruction following the NEXT.
5. As the FOR/NEXT loop occurs within a single program scan, a large value of D will lengthen the scan time of the program considerably.
6. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

Initial condition: W0 = 10
M0 = 0

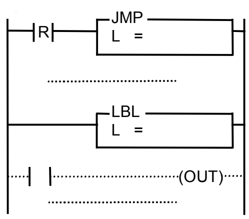
Operation results: W0 = 0
M0 = 10

When the R0.0 contact changes from Off→On, execution of the FOR/NEXT loop occurs. At the FOR instruction, the value of W0 is evaluated. If W0 is not 0, then the instructions between the FOR and NEXT (INC D = M0) is performed. At the NEXT instruction, 1 is subtracted from the value of W0, and execution returns to the FOR instruction. This is repeated 10 times, until the value of W0 is 0. When this occurs, execution goes directly the instruction following the NEXT instruction.

Instruction

Mnemonic	Jump by Pointer	Range
JMP LBL	JMP: Jump by pointer LBL: Specify the pointer	☐ Bit ☐ Word ☐ Double words

Ladder



JMP: Jump to the LBL instruction L (L = 0 to 63).

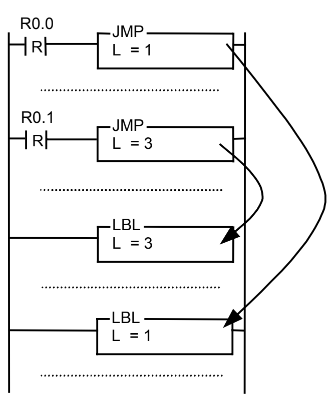
LBL: Position jumped to by the JMP instruction.

Description

1. This instruction is used to conditionally perform a set of instructions in the program. When the input condition to the JMP instruction is true, execution will jump over the following instructions, directly to the corresponding LBL label. When the input condition is false, the instructions following the JMP will be executed normally, and no jump occurs.
2. The range of L is 0 to 63, allowing 64 jumps to be used.
3. The given L label may only be used once in a program. It may not be duplicated.
4. For a given JMP with parameter L, there MUST be a corresponding LBL with the same L value. Also, the LBL instruction must come after the JMP instruction in the program. If either of these two conditions is not satisfied, an error will occur preventing execution of the program.
5. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



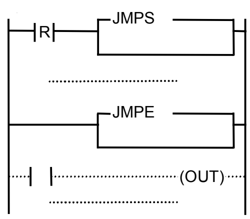
Operation Results

- When contact R0.0 turns On, JMP 1 occurs, and execution jumps directly to LBL 1—the instructions between the JMP and LBL are not executed.
- When contact R0.1 turns On, execution of the program jumps directly from JMP 3 to LBL 3.

Instruction

Mnemonic	Jump	Range
JMPS JMPE	JMPS: Start jump JMPE: End jump	☐ Bit ☐ Word ☐ Double words

Ladder



JMPS: Jump directly to the corresponding JMPE instruction.

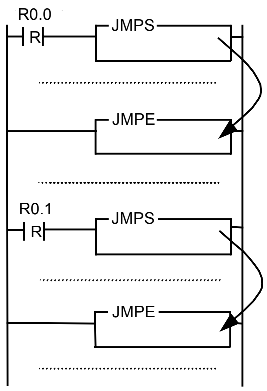
JMPE: Position jumped to by JMPS instruction.

Description

1. The JMPS and JMPE instruction function identically to the JMP and LBL instructions, but do not require the use of a label. Additionally, the JMPS/JMPE pair may be used more than once in a program.
2. This instruction is used to conditionally perform a set of instructions in the program. When the input condition to the JMPS instruction is true, execution will jump over the following instructions, directly to the corresponding JMPE. When the input condition is false, the instructions following the JMPS will be executed normally, and no jump occurs.
3. For the JMPS instruction, there MUST be a corresponding JMPE. Also, the JMPE instruction must come after the JMPS instruction in the program. If either of these two conditions is not satisfied, an error will occur preventing execution of the program.
4. The JMPS/JMPE instructions may NOT be nested—after each JMPS instruction, there must be a JMPE instruction before the next JMPS instruction may be programmed.
5. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

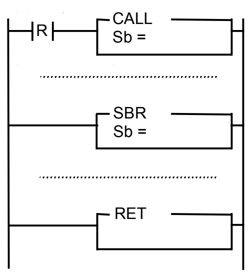
By executing a JMPS:

- When contact R0.0 or R0.1 turns On, execution of the program jumps directly from the associated JMPS to its corresponding JMPE.

Instruction

Mnemonic	Call Subroutine	Range
CALL SBR RET	CALL: Call subroutine SBR: Start subroutine RET: End subroutine	☐ Bit ☐ Word ☐ Double words

Ladder



CALL: Call subroutine Sb (Sb = 0 to 63)

SBR: Start Subroutine

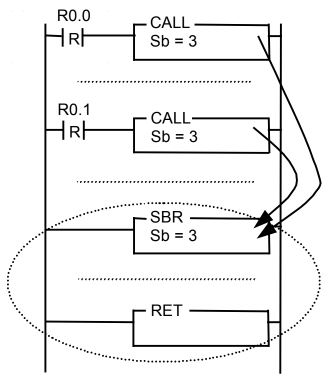
RET: Return from Subroutine

Description

1. The subroutine instructions are used when a block of instructions needs to be called more than once, or called with different values, from the main program.
2. The subroutine to be called is specified by the Sb parameter in the CALL and SBR instructions. The CALL instruction causes execution to jump to the specified SBR instruction. After executing the instructions between SBR and RET, program execution is returned to the instruction following the CALL instruction that called the subroutine.
3. The subroutine defined by the SBR and RET instructions must come after the associated CALL instruction. All subroutines must be defined and programmed at the end of the control program. A total of 64 subroutines are available (Sb = 0 to 63).
4. The same subroutine (SBR Sb) can be called by multiple CALL instructions. However, each subroutine number may only be used once by an SBR instruction.
5. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



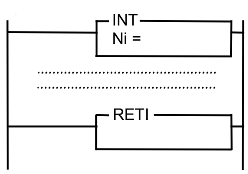
Operation Results

When contact R0.0 and/or R0.1 turns On, the CALL Sb = 3 instruction is executed and the instructions between SBR Sb = 3 and RET are executed. After executing this subroutine, the program returns to the next instruction after the CALL.

Instruction

Mnemonic	Constant Cycle Interrupt Routine	Range
INT RETI	INT: Start of constant cycle routine RETI: End of constant cycle routine	☐ Bit ☐ Word ☐ Double words

Ladder



INT: Begin block of constant cycle scan instructions.

Ni: The constant cycle interrupt time interval.
Range: 1 to 999 (20 ms to 10 sec)
Time interval: (Ni + 1) × 10 msec

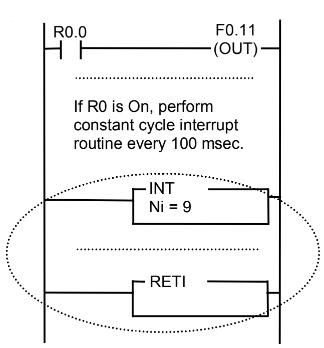
RETI: End block of constant cycle scan instructions.

Description

1. The INT/RETI instructions are used to mark a block of instructions that are to be executed on a constant time cycle, asynchronous with the scan time of the PLC.
2. The time interval of the constant cycle routine can be set from a minimum of 20 msec to a maximum of 10 sec. The constant cycle time is indicated by the Ni parameter. The time calculation is (Ni+1) × 10 msec.
3. The constant cycle routine is controlled by the F0.11 contact. If the F0.11 contact is On, the constant cycle routine is executed. If it is Off, the constant cycle routine block is ignored.
4. Only one constant cycle routine can be made within a program.
5. The time required to execute the constant cycle routine instructions MUST be less than the overall scan time of the main program. If the execution time of the constant cycle routine is greater than the overall scan time, the program will not operate properly. For this reason, the constant cycle routine should be limited to a minimum number of steps.

Example

Program Expression



Operation Results

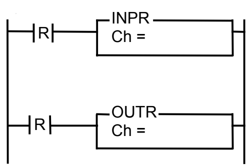
- If the R0.0 input is On, the constant cycle interrupt routine will be executed. Instructions between INT/RETI shall be executed on a constant time base of (9+1) × 10 msec = 100 msec. The constant cycle interrupt is controlled in the main program using the R0.0 contact.
- F0.11 is the system flag that controls the execution of the INT routine.

Special Instruction Details

Instruction

Mnemonic	Refresh External Input and Output	Range
INPR OUTR	INPR: Refresh external input OUTR: Refresh external output	■ Bit □ Word □ Double words

Ladder



INPR: Immediately update the state of an external input signal during program execution.

OUTR: Immediately update the state of an external output signal during program execution.

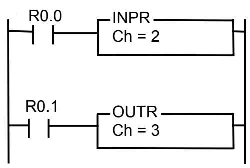
Ch: The external input/output address (0 to 127).

Description

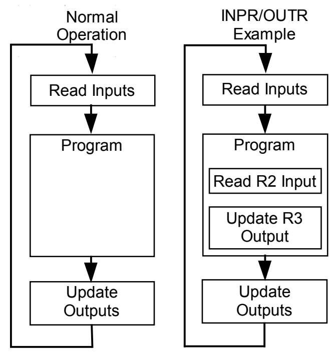
1. Refreshes the input/output data for the external I/O module at register address Ch.
2. These instructions are used when it is necessary to provide high-speed input and output updates without limiting the size and length of the PLC program.
3. Under normal operation, the external inputs are read before the execution of the control program, and the external outputs are updated at the end of the control program. The INPR instruction is used to provide immediate input from the external input modules at any point inside the control program without waiting for the end of the scan. Likewise, the OUTR instruction allows the user to immediately update the state of an external output module at any point in the program.
4. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



Operation Results

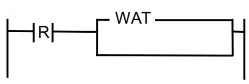


- When R0.0 is On, get Ch = 2 (R2 word) immediately from the external input.
- If R0.1 is On, send out Ch = 3 (R3 word) immediately to the external output.
- For this example, R2 is an external input module, and R3 is an external output module.

Instruction

Mnemonic	Clear Watchdog Time	Range
WAT	WAT: Clear watchdog time	■ Bit
		☐ Word
		☐ Double words

Ladder



WAT: Clears the watchdog timer while executing the program.

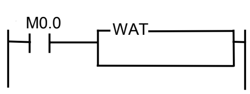
Description

1. This instruction clears the watchdog timer within the CPU module to prevent the program from stopping even if the scan time exceeds the maximum watchdog time. The default watchdog time is 3 seconds.
2. Under normal operation, the PLC executes the following process:
   - Read external inputs.
   - Process the control program.
   - Update the external outputs.

   One execution of this process is termed a scan. When the time it takes to process a single scan (the scan time) is excessively long, abnormal results may occur caused by the delay in reading inputs and updating outputs. For this reason, a watchdog time is set by the PLC which, when exceeded, indicates that an error has occurred. When this happens, the PLC stops the program to prevent abnormal operation.
3. Under certain circumstances, extremely lengthy scan times may be allowable. The WAT instruction allows the user to reset the watchdog timer to prevent the PLC from automatically going into the error condition and stop mode when the watchdog time is exceeded.
4. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

Example

Program Expression



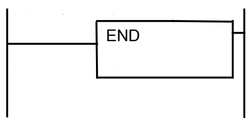
Operation Results

In certain applications, the user program may contain loops which cause lengthy scan times. In the example, turning on M0.0 prevents the PLC from stopping when the watchdog time (maximum of 3 sec) is exceeded. For normal PLC control applications, this instruction should not be used.

Instruction

Mnemonic	End Control Program	Range
END	END: End control program (Inserted automatically)	☐ Bit
		☐ Word
		☐ Double words

Ladder



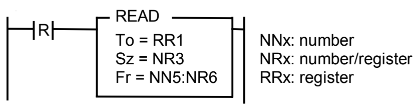
Description

1. This instruction indicates the end of the control program.
2. This instruction is automatically added by GPC. It is not programmed by the user.

Instruction

Mnemonic	Read Intelligent I/O Data	Range
READ	Read data from the shared memory of an intelligent I/O unit.	☐ Bit
		■ Word
		☐ Double words

Ladder



READ: Read NR3 words from slot NN5, module memory address NR6, and store in words starting at RR1.

Description

1. RR1: Starting address for storing read data (register).

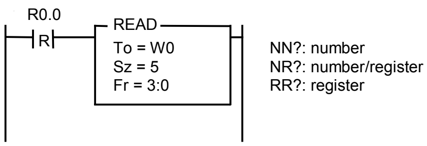
   NR3: Number of words to read (number/register).

   NN5: Slot number of the intelligent I/O module to read from. The first slot in the backplane is slot 0.

   NR6: Starting address to be read from on the shared memory of the intelligent I/O module (number/ register).
2. This instruction is used to read data from the shared memory of an intelligent I/O module such as the high-speed counter, SDU module, analog module, or position control module. Refer to the specific intelligent I/O module user’s manual for detailed instructions on using the READ instruction with the given module.
3. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

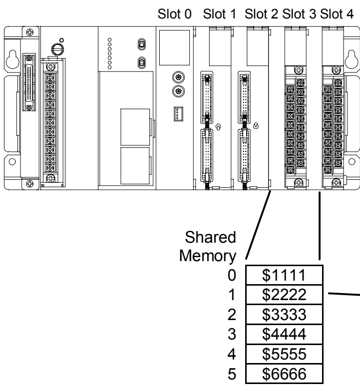
Example

Program Expression



Operation Results

Read 5 words from the 0 address of the shared memory of the intelligent I/O module located in the third slot of the backplane, and write to memory addresses starting at W0 (W0, W1, W2, W3, W4).



Before Operation

W0	$0011
W1	$2233
W2	$4455
W3	$6677
W4	$8899
W5	$AABB

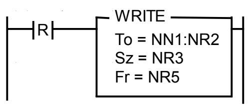
After Operation

W0	$1111
W1	$2222
W2	$3333
W3	$4444
W4	$5555
W5	$AABB

Instruction

Mnemonic	Write Intelligent I/O Data	Range
WRITE	Write data to the shared memory of an intelligent I/O unit	☐ Bit
		■ Word
		☐ Double words

Ladder



NNx: number
NRx: number/register
RRx: register

WRITE: Read NR3 words from NR5, and write them to slot NN1, module memory address NR2.

Description

1. NN1: Slot number of the intelligent I/O module to write to. The first slot in the backplane is slot 0.

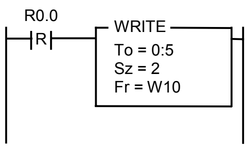
   NR2: Starting address to write to on the shared memory of the intelligent I/O module (number/register).

   NR3: Number of words to write (number/register).

   NR5: Starting address of the data to write (number/register).
2. This instruction is used to write data to the shared memory of an intelligent I/O module such as the high-speed counter, SDU module, analog module, or position control module. Refer to the specific intelligent I/O module user's manual for detailed instructions on using the WRITE instruction with the given module.
3. If the NR5 parameter is a constant value instead of a register address, then this constant value will be written to all of the shared memory locations specified. This function is useful for initializing the shared memory of an intelligent I/O module.
4. This operation will occur on every scan for which the input condition is true (On). To perform the operation only on a change of input condition, use the rising/falling edge contact.

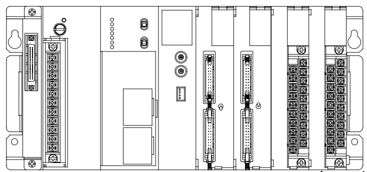
Example

Program Expression



Operation Results

Reads two words from W10 and W11, and writes them to word addresses 5 and 6 of the shared memory of the intelligent I/O module in slot 0 (the first I/O slot).



W8	$0011
W9	$2233
W10	$4455
W11	$6677
W12	$8899
W13	AABB

Shared Memory

Before Operation

3	$1111
4	$2222
5	$3333
6	$4444
7	$5555
8	$6666

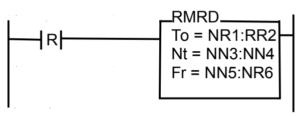
After Operation

3	$1111
4	$2222
5	$4455
6	$6677
7	$5555
8	$6666

Instruction

Mnemonic	READ Remote Intelligent I/O Data	Range
RMRD	Read data from the shared memory of an intelligent I/O unit on a remote I/O drop	☐ Bit
		■ Word
		☐ Double words

Ladder



NNx: number
NRx: number/register
RRx: register

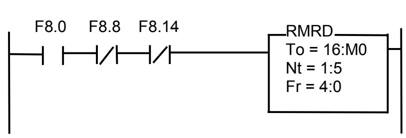
Read NR1 words from remote I/O loop NN3, station NN4, slot NN5, module memory address NR6, and store in words starting at RR2.

Description

1. NR1: Number of words to read (number/register).
   RR2: Starting address for storing read data (register).
   NN3: Remote I/O network number (number).
   NN4: Station number on the remote network (number).
   NN5: Slot number of the intelligent I/O module to read from (number).
   NR6: Starting address of the shared memory to read (number/register).
2. This instruction is used to read data from the shared memory of intelligent I/O modules installed on remote I/O drops. Intelligent modules include the high-speed counter, analog module, SDU module, or positioning module. Refer to the specific intelligent I/O module user's manual for detailed instructions on using the RMRD instructions with the given module.
3. The remote I/O network is a number from 1 to 3. The first remote I/O module in the base rack is assigned network ID 1, the second is 2, and the third is remote I/O network 3.
4. Each intelligent I/O module on a remote I/O network may only be read from once in a given scan. To prevent reading from a module more than once per scan, place the RMRD instruction at the end of the program.

Example

Program Expression



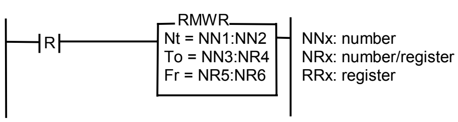
Operation Results

The first remote master (F8.0) is installed and there are no initialization errors (F8.8). The communication is completed (F8.14). Once these conditions are true, the program reads 16 words from shared memory address 0, slot 4, remote I/O station 5 on remote I/O network 1. This data is written to registers starting at M0.

Instruction

Mnemonic	WRITE Remote Intelligent I/O Data	Range
RMWR	Write data to the shared memory of an intelligent I/O unit on a remote I/O drop	☐ Bit ■ Word ☐ Double words

Ladder



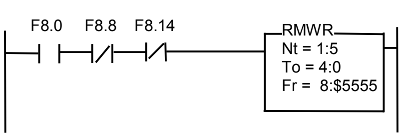
Read NR5 words from NR6, and write them to remote I/O loop NN1, station NN2, slot NN3, module memory address NR4.

Description

1. NN1: Remote I/O network number (number).
   NN2: Station number on the remote network (number).
   NN3: Slot number of the intelligent I/O module to write to (number).
   NR4: Starting address of the shared memory to write (number/register).
   NR5: Number of words to write (number/register).
   NR6: Starting address of the data to write (number/register).
2. This instruction is used to write data to the shared memory of intelligent I/O modules installed on remote I/O drops. Intelligent modules include the high-speed counter, analog module, SDU module, and positioning module. Refer to the specific intelligent I/O module user's manual for detailed instructions on using the RMWR instructions with the given module.
3. If the NR6 parameter is a constant value instead of a register address, then this constant value will be written to all of the shared memory locations specified. This function is useful for initializing the shared memory of an intelligent I/O module on a remote I/O drop.
4. The remote I/O network is a number from 1 to 3. The first remote I/O module in the base rack is assigned network ID 1, the second is 2, and the third is remote I/O network 3.
5. Each intelligent I/O module on a remote I/O network may only be written to once in a given scan. To prevent writing to a module more than once per scan, place the RMWR instruction at the end of the program.

Example

Program Expression



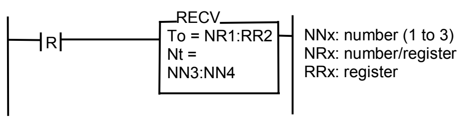
Operation Results

The first remote master (F8.0) is installed and there are no initialization errors (F8.8). The communication is completed (F8.14). Once these conditions are true, the program then writes eight words to shared memory address 0 of the intelligent module located in slot 4 of station 5 of remote I/O network 1. All eight addresses are written with the value of $5555.

Instruction

Mnemonic	Word Data Receive	Range
RECV	Word data receive command using link network	☐ Bit
		■ Word
		☐ Double words

Ladder



Read NR1 words from link network NN3, station NN4, register type NN5, address NR6, and write them to words starting at RR2.

Description

1. NR1: Number of words to read (number/register).

   RR2: Starting address for storing read data (register).

   NN3: Link network number (number).

   NN4: Station number on the link network (number).

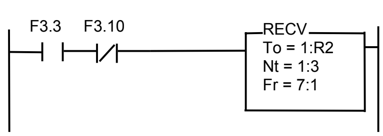
   NN5: Register type to read (number):

   - 0: L register
   - 1: M register
   - 2: R register
   - 3: K register
   - 4: T/C Setting Value (SV)
   - 5: T/C Present Value (PV)
   - 6: W register
   - 7: F register

   NR6: Starting address of register to read (number/register).
2. The link network loop number is a number from 1 to 3. The first link module in the base rack is assigned network ID 1, the second is 2, and the third is link network 3.
3. The RECV instruction can read up to 56 words at a time (NR1 = 1 to 56).
4. The RECV instruction can only by executed once in a given scan. To prevent reading over the link network more than once per scan, place the RECV instruction at the end of the program.

Example

Program Expression



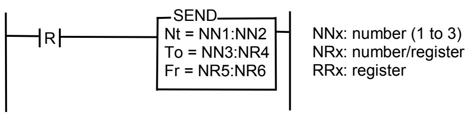
Operation Results

Verify that the first link module has been installed (F3.3) and sent through the first module (F3.10). Then, from link network 1, station 3 (Nt = 1:3), register type F, address 1 (Fr = 7:1), read one word and write it to register R2 (To = 1:R2).

Instruction

Mnemonic	Word Data Send	Range
SEND	Word data send command using link network	☐ Bit
		■ Word
		☐ Double words

Ladder



Read NR5 words from NR6, and write them to link network NN1, station NN2, register type NN3, address NR4.

Description

1. NN1: Link network number (number).

   NN2: Station number on the link network (number).

   NN3: Register type to write (number):

   - 0: L register
   - 1: M register
   - 2: R register
   - 3: K register
   - 4: T/C Setting Value (SV)
   - 5: T/C Present Value (PV)
   - 6: W register
   - 7: F register

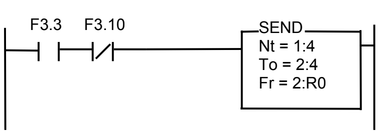
   NR4: Starting address of the register to write (number/register).

   NR5: Number of words to write (number/register).

   NR6: Starting address of register to read (number/register).
2. The link network loop number is a number from 1 to 3. The first link module in the base rack is assigned network ID 1, the second is 2, and the third is link network 3.
3. The SEND instruction can write up to 56 words at a time (NR5 = 1 to 56).
4. The SEND instruction can only by executed once in a given scan. To prevent writing over the link network more than once per scan, place the SEND instruction at the end of the program.

Example

Program Expression



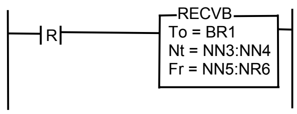
Operation Results

Verify that the first link module (F3.3) has been installed and sent through the first module (F3.10). Then, write two words from R0 (Fr = 2:R0) to link network 1, station 4 (Nt = 1:4), register type R, address 4 (To = 2:4).

Instruction

Mnemonic	Bit Data Receive	Range
RECVB	Bit data receive command using link network	☐ Bit
		■ Word
		☐ Double words

Ladder



NNx: number (1 to 3)
NRx: number/register in case of number display in hexadecimal
BRx: bit register

Read the bit value from link network NN3, station NN4, register type NN5, bit address NR6, and store to bit address BR1.

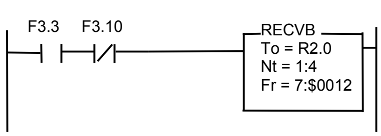
Description

1. BR1: Bit address to write (bit).
   NN3: Link network number (number).
   NN4: Station number on the link network (number).
   NN5: Register type to read (number):
   - 0: L register
   - 1: M register
   - 2: R register
   - 3: K register
   - 4: T/C Setting Value (SV)
   - 5: T/C Present Value (PV)
   - 6: W register
   - 7: F register

   NR6: Bit address to read in hexadecimal form (number/register).
2. The link network loop number is a number from 1 to 3. The first link module in the base rack is assigned network ID 1, the second is 2, and the third is link network 3.
3. The network bit address to read (NR6) is represented in hexadecimal form, where the low 4 bits indicate the bit number to read (from 0 to F), and the high 12 bits represent the word number. For example, to read the 5^{th} bit of word 3, the value of NR6 would be $0035.
4. The RECVB instruction can only by executed once in a given scan. To prevent reading over the link network more than once per scan, place the RECVB instruction at the end of the program.

Example

Program Expression



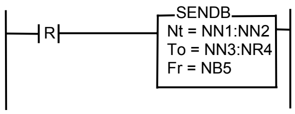
Operation Results

Verify that the first link module has been installed (F3.3) and sent through the first module (F3.10). Then read the 2^{nd} bit of word 1 of register type F (Fr = 7:$0012) from link network 1, station 4 (Nt = 1:4), and write to bit address R2.0 (To = R2.0).

Instruction

Mnemonic	Bit Data Send	Range
SENDB	Bit data send command using the link network	☐ Bit
		■ Word
		☐ Double words

Ladder



NNx: number (1 to 3)
NRx: number/register (in case of number display in hexadecimal)
NBx: STATUS/bit register

Read the bit value of NB5, and write it to link network NN1, station NN2, register type NN3, bit address NR4.

Description

1. NN1: Link network number (number).

   NN2: Station number on the link network (number).

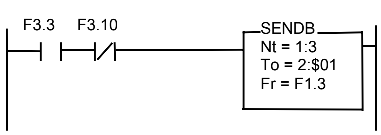
   NN3: Register type to write (number):
   - 0: L register
   - 1: M register
   - 2: R register
   - 3: K register
   - 4: T/C Setting Value (SV)
   - 5: T/C Present Value (PV)
   - 6: W register
   - 7: F register

   NR4: Bit address to write in hexadecimal form (number/register).

   NB5: Bit value to write (bit).
2. The link network loop number is a number from 1 to 3. The first link module in the base rack is assigned network ID 1, the second is 2, and the third is link network 3.
3. The network bit address to write (NR4) is represented in hexadecimal form, where the low 4 bits indicate the bit number to write (from 0 to F), and the high 12 bits represent the word number. For example, to write the 5th bit of word 3, the value of NR4 would be $0035.
4. The SENDB instruction can only by executed once in a given scan. To prevent reading over the link network more than once per scan, place the SENDB instruction at the end of the program.

Example

Program Expression



Operation Results

Verify that the first link module has been installed (F3.3) and sent through the first module (F3.10). Then write the 1st bit of word 0 of register type R (To = 2:$01) on link network 1, station 3 (Nt = 1:3) with the value of bit address F1.3 (Fr = F1.3).

Testing and Troubleshooting

7

This chapter provides information on testing and troubleshooting the D320 PLC.

This chapter discusses:

- *Testing procedures for the D320 PLC*
- *How to troubleshoot the D320 PLC*

Test Precautions

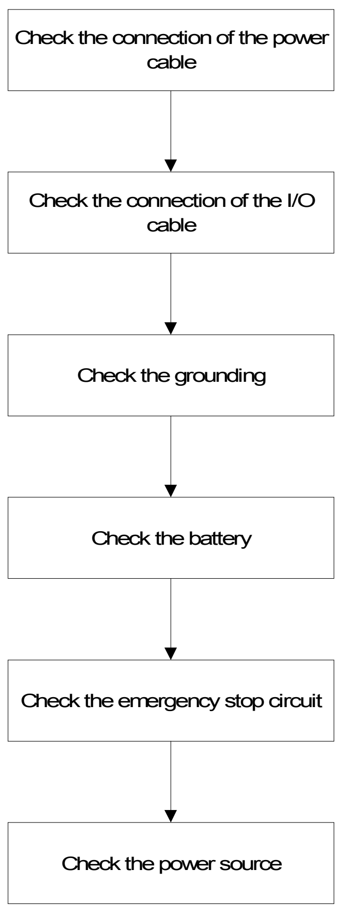
When checking the system:

⚠ **CAUTION:** Always turn off the power whenever you install or remove a module.

1. Check the module more than one time before exchanging the part.
2. Include a complete description of the symptoms when you return a defective module for repair.
3. When you suspect that a contact may be defective, it might only need cleaning. Clean the contact using a clean cotton cloth and alcohol. Then retest the module.
4. Do not use thinner to clean any of the parts.

System Checks

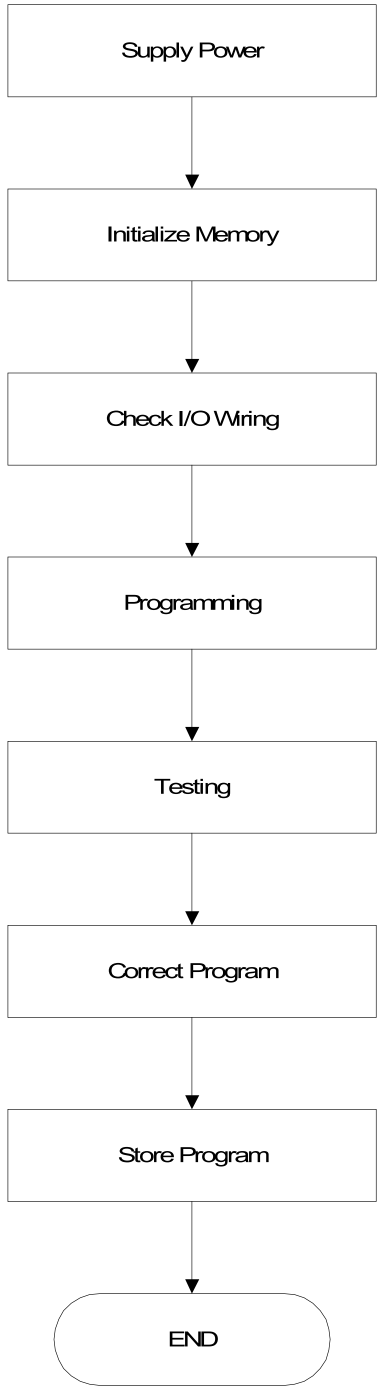
Before installing the I/O wiring of the PLC and supplying power, check the following items.



Item	What to Check
The connection of the power cable and the I/O cable.	• Check that the wiring is secure and intact. • Check that the terminal screws are tightly fastened. • Check that I/O module is firmly fixed. • Check that the power cable connection is secure. • Check that the cable size is correct.
Grounding	• Check that the grounding is triple grounded and separate from other device grounds.
Battery	• Check that the battery is installed into holder on CPU module. • Check that the battery fail (Batt.) LED is not illuminated.
Emergency stop circuit	• Check that the emergency stop circuit for problems external to the PLC is wired accurately, and will IMMEDIATELY disconnect power on demand.
Power source	• Check that the power and voltage sources are within specifications. For 110 VAC (90 to 132 VAC) For 220 VAC (180 to 264 VAC) • Check that the power to the AC input module is within specifications.

Testing Procedures

When the PLC has been installed and wired, begin testing in the following order.

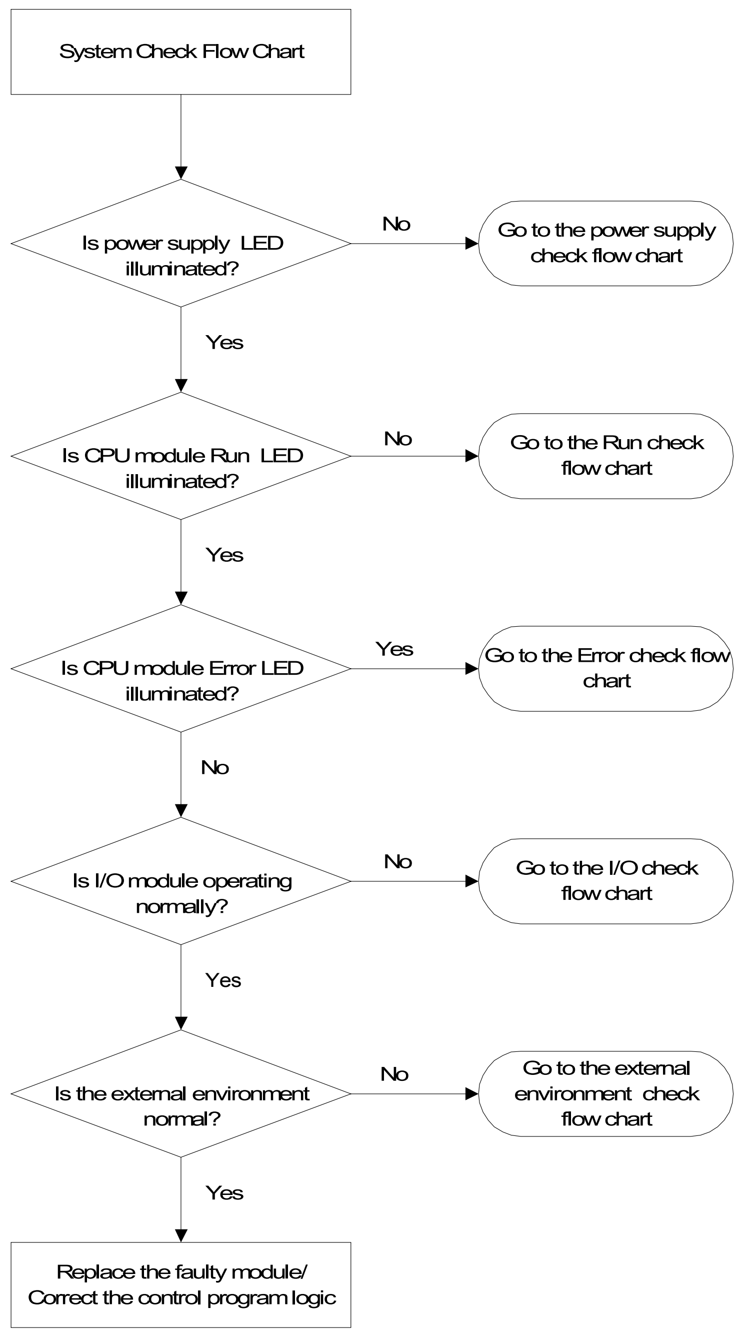


Item	What to Check/Do
Power source	• Check that the input voltage to the power supply is within specification. • Check that the control voltage to the I/O modules is within specification. • Turn on the power source. • Check the LED display of the power module.
Initialize memory	• Initialize the CPU module using GPC. (This clears the program on the PLC.)
Check I/O wiring	• Check the LED of the input modules and use the monitor function of GPC after testing the input device. • Check the wiring of the output by turning the output On/Off using the monitor mode of GPC (set CPU module to Run mode).
Programming	• Check the input program. • Download the program into the CPU module.
Testing	• Check the Run LED for illumination by setting the mode switch of the CPU module to Run. • Check the sequence operation.
Correct programming	• Correct any program errors. • Program is stored.
Store program	• Store the program onto a floppy disk or similar storage device and place in a secure place. • Record the PLC type, program capacity, name of installation, and date for the recorded program. • Print the program (ladder, mnemonic) and store it in a secure place.

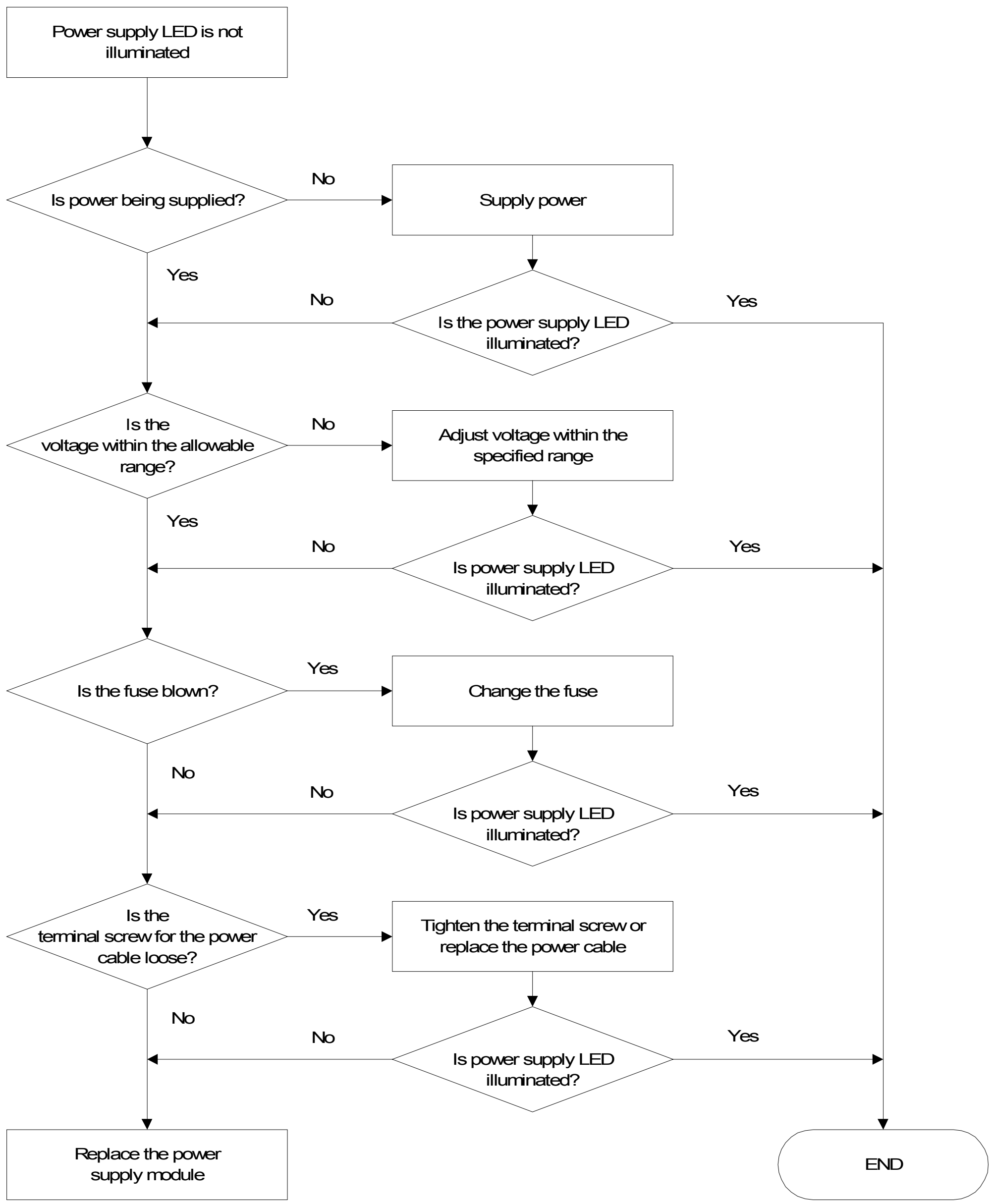
Correcting Errors

System Check

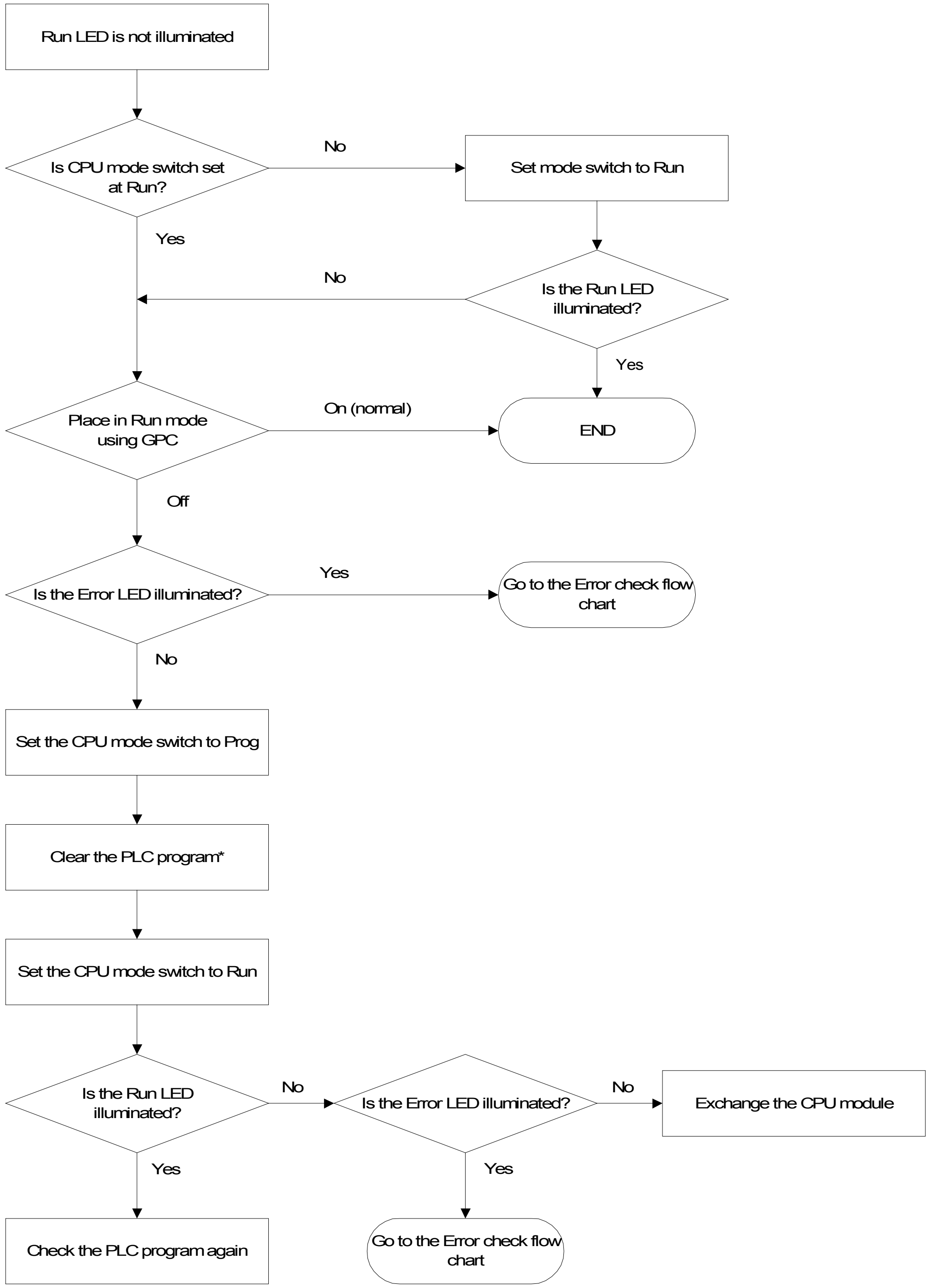
Refer to the system check flow chart when you encounter problems during startup and testing.



Power Supply Check

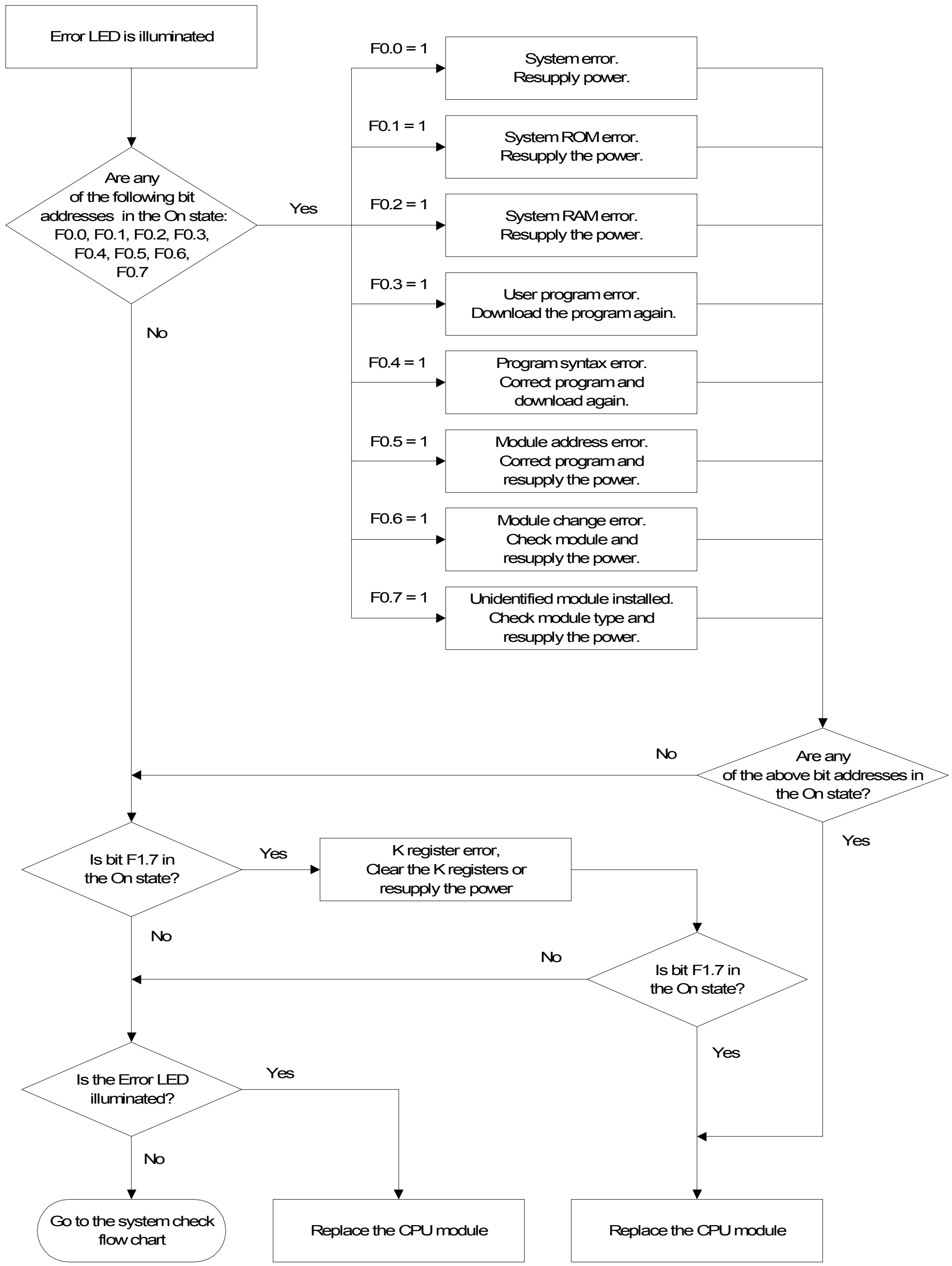


Run Check



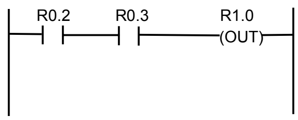
*Be certain to save the program before clearing the PLC program so it is not lost.

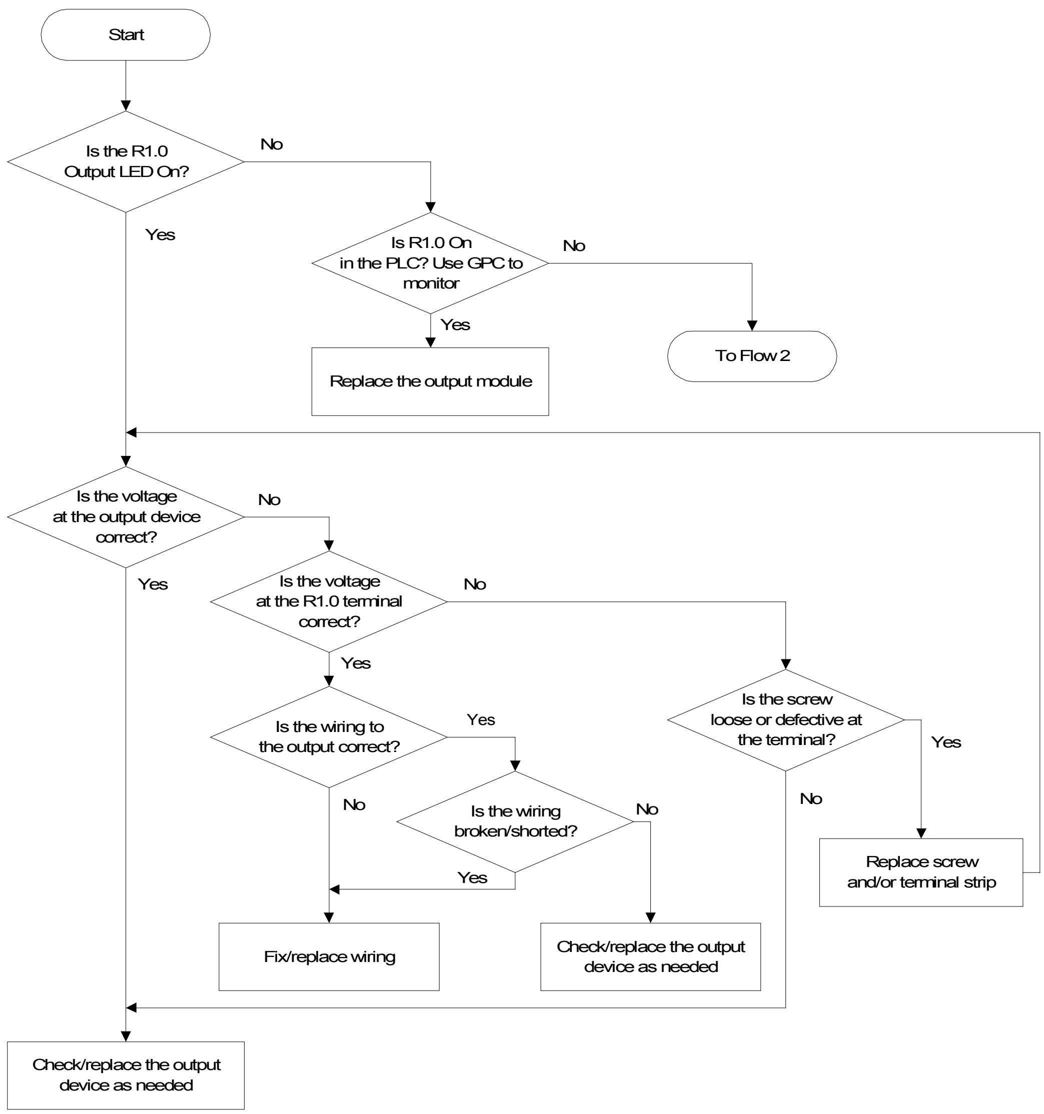
Error Check

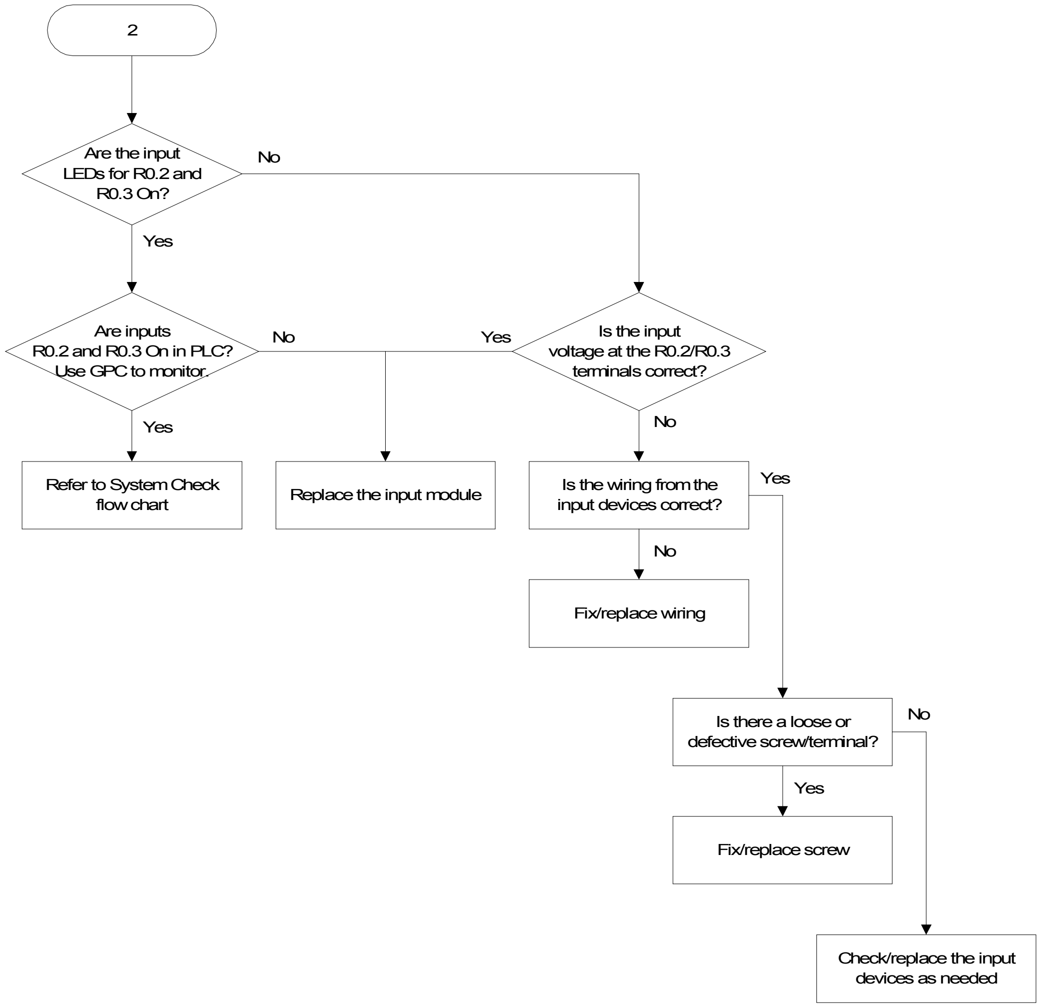

Error LED is illuminated
Are any of the following bit addresses in the On state: F0.0, F0.1, F0.2, F0.3, F0.4, F0.5, F0.6, F0.7
Yes
No
F0.0 = 1
System error. Resupply power.
F0.1 = 1
System ROM error. Resupply the power.
F0.2 = 1
System RAM error. Resupply the power.
F0.3 = 1
User program error. Download the program again.
F0.4 = 1
Program syntax error. Correct program and download again.
F0.5 = 1
Module address error. Correct program and resupply the power.
F0.6 = 1
Module change error. Check module and resupply the power.
F0.7 = 1
Unidentified module installed. Check module type and resupply the power.
Are any of the above bit addresses in the On state?
No
Yes
Is bit F1.7 in the On state?
Yes
K register error, Clear the K registers or resupply the power
No
Is bit F1.7 in the On state?
No
Yes
Is the Error LED illuminated?
Yes
No
Go to the system check flow chart
Replace the CPU module
Replace the CPU module

I/O Check

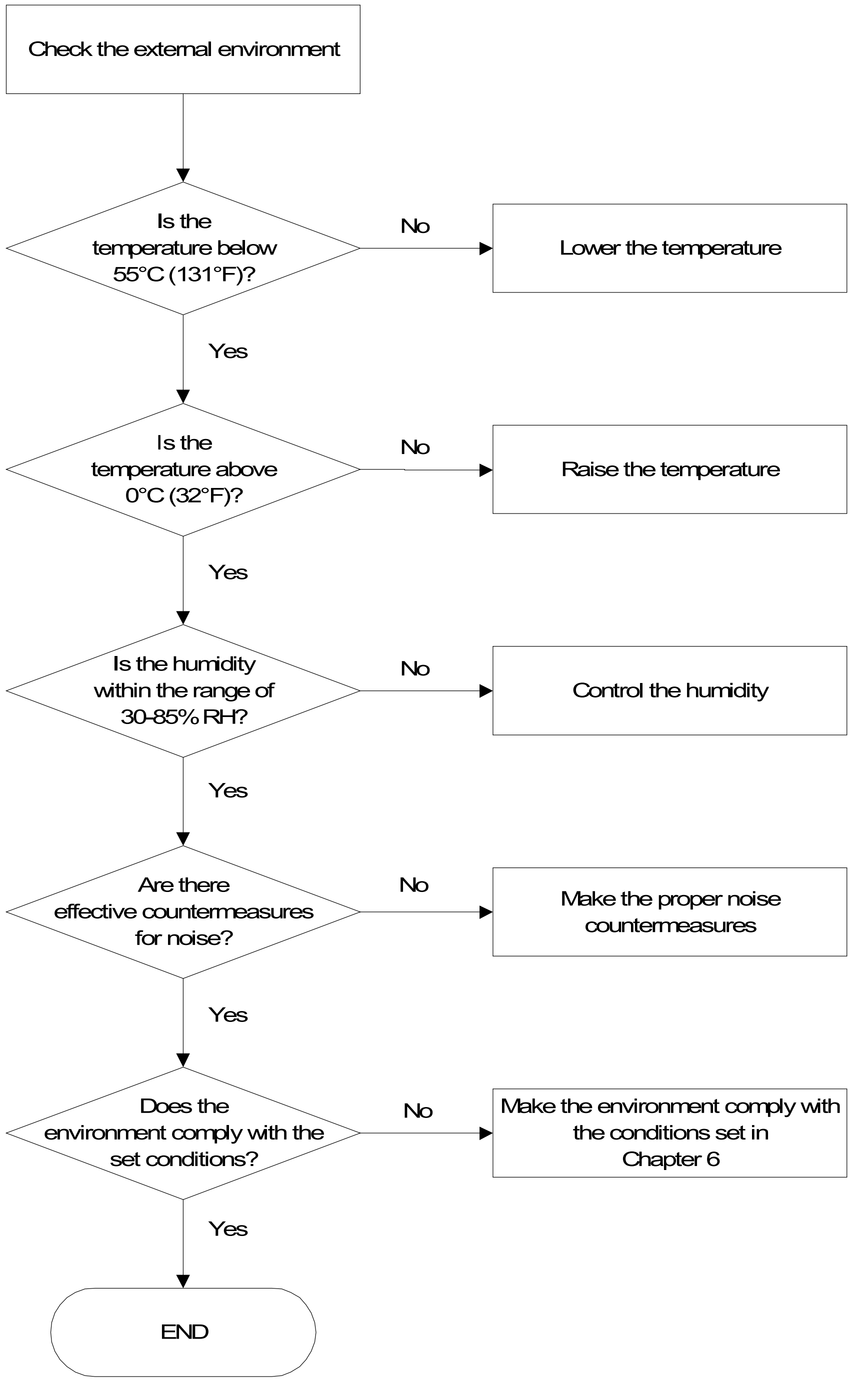
This page presents an example of a troubleshooting procedure to follow when errors are encountered with the external I/O. In this example, a digital input module is located in slot 0 (R0), and a digital output module is located in slot 1 (R1). This flow chart is based on the following circuit, and assumes that the error encountered is that the output connected to R1.0 is not turned On when it should be.






2
Are the input LEDs for R0.2 and R0.3 On?
No
Yes
Are inputs R0.2 and R0.3 On in PLC? Use GPC to monitor.
No
Yes
Is the input voltage at the R0.2/R0.3 terminals correct?
Yes
No
Refer to System Check flow chart
Replace the input module
Is the wiring from the input devices correct?
Yes
No
Fix/replace wiring
Is there a loose or defective screw/terminal?
No
Yes
Fix/replace screw
Check/replace the input devices as needed

External Environment Check



Troubleshooting, Maintenance and Inspection Tables

The following tables list some common problems and troubleshooting procedures for the PLC system in the event of faulty operation. Additionally, a table is provided which covers the routine maintenance procedures to be followed to ensure long life of the PLC system with minimum downtime and maintenance cost.

System Operation

Symptom	Expected Cause	Troubleshooting
Power supply LED will not illuminate.	Blown fuse	Replace the fuse.
Power supply fuse blows frequently.	Short circuit/ Defective part	Replace the power supply.
Run LED will not illuminate.	Program errors	Correct the program.
	Power line defect	Replace the CPU module.
Output will not turn to On state during Run.	Short or open circuit	Replace the CPU module.
I/O Modules above a certain address will not operate.	I/O bus error	Replace the backplane.
Not all points on an I/O module operate properly.	I/O bus error	Replace the backplane.

Input Module

Symptom	Expected Cause	Troubleshooting
No inputs on an input module will turn On (LEDs are not illuminated).	No external input power	Supply power.
	Low external input voltage	Make sure full voltage is being supplied.
	Terminal screw is loose/ Defective contact	Tighten screw/ Reconnect the module
Inputs will not turn to On state (LEDs are illuminated).	Defective input circuit	Replace the input module.
One or more inputs on an I/O module will not turn On.	Device connected to input module is defective.	Replace the input device.
	Loose input wiring	Reconnect the input wiring.
	External input time is too short.	Adjust the input module.
	Terminal screw is loose/ Defective contact	Tighten screw/ Reconnect module
One or more inputs on an I/O module will not turn Off.	Defective input circuit	Replace the input module.
Input changes On/Off state erratically.	Low external input voltage	Make sure full supply voltage is being input.
	Noise error	Troubleshoot for noise.
	Terminal screw is loose/ Defective contact	Tighten screw/ Reconnect module
Input display LED will not illuminate (input is On in PLC).	LED error	Replace the input module.

Output Module

Symptom	Expected Cause	Troubleshooting
No outputs on an output module will turn On.	No external input power	Supply power.
	Low external input voltage	Make sure full voltage is being supplied.
	Terminal screw is loose/ Defective contact	Tighten screw/ Reconnect module
	I/O contact connection	Replace the output module.
	Defective output circuit	Reconnect the output module.
One or more outputs on an I/O module will not change to On or Off state.	Output circuit error	Replace the output module.
Output on an I/O module will not turn Off (LED is not illuminated).	Output time too short	Correct the program.
	Defective output circuit	Replace the output module.
Output on an I/O module will not turn Off (LED is illuminated).	Incorrect output load	Replace the output load.
	Loose output wiring	Reconnect the output wiring.
	Terminal screw is loose/ Defective contact	Tighten screw/ Reconnect module
	Output contact error	Replace the output module of the relay.
	Defective output circuit	Replace the output module.
Output on an I/O module will not turn On (LED is illuminated).	Output contact error	Replace the output module of the relay.
	Leakage current to low-current load	Apply leakage current protection (see Chapter 4).
Output on an I/O module will not turn On (LED is not illuminated).	Defective output circuit	Replace the output module.
Output changes On/Off state erratically.	Low external input voltage	Make sure full supply voltage is being input.
	Noise error	Troubleshoot for noise.
	Terminal screw loose/ Defective contact	Tighten screw/ Reconnect module
A set of 8 points on an I/O module operate incorrectly or identically.	Common terminal screw loose	Tighten the screw.
	Defective contact/ Terminal connector	Reconnect the module.
	CPU module error	Replace the CPU module.
Output display LED is not on (output is On to field device).	LED error	Replace the output module.

Periodic Inspection and Preventive Maintenance

The D320 PLC Series requires regular inspection and maintenance for proper operation. The following items should be checked every six months.

Item	What to Check	Criteria	Test Equipment
Supplied Power	Does the voltage measured within the power terminal fall within the specified range?	Voltage must fall within the power module input voltage specifications.	Voltmeter
Environment	Does the temperature fall within the specified range?	0 to 55°C (32 to 131°F)	Thermometer
	Does the humidity fall within the specified range?	Humidity levels below 30% RH.	Hygrometer
	Is there any dust present?	No dust.	Visual
I/O Power	Does the control voltage supplied to the I/O modules fall within the specified limit?	Control voltage must fall within the input and output modules specifications.	Voltmeter
Module Mounting and Wiring	Are all of the modules secure?	All should be firmly secured.	Screwdriver
	Is the connection cable secure?		
	Is the external wiring screw loose?		
Life expectancy of Parts	Contact relay	Electric life: approx. 10K to 300K operations – refer to output module specifications.	
	Battery	3 years at 25°C (77°F)	

Troubleshooting Noise Problems

8

This chapter outlines the various causes of noise that affect the D320 PLC system. Installation tips and troubleshooting methods for identifying noise problems are also provided.

This chapter discusses:

- *The causes of noise*
- *Installation tips for avoiding noise*
- *Methods to identify and resolve noise problems*

Noise Occurrence

Types of Noise

- Radiation noise is transmitted in the form of a magnetic wave. The amplitude of the magnetic wave is measured in Gauss.
- Conduction noise is transmitted through a direct path such as signal wiring or ground connections as a strong, high-voltage surge. This type of noise is measured as voltage, current, or power.
- Normal mode (single ended developed) noise can come through the power and/or the signal cables. This type of noise is not equally distributed across the PLC input terminals.
- Common mode noise can come through the power and/or the signal cables. In this case the noise is close to the same amplitude thus the term common on both leads of the cable.
- Impulse noise is electrical or magnetic energy that has less than a 200 msec pulse duration.
- Surge noise is electrical energy that has a pulse duration of 200 msec to 2 sec.
- Transient noise is electrical energy that has an extremely short duration usually lasting only a few nanoseconds (1×10^{-9}).

Electrical Noise Fundamental Definitions

- Isolation means to physically separate the connection between areas. Isolation is effective for common mode noise.
- Filters are effective against conduction noise such as impulses. Filtering is used to remove normal mode noise and common mode noise that has been imprinted onto the signal or power cables. A low-pass filter passes only low frequency signals. Low-pass filters are classified as either LC (L = inductor and C = capacitor) filters or RC (R = resistor and C = capacitor) filters, according to the electrical parts that form the filter.
- Surge absorbers are devices that protect electronic equipment by clamping down extremely high voltage spikes (lightning strikes) in power cables to a safe level.
- Charge is an excess or deficiency of electrons in an object. When an object becomes charged, a magnetic field forms around the object and can radiate noise as the amplitude of the charge is varied.
- An inductive load is a device which creates a large magnetic field that opposes any change in the voltage applied across the device. Devices that act as inductive loads are relay coils, motor coils, starter coils and actuator coils.
- Stray capacitance and inductance is created during the installation of an electrical system. When excess cabling is left wound up this creates stray inductance in the form of a coil. All cabling inherently has a capacitive rating (so many picofarads per meter). Excessively long cable runs or untrimmed cable lengths or poorly specified cable types can add large levels of stray capacitance.

Sources of Noise

There are three main sources of noise. Some of these sources generate large noise amplitudes. The occurrence time can be very short (impulse type) or continuous (power line induced). Some noise levels can damage the D320 PLC components and peripheral devices.

1. **Noise Generated by Electronic Equipment**
   All electronic devices radiate noise in the form of a magnetic field. The magnetic field is created around the printed circuit board or the wiring of electronic devices due to the flow of electrical current. The amplitude of the magnetic field changes over time due to changes in the flow of the electrical current. The magnetic field strength increases as the amount of the electrical current flow increases.

   As a device crosses the magnetic field, electrical currents will be induced. The induced current could be summed vectorially with the normal electrical currents. In some cases this could cause cancellation of electrical current flow (essentially shutting down the circuit). In other cases this could create large surge currents that cause severe damage to the circuit. In most cases the summation of the currents cause errors in readout and control values. Some sources of this kind of noise are relays, magnetic contactors, inverters, computer monitors, and motors.
2. **Noise from Power Cables**
   When various loads are connected to a single power source the current draw conditions and impedance imbalance can cause unwanted noise. The noise created by these sources can affect other devices connected to the power source, via spikes, sags, reflected high speed switching noise, and ground pulse. This is the most frequent cause of noise in a PLC’s environment.
3. **Noise from Natural Causes and Work Practices**
   Lightning, welding, shared cable trays, “grandfather’d plant wiring,” and static electricity can also be sources of noise.

In the first case, the noise is caused within the equipment and is called internal noise. In the second case, the noise is caused by external factors and referred to as external noise. These two types of noise may also be referred to as artificial system noise.

The noise caused by natural occurrences can not be prevented, but can be controlled. Precautions such as good grounding techniques, surge suppressors, and burying cables underground can help minimize the affect. This type of noise may be referred to as natural noise.

Advised Installation Practices

Shield the PLC

The most common method of shielding, is to install the PLC inside a grounded steel enclosure.

Proper Cable Selection

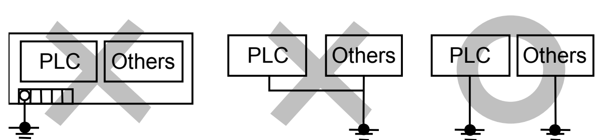
Use twisted, shielded-pair cable for the power cable and field wiring. Properly terminate the shields of all cables to a single-point high-quality ground. (See section on shielding.)

Ground the PLC

The purpose of grounding the PLC is to protect the electronic equipment from electric shock and harmful noise.

To ground the PLC, connect a 12 to 16 gauge wire from the frame ground terminal strip screw of the power supply to a high quality earth ground (less then 2 Ω). Since electrical currents always take the path of least resistance, the noise currents induced by a magnetic field will flow through the PLC frame ground terminal screw to earth ground. This essentially draws the noise away from the PLC modules.

The most effective method of grounding the PLC frame is to ground the PLC independent of other equipment. Avoid grounding the PLC through a daisy chain of wire connections with other equipment. See figures below for good and bad examples:



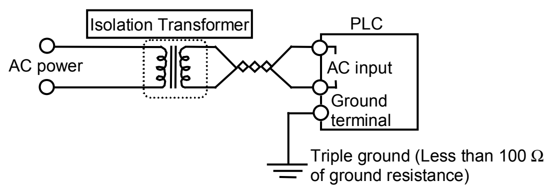
The length of the ground cable should not exceed 65 feet (20 m). For best results, the resistance of the ground cable should be less than 2 Ω. If single grounding is not possible, connect the frame ground terminal of the PLC power supply to the equipment panel metal chassis via one of the PLC rack panel base mounting screws.

Isolation and Filtering Techniques

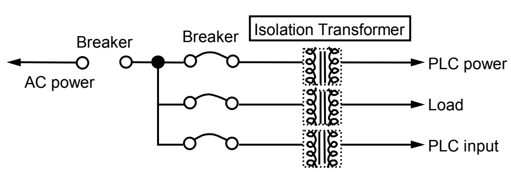
Isolation

There are several methods of isolation:

- Attach an isolation transformer between the PLC power supply and the VAC source to help remove noise that flows in the power cable. Try to attach the isolation transformer as near to the PLC power supply input terminal strip as possible.
- Some isolation transformers come with a shield that can be grounded. This shield, when properly grounded, enhances the transformers ability to remove unwanted spikes.
- Be certain to size the isolation transformer to handle the necessary power rating required by the system. A good practical rule in specifying an isolation transformer is to multiply the required load capability by 1.35 (35% additional deliverable power). This allows expansion of the PLC system at a later date without the immediate need to upgrade the isolation transformer.



- When heavy noise is expected, also use an isolation transformer on the AC control power to the I/O modules and devices. A cost-effective way of specifying the isolation transformer for this requirement would be to specify a transformer with multiple primary and secondary windings and wiring the PLC as shown below. Again, be certain to size the isolation transformer to handle the necessary power required plus a 35% surplus and additional windings to allow for future expansion of the system.



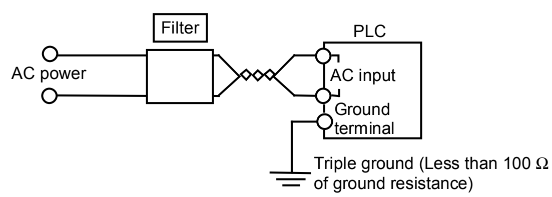
Filters

Filters should be used to suppress high frequency noise.

When using a low-pass filter specify one that is designed for power line applications. Many different types are available from simple modules to complex units.

A single device is not necessarily the most cost-effective device for all applications. In specifying the proper filter one must take into account the amplitude/power level of the noise and how often the noise is present.

When the proper device is selected it is best to place the device as close to the PLC power supply connections as possible. Below is an example of how to install a filter. The chart lists a typical midrange power line filter for reference.



For installation and application details, refer to the manufacturers manuals.

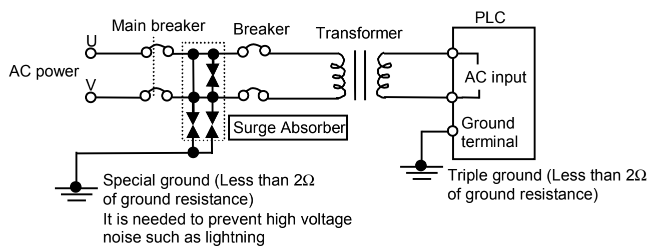
Model Name	Manufacturer	Remarks
PQI-3120N12	Superior Electric, DANA/ Warner Electric Division	Used for 120 V power
PQI-3220N12	Superior Electric, DANA/ Warner Electric Division	Used for 240 V power

The PQI-3120N12 and PQI-3220N12 come in a NEMA 12 rated enclosure.

Methods of Handling Large Voltage Spikes Such as Lightning

Surge Absorber

- A surge absorber reduces the electrical shock to the PLC by taking high-voltage spikes to ground. Attach a surge absorber in the power line in front of the PLC to prevent damage from lightning. The surge absorber will clamp the unwanted high voltage and prevent it from flowing to the PLC power supply. When specifying a surge absorber, the present wiring system must be carefully reviewed. Some surge absorbers are designed to be placed into the main power distribution panel while others are designed to be installed in the field close to the PLC. It is always best to place the surge absorber as close to the PLC as possible.
- Surge absorbers can consist of either series resistors with capacitors that will couple the spike to ground, or Zener diodes that safely clamp the high voltage spikes or MOVs (Metal Oxide Varistors). Some surge absorbers will need replacement after they have suppressed a spike (similar to a fuse). Others can be reset. In specifying a surge absorber consider how often the surges are occurring and the maximum amplitude in volts or joules.



Some typical surge absorbers are listed in the following table. For actual installation and application details, refer to manufacturers manuals**.**

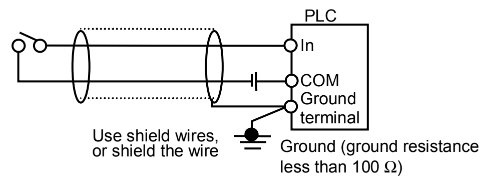
Model Name	Specifications	Manufacturer	Remarks
CHSA	470 V	Cutler-Hammer	120/240 V power
CHSA01	490 V	Cutler-Hammer	120/240 V power

Burying Wire

- Cabling that is strung from pole to pole in free space is an antenna for lightning. When possible bury the cable underground. The earth acts like a shield and absorbs most if not all of the lightning induced noise signals before they are able to reach the cable.

Shielding Cabling

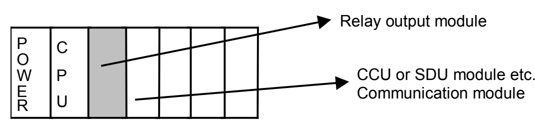
- When the wiring for the I/O module is more than 165 ft (50 m), shield the wire by installing it in ferrous (steel) conduit and use shielded wire. Attach the conduit/shield to the ground at the PLC ground terminal as shown below.



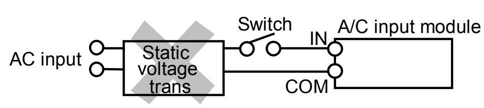
- Separate the input and output module wiring, and power circuit cables. Make sure to properly ground the shields of each cable directly to ground. Do not create a daisy chain of ground jumpers over several feet and then pigtail one end lead to ground. This method allows multiple ground current paths to exist and can induce noise.

Switching Noise/Crosstalk

- The noise caused by the On/Off switching of the relay output module (especially on heavy loads) could affect the CPU module and the communications module. If possible, avoid installing the relay output module next to the CPU or the communication module (CCU, SDU, link modules, etc.).



- Do not use the AC power input to the PLC power supply as the input signal for the AC input module. The waveform could be greatly distorted, due to the switching of the module.

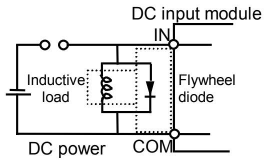


Methods to Handle I/O Inductive Loads

Several methods exist for handling I/O inductive loads.

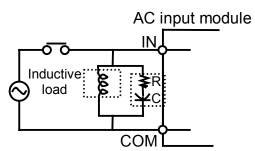
DC Input Module

Attach a diode in a reverse biased direction parallel to the inductive load, as close as possible to the load.



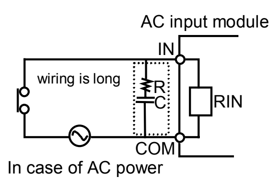
AC Input Module

Attach an RC network parallel to the inductive load.



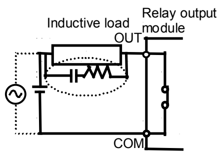
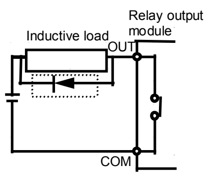
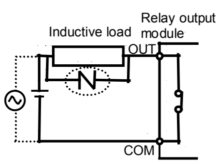
Handling Long Cable Runs

When a long cable run is needed to attach the AC input module to an external input device attach a surge suppressor parallel to the input module. When possible, convert the application so a DC input module can be used instead of the AC input module. The input circuitry of DC input modules inherently have filters that suppress noise and therefore are less affected by the noise from inductive loads and stray wiring capacitance.



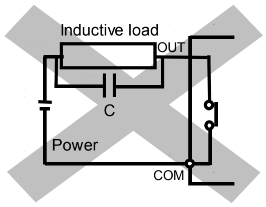
Protecting Against Arcing

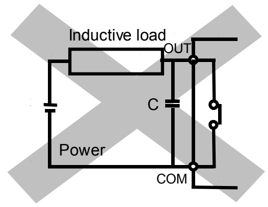
When a relay output module switches an inductive load, a surge voltage measured in thousands of volts is generated across the relay contacts. This causes arcing (an electrical discharge between two contact points that can vaporize the contact material) and shortens the contact life of the relay. Eventually this arcing can destroy the relay contacts. Below is a chart of some methods to protect the relay contacts.

Countermeasures	Application		Characteristics	Selection of Parts
	AC Load	DC Load		
Attach a surge suppressor: 	○	○	If the load is a relay or a solenoid, the load is slow to return to the normal status. When using a DC power source, place the surge suppressor across the inductive load. When using an AC power source, place the surge suppressor across the switching relay contacts. The example shows how to connect the surge suppressor for a DC power source	For a contact voltage of 1 V and a contact current of 1 A, use the following C and R values: C: 0.5-1.0 μF R: 0.5-1.0 Ω Another example; for a contact current of 0.5 A and a contact voltage of 200 VAC use the following C and R values: C: 0.25-0.5 μF R: 100-200 Ω For DC circuits use a minimum of a 250 V rated capacitor. For AC circuits use a minimum of a 1000 V rated capacitor.
Attach a flyback diode: 	×	○	The diode connected in parallel allows the energy accumulated in the inductive load to flow back into the inductive load in the form of an electrical current. The energy is then dissipated as heat based on the resistance of the inductive load. The time required to return to the normal status is longer than the surge suppressor method.	Use diodes with low reverse leakage current and with a reverse voltage value that is at least three times greater than the nominal applied voltage. Verify the diode has the proper power rating. The steady state current that flows when the inductive load is turned on should be greater than the current produced when the inductive load is turned off.
Attach a varistor: 	○	○	A varistor functions as a voltage clamping device. When the applied voltage exceeds the rated voltage value of the varistor, the varistor turns on, creating a short circuit connection across the inductive load. This method has a slow recovery time. When using a DC power source, place the varistor across the inductive load. When using an AC power source, place the varistor across the switching relay contacts.	To specify the varistor do the following: Chose a maximum continuous voltage rating just above the expected applied voltage. Chose a varistor that can handle the energy level that will be generated by the inductive load BUT avoid overspecifying. As the varistors energy level capability goes up so does the capacitance which will slow down the response time of the system.

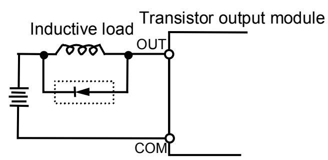
Warning

The following two protection methods should be avoided. Each of these methods can be effective in removing the sparks when power to the inductive load is turned off. However when power is turned on to the inductive load there will be a high inrush current applied across the relay contacts as they are mating. Since all relay contacts have some bounce while mating, arcing will occur and potentially melt the relay contact points. This is the reason for having the resistor in the RC network described earlier.

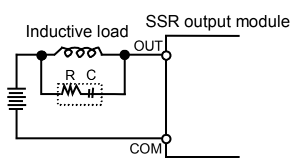




- Transistor Output Module—it is best to attach a flyback diode parallel to the inductive load, as close as possible to the load. In this configuration output switching frequency should be held to less than 20 times per minute.



- SSR Output Module—attach a surge suppressor parallel to the inductive load, as close as possible to the load. In this configuration output switching frequency should be held to less than 20 times per minute.



Troubleshooting

- Noise from magnetic fields induced by other electrical/electronic equipment onto the PLC can be avoided by relocating the PLC during the design process, installing the PLC in a grounded steel enclosure, or attaching a filtering or suppression shield/circuit to the device which is generating the magnetic field.
- Noise from power cables can be corrected by using a different ground for the PLC, an isolation transformer, attaching a line/ground filter, or changing the power wire connection of the PLC so that it is closer to the source of the power, therefore lowering the power source impedance.
- Noise from lightning should be suppressed by use of surge suppressors that are specifically designed to protect electronic equipment from lightning.
- Whenever welding near an electronic device, care must be used to avoid connecting the ground cable of the welder to a ground of the electronic device. One method of protecting the PLC is to disconnect the PLC from power and lifting all power and ground connection. An alternate method is to establish two separate grounds, one for electronic equipment and one for welding. Test the ground separation carefully before having electronic equipment up and running while welding.
- The quickest way to avoid noise from shared cable trays is to have two cable tray runs. One for power and power control cabling and the other for electronic equipment and low level control wiring. Proper cable selection with good shielding properties in some instances will allow both types of cabling/wiring to co-exist in the same tray system.
- “Grandfather’d” plant wiring has to be analyzed on a case by case basis. The best approach is to always install new cabling, conduit, and cable tray runs. Though this may not always be practical, it removes the surprise of high noise and system problems during system startup.
- Static electricity suppression requires good grounding practices throughout the plant. Static electricity is a potential difference developed on a material surface due to the loss of protons or electrons. Since rubbing action can cause the build up of static electricity, the best protection is to have the electronic equipment enclosed in a grounded housing that requires the user to first make contact with a safe discharge path. In high static environments like styrofoam manufacturing or glass manufacturing, electronic equipment should always be protected from static electricity.

External Dimensions

9

This chapter provides the D320 PLC system dimensions. It includes diagrams of the modules with their dimensions.

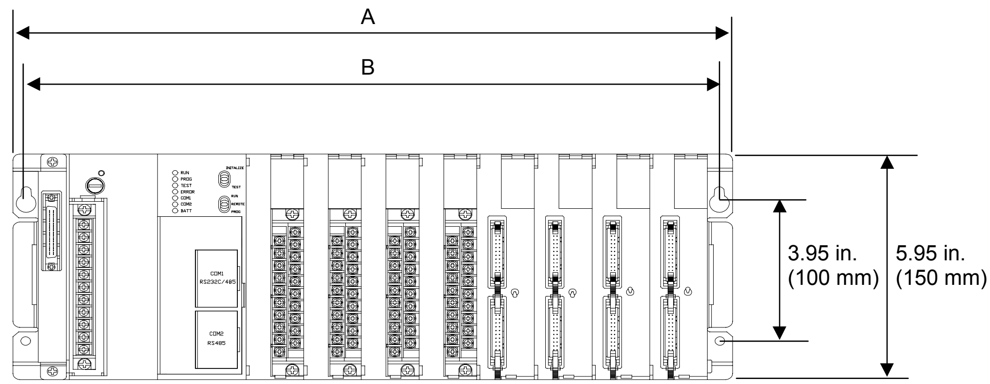
This chapter contains:

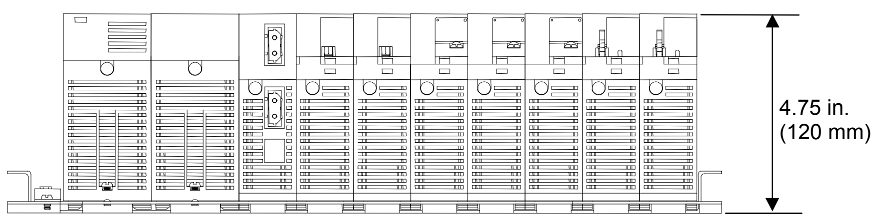
- *The system dimensions*

Note: Dimensions are rounded to the nearest 0.05 inch.

System Dimensions

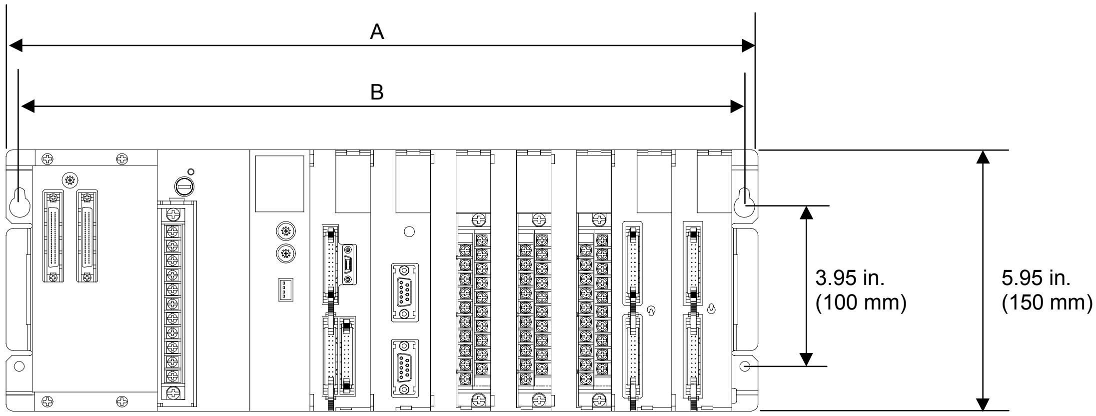
Base Backplane

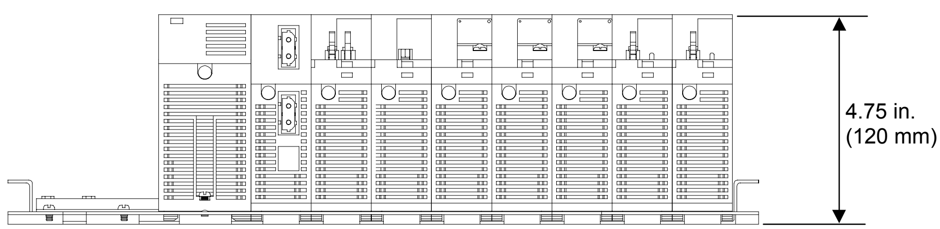




Slot type	Dimension	
	A	B
3 Slot	10.25 in. (260 mm)	9.65 in. (245 mm)
5 Slot	13.0 in. (330 mm)	12.4 in. (315 mm)
8 Slot	17.15 in. (435 mm)	16.55 in. (420 mm)

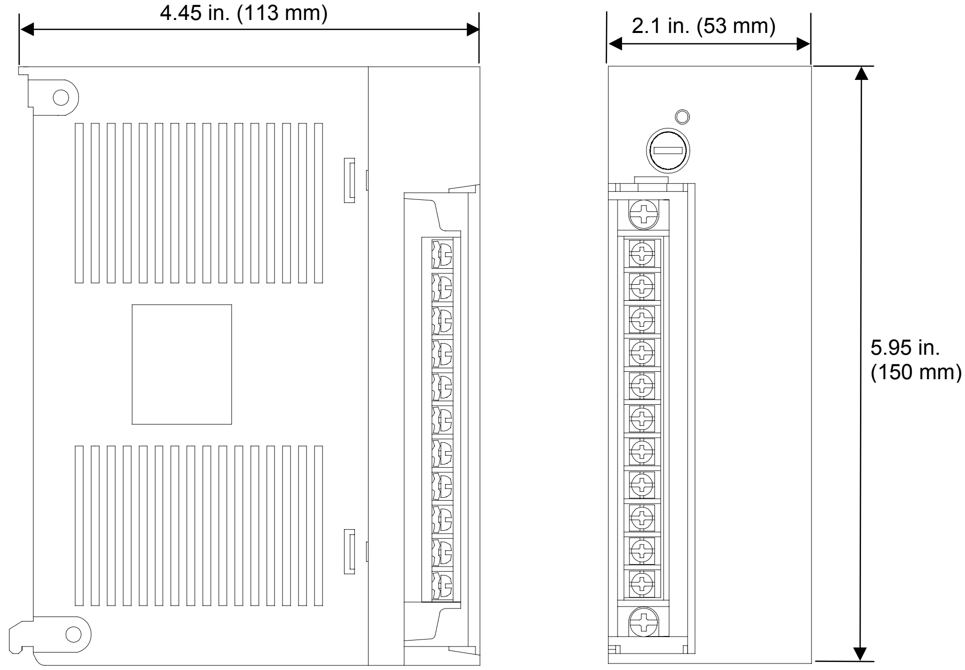
Expansion Backplane



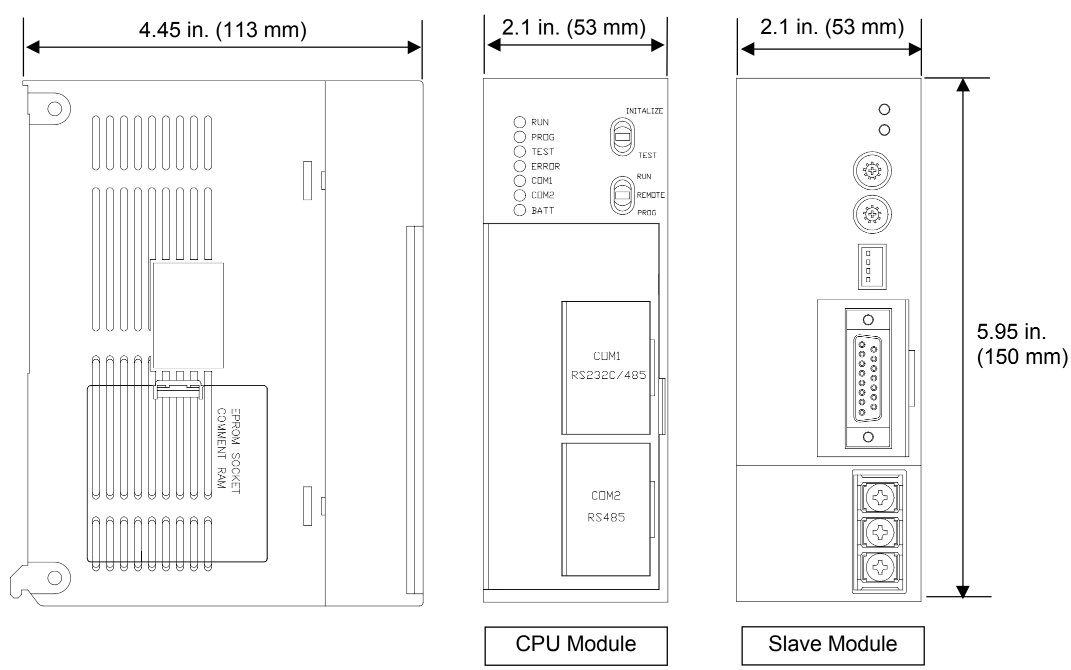


Slot type	Dimension	
	A	B
5 Slot	13.0 in. (330 mm)	12.4 in. (315 mm)
8 Slot	17.15 in. (435 mm)	16.55 in. (420 mm)

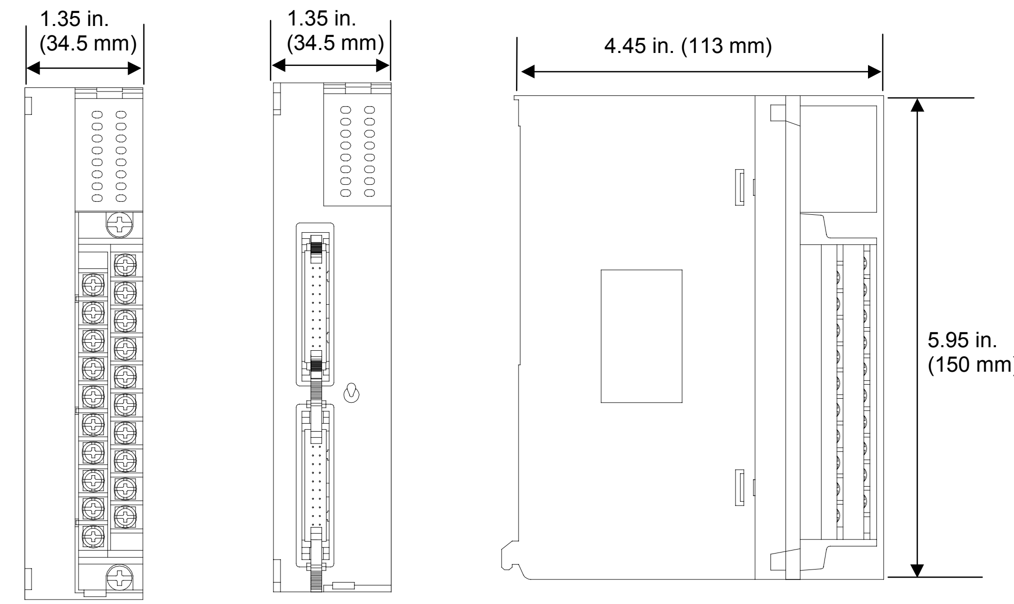
Power Supply Module Dimensions



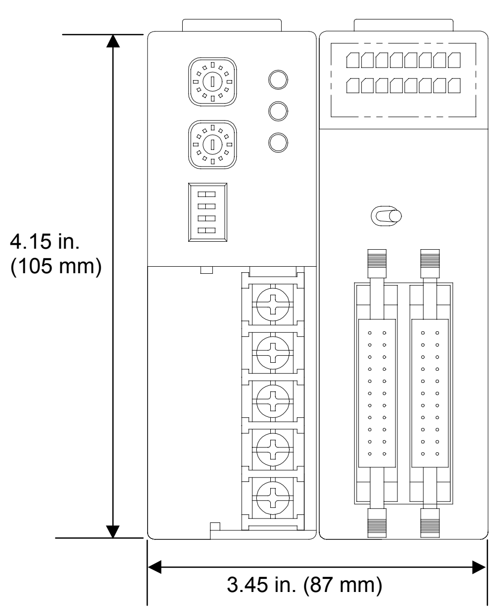
CPU and Remote I/O Slave Module Dimensions



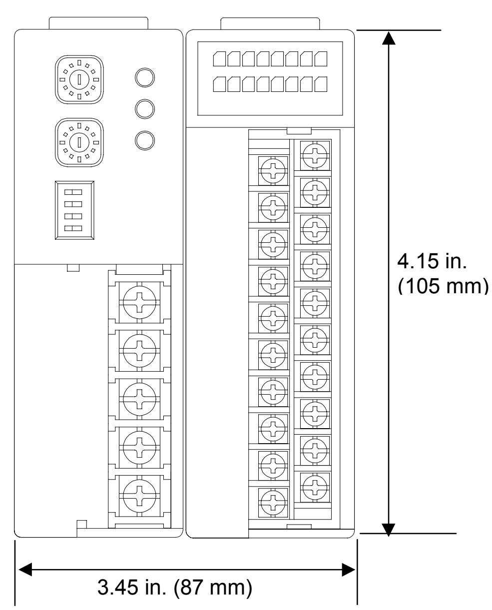
I/O Module and Intelligent Module Dimensions



Integrated Remote I/O Drop Dimensions



32 Point Remote I/O Module



16 Point Remote I/O Module

Appendix A: D320 PLC Communication Protocol

A

The D320 PLC communication protocol provides a simple, yet complete method of communications between the Cutler-Hammer program loader software (GPC) and the PLC. Using the open protocol outlined in this appendix, the user can quickly and easily expand the capabilities of the overall PLC system by communicating to the PLC using a variety of peripheral communications equipment such as operator interfaces and computers. Additionally, the communications protocol allows for multiple Cutler-Hammer D50, D300, and D320 PLC's to communicate to a central computer on a single network using RS-485, at distances of up to 4000 ft (1.2 km).

Communication Rules

Communication Environment

The D320 PLC communications protocol uses the following settings:

- Half Duplex Asynchronous
- No Parity
- 1 Stop bit
- Communication method: RS232C, or RS485
- Communication speed: 9600, 19200, or 38400 bps
- Communication cable: Refer to the cable configuration in Chapter 4.
- Number of PLCs on a single network: Maximum of 64 (communicating 1:N using RS485)
- Maximum communication delay time: 3 sec

Communication Protocol

Step 1—Query (Q)

Set the network ID number for the PLC to communicate with and send a Q signal from the peripheral device to the PLC.

Step 2—Query Acknowledge (QA)

A QA signal is sent from the PLC to the peripheral device, indicating that the Q signal from the peripheral device was received.

Step 3—Response Request (RR)

An RR signal goes from the peripheral device to the PLC, indicating that the QA signal from the PLC was received, and requesting the final data response. This signal is sent when Q→QA is normal.

Step 4—Response (R)

When the PLC receives the RR from the peripheral device, it sends an R signal which gives the results of the original Q signal sent by the peripheral device. The communication cycle for one function code ends when the PLC sends the R.

Step 5—Repeated Response

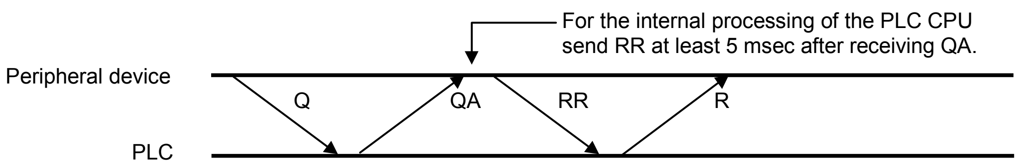
Once the original Q has been sent to the D320 PLC, the R message containing the requested data for that query can be repeatedly received by sending only the RR message again.

Communications Delay

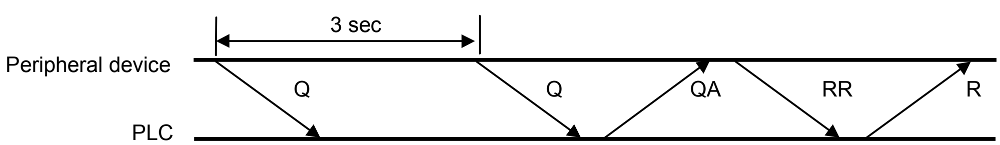
The D320 PLC will return a signal after receiving a Q or an RR within a specific time. However, due to errors in the communications network, CRC values, and communication speed flux, there are occasions when the PLC will not receive the signal from the peripheral device. The peripheral device should allow up to three seconds for a response from the PLC. If there are no responses to the Q or the RR message, the communication is considered to have failed, and the Q or RR should be sent again.

Example

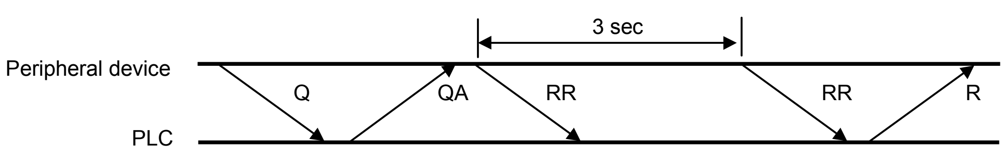
1. No communication error.



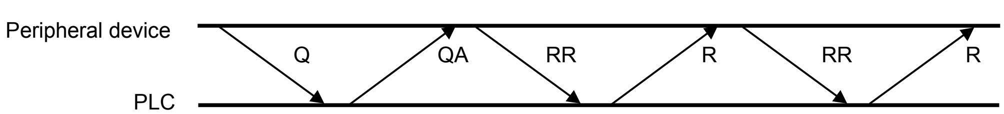
2. When QA is not received.



3. When R is not received.



4. Repeated Response communications.



CPU ID

All devices connected to the network need a network ID number for communication. There is an available range of 0 to 191 network ID numbers. Redundancy is not permitted. When a single PLC and a peripheral device are connected, usually 0, 1, or 255 is assigned as the network ID number to the PLC. When the peripheral device wishes to communicate to a connected PLC regardless of its programmed network ID number, it can use global network ID number 255, to which any PLC will respond. When several CPU modules are connected to one communication network, they must use individual ID numbers from 0 to 191. The PLC's network ID number is configured using the GPC program loader software.

Function Codes Included in the Query

- Each function code is 1 byte. When the PLC receives a query (Q), the function code of the final response (R) is formed by adding $80 (hex) to the function code sent by the query.
- The function code of the R message can be used by the peripheral device to verify that the correct Q message has been received by the PLC.

Communication function
* $ notes hexadecimal notations

Communication Function	Query Function Code	Response Function Code
Read Bits	$01	$81
Write Bits	$02	$82
Read Words	$03	$83
Write Words	$04	$84
Read Bits and Words	$05	$85
Write Bits and Words	$06	$86
Read Program	$07	$87
Write Program	$08	$88
Read Instruction	$09	$89
Change Instruction	$0A	$8A
Change Parameter	$0B	$8B
Insert Instruction	$0C	$8C
Delete Instruction	$0D	$8D
Find Instruction	$0E	$8E
Find Parameter	$0F	$8F
Delete Section	$10	$90
No Service	$00	$00

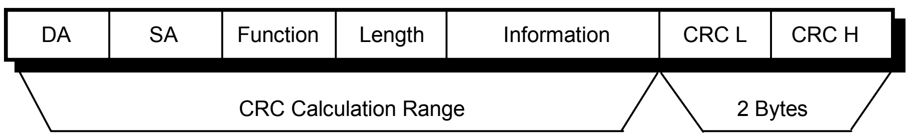
Note: Function codes $07 to $10 are used for programming and system control functions, and are beyond the scope of this manual. Please contact Cutler-Hammer technical support for more information.

Note: The bit/word address assignment uses the absolute address method for reading memory locations. (See Chapter 5 for memory map.)

Cyclic Redundancy Checking (CRC)

- The CRC is a 2-byte checksum that is calculated from the data of every message and then attached to the end of the message by the sender. It is used as an error-checking device to prevent loss or corruption of data during transmission of the message.
- The sender of the message calculates and attaches the CRC when it generates and sends the message. The receiver should also calculate the CRC from the data of the message and compare the calculated value to the CRC that was sent. If the calculated CRC does not match the CRC received, an error has occurred in the message during transmission.

CRC Calculation Range



The following subroutines illustrate the program code required to calculate the CRC for a message. The initial value of the CRC (CRC_Sum) is set to 65535 ($FFFF). Then one of these subroutines would be called once for each byte (data) of the CRC calculation range shown above.

CRC-16 Calculation Subroutine (BASIC)

```
     CRC_Sum: CRC-16 reserve code after the calculation (CRC content to be sent at end of message)
     Data: CRC-16 Data input to be calculated (Byte Data from message)
1000 CRC_Sum = CRC_Sum XOR Data
1010 FOR I=1 to 8
1020 CARRY=CRC_Sum AND 1
1030 CRC_Sum=CRC_Sum SHR 1
1040 IF CARRY=1 THEN CRC_Sum XOR 0A001H
1050 NEXT I
1060 RETURN
```

CRC-16 Calculation Subroutine (PASCAL)

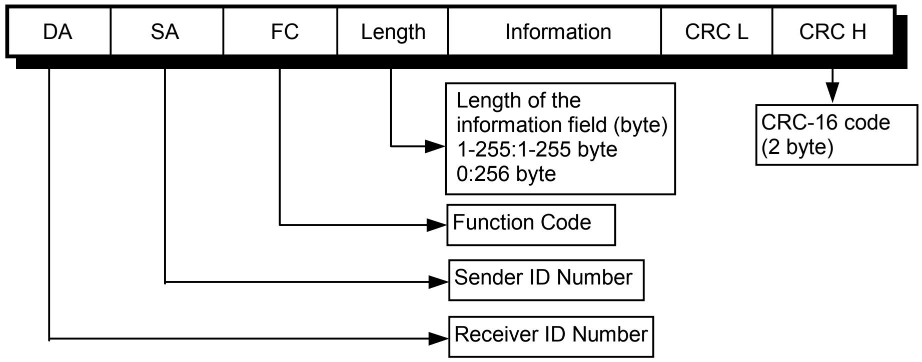
```
Procedure CRC16(Data : Byte)
    Var i : Byte;
Begin
    CRC_Sum := CRC_Sum x or Data;
    for i : 1 to 8 do
    begin
        if((CRC_Sum and 1)=1) then CRC_Sum := (CRC_Sum shr 1) xor $A001;
                                  else CRC_Sum := CRC_Sum shr 1;
    end;
End;
```

CRC-16 Calculation Subroutine (C)

```
void Crc16(unsigned int Data) {
    unsigned int i;
    Crc=Crc^(Data & 0x00FF);
    for(i=0;i<=7;I++) {
        if((Crc & 0x0001) == 0x0001) Crc=(Crc>>1)^0xA001;
        else Crc=Crc>>1;
    }
 }
```

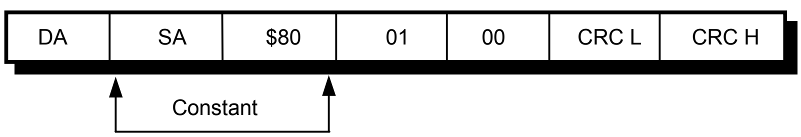
The Structure of the Communications Frame

Query and Response Frame

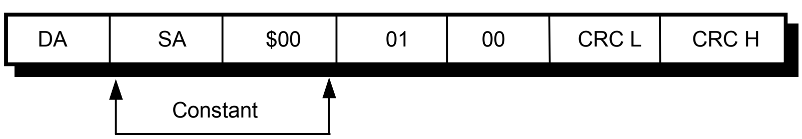


The frame is sent from the source address (SA) by the sender to the destination address (DA), the receiving device. For the query (Q) and the response request (RR), the SA is the address of the peripheral device, and the DA is the address of the PLC to which the message is being sent. For the query answer (QA) and the response (R), the PLC becomes the sender of the message, and so the PLC address is the SA and the peripheral device's address is the DA.

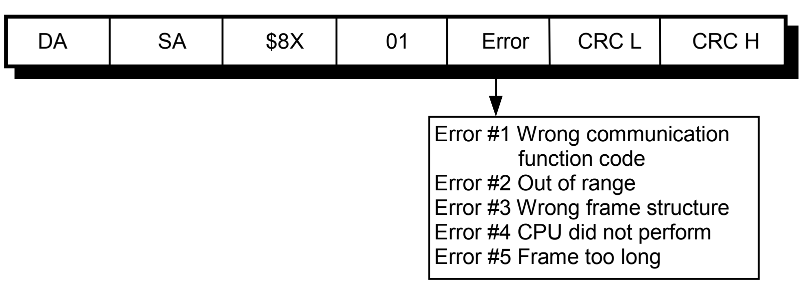
Query Acknowledge Frame



Response Request Frame



Response Frame for an Error

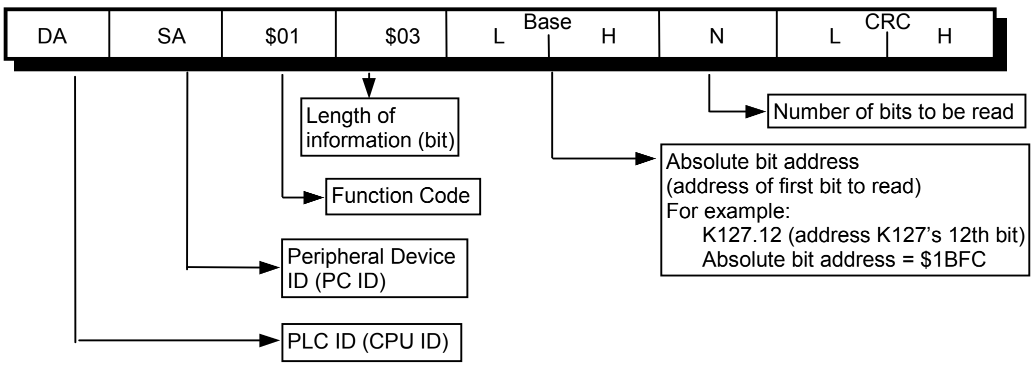


Read Bits

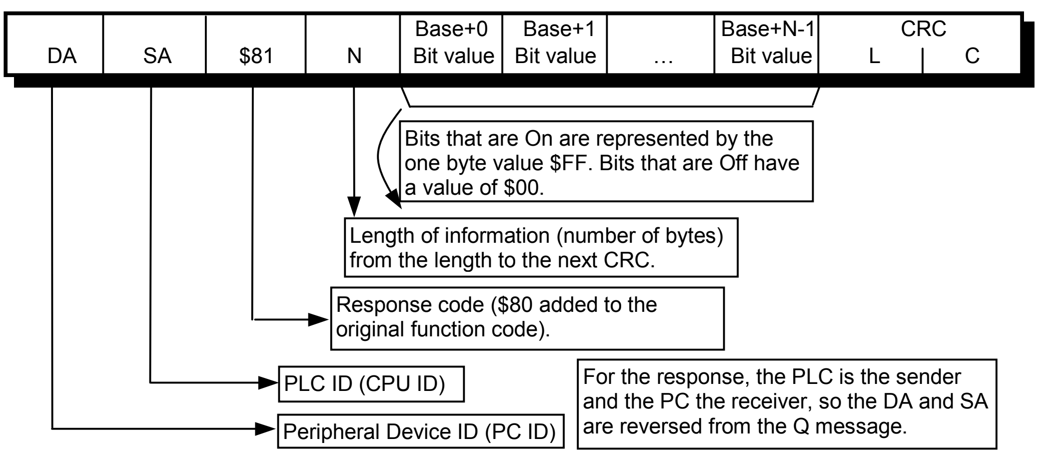
The following can be read:

- Bits stored in the absolute address (R, L, M, K, or F).
- N consecutive bit contents (On/Off).

Query (Q) frame



Response (R) Frame

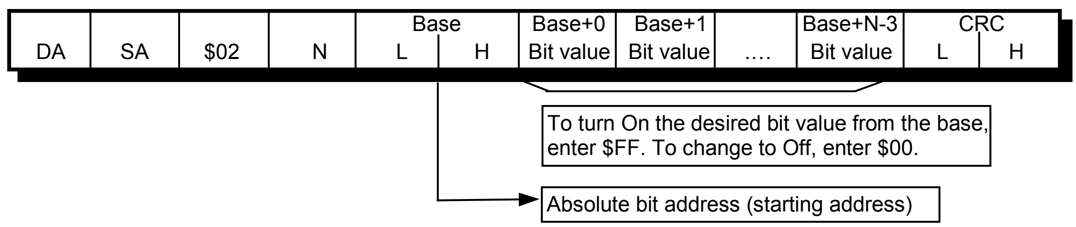


Write Bits

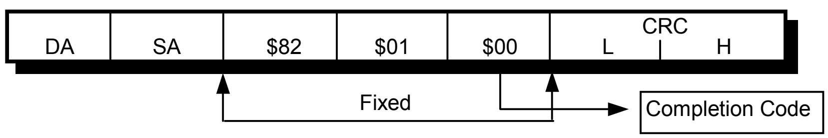
Writing bits allows you to:

- Modify the contents of the bits stored in the absolute address (R, L, M, K, or F).
- Change the bit state between On/Off.
- Change multiple consecutive bytes.

Query (Q) Frame



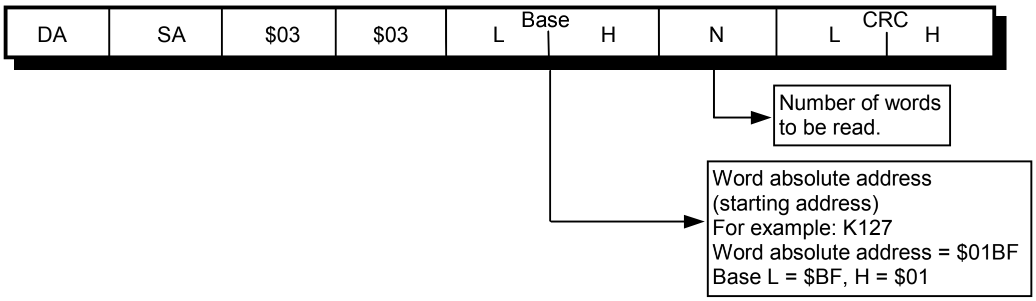
Response (R) Frame



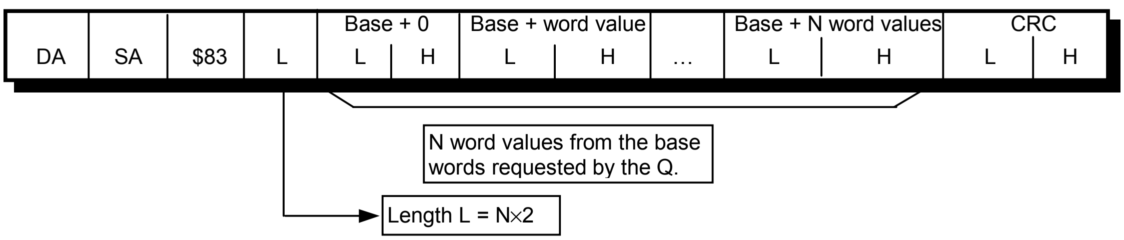
Read Words

- Read the content of the words (R, L, M, K, F, or W) assigned to the absolute address.
- Read n consecutive words.

Query (Q) Frame



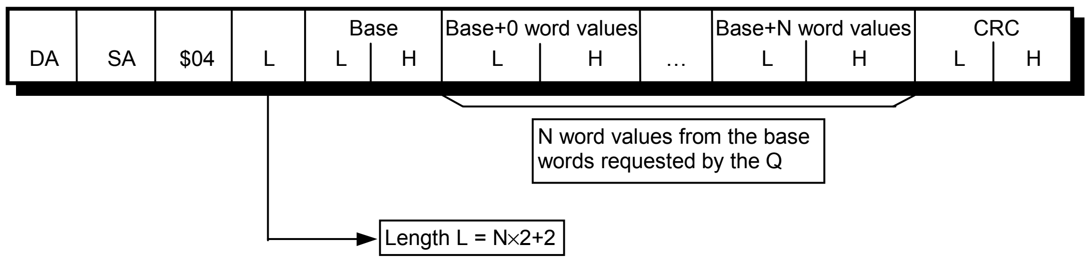
Response (R) Frame



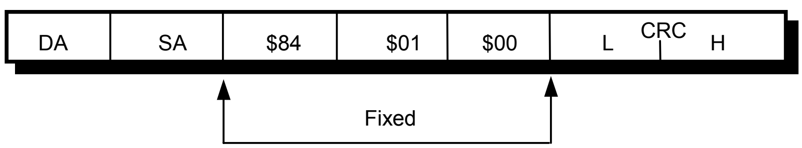
Write Words

- Changes the content of the words assigned to the absolute address (R, L, M, K, F, or W).
- Can change n consecutive word contents.

Query (Q) Frame



Response (R) Frame



Read Bits and Words

- Reads the bits and/or word contents of the specified absolute addresses.
- Can read bits and words regardless of their order and location in memory.

Query (Q) Frame

				AO		A1			AN		CRC	
DA	SA	$05	L	L	H	L	H	…	L	H	L	H

Methods of assigning bit/word abs. address

15	14	13 … 0
		Absolute Address
0	0	Bit Address
0	1	Word Address
1	x	Not Used

Ax = A0, A1,…, An Dx = D0, D1,…, Dn

Assigning absolute address for bits
Abs. address for the K127 12th bit = $1BFC
Ax = 0001 1011 1111 1100
Ax L = $FC, H = $1B
Assigning absolute address for word
Abs. address for the K127 word = $01BF
Ax = 0100 0001 1011 1111
Ax L = $BF, H = $41

Response (R) Frame

					D1			Dn		CRC	
DA	SA	$85	Lx	DO	L	H	…	L	H	L	H

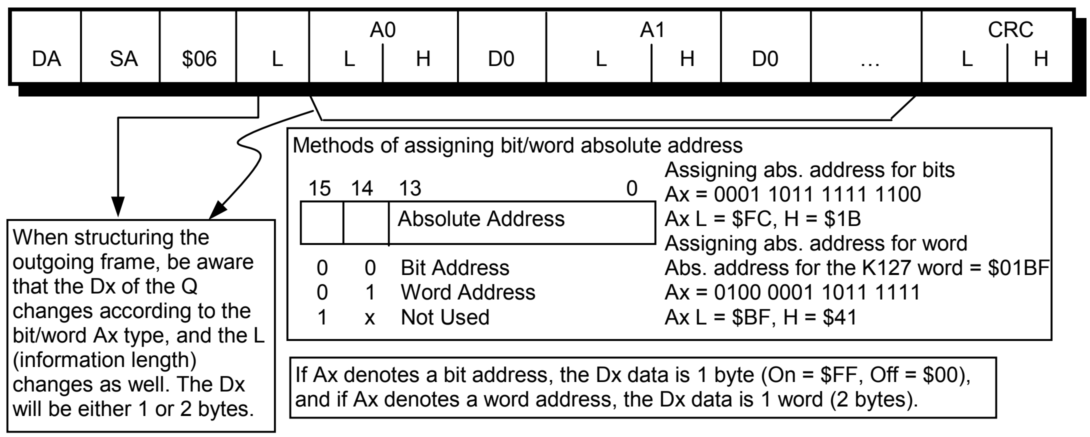
The size and location of the returned data depends on the combination of bit/word addresses requested. The Lx parameter should be checked to verify data size.

For the A0, A1,…, An requested by the Q, the content D0, D1,…, Dn of the word/bit is returned.
If Ax denotes a bit address, the Dx data is 1 byte (On = $FF, Off = $00), and if Ax denotes a word address, the Dx data is 1 word (2 bytes).

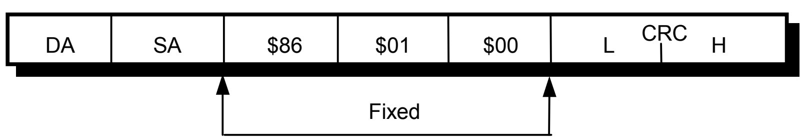
Write Bits and Words

- Changes the content of the bits or words at the specified absolute addresses.
- Words and bits may be modified regardless of their order and location in memory.

Query (Q) Frame



Response (R) Frame



Communication Program Example

The following program is an example program written in C code to demonstrate the D320 PLC open communications protocol. This program consists of a header, the main program, and various subroutines. The buffers and a few variables needed to store the communication data are set as global variables, so that the main function and the various functions may have access. Notes are provided alongside the main program to help explain the exact purpose and function of the individual parts of the program.

Note: This program is provided for illustrative purposes only. It is left to the responsibility of the user/programmer to ensure that any programs written based on, and using the information contained in this program, satisfy the requirements of their particular application.

Program

```
#include <stdio.h>
#include <stdlib.h>
#include <dos.h>
#include <conio.h>


#define PC_ID 0xE2
#define Time_limit 28
#define retrial_limit 2
#define TRUE 1
#define FALSE 0
#define lower_byte(x) (unsigned int) ((x)& 0x00FF)
#define upper_byte(x) (unsigned int) (((x)& 0xFF00)>>8)


typedef int BOOL;
unsigned int PORTADD,DIVISOR,sending_delay, receiving_delay;
unsigned int sending_frame[262],receiving_frame[262];
unsigned int Crc;
unsigned int card,i,ix,iy,smode;
unsigned int port_number;
unsigned int PlcID,OldID;
BOOL Success;
unsigned int data,JobID,retrialC;
unsigned int Old,New,receiving_Index_max,sending_Index_max,index,watchdog;
unsigned int M[128],K[128]; /* Example Register */


void RR_occurring(void);
void Trsport(unsigned int);
unsigned int Recport(void);
BOOL sending_occurring(void);
BOOL receiving_occurring(void);
void Crc16(unsigned int);
void Job(void);
unsigned int communication(void);
void Mword_reading(void);
void Kword_writing(void);
```

Notes

This program was written in Borland C++. It uses the peripheral device (PC) to read the M000 to M127 words, and stores them in the K000 to K127, and then compares the two registry values and indicates the results on the screen using the OK or the FAIL notation. The user may read or manipulate the various communication function codes and the information sent to control the PLC in various ways.

This program consists of a header, the main program and various functions. The buffers and variables needed to store the communication data are set as global variables, so that the main and various other functions may reference them.

By using the COM1 and COM2 ports of the computer, serial communication is possible. By using the GPU-300 card, parallel communication is also enabled (NOTE: The GPU-300 card is not currently offered by Cutler-Hammer).

The Qs, QAs, RRs, Rs are handled in the job functions. If there are communication errors or a frame breakdown, retry 3 times, then issue a communication error.

The procedure of the communication, according to the JobID is:
1. Q sending
2. QA receiving
3. RR sending
4. R receiving
When an error occurs in a frame, a retransmission should be made.

Major operations of the program
1. Adjusts the initial communication port and the board rate for communication. Then initializes the

	variables. 2. Using the communication function codes, reads the data of the M field, reads the word values of the M0 to M127 area and stores them in the K0 to K127 word area. The K registers are the retentive registers. 3. Uses the communication code to read the data of the K area. 4. Compares the values of the M area and the values of the K area, and indicates OK when the values are the same.

void main(void)
{
unsigned int i;
/* Selection of communication port */
clrscr();
printf("PORT : COM1[1]/ COM[2]/ GPC-232[3]/GPC-485[4]/ GPC-Parallel[5] = ");
scanf("%d",&port_number);
if ((port_number < 1) || (port_number > 5)) port_number=5;
/* Selection of Baudrate for Serial communication */
sending_delay=10;
if (port_number != 5)
{
printf("GPC «å BAUD-RATE : 9600[1]/ 4800[2]/ 2400[3] = ");
scanf("%d",&i);
if ((i < 1) || (i > 3)) i=1;
if (i == 3) i=4;
if ((port_number == 1) || (port_number == 2)) DIVISOR=12 * i;
else DIVISOR=40 * i;
receiving_delay=3 * i + 1;
}
	Beginning of the main program
	Select the port of the peripheral device for the communication:
	Serial 9 PIN, 25PIN
	Parallel GPU-300 parallel port
	
	Select board rate:
	9600 bps (max)
	4800 bps
	2400 bps
	Set the communication environment (delay time) for the selected ports.

/* Initialization of GPC card */
if(port_number == 1) PORTADD=0x3F0;
if(port_number == 2) PORTADD=0x2F0;
if ((port_number >= 3) && (port_number <=5))
{
PORTADD=0x300;
outportb(0x303,0xC0);/* Mode=2 of 8255 */
outportb(0x303,0x05);/* PC2=1 of 8255 :Disable IRQ2 */
outportb(0x301,0xFF);/* PB0=1 of 8255 :sending Enable RS-485*/
outportb(0x303,0x01);/* PC0=1 of 8255 :Serial Input Enable*/
if(port_number == 3) outportb(0x303,0x02);/* PC1=0 of 8255 :Select RS-232 */
if(port_number == 4) outportb(0x303,0x03);/* PC1=1 of 8255 :Select RS-485 */
if(port_number == 5) outportb(0x303,0x00);/* PC0=0 of 8255 :Disable SerialInput*/
}
else outportb(PORTADD+0x09,(inportb(PORTADD+0x09)&0xF0));/*Disable Interrupt*/
/* Initialization of USART-Chip : 8250 */
if (port_number != 5)
{
outportb(PORTADD+0x0B,0x80);/* Set of DLAB=1 */
outportb(PORTADD+0x09,0x00);/* Set of High Byte DIVISOR */
outportb(PORTADD+0x08,DIVISOR);/* Set of Low Byte DIVISOR */
outportb(PORTADD+0x0B,0x03); /* parity=None/Stop=1/ Length=8 */
}
/* Processing communication of Read & Write */
for(; ;)
{
	GPC-300 card Setting (8255chip setting):
	Uses the communication card that is connected, and sets the environment according to the PLC communication spec., so that communication is possible. Not currently offered by Cutler Hammer.

printf("----------------\nPLC-ID (CPU ID) :");
scanf("%d",&PlcID);
if(PlcID<256)
	CPU-ID: Input PLC ID (0 to 255)

{
Mword_reading();
Kword_writing();
}
else
exit(0);
}
}
	Read the register value for the M area (M0 to M127)
	Store the value for the M area in the K area (K0 to K127)

void RR_occurring(void)
{
receiving_frame[2]=0;
receiving_frame[3]=1;
receiving_frame[4]=0;
}
	RR (Request Response) request function.

void Trsport(unsigned int data)
{
if (port_number == 5) outportb(PORTADD,data);
else outportb(PORTADD+0x08,data);
}
	Sends data to the communication port.

unsigned int Recport(void)
{
unsigned int dt;
if (port_number == 5) dt=inportb(PORTADD);
else dt=inportb(PORTADD+0x08);
return(dt);
}
	Reads the received data from the communication port.

BOOL sending_occurring(void)
{
BOOL tf;
if (port_number == 5) tf=((inportb(PORTADD+0x02) & 0x80)==0x80);
else tf=((inportb(PORTADD+0x0D) & 0x20)==0x20);
return(tf);
}
	Outputs the data when a send event occurs.

BOOL receiving_occurring(void)
{
BOOL rf;
if (port_number == 5) rf=((inportb(PORTADD+0x02) & 0x20)==0x20);
else rf=((inportb(PORTADD+0x0D) & 0x01)==0x01);
return(rf);
}
	Inputs the data when a Receive event occurs.

void Crc16(unsigned int data)
{
unsigned int i;
Crc=Crc^(data & 0x00FF);
for(i=0;i<=7;i++)
{
if((Crc & 0x0001) == 0x0001) Crc=(Crc>>1)^0xA001; /* 0x0001 : mult-nominal expression */
else Crc=Crc>>1;
}
}
	CRC Calculation:
	Encodes the communication data in the byte stream. When one communication function is complete, it is attached to the most recent frame, or is compared with the attached CRC to check for data errors.

void Job(void) { /* JobID=0 : Change to sending-Mode for Serial port */ /* JobID=1 : Transmit sending-Frame */ /* JobID=2 : Change to receiving-Mode for Serial port */ /* JobID=3 : Address Polling of ACK from CPU */ /* JobID=4 : Receive ACK from CPU */ /* JobID=5 : Change to sending-Mode for Serial port */ /* JobID=6 : Transmit RR-Frame */ /* JobID=7 : Change to receiving-Mode for Serial port */ /* JobID=8 : Address Polling of RES from CPU */ /* JobID=9 : Receive RES from CPU */	**Communication sequence functions**: Job ID=0~4 Q,QA Frame handling Job ID=5~9 RA,R Frame handling

```
/* JobID=10 : Success communication Processing */
switch(JobID)
{
case 0: case 5:if (port_number != 5)
{
if (port_number == 4) outportb(0x301,0xFF);
else outportb(PORTADD+0x0C,(inportb(PORTADD+0x0C) | 0x02));
delay(sending_delay);
}
if (JobID == 5) RR_occurring();
watchdog=0; index=0; sending_Index_max=5; Crc=0xFFFF; JobID++;
break;
```

JobID 0,5:
A frame sends the data from the peripheral device to the PLC. It resets the watchdog and the CRC.
Use a delay after the send to avoid errors due to communications delays.

```
case 1: case 6:if (receiving_occurring()) data=Recport();
if (sending_occurring())
{
if (index<sending_Index_max-1)
{
Trsport(receiving_frame[index]);
Crc16(receiving_frame[index]);
if (index==3)
{
if (receiving_frame[3]==0) sending_Index_max=256+5;
else sending_Index_max=receiving_frame[3]+5;
}
}
else if (index==sending_Index_max-1)
{
receiving_frame[index]=lower_byte(Crc);
Trsport(receiving_frame[index]);
}
else if (index==sending_Index_max)
{
receiving_frame[index]=upper_byte(Crc);
Trsport(receiving_frame[index]); watchdog=0; JobID++;
}; index++;
}
break;
```

JobID 1,6:
Sends the Q and RR data.
When there are no errors, it resets the watchdog and proceeds on to the next sequence.

```
case 2: case 7:if (port_number != 5)
{
delay(receiving_delay);
if (port_number ==4) outportb(0x301,0x00);
else outportb(PORTADD+0x0C,(inportb(PORTADD+0x0C) & 0xFD));
}
JobID++;
break;
```

JobID=2,7:
A sequence that senses the sending of the QA and R data to the peripheral device after the completion of the functions that are received by the PLC from the previous frame.

```
case 3:
case 8:if (receiving_occurring())
{
data=Recport();
if(data==PC_ID)
{
Crc=0xFFFF; index=1; receiving_Index_max=5;
receiving_frame[0]=data; Crc16(data); JobID++;
}
}
break;
```

JobID=3,8:
Handles the received data, and calculates the CRC of the received data.

```
case 4:
case 9:if(receiving_occurring())
{
if(index<receiving_Index_max-1)
{
receiving_frame[index]=Recport();
Crc16(receiving_frame[index]);
if(index==3)
{
if(receiving_frame[3]==0) receiving_Index_max=256+5;
```

JobID=4,9:
Stores the received data in the internal receivable buffer and compares the CRC value sent by the PLC to the calculated CRC value. It notifies the system that a successful communication is made when the two values match, and proceeds on to the next sequence.

```
        else receiving_Index_max=receiving_frame[3]+5;
        }
        }
        else if(index==receiving_Index_max-1)
        {
        receiving_frame[index]=Recport();
        if(receiving_frame[index]!=lower_byte(Crc)) JobID=(JobID & 0x05);
        }
        else if(index==receiving_Index_max)
        {
        receiving_frame[index]=Recport();
        if(receiving_frame[index]==upper_byte(Crc)) JobID++;
        else JobID=(JobID & 0x05);
        }; index++;
        }
        break;
        case 10:Success=TRUE;
        }
        }
```

JobID=10:
Receiving

```
unsigned int communication(void)
        {
        struct time t;
        unsigned  far *tm;
        int ret;
        Success=FALSE;
        receiving_frame[0]=PlcID;receiving_frame[1]=PC_ID; retrialC=retrial_limit;
        watchdog=0; JobID=0; index=0; sending_Index_max=5; Crc=0xFFFF;
        do
        {
        tm=(unsigned far *) 0x046C;
        New=*tm;
        Job();
        if(watchdog>Time_limit)
        {
        watchdog=0; retrialC--;
        JobID=(JobID & 0x05);
        }
        if(!(((Old^New) & 0x02)==0))
        {
        watchdog=watchdog+1;
        Old=New;
        }
        }while((retrialC!=0) && (Success==FALSE));
        if(retrialC==0) ret=1;
        else ret=0;
        return(ret);
        }
```

If the frames that were sent have no response within 3 seconds, assumes it failed communication, and retransfers the data.
The time from the sending and receiving is counted using the watchdog timer. Reset the watchdog timer when a retransfer is being made. No response after 3 retransmissions indicates a communication error. (Normal return value = 0, Abnormal return value = 1)

```
void Mword_reading(void)
        {
        /* Example of Read-Register */
        int  i;
        receiving_frame[2]=3;/* EXAMPLE READ WORD(M000-M0127) */
        receiving_frame[3]=3;/* Number Of Byte For Information = 3 */
        receiving_frame[4]=0xC0;/* BASE(M000=$00c0) */
        receiving_frame[5]=0;/* BASE HIGH  */
        receiving_frame[6]=128;/* Number Of Byte M000-M127 */
        if(communication() == 0)
        {
        printf("READ M0000-M0127 OK - ");
        for(i=0;i<=127;i++) M[i]=receiving_frame[i*2+4] +receiving_frame[i*2 +5]*256;
        }
        else printf("communication error\n");
        }
```

Reading Function of the register M.
Uses the communication function code number 3 (reading N consecutive words) to read the M area.
Note:
Sending frame[4] = The lower byte of the abs. address of the words to be read.
Sending frame[5] = The upper byte of the abs. address of the word to be read.

Abs. address of the M0 = 0x0C0
Note:
Sending frame[6] = The number of words to be read.

	Sends a function code requesting to read the M area, and stores the received data in the buffer.

`void Kword_writing(void)`
`{`
`/* Example of Write-Register */`
`int i;`
`receiving_frame[2]=4; /* EXAMPLE write WORD(K000-K063) */`
`receiving_frame[3]=130; /* Number Of Byte For Information */`
`receiving_frame[4]=0x40; /* BASE(K000=$0140) LOW */`
`receiving_frame[5]=1; /* BASE HIGH */`
`for(i=0;i<=63;i++)`
`{`
`receiving_frame[i*2 +6]= lower_byte(K[i]);`
`receiving_frame[i*2 +7]= upper_byte(K[i]);`
`}`
`if(communication() == 0) printf("WRITE K0000-K0063 OK\n");`
	Writing Function of the K Register. Uses the communication function code 4 (writing N consecutive words) to store the specified value in the K000 to K063 word.
	Note:
	Abs. address of K0 = 0x0140

`else printf("communication error\n");`
`receiving_frame[2]=4; /* EXAMPLE write WORD(K064-K0127) */`
`receiving_frame[3]=130; /* Number Of Byte For Information */`
`receiving_frame[4]=0x80; /* BASE(K000=$0180) LOW */`
`receiving_frame[5]=1; /* BASE HIGH */`
`for(i=0;i<=63;i++)`
`{`
`receiving_frame[i*2 +6]= lower_byte(K[i+64]);`
`receiving_frame[i*2 +7]= upper_byte(K[i+64]);`
`}`
`if(communication() == 0) printf("WRITE K0064-K0127 OK\n");`
`else printf("communication error\n");`
`}`
	Writing Function of the K Register. Uses the communication function code 4 (writing N consecutive words) to store the specified value in the K064 to K127 word.
	Note:
	Abs. address of K64 = 0x0180

Appendix B: PID Loop Control

B

The D320 PLC is capable of simultaneous PID loop control of up to eight loops at a time. This appendix describes in detail the configuration and programming required to properly implement a PID loop control application.

Overview

As small Programmable Controllers gain analog and math capability, the need to perform related functions has increased. One of these functions is closed-loop control or PID. PID stands for **P**roportional, **I**ntegral, **D**erivative control, and comes from the error equation used to perform this type of control:

$$\Delta CV = K_p E + K_i \int E dt + K_d(\Delta E/\Delta t) + Bias$$

A closed-loop system is characterized by an ability to compare the actual value of a process variable (PV) with its desired value (Setpoint SP) and to take the necessary corrective action (Output). The calculations required to do this smoothly are beyond simple arithmetic and comparison functions.

Figure 1 contains a block diagram of a typical closed-loop system.

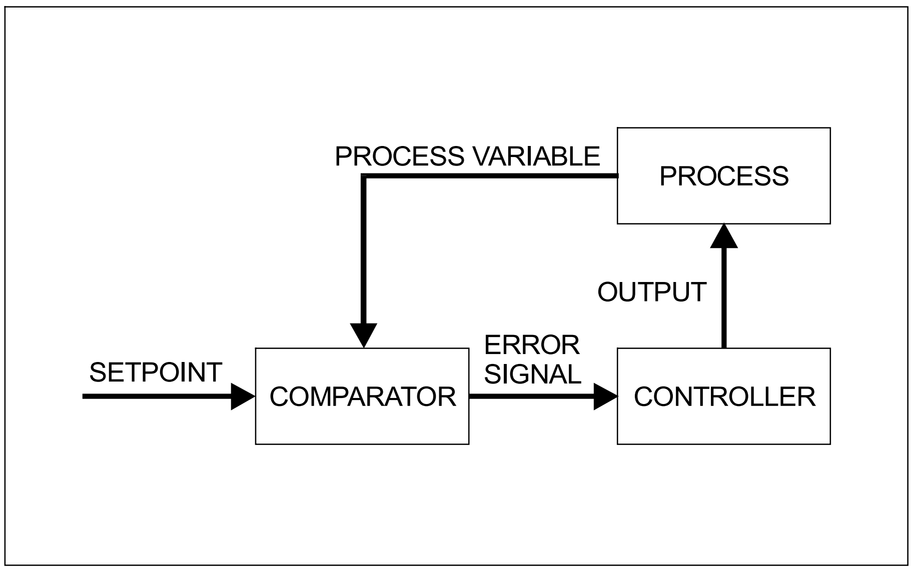


Figure 1. Closed Loop System

The PLC must process the input signals for process variable (PV) and setpoint (SP), calculate the error (E = SP - PV), and change the output, or control value (CV). The PID control function is designed specifically to do this.

PID Algorithm in the D320CPU320

The D320CPU320 (hereafter referred to as the D320) contains the capability of performing PID control on up to eight separate closed loop systems. These loops independently operate on their own process variable, setpoint, and output values.

Each of the PID loops has its own block of 32 register words which defines all of the parameters for that loop, for a total of 256 words for all eight loops. The first word of the 256 word block is defined by the value in System Register 8 (SR008). Each loop is also controlled by setting bits in System Flags F14 and F15. The block list and enable bits are shown in Table 1.

TABLE 1 – PID Block Memory Map

Loop Number	Parameter Block Starting Address*	Control Bits
0	[SR008]	F14.0-F14.3
1	[SR008]+32	F14.4-F14.7
2	[SR008]+64	F14.8-F14.11
3	[SR008]+96	F14.12-F14.15
4	[SR008]+128	F15.0-F15.3
5	[SR008]+160	F15.4-F15.7
6	[SR008]+192	F15.8-F15.11
7	[SR008]+224	F15.12-F15.15

Note: [SR008] indicates the value in SR008. For example, if SR008 holds the value 1000, then Loop 0 starts in W1000, Loop 1 starts in W1032, etc.

Each loop has 4 control bits assigned to it, as shown in the table above. The control bits perform the following functions:

TABLE 2 – PID Loop Control Bits

Bit Number	Description
0	PID Operation/Stop Flag: 1=Operating, 0=Stopped
1	Parameter Setting Error Flag: 1=Range Error, 0=normal
2	CV Value Setting Mode: 1=Manual, 0=PID Loop
3	PID Execution Completion Flag: 1=Complete, 0=Calculating

PID Operation/Stop Flag: This flag defines whether the PID Loop is turned On. When the flag is On, the PID loop is turned On. When this bit is off, no PID loop calculations are performed.

Parameter Setting Error Flag: The D320 PLC checks the value of each PID loop parameter on a continuous basis to verify that the value is not too large or too small. When one of the parameters goes out of range, this error flag is turned On.

CV Value Setting Mode: This bit determines whether the Output Value (CV) of the PID loop calculation is calculated by the PID loop equation, or set to a given constant value (defined by word 14 of the PID loop block – see below).

PID Execution Completion Flag: The PID loop is executed on a constant time basis. While the PID loop is calculating, this bit is set Off. When the PID loop has completed its calculation, the bit is turned On, until the next calculation occurs.

The individual words of the register block define the operating parameters for the functioning of a given PID loop, as well as providing a workspace for the D320 to perform its calculations. These parameters are summarized in Table 3 below.

TABLE 3 – PID Parameter Block

Word #	Description	Type	Abbrev.	Range
0	Status Register	System Output	SR	See Table 3
1	Setpoint	User Input	SP	-327.67 – +327.67
2	Process Value	System Input	PV	-327.67 – +327.67
3	Process Value (Scaled)	System Input	PVs	-327.67 – +327.67
4	Control Value	System Output	CV	-327.67 – +327.67
5	Control Value (Scaled)	System Output	CV	-327.67 – +327.67
6	Control Value Maximum	User Input	CVmax	-327.67 – +327.67
7	Control Value Minimum	User Input	CVmin	-327.67 – +327.67
8	Proportional Term	User Input	Kp	0 – +327.67
9	Integral Term	User Input	Ki	0 – +327.67
10	Derivative Term	User Input	Kd	0 – +327.67
11	FeedForward or Bias	User Input	FF/Bias	-327.67 – +327.67
12	Sampling Cycle Time (unit: 10ms)	User Input	Dt	0.01s – +327.67s
13	Dead Band	User Input	DB	-327.67 – +327.67
14	Manual CV Setting	User Input	CVm	-327.67 – +327.67
15	Reserved	-	-	-
16	Reserved	-	-	-
17	Maximum Scaling Value	User Input	Smax	-327.67 – +327.67
18	Minimum Scaling Value	User Input	Smin	-327.67 – +327.67
19	Number of PID Operations	System Output	-	0 – 65535
20-31	Reserved	-	-	-

As shown in the parameters listed in table 3, there is one special register in each block of parameters, the Status Register (word 0). This register is comprised of bit-level parameters that control and display the status of the PID operation. The bits and their meanings are shown in Table 4.

Table 4 – Status Register

Bit #	Function	Remarks
0	PID Control Algorithm: 0=Independent, 1=ISA	ISA Not Currently Supported
1	Reserved	
2	Normal/Reverse Operation: 0=Normal, 1=Reverse	
3	Output Limiting: 0=No, 1=Yes	Not Currently Supported
4	Reserved	
5	Scaling Mode Setting: 0=Not scaled, 1=Scaled	
6	Derivative Operation Setting: 0=PV, 1=Error	Factor used in Kd term
7	WindUp Function: 0=Disabled, 1=Enabled	Not Currently Supported
8	Deadband state flag	
9	CV Overrange error flag	Not Currently Supported
10	CV Underrange error flag	Not Currently Supported
11	Parameter Setting Range error flag	Not Currently Supported
12	Windup state flag	Not Currently Supported
13	Reserved	
14	Reserved	
15	Reserved	

Parameter Descriptions

Each parameter in the PID Loop data block provides a different function to the PID loop control. The descriptions and purposes for each parameter are listed below.

STATUS REGISTER

Control Bits

Control Algorithm	Defines PID equation used in calculation. Currently, the ISA form is not yet supported, so this bit must be set to 0.
Normal/Reverse Oper.	In Reverse mode (Bit = 1) the PID equation acts in the opposite direction as the process value – that is, a positive error change in PV results in a negative movement in CV. In Direct mode (Bit = 0), the action is in the same direction.
Output Limiting	When this bit is set, CV is limited by CVmax and CVmin. Otherwise, CV will change over the entire possible range (0-32767).
Scaling Mode	When set (Bit = 1), the Process Value and Control Value are scaled to an application specific range, as defined by words 17 and 18 of the PID parameter block. These scaled values are used for the PID loop calculation.
Derivative Term	When set, the derivative term of the PID control equation is based on the derivative of PV with time. When not set, the derivative term is based on the derivative of the error value.
WindUp Function	Enables the reset wind-up control. This can be used to limit an overreaction to a large change in SV, or at startup.

Status Bits

Deadband State	Bit is set when the PV is within the DB range of the SP.
CV Overrange	Bit is set when the calculated CV is above CVmax.
CV Underrange	Bit is set when the calculated CV is below CVmin.
Parameter Setting	Bit is set under the following conditions: PID Block Start Address (SR008) > 1792. Scale Parameter Smin > Smax Kp, Ki, Kd values are < 0. Dt = 0. CV Calculation is above maximum.
WindUp State	Bit is set when the PID calculation is in WindUp (large accumulated error term).

SETPOINT	The desired value for the Process Value (PV).
PROCESS VALUE	The actual value of the input that control is being performed on. In most applications, this will be an analog value that is desired to be at a certain level (SP), such as a water level, temperature, flow rate, etc.
CONTROL VALUE	The automatically or manually calculated value of the PID loop used to adjust the PV. This is normally tied to an analog or digital output such as a valve, solenoid, etc.
CONTROL VALUE MAXIMUM	The maximum allowable value for CV.
CONTROL VALUE MINIMUM	The minimum allowable value for CV.
PROPORTIONAL	The proportional term of the PID loop equation.
INTEGRAL	The integral term of the PID loop equation.
DERIVATIVE	The derivative term of the PID loop equation.
FEEDFORWARD	A bias term applied as an offset to the PID loop equation.
SAMPLING TIME	The amount of time between taking samples of the PV. At this time, a PV is taken, and a new CV is calculated. The D320 then waits for this amount of time before performing the next calculation.
DEADBAND	The acceptable amount of error between the PV and SP. When the error is less than or equal to this amount, no additional adjustment is performed to the CV.
MANUAL CV SETTING	The value to set the CV to when the PID loop is set to Manual Mode (PID Loop Control Bit 2 – see Table 2 above).
MAXIMUM SCALING VALUE	The maximum process value that will be seen. Setting this value allows the PID loop to calculate the full range of CV based on a limited input range. The PV and CV are scaled to reflect the scaling ranges set.
MINIMUM SCALING VALUE	The minimum process value that will be seen. Used with the above parameter to scale the PV and CV for maximum effectiveness.

The remaining parameters of the PID loop parameter block are used by the D320 for calculation of the PID loop equation. These values are carried over from calculation to calculation, and <u>must not</u> be modified by the user program.

PID Example

Description

The difficulties involved with set up of PID loop control include the problem of simulating a real-world closed-loop process. One method of simulating such a process is through the use of an RC (resistor-capacitor) network between an analog input (the process value) and an analog output (the control output value). The RC circuit introduces a response delay between the analog output voltage, and the voltage seen at the analog input, providing a reasonable model of a real-world process.

For this example, a D320 PLC is assembled consisting of the following: 5-slot rack, power supply, D320 CPU, 3 digital I/O modules, a 0-10V Analog Output module, and a 0-10V Analog Input module. Channel 0 of the analog input module is connected to channel 0 of the analog output module by the RC network mentioned above. This configuration is illustrated in Figure 2.

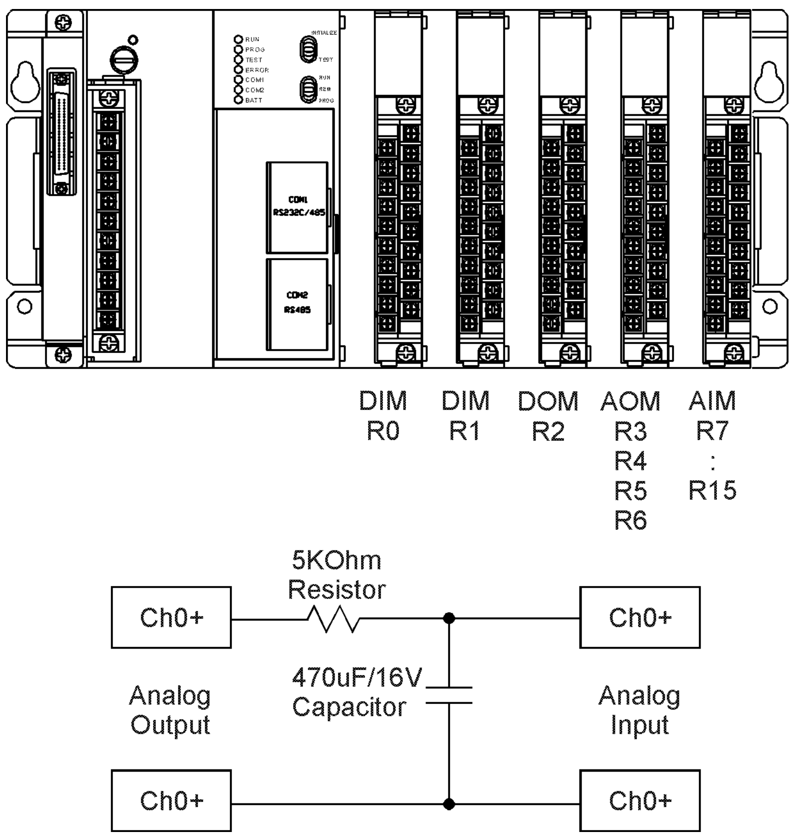


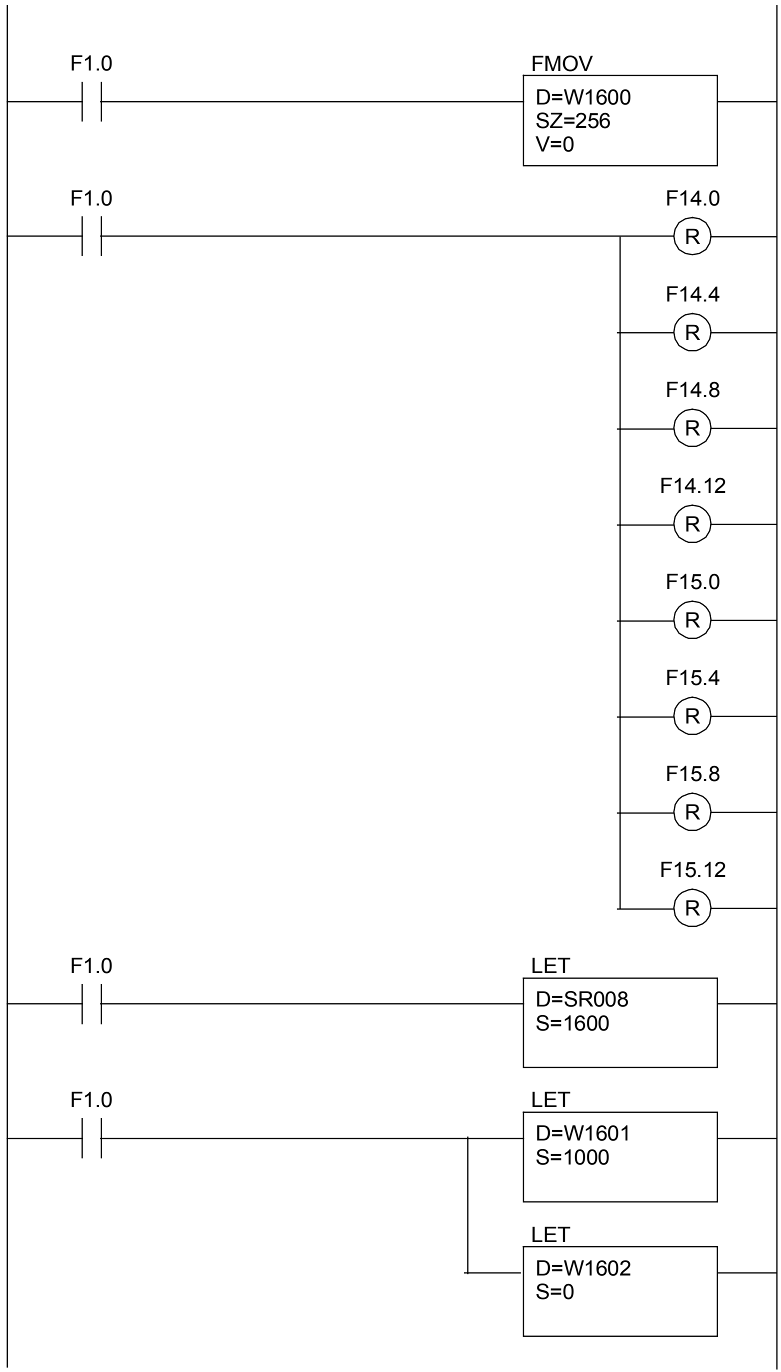
Figure 2. PID Example PLC Setup

Ladder Program

The final step in setting up the example PID loop control application is programming the PLC. The following ladder was generated for the D320 using the Cutler-Hammer GPC5 Programming Software.

Initialization of the PID loop parameters occur in the first scan of the program after power-on or a stop to start transition. This is accomplished through the use of the special “First Scan On” contact F1.0. During every consecutive scan, the analog input value (which comes in through I/O register R7) is stored in the PV register (W1602), while the CV register (W1604) is sent out to the analog output (I/O register R3).

To observe the operation of the PID loop control, simply monitor the PID register block W1600 to W1631, paying special attention to the interaction of the PV, SP, and CV. Changing the SP value will cause the PID loop to recalculate on a continuous basis the necessary CV to achieve the desired PV. Modification of the Proportional, Integral, and Derivative terms will modify the reaction speed and stability of the PID process.

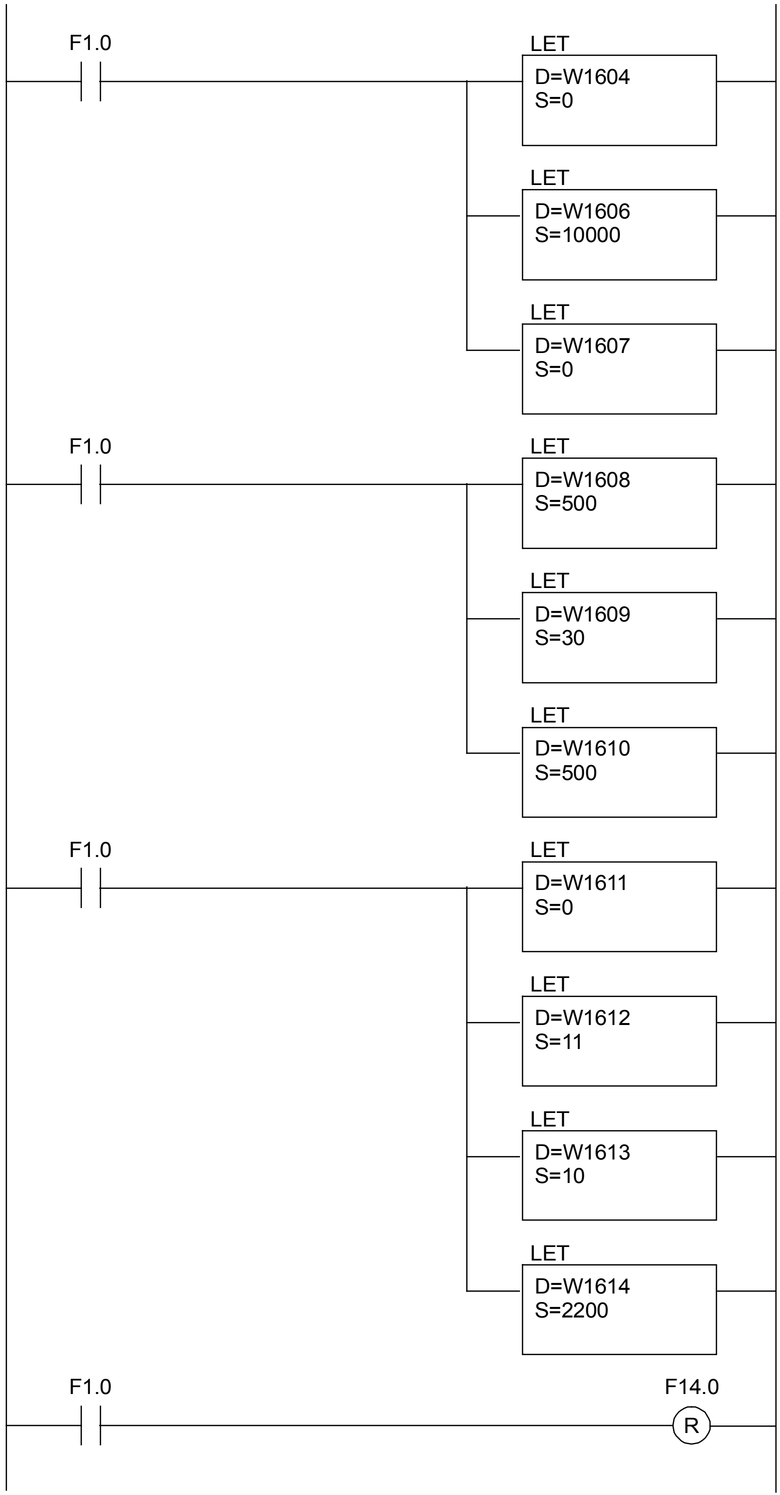


Rung 1:
Initialize the PID Loop Parameter Block (W1600-W1631) to 0's.

Rung 2:
Disable all 8 PID Loops by resetting flags F14.0, F14.4, F14.8, F14.12, F15.0, F15.4, F15.8 and F15.12.

Rung 3:
Set the Starting Address of the PID Loop Parameter Blocks to W1600

Rung 4:
Set the initial values for the Setpoint and Process Variable.

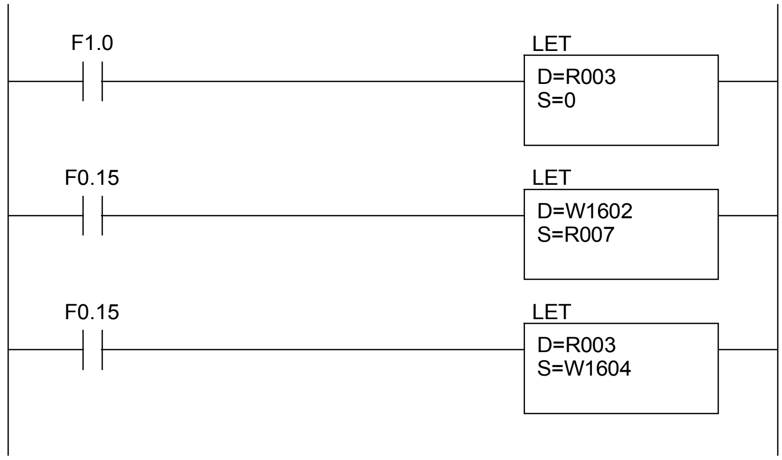


Rung 5:
Set the initial values (Current, high, and low) for the Output Control Variable.

Rung 6:
Set the initial values for the Proportional, Integral, and Derivative terms of the PID Loop equation.

Rung 7:
Set the initial values for feedforward (bias), sample time, deadband, and manual mode output value.

Rung 8:
Enable PID Loop 1 by turning On flag F14.0.



Rung 9:
Initialize Analog Output value to 0.

Rung 10:
Use Analog Input 0 as Process variable.

Rung 11:
Set the Analog Output to the PID Control Output value.

Appendix C: COM2 UDCP Specification

C

The D320 PLC provides two program loader ports for communications. This appendix describes in detail the specifications and operation for the User Defined Communications Protocol capability of the second program loader port, COM2.

Overview

This appendix describes in detail the user-defined communications protocols supported by the second program loader port located on the D320 CPU. Through the use of internal Flags (F) and System Registers (SR), the second port can be configured to support three separate modes of operation; the D320 program loader port protocol (D320 mode), the MODBUS RTU slave protocol (MODBUS mode), and the User-Defined ASCII/Binary transmit/receive protocol (UDCP mode).

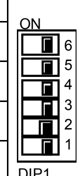
Port Configuration

Communications port #2 on the D320 CPU module is user-configurable for a variety of protocols, baud rates, parities, and so on. The port contains line-driver support for both RS232 and RS485 hardware communications. The CPU auto-detects the incoming signal, and uses the correct hardware protocol as required. Refer to Chapter 4 for a detailed pin-out of the 9-pin D-connector.

Baud rates supported by Comm. Port 2 are 4800 baud to 38,400 baud. The baud rate at which the port communicates is configured through the use of a bank of dip-switches located on the CPU module, between ports 1 and 2. Table 1 shows the proper dip-switch settings for the given baud rate.

Additionally, when using RS-485 communications, the "nodes" at the end of the RS-485 communications network should always be terminated with impedance matching resistors. These "Terminating Resistors" match the natural resistance of the communications line, and prevent reflected voltages from disrupting communications along the line. When the CPU module is at the end of the communications line, dip-switches 5 and 6 can be used to properly terminate the network. See Table 1 below.

Table 1 – Comm. Port Configuration

Switch Number		Switch Position		Function	Diagram
1		Off		COM1, 9,600 bps	
		On		COM1, 19,200 bps	
2	3	Off	Off	COM2, 9,600 bps	
		On	Off	COM2, 19,200 bps	
		Off	On	COM2, 38,400 bps	
		On	On	COM2, 4,800 bps	
4				Not used.	
5	6	Off	Off	Terminating resistors for RS485 communications not connected.	
		On	On	Terminating resistors for RS485 communications connected.	

Configuration Flags

To support the three separate modes of operation for port 2 on the D320 CPU, the processor uses two special internal Flags, F11 and F12. Individual bits in these flags set the mode of operation, trigger communications, indicate status of communications, and configure the port parameters. Table 2 below describes each flag bits function in the operation of the port.

Table 2 – Communications Flags

Flag Bit	Function Description	State Description	
Flag Word F11			
F11.0	Request Transmission	0: No operation	1: Start Transmission
F11.1	Indicates Transmission Failure	0: Normal	1: Transmission Error
F11.2	Enables the Start Code in ASCII mode	0: No Start Code	1: Start Code Enabled
F11.3	Enables the End Code in ASCII mode	0: No End Code	1: End Code Enabled
F11.4	Indicates that a message has been received	0: No message	1: Message Received
F11.5	Clears the Receive Buffer	0: Normal	1: Clear Receive Buffer
F11.6	Indicates a Port Overrun Failure	0: Normal	1: Overrun Error
F11.7	Indicates a Receive Failure (e.g. bad CRC)	0: Normal	1: Receive Error
F11.8	Enable Conversion of ASCII data to Binary	0: Enabled	1: Disabled
F11.9	Ignore Receive Errors	0: Signal Error	1: Ignore Error
F11.10	Enable Parity Setting	0: Disabled	1: Enabled
F11.11	Select ODD or EVEN Parity	0: ODD	1: EVEN
F11.12	Select the Number of Data Bits	0: 7 Bits	1: 8 Bits
F11.13	Select ASCII or Binary Communications	0: ASCII	1: Binary
F11.14	Reserved	Do not use	
F11.15	Enable Automatic CRC mode	0: Disabled	1: Enabled
Flag Word F12			
F12.8	Enable User-Defined Communications (UD)	0: Disabled	1: Enabled
F12.9	Enable MODBUS RTU Communications (MODBUS)	0: Disabled	1: Enabled

Communication System Registers

In addition to the special Flags used to configure communications, a bank of System Registers (SR298-SR373) is provided for holding the data transmitted and received. The descriptions of the system registers are contained in Table 3 below.

Table 3 – Communications Registers

System Registers	Description	Explanation
SR298-SR333	Transmit Data Buffer	Holds up to 36 words of data to be transmitted
SR334-SR369	Receive Data Buffer	Holds up to 36 words of received data
SR370	Transmit Data Length	Number of Bytes to be transmitted
SR371	Receive Data Length	Number of Bytes that have been received
SR372	Start Code	Start code for ASCII Comm.– one byte, high byte unused
SR373	End Code	End code for ASCII Comm. – one byte, high byte unused

Descriptions of Configuration Flags and Registers

Each of the Flags and Registers has a specific purpose, based on the mode of communications. The following paragraphs describe in greater detail the operation and use of each flag and register.

F11.0 REQUEST TRANSMISSION

UDCP Mode. Once the ladder program has filled the Transmit Data Buffer (SR298 – SR333), and set the number of Bytes to send (SR370), the program sets this flag to indicate to the CPU that it is time to send the data. Once the CPU has sent the number of bytes indicated, this bit is automatically reset by the CPU.

F11.1 TRANSMISSION FAILURE

UDCP Mode. If the CPU encounters a failure in transmitting the data indicated (e.g. the number of Bytes to send > 72), this flag is set. This flag is not automatically reset, and must be reset by the user program after each occurrence.

F11.2 ENABLE START CODE

UDCP Mode. In the ASCII mode of communications, it is possible to define a “start code” to signal the beginning of a message. Setting this flag enables the Start Code mode of operation. When set, the CPU will look for the Start Code (SR372) on any message received before storing the data into the Receive Data Buffer (SR334-SR369).

F11.3 ENABLE END CODE

UDCP Mode. In the ASCII mode of communications, it is possible to define an “end code” to signal the end of a message. Setting this flag enables the End Code mode of operation. When set, the CPU will look for the End Code (SR373) on any message being received. When the End Code is received, the CPU stops storing the incoming message, sets the Receive Data Length (SR371), and sets the Message Received Flag (F11.4).

F11.4 MESSAGE RECEIVED

UDCP Mode. When the CPU has successfully received a complete message, this flag is set to indicate to the user program that a new message is available in the Receive Data Buffer (SR334-SR369). This flag is reset by the CPU after the Clear Buffer Flag (F11.5) is set to indicate that the data has been read by the program. Until this flag is reset, no new data can be received.

F11.5 CLEAR RECEIVE BUFFER

UDCP Mode. This flag is set by the user program to indicate to the CPU that the received data has been read. When this flag is set, the Message Received Flag (F11.4) is reset, and the data is cleared from the Receive Data Buffer (SR334-SR369).

F11.6 PORT OVERRUN ERROR

When an error occurs on the Receive port (e.g. more than 72 bytes are received), this flag is set to signal that an overrun error has occurred. The flag will remain set until the user program clears it.

F11.7 RECEIVE FAILURE

This flag is set whenever an error occurs in the received message (e.g. bad CRC, wrong baud rate, etc.). The flag will remain set until the user program clears it.

F11.8 ENABLE ASCII→BINARY CONVERSION

UDCP Mode. When this flag is set by the user program, incoming ASCII text values are automatically converted to their binary values. For example, if the hex word value $3130 is received, the equivalent ASCII characters are “10”. The ASCII→Binary conversion will convert this ASCII data automatically into a single byte value of 10 when it is received.

F11.9 IGNORE RECEIVE ERRORS

UDCP Mode. This flag is set by the user program. Setting this flag disables the detection of Receive errors. All data is received as is, and the Receive Error Flags (F11.6, F11.7) are ignored.

F11.10 ENABLE PARITY

The communications port is capable of being configured for three types of parity checking on transmitted and received messages; odd, even, and none. When this flag is turned Off, the parity is set to None. When this flag is set by the user program, the parity is determined by the Select Parity Flag (F11.11).

F11.11 SELECT PARITY

This flag sets the parity for communications when the Enable Parity Flag (F11.10) is turned On. When this flag is On, Even parity is used. When it is Off, Odd parity is used.

F11.12 SELECT DATA BITS

This flag sets the data bit size for communications. When it is Off, 7 bit communications is used. When it is On, 8 bit communications is enabled.

F11.13 SELECT ASCII/BINARY

UDCP Mode. In the User-Defined Communications mode, the messages can be transmitted and received in either ASCII mode, or binary mode. This flag sets which mode will be used. When the flag is set, all communications are in binary. Otherwise, ASCII communications is assumed.

F11.14 RESERVED

This flag is not currently defined for communications and should not be used or referenced.

F11.15 ENABLE AUTOMATIC CRC

UDCP Mode. The CPU is capable of automatically generating a CRC-16 checksum on communications sent and received. When this flag is turned on, the CPU automatically calculates and appends a CRC-16 checksum to the transmit data stored in the Transmit Data Buffer. Additionally, when data is received, the CPU checks the Receive Data Length (SR371), calculates a CRC-16 on the received data, and compares it to the data received at the end of the receive message. If the CRC does not match, the Receive Error Flag (F11.7) is set.

F12.8 ENABLE USER-DEFINED (UD) COMMUNICATIONS

Setting this flag enables port 2 of the CPU to support ASCII/Binary transmit and receive functions. It also necessarily disables the standard D320 Program Loader Port protocol support on the port.

F12.9 ENABLE MODBUS RTU SLAVE COMMUNICATIONS

When this flag is set, port 2 of the CPU is configured to support the open industry-wide MODBUS RTU slave protocol. Peripheral devices can communicate to the D320 CPU using the standard MODBUS RTU communications for reading and writing data. Setting this flag disables the standard D320 Program Loader Port protocol support for port 2.

Description of Operation – MODBUS RTU mode

When configured for operation as a MODBUS RTU slave (by setting the Enable MODBUS Flag F12.9), the D320 communication port supports the open standard MODBUS RTU slave instructions shown in Table 4 below.

Table 4 – Supported MODBUS RTU Slave Commands

Command	Code (Hex)	Description
Read Coil	01	Read ON/OFF status of logic coil(s)
Read Input	02	Read ON/OFF status of discrete input(s)
Read Holding Register	03	Read value of internal register(s)
Read Input Register	04	Read value of input register(s)
Write Coil	05	Write single logic coil to ON/OFF
Write Register	06	Write value into single internal register
Read Exception	07	Read internal status register (special)
Write Multiple Coils	15	Write multiple logic coils to ON/OFF
Write Multiple Registers	16	Write values into multiple internal registers
Report Slave ID	17	Report Slave node address on network

MODBUS Memory Mapping

When a D320 responds to a MODBUS RTU master message to read or write a coil or register, the address contained in the MODBUS message is directly mapped to the absolute memory address in the D320 PLC. No distinction is made between the memory location of coils, inputs, holding registers, or input registers with regard to the address being requested. For example, a MODBUS Read Coil request from address 0 will reply with a single bit from D320 absolute address 0, and the value of contact R0.0 will be returned. Likewise, a MODBUS Read Holding Register request for 3 registers, starting at address 512, will return the values of D320 memory locations W0, W1, and W2. See Chapter 5 and Table 5 below for a listing of the absolute addresses of the memory locations in the D320 CPU.

Table 5 – Absolute Memory Addresses

		Absolute Address	
Memory Type	Register Addresses	Decimal	Hexadecimal
External I/O	R000 – R127	0 – 127	0000 – 007F
Link Network Relays	L000 – L063	128 – 191	0080 – 00BF
Internal Contacts	M000 – M127	192 – 319	00C0 – 013F
Internal Keep Contacts	K000 – K127	320 – 447	0140 – 01BF
System Flags	F000 – F015	448 – 463	01C0 – 01CF
Data Registers	W0000 – W2047	512 – 2559	0200 – 09FF
T/C Set Value	SV000 – SV255	2560 – 2815	0A00 – 0AFF
T/C Present Value	PV000 – PV255	2816 – 3071	0B00 – 0BFF
System Registers	SR000 – SR511	3072 – 3583	0C00 – 0DFF

Description of Operation – UDCP Mode

When the PLC is configured for the User-Defined Communications mode, the following order of operation should be followed by the user program for Transmit/Receive sequences:

1. Set the proper configuration flags for the mode of operation desired (F12.8, F11.2, F11.3, 11.8, F11.10, F11.11, F11.12, F11.13, F11.15). See Table 2 above.
2. Set the Start Code (SR372) and End Code (SR373) as required by the application.
3. Fill the Transmit Data Buffer (SR298-SR333) with up to 36 words of data to be transmitted.
4. Set the Transmit Data Length (SR370) indicating the number of bytes to send.
5. Set the Receive Data Length (SR371) indicating the expected number of bytes in the response.
6. Set the Request Transmission Flag (F11.0) to begin transmission of the data.
7. When the CPU has finished it will reset the Request Transmission Flag (F11.0).
8. As data is received, it will be placed in the Receive Data Buffer (SR334-SR369). When the number of bytes indicated by the Receive Data Length (SR371) have been received, the CPU will set the Message Received Flag (F11.4).
9. After moving and using the received data as required, clear the Receive Data Buffer (SR334-SR369) by setting the Clear Buffer Flag (F11.5).
10. The CPU will reset the Message Received Flag (F11.4)
11. Repeat steps 3 through 10 as required by the application.

IMPORTANT: When transmitting and receiving data by placing data into and retrieving data out of the send and receive buffers, the data is in low byte, high byte order. The low byte always comes before the high byte. For example, to send the characters “AB” in that order, the “A” is placed into the low byte of SR298, and the “B” is placed into the high byte. Since “A” is ASCII code $41 and “B” is ASCII code $42, the value $4241 is placed into SR298.

The two example programs given below illustrate the usage of the UDCP Mode on the D320 PLC. The first example is a very basic example that demonstrates a simple ASCII Transmit function for printing out a pre-defined error message when an input turns On. The second example is an application demonstrating the use of the UDCP Mode to allow the D320 PLC to act as a master to a network of D50 PLC’s.

Example 1 – Printing an Error Message from an Input

As described above, sending a message out of the COM2 port on the D320 PLC is a very simple procedure. This example illustrates how to send a text message out of COM2 whenever an input condition comes true.

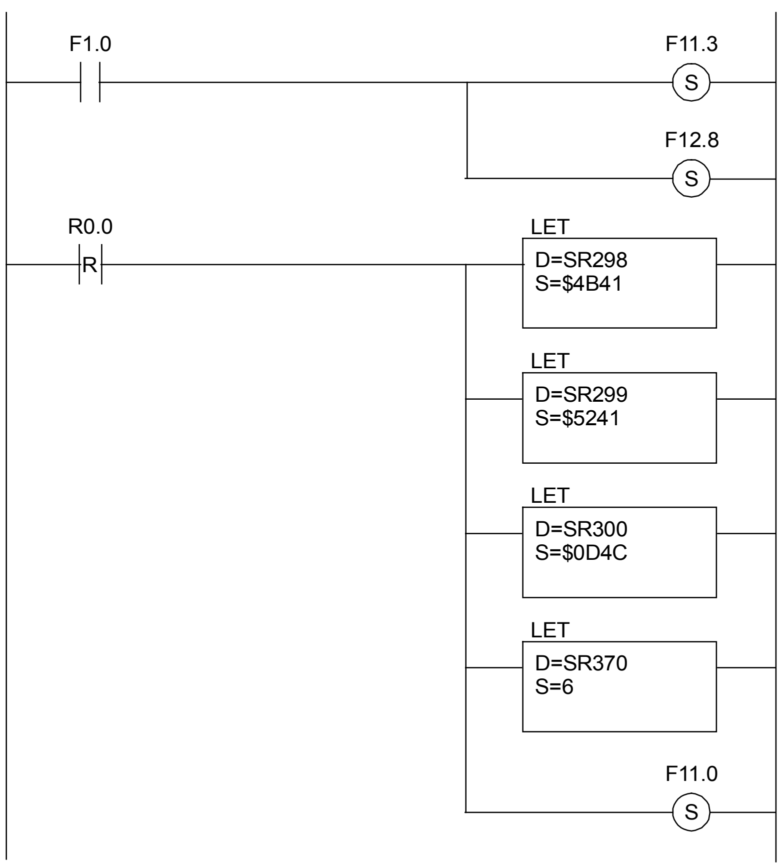
For this example, input R0.0 is defined as an error-condition input. When it turns On, the D320 PLC will print out the simple text string "ALARM" on COM2. The procedure is as follows:

1. Set the COM2 port into UDCP mode. Also, for this example, the carriage return (CR) end code will be used.
2. When the input R0.0 turns On, place the text string "ALARM" into the Send buffer. The string is created using the ASCII codes for each character, as follows:

   "A" = $41
   "L" = $4B
   "A" = $41
   "R" = $52
   "M" = $4C
   CR = $0D

3. Set the Request Transmission flag F11.0 to send the message.

Ladder Program



Rung 1:
This rung initializes the port and communications program by:
F11.3 - Enable End Code
F12.8 - UDCP Mode

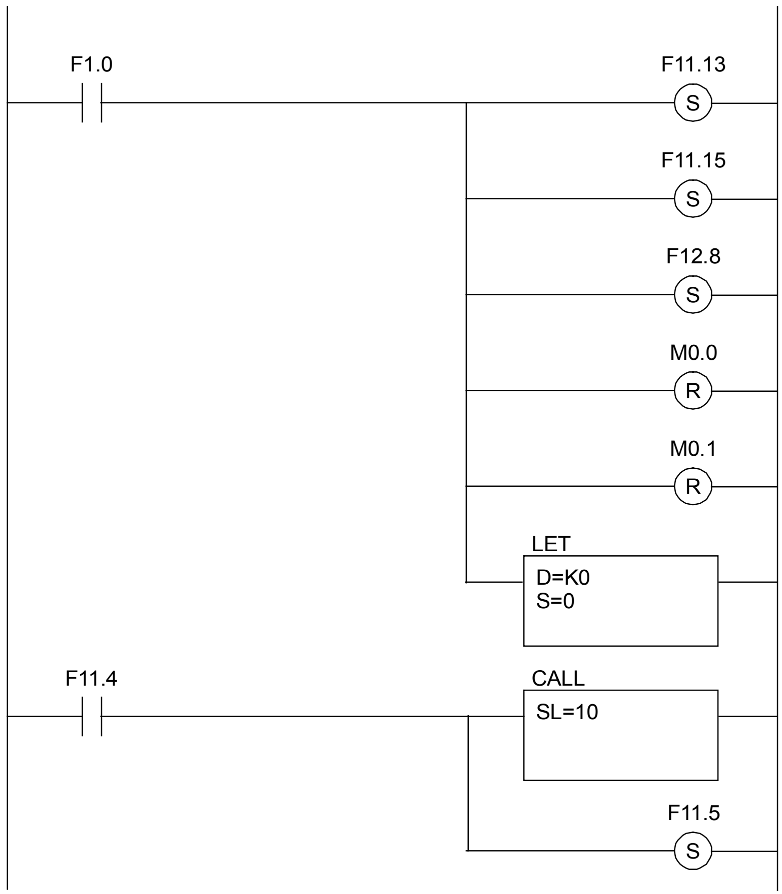
Rung 2:
When input 0 (R0.0) is first triggered, the "ALARM" message is loaded into the Send buffer (SR298 to SR301). Then the Send Request flag F11.0 is set to request the message be sent out by the PLC.

Example 2 – D320 Master on D50 Network

One of the special features of the UDCP Mode is the ability to act as a Master on a network of Cutler-Hammer D50, D300 and/or D320 PLC slaves. Using the Binary mode of communications, in conjunction with the Automatic CRC generation, the second port on the D320 can be programmed to transmit and receive messages to a network of PLC's using the D50/D300/D320 standard program loader port protocol.

The following program illustrates this technique. In the program, a single word of data is continuously transmitted from the D320 master PLC to a single D50 slave node. The message to perform this "Write Word(s)" function is created using the open protocol information available in Appendix A. The protocol information is also available in the D50 Hardware Manual, catalog number D50SA122.

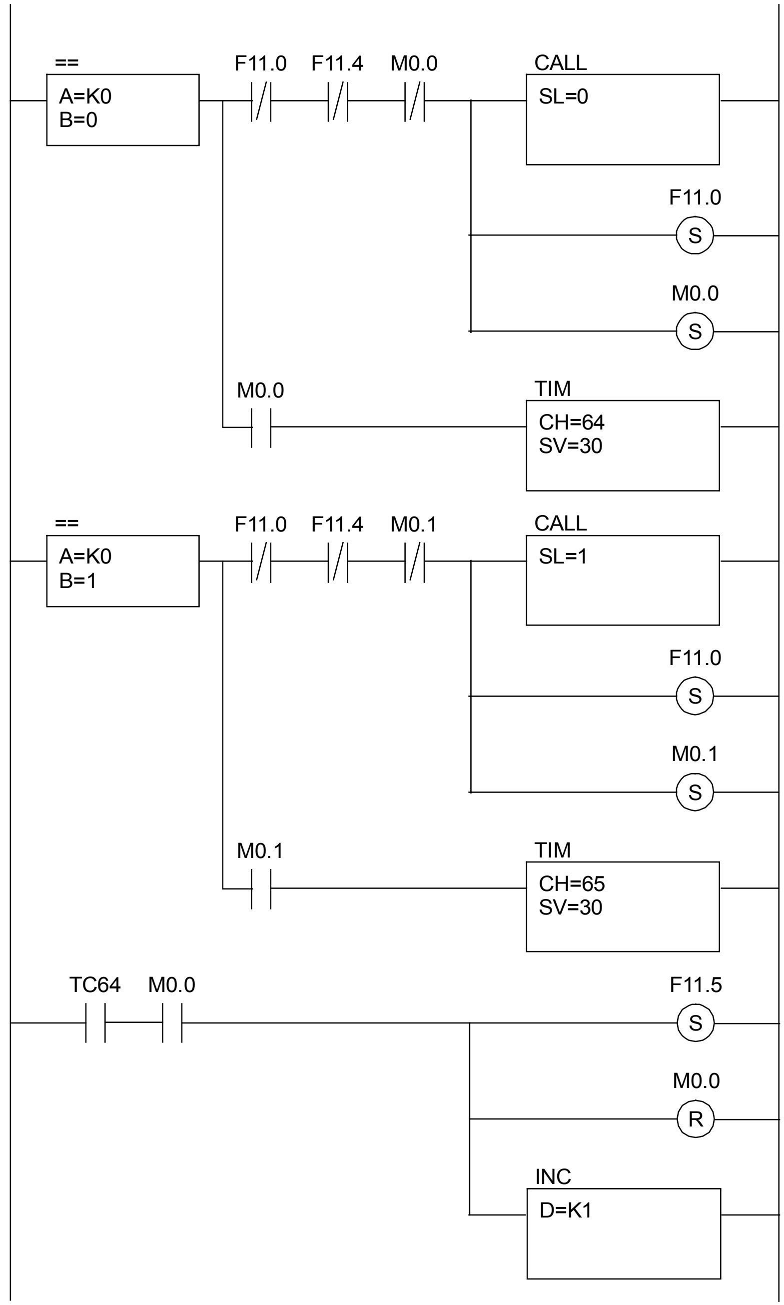
Ladder Program



Rung 1:
This rung initializes the port and communications program by:
- F11.13 - Set Binary Mode
- F11.15 - Enable CRC
- F12.8 - UDCP Mode

Internal contacts M0.0 and M0.1 and internal word K0 are used for proper sequencing of the Query and Response messages.

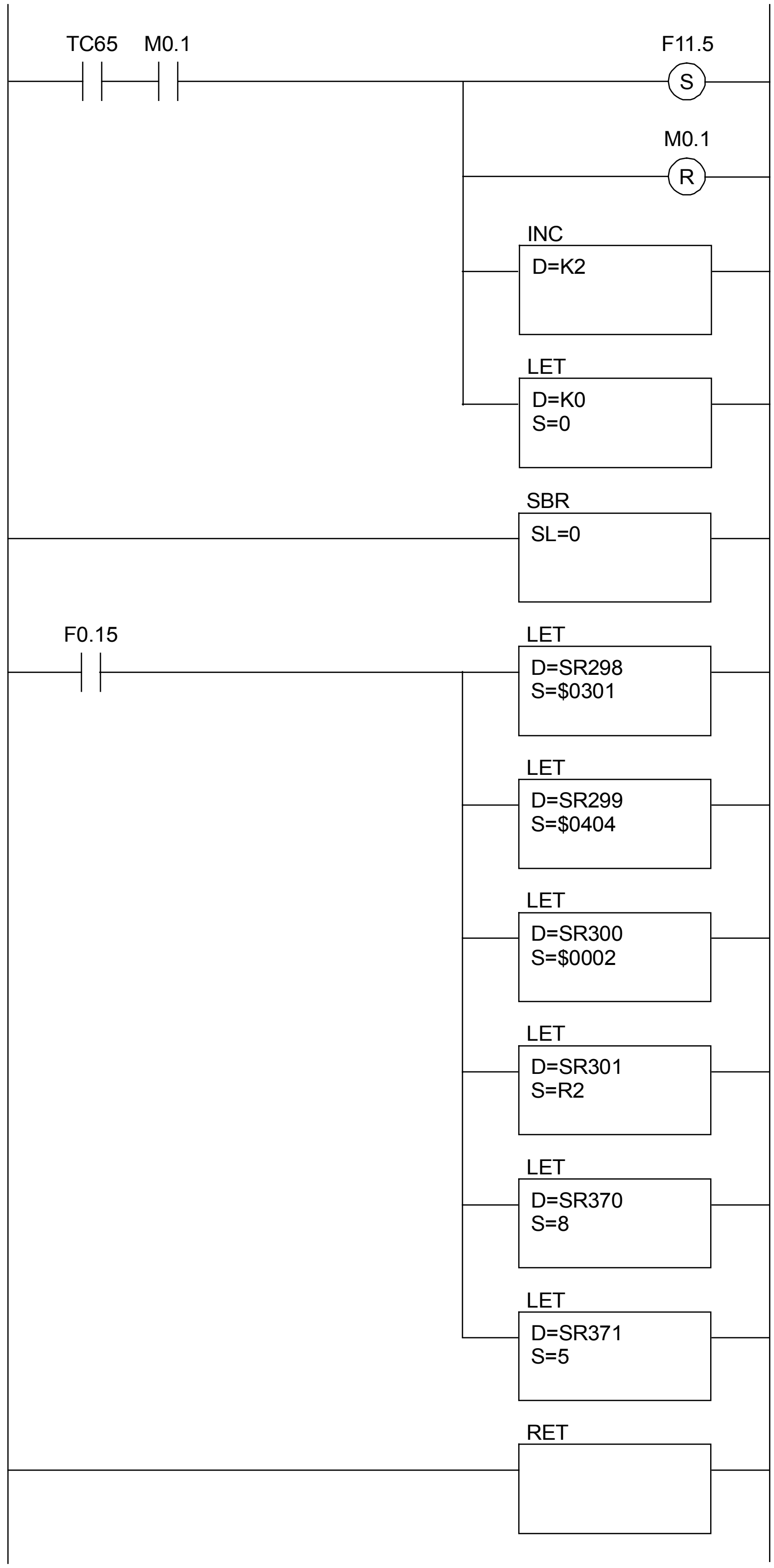
Rung 2:
The Receive Flag F11.4 is continuously checked for an incoming message. If detected, Subroutine 10 is called to process the message.



Rung 3:
This rung handles the Query message. If no message is currently active, it starts the process by creating the Query, setting the Send Request bit (F11.0), and starting a Timeout timer.

Rung 4:
This rung handles the Response Request message. If the Query has been successfully sent and Acknowledged, it starts the process by creating the Response Request, then setting the Send Request bit (F11.0) and starting a Timeout timer.

Rung 5:
This rung checks the 3 second timer started after the Query message was sent. If the timer times out, it increments an error counter (K1), and restarts communications.



Rung 6:
This rung checks the 3 second timer started after the Response Request message was sent. If the timer times out, it increments an error counter (K2), and restarts communications.

Rung 7:
Subroutine 0 creates the Query message (Write Word).

Rung 8:
The Query message is placed in the Send buffer, SR298 to SR301. The message data to send is:

010304040002####

which translates to:

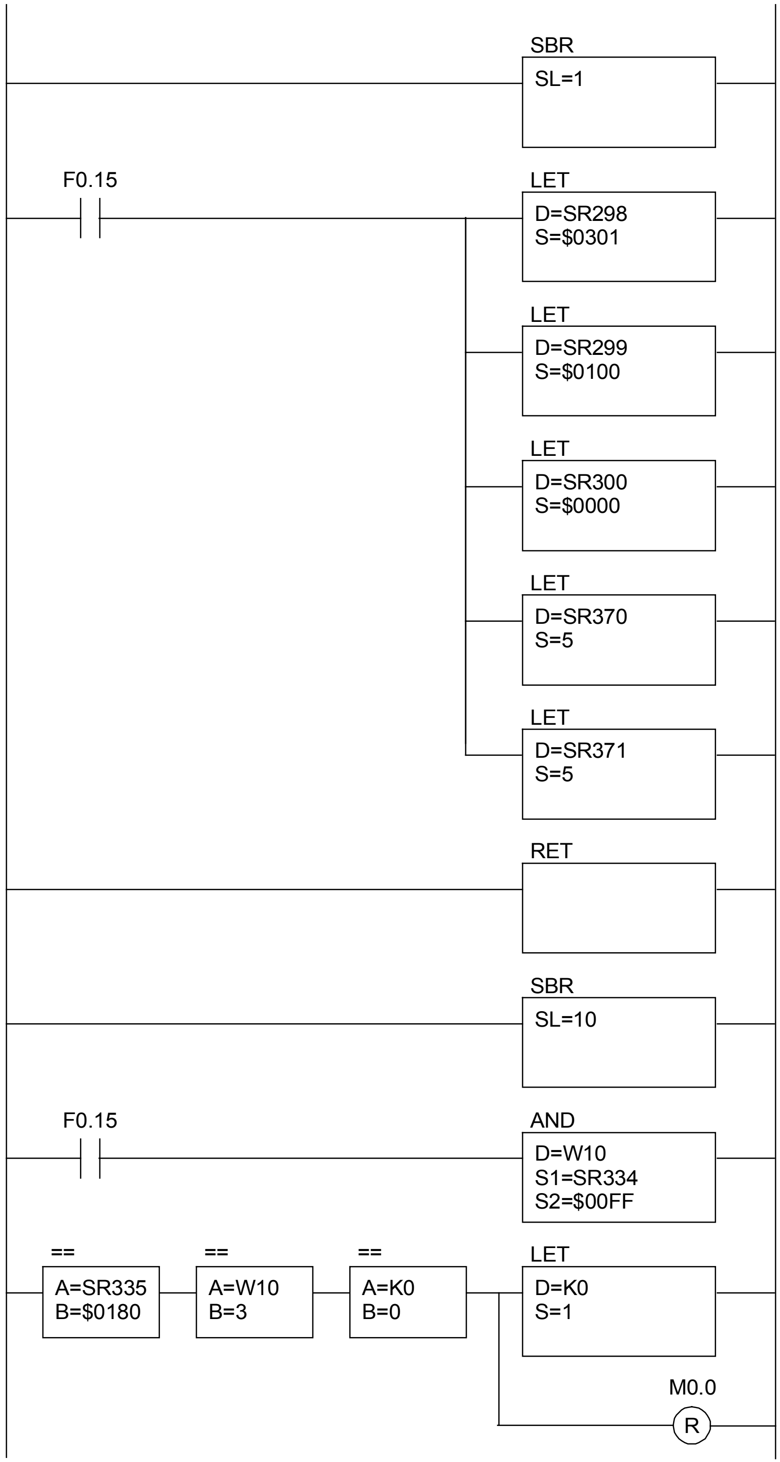
Write 1 word of data with the value #### to W0 in PLC station #3

See Appendix A for a detailed explanation.

For this example, the value in register R2 is being sent to PLC #3.

After creating the message, the send length is placed in SR370, and the expected receive length is placed in SR371.

Rung 9:
End of Subroutine 0.



Rung 10:
Subroutine 1 creates the Response Request.

Rung 11:
The Response Request is placed in the Send buffer, SR298 to SR300. The message data to send is:
010300010000
which translates to:
Perform the previously requested Write operation.
This message is always the same. See Appendix A for a detailed explanation.

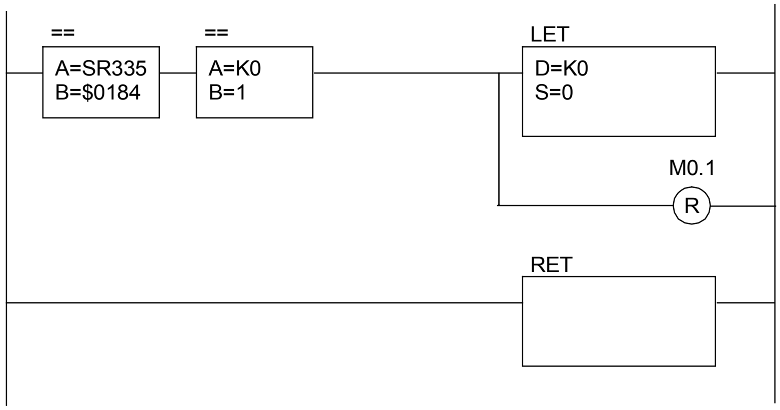
After creating the message, the send length is placed in SR370, and the expected receive length is placed in SR371.

Rung 12:
End of Subroutine 1.

Rung 13:
Subroutine 10 processes the responses (Query Acknowledge/Response) from the network.

Rung 14:
This rung masks out the Source Address from the received message, into W10.

Rung 15:
This rung checks for the Query Acknowledge from Station #3. When received, it proceeds to the next step by incrementing the step counter K0 and resetting the internal flag M0.0.



Rung 16:
This rung checks for the last Response from Station #3. When received, it resets communications back to the initial step.

Rung 17:
End of Subroutine 10.

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