Data Sheet

Programmable logic controller (PLC) system F1-series

The **RS**/Mitsubishi F1 PLC range

The F1-series PLC system is an integrated family of components using a modular approach. They are compatible with the majority of the components of the F2-series thus allowing a high degree of user flexibility.

Section index

Note: There are numerous references made to the F2 series PLC range, which is no longer available, but many of these items may be used with either items from the F1 or F2 range.

1 Introduction

A programmable logic controller is a system for controlling industrial and production processes, electromechanical equipment and automated assembly operations. This control function is performed by continuously monitoring the states of all the input devices connected to the controller (eg. proximity switches and mechanical contacts). Following the user instructions stored in the controller (known as the program), the states of all of its output devices are set as appropriate (eg. relays, solid state relays or transistors). These output elements can in turn control the operation of an external system.

Due to the simplicity of entering and modifying the programmed instructions to suit the requirements of the process under control, the PLC is a truly versatile and flexible device that can be employed easily and efficiently to repeatedly control tasks that vary in nature and complexity.

A schematic diagram of the basic PLC control system is shown in Figure 1.

In this representation the central processing unit controls the overall operation of the system. Input devices may be switches, relay contacts, timers, solid state switches, proximity and limit switches, sensors, analogue to digital converters or other electronic circuits. The output devices may be external relays, heating elements, lights, alarms, sub-assemblies, electronic and electrical circuits, motors or other electronic and electrical circuits, motors or other electromechanical devices.

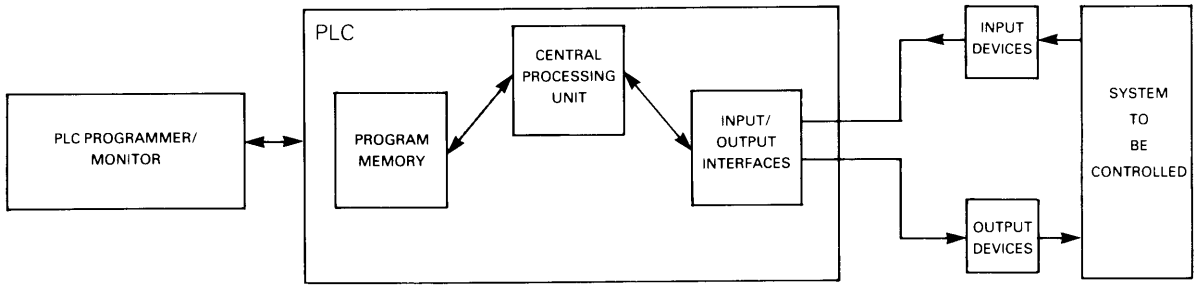
To illustrate the advantages of using a PLC over a traditional electromechanical system consider a control system with 20 input/output points. This assembly could comprise 60-80 relays, some counters and/or timers and a great deal of wiring. This assembly would be cumbersome with a power consumption of 30-40VA. A considerable time would be required to design, build, test and commission the assembly and once it is in full working order any desired modifications, even of a minor nature, could require major hardware changes.

Alternatively, in the majority of applications the same control function can be performed using the F1-20I/O plc base unit (**RS** stock no. 318-250). Once programmed (using a programming panel) the controller can be directly connected to the input and output devices. Programming will typically take 1-2 hours. Any alterations to the control function of the system can be simply implemented within minutes by modifying the stored program. Other advantages over more conventional systems include compact size, low power consumption, fast response, versatility and lower overall cost. As the input/output requirements of a system increase, the advantage of using a PLC becomes much more significant due to the complexity of the equivalent hardwired system and its labour and material costs.

1.1 System features

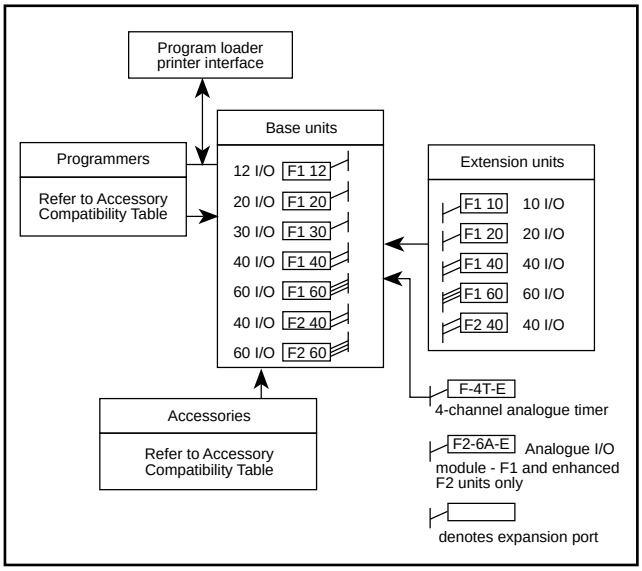
- 12 to 120 I/O capacity
- All mains powered components are suitable for 110/240Vac operation
- Same physical size as the equivalent F2-series components
- Removable terminal blocks on the 40 and 60 I/O units
- Analogue I/O capability for interfacing with sensors, transducers, drivers and indicators
- Arithmetic functions
- Built-in high speed counting facility
- Choice of external program storage (EPROM, EEPROM or cassette tape)
- 1000 step program capacity on all units
- I/O status and self monitoring via LED indication
- User instructions are supplied where necessary.

Figure 1 **Schematic diagram**



Note: For a comprehensive description of features and facilities relating to the F1 PLC, refer to the F1-F2 series programming manual (**RS** stock no. 319-613).

Table 1 F1 and F2 series compatibility



Notes: 1. F2 base units are compatible with F1-10, 20 and 40 extension units see I/O selection chart.
2. F1/F2 base units (24Vdc input versions) interface directly to input devices such as limit switches, relays, timers and counters with relay or switch output. PNP versions of inductive and optical proximity switches may also be directly interfaced - refer to sensors/transducers section.
3. For a comprehensive description of features and facilities relating to both the F1 and F2 PLC systems a detailed programming manual RS stock no. 319-613 is available.

F1 and F2 Accessory Compatibility Table

Description	RS stock no.	Mitsubishi part no.	F1	Old F2	Enhanced F2
MING graphics computer package	628-800	FX-MING	YES	YES	YES
MEDOC documentation software package	628-793	FX-MEDOC	YES	YES	YES
Graphic programming panel	318-834	GP-20F-E	YES	YES	YES
Advanced F2 programming panel	331-663	F2-20P-E	YES	YES	YES
Programming panel	354-846	F1-20P-E	YES	YES	YES
Data access unit	354-997	F-20DU2	YES	YES	YES
Program loader/printer interface	330-806	F2-20H-DE	YES	YES	YES
EPROM/EEPROM programmer	354-975	F2-20MW-E	YES	YES	YES
EPROM cassette	332-789	F-ROM-1	YES	YES	YES
1K EEPROM cassette	318-345	F-EEPROM-1	YES	NO	YES
Programming panel/EPROM programmer extension cable	331-708	F-20P-CAB	YES	YES	YES
Analogue timer -4-channel	331-225	F-4T-E	YES	YES	YES
Analogue I/O module	318-351	F2-6A-E	YES*	NO	YES
Peripheral power supply	343-931	F-PSU-2A	YES	YES	YES
Input simulators		Refer to text			
DIN-rail kits					
F1/F2 to FX MEDOC upgrade kit	354-981		YES	YES	YES

*Except F1-12

Table 2 The **RS** PLC system (F1/F2) - possible I/O combinations

Total I/O	12	20	22	30		32	40			50		60			70	
Inputs	6	12	10	16	16	18	24	20	24	28	28	36	32	36	40	40
Outputs	6	8	12	14	14	14	16	20	16	22	22	24	28	24	30	30
Base	12	20	12	20	30	12	20	30	40	30	40	40	40	60	40	60
Extension			10	10		30	20	10		20	10	20	10		20	10
													10		10	

Total I/O	80				90		100			110		120		
Inputs	48	48	48	44	52	48	60	60	56	64	64	72	72	72
Outputs	32	32	32	36	38	42	40	40	44	46	46	48	48	48
Base	40	40	60	60	60	60	60	60	60	60	60	60	60	60
Extension	40	20	20	10	20	10	40	20	20	20	40	40	60	20
		20		10	10	10		20	10	20	10	20		20
						10			10	10				20

1.2 System interconnection

In general a PLC system comprises a base unit plus one or more extension units and or analogue I/O unit(s) or timer(s). The F1 system base and extension units can be integrated with the F2-series base and extension units to form many I/O combinations as shown in Tables 1 and 2.

Note: The criterion for adding extension units, analogue timers and analogue I/O units to a PLC base unit is determined by the number of extension ports available on the base unit and the number of extension ports required by the add-on units as shown below.

Base unit	Number of extension ports available
F1-12	1
F2/F1-20	1
F1-30	1
F2/F1-40	2
F2/F1-60	3

Thus the F1-60 base unit can have for example an F1-20 extension unit plus one analogue timer plus an analogue I/O unit **or** it can have one F2-40 extension unit plus one other add-on unit requiring a single port etc.

Add-on unit	Number of extension ports required
F1-10	1
F1-20 extension	1
F2/F1-40 unit	2
F1-60	3
F-4T timer	1
F2-6A analogue I/O unit	1

2 Base and extension units

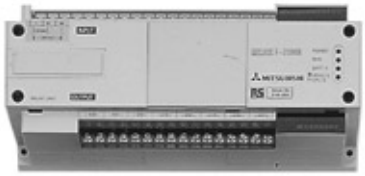
2.1 Base units

This is the main component of the PLC system. It contains the central processing unit (CPU) and the program memory as well as specified I/O capability. Built-in timers, counters and internal (auxiliary) relays are also incorporated. The F1-series base units range from 12 (F1-12) to 60 I/O (F1-60) in size.

Base units

F1-12
W.165 H.90 D.90

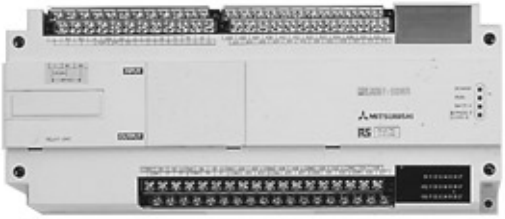
F1-20
W.250 H.90 D.90



F1-30
W.275 H.90 D.90

F1-40
W.300 H.110
D.110

F1-60
W.350
H.110
D.140



Mitsubishi part no.	**RS** stock no.
F1-12MR-ES	318-244
F1-20MR-ES	318-250
F1-30MR-ES	318-266
F1-40MR-ES	318-272
F1-60MR-ES	318-288

Instruction manual supplied.

Features

- 110/240Vac supply operation
- Opto-isolated inputs
- LED indication for I/O status and system operation conditions
- Relay outputs
- Removable screw terminal blocks on the F1-40 and F1-60
- Surface/DIN rail mounting (except the F1-60)
- 1000-step program capacity on all units
- 5 year battery back-up for the built-in RAM memory
- External program storage in EPROM, EEPROM or cassette tape*
- Mathematical capabilities on BCD data
- Analogue I/O capability (except for the F1-12) via the analogue I/O unit which provides 4 input and 2 output channels
- 32 timers, 30 counters and 232 internal relays
- Standard ladder logic and step ladder programming
- Built-in 2kHz high speed counter for sensor interface
- External or programmed 'emergency off' switching for all inputs
- Input simulators available for all base units.

* For this type of storage the F2 programming panel (**RS** stock no. 331-663) or LCD programming panel (**RS** stock no. 318-834) is required. Alternatively the program loader (**RS** stock no. 330-806) can offer this facility.

The following F2 PLC system components are compatible with the F1 base units (refer to the current **RS** catalogue for details).

20/40 I/O extension units
Basic, F2 advanced and LCD programming panels
EPROM programmer
EPROM cassette
Programmer extension lead
Analogue timer units
DIN rail kits
Program loader/printer interface.

Note: For a comprehensive description of features and facilities relating to the PLC, refer to the F1-F2 series programming manual (**RS** stock no. 319-613).

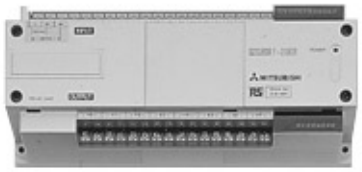
2.2 Extension units

An extension unit increases the I/O capability of the base unit. Possible combinations of base and extension units are given in Table 2.

Extension units

F1-10
W.165 H.90 D.90

F1-20
W.250 H.90 D.90



F1-40
W.300 H.110
D.110

F1-60
W.350
H.110
D.140

Features

- 110/240Vac supply operation
- Opto-isolated inputs and relay outputs
- Screw terminal connections, with the 40 and 60 I/O versions having removable terminal blocks to simplify maintenance
- LED indication for I/O status and power 'on'
- Surface/DIN rail mounting (except for the 60 I/O version)
- Totally compatible with the F2 series base units
- Input simulators available for the 20, 40 and 60 I/O versions
- Dimensionally identical to the corresponding base unit.

Mitsubishi part no.	**RS** stock no.
F1-10ER-ES	318-294
F1-20ER-ES	318-301
F1-40ER-ES	318-317
F1-60ER-ES	318-323

The following F2 PLC system components are compatible with the F1 extension units (refer to the current **RS** catalogue for details).

All base units
DIN rail kits

Mitsubishi part no.	**RS** stock no.	Suitable base unit	Suitable extension unit
F1-12M-IS	318-367	F1-12MR-ES	
F1-20M-IS	318-373	F1-20MR-ES	F1-20ER-ES
F1-30M-IS	318-389	F1-30MR-ES	
F1-40M-IS	318-395	F1-40MR-ES	F1-40ER-ES
F1-60M-IS	318-402	F1-60MR-ES	F1-60ER-ES

Base and extension unit specifications

General specifications

Power supply	93.5-132V/187-264Vac
Ambient temperature	0±C to +55±C
Ambient humidity	45-95%, no condensation
Insulation withstand voltage	ac 1500V, 1 min. (between earth terminal and all other terminals)
Insulation resistance	5MΩ 500Vdc (between earth terminal and all other terminals)
Grounding	Less than 100Ω

Functional specifications (base unit)

Execution speed		Average 12μ second/step
Program capacity		1000 steps
Instructions	Basic sequence	20 instructions (including MC/MCR, CJP/EJP, S/R)
	Stepladder	2 instructions (STL, RET)
	Function block	87 instructions (including +, -, ×, ÷, <, =, ≥, etc.)
Program memory		CMOS-RAM built in, EPROM-EEPROM and tape cassette
Auxiliary relays	Standard	128
		64 with battery back-up
	State	40 (can be used as normal with battery back-up)
	Special relays	16
Data register		64
Timers	0.1 sec timers	24 on-delay timers (0.1-999 seconds)
	0.01 sec timers	8 on-delay timers (0.01-99.9 seconds)
Counters (retentive)		30 down counters (0-999)
High speed counter (retentive)		1 up/down counter (0-999999), maximum 2kHz
Battery back-up		Lithium battery approximately five years life
Diagnosis		Program check (sum, syntax, circuit check), watch-dog timer, battery voltage, power supply voltage

Input specifications

Input device		Non-voltage contacts or PNP open collector transistor
Isolation		Photo-coupler isolated
Input voltage		Built-in supply 24V±4Vdc, external supply 24V±8Vdc
Input impedance		Approximately 3.3kΩ
Operation current	OFF→ON	dc 4mA minimum
	ON→OFF	dc 1.5mA maximum
Response time	OFF→ON	Approximately 10ms (8 inputs can be changed from 0 to 60ms)
	ON→OFF	

Output specifications

Output		Relay output
Output load	Resistive load	2A/point
	Inductive load	35VA/up to 300,000 operations (without additional components)
	Lamp load	100W
Leakage current		0mA
Response time	OFF→ON	Approximately 10m sec
	ON→OFF	

Individual specifications

Models	F1-12MR-ES F1-10ER-ES	F1-20MR-ES F1-20ER-ES	F1-30MR-ES	F1-40MR-ES F1-40ER-ES	F1-60MR-ES F1-60ER-ES
Number of inputs	6 (F1-12) 4 (F1-10)	12	16	24	36
Number of outputs	6	8	14	16	24
Terminal block	Fixed terminals			Removable terminals	
Power consumption	18VA	20VA	22VA	25VA	40VA
Input sensor power	0.1A	0.1A	0.1A	0.1A	0.2A

3 Programmers

3.1 Graphic programming panel

This powerful, small graphic programming panel is compatible with all **RS** PLC base units (F1 and F2). The unit offers a large LCD display area upon which PLC programs may be entered, modified and monitored.

Graphic programming panel

Mitsubishi part no.	**RS** stock no.
GP-20F-E	318-834

Features

- A high resolution liquid crystal display (128 dot × 128 dot) with adjustable contrast control, incorporating system prompt and message information. (11 lines × 9 columns: 11 contacts + 1 coil per line)
- A choice of programming mode and display formats, including ladder, list and batch representations
- A ladder 'zoom' facility incorporating enhanced element identification
- Output force and online monitoring capabilities
- A tactile programming keypad with adjustable audible feedback
- A retentive memory for up to 12 hours
- A standard cassette tape recorder interface (via lead supplied) to provide program storage facilities on tape. Program transfer from tape to the PLC base is also possible as is program comparison between tape and RAM
- May be plugged directly into the base unit. Alternatively a 1.5m extension cable **RS** stock no. 331-708 is available
- A single portable panel can be used to program any number of base units.

  Supplied complete with instruction manual and cassette lead.

3.2 Advanced F2 series programming panel

This programming panel is compatible with all of the RS PLC range of base units. It is particularly suitable for F2 base units incorporating expanded program memory capacity of 2000 steps as it features an enhanced LED display and all necessary keys to simplify the programming of the more powerful functions and facilities available. Most keys have a dual function whose operation is defined automatically according to the previous keystrokes entered.

Note: This panel allows F1 series users to take advantage of the standard cassette tape recorder interface to facilitate program storage and program comparison.

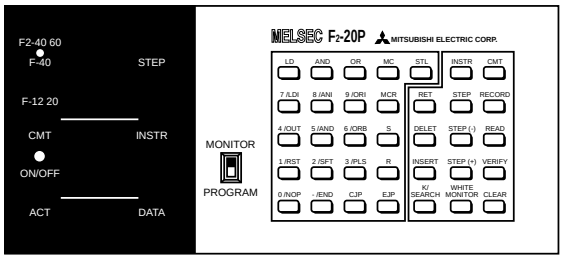
Advanced F2 programming panel

Mitsubishi part no.	**RS** stock no.
F2-20P-E	331-663

Features

- 35-key programming keypad incorporating tactile feedback
- Simultaneous display of program step number instructions and element number or data
- Operation mode selector switch
- Base unit type selector switch and LED indication
- On/Off state monitoring of program elements and instructions during PLC operation
- Standard cassette tape recorder interface (via lead supplied) to provide program storage facility on tape. At least five copies of one complete program can be stored on one side of a 30-minute tape. Program transfer from tape to the PLC base RAM is also possible as is program comparison between tape and RAM
- May be plugged directly into the base unit. Alternatively a 1.5m extension cable **RS** stock no. 331-708 is available
- A single portable panel can be used to program any number of base units. User instruction manual is supplied; however a comprehensive programming manual **RS** stock no. 319-613 is essential for programming the system and is available separately.

Display description



Indicator LED	Indicator description
Base unit type indicator	This shows the position of the base unit selector switch on the side of the programming panel. Important: ensure base unit selector switch is set correctly before programming or monitoring.
CMT indicator	This is turned 'ON' when the programming panel is in cassette tape mode.
ON/OFF indicator	This indicates the ON/OFF status of an element whilst being monitored.
ACT indicator	This indicates that a given rung in the program is energised. This is used in conjunction with instruction monitoring which is possible on the F2 series while the PLC is in RUN or STOP mode.
In addition the F2 programming panel displays simultaneously the step number (max 1999), instruction and the element number or data (eg. counter value).	

3.3 Basic programming panel

This programming panel is compatible with all of the RS PLC base units. It has a group of dedicated keys to simplify programming of some of the more powerful functions and facilities available on the base units.

Programming panel

Main features

- 31-key programming keypad
- 4-digit LED step number display. Compatible with F1 PLC
- Simultaneous display of program step number, instruction and element number or data
- Operation mode selector switch
- Base unit type selector switch and LED indication
- Automatic repeat stepping function
- Keypad audible tactile feedback
- On/Off state monitoring of program elements and instructions during PLC operation
- May be plugged directly into the base unit. Alternatively a 1.5m extension cable (RS stock no. 331-708) is available
- A single portable panel can be used to program any number of base units.

User programming manual is supplied which must be referred to when programming the F1 series.

Mitsubishi part no.	**RS** stock no.
F1-20P-E	354-846

The following F2 PLC system components are compatible with the basic programming panel (refer to the current RS Catalogue for details).
F2-series base units
Programmer extension cable

3.4 Data access unit (**RS** stock no. 354-997)

This data access unit is specifically designed to be 'panel' mounted and may be used with both F1 and F2 PLC systems.

The unit enables operations to be performed via a keyboard and large easy-to-read LED display.

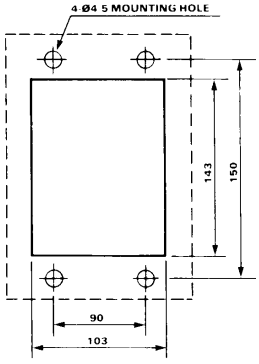
Data access unit

Main features

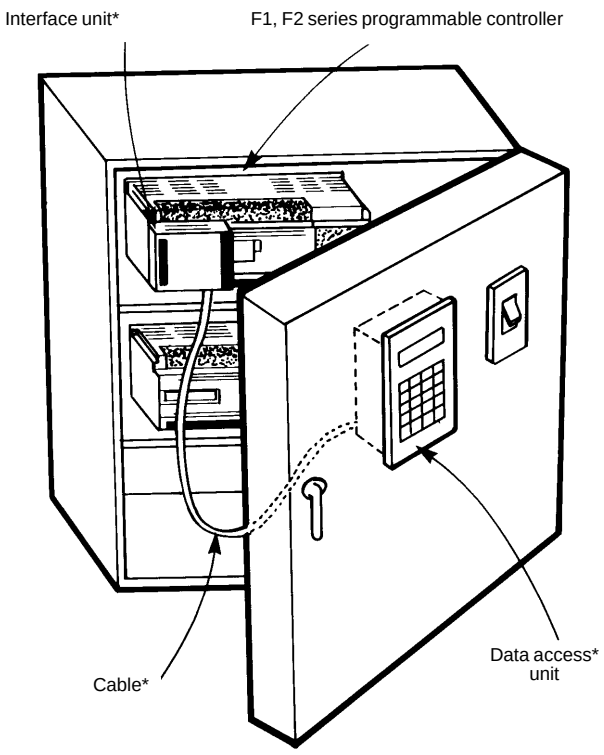
- Full monitoring of Timers (T), Counters (C), Data registers (D) and stepladder states
- Enables values of T, C and D to be modified directly without reverting to the program via programming panels
- Unit incorporates a 'user-definable' entry code facility, prohibiting unauthorised access
- Real time clock facility for time and calendar setting and display, and transfer to PLC.

The data access unit is supplied complete with an interface unit, which connects directly to the PLC base unit and connection cable (3m in length). Instruction manual supplied.

Mounting requirements



Typical configuration



*Items supplied in **RS** stock no. 354-852 package

Data access unit specification

Power source	5Vdc, 100mA (supplied from programmable controller)
Working ambient temperature	0°C to +55±C
Working ambient humidity	45% to 85% RH (no condensation)
Vibration	10Hz to 55Hz, 0.5mm (2G max.) 2 hours to each direction of 3 axes
Shock	10G (3 times to each direction of 3 axes)
Working atmosphere	Must be free from corrosive gas and excessive dust
Keyboard	Key sheet type using polycarbonated flat film
Display	7-digit red, 7-segment type (4.5 × 7mm)
Access unit dimensions	W 120 H 174 D 50

Note:
Access unit equivalent to Mitsubishi part no. F-20 DU2.
Interface unit equivalent to Mitsubishi part no. F-20 DF.
Data access cable equivalent to Mitsubishi part no. F-20 DU-CAB.

3.5 FX-MEDOC documentation software

This software package enables programs for F1, F2 and FX PLCs series to be generated, in list or ladder format (and transposed either way) on an IBM PC, XT, AT or 100% compatible. A colour monitor should be regarded as a minimum requirement.

FX-MEDOC supersedes F-MEDOC **RS** stock no. 319-635, now discontinued.

These programs may be annotated with comments to identify, locate and define functions such as timers, counters, input and output usage, etc.

These annotations are permanently stored within the computer or on disk and may be displayed or included in program printouts.

The package includes a comprehensive user manual and both software diskettes and protocol converter.

The package enables the following functions to be performed.

File handling - Project files can be read, written, copied, created, erased and renamed on a disk.

Names - These may be given to all I/O addresses and used while programming.

Comments - Program comments may be written and edited in either instruction or ladder form.

Lists - The following may be output on a printer:

- Comment list
- I/O list
- Program list in instruction type
- Program list in ladder type
- Cross reference list
- I/O use list
- Parameter list.

Transfer a program direct to and from the programmable controller.

Monitoring of the program in the PLC in ladder mode and in name mode on the VDU screen.

MEDOC is simplified by an easy-to-learn menu system with a powerful help facility.

It is always possible to obtain an explanation of a MEDOC function by simply pressing the HELP key.

FX-MEDOC requirements

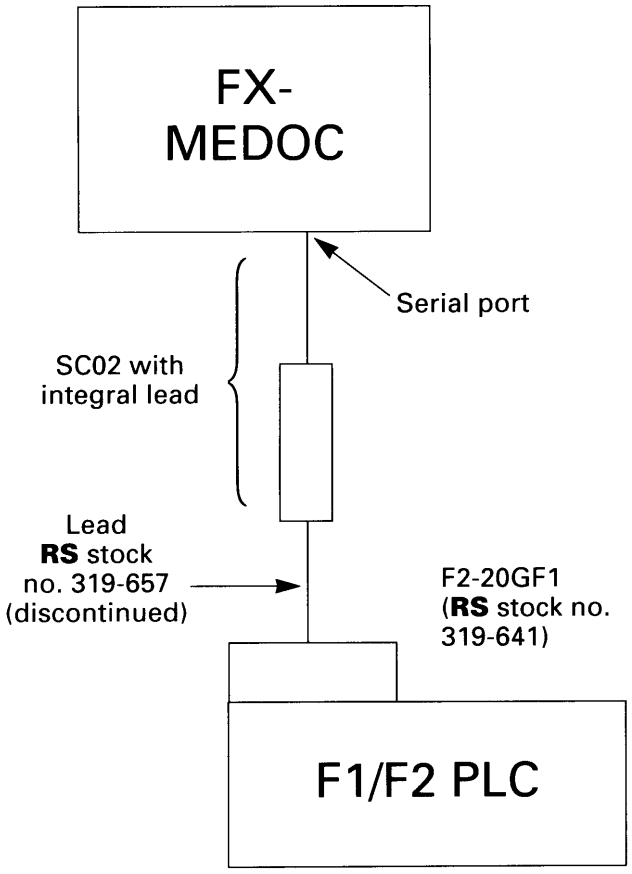
To run the MEDOC software the following conditions must be fulfilled:

- The host computer must be an IBM-PC/XT/AT, IBM-PS/2 or compatible computer
- The IBM-PC must have a 'hard' disk and 'floppy' drive
- The RAM memory must be at least 512Kbyte
- The IBM-PC must be equipped with an asynchronous serial port; and a parallel port.

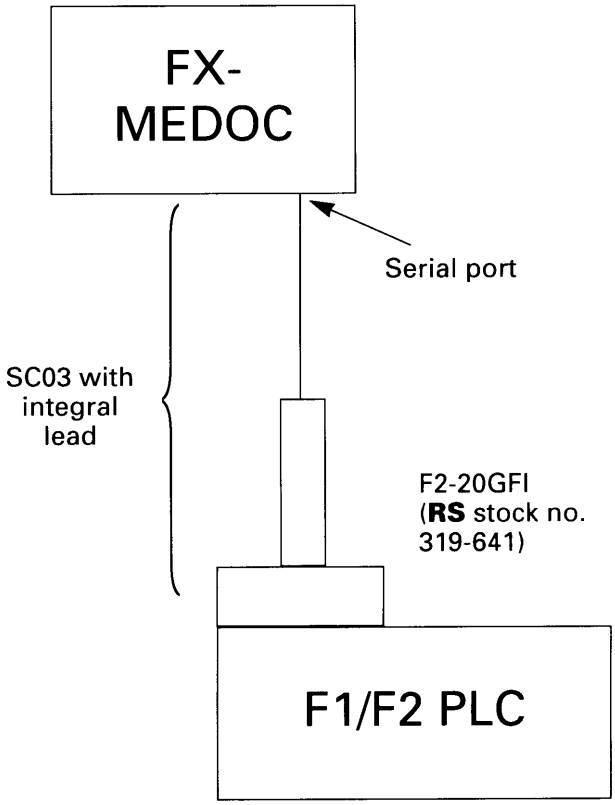
F1 PLC to PC connection

Programs may be transferred from the computer to F1 PLC using one of the following ways:

i) Using the protocol converter (SC02) previously supplied with F-MEDOC



ii) Using the protocol converter (SC03) supplied with initial supplies of FX-MEDOC, or protocol converter (S03 S1) supplied subsequently.



Note: SC03 and SC03 S1 protocol converter have a port marked program. This port is not for FX hand held programmer RS stock no. 628-692.

Mitsubishi part no.	**RS** stock no.
FX-MEDOC package	628-793

3.6 F1/F2 to FX-MEDOC software upgrade kit (**RS** stock no. 354-981)

This software upgrade kit enables existing MEDOC-F documentation software users to compile programs for F1, F2 and FX PLCs. It includes disks and interface cable to be used via existing protocol converters.

3.7 F/PLC interface unit

F/PLC interface unit

Mitsubishi part no.	**RS** stock no.
F2-20 GF1	319-641

The unit enables programs to be transferred in either direction between computer and PLC. Connection to the FX-MEDOC package is detailed in the previous entry. Connection to the F-MING package requires cables to be made to length to suit the system's installation requirements – see F-MING details for further information.

The unit comes complete with 3 system PROMS, marked F-20 GC-1, F-20 GC-2 and F-40 GC. They are required to enable FX-MEDOC to display values of registers, timers, counters and I/O status, when used with older F-20 and F-40 PLCs.

Note: They are not required when using F1 or F2 series programmable logic controllers.

Note: Before the MONITOR function is selected, both programs within the FX-MEDOC memory and PLC system must be identical, otherwise misleading information will be displayed.

System PROM usage:

PLC	Comment
F-12	It is not possible to perform MONITORING on the F-12 system.
F-20	Check the system type and serial number on the side of the unit. If the system type is F-20R**, then PROM installation and hence MONITORING is not possible. If the system type is F-20M** and the first two digits in the serial number form a number that is less than 38, then the F-20 GC-1 system PROM should be installed, otherwise F-20 GC-2.
F-40	The F-40 GC system PROM should be installed.

4 FX-MING graphics package

This colour graphics IBM® or compatible personal computer based software package FX-MING is designed to enable complete plant emulation/operation for users of F1, F2 and FX-Series PLCs, so as to eliminate the need for hard wired mimics and other monitoring devices. It allows pictorial representation of the process being controlled by the PLCs, with interactive display capability for data values, input/output status for real time monitoring.

The manual supplied within the MING package describes in depth the features and facilities available.

Topics covered include:

Introduction
Software overviews and installation
Hardware configuration
Drawing tutorial
F GEN reference section (system generation)
F MON reference section (system monitor).

Features

- Up to 100 digital items per screen displayed per PLC
- Up to 8 time/counter values per screen displayed per PLC
- 100 screens
- 500 interactive elements
- 6 password levels
- Associated name tagging for devices
- Documentation facility for interactive element listing
- User definable screen grid size for quick and accurate graphic construction
- Extensive alarm capabilities including transitional alarms
- Display items: icons, dynamic labels, lines, etc.
- Test mode ON/OFF
- Save, restore 'current set-up'
- Move 'window' in display
- Interactive system parameter adjustment
- Data register input command
- Report facility.

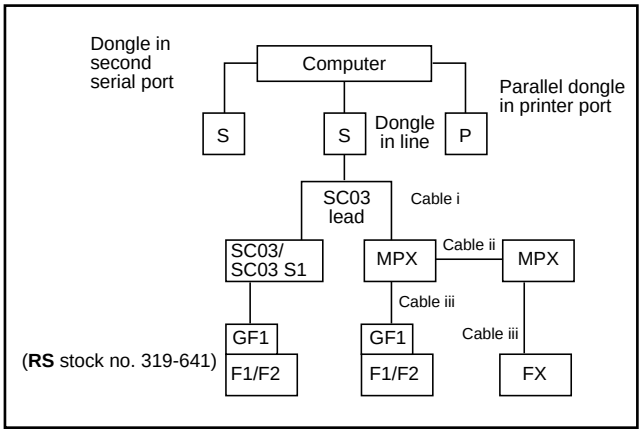
Note: F GEN is a drawing package, similar in concept to some of the commercially available drafting packages available for the IBM PC. F GEN is used during the design and implementation phases of a PLC system to create a description (drawing) of the system to be monitored.

Once F GEN has created the required 'plant', F-series system, the F MON program communicates to the PLCs and animates the graphical display as defined in F GEN. Within F MON a plant operator may interrogate the PLC system and if permitted by the levels of security designed into the drawing by F GEN, adjust control parameters of the system.

PLC to PC connection

F1 or F2 PLCs may be connected to the computer in one of the following ways. Each way requires a dongle, supplied. FX-MING comes with a dongle to be plugged into the parallel part of the computer, F-MING (RS stock no. 354-868, discontinued) was supplied with a serial dongle to be used either in line or in a second serial port.

- Protocol converter SC03 or SC03 S1, supplied with FX-MEDOC, **RS** stock no. 628-793
- Multiplexer MPX, **RS** stock no. 320-348.



Using multiplexer MPX **RS** stock no. 320-348 allows;

- the computer to be sited up to 15m away from MPX unit
- up to 24 F1, F2 or FX PLCs to be configured on the same system using up to 3MPX units
- a common system baud rate of up to 19,200. All PLCs must be set to the same baud rate
- Each PLC to be sited up to 250m from the MPX unit using RS-422 serial line.

Connecting cable configuration

Each cable must be terminated with a 25-way D plug **RS** stock no. 474-029, socket **RS** stock no. 474-035 and covers **RS** stock no. 469-588 (see current **RS** catalogue).

Cable i. Computer (dongle) to MPX unit.

Female (computer)		Male (MPX)	
1	----------	1	(optional)
2	_____	2	
3	_____	3	
4	_____	4	
5	_____	5	
6	_____	6	
7	_____	7	
8	_____	8	
20	_____	20	

Maximum cable length 15m.

Cable ii. MPX to MPX

Male (MPX)		Female (MPX)	
1	----------	1	(optional)
2	_____	2	
3	_____	3	
4	_____	4	
5	_____	5	
7	_____	7	

Cable iii. MPX to F2-20GF1 (**RS** stock no. 319-641)

Male (MPX)		Female (**RS** stock no. 319-641)	
1	----------	1	(optional)
2	_____	2	
3	_____	3	
4	_____	4	
5	_____	5	
6	_____	6	
7	_____	7	
15	_____	15	
16	_____	16	
17	_____	17	
18	_____	18	

Cable should have 120Ω characteristic impedance and be no more than 250m in length.

FX-MING requirements

To run the FX-MING software the following conditions must be fulfilled:

- The host computer must be an IBM-PC/XT/AT, IBM-PS/2 or 100% compatible computer
- The IBM-PC must have a 'hard' disc and 'floppy' drive
- The RAM memory must be at least 640Kbyte
- MS DOS 2.1 or higher must be installed
- Real time clock
- EGA card or VGA card
- Colour monitor (EGA or VGA)
- RS-232 communication card
- Microsoft mouse or 100% compatible (bus or serial)

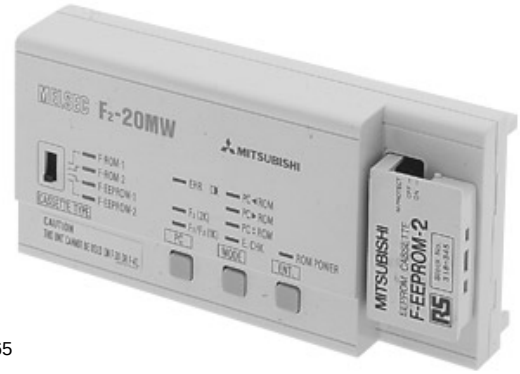
FX-MING consists of user manual, dongle and software discs.

Mitsubishi part no.	**RS** stock no.
FX-MING package	628-800

5 Accessories

5.1 EEPROM/EPROM programmer (**RS** stock no. 354-975)

EEPROM/EPROM programmer



H.80
W.165
D.33

Equivalent to **Mitsubishi part no. F2-20MW-E**

This unit clips onto the base unit for the transfer of programmed instructions between the base unit battery backed RAM memory and the non-volatile memory on the EPROM cassette (**RS** stock no. 332-789) or EEPROM cassettes (**RS** stock nos. 318-345 and 319-629).

Connection to the base unit

Switch off the system power supply prior to inserting/removing the programmer. Remove the memory cassette connector cover on the base unit. Plug the EPROM or EEPROM cassette (ordered separately) into the programmer. The latter may now be connected to the base unit in the same way as the programming panel.

Bidirectional data transfer between RAM and user EPROM or EEPROM cassette can now be initiated.

Main features

- Bidirectional data transfer (EPROM or EEPROM to RAM; RAM to EPROM or EEPROM)
- Comparison of program data in RAM and EPROM or EEPROM
- Data transfer error detection and diagnosis
- Plugs directly into the base unit. Alternatively a 1.5m extension cable (**RS** stock no. 331-708) is available
- A single portable unit can be used to program EPROMs or EEPROMs for any number of base units.

5.2 EPROM cassette (**RS** stock no. 332-789)

EPROM cassette

W.50
D.31
H.16

Equivalent to **Mitsubishi part no. F-ROM-1**

This unit plugs into a special connector port on the base unit. It is programmed using the EPROM programmer **RS** stock no. 354-975 (see above) by transferring data from the RAM in the base unit into the memory IC. Once the fully programmed cassette is plugged in, it overrides the RAM program in the base unit and controls the system operation. The plugged in cassette program can also be monitored using the programming panel. Different programs can be stored on various cassettes if required. Thus a system's operation can be quickly changed using a different EPROM cassette. The EPROM may be erased using a suitable UV eraser eg. **RS** stock no. 424-254.

Technical specification

Typical life _____ 100 program/erase operations
Erase time _____ 42 minutes (minimum)
using 6mW/cm^2 eraser

5.3 EEPROM cassette

EEPROM cassette

W.50
H.16
D.31

Mitsubishi part no.	**RS** stock no.
F-EEPROM-1	318-345

This unit is used to store the F1 PLC program. The unit plugs into a special connector port on the base unit. It is programmed using any of the programming panels basic, F2 advanced, LCD, or EEPROM programmer **RS** stock no. 354-955 by transferring data from the RAM in the base unit into the ic memory. Once the fully programmed cassette is plugged-in it overrides the RAM program in the base unit and controls the system operation. Different programs can be stored on various cassettes if required. Thus, a system's operation can be quickly changed using a different 1K EEPROM cassette. Program transfer from EEPROM to RAM is also very simple using a programming panel.

Note: This 1K EEPROM cassette may also be used with the 'Enhanced' F2 series PLC.

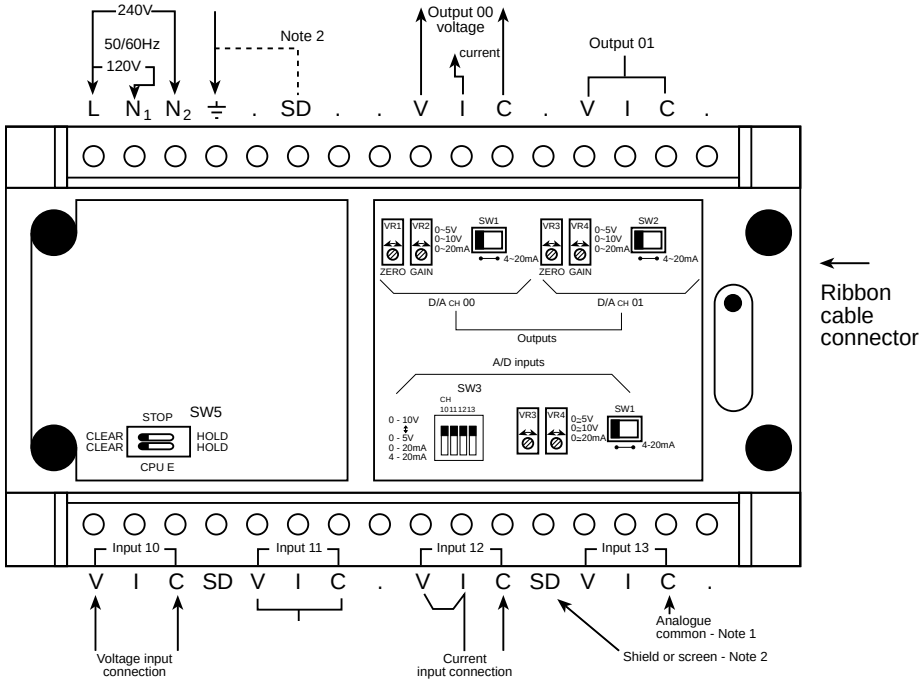
5.4 Analogue I/O unit

This unit enables the F1 PLC base units (except the F1-12) to interface with analogue input devices eg. temperature flow and pressure sensors and provides analogue output to energise voltage or current driven loads. In principle analogue input (voltage or current) data is converted to digital values which can then be processed by the base unit and the resultant outcome can be transferred back to the analogue I/O unit and converted to analogue output (voltage or current). The module is connected to the base unit via a ribbon cable (supplied). Each module can provide 4 input and 2 output channels via the screw terminal connections (3 terminals per channel, common, voltage input and current input).

Technical specification

Supply voltage		110/240V ac 50/60Hz
Supply voltage tolerance		+10% -15%
Number of inputs/outputs		4 inputs/2 outputs single-ended
I/O occupation on base unit		20/unit (one extension connector)
Input range	Voltage	0-10Vdc (input impedance 85kΩ)
	Current	0-20mAdc (input impedance 250Ω)
Digital output to CPU		8 bit binary
Output range	Voltage	0 to +10Vdc (load 500Ω-1MΩ)
	Current	0 to +20mAdc (load 0-500Ω)
Digital input from CPU		8 bit binary
Absolute voltage and current		±12V/±22mA
Conversion speed	A/D	Approximately 350µsec.
	D/A	Approximately 200µsec.
Insulation between I/O		Photo-coupler isolated

Analogue I/O unit - front view with covers removed



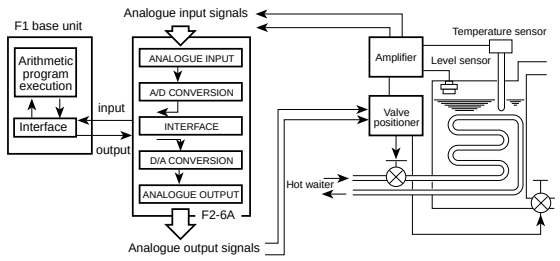
Notes: 1. All analogue common terminals are connected together internally.
2. All shield terminals are connected together internally and normally connected to earth.
3. Terminals marked ● are not connected internally.

Analogue I/O unit

W.165
H.90
D.90

Mitsubishi part no.	**RS** stock no.
F2-6A-E	318-351

Typical application



Inputs

Four input channels that can be arranged to accept voltage or current input signals. Voltage input is connected by using the V and C terminals. Current signals are entered via C and the commoned V and I terminals.

The input channels can be configured to accept 0-5V, 0-10V, 0-20mA or 4-20mA signals. Where the 4-20mA option is selected then all the channels must be of the 4-20mA current type, otherwise input channels may be configured independent of one another. A single set of 'ZERO' and 'GAIN' controls allows accurate and/or alternative scalings to be achieved.

Input type*	Input impedance	Max. input	SW3**	SW4
0-5V	200kΩ	12V	down	left
0-10V	85kΩ	12V	up	left
0-20mA	250Ω	22mA	down	left
4-20mA	250Ω	22mA	down	right

* Range values given are at factory set 'ZERO' and 'GAIN' controls.

** SW3 selects the individual channel input mode. It has one switch designated for each input channel.

Input mode selection example

SW3/CH.10	CH.11	CH.12	CH.13
up	down	up	down

SW4 set to the left

This combination allows input channels 10 and 12 to accept 0-10V inputs and channels 11 and 13 to accept 0-5V or 0-20mA each.

If SW4 is set to the right then input channel should all be used in the 4-20mA mode (all SW3 switches down).

Outputs

Two independent channels that can each be configured in voltage or current modes (0-10V, 0-20mA or 4-20mA) depending upon the slide switch (SW1 for channel 00 and SW2 for channel 01) position. Each channel has 'ZERO' and 'GAIN' adjustment to enable alternative output ranges eg. 0-5V or 0-20mA etc. The 'GAIN' potentiometer is factory set for 0-10V, 0-20mA or 4-20mA.

Example: If SW1 is switched to the left channel 00 will provide output voltage in the range 0-10V or current output in the range 0-20mA depending on the output terminal. The 'ZERO' and 'GAIN' adjustment can be used to alter these ranges.

Note: Either output can be arranged (via SW5) to hold its value or reset to zero on CPU error-condition or when the base unit is in the STOP mode.

Integration with the base unit

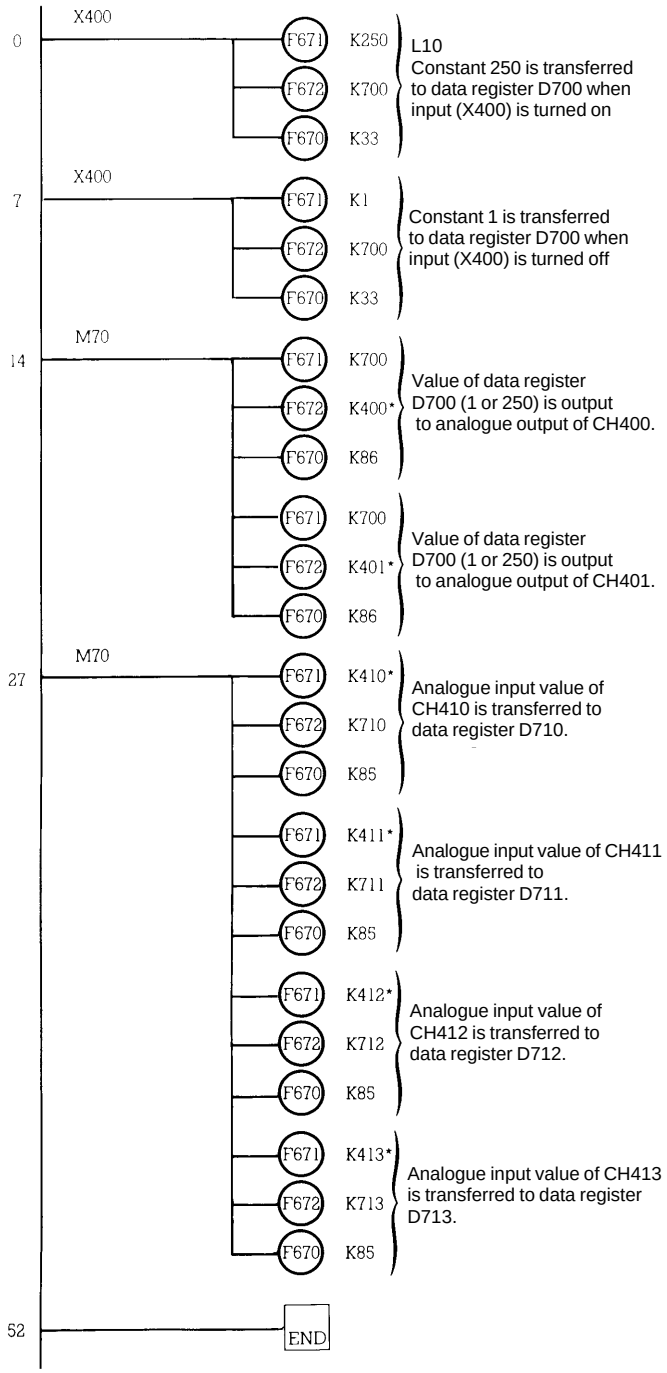
The inputting from and outputting to the analogue I/O unit of data is accomplished via registers D700-770 on the base units. The data to be transferred is a digital constant in the range 0-250 as standard to correspond to 0-10V, 0-20mA or 4-20mA, or any scaled version of these ranges. It is possible to arrange for 0-255 digital range to correspond to the current or voltage range, a higher value than 255 will not be recognised. Thus if the constant '125' was transferred onto one of the outputs set in the 0-10V mode the analogue output voltage resulting after conversion is 5V.

Program examples for transferring data between the analogue I/O unit and the PLC base unit are given later in this data sheet.

5.4.1 Data transfer programming – analogue unit

In order to transfer data between the base unit and the analogue I/O unit, special functions F670, 671 and 672 (refer to programming manual) are used and the type of transfer is determined by the K value of F670. The program below can be used for the initial settings of the input and output 'ZERO' and 'GAIN' adjustments. Thus if a 0-250 digital range is to correspond to 0-6V then the ZERO control will be used to give 0V output at the lower limit and the GAIN adjustment to give 6V at 250. Each incremental step corresponds to 24mV output.

Program listing



Program listing

0	LD	400	27	LD	70
1	OUT	671	28	OUT	671
2	K	250	29	K	410
3	OUT	672	30	OUT	672
4	K	700	31	K	710
5	OUT	670	32	OUT	670
6	K	33	33	K	88
7	LDI	400	34	OUT	671
8	OUT	671	35	K	411
9	K	1	36	OUT	672
10	OUT	672	37	K	711
11	K	700	38	OUT	670
12	OUT	670	39	K	85
13	K	33	40	OUT	671
14	LD	70	41	K	412
15	OUT	671	42	OUT	672
16	K	700	43	K	712
17	OUT	672	44	OUT	670
18	K	400	45	K	712
19	OUT	670	46	OUT	671
20	K	86	47	K	413
21	OUT	671	48	OUT	672
22	K	700	49	K	713
23	OUT	672	50	OUT	670
24	K	400	51	K	85
25	OUT	670	52	END	
26	K	86			

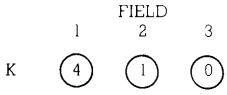
*Note:

Field (K value)

(1) Extension number
given by port of base unit (ie 0, 4 or 5)

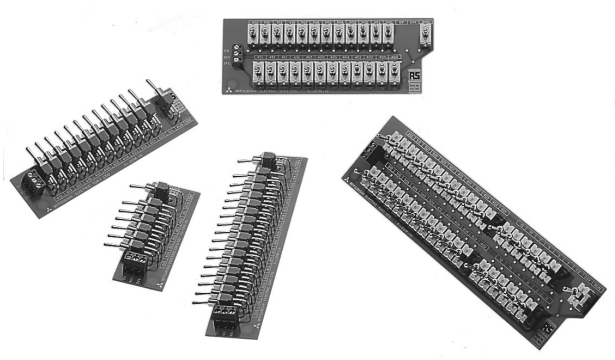
(2) Output (O)
or Input (I)

(3) Channel
Outputs 0 or 1
Inputs 0 to 3



5.5 Input simulators

Input simulators



A pcb carrying changeover switches for energising the PLC inputs from the 24V on-board supply. Some of these switches have both latching and momentary 'on' positions to allow for pulsed input simulation. An additional stop/run switch is available to control the mode of operation of the base unit. The board has rigid terminal posts that fit directly into the screw terminal block on the PLC component. In addition each board has a 3-way screw terminal block for wiring a single PNP type sensor. These modules are ideal for program testing and verification during commissioning and service.

5.6 Other accessories for use with F1 PLC

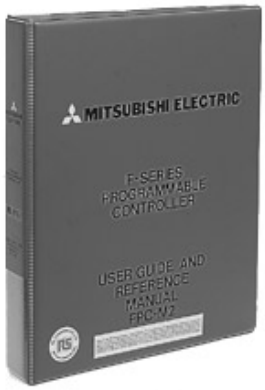
The F1-series is compatible with many F2-series accessories. A list of these items in the RS catalogue is given below.

Description	Mitsubishi part no.	**RS** stock no.
EPROM programmer*	F-20MW	332-773
Program loader/printer interface	F2-20H-De	330-806
Programmer extension cable	F-20P-CAB	331-708
4-channel analogue timer	F-4T-E	331-225

* Units purchased from RS prior to July 1987 will require a software update before they can be used with the F1-series base units. (Refer to the current RS catalogue for details)

5.7 F1-F2 series programming manual

F1-F2 Programming manual



Mitsubishi part no.	**RS** stock no.
F-PC-M2	319-613

Programming the F1-series PLC is very similar to the F2-series. To fully exploit the F1-series it is strongly recommended that the F1-F2 programming manual (RS stock no. 319-613) be used.

This programming manual describes in depth the features and facilities available from the F1-series PLC. It provides a comprehensive reference work for all levels of user and forms an essential user guide.

Topics include:

- Principles of operation
- Installation
- Controls and indications
- Programming, elements and element numbering covering:
  Auxiliary relays (M)
  Counters
  Input elements (X)
  Output elements (Y)
  State elements (S)
  Timers (T)
- Function keys covering:
  AND, ANI, ANB, CJP, EJP, END, LD, LDI, MC, MCR, NOP, OR, ORI, ORB, OUT, PLS, RST, R, S, SFT, STL, STEP LADDER PROGRAMMING, OPERATING KEYS.
- Functional instructions covering:
  Overview
  Reset instructions
  Data register functions
  Data calculations
  Arithmetic functions and
  Miscellaneous

The manual includes many worked examples and hints to better programming understanding and techniques.

6 Programming

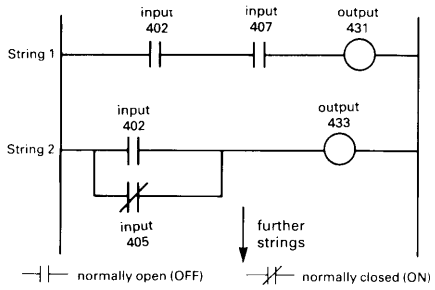
6.1 Basics

Programming is the entering and storing of a sequence of instructions in a PLC memory. This memory is normally built into the base unit. Alternatively the program may be stored on an external memory eg. EPROM, EEPROM or cassette tape. The program is executed by the PLC to control the states of its output.

6.1.1. Ladder logic representation of a program

Starting from the left, string 1 implies an instruction to switch ON output 431 only when input 402 AND input 407 are both ON. String 2 instructs the PLC to switch output 433 ON when input 402 is ON OR input 405 is OFF - either condition when satisfied will switch output 433 ON.

Ladder logic example



Note: Inputs and outputs may refer to the inputs and outputs on the PLC base (and extension) units or they may represent the states of counters, timers and internal flags.

To avoid confusion when ladder logic diagrams are being drawn, it is recommended that the following letters should accompany the numeric assignment of each element.

Element type	Letter
Input terminal	X
Output relay	Y
Timer	T
Counter	C
Auxiliary relay	M

Thus

represents an instruction to switch output relay 432 ON when input 412 and auxiliary relay 103 are both ON.

6.1.2 Ladder logic diagram implementations

To convert the ladder diagram into instructions acceptable by the PLC, the programming panel is equipped with a set of instruction keys. Together with the numeric assignments of the various elements in the diagram these instructions form the PLC program corresponding to the original ladder diagram. Table 3 shows the application of each instruction key. Letters X, Y etc. underneath certain elements represent the allowable types of operable instructions for that element (ie. inputs, outputs, counters etc.)

Notes:

1. Inputs

The inputs are all 24Vdc and source type in order to meet the DIN standards. A 24Vdc supply is internally generated which will power no-voltage contacts and in some cases external devices such as proximity devices. Each input is photo-coupler isolated so as to minimise the effect of external electrical interference and to isolate each input circuit for safety. The input filter constant may be changed in the software between 200µs and 60ms.

2. Outputs

F1-series base and extension units are only available with relay outputs. These will handle up to 2 amps (resistive) at 240Vac or 24Vdc. These relays have no leakage components across the contacts.

3. Timers

There are 32 digital timers of which 24 have a range 0.1 to 999 seconds and eight have a range 0.01 to 99.9 seconds. The timers may be monitored by any of the programming panels and their values are set in the software. The timers are crystal controlled and are therefore very accurate. Timers may be cascaded in order to give long time durations.

4. Counters

There are 30 pre-settable down counters with reset inputs and the count value is retained when power is removed from the unit. Each counter has a range from 1-999 and they may be cascaded in order to extend the count value.

Timer or counter setting value may be changed while the PLC is operating. This is useful for applications where the PLC cannot always be stopped during a control process.

5. Auxiliary relays

There is a total of 232 internal relays of which 128 are standard auxiliary relays, 64 are latch relay (power loss retentive) and 40 are used as state relays and are used for flow-chart programming or may be used as additional latch relays.

6. I/O forcing

By using the programming panel, the logic status of any input, output, internal relay or STATE relay can be forced ON or OFF. Also, any timer or counter can be forced to time-up or count-up regardless of the program stored in the processor memory.

6.2 Memory map F1 series

The F1 PLCs have inputs, outputs etc assigned in the following way. Not all units have the inputs and outputs (X and Y) as these will depend upon the base unit and any extensions used. The remainder are not physical devices but are locations in the memory of the PLC and are common to all the base units except where noted.

Inputs	X	00-27,	00-427, 500-527
Outputs	Y	30-37,	430-437, 530-537
Auxiliary relays	M	100-377	
Special functions	M	70-77	
Timers	T	50-57,	450-457, 550-557, 650-657
Counters	C	60-67,	460-467, 560-567, 660-667
Stepladder	STL	600-647	
Conditional jumps	CJP	700-777	
Data registers	D	700-777	(Except F1-12)

6.2.1 Special function relays

This is a group of relays which is of general use with the following functions. With the exception of relay 77 they are only accessible via their contacts ie. they do not have coils.

70	Run monitor	Continuously ON when the PLC is in RUN
71	Initialise pulse	A single pulse lasting 1 execution cycle which occurs when the PLC is put in to RUN
72	Clock (100ms)	A continuous pulse train of 50ms ON, 50ms OFF
73	Clock (10ms)	A continuous pulse train of 5ms ON, 5ms OFF
76	Battery voltage	Turns ON when the memory back-up battery is becoming discharged
77	Output inhibit	If this coil is energised all outputs are turned OFF regardless of the rest of the program

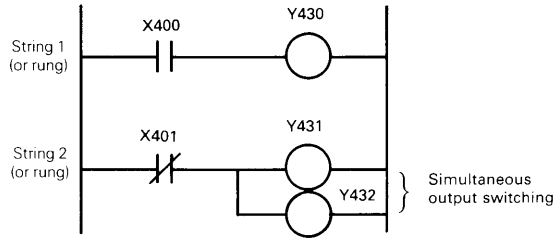
Table 3 **Programming function guide**

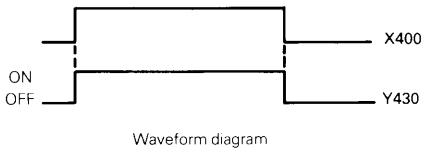
Instruction code	Function	Applicable element type
LD LOAD	Starts logic operation (normally open contact)	X,Y,M,T,C,S,F
LDI LOAD INVERSE	Starts logic operation (normally closed contact)	X,Y,M,T,C,S,F
AND AND	AND (normally open contact serial connection)	X,Y,M.T,C,S,T
ANI AND INVERSE	AND inverse (normally closed contact serial connection)	X,Y,M,T,C,S,F
OR OR	OR (normally open contact parallel connection)	X,Y,M,T,C,S,F
ORI OR INVERSE	OR inverse (normally closed contact parallel connection)	X,Y,M,T,C,S,F
ANB AND BLOCK	Serial connection between blocks	-
ORB OR BLOCK	Parallel connection between blocks	-
OUT OUT	Coil (output) drive instructions	Y,M,T,C,S,F
RST RESET	Resets shift register and counter	C M100, 120, 140, 160, 200, 220, 240, 260, 300, 320, 340, 360
PLS PULSE	When the input signal is rising a pulse is produced for the length of one execution cycle	M100~M377
SFT SHIFT	Temporary memory 1 bit shift	M100, 120, 140, 160, 200, 220, 240, 260, 300, 320, 340, 360
S SET	Holds Y, M and S operations	Y.M200~M377.S
R RESET	Cancels Y, M and S operations	Y.M200~M377.S
MC MASTER CONTROL	Common serial contact point	M100~M177
MCR MASTER CONTROL RESET	Cancels common serial contact point	-
CJP CON-DITIONAL JUMP	Conditional jump to EJP when input is on	M=700~777

Note: Examples of converting various ladder diagram configurations into PLC program instructions using the programming panel keypad are given as follows (additional configurations are available in the manual supplied with the programming panels).

6.3 Programming examples

6.3.1 LD, LDI, OUT





Waveform diagram

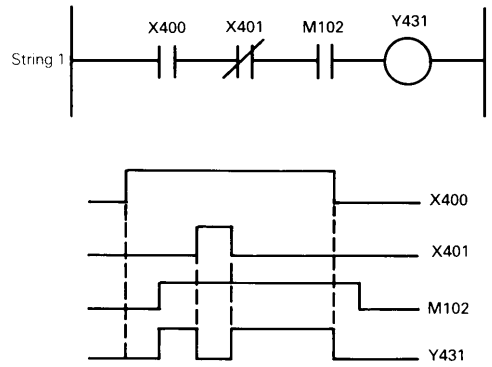
String (or rung) 1 implies output 430 (relay) turns ON when input 400 is ON. String 2 implies outputs 431 and 432 (relays) turn ON when input 401 is OFF. The output element(s) in a particular string can subsequently be entered as input(s) in other parts of the ladder diagram. The corresponding instruction set for the above diagram is:

	step	instruction	element
String 1	0	LD	400
	1	OUT	430
String 2	2	LDI	401
	3	OUT	431
	4	OUT	432

It is advisable when forming the instruction set to follow the same string order as the ladder diagram.

Note: Step No. is only to indicate the program order and size and is not physically entered via the programming panel.

6.3.2 AND, ANI (AND INVERSE)

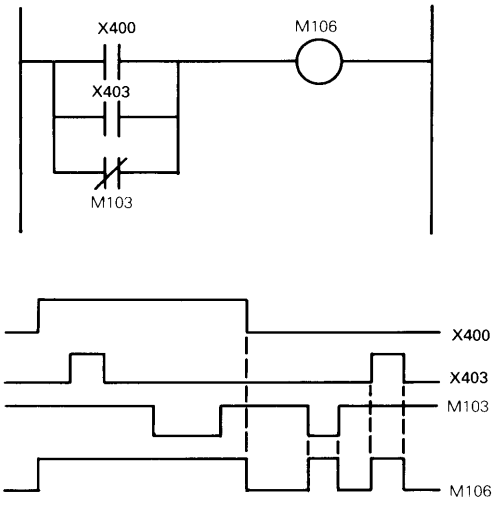


String 1 implies output 431 (relay) turns ON when input 400 is ON, input 401 is OFF and auxiliary relay 102 is ON.

Equivalent instructions

step	instruction	element
0	LD	400
1	ANI	401
2	AND	102
3	OUT	431

6.3.3 OR, ORI (OR INVERSE)



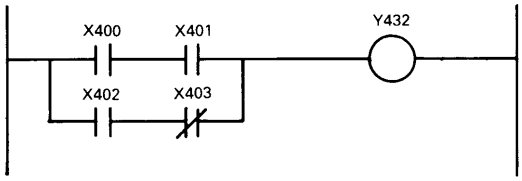
This implies auxiliary relay 106 is ON when input 400 is ON or input 403 is ON, or auxiliary relay 103 is OFF ie. any one or more of these input conditions will turn the output ON.

Equivalent instructions

step	instruction	element
0	LD	400
1	OR	403
2	ORI	103
3	OUT	106

6.3.4 ORB (OR BRANCH)

Connects two branches in parallel

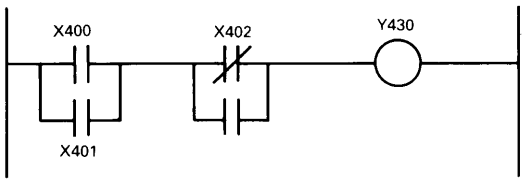


Equivalent instructions

step	instruction	element
0	LD	400
1	AND	401
2	LD	402
3	ANI	403
4	ORB	-
5	OUT	432

6.3.5 ANB (AND BRANCH)

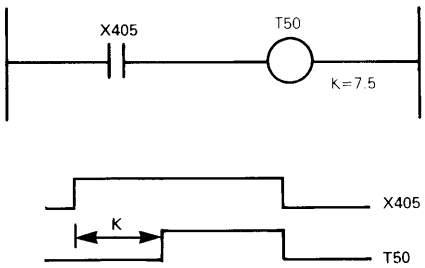
Connectors two groups in series



Equivalent instructions

step	instruction	element
0	LD	400
1	OR	401
2	LDI	402
3	OR	107
4	ANB	-
5	OUT	430

6.3.6 Setting an internal timer



Implies that when input 405 turns ON the output of timer 50 turns ON after 7.5 seconds (K=7.5).

Equivalent instructions

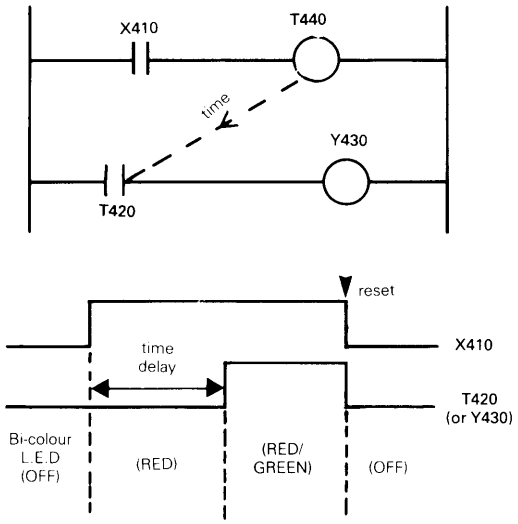
step	instruction	element
0	LD	405
1	OUT	50
2	K	7.5

The value of K can be set within 0.1 - 9.9 in 0.1 second increments or 1-99 in 1 second increments. The timer output resets if the input is switched OFF. Timer cascading with other timers and counters is possible.

6.3.7 Setting the analogue timer

In order to incorporate any of the analogue timer circuits into the PLC program the timer coil, and the associated timer output have to be specified.

Example. Timer circuit 440 (having output 420)



Equivalent instructions

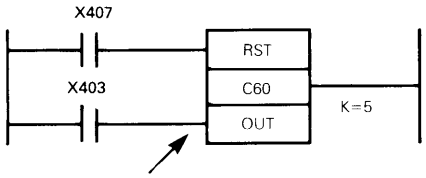
step	instruction	element
0	LD	410
1	OUT	440
2	LD	420
3	OUT	430

The ladder logic diagram indicates that if input 410 is closed then timer coil 440 is energised, and after a delay equal to the time set on the circuit (by the DIL switch pair and front potentiometer for that circuit), the timer output 420 is energised.

Note: As the timer output 420 is only internal it should be connected to an output in the base unit if external switching is required. In the example above output 430 was used as the external relay.

An example of analogue timer and internal PLC timer cascading is given later.

6.3.8 Setting a counter



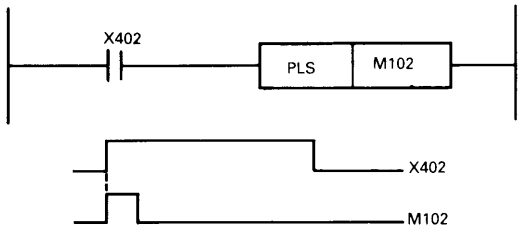
A positive pulse on X407 resets counter 60 to OFF state. If 5 positive pulses (or OFF to ON transmissions) appear on X403 the counter output turns ON (K × 5). Any changes on X403 are disregarded as long as X407 is ON.

Equivalent instructions

step	instruction	element
0	LD	407
1	RST	60
2	LD	403
3	OUT	60
4	K	5

6.3.9 PLS (PULSE)

Introduces a positive pulse onto an auxiliary relay.



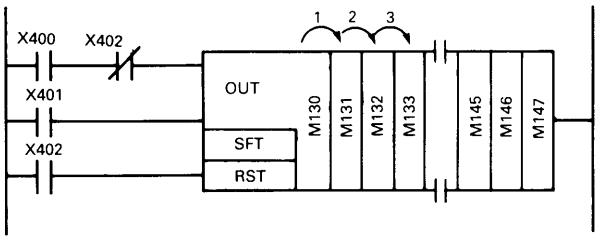
Whenever input 402 turns ON a positive pulse is generated on auxiliary relay 102. This pulse can feed internally elsewhere eg. to reset a counter. Pulse width equals one program execution cycle time.

Equivalent instructions

step	instruction	element
0	LD	402
1	PLS	102

6.3.10 SFT (SHIFT)

This instruction applies to a shift register which is a block of 16 auxiliary relays with consecutive numbers ie. 100-127, 130-147 ... up to and including 370-377.



Equivalent instructions

step	instruction	element
0	LD	400
1	ANI	402
2	OUT	130
3	LD	401
4	SFT	130
5	LD	402
6	RST	130

The ladder diagram implies that when input 402 is OFF M130 has the same state as input 400. Input 401 is the shift input and every time this input switches ON (or pulsed) the original state of M130 advances one step through the register until it 'drops off' or feeds through to another element. If input 401 continues to be clocked any subsequent changes on input 400 (ie. M130) will similarly advance through the register.

This facility is used in sequence control applications by utilising the auxiliary relay states to control various output devices. Input 402, when turned ON, resets the shift register (ie. turns OFF all the auxiliary relays) and shift pulses are not accepted whilst input 402 is ON.

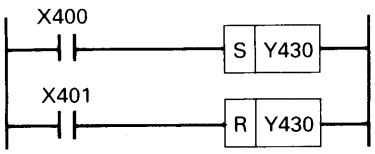
Note: Shift register cascading is possible for longer sequence requirements.

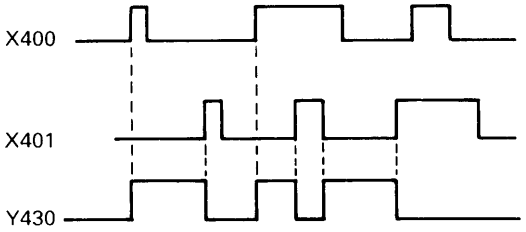
6.3.11 Set and Reset - S, R

For latching and releasing certain elements. These features also form the basis for stepladder programming (see later).

Applicable elements: M200-377, all outputs, all state elements.

Example:





Equivalent instructions

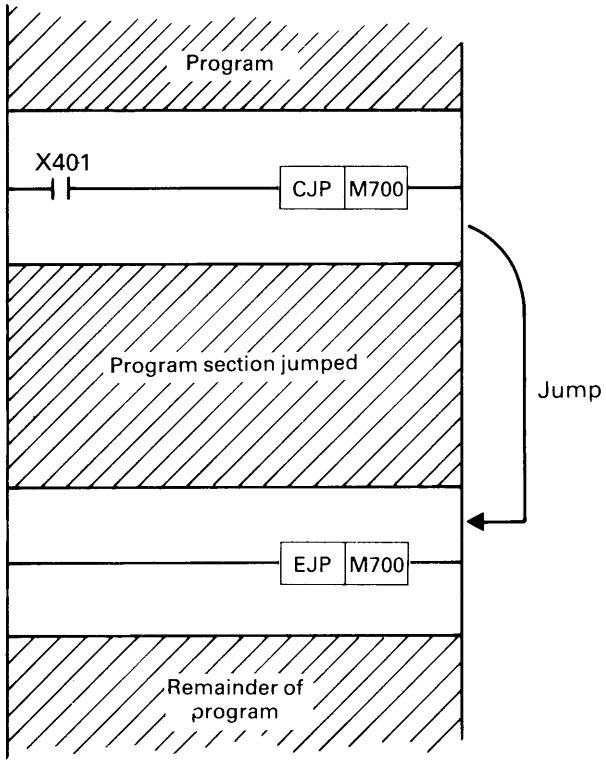
step	instruction	element
0	LD	400
1	S	430
2	LD	401
3	R	430

6.3.12 Conditional jump 'CJP' and end of jump 'EJP'

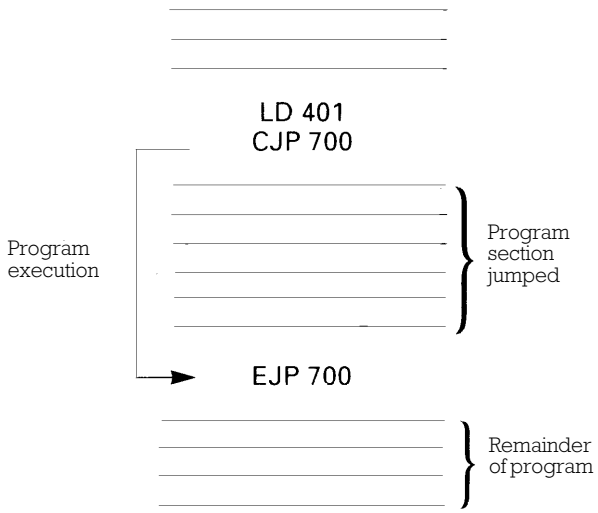
This allows areas of the program to be selectively jumped. The jump instruction accompanied by an element number together with 'end of jump' instruction with the same number define the boundary of the program section to be jumped.

Applicable elements: auxiliary relays M700-M777.

Example:



Equivalent program



In this example the jump operation is performed on the condition that input 401 is turned ON.

Note: Program section jumped is not scanned, thus the overall scan time of the PLC program is reduced when conditional jump is operative.

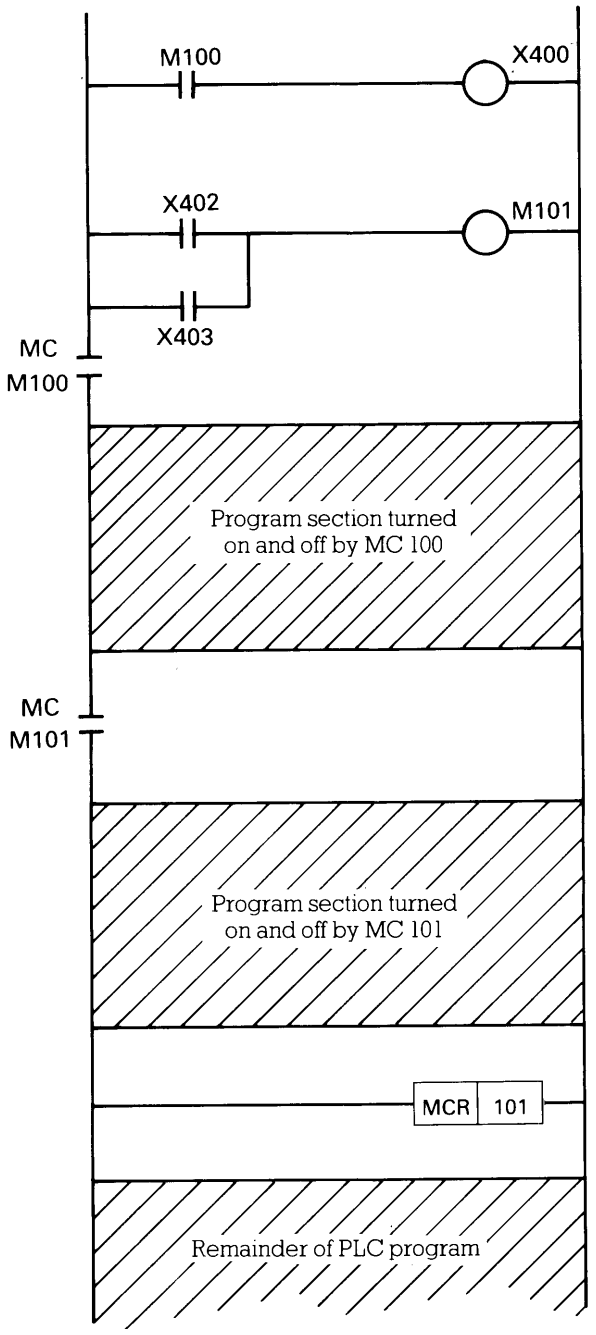
6.3.13 Master control 'MC' and Master control reset 'MCR'

Master control instruction MC effectively positions an auxiliary relay on the busbar of the ladder diagram thus allowing sections of the program to be turned on and off.

Master control reset MCR is required to terminate MC instruction and thus returns the processor to the remainder of the PLC program.

Applicable elements: M100-177.

Example:



Equivalent program

```
LD      400
OUT     100
LD      402
OR      403
OUT     101
MC      100
_____ }
_____ }
_____ }  Program section switched on and off by MASTER CONTROL 100
_____ }
_____ }

MC      101
_____ }
_____ }
_____ }  Program section switched on and off by MASTER CONTROL 101
_____ }
_____ }

MCR     101     Resets master control
_____
_____
_____   Remainder of program
_____
_____
```

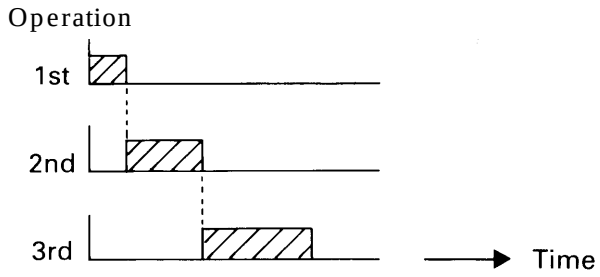
In this example when input 400 is ON auxiliary relay 100 is turned ON and thus part of the program controlled by Master Control 100 will be executed. Similarly if either of inputs 402 and 403 is ON then program section under MC101 control will be executed.

Notes:

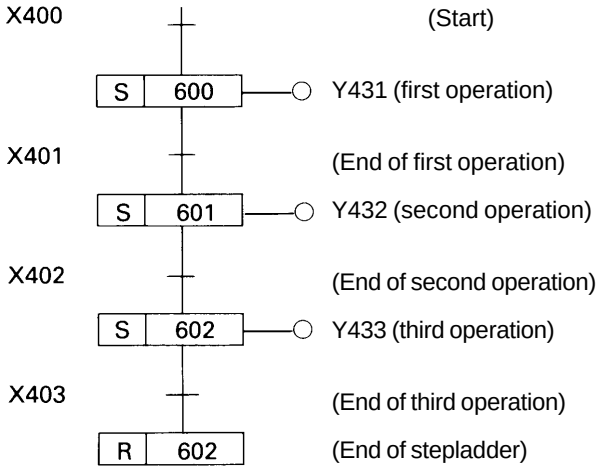
1. In this example only one reset instruction MCR 101 was required. This is because the MCR instruction will automatically cancel all lower order Master Control instructions.
2. The program sections under Master Control are always scanned by the processor regardless of the states of MC elements. This program scan time is not shortened by turning off a Master Control function.
3. When a Master Control element is turned off all timers within the program section of that element will reset.
4. Use of Master Control and Conditional Jump instructions may be combined. Refer to programming manual **RS** stock no. 319-613 details.

6.3.14 Stepladder programming

This is a special feature which makes the PLC behave in a similar way to a step sequencer (sequence controller). Here a sequence of operations is executed in series ie. the end of a particular operation triggers the start of the following one.



Using the state elements (S600-647), the PLC can perform stepladder operations. A schematic representation of a stepladder program is shown below.



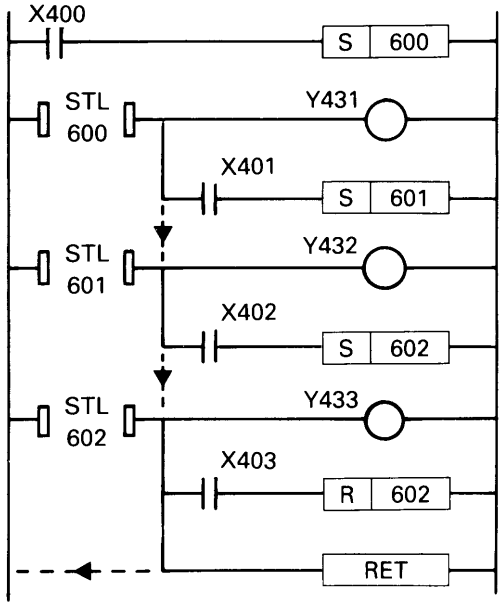
Inputs 401, 402 and 403 are arranged to turn on at the end of output 431, 432 and 433 respectively, eg. a limit switch at the end of carriage travel.

Here the setting of the stepladder element causes the automatic resetting of the previous element. This is the key to stepladder programming.

The sequence of operations will be as follows:

X400 on → S600 is set and Y431 on
↓ 1st operations performed until
X401 on → S600 is reset and Y431 off
S601 is set and Y432 on
↓ 2nd operation performed until
X402 on → S601 is reset and Y432 off
S602 is set and Y433 on
↓ 3rd operation performed until
X403 on → S602 is reset and Y433 off.

The ladder diagram for the previous example is:



The equivalent program is listed below:

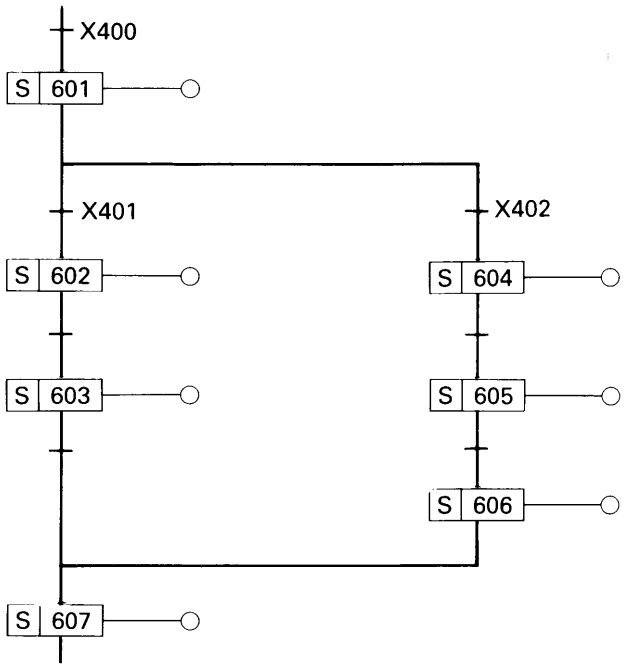
LD	400
S	600
STL	600
OUT	431
LD	401
S	601
STL	601
OUT	Y32
LD	402
S	602
STL	602
OUT	433
LD	403
R	602
RET	

Notes:

1. STL instruction effectively shifts the busbar to the dotted line above.
2. Reset instruction R is necessary to reset the last stepladder element in the sequence.
3. RET instruction returns the program to normal busbar.

Auxiliary relay M574 is used as an emergency stop facility to inhibit stepladder program execution.

Stepladder programs can be split for parallel or conditional sequences eg.

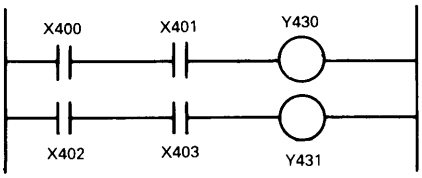


In addition repeated sequences or parts of sequences are possible.

Further details on these facilities are given in the programming manual RS stock no. 319-613.

6.3.15 NOP (NO OPERATION)

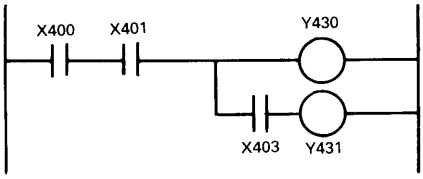
This instruction produces a blank program step which the PLC scans without taking any action. If this instruction replaces another program instruction it can change the program flow eg:



Equivalent instructions

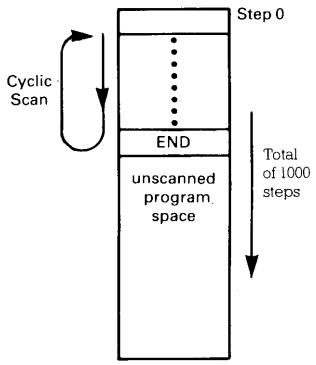
instruction	element
LD	400
AND	401
OUT	430
LD	402
AND	403
OUT	431

Should LD402 be replaced by 'NOP' instruction ie. 'rubbed off'. The resulting ladder diagram is:



6.3.16 End

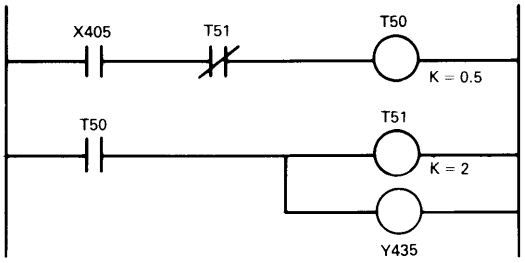
This instruction terminates the program. When not used the PLC scans the full program space (1000 steps) regardless of the program length. However if 'END' is used the PLC will only scan and execute the program portion up to the 'END' position thus increasing the speed of the PLC response to fast I/O changes.



6.4 Circuit examples

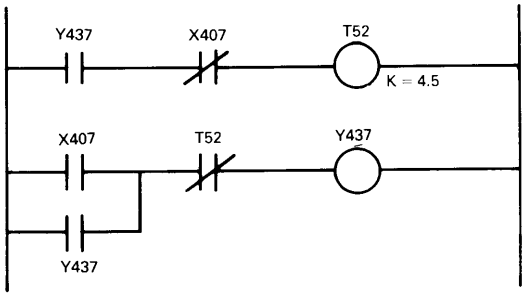
Some common circuit programs are shown below.

6.4.1 Cyclic timer



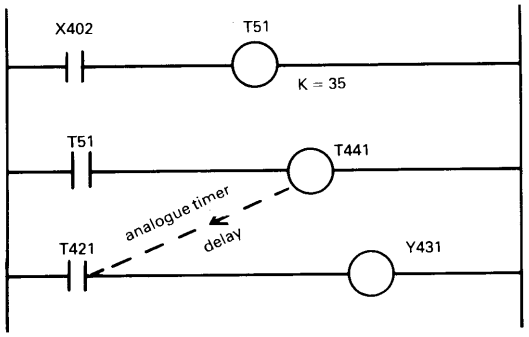
While input X405 is ON, output Y435 continues to cyclically turn ON for 2 seconds and OFF for 0.5 seconds. On and OFF periods can be set to a minimum of 0.1 seconds. Considerably longer periods can be achieved by timer/timer (or counter/timer) cascading.

6.4.2 Delay on de-energise



Output Y437 immediately follows input X407 on switch ON but when input X407 is turned OFF output Y437 remains energised for 4.5 seconds before switching OFF.

6.4.3 Internal and analogue timer cascading

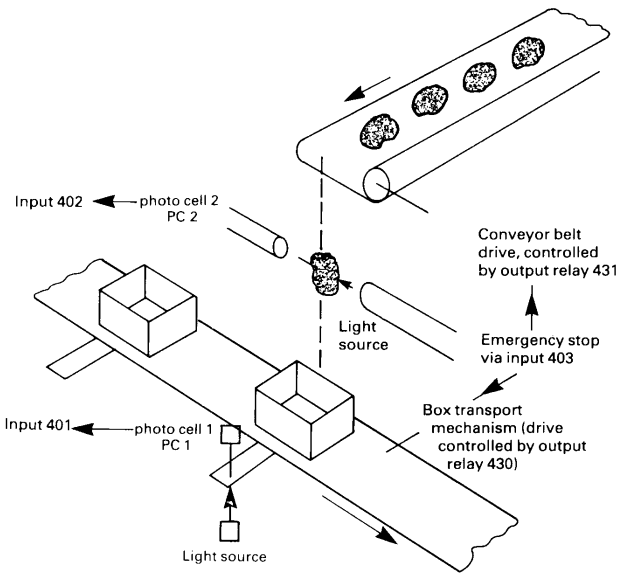


Total time delay between input 402 energisation and output 431 switching ON equals, in the example shown, 35 seconds plus the time delay of analogue timer circuit 441.

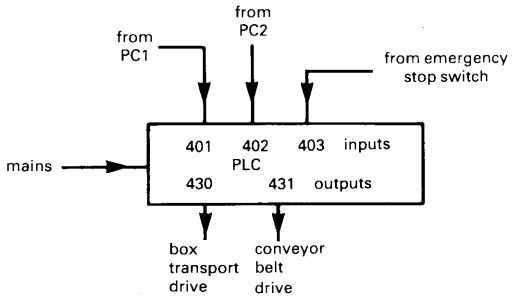
7 Typical control application

This example shows how the RS PLC can be used to control a conveyor belt system below.

Conveyor belt system control example



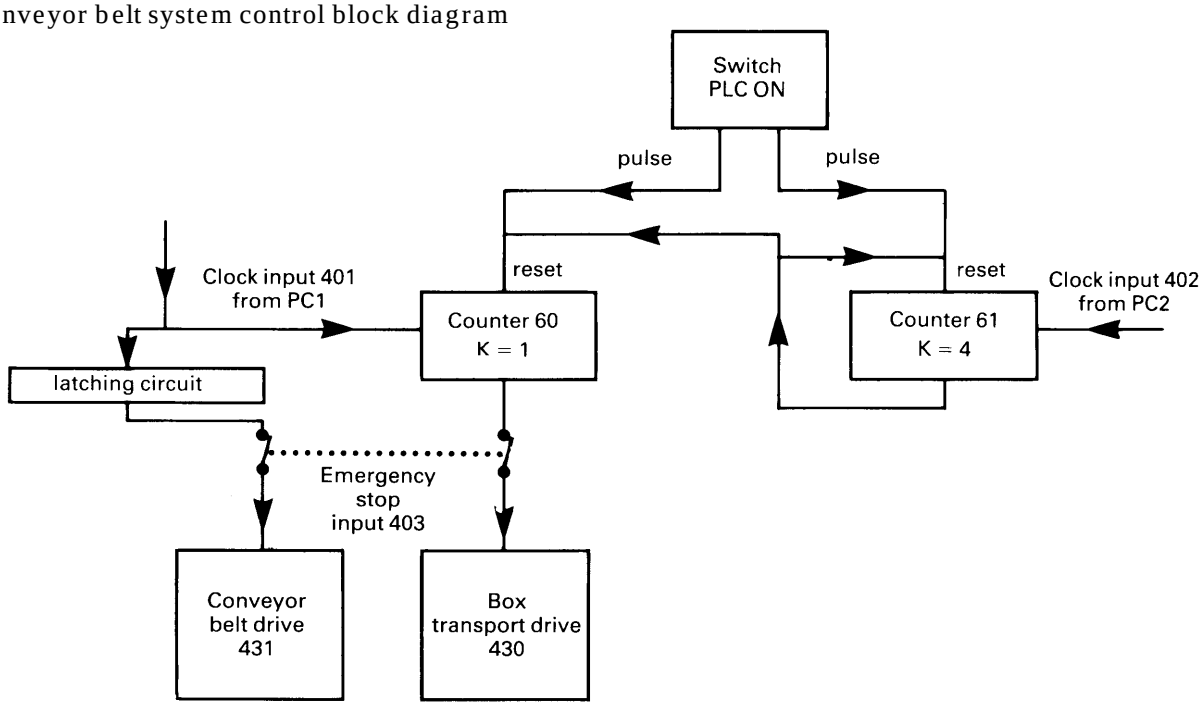
The PLC task is to initially move the box transport mechanism (low inertia assembly) until the first box is directly underneath the conveyor belt roller. The PLC is then to start the conveyor belt and when 4 items fall into the box it is to be swiftly replaced by another empty box with the conveyor belt still moving (assuming sufficient time between the production items falling into the box). This process is to continue until the system is turned OFF. In addition, the two drive mechanisms are to have a common emergency stop switch. In order to program the PLC for controlling this system all the inputs and outputs used must be assigned. In this example the following connections are chosen:



Before programming it is useful to draw a block diagram to represent the detailed system operation and then convert this into a ladder logic diagram, which can be translated into program instructions. For the conveyor belt system the block diagram is shown below.

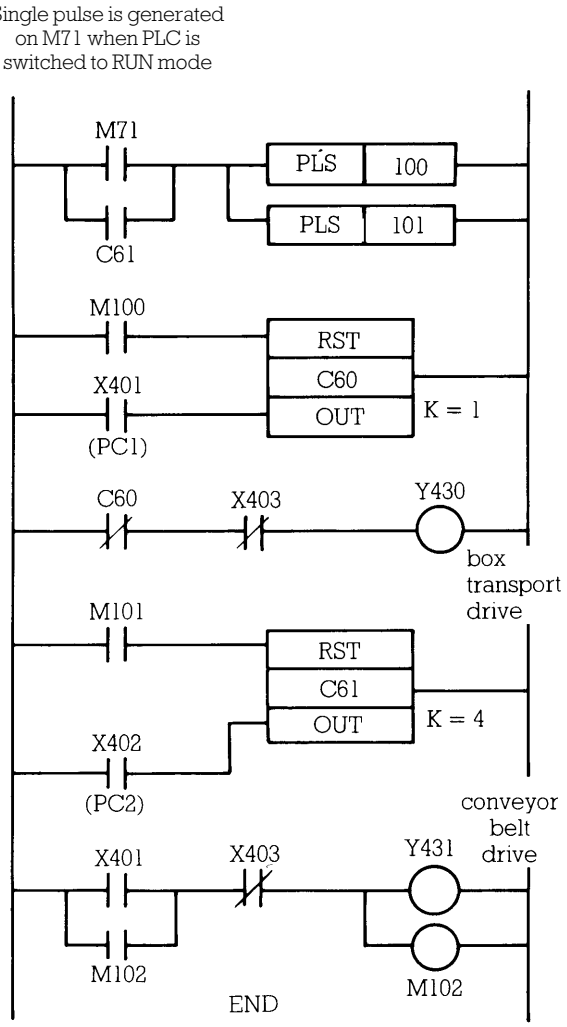
The flow chart can now be converted into a ladder logic diagram and the actual program can also be listed as shown in Table 4.

Conveyor belt system control block diagram



When the PLC is switching ON two pulses are generated, one rests counter 61, the other resets counter 60 and starts the box transport drive until PC1 detects the correct positioning of a box and increments C60 (to the specified K value) which turns the box transport OFF. At the same time the conveyor belt starts moving and PC2 detects the production items falling into the box. When four of these have dropped, counter C61 resets C60 thus starting the box transport again, and at the same time C61 resets itself ready to count the next four items.

Table 4 Ladder logic diagram for conveyor belt system




```
1   LD    71      } generates reset pulses
2   OR    61      } after switch ON and
3   PLS   100     } whenever four production
4   PLS   101     } items fall into a box

5   LD    100     } moves box transport
6   RST   60      } until photo cell or
7   LD    401     } emergency switch X403
8   OUT   60      } stops the mechanism.
9   K     1)      }
10  LD1   60      }
11  ANI   403     }
12  OUT   30      }

13  LD    101     } when four items fall into a
14  ST    61      } box, this part resets counter
15  LD    402     } 61 which in turn resets
16  OUT   61      } counter 60 thus restarting box
17  K     4       } transport mechanism

18  LD    401     } Latching circuit which
19  OR    102     } maintains the belt drive 'ON'
20  ANI   403     } after the 1st signal from PC1
21  OUT   31      } unless reset by the
22  OUT   102     } emergency switch 403)
23  END
```

Note: The length of the program (terminated by 'END' instruction) determines the frequency at which the PLC scans the program. The shorter the program the faster the scan – resulting in a faster response to varying input/output conditions.

Important. If the PLC is programmed to control a particular plant or assembly, it is essential to check that the required control sequence can be correctly achieved by simulating the input and output conditions and testing the entire program before connecting the PLC to the actual system requiring control.

8 F1 facilities - additional features

Mathematics

The arithmetic functions operate with BCD data. They are: addition, subtraction, multiplication and division. It will also compare for equality, 'greater-than' and 'less-than'. There is a data-transfer facility to aid the use of the mathematical functions.

Data transfer

This allows the storage and transfer of BCD data from one storage resister to another. This is useful for applications where the PLC must select stored data for processing controls or where data must be stored for use on display.

Momentary input signal detection

Two input points can recognise input pulse signals shorter than the PLC program scanning time (approximately 200μsec.). The momentary signals are caught by hardware circuits and utilised in the program. This is useful for applications where such detection is necessary.

High speed counter

A built-in digital counter with a range from 0 to 999999 can count either up or down a single phase signal of up to 2kHz for interfacing to external sensors, detecting objects or speed etc. Counting starts from either zero or another preset value. The counter is preset by an external input signal or special internal preset function (auto-reload function). The counting value is compared with programmed values, causing program execution to be interrupted at the preset points. Counter output is considerably faster than in normal program scanning (direct output function). This counter may also be used as a six-digit normal counter.

Auto-reload function

Immediately after data comparison is executed, it is possible to internally preset the counter. (Note: comparison interrupts program scanning). This is very useful when it is not possible to externally preset the counter, for example, when producing coil or film windings.

Direct output function

After data comparison is executed (interrupting program scanning), the comparison result is immediately directed to an external output. This eliminates problems caused by program scanning, hence improving the accuracy of control.

9 Special function listing

As with the F2-series, the F1 PLC base unit has a powerful set of special functions to enable the following tasks to be performed:

- Input/Output refresh
- The I/O image memory data can be updated by interruption program execution
- Data transfers
- Data can be transferred between any of the X, Y, M, S, data registers and timer/counter current value registers
- Arithmetic (+, -, ×, ÷, <, =, ≥)
- High speed counter data handling
- Momentary pulse handlings
- Analogue input/output data handling*
- Data set/reset.

***See data transfer programming - analogue I/O unit - end of data sheet.**

The following table gives a summary of the special functions available and the corresponding K values for element F670 - for full details refer to F1-F2 programming manual (**RS** stock no. 319-613).

Table 5 **F1 special functions summary**

K	Special functions summary
00	Immediate update of the status of all input contacts
02	Immediate update of the status of all output contacts
04	Refreshes the watchdog timer at any point in the program
10	Resets the 'counter full' flag M473 of counter C660/C661
11	Resets the output contact of counter C660/C661
14	Sets the carry flag
15	Resets the carry flag
16	Sets the zero flag
17	Resets the zero flag
18	Sets the borrow flag
19	Resets the borrow flag
26	Resets all elements within a band defined by the first and last elements to be reset
27	Converts a decimal constant into its BCD equivalent. Sets value into a series of output contacts (Y), state elements (S) or auxiliary relays (M100-M377)
28	Writes an octal number into a series of output contacts (Y), state elements (S) or auxiliary relays (M100-M377). Octal range between 0 and 377
29	Reads the BCD value set into a series of input elements (X), output contacts (Y), auxiliary relays (M100-M377) or state elements (S) and copies that value to another series of Y, S or M elements. BCD range 1 to 16 bits
33	Writes a decimal constant into any data register, including the current value registers and setting registers of counters and timers
34	Reads the BCD value set into a series of input contacts (X), output contacts (Y), auxiliary relays (M100-M377) or state elements (S) and copies that value to any data register, including the current value registers and setting registers of counters and timers

35	Reads the current value of any data register, including the setting values for counters and timers and copies that value to auxiliary relays, output contacts or state elements
36	Reads a 12-bit BCD value set into a series of input contacts (X), output contacts (Y), auxiliary relays (M100-M377) or state elements (S) and copies that value into a data register
37	Reads the 3 digits of a given data register and copies that data to a series of input elements (X), output contacts (Y), auxiliary relays (M100-M377) or state elements (S) as a 12-bit BCD value
38	Writes a given 3-digit decimal value into a series of data registers
39	Copies the contents of any data register into a series of data registers
40	Compares a 3-digit decimal constant with the contents of any data register, including the current value and setting registers of counters and timers
41	Compares the contents of a data register or the current value of a counter or timer, with a 3-digit BCD value set into a series of state elements (S), input elements (X), output relays (Y) or auxiliary relays (M)
42	Compares the contents of a counter or a data register with a 3-digit BCD value set into a series of state elements (S), input elements (X), output relays (Y) or auxiliary relays (M)
43	Compares the contents of any registers with two 3-digit decimal values
44	Compares a 6-digit value from a counter or data register with two 6-digit decimal constants
45	Compares the contents of a counter or data register with the contents of another counter or data register
46	Interrogates any specified data register for zero content
48	Reads the contents of a given data register, clears a specific digit and stores the resultant value in a data register selected by the user
49	Exchanges the contents of two data registers
51	Transfers a 3-digit BCD value from any data register, current value register or setting register to any other data register, current value register or setting register
52	Copies the contents of one data register to another data register. The address of the data source is obtained indirectly from another register
53	Copies the contents of one data register to another data register. The address of the data destination is obtained indirectly from another register
54	Copies the contents of one data register to another data register. The addresses of both source and destination registers are obtained indirectly from other data registers
55	Adds a programmed decimal value to the contents of a data register and stores the results in another data register
56	Adds a programmed decimal value to the contents of a data register, adds in the carry bit and stores the results in another data register
57	Adds the contents of two 3-digit (BCD) data registers and stores the result in a third register
58	Adds the contents of two 3-digit (BCD) data registers, adds in the carry bit and stores the results in a third data register
59	Adds the contents of two 6-digit (BCD) data registers, adds in the carry bit and stores the results in a third data register
60	Adds the contents of two 3-digit (octal) data registers, adds in the carry bit and stores the results in a third data register
61	Adds 1 to the contents of a 3-digit BCD specified data register and if appropriate, sets the carry flag or the zero flag
62	Adds 1 to the contents of a 6-digit BCD specified data register and if appropriate, sets the carry flag or the zero flag
63	Adds 1 to the octal contents of a given 3-digit data register and if appropriate, sets the carry flag or the zero flag
64	Adds 1 to the contents of the current value register of a given counter and if appropriate, sets the carry flag or the zero flag
66	Subtracts a given 3-digit decimal constant from a specified 3-digit BCD data register, using the borrow bit when necessary, and stores the result in another data register
67	Subtracts a given 6-digit decimal constant from a specified 6-digit BCD data register, using the borrow bit when necessary, and stores the result in another data register
68	Subtracts one 3-digit BCD data register from another and stores the result in a third data register
69	Subtracts one 3-digit BCD data register from another and stores the result in a third data register. The borrow bit is used when necessary
70	Subtracts one 6-digit BCD data register from another and stores the results in a third data register. The borrow bit is used when necessary
71	Subtracts one 3-digit octal data register from another and stores the results in a third data register
72	Subtracts 1 from the BCD contents of a specified 3-digit data register and if appropriate, sets the borrow flag or the zero flag
73	Subtracts 1 from the BCD contents of a specified 6-digit data register and if appropriate, sets the borrow flag or the zero flag
74	Subtracts 1 from the octal contents of a given 3-digit data register and if appropriate, sets the borrow flag or the zero flag
75	Subtracts 1 from the 3-digit BCD current value of a specified counter
77	Multiplies the contents of a given 3-digit BCD data register by a 3-digit decimal number and stores the results in a 6-digit data register
78	Multiplies the contents of a given 6-digit BCD data register by a 6-digit decimal number and stores the result in a 12-digit data register
79	Multiplies together the contents of two 3-digit BCD data registers and stores the product in a 6-digit data register
80	Multiplies together the contents of two 6-digit BCD data registers and stores the product in a 12-digit data register
81	Divides the contents of a given 3-digit BCD data register by a 3-digit decimal number and stores the result, and the remainder in other data registers

82	Divides the contents of a given 6-digit BCD data register by a 6-digit decimal number and stores the result, and the remainder in other data registers
83	Divides the contents of a data register by the contents of another data register, both 3-digit BCD, and stores the result and the remainder in other data registers
84	Divides the contents of a data register by the contents of another data register, both 6-digit BCD, and stores the result and the remainder in other data registers
85	Reads the 8-bit binary output from the analogue unit and converts it into 3-digit BCD for storage in a data register
86	Converts the contents of the specified data register into 8-bit binary format and writes it to the analogue unit
87	Sets the format for the subtraction instructions F670-K66, K67, K68, K69, K70 and K71
88	Interrogates a series of data registers within the range D700 to D777 to determine if the contents are in BCD and the correct format for the controller
100	Immediate update of the status of all input contacts
101	Immediate memory update - input contacts X400 to X407
102	Immediate update of the status of all output contacts
103	Resets all elements within a band defined by the first and last elements to be reset
104	Transfers a 3-digit BCD value from auxiliary relays M260 to M273 into a counter current value register
105	Transfers the current value of any 3-digit BCD counter to auxiliary relays M260 to M273 (which can drive output elements)
106	Compares the current value register of a specified counter with two 3-digit decimal values. Flags M571, M572 and M573 indicate the results
107	Compares the contents of a counter current value register with the value set into the series of auxiliary relays, M260 to M273. The results are indicated by flags M572, M572 and M573
108	Compares the current value of a 6-digit counter with two 6-digit decimal constants. Flags M571, M572 and M573 indicate the result
109	Converts a 6-digit decimal constant into its BCD equivalent and sets the value into a series of auxiliary relays M240 to M253, M260 to M273
110	Resets the 'counter full' flag M473 of counter C660/C661
111	Resets the output contact of counter C660/C661
112	Detects the leading edge of a signal appearing at input contact X400
113	Detects the leading edge of a signal appearing at input contact X400
114	Detects the leading edge of a signal appearing at input contact X401
115	Detects the leading edge of a signal appearing at input contact X401
116	Used when M470 is in force, to remove the high-speed counter reset function from relay X401
117	Performs an automatic reload of counters C660/C661 when the combined current values reach a predetermined level
118	Authorises automatic reload of counters C660/C661
119	Performs an immediate 'read and compare' operation on the current value register of high-speed counter (C660/C661) and uses the result of the comparison to drive a selected output contact, giving a direct output at the time the counter current value reaches a specific number
120	Inhibits direct output mode for high-speed counter
121	Enables simultaneous output in direct output mode
122	Measures the pulse width, in 1ms increments, of a signal appearing at input contact X402
123	Measures the pulse width, in 1ms increments, of a signal appearing at input contact X403
124	Used to count the pulses appearing at input contact X400
125	Used to count the pulses appearing at input contact X401
130	Generates a shift in a specified shift register
131	Converts a BCD number into a binary number
132	Converts a binary number into a BCD number

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