Dr. Norbert Cheung's Series in Electrical Engineering

Level 4 Topic no: 02

Programmable Logic Controllers

Contents

Reference:

"Fundamentals of Electrical Control," Clarence A Philips
"OMRON – Zen Operation Manual" Omron Manual Reference: Z211-E1-03

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1. Introduction

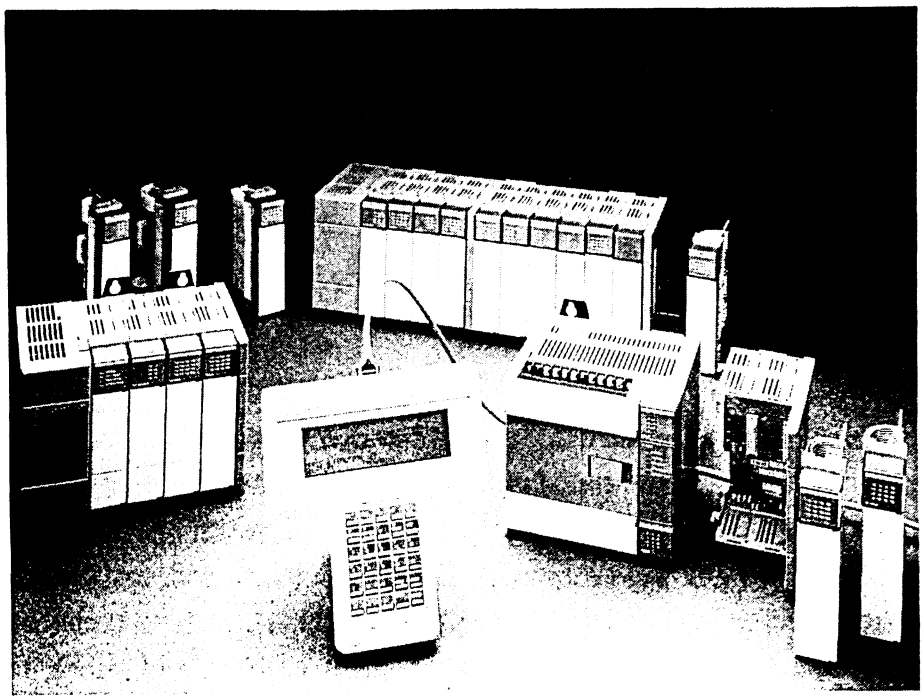
- The development of Programmable Logic Controllers (PLCs) was driven primarily by the requirements of automobile manufacturers who constantly changed their production line control systems to accommodate their new car models.
- In the past, this required extensive rewiring of banks of relays - a very expensive procedure.
- With the emergence of solid-state electronic logic devices, several auto companies challenged control manufacturers to develop a means of changing control logic without the need to totally rewire the system.
- The Programmable Logic Controller (PLC) evolved from this requirement. (PLC™ is a registered trademark of the Allen-Bradley Co. but is now widely used as a generic term for programmable controllers.)

Features:

- Use computers to replace relays logic
- Easy to compile and modify the control program
- Reduce wiring cost, maintenance effort, easy to check/debug.
- May contain advance functions (e.g. mathematic functions, communications, etc.)
- Modular construction, expandable, reconfigurable, and mass produce-able.
- The unit is EMI/EMC proof.

2. PLC Hardware

- Programmable controllers have a modular construction. They require a power supply, control processor unit (CPU), input/output rack (I/O), and assorted input and output modules.
- Systems range in size from a compact "shoe-box" design with limited memory and I/O points, as shown in figure below, to systems that can handle thousands of I/O, and multiple, inter-connected CPUs.
- A separate programming device is required, which is usually an industrial computer terminal, a personal computer, or a dedicated programmer.



Small logic controller, SLC 500, showing variety of modules (Courtesy Allen-Bradley Co., Milwaukee Wl)

Power Supply – usually work with a 24V dc or 220V ac

CPU – the brain of the PLC, contains display and status keys/lights. The program is stored in flash RAM or EPROM.

I/O rack – usually expandable. Connection to the inputs & outputs

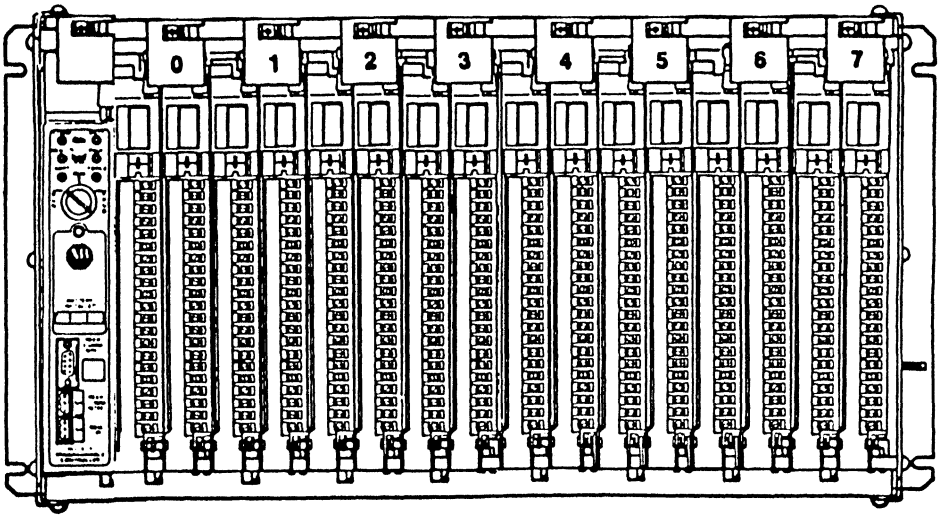
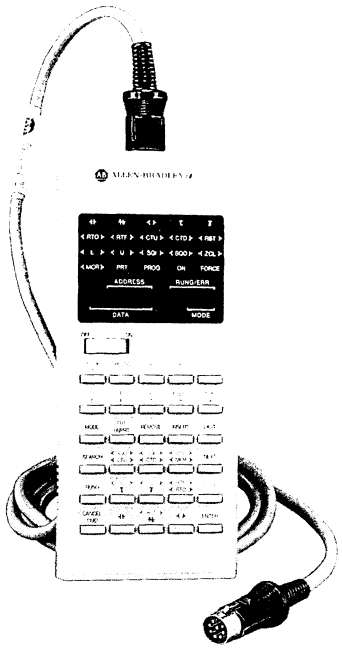


Figure 错误!文档中没有指定样式的文字。**-1 PLC-5 with 128 I/O (Courtesy Allen-Bradley Co., Milwaukee Wl)**

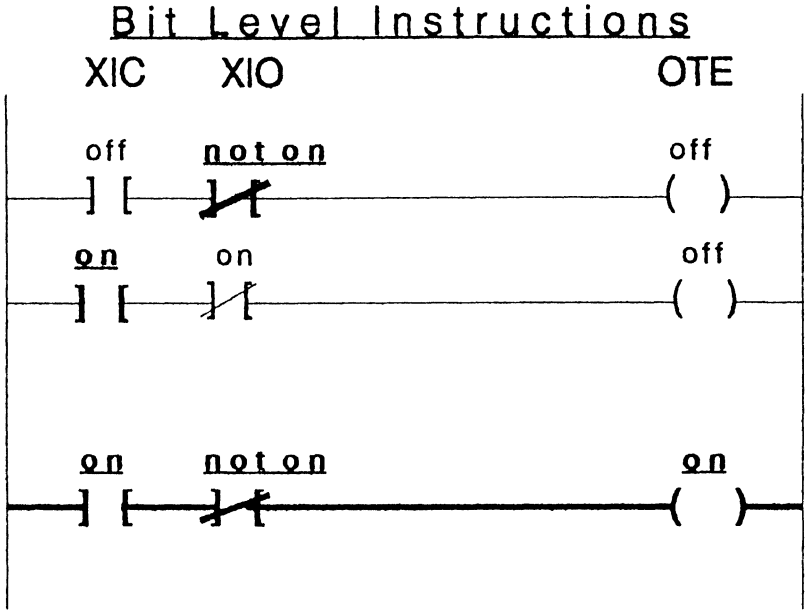
In the figure above, user can choose different types of I/O cards.

Programming Device – can be “a front panel LCD”, “handheld programming device” or “PC based off line programming”.



3. Programming

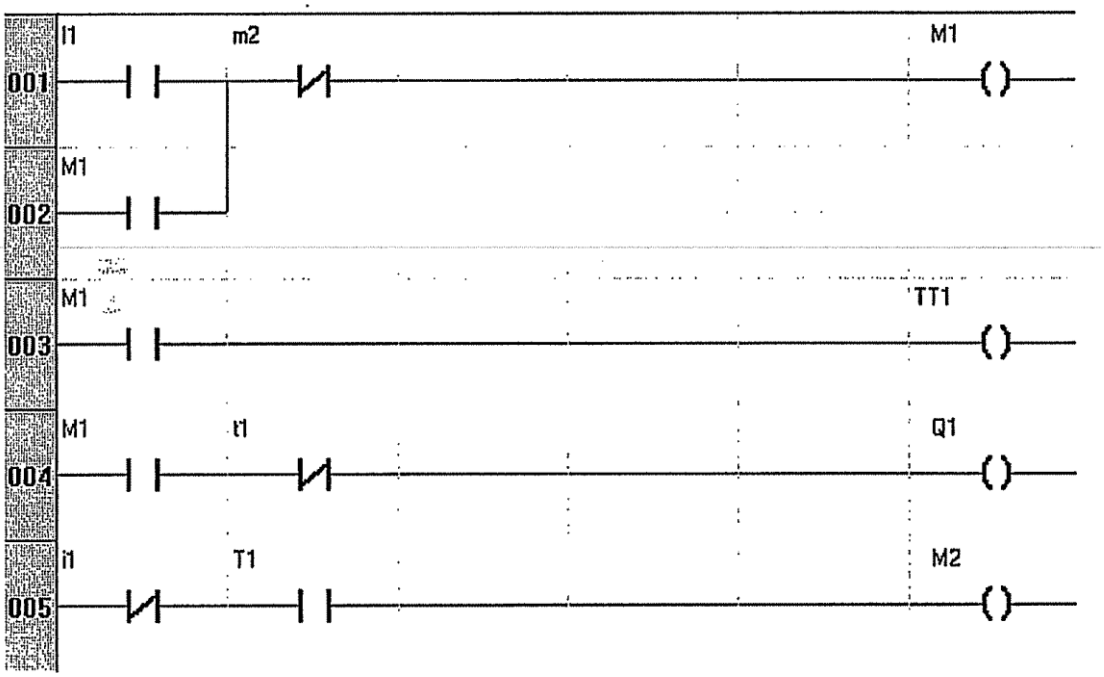
For small PLCs, the most essential instruction set is the bit manipulation instruction set. The instruction set is a straight derivation from the ladder logic. See example below:



Instruction	Description
LD	Load contact
OUT	Output
AN	Logical AND operation
OR	Logical OR operation
LDI	Load inverse
ANI	Logical AND NOT operation
ORI	Logical OR NOT operation
ANB	Logically AND two subcircuits
ORB	Logically OR two subcircuits
TMR	Delay on timer (0.1s resolution)
END	End ladder

Example on the Ladder Logic Programming:

Ladder Circuit:



Programming:

```
LD    I1
OR    M1
ANI   M2
OUT   M1
LD    M1
TMR   1     20
LD    M1
ANI   TMR   1
OUT   Q1
LDI   I1
AN    M2
END
```

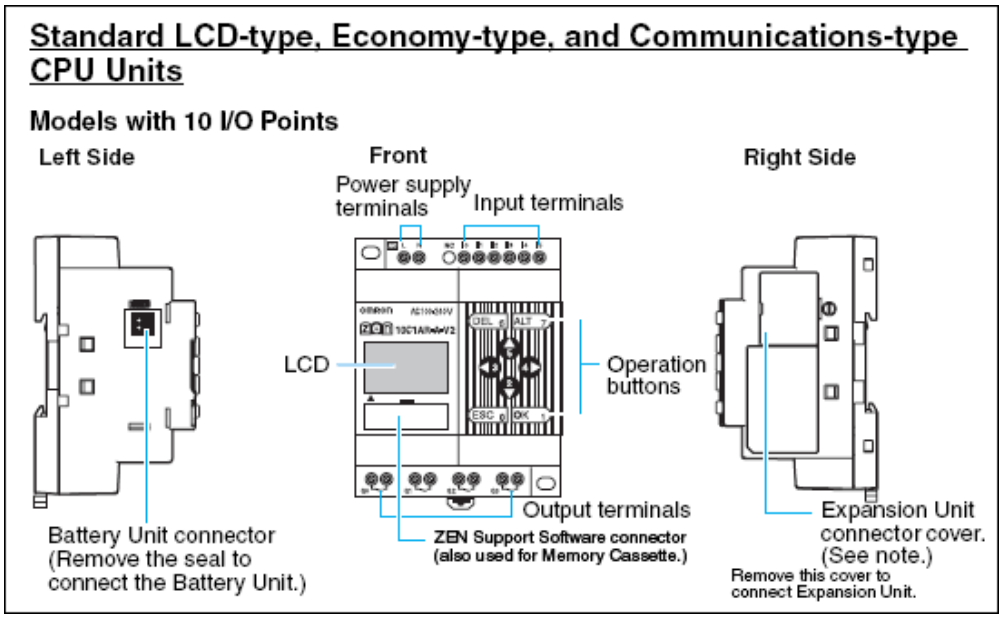
4. Application Example: ZEN series from OMRON

Standard LCD-type, Economy-type, and Communications-type CPU Units

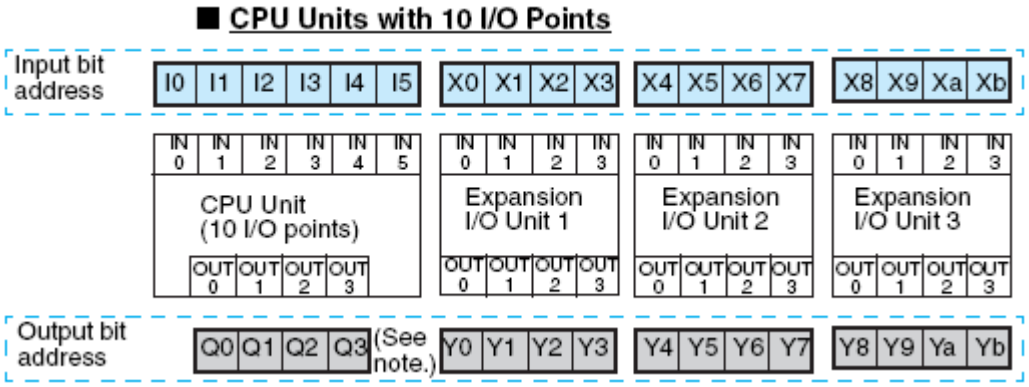
- Simple button-operated programming.
- Highly visible, backlit LCD.
- Adjustable automatic cutout time for the backlight.
- Six-language display.
- Display function for user-specified messages (4 lines x 12 characters), time, or timer, counter, or analog-converted value displays.
- Button switches allowing operation buttons to be used as input contacts.
- Built-in weekly and calendar timers to allow simple seasonal, daily, or time-based operation.
- Remote monitoring via RS-485 communications (Communications-type CPU Units).

Common Features

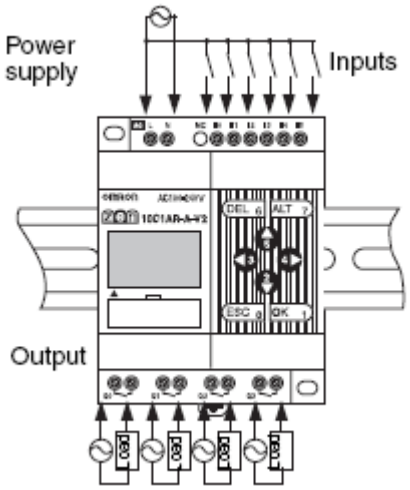
- Both 100 to 240-VAC and 12 to 24-VDC power supply models available.
- Built-in analog comparator for temperature control and other analog applications (provided on CPU Units with DC power supply inputs, two analog inputs 0 to 10 V).
- Input filter settings to prevent noise-related malfunctions for both CPU Units and Expansion I/O Units.
- Program and settings data backed up on built-in EEPROM.
- Programming using ladder diagrams.
- Password function to protect programs.
- Connect up to 3 Expansion I/O Units for a maximum of 24 inputs and 20 outputs.



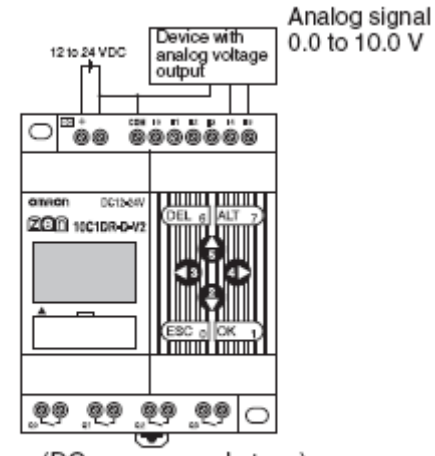
Wiring and connection



Connection to I/O

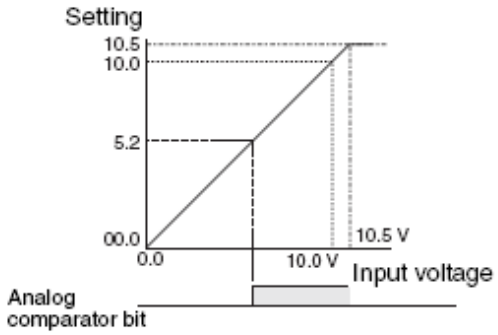


Analogue Inputs



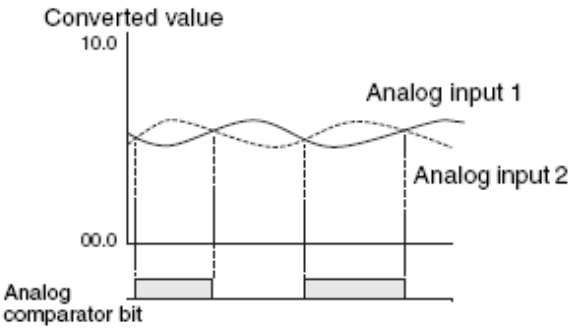
Operation

- Example 1
  (When comparison shows analog input 1 ≥ 5.2 V)



The analog comparator bit turns ON when the analog input voltage reaches is 5.2 V or higher.

- Example 2
  (When comparison shows analog input 1 is ≤ analog input 2)



The analog comparator bit turns ON when the analog input 2 voltage is higher than the analog input 1 voltage.

Application Example:

Lighting Pattern Control

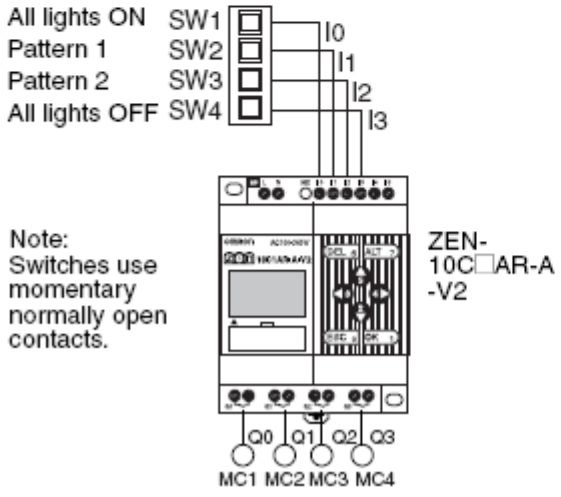
Application

The ZEN can help conserve energy if the lighting patterns required for offices and similar environments are set to the ZEN.

Use the switch operation to switch between lighting patterns.

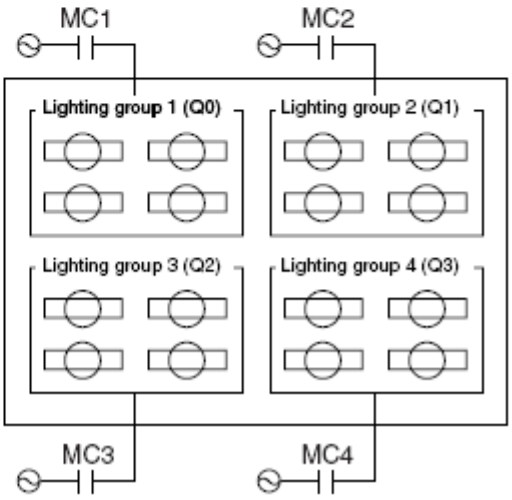
Operation	Switch	Lighting group			
		1	2	3	4
		(Q0)	(Q1)	(Q2)	(Q3)
All lights ON	SW 1 (I0)	ON	ON	ON	ON
Pattern 1	SW 2 (I1)	ON	OFF	ON	OFF
Pattern 2	SW 3 (I2)	ON	ON	OFF	OFF
All lights OFF	SW 4 (I3)	OFF	OFF	OFF	OFF

System Configuration

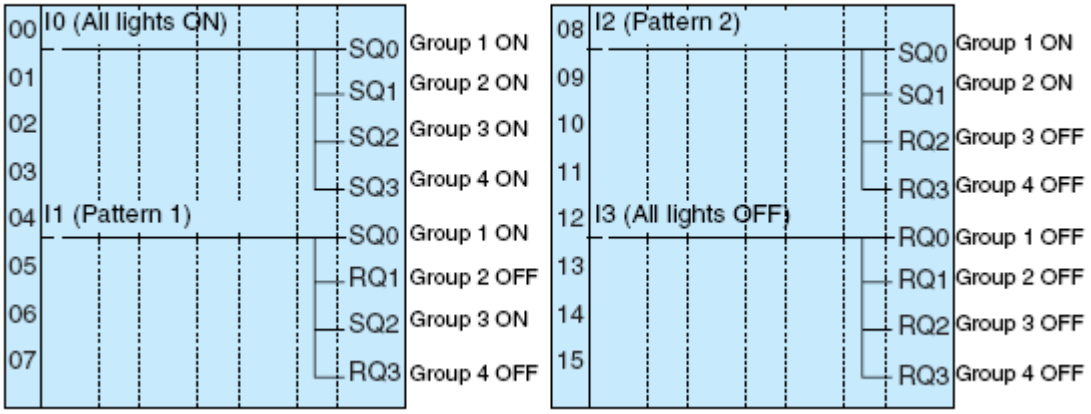


Note:
Switches use momentary normally open contacts.

ZEN-10C□AR-A-V2



Program Example

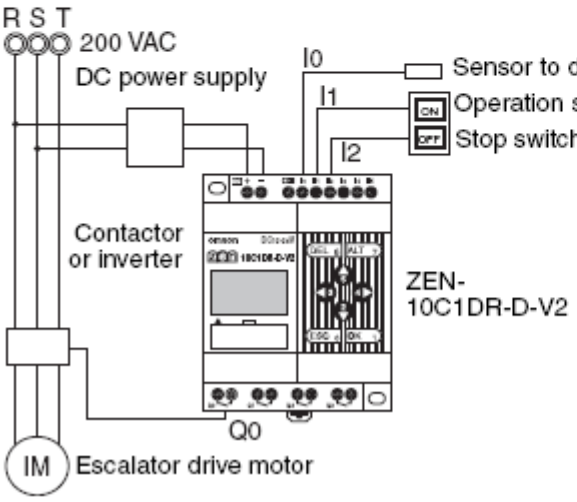


Escalator with Automatic Operation Function (Weekly Timer, OFF Delay Timer)

Application

The ZEN can be simply used to conserve energy for an escalator with an automatic operation function. The escalator can be set to operate continuously from 7:00 to 10:00 and 17:00 to 22:00 weekdays and then operate at other times and on weekends only when people approach the escalator.

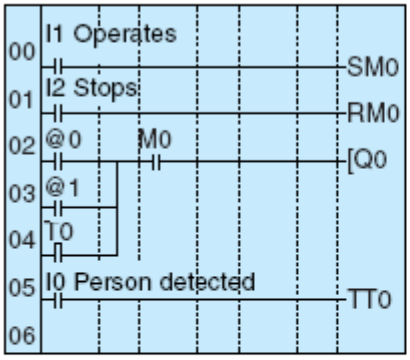
System Configuration



Use two weekly timers for the 7:00 to 10:00 and 17:00 to 22:00 weekday operation.

For the rest of the time, use an OFF delay timer to operate the escalator for 3 minutes when pedestrians are detected.

Program Example



Escalator operates

Off delay timer starts

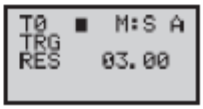
Operates 3 minutes after person passes by the sensor.

Parameter Settings

Weekly timer @0
(Mon to Fri: 7:00 to 10:00)

Weekly timer @1
(Mon to Fri: 17:00 to 22:00)

OFF delay timer T0

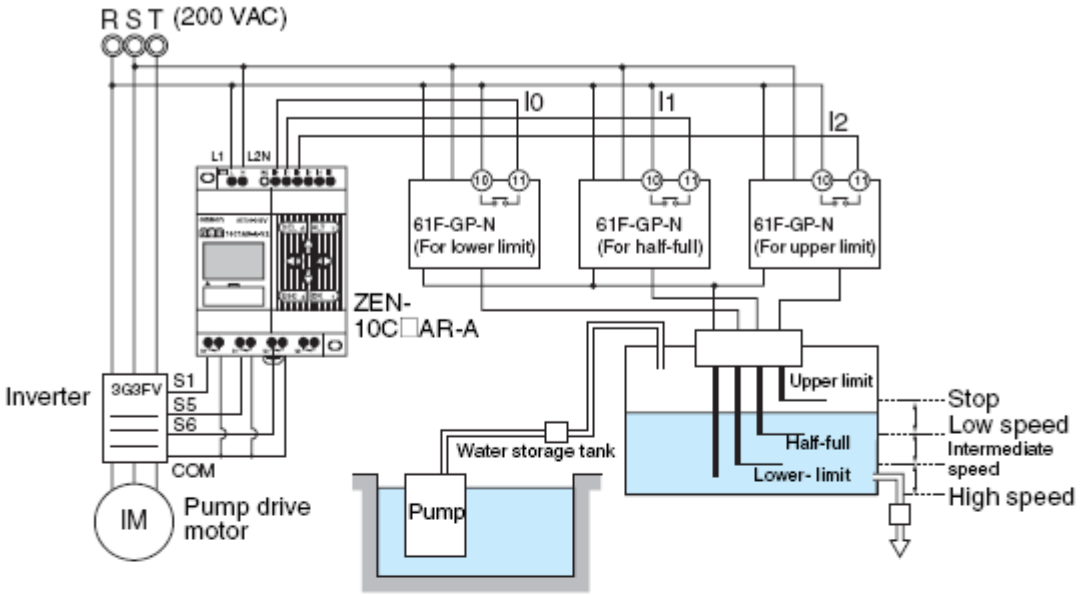


Water Supply Tank Control

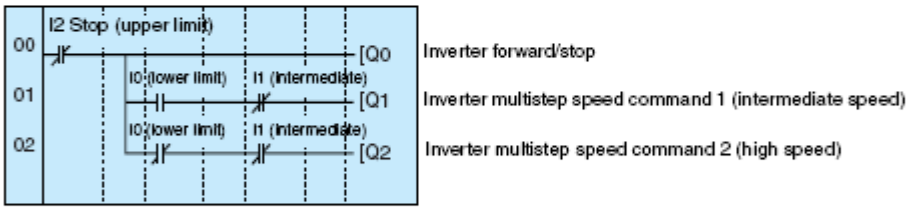
Application

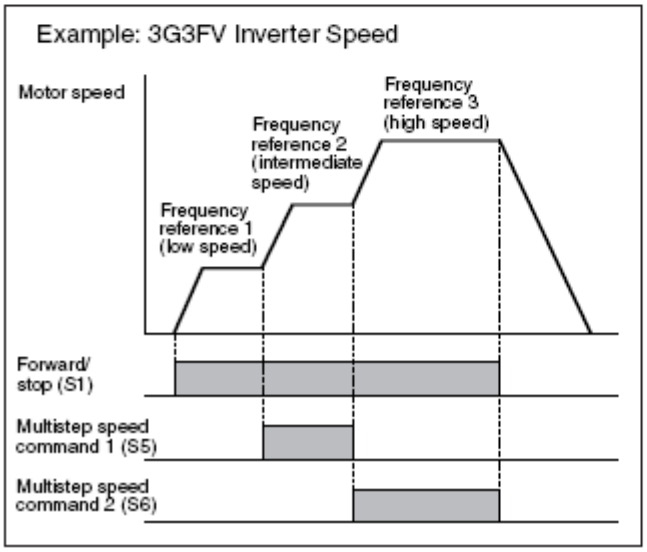
Basic water supply control is possible with the 61F Switch (without float) alone, however relay logic is required for inverter control of high-speed operation (when empty) and low-speed operation (when half-full).

System Configuration



Program Example





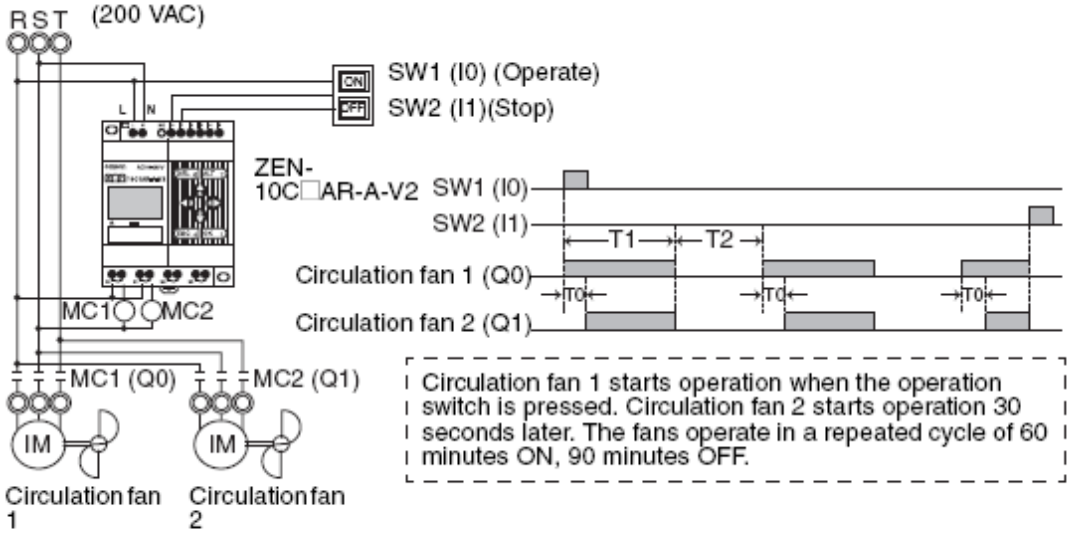
Greenhouse Air Circulation Control (1/3) (Bit Logic and Timer)

Application

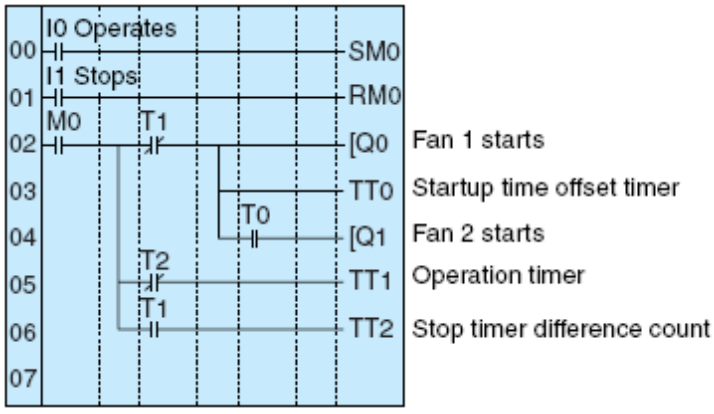
The ZEN can be used to control circulation intermittently at set times. This circulates the carbon dioxide and warm air around plants in a greenhouse.

In this example, two circulation fans are operated at set intervals. The starting current is kept to a minimum and, as a result, the circulation fans are set to start operating at different times.

System Configuration

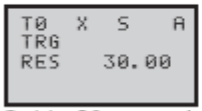


Program Example



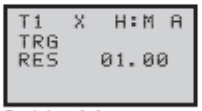
Parameter Settings

Offset start timer setting T0



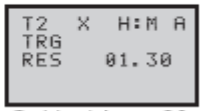
Set to 30 seconds.

Operation timer setting T1



Set to 1 hour.

Operation timer setting T2



Set to 1 hour 30 seconds.

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