

**Programmable Logic Controllers**

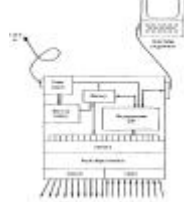
**Definition**

A digitally operated electronic apparatus which uses a programmable memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting, and arithmetic to control, through digital or analog input/output modules, various types of machines or processes.

- National Electrical Manufacturers Association (NEMA)

**Components**

- Input and output module
- Processor
- Memory
- Power supply
- Detachable programming device



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**Programmable Logic Controllers**

**History**

1969 specifications (General Motors)

- Must be programmable (and reprogrammable)
- Designed to operate in an industrial environment
- Must accept 120 V ac signals from pushbuttons, switches
- Outputs must switch and continuously operate loads such as motors and relays of two amps rating

Before the 1980's, programmable controllers were called PCs.



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**Programmable Logic Controllers**

**PLC Functions**

A PLC performs the functions of conventional relays, timers, counters

**Advantages (over conventional devices)**

- More flexibility
- Less space, more compact
- Higher reliability (less mechanical parts)
- Modular, can be easily connected to computer systems and to hardware



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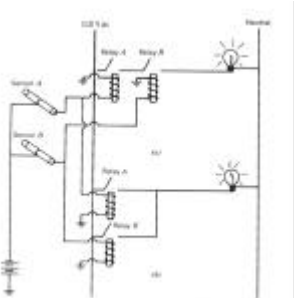
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Programmable Logic Controllers

Conventional devices

Relays



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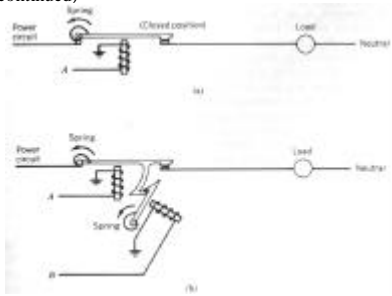
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Conventional devices

Relays (continued)



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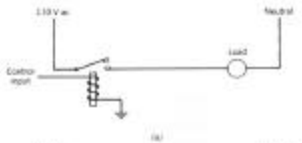
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Programmable Logic Controllers

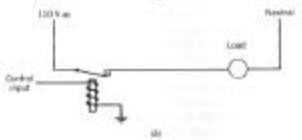
Conventional devices

Relays (continued)

• Normally open



• Normally closed



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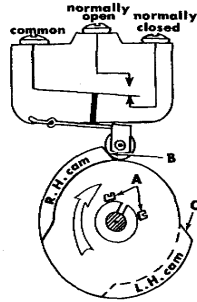
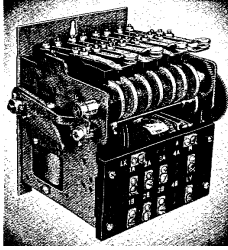
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Programmable Logic Controllers

Conventional devices (continued)

Timers



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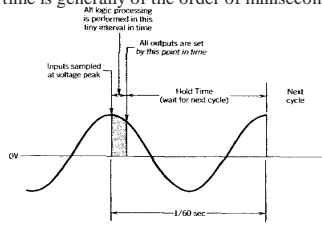
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Programmable Logic Controllers

Operation

- Inputs are sampled and stored in memory
- Control program is executed
- Calculated values are used to update the outputs
- Scan time is generally of the order of milliseconds



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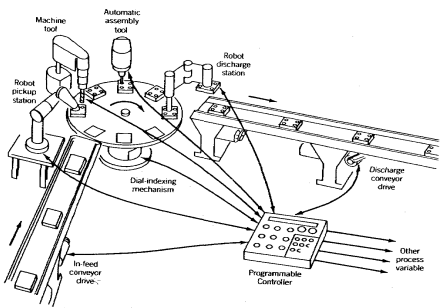
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Programmable Logic Controllers

Application



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Programmable Logic Controllers

PLCs versus Computers

PLC	Computer
executes simple program in milliseconds, scan time is much smaller than 1/60 seconds	possibly complicated program, often timing is not critical
objective is to make yes/no, 0/1 decisions	tasks may include floating point arithmetic, manipulation of data
special purpose device, same program is repeated continuously	general purpose, possibly different programs
no peripherals	need peripherals
programmed using ladder logic	programmed using high-level languages

Conceptually very similar, though there are practical differences.

- PLCs are based on solid state technology and generally use microprocessors as their processing unit.
- PLCs are used to simulate electromechanical devices that were typical of transfer lines and mass production.

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Programmable Logic Controllers

Why PLCs?

Advantages	Disadvantages
+ many inputs and outputs, excellent for controlling and monitoring many processes	- do not use the full capabilities of the microprocessor
+ designed for industrial environments, robust and reliable	- ladder logic programming style is cumbersome and prone to mistakes
+ reprogrammable	- only good for yes/no decisions
+ modular	- do not handle continuous inputs and outputs, not good for "direct control"
+ ideally suited to supervisory control	- inflexible (compared to microprocessors)
+ easy to set up, good for FMS environment	
+ inexpensive	

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Programmable Logic Controllers

Logic Control Systems

Consider a system with two inputs (A, B) and two outputs (X, Y) where Y is on (true) if and only if A and B are both off (false), and X is on if and only if A and B are both on (true) or both off (false).

1. Relays

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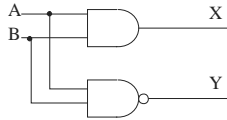
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Programmable Logic Controllers

Logic Control Systems (continued)

2. Logic Gates

- X is on if and only if A and B are both on (true) or both off (false).
- Y is on (true) if and only if A and B are both off (false).



3. PLCs



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Programmable Logic Controllers

Logic Control Systems - Representation

Computer program

```
if ((A=0) and (B=0)) or ((A=1) and (B=1)),
  X:=1
else
  X:=0;
if ((A=0) and (B=0))
  Y:= 1
else
  Y:=0;
```

Truth table

A	B	X	Y
0	0	1	1
1	0	0	0
0	1	0	0
1	1	1	0



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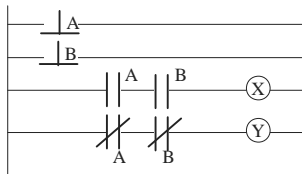
Programmable Logic Controllers

Logic Control Systems - Representation

Boolean Logic

```
X:= A.B
Y:= ~(A+B)
```

Ladder Logic



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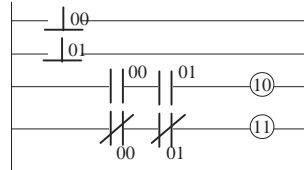
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Logic Control Systems - Representation

PLC Program

```

STR   SHF 00 ENT
AND   SHF 01 ENT
OR    SHF 11 ENT
OUT   SHF 10 ENT
STR NOT SHF 00 ENT
AND NOT SHF 01 ENT
OUT   SHF 11 ENT
    
```




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Programmable Logic Controllers

Ladder Logic Diagrams

Input contacts (switches, relays, photoelectric sensors, limit switches)

Output loads (actuators, alarms, lights)

Logical inverse (NOT)

Logical AND operation

Logical OR operation




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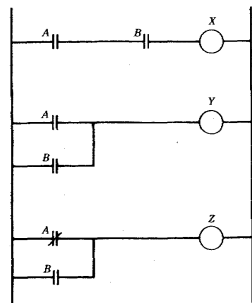
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Programmable Logic Controllers

Ladder Logic Diagrams (continued)

Example




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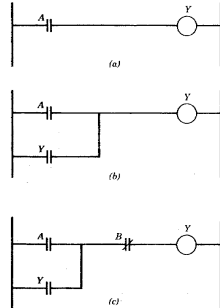
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Programmable Logic Controllers

Ladder Logic Diagrams

Push-button switch




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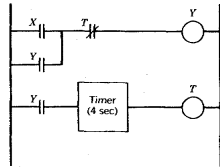
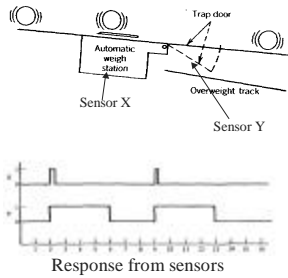
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Programmable Logic Controllers

Ladder Logic Diagrams

Automatic weigh station on a conveyor



Ladder logic diagram

Response from sensors




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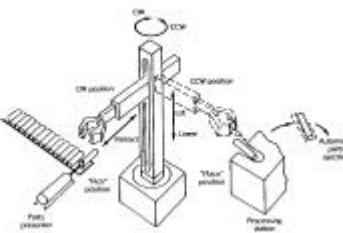
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Programmable Logic Controllers

Application: Direct Robot Control

- 20 Rotate base CCW
- 21 Rotate base CW
- 22 Lift arm
- 23 Lower arm
- 24 Extend arm
- 25 Retract arm
- 26 Close gripper
- 27 Open gripper




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