# TI-3222: Otomasi Sistem Produksi

**Programmable Logic Controller**

Laboratorium Sistem Produksi
www.lspitb.org
©2004

---

# Hasil Pembelajaran

- Umum
  - Mahasiwa mampu untuk melakukan proses perancangan sistem otomasi, sistem mesin NC, serta merancang dan mengimplementasikan sistem kontrol logika.

- Khusus
  - Memahami fungsi PLC serta komponen-komponen PLC

2

# PURPOSE OF Programmable Logic Controllers (PLCs)

- Initially designed to replace relay logic boards
  - Sequence device actuation
  - Coordinate activities
- Accepts input from a series of switches
- Sends output to devices or relays

**3**

---

# PURPOSE OF Programmable Logic Controllers (PLCs)

- Initially designed to replace relay logic boards
  - Sequence device actuation
  - Coordinate activities
- Accepts input from a series of switches
- Sends output to devices or relays

**4**

# FUNCTIONS OF CONTROLLERS

- 1) on-off control,
- 2) sequential control,
- 3) feedback control, and
- 4) motion control.

**5**

---

# CONTROL DEVICES

1) mechanical control - cam, governor, etc.,

2) pneumatic control - compressed air, valves, etc.

3) electromechanical control - switches, relays, a timer, counters, etc,

4) electronics control - similar to electromechanical control, except uses electronic switches.

5) computer control.

**6**

# PROGRAMMABLE LOGIC CONTROLLER

**Invented in 1968 as a substitute for hardwired relay panels.**

"A digitally operating electronic apparatus which uses a programmable memory for the internal storage of instructions by 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. The digital computer which is used to perform the functions of a programmable controller is considered to be within this scope. Excluded are drum and other similar mechanical sequencing controllers."

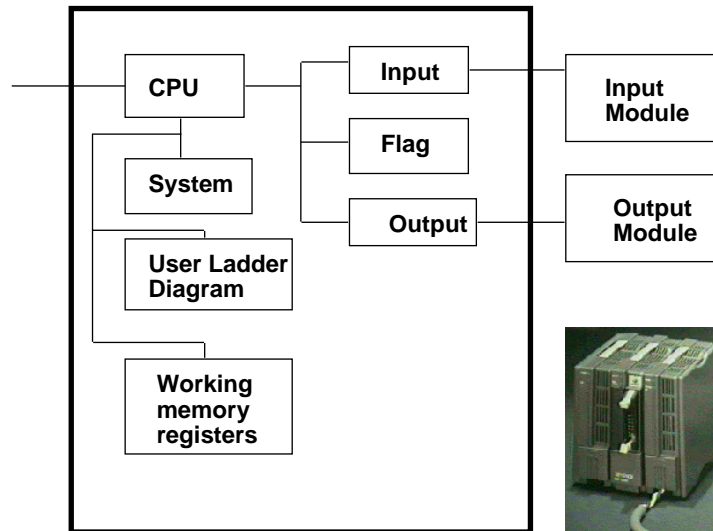**National Electrical Manufacturing Association (NEMA)**

TI-3222: Otomasi Sistem Produksi - 7

**7**

---

# VENDORS

- Rockwell
- GE/Fanuc
- Schnieder
- MODICOM - GOULD
- ALLEN-BRADLEY
- Honeywell
- SQUARE-D

etc.

TI-3222: Otomasi Sistem Produksi - 7

**8**

# PLC



```
                CPU ─── Input ──── Input
                 │                 Module
                 │       Flag
               System
                 │      Output ─── Output
            User Ladder            Module
            Diagram

            Working
            memory
            registers
```

**9**

---

# PLC Configuration

| Input Circuit | → | Input Relays | Counters | Output Relays |
|---|---|---|---|---|
| CPU | | Internal Utility Relays | Timers | Data Storage |
| Memory | | | | |
| Output Circuit | | | | |

**10**

5
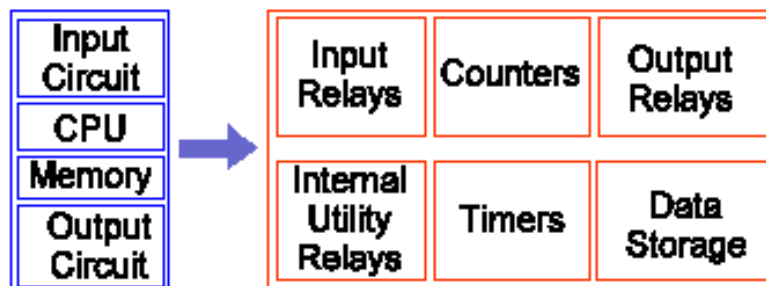
## What devices does a PLC interact with?

- INPUT RELAYS-(contacts)These are connected to the outside world. They physically exist and receive signals from switches, sensors, etc. Typically they are not relays but rather they are transistors.
- INTERNAL UTILITY RELAYS-(contacts) These do not receive signals from the outside world nor do they physically exist. They are simulated relays and are what enables a PLC to eliminate external relays.  There are also some special relays that are dedicated to performing only one task. Some are always on while some are always off. Some are on only once during power-on and are typically used for initializing data that was stored.
- COUNTERS-These again do not physically exist. They are simulated counters and they can be programmed to count pulses. Typically these counters can count up, down or both up and down. Since they are simulated they are limited in their counting speed. Some manufacturers also include high-speed counters that are hardware based. We can think of these as physically existing. Most times these counters can count up, down or up and down.

TI-3222: Otomasi Sistem Produksi - 7

**11**

## What devices does a PLC interact with?
## Continued

- TIMERS-These also do not physically exist. They come in many varieties and increments. The most common type is an on-delay type. Others include off-delay and both retentive and non-retentive types.  Increments vary from 1ms through 1s.
- OUTPUT RELAYS-(coils)These are connected to the outside world. They physically exist and send on/off signals to solenoids, lights, etc. They can be transistors, relays, or triacs depending upon the model chosen.
- DATA STORAGE-Typically there are registers assigned to simply store data. They are usually used as temporary storage for math or data manipulation. They can also typically be used to store data when power is removed from the PLC. Upon power-up they will still have the same contents as before power  was removed. Very convenient and necessary!!

TI-3222: Otomasi Sistem Produksi - 7

**12**

# SWITCHES



Non-locking

Locking

Normally Open

Normally Closed

**SPDT**

P1

P2

Multiple Throw

**DPST**

Multiple Pole

Break-before-make

Make-before-break
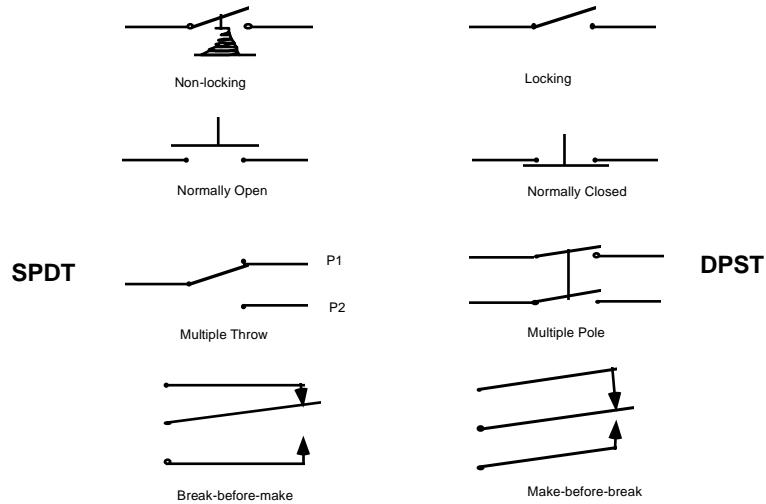
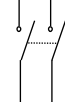TI-3222: Otomasi Sistem Produksi - 7

**13**

---

# TERMS

**Throw -** number of states

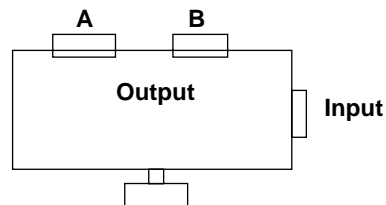**Pole -** number of connecting moving parts (number of individual circuits).

**A serial switch box (A-B box) has two 25 pin serial ports to switch from.**

**SPDT**

**DPST**



**A**     **B**

**Output**     **Input**

**Knob**
**How is this switch classified?**

TI-3222: Otomasi Sistem Produksi - 7

**14**

7

# TYPES OF SWITCHES

1. Basic switch, operated by a mechanical level,
2. Push-button switch,
3. Slide switch,
4. Thumbwheel switch,
5. Limit switch,
6. Proximity switch, and
7. Photoelectric switch.

**RATING:  voltage, current**

TI-3222: Otomasi Sistem Produksi - 7

**15**

---

# RELAYS

**A switch whose operation is activated by an electromagnet is called a "relay"**



contact

coil

input

**Relay coil**    **Output contact**
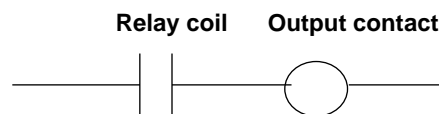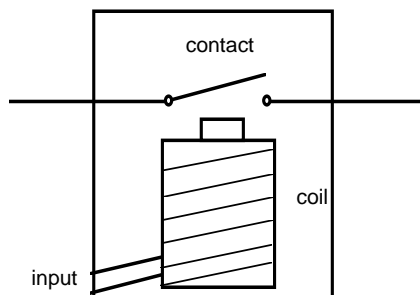
TI-3222: Otomasi Sistem Produksi - 7

**16**

# COUNTER

Digital counters output in the form of a relay contact when a preassigned count value is reached.



| | Count |
|---|---|
| Input | |
| Reset | |
| Output | |
| Count | 0  1 2   3   4   5   0 1 |
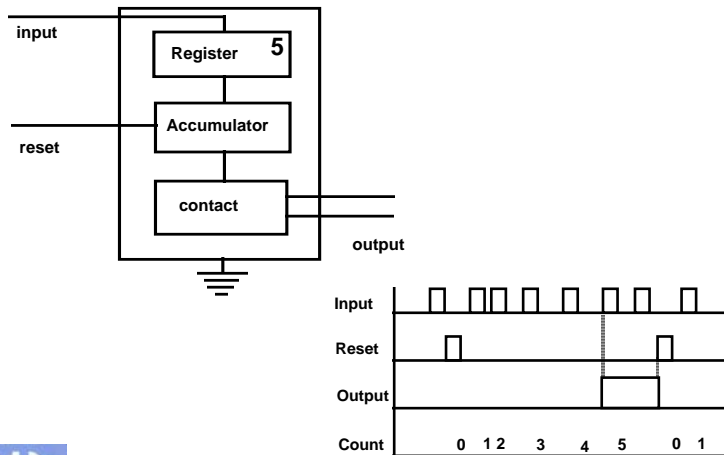
TI-3222: Otomasi Sistem Produksi - 7

**17**

---

# TIMER

A timer consists of an internal clock, a count value register, and an accumulator. It is used for or some timing purpose.



| Clock | |
|---|---|
| Reset | |
| Output | |
| Count | 0    1    2    3    4    5 |
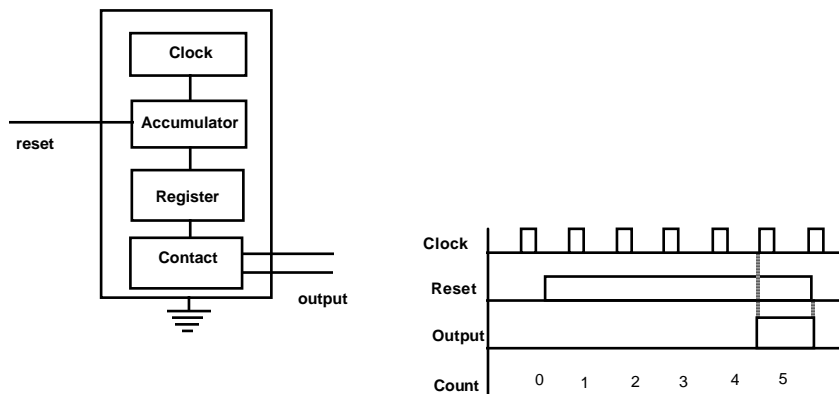
**Time 5 seconds.**

TI-3222: Otomasi Sistem Produksi - 7

**18**

# AN EXAMPLE OF RELAY LOGIC

For process control, it is desired to have the process start (by turning on a motor) five seconds after a part touches a limit switch. The process is terminated automatically when the finished part touches a second limit switch. An emergency switch will stop the process any time when it is pushed.
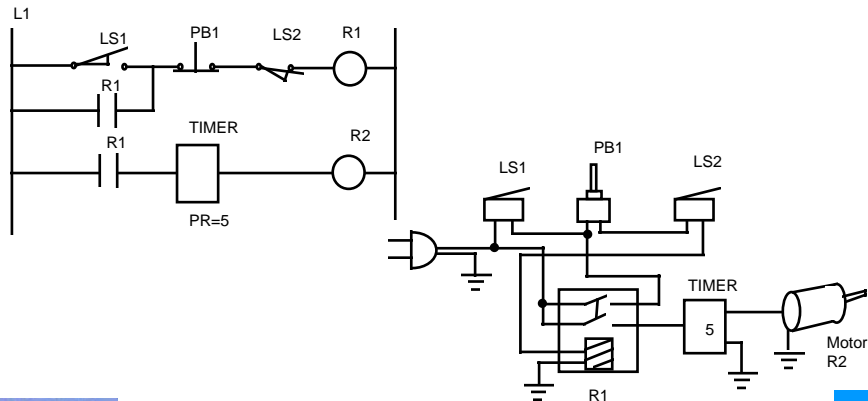


TI-3222: Otomasi Sistem Produksi - 7

**19**

---

# PLC ARCHITECTURE

Programmable controllers replace most of the relay panel wiring by software programming.
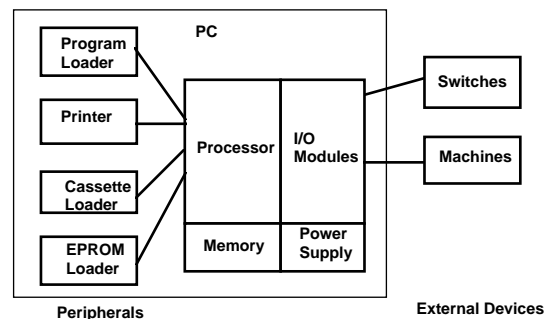


**A typical PLC**
TI-3222: Otomasi Sistem Produksi - 7

**20**

# PLC COMPONENTS

1. Processor   Microprocessor based, may allow arithmetic operations, logic operators, block memory moves, computer interface, local area network, functions, etc.

2. Memory   Measured in words.

ROM (Read Only Memory),

RAM (Random Access Memory),

PROM (Programmable Read Only Memory),

EEPROM (Electronically Erasable Programmable ROM),

EPROM (Erasable Programmable Read Only Memory),

EAPROM (Electronically Alterable Programmable
             Read Only Memory), and

Bubble Memory.

---

# PLC COMPONENTS

3. I/O   Modular plug-in periphery

AC voltage input and output,

DC voltage input and output,

Low level analog input,

High level analog input and output,

Special purpose modules, e.g.., high speed timers,

Stepping motor controllers, etc.  PID, Motion

4. Power supply AC power

5. Peripheral   Hand held programmer (loader),

CRT programmer,

Operator console,

Printer,

Simulator,

EPROM loader,

Cassette loader,

Graphics processor, and

Network communication interface.  MAP, LAN

# LADDER DIAGRAM

A ladder diagram (also called contact symbology) is a means of graphically representing the logic required in a relay logic system.
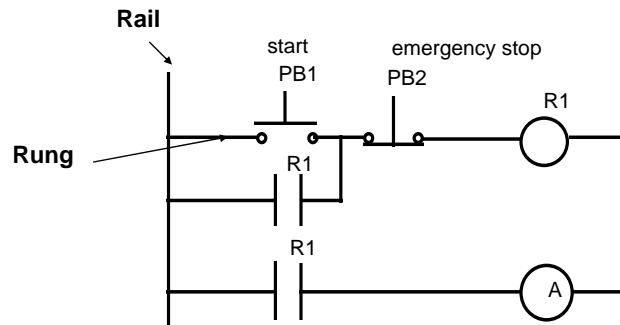
**23**

---

# Ladder Representation

**24**

# PLC WIRING DIAGRAM



Input | PLC | Output

External switches
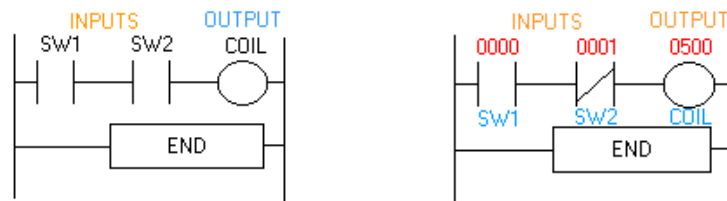
Stored program
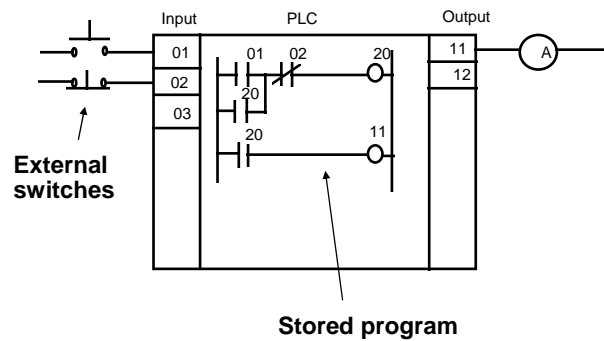
TI-3222: Otomasi Sistem Produksi - 7

**25**

---

# SCAN

A PLC resolves the logic of a ladder diagram (program) rung by rung, from the top to the bottom.  Usually, all the outputs are updated based on the status of the internal registers.  Then the input states are checked and the corresponding input registers are updated.  Only after the I/Os have been resolved, is the program then executed.  This process is run in a endless cycle.   The time it takes to finish one cycle is called the scan time.



**Output**

**Input**

**begin**

**Idle**

**Scan cycle**

**Resolve logic**
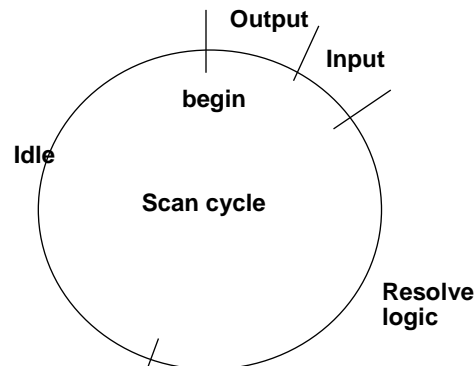
TI-3222: Otomasi Sistem Produksi - 7

**26**

13

# PLC INSTRUCTIONS

1) Relay,

2) Timer and counter,

3) Program control,

4) Arithmetic,

5) Data manipulation,

6) Data transfer, and

7) Others, such as sequencers.

**27**

---

# LOGIC STATES

ON : TRUE, contact closure, energize, etc.

OFF: FALSE, contact open , de-energize, etc.

**Do not confuse the internal relay and program with the external switch and relay.  Internal symbols are used for programming.  External devices provide actual interface.**

**(In the notes we use the symbol "~" to represent negation.  AND and OR are  logic operators.  )**

**28**

14

# AND and OR LOGIC

**AND**

PB1　PB2　R1

R1 = PB1.AND.PB2

PB3　PB4　R2

R2 = PB2.AND.~PB4

**OR**

PB1　R1

R1 = PB1 .OR. PB2

PB2

**29**

---
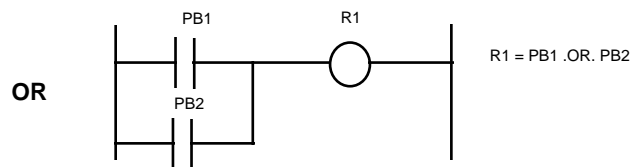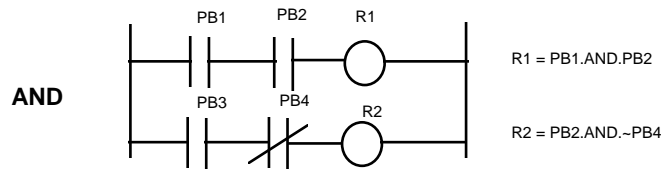
# COMBINED AND & OR

**R1 = PB1 .OR. (PB2 .AND. PB3)**

PB1　R1

PB2　pb3

**30**

15
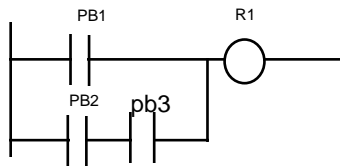
# Relay diagram symbols

| | | | |
|---|---|---|---|
| Limit switch | Normally open | | LS  |
| | Normally closed | | LS  |
| | Held open | |  |
| | Held closed | |  |
| Proximity switch | Open | |  |
| | Closed | |  |
| Toggle switch | | |  |
| Rotary selector | Nonbridging contacts | | RSS  |
| | Bridging contacts | | RSS  |

TI-3222: Otomasi Sistem Produksi - 7

**31**

---

# Relay diagram symbols

| | | | |
|---|---|---|---|
| Push button | Single circuit | Normally open | PB  |
| | | Normally closed | PB  |
| | Double circuit | | PB  |
| Contacts | Relay | Normally open |  |
| | | Normally closed |  |
| Coils | Relays | | CR  |
| | Solenoids | | SOL  |
| Motor | DC armature | | A — MTR  |
| Pilot lights | | | R — LT  |

TI-3222: Otomasi Sistem Produksi - 7

**32**

16

# RELAY

**A Relay consists of two parts, the coil and the contact(s).**

Contacts:

| | | |
|---|---|---|
| a. | Normally open | -\| \|- |
| b. | Normally closed | -\|/\|- |
| c. | Off-on transitional | -\|↑\|- |
| d. | On-off transitional | -\|↓ \|- |

Coil:

| | | |
|---|---|---|
| a. | Energize Coil | -( )- |
| b. | De-energize | -(/)- |
| c. | Latch | -(L)- |
| d. | Unlatch | -(U)- |

---
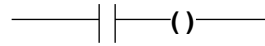
# TIMERS AND COUNTERS

Timers:

|  | **Input** | | |
|---|---|---|---|
|  | **True** | **False** | **True** |
| **RTO** | counting | stop | counting resume |
| **RTF** | stop | counting | stop |

a. Retentive on delay -(RTO)-
b. Retentive off delay -(RTF)-
c. Reset -(RST)-

**RTO reach PR value, output ON**
**RTF reach PR value, output OFF**

Counter:

**PR value in 0.1 second**

a. Counter up -(CTU)-
b. Counter down -(CTD)-
c. Counter reset -(CTR)-

# SEQUENCER

**Sequencers are used with machines or processes involving repeating operating cycles which can be segmented into steps.**

| Output | | | | |
|--------|------|------|------|------------|
| Step | A | B | C | Dwell time |
| 1 | ON | OFF | OFF | 5 sec |
| 2 | ON | ON | OFF | 10 sec |
| 3 | OFF | OFF | ON | 3 sec |
| 4 | OFF | ON | OFF | 9 sec |

---

# A-B PLC

I/O points are numbered, they correspond to the I/O slot on the PLC.

For A-B controller used in our lab
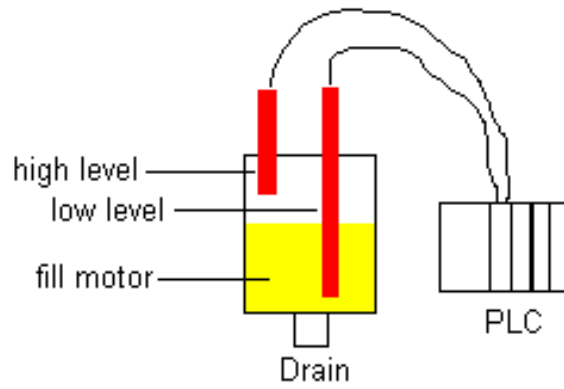
I/O   uses 1-32

Internal relays use  033 - 098

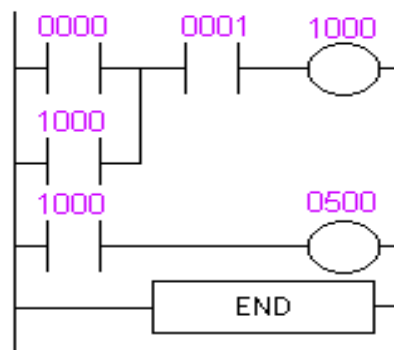Internal timers/counters/sequencers use 901-932
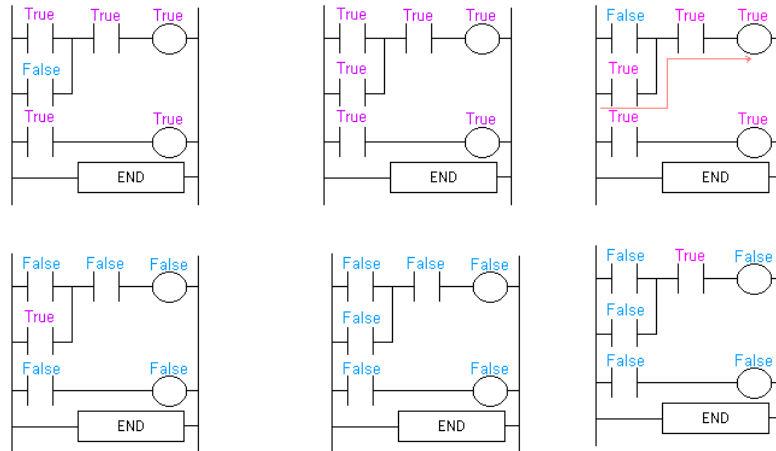
Status  951-982

# Programming a PLC



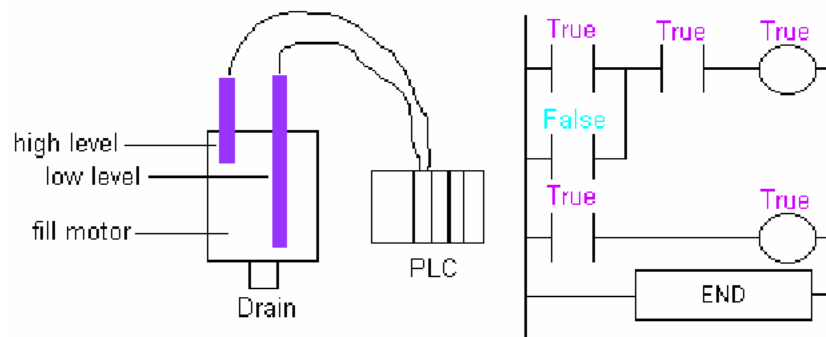Dispensing oil from a tank

# Ladder Logic for Tank

19

# Logic for Ladder Solution

**39**

---

# How does it work?

**40**

20

# PROGRAMMING EXAMPLE 1
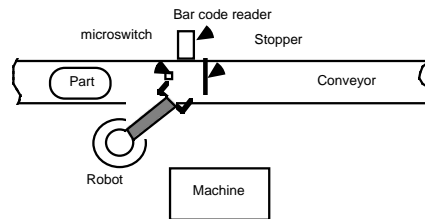


| id | Description | State | Explanation |
|-----|-------------|-------|-------------|
| MSI | micro switch | 1 | part arrive |
| R1 | output to bar code reader | 1 | scan the part |
| C1 | input from bar code reader | 1 | right part |
| R2 | output robot | 1 | loading cycle |
| R3 | output robot | 1 | unloading cycle |
| C2 | input from robot | 1 | robot busy |
| R4 | output to stopper | 1 | stopper up |
| C3 | input from machine | 1 | machine busy |
| C4 | input from machine | 1 | task complete |

TI-3222: Otomasi Sistem Produksi - 7

**41**

---

# SOLUTION
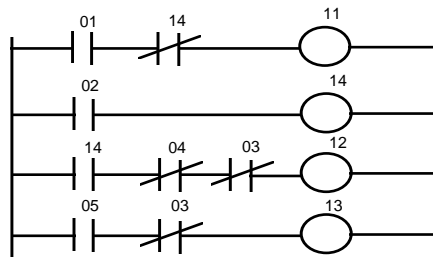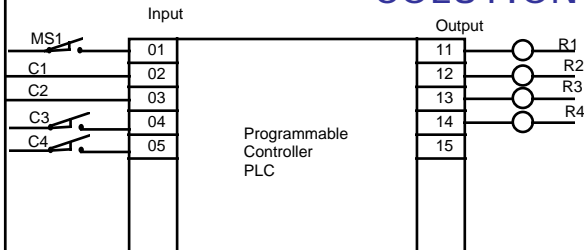


- **Rung 1.** If part arrives and no part is stopped, trigger the bar code reader.
- **Rung 2.** If it is a right part, activate the stopper.
- **Rung 3.** If the stopper is up, the machine is not busy and the robot is not busy, load the part onto the machine.
- **Rung 4.** If the task is completed and the robot is not busy, unload the machine.

TI-3222: Otomasi Sistem Produksi - 7

**42**

21

# EXAMPLE 2 TRAFFIC LIGHTS

Jefferson street

**Main street**

| Cycle time | | | |
|---|---|---|---|
| Street | Red | Yellow | Green |
| Main | 3 | 1 | 4 |
| Jefferson | 5 | 1 | 2 |

---

# WIRING DIAGRAM

input      output

**Programmable Controller**

| 64 | Jefferson Red |
| 65 | Jefferson Yellow |
| 66 | Jefferson Green |
| 67 | Main Red |
| 70 | Main Yellow |
| 71 | Main Green |

# PROGRAM (1)

RUNG1 — 901 RTO 80

RUNG2 — 901 901 RST

RUNG3 — 901 902 67 — M. Red

RUNG4 — 67 — 902 RTO 30

RUNG5 — 901 902 RST

RUNG6 — 901 903 66 — J. Green

RUNG7 — 66 — 903 RTO 20

RUNG8 — 901 903 RST

RUNG9 — 902 904 71 — M. Green

RUNG10 — 71 — 904 RTO 40

RUNG11 — 901 904 RST

RUNG12 — 904 905 70 — M. Yellow
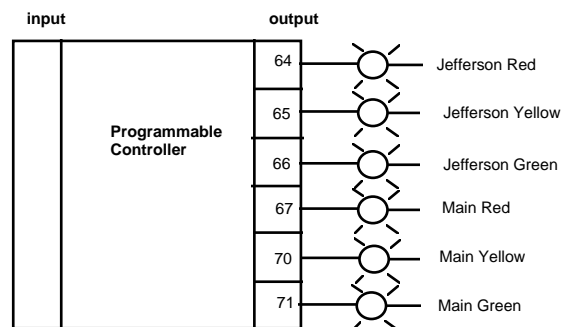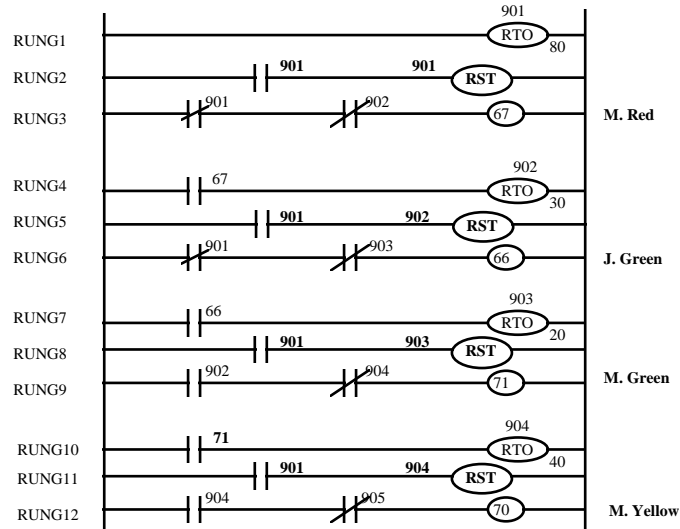
TI-3222: Otomasi Sistem Produksi - 7

**45**

# PROGRAM (2)

RUNG13 — 70 — 905 RTO 10

RUNG14 — 901 905 RST

RUNG15 — 903 906 65 — J. Yellow

RUNG16 — 65 — 906 RTO 10

RUNG17 — 901 906 RST

RUNG18 — 902 907 64 — J. Red

RUNG19 — 64 — 907 RTO 50

RUNG 20 — 901 907 RST

TI-3222: Otomasi Sistem Produksi - 7

**46**