



3. PLC's Hardware

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[Sasaran]

- Mahasiswa mampu :
 - Memahami definisi PLC
 - Menyebutkan jenis – jenis PLC
 - Menyebutkan bagian – bagian hardware PLC dan prinsip kerjanya
 - Memiliki *product knowledge* PLC merk tertentu

[Introduction]

- PLC menurut NEMA¹
 - Alat elektronika digital
 - yang menggunakan *programmable memory* untuk menyimpan instruksi
 - dan untuk menjalankan fungsi – fungsi khusus seperti :
 - logika, *sequence* (urutan), *timing* (pewaktuan), penghitungan dan operasi aritmetika
 - untuk mengendalikan mesin dan proses.

¹ National Electrical Manufacturers Association (USA)

[Introduction]

- PLC (definisi lain):
 - komputer industri khusus untuk mengawasi dan mengendalikan proses industri.
 - menggunakan bahasa pemrograman khusus untuk kontrol industri (*ladder diagram*)
 - didesain untuk tahan terhadap lingkungan industri yang banyak gangguan
 - *noise, vibration, shock, temperature, humidity*

[Jenis - jenis PLC]



Jenis PLC (berdasarkan ukuran)

1. Tipe *compact*

- Seluruh komponen (power supply, CPU, modul input – output, ...) menjadi satu
- Umumnya berukuran kecil (*compact*)
- Mempunyai jumlah I/O relatif sedikit dan (umumnya) tidak dapat *diexpand*
- (Umumnya) tidak dapat ditambah modul – modul khusus

[Contoh PLC *compact*]



[Jenis PLC]

2. Tipe modular

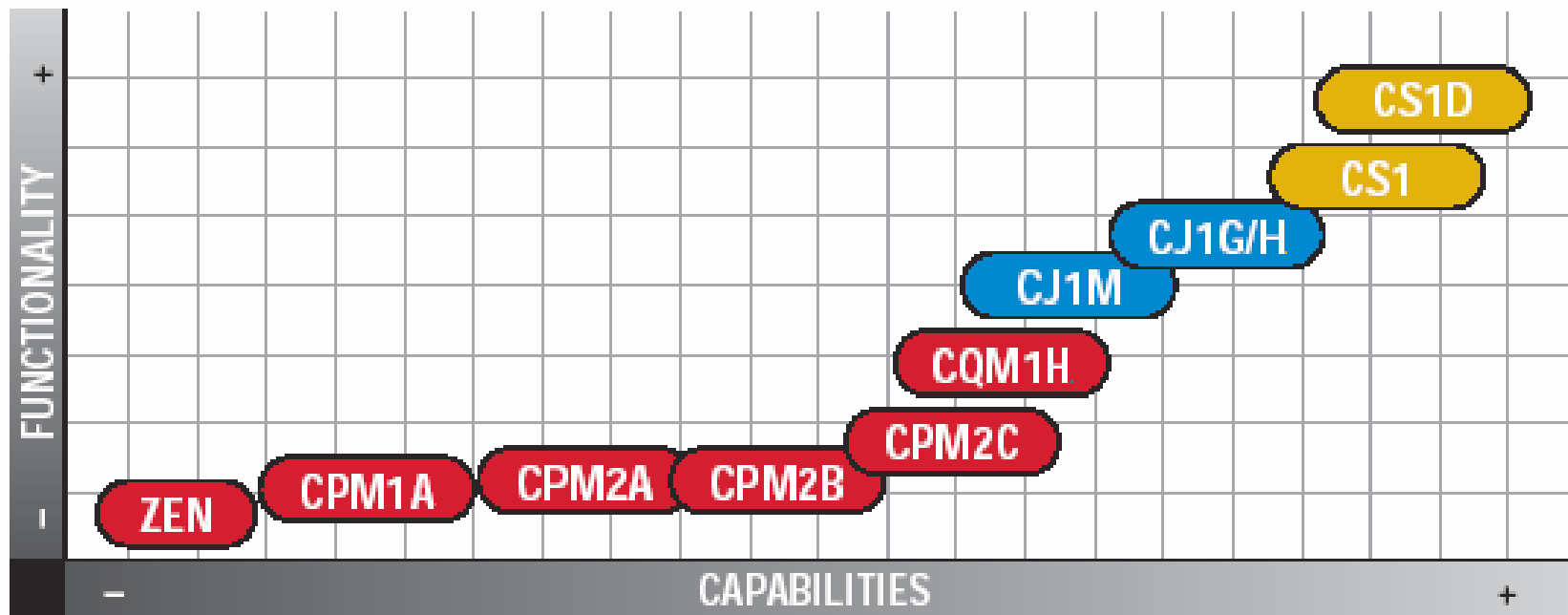
- Komponen – komponennya terpisah ke dalam modul – modul
- Berukuran besar
- Memungkinkan untuk ekspansi jumlah input /output (sehingga jumlah lebih banyak)
- Memungkinkan penambahan modul – modul khusus

[Contoh : PLC Modular]



Other category

Contoh : Omron PLC Selection



Other category

Contoh : Omron PLC Selection

Micro PLCs



Space-saving block, modular and board style PLCs deliver features and communications for small machine control.

CJ1 Series



Compact rackless PLCs offering the ultimate in scalability by enabling you to mix and match CPU power with special and standard I/O to meet every automation need.

Other category

Contoh : Omron PLC Selection



[Many Brands of PLC]

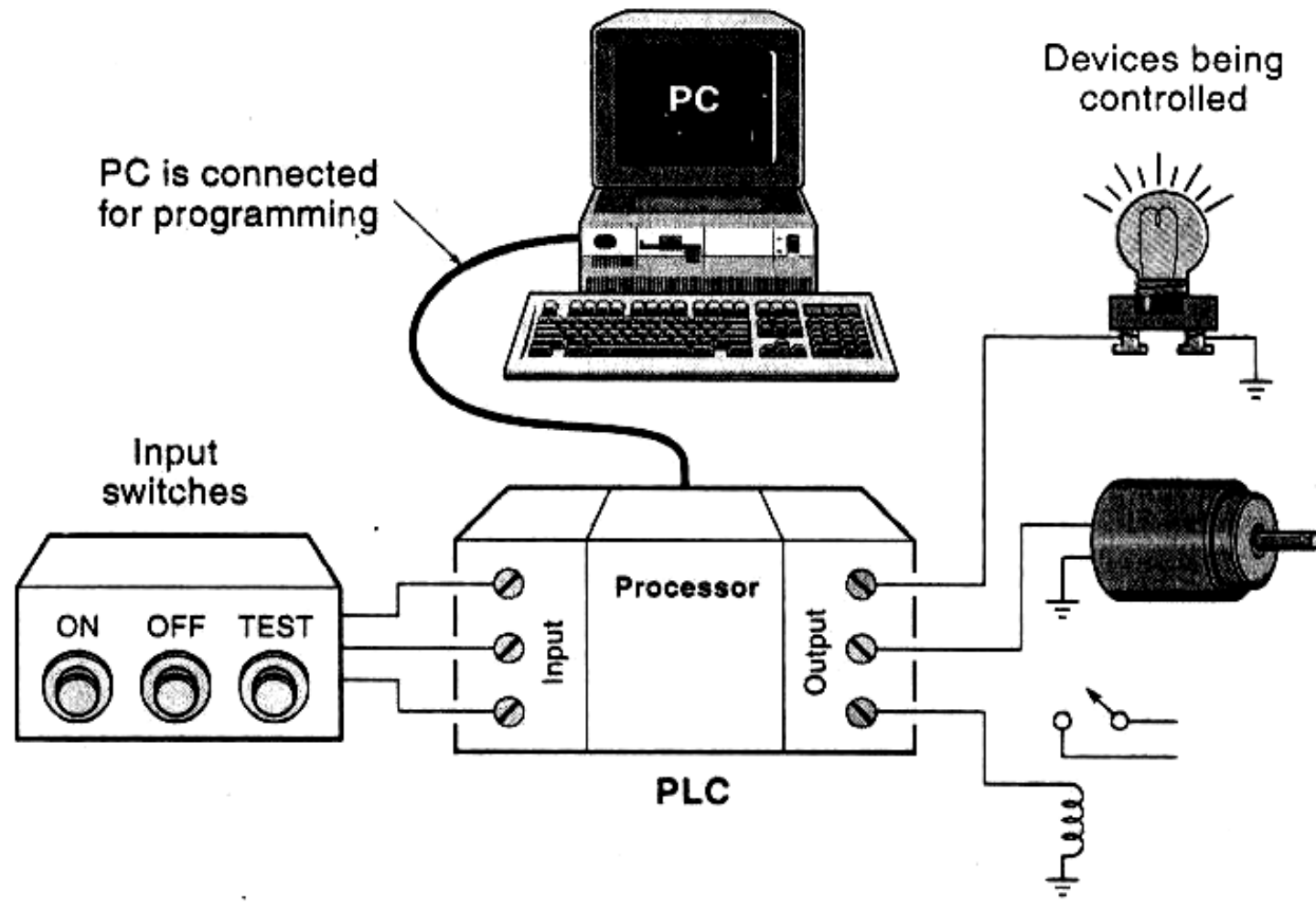
1. Omron : Yosua cs., Arthur cs.
 - CQM1 / C200H / CJ 1, www.omron247.com
2. Schneider/Modicon : Rudy cs, Nura cs.
 - Twido / Micro / Premium, www.telemecanique.com
3. Siemens : Teddy cs, Yongky cs.
 - S7-300 / S7-400, www.sea.siemens.com
4. Allen Bradley : Lamekh cs., Disyon cs.
 - SLC 500 / PLC 5, www.ab.com

[

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1. Festo
2. LG
3. Yokogawa
4. GE
5.

[PLC's component]



[PLC's component]

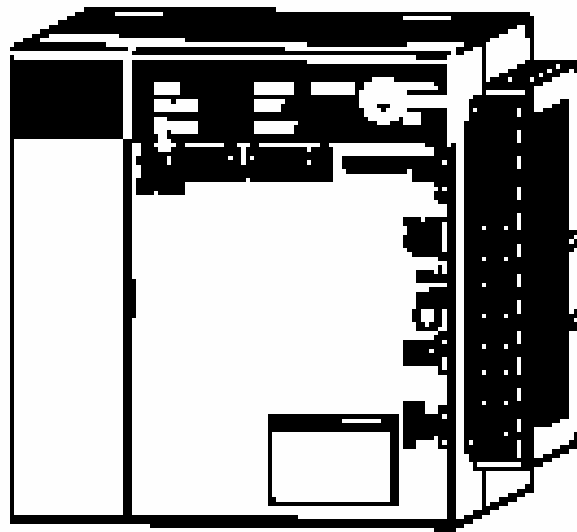
1. Power Supply
2. Processor
3. Memory
4. Input and Output Module
5. Programming Device – Communication Module

[Power Supply]

- Sebagai penyedia daya bagi PLC, bisa berupa :
 - Tegangan AC (misal : 120/240 Vac.)
 - Tegangan DC (misal : 24 V DC)
- PLC juga memiliki *power supply* (24V DC) internal yang bisa digunakan untuk menyediakan daya bagi *input/output* PLC

[Power Supply – Contoh]

I/O Power Supplies



100/200 VAC:
24 VAC:

C200H-PS221
C200H-PS211

Programming Device – Programming console

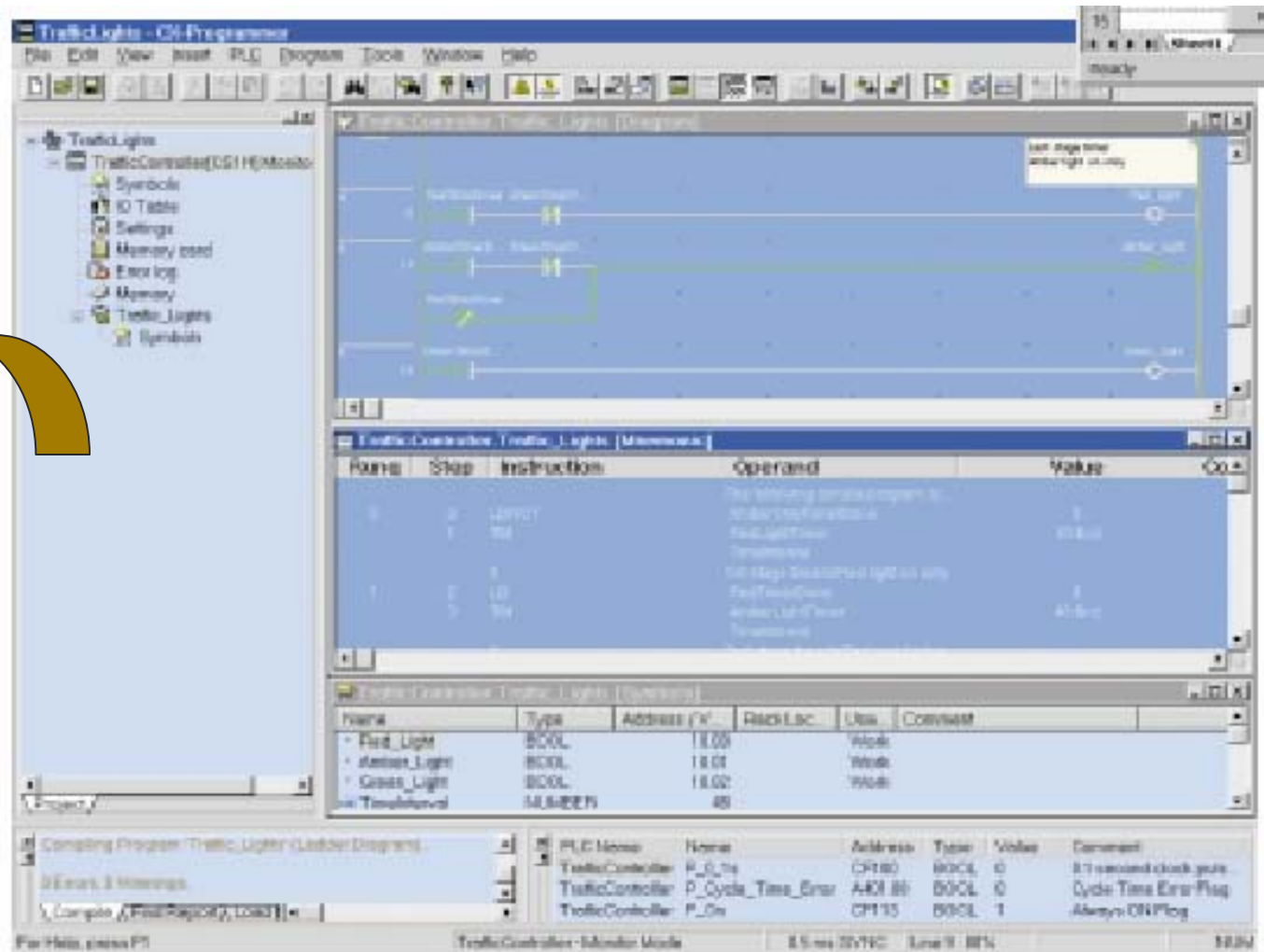
- Alat untuk membuat atau mengedit program PLC
- Berupa PC atau *hand held programmer*
- Terhubung dengan PLC melalui programming port (umumnya RS 232)



**Contoh Programming Console
(Hand Held Programmer)**

Programming Device – Software in PC

PLC software
in PC

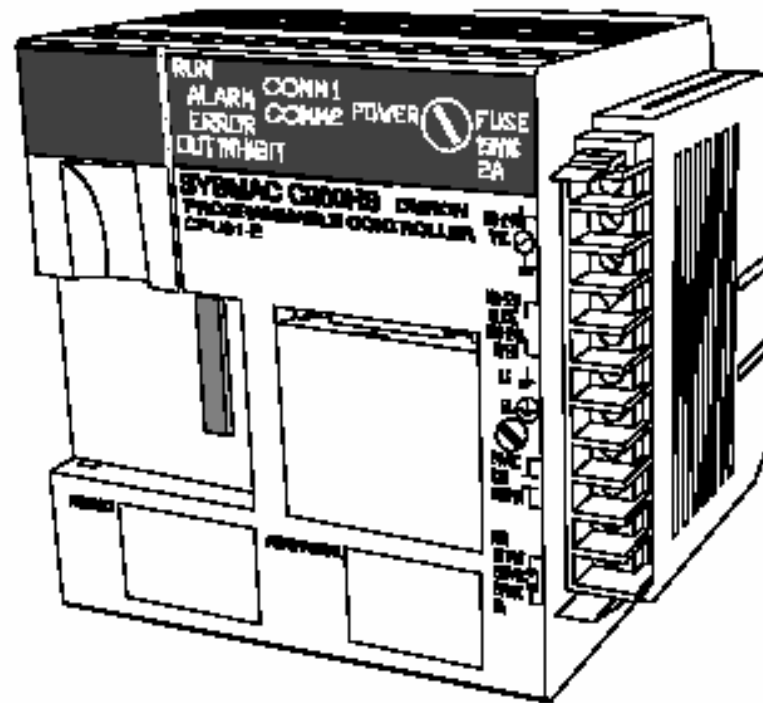


[Processor]

- *Processor*

- Bagian PLC yang bertugas membaca dan mengeksekusi instruksi program.
- Mempunyai elemen kontrol yang disebut *Arithmetic and Logic Unit (ALU)*, sehingga mampu mengerjakan operasi logika dan aritmetika.

[Contoh : Omron Processor]



C200HS-CPU31-E/CPU33-E CPUs

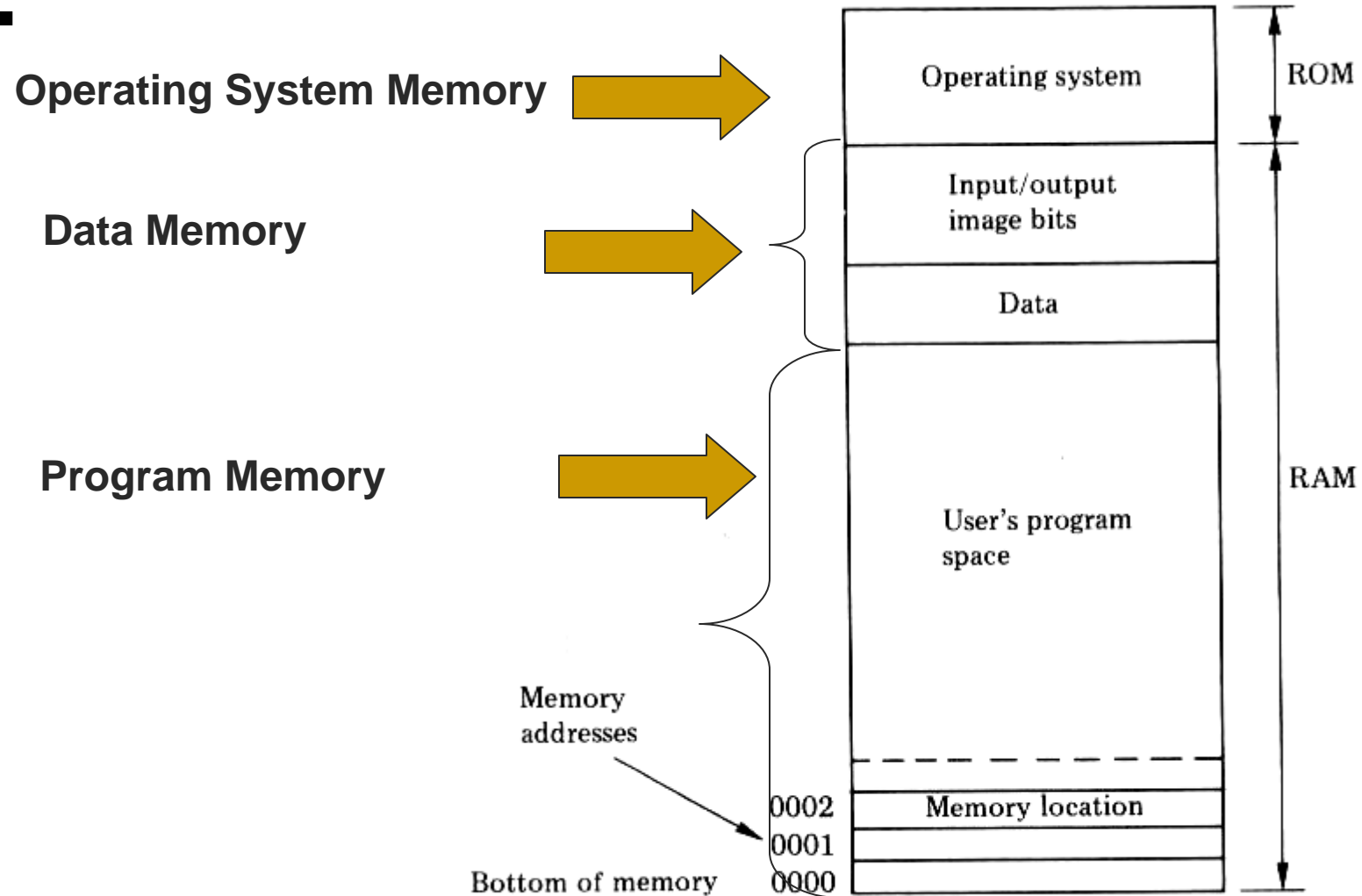
C200HS Specifications

Part number	C200HS-CPU01-E/CPU03-E	C200HS-CPU21-E/CPU23-E	C200HS-CPU31-E CPU33-E
Main Control Element	MPU, CMOS, LS-TTL		
Programming languages	Ladder diagram		
Instruction set	239 (14 basic instructions + 225 special instructions)	239 (14 basic instructions + 225 special instructions)	243 (14 basic instructions + 299 special instructions)
Instruction length	1 to 4 words/instruction, 1 address/instruction		
Execution time	0.375-1.313 μ s (basic instructions)		
I/O control method	Cyclic, programmed, scheduled, and zero-cross refreshing		
Control input signal	START INPUT (in RUN mode, PLC operates when contacts are closed and stops when contacts are opened; 24 VDC, 10 mA)		
Control output signal	RUN OUTPUT; dry contact (contacts are closed while PLC is in RUN mode; maximum switching capacity: 2 A, 250 VAC (resistive load, p.f. = 1), 0.5 A, 250 VAC (inductive load, p.f. = 0.4), 2 A, 24 VDC)		
Memory protection	Status of HR bits, AR bits, preset value of counters (CNT), and contents of data memory (DM) are retained during power failure. RAM Pack, battery back-up: Program (including clock function) and data areas protected. RAM Pack, capacitor back-up: Program and data areas protected. EEPROM Pack (without clock function): Data areas protected. EEPROM Pack (with clock function): Clock function and data areas protected. C200H-CPU31-E: Program and data areas (including clock function) protected.		
Battery life	4 years at 25°C (77°F); shortened at temperatures higher than 25°C. Replace battery with new one within 1 week when ALARM indicator blinks.		
Self-diagnostics	Errors for CPU failure, Battery, Scan time, Memory failure, I/O bus, I/O verify, Remote I/O, Link error, Special I/O Modules, CPU Bus Modules		
Agency approvals	UL listed, file number: E95399 CSA certified, file number: LR51460		

[Memory]

- Tempat penyimpanan dalam PLC
 - Operating System PLC
 - Status input – output, data memory
 - Program yang dibuat pengguna
- Umumnya menjadi satu dengan *processor*.
- Jika ada memori eksternal merupakan memori tambahan.

[Memory - PLC's Memory Map]



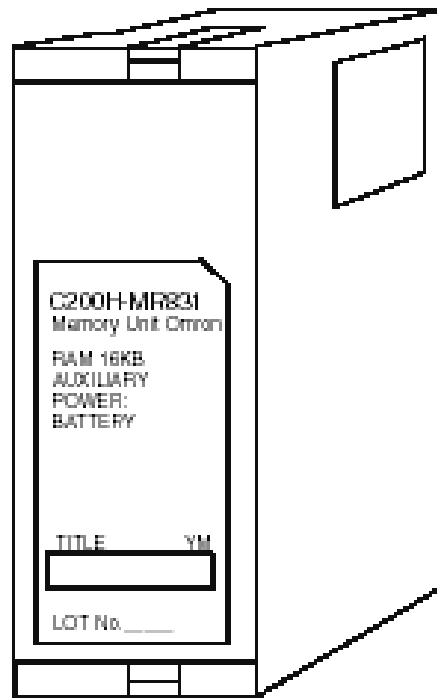
[PLC's Memory Map]

- *Operating System Memory*
 - Untuk menyimpan *operating system* PLC
 - Berupa ROM (*Read Only Memory*)
 - Tidak dapat dirubah oleh *user*
- *Data (Status) Memory*
 - Menyimpan status input-output tiap saat.
 - Berupa RAM (*Random Access Memory*).
 - Dapat berubah sesuai kondisi *input/output*.
 - Status kembali ke kondisi awal jika PLC mati.

[PLC's Memory Map]

- *Program Memory*
 - Untuk menyimpan program pengguna
 - Berupa
 - RAM
 - RAM - *battery backup* → untuk menyimpan program selama jangka waktu tertentu
 - EEPROM (*Electrically Erasable Programmable Read Only Memory*) → jenis ROM yang dapat diprogram dan dihapus oleh *user*

[Contoh – Omron Memory Unit]



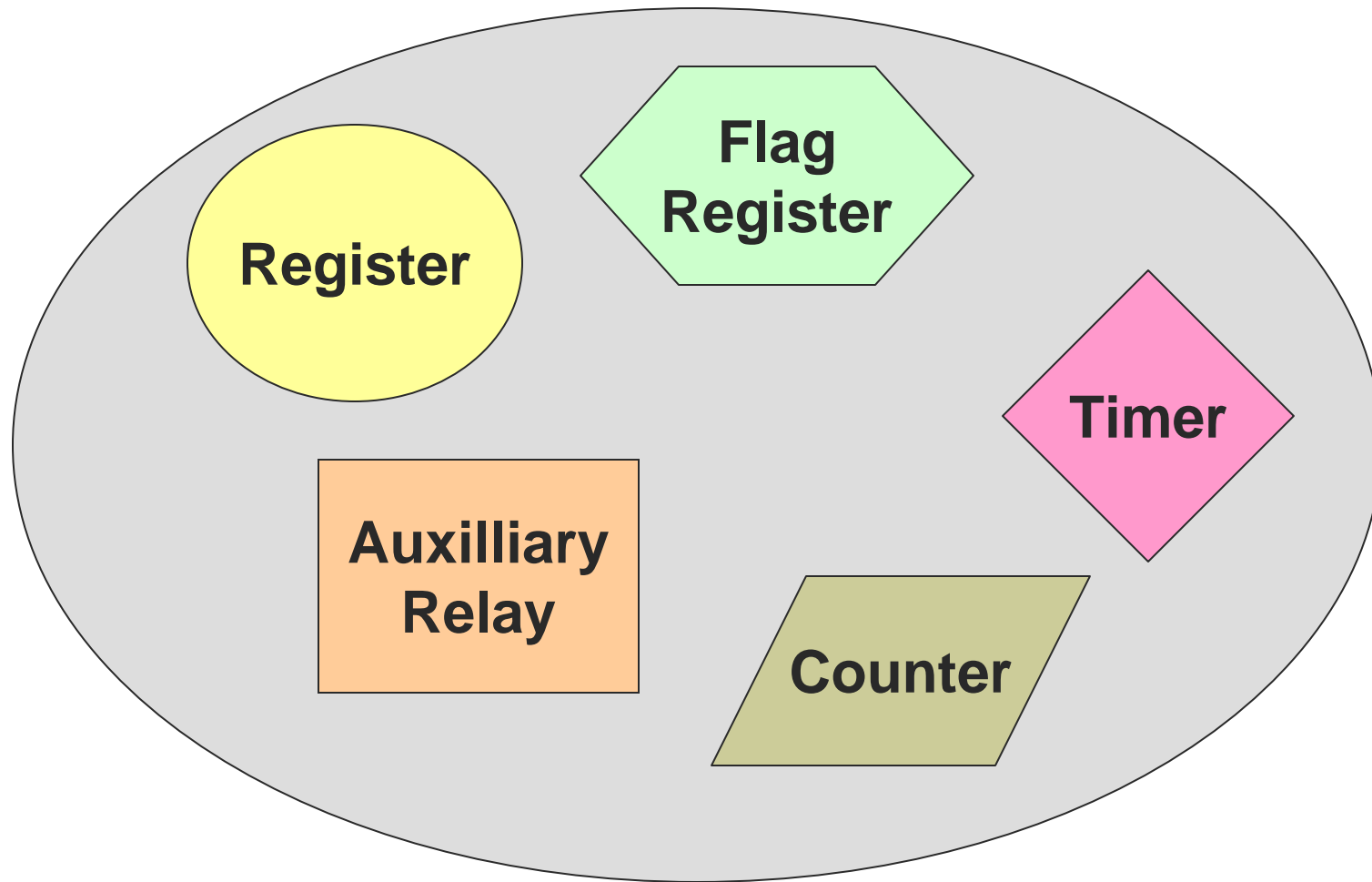
General Information

Memory Packs store programs and data for C200H controllers. Select 4 or 8 K word memory packs to match your requirements. To take advantage of the clock/calender option for C200H-CPU21 and -CPU23, select a memory pack with clock. Increase the C200HS built-in RAM with an additional 16 K words of file memory for large processing loads.

Features

- ◆ Three types available: EPROM, EEPROM, RAM
- ◆ Optional clock and calender for C200H-CPU21/CPU23
- ◆ File memory boards available for C200HS-CPU01/CPU03
- ◆ C200HS has built-in RAM memory

PLC's Memory Area – Addressing



PLC's Memory Area – Addressing

■ Register

- Register data dalam RAM berfungsi untuk menyimpan **sekumpulan bit** data
→ *nibble* (4 bit), *byte* (8 bit), *word* (16 bit)



Register

■ Flag register

- Untuk mengindikasikan perubahan kondisi (*state*) input/output fisik, berupa **satu bit** data.
- CPU mempunyai **internal flag** untuk berbagai keperluan internal PLC.



Flag
Register

PLC Memory Area – Addressing

■ Auxiliary relays

- Elemen memori **1 bit** dalam RAM yang digunakan untuk manipulasi data dalam program.
- Merupakan ***imaginary internal relays***

Auxilliary
Relay

■ Timer

- CPU mempunyai *built in clock oscillator* sebagai *timer* internal
- Umumnya memiliki alamat khusus

Timer

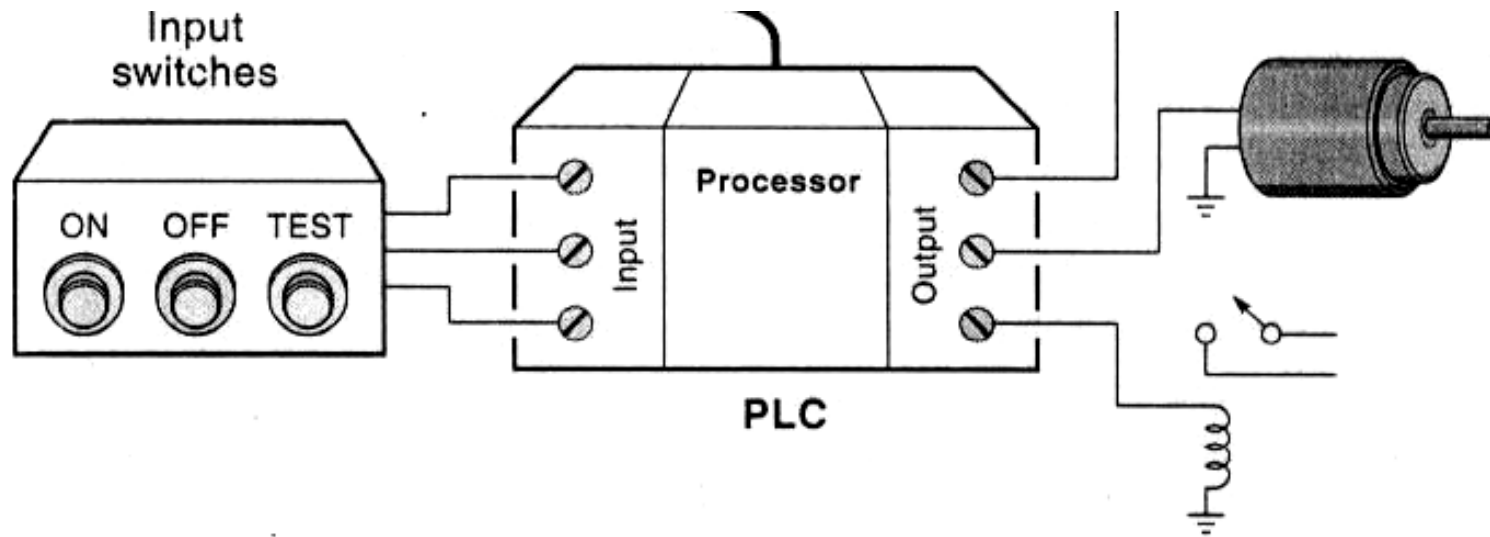
■ Counter

- CPU memiliki *counter* internal
- Umumnya memiliki alamat khusus

Counter

- 
- Bagaimana PLC terhubung dengan dunia luar? *Do you have any idea?*

[Input - Output Module]



- Bagian manakah **Input - Output Module** ?
- Berdasar gambar, apa fungsi bagian tersebut ?

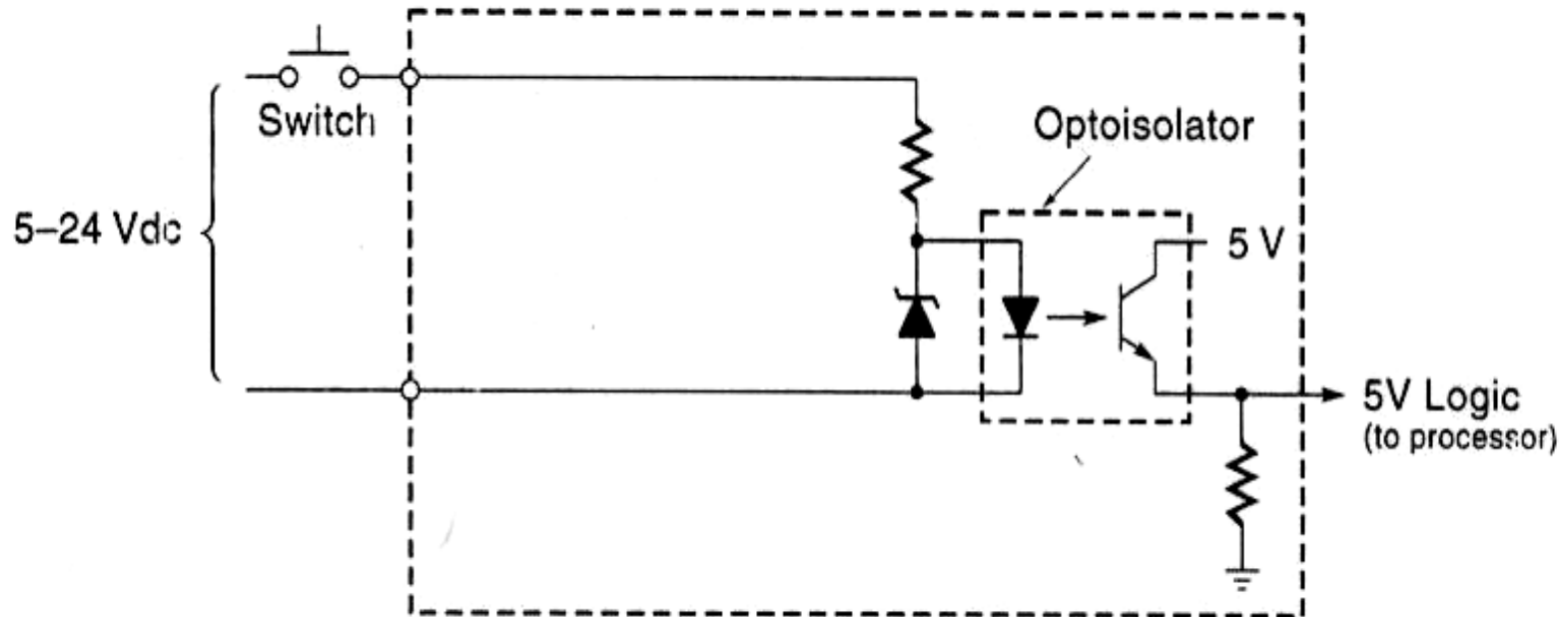
[Input - Output Module]

- *Interfacing* PLC ke dunia luar.
- Untuk PLC *compact* sudah *built-in* di PLC
- Untuk PLC modular berupa modul I/O tersendiri yang terpisah dari CPU PLC
- Terbagi menjadi :
 - Digital Input / Output Module
 - Analog Input / Output Module

[Digital Input Module]

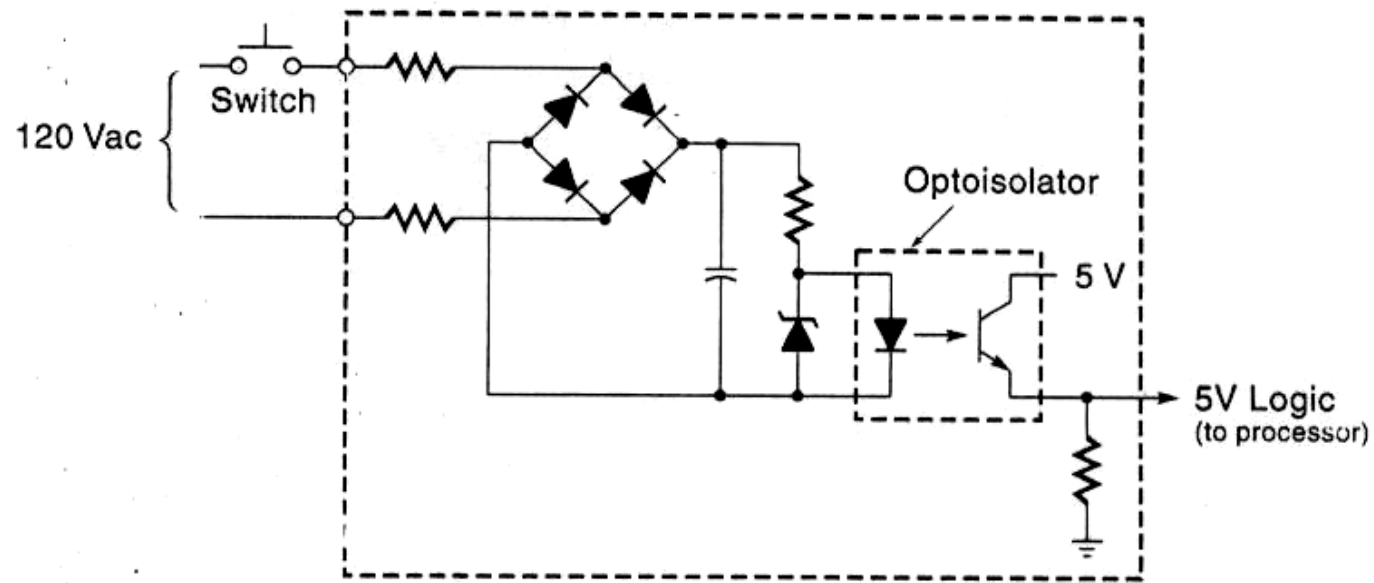
- Menghubungkan input **diskrit** fisik (switch, sensor) dengan PLC.
- Tersedia dalam tegangan **DC** dan **AC** (umumnya : 240 Vac, 120 Vac, 24 Vdc, 5 Vdc).
- Ada “*optoisolator*” untuk mencegah lonjakan tegangan tinggi masuk PLC (sbg pengaman)

[Digital Input Module (tegangan DC)]



(b) DC input module circuit

[Digital Input Module (tegangan AC)]



(a) AC input module circuit

Input module yang dapat menerima tegangan AC memiliki rangkaian penyearah di dalamnya.

Contoh : Spesifikasi DC input module Omron

Specifications

Part number	C200H-ID001	C200H-ID002
Number of inputs (per common)	8 pts (8 pts/com, 1 circuit)	8 pts (8 pts/com, 1 circuit)
Input voltage	No-voltage contact/NPN output type (negative common)	No-voltage contact/NPN output type positive common)
Input current	7 mA, typical	7 mA, typical
Operating voltage		
ON	14.4 VDC min.	14.4 VDC min.
OFF	5.0 VDC max.	5.0 VDC max.
Input response time		
ON	1.5 ms max.	1.5 ms max.
OFF	1.5 ms max.	1.5 ms max.
Style/External connections	A/Removable terminal block	
Input device requirement	–	–
Manual	C200H Installation Guide: W111	

Macam - macam digital input module Omron

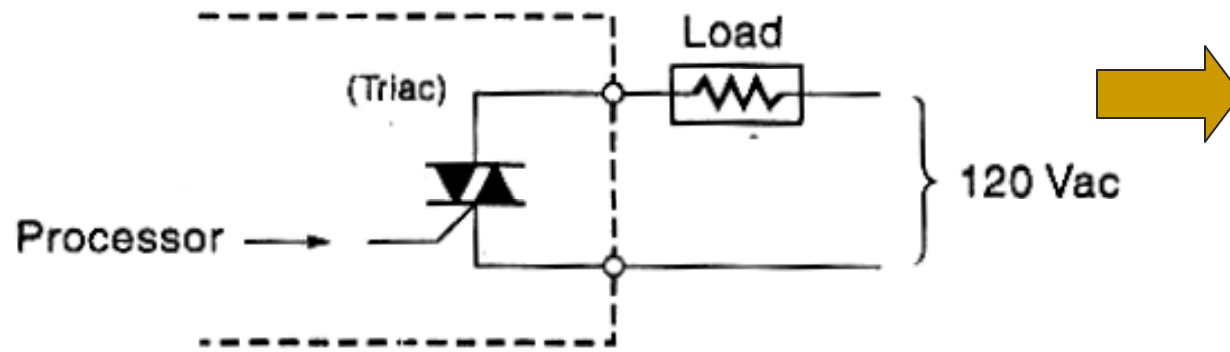
Input Modules

<i>Name</i>	<i>Specifications</i>		<i>Model</i>
AC Input	8 pts	100 to 120 VAC	C200H-IA121 *
	16 pts	100 to 120 VAC	C200H-IA122 *
	8 pts	200 to 240 VAC	C200H-IA221 *
	16 pts	200 to 240 VAC	C200H-IA222 *
DC Input	8 pts	12 to 24 VDC	C200H-ID211 *
	16 pts	24 VDC	C200H-ID212 *
AC / DC Input	8 pts	12 to 24 VAC/DC	C200H-IM211 *
	16 pts	24 VAC/DC	C200H-IM212 *

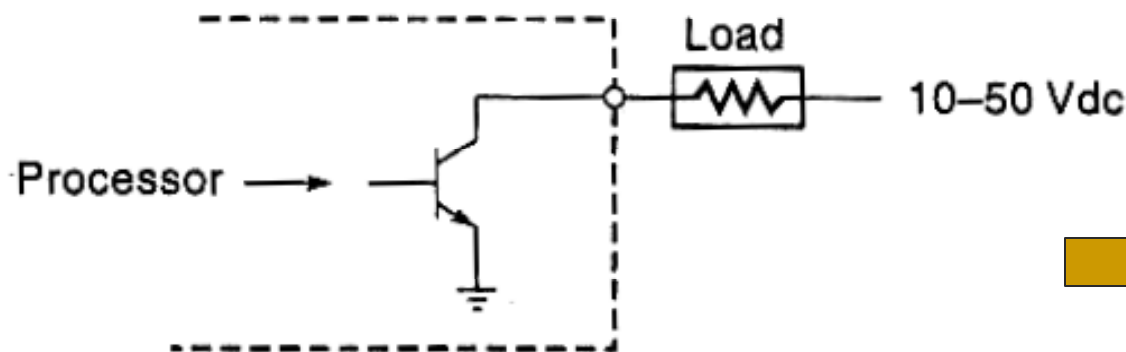
[Digital Output Module]

- Menghubungkan output diskrit fisik (lampu, relay, solenoid, motor) dengan PLC
- Jenis-jenis:
 - Triac output (output tegangan AC)
 - Transistor output (output tegangan DC)
 - Relay output (output tegangan AC/DC)

[Digital Output Module]

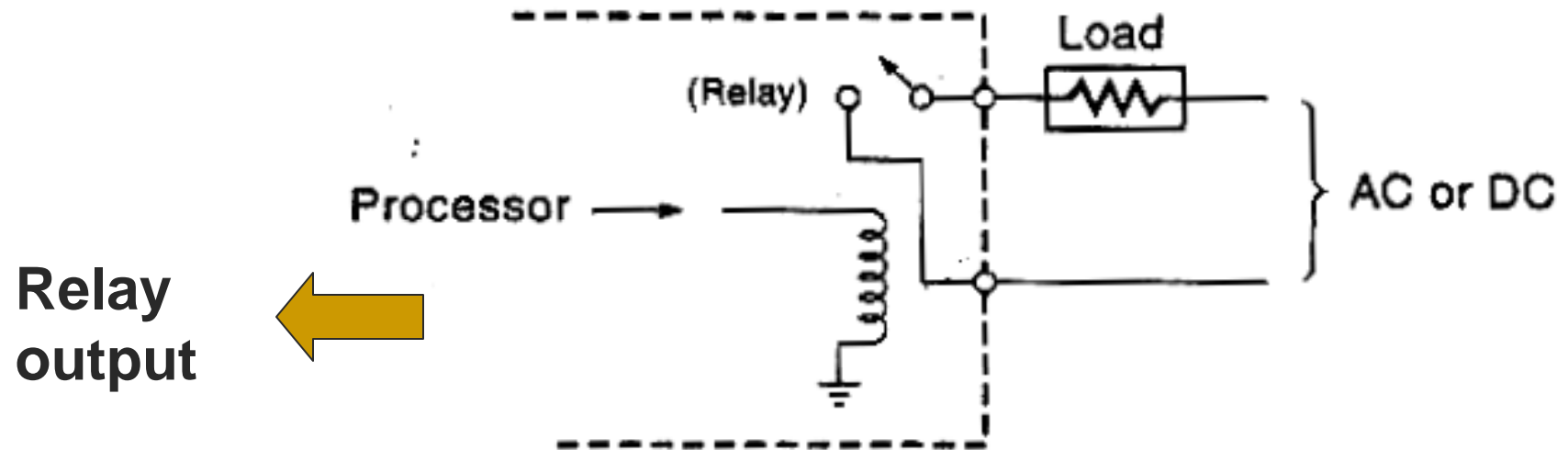


Triac output



Transistor output

[Digital Output Module]



Contoh : Spesifikasi transistor output module Omron

Specifications

Part number	C200H-OD211	C200H-OD212
Number of outputs (per common)	12 pts (12 pt/com, 1 circuit)	16 pts (16 pts/com, 1 circuit)
Max. load current	0.3 mA/pt, 2 A/module	0.3 mA/pt, 2 A/module
Rated load voltage	24 VDC $\pm 10\%$ /-15%	24 VDC $\pm 10\%$ /-15%
Min. switching capacity	Residual voltage: 1.4 V max.	Residual voltage: 1.4 V max.
Output response times		
ON	0.2 ms max.	0.2 ms max.
OFF	0.3 ms max.	0.3 ms max.
Style/External connections	B/Removable terminal block	B/Removable terminal block
Leakage current	0.1 mA max.	0.1 mA max.
Fuse	125 V, 5 A	125 V, 8 A
External power supply	24 VDC, 25 mA min.	24 VDC, 35 mA min.
Operation	Sinking (NPN)	Sinking (NPN)
Manual	C200H Installation Guide: W111	

Macam - macam digital output module Omron

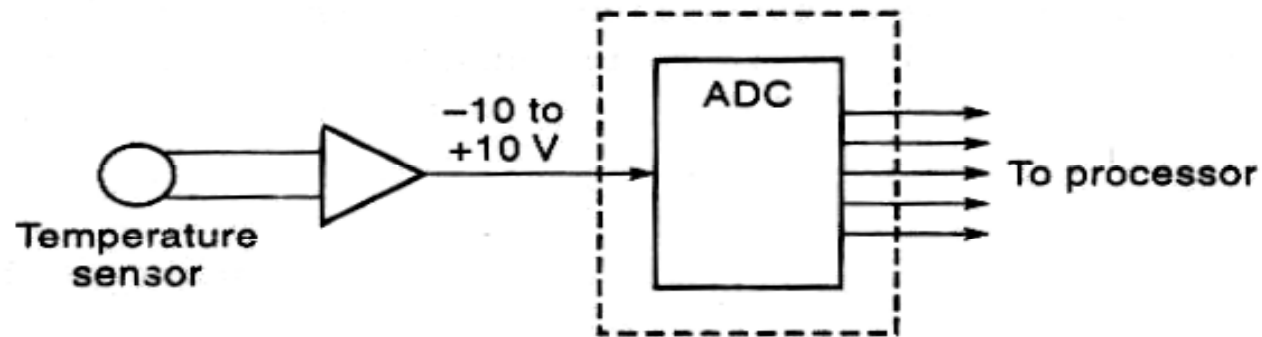
Output Modules

Name	Specifications		Model
Relay Output	8 pts	2A, 250 VAC/24 VDC	C200H-OC221
	12 pts	2A, 250 VAC/24 VDC	C200H-OC222
	5 pts	2A, 250 VAC/24 VDC - Independent contact	C200H-OC223
	8 pts	2A, 250 VAC/24 VDC - Independent contact	C200H-OC224
	16 pts	2A, 250 VAC/24 VDC - independent contact	C200H-OC225
Triac Output	8 pts	1A, 200 VAC	C200H-OA221
	12 pts	0.3A, 200 VAC	C200H-OA222
Transistor Output	8 pts	1A, 12 to 48 VDC	C200H-OD411
	12 pts	0.3A, 24 VDC	C200H-OD211
	16 pts	24 VDC	C200H-OD212
	8 pts	2.1A, 24 VDC	C200H-OD213
	8 pts	0.8A, 24 VDC; pos. com.; short cct protection	C200H-OD214
	8 pts	0.3A, 5 - 24 VDC, PNP	C200H-OD216
	16 pts	0.3A, 5 - 24 VDC, PNP	C200H-OD217

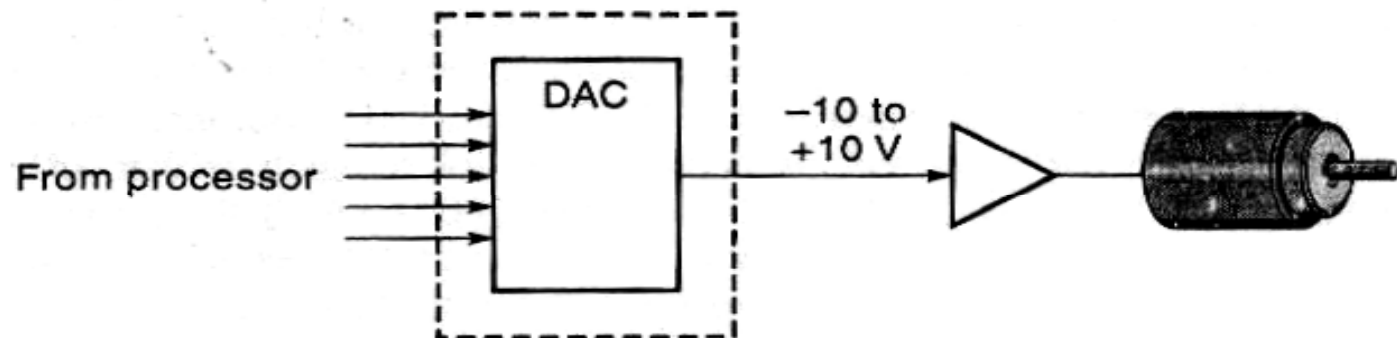
[Analog Input-Output Module]

- Menghubungkan input-output analog fisik dengan PLC.
- Memiliki range tegangan tertentu (bukan hanya 0 dan 1)
- Umumnya merupakan modul khusus yang ditambahkan pada PLC modular
- Merupakan ADC dan DAC khusus PLC

[Analog Input-Output Module]



(a) Analog input module



(b) Analog output module

[PLC Selection]

- Pemilihan PLC berdasar
 1. Jumlah dan karakteristik input - output
 2. Fitur hardware PLC
 - *power supply*, modul input/output, kemampuan untuk diekspansi dengan modul – modul lain, port komunikasi, dll
 3. Fitur software PLC
 - Kapasitas memori, kecepatan pemrosesan data, jumlah instruksi yang dapat digunakan, dll

Contoh : Omron PLC Selection Micro PLC

1 - Base I/O

Jumlah **base I/O**
(belum diekspansi)
yang dimiliki PLC

10 I/O	ZEN	CPM1A CPM2C	CPM2B CPM2C-S	CPM2A CQM1H
20 I/O	ZEN	CPM1A CPM2C	CPM2B CPM2C-S	CPM2A CQM1H
30 I/O	ZEN	CPM1A CPM2C	CPM2B CPM2C-S	CPM2A CQM1H
40 I/O	ZEN	CPM1A CPM2C	CPM2B CPM2C-S	CPM2A CQM1H
60 I/O	ZEN	CPM1A CPM2C	CPM2B CPM2C-S	CPM2A CQM1H
Distributed I/O	ZEN	CPM1A CPM2C	CPM2B CPM2C-S	CPM2A CQM1H

2 - Package Style

Bentuk PLC : brick
(compact), modular,
board







3 - Features

Kelengkapan *PLC* system

Online Editing	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
Expansion	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
Removable Terminals	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
Analog I/O	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
Built-in RS-232C Port	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
Multiple Comm. Ports	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
RS-232C/422/485 Support	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H

Real Time Clock	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
High Speed Counter	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
Position Control	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
Quadrature Encoder Inputs	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
AC Inputs	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
EEPROM Loader	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
Temperature Sensor Input	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H
DeviceNet Slave	ZEN	CPM1A	CPM2B	CPM2A
		CPM2C	CPM2C-S	CQM1H

Contoh : Omron PLC Selection Micro PLCs

MICRO PROGRAMMABLE CONTROLLERS				
				
	<i>Page A-8</i>	<i>Page A-22</i>	<i>Page A-46</i>	<i>Page A-70</i>
	ZEN	CPM1A-V1	CPM2A	CPM2B
CPU I/O	10, 20	10, 20, 30, 40	20, 30, 40, 60	32, 40
Max I/O points (with expansion)	44	100	120	168
AC power supply	100 to 240 VAC	100 to 240 VAC	100 to 240 VAC	–
DC power supply	24 VDC	24 VDC	24 VDC	24 VDC, 12 VDC
Memory backup	Yes	No	Yes	Yes
Max. program cap.	96 lines	2K	4K	4K
Basic instruction execution time	.85 ms	.72 µsec	.64 µsec	.64 µsec
No. of instructions	15	91	119	119

Contoh : Omron PLC Selection

Micro PLCs

	ZEN	CPM 1A	CPM 2A	CPM 2B
AC Inputs	Yes	No	No	No
DC Inputs	Yes	Yes	Yes	Yes
Max. # of inputs*	24 max.	60 max.	72 max.	88 max.
Max. # of outputs*	20 max.	40 max.	48 max.	80 max.
Max. # of relay outputs*	20 max.	40 max.	48 max.	48 max.
Max. # of transistor outputs*	20 max.	40 max.	48 max.	80 max.
High speed counter	No	5kHz	20kHz	20 kHz
Pulse output	No	2kHz	10kHz (Synchronized)	10 kHz
Analog I/O	2 points	Expansion Module	Expansion Module	Expansion boards
Real time clock	Yes	No	Yes	Yes
External interrupts	No	2, 4	2, 4	4
Network connectivity	No	RS-232C/422, Hostlink, 1:1 NT Link, CompoBus/S Slave, DeviceNet Slave, Profibus-DP Slave	RS-232C/422, Hostlink, 1:1 NT Link, CompoBus/S Slave, DeviceNet Slave, Profibus-DP Slave	RS-232C/422, Hostlink, 1:1 NT Link
Suggested programming tools	ZEN Support Software	CX-Programmer	CX-Programmer	CX-Programmer
Peripheral devices	–	Hand Held Terminal, NT/NS Series HMI	Hand Held Terminal, NT/NS Series HMI	Hand Held Terminal, NT/NS Series HMI
Built in comm. ports	–	Peripheral	Peripheral/RS-232C	Peripheral/RS-232C

[Review Questions]

- Sebutkan komponen – komponen utama PLC!
- Jelaskan *memory map* dan *memory area* PLC!
- Jelaskan macam – macam input/output module PLC!
- Jelaskan dasar – dasar pemilihan PLC!

[Tugas : Presentasi (1)]

- Dari merk PLC yang ditentukan :
 - Kelompokkan tipe – tipe PLC yang ada (*small, medium, big*)
 - Ambil satu jenis tipe PLC modular, dan jelaskan bagian – bagiannya (*power supply, input-output, processor, memory,*)
- Presentasikan, **seolah – olah** anda adalah ***sales engineer*** dari perusahaan

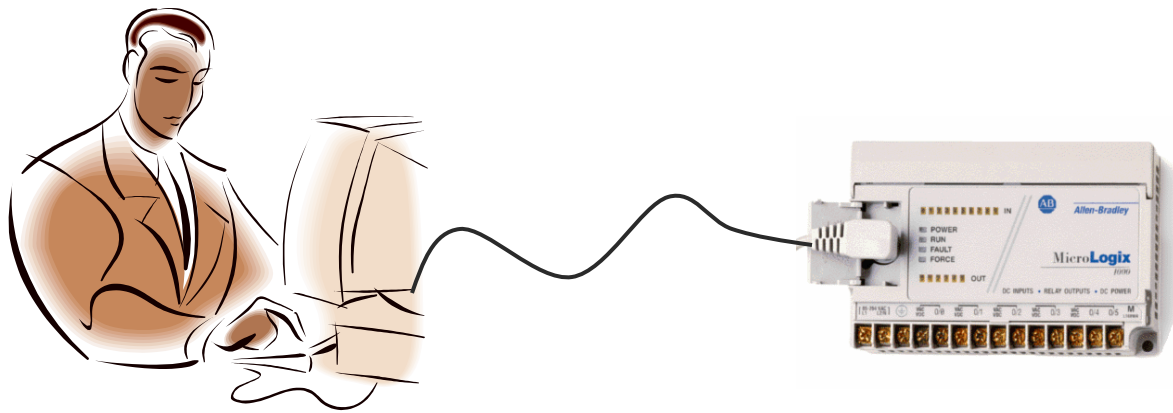
[Tugas : Presentasi (2)]

- Nilai diambil dari :
 - Product knowledge (penguasaan produk)
 - Metode presentasi yang baik
 - Bahan presentasi yang terorganisir (*slide, handout, dll*)
 - Mutu pertanyaan untuk kelompok yang lain
- Presentasi : 15 menit
- Soft copy dan hard copy

[Tugas : Presentasi (3)]

- Nilai Plus :
 - Menggunakan bahasa Inggris
 -

[Next



PLC Programming!