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INTRODUCTION

1. About This Manual

Hello, everybody! Welcome to the “Regulating” industry. Well I guess some explanation will be needed for everyone to understand what “Regulating” industry is . This manual provides information about the basics of electricity and the most fundamental FA & CC products, such as switches, relays timers, PLC, Inverter, Touchscreen and others, for the benefit of newcomers to the industry.

Real-life examples are incorporated in the text. So, lets learn the basics one by one.

2. Intended Audience

This manual is intended for the following personnel, who do not have any or little knowledge on Electricity, Basic Omron FA & CC products.

- Customer Service Staffs
- Sales & Support Staffs
- Administration staffs

SECTION 1
Basics of Electricity

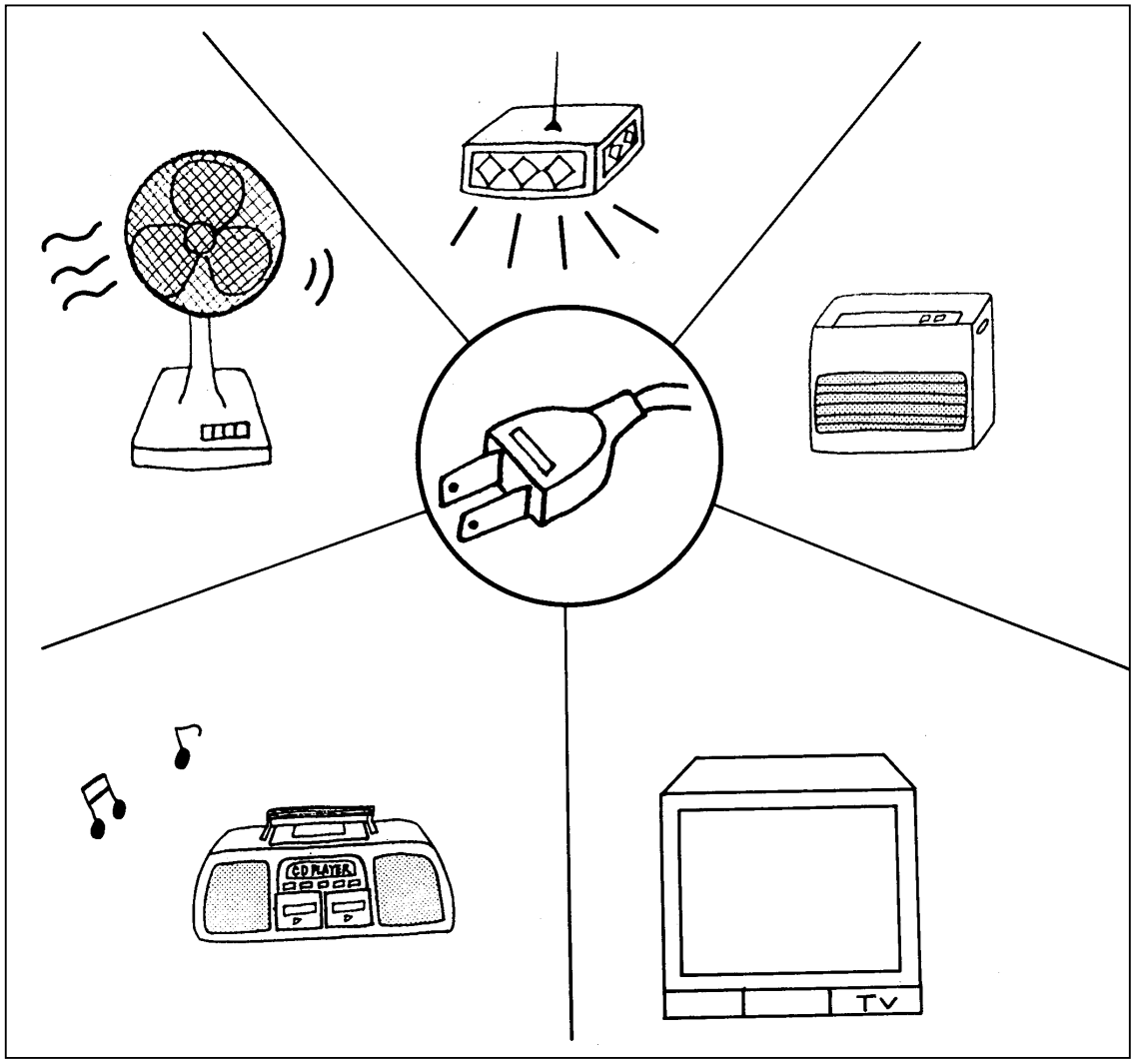
1-1 Our Life Electricity

Electricity is everywhere in our daily life. Just take a look at your house. Press a switch and a light comes on. Press a button of the remote controller and the television comes to life. Tea made with hot water boiled using the electrical kettle and barbecue parties with hot-plate roasted meat! When the room gets stuffy or warm, simply switch on the air conditioner! Such is our life which is closely knitted with "Electricity".

Electricity has become an indispensable part of our life.

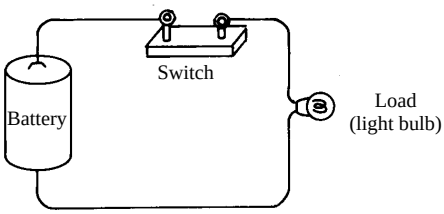
Well, most people understand that a machine moves when the switch is pressed but not the electricity that drives it.

From home electrical appliances to regulating equipment which we are going to study later, let's learn the basic knowledge of electricity so that we could make informed selections for safety use.

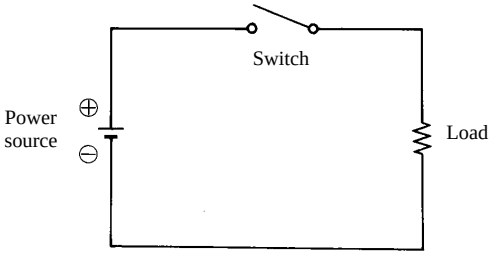


1-2 What is a Electric Circuit?

In the following diagram, the light bulb will come on when the switch is pressed.
When the switch is pressed, current flows from the Plus (+) end to the Minus (-) end of the battery through the light bulb.
The current makes a round trip and is therefore known as an Electric Circuit.

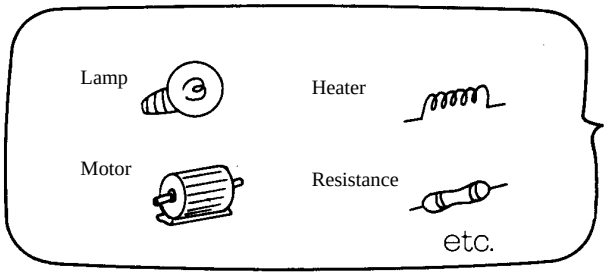


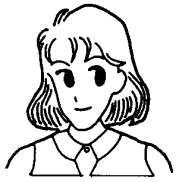
A wiring diagram



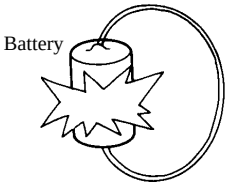
A circuit diagram

As shown in the above diagram, the bulb or anything that consumes electricity is known as the "Load". Load is expressed by LOAD

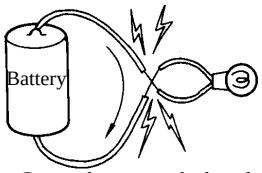




Short-circuit is dangerous!



Short-circuit



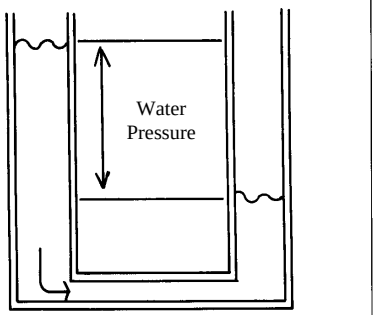
Contact between naked cords
(Electricity is unable to flow
to the load)

When electricity flows from (+) to (-) without a load standing in between, an excessive current flow may be generated. This phenomenon is known as short or short-circuits.

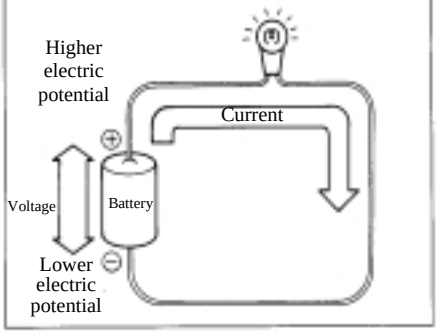
1-3 Current • Voltage • Resistance and their Correlation

- **Current and Voltage**
  The flow of electricity is not visible to human eyes.
  Let's compare it to the flow of water.

When two water tanks are linked by a pipe, water will flow from the one with the higher water level to the one with the lower level.



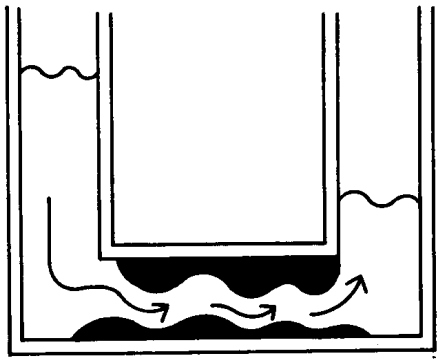
The relationship is the same in the case of electricity-electricity flows from the higher electric potential to the lower electric potential.



Some information on electricity and electric potential

	Unit	Designation
Volume of flowing electricity	A (ampere)	Electricity
Potential difference (strength of electricity flow)	V (Volt)	Voltage

- **Electrical resistance**



Thwarted water flow

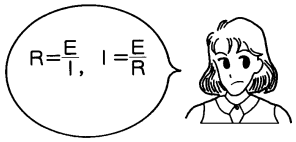
Thwarted water flow through a pipe, the flow will be weakened when the valve is tightened and increased when the valve is loosened.
Also, when the pipe is stained, water flow will be thwarted.

In the case of electricity,

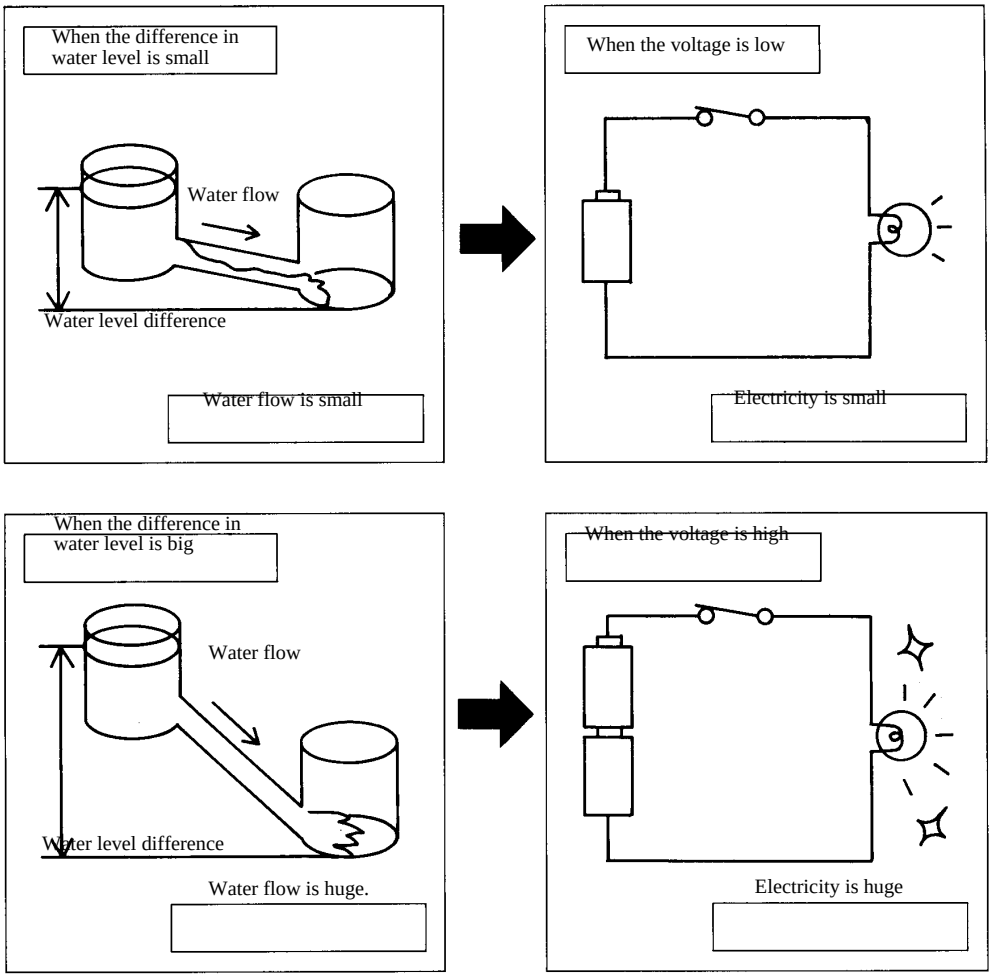
	Unit	Designation
Obstruction to the flow of current in a circuit	Ω (ohm)	Resistance

- **The rule of ohm**
  The size of current flowing through a electric circuit is directly proportional to the size of the voltage and indirectly proportional to the size of the resistance. This is known as the **Rule of Ohm**.

Voltage (V)	=	Electricity (A)	x	Resistance Ω
E	=	I	x	R



Let's compare it to water….



EXERCISE

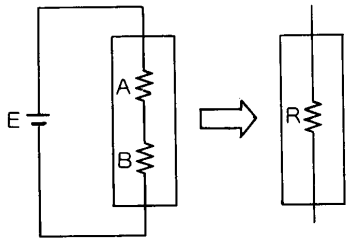
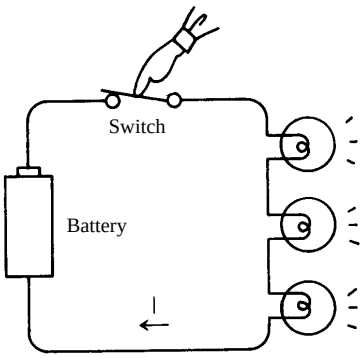
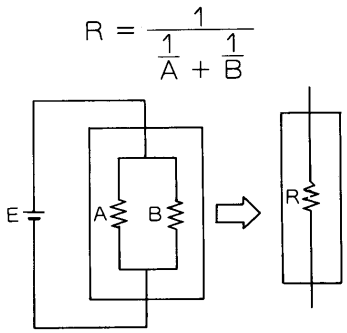
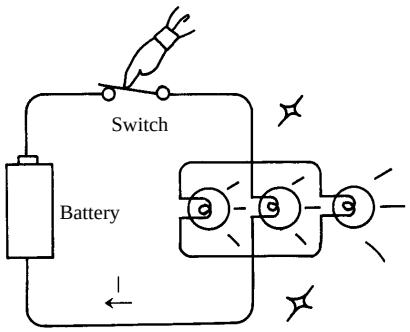
A hot plate of 15Ω resistance is connected to a wall outlet of 100V voltage.
What is the amount of electricity flowing to the hot plate?

Formula:_____

Answer:_____

1-4 Serial Connection • Parallel Connection for Resistance

When two instances of resistance are linked via a serial or parallel connection, the combined value of the resistance is known as the Combined Resistance.

Serial Connection	**Parallel Connection**
Resistance $R = A + B$  Combined resistance is the sum of various resistances  When all the three lamps are on, the light produced is **dimmer** than that produced when one lamp is on. As the supply voltage is divided among the lamps, these lamps are dimmer when all of them are switched on at the same time. The electricity which flows through the wire is $^1/_3$ smaller than that when only one lamp is on.	Combined Resistance $R = \frac{1}{\frac{1}{A} + \frac{1}{B}}$  Combined resistance is the reciprocal sum of the reciprocals of various resistances  When all the three lamps are on, the light produced is **as bright as** that produced when one lamp is on. Each lamp uses the supply voltage as-is. Thus, their brightness is not reduced. However, in this case, the electricity that flows through the wire has become larger to cater to the number of lamps.

1-5 Electric Power

All electrical appliances come with an indication of their power expressed by “Watt (W)”. For example, light bulbs come in 100W, 60W and 30W, etc. The higher the watt is, the brighter the light bulb will be. Hair dryers, for example, come in 1000W and 1200W, etc. Similarly, the higher the watt is, the stronger a hair dryer will blow.

As such, electricity is channeled to produce light, drive motors, produce heat and do a host of other jobs.

	Unit	Designation
Power of electricity per unit of time	W(Watt)	Electric power

- **Correlation between electric power and current • voltage**
  If electric power is P, its correlation with current • voltage is shown in the following formula.

P=EI
P: Electric power (W)
E: Voltage (V)
I: Current (A)

Example

To seek the current value when a 1200W-hair dryer is in use.

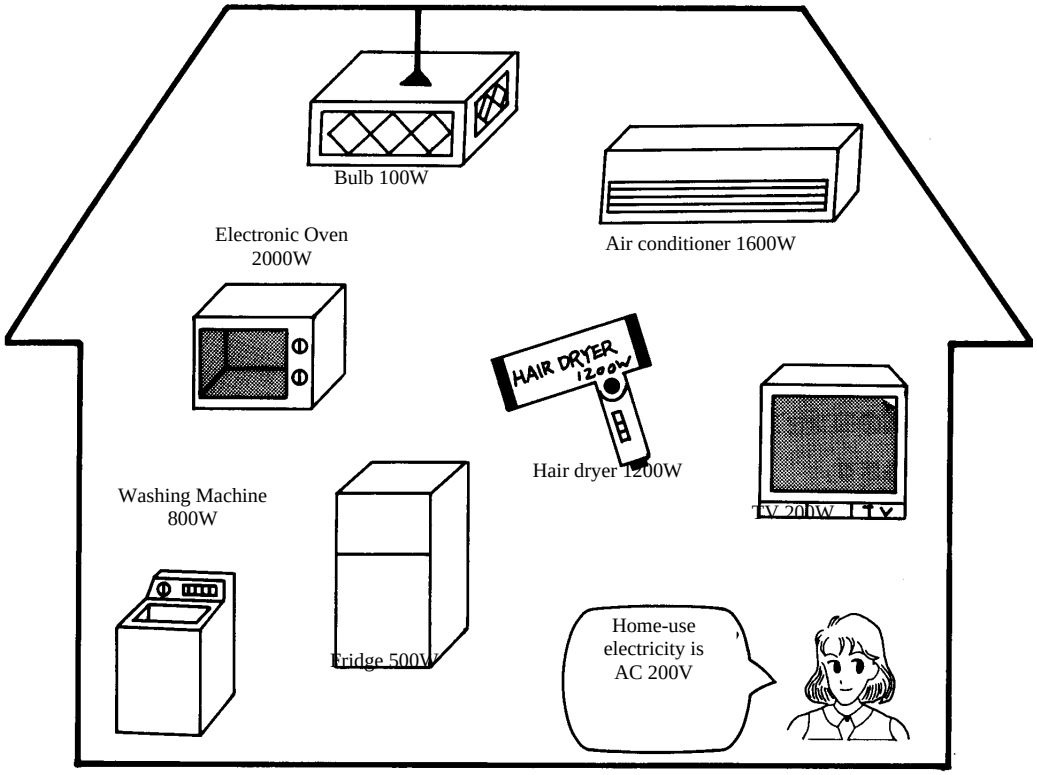
The voltage for home-use electricity is AC200V, thus,

$$\text{Current value} = \frac{1200\text{W}}{200\text{V}} = 6\text{A}$$

Beware of current over-use
The volume of current required by a family is contracted with a power-supply company in terms of current value (ampere) in advance.
When too many electrical appliances are used at the same time which leads to the demand for more electricity than the contracted volume, a breaker function will automatically work to stop the supply of electricity.
There are various contracted current values including 10A, 15A, 20A and 30A, etc.

Exercise

In a family, for which the contracted current value is 30A, can the following equipment be working at the same time?

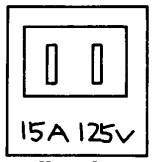


What about the electric power required by factory?
A factory uses a great deal more of power. E.g., power is required for

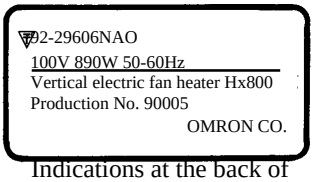
Heater	2KW
Motor	1.5KW
Pump	3.7KW
Elevator	15KW

- **Stick to the power rating for safety use**

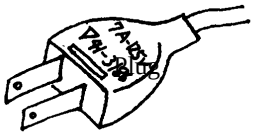
  Maximum current values and maximum voltage value are determined for all electrical equipment, including plugs and wall sockets. These are known as the allowable current and allowable voltage. All electrical appliances come with a power rating.

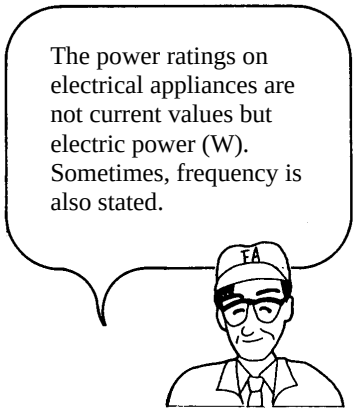


Wall outlet



Indications at the back of electrical appliances.

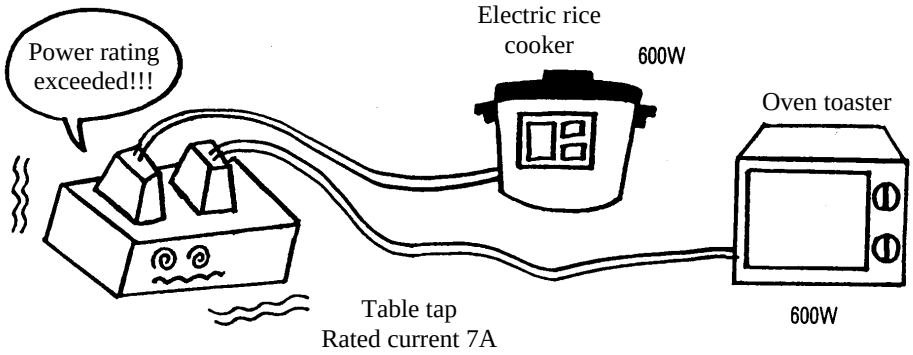

Plug



- **Watch out for starburst connections!**

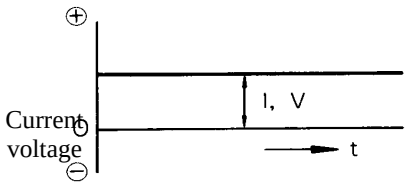
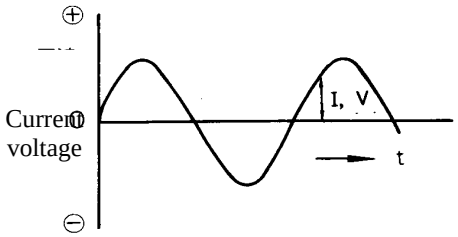
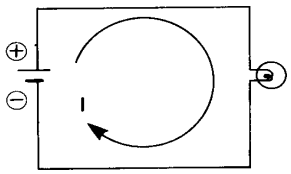
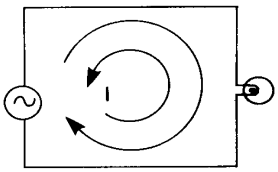
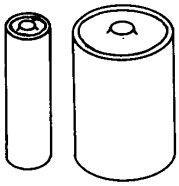
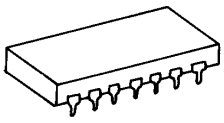
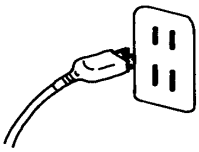
  When there are not enough built-in wall sockets, the use of extension cord, such as a table tap, allows electricity to be tapped easily.
  Most of the power rating for extension cords is approximately 7A.
  If a 600W electric rice cooker and a oven toaster are used at the same time, the current value will be:

  $\frac{600W}{100V}$ = 6A and 6A+6a=12A. When the total value goes beyond the power rating, such as this case, it becomes dangerous.



1-6 Direct Current and Alternate Current

The flow of current can be direct or alternate. DC stands for direct current while AC, alternate current.

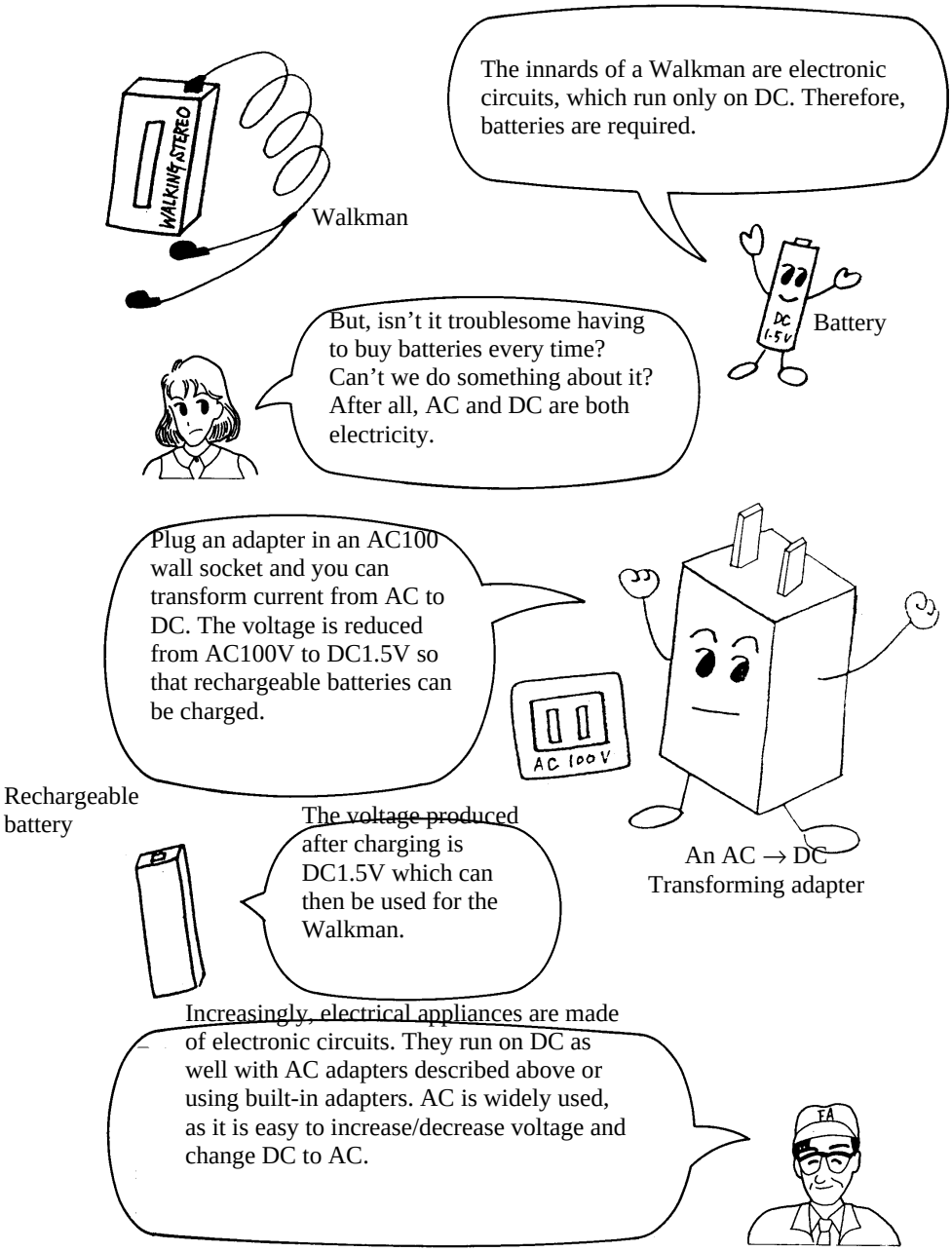
Direct Current (DC)	**Alternate Current (AC)**
When viewed under a synchroscope	
	
The size of current and voltage is constant and does not vary with time.	The size of current and voltage undergoes cyclical variation with time.
	
The direction is constant	The direction is reversed with time.
The current is flowing directly.  DC 1.5V	Electronic circuits are driven by direct current. 
	Home-used electricity is alternate current.  AC 100V

For regulating equipment, the power consumption for DC and AC is expressed in different units.

	Unit	Name
AC	VA	VA
DC	W	Watt

- **Alternate Current can be transformed into Direct Current.**

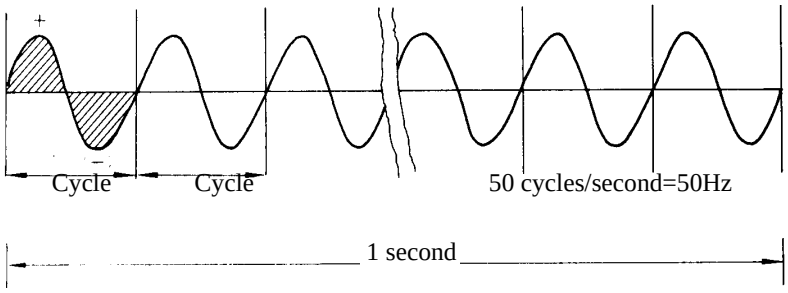
In the case of a Walkman



1-7 Frequency

For AC, cyclical variations which reverse Plus and Minus at a fixed regular occur.
Each of these waves is known as a cycle and the number of waves returned in a second is known as the frequency.

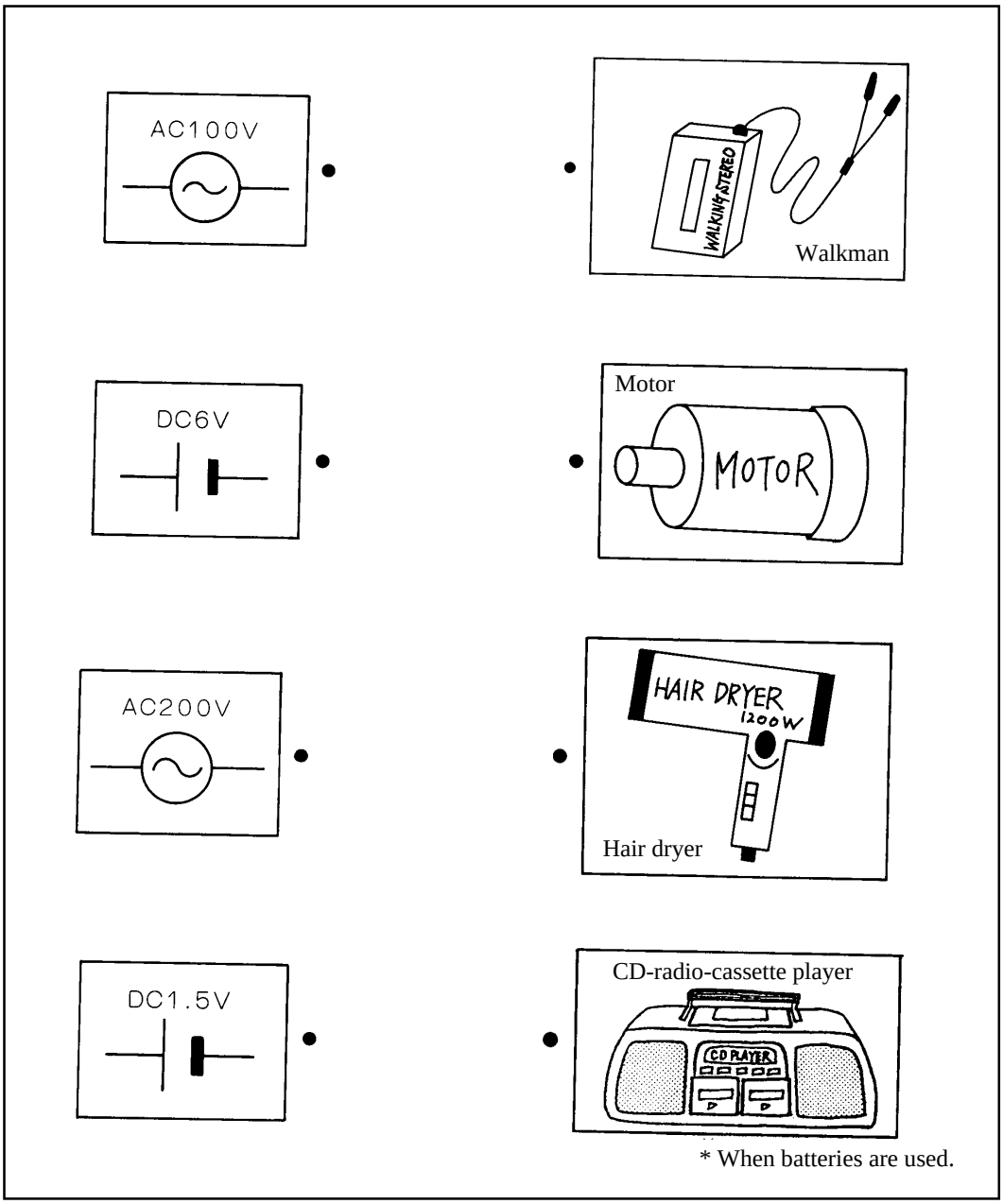
	Unit	Designation
Frequency	Hz	Hertz



1-8 Supply Voltage

A load requires a matching power source.
If inappropriate AC/DC or voltage is used, the load will not function or may even be damaged.
Let's check out the appropriate supply voltage for electrical appliances which we use daily.

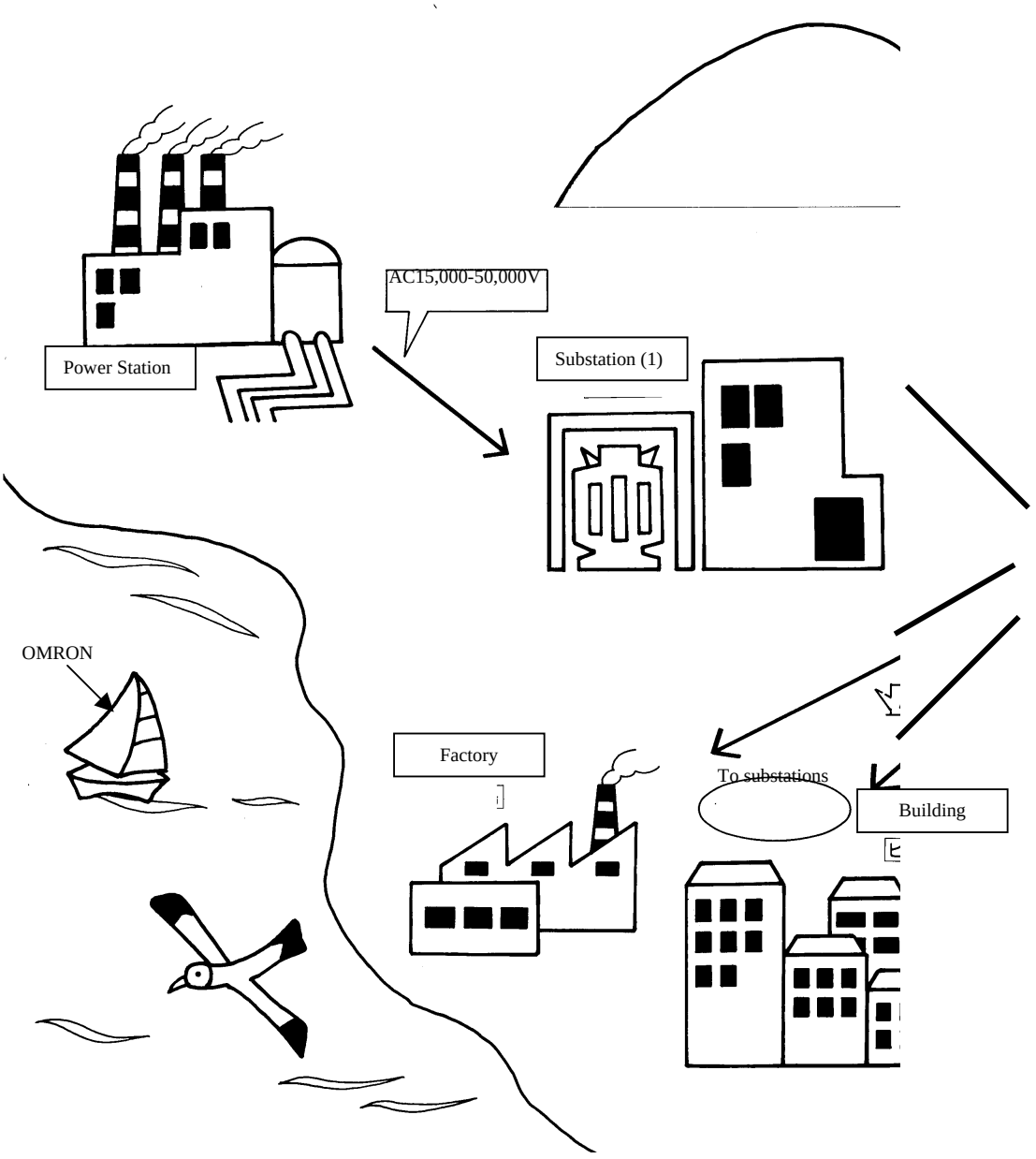
Select the appropriate power sources that match the loads and link them with lines.

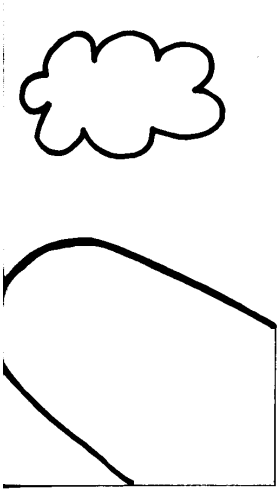


* When batteries are used.

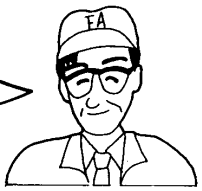
1-9 How Electricity Reaches You

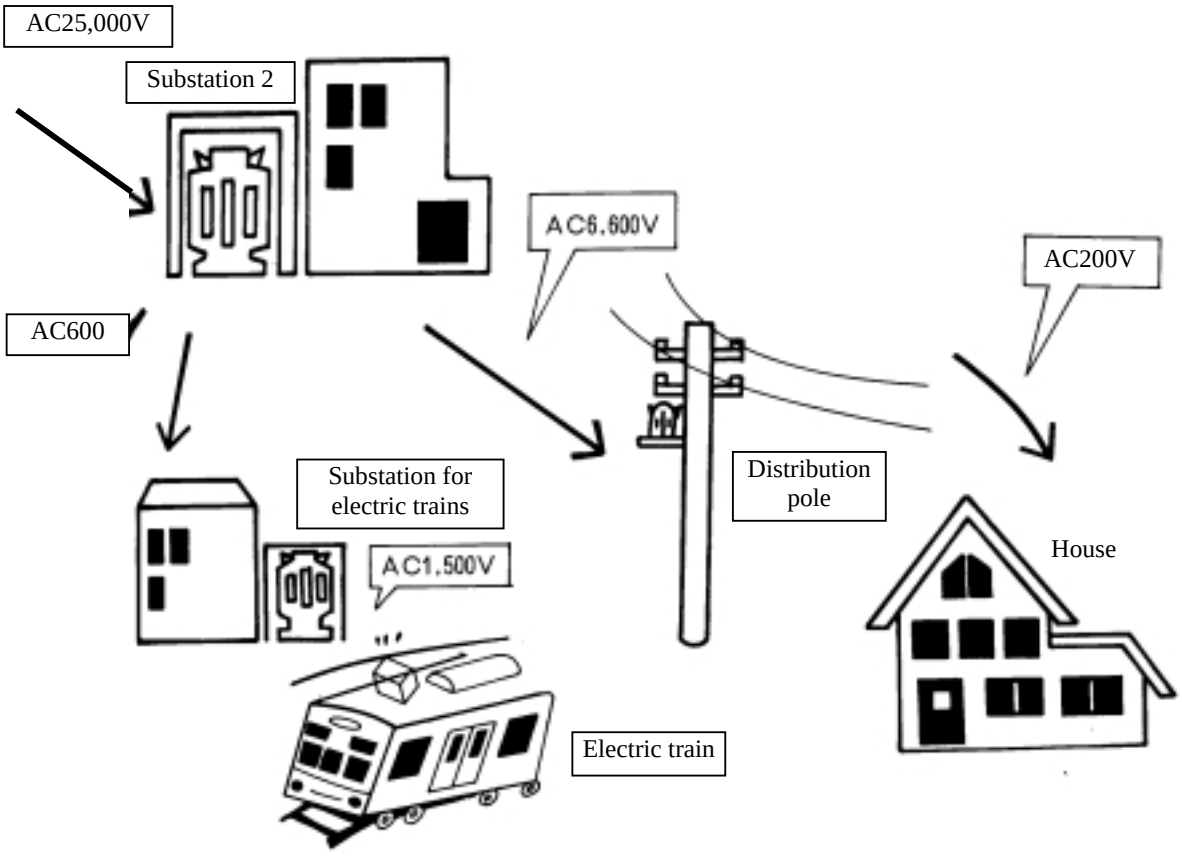
So far, we have learnt something about electricity. But what are the routes taken by electricity before it reaches factories or houses?





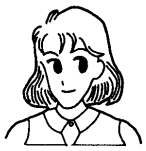
The electricity delivered by power stations is high-voltage current of AC15,000 - 50,000V. In order to lower the voltage to AC200V for home use, the electricity passes through several substations and distribution poles.
The voltage is reduced using the transformers at these locations to transform the electricity into an appropriate voltage for factory, building and home use.





1-10 Symbols and Units

The symbols and units that we have learned so far are summarized in the following tables.



Electrical Units

Item	Abbr.	Unit		Symbol	Example
		Symbol	Designation		
Voltage	E	V	Volt	Battery AC	AC100V, DC12V
Current	I	A	Ampere		1A, 120mA
Resistance	R	Ω	Ohm		100Ω, 10kΩ
Power	P	W(DC)	Waatt		100W
		VA(AC)	VA		1.2Va
Electric energy		WH	Watt-hour		800WH, 24kWH
Frequency	f	Hz	Hertz		50Hz, 60Hz 1,280kHz

Numeric Unit

Unit	Designation	Symbol	Example	Unit	Designation	Symbol	Example
10^{12}	tera	T	-	10^{-1}	deci	d	-
10^{9}	giga	G	GHZ-	10^{-2}	centi	c	-
10^{6}	mega	M	MΩ, MHz	10^{-3}	mill	m	mA, mV, mΩ
10^{3}	kiro	K	kΩ, Kv, kW	10^{-6}	micro	μ	μA, μF
10^{2}	hecto	H	-	10^{-9}	nano	n	nS
10^{1}	deca	da	-	10^{-12}	pico	p	pF

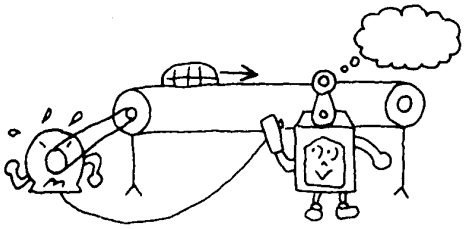
SECTION 2
Switches

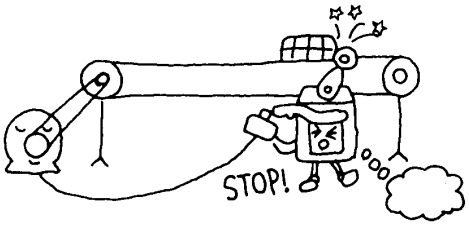
2-1 What is a Switch?

Switches are one of the most common thing in our daily life nowadays. They come with different equipment, such as switches for radios, televisions and lamps.
There are also a wide variety of switches for regulating circuits. Let's take a closer look.

- **Detection switches: Switches which function when an object arrives.**

  - Micro switch
  - Limit switch
  - Photoelectric switch, proximity switch, level switch

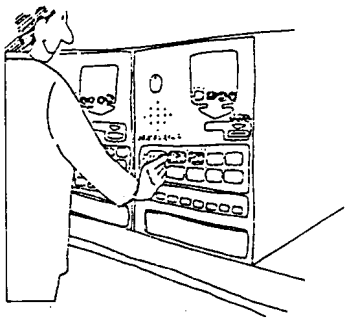




- **Operation switches: Switches which are operated by man.**

  - Push-button switch
  - Illuminated push-button switch
  - Sum rotary switch
  - Dip switch
  - Mechanical key switch

Ticket vending machine

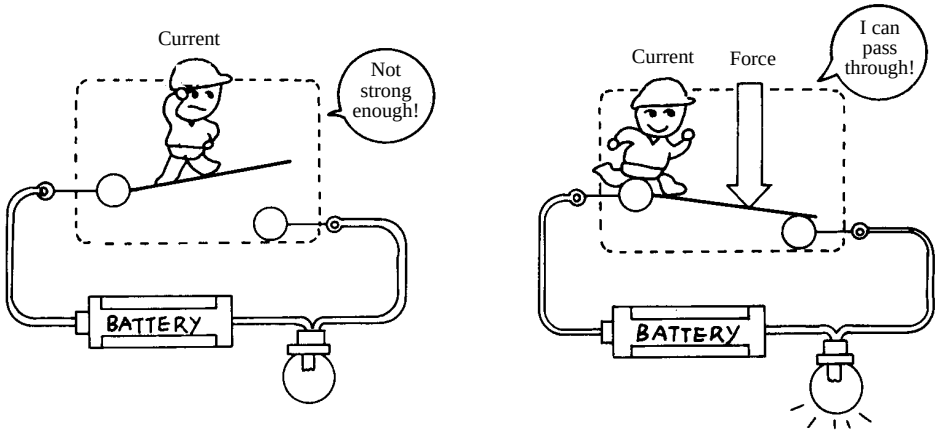


2-2 What is a Contact?

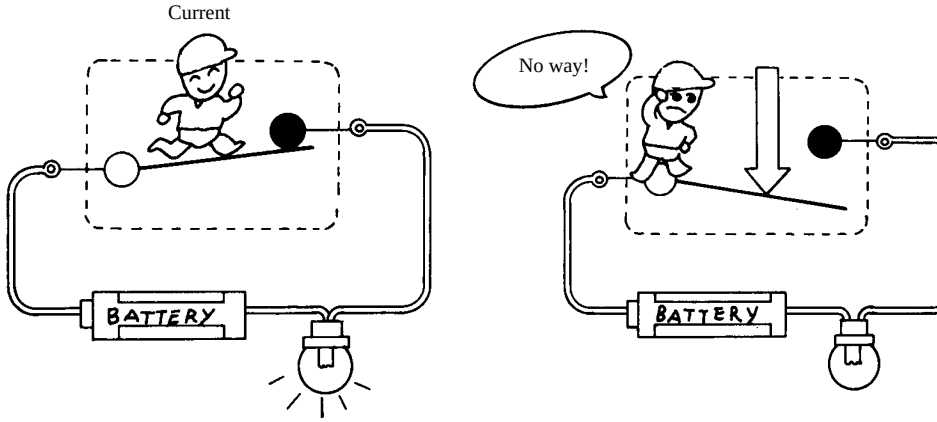
There are “contacts” in a switch. When a contact is switched over, current may flow or stop to flow.
The “contact” of a switch is switched over by force.

- **Contact a and contact b**

Connecting to contact a

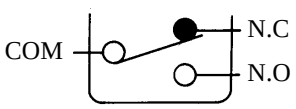


Connecting to contact b



- **Structure of a contact**

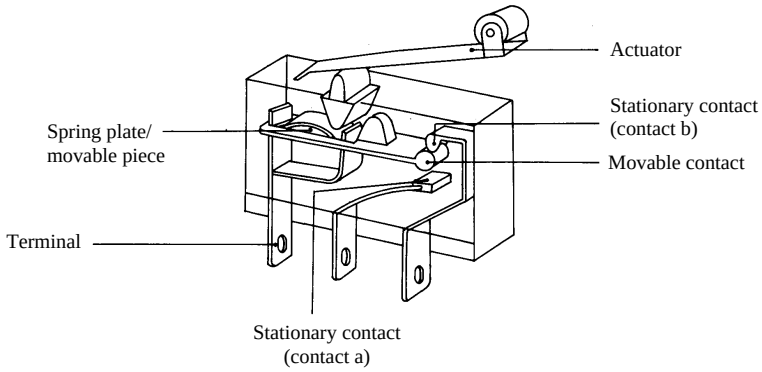
* Meaning of the symbols of the terminals



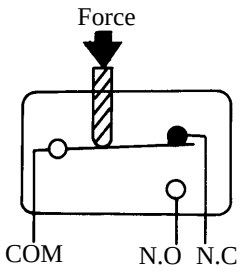
COM	**Common Terminal**
N.O	**Normally Open Terminal**
N.C.	**Normally Close Terminal**

2-3 Micro Switch

- **Structure**



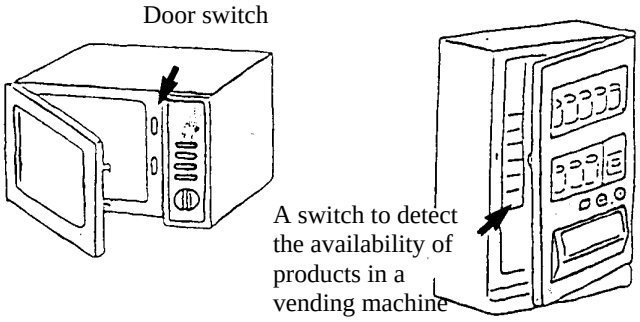
- **Contact**



- **Characteristics**
  - Small
  - High capacity make and break

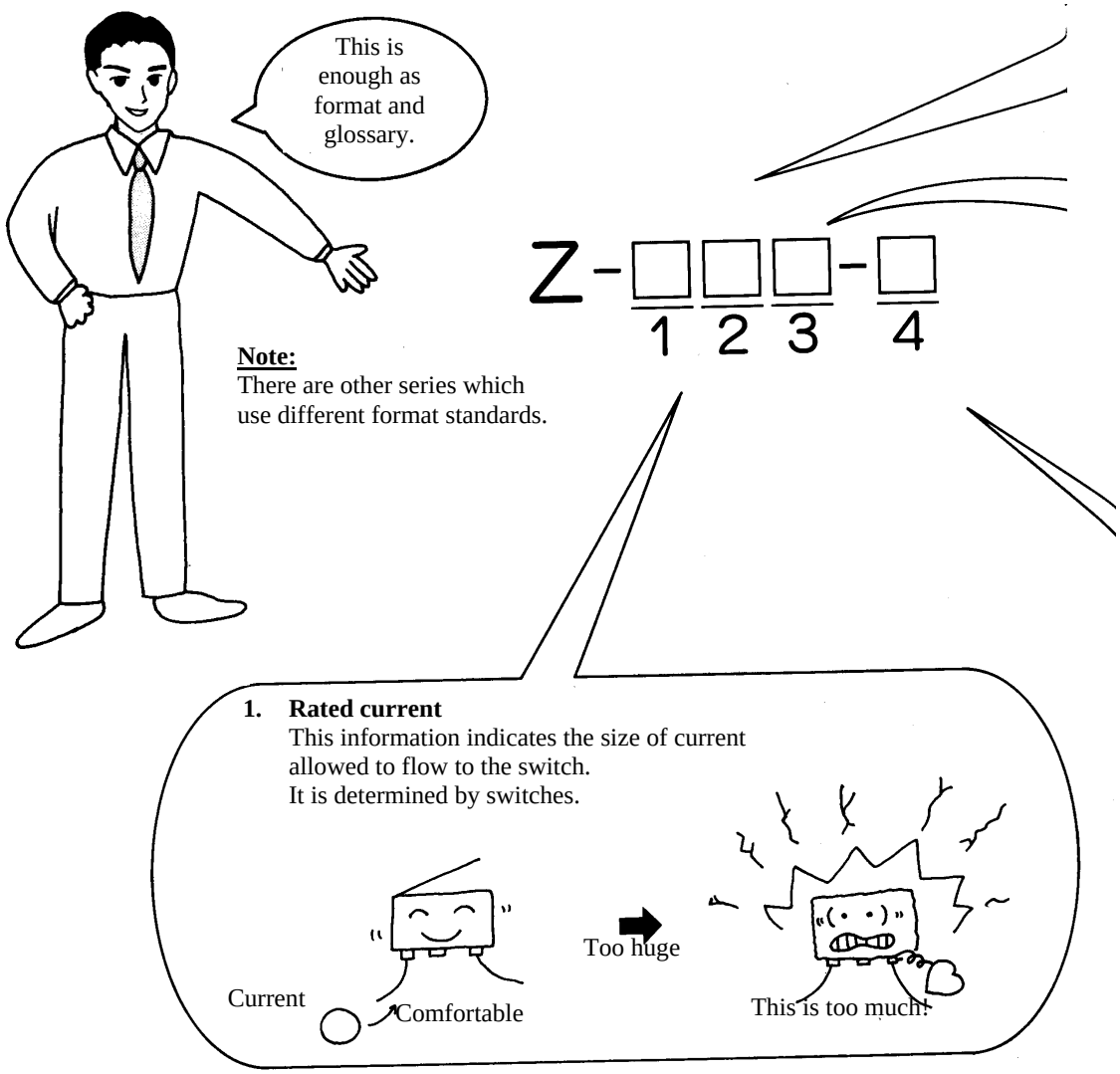
- **Example of uses**

This kind of switch can be used to detect whether doors are open or close, e.g., electronic oven or cars. It can also be used to detect whether products are sold out, e.g., vending machines.



2-4 Useful Glossary about the Switch

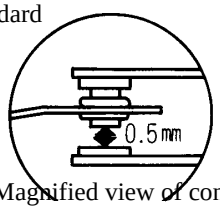
There are many kinds of switches. How can we differentiate them?
They can be differentiated in many ways depending on their uses and installed locations.
Let's first learn how to read a format which contains keywords needed to understand what a switch is.



2. Distance between contacts

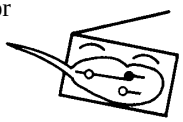
This is the distance between contacts.
The amount of current allowed to flow through depends on the distance between contacts.

Standard



Magnified view of contact

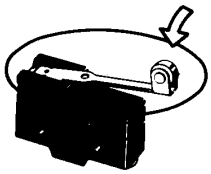
The distance can be larger or smaller than the standard.



3. Actuator

It transmits force or position accurately to the switch.
There are many types of actuator depending on uses.

These are just some of them



Pin push-button type

Roller push-button type

Hinged lever type

Hinged roller lever type

4. Types of terminal

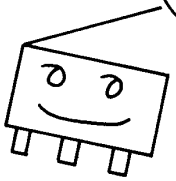
Some switches require predetermined terminals while others can select from several types.

Soldered terminal
(No indication)

Threaded terminal (B)

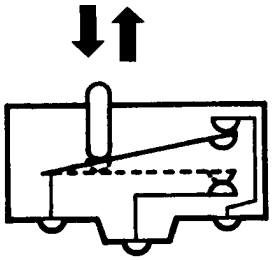
Tab terminal (C)
* The symbols contain in the ( ) are indicated in the format.

There are various types of legs.



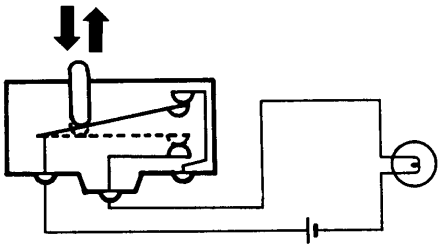
- **Life Span**

- Mechanical life span -



If a switch is switched on/off repeatedly under load-free state, how many times will it take before the innards of the switch gets damaged?

- Electrical life span -

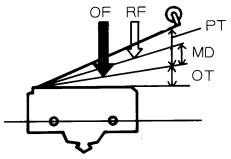


If a switch is switched on/off repeatedly with the rated load (predetermined load) of the switch applied, how many times will it take before the innards of the switch (especially the contact) gets damaged?

Q. Which life span is longer, mechanical or electrical?

- **Operation Characteristics**

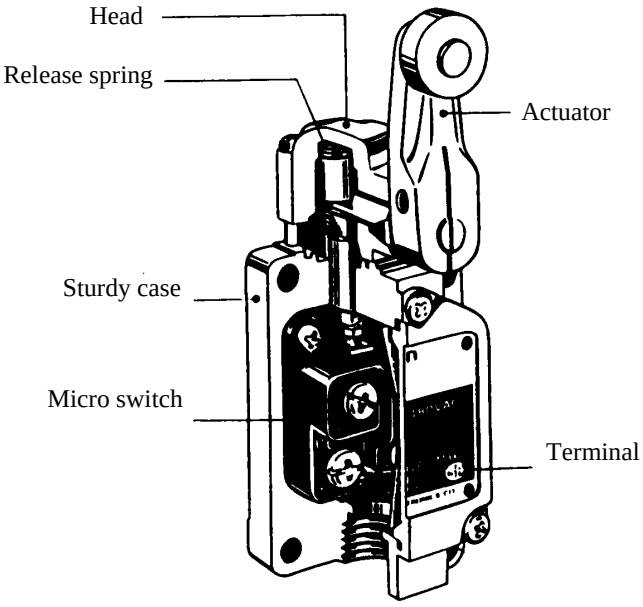
The amount of force has been determined so that the switch can operate.

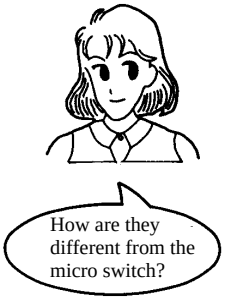


Force	OF Force required for operation (Operating Force) This is the force required to work the contact which is applied on the actuator. RF Force required for release (Release Force) This is the force required to loosen actuator of the operating switch so that the contact can be released.
Movement	PT Pre-operation movement (Pre Travel) This is the distance between the free position and the operating position of the actuator. OT Post-operation movement (Over Travel) This is the distance for which the actuator is allowed to move after operation MD Differences in movement (Movement Differential) This is the distance between the operation position and the position.

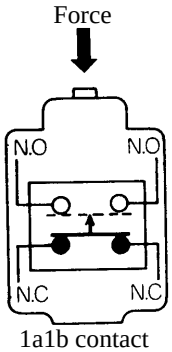
2-5 Limit Switch

- **Structure**





- **Contact**

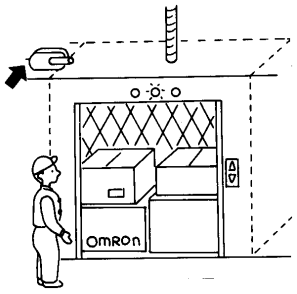


1a1b contact

- **Characteristics**
  - High mechanical intensity
  - Oil-resistant, water and dust-proof mechanism.

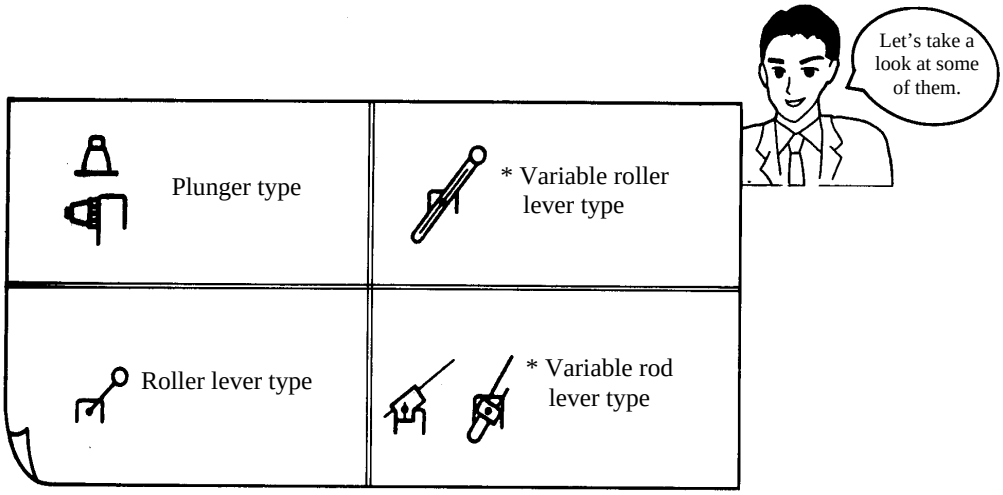
- **Example of use**

Cargo lift
Detection of stopping position of multi-level car park



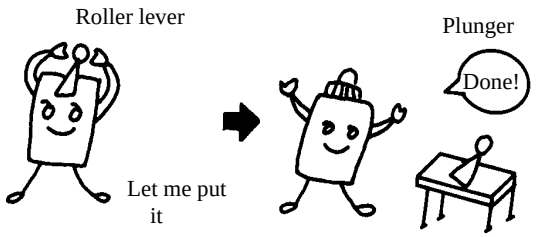
Detection of life position

- **Actuator**
  There are many types of actuators.



* Variable: The length of the lever is variable.

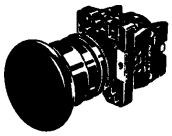
☐ There are renewable types as well, such as the D4A type.

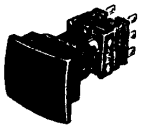


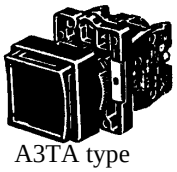
2-6 Operation Switches

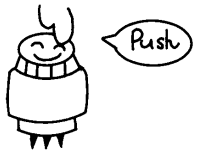
- **Push-button Switch**

These switches can be switched on and off when pushed by an operator.


A3TM type


A3GJ type


A3TA type

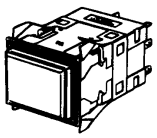


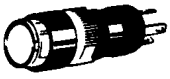
Structure: operation section + switch section

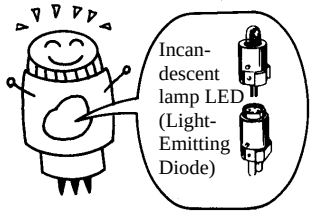
- **Illuminated Push-button Switch**

These switches have built-in LEDs (or incandescent lamps) on the inside of the push-button switch. The on/off operation can be linked to the operation of the lamp.
With the lamp, it is easy to check whether the switch is on or off visually.


A3TP type


A3PJ type


A3DT type



Structure: Push-button + lamp

* It can be used as an indication lamp as well.

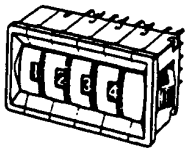
Momentary Operation : When the switch is pressed, it comes on. When the switch is released, it automatically resets to the initial state instantly.

Alternate Operation: When the switch is first pressed, it comes on and remains in the operating state. When it is pressed again, the lock will be released. “Push on, push off”.


Maintained

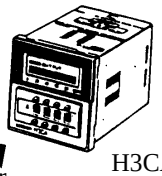
- **Sum Rotary Switch**

This kind of switch outputs force which matches the display and switches electric circuits.



A7MA type

A3PS type



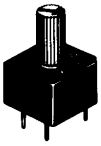
Setting of timer operation time

H3CA type

Example of uses: Setting of temperature, time, frequency and dimension, etc. for measuring instruments.

- **Dip Switch**

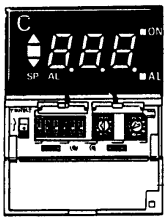
This kind of switch is used on printed circuit board. It has a small operation section and is used for program setup and switching circuits.



A6A type

A6A type

A6DR type



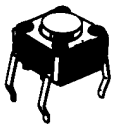
Temperature regulator E5CS type

Here

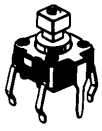
It's purpose is similar to that of the sum rotary switch. The "sum rotary switch" is used when settings need to be changed frequently whereas the "dip switch" is used when changing of settings is less frequent.

- **Mechanical Key Switch**

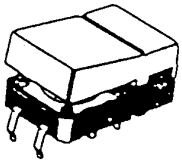
This switch is small, thin and has simple structure. It is installed on a printed circuit board.



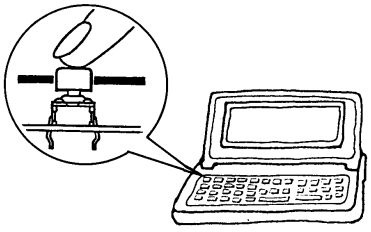
B3F type



B3F type



B3J type



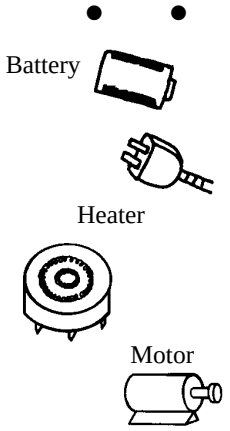
Example of uses: Office equipment, video, television, OA equipment and calculators.

2-7 Pointers for the Selection of Switches

< Common Pointers >

1. AC or DC?
   - ☐ AC ☐ DC
   - ☐ _____V (Volt)

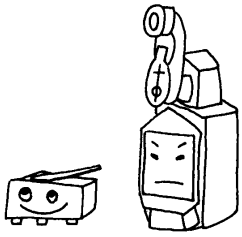
2. What is the type of connected load?
   - ☐ Resistance load
   - ☐ Inductive load
   - ☐ Others



● Shape ●

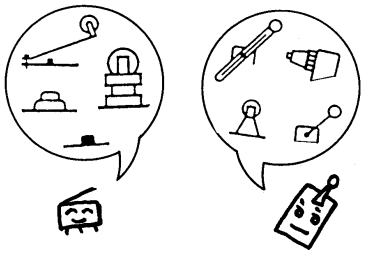
1. Size?
   - ☐ Big (limit SW)
   - ☐ Small (micro S

2. Shape?
   - ☐ Vertical
   - ☐ Horizontal



● Actuator ●

Select according to purposes.

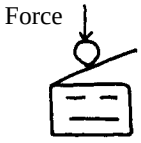


● Force applied for operation ●

How much force is applied on the actuator?

☐_____ g


Let's do it!



I simply can't work with such strength.

● Environment ●

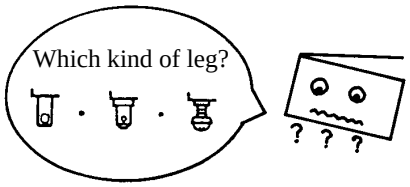
Is it going to be used in a severe environment exposed to oil and water, vibration and impact?

☐ Yes (Limit switches are superior against negative environment factor. Check out its protection characteristics!)

☐ No

● ●

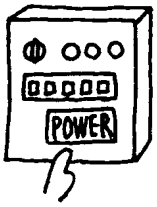
1. What type of wiring
   - ☐ Tab ☐ Soldered
   - ☐ Threaded ☐ Others



< Operation Switch >

● ●

What is it for?
- ☐ Operation
- ☐ Emergency
- ☐ Others

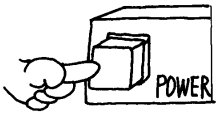


● **Shape** ●

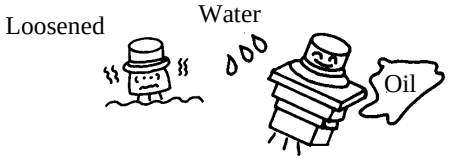
1. Shape
   - ☐ Round ☐ Square
2. Color
   - ☐ Red ☐ Yellow
   - ☐ Green ☐ Others
3. ☐ Illuminating
   ☐ Non-illuminating
4. Size (Panel-cut dimension)
   - ☐ ϕ8 ☐ ϕ12 ☐ ϕ16

● **Operation method** ●

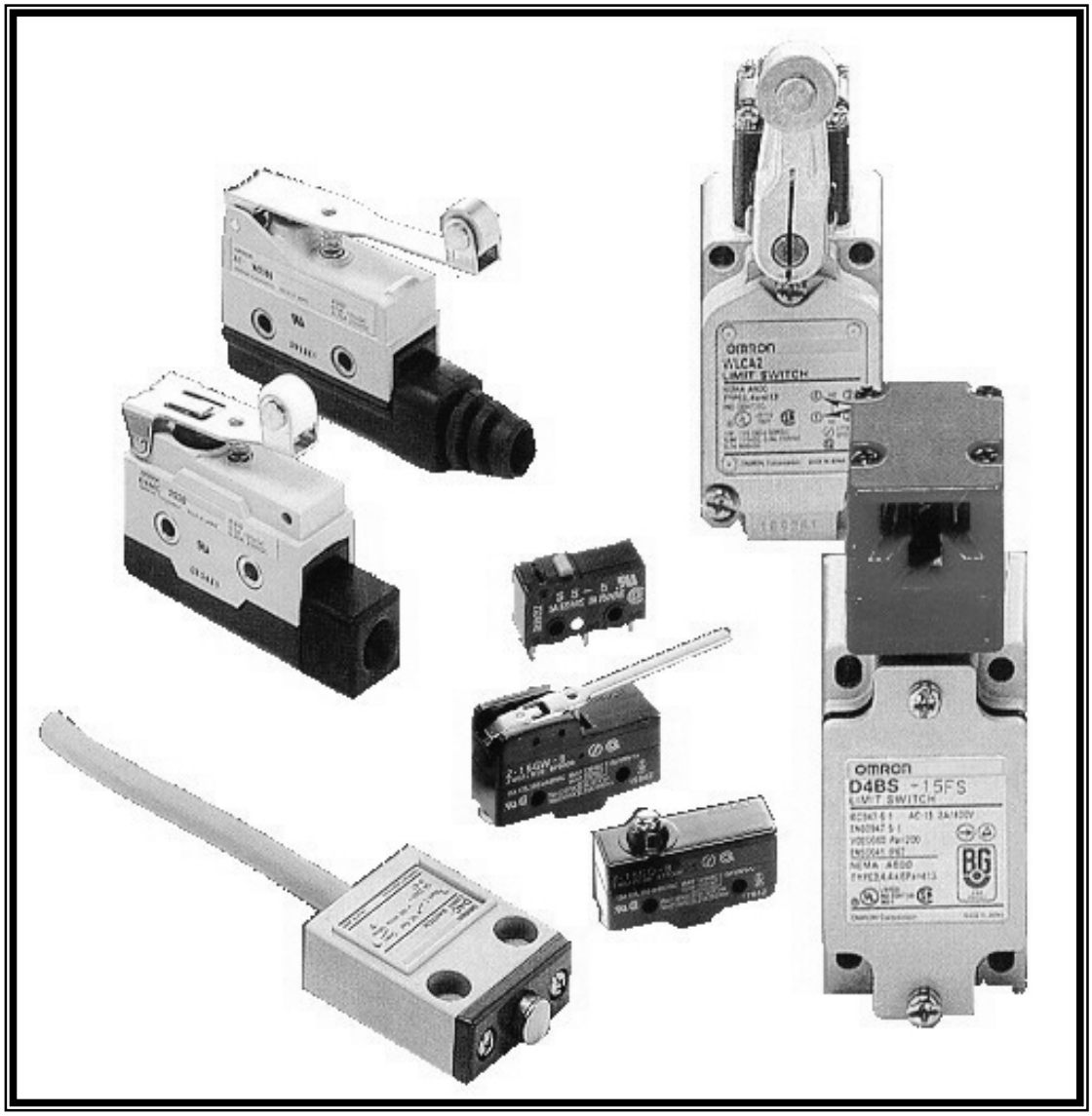
What kind of operation is required?
- ☐ Momentary (self-respect)
- ☐ Alternate (self-maintained)
- ☐ Others



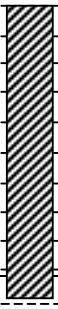
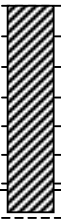
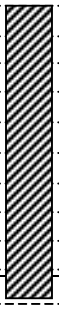
Environment? ● **Environment** ●
- ☐ Exposed to oil and water
- ☐ Exposed to vibration and impact



2-8 Omron Models



Basic Switch

Classification			General-Purpose Basic Switch		Subminiature Basic Switch	Miniature Basic Switch
Model			Z-15G	Z-15H	SS-5	V-15
Appearance						
Features			• Best-selling basic switch boasting high precision • Large switching capacity with high repeat accuracy		• Economical • Large switching capacity with high repeat accuracy • Model with special contacts made of silver alloy are tough and highly conductive	• Reliable and safe • Applications include industrial equipment and commercial products
Contact Ratings	Resistive Load		15A at 250VAC		3A at 250 VAC	15A at 250 VAC
			0.5A at 125 VDC	0.4A at 125VDC		0.3A at 250 VAC
	Max. Operating Current (A)	20 15 10 8 5 3 2 1 0.5 0.3 0.1				
	Min. Permissible Load (mA)	100 10 1 0.1 0.01				
Operating Force (OP) (Pin Plunger Type)			200 to 430 gf		25, 50, 150 gf	100, 200, 400 gf
Life Expectancy (Pin Plunger type)	Mechanical		20 x 10^6 min.		30 x 10^6 min.	50 x 10^6 min.
	Electrical		500 x 10^3 min.		200 x 10^3 min.	100 x 10^3 min.
Mounting Pitch			25.4mm		9.5mm	10.3 x 22.2mm
Actuator			Pin Plunger, panel mount plunger mount roller plunger, leaf spring, hinge lever, roller leaf spring, hinge roller lever, flexible rod		Pin Plunger, hinge lever, stimulate hinge lever, hinge roller lever	Pin Plunger, Hinge lever, stimulate hinge lever, hinge roller lever
Terminals			Solder, screw		Solder, quick connect (#110), PCB terminal	Solder/quick connect (#187), quick connect (#250), screw terminal
Weight (Approx.)			22 to 58g		1.6g	6.2g
Approved Standards & Markings			UL, CSA, SEV, CE		UL, CSA, VDE, SEMKO, SEV	UL, CSA, VDE, SEMKO, DEMKO, SEV
Remarks			Drip-proof terminal models are also available		Split double spring mechanism assures life as long as 30 million operations	-

Limit Switch

Classification		General - Purpose Limit Switch					
Model		**WL**	**D4A-N**	**HL-5000**	**D4D-N**	**ZE/ZV**	**ZC**
Appearance							
Features		Wide selection of two-circuit double break.	A new version with better seal, shock resistance and strength.	Economical miniature limit switch boasting rigid construction	Fail-safe mechanism assures sue switching even if an abnormally occurs	Long-service life and large breaking capacity.	Small, high-precision enclosed switch.
Enclosure Ratings	**IEC**	IP67	IP67	IP65	IP65	IP65-(N type)/ IP60 (-Q type)	IP67
	JIS	Immersion-proof	Immersion-proof	Jet-proof	Jet-proof	Jet-proof (N type) Dust-proof (-Q type)	Immersion-proof
	NEMA	3,4,13	3,4,4X,6P,12,13	-	1,2,3,4,12,13	3,4,13, (-N type)	1,2,3,4,5
Rated Current (A)	**20** **15** **10** **5**	500 VAC	480 VAC	250 VAC	400 VAC	250 VAC	250 VAC
Micro-load type		Yes	Yes	Yes	-	-	Yes
Mechanical life expectancy (operations min.)	**($x10^6$)** **50** **40** **30** **20** **10**		Two circuits Four circuits				
Electrical Life Expectancy (operations min.)	**($x10^6$)** **1** **0.8** **0.6** **0.4** **0.2**		Two circuits Four circuits		150,000		
Operation Indicator		Yes	Yes	-	-	-	Yes
Mounting Pitch		58.7 x 30.2mm	59.5 x 29.4mm	50 x 24mm	47 x 20mm	ZE:25.4mm, ZV: 41.3mm ZV2:31 x 75mm	25.4mm
Actuators		Roller lever, adjustable roller lever, adjustable rod lever, fork lever lock, top plunger, top roller plunger, side roller plunger, top ball plunger, side ball plunger, coil spring	Roller lever, adjustable roller lever, top plunger, side roller lever, coil spring.	Roller lever, adjustable roller lever, top plunger, top roller plunger, coil spring.	Roller lever, adjustable roller lever, top plunger, top roller plunger, coil spring.	Top plunger, top roller plunger, top arm lever	Top roller plunger, hinge lever, hinge roller lever, top plunger
Approved Standards and Markings		UL,CSA,SEV,LR, CE	UL, CSA	-	UL,CSA,CE,BIA, SUVA	UL,CSA	UL,CSA,CE
Weight (Approx.)		275g	290g	130 to 190g	70g	260 to 280g	110g

Limit Switch

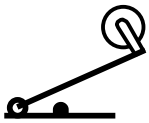
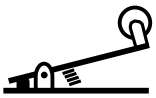
Classification		Enclosed Limit Switch			Special-Purpose Limit Switch	Safety-Door Switch
Model		**SHL**	**D4MC**	**D4C**	**D5B**	**D4BS**
Appearance						
Features		Subminiature limit switch with high sealing property	Economical, high utility enclosed switch.	Small, slim-bodied high-precision enclosed switch	Detect object in multiple directions.	Safety-door limit switch's special operation key positively pulls apart the contacts from each other and contributes to the safety of the production site.
Enclosure Ratings	**IEC**	IP67	IP67	IP67	IP67	IP67
	JIS	Immersion-proof	Immersion-proof	Immersion-proof	Immersion-proof	Immersion-proof
	NEMA	-	-	3,4,13	-	3,4,4X,6P,13
Rated Current (A)	**20** **15** **10** **5**	250 VAC	250 VAC	250 VAC	30 VDC	400 VAC
Micro-load type		Yes	Yes	Yes	-	-
Mechanical life expectancy (operations min.)	**($x10^6$)** **50** **40** **30** **20** **10**					1,000,000
Electrical Life Expectancy (operations min.)	**($x10^6$)** **1** **0.8** **0.6** **0.4** **0.2**				5,000,000	
Operation Indicator		Yes	-	Yes	-	Yes
Mounting Pitch		16.5mm	25.4mm	25mm	M5, M8, M10 (Screw mounting)	60 x 30mm
Actuators		Roller lever, adjustable roller lever, adjustable rod lever, fork lever lock, top plunger, top roller plunger, side roller plunger, top ball plunger, side ball plunger, coil spring	Roller lever, adjustable roller lever, top plunger, side roller lever, coil spring.	Roller lever, adjustable roller lever, top plunger, top roller plunger, coil spring.	Roller lever, adjustable roller lever, top plunger, top roller plunger, coil spring.	Top plunger, top roller plunger, top arm lever
Approved Standards and Markings		UL,CSA,CE	UL,CSA	UL,CSA,CE	-	UL,CSA,CE,BIA,SUVA
Weight (Approx.)		62g to 72g	71g	360g (with VCTF3m) 540g (with VCTF 5m)	14g to 21g	285g

Basic Switch

Classification	Actuator And Their Functions: Basic Switch					
	Pin Plunger	**Slim Spring Plunger**	**Short Spring Plunger**	**Panel Mounted Plunger**	**Panel Mounted (Cross) Roller Plunger**	**Hinge Lever**
Shape						
Pretravel (PT)	Small	Small	Small	Small	Small	Large
Overtravel (OT)	Small	Medium	Medium	Large	Large	Medium
Operating Force (OF)	Large	Large	Large	Large	Large	Small
Accuracy	★★/★★★★	★★★	★★★	★★★	★★★	★
Vibration/ Shock	★★★★	★★	★★★	★★★	★★	★
Features	Ideal for straight movement with a short stroke. Best in detecting the position of an object in terms of accuracy. However, has the smallest overtravel (OT) of all actuators and thus need an accurate stopper.	Used in the same way as the pin plunger actuator, except the overtravel (OT) is larger than that of the pin plunger actuator. The plunger head size is designed a bit larger with respect to the actuator size. To avoid an unbalanced load, the operating force has to be applied to the shaft center.	Overtravel (OT) is the same as the slim spring plunger. The plunger height is short. The plunger head size is designed larger to simplify contact with the center of the plunger.	Has the largest overtravel (OT) of all straight movement plungers. Mount with the hex nut of lock nut to a panel. By adjusting these nuts, the desired mounting position can be achieved. Operated manually or mechanically.	A panel-mounting plunger actuator with a roller attached. Ideal for being driven by a cam or dog. The overtravel (OT) is slightly smaller than the panel mounting plunger but it can be adjusted by changing the mounting position in the same way as the panel-mounting plunger. This plunger can also be mounted with the roller crossed.	Use with a low-speed, low-torque cam. The lever can be in various shapes but must be rigid enough.

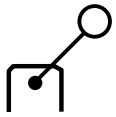
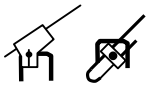
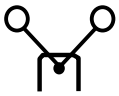
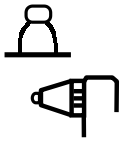
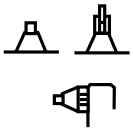
Note: ★ Fair, ★★Fine, Good, ★★★★Excellent

Basic Switch

Classification	Actuator And Their Functions: Basic Switch				
	Hinge Roller Lever	**One Way Operation Hinge Roller Lever**	**Reverse Operation Hinge Roller Lever**	**Reverse Operation Short Hinge Roller Lever**	**Flexible Rod**
Shape					
Pretravel (PT)	Large	Medium	Medium	Small	Large
Overtravel (OT)	Medium	Medium	Medium	Medium	Large
Operating Force (OF)	Small	Medium	Medium	Large	Small
Accuracy	★	★	★	★	★
Vibration/ Shock	★	★	★★	★★	★
Features	A hinge lever actuator with a roller. Ideal for being driven by high-speed cam.	Hinge roller lever type. Detection for only one way direction. Can be used for anti-reverse operation	Roller is added to the above type. Suitable for cam operation. Superior in anti-vibration and impact in a free condition.	Shorter type of reverse hinge/roller/lever type. Larger operation force. Suitable for short stroke cam operation. Superior in anti-vibration and impact in free condition.	Operates in all directions 360°C with a very light torque. Ideal for applications where high precision and high sensitivity are required.

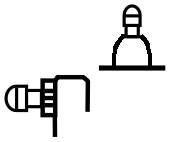
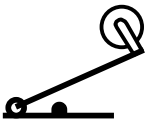
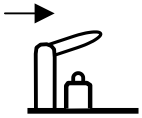
Note: ★ Fair, ★★ Fine, Good, ★★★ ★★★★ Excellent

Limit Switch

Classification	Actuator And Their Functions: Limit Switch					
	Roller Lever	**Adjustable Roller Lever**	**Adjustable Rod Lever**	**Fork Lever Lock**	**Plunger**	**Roller Plunger**
Shape						
Pretravel (PT)	Small-Large	Small-Large	Large	Large	Small	Small
Overtravel (OT)	Large	Large	Large	Medium	Medium	Medium
Operating Force (OF)	Medium	Medium	Medium	Medium	Medium	Large
Accuracy	★★★/★★★★	★★★/★★★★	★★★	★★★	★★	★★
Vibration/ Shock	★★	★★★	★★★	★★★	★★	★★
Environmental Resistance	★★★★	★★★★	★★★★	★★★★	★★	★★
Features	The roller lever is convenient in that the lever stroke in the direction of rotation has a range of 45 to 90°C. The lever can be set at any position within 360°C. High sensitivity with a wide angle. This can be used with a wide range of positioning during work detection.	A roller lever actuator with an adjustable lever attached. When this feature is put to good use, the work can be detected roughly.	Convenient when the width of the work area is wide or the shape of the work is uneven. The rotating torque is lowest for the roller lever limit switches. The rod length and bending can be adjusted easily.	During operation the lever rotates by itself up to 55°C, and holds that position. Can be operated by a single dog reciprocating operation or by two dogs when the position of the rollers is shifted.	Highly accurate in detecting the status of oil pressure and/or air cylinder operation. (Mount the switch securely avoiding an unbalanced load according to the movement of the operating object).	A wide range of uses when mounting with the auxiliary actuators and a cam, a dog, or a cylinder. Highly accurate in position detection.

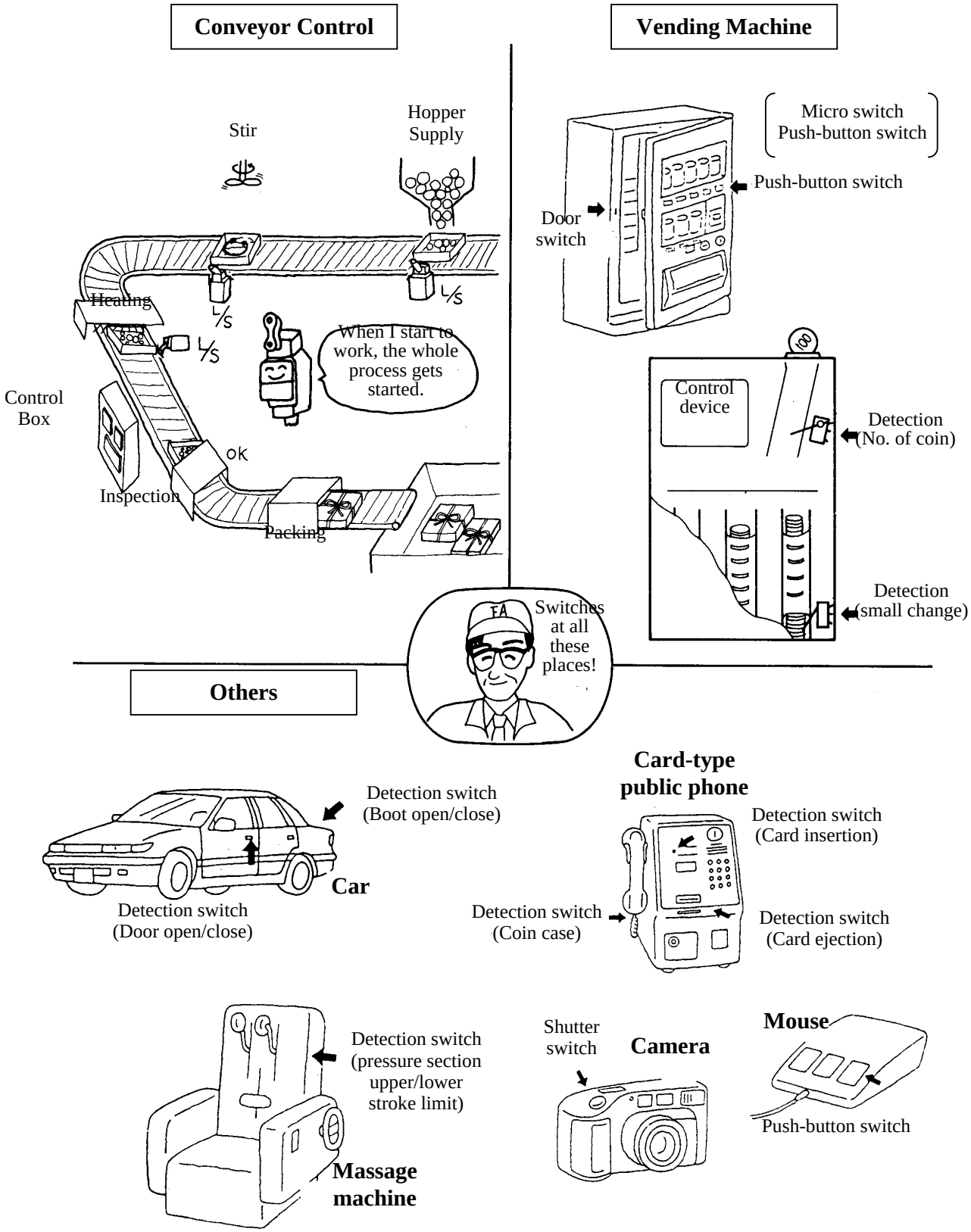
Note: ★ Fair, ★★ Fine, Good, ★★★ ★★★★ Excellent

Limit Switch

Classification	Actuator And Their Functions: Limit Switch				
	Ball Plunger	**Coil Spring**	**Hinge Lever**	**Hinge Roller Lever**	**Roller Arm**
Shape					
Pretravel (PT)	Small	Medium	Large	Large	Medium
Overtravel (OT)	Medium	Large	Medium	Medium	Medium
Operating Force (OF)	Large	Small	Small	Small	Medium
Accuracy	★★★	★	★	★	★
Vibration/ Shock	★★	★	★	★	★
Environmental Resistance	★★	★★★	★★	★★	★★★
Features	Since the plunger is a steel ball, the operating direction is not restricted. Convenient when the mounted surface and operating direction vary, or when the cross-operation of the two are required. Since the dog angle is small, the work surface requires the proper frictional properties.	Able to operate in all direction 360°C except on the shaft center. The operating force required is the smallest available relative to the limit switches and thus effective for detecting works using different directions and shapes. The wide range of work is possible because the overtravel (OT) is absorbed by the actuator.	Used with a low-speed, low torque cam. The lever can be in various shapes but must be rigid enough.	A hinge lever actuator with a roller attached. Ideal when being driven by a high-speed cam.	Can respond to a wide range of operating directions with the adjustable roller.

Note: ★ Fair, ★★ Fine, Good, ★★★ ★★★★ Excellent

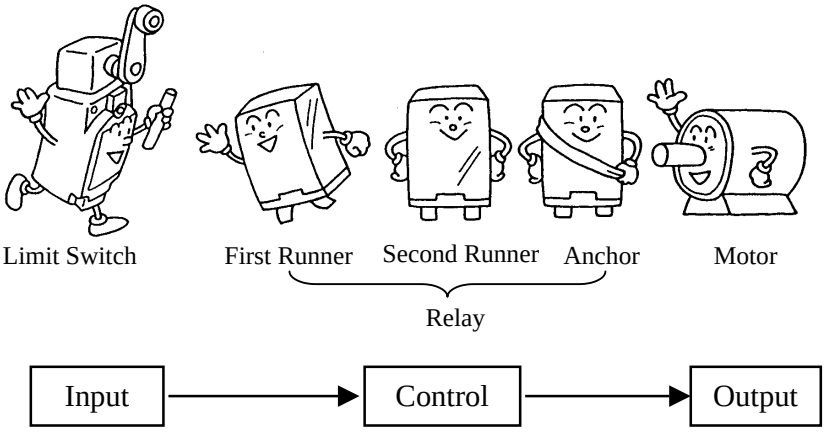
2-9 Application



SECTION 3
Relays

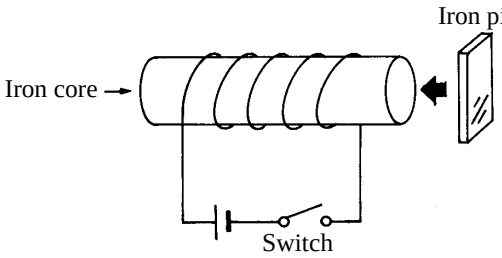
3-1 What is a Relay?

Imagine the track and field relay race we all participated during school sports days. In track and field competitions, a relay is a race whereby a runner runs to the next and hands him a baton, and the next runner repeats the process until the anchor runner gets hold of the baton and dashes across the finishing line.
The relay of regulating machines is exactly the same. Instead of baton, however, switches receive "electrical signals" and transmit them to output sections, e.g., motors.



Can you recall what you have learned about "electromagnet" in your science lessons?
By coiling copper wire around a piece of iron core and charging it, the iron core becomes magnetic. In fact, this principle of "electromagnet" is being adopted for the relay.

- **Electromagnet**



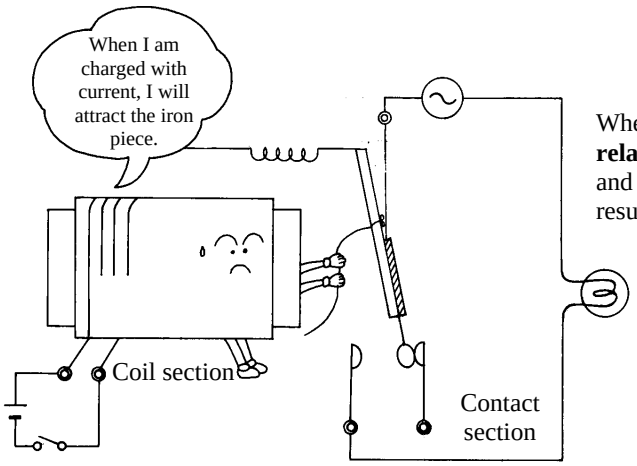
When **current flows to the coil**, the iron core is transformed into a piece of **electromagnet**. As a result, **the iron piece in front of the iron core becomes attracted to it**.

3-2 Types of Relay

3-2-1 General Relay (Hinged Relay)

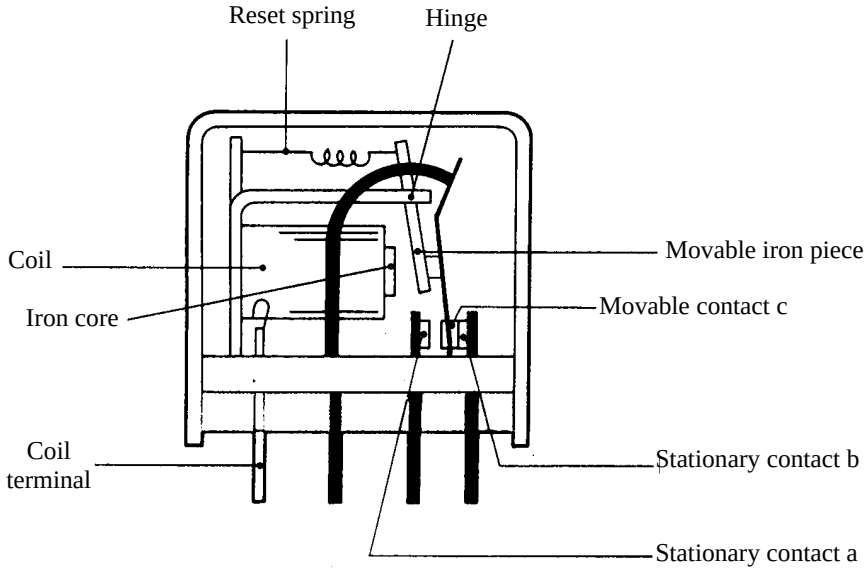
This is a small relay which is most widely used in industrial machines. Taking this type of relay as an example, let us study the relay in detail.

- **Principles of the relay**



When **current flows to the coil in the relay**, the iron piece will be attracted and **the contact will be switched** as a result.

- **Structure and operation of the relay**

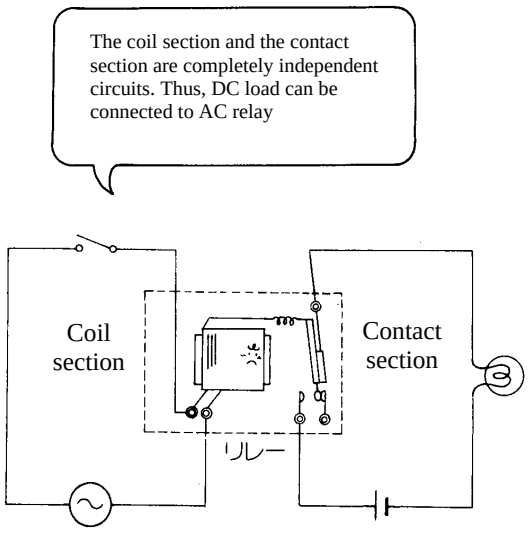


Operation: When the coil section is charged, the movable iron piece will be attracted to the iron core of the coil section by the force of the electromagnetic, with the hinge serving as the fulcrum. As a result, movable contact c is switched from the position of stationary contact b to stationary contact a.

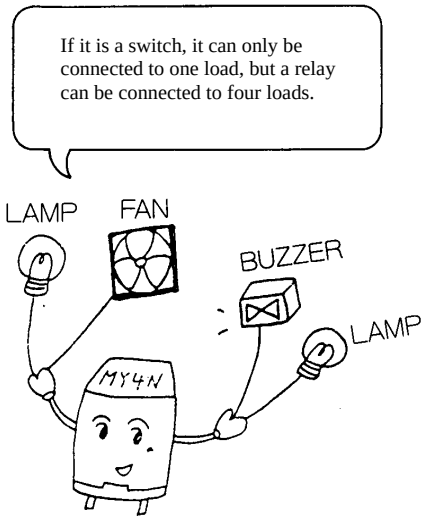
Reset: When the voltage to the coil section is cut off, the movable iron piece will be returned to the original position by the force of the reset spring. As a result, movable contact c is switched from the position of stationary contact a to stationary contact b.

- **Characteristics of the relay**

1. The coil section and the contact section are completely insulated. They are independent circuits.

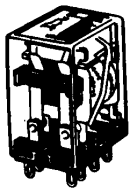


2. A single input signal to the coil section triggers (control) the open-close action of multiple circuits simulanteously.

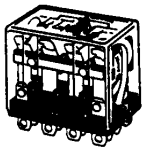


- **The external appearance of general relays**

MY2 type

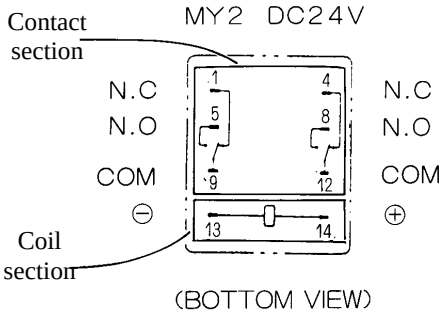


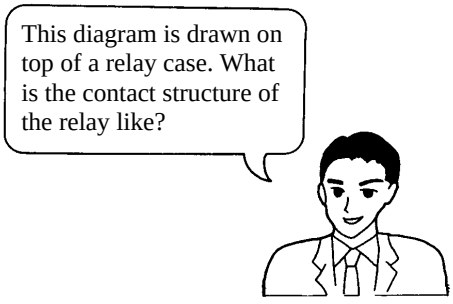
LY4 type



These relays are small and suitable for small-medium load (1-10A). They are used for various purposes, e.g., they are used in control boards and incorporated in robots.

- **Terminal placement/internal connection diagram**





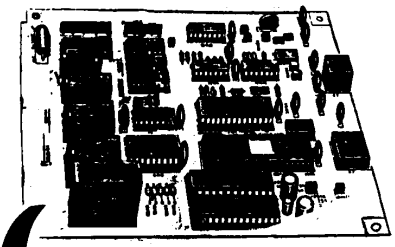
3-2-2 Other Relays

1. Contactor (plunger-type relay)

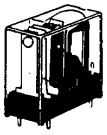
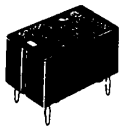
LC1-D type

Compared with the hinged type, it is bigger and more sturdy. It has bigger contact and wider contact distance to allow open-close action for more amount of current (approximately 20A-600A).

2. Printed circuit board (PCB) relay

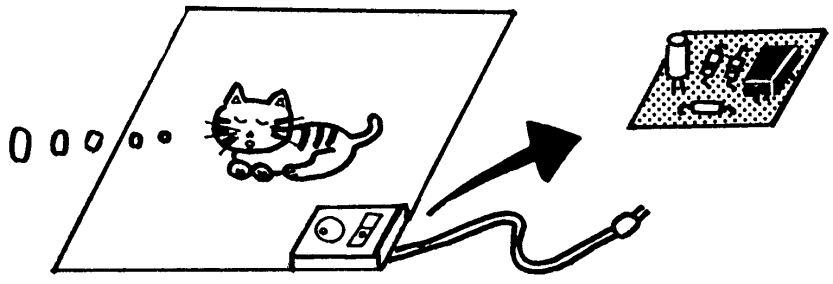


PCB stands for printed circuit board. As circuits are printed, there is no need to wire them one by one.

	Flat type	Vertical type	Cubic type
External appearance	 (Flat)	 (Vertical length)	 (Square)

- Characteristics of PCB
  As its installation is automated,
  1. The cost is low (no need for manual wiring)
  2. Reliable (no wiring error)
- Examples of application
  Electronic carpet
  Switch for heater

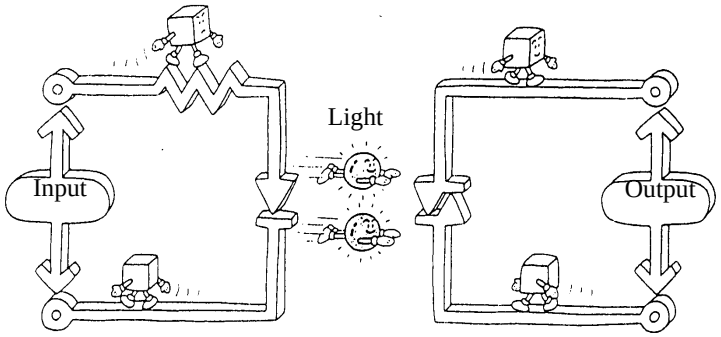
PCB relay can be used on application that are extremely compact

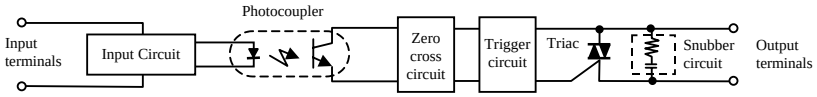


3. Solid State Relay (SSR)

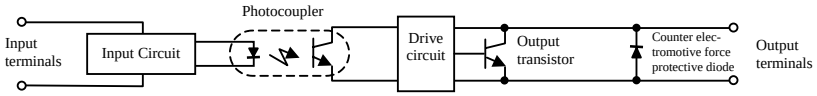
SSR stands for Solid State Relay. It is different from conventional relays in that it uses semi-conductor and is contact-less.

- **Principle**





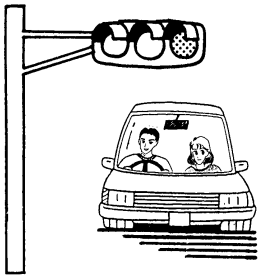
AC Load : Triac Output



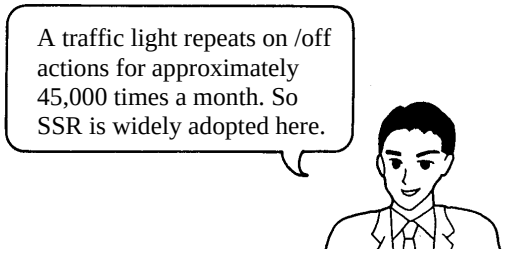
DC Load : Transistor Output

- **Characteristics**
  - As it is contact-less, it does not suffer from the wear and tear of a contact. So, it enjoys a longer life span (maintenance free).
  - No operation sound as it has no mechanical movement.
  - High-speed high-frequency operation* is possible as it has not mechanical movement (on/off by light).
  - No faulty contact as it is contact-less.
- Example of application

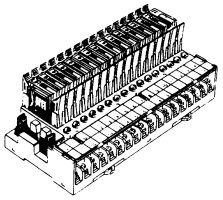
* It means more frequency per unit of time.



Traffic light: on/off of red, green and yellow lamp.



I/O terminal series



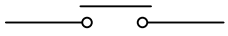
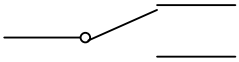
G7TC relay terminal

I/O stands for Input and Output respectively. This compact terminal packs common relay (or SSR), transistor and socket for input or output.
The use of this terminal saves space and the need for wiring.

3-3 Useful Glossary About The Relay

3-3-1 Contact of relay

- **Structure of a contact**

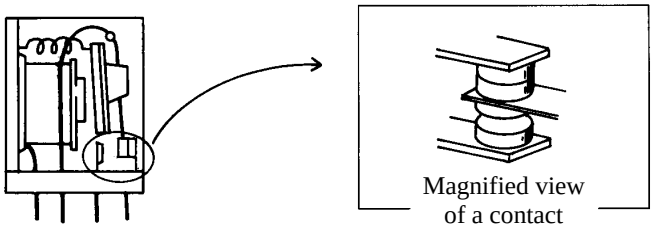
Contact a	Contact b	Contact c
		

*** PCB relay: ..... There are various types of contact 1a1b, and contact 1c.**
General relay: .....There are so many combinations for contact 1c, 2c, 3c, 4c and c.
Contactor: ... There are also many combinations for contact a and contact b, such as contact 3a+1a, 3a+1b, etc.

- **Number of contact poles**
  The number of contact poles determine how many circuit a relay can makes and breaks (e.g., 2 poles, 4 poles).

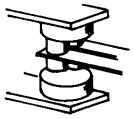
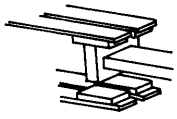
- **Rated current**
  This refers to the amount of current allowed to flow to a contact.

- **Shape and material of a contact**
  The basic shape and material for a relay contact is single contact (standard shape) and silver (Ag) respectively.



However, special shapes and materials are required for relays used to make and break a small amount of current.

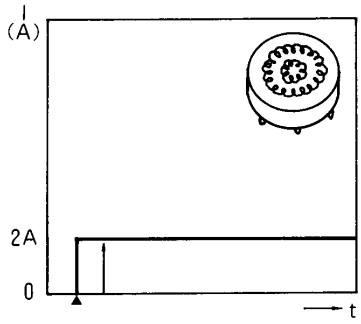
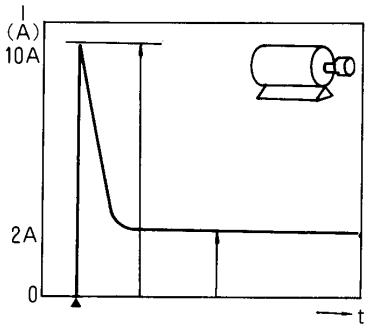
(1) Shape of contact

Twin contact	Twin close-bar contact
	
Better reliability compared with single contact	Better reliability compared with twin contact. Suitable for micro loads (widely used for PCB relays)

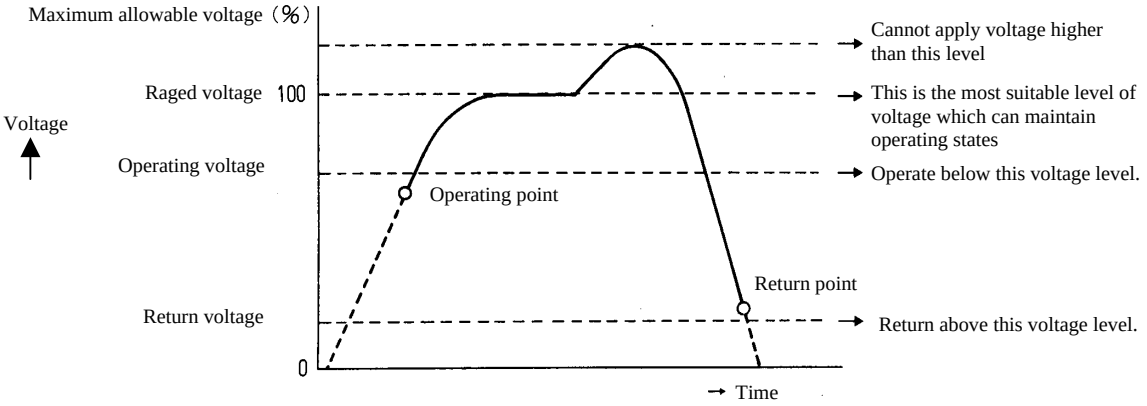
(2) Materials of contact
- Apply gold (Au) on the contact surface of silver contact, or
- Use silver palladium (AgPd) for the contact, etc.

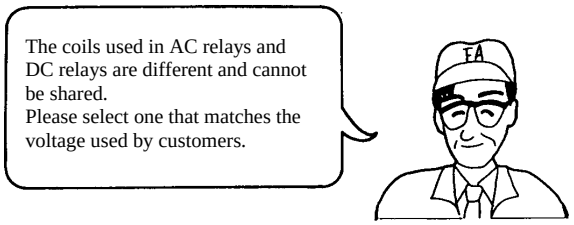
❖ On the other hand, to open-close large amount of current, silver indium tin (AgInSn) may be used for the contact.

- **Load**

Resistance load	**Inductive load**
	
This is a load to which current of a constant value flows when the voltage is applied, e.g., heaters.	This is a load to which a large amount of current flows instantly when the voltage is applied, e.g., motor, solenoid and relay.

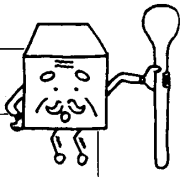
3-3-2 Relay Coil

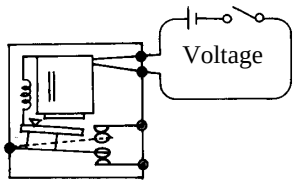
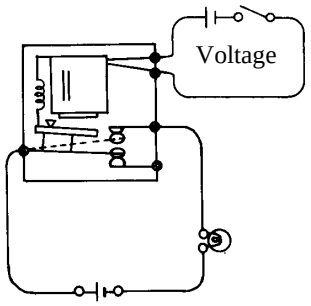




3-3-3 Performance of relays

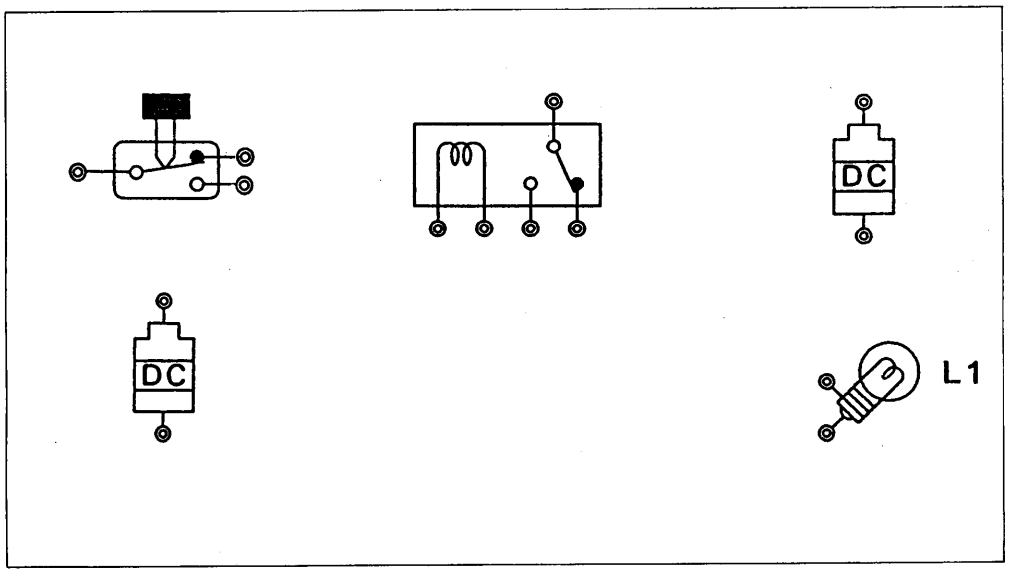
- **Life Span**



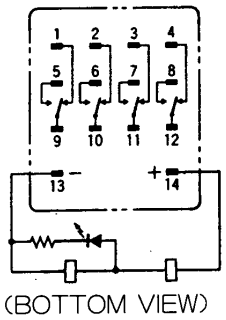
Mechanical Life Span	Electrical Life Span
	
This refers to the life span when rated voltage is applied on the coil and the contact is open/closed under a load free state.	This refers to the life span when rated voltage is applied on the coil and the contact is open/closed with rated load applied.

3-4 Exercises

Relay operation checks



Terminal placement/internal connection diagram



MY4N Type
24VDC

Contents of exercise

Carry out wiring with the relay (MY). Press the switch and consider the circuit of the lighted lamp.
At the same time, check the switch-over of the relay contact.

Method:

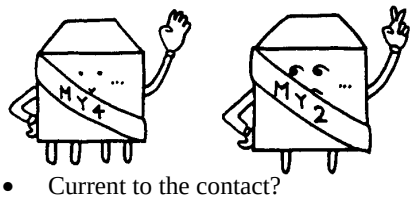
1. Consider the circuit of the lighted lamp which makes use of the relay. Carryout wiring as shown in the above diagram.
2. Carry out wiring.
3. Press the switch and check that the lamp comes on.
   Check the movement of the contact of the relay at the same time.

Study: Try and build a circuit whereby the lighted lamp will be turned off when the switch is pressed.

3-5 Pointers for Selection

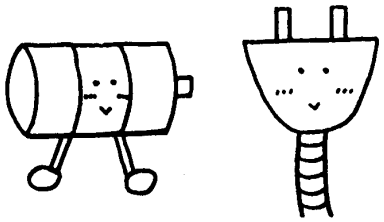
- **Important pointers**

1. Contact



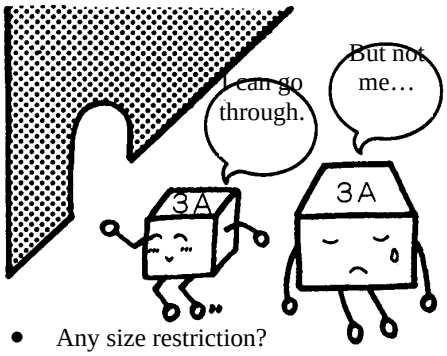
- Current to the contact? (contact volume?)
- Contact pole? (How many circuits are required?)
- Load connected to the contact? (Inductive load or resistance load?)
- For micro load?

2. Coil



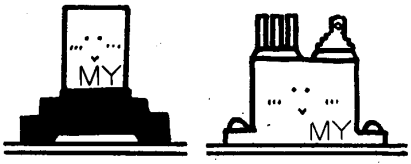
- AC or DC?
- Coil voltage?

3. Size



- Any size restriction?

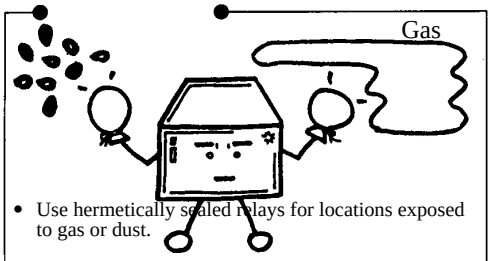
4. Installation



- Socket mounted or direct connection?

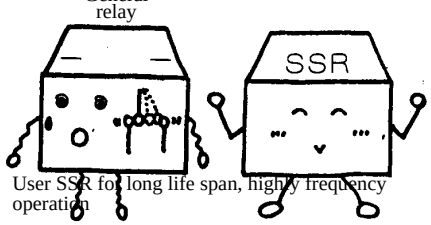
- **Important pointers**

1. Environment



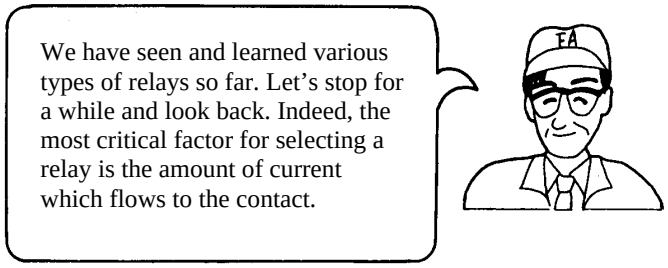
- Use hermetically sealed relays for locations exposed to gas or dust.

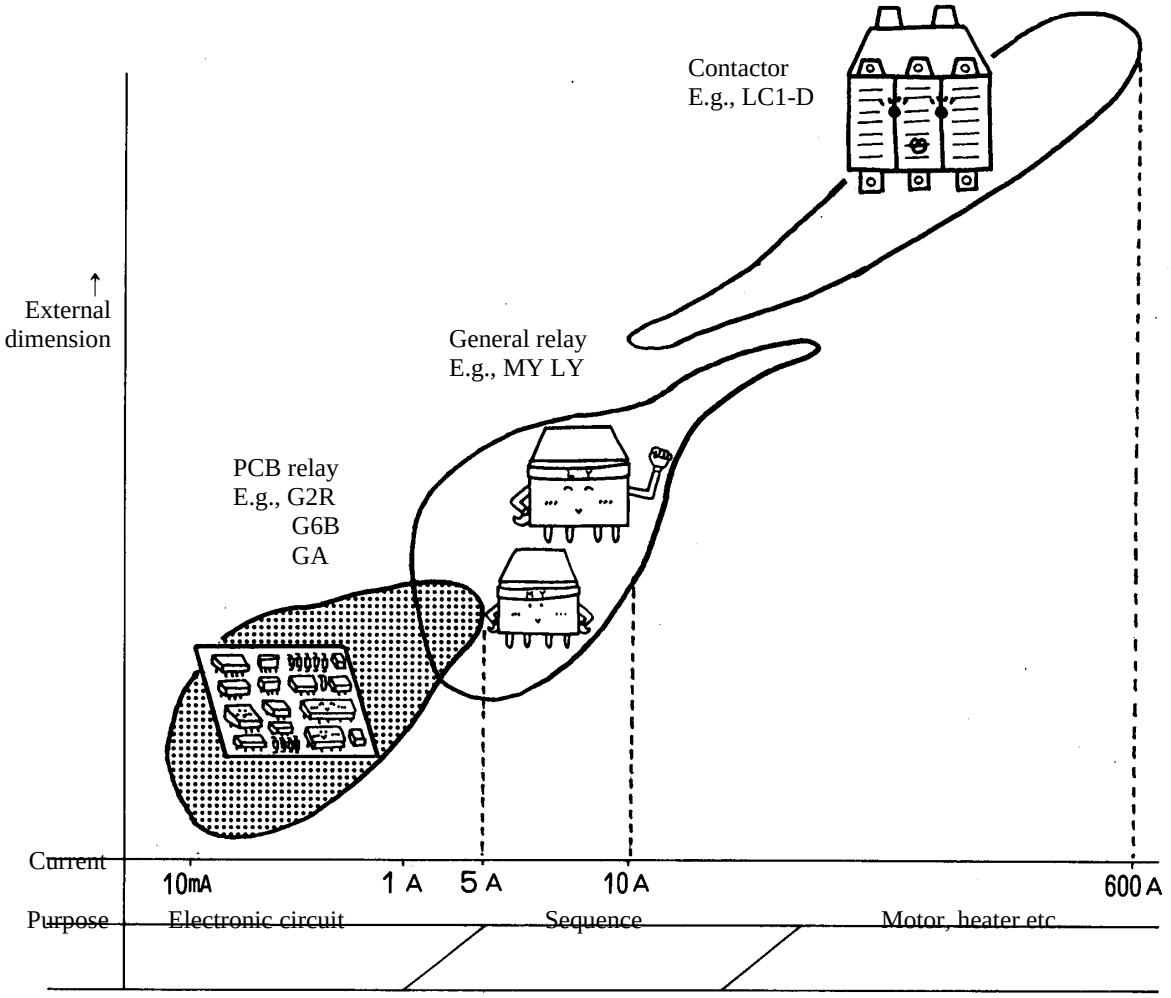
2. Life span



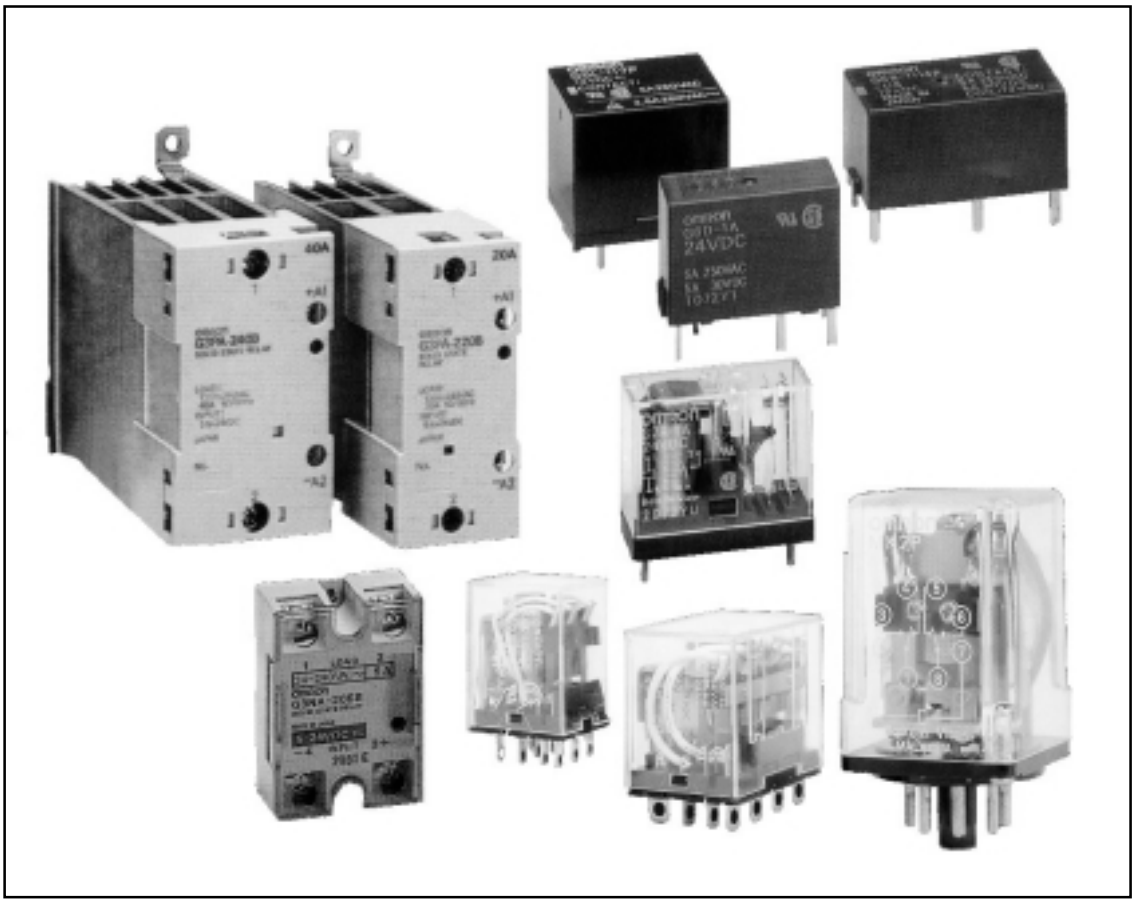
- User SSR for long life span, highly frequency operation

- **System diagram of relays**





3-6 Omron Models



Relays

Classification		General - Purpose Relays								
		MY			LY			MK-1		
Model										
Features		• Versatile relays, ideal for power and sequence control applications, meeting many other application requirements			• Compact, general-purpose relays equipped with arc barrier ideal for many applications.			• Exceptionally reliable relays which feature mechanical indicator/test buttons		
Coil Rating	Rated voltage	6 to 100/110VDC 6 to 220/240VAC			6 to 100/110VDC 6 to 220/240VAC	6 to 100/110VDC 6 to 200/220VAC		6 to 110VDC 6 to 240VAC		
	Power consumption	DC:0.9W AC:0.9 to 1.2VA			DC:0.9W AC:0.9 to 1.2VA	DC:15W AC:1.95 to 2.5VA		DC:1.5W AC:2.3VA		
Contact Rating	Contact Form	DPDT	3PDT	4PDT	DPDT	4PDT		DPDT	3PDT	
	Material	Ag		Au-plated+Ag	AgCdO			Ag		
	Rated Load	5A at 24VDC 5A at 220VAC		3A at 24VDC 3A at 220VAC	10A at 240VDC 10A at 110VAC			10A at 28VDC 10A at 250VAC		
	Max. Switching Current	5A		3A	10A			10A		
Life Expectancy	Mechanical	$50x10^6$ (AC);$100x10^6$ (DC)			$50x10^6$ (AC);$100x10^6$ (DC)			10×10^6 (AC)		
	Electrical	50×10^3	200×10^3		500×10^3	200×10^3		100×10^3		
Dielectric Strength	Between Coil and Contact	2,000VAC for 1 min.			2,000VAC for 1 min.			2,500VAC for 1 min.		
	Between Contact of Same Polarity	1,000VAC for 1 min.			1,000VAC for 1 min.			1,000VAC for 1 min.		
Ambient Temperature		-55 to 70°C			-25 to 55°C	-25 to 40°C		-10 to 40°C		
Variations		• Plug-in/Solder terminal • Plug-in/Solder terminal with LED indicator			• Plug-in/Solder terminal • Plug-in/Solder terminal with LED indicator			• Plug-in terminal with mechanical indicator		
Socket		PYF08A-E, PYF08A-P, PYF11A, PYF14A-E, PYF14A-P, PY08-0, PY14, PY14-0			PTF08A-E, PTF11A, PTF14A-E, PT08, PT14			PF083A-E, PF113A-E		
Weight (Approx.)		35g			40g	70g		85g		
Approved Standard & Markings		UL,CSA,LR,EN/IEC,CE			UL,CSA,SEV,IEC,VDE,LR,CE			UL,CSA,SEV,DEMKO,NEMKO,SEMKO,VDE,EN/IEC,CE		

Relays

Classification		General - Purpose Relays			
		MYK	**MKK**	**G4Q**	**G7L**
Model					
Features		• Magnetic latching relays ideal for memory and data transmission circuits	• Special magnetic material ensures long continuous holding time	• Unique ratchet mechanism assures positive alternate transfer/switching operations • Quick response speed allows continuous use of the relay	• A high capacity, high withstand voltage relay compatible with momentary voltage drops
Coil Rating	**Rated voltage**	6 to 24VD 6 to 1000VAC	6 to 100VDC 6 to 200/(220)VAC	6 to 200VDC 6 to 200/(220)VAC	6 to 100VDC 6 to 200/240VAC
	Power consumption	Set: DC:1.3W AC:0.6 to 0.9VA Reset: DC:0.6W AC:0.2 to 0.5VA	Set: DC:2.3 to 2.7W AC:1.5 to 2VA Reset: DC:0.5 to 1.2W AC:0.1 to 0.7VA	DC:3.9W AC:6.4VA	DC:1.9W AC:1.7 to 2.5VA
Contact Rating	**Contact Form**	DPDT	DPDT	DPDT	DPST-NO
	Material	Au-plated+Ag	Ag	Ag alloy	Ag alloy
	Rated Load	3A at 24VDC 3A at 220VAC	3A at 24VDC 5A at 220VAC	5A at 24VDC 5A at 220VAC	25A at 220VAC
	Max. Switching Current	3A	5A	5A	25A
Life Expectancy	**Mechanical**	$100x10^6$	$5x10^6$	$5x10^6$ (Step)	$1x10^6$
	Electrical	$200x10^3$	$500x10^3$	$500x10^3$ (Step)	$100x10^3$
Dielectric Strength	**Between Coil and Contact**	1,500VAC for 1 min.	2,000VAC for 1 min.	2,000VAC for 1 min.	4,000VAC for 1 min.
	Between Contact of Same Polarity	1,000VAC for 1 min.	1,000VAC for 1 min.	1,000VAC for 1 min.	2,000VAC for 1 min.
Ambient Temperature		-55 to 60°C	-10 to 40°C	-10 to 55°C	-25 to 60°C
Variations		• Solder terminal • Plug-in terminal with mechanical indicator	• Plug-in terminal with mechanical indicator	• Plug-in terminal	• Quick-connect terminals
Socket		PYF14A-E, PYF14A-P, PY14	PF113A-E	8PFA1, PL08	-
Weight (Approx.)		30g	85g	340g	90g
Approved Standard & Markings		-	-	-	UL,CSA,EN/IEC, VDE,CE

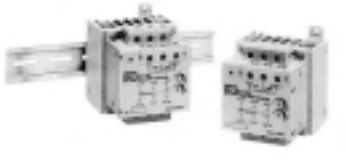
Relays

Classification		PCB Power Relays			
		G2R	**G5L**	**G6B**	**G6D**
Model					
Features		• A high withstand voltage general-purpose PCB power relay	• A cubic, single-pole PCB power relay	• Subminiature relay that switches up to 5A	• Slim, miniature relay capable of relaying programmable controller and temperature controller outputs
Coil Rating	**Rated voltage**	5 to 100VD 12 to 200/(220)VAC	5 to 24VDC	5 to 24VDC	5 to 24VDC
	Power consumption	DC:530mW AC:900mVA	400mW	200mW / 300mW	200mW
Contact Rating	**Contact Form**	SPST-NO SPDT / DPST-NO DPDT	SPST-NO	SPST-NO / DPST-NO	SPST-NO
	Material	AgCdO	AgCdO	AgCdO	AgCdO
	Rated Load	10A at 30VDC 10A at 250VAC / 5A at 30VDC 5A at 120VAC	5Aat 30VDC 5A at 120VAC	5A at 30VDC 5A at 250VAC	5A at 30VDC 5A at 250VAC
	Max. Switching Current	10A / 5A	5A	5A	5A
Life Expectancy	**Mechanical**	DC:$20x10^6$,AC:$10x10^6$	$10x10^6$	$50x10^6$	$20x10^6$
	Electrical	$100x10^3$	$100x10^3$	$100x10^3$	$100x10^3$ min (5A load) $300x10^3$ min (2A load)
Dielectric Strength	**Between Coil and Contact**	5,000VAC for 1 min.	2,000VAC for 1 min.	3,000VAC for 1 min.	3,000VAC for 1 min.
	Between Contact of Same Polarity	1,000VAC for 1 min.	750VAC for 1 min.	1,000VAC for 1 min.	750VAC for 1 min.
Ambient Temperature		-40 to 70°C	-25 to 70°C	-25 to 70°C	-25 to 70°C
Variations		• Flux-protection • Plastic-sealed • Plug-in terminal	• Flux-protection • Plastic-sealed • Plug-soldered type	• Double/single-winding • Plastic-sealed • Plug-in terminal	• Plastic-sealed
Socket		P2RF-05-E, P2RF-08-E	-	P6B-04P,P6B-26P	P6D-04P
Weight (Approx.)		17g	12g	3.5g	3g
Approved Standard & Markings		UL,CSA,SEV,SEMKO, EN/IEC,VDE,CE	UL,CSA,IEC,VDE,CE	UL,CSA,IEC,VDE, SEV,CE	UL,CSA,IEC,VDE

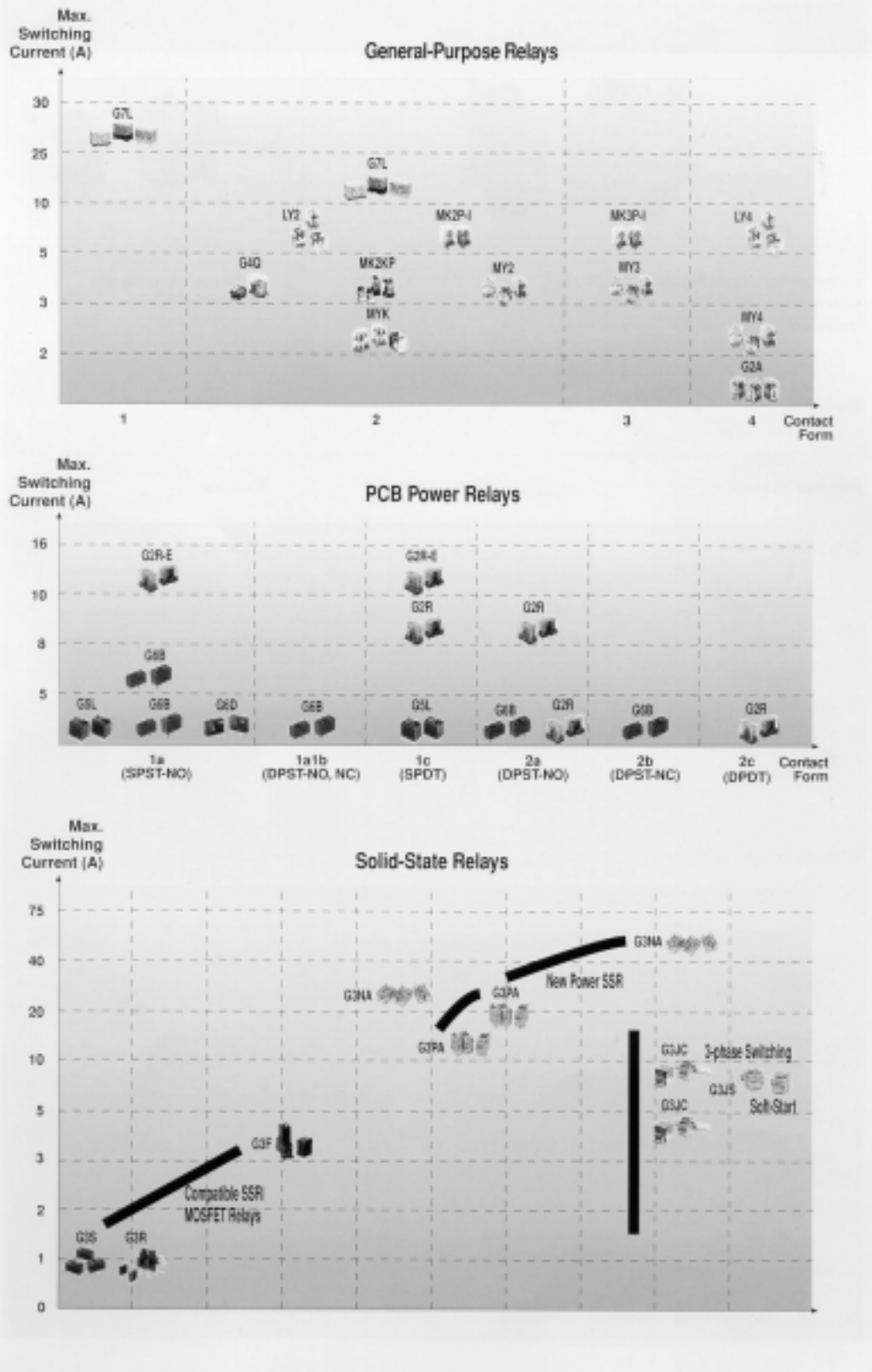
Relays

Classification		Solid State Relay		
		G3F/G3FD	G3NA	
Model				
Features		• Wide voltage range • Terminal compatible with MY relays	• Built-in varistor absorbs external surges Operation indicator enables monitoring operation	
Rated Input voltage		4 to 24VDC, 100/110VAC, 200/220VAC	5 to 24VDC 200 to 240VAC	5 to 24VDC 100 to 240VAC
Output	Insulation	Photocoupler	Phototriac	Photocoupler
	Load voltage	75 to 264VAC	19 to 264VDC	180 to 528VAC
	Max. Switching Current	3A	40A	
	Leakage current	at 100VAC:5mA max. at 200VAC:10mA max.	at 100VAC: 5mA max. at 200VAC: 10mA max.	at 200VAC: 10mA max. at 400VAC: 20mA max.
Dielectric Strength (Between input and output terminals)		1,500VAC, 50/60Hz for 1 min.	2,500VAC, 50/60Hz for 1 min.	
Ambient Temperature (Operating)		-30 to 80°C	-30 to 80°C	
Variations		• Plug-in terminal	• Panel mounting • Screw Terminal	
Socket		PYF08A-E, PY08,PYF08A-P	-	
Weight (Approx.)		50g	60g	80g
Approved Standard & Markings		-	UL,CSA,EN/IEC,VDE,CE	

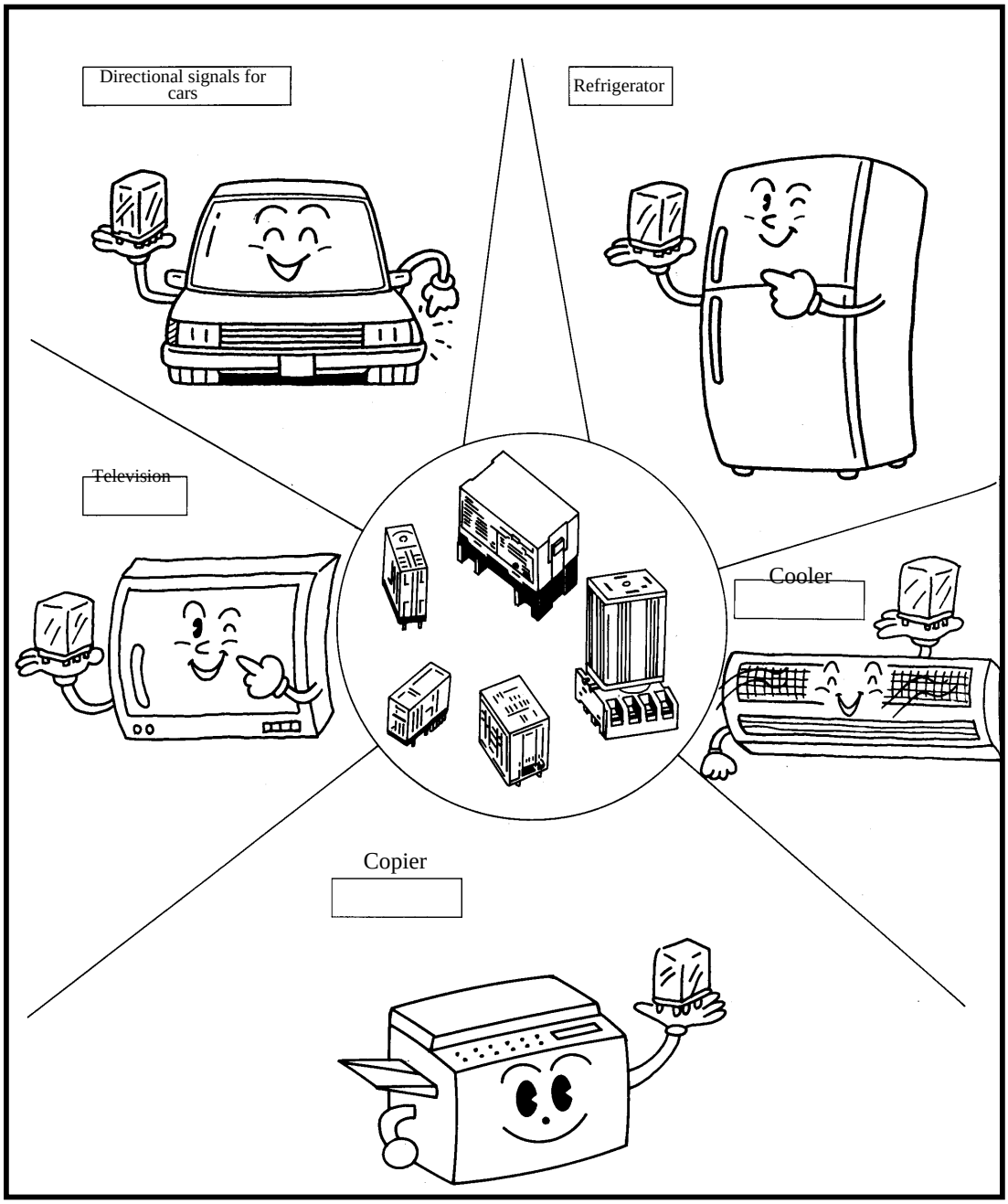
Relays

Classification		Solid State Relay					
		G3PA					G3J-S
Model							
Features		• Extremely thin relays integrated with a heart sink • Subminiature, thin profile • Replaceable power cartridge					• Motor starts smoothly with the soft-start function.
Rated Input voltage		5 to 24VDC					12 to 24VDC
Output	Insulation	Phototriac coupler			Photocoupler		Phototriac
	Load voltage	19 to 264VAC			180 to 528VAC		200 to 400VAC
	Max. Switching Current	10A	20A	40A	20A	30A	11.1A
	Leakage current	at 100VAC: 5mA max. at 200VAC: 10mA max.		at 100VAC: 10mA max. at 200VAC: 20mA max.	at 200VAC: 10mA max. at 400VAC: 20mA max.		at 400VAC:10mA max.
Dielectric Strength (Between input and output terminals)		4000VAC, 50/60Hz for 1 min.					2,500VAC, 50/60Hz for 1 min.
Ambient Temperature (Operating)		-30 to 80°C					-20 to 60°C
Variations		• Track mounting • Screw Terminal					• Track mounting • Screw Terminal
Socket		-					-
Weight (Approx.)		260g	340g	460g	380g	500g	730g
Approved Standard & Markings		UL,CSA,EN/IEC, VDE,CE			UL,CSA		-

- **Product Positioning**



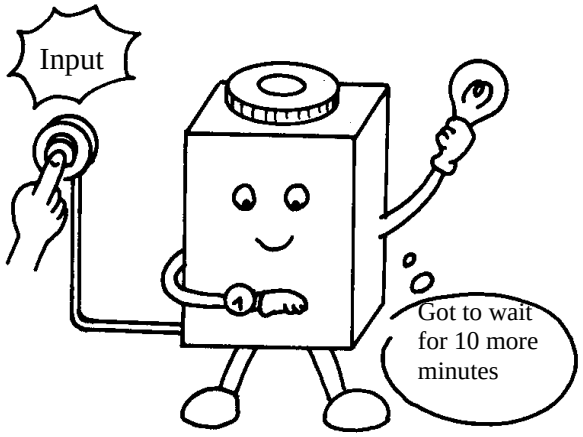
3-7 Application



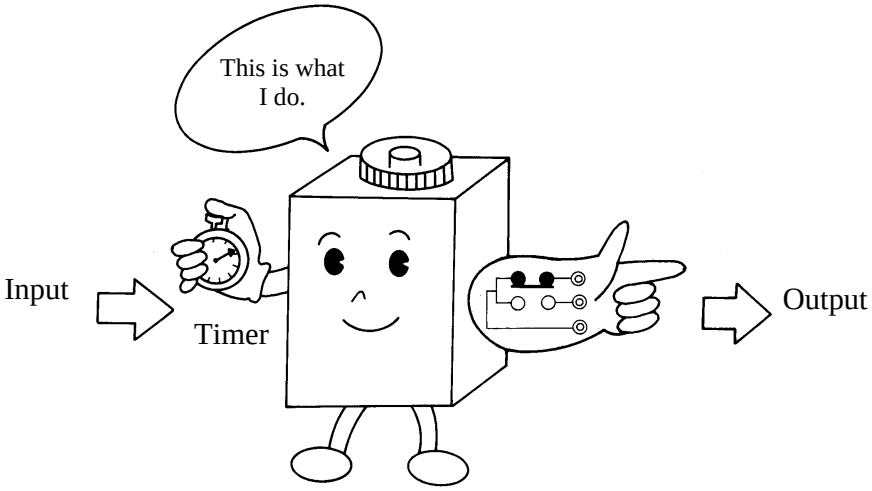
SECTION 4
Timer

4-1 What is a Timer?

A timer keeps track of time and provides certain notifications or carries out certain functions at a predetermined time.



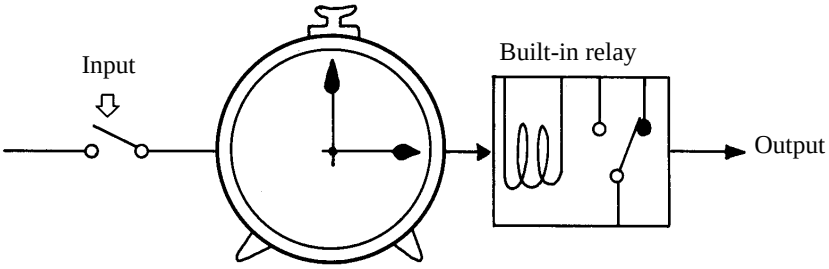
As shown in the following drawing, when a timing is input, the built-in contact executes a switch-over at the programmed time (operation time). (=time up)



4-2 Electronic Timer

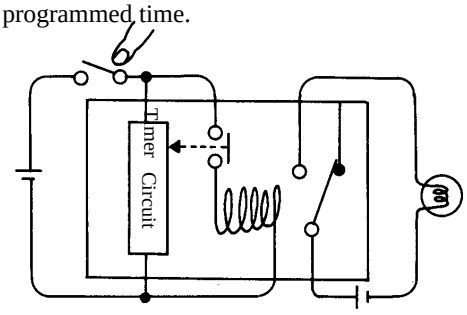
An electronic timer makes use of electronic circuits to keep track of time.

- **Principle of structure and operation**



The contact switches over at programmed time.

The internal structure is shown on the right



- **Programming method**

Select one of the two programming methods according to the purpose.

Analogue setup	Digital setup
Easy setup Fine-tuning Low price	Precise operation time (=high precision) Zero setup error
Example H3CR type H3YN type	H5CL type H5CN type

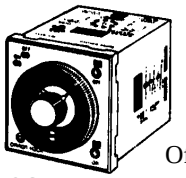
▪ A timer is useful in the following situations

A timer serves to fulfill various purposes.

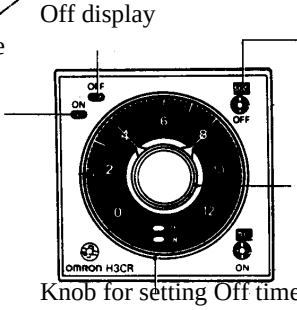
When you need to change the on/off time respectively to automatically start/stop the machine.

▪ Twin timer

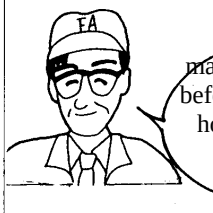
High frequency repetitive operations can be carried out with one unit of timer. The On and Off timer can be programmed respectively.*



H3CR-F type

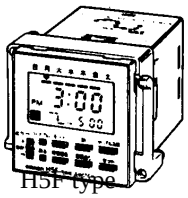


At midnight, alcohol becomes unavailable at the vending machine

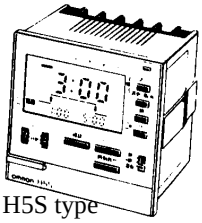


Turn on the machine one hour before the working hour every day.

▪ Timer switch



H5F type



H5S type

There are daily timer switches which execute predetermined operations daily and weekly timer switches which execute predetermined operations weekly.
There are 1, 2 and 4 circuits for output. On/Off times can be programmed for each output.

4-3 Useful Glossary about the Timer

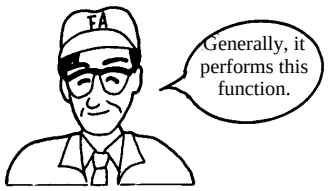
A timer does more than keep track of time and outputs. It has various functions. Let's take a look at what a timer can do here.

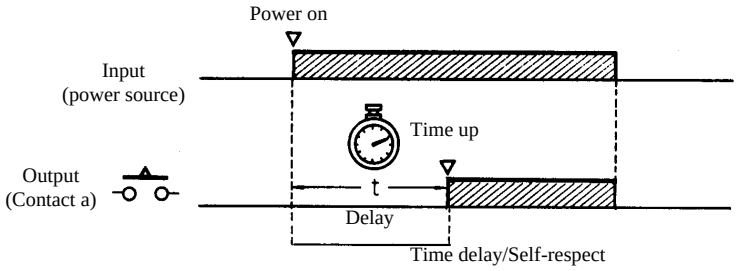
▪ Operation

Various operations can be performed depending on when the timer starts counting the time.

On-delay operation

After the power is on, the contact is switched over after a lapse of time (delay).



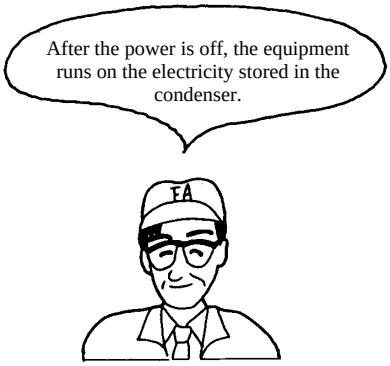


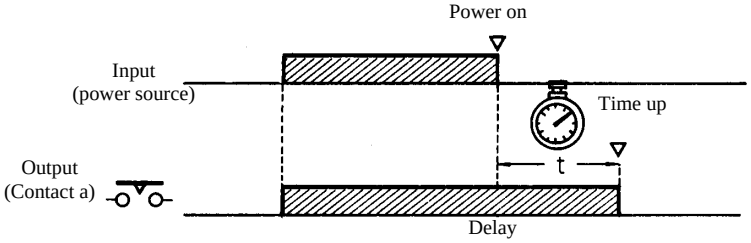
(The timer starts as soon as the power is on.)

*Time delay: after the programmed time.

Off-delay operation

After the power is off, the contact is switched over after a lapse of time (delay).





Instant action/delay reset

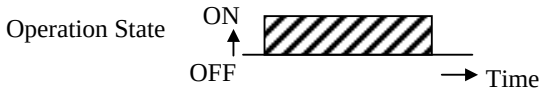
(The timer starts as soon as the power is off.)

* There are other operations which are not triggered by the power. Instead, on-delay operations and off-delay operations are executed based on start signals received (on-delay operation signal, off-delay operation signal).

* **Time Chart**

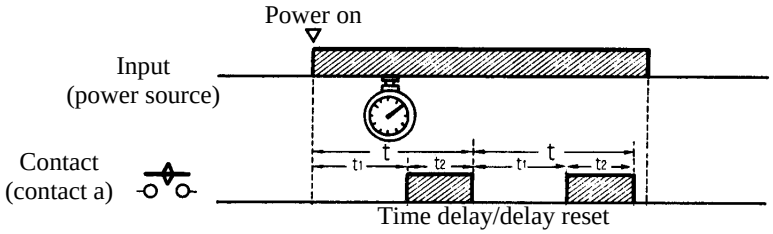
All timer operations are expressed by ▨
This is known as the "Time Chart" or the "Operation Chart".

*For the time chart, the y axis indicates the "operation state" while the x axis, the "passage of time" (second, minute, and hour).



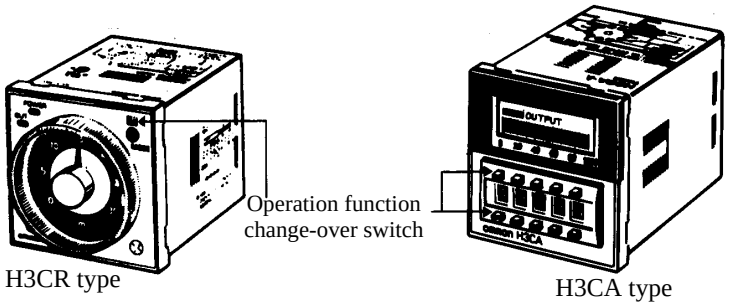
Flicker Operation

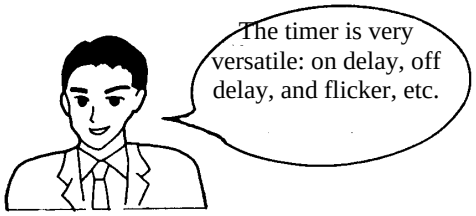
After the power is on, the contact switches over repeatedly at a **constant cycle**.



Multiple Operation

A single unit of timer can handle multiple operation functions.

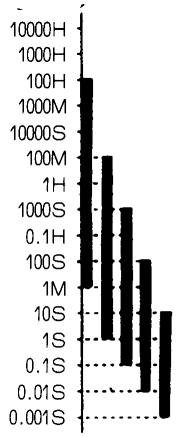




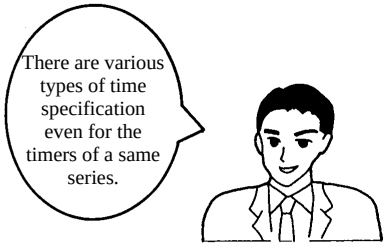
▪ Time

Time Specification

This refers to the time which can be counted by a unit of timer.



H5CN



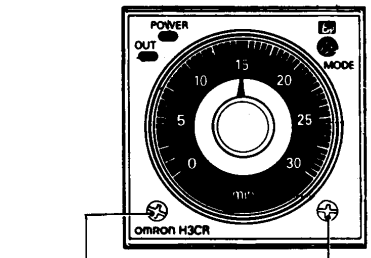
Multi-time

By changing to a switch with a scale numbers or time unit, a single unit of timer can also be used to handle a wide range of time specifications.

H3CR-A type

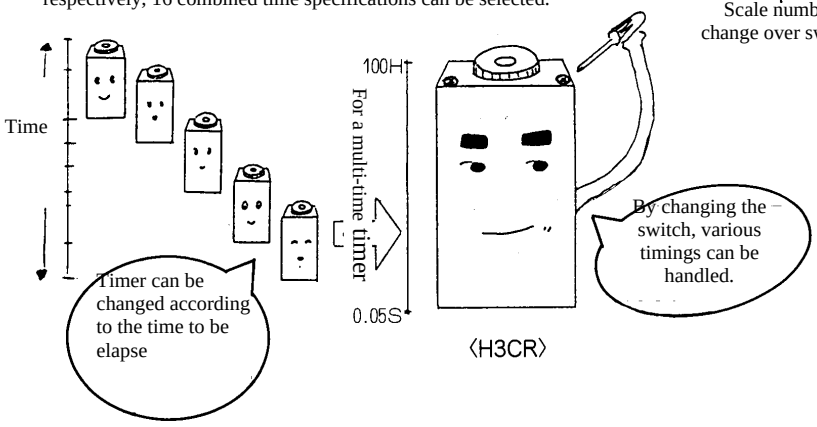
Time unit / Scale number		sec	min	hrs	×10h (hours)
1.2	Range of program time	0.05～1.2	0.12～1.2		1.2～ 12
3		0.3～ 3			3 ～ 30
12		1.2～12			12 ～120
30		3 ～30			30 ～300

By switching to scale number display and time unit display, which are located at the lower left and lower right of the timer (at the front) respectively, 16 combined time specifications can be selected.



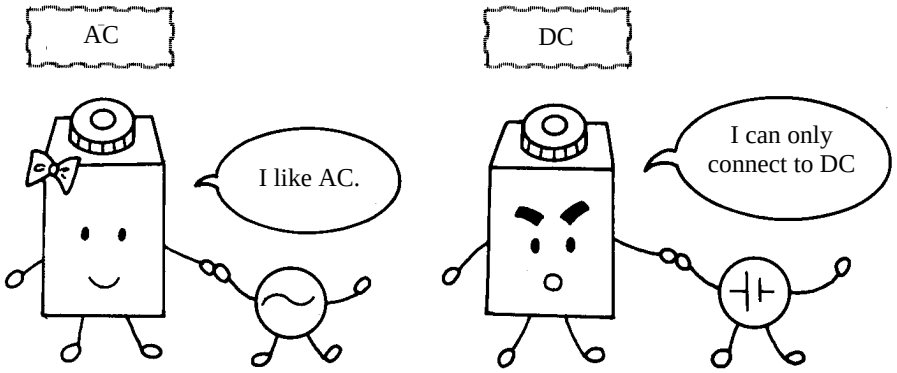
Scale number change over switch

Time unit change over switch

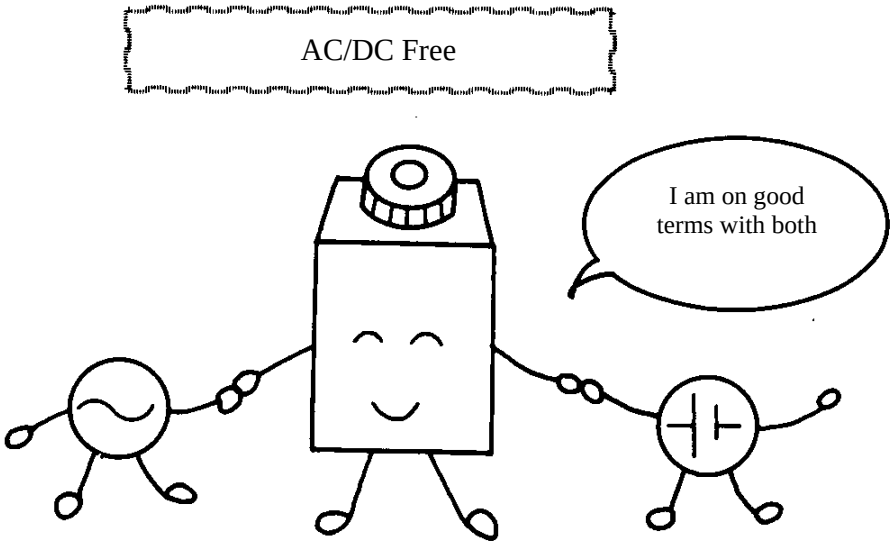


- **Power**

Rated voltage
There are dedicated AC timers and DC timers. An appropriate format must be selected according to the power used.

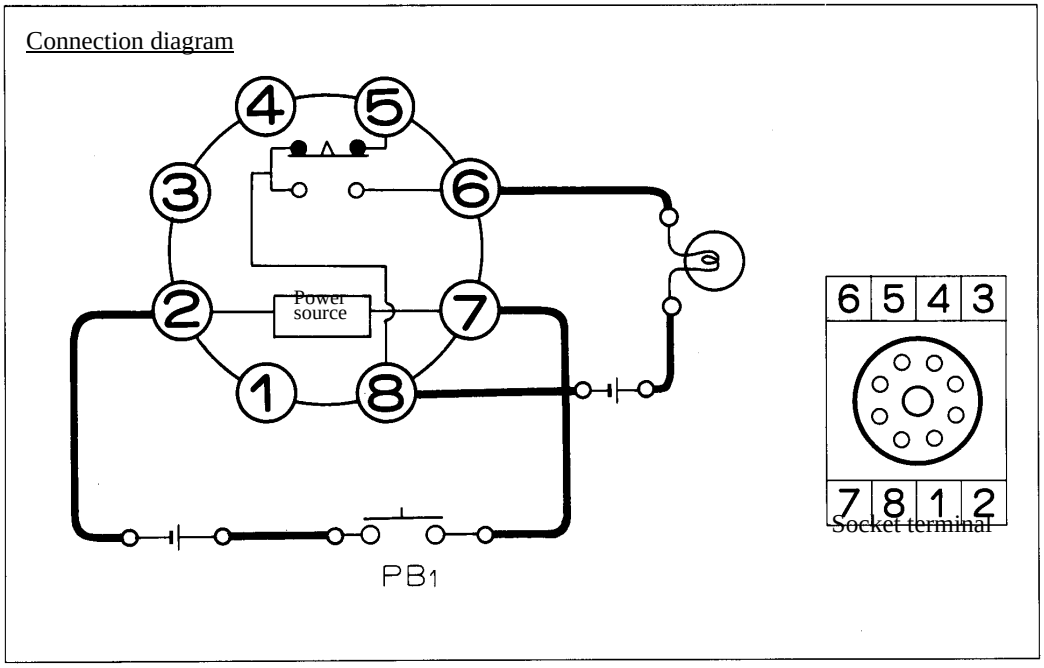


Free power source
There are also some timers, known as AC/DC free power source, which can be used for AC and DC.



4-4 Assembly Exercise

- **Power on delay**

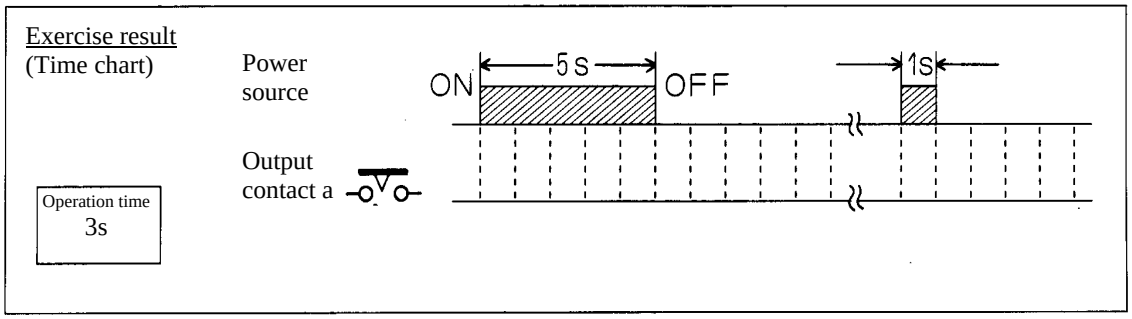


Contents of exercise:

To understand the operation of power on delay timer using the time chart.

Methods:

1. Make use of H3CR-A8 type power on delay timer and set the operation time to 3 seconds.
2. Wire it up as shown in the connection diagram.
3. Switch on and off the timer power source PB1 and operate it as shown in the following time chart.
4. Record the result in the following timer chart (operation of output contact a)

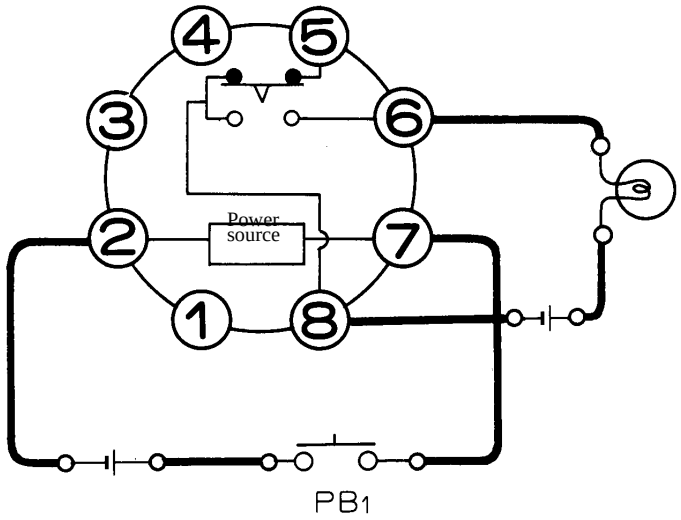


Study:

1. Please explain the power on delay timer operation using the time chart.
2. How should it be wired so that the lighted lamp will go off after the operation time.
3. Change it to the digital timer and study it (H5CL type).

- **Power off delay**

Connection diagram

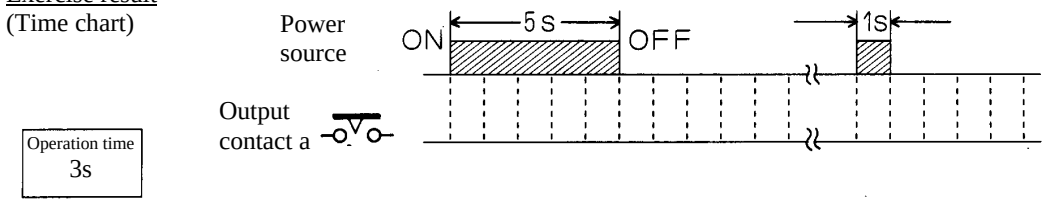


Contents of exercise:
To understand the operation of power off delay timer using the time chart.

Methods:

1. Make use of H3CR-H8L type power off delay timer and set the operation time to 3 seconds.
2. Wire it up as shown in the connection diagram.
3. Switch on and off the timer power source PB1 and operate it as shown in the following time chart.
4. Record the result in the following timer chart (operation of output contact a)

Exercise result
(Time chart)



Study:

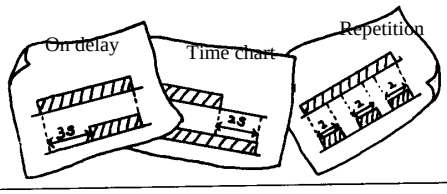
1. Please explain the power off delay timer operation using the time chart.
2. Why is the timer functioning after the power has been switched off?
3. What kind of devices uses off delay timers?

4-5 Pointer for Selection

• Operation •

What kind of operations are required?

On delay Repetitive action
Off delay Multi-operation



• Time specification •

What is the range of programmed time?

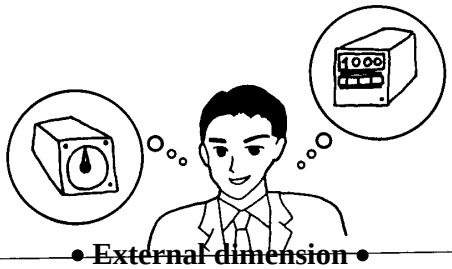
_____Seconds, minutes, hours
Multi-time

This is recommended if several types of time settings are to be programmed.

• Program method •

What kind of setting is better?

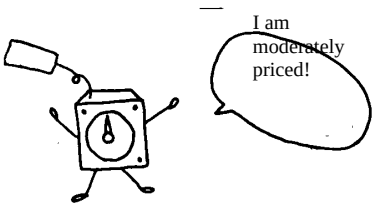
High precision digital setup
Simple analogue setup



• Price •

What is your budget?

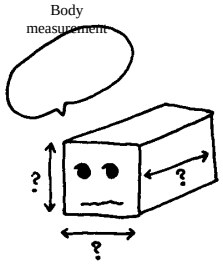
¥_____



• External dimension •

1. Size?
48 Small Slim

2. Body length?
Short Others



• Power source •

1. AC or DC?
AC
DC
AC? DC Free

Battery

2. Rated voltage?

_____(V)

• Resolution •

What is the smallest time division required?

0.001s
0.01s
0.05s
0.1s
1.0s

• Accuracy of operating Time •

The Accuracy of Operating Time varies differently for different models.

e.g. ±0.01%
e.g. ±0.05%

4-6 Omron Models

Classification		Solid State Timer							
Model		H3CR-A		H3CR-F	H3CR-G		H3CR-H		
		Multi-function Operation		Twin Operation	Star-delta Operation		OFF Delay Operation		
Appearance									
Dimension (W x H x D) mm		**48 x 48 x 52.3**		**48 x 48 x 52.3**	**48 x 48 x 63.7**		**48 x 48 x 63.7**		
Features		▪ Wide range of AC or DC supply voltage ▪ Enable sequence checks through instantaneous contact.		▪ Independent ON and OFF settings enable Long ON and short OFF or vice versa	▪ Long Power-OFF delay time range		▪ Long Power-OFF delay time range		
Operation Modes		ON Delay, Flicker OFF/ON start,		Flicker OFF start, Flicker ON start	--		OFF Delay		
Time Range		0.05 sec. to 300 hrs.		0.05 sec. to 30 hrs.	0.05 sec. to 120 sec.		0.05 sec to 12 min.		
Accuracy of Operating Time		±0.3% FS max.		±0.3% FS max.	±0.3% FS max.		±0.3% FS max.		
Supply Voltage (AC: 50/60Hz)		100 to 240VAC, 24VAC/DC, 12VDC, 48 TO 125VDC		100 TO 240VAC, 24VAC/DC, 12VDC, 48 to 125VDC	100 to 120VAC, 200 to 240VAC		100 to 120VAC, 200 to 240VAC, 24VAC/DDC, 48VDC, 100 to 120VDC		
Power Consumption		10VA, 2VA, 1W, 1.5W		10VA, 2VA, 1W, 1.5W	6VA/2.4W,12VA/2.6W		0.18VA, 0.25VA, 0.24VA/140W, 130mW, 300mW		
Input Signal		Start, Reset, Gate		---	---		---		
Contact Configuration	**Time-limit**	DPDT	SPDT	DPDT	SPST-NO	STST-NO	DPDT	SPST	
	Instantaneous	---	SPDT	---	SPST-NO	---	---		
Control Output		5A at 250VAC		5A at 250VAC	5A at 250VAC		5A at 250VAC		
Life Expectancy (mechanical)		$20x10^6$ operations		$20x10^6$ operations	$20x10^6$ operations		$10x10^6$ operations		
Weight (approx.)		100g		100g	120g		120g		
Approved Standards & Markings		UL,CSA, VDE,CE		UL,CSA,VDE,CE	UL,CSA,VDE,CE		UL,CSA,VDE,CE		

Classification		**Solid State Timer**					
Model		**H3RN**		**H3Y**		**H3G**	
		Miniature Multi-function operation		**Subminiature ON Delay Operation**		**Economical ON Delay Operation**	
Appearance							
Dimension (W x H x D) mm		28 x 12.8 x 47.4		28 x 21.5 x 52.6		30 x 36 x 60	
Features		▪ Multi-operation modes and time range ▪ Ultra-slim with pin configuration compatible with Omron slim G2R Power Relay		▪ Semi-multi supply voltage ▪ Large transparent time setting knob ▪ A flat blade provided for time setting with Philips screwdriver ▪ Pin configuration compatible with Omron slim G2R Power Relay		▪ Time limit operation with automatic resetting	
Operation Modes		ON Delay, Flicker OFF/ON start, Signal ON/OFF delay, Interval		ON Delay		ON Delay	
Time Range		0.1 sec. to 1 min.	0.1 min to 10 hrs.	0.04 sec. to 3 hrs		0.1 sec. to 3 hrs.	
Accuracy of Operating Time		±1% FS max.		±1% FS max.		±2% FS max.	
Supply Voltage (AC: 50/60Hz)		24VAC/DC, 12VDC, 24VDC		24, 100 to 120, 200, 230VAC, 12, 24, 48, 100 to 110, 125 VDC		100/110/120VAC, 200/220/240VAC, 24VAC, 12 to 24VDC	
Power Consumption		0.8VA, 0.4W, 0.5W		1.5VA, 1.8VA, 0.9W, 1W, 1..3W		2.2VA, 1.5W	
Input Signal		---		---		---	
Contact	Time-limit	SPDT, DPST-NO		DPDT	4PDT	SPDT	DPDT
Configuration	Instantaneous	---		---		---	
Control Output		3A at 250VAC		5A at 250VAC	3A at 250VAC	5A or 7A at 120/250VAC	
Life Expectancy (mechanical)		$10x10^6$ operations		$10x10^6$ operations		$10x10^6$ operations	
Weight (approx.)		18g		50g		55g	
Approved Standards & Markings		UL,CSA, VDE,CE		UL,CSA,VDE,CE		UL,CSA, SEV	

Classification		**Solid State Timer**			
Model		**H3DE**		**H3CA**	
		Multi-function Operation		**Multi-function Operation**	
Appearance					
Dimension (W x H x D) mm		79 x 22.5 x 100		48 x 48 x 89	
Features		▪ Programmable contact enables the building of a self-holding relay circuit ▪ Easy sequence checks through instantaneous contacts ▪ Wide AC/DC power supply ▪ Incorporate environment-friendly cadmium-free contacts		▪ Dual AC/DC supply voltage ▪ ON/OFF indicator for control output ▪ Bar indicator for remaining time ▪ Eight operation modes selectable	
Operation Modes		ON Delay, One Shot, Interval, Flicker OFF start, Flicker ON start, Signal ON/OFF delay, Signal OFF delay		ON Delay, Flicker OFF/ON start, Signal ON/OFF delay, Interval, One shot	
Time Range		0.1 sec. to 120 hrs.		0.1 sec. to 999 hrs.	
Accuracy of Operating Time		±1% FS max.		±0.3% FS max.	
Supply Voltage (AC: 50/60Hz)		24 to 230VAC, 24 to 230VDC		24 to 240VAC, 12 to 240VDC	
Power Consumption		2.75VA max.		2 to 10VA, 1 to 2W max.	
Input Signal		Start		Start, Reset	
Contact	Time-limit	SPDT DPDT		SPDT	SPDT, DPDT
Configuration	Instantaneous	SPDT		---	SPDT
Control Output		5A at 250VAC		3A at 250VAC	
Life Expectancy (mechanical)		$10x10^6$ operations		$10x10^6$ operations	
Weight (approx.)		50g		55g	
Approved Standards & Markings		UL,CSA, VDE,CE		UL,CSA,VDE,CE	

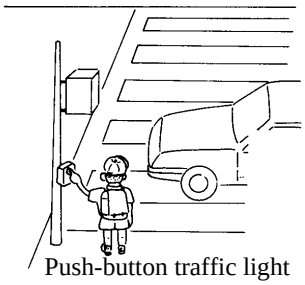
Classification		**Digital Timer**		
Model		**H5AN**	**H5F**	**H5S**
		Multi-function Operation	**Daily Operation**	**Weekly Operation**
Appearance				
Dimension (W x H x D) mm		72 x 72 x 115	48 x 48 x 86.7	72 x 72 x 49
Features		▪ Simultaneous control outputs of both contact and solid-state type ▪ Draw-out construction allows maintenance without disconnecting the wirings	▪ Precision control of both regular and special half day operation ON/OFF time ▪ Multiple day operation with time or pulse operation ▪ Timing chart display confirmed at a glance.	▪ Different program possible each day ▪ Multiple day operation with time, cycle or pulse operation ▪ Easy operation monitor with timing chart display ▪ 2 independent circuit operation
Operation Modes		ON Delay, Cyclic	Timer, Cyclic, Pulse	Timer, Cyclic Pulse
Time Range		0.01 sec. to 9999 hrs.	24 hrs.	1 week
Accuracy of Operating Time		±0.01% set time ±0.05s (power start) ±0.005% set time ±0.03s (control signal start)	±0.01% set time ±0.05s max.	±0.01% set time ±0.05s
Supply Voltage (AC: 50/60Hz)		100 to 240VAC, 12 to 24, 48, 100VDC	100 to 240VAC	100 to 240VAC, 24VDC
Power Consumption		10VA, 5W	2VA	3VA
Input Signal		Reset,Gate	---	---
Contact Configuration	**Time-limit**	SPDT, Solid-state	SPST-NO	SPST-NO X 2 CIRCUITS
	Instantaneous	---	---	---
Control Output		3A at 250VAC	15A at 250VAC	15A at 250VAC
Life Expectancy (mechanical)		$10x10^6$ operations	$50x10^6$ operations	$50x10^6$ operations
Weight (approx.)		360g	140g	200g
Approved Standards & Markings		UL,CSA	UL,CSA	UL,CSA

Classification		**Digital Timer**			
Model		**H5CL**	**H5CR**	**H5BR**	**H5CN**
		Multi-function Operation	**Multi-function Operation**	**Multi-function Operation**	**Time-limit Operation**
Appearance					
Dimension (W x H x D) mm		48 x 48 x 78.5	48 x 48 x 69.7	72 x 72 x 106	48 x 48 x 72.5
Features		▪ Water and dust protection for severe environment ▪ Simple setting with increment and decrement keys ▪ 12 mm height LED display	▪ Precision control possible to 0.001 sec. ▪ Selectable time Up or Down display ▪ Selectable key protection level	▪ Contact and solid-state outputs available simultaneously ▪ Precision control possible to 0.01 sec ▪ Selectable time Up or Down display ▪ Selectable Key Protection level ▪ Batch count operation ▪ Auxiliary power supply provided	▪ Wide variation of selection
Operation Modes		ON Delay, Accumulative	ON Delay, Cyclic, OFF delay, Accumulative, Interval	ON Delay, Cyclic, Signal OFF delay, Accumulative Interval	ON Delay
Time Range		0.001 sec. to 999.9 hrs	0.001 sec. to 9999 hrs.	0.1 sec. to 9999 hrs.	0.01 sec. to 99 hrs. 59 min.
Accuracy of Operating Time		±0.01% set time ±0.05s (power start) ±0.005% set time ±0.03s (control signal start)	±0.01% set time ±0.5s (power start) ±0.005% set time ±0.03s (control signal start)	±0.01% set time ±0.5s (power start) ±0.005% set time ±0.03s (control signal start)	±0.01% set time ±0.5s (power start) ±0.005% set time ±0.03s (control signal start)
Supply Voltage (AC: 50/60Hz)		100 to 240VAC, 24VAC/DC, 12VDC, 48 TO 125VDC	100 TO 240VAC, 24VAC/DC, 12VDC, 48 to 125VDC	100 to 120VAC, 200 to 240VAC	100 to 120VAC, 200 to 240VAC, 24VAC/DDC, 48VDC, 100 to 120VDC
Power Consumption		100 to 240VAC, 12 to 24VDC	24, 100 to 240VAC, 12 to 24VDC	24VAC, 100 to 240VAC, 12 to 24VDC	100 to 240VAC, 12 to 48VDC
Input Signal		10VA, 3W	3VA/1W, 5VA, 2W	8VA, 5W	12VA/2.5W, 2.5W
Contact Configuration	Time-limit	SPDT	Solid-state	SPDT	Solid-state	SPDT, Solid-state	SPDT, Solid-state
	Instantaneous	---		---		---	---
Control Output		3A at 250VAC		3A at 250VAC		5A at 250VAC	3A at 250VAC
Life Expectancy (mechanical)		$10x10^6$ operations		$10x10^6$ operations		$10x10^6$ operations	$10x10^6$ operations
Weight (approx.)		AC:130g DC:110g		130g		270g	150g
Approved Standards & Markings		UL,CSA, EMC, CE		UL, CSA, EMC, CE		UL, CSA, EMC, CE	UL, CSA

4-7 Application

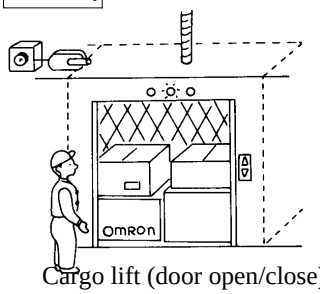
On delay operation

On the street



Push-button traffic light

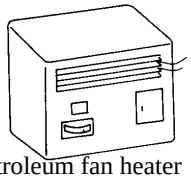
In the factory



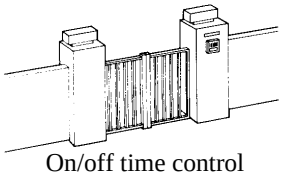
Cargo lift (door open/close)

Off delay operation

After the power is switched off, the fan continues to run for a while to drive out the heat.



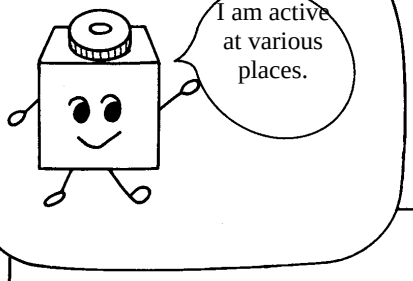
Petroleum fan heater



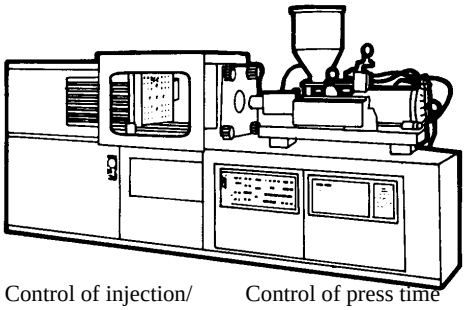
On/off time control (gate light)

■ 

H5F type time switch



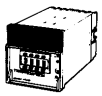
<Injection molding machine>



Control of injection/ cooling/cycle time

■ 

Control of press time

■ 

Control of heater on/off time

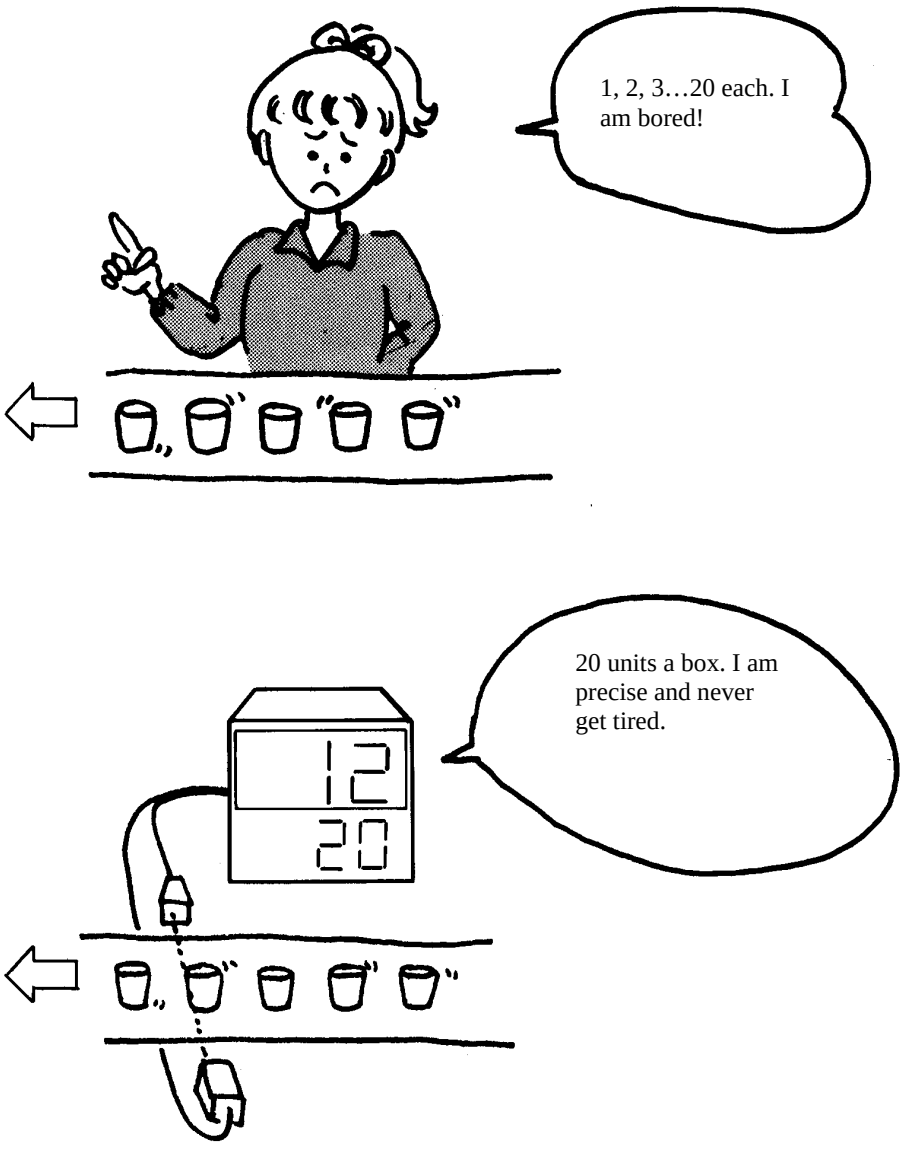
■ 

SECTION 5
Counters

5-1 What is a Counter?

Literally, a counter counts. It counts signals transmitted by switches. The counters, which we will be learning later, can,

- display the number of counts
- send notifications when the predetermined count is up.

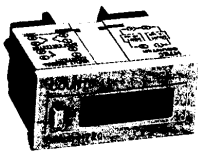


5-2 Types of Counters

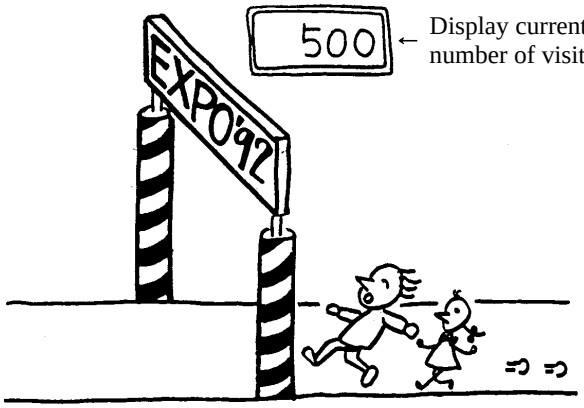
Based on their functions, counters can be broadly divided into the “total counter” and the “preset counter”.

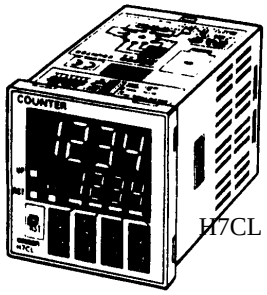
Total Counter

This kind of counter counts and displays input signals only. “Total” means the total number of counts.



H7EC type

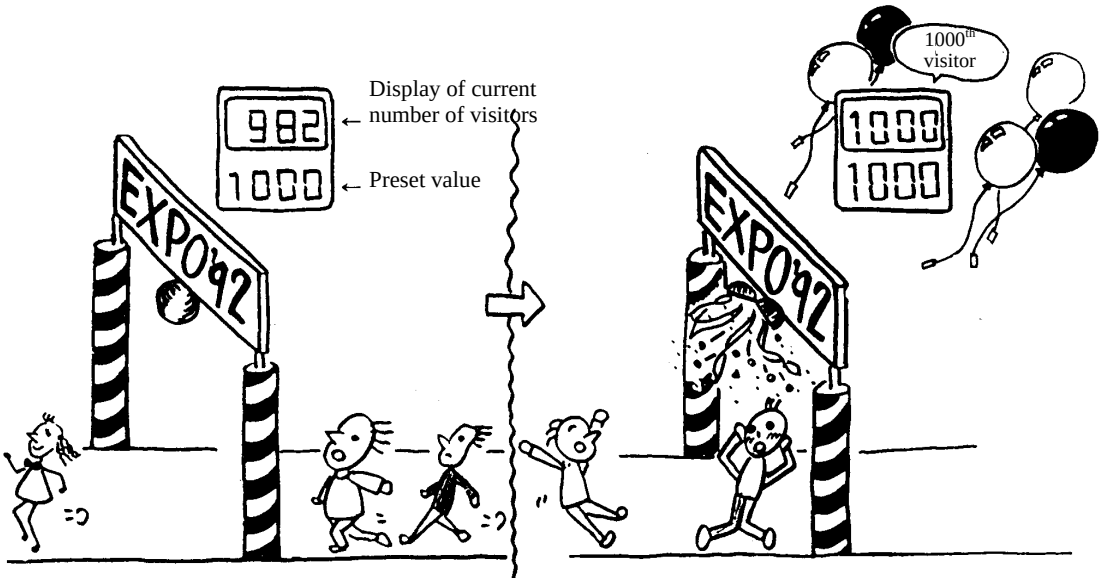




H7CL type

Preset Counter

This kind of counter counts input signals against a value, which is programmed in advance (preset). When the preset value is up, the contact in the counter will be switched and signals is output.



5-3 Useful Glossary about the Counter

A counter does more than counts and outputs when a preset value is up. Let's see what else is capable of.

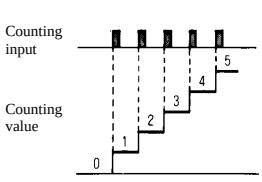
(1) Common glossary for total counter • preset counter

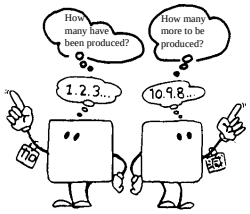
Operation method

When an input signal comes in, counter may increase or decrease a value.

Incremental (UP) counter

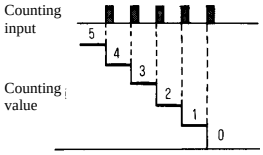
The counting value increases with every single input.





Decremental (DOWN) counter

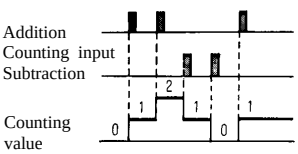
The counting value decreases with every single input.

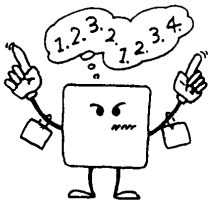


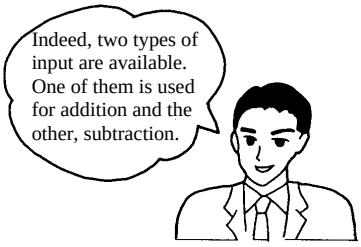
Some counters can be used both ways.

Additive/subtractive (Up/Down, Reversible) counter

This kind of counter is equipped with both the additive and the subtractive functions.





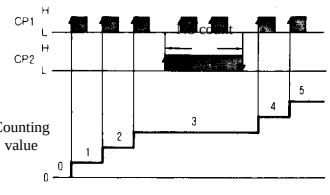


It can be used to stop a single instance of input (gate), which is useful when counting defective products.

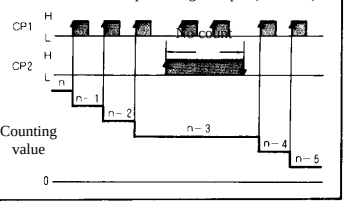
Input prohibition (gate)

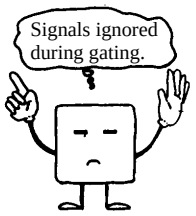
Input which instructs the counter to stop taking in input signal during counting. When CP2 is input, CP1 will not be accepted.

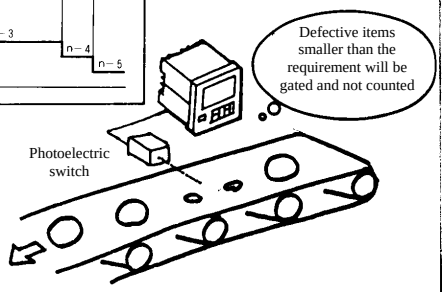
- UP mode
  CP1: count input CP2 gate input (no count)



- DOWN mode
  CP1: count input CP2 gate input (no count)





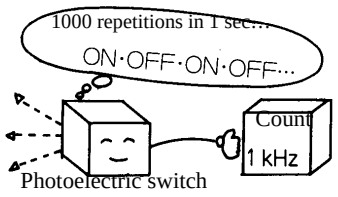


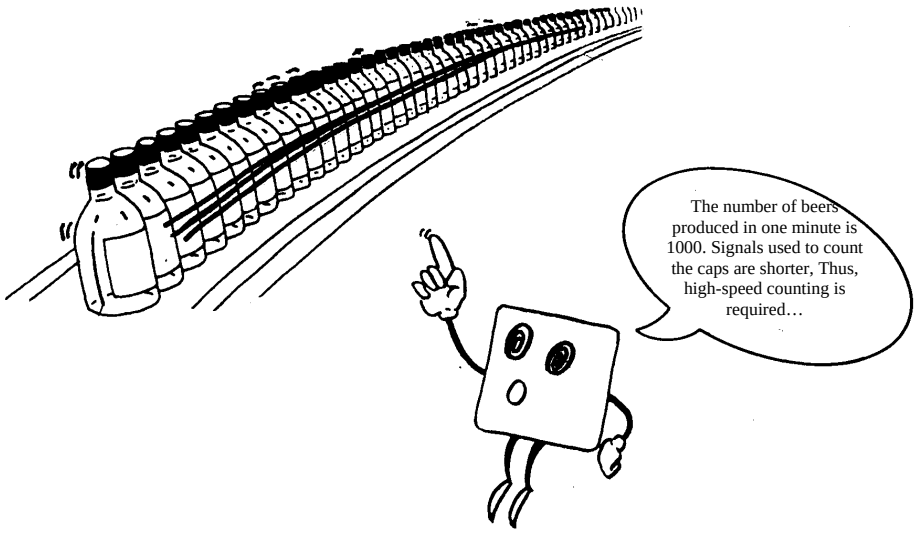
Speed of Counting

Speed of counting refers to the number of counting which can be executed in one second. It indicates the highest speed which is expressed in Hz.
30 Hz means 30 counts are done in one second while 1kH means 1000 counts per second.

Selecting speed of counting
It is important to select an optimal speed of input counting speed.

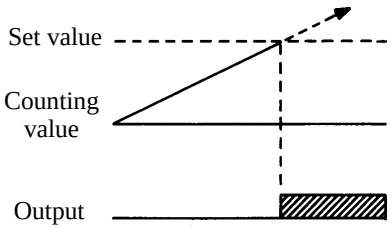
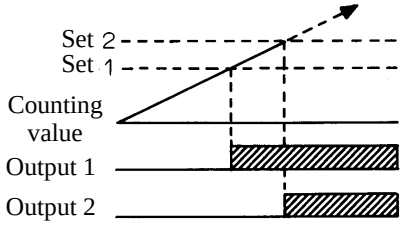
High speed counting (1kHz, 5kHz…)	Low speed counting (30Hz)
When count input is executed by contact-less switch, such as photoelectric switches or proximity switches, which are to use to handle high-frequency on/off action, the counter must be capable of high-speed counting.	When count input is executed by contact switches, such as switches or relays, which may take in extra counts due to the bouncing of the contact, the counter must be a low-speed 30Hz counter.

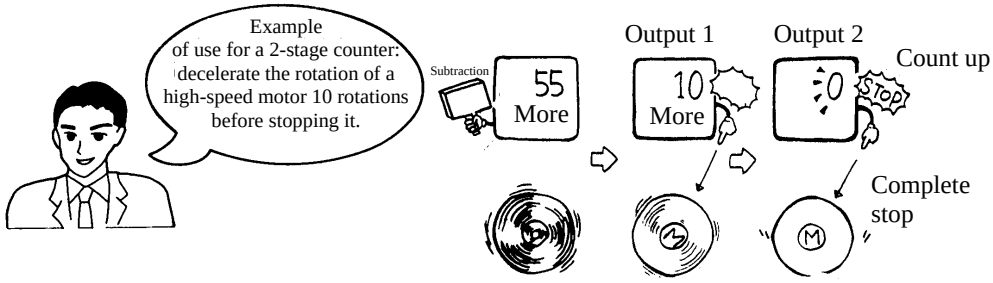




(2) Preset Counter

Number of stages

1-stage counter	2-stage counter
	
1 set value is programmed and an output is executed when the counting reach the value. This is a preset counter.	2 set values are programmed and outputs are executed for each value.



Reset

A reset action restores the counting section, display section and the output section to the initial stage before starting a counting operation. There are 4 methods to do a rest.

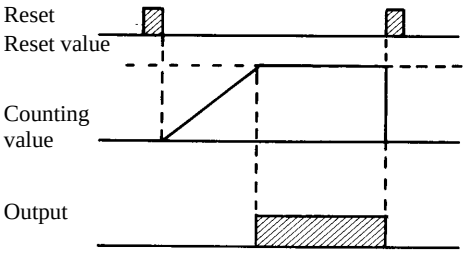
Power-off reset	Reset by switching off the power.
External reset	Reset by sending signals to the reset input terminal.
Manual reset	Reset manuallyy (by pressing the front button).
Auto reset	Automatic rest triggered by the signal generated by the counter.

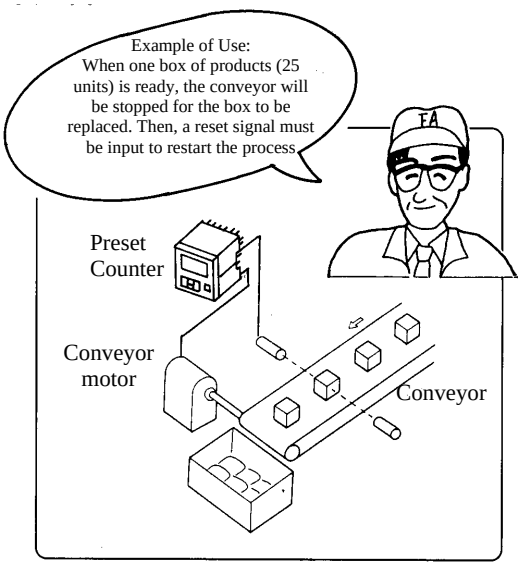
Operation Mode

An operation mode is the way an output or the changing pattern of a display is produced when the set value is up. There are many types of modes but the two most common ones are described below.

- **Standard format**
  An output is executed when the set value is up. The contact remains as is until it is reset. To restart a counting process, it must be reset.

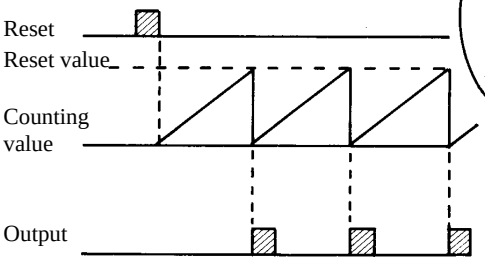
N mode
(Normal)

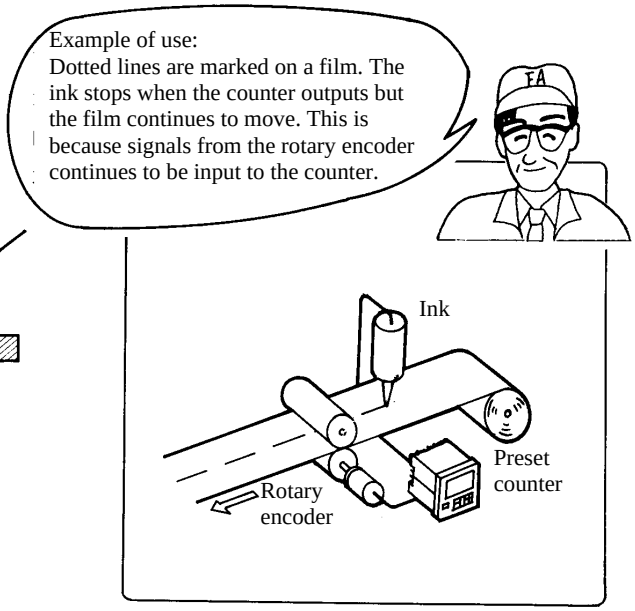




- **Repetitive format**
  Output is executed all at one go until the set value is up. At the same time, auto-reset signals are sent out internally. So, the counter will be restarted.

C mode
(Continuous)

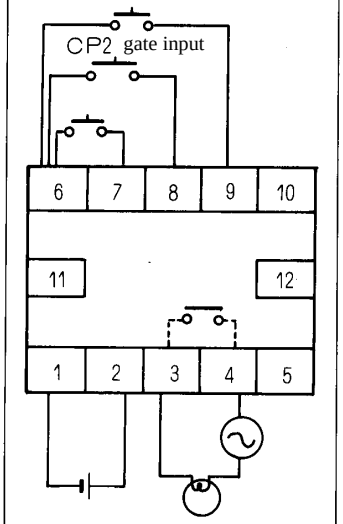




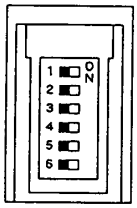
5-4 Using the Counter

H7CR Type

Connection diagram



Setting up dip switches



	Item	OFF	ON
1	Counting speed	30Hz(cps)	5kHz(cps)
2	Input mode	Additive mode	Subtractive mode
3	Output mode	(	)
4			
5	One-shot time	500ms	50ms
6	Min.signal width for reset	20ms	1ms

Switch No.					
3	OFF	ON	OFF	ON
4	OFF	OFF	ON	ON
Output mode	N	F	C	K

Methods

1. Please execute the wiring based on the connection diagram.
2. Please set it up as follows based on the setup method.
   Output mode: Additive mode
   Input mode: N
   Counting speed: 30Hz (cps)
3. Check the following:
   (1) Input counts and check the display.
   (2) Check gate input operations.
   (3) How to set up the subtractive counter?
   (4) When the counting speed is set to 5Hz and a reset signal is input, what will happen?
   (5) When a reset signal is input while the counting is being displayed, when will happen?
   (6) When the output mode is changed to C operation, how will the lamps be lighted?

Study

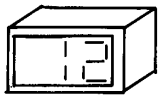
1. How many reset methods are there?
2. What are the differences between the N operation and the C operation?

5-5 Pointers for Selection

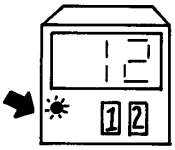
• Output •

Is it for display? Any output required?

☐ Total



☐ Preset



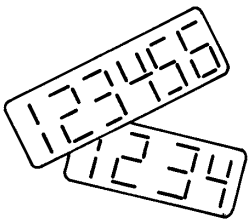
• Number of digits •

Number of digits?

☐ 4 digits

☐ 6 digits

☐ Others



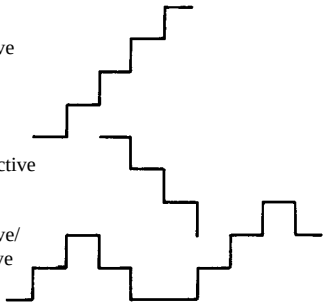
• Operation method •

Operation method?

☐ Additive

☐ Subtractive

☐ Additive/ Subtractive

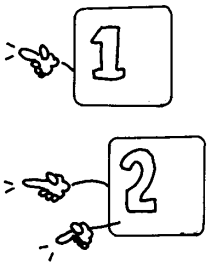


• Output stages •

Output stages?

☐ 1 stage

☐ 2 stages

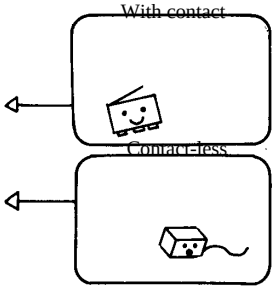


• Speed of counting •

Speed of counting?

☐ 30 Hz

☐ 1 kHz



• Size •

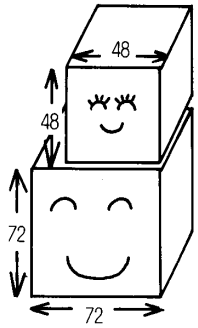
Size?

☐ 48×48

☐ 72×72

Others

☐



• Price •

What is your budget?

S$

5-6 Omron Models

Classification	**Electromagnetic**	**Self-powered Counter**	
Model	**CSK**	**H7EC**	**H7ET**
	Totalizing Counter	**Totalizing Counter**	**Time Counter**
Appearance			
Dimension (W x H x D) mm	32.6 x 22.6 x 80	48 x 24 x 56	48 x 24 x 56
Features	▪ Miniature electromagnetic totalizing counter ▪ High speed response (35cps) ▪ Locking mechanism for errorless operation ▪ Unique mechanism eliminates digit displacement during resets	▪ Subminiature totalizing counter ▪ No external power required ▪ AC/DC voltage, DC voltage and No-voltage inputs available	▪ Subminiature time counter ▪ No external power required ▪ Displays accumulative time by counting the outputs signals received from external (eg: a sensor) ▪ AC/DC voltage, DC voltage and No-voltage inputs available
Operation Modes	Up type	Up type	Up type
Counting Speed	DC input: 20cps (contact) AC input: 15cps (contact)	No voltage and DC input: 30cps/1kcps AC/DC input:20cps	
Number of Digits Displayed	4 or 6	6 or 7	6 or 7
Display	Digital display: LCD	Digital display: LCD	Digital display: LCD
Supply voltage (AC:50/60Hz)	100,200VAC, 6,12,24,48,100VDC	---	---
Power Consumption (approx.)	3VA, 3.5W	---	---
Input Mode	Up	Up	Up
Input Signal	Count	Count, Reset	Gate/Timer, Reset
Input Method	Contact input: voltage input*	No-voltage/voltage input*	No-voltage/voltage input*
Control Output	---	---	---
Power source for External Supply	---	---	---
Weight (approx.)	100 to 110g	90g	90g
Approved Standards & Markings	UL	UL,EMC,CE	UL,EMC,CE

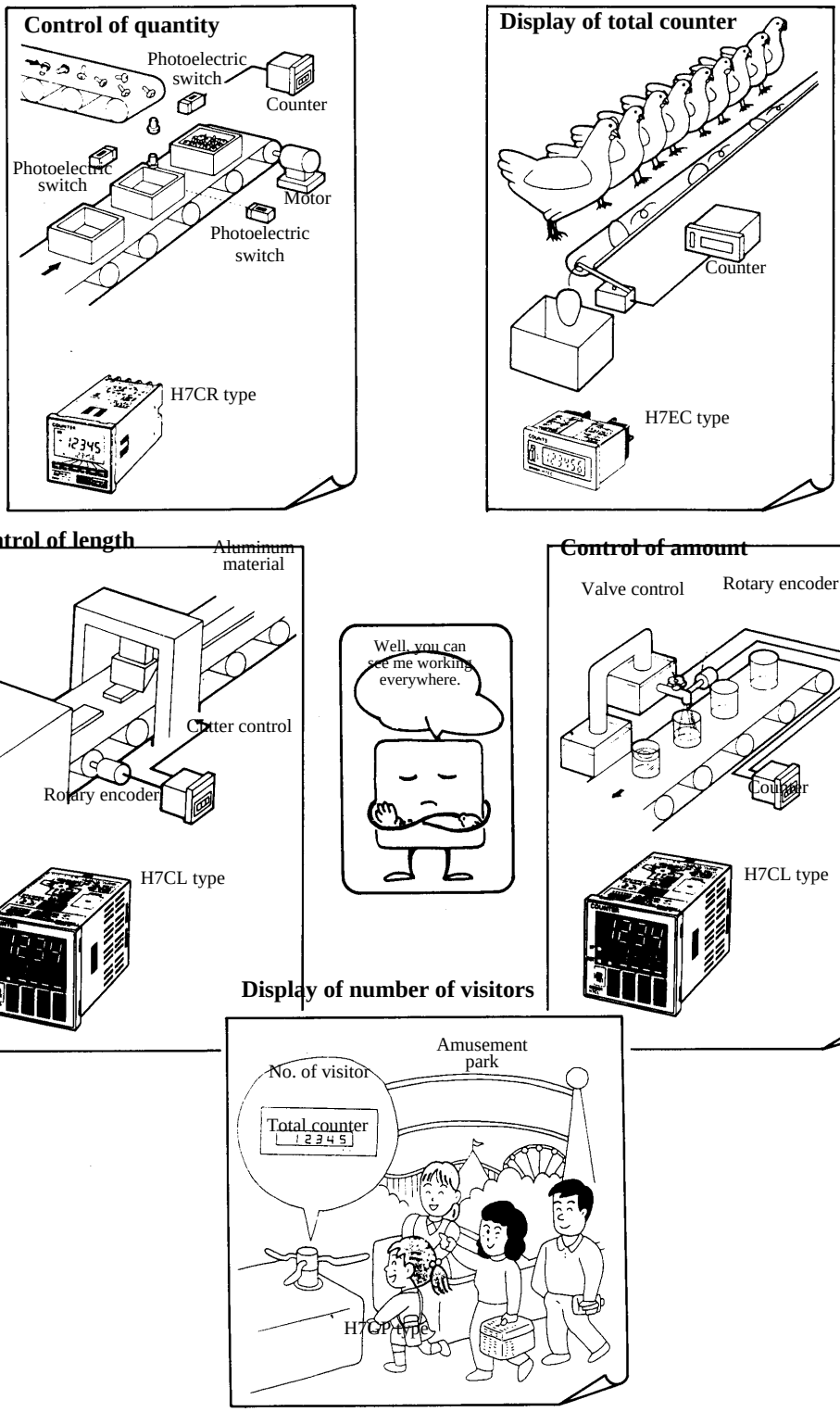
Classification	**Self-powered Counter**	**LCD Display with LED Backlight**	
Model	**H7ER**	**H7GP**	**H7HP**
	Tachometer	**Totalizing/Time Counter**	**Totalizing/Time Counter**
Appearance			
Dimension (W x H x D) mm	48 x 24 x 56	48 x 24 x 80	72 x 36 x 66
Features	▪ Subminiature tachometer ▪ No external power required ▪ Display of encoder revolution in rpm/rps is possible with DC power model ▪ AC/DC voltage, DC voltage and No-voltage inputs available	▪ Compact totalizing counters and time counter ▪ Switch between NPN and PNP operation ▪ Both external and manual resets provided ▪ Negative transmittive LCD display with built-in red LED backlight for high visibility and power saving ▪ IP66/NEMA4 water and oil resistance	▪ Compact totalizing counters and time counter ▪ Switch between NPN and PNP operation ▪ Both external and manual resets provided ▪ Negative transmittive LCD display with built-in red LED backlight for high visibility and power saving ▪ IP66/NEMA4 water and oil resistance
Operation Modes	Up type	Up type	Up/Down type
Counting Speed	---	30cps/5kcps	30cps/5kcps
Number of Digits Displayed	4 or 5	6	6 or 8
Display	Digital display: LCD	Digital display: LCD	Digital display: LCD
Supply voltage (AC:50/60Hz)	---	100 to 240VAC, 12 to 24VDC	100 to 240VAC, 12 to 24VDC
Power Consumption (approx.)	---	6.5VA, 0.6W	6.5VA, 0.6W
Input Mode	Up	Up (Counter)/ Accumulative (Timer)	Up/Down (Counter)/ Accumulative (Timer)
Input Signal	Encoder/Pulse	Count,Reset,Key protection	Count,Reset,Key protection
Input Method	No-voltage/voltage input*	No-voltage/voltage input*	No-voltage/voltage input*
Control Output	---	---	---
Power source for External Supply	---	50mA at 12VDC	50mA at 12VDC
Weight (approx.)	80g	76g	106g
Approved Standards & Markings	UL,EMC,CE	UL,CSA,EMC,CE	UL,CSA,EMC,CE

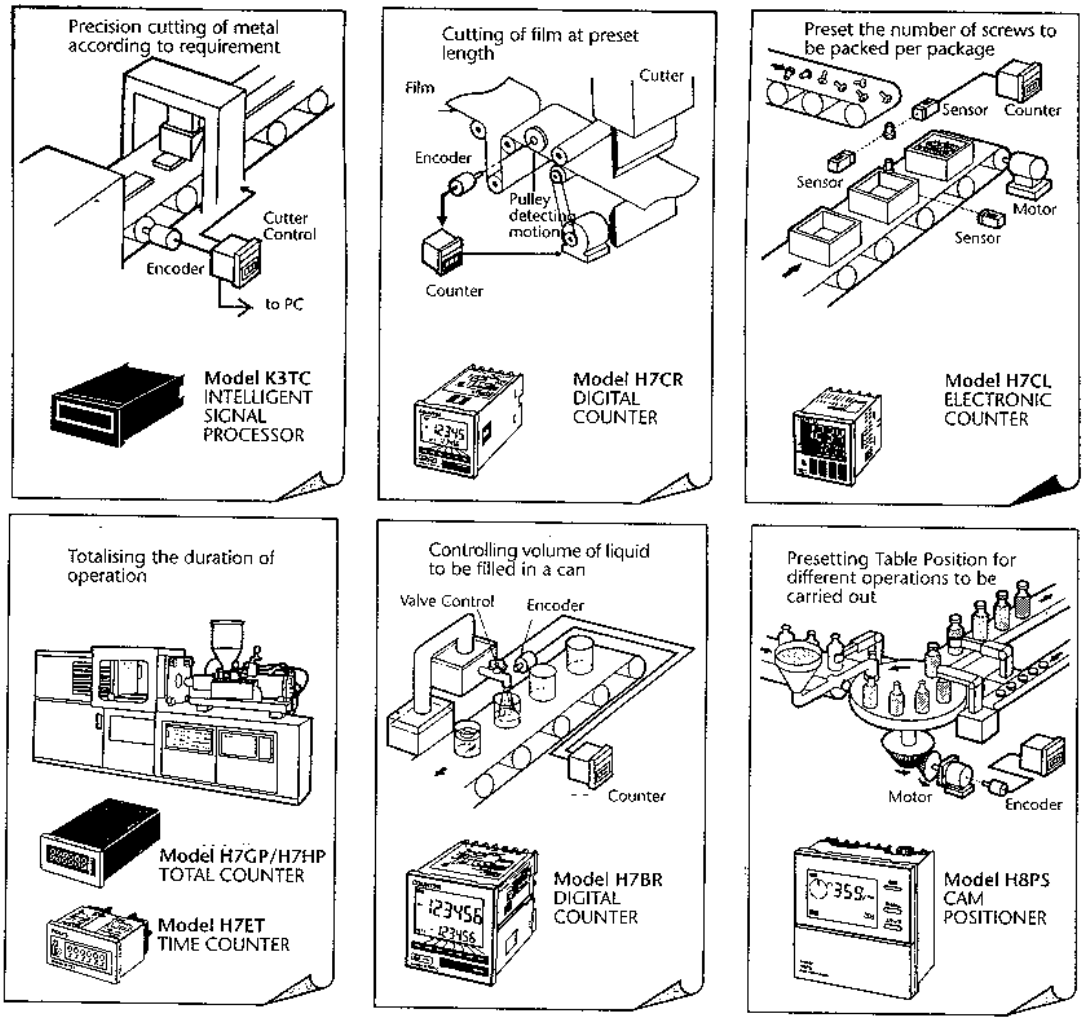
Classification	**Multi-function**	**Thumbwheel Setting**	
Model	**H8CA-S**	**H7AN**	**H7CN**
	Counter/Timer	**LED Counter**	**LED Counter**
Appearance			
Dimension (W x H x D) mm	48 x 48 x 78	72 x 72 x 115	48 x 48 x 97.6
Features	▪ Counter and timer function modes switch selectable. ▪ Selectable operating modes N,F,C,R* ▪ Large easy-to-read LCD display ▪ Wide range of power supply ▪ Non-significant zeros suppressible	▪ LED display ▪ Up/Down/Reversible counter with an option of 1 or 2 Pre-set value. ▪ Selectable operating modes N,F,C,R,K,P,Q* ▪ Simultaneously produce control output of both contact and solid-state ▪ Draw-out construction for ease of maintenance	▪ Up/Down/Reversible counter ▪ High speed counting: 5kcps ▪ Model with memory backup function against power failure available
Operation Modes	Reversible type	Up/Down/Reversible type	Up/Down/Reversible type
Counting Speed	Contact and solid-state input: 30cps Solid state input: 1kcps	30cps/3kcps/5kcps	Contact and solid-state input: 30cps Solid-state input: 5kcps
Number of Digits Displayed	6	2,4,6 or 8	4
Display	Digital display: LCD	Digital display: LED	Digital display: LED Indicator:Count-up indicator
Supply voltage (AC:50/60Hz)	24 to 240VAC, 12 to 24VDC	24, 100 to 240VAC 12 to 24, 48, 100VDC	24, 100 to 240VAC, 12 to 48VDC
Power Consumption (approx.)	2.2VA, 1W	10VA, 5W	12VA, 2.5W
Input Mode	Up/Down (Selectable A,B,C mode), Time limit, Integration	Up,Down, Up/Down (Selectable A,B,C,D,E,F, mode)	Up, Down, Up/Down (Selectable A, B mode)
Input Signal	Count 1, Count 2, Reset, Gate, Start	Count 1, Count 2, Reset and Key protection	Count 1, Count 2, Reset and Key protection
Input Method	No-voltage/voltage input*	No-voltage/voltage input*	No-voltage/voltage input*
Control Output	Contact: SPDT 3A at 250VAC Open collector: 100mA max. at 30VDC max.	Contact: SPDT or SPST-NO 3A at 250VAC (One per stage) Open collector: 100mA max. at 30VDC max.	Contact: SPDT or SPST-NO 3A at 250VAC (One per stage) Open collector: 100mA max. at 30VDC max.
Power source for External Supply	---	80mA at 12VDC	---
Weight (approx.)	130g	360g	150g
Approved Standards & Markings	UL,CSA	UL,CSA	UL,CSA

Classification	**Multi-function**		
Model	**H7CL**	**H7CR**	**H7BR**
	LED Digital Counter	**LCD Digital Counter**	**LCD Digital Counter**
Appearance			
Dimension (W x H x D) mm	48 x 48 x 72.5	48 x 48 x 100	72 x 72 x 100
Features	▪ Simple setting with Incremental Decremental keys ▪ Operating modes include N,F,C,K* ▪ High speed response: 5kcps ▪ Large, high visibility LED display ▪ IP66/NEMA4 water and dust protected	▪ Designed with an emphasis on ease of operation ▪ Up/Down/Reversible counter with optional 1 or 2 pre-set value ▪ Selectable operating modes N,F,C,R,K,P,Q,A,D,L,H* ▪ Pre-scale function to display actual physical parameters (length, volume etc.) ▪ High speed response: 5kcps ▪ On-line change of set value possible	▪ Designed with an emphasis on ease of operation ▪ Up/Down/Reversible counter with optional 1 or 2 pre-set value ▪ Selectable operating modes N,F,C,R,K,P,Q,A,D,L,H* ▪ Pre-scale function to display actual physical parameters (length, volume etc.) ▪ High speed response: 5kcps ▪ On-line change of set value possible
Operation Modes	Up/Down type	Up/Down type	Up/Down Reversible type
Counting Speed	30cps/5kcps	30cps/1kcps/5kcps	30cps/1kcps/5kcps/10kcps
Number of Digits Displayed	-3 to 4	6 or 4	±6
Display	Digital display: LED	Digital display: LCD with backlight	Digital display: LCD with backlight
Supply voltage (AC:50/60Hz)	100 to 240VAC, 12 to 24VDC	24, 100 to 240VAC, 12 to 24VDC	24, 100 to 240VAC, 12 to 24VDC
Power Consumption (approx.)	10VA, 3W	6.5VA, 3.2W	10VA, 6W
Input Mode	Up/Down	Up, Down, Up/Down (selectable A,B,C mode)	Up, Down, Up/Down (Selectable A, B,C mode)
Input Signal	Count, Gate, Reset and Key protection	Count 1, Count 2, Reset and Key protection	Count 1, Count 2, Gate, Reset, Batch Count Reset and Key protection
Input Method	No-voltage input: NPN transistor or switching contact*	No-voltage/voltage input*	No-voltage/voltage input*
Control Output	Contact: SPDT 3A at 250VAC Open collector: 100mA max. at 30VDC max.	Contact: SPDT 3A at 250VAC Open collector: 100mA max. at 12VDC max.	Contact: SPST-NO 3A at 250VAC Open collector: 100mA max. at 30VDC max.
Power source for External Supply	50mA at 12VDC	50mA at 12VDC, 100mA at 24VDC	160mA at 12VDC, 80mA at 24VDC
Weight (approx.)	110 to 130g	120 to 230g	270g
Approved Standards & Markings	UL,CSA,EMC,CE	UL,CSA,EMC,CE	UL,CSA,EMC,CE

Classification	**Intelligent Signal Processor**	**Multi-maintenance**	**Cam Positioner**	
Model	**K3TC**	**H8BM**	**H8PS**	**H8PR**
	High Speed Counter	**Counter/Timer**	**LCD Counter**	**LED Counter**
Appearance				
Dimension (W x H x D) mm	48 x 96 x 130	75 x 75 x 85.7	96 x 96 x 65	144 x 192 x 60
Features	▪ High-speed Up/Down counting for an input range of 50kcps ▪ Wide selection of output:relay transistor, BCD, linear or communications ▪ Pre-scale function to display physical parameters (length, volume, etc.) ▪ Built-in power supply ▪ Banks with four set values and pre-scale values ▪ Five stage outputs	▪ Nine built-in counter/ timers to measure equipment utilization ▪ Can be used as a multi-stage counter ▪ Individual output to indicate maintenance timing ▪ Pre-forecast/Forecast and machine stoppage output provided ▪ Directly connectable to 2-wire sensors ▪ IP54 enclosure rating for resistance to water and oil	▪ Economical electronic high-performance 8-cam control switch ▪ Easy setting ▪ Accepts 330 rpm input for easy compatibility ▪ Functions for switching encoder direction, designating encoder origin etc. ▪ Up to 16-cam control possible using parallel input adapter and two H8PS	▪ Low cost high-performance electronic cam switch ▪ Control outputs can be programmed to turn ON/OFF in 1° units of rotary encoder shaft rotation ▪ A single control output can be programmed to turn ON/OFF up to 10 times ▪ Functions for switching encoder direction, designating encoder origin etc. ▪ Quick response of 5 kHz max.
Operation Modes	Up/Down type	Up type	---	---
Counting Speed	30cps (contact), 50kcps (solid state)	30cps	330rpm	833rpm
Number of Digits Displayed	-4 to 5	6	3 (0 to 359°)	3 (0 to 359°)
Display	Digital display: LED	Digital display: LCD with backlight	Digital display: LCD with backlight	Digital display: LED
Supply voltage (AC:50/60Hz)	100 to 240VAC, 12 to 24VDC	24VDC	24VDC	100 to 240VAC
Power Consumption (approx.)	15VA, 10W	1.8W	4W	10W
Input Mode	Up/Down (selectable B, C mode)	Up/Down (F mode)	---	---
Input Signal	Control input, Sensor A, Sensor B	Count Reset,Re-monitor, Counter select, I/O inhibit	Rotary encoder (Omron E6CP/E6F)	Rotary encoder (Omron E6F), inhibit, Forced Run
Input Method	No-voltage: Contact and solid state	No-voltage/voltage input*	---	---
Control Output	Relay contact (5 output): 5A at 250VAC, Open collector: 50mA at 24VDC, Parallel BCD, Linear output and Communication	Open collector NPN/PNP Forecast (9 lines): 100mA max. at 30VDC max. Machine stoppage: 100mA max. at 30VDC max. Run: 100mA at 30VDC max.	Open collector NPN/PNP: 100mA max. at 30VDC max. Cam: 8 outputs Tachometer: 60-ppr signal out	Open collector NPN/PNP 8/16/24 points: 100mA max. at 30VDC max.
Power source for External Supply	---	---	---	---
Weight (approx.)	450g	290g	300g	1.3kg
Approved Standards & Markings	UL,CSA,EMC,CE	UL,CSA	UL,CSA,EMC,CE	UL,CSA

5-7 Application




Precision cutting of metal according to requirement
Cutter Control
Encoder
to PC
Model K3TC
INTELLIGENT SIGNAL PROCESSOR
Cutting of film at preset length
Film
Cutter
Encoder
Pulley detecting motion
Counter
Model H7CR
DIGITAL COUNTER
Preset the number of screws to be packed per package
Sensor
Counter
Sensor
Motor
Sensor
Model H7CL
ELECTRONIC COUNTER
Totalising the duration of operation
Model H7GP/H7HP
TOTAL COUNTER
Model H7ET
TIME COUNTER
Controlling volume of liquid to be filled in a can
Valve Control
Encoder
Counter
Model H7BR
DIGITAL COUNTER
Presetting Table Position for different operations to be carried out
Motor
Encoder
Model H8PS
CAM POSITIONER

SECTION 6
Power Supply

6-1 What is a Power Supply

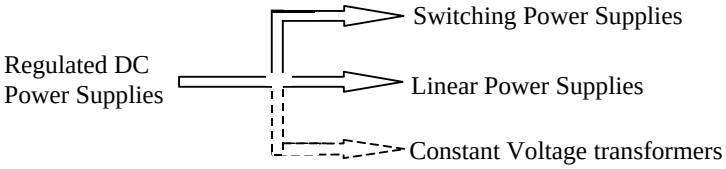
Commercial AC power distributed from power plants cannot be supplied directly to ICs or other electronic components built into Office Equipment and factory Machinery/Equipment. It is because the higher voltage of Commercial AC power supply will destroy/damage them.

Therefore devices called Power supplies (specifically, regulated DC Power Supplies) are thus required to convert Commercial AC power into Regulated DC Power to drive these equipments.

There are a full Range of Power Supplies available from OMRON.

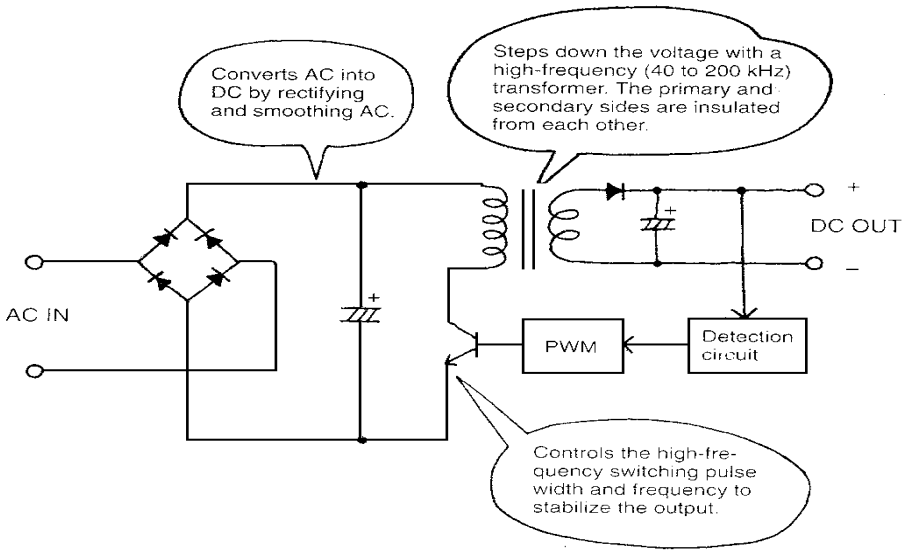
6-2 Regulated DC Power Supplies

There are three kinds of regulated DC power supplies: switching power supplies, linear power supplies, and CVT (constant voltage transformer) power supplies. Of these, switching power supplies and linear power supplies are generated referred to as power supplies. CVT power supplies, though reliable and limited in the number of internal parts, are large and heavy, and are usually treated separately from power supplies in general.



6-3 Switching Power Supplies

Switching power supplies convert commercial AC power into high-frequency DC power using the high-speed switching of semi-conductors built into the switching power supply. Switching power supplies are so compact, light, and efficient that they are used as power supplies by most electronic devices.



Advantages

- Highly efficient, compact, and light.
- A wide input voltage range is available.
- The output is maintained for a certain for a certain period after input power is turned off.

Disadvantages

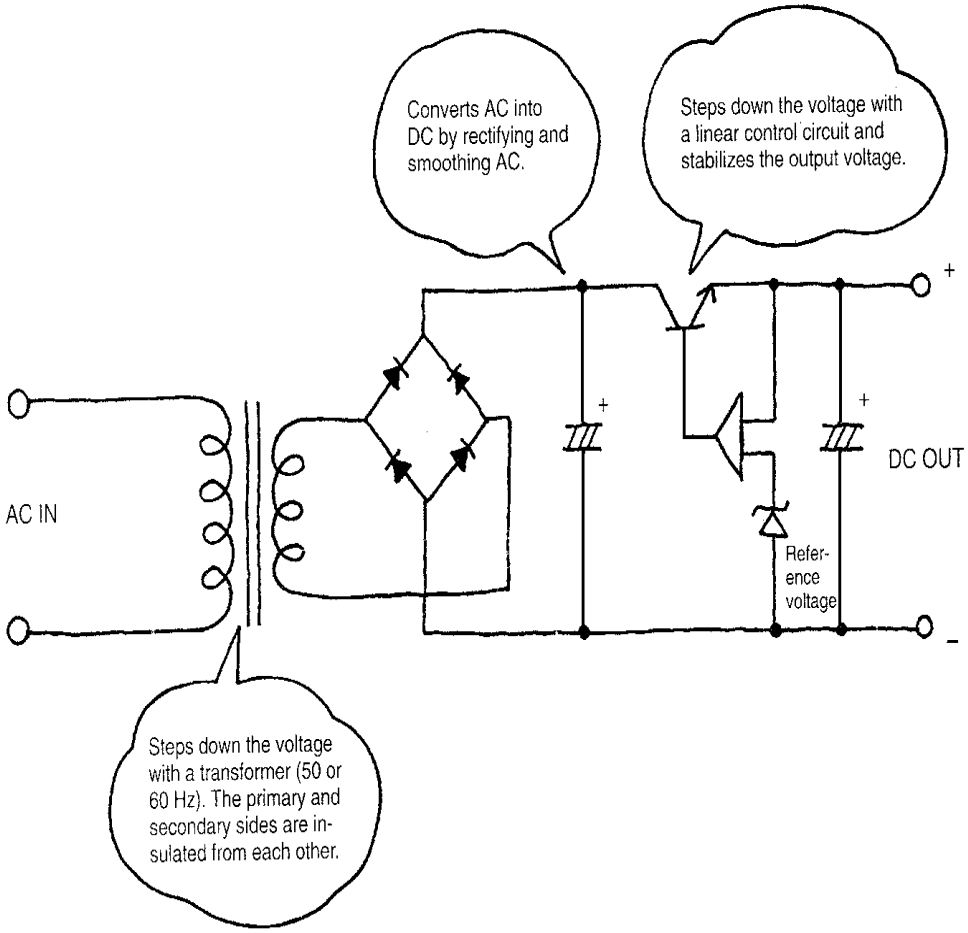
- Switching noise is generated.

Market Share

90% or more of power supplies are switching power supplies.

6-4 Linear Power Supplies

Linear power supplies convert commercial AC into DC power via a step-down transformer (50 or 60 Hz) and a variable resistor. Linear power supplies are so large and heavy that they are used only in special applications.



- Output voltage is very stable.
- No noise is generated.

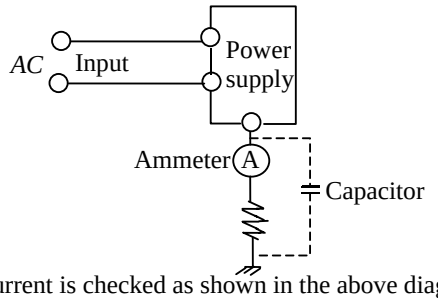
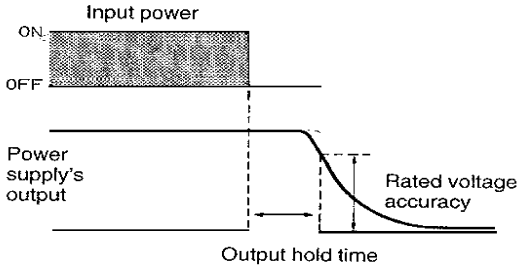
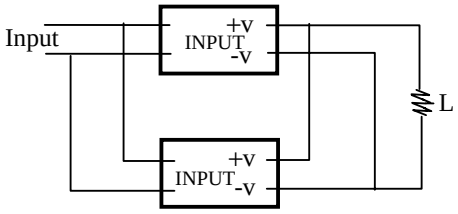
Disadvantages

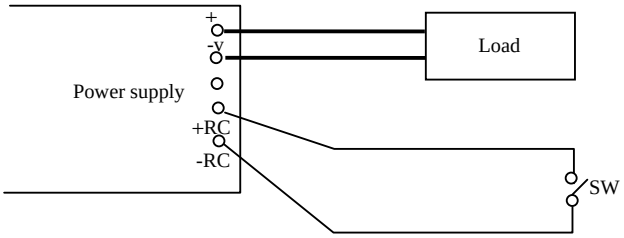
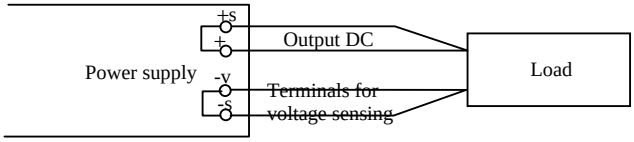
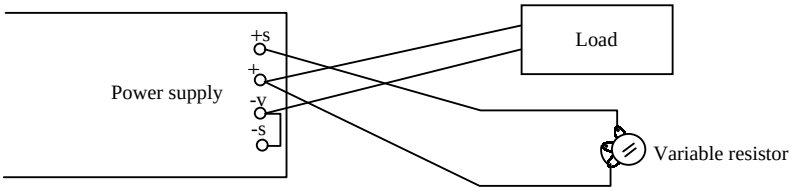
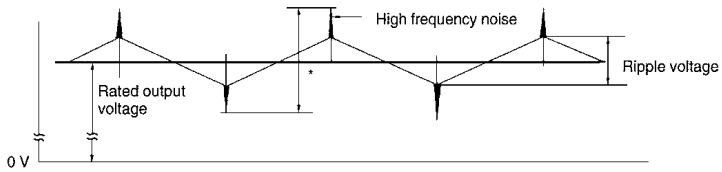
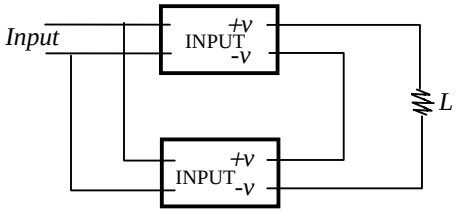
- The transformer is heavy.
- Excessive heat is generated by the power transistor for linear control.

6-5 Linear Power Supplies vs. Switching Power Supplies

Characteristic	Meaning	Linear power supplies	Switching power supplies
Input fluctuation	Output voltage fluctuation resulting from input voltage fluctuation	Good (0.1%)	Fair (0.5%)
Load fluctuation	Output voltage fluctuation resulting from load current fluctuation	Good (0.3%)	Fair (1%)
Ripple noise	Output ripple and noise	Excellent (0.04%)	Fair (1%) Due to high-frequency switching
Input voltage range	Permissible input voltage range	Fair (±10%)	Excellent (+32%/–15%)
Efficiency	(Output power/Input power) x 100%	Fair (40%) • The transformer and transistor built into a linear power supply are so large that the heat generated by the power supply is twice as great as that for switching power supplies. • The efficiency of a linear power supply is 40% due to power lost through transformer coils and magnetic cores.	Excellent (75%) • A switching power supply is nearly twice as efficient as a linear power supply.
Output holding time	Time between power supply input turning off and a drop in power supply output.	Fair (2 ms)	Good (20 ms)
Weight	—	• Very heavy due to the transformer built into the linear power supply.	• A switching power supply is five times lighter than a linear power supply.

6-6 Glossary

Item	Definition
Constant voltage accuracy	The fluctuation of the output voltage due to a change in input, load, or temperature.
Efficiency	Efficiency = (output power/input power) × 100 (%)
Inrush current	There will be an inrush current at the moment AC power is input to the power supply. The inrush current is caused by the charge current flowing into the high-capacity electrode capacitors of the power supply when the power supply is turned on.
Leakage current	The current leaking to the ground from the input lines through the casing of the power supply.  The leakage current is checked as shown in the above diagram. A bypass capacitor is used in accordance with the UL standards.
Noise terminal voltage	A kind of electromagnetic interference. The high-frequence noise voltage generated from the input terminals of the power supply.
Output hold time	The period the power supply keeps outputting at its rated output voltage after the input has turned off. Usually a period of 20 ms minimum is required so that the computer data will not be corrupted at the time of power failure. 
Overload protection	Turns off the output so that the output current will not be more than the value that has been specified to protect the power supply from damage when the load is short-circuited.
Overvoltage protection	Turns off the output to protect the load when the power supply output is excessive. Usually, the output is turned off if the output voltage reaches approx. 120% of the rated output voltage.
Parallel operation	More than one power supply can be connected in parallel. In which case, the total output current is obtained by adding the output current of each power supply connected in parallel. 
Power factor	Power factor = Effective power/Apparent power = Effective power/(Root mean square of voltage × root mean square of current)

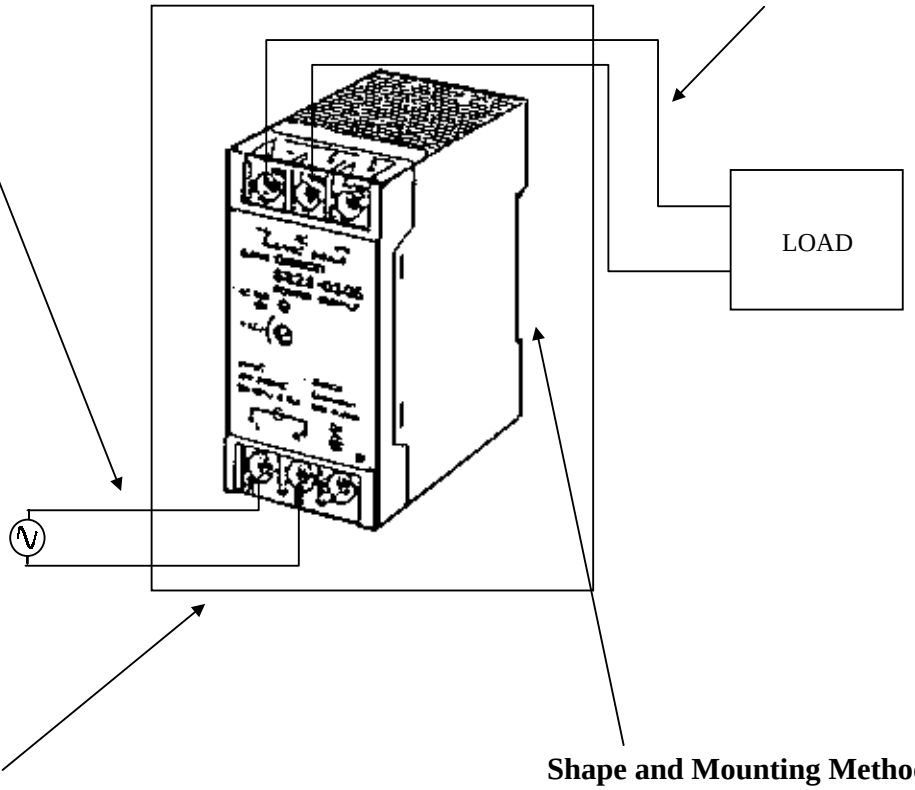
Item	Definition
Rated I/O conditions	The conditions required to operate the power supply at its rated AC input (50/60 Hz), rated output voltage, and rated output current at an ambient temperature of 23°C ±2°C and an ambient humidity of 65% ±5% are called rated I/O conditions.
Rated input voltage	Nominal input voltage such as 100, 110, or 120 VAC
Rated output voltage	Nominal output voltage such as 5, 12, or 24 VDC
Remote control	Remote control function turns the output of the power supply on or off from a distance. 
Remote sensing	The remote sensing function compensates for voltage drop caused by the lead wires between the output terminals and load.  The voltage drop is fed back to the voltage sensing terminal of the power supply to increase the voltage supply by calculating the difference between the set value and the actual voltage supplied to the load.
Remote voltage adjustment	Remote voltage adjustment function is used to adjust the output voltage externally. 
Ripple noise	The combined value of ripple noise added to the output voltage.  *The ripple voltages mentioned in specification sheets include high-frequency noise.
Serial operation	More than one power supply can be connected in series. In which case, the total output voltage is obtained by adding the output voltage of each power supply connected in series. 

6-7 Points of Selection

The input voltage and output capacity (voltage × current) are the most important factors for selecting the most suitable power supply for any application. These and other basic selection points are shown in the following illustration. Confirm all points before selecting a power supply.

Input Voltage
Each power supply has an input voltage range. Select the power supply according to the available input voltage.

Output Capacity (Voltage × current)
The maximum load capacity must be less than the maximum output capacity of the power supply.



Safety Standards
UL-, CSA-, or VDE-approved power supplies are available.

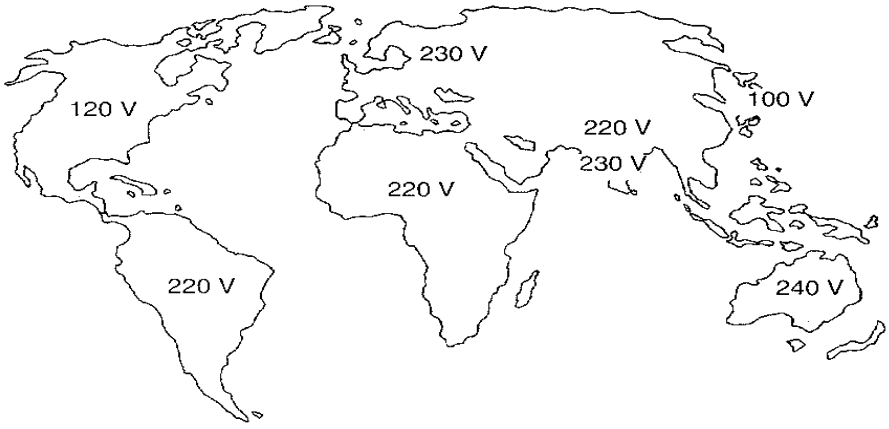
Shape and Mounting Method
Power supplies of various shapes are available. Use the most suitable power supply according to the application. Various mounting brackets are also available.

Main Selection Points:
1. Input Voltage
2. Output Capacity (voltage × current)

6-7-1 Input Voltages

1 Permissible Input Voltage Range

The voltage of commercial AC power varies between different regions of the world as shown in the following diagram.



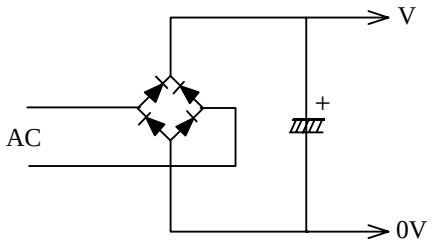
AC Voltages Used Around the World

The following table lists the rated input voltages and permissible voltage ranges of OMRON power supplies.

Rated input voltage	Permissible AC voltage range	Models
100, 110, and 120 VAC	85 to 132 VAC	S82J, S8E1, S82R
200, 220, and 240 VAC	170 to 264 VAC	S82J, S82R
100,110, and 120 V or 200, 220, and 240V (selectable)	85 to 132 V or 170 to 264 V	S82F, S82H, S82L, S82D, S82F-P, S82V, S82G, S82K (30,50, or 100 W)
100, 110, 120, 200, 220, and 240 V	85 to 264 V	S82S, S82K (15 W)

2 Precautions

Switching power supplies rectify the full waves of AC input to output DC using a circuit like the one shown below.



V_{DC} is obtained by multiplying the AC input by √2 (approximately 1.414). If the input is DC, V_{DC} will be obtained in the same way by inputting V_{DC}.

Rectangular pulses are output from uninterruptive power supplies or inverters, and they thus cannot be connected to linear power supplies. Before connecting an uninterruptive power supplies or inverter to a switching power supply, check the input voltage. Inverters generate regenerative voltage, which must be taken into consideration.

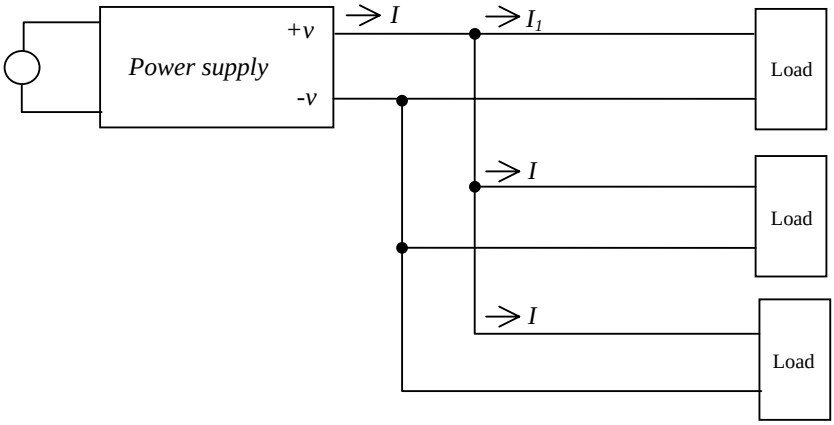
6-7-2 Output Capacities

1 Rated Output Currents

The rated output current of a power supply is computed as follows:

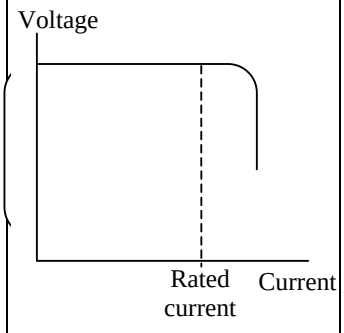
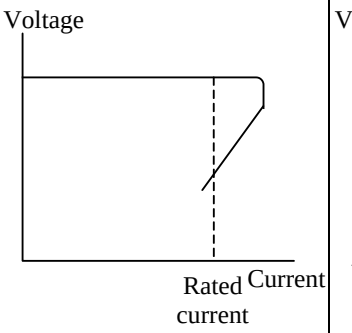
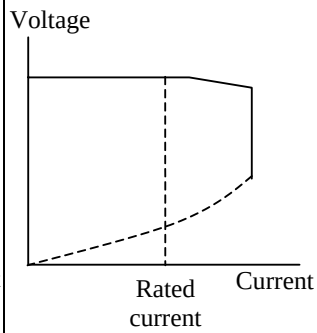
Load current $I_0 = I_1 + I_2 + I_3 \ldots + I_n$

Select a power supply with a sufficient rated output current for the required load current I_0.



2 Overcurrent Protection

Overcurrent protection in a power supply reduces or cuts off the output voltage to protect the power supply and load from being damaged.

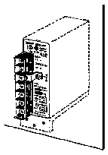
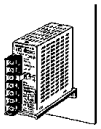
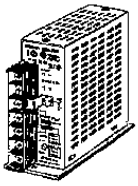
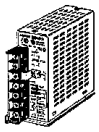
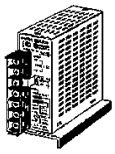
Item	Voltage drop	Hook Drop	Shut Off
Characteristic			
Feature	Automatically resets easily after inrush current flows into the load connected to the power supply.	Lowers the current when subjected to overcurrent. Difficult to reset for loads into which inrush current flows.	Power supply output is interrupted if overcurrent continues for a specified period. Protects the lower supply and load when there is a short circuit.

6-7-3 Mounting Methods

There are various mounting brackets available for OMRON power supplies, including panel mounting and DIN-track mounting.

Model		Mounting Bracket
S82K-series models		Not required
S82S-series models		Not required
S82V-series models		Not required
S82J	10 W	S82Y-01N
	25 W	S82Y-03N
	50W	S82Y-05N
	100/150 W	S82Y-10N
S82H	15 W	S82Y-01N
	30 W	S82Y-03N
	50 W	S82Y-05N
S82R-series models		S82Y-05N
S8E1	10 W	S82Y-01N
	15 W	S82Y-01N
	25 W	S82Y-03N
	50 W	S82Y-05N

Mounting Brackets

Item		F models		B models	S models		Purpose
		Rear mounting	Front mounting		Left-side mounting	Right-side mounting	
							
S82J-series models		Provided with Supply.		None	None		Panel-mounting
S82J (100/150 W)		S82Y-J01F		None	None		
S82L-series models		Provided with Supply		Provided with Supply	Provided with Supply		
S82H	15 W	S82Y-H01F		S82Y-H01B	S82Y-H01S		
	30 W	S82Y-H03F		S82Y-H03B	S82Y-H03S		
	50 W	S82Y-H05F		S82Y-H05B	S82Y-H05S		
	100 W	S82Y-H10F		S82Y-H10B	S82Y-H10S		
S82G	30 W	None		S82Y-G03B	None		
	60 W	None		S82Y-G06B	None		
	100 W	None		S82Y-CM1B	None		
	150 W	None		S82Y-C15B	S82Y-CM1S		
S82F (150/300 W)		None		Provided with Supply	Provided with Supply		
S82D	300 W	None		S82Y-D30B	S82Y-D30S		
	600 W	None		S82Y-D60B	S82Y-D60S		
S82R-series models		Provided with Supply		None	None		
S8E1-series models except PCB models		None		None	None		Built-in
S82F-P (120/240 W)		None		Provided with Supply	Provided with Supply		Peak loads

6-7-4 Safety Standards

Various safety standards have been established to prevent electric shock or fire. For details on each, refer to reference books available on the safety standards.

OMRON's Power Supplies Approved by Safety Standards

Model	UL	CSA	VDE
S82J	UL1012	CSA EB 1402	---
S82K	UL508	CSA C22.2 No.14	VDE 0160
S82S	UL508	CSA C22.2 No.14	---
S82V	UL508	CSA C22.2 No.142	VDE 0160
S8E1	UL1950-D3	CSA C22.2 No.0, EB 1402C	---
S82F	UL1012	CSA EB 1402	---
S82L	UL1012	CSA EB 1402	VDE 0160
S82D	UL1012	CSA EB 1402	---
S82H	UL1012	CSA EB 1402	---
S82G	UL1012	CSA EB 1402	---
S82R	UL1012	CSA EB 1402	---
S82F-P	Approved	Approved	VDE 0160

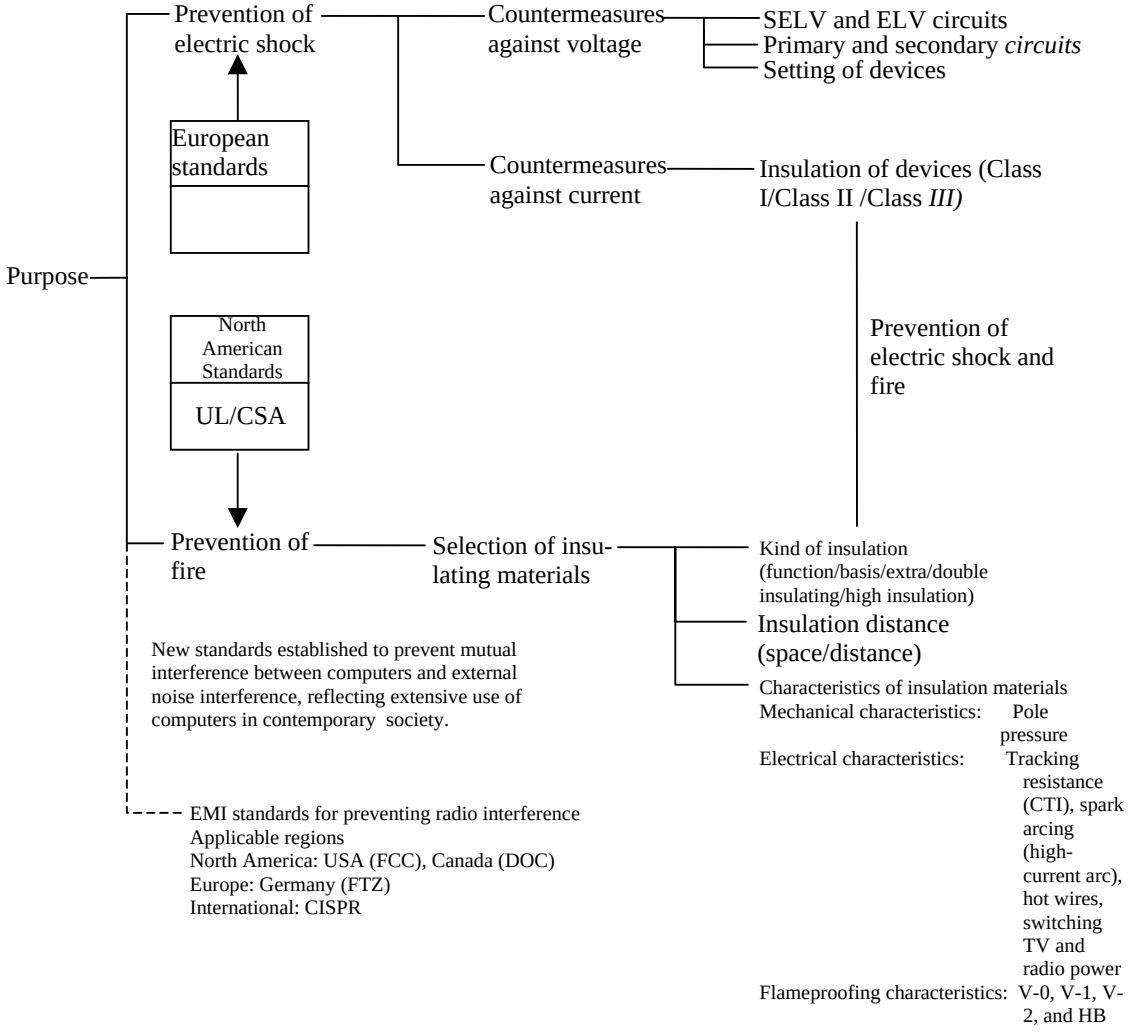
Safety Standards

Today, safety is required from all equipment including power supplies. Strict rules and regulations have been established for safety, such as the USA's UL standards, Canada's CSA standards, and Germany's VDE standards. To protect people and property from electric shock, fire, and other accidents, these standards stipulate the construction and capabilities of individual products. The following table lists the main standards related to power supplies.

Type of standard		International	North America	Europe
Safety standards North America: Protects human life and properly. European: Protects people from death caused by electric shock or prevents electrical fire.		IEC	UL (USA) CSA (Canada)	VDE (Germany) SEV (Switzerland) SEMKQ (Sweden) NEMKQ (Norway) DEMKQ (Denmark) KEMA (Holland) BS (UK) USE (France) CEI (Italy) CEBEC (Belgium) CEE (Europe)
Manufacturing standards (compatible)		ISO	ANSI (USA)	DIN (Germany)
Maritime standards		---	ABS (USA)	LR (UK) GL (Germany) BV (France)
Others	Radio interference	CISPR	FCC (USA) DOC (Canada)	FTZ (Germany)
	Industrial standards	---	NEMA (USA) ASTM (USA)	---

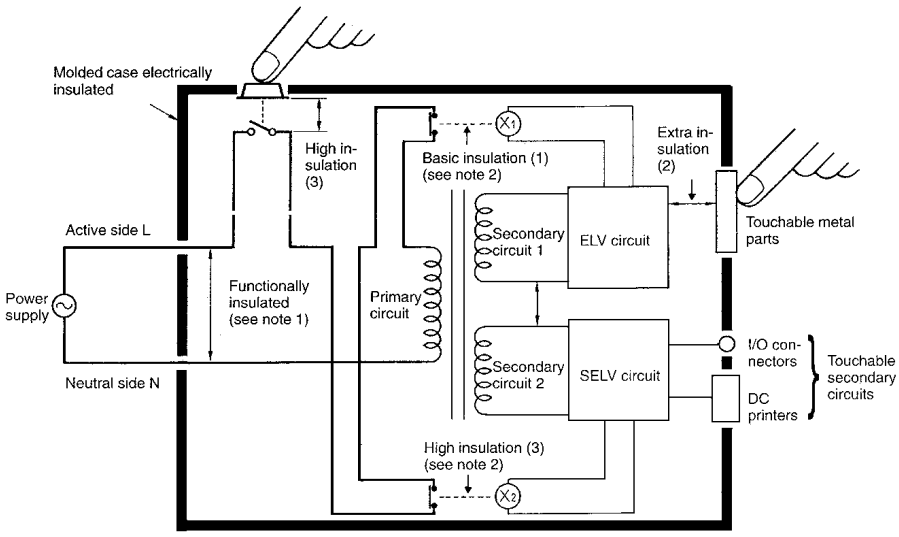
2 Terminology

The following chart shows the relationship between the terms that are often found in approval reports on power supplies and safety standards, including the EMI standards. EMI standards, reflecting contemporary computer proliferation, were established to prevent radio interference.



3 Insulation

Example of Class-II Equipment



*Basic insulation (1) + extra insulation (2) = double insulation, the insulation distance of which is twice as large as that of basic insulation and equivalent to high insulation (3).

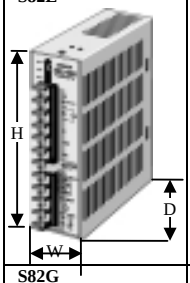
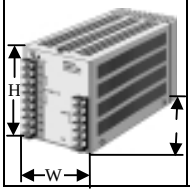
Note 1. The terminals of the primary coil of the transformer are functionally insulated from each other.

2. Basic insulation (1), double insulation, or high insulation may be required of relays depending on how they are used. Relays from which double insulation or high insulation are required are called class-II relays.

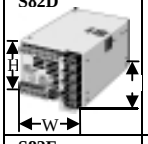
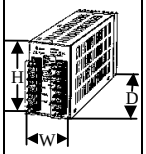
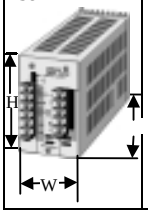
6-8 OMRON Models

This section provides tables for selecting OMRON Power Supplies and converting model numbers.

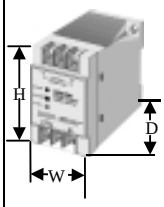
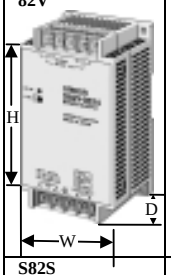
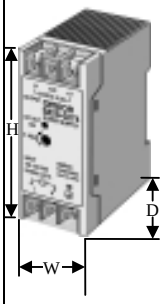
High-grade Power Supplies

Appearance	Input voltage	Output capacity	Output current/voltage and model number				W × H × D	Features	Applications
S82L 	100 or 200VAC (switchable)	30W	**6A at 5V** S82L-0305	**2.5A at 12V** S82L-0312	**2A at 15V** S82L-0315	**1.3A at 24V** S82L-0324	45×150×120	• 7-year guarantee • High-grade power supply • VDE approval	• Public facilities (transportation systems, water-works, and sewer-systems) • Plants and factories • 24-hour lines
		60W	**12A at 5V** S82L-0605	**5A at 12 V** S82L-0612	**4A at 15 V** S82L-0615	**2.5A at 24V** S82L-0624	55×150×120		
		100W	**20 A at 5V** S82L-1005	**9A at 12 V** S82L-1012	**7.2A at 15V** S82L-1015	**4.6A at 24V** S82L-1024	60×190×120		
		150W	**30A at 5V** S82L-1505	**13.5A at 12V** S82L-1512	**10.8A at 15V** S82L-1515	**7A at 24V** S82L-1524	110×200×120		
S82G 	100 or 200 VAC (switchable)	30W	**6A at 5V** S82G-0305	**2.5A at 12V** S82G-0312	**2A at 15V** S82G-0324	**1.3A at 24V** S82G-0324	45× 110× 170	•Highly functional •High quality	
		60W	**12A at 5V** S82G-0605	**5A at 12V** S82G-0612	**4A at 15V** S82G-0615	**2.5A at 24V** S82G-0624	50×110× 190		
		100W	**20A at 5V** S82G-1005	**9A at 12V** S82G-1012	**7.2A at 15V** S82G-1015	**4.6A at 24V** S82G-1024	60× 110× 200		
		150W	**30A at 5V** S82G-1505	**13.5A at 12V** S82G-1512	**10.8A at 15V** S82G-1515	**7A at 24V** S82G-1524	100×120×230		

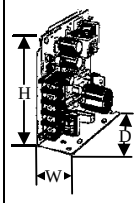
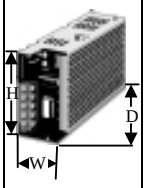
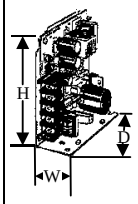
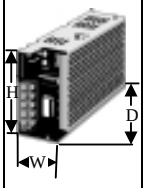
High-capacity Power Supplies

Appearance	Input voltage	Output capacity	Output current/voltage and model number				W× H× D	Features	Applications
S82D 	100 or 200VAC (switchable)	300W	**60A at 5V** S82D-3005	**27A at 12V** S82D-3012		**14A at 24V** S82D-3024	120×92×190	▪ Forced cooling ▪ Built-in fan with an alarm	▪ Large-scale control panels ▪ Molding machines ▪ Factory machines ▪ Robots ▪ Large-scale LED indicators
		600W	**120A at 5V** S82D-6005	**53A at 12V** S82D-6012		**27A at 24V** S82D-6024	190×92×200		
S82F 	100 to 200VAC (switchable)	150W		**13.5A at 12V** S82F-1512		**7A at 24V** S82F-1524	74×120×230	▪ Natural air cooling ▪ Automatic input selection	
		300W				**14A at 24V** S82F-3024	146×120×230		
S82F-P 	100 to 200VAC (switchable)	120W (240W)		5A (a peak current of 10A) at 24V S82F-1224P			74×120×230	▪ Ideal for peak loads ▪ Automatic input selection ▪ VDE approved	▪ Robots ▪ Molding machines ▪ Lab system
		240W (480W)		10A (a peak current of 20A) at 24V			146×120×230		

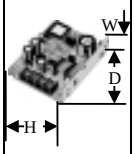
Direct DIN Track-mounting Power Supplies

Appearance	Input voltage	Output capacity	Output current/voltage and model number				W×H×D	Features	Applications
S82K 	100 to 200VAC	15W	2.5A at 5V S82K-01505	1.2A at 12V S82K-01512		0.6A at 24V S82K-01524	45×75× 96	• Direct DIN track mounting • Box-shape • S82K-T models indicate output voltage drop (15-, 30- and 50-W models) and output an alarm signal (100-W model)	• Medium- and small-scale control panels • Control panels • Food processing and packing machines • Industrial machines
	100 or 200VAC (switchable)	30W		2.5A at 12V S82K-03012		1.3A at 24V S82K-03024	90×75× 96		
		50W				2.1A at 24V S82K-05024	90×75× 96		
		100W				4.2A at 24V S82K-10024	135×75× 96		
82V 	100 or 200VAC (switchable)	30W				1.3A at 24V S82V-0324	90×75×96	• Same shape as the thin C20H • 65 mm depth • VDE approval	• Thin control panels • Control panels
		50W				2.1A at 24V S82V-0524	75× 130× 65		
S82S 	100 to 200VAC	3W	0.6A at 5V S82S-0305	0.25A at 12V S82S-0312	0.2A at 15V S82S-0315	0.13A at 24V S82S-0324	37.5×75× 65	• Sensor power supply • Signal switching • Auxiliary power supply • A wide input range	
		7.5W	1.5A at 5V S82S-0705	0.6A at 12V S82S-0712	0.5A at 15V S82S-0715	0.3A at 24V S82S-0724		• 12- to 24-VDC input • DC-DC converter	• PCB power supply • Auxiliary power supply
				+0.3A,–0.2A at ±12V S82S-0727	0.2A at ± 15V S82S-0728				
	12 to 24VDC	3W	0.6A at 5V S82S-7305	0.25A at 12V S82S-7312	0.2A at 15V S82S-7315	0.13A at 24V S82S-7324			
		7.5W	1.5A at 5V S82S-7705	0.6A at 12V S82S-7712	0.5A at 15V S82S-7715	0.3A at 24V S82S-7724			
				+0.3A, –0.2A at ±12V S82S-7727	0.2A at ±15V S82S-7728				

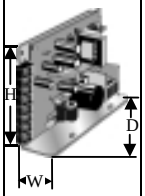
Economical, 100/200 VAC-input Power Supplies

Appearance	Input voltage	Output capacity	Output current/voltage and model number				W× H× D	Features	Applications
S82J  	100VAC	10W	**2A at 5V** S82J-0105	**1A at 12V** S82J-0112	**0.7A at 15V** S82J-0115	**0.5A at 24V** S82J-0124	35× 97× 90	• Each model provided with a mounting bracket for mounting to a control panel • DIN track mounting brackets available (sold separately)	• Medium- and small-scale control panels
		25W	**5A at 5V** S82J-0205	**2.1A at 12V** S82J-0212	**1.7A at 15V** S82J-0215	**1.1A at 24V** S82J-0224	40× 97× 124		
		50W	**10A at 5V** S82J-0505	**4.2A at 12V** S82J-0512		**2.1A at 24V** S82J-0524	40× 97× 161		
		100W	**20A at 5V** S82J-10005A1	**8.5A at 12V** S82J-10012A1	**7.0A at 15V** S82J-10015A1	**4.5A at 24V** S82J-1024	5-,12-,15-V models: 50× 97× 198		
							24-V model: 50× 97×170		
		150W				**6.5A at 24V** S82J-15024A1	50× 97× 198		
S82J  	100VAC	10W	**2A at 5V** S82J-5105	**1A at 12V** S82J-5112	**0.7A at 15V** S82J-5115	**0.5A at 24V** S82J-5124	35× 97× 90		
		25W	**5A at 5V** S82J-5205	**2.1A at 12V** S82J-5212	**1.7A at 15V** S82J-5215	**1.1A at 24V** S82J-5224	40×97× 124		
		50W	**10A at 5V** S82J-5505	**4.2A at 12V** S82J-5512		**2.1A at 24V** S82J-5524	40×97× 161		
		100W	**20A at 5V** S82J-10005D1	**8.5A at 12V** S82J-10012D1	**7.0A at 15V** S82J-10015D1	**4.5A at 24V** S82J-5024	5-,12- and 15-V models: 50×97× 198		
							24-V model: 50×97× 170		
		150W				**6.5A at 24V** S82J-15024D1	50×97× 198		
S82J  	200VAC	10W	**2A at 5V** S82J-2105	**1A at 12V** S82J-2112	**0.7A at 15V** S82J-2115	**0.5A at 24V** S82J-2124	35×97×90	• Each model provided with a mounting bracket for mounting to a control panel • DIN track mounting brackets available (sold separately)	• Medium- and small-scale control panels
		25W	**5A at 5V** S82J-2205	**2.1A at 12V** S82J-2212	**1.7A at 15V** S82J-2215	**1.1A at 24V** S82J-2224	40×97× 124		
		50W	**10A at 5V** S82J-2505	**4.2A at 12V** S82J-2512		**2.1A at 24V** S82J-2524	40×97× 161		
		100W	**20A at 5V** S82J-10005A2	**8.5A at 12V** S82J-10012A2	**7.0A at 15V** S82J-10015A2	**4.5A at 24V** S82J-2024	5-,12-,and 15-V models: 50×97× 198		
							24-V model: 50×97× 170		
		150W				**6.5A at 24V** S82J-15024A2	50×97× 198		
S82J  	200VAC	10W	**2A at 5V** S82J-6105	**1A at 12V** S82J-6112	**0.7A at 15V** S82J-6115	**0.5A at 24V** S82J-6124	35×97× 90		
		25W	**5A at 5V** S82J-6205	**2.1A at 12V** S82J-6212	**1.7A at 15V** S82J-6215	**1.1A at 12V** S821J-6212	40×97× 124		
		50W	**10A at 5V** S82J-6505	**4.2A at 15V** S82J-6215		**2.1A at 24V** S82J-6524	40×97× 161		
		100W	**20A at 5V** S82J-10005D2	**8.5A at 12V** S82J-10012D2	**7.0A at 15V** S82J-6024	**4.5A at 24V** S82J-2024	5-,12-, and 15-V models: 50×97× 198		
							24-V model: 50×97×170		
		150W				**6.5A at 24V** S82J-15024D2	50×97× 198		

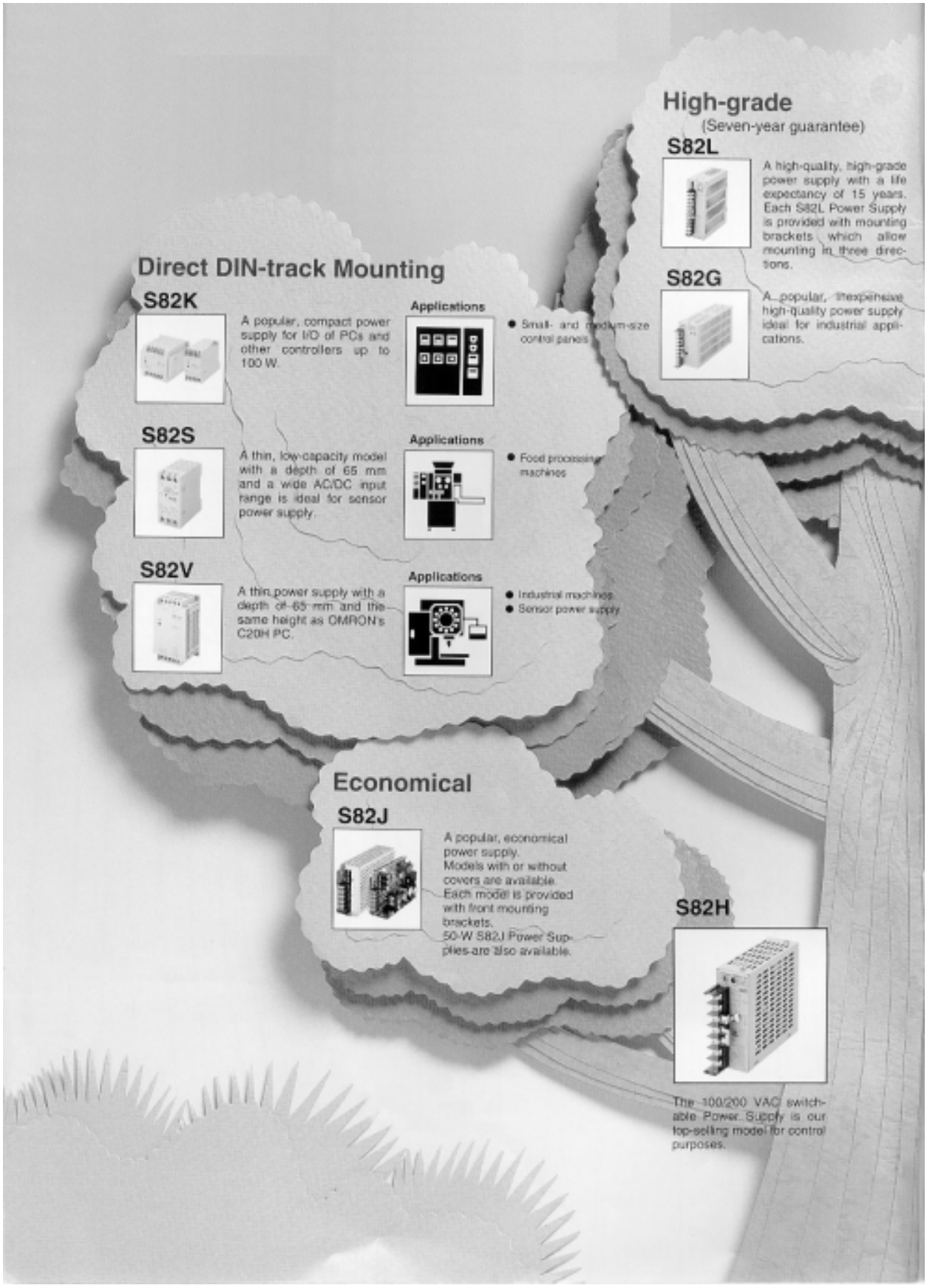
Built-in Power Supplies

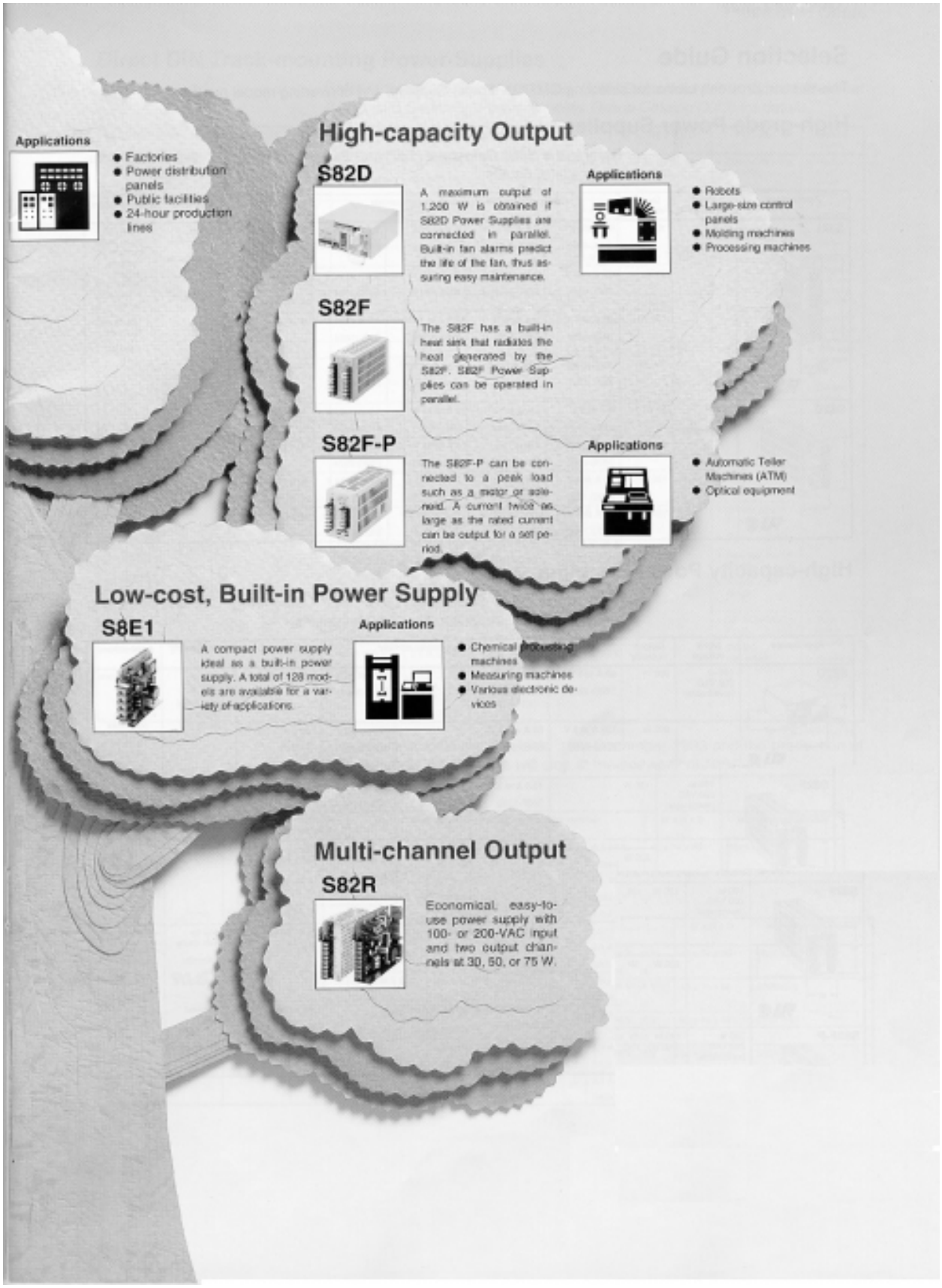
Appearance	Input voltage	Output capacity	Output current/voltage and model number				W×H×D	Features	Applications
S8E1  	100VAC	10W	24A at 5V S8E1-01005	1A at 12V S8E1-01012	0.7A at 15V S8E1-01015	0.5A at 24V S8E1-01024	24× 69× 85	• Twice as compact as the S82J • A total of 128 models available for a variety of applications	• Measuring equipment • Chemical equipment • Terminals • Automobile parking systems • Home security systems • Built-in power supplies for electronic devices.
		15W	3A at 5V S8E1-01505	1.3A at 12V S8E1-01512	1A at 15V S8E1-01515	0.7A at 24V S8E1-01524	34× 69× 94		
		25w	5A at 5V S8E1-02505	2.1A at 12V S8E1-02512	1.7A at 15V S8E1-02515	1.1A at 24V S8E1-02524	35× 69× 123		
		50W	10A at 5V S8E1-05005	4.2A at 12V S8E1-05012	3.4A at 15V S8E1-05015	2.2A at 24V S8E1-05024	37× 69× 161		

Multi-point Power Supplies

Appearance	Input voltage	Output capacity	Output current/voltage and model number		W×H×D	Features	Applications
S82R  	100VAC	30W	**2A at 5V and 2A at 12V** S82R-0321	**2A at 5V and 1A at 24V** S82R-0322	40×97× 161	• Same depth and mounting method for all models • Mountable in any of three directions	• Measuring equipment • Chemical equipment • Built-in power supplies for electronic devices.
			1.7A at 12V and 0.8A at 12V S82R-0327	**1A at ±15V** S82R-0328			
		50W	**3A at 5V and 3A at 12V** S82R-0521	**2A at 5V and 2A at 24V** S82R-0522	40× 112× 161		
			3A at 12V and 1.2A at 12V S82R-0527	**1.7A at ±15V** S82R-0528			
		75W	**5A at 5V and 2A at 24V** S82R-5722		44× 123× 161		

6-9 Applications




Applications
● Factories
● Power distribution panels
● Public facilities
● 24-hour production lines
High-capacity Output
S82D
A maximum output of 1,200 W is obtained if S82D Power Supplies are connected in parallel. Built-in fan alarms predict the life of the fan, thus assuring easy maintenance.
Applications
● Robots
● Large-size control panels
● Molding machines
● Processing machines
S82F
The S82F has a built-in heat sink that radiates the heat generated by the S82F. S82F Power Supplies can be operated in parallel.
S82F-P
The S82F-P can be connected to a peak load such as a motor or solenoid. A current twice as large as the rated current can be output for a set period.
Applications
● Automatic Teller Machines (ATM)
● Optical equipment
Low-cost, Built-in Power Supply
S8E1
A compact power supply ideal as a built-in power supply. A total of 128 models are available for a variety of applications.
Applications
● Chemical processing machines
● Measuring machines
● Various electronic devices
Multi-channel Output
S82R
Economical, easy-to-use power supply with 100- or 200-VAC input and two output channels at 30, 50, or 75 W.

SECTION 7
Sensors

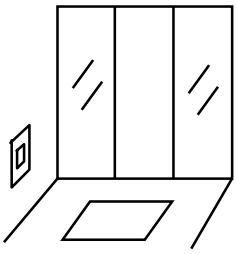
7-1 What is a Sensor?

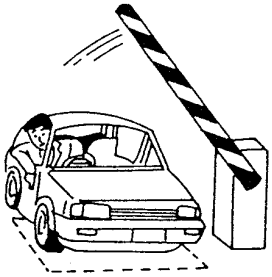
An equipment use to capture the outer changes (information) like power, heat, lightning, magnetic, sound waves and convert it to a electric signal and then transmit it to the related control components.

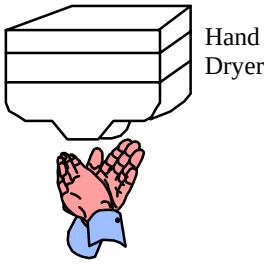
7-1-1 Sensor Field Usage

Sensor is not only use in the control business. But also in other field. So, what is the objective and in what way is it use for.

7-1-2 Example







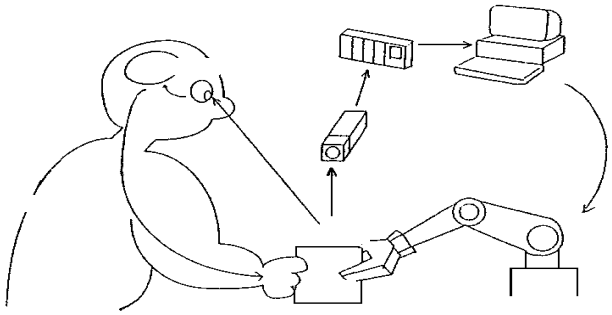
7-1-3 Human 5 Senses and Sensor

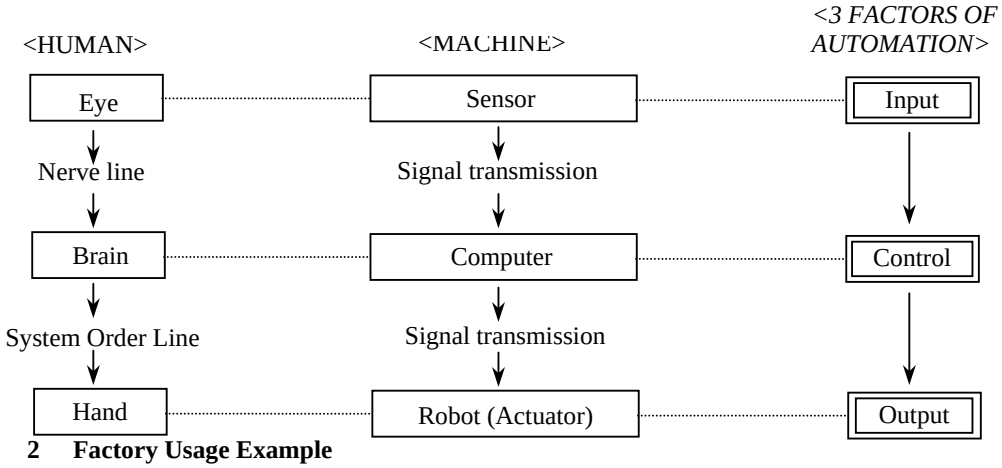
Human is using its 5 senses in order to capture the other changes. Let's think about the corresponding of sensor with human's 5 senses.

5 Senses	Outer Changes	Sensor
Vision	Brightness and Darkness/ Object size/Style/Distance/Color	TV Camera
Touch	Pressure/Temperature/Pain/Itchiness/Article contact/Approach	Thermometer Switch
Taste	Sweet/Spicy/Sour/Bitter/Salty	PH
Hearing	Air vibration Sound Strength/High Low/Tune	Microphone
Smelling	Gas Chemical Content	Alcohol Detection Gas Detection

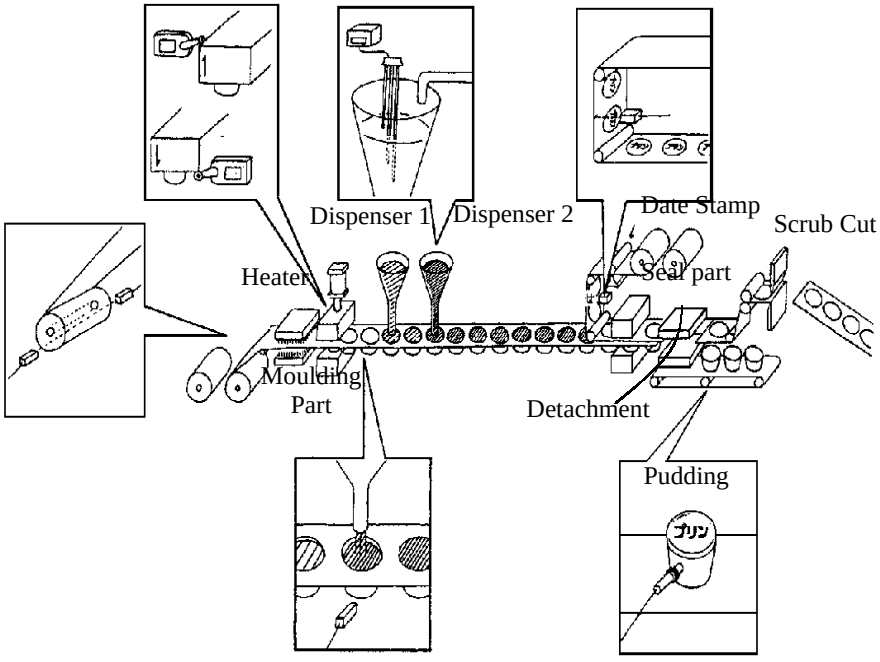
7-1-4 Sensor Role In Automation

1 Corresponding Relation Within Human & Machine



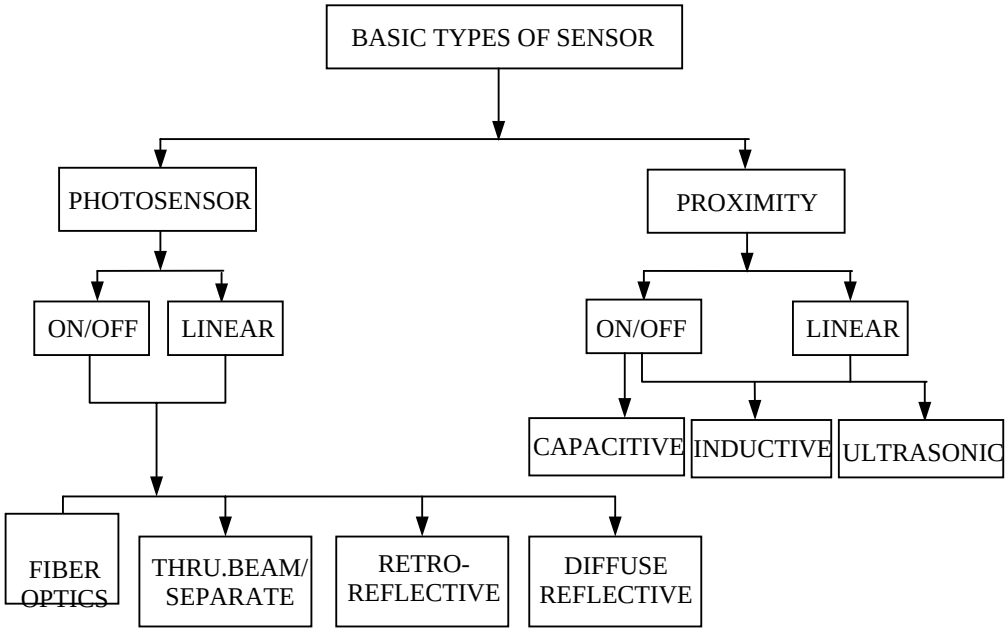


2 Factory Usage Example



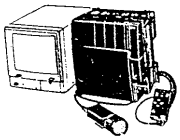
1 Sensor is taking up a responsibility to call [Input] in the 3 elements in automation

7-1-5 Classification of Sensors



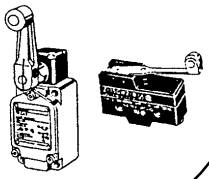
7-1-6 Types of Omron Sensors

Vision Sensor



Thermacoupl

Switch



Pressure Sensor

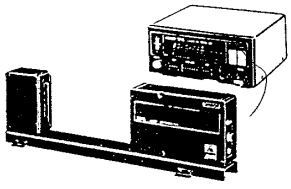
Displacement Sensor

Rotary Encoder

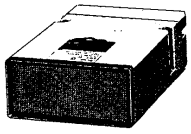
Photoelectric Sensor

Proximity Sensor

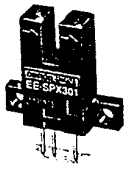
Laser Micro Meter



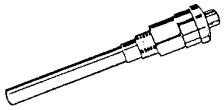
Ultrasonic Sensor



Photomicro Sensor



Level Sensor



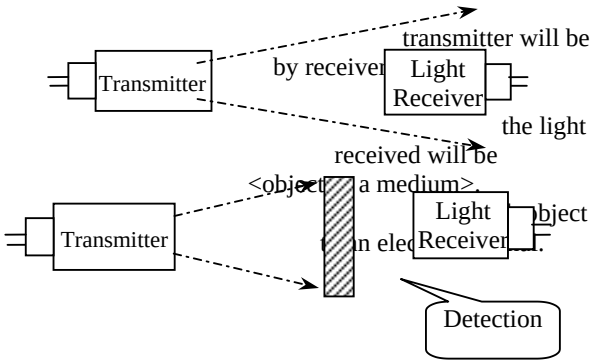
7-2 Photoelectric Sensor (PES)

What is PES (Photoelectric Sensor)?

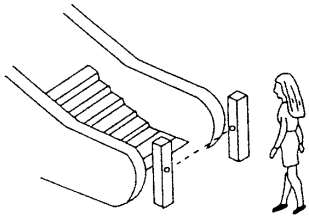
An equipment which uses [Light] as signal media, to detect the changes of condition without any contact, and then convert it to a electrical output signal.

Concept
There will be little changes depending on the type. Basically detects through the following concept.

1. Usually light emit out from transmitter will be received by receiver
2. If an object passed through path, the light received will be interrupted.
3. Receiver will change the pass information



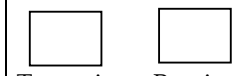
Eg) Escalator



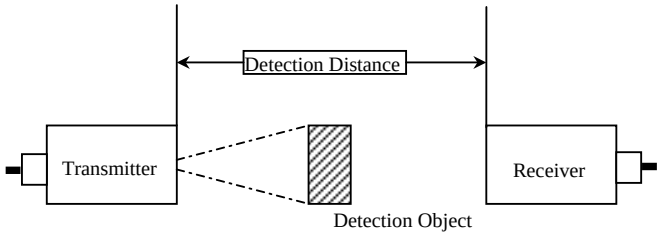
7-2-1 Photoelectric Sensing Methods

Thru Beam Type (Separate/Thru-Beam Type) — **E3S-AT**

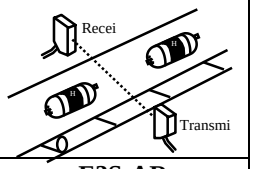
<Detection Theory>
Position the transmitter & receiver in a Face to Face position, usually light transmitted out from transmitter goes into the receiver. If the object blocks the light, the volume of light received by the receiver will be changed, and the operating mode will depend on the light volume.



<Diagram>

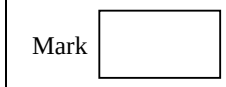


Application

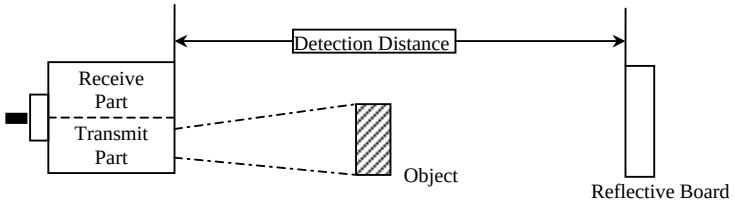


Retroreflective Type — **E3S-AR**

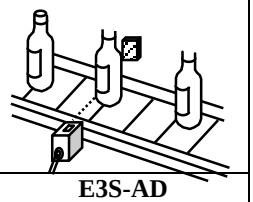
<Detection Theory>
The transmitter & receiver are in the same housing unit, usually light from transmitter will be beam towards the reflector and then reflect back to the receiver. If object blocks the light, the volume of light the receiver received will be changed and the operating mode will depend on the light volume.



<Diagram>

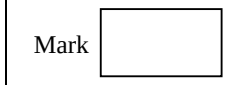


Application

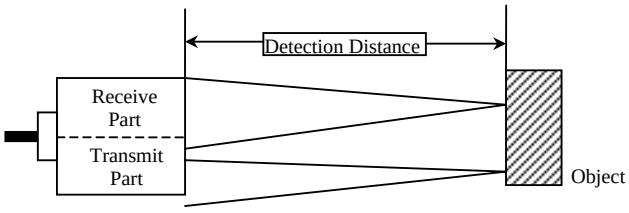


Diffuse reflective Type — **E3S-AD**

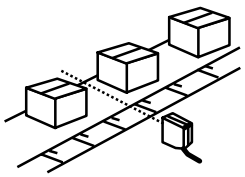
<Detection Theory>
The transmitter & receiver are in the same housing unit; usually light is continuously send from transmitter. It uses object, as a medium to reflect the transmitted light back to the receiver and the operating mode will depend on the transmitted light volume.



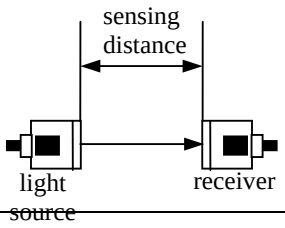
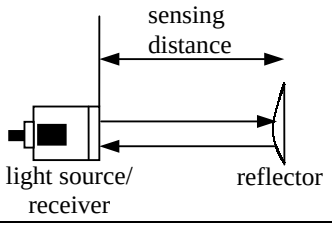
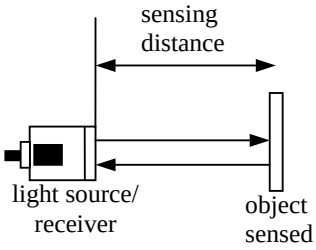
<Diagram>



Application



7-2-2 Classification by Sensing Methods

TYPE	DEFINITION	FEATURES
Separate Type		- Longest Range - Highest light/dark ratio - Not effected by target colour or surface
Retro-reflective Type		- Long Range - High light/dark ratio - Adhesive and sticker reflector available
Diffuse reflective Type		- Detecting distance max. 2M - Easy installation - Light/dark ratio is more critical than the above

7-2-3 Typical Omron Built in Amplifier Photoelectric Sensors

E3S-R	E3V3	E3F2
Transparent Object Detection	Vibration Resistance	Cylindrical Size
		

E3J2	E3T
Low- cost	Mini-mini Sensor
	

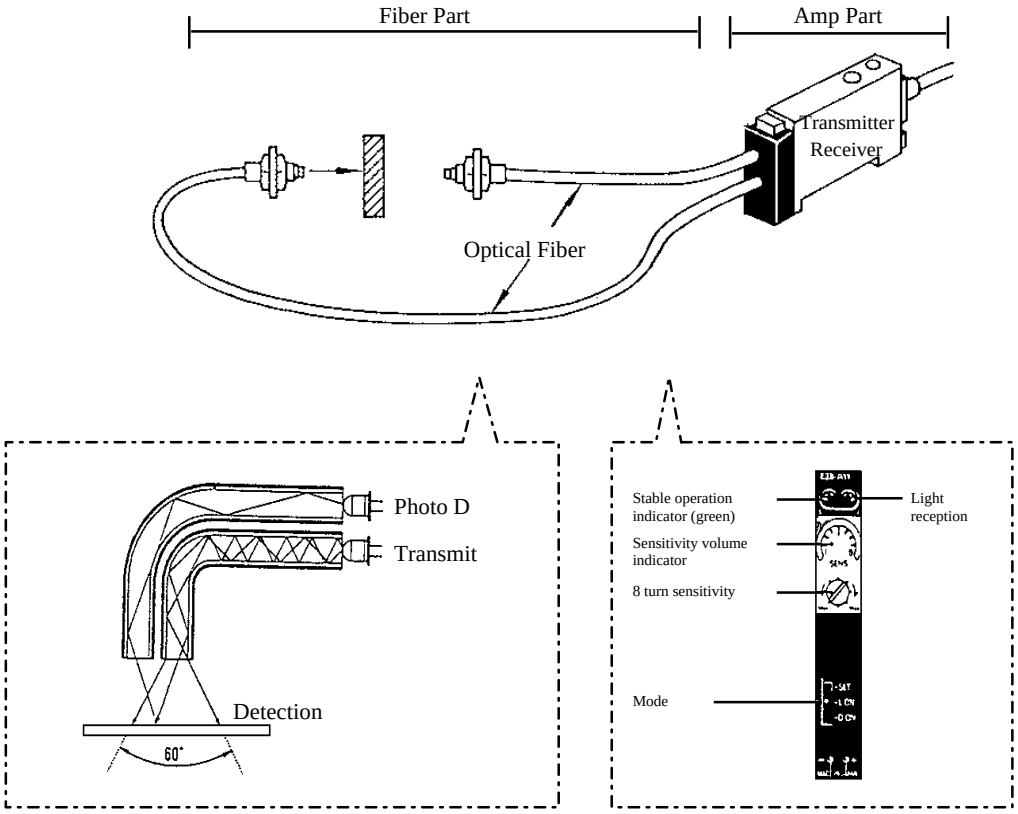
E3S-A	E3S-B	E3S-C
Standard Size	Compact Size	Heavy-duty Plug-in
		

7-2-4 Optical Fiber Photoelectric Sensor

What is Optical Fiber Photoelectric Sensor?

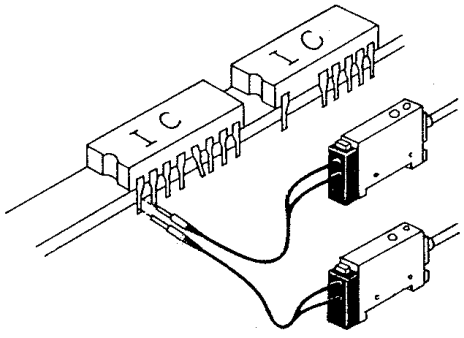
In the earlier session the PES has a built in Amplifier and the Transmitter & Receiver utilises lenses. And Optical Fiber PES actually replaces these lenses with Fiber Optics

Configuration Diagram



Application Example

IC lead bent & slipped pin detection
(Use Diffuse Reflective)



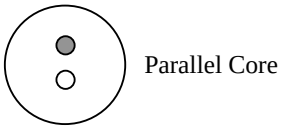
7-2-5 Three Common Types of Optic Fiber

1 Separate/Thru-Beam

2 Retroreflective

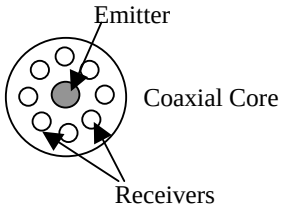
Emitter & Receiver (Operates with reflector)

3 Diffuse Reflective



Emitter & Receiver

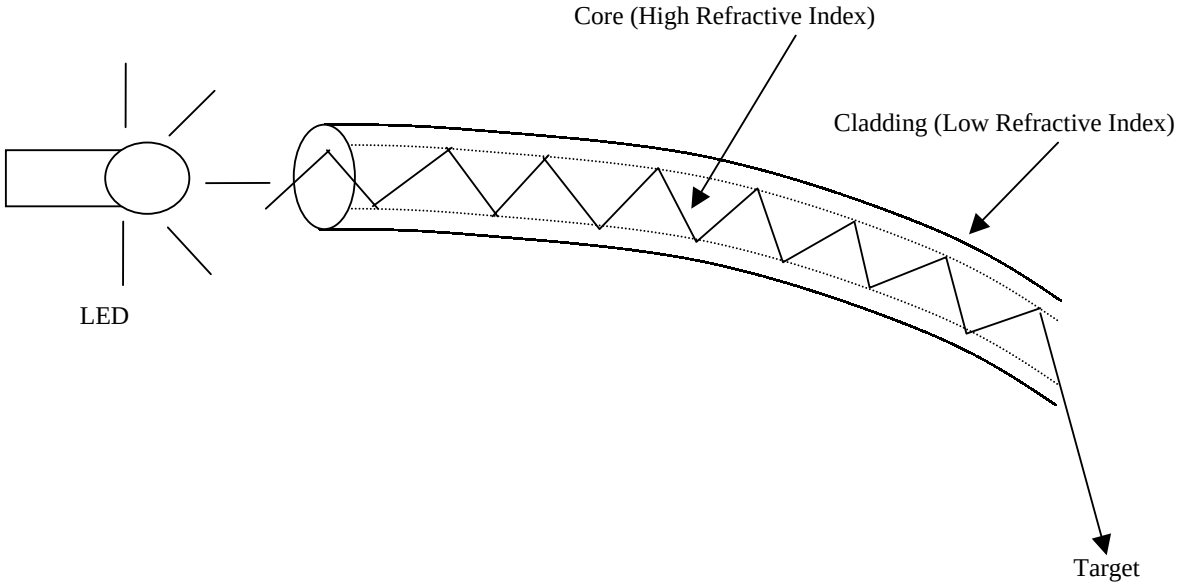
- General used in most fiber sensors



- High precision type
- Operating position is not affected by the direction of target entering the detecting area.

7-2-6 Operating principle

- The Optical Fiber consists of the Core and the Cladding.
- The light beam, which travels through the Core at a bouncing angle of approx. 60-degree, was emitted to the target without any loss in light intensity.



7-2-7 Types of Fiber Optic

A) Plastic Filament Fiber

- The Core of the plastic-fiber consists of one or more fibers 0.25 to 1.5mm in diameter, encased in plastic or polyethylene sheath.
- Used in most of the optical fiber sensor
- Features: Light, flexible & cost-effective

B) Glass Filament Fiber

- Consists of glass fiber encased in stainless steel tubing.
- Best to use at high operating temperatures(400°C).

7-2-8 Typical Omron Fiber Optic Photoelectric Sensors

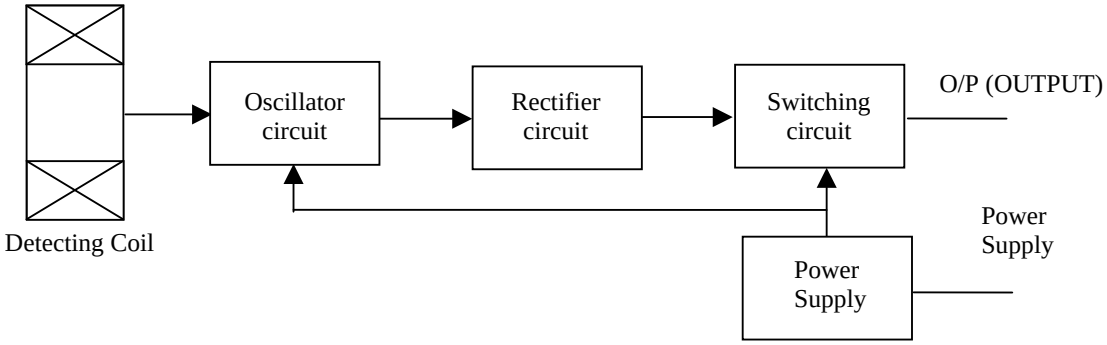
E3X-N		E3X		
E3X-NT/NM	E3X-NH	E3X-A	E3X-F	E3X-VG
Teaching Optical Fiber	Fine Tuning Fiber	General-Purpose	Shorter Response Time	Mark-Sensing
				

7-3 Proximity Sensor

What is a Proximity Sensor?

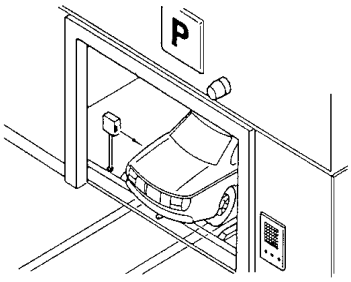
Proximity sensor is a device for detecting objects by making use of the changes in the magnetic/electric field without any contact to the object.
There are basically 2 types of Proximity Sensor available:
1. Inductive
2. Capacitive

7-3-1 Inductive



- High Frequency Magnetic Field is Generated by the Coil.
- Metallic Target Approaches the Detecting Coil will Dampen the Oscillation Around the Detecting Coil.
- The Changes of Condition Thus Causes the Switching Circuitry to Change State.

Familiar application



[Car Park Vehicle Detector]
In front of the entrance gate, a big proximity sensor was set underground and it detect the on ground vehicle by sending the signal to the closing gate motor.

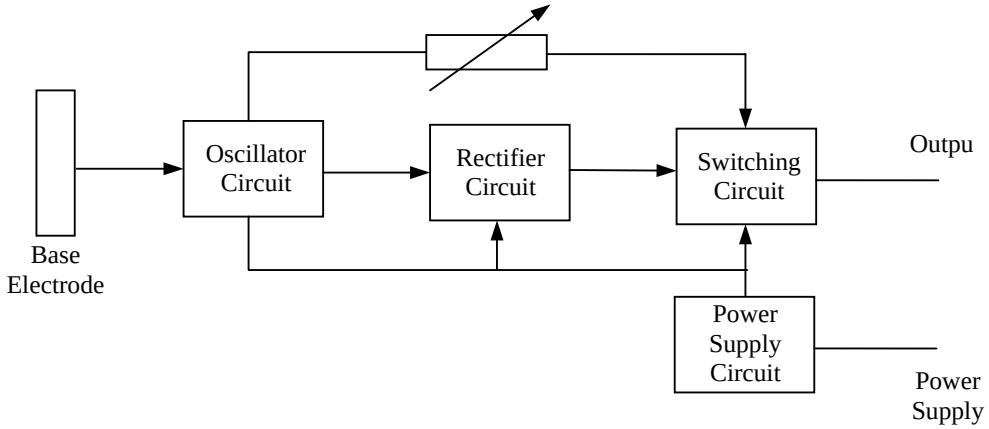
Note: Some car park uses PES

7-3-2 Typical Omron Inductive Sensors

E2E	**E2EC**	**TL-W**
Cylindrical Type	Subminiature Cylindrical Type	Flat Type
		

TL-N	**TL-Q/TL-G**
Square type	Subminiature Square Type
	

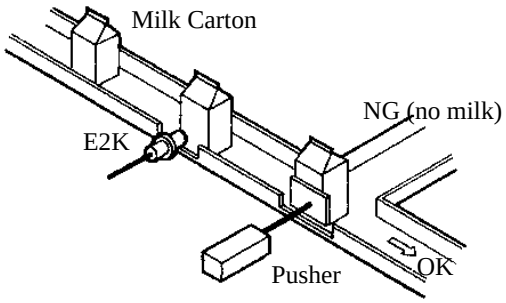
7-3-3 Capacitive



- Approach of object will cause electrostatic capacitance of the base electrode to change.
- Electrostatic capacitance increases as the object approaches.
- Oscillator circuit changes the amplitude of oscillation proportionally.
- Increase in oscillation increases the output voltage of the rectifier circuit, thus causes the switching circuit to change state.

Familiar application

Milk Detection (in carton)
The use of a capacitive proximity switch ensures that the contents of opaque containers are present.



Capacitive Proximity Switch

7-3-4 Typical Omron Capacitive Sensors

E2K	
E2K-C	E2K-F
Cylindrical Type	Square Type
	

7-3-5 Features of Inductive Proximity Sensors

- No Physical Contact.
- Reliable in Hazardous.
- Long Service Life.
- Fast Response.

7-3-6 Features of Capacitive Proximity Sensors

- Senses Almost Every Kind of Object, Metallic and Nonmetallic (Glass, Water, Oil, Plastic, Etc).
- Indirectly Senses Object Buried in a Nonmetallic Wall or Placed in a Nonmetallic Container.
- Protection Against Dust and Jets of Water.
- LED Operation Indicator.

7-4 Comparison between PES and Proximity Sensor

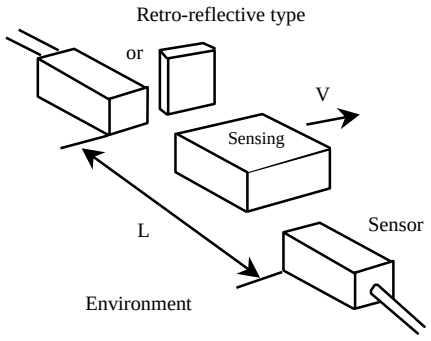
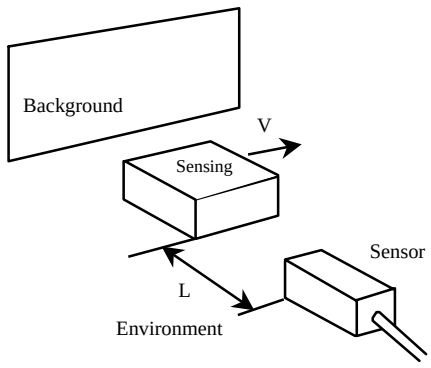
It is because both PES and Proximity Sensor works on ”NO CONTACT” detection method, therefore both will have a very long life span, and fast response performance.

Features	PES	Proximity Sensor (Inductive)
Detection object	Can detect almost/any object	Metal only (even conceal/hide also can be detected)
Detection distance	Long Sensing Distance	Short Sensing Distance
Protect structure	Also provided with IP67 protection but generally it is not so superior	Excellent (also excel in oil resistance)
Shock resistance Vibration resistance	Weak	Strong
Price	High cost	Low cost

7-5 Pointers of Selection

7-5-1 Photoelectric Sensor

1. Points for good selection

<table>
<tr><th colspan="2">Thru-Beam type and retro-reflective type</th><th colspan="2">Reflective type</th></tr>
<tr><td>Sensing object</td><td>1. Size and shape (length × depth × height)
2. Transparent ratio (non-transparent, half-transparent, full-transparent)
3. Movement speed V (m/s or pcs/min)</td><td>Sensing object</td><td>1. Size and shape (length × depth × height)
2. Color
3. Materials (Steel, timber, paper, etc).
4. Surface (rugged, luster)
5. Movement speed V (m/s or pcs/min)</td></tr>
<tr><td>Sensor</td><td>1. Sensing distance (L)
2. Restrictions on shape and size (a) Sensor
(b) Retro-reflector for retro-reflective type
3. Use of several sensors
(a) Quantity
(b) Installation pitch
(c) Alternate installation
4. Restrictions on installation (Install at certain angle to object)</td><td>Sensor</td><td>1. Sensing distance (distance to object) (L)
2. Restrictions on shape and size
3. Use of several sensors
(a) Quantity
(b) Installation pitch
4. Restrictions on installation (Install at certain angle to object)</td></tr>
<tr><td>Environment</td><td>1. Surrounding temperature
2. Use of water, oil, chemicals
3. Others</td><td>Background</td><td>1. Color
2. Materials (Steel, timber, paper, etc)
3. Surface (rugged, luster)</td></tr>
<tr><td colspan="2" rowspan="2">Application
 
</td><td>Environment</td><td>1. Surrounding temperature
2. Use of water, oil, chemicals
3. Others</td></tr>
<tr><td colspan="2">Application
 
</td></tr>
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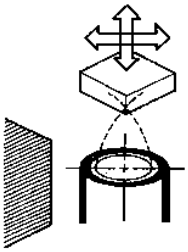
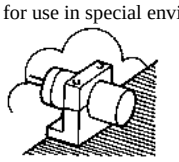
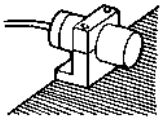
7-5-2 Proximity Sensors

(1) Applications

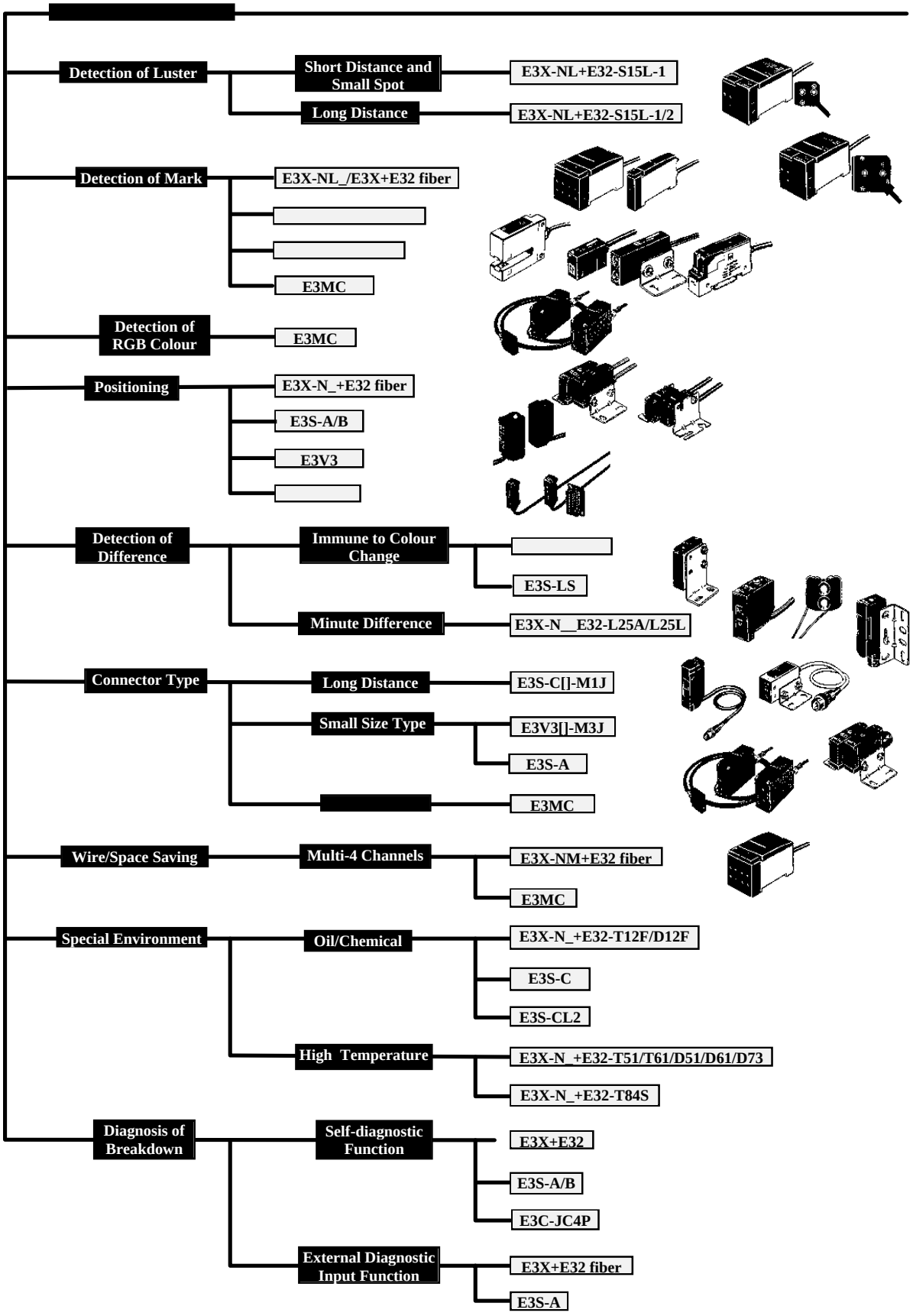
Conditions	Review Points
Applications	 *Flow of object* — Intervals, speed, vibration — Detection distance, Temperature voltage, Response (response frequency) Object — Size, shape, plated or non-plated, materials — Detection distance, Shape of detection point (prism, cylinder, piercing or gutter) Detection distance — Ununiform passing point Permissible error — Temperature voltage, Surrounding metal (shield or unshield type) Shape of part detected — Prism, cylinder, piercing or gutter Surrounding metal — Distance to part detected, vertical/horizontal material of metal — Surrounding metal (shield or non-shield type)

(2) Environment/installation

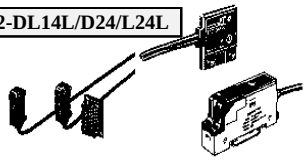
Conditions	*Review Points*
Environment	Anti-environment feature of proximity switch is superior to other switches. However, enough review is necessary for use in special environment.  Temperature/humidity — Highest/lowest, direct sunshine, etc. — Temperature, for high/low temp, sunshade needed Surrounding — Water, oil, steel chips, special chemicals, etc. — Anti-water/ oil/ explosion needed Vibration/impact — Size/length (time) — Rigid type needed, installation method
Installation	Installation method should be decided considering restriction from the machine, maintenance, and interaction with other sensors.  Wiring method/conductor surge — Cable used, type of cable, length, anti-oil code, shielded type. Connection method — Cable tube wiring, tact wiring Direct withdrawal, terminal connection Easier maintenance Installation method — Metal fittings needed, direct installation Bolt or screw installation Easier maintenance — Easier maintenance, Space for installation
Others	Economical — Price, Delivery, Standard item, Semi-standard Economical — Duration of power-on, Frequency

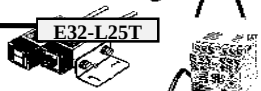
7-6 Omron Models

7-6-1 Photoelectric Sensors



- **General Purpose**
  - E3S-A
  - E3S-B
  - E3V3
- **Long Distance**
  - **DC Power Supply**
    - E3S-C
    - E3X-NH+E32-T17L
  - **AC Power Supply**
    - E3JM/E3JK
- **Minute Object**
  - E3X-N_/E3X+E32 fiber
  - E3S-A
  - E3T
- **Small Size Type**
  - **Space Saving Separate Type**
    - E3X-N_/E3X+E32-T14/T14L/T24/T24S
    - E3C-S
    - E3T
  - **Diffuse Reflective Type**
    - E3X-N_/E3X+E32-DL14L/D24/L24L
    - E3C-DS
    - E3C-DS
- **Transparent/ Translucent Object**
  -
  - E3T
- **Immune to Background**
  - **Detection Distance of 50cm or less**
    - E3S-CL2
  - **High Performance**
    - E3S-CL1
  - **Small Size type (Small Spot)**
    - E3S-LS
- **Movement Durability**
  -
  - E3C-S30
- **Detection of Liquid Level**
  - **Liquid Contact Type**
    -
  - **Pipe Installation Type**
    - E32-L25T
- **Area Detection**
  - Z4LA
  - E3X-N/E3X+E32-T16P
- **Liquid in Paper**
  - E3S-5E4S-45
- **Linear Displacement**
  -
  - Z4LA
  -

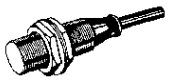




Proximity Sensors

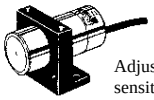
Detection of Presence Output

- **Detection of Magnetic Metal**
  e.g. Iron, Steel etc.



- **Detection of Non-Metallic Metal**
  e.g. Aluminium, Copper etc.

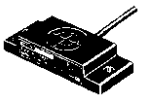
- **Detection of all Metal** — **Small Size Cylindrical Type**



Adjustable sensitivity

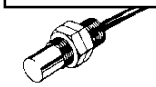
- **Detection of Metal/Non-metal**
  eg. Resin, Paper, Carton etc.
  - **General Environment**
    - **Cylindrical Type**

Fix sensitivity



Fix sensitivity

    - **Flat Type**

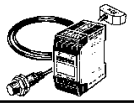


Adjustable sensitivity

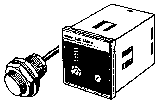
  - **Chemical**

Ring Detection

Displacement Detection — **ON/OFF Output**

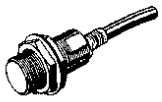


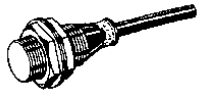
Analog Output



General Environment

Cylindrical Type

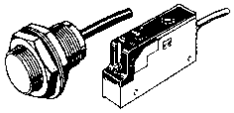




Insusceptical to Cutting or Drilling Chips Environment

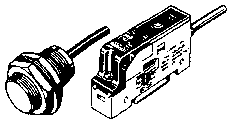
Compact Head

Built-in Small Amplifier

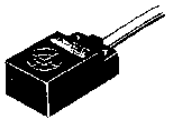


Small Size

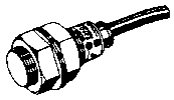
Adjustable Sensing Range



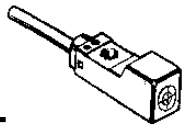
High Temperature Environment



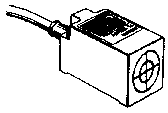
Flat Type

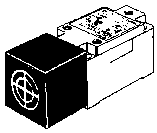


Chemical Environment

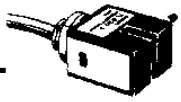


Square Type

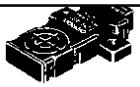




Strong Magnetic Field Environment



Groove Type

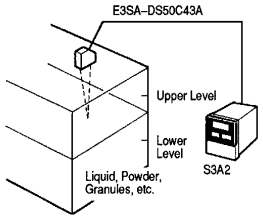


Built-in Amplifier

7-7 Application

7-7-1 Photoelectric Sensors

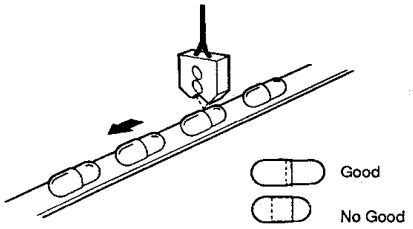
Distance Measurement
(Upper/Lower Limit Detection)
Using E3SA and S3A2 medium range upper or lower level distances can be detected.



Detection Subject: Liquid, powder, granules, etc.
Analog Photoelectric Sensor E3SA, Linear Sensor Controller S3A2

Capsule Length Judgement

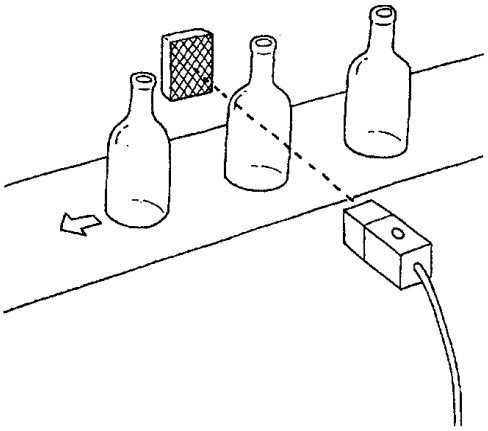
Capsules and their contents come in many different colors, including transparent. A wafer sensor type is used to detect the capsule's length to decide if it is Good or No Good.



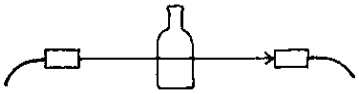
Fiber Unit E32-L25A
Amp Unit E3XR-CE4

Transparent Bottle Detection

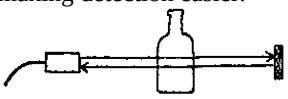
An exclusive optical method for the detection of transparent objects is used. This enables accurate detec-tion of transparent bottles, test tubes, glass tubes, beakers and other transparent containers as well as cellophane tape.



Transmission Type Light passes through once.

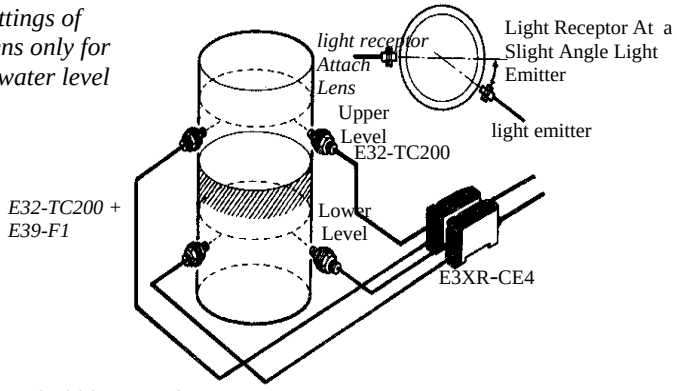


Feedback Reflection Type Light passes through twice making detection easier.



Internal Amp Photoelectric Switch E3S-RS30E4-30

Water Level Detection (Inside Glass Pipe)
By slightly changing the individual angle settings of the light emitter and receptor and using a lens only for the light emitter, accurate determination of water level within ± 1mm is possible

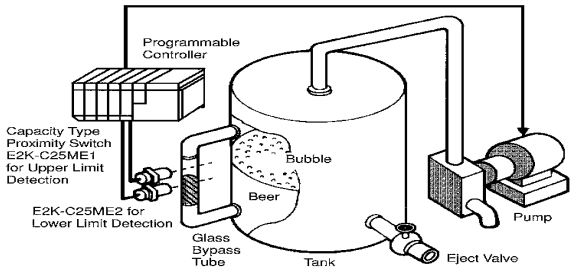


Fiber Optic Photoelectric Switch E32-TC200/ E3XR-CE4
Lens Unit E39F1

7-7-2 Proximity Switch

Why the need for Proximity Switch?

- No physical contact (i.e. no wear and tear)
- Reliable in hazardous environment (e.g. mist and air)
- Long service life
- Fast response time

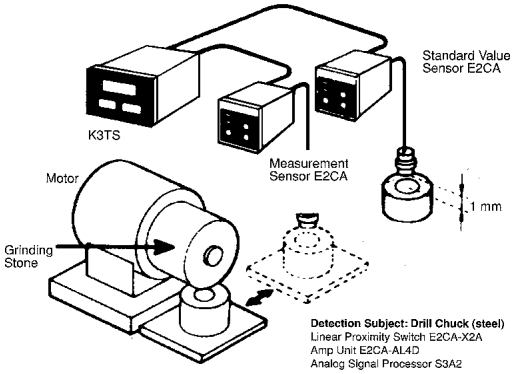


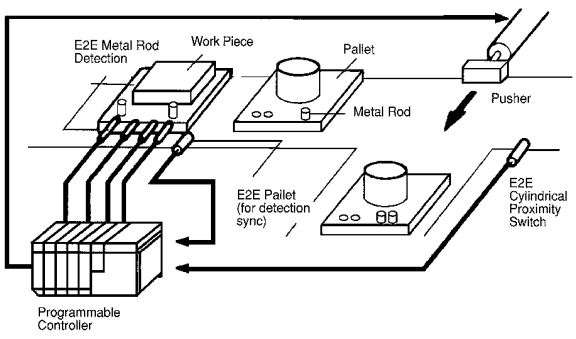
Tank Level Control

The level of liquid in a tank is controlled by two proximity switches. A glass bypass tube is installed on the side of the tank so that the proximity switches can monitor the liquid level in the bypass tube.

Grinding Amount Detection

This system uses a standard reference sensor and detection sensor in conjunction to prevent temperature and voltage drift. Accuracy is within ±0.02mm and it can be inspected on-line.





Proximity Switch Control Work Piece Sorting

Work pieces are placed on pallets, which are coded according to metal rods in the edge. When the pallets pass the inductive proximity sensors, they are sorted according to the code.

SECTION 8
Temperature Controller

8-1 What is Temperature Control?

Control system can be classified into two types:
Feedback control systems and sequence control systems.
Temperature Control is actually a variation of the feedback control.

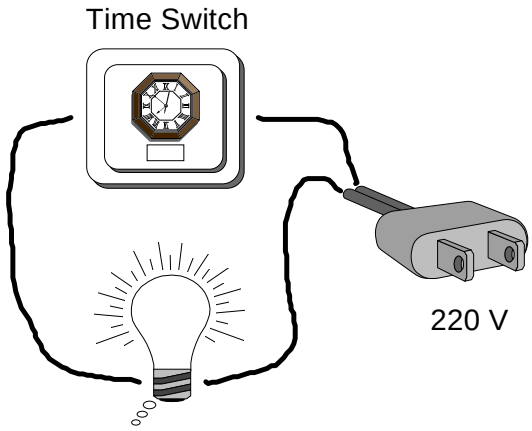
- **Sequence Control Systems:**

Sequence control is to perform control actions step by step according to some previously determined sequences.

As an example of sequence control, an electric light can be turned on at the desired time in the evening by a time switch. Even if the night falls early, the light will not illuminate until the set time arrives.

In this example, there is no self-correcting action, which checks whether the lights are actually on, or if the brightness is appropriate.

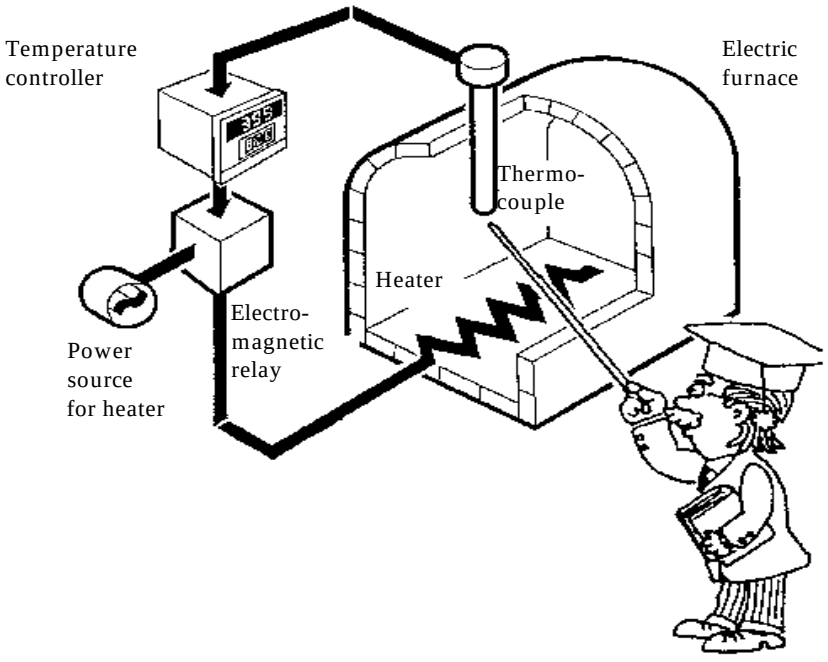
Example of Sequence Control



- **Feedback Control Systems**

Temperature control is a variation of the feedback control. The principle of temperature control is explained in the example of Furnace Control.

For example, to maintain the temperature in a furnace. Firstly, the temperature (set point) on the Temperature Controller (TC) must be set. e.g 150 degree Celsius.
The thermocouple (Temperature Sensor) relays the furnace temperature back to the TC as a feedback. This feedback is compared to the TC setpoint.
If the furnace temperature falls below 150 C, the TC must turn on the heater to heat up the furnace temperature to the set point.
In simplicity, the TC is use to raise or lower the furnace temperature to the setpoint.


Temperature controller
Electric furnace
Thermo-couple
Heater
Electro-magnetic relay
Power source for heater

8-2 What is Temperature Controller?

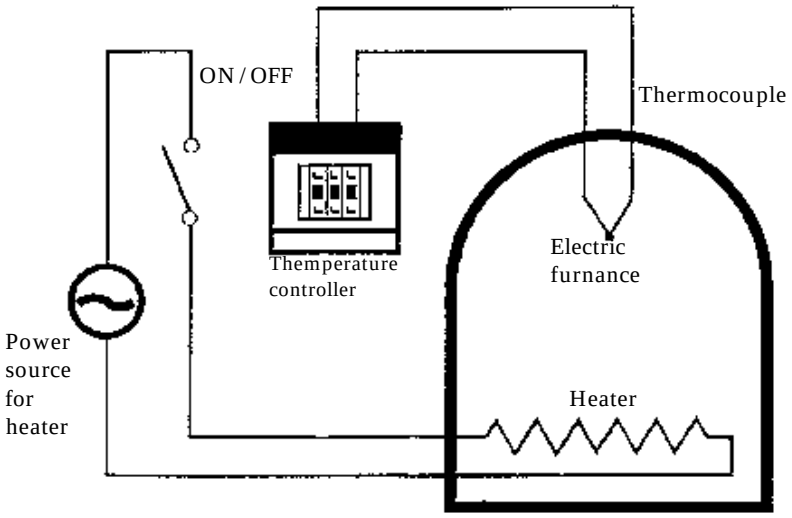
It is a device use for controlling or maintaining the **setpoint Temperature** of a Temperature Related Control System.

Typical Omron Temperature Controller

8-3 Temperature Control Methods

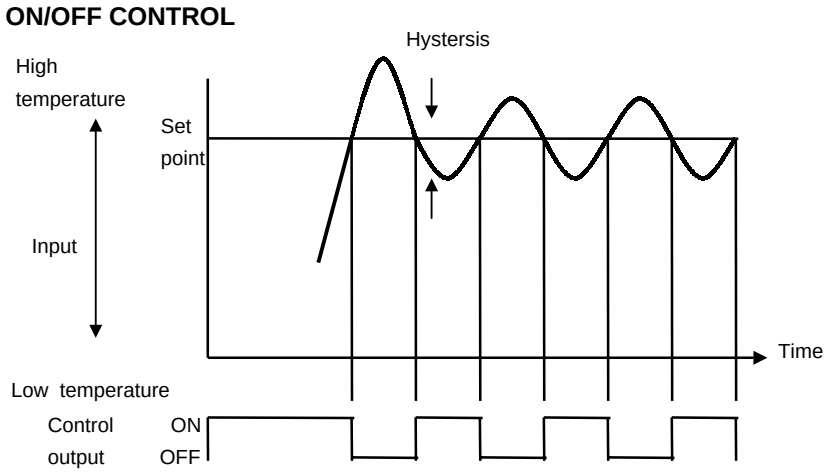
8-3-1 ON/OFF Control Action

The ON/OFF control action is to repeatedly turn on and off the controlled system according to the set point. For example, in this figure, the output relay is operated (ON) when the temperature in the furnace is below the set point, and is released (OFF) when the temperature reaches the set point.



The ON/OFF control action is also called “two-position control action” because two manipulated variables (0% and 100%) are used in relation to the set point.

If the output relay is turned on/off at one set point, chattering of the output may occur, causing the controlled system to be susceptible to the influences of noise. For this reason, a hysteresis between the ON and OFF is usually provided to the output. This hysteresis called “adjustment sensitivity” (also called “dead band (zone)” or “insensitive zone”). A higher adjustable sensitivity is required for such a device such as the air compressor of a freezer whose frequent ON/OFF operation must be avoided.



8-3-2 Proportional (P) Control Action

Proportional (P) control action is an action in which the manipulated variable (control output variable) is proportional to the deviation from the set point.

When the current temperature is lower than the lower limit of the proportional band, the manipulated variable is 100%. When the temperature is within the proportional band, the manipulated variable gradually decreases in proportion to the deviation and decreases to 50% when the present temperature becomes equal to the set point. Therefore, P action enables smoother temperature control with smaller hunting than the ON/OFF control action.

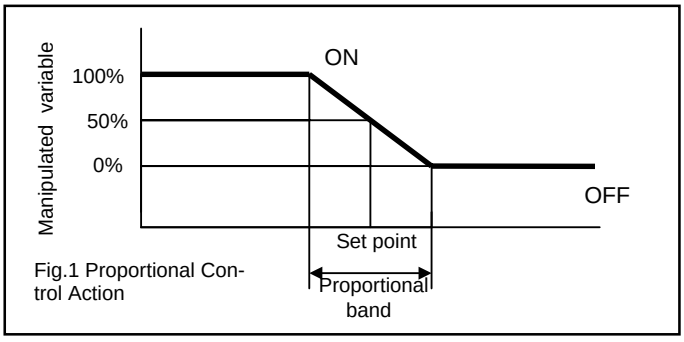


Fig.1 Proportional Control Action

- **Time-Division Proportional Control Action**

  A device that issues its output in the form of pulses indicating its ON and OFF states may be used as the output device of a temperature controller. These output include relay output, SSR (solid-state relay) output, and voltage output. The output device is repeatedly turned ON and OFF in the proportional band at a fixed cycle.

  A cycle of ON and OFF operations of the output device is called “proportional period”.

- Offset

  In a proportional control action, a fixed deviation is created by the correlation between the thermal capacity of the controlled system and the capacity of a heating device that remains after the controlled system reaches a steady state. This deviation is called “offset”. If the offset occurs in a temperature controller that performs only P action, it can be corrected with the variable resistor on the temperature controller.

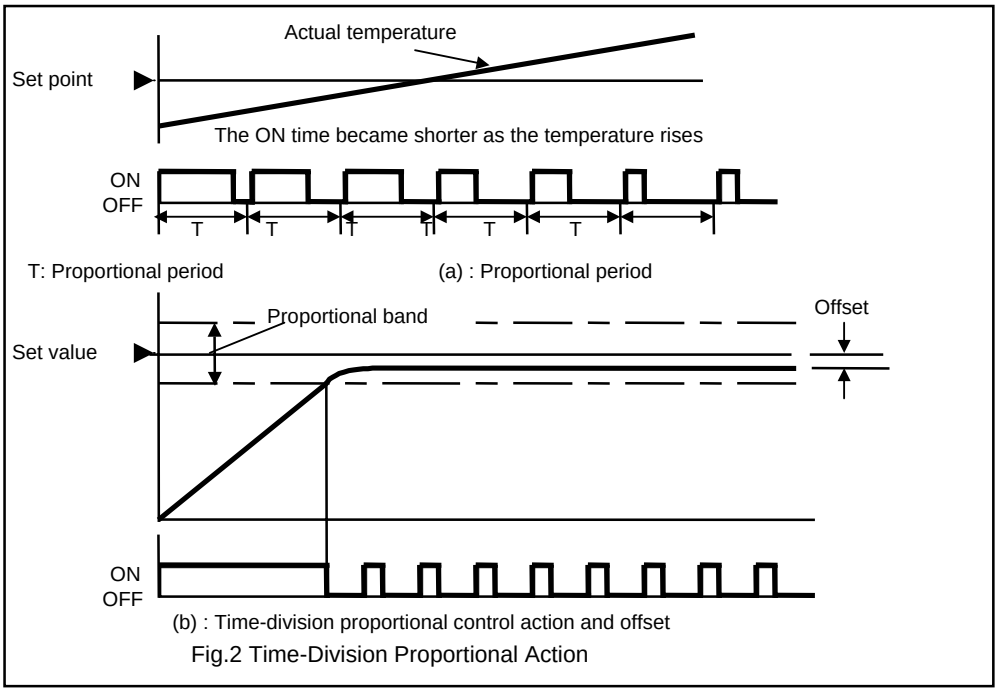


Fig.2 Time-Division Proportional Action

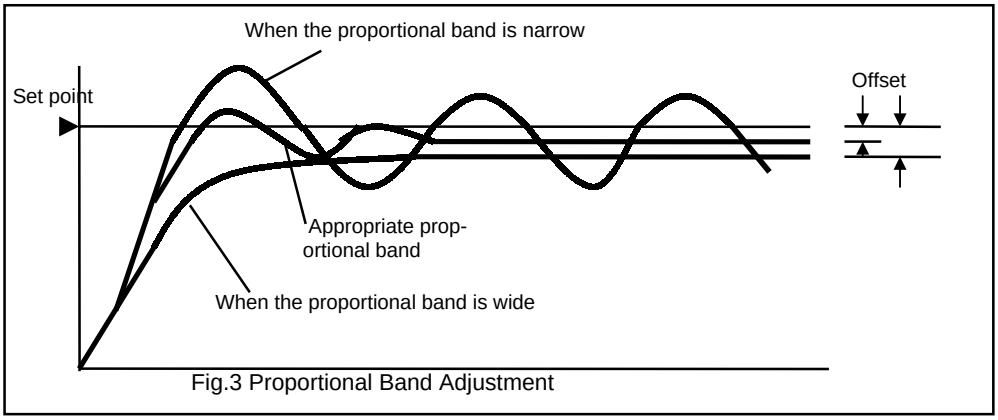


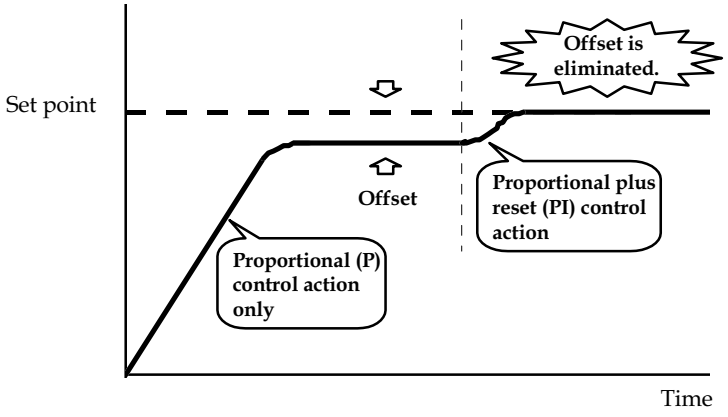
Fig.3 Proportional Band Adjustment

Selection of Proportional Period

If the proportional band is short, the hunting amplitude of the controlled temperature is narrowed and good results of the control action occur. Therefore, if an output device that can frequently repeat is ON/OFF operations (such as an SSR or thyristor) is used, the proportional band should be set to be short. However, is a relay is used. The proportional period must be set to be long because too frequent operations will affect the service life of the relay.

8-3-3 Integral (I) or Reset Control Action

Offset is likely to occur in P action. To diminish and eliminate the offset so that the controlled temperature agrees with the set point, the P action is used in combination with a reset or integral (I) control action. This combinations is called PI action.



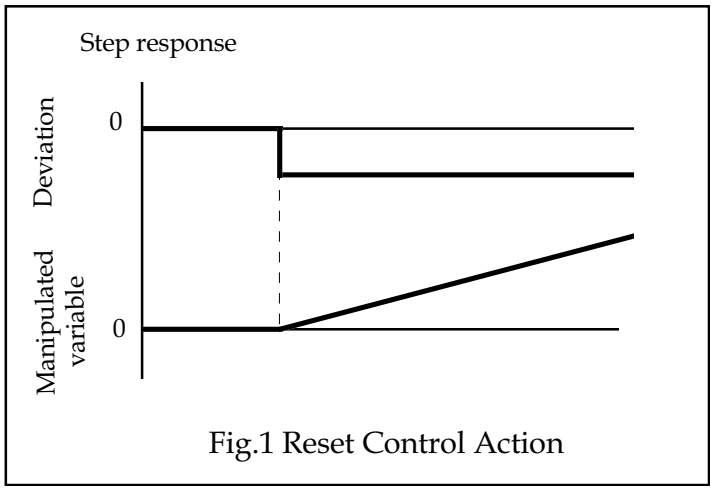


Fig.1 Reset Control Action

- **Reset Time**

Reset time is a quantity, which expresses the strength of reset action. This is the time required for the manipulated variable of the integral to reach the same manipulated variable as in P action when the change in the deviation takes place. Therefore, the shorter the reset time, the more effective the reset action being performed. However, too short reset time may cause hunting to occur.

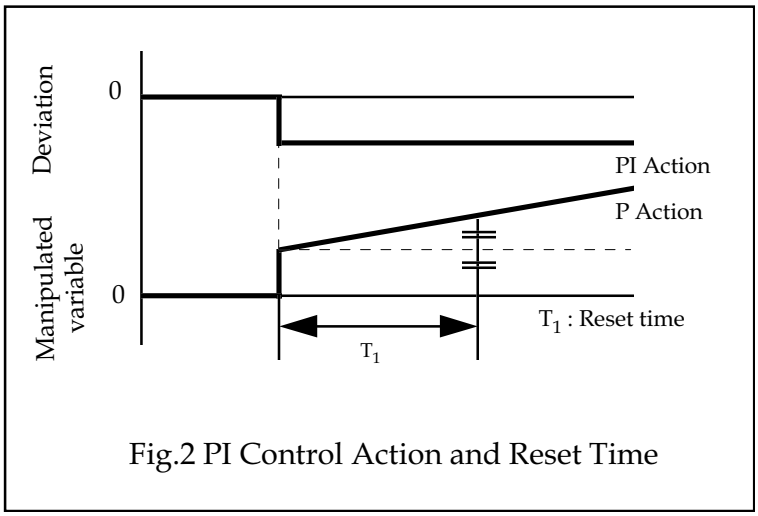
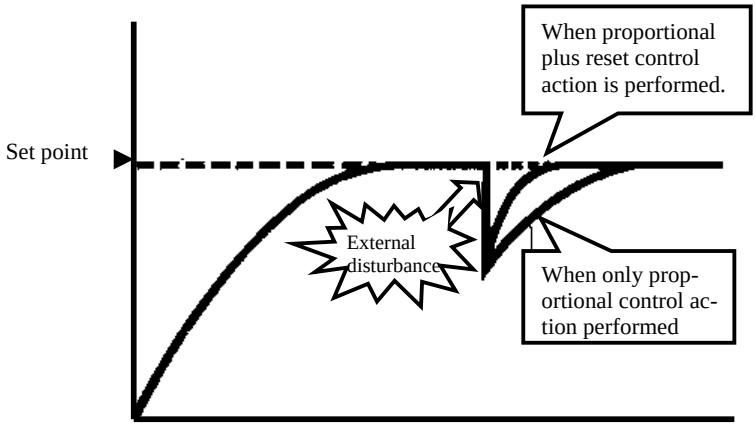


Fig.2 PI Control Action and Reset Time

8-3-4 Derivative (D) or Rate Control Action

Follow-up control of P or I action will be delayed because both actions use the manipulated variable related to the present or past deviation. Derivative or Rate Action is required to compensate. It performs a corrective action with the manipulated variable proportionally to the slope at which the deviation is generated. A large value of manipulated variable is given to quickly reestablish a normal control state after a rapid change caused by external disturbances.



- **Rate (Derivative) Time**

Rate time is a quantity, which expresses the strength of rate action. This is the time required for the manipulated variable or the rate action to reach the same manipulated variable as in proportional action when a change in the deviation occurs.

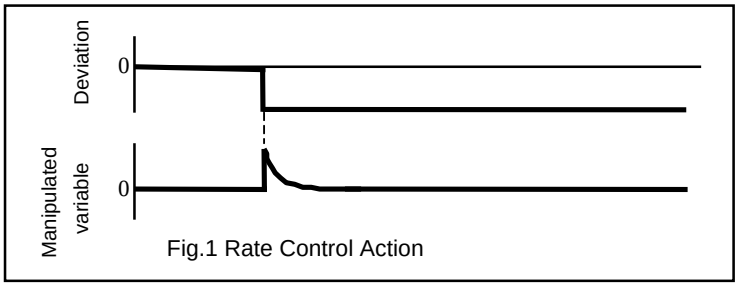


Fig.1 Rate Control Action

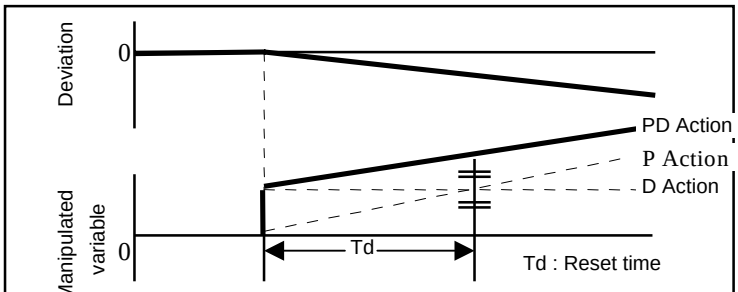


Fig.2 PD Control Action and Reset Time

- **Differential Effect**

In case a sudden deviation occurs in time-division proportional action, the first ON or OFF time of the output relay is prolonged by performing a certain control to reach the set point (set temperature) sooner. This referred to as “differential effect”.

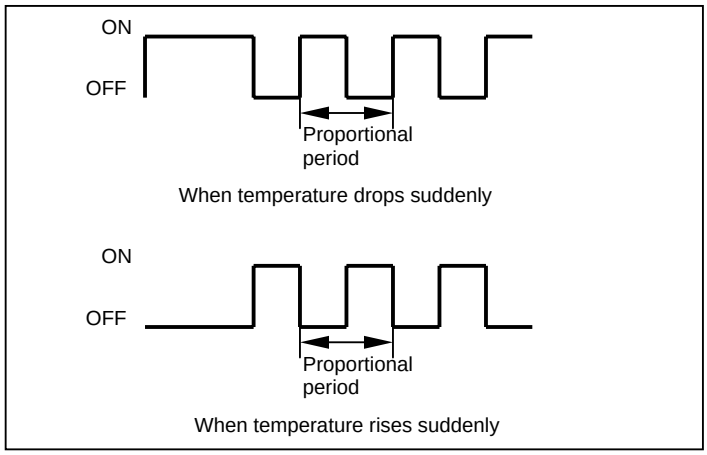


Fig. 3 Differential Effect

8-3-5 PID Control Action

PID Control Action is a combination of P, I and D control action. The best results of the control can be obtained when the PID control action is performed on a controlled system having a long idle time. Of the three actions, the P action enables control to be performed free from hunting while I action is used to automatically correct the offset. Additionally, D action quickly corrects the change in the manipulated variable caused by external disturbances. This interaction of the 3 control actions assures optimum control.

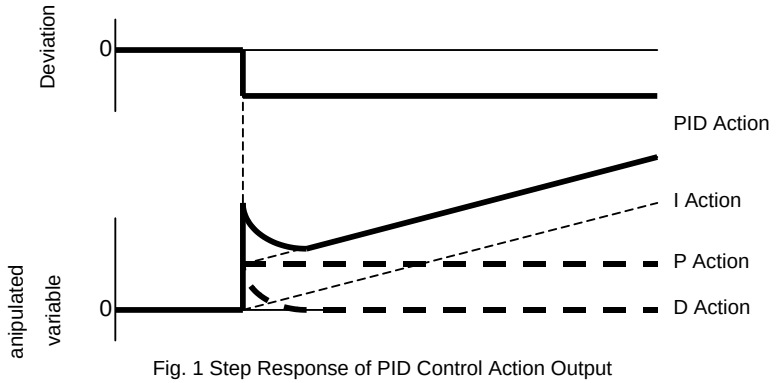


Fig. 1 Step Response of PID Control Action Output

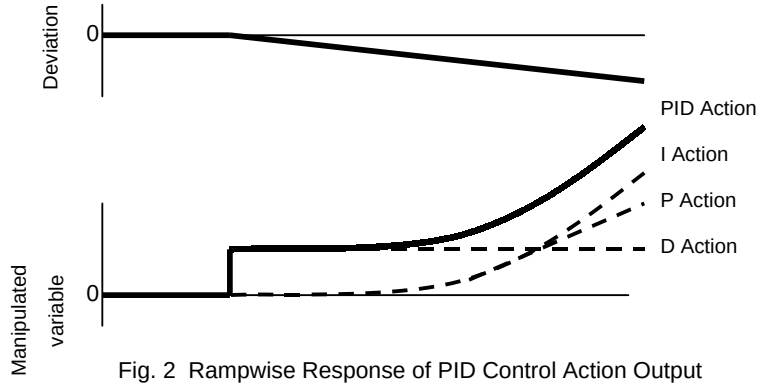


Fig. 2 Rampwise Response of PID Control Action Output

The strong and weak points of different control actions are summarized in the following table:

Control Action	Advantages	Disadvantages
On-Off	- Control is simple - No offset occurs	- Overshoot and hunting occurs
Proportional (P)	- Overshoot and hunting are small	- A long time is required until the controlled variable is stabilized - Offset occurs
Reset (Integrate (I))	- Offset is eliminated	- A longer time is required than P action until the controlled variable is stabilized.
Rate (Derivative (D))	- The response is quickened.	- This control action can not be performed alone.
PID	- The best control action can be performed.	- Setting the PID parameters is necessary.

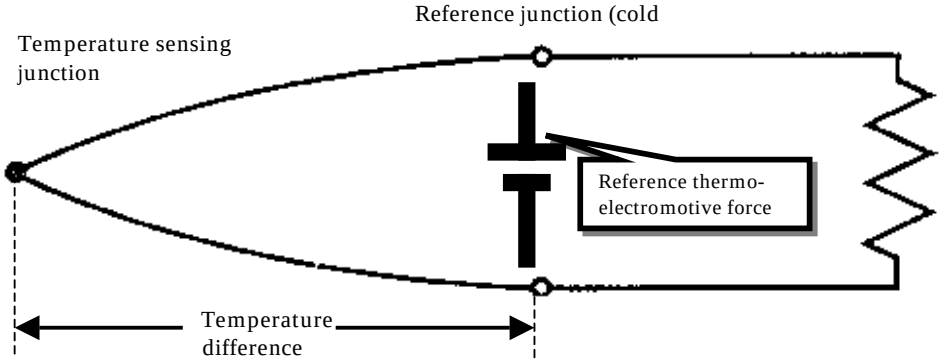
8-4 Temperature Sensors

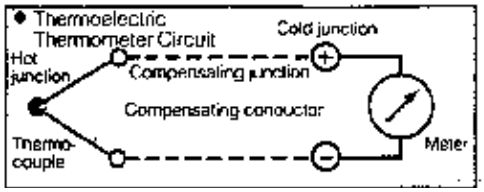
8-4-1 Thermocouples

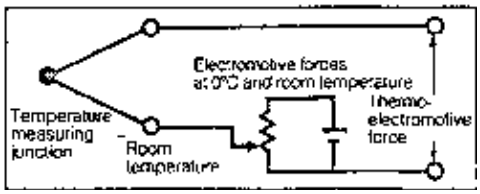
The thermocouple is made of two different metals (element wire) whose ends are welded to each other so that a voltage is developed when the two junctions are at different temperatures. This developed voltage is referred to as “thermoelectromotive force”.

Normally, a special conducting wire is used as substitute wire at the other end of the thermocouple. That wire is called compensating conductor. A shielded type of wire should be used to prevent noise induction. Also one of the edges of the conductor should be earthed.

Temperature controller normally has a built-in cold junction compensating circuit, which develops an electromotive force between 0°C and room temperature.







1. General Type Thermocouple

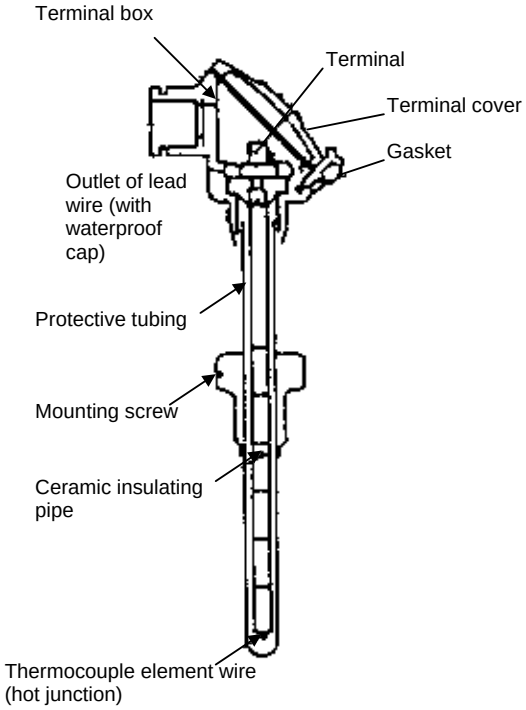
This type has a thermocouple element wire in a ceramic-insulating pipe enclosed in protective tubing. The protective tubing is made mainly from stainless steel and must not be bent.

2. Sheathed Thermocouple

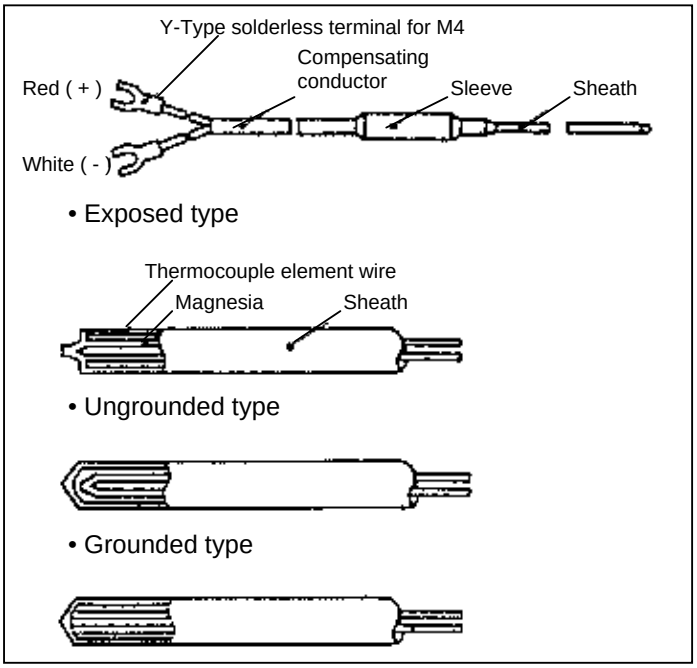
- Exposed type: The thermocouple element wire is exposed, has fast thermal response and short service life.
- Ungrounded type: The thermocouple wire is externally shielded. This type is widely used.
- Grounded type: The thermocouple wire is welded to the sheath, has faster thermal response than the ungrounded type.

The protective tubing is a thin stainless steel tube and can be bent, so the thermocouple can be inserted to hardly accessed places.

General Type Thermocouple

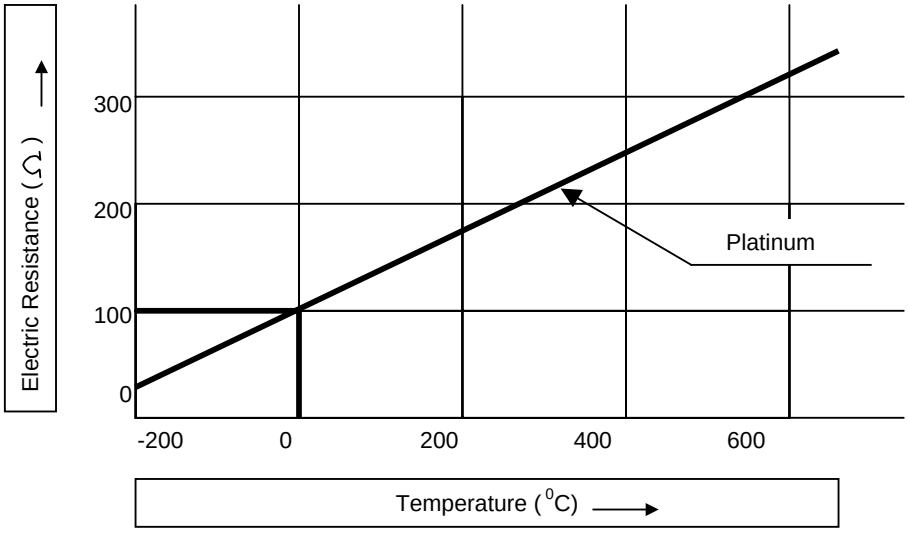


Sheathed Thermocouple



8-4-2 Resistance Thermosensors

Because the electric resistance of some metals is directly related to temperature, it is possible to determine a temperature by measuring changes in the resistance of some metals. The most popular metal used is platinum.



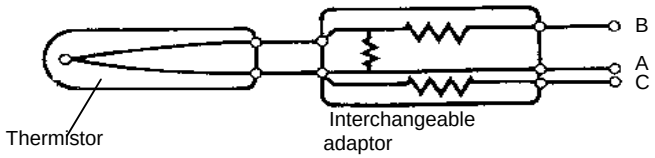
Platinum RTD Sensors are divided into groups as follows:

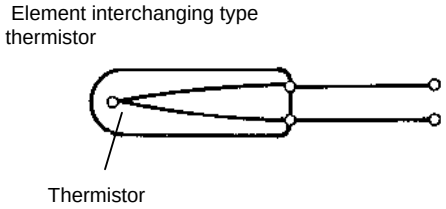
1. General purposes:
- Exposed terminal type
- Enclosed terminal type

2. Sheathed type:
- Exposed lead wire type
- Enclosed terminal type

8-4-3 Thermistor

A thermistor is a temperature sensor, which is metal oxide, and is a resistor element with a negative temperature coefficient.





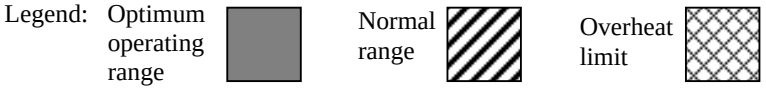
8-4-4 Thermosensor Selection

Selecting the right sensor for your control application assures reliable input to your Omron temperature controller.

The decision to select thermocouple, platinum RDT (resistance temperature detector), or thermistor is based on the optimum range, accuracy, and response time of the sensor.

Operating Temperature Range of Omron Temperature Sensors

Scale		Thermocouples			Platinum RTD	Thermistor	
°F	°C	Type K	Type J	Types R, S			
2912	1600						
	1500						
	1400						
	1300						
2192	1200						
	1100						
1832	1000						
	900						
1472	800						
	700						
1112	600						
	500						350
752	400						
572	300						
392	200					100	
212	100						100
32	0						
-148	-100					-50	
-328	-200						



- Comparison of Temperature Sensor Performance

Sensor **type**	Thermocouple	Platinum RTD	Thermistor
Temperature range	0° to 1,600°C	-100° to 400°C	-50° to 350°C
Accuracy	Ordinary	Good	Fair
Advantage	Good thermal response Self-powered Simple Rugged Inexpensive Wide variety Wide temperature range	Most accurate Most stable More linear than thermocouple	Fast thermal response Small error due to resistance of conductor
Disadvantage	Compensating cinductor necessary Non-Linear Low voltage Least stable Least sensible	Likely to be affected by conductor resistance Slightly slow thermal response because the heat sensing element is long Expensive	Non-linear Limited temperature range Fragile

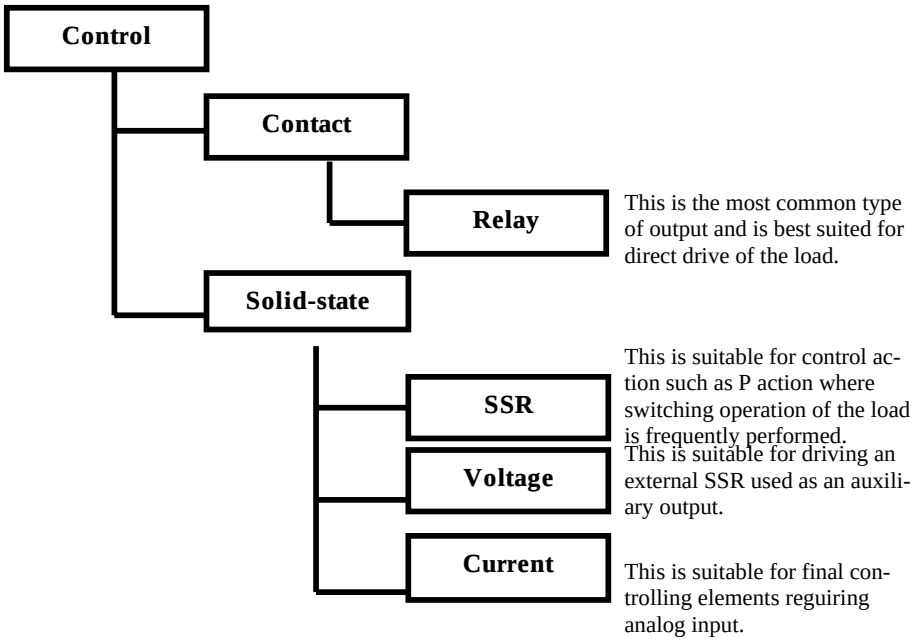
■ TYPES AVAILABLE

Temperature sensor		Output terminal	Length of protective tubing (mm)								
			50	65	100	150	200	350	500	750	1,000
PT	Platinum resistance thermometer (Pt 100Ω)	A			—	-PA15A	-PT20A	-PT35A	-PT50A	—	
		B	—		—	—	-PT20B	-PT35B	PT50B	-PT75B	PT100B
		C					-PT20C*	PT35C*	-PT50C*	-PT75C*	-PT100C
CA K	Chromel alumel thermocouple	A		CA6AS	-CA10AS	-CA15A -CA15AS	-CA20A -CA20AS	CA35A	-CA50A		—
		B	—		—	—	CA20B	-CA35B*	CA50B*	-CA75B*	-CA100B
		C			—		-CA20C	-CA35C*	-CA50C*	-CA75C*	-CA100C
IC J	Iron-constantan thermocouple	A	—	-IC6AS	IC10AS	-IC15A -IC15AS	IC20A -IC20AS	-IC35A	-IC50A	—	—
		B	—				-IC20B	-IC35B*	-IC50B*	-IC75B*	-IC100B
		C					-IC20C	-IC35C*	-IC50C*	IC75C*	-IC100C
PR R	Platinum platinum-rhodium thermocouple	C			—	—	—	—	-PR50C	-PR75C	-PR100C
TH	Thermistor	A	TH5A				-TH20A	-TH35A	—		—
		B					-TH20B	-TH35B	-TH50B	—	—
		C	—	—	—	—	TH20C	-TH35C	-TH50C		—

NOTE: * Available with a choice of flexible protective tubing and general type protective tubing.

8-4-5 Output Types

Selection of the output is made depending upon the type, capacity, and operation frequency of the load. The voltage output is 5VDC (10 to 20mA); current output is continuous and in the range of 4 to 20mA.



8-5 Omron Models

Classification	Economical Temperature Controllers			General Purpose Temperature Controllers
	E5EM	E5C2	E5CS	E5 W
Appearance				
Dimensions (H× W× L)mm	96× 48× 100	48× 48× 96	48× 48× 100	E5AW: 96× 96× 100 E5BW: 72× 72× 100 E5CW: 48× 48× 100 E5EW: 96× 48× 100
Features	• P control • Thumbwheel switch setting • Maximum heater current: AC 5A/20A/30A single phase (SW selectable) • Deviation indication (meter)/LED PV display	• ON/OFF or PD control • Economical plug-in unit • Panel adapter supplied	• PID or ON/OFF control • Compact, panel mount or socket mount unit • Large, easy to read LED display • Selectable temperature ranges • Input shift • Self diagnostics • 8 alarm modes • °C/°F selectable • Key protect function	• Automatic tuning PID or ON/OFF control • Selectable temperature ranges • Displays Present Value and Set Value simultaneously • Input shift • Self diagnostics • 8 alarm modes • °C/°F selectable • Key protect function
Model Variations	• Heater burnout alarm • Digital indication • Deviation indication (meter)	---	---	• Heater burnout alarm
Indication Accuracy	±1.5% max. of full scale	±2% max. of full scale (setting)	±0.5% of full scale, ±1 digit max.	±0.5% of full scale, ±1 digit max.
Control Modes	P	ON/OFF or PD	ON/OFF or PID	ON/OFF or PID
Temperature Sensors and Input Ranges	Type K Thermocouple: 0 to 399°C	• Type K Thermocouple: 0 to 1,200°C (7 scales) • Type J Thermocouple: 0 to 400°C (3 scales) • JPt100: -50 to 400°C (7 scales) • Thermistor: -50 to 300°C (5 scales)	• Type K Thermocouple: 0 to 999°C (6 ranges) • Type J Thermocouple: 0 to 500°C (5 ranges) • JPt100, Pt100: -50 to 400°C (9 ranges) • Thermistor: -50 to 300°C (10 ranges)	• Type K Thermocouple: 0 to 999°C (6 ranges) • Type J Thermocouple: 0 to 500°C (4 ranges) • JPt100, Pt100: -50 to 400°C (9 ranges)
Supply Voltage	100/110 or 200/220VAC, 50/60Hz	100/110 or 200/220VAC, 50/60Hz	100 to 240VAC, 50/60Hz or 24VDC/AC	100 to 240VAC, 50/60Hz or 24VAC/Dc
Control Outputs	• Relay: SPDT, 3A,250VAC (Resistive load)	• Relay: SPDT, 3A, 250VAC (Resistive load)	• Relay: SPDT, 3A, 250VAC (resistive load) • Voltage: 12VDC, 20mA • Alarm: SPST-NO, 1A, 250VAC (Resistor load)	• Relay: SPDT, 3A, 250VAC (Resistive load) • Voltage: 12VDC, 20mA • Alarm: SPST-NO, 1A, 250VAC (Resistive load)
Weight (approx.)	340g	200g	170g	150 to 300g
Front Panel Approval	---	---	IEC IP50	---
Approved Standards & Markings	---	UL, CSA, CE	UL, CSA, CE	UL,CSA

Classification	Advanced Temperature Controllers		Digital Controllers	Special Purpose Temperature Controllers
	E5 J	E5 X	E5 K	E5 F
Appearance				
Dimensions (H× W× L)mm	E5AJ: 96× 96× 98 E5BJ: 72× 72× 98 E5CJ: 48× 48× 100 E5EJ: 96× 48× 98	E5AX: 96× 96× 89 E5BX: 72× 72× 89 E5CX: 48× 48× 87.5 E5EX: 96× 48× 89	E5AK: 96× 96× 100 E5CK: 53× 53× 100 E5EK: 96× 48× 100	E5AF: 96× 96× 100 E5EF: 96× 48× 100
Features	• Fuzzy advanced self-tuning. PID control with two degrees of freedom or ON/OFF control • Selectable temperature inputs • Plug-in output modules (except E5CJ) • Self diagnostics • 4-event inputs (E5AJ, E5EJ) • Heater burnout alarm • 9 alarm modes • °C/°F selectable • Key protect function	• Advanced PID control with two degrees of freedom improves stability and response speed • Select from 7 temperature sensors for a total of 14 temperature ranges • 8 alarm modes • °C/°F selectable • Key protect function	• Modular structure • Fuzzy self-tuning, advanced PID or manual control • Auto/manual operation • Heat & cool control • Selectable temperature & analog input • Multi-set point, SP ramp function • Event input • Plug-in control output & optional units • Transfer output • 11 alarm modes • Key protect function	• Improve response to disturbance through Fuzzy logic • Hybrid Fuzzy-PID control with auto-tuning • Selectable temperature inputs • Plug-in control output modules • Displays Present Value and Set Value simultaneously • Input shift • Self diagnostics • Two alarm outputs with 9 modes each • Easily adjustable Fuzzy parameters • °C/°F selectable • Key protect function
Model Variations	• Communication options (E5AJ,E5EJ only) RUN /STOP operation (E5AJ, E5EJ only)	• Position-proportional control • Heat & cool control • Communication options (E5AX, E5EX only)	• Position-proportional control (E5AK, E5EK only) • Heater burnout alarm (E5AK, E5EK only) • Communication options • Remote set point (E5AK, E5EK only) • Loop break alarm (E5AK, E5EK only)	• Communication options • 8 memory banks (E5EF-B only) • heater burnout alarm
Indication Accuracy	±0.5% of set value or ±1°C, ±1 digit max.	±.0.3% of set value, 1 digit max.	±0.3% of indication value, ±1 digit max.	±0..3% of set value, ±1 digit max.
Control Modes	ON/OFF or PID	ON/OFF or PID	ON/OFF or PID	ON/OFF or PID
Temperature Sensors and Input Ranges	• Type K Thermocouple: -200 to 1,300°C • Type J Thermocouple: -100 to 850°C • Type T Thermocouple: -199.9 to 400.0°C • Type N Thermocouple: -200 to 1,300°C • JPt100, Pt100: -199.9 to 650°C	• Type K Thermocouple: -200 to 1,300°C • Type J/L Thermocouple: -100 to 850°C • Type T/U Thermocouple: -200 to 400°C • Type E Thermocouple: 0 to 600°C • Type R/S Thermocouple: 0 to 1,700°C • JPt100, Pt100: -99.9 to 450.0°C	• Thermocouples types: K, J, T, E, L, U, N, R, S, B, W, PL II(-199.9 to 2,300°C) • Platinum RTD: Pt100, JPt100 (-199.9 to 650.0°C • Current: 4 to 20mA, 0 to 20mA • Voltage: 1 to 5VDC, 0 to 5VDC, 0 to 10VDC	• Type K Thermocouple: -200 to 1,300°C • Type J Thermocouple: -100 to 850°C • Type T Thermocouple: -200 to 400°C • Type N Thermocouple: 0 to 1,300°C • JPt100, Pt100: -99.9 to 450.0°C • Types E, R, S and B also applicable
Supply Voltage	100 to 240VAC, 50/60Hz	100 to 240VAC, 50/60Hz	100 to 240VAC, 50/60Hz, 24VAC/VDC	100 to 240VAC, 50/60 Hz
Control Outputs	Plug-in Control Output Modules: • Relay: SPDT, 5A, 250VAC (Resistive load) • SSR: SPST-NO, 1A, 75-250VAC • Voltage: 12VDC, NPN, 40mA 24VDC, NPN/PNP, 20mA • Linear: 4 to 20mA/0 to 20mA • 0 to 10VDC/0 to5VDC	Plug-in Control Output Modules: • Relay: SPDT, 5A, 250VAC (Resistive load) • SSR: SPST-NO, 1A, 75 to 250VAC • Voltage: 12VDC, NPN, 40mA 24VDC, NPN/PNP, 20mA • Current: 4 to 20mA DC	Plug-in Control Output Modules: • Relay: SPST, 3A(5A*), 250VAC (Resistive load) • SSR: 1A, 75 to 250VAC* • Voltage: 12VDC, NPN, 40mA* 24VDC, NPN/PNP, 20mA 12VDC, NPN/PNP, 20mA (E5CK only) • Linear: 0 to 10VDC, 4 to 20mA 0 to 5VDC*, 0 to 20mA • E5AK/E5EK only	Plug-in Control Output Modules: • Relay: SPDT, 5A, 250VAC (Resistive load) • SSR: SPST-NO, 1A, 75 to 250VAC • Voltage: 12VDC, NPN, 40mA 24VDC, NPN/PNP, 20mA • Current: 4 to 20mA DC
Weight (approx.)	170 to 360g	160 to 400g	170 to 450g	310 to 430g
Front Panel Approval	IEC IP50	IEC IP50	IEC IP66	IEC IP50
Approved Standards & Markings	UL, CSA, EN/IEC,CE	UL, CSA, SEV	UL, CSA, EN/IEC, CE	UL, CSA

E5CN/E5GN (Multifunctional Temperature Controllers)

Industry's smallest model (48× 24× 100mm) offers high functionality for a wide variety of temperature control applications

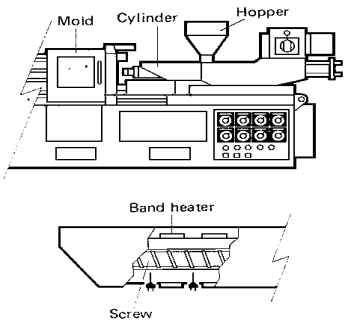
E5CN/GN Standard Models

Size	Power supply voltage	No. of alarm points	Output	Thermocouple model	Platinum resistance thermometer model
E5CN (note 1 & 2) 1/16 DIN 48(W)× 48(H)× 78(D)mm	100 to 240VAC	---	Relay	E5CN-RMTC-500	E5CN-RMP-500
			Voltage output (for driving SSR)	E5CN-QMTC-500	E5CN-QMP-500
		2	Relay	E5CN-R2MTC-500	E5CN-R2MP-500
			Voltage output (for driving SSR)	E5CN-Q2MTC-500	E5CN-Q2MP-500
	24VAC/VDC	---	Relay	E5CN-RMTC-500	E5CN-RMP-500
			Voltage output (for driving SSR)	E5CN-QMTC-500	E5CN-QMP-500
		2	Relay	E5CN-R2MTC-500	E5CN-R2MP-500
			Voltage output (for driving SSR)	E5CN-Q2MTC-500	E5CN-Q2MP-500
E5GN (note 3) 1/32 DIN 48(W)× 24(H)× 100(D)mm	100 to 240VAC	---	Relay	E5GN-RTC	E5GN-RP
			Voltage output (for driving SSR)	E5GN-QTC	E5GN-QP
		1	Relay	E5GN-R1TC	E5GN-R1P
			Voltage output (for driving SSR)	E5GN-Q1TC	E5GN-Q1P
	24VAC/VDC	---	Relay	E5GN-RTC	E5GN-RP
			Voltage output (for driving SSR)	E5GN-QTC	E5GN-QP
		1	Relay	E5GN-R1TC	E5GN-R1P
			Voltage output (for driving SSR)	E5GN-Q1TC	E5GN-Q1P

8-6 Application

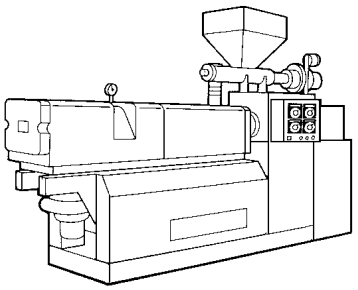
* Injection Molding Machine

To dissolve the raw material (i.e., plastics) from the hopper, the respective parts of the cylinder are heated by a band heater. At the most, 15 temperature controllers are employed to change the temperatures of the respective parts of the cylinder in stages. The dissolved raw material is in-jected into a mould and made into the end product.
The set temperature generally ranges from 200 to 230°C. As the temperature sensor, CA is usually employed but IC is also employed in many cases.



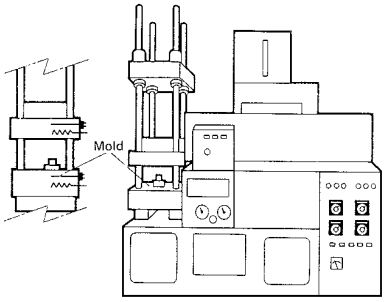
* Extrusion Molding Machine

Long-shaped products such as pipes, sheets, wire sheaths are molded by extruding raw material from the nozzle by the revolving screw.
Usually, 4 to 6 temperature controllers are used for con-trolling cooling fans and heaters at the respective parts of the cylinder.



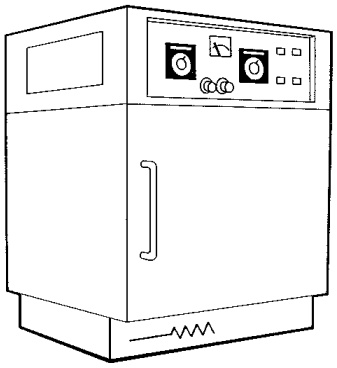
* Compression Molding Machine

Compression molding is performed by oil pressure with a mold placed between the movable and fixed heating plates. Usually, 2 to 4 temperature controllers are employed to keep the temperature of the metal mold constant. In addition, the temperature controller is also used to turn on or off the cooling water pump for the mold heated by the dissolved raw material.



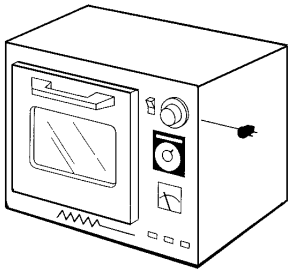
* Constant Temperature Humidity Oven

This machine is employed in laboratories, etc., for the equality testing of electronic parts, precision parts, etc.
Two temperature controllers are used for drybulb and wet-bulb temperatures respectively to control the freezer, heater, and humidifier.



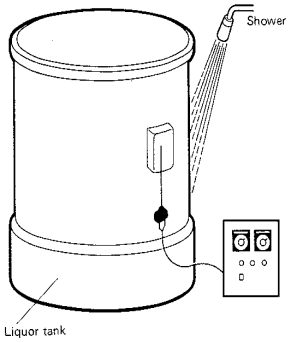
* Commercial Electric Oven

A temperature controller is used to keep constant the temperature within a cooking oven. This internal temperature is held at about 250°C with a heater load of 10 to 70kW.



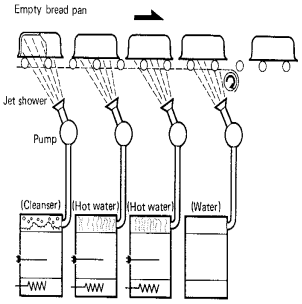
* Outdoor Liquor Storage Tank

To prevent the temperature of liquor within the tank from abnormally rising due to sunlight, etc., water is sprinkled against the tank with the use of a temperature controller. The set temperature is usually 25 to 30°C and the temperature sensor is puttied to the outside wall of the tank.



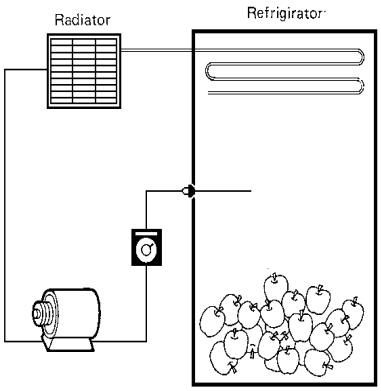
* Automatic Washer

Shown below is an example of hat water temperature control. For washing the empty bread pans of the baking machine, the hot water temperature is maintained at 80°C to facilitate washing the dirt off.
In this case, a temperature controller is used for proportional control of the pipe heater (3kW).



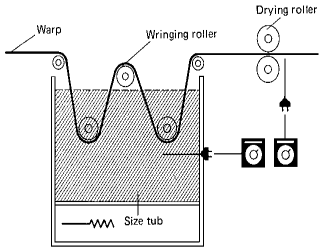
* Cold Storage for Apples

Apples harvested in autumn are kept in cold storage for supply at any time in winter, spring and summer. The temperature within the cold storage is set to -1°C with a temperature controller for ON-OFF control of the compressor.



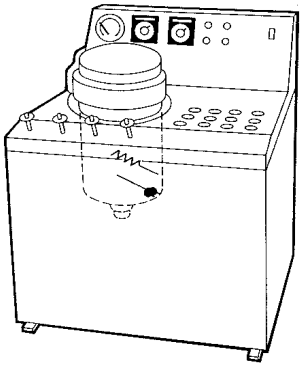
* Sizing Machine

As the auxiliary pre-processing machine for a weaving machine, this sizing machine is employed to size and dry warp. Since the workmanship of a woven cloth depends upon the sized condition of warp, a temperature controller is employed for control of the sizing and drying temperatures, respectively. The temperature of the size is set to 98°C, while the temperature of the drying roller is set to 130 to 150°C.



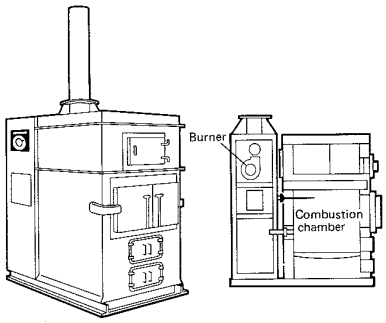
* Dye Testing Machine

The dye testing machine for yarns, cloths, knits, etc., is available in two types: steam heating type and electric heating type. In either type, the heating-cooling control is effected with a temperature controller.



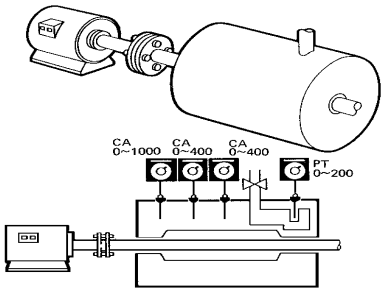
*** Smoke-consuming Type Incinerator**

In incinerators such as in factories, schools, housing developments, etc., low combustion temperatures cause smoke to occur excessively, thus resulting in environmental pollution. To avoid this problem, complete combustion is made possible by control of the burner with a temperature controller so that the temperature within the incinerator can be maintained at 800°C. The automatic control of this temperature enables oil saving.

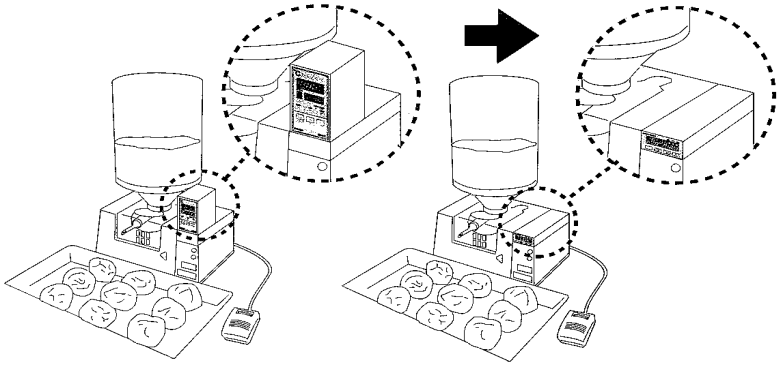


* Temperature Control of Motor Bearings

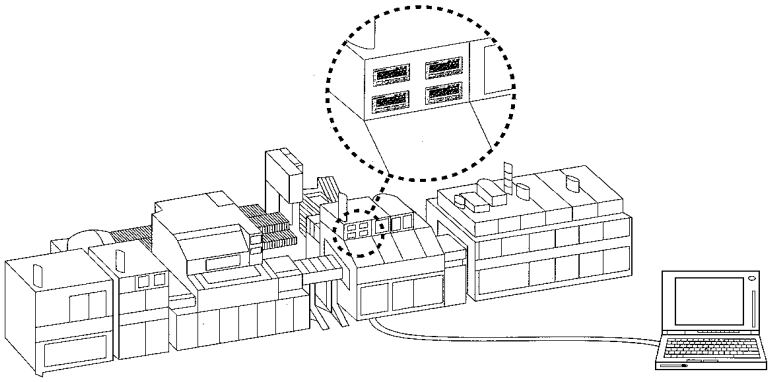
Temperature are detected at the four respective points to prevent the motor bearings from overheating, and water-cooling control or motor stop is effected with temperature controllers through the valves. The set temperatures differ with the temperature detecting sections and are usually within a range of 150 to 550°C.



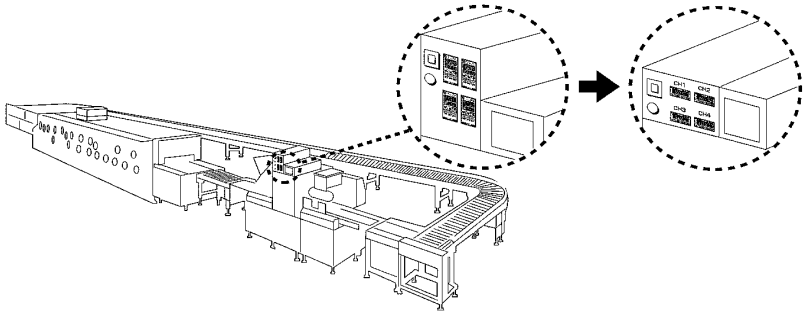
Food processing



Semiconductor Manufacturing



Assembly Line



SECTION 9
Intelligent Signal Processor/Digital Panel Meter

9-1 What is a Intelligent Signal Processor (ISP)/Digital Panel (DPM)

1. A (DPM) is a device that displays various values (eg. Length mm, speed rpm voltage volt) measured from the input, for easy readability and monitoring purposes.
2. A (ISP) is a device that is similar to the DPM, but it is equipped with an Intelligent Signal Processor that can process the Input (read in value) and then make decision to generate a required output.

The ISP/DPM of Omron are designed to solve many advanced and complex applications. They are types available for measurement and control of current, voltage, load cell signals, temperature, standard analog signals and pulses.

Typical view of ISP/DPM

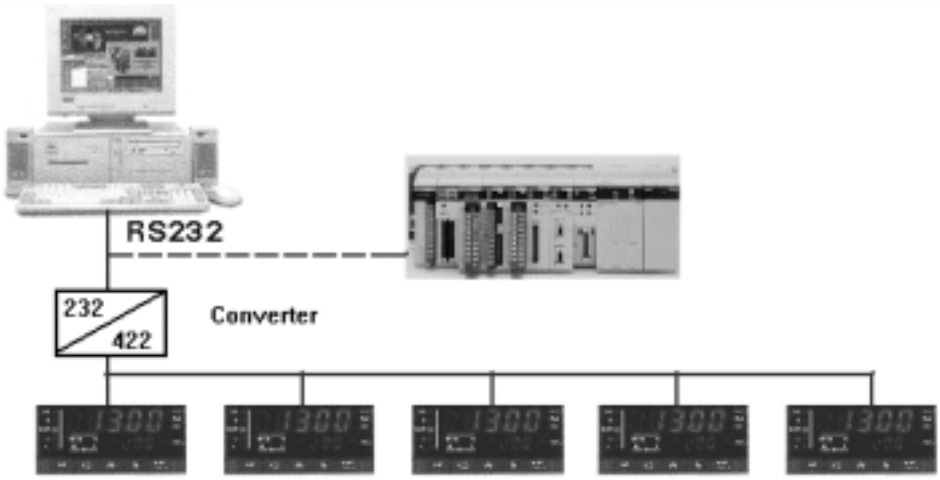
9-2 Features

- High accuracy/high speed processing
- Excellent water & dust protection IP66 (NEMA-4) front panel
- Can be used under hard Industrial conditions
- High visibility 14.2mm high, five digit display
- Minimum & maximum storage of measured values
- Wide selection of plug in output boards
- Relay, Transistor, BCD, linear, or communication board and label (Combine board also possible)
- Enhanced programming features allow easy setup & calibration
- Programmable via front panel or by means of serial port RS-232C, RS485, or RS-422
- Programmable decimal point selection
- Single & dual display models available
- Scaling function to easily adjust display range
- Field calibration (for the K3NX/K3NV/K3NH models)
- EN/IEC conformity with CE marking and UL/CSA approval

Communications, Output Options & Output Cards

Serial communication

The serial communications boards allow easy data logging and remote setting/monitoring functions.



- Communication to PC: By plugging a communication card in the K3N ISP's a network can be created so connecting the ISP's to a personal or central computer system.
- Connection to PLC systems: When the Sysmac C200H PLC's are used data can easily be exchanged between the ISP's and PLC directly from the ladder instructions, using the Protocol Macro Function.

Easy to use plug-in output options and communication boards

The above mentioned ISP's can be equipped with one of the following boards to output alarm signals, linear transfer signals, or to add communication functions:

- Relay output boards
- Transistor output boards
- Linear output boards
- BCD communication boards
- Serial communication boards (RS232/R422 or RS485)
- Also combined boards are available, to suit your applications in the best way

Available output cards for above K3N models

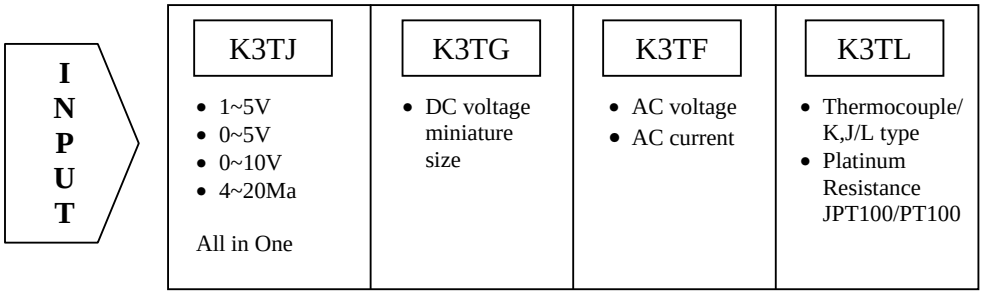
By means of output cards the above mentioned ISP's can be equipped with relay, transistor or linear outputs. Also serial communication boards are available. Combined output cards are also available; for example 5 Transistor outputs can be combined with a serial port.

9-3 Pointers of Selection (DPM)

Digital Panel Meter is mainly utilise for various Monitoring and Measurement purposes.

The selection of a DPM, depends also on what measurements the application requires, whether it is a linear input, Temperature input, AC voltage Input, AC current input or DC voltage input.

Below is a quick guide for selecting the appropriate OMRON DPM.



9-4 Omron Models (DPM)

Easy-to-use, Low-cost Digital Panel Meter that Accepts DC Input

K3TE

- Compact DIN-size (96 x 48 (W x H)) body.
- Mounting thickness of only 3.5mm required.
- Highly visible display with 14.2-mm-high LEDs.
- Easy-to-mount snap-in construction.
- Water-resistance (IP51) construction (optional)

Low-cost, High-quality Digital Thermometer with Built-in Microcomputer

K3TJ

- Compact DIN-size (96 x 48 (W x H x D)) body.
- Mounting thickness of only 3.5mm required.
- Highly visible display with 14.2-mm-high LEDs.
- Multi-temperature range incorporated.
- Upper or lower limit selectable (models with alarm output).
- Water-resistance (IP51) construction (optional).

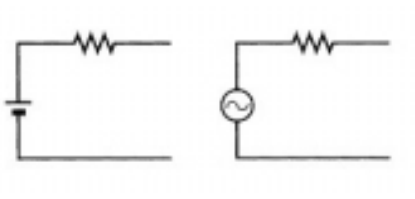
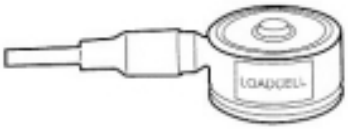
Highly Functional Scaling Meter with Versatile, Easy-to-read Red or Green Display

K3TL

- Red or green display color available.
- Wide range of scaling settings, including negative scaling.
- Simple average and movement average processing methods allow 4 s max. to display the process value, thus reducing display blinking and making it easier to read the display.
- Step display setting adjusts the step of the displayed rightmost digit to 2, or 5.
  It is possible to fix the displayed rightmost digit to 0.
- Zero limit setting enables the K3TJ to display zero for any value less than the set value and is ideal for water depth display.
- Display brightness can be adjusted.

9-5 Pointers of Selection (ISP)

Each ISP model is dedicatedly built for a specific function, for example K3NH is for Temperature Processes.
Below is a quick selection on the appropriate OMRON ISP Model.

Input signal	Measurement/Available Intelligent Signal Processor:
Current, Voltage, or Standard analog signals 	Analog Process Meter: K3NX series • For measurement and control of Voltage or current, AC or DC. • Also equipped with inputs for standard industrial analog signals, like 4-20mA, 0-10VDC, 0-5VDC etc. • Easy to scale the measured values to your standard needs.
Load cell signal 	Weighing Meter: K3NV series • For a large variety of weighing applications. • Easy set-up and calibration. • Tare function allows zero adjustment at the reference position. • With built-in 10VDC loadcell power supply.
Thermocouple, Pt100, or standard analog signals 	Temperature Meter, Analog Process Meter: K3NH series • For accurate measurement and control of process temperatures. • Multifunction input can accept signal from Pt100, basically all thermocouples and also the standard industrial analog signals, like 4-20mA, 0-10VDC, 0-5VDC etc.
Pulses, NPN/PNP or open collector signals 	Frequency/Rate meter: K3NR series • Multifunction processor for the measurement and control of rotation speed, flow rate, ratio or passing time.
	Time/Period meter: K3NP series • Advanced processor for the measurement and control of interval time.
	Up/Down counting meter: K3NC series • High speed Up/Down counting processor

Output Modules

Easy to use plug-in output options and communication boards.

The above mentioned ISP's can be equipped with one of the following boards to output alarm signals, linear transfer signals, or to add communication functions:

• Relay output boards • Transistor output boards • Linear output boards • BCD communication boards • Serial communication boards (RS232/RS422 or RS485) • Also combined boards are available, to suit your applications in the best way.

Available output cards for above K3N models.

By means of output cards the above mentioned ISP's can be equipped with relay, transistor or linear outputs. Also serial communication boards are available. Combined output cards are also available so that for example 5 Transistor outputs can be combined with a serial port.

9-6 Omron Models (ISP)

K3NX — Process Meter

- ±0.1% rdg ±1 digit max. accuracy
- Wide selection of DC/AC voltage ranges and DC/AC current ranges
- Scaling
- Forced-zero
- 80mA at 12 VDC sensor load

K3NR — Frequency/Rate Meter

- Up to 50-kHz input
- ±0.006% rdg±1 digit accuracy
- Prescaling
- Four bank settings for set values and linear output ranges
- 80mA at 12VDC sensor load

K3NV — Weighing Meter

- ±0.1% rdg ±5 digit max. accuracy
- Connectable with load cell sensor inputs up to 20mV/V
- Scaling
- Forced-zero
- 100mA at 10 VDC sensor load

K3NP — Period Meter

- Up to 50-kHz input
- ±0.08% rdg±1 digit accuracy
- Prescaling
- Four bank settings for set values and linear output ranges
- 80mA at 12VDC sensor load

K3NH — Temperature Meter

- Thermocouple, RTD, and analog inputs available in one model
- °F or °C indication
- 100-ms sampling for analog input
- Input shift

K3NC — Up/Down Counting Meter

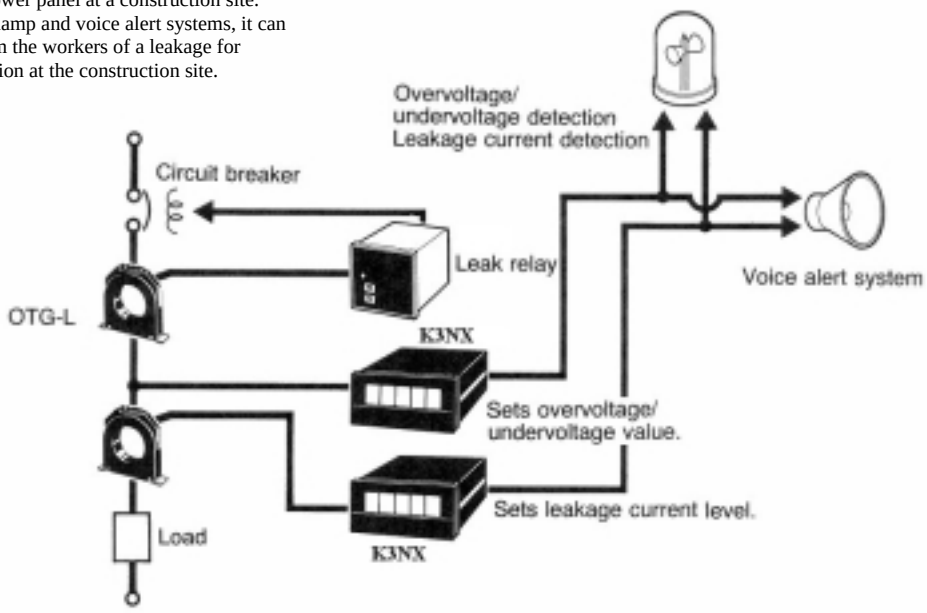
- Up to 50-kHz counting
- Prescaling
- Up/Down counting mode
- Four bank settings for set values and linear output ranges
- 80mA at 12VDC sensor load

9-7 Application (ISP/DPM)

1 Detecting A Leakage Current

The K3NX can be used as a monitoring device for a low-voltage power panel at a construction site. Combined with lamp and voice alert systems, it can be used to inform the workers of a leakage for accident prevention at the construction site.

Industry: Construction

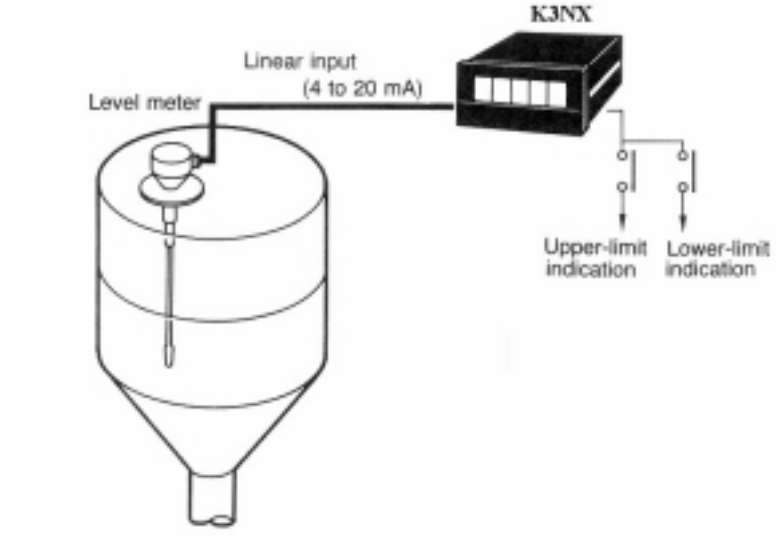


Example: Mounted in a crane for use at a construction site.

2 Detecting The Fluid Level Of A Tank

The K3NX converts the fluid level of a tank in food processing by scaling, and displays the level. At the same time, the meter sends upper-limit or lower-limit signals to the controller.

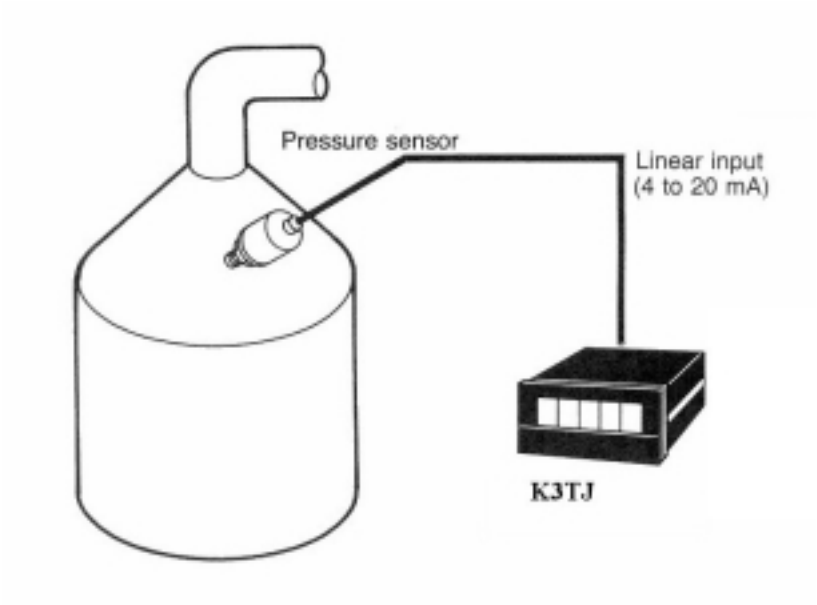
Industry: Food Processing



3 Beer Brewing System

The K3TJ monitors the pressure of carbon dioxide in a beer brewer.

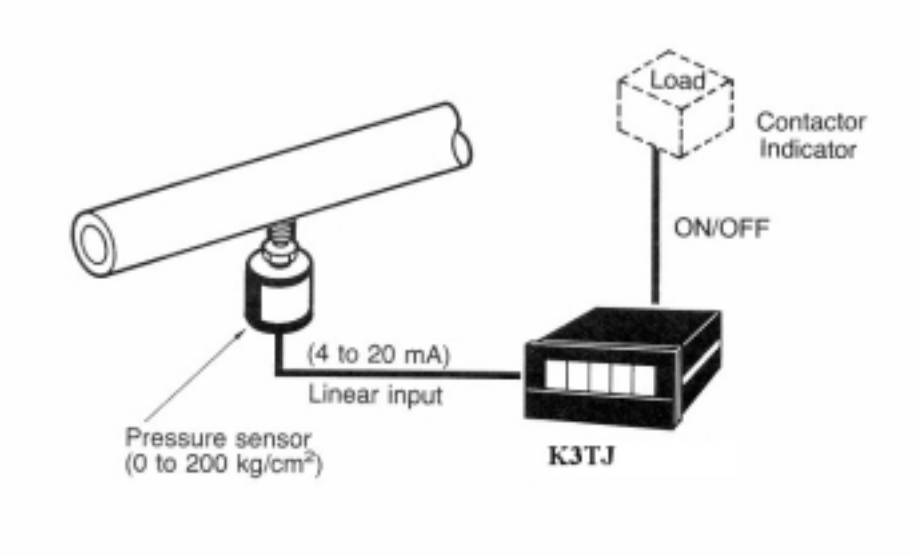
Industry: Food processing



4 Monitoring The Pressure Of Gas In A Gas Supply System For A Semiconductor Production Line

The K3TJ constantly monitors the pressure of gas in a special gas supply system for semiconductor production.

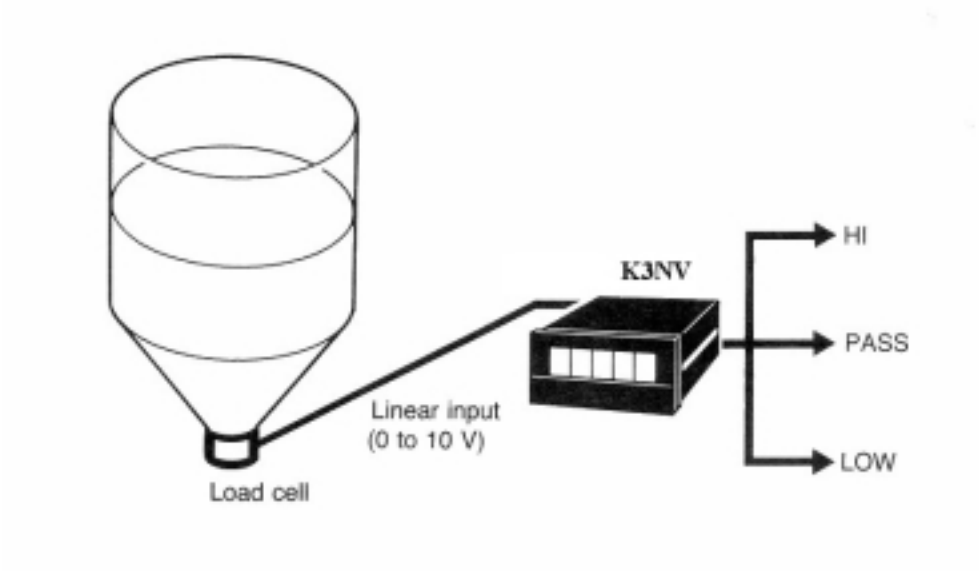
Industry: Semiconductor manufacturing



5 Measuring The Weight Of A Liquid Nitrogen Tank

Industry: Measuring instruments

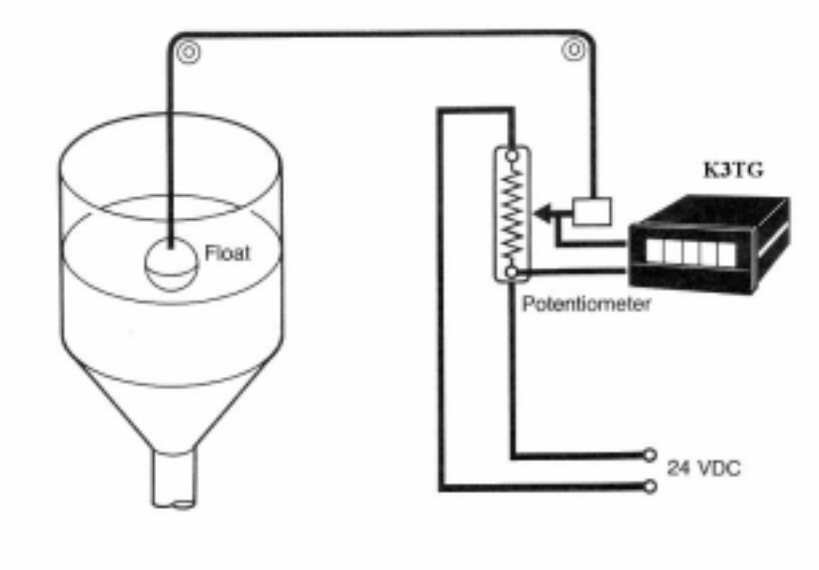
The weight of a liquid nitrogen tank is first measured with a load cell. The measured value is then converted to the amount of fluid (weight) using the scaling function of K3NV.



6 Measuring The Fluid Level Of A Tank

Industry: Measuring instruments

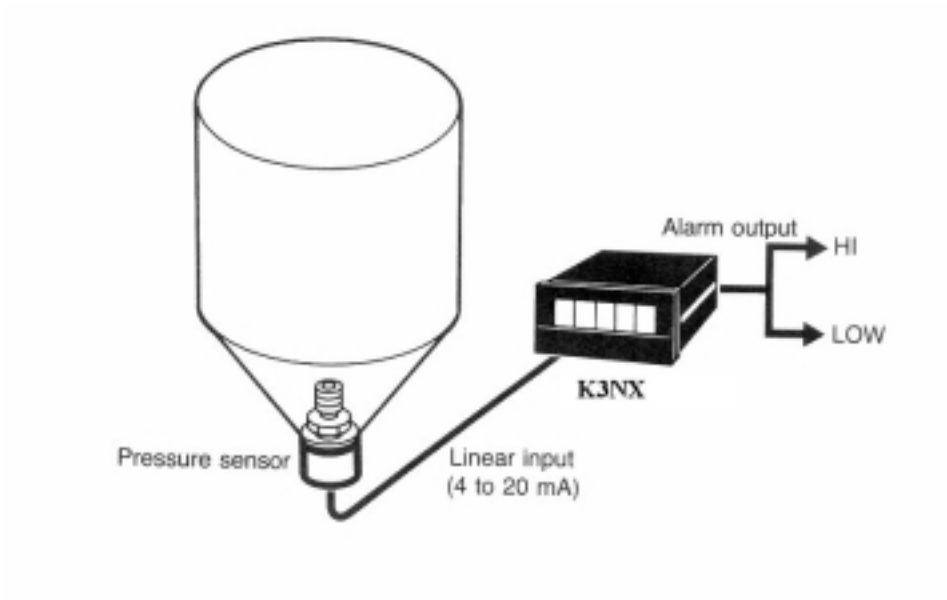
The K3TG displays the fluid level of a tank when interlocked with a float that resets on the surface of the fluid.



7 Monitoring The Fluid Surface Condition Of A Tank

The K3NX performs constant linear monitoring of the fluid level position using a pressure sensor for level detection.

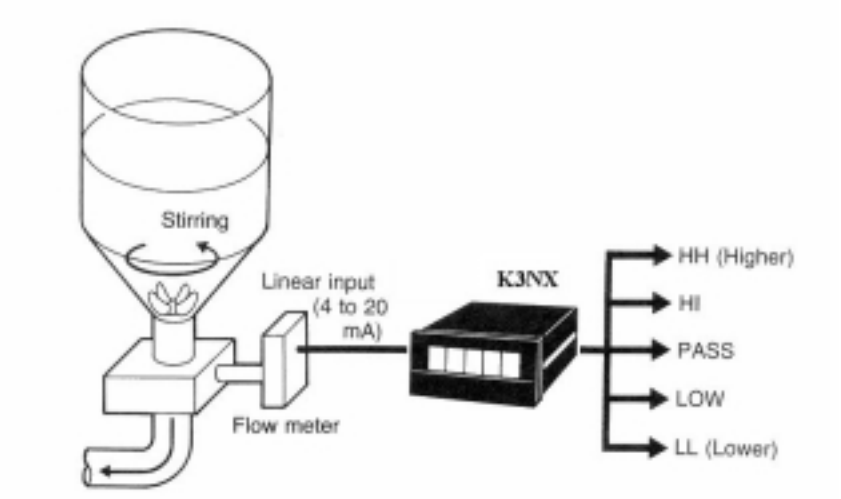
Industry: Measuring instruments



8 Monitoring The Fluid Level Of A Tank And Displaying Its Flow Rate

The K3NX measures the flow rate of fluid being exhausted from the tank, and displays the measured flow rate using its scaling function. The K3TX can also be used to measure the flow rate of coolant and for other controlling processes.

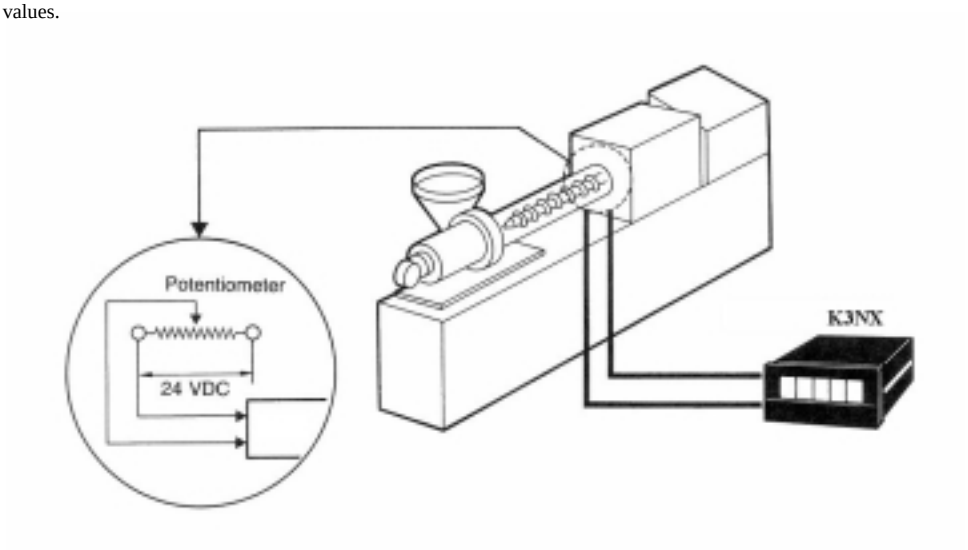
Industry: Measuring instruments



9 Detecting The Cylinder Position Of An Injection Molding Machine

Industry: Injection molding machine

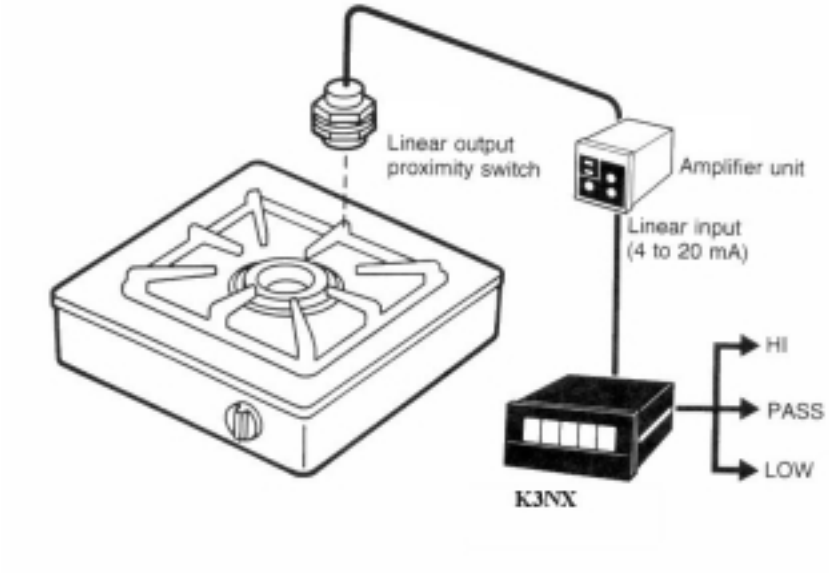
The K3NX converts the amount of movement of the injection cylinder in an injection molding machine and the resistance of the potentiometer to voltage values (or current values) so that the injection cylinder can be moved according to the preset values.



10 Determining The Height Of A Trivet In A Gas Heater

Industry: Testing equipment

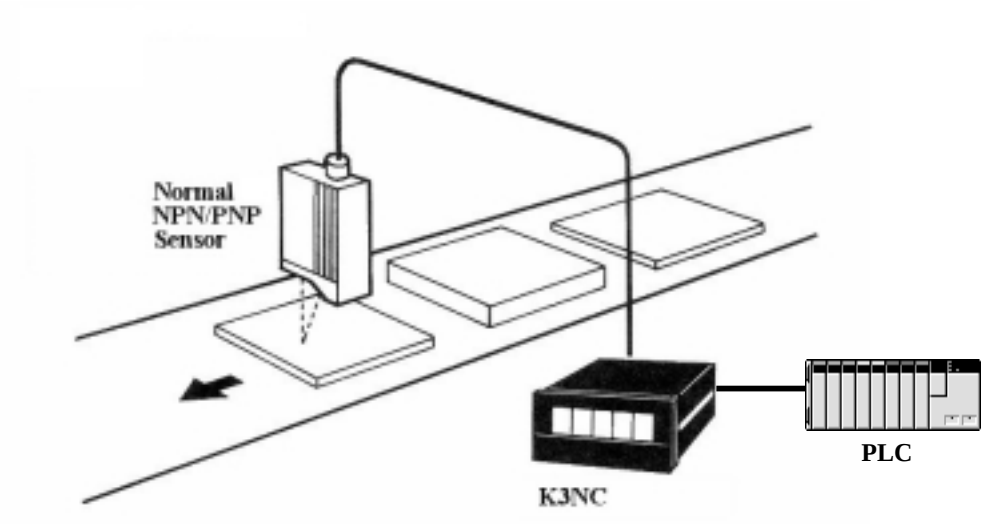
The K3NX measures the height of a trivet using the linear sensor to determine the acceptance /rejection of each heater product.



11 Discrimination By Height

Pallet counting application.

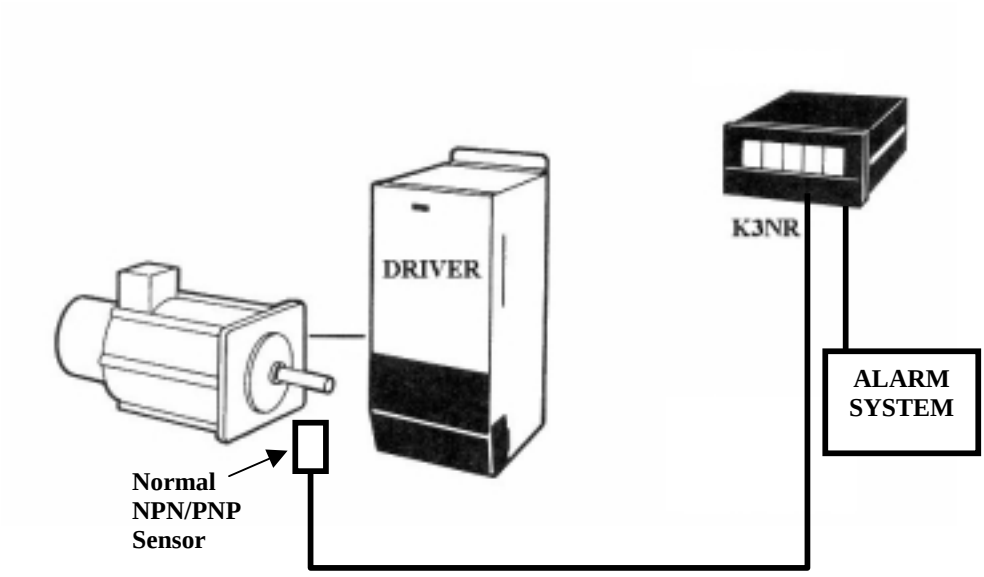
Industry: Various



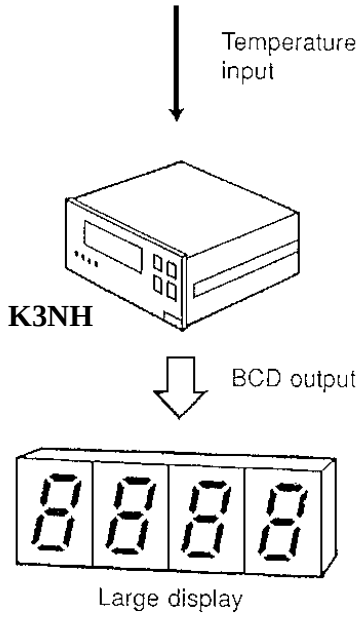
12 Displaying The Rpm Of A Servomotor

The K3NX measures and displays the motor rpm and sends the upper limit signal to an alarm system.

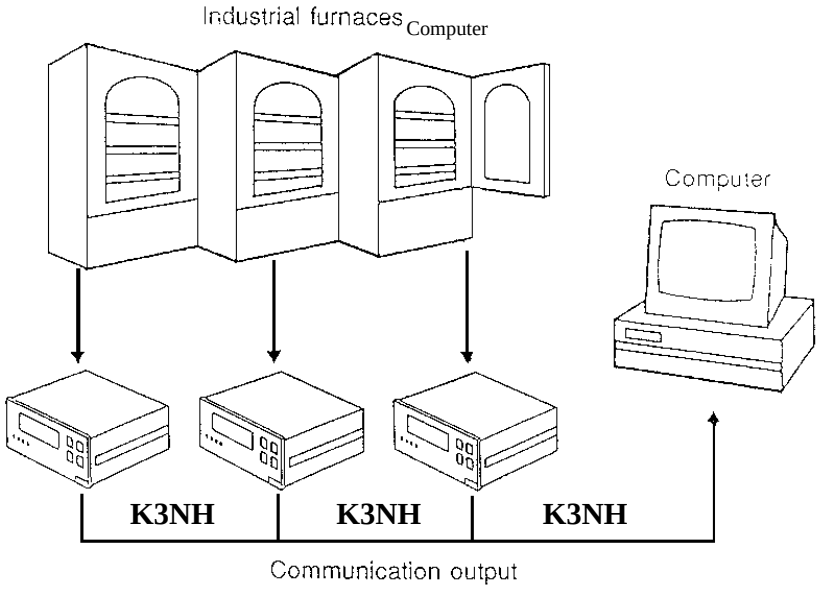
Industry: Various



13 Interfacing Large External Display



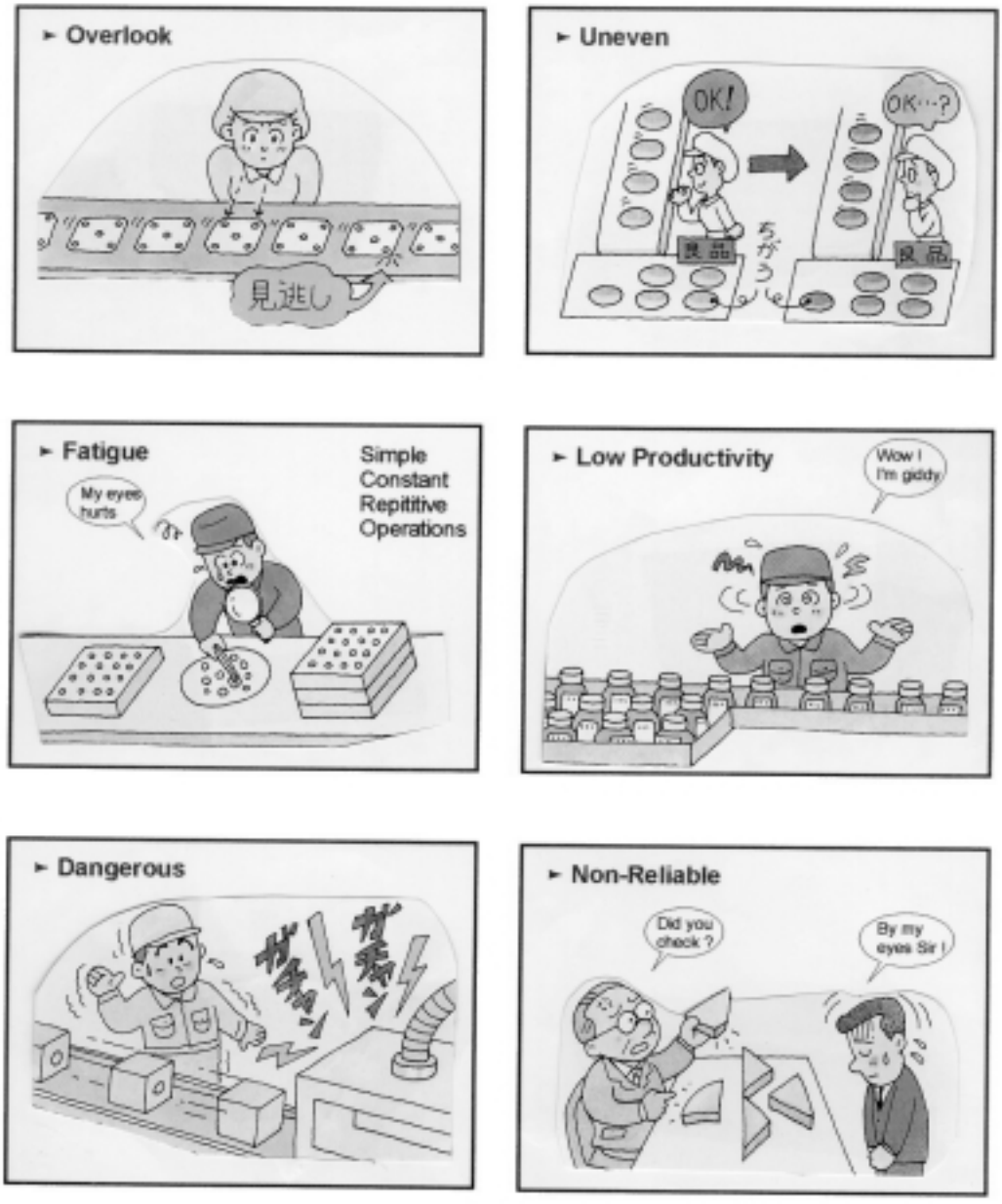
14 Centralized Temperature Monitoring For Industrial Furnaces



SECTION 10
Vision

10-1 Introduction to Vision System

How can Vision help you?



10-2 Why Use Vision System

1. Replace Human Inspection

- ✓ Human visual inspection is prone to error
- ✓ Human visual depend on physical condition of the workers
- ✓ The constant repetition of simple operations and the need to concentrate for long periods can cause fatigue
- ✓ Safety condition
- ✓ Speed

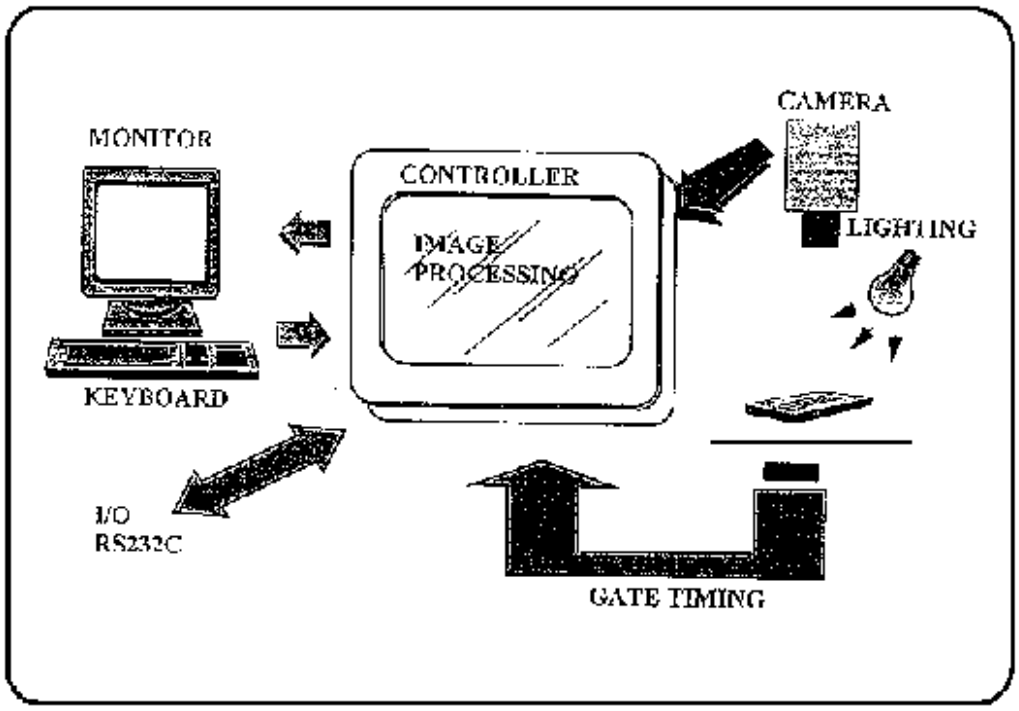
1-1-2 Wide Application

- ✓ is part of the CIM application
- ✓ Stand-alone System
- ✓ Robotics Guidance

1-1-3 Visual Inspection Requirements Are Getting Tougher

- ✓ Due to the Demand for higher quality products
- ✓ The need for more precise inspections

10-3 What Is A Vision System



1. Human Vision

Human Eye ★ Analog image

Brain ★ Process the analog image

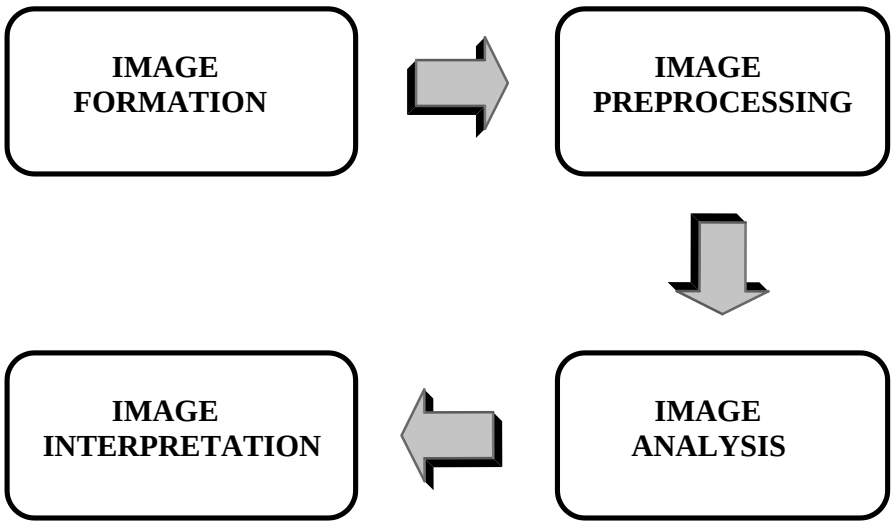
Parallel Processing
- ★ To see an entire scene
- ★ To form an immediate impression

2. Visual Inspection System

Camera ★ Digital image

Microprocessor / Controller
- ★ Process the digital image processing
- ★ One bit at a time

3. Visual Inspection Process



3-1 Image Formation

- Illumination
- Camera
  - ★ Photosensor in two dimensional arrays format
  - ★ Create two dimension image
- Output : voltage signal

3-2 Image Preprocessing

- A/D converter
- Produce an array of digital numbers which represent the light intensity distribution over the image area.
- One pixel is allow up to 256 different values
- Histogram & Thresholding
- Output : digitized image

3-3 Image Analysis

- Windowing
- Measure item
- Template Matching & position compensation
- Output : image description

3-4 Image Interpretation

- Decision making
- Inspection result
  - ★ OK
  - ★ NG
- Measurement result
  - ★ position
  - ★ dimension

10-4 Components of a Vision System

In summary the physical components of a machine vision system can be considered to comprise of the following:

1. Illumination, Illumination Control and Scene Structuring Elements.
2. Optics, Imaging Sensors and Cameras.
3. Frame Grabbers/Image Digitizers, Scanners, and Video Multiplexers.
4. Image Processing Computer or Vision Computer/Processor.
5. External Process Coupling: Interfaces to PLC's Robots, XY-Table, Parts Indexer etc.
6. Development Platform: PC's, Workstations, Software Development Environment including Image Processing Tools and Software Libraries.

1. Camera

The camera forms an important equipment in a Visual Inspection System. There is a wide range of Cameras to select from depending on the Application requirements.
Important Points to take note when selecting a camera:
1. Picture Element
2. Effective Pixels
3. Synchronization
4. Shutter Speed
5. Lens Mounting

F200-S Camera

Compact, high-resolution (250,000-pixel) CCD camera

F300-S Camera

Compact, high-resolution (380,000-pixel) CCD camera. Can be used for simultaneous monitoring from two directions.

F300-S3DR Shutter Camera

Separate amplifier allows use in confined spaces

F300-S2R Shutter Camera

F300-S4R Frame Shutter Camera

Lens

*** Camera with Light Source**
F150-SL20
(20-mm field of view)
F150-SL50
(50-mm field of view)

*** Camera**
F150-S1

2. Lighting (Illumination)

The importance of Illumination

Object illumination plays a key role in the machine vision process. The purpose of imposing controlled constant illumination is to enhance visually the parts to be imaged so that their flaws, defects, and other features are highlighted and so that their identification and classification by the vision system becomes somewhat easier.

Good image quality is the result of proper illumination, lens selection, camera and lens placement, and object positioning.

♦ *Remember the first law of machine vision:*

"If you can't see it clearly in the video monitor, you can't inspect it with the vision system."

To operate the vision system most effectively, a well-formed image must be received by the vision system. A well-formed image is easier to process and is less likely to create future analysis and interpretation problems.

You must select the type of illumination that best suits your application. Evaluate the object's features, color and reflectivity as well as the color of the background in order to determine which type of lighting works best. It may require as much as 30% of the application effort. However, it is far easier to control the illumination in order to attain a good quality image than to process and filter a poorly illuminated object. So there are no general lighting for every applications, i.e., need to customize the lighting for each application (or application-dependent).

It is recommended to have light shield to prevent environmental lighting from affecting the image quality. Other factors affecting the lighting are:

- **Voltage change resulting from activation of nearby equipment.**
- **Change of room temperature.**

It is necessary to continue monitoring light level to ensure smooth running of vision processing.

Needs:

- **To overcome fluctuations in ambient lighting conditions.**
- **To provide sufficient contrast in the image so that features can be revealed.**
- **A key parameter affecting the input to a machine vision system since it directly affects the quality of the input data.**
- **To reduce the amount of image processing significantly.**

When light strikes a surface, it can be:

- Absorbed
- Transmitted
- Reflected

Absorbed, dark objects absorbed great deal of light. Light objects absorb very little light; most of it is reflected.

Transmitted, light passes through many types of glasses and plastics. The light path is often radically modified by this transmission; this light is called transmitted light.

Reflected, light that is not absorbed or transmitted is reflected. The 2 types of reflected light are: Specular, and Diffuse. The figure below illustrates both type of reflection.

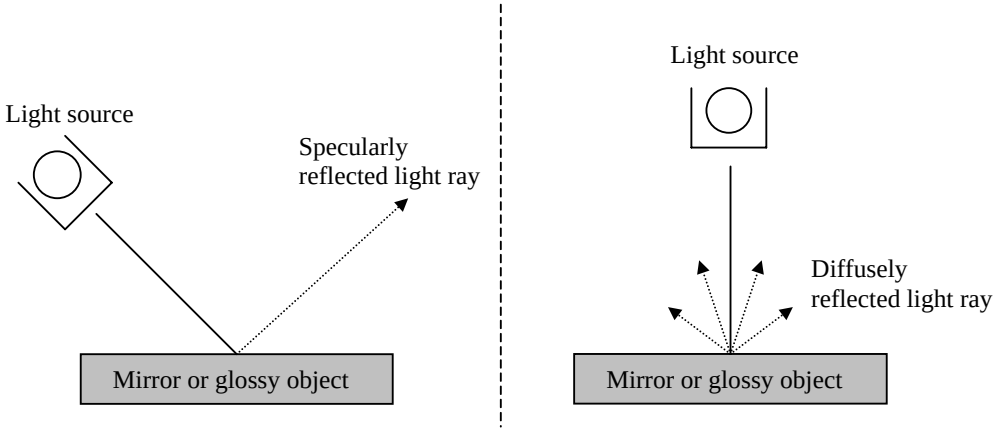


Figure 1. Types of reflected light.

Light Sources

Ambient Light, too uncontrolled for available technology to work reliably. Usually a source of noise.

Types of Light Sources: *SPOT Sources*

- Incandescent – halogen, vacuum
- Strobe Lamp
- Laser
- Light Emitting Diode (LED)

EXTENDED Sources

- Fluorescent
- LED array
- Fiber Optics
- Neon

Incandescent, light is obtained from a tungsten metal filament heated to 2000-2500K by passing an electrical current. They are economical and their intensity can be easily adjusted. However, ordinary incandescent lamps are not recommended since they exhibit a constant degradation in light during their operating life.

Quartz halogen bulbs contain a small amount of halogen gas, generally iodine. The iodine combines with the cool tungsten on the inside of the wall. This allows the tungsten to be operated at a higher temperature, resulting in a more efficient source with more white light emission. Care must be taken with bulb, it must not be scratched or handled.

Fluorescent, for most machine vision applications, a diffuse source of light is the most suitable. Diffuse lighting is non-directional and produces a minimum amount of shadow. Fluorescent lighting is the simplest and most common method of obtaining diffuse illumination. It produces much less heat than an incandescent lamp yet produces the same amount of light. Fluorescent lamps, in multiple lamp fixtures, provide large, diffuse **Strobe lamp**, when an object is moving past the camera, the strobe lamp can 'freeze' the image so processing can be done. The strobe produces a high intensity light for a very short time. The timing of the flash must be synchronized so that the part is present when the camera scans the area. It reduces the effects of image blur that occurs while photons are accumulated by the vision sensor during its finite scan period as the object moves through its Field-of-View (FOV).

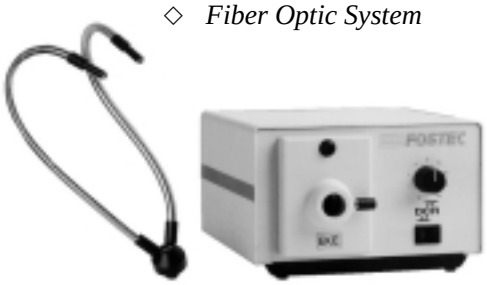
Light-Emitting Diode (LED), semiconductor LEDs emit light in a rather narrow band of wavelength in the IR, red, yellow, and green. The total energy is low. This is not a consideration in backlighting arrangements.

Laser, lasers are monochromatic and coherent sources and they produce a spectrally pure light useful for illuminating small areas. The beam can be focused to a very small spot with enormous energy density and that it can be perfectly collimated. They are used for special imaging applications, such as structured light, or as a means of measuring the distance to an object. Several types of lasers have been developed: gas, solid-state, injection, and liquid lasers. The most popular one is the He-Ne gas, it provides very bright points or lines of illumination that are visible to the eye.

◇ *Laser Diode Modules*

Fiber optic, a bundle of such thin fibers made of glass or plastic provides a channel for convenient translation of light to small constricted areas and hard-to-get-at places. The source of light is typically a small quartz halogen bulb. It should coupled efficiently to the entrance end of the bundle and the bundle exit end efficiently coupled to the illuminated.

◇ *Fiber Optic System*

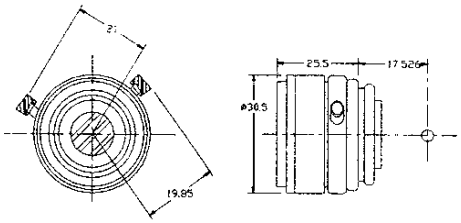


Others, Polarized, ultraviolet, and arc lamps are also occasionally used.

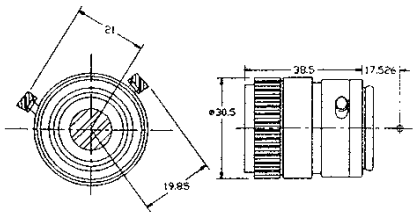
3. Lens

FA Lenses-High Resolution/Low Distortion

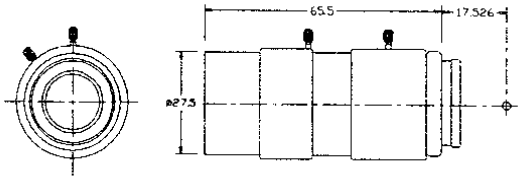
S20HC
25mm F1.6 2/3" w/Iris/Focus



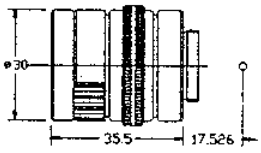
S21HC
50mm F2.8 2/3" w/Iris/Focus



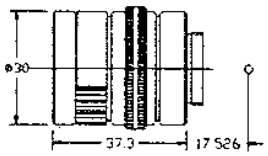
S1A1HB
75mm F4 2/3" c-m w/Iris/Focus



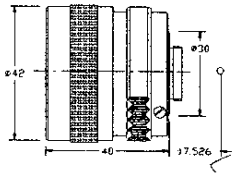
H1212B(C61215)
12mm F1.2 1/2" c-m w/Iris/Focus



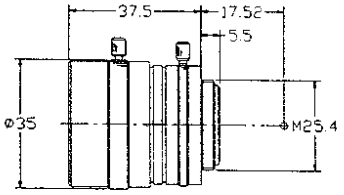
B2514D(C22525)
25mm F1.4 1" c-m w/Iris/Focus



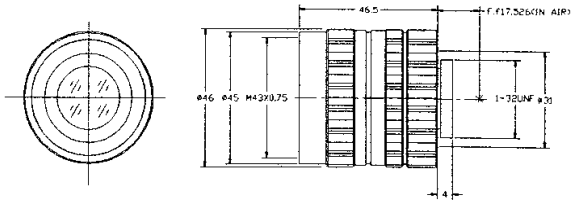
B2518(C22516)
25mm F1.8 1" c-m w/Iris/Focus



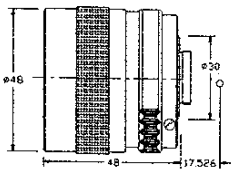
OM35NC
35mm F1.4 2/3" c-m w/Iris/Focus



HF35A-2
35mm F1.7 2/3" c-m w/Iris/Focus

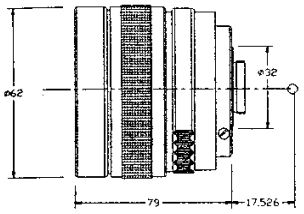


B5014A(C25011)
50mm F1.4 1" c-m w/Iris/Focus

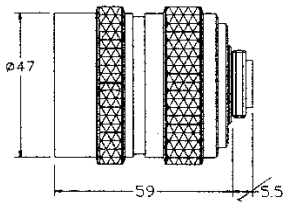


Fixed / Zoom Lenses

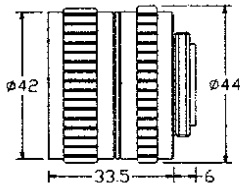
B7514C(C27509)
75mm F1.4 1” c-m w/Iris/Focus



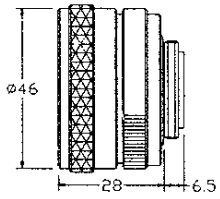
S1253
12.5mm F1.3 1” c-m w/Iris/Focus



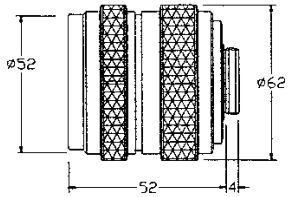
S2509
25mm F0.95 1” c-m w/Iris/Focus



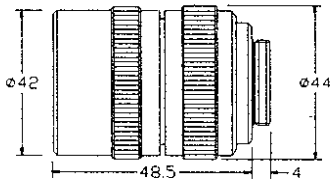
S2514
25mm F1.4 1” c-m w/Iris/Focus



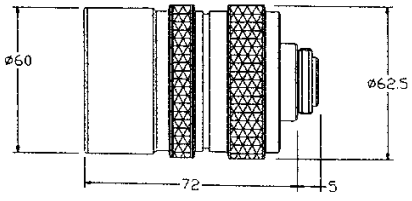
S5013
50mm F1.3 1” c-m w/Iris/Focus



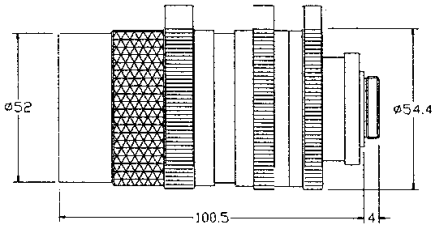
S5018
50mm F1.8 1” c-m w/Iris/Focus



S7513
75mm F1.3 1” c-m w/Iris/Focus

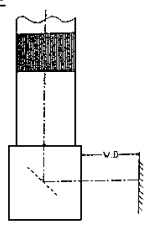


S12575K
12.5~75mm F1.8 2/3” c-m w/6X Zoom/Iris/Focus

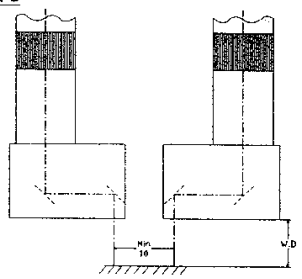


Attachment Accessories for Zoom / Fixed Lenses

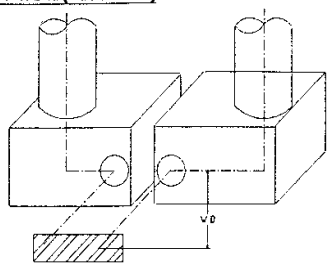
PM-2



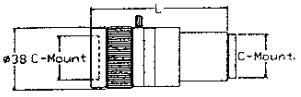
PM-5



PM-4R/4L(not shown)

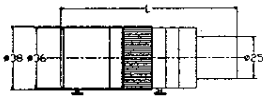


"C-Mount Lens" Relay Lens Adapter for Scales



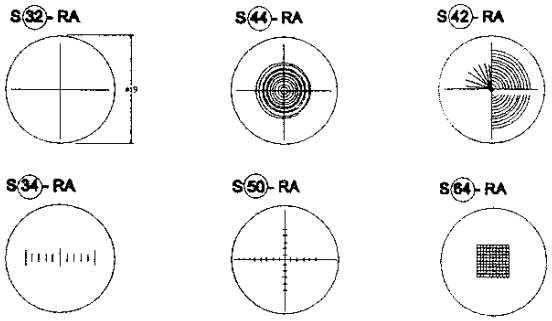
Model	Mag.	Length
RA-15C	1.5X	76-86
RA-20C	2.0X	86-96

Relay Lens Adapter for Scales



Reticle Scales

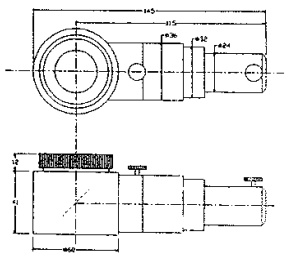
* Special-made Scales are available



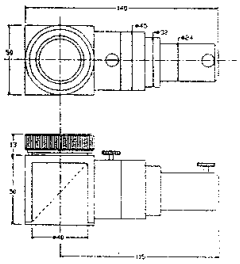
Co-Axial Lighting System (Filter-Insertion Type)

Wide-Field Half Mirror Box

DU-60

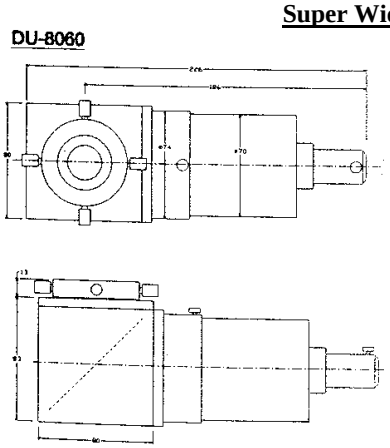


DU-5540

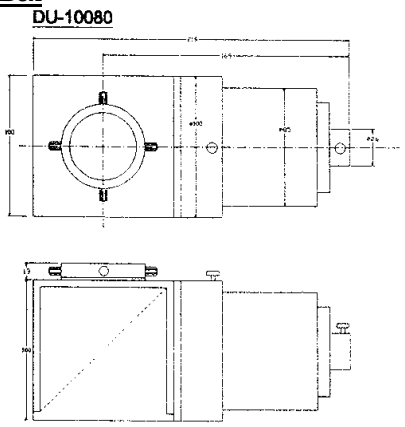


Super Wide-Field Half Mirror Box

DU-8060



DU-10080



4. Monitor

PM-509 (5-inch)/PM-909 (9-inch)/PM-129 (12-inch)

PM Series Black and White Video Monitors [EIA/CCIR]

■ Specifications

	PM-509	PM-909	PM-129
Picture tube	S1402PS20N1W1 or equivalent	S2311PS20N1H34 or equivalent	S3112PS20N1L21 or equivalent
Video input level	VS 1.0Vp-p Video:0.7Vp-p (positive)/Sync.:0.3Vp-p (negative)		
Video output level	25Vp-p	30Vp-p	30Vp-p
Sync. input level	4.0Vp-p (negative) [EIA:Option/CCIR:Standard]	[4.0Vp-p(negative) [Option]]	
Sync. input impedance	High or 75 Ω Switchable [EIA:Option/CCIR:Standard]	[High or 75 Ω Switchable [Option]]	
Video frequency response	60Hz~80Hz ± 3dB or less (100kHz reference)		
Horizontal resolution	700 lines or more at center	700 lines or more at center	750 lines or more at center
S/N ratio	Hum noise:- 60dB or less / Sync noise:- 40dB or less		
Video amp linearity	10% or less (by the DG method)		
Scanning system	EIA:525/60Hz / CCIR:625/50Hz*		
Power requirement	EIA:AC120V/60Hz / CCIR:AC230V/50Hz		
Environment temperature	-10 C~+45 ℃		
Dimensions (WHD)	147X153.5X221mm	219.5X217.5X240mm	304X285X305mm
Weight (Standard Type)	Approx.3kg	Approx.5kg	Approx.9kg
Power consumption	16W or less	20W or less	25W or less
Rack mount (option)	XRME-7069 (Triple type)	XRME-7079 (Dual type)	XRME-7099 (Single type)

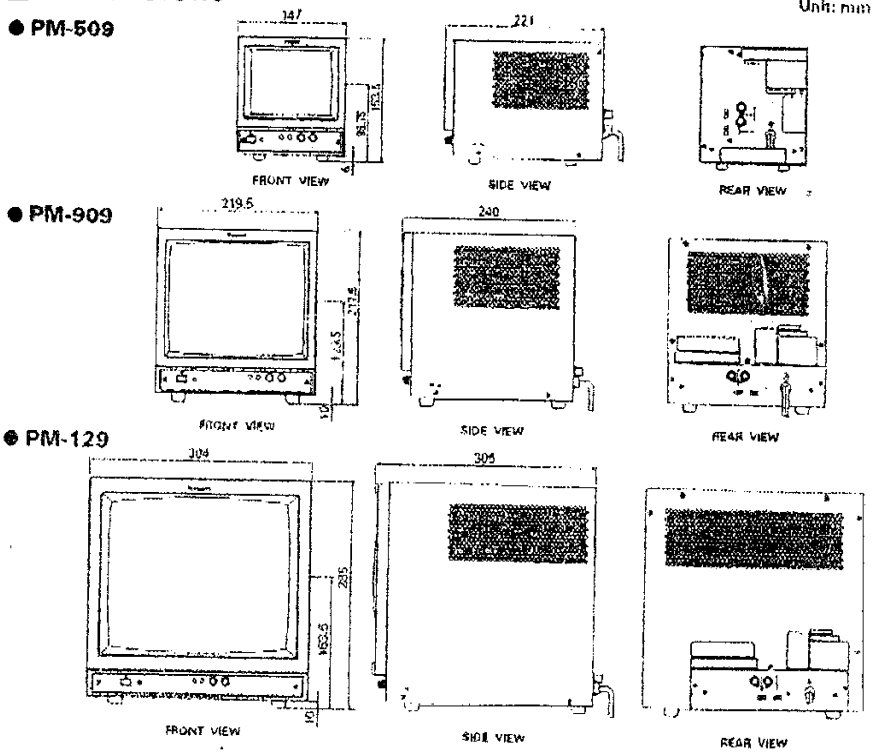
* Non switchable

■ Controls

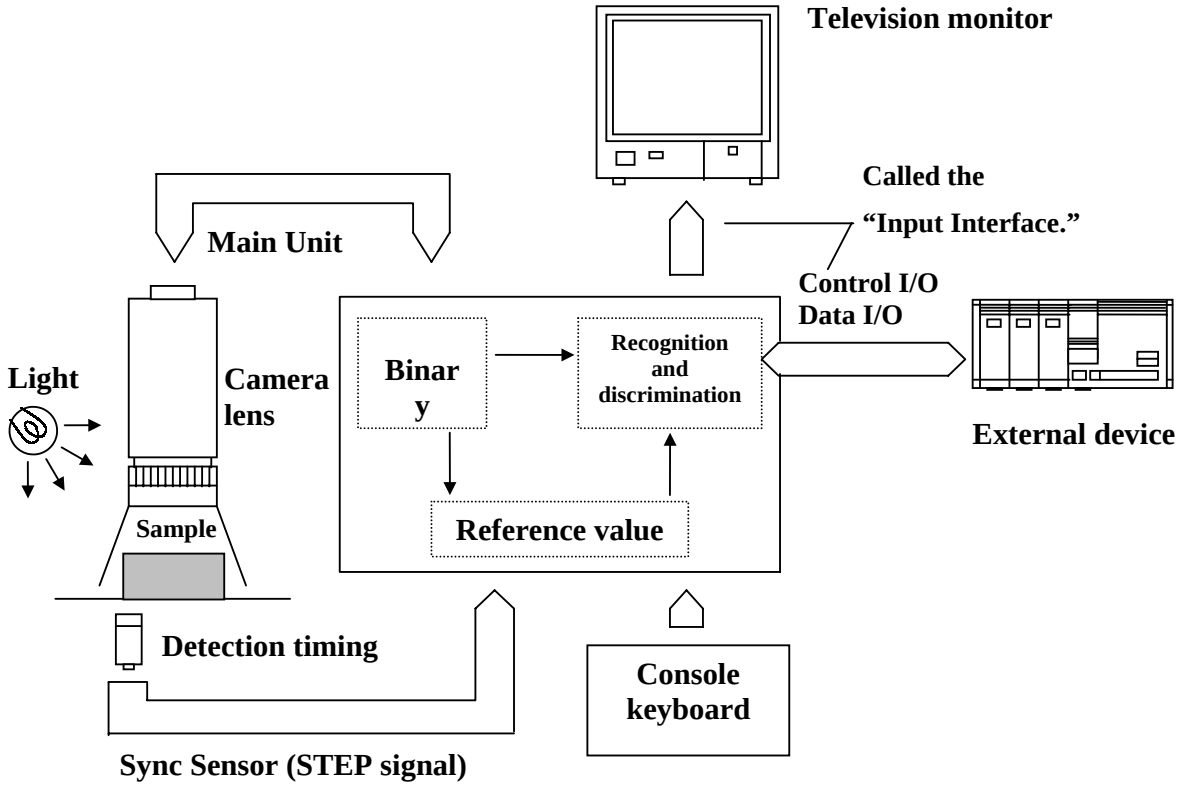
- Power Switch
- V. hold control
- H. hold control
- Brightness control
- Contrast control
- Video termination switch (75Ω / HIGH)
- AFC mode switch (FAST-SLOW)
- Sync. termination switch (Only PM-509[CCIR]) (75Ω / HIGH)
- Sync. mode switch (Only PM-509[CCIR]) (INT-EXT)

■ Dimensions

Unit: mm



10-5 Basic Vision Sensor Configuration



10-6 OMRON Family of Vision System

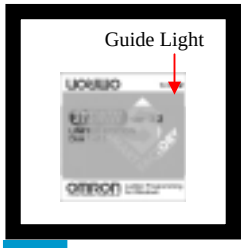
F10 Pattern Matching Sensor

Industry's first in high speed pattern detection
The low cost F10 pattern matching sensor bridges the gap between vision systems and photoelectric sensors. The F10 can recognize patterns instead of simple spots and may be used in applications previously requiring multiple photoelectric sensors. The guide light and one push "Teach" button makes the F10 extremely easy to set up while fast and precise detection make it suitable for the most demanding of applications.

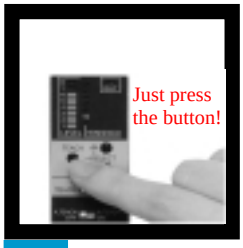
Key Features

- 4 easy steps to inspection with guide light and "Teach" button
- Detects patterns instead of spots
- High speed pattern matching in 3.6ms

Easy Setup

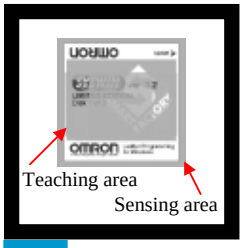


1 Focus guidelight on object.



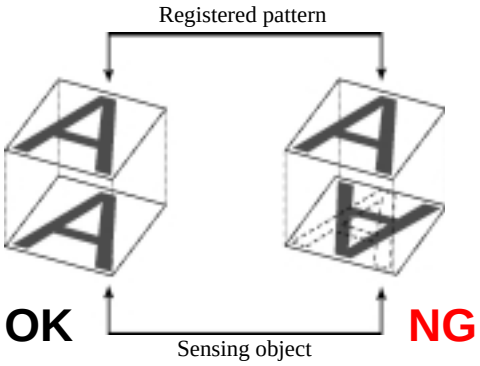
2 Press Teach button to register pattern.

3 Press Select buttons to adjust threshold.



4 Start inspection.

Pattern Matching Principle



The F10 checks the degree of conformity of the sensing object pattern to the registered pattern.

2. F30 Vision Sensor

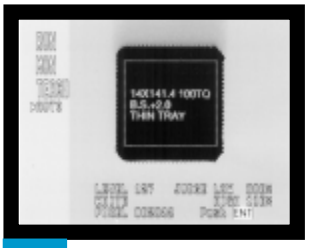
Compact vision sensor redefines "easy to use" The low cost and easy to use F30 vision sensor offers a vision solution to a whole new range of users. It offers the function of high end vision systems but does away with difficult lighting adjustments by combining the camera, light source and controller into one compact unit. The F30 also eliminates time consuming programming thanks to its easy to use "Auto Teach" function which memorizes image data and automatically sets high/low limits. In sum, the low cost and ease of use make the F30 an effective vision solution possible for users previously unable to invest the time or money in one.

Key Features

- Easy installation with array camera, light sourc ody (70 x 72 x 139mm)
- Easy setup with "Auto teach" function which memorizes image data and automatically sets high/low limits
- Stable sensing with Omron's unique optical construction makes it possible to detect glossy objects

Easy Setup

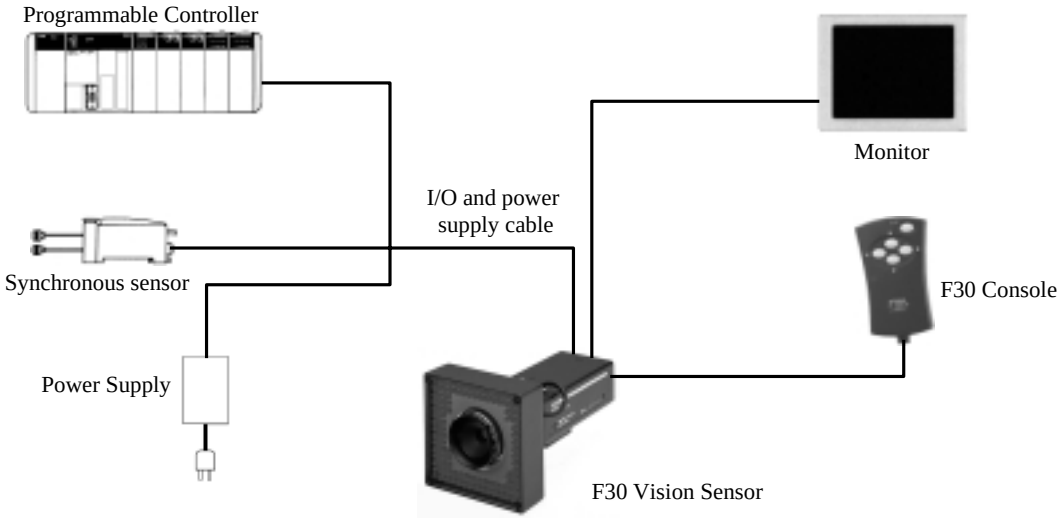
1 Choose Auto in Teach menu.



2 Press Enter when inspection area is identified.

3 Begin inspection.

Simple System Configuration



3. F150 Vision System

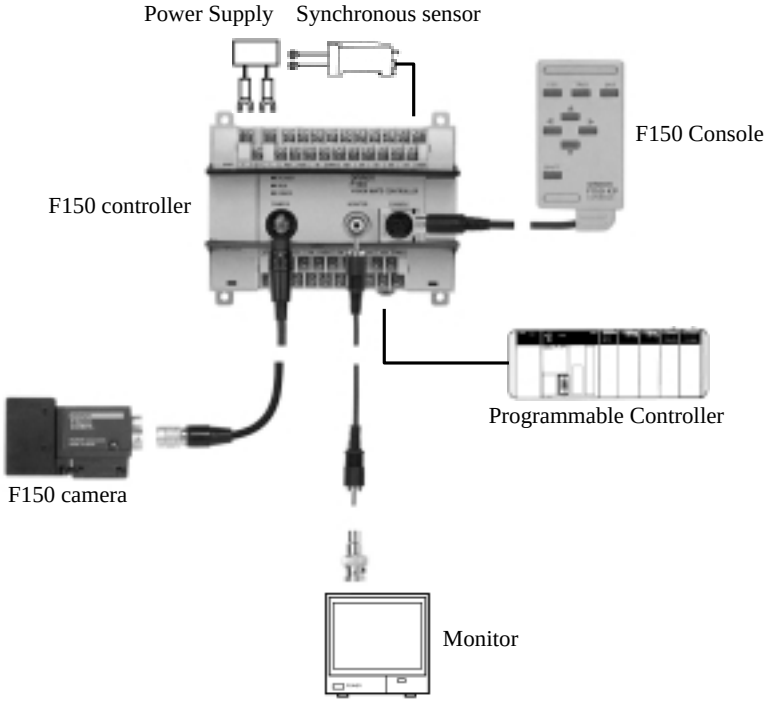
High performance, low cost vision system

The F150 vision system is a sophisticated vision solution that through its low price and ease of use provides significant cost reduction to users. The system's 3 step "Auto Menu" function makes it easy for user's to register up to 23 images in memory for more accurate inspections. The "Expert Menu" unleashes the full power of the F150 for multiple and complex inspections. The F150 is also easy to install with its compact body and camera with built-in light source and lens. The F150 is the best solution for vision applications where high function is necessary but high price is not.

Key features

- "Auto Menu" enables 3 step setup while "Expert Menu" enables complex and multiple inspections
- Large CCD (1/3 inch) with built-in lens and LED lighting in compact body for easy mounting
- Fast and precise gray scale processor highlights defect area and stores up to 23 images in memory

Simple System Configuration



Automatic and Expert Menus

AUTO MENU FUNCTION

1 **REGISTER IMAGES**
Register up to 23 sample images to automatically set measurement parameters.

2 **INPUT "OK" AND "NG" INFORMATION**
Register "OK" or "NG" for each sample image.

3 **BEGIN INSPECTION**
The F150 is ready to begin inspection.

EXPERT MENU FOR MULTIPLE AND COMPLEX INSPECTIONS

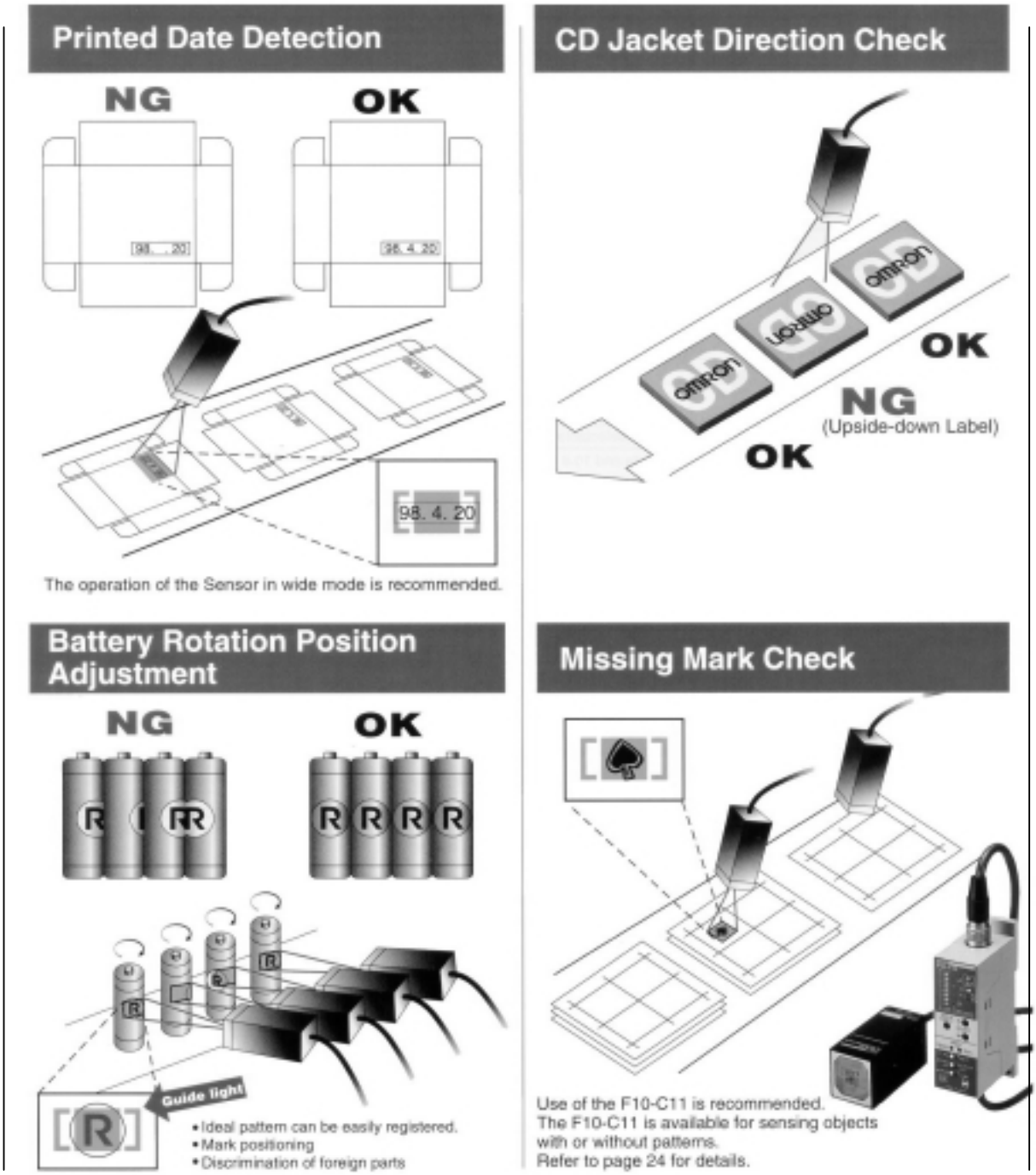
POSITIONING
Ability to capture measurement values makes F150 ideal for positioning applications.

CALCULATIONS
Calculations using measurement values makes F150 ideal for dimension measurement applications.

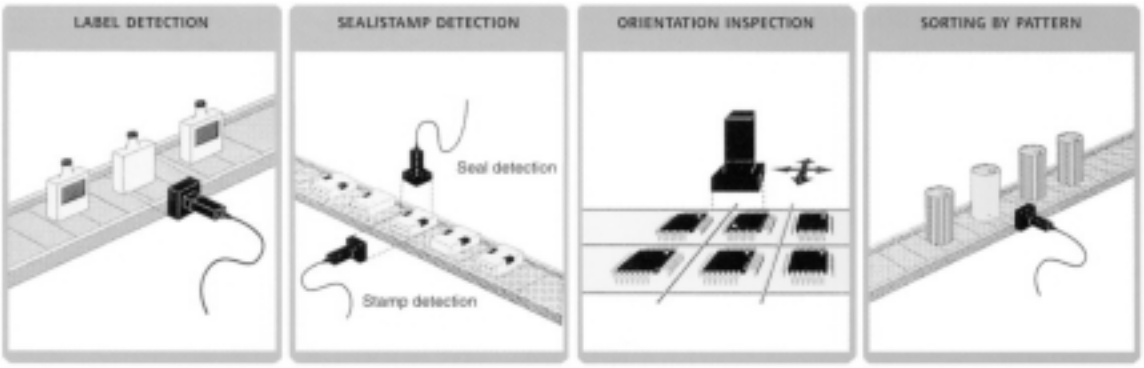
AREA IDENTIFICATION
Inspection results obtained by region enable quick identification of failed area.

10-7 Application Examples

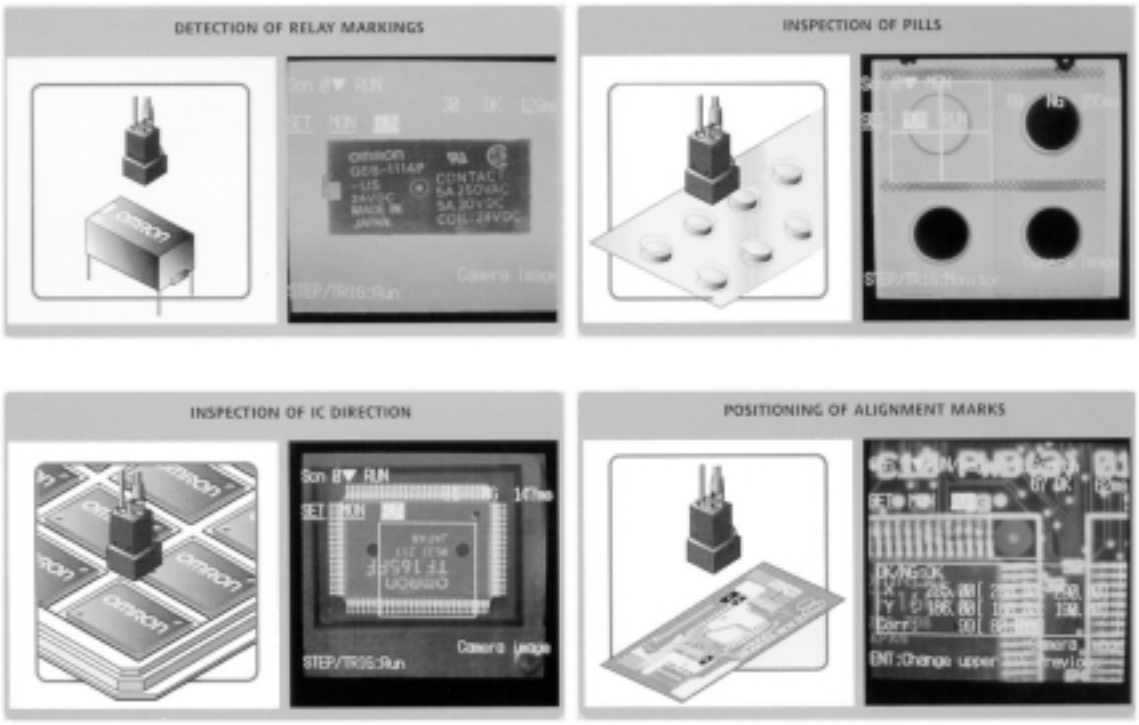
1. Application of F10 (Gray Scale Pattern Matching)



2. Application of F30 (Binary Processing of Inspection Area)



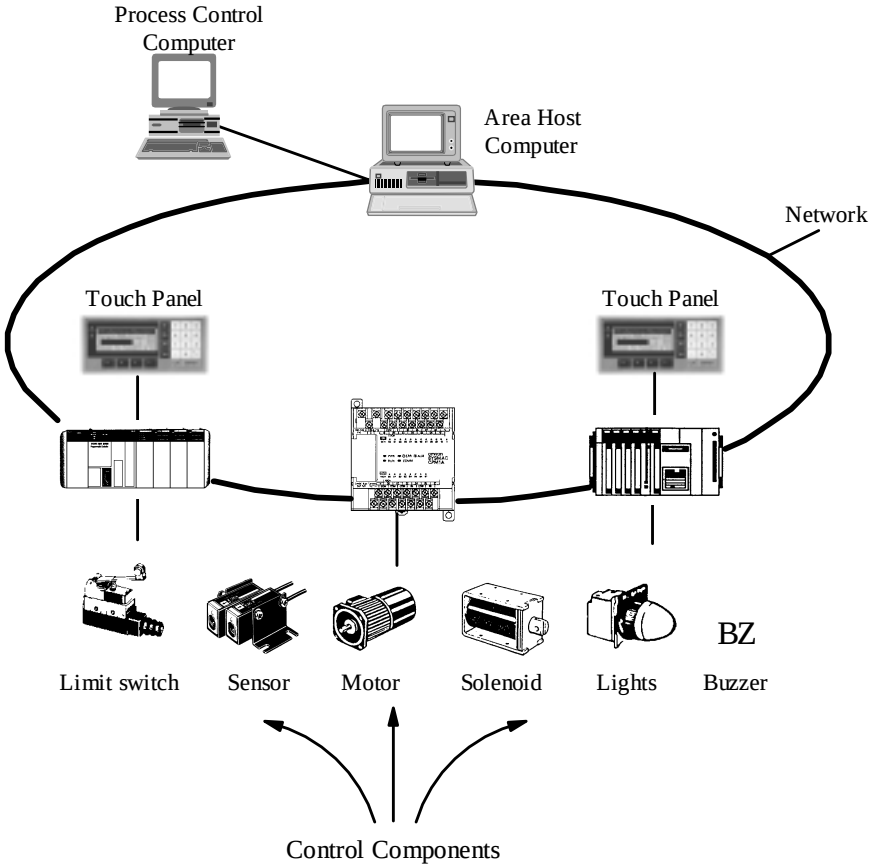
3. Application of F150 (256 Level Gray Scale Processing)



SECTION 11
Programmable Logic Controller (PLC)

11-1 What is a Control System?

In general, a Control System is a collection of electronic devices and equipment which are in place to ensure the stability, accuracy and smooth transition of a process or a manufacturing activity. It takes any form and varies in scale of implementation, from a power plant to a semiconductor machine. As a result of rapid advancement of technology, complicated control tasks accomplished with a highly automated control system, which may be in the form of Programmable Controller (PLC) & possibly a host computer, etc. Besides signal interfacing to the field devices (such as operator panel, motors, sensors, switches, solenoid valves and etc.), capabilities in network communication enable a big scale implementation and process coordination besides providing greater flexibility in realizing distributed control system. Every single component in a control system plays an important role regardless of size. For instance, as shown in Fig 1.1 the PLC would not know the happenings around it without any sensing devices. It is also unable to activate any moving mechanism if there is no motor installed. And if necessary, an area host computer has to be in place to coordinate the activities in a specific area at the shopfloor.



It could also be an application as small as a single PLC controlling a single or some output devices.

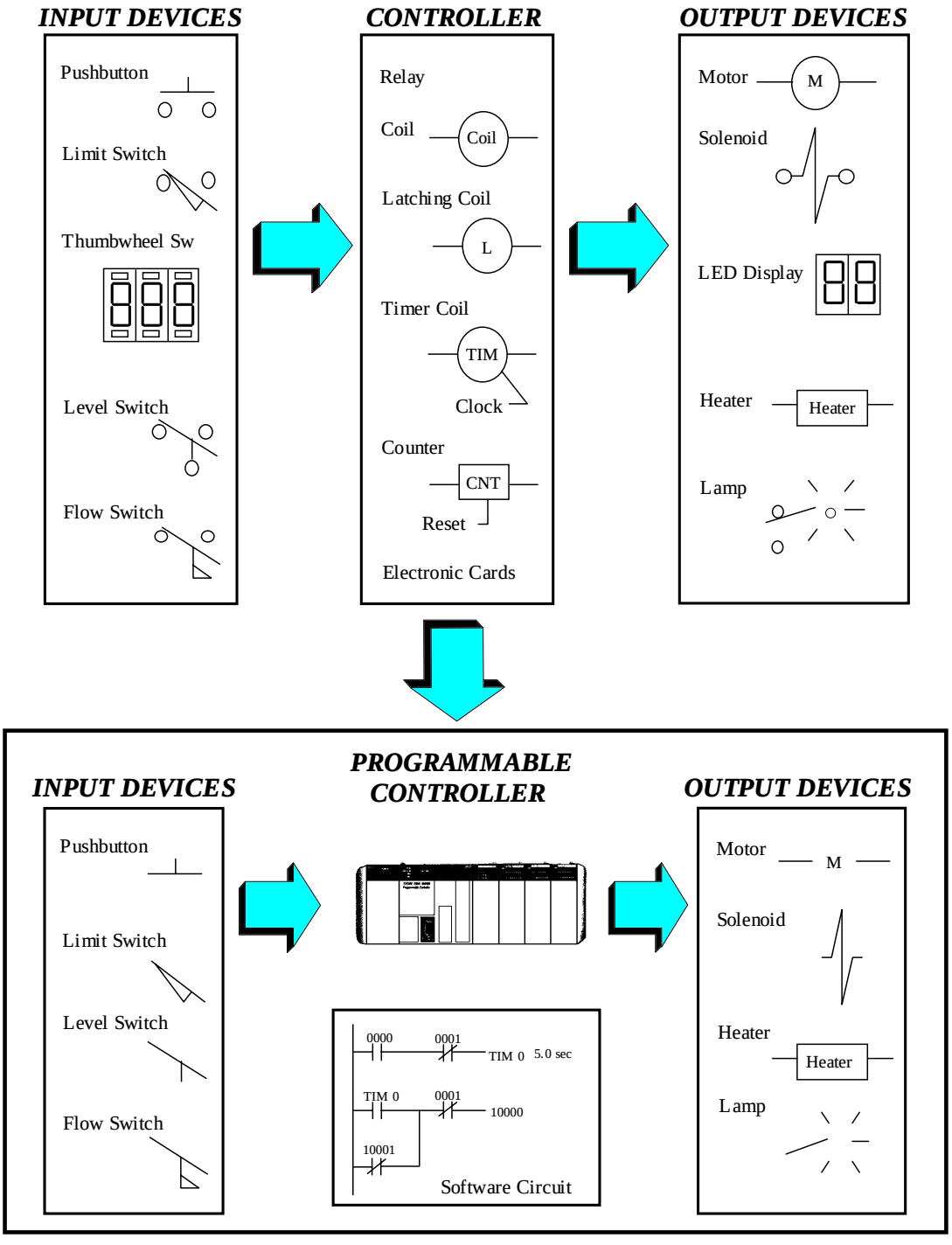
Gantry Robot Control System
(Courtesy of Gintic)

Typical Programmable Logic Controller-based Control System

This picture is a typical application of a Gantry Robot Control Machine. It is used in a pick and place operation. The whole process sequence is controlled by a PLC. The various input devices such as selector switches, push buttons, toggle switches, sensors are connected to the input of the PLC via the input terminal block. The output devices such as the revolving light, indicators, relays, contactors and solenoid valves are connected to the output terminals of the PLC. The whole process is controlled by a ladder program loaded into the PLC CPU memory. The program will execute a sequence automatically according to the pre-defined sequence of operations. Manual operation are also provided to allow operator to activate the machine manually by the switches, emergency push-button for the purpose of safety in case you need to stop the operation abruptly. In this application, the control system operates as a stand-alone operation.

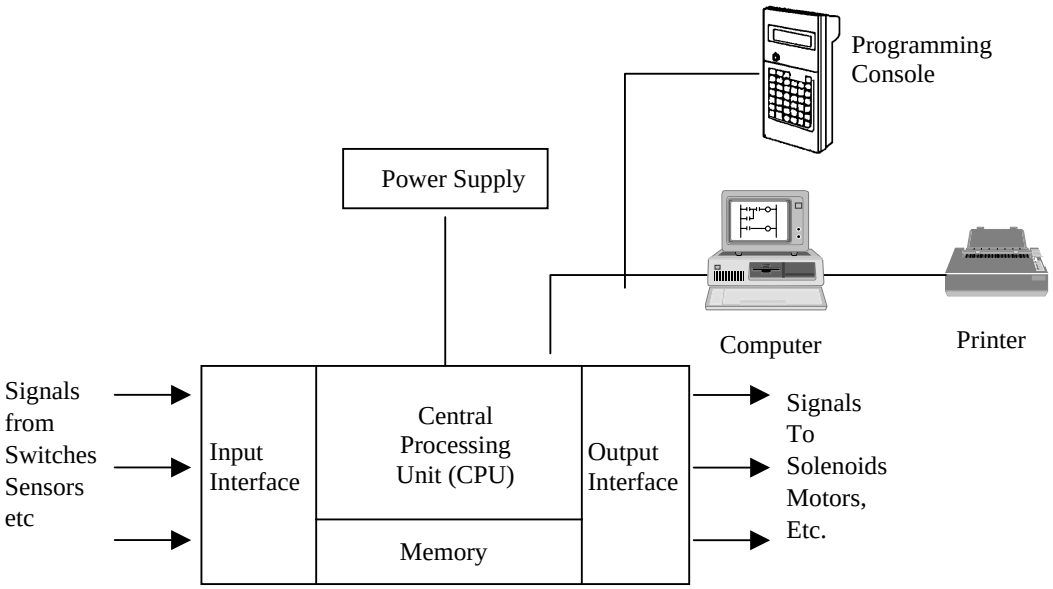
11-2 What is a Programmable Logic Controller?

1. A Typical Control System



2. PLC

A PLC consists of a Central Processing Unit (CPU) containing an application program and Input and Output Interface modules, which is directly connected to the field I/O devices. The program controls the PLC so that when an input signal from an input device turns ON, the appropriate response is made. The response normally involves turning ON an output signal to some sort of output devices.



Central Processing Unit
The Central Processing Unit (CPU) is a microprocessor that coordinates the activities of the PLC system. It executes the program, processes I/O signals & communicates with external devices.

Memory
There are various types of memory unit. It is the area that holds the operating system and user memory. The operating system is actually a system software that coordinates the PLC. Ladder program, Timer and Counter Values are stored in the user memory. Depending on user's need, various types of memory are available for choice:

(a) Read-Only Memory (ROM*)*
ROM is a non-volatile memory that can be programmed only once. It is therefore unsuitable. It is least popular as compared with others memory type.

(b) Random Access Memory (RAM)
RAM is commonly used memory type for storing the user program and data. The data in the volatile RAM would normally be lost if the power source is removed. However, this problem is solved by backing up the RAM with a battery.

(c) Erasable Programmable Read Only Memory (EPROM)
EPROM holds data permanently just like ROM. It does not require battery backup. However, its content can be erased by exposing it to ultraviolet light. A prom writer is required to reprogram the memory.

(d) Electrically Erasable Programmable Read-Only Memory (EEPROM)
EEPROM combines the access flexibility of RAM and the non-volatility of EEPROM in one. Its contents can be erased and reprogrammed electrically, however, to a limited number of times.

3. Programmable Logic Controller

In the present state of intense industrial competition, production efficiency is generally regarded as the key to success. Production efficiency covers a wide field such as:

a) The speed at which production equipment and production line can be set up to manufacture a product
b) Lowering material and labour cost of a product
c) Improving quality and lowering rejects
d) Minimizing downtime of production equipment
e) Low cost production equipment

The Programmable Logic Controller meets most of the above needs and is a key factor in furthering production efficiency in the industries.

Traditionally, automation is only applicable to single item high volume production. It is now necessary to automate production of multiple variety of goods, in moderate quantity, as well as achieving higher overall productivity and requiring minimum investment in plant and equipment.

The Flexible Manufacturing System answers these needs. The system includes such automatic equipment as NC machines, industrial robots, automatic transports and computerizes control of production. You will find the Programmable Logic Controller in the use of automated production equipment.

4. Background and Development

Before the introduction of Programmable Logic Controllers, there have been many sequence control devices, including those using cam shafts and drums. When electromagnetic relays appeared, relay control panels become the mainstay of sequence control. When transistors appeared, they were also applied in fields where electromagnetic relays are inadequate, such as high-speed control response.

Nowadays, the control field is expanding to include the complete factory and total control systems combined with feedback control, data processing and centralized monitoring systems.

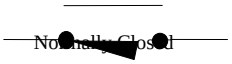
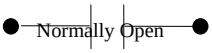
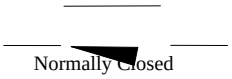
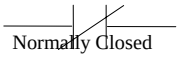
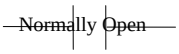
Conventional wired logic control systems cannot perform total control and Programmable Logic Controllers or microcomputers are necessary.

Let us make a comparison between wired logic and Programmable Logic Controllers.

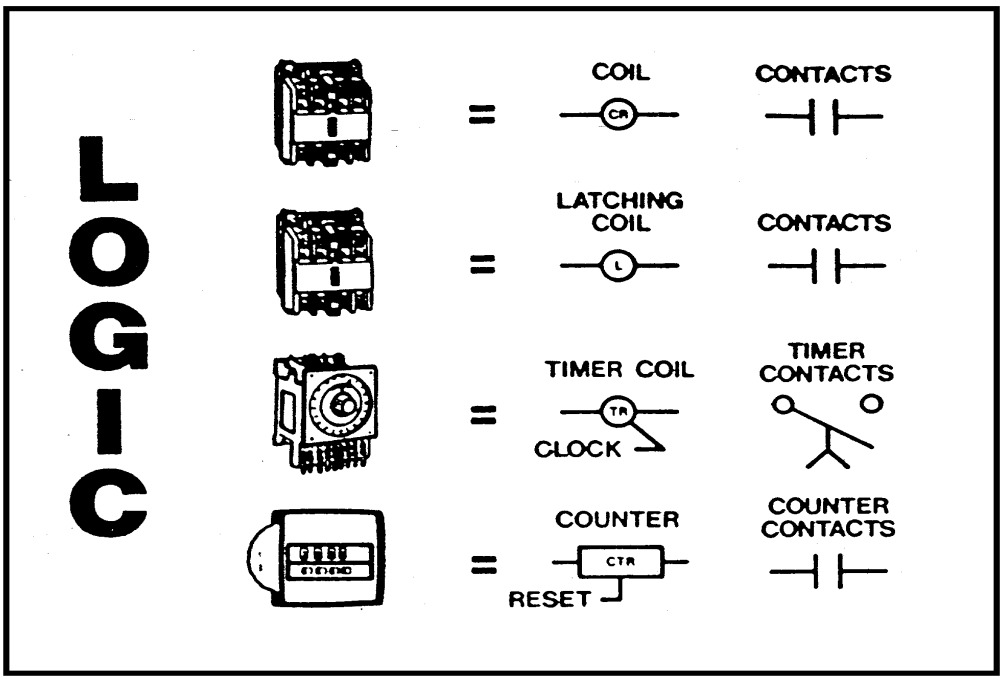
	WIRED LOGIC	**PROGRAMMABLE CONTROLLER**
Controlled Device (Hardware)	Specific purpose	General purpose
Control Scale	Small and Medium	Medium and Large
Change or addition to specification	Difficult	Easy
Delivery period	Several days	Almost immediate
Maintenance (by makers and users)	Difficult	Easy
Reliability	Depends on design and manufacture	Very high
Economic efficiency	Advantage on small scale operation	Advantage on small, medium and large scale operation

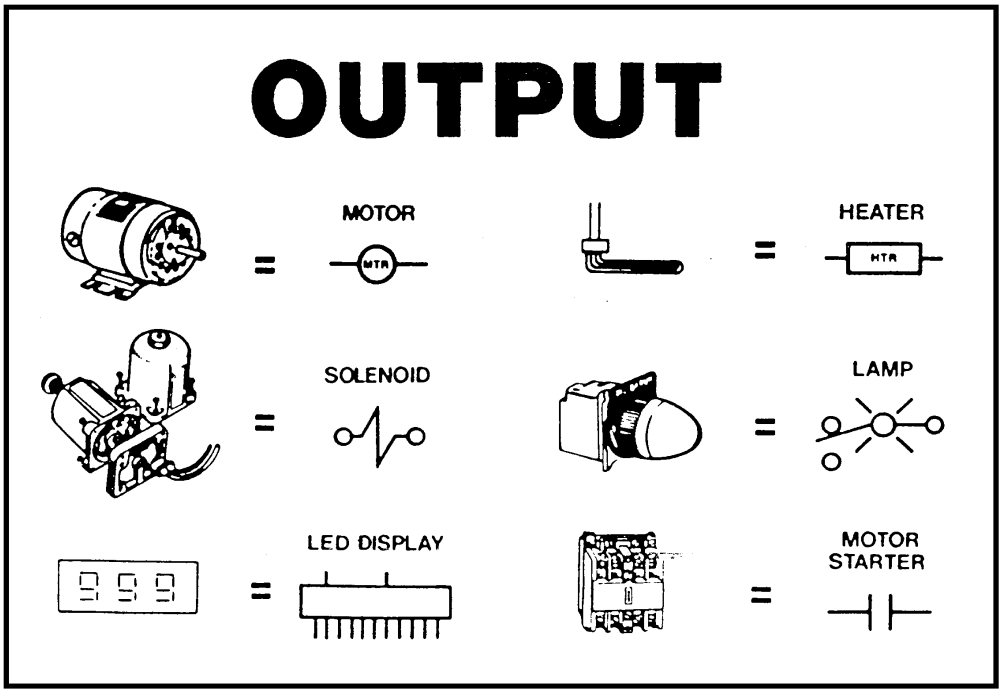
11-3 Mechanical & Electrical Field Input Devices

1. Input Devices

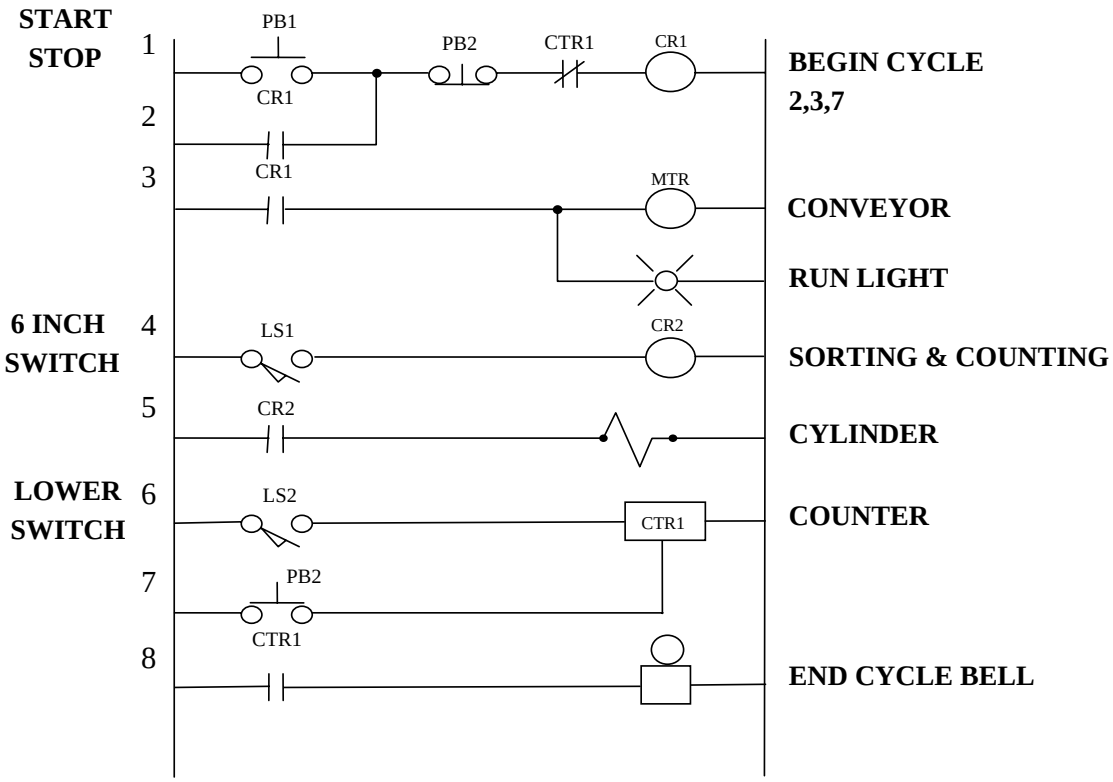
FIELD DEVICE CONFIGURATION	DESIRED CIRCUIT CONFIGURATION	PROPER PLC INSTRUCTION
 Normally Open	 Normally Open	 Normally Open
 Normally Open	 Normally Open held closed	 Normally Closed
 Normally Open held closed	 Normally Open held closed	 Normally Closed
 Normally Open held closed	 Normally Open	 Normally Open
 Normally Closed	 Normally Closed	 Normally Open
 Normally Closed	 Normally Closed held open	 Normally Closed
 Normally Closed held open	Normally Closed	 Normally Closed
 Normally Closed held open	 Normally Closed held open	 Normally Open

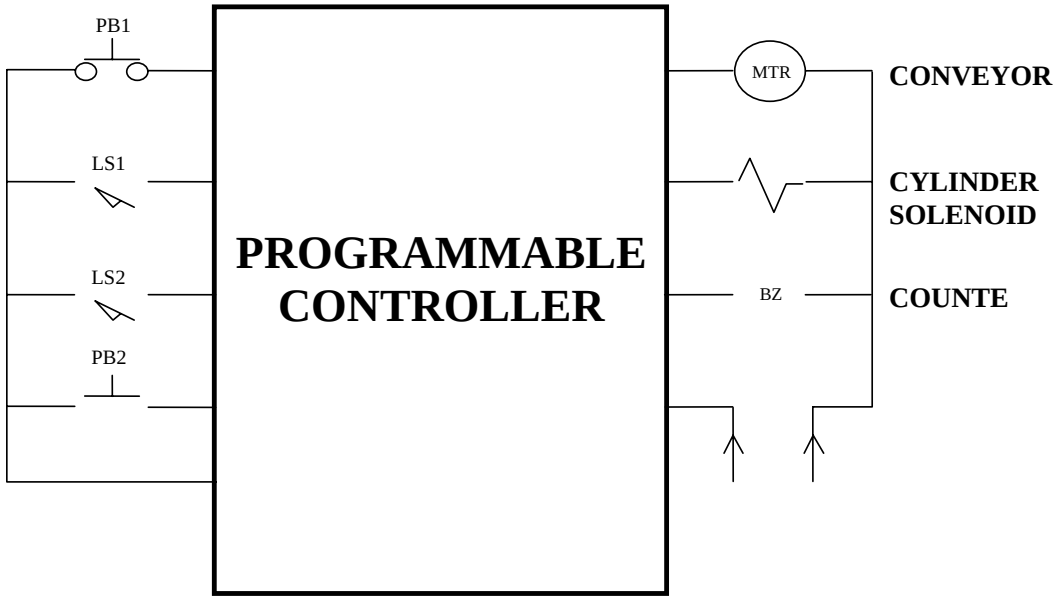
2. Output Devices





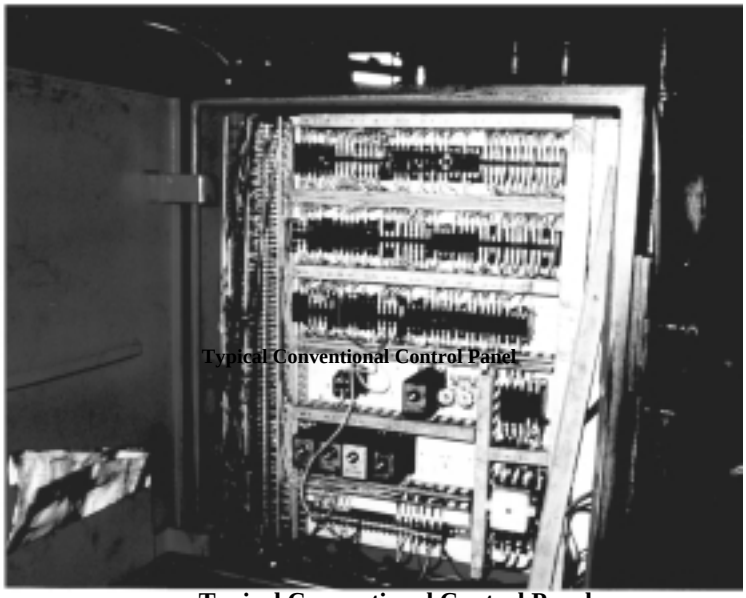
3. Conventional Circuit





11-4 Conventional Control Panel and Its Difficulties

In the beginning of the Industrial revolution, especially in the 1960 & 1970, automated machines were controlled by electromechanical relays. These relays were all hardwired together inside the control panel. In some cases, the control panel was so huge that it could cover the entire wall. Every connections in the relay logic must be connected. Wiring is not always perfect, it takes time to troubleshoot the system. This is a very time consuming affair. On top of that, the relays have limited contacts. If modification is required, the machine has to be stopped, space may not be available and wiring has to be traced to accommodate changes. The control panel can only be used for that particular process. It cannot be changed immediately to a new system. It has to be redone. In terms of maintenance, an electrician must be well trained and skillful in troubleshooting the control system. In short, conventional relay control panel are very inflexible.



Typical Conventional Control Panel

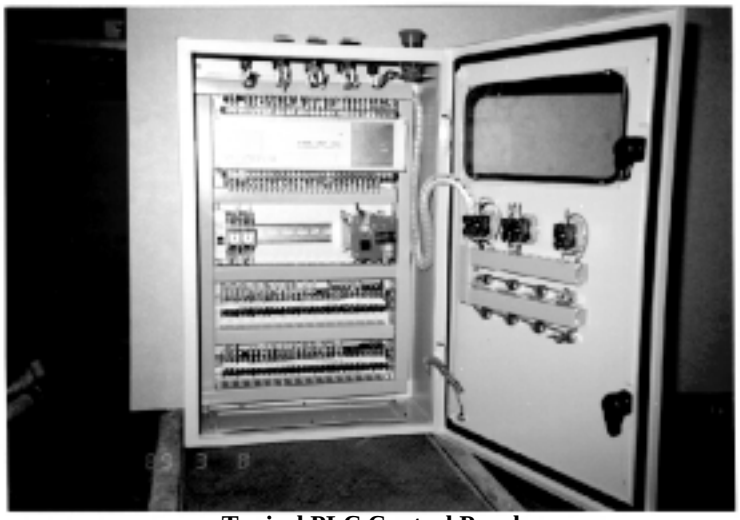
Disadvantages of Conventional Control Panel

In this panel we can observe the following points

- There are too many wiring work in the panel
- Modification can be quite difficult
- Troubleshooting can be quite troublesome as you may require a skillful person
- Power consumption can be quite high as the coil consumes power.
- Machine downtime is usually long when problems occur, as it takes a longer time to troubleshoot the control panel
- Drawings are not updated over the years due to changes. It causes longer downtime in maintenance and modification.

Programmable Controller Control Panel and Their Advantages

With the arrival of programmable controllers, the control design and concept improve tremendously. There are many advantages in using the programmable controllers.



Typical PLC Control Panel

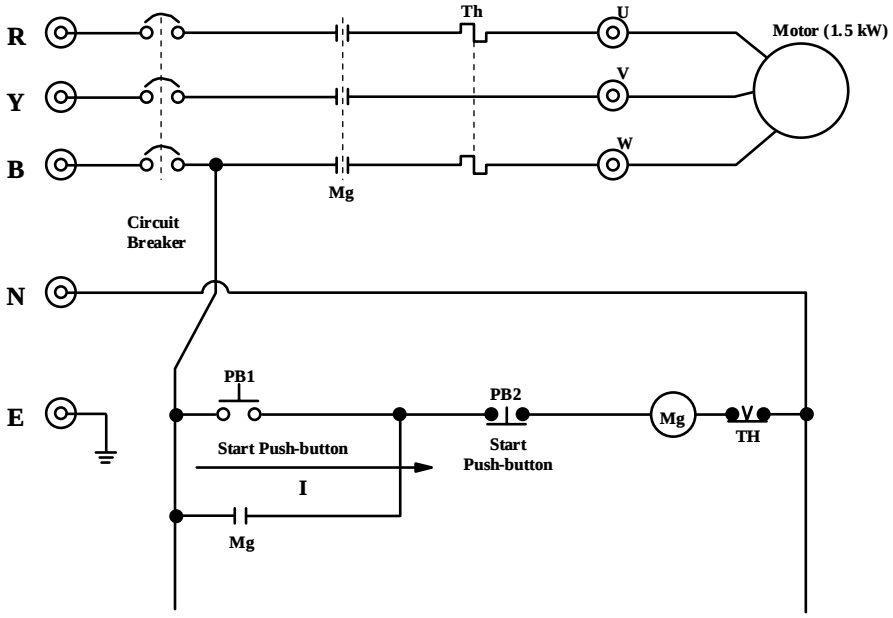
Advantages of PLC Control Panel

Here are the major advantages that can be distinguishably realized.

- The wiring of the system usually reduces by 80% compared to conventional relay control system.
- The power consumption is greatly reduced as PLC consume much less power.
- The PLC self-diagnostic functions enable easy and fast troubleshooting of the system.
- Modification of control sequence or application can easily be done by programming through the console or computer software without changing of I/O wiring, if no additional Input or Output devices are required.
- In PLC System spare parts for relays and hardware timers are greatly reduced as compared to conventional control panel.
- The machine cycle time is improved tremendously due to the speed of PLC operation is a matter of milliseconds. Thus, productivity increases
- It cost much less compared to conventional system in situation when the number of I/Os is very large and control functions are complex.
- The reliability of the PLC is higher than the mechanical relays and timers.
- An immediate printout of the PLC program can be done in minutes. Therefore, hardcopy of documentation can be easily maintained.

Conversion of Conventional Control Circuit to PLC

Example 1: Starting and Stopping of a 3-phase motor.



When the push-button PB1 is pressed, current I will flow through the circuit and energize magnetic contactor Mg which in turn closes the Mg contacts. The contact Mg parallel the push-button PB1 is for self-holding so that PB1 can be released. The other Mg contacts closes to switch on the 3-phase motor.

To connect the above circuit in a PLC system to PLC wiring circuit, we need to identify the input and output devices. The input devices are start push-button (PB1) and stop push-button (PB2) and the output device in this case is only one magnetic contactor that controls the 3-phase motor.

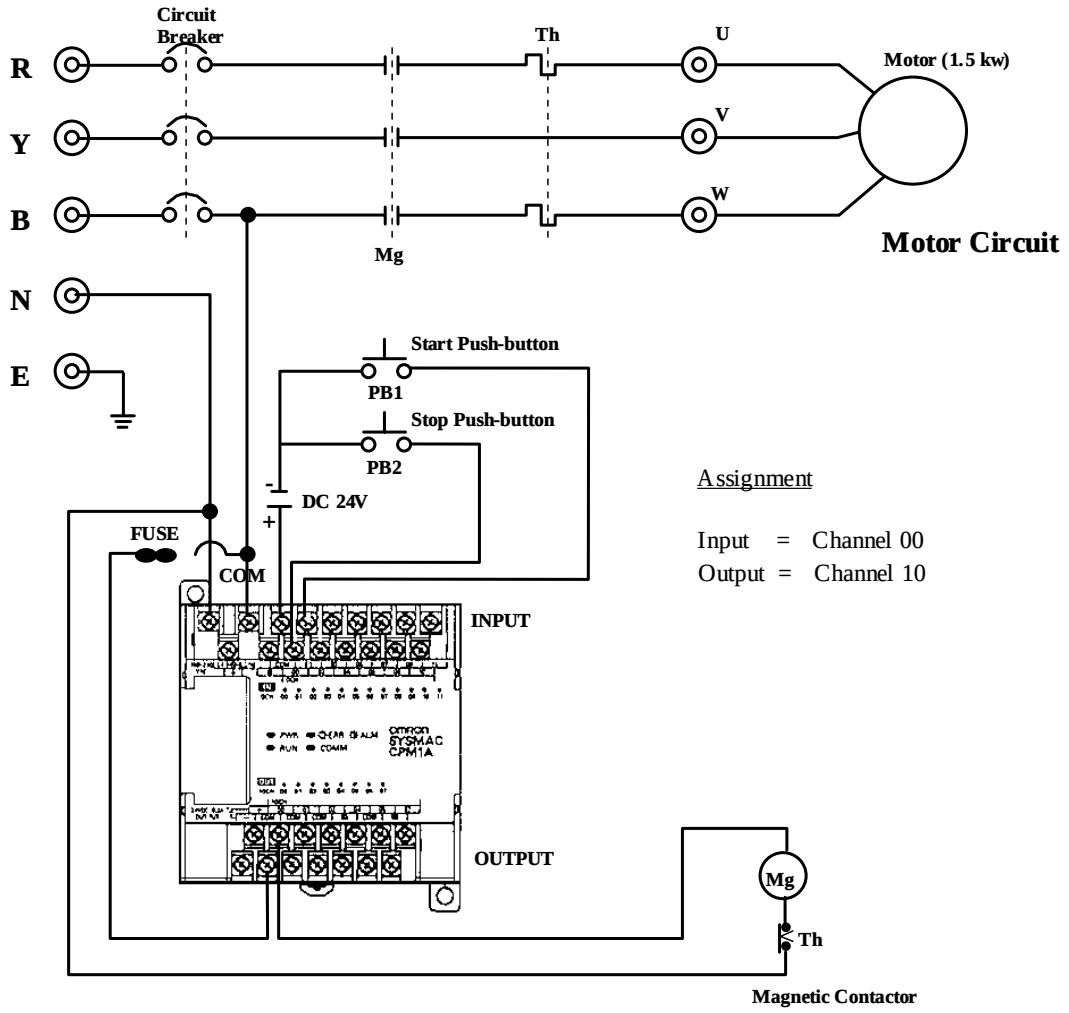


Fig. 1 Hard Wire Circuit for PLC Connection

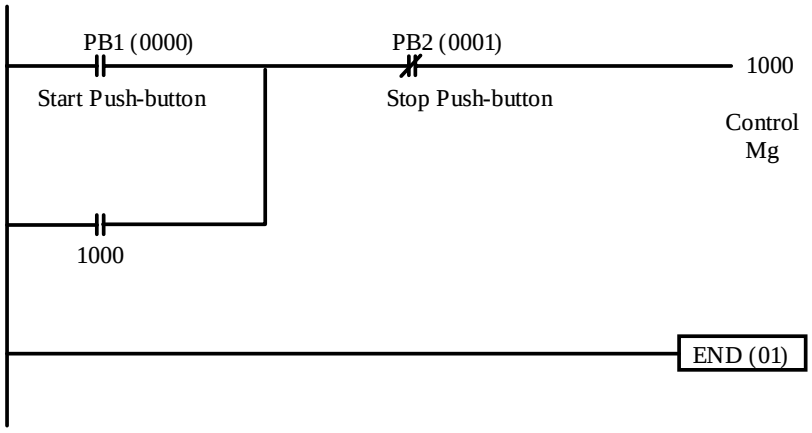
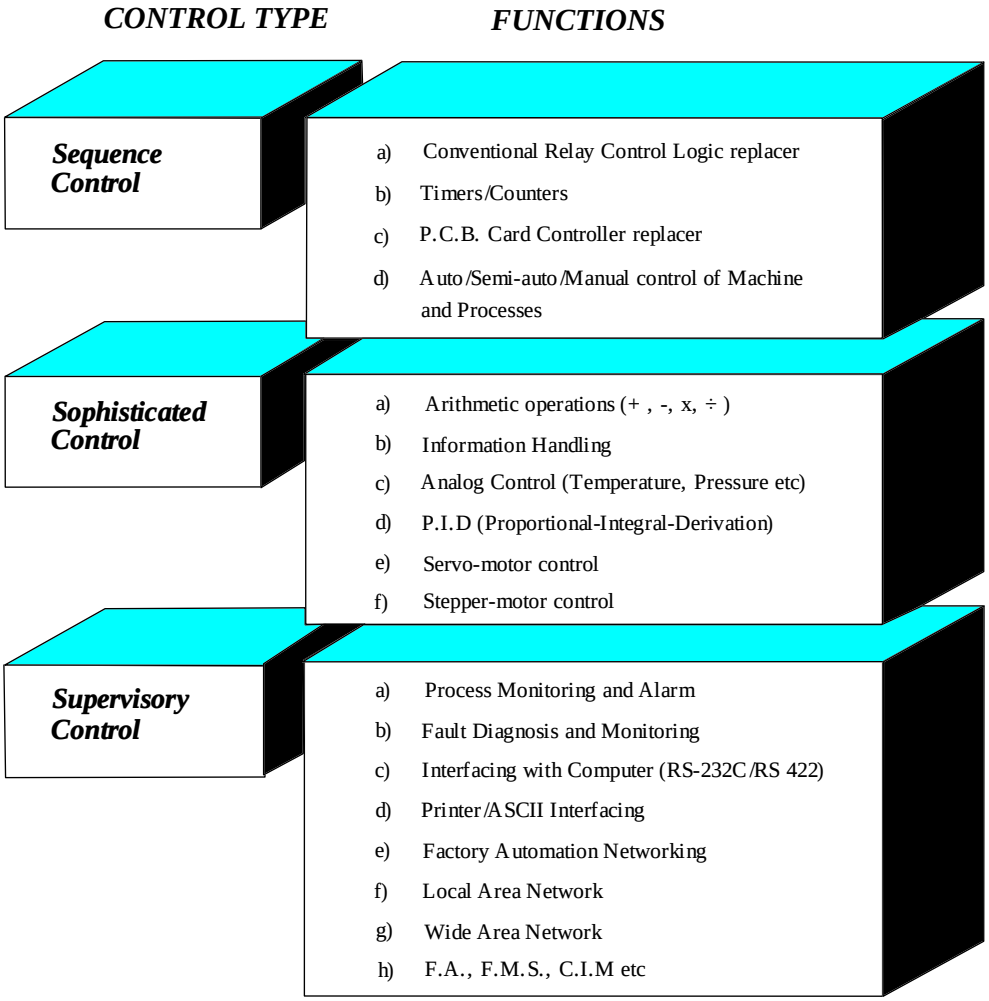


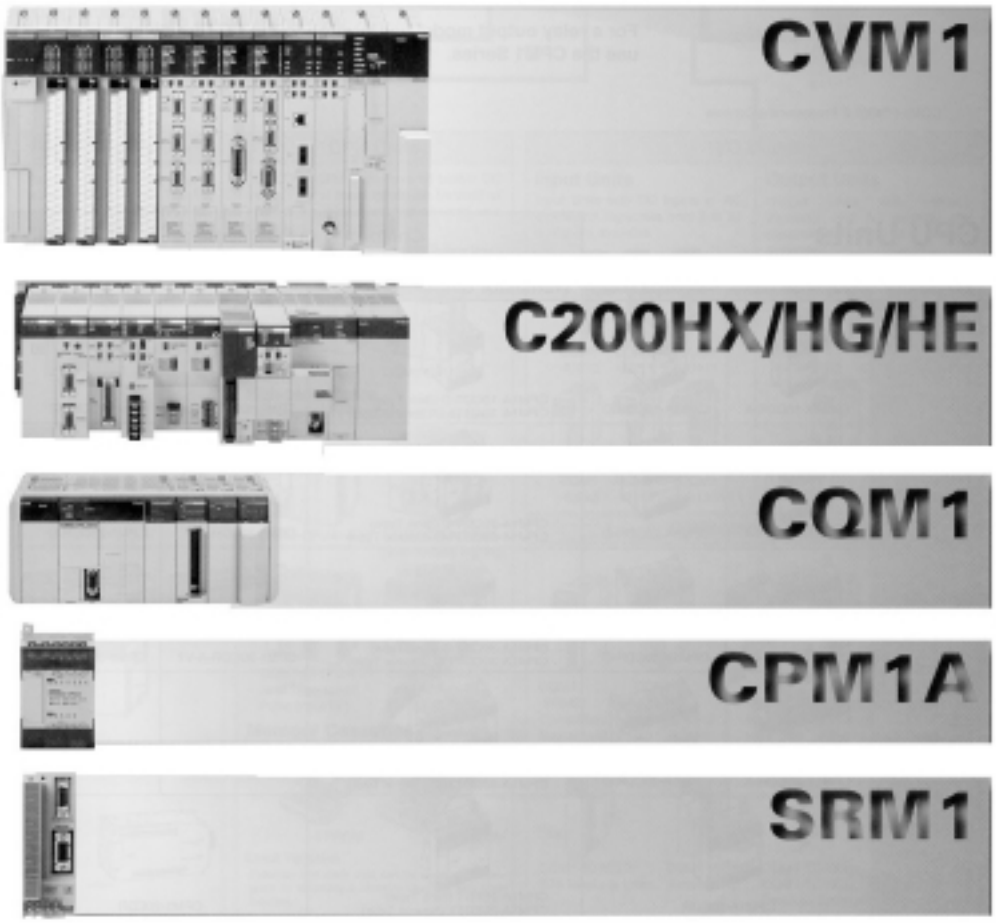
Fig. 2 Ladder diagram

Fig 1. Shows the wiring circuit of the I/O devices.
Fig 2. Is the ladder diagram for the conversion. It must be programmed into the PLC.

11-5 What a Programmable Controller can do?

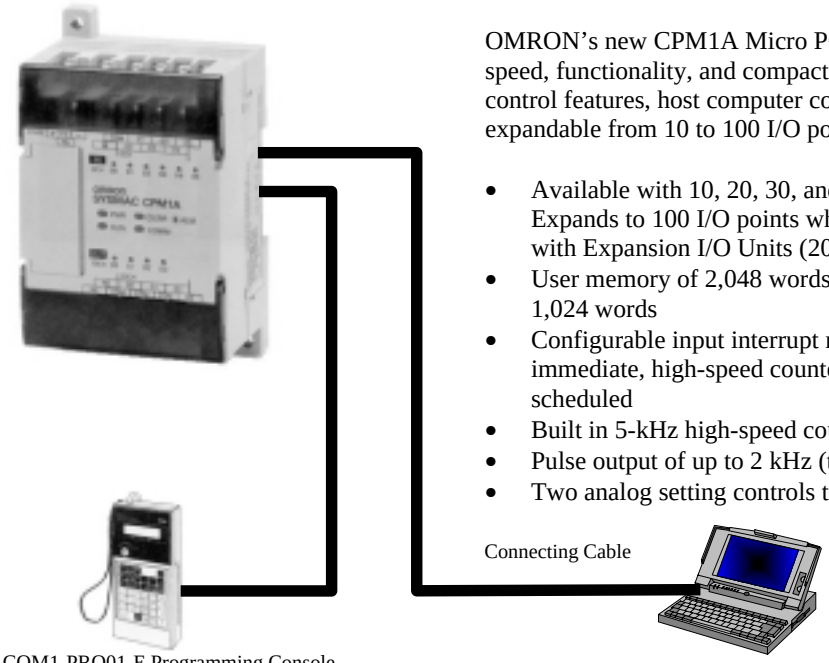


11-6 OMRON Models



CPM1A Programmable Controllers

Suitable as a Relay Control Panel or Sensor Controller

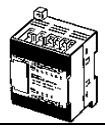
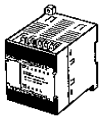
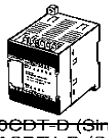
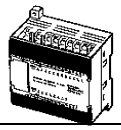
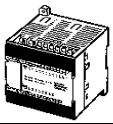
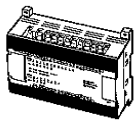
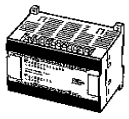
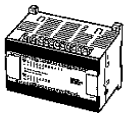
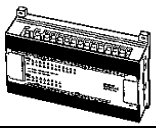
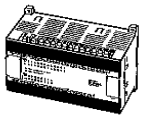
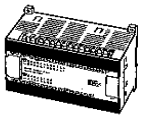
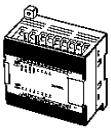


CQM1-PRO01-E Programming Console

OMRON's new CPM1A Micro PCs offer the ultimate in speed, functionality, and compact size. It offers powerful control features, host computer connectivity, and is expandable from 10 to 100 I/O points.

- Available with 10, 20, 30, and 40 I/O points Expands to 100 I/O points when used in combination with Expansion I/O Units (20 points)
- User memory of 2,048 words and data memory of 1,024 words
- Configurable input interrupt response modes: immediate, high-speed counter, quick response, and scheduled
- Built in 5-kHz high-speed counter
- Pulse output of up to 2 kHz (transistor output type)
- Two analog setting controls to fine-tune timer and

For a relay output model conforming to the EC Directives, use the CPM1 Series.

CPU Units			Conformity to EC Directives
Number of I/O points	**AC power supply Relay output models**	**DC power supply Relay output models**	**DC power supply Transistor output models**
10 I/O points	 CPM1A-10CDR-A	 CPM1A-10CDR-D	 ~~CPM1A-10CDT-D (Sink Type)~~ CPM1A-10CDT1-D (Source Type)
20 I/O points	 CPM1A-20CDR-A	 CPM1A-20CDR-D	 ~~CPM1A-20CDT-D (Sink Type)~~ CPM1A-20CDT1-D (Source Type)
30 I/O points	 CPM1A-30CDR-A	 CPM1A-30CDR-D	 ~~CPM1A-30CDT-D (Sink Type)~~ CPM1A-30CDT1-D (Source Type)
40 I/O points	 CPM1A-40CDR-A	 CPM1A-40CDR-D	 ~~CPM1A-40CDT-D (Sink Type)~~ CPM1A-40CDT1-D (Source Type)
20 Expansion I/O points	 ~~CPM1A-20EDR~~		 CPM1A-20EDT (Sink Type) ~~CPM1A-20EDT1 (Source Type)~~

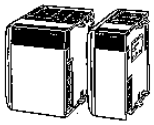
CQM1 Programmable Controllers
Suitable for Controlling Small-scale Machines
Number of I/O Points Increased from 192 to 256

Innovative packaging, high-speed response, and a wide variety of high-function I/O make OMRON's CQM1 PC's the ideal solution for small machine control applications with up to 256 I/O. The unique, rackless connect-and-lock design allows configuration of a PC that meets your exact application requirements. Choose from seven CPU Units and more than twenty Standard and Dedicated I/O Units including those for analog I/O, temperature control, and communications. All CPU Units feature a built-in 5-kHz high-speed counter and accept quadrature inputs. Higher performance CPU Units feature dual absolute encoder interfaces, dual high-speed (50 kHz) interfaces with pulse outputs for two-axis position control applications, or built-in analog I/O.

- Compact, connect-and-lock design
- Wide variety of CPU Units, Power Supply Units, and discrete, analog and special I/O modules
- Four built-in hardware interrupts for managing high-priority signals
- 137-instruction set for sophisticated programming

Power Supply Units

Power Supply Units are available in AC or DC. The AC Units take 100 to 240 VAC and come with or without a built-in 24-VDC service power supply.



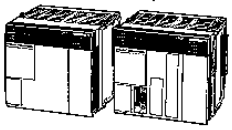
CQM1-PA206,
CQM1-PA203,
CQM1-PA216

CQM1-PD026

CPU Units

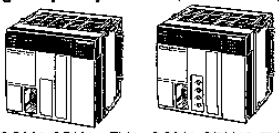
The CQM1 CPU Units have 16 built-in DC inputs. Four of these inputs can be used as interrupt inputs and one can be used as a high-speed counter input.

Standard Models (128 Points Max.)

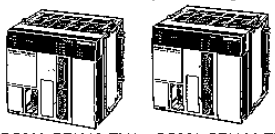


CQM1-CPU11-E CQM1-CPU21-E

High-performance, High-capacity Models (256 Points Max.)

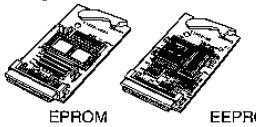


CQM1-CPU41-EV1 CQM1-CPU42-EV1 (with Analog Setting)



CQM1-CPU43-EV1 (with High-speed Pulse Input I/F) CQM1-CPU44-EV1 (with ABS Encoder I/F)

Memory Cassettes (Optional)



EPROM EEPROM

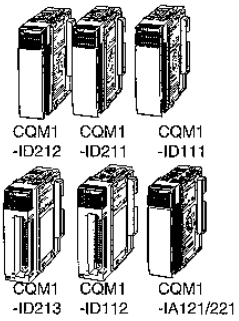
Clock Function

Calendar and clock data can be used on the program by mounting a Memory Cassette with clock function.

I/O Units

Input Units

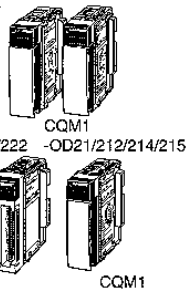
Input Units with DC inputs or AC inputs and capacities from 8 to 32 points are available.



CQM1 -ID212 CQM1 -ID211 CQM1 -ID111
CQM1 -ID213 CQM1 -ID112 CQM1 -IA121/221

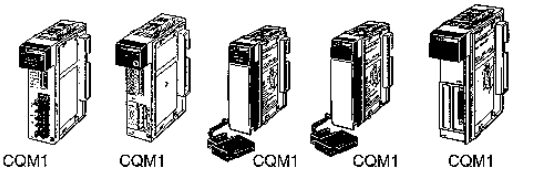
Output Units

Output Units with contact, transistor, and AC outputs, and capacities from 8 to 32 points are available.

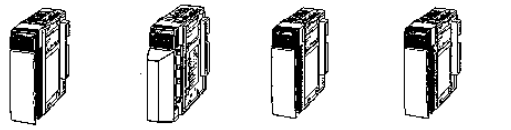


CQM1 -OC221/222 CQM1 -OD21/212/214/215
CQM1 -OD213 CQM1 -OA221/222

Dedicated I/O Units



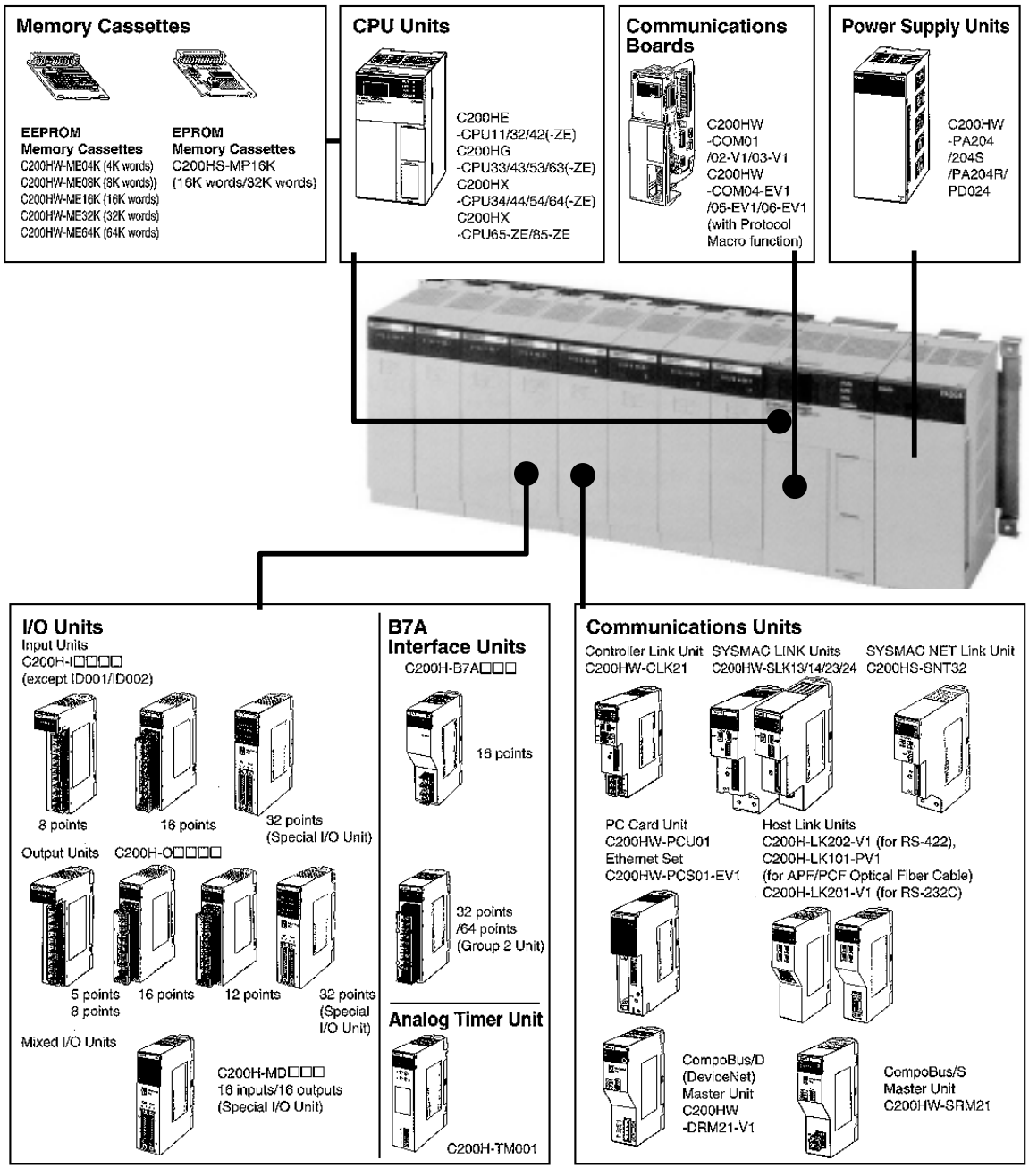
CQM1 -SRM21 CompoBus/S Master Unit
CQM1 -DRT21 CompoBus/D I/O Link Unit
CQM1 -AD041 Analog Input Unit
CQM1 -DA021 Analog Output Unit
CQM1 -IPS01/02 Power Supply Unit



CQM1-B7A□□ B7A Interface Units
CQM1-SEN01 Sensor Unit
CQM1-TC00□, CQM1-TC10□ Temperature Control Units
CQM1-LSE□□ Linear Sensor Interface Unit

High-end Performance and Connectivity for Advanced Machine Control and Data Management

OMRON's new SYSMAC α C200HX/HG/HE PCs offers the advantage of large PC performance and I/O versatility in a mid-sized package and price range. It is the flagship of the OMRON line of PCs and is the most advanced of a long line of C200H models with more memory, more powerful instruction set, faster processing speeds, and more communications options for more integrated control. New features that include the Protocol Macro Function and optional PCMCIA slots for direct Ethernet connections make the SYSMAC α C200HX/HG/HE PCs a powerful on-site data processing system and help turn your manufacturing site into a highly responsive information-based operation, of course, the SYSMAC α C200HX/HG/HE PCs can be programmed, set up, and debugged using OMRON's easy-to-use Windows-based programming and documentation software.

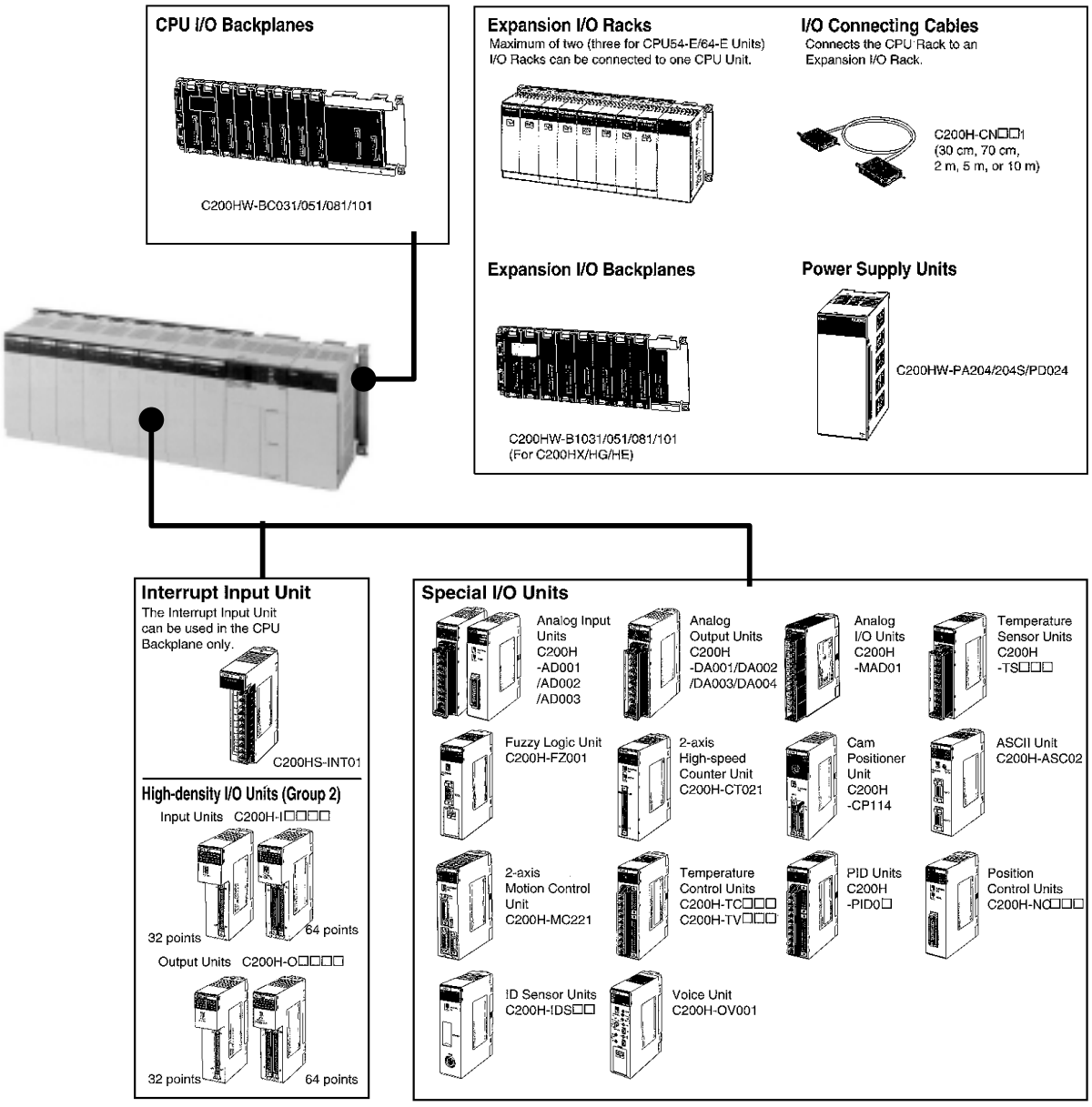


Power and Modularity for Improved Application Flexibility

Choose from eleven CPU Units that support up to 1,184 I/O, 32K words of user memory, 24K words of data memory, or that feature a built-in real-time clock, RS-232C port, and expanded communications. The SYSMAC α C200HX/HG/HE PCs accept all C200H-series Standard and Special I/O Units, and now can accept up to sixteen Special I/O Units per CPU Unit. Versatile communications options allows the PC to connect to supervisory to MES computers via the host link or Ethernet, or directly to any of OMRON' advance control or I/O bus networks.

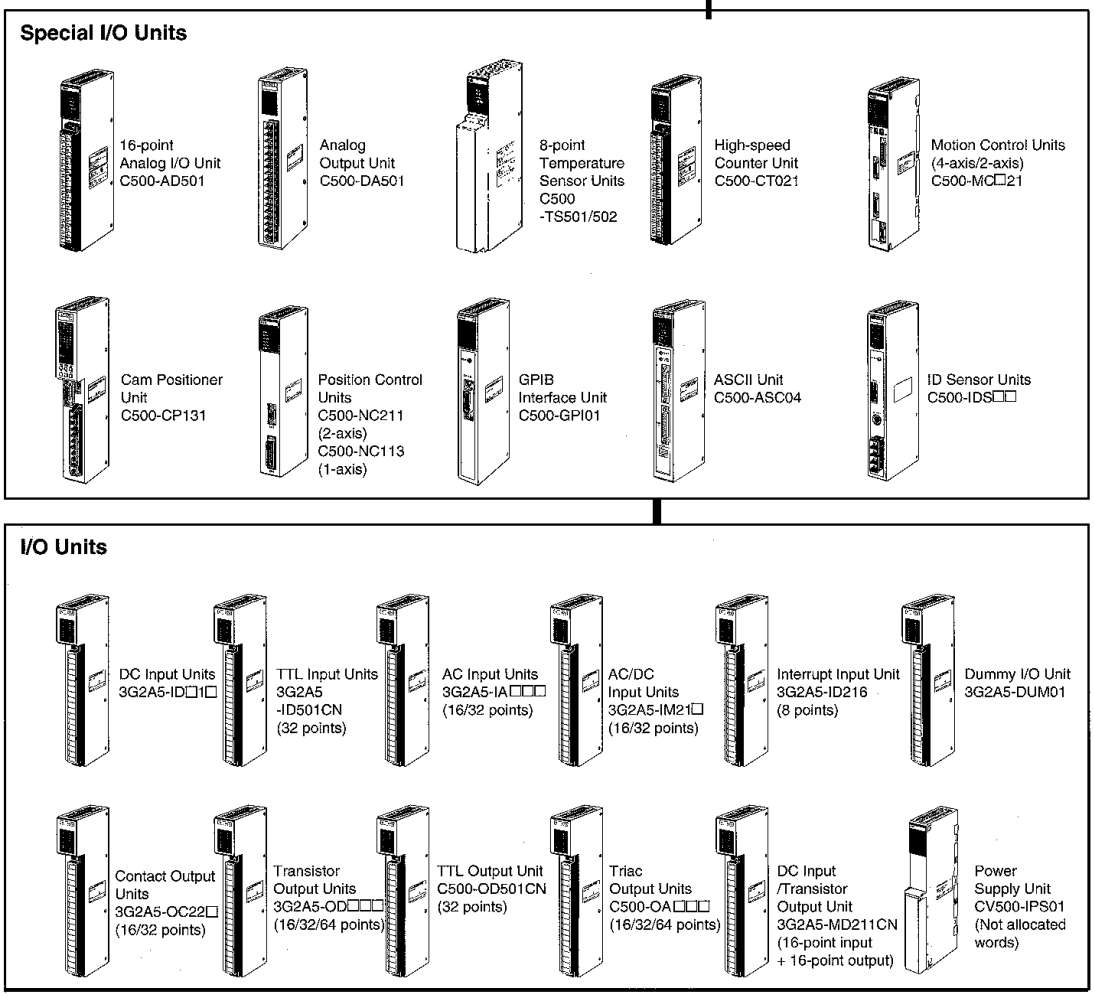
Enhanced Serial Device Communications

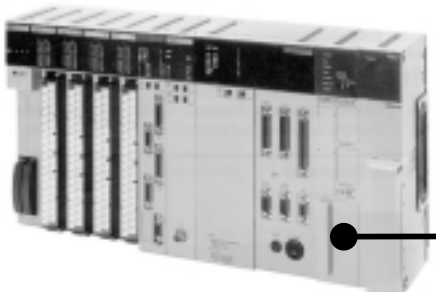
OMRON's unique Protocol Macro Function provides built-in protocol support for many common serial devices or allows customization of one of your own for RS-232C, RS-422, and RS-485 communications.



CV/CVM1 Programmable Controllers
Ideal for Improving Productivity of Factories Manufacturing Diversified Products at Various Production Rates With High Data Processing Requirements

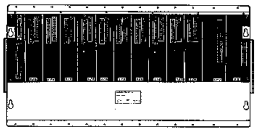
- I/O capacity: 512 to 2,048 points
- Programming capacity: 62K words max
- Basic instruction execution time: 0.125 to 0.15µs
- Applicable to any network with Ethernet for data processing systems, SYSMAC LINK Units and Controller Link Units for networks between PCs,





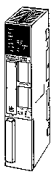
CPU Rack

Mount up to 8 Special I/O Units.

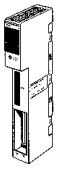


CPU Backplanes
CV500-BC101/BC031/BC051
CVM1-BC103/BC053

Memory Cards
HMC-ES□□1 (RAM type)
HMC-EE□□1 (EEP-ROM type)
HMC-EP□□1 (EP-ROM type)



CPU Units
CVM1-CPU01-EV2
CVM1-CPU11-EV2
CVM1-CPU21-EV2
CV500-CPU01-EV1
CV1000-CPU01-EV1
CV2000-CPU01-EV1



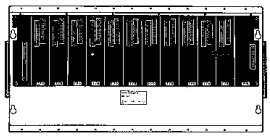
Power Supply Units
CV500-PS221/211
CVM1-PA208

I/O Control Units
CV500-IC101/201/301

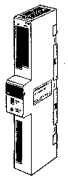
Expansion Data Memory Units
CV100-DM□□1

Expansion CPU Rack

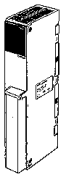
Required when mounting
more than 11 Special Units.



Expansion CPU
Backplane
CV500-BI111



I/O Interface
Unit
CV500-II101



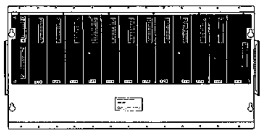
Power Supply
Units
CV500-PS221/211
CVM1-PA208

I/O Cables
CV500-CN□□2
CPU Bus Cable
CV500-CN□□1

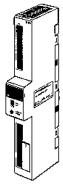
Mount up to 8 Special I/O Units.

Expansion I/O Racks

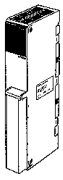
Required to increase number of I/O Units.



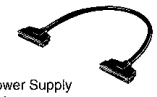
CV500
-BI112/BI062/BI042
CVM1-BI114/BI064
(I/O Backplanes)



I/O Interface
Unit
CV500-II201



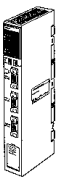
Power Supply
Units
CV500-PS221/211
CVM1-PA208



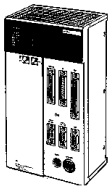
I/O Cables
CV500-CN□□2/3

Mount up to 8 Special I/O Units.

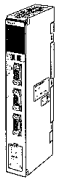
CPU Bus Units



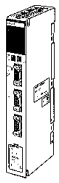
BASIC Units
CV500-BSC□1



Personal Computer
Units
CV500-VP2□□-E

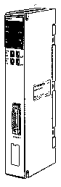


Temperature
Controller Data Link Unit
CV500-TDL21

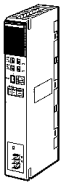


Motion Control Units
CV500-MC421
CV500-MC221

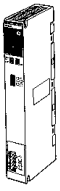
CPU Bus Units for Communications



Ethernet
Unit
CV500
-ETN01



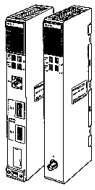
Controller
Link Unit
CVM1
-CLK21



CompoBus/D
Master Unit
CVM1
-DRM21-V1

SYSMAC
NET Link
Unit
CV500
-SNT31

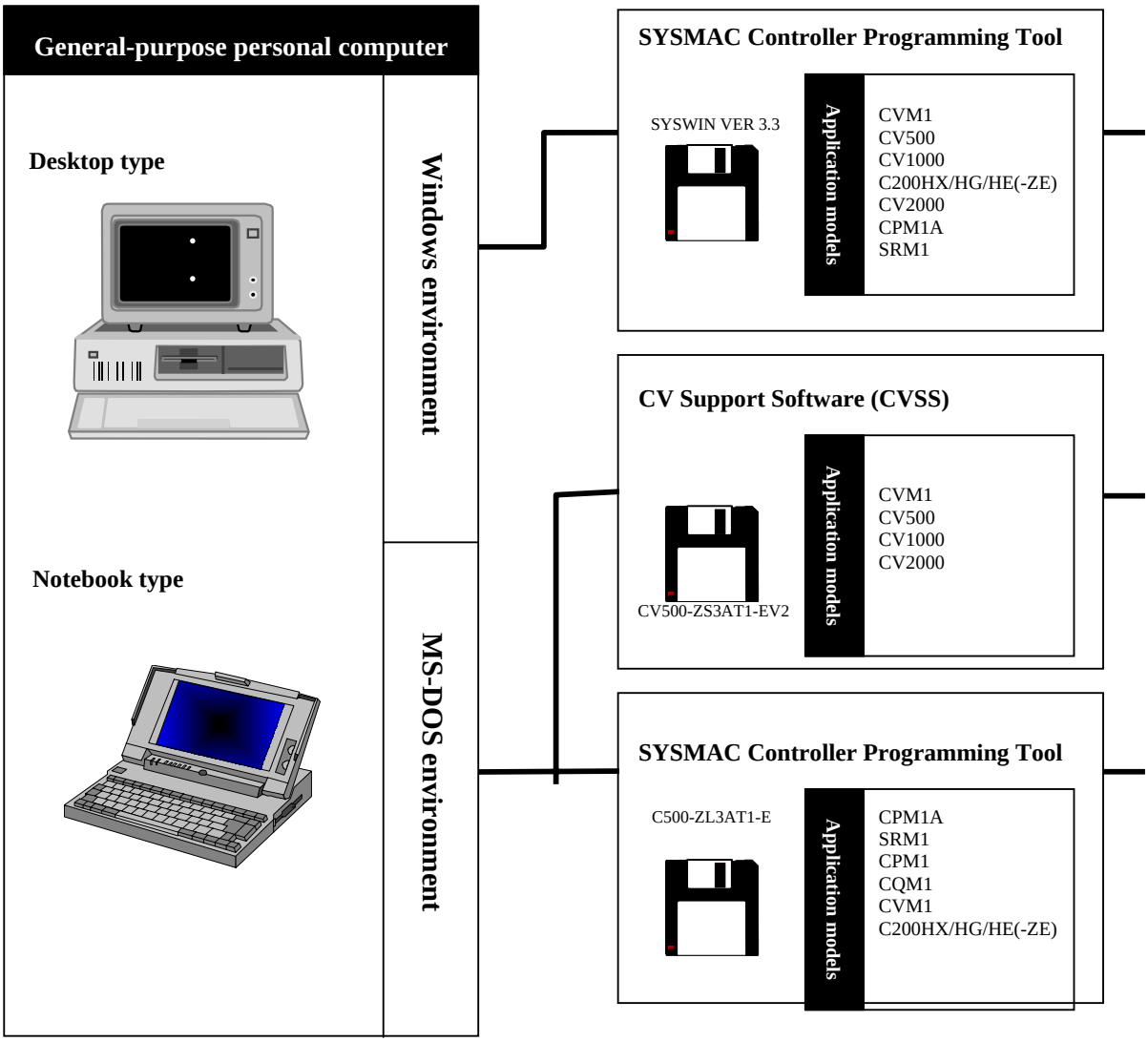
Host Link
Unit
CV500
-LK201



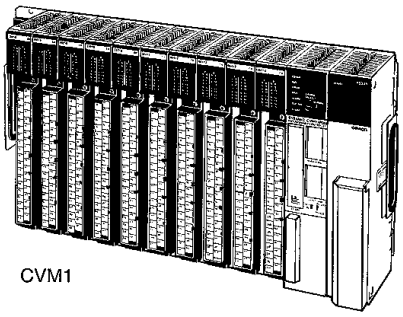
SYSMAC
LINK Units
CV500
-SLK11 (optical)
CV500
-SLK21 (coaxial)

Power
Feeder Unit
C1000H
-APS01
(for optical
SYSMAC
LINK Unit)

Peripheral Devices Supporting SYSMAC Units

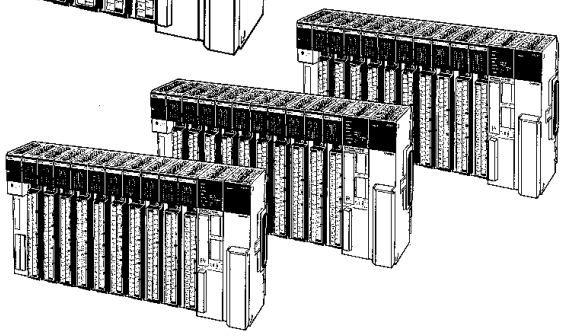


CV Series



CVM1

CV500/CV1000/CV2000



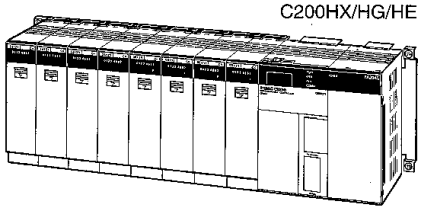
SYSMAC Support Software cannot be used with the CV500/1000/2000 PCs.

Programming Console (Handheld Type)

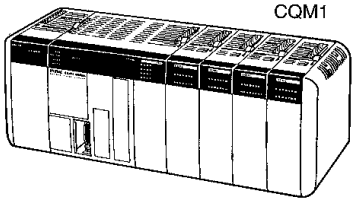
CVM1-PRS21-EV1

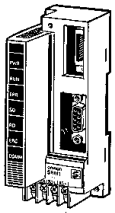
C Series

C200HX/HG/HE



CQM1





SRM1

CPM1A

Programming Console (Handheld Type)

C200H-PRO27-E

CQM1-PRO01-E (with cable)

11-7 Application

Programmable Controller Applications

There are so many applications that you can find PLCs use in the various industries. Here are the list of applications.

- Material Handling
- Conveyor system
- Packaging Machine
- Pick and Place Robot Control
- Pump Control
- Swimming Pool
- Water Treatment
- Chemical Processing Plant
- Paper and Pulp Industries
- Glass Manufacturing
- Precast Concrete Industries
- Cement Manufacturing
- Printing Industries
- Electro-plating Plants
- Food Processing
- Machine Tools
- Tobacco Industries
- Plastic Moulding Machine
- Semi-conductor Manufacturing Machine
- Sugar Manufacturing Plant
- Palm Oil Manufacturing Plant
- Air Condition Control
- TV Manufacturing Plant
- Power Station Plant
- Process Monitoring Control
- Electrical/Electronic Appliance Manufacturing
- Disk Drive Manufacturing
- Petrol Chemical Plant
- Traffic Light System
- Train Control Station System
- Plastic Manufacturing Industries
- Car Manufacturing Industries
- Iron and Steel Mill
- Dairy Product Manufacturing Plant
- Building Automation
- Tyre Manufacturing
- Integrated Circuit Chip Manufacturing
- Sewage Treatment Plant
- Security Control System
- Lift Control System
- Generator Control System
- Amusement Park Control

SECTION 12
Programmable Terminal (PT)

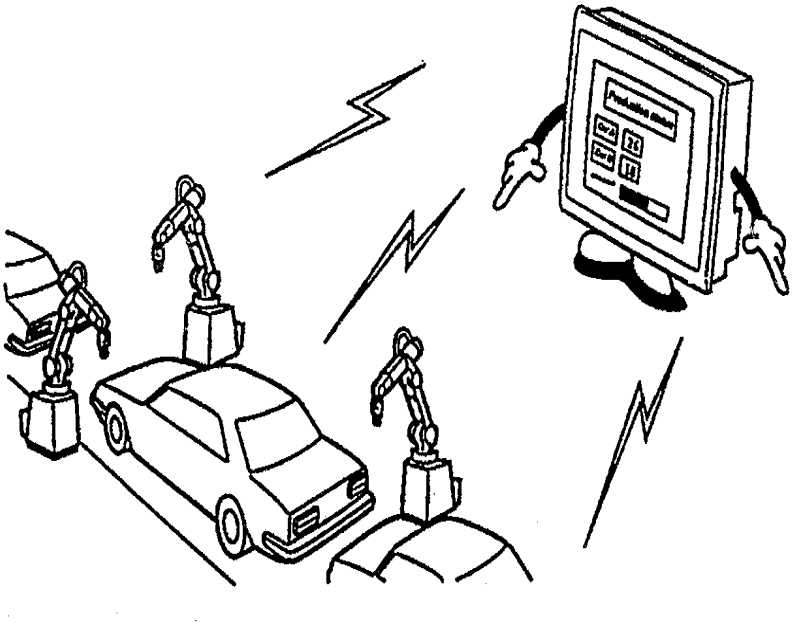
12-1 What is a PT?

A Programmable Terminal has a clear EL (Electro Luminescense) display or LCD (Liquid Crystal Clear) panel that provides a graphic display and input functions.

A PT performs various activities in production fields, such as displaying information in the factory and communicating information to the PLC.

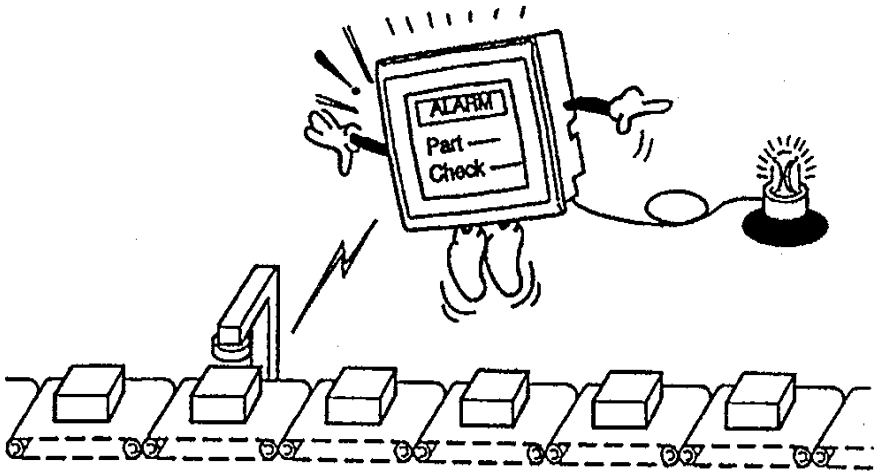
1. Monitoring of Production Line Operation Statuses

A PT displays information sent from the PLC on a real-time basis.



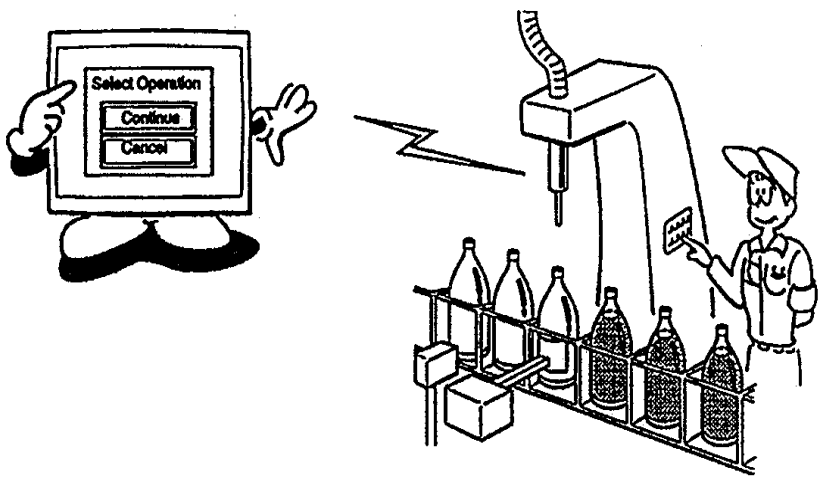
2. Instruction to Factory Workers

By displaying on the screen or giving the alarm, a PT notifies workers of various information such as work procedures and system or equipment failures in order to prompt the appropriate work or remedial action.



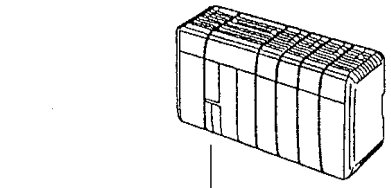
3. Switch Function

A PT sends data input from touch panels or expanded I/O units to the PC. It may be used as an operating panel or an outside unit control terminal.



12-2 System Configuration

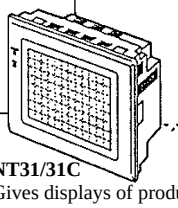
This section gives the basic configuration of a system, which uses an NT31/31C. Use an RS-232C cable or an RS-422 cable to connect to a PC. Refer to the manual for individual device for information on the equipment other than the NT31/31C in the system.

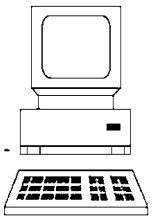


OMRON's PLC
Controls NT31/31C as required while controlling machines and monitoring the production line.
Host link: CQM1, CVM1/CV series PC, CSI series, C200HX, CPM1A , NT31/31C can be connected directly to the CPU unit.

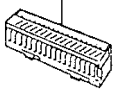
RS-232C cable
(for host link)
(Max. 15m) or
RS-422 cable
(for host link)
(Max. 500m)

B7A I/F unit
type NT-B7A16





Support tool



NT31/31C
Gives displays of production line monitoring and instructions to the operation site and notifies the switch ON/OFF status and numeric value inputs to the PC.

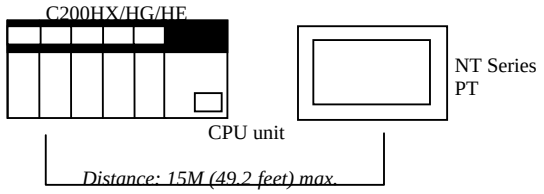
Computer (support tool)
Connected to NT31/31C as required and used to transfer the NT31/31C screens and make settings for the NT31/31C.
Computer: IBM PC/AT or compatible
Support tool: NT series support tool ver3.0.

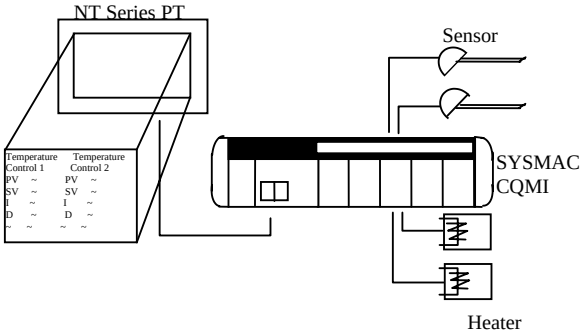
B7A unit
A B7A unit can be connected as an expanded I/O unit.

12-3 Communications

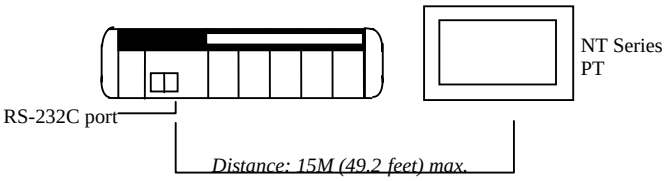
Host Link

The Host Link communication method is built into our full line of Omron NT Series Terminals. Communication baud rates range from 9,600 to 19,200 bps with a typical response speed of .5 seconds. With Host Link, you can connect multiple terminals to a single PLC (up to four on the C200HX/HG/HE system) gaining greater accessibility and multiple views of your larger applications.



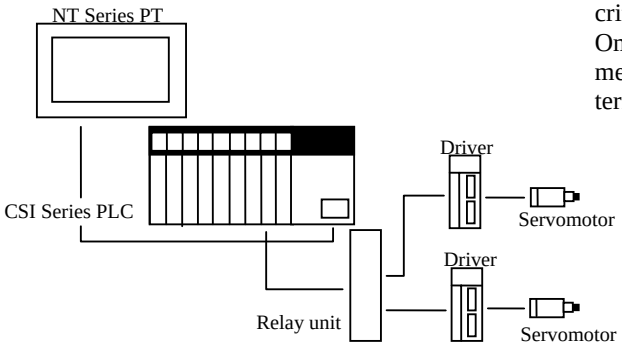


Application
SYSMAC
- CVM1/CV Series (EV1, 2 versions only)
- C200HX/HG/HE (excluding C200HE-CPU11 COM 1 (except CPU11)
- C-Series
- CSI Series
- CPMIA
- SRM1



NT Link

Omron's NT Link communication method can rapidly transmit large amounts of data. With response speeds of up to .2 seconds, NT Link displays important information fast. When you need a guarantee of high speed data delivery on your time critical applications, use NT Link, Omron's fastest communication method for operator interface terminals.



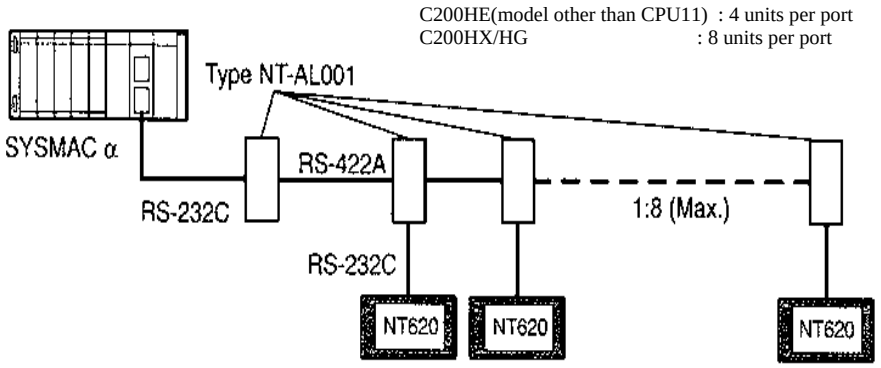
Applicable PLC's
SYSMAC-
- CVM1?CV Series (EV1, 2 versions only
- C200HX/HG/HE
- CQM1-CPU4_-E
- CSI Series CPMIA, SQM1

1 : N Connection

1 : N NT Link

- Example of a Maximum 8 Connection Configuration

The number of connections possible varies depending on the model of the SYSMAC PLC's CPU.



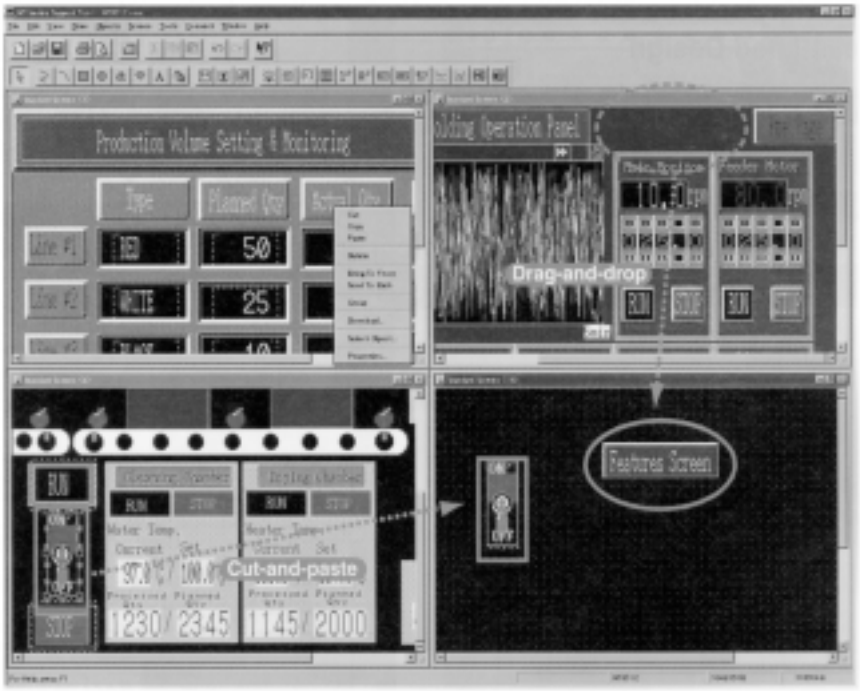
*When connecting the C200HX/HG/HE and an RS-232C/RS-422A converter unit, use a converter until whose number is 15Y5 or higher. Converter units previous to 15YS cannot be connected.

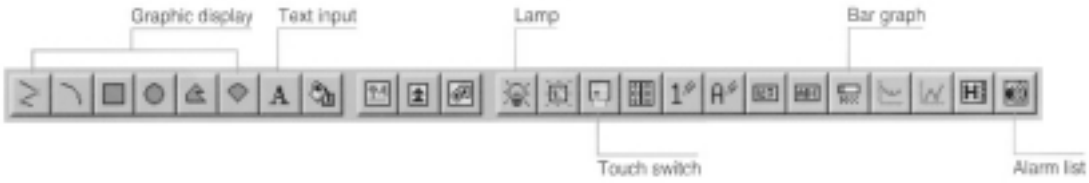
12-4 Support Tool

NT Support Tool : NTSS Ver 3.0

Combined with the Excellence of Windows 95

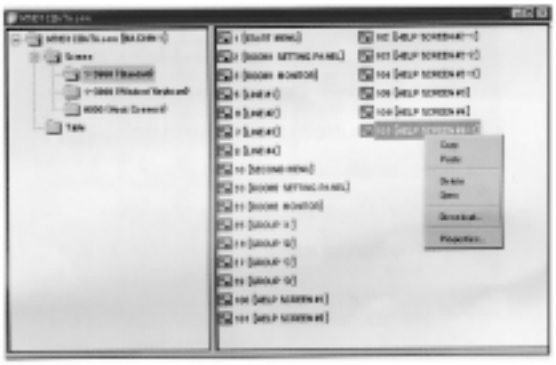
- Drawing, copying, pasting, and drag-and-drop editing can all be done on screen, thus ensuring versatile image creation.
- OMRON's unique zoom function enlarges images from 100% to 800%, thus allowing easy drawing or editing of images
- The undo function can be used a maximum of 10 times continuously.
- Window 95's unique and convenient right click operation is available for frequently used functions.

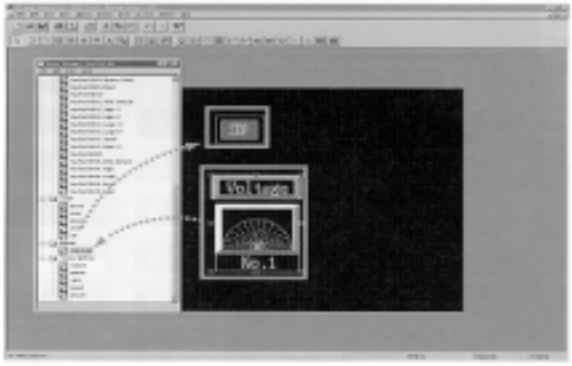




Application Manager Maintains Screens and Tables Visually

- Screen and table files can be easily stored in folders.
- Screens can be easily copied and pasted visually.



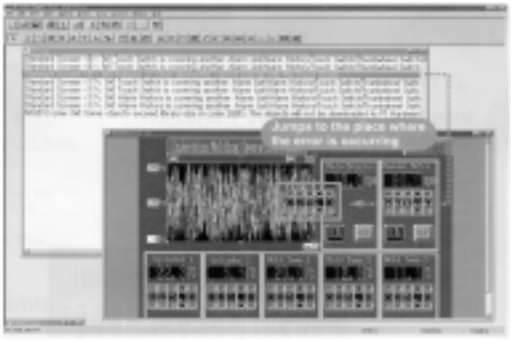


Symbol Manager
Registers the Element You Made

- Allows drag-and drop registration.
- Registered and saved graphics can be used for other screen data whenever necessary.
- The CD-ROM version is provided with template data approximately 1,200 ISO7000 parts.

Error Log Viewer
Automatically Detects Errors in Screen Data

- Allows data checking for both whole screen data and each screen.
- By double-clicking on the error message, the error can be tracked down on screen.



All PLC Addresses are Managed in the I/O Comment Table

- While numerical or character-string tables are edited, addresses are automatically allocated in sequence and registered.
- Parts, such as lamps, are available for referring to PLC addresses and vice versa.

User-friendly Online Help Functions

- Click the Help icon when you are not sure how to proceed. The information you need will appear by touching the elements on the screen.

Operating Environment

Computer: IBM PC/AT or compatible computer with Windows 95
Memory: 16 MB min.
Hard Disk: 20 MB min. or the program itself
OS: Windows 95 (see note)
Package: CD-ROM or FD

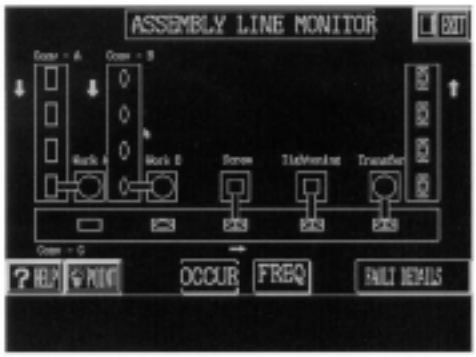
Note: This application is not compatible with Windows 3.1 or Windows NT.

12-5 Omron Models

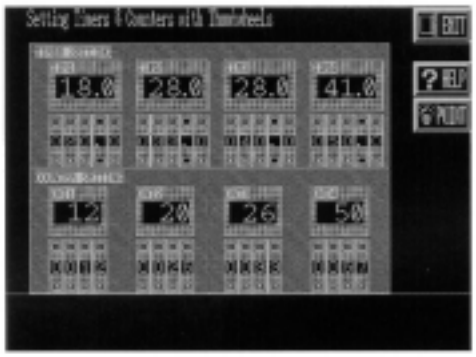
Appearance				
MODEL	NT11S	NT20S	NT30	NT30C
Display **Size** **Type** **Resolution** **Interface** **Touch cells**	4 line × 20 character Backlit LCD 160 × 64 pixels Alphanumeric —	5 ″diagonal Backlit STN LCD 256 × 128 pixels Touch screen 72 per screen	5.7 ″ diagonal Bicolor backlit STN LCD 320 × 240 pixels Touch screen 192 per screen	5.7 ″ diagonal 8-color backlit STN LCD 320 × 240 pixels Touch screen 192 per screen
Features	Large characters Contrast control Password protect screens	Slim profile Easy to configure screens Replacement backlight	Bicolor display Full graphic capabilities Replacement backlight	8-color display Full graphic capabilities Replacement backlight
Memory **Type** **Size** **Max. # of screens**	Flash memory 32 K 250 screens	Flash memory 64-92 K 250 screens	Flash memory 512 K 2000 screens	Flash memory 512 K 2000 screens
Graphic Capabilities **Freeform drawing** **Bitmap** **Tiling** **Bar graph** **Line trending** **Thumbwheel switch** **Text and numeric**	 ■ ■	■ ■ ■ ■	■ ■ ■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■ ■
Real Time Clock			■	■
Printer Port	■		■	■
Communication	Host link/NT Link	Host Link/NT Link/ C200H Interface	Host Link/NT Link	Host Link/NT Link
Overall Dimensions	$218_W \times 113_H \times 38.2_D$ mm $8.58_W \times 4.45_H \times 1.50_D$ mm	$190_W \times 110_H \times 58_D$ mm $7.48_W \times 4.33_H \times 2.28_D$ mm	$195_W \times 142_H \times 55.6_D$ mm $7.68_W \times 5.59_H \times 2.19_D$ mm	$195_W \times 142_H \times 55.6_D$ mm $7.68_W \times 5.59_F \times 2.19_D$ mm
Environmental **Ratings** **Approvals**	NEMA 4 UL/CSA/CE	NEMA 4 UL/CSA/CE	NEMA 4 UL/CSA/CE	NEMA 4 UL/CSA/CE
Accessories	—	Backlight Chemical resistant cover Protective sheet C200H Interface	Backlight Chemical resistant cover Protective sheet B7A Interface	Backlight Chemical resistant cover Protective sheet B7A Interface

Appearance				
Model	NT600S (LCD)	NT600S (EL)	NT620S	NT620C
Display **Size** **Type** **Resolution** **Interface** **Touch cells**	9 ″ diagonal Backlit STN LCD 640 × 400 pixels Touch screen 128 per screen	9 ″ diagonal Electroluminescent 640 × 400 pixels Touch screen 128 per screen	9 ″ diagonal Electroluminescent 640 × 400 pixels Touch screen 512 per screen	9 ″ diagonal 8-color backlit STN LCD 640 × 480 pixels Touch screen 768 per screen
Features	Large screen Slim profile Replaceable backlight	Clear EL display Extra-wide viewing angle Slim profile	Clear EL display Full graphic capabilities Extra-wide viewing angle	8-color display Full graphic capabilities Replaceable backlit
Memory **Type** **Size** **Max. # of screens**	Flash EPROM 128 K 500 screens	Flash EPROM 128 K 500 screens	Flash EPROM 512 K 2000 screens	Flash EPROM 1 MB 2000 screens
Graphic Capabilities **Freeform drawing** **Bitmap** **Tiling** **Bar graph** **Line trending** **Thumbwheel switch** **Text and numeric**	■ ■ ■ ■	■ ■ ■ ■	■ ■ ■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■ ■
Real time **Clock**			■	■
Printer Port			■	■
Communication	Host Link/NT Link/ C200H Interface	Host Link/NT Link/ C200H Interface	Host Link/NT Link	Host Link/NT Link
Overall Dimensions	275_W× 192_H×71_D mm 10.83_W×7.56_H×2.80_D mm	275_W× 192_H× 71_D mm 10.83_W×7.56_H×2.80_D mm	275_W×192_H×71_D mm 10.83_W×7.56_H×2.80_D mm	275_W×196_H×76.8_D mm 10.83_W×7.72_H×3.02_D mm
Environmental **Ratings** **Approvals**	NEMA 4 UL/CSA/CE	NEMA 4 UL/CSA/CE	NEMA 4 UL/CSA/CE	NEMA 4 UL/CSA/CE
Accessories	Backlight Chemical resistant cover Protective sheet C200H Interface	Chemical resistant cover Protective sheet C200H Interface	Chemical resistant cover Protective sheet	Backlight Chemical resistant cover Protective sheet

12-6 Application



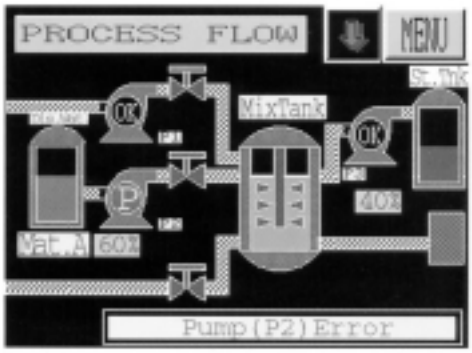
Production Monitoring
Production or assembly operations can be monitored with a quick glance using the graphic capabilities of the NT Series Terminals. In this example screen, the graphic representation provides an assembly line overview. Lamps simulate motion and can also be used to show errors, quickly alerting your operators to problems in production. And error messages provide the information necessary to fix these problems fast.



Timers, Counters, Thumbwheels
Replacing or adding timers, counters, and thumbwheel switches has never been easier. With the NT Series Terminals you get a complete selection on a single screen. And because there's no costly hard-wire redesign considerations, you have the flexibility to choose from a variety of thumbwheel switches in two, four, or eight digits and you can set high/low limits for each.

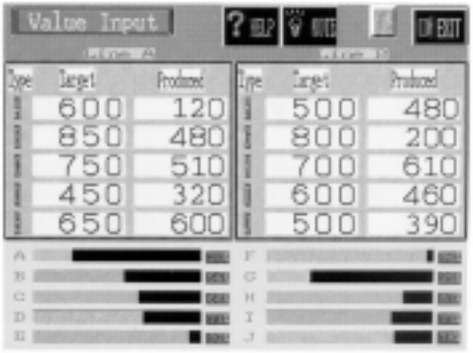
Pop-up Window Function
A pop-up window function is available on the NT30/30C and NT620S/620C terminals. Save on valuable screen space while you input numbers or characters to change set points, production targets, lot codes, or product types. Pop-up windows can also be used for error and help messages which means you won't have to switch off your main screen for monitoring.

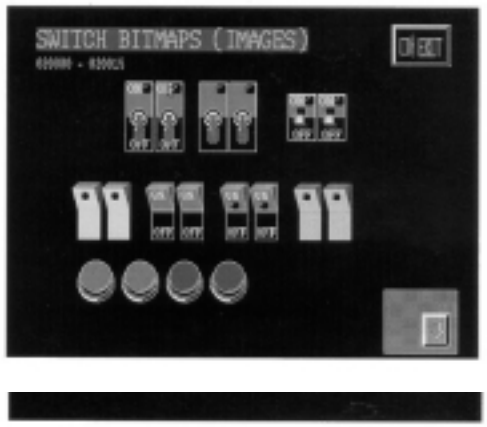
Process Monitoring
The graphic capabilities of the NT Series Terminals make process illustration simple. On this display screen, bar graphs are used to simulate tank levels, and lamps show on/off value or motor status. Combine these graphic images with the variety of touch switches and error messages available and you have a detailed process monitoring application.



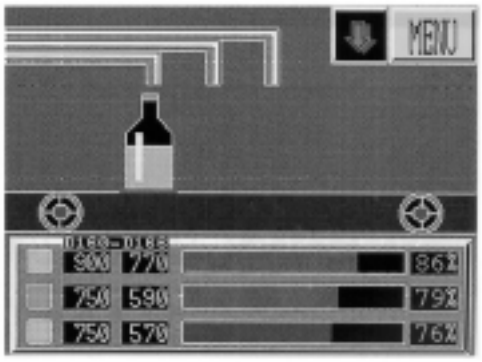
Temperature Monitoring
With the NT Series Terminals, you can easily consolidate many separate gauges, thumbwheels, and panel meters into one convenient control center. Here, temperature values are monitored on the display using graphs and thumbwheel switches. You can set high/low limits on the thumbwheel switches and use them to quickly change temperature set values.

Production Monitoring
Track real production levels against target projections with the NT Series Terminals. Monitor multiple lines from a single point and change target values with a quick touch of the screen.





Pushbuttons, Lamps, Switches
These display screens show how the NT Series Terminals replace hard-wired pilot lights and pushbuttons with realistic graphic icons. Saving on valuable panel space and wiring expense, additional pushbuttons and pilots lights can be added easily – just change your program. You won't need to endure the costly redesign of hard-wire devices. A variety of pushbuttons including: standard, momentary, and set/reset are available. And with the NT30/30C and NT620S/620C terminals, you can use bitmap images to create ultra-realistic switches and lamps.



Custom Graphics
With all the graphic possibilities of the NT Series Terminals, you can custom design dynamic application screens for your plant operation. Freeform drawing capabilities allow you to accurately illustrate each stage in the production process. And bitmap images can be used with the NT30/30C and NT620S/ NT620C models, allowing you to include realistic graphic representations of anything from lamps and touch switches to company logos. Here, process status is monitored using bar graphs to track actual production values to target projections.

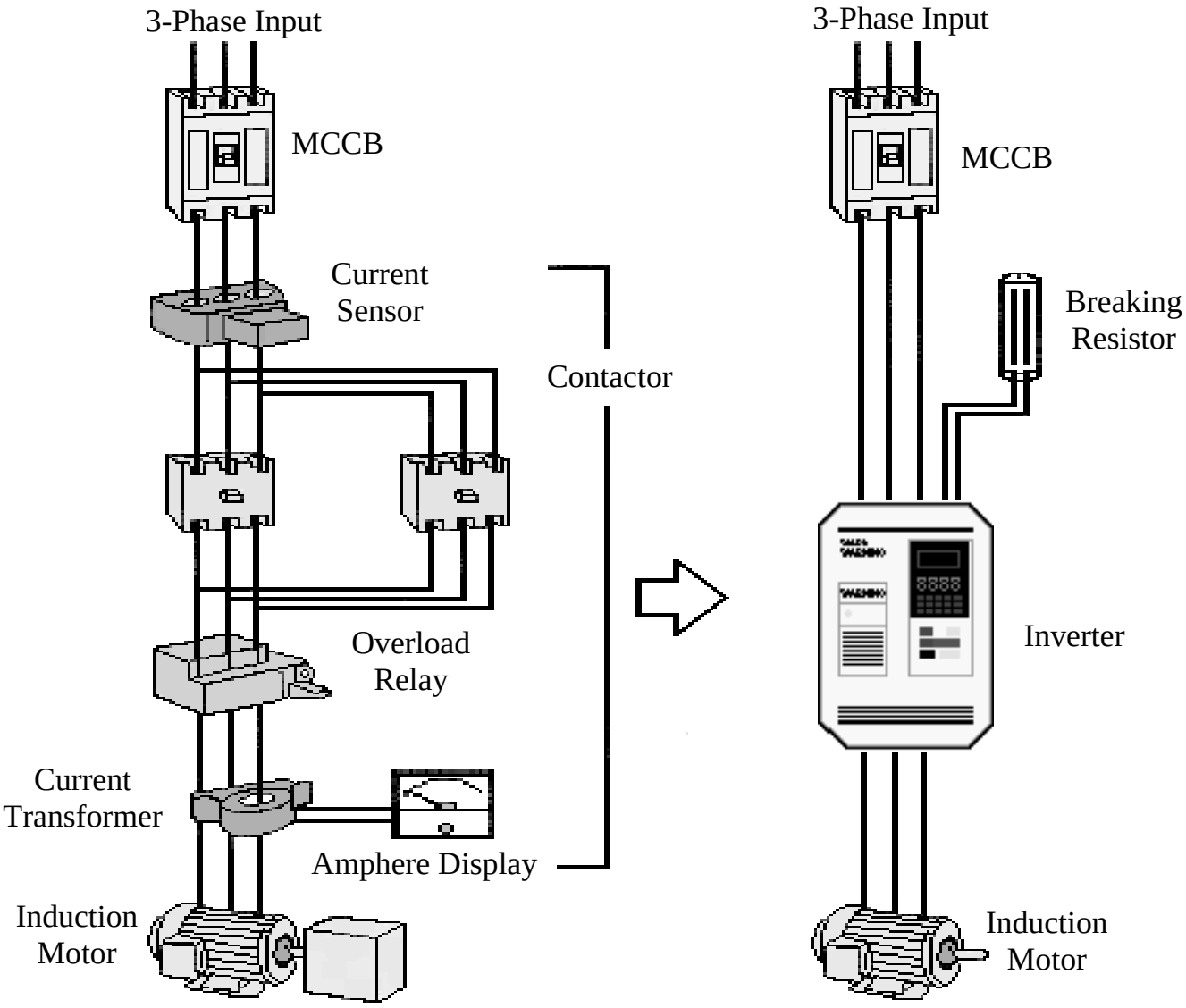
SECTION 13
Inverter

13-1 What is an Inverter?

A Inverter is a Device that converts the incoming AC Voltage Supply into a Controllable Variable Frequency AC Voltage output for driving an AC Induction Motor.

Typical View of A Omron Inverter

Conventional Method Over Inverter



13-2 Basic Function of Inverter

■ Why do you think Inverter is needed?

There are many and diverse reasons for using Inverter. Some applications, such as paper making machine, cannot run without them while others, such as paper centrifugal pumps, can benefit from energy savings.

■ In general, Inverter are used to :-

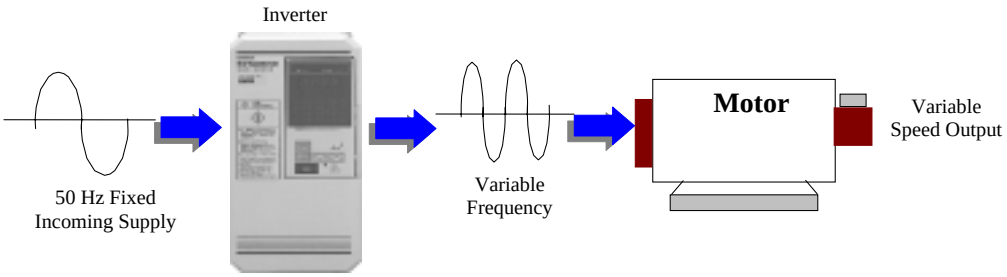
- Match the **Speed** of a process requirements
- Match the **Torque** of a process requirements
- Save **Energy** and improve efficiency

■ Basic Function of Inverter

The Main Function of an AC inverter is to control the speed of an AC Induction Motor.

How?

By supplying a variable frequency current to the motor.



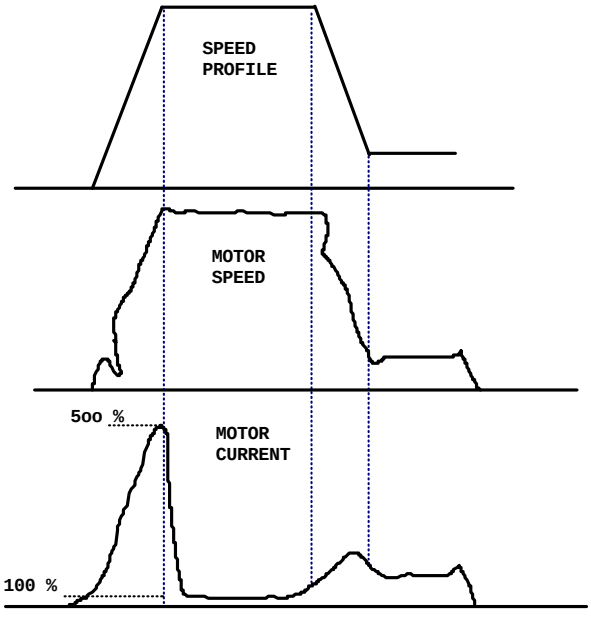
■ The 2 Speed Motor/DOL

Advantages

- Cheaper than inverter solution
- Easy to install
- Fully regenerative
- Reduced EMI

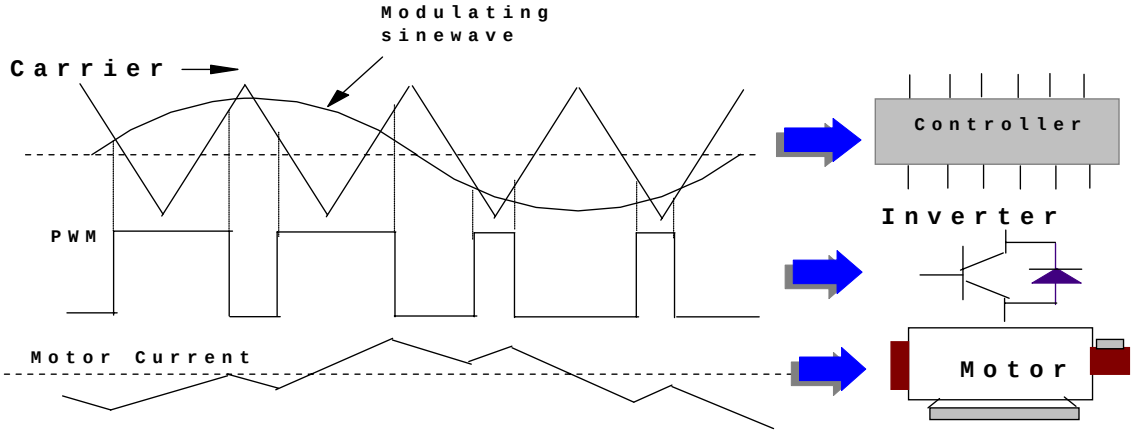
Disadvantages

- Large starting current 400 to 500% of motor nominal current
- High jerk at start and stop
- No speed control
- Longer down time to change speed

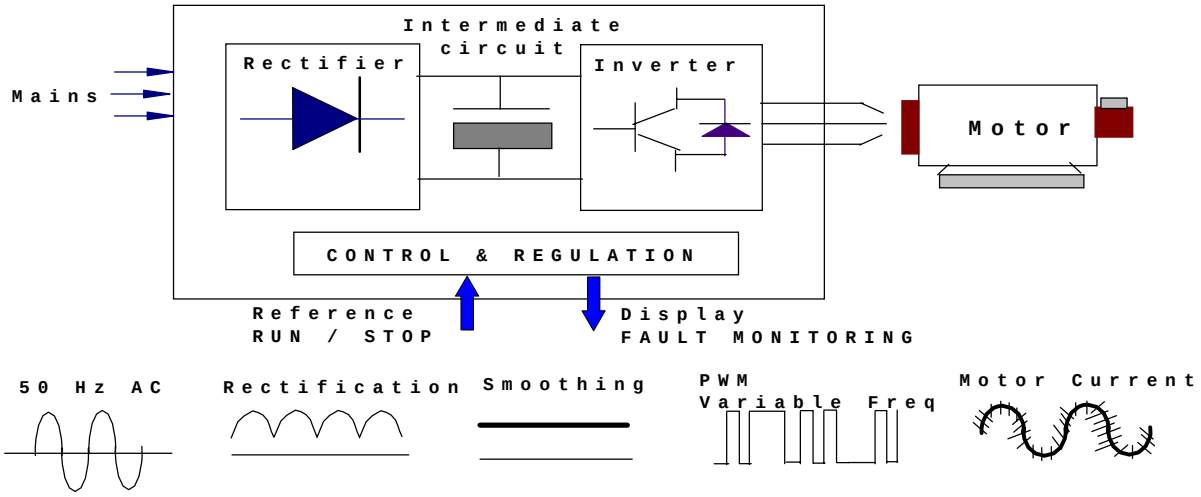


13-3 What is PWM?

It is a digital **Pulse Width Modulation** signal which is modulated by a reference sinewave.



(PWM) AC drives use a fixed diode rectifier to provide a fixed DC voltage to the Inverter Bridge.
Then, in the inverter bridge, high speed power transistor **control both voltage** & frequency to the motor.



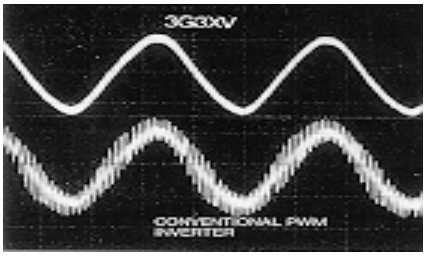
13-4 IGBT

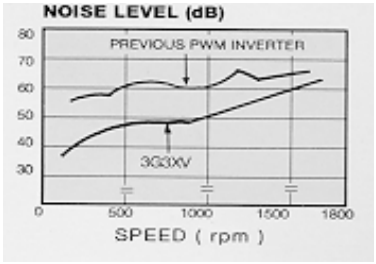
■ What IGBT can do?

Omron's inverter employed state-of-art Insulated Gate Bipolar Transistor (IGBT) which provides precise waveform control that coupled with the high performance of IGBT provides outstanding benefits that cannot be achieved with conventional inverters.

■ High Speed Switching and Quiet Operation

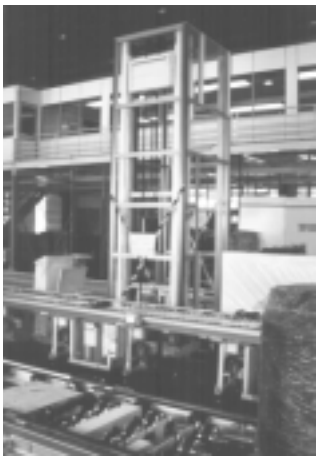
Current Wave Example At 10Hz





Employing our original asynchronous high-carrier…. technique for sine wave PWM control, we have succeeded in eliminating the motor noises that plagued conventional PWM inverters. Running noise has been reduced by approximately 20dB as compared to conventional PWM inverters. This quiet operation assures a more comfortable working environment.

■ Area where Inverter can be used



Lifter & Conveyor

Packaging

Pumps

13-5 Features of Inverter

■ Easy to Use

Constants for basic operations such as frequency setting and acceleration/deceleration time setting are displayed on dedicated indicators. Therefore, constant numbers can be confirmed easily.

■ Easy to Install

- **Very small and Lightweight**
  The 3G3EV Inverter is approximately half the size of our Low-Noise General Purpose Inverters in terms of volume and weight percentage. This improves space efficiency and operating efficiency.
- **Optional DIN Track**
  An optional DIN is available. The DIN track enables the user to mount the 3G3EV Inverter on the DIN trace with a one-touch operation.

■ Easy to Wire

- **Easy wiring without having to open the front cover**
  This inverter can be wired just by opening the terminal block cover.
- **Separate Input and Output Terminal Blocks**
  Power input terminals are located in the upper sections, while motor output terminals are in the lower section.
  In this way, the input and the output terminal blocks are separated according to the contactors.
- **Soldering no longer necessary**
- **No connector means no soldering**

■ Easy to Operate

- **Switching the operation mode with One-Touch Operation**
  The inverter can switch from Digital Operator to a production run using control terminal switch a one-touch operation
- **Checking a test run with various monitors**
  Output frequency, output current, and direction of motor rotation appear in the display section of Digital Operator so the mechanical system can be easily monitored during a test run. Multi-function analog output is also available, which can use for output frequency or current monitoring.

■ Fine Setting Allow Smooth Machine Control

Voltage and frequency fine-tuning, frequency jump, and S-shape acceleration and deceleration functions are available and ideal for controlling machines that cannot be controlled by conventional standard inverters.

■ Multi-step Speed Selection

Speed selection with a maximum of eight steps is possible.

■ Low Noise

An insulated gate bipolar transistor (IGBT) power element has been adopted to eliminate metallic noise.

■ High-torque Operation Even in Lowe Speed Range

A torque rate of 150% can be achieved even in low speed range where output frequency is only 3 Hz.

13-6 Omron Models

3G3EV MODEL	3G3XV MODEL	3G3HV MODEL	3G3FV MODEL
			
3G3EV-A [][][][] / M-E	3G3XV-A [][][][] -E	3G3HV- [][][][] -E	3G3FV- [][][][] -E
V/F Control	**V/F Control**	**V/F Control**	**V/F or Flux Vector Control**

200V SERIES			400V SERIES		
Model	**KW**	**Inverter Type**	**Model**	**KW**	**Inverter Type**
3G3EV	0.1	3G3EV-A2001/M-E	**3G3XV**	0.2	3V3XV-A4002-E
	0.2	3G3EV-A2002/M-E		0.4	3G3XV-A4004-E
	0.4	3G3EV-A2004/M-E		0.75	3G3XV-A4007-E
	0.75	3G3EV-A2007/M-E		1.5	3G3XV-A4015-E
	1.5	3G3EV-A2015/M-E		2.2	3G3XV-A4022-E
3G3XV	2.2	3G3XV-A2022-E		3.7	3G3XV-A4037-E
	3.7	3G3XV-A2037-E			
3G3HV	3.7	3G3HV-A2037-E	**3G3HV**	3.7	3G3HV-A4037-E
	5.5	3G3HV-A2055-E		5.5	3G3HV-A4055-E
	7.5	3G3HV-A2075-E		7.5	3G3HV-A4075-E
	11	3G3HV-A2110-E		11	3G3HV-A4110-E
	15	3V3HV-A2150-E		15	3G3HV-A4150-E
	18.5	3G3HV-B2185-E		18.5	3G3HV-B4185-E
	22	3G3HV-B2220-E		22	3G3HV-B4220-E
	30	3G3HV-B2300-E		30	3G3HV-B4300-E
	37	3G3HV-B2370-E		37	3G3HV-B4370-E
	45	3G3HV-B2450-E		45	3G3HV-B4450-E
	55	3G3HV-B2550-E		55	3G3HV-B4550-E
	75	3G3HV-B2750-E		75	3G3HV-B4750-E
				110	3G3HV-B411K-E
				160	3G3HV-B416K-E
				185	3G3HV-B418K-E
				220	3G3HV-B422K-E
				300	3G3HV-B430K-E
3G3FV	0.4	3G3FV-A2004-E	**3G3FV**	0.4	3G3FV-A4004-E
	0.75	3G3FV-A2007-E		0.75	3G3FV-A4007-E
	1.5	3G3FV-A2015-E		1.5	3G3FV-A4015-E
	2.2	3G3FV-A2022-E		2.2	3G3FV-A4022-E
	3.7	3G3FV-A2037-E		3.7	3G3FV-A4037-E
	5.5	3G3FV-A2055-E		5.5	3G3FV-A4055-E
	7.5	3G3FV-A2075-E		7.5	3G3FV-A4075-E
	11	3G3FV-A2110-E		11	3G3FV-A4110-E
	15	3G3FV-A2150-E		15	3G3FV-A4150-E
	18.5	3G3FV-B2185-E		18.5	3G3FV-B4185-E
	22	3G3FV-B2220-E		22	3G3FV-B4220-E
	30	3G3FV-B2300-E		30	3G3FV-B4300-E
	37	3G3FV-B2370-E		37	3G3FV-B4370-E
	45	3G3FV-B2450-E		45	3G3FV-B4450-E
	55	3G3FV-B2550-E		55	3G3FV-B4550-E
	75	3G3FV-B2750-E		75	3G3FV-B4750-E
				110	3G3FV-B411K-E
				160	3G3FV-B416K-E
				185	3G3FV-B418K-E
				220	3G3FV-B422K-E
				300	3G3FV-B430K-E

Note: 3G3EV-A [][][][]-E (Standard Type)
3G3EV-A [][][][]/M-E (Multi-Function Type)

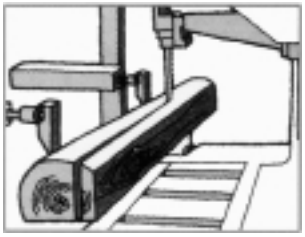
	Inverters			
Product Model	**3G3EV**	**3G3XV**	**3G3HV**	**3G3FV**
				
Features	• Simple operation, with LED display for rotation, frequency & amphere • Compact in size • IGBT switching • Low speed high torque and smooth shaft rotation at low speed • Automatic torque boost	• Highly compact and fully silence • Brake sequence control frequency or torque detection • Motor Thermal Protection for standard and special motor • Stall prevention & three programmed S-curves	• Special indicator for basic parameter constants • Energy-saving control function • PID control • Effective harmonic counter measure for power supply	• Manualess digital operator panel • True flux vector control allows DC performance or higher with a standard AC induction motor • PID control, droop control, torque limit & zero-servo • Built-in auto-tuning • Optional card for close loop flux vector control
Capacity (kW)	0.1 to 1.5 kW	0.1 to 3.7 kW	3.7 to 300 kW	0.4 to 300 kW
Supply Voltage (VAC)	200VAC-230VAC, 3 Phase/1 Phase 380VAC-460VAC, 3 Phase (Available Oct'97)	200VAC-230VAC, 3 Phase/1 Phase 380VAC-460VAC, 3 Phase	200VAC-230VAC, 3 Phase 380VAC-460VAC, 3 Phase	200VAC-230VAC, 3 Phase 380VAC-460VAC, 3 Phase
Supply Frequency (Hz)	50/60 Hz			
Allowable Voltage Fluctuation (%)	-15% to +10%	±10%	-15% to +10%	-15% to +10%
Frequency Control Range (Hz)	0.5 – 400 Hz	0.1 – 400 Hz		
Output Frequency Resolution (Hz)	0.1Hz		0.01Hz	
Micro-processor	16 bits			32 bits
Voltage Frequency Curve	Configurable V/F		15 Fixed V/F 01 Configurable	15 Fixed V/F 01 Configurable / Open/Close Loop Flux Vector
Carrier Frequency (kHz)	2.5 – 10 kHz	2.5 – 15 kHz	2.5 – 15 kHz	0.4 – 15 kHz
Communication	Sysmac Bus	-	Modbus	Compo Bus/D Sysmac Bus
Analog Output (0-10 VDC)	Standard ➔No Multi-Function➔Yes	Yes	Yes	Yes
Pre-set Speed	Standard ➔ 2 Multi-function ➔ 8	4	4	8
Frequency Setting Signal	0 – 10 VDC 4 – 20 mA			0 -±10 VDC 0 – 10 VDC 4 – 2 mA
Acceleration/Deceleration Time	0.0 to 999 sec.	0.1 to 600 sec.	0.1 to 3600 sec.	0.1 to 6000 sec.

13-7 Application

	Simple	General	Difficult	Very Difficult
Application Examples	• Fans • Pumps • Mixers	• Conveyors • Lifters • Grinders • Indexer	• Hoist • Low Speed Elevators • Extruder	• Tension Control • High Speed Lifts • Positioning • Load Sharing
Models Used/ Recommended	• 3G3HV • 3G3EV (standard) • 3G3XV	• 3G3HV • 3G3FV • 3G3EV (multi-function) • 3G3XV	• 3G3FV	• 3G3FV plus PGB2 card

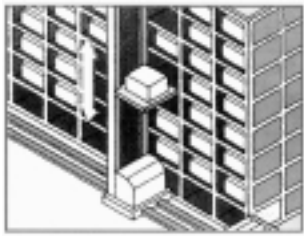
General Machinery (Machinery with Varying Loads)

- Speed/Torque control ensures the stable operation of cutting machines which have load that can change suddenly.



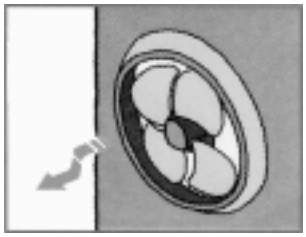
Elevators

- High starting torque shortens the positioning time of stacker cranes.
- The Pulse Generator ensures high holding capability at 0 Hz and precise positioning.



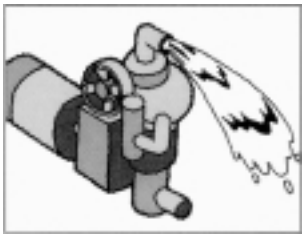
Fan (Air Flow Control)

- The optimum air flow control can be found according to the room temperature.
- No contact air flow control improves safety and reliability compared to control based on the tuning ON and OFF of contacts. And finding the optimum air flow also cuts down on energy usage.



Pumps (Current Control)

- More efficient current control saves energy compared to controlling the amount of current by adjusting valves.
- Even during momentary power interruptions, the speed search function continues operation without stopping the motor. This eliminates problems caused by motor stoppage.

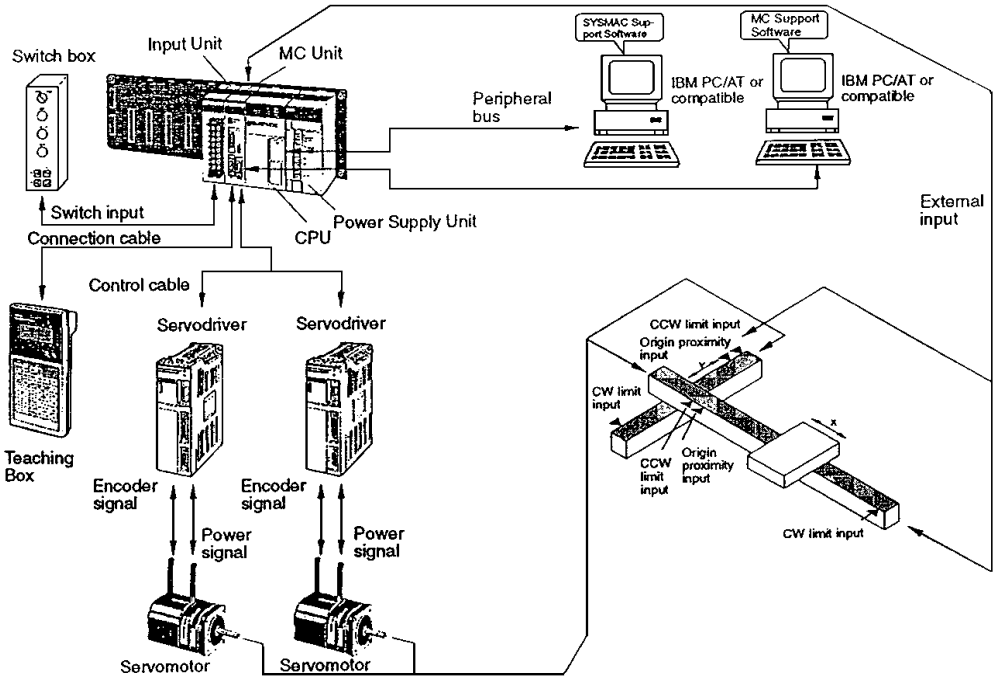


SECTION 14
Servo

14-1 What is a Servo System?

Servo derives form the Greek word call Servus (Servant).
The system is called a Servo System because it responds faithfully or precisely to positioning commands.
Strictly speaking, it is a system to control mechanisms in compliance with the variation of position or speed target value (designated value, command value).

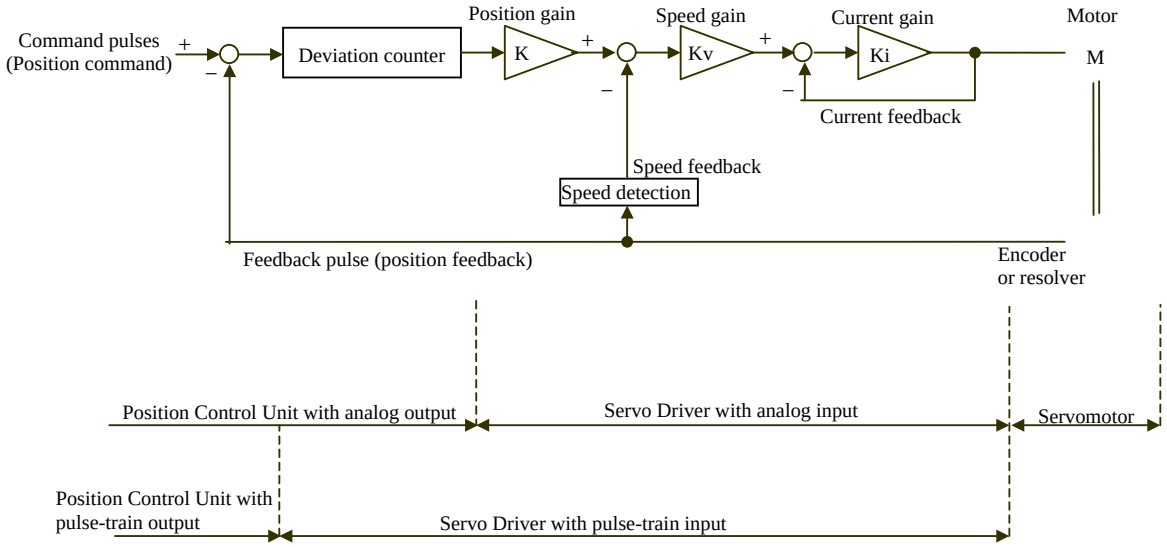
Typical example of a Servo System



14-2 How does a Servo System work?

The Servo System uses a feedback loops. In a feedback loop, the response value is feed back after the command so that the difference between the response and command values will be as close as possible to zero.

A Servo System consists of 3 feedback loops (i.e. position loop, speed loop and current loop).



Position Loop
The position loop is used to let the rotation angle of the motor reach the desired position (i.e. the desire rotation angle) that was externally designated.

The speed command is output from the position loop to the speed loop.

The position loop feeds back the position data (i.e. the information on rotation angle) of the encoder or resolver.

Speed Loop
The Speed Loop is used to let the motor rotate at the speed designated by the external analog speed command or the speed command that is output from the position loop.

The current command is output from the speed loop to the current loop

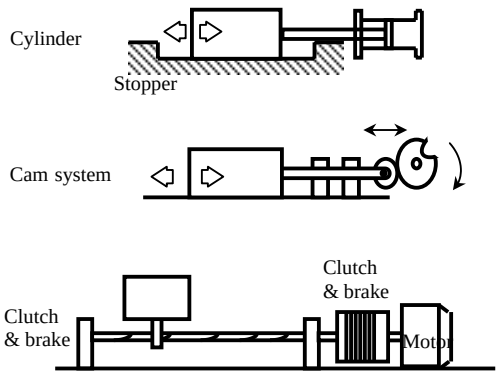
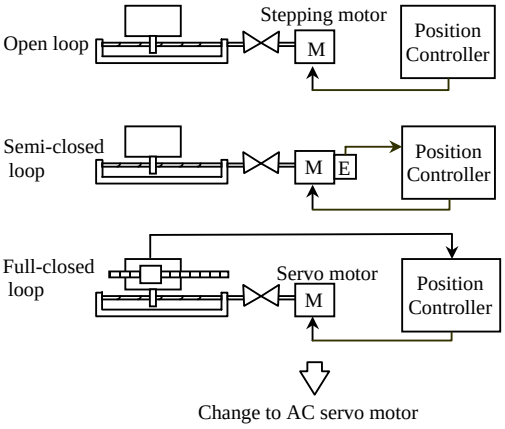
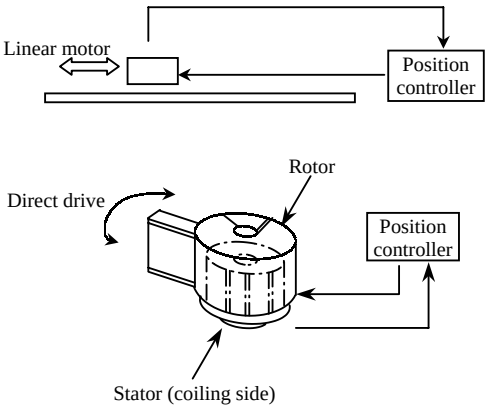
The speed loop feeds back the speed data of the encoder or resolver.

Current Loop
The current loop provides the motor with the current designated by the current command that is output from the speed loop.

The current loop feeds back the motor current value.

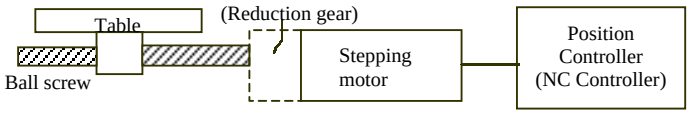
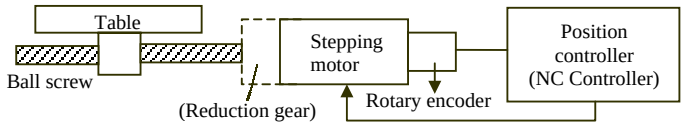
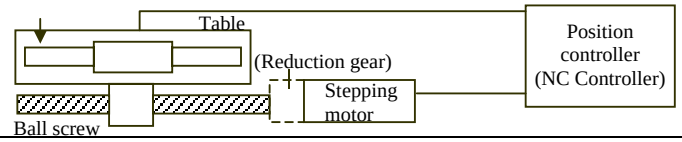
14-3 Positioning Mechanisms

The servo system is not the only alternative to control positioning and feed speed of mechanical facilities. Beside simple mechanical devices, however, the servo system is now the major control system to positioning and feed speed.

Simple positioning		Simple mechanisms Low cost Available high speed operation
Flexible positioning by servo motor		Precise. High speed. Easy to change target position and feed speed. No maintenance. High speed response.
Direct driving system		Simple mechanism. No backlash. No trouble about gear life.

14-4 Three Types of Control Systems

At present, there are three major control systems: 1) open loop, 2) semi-closed loop, and 3) full-closed loop systems.

System	Configuration
Open loop	
Semi-closed loop	
Full-closed loop	

Features of each system

	Open loop	Semi-closed loop	Full-closed loop
Control system	Simple	Little complicated	Complicated
Detection method	None	Not required as installed in motor	Required
Against load fluctuation	Week	Strong	Strong
Precision	Mechanical difference	Mechanical difference	By precision of detector
Difference (backlash pitch difference)	Difficult to correct	Correction available	Correction not required
Motor	Stepping motor	AC servo DC servo	AC servo DC servo
Feed rate	Low	High	High
Cost	Cheap	Little expensive	Expensive
Complicity of system configuration	Simple	Little complicated	Complicated

14-5 Servo Motor

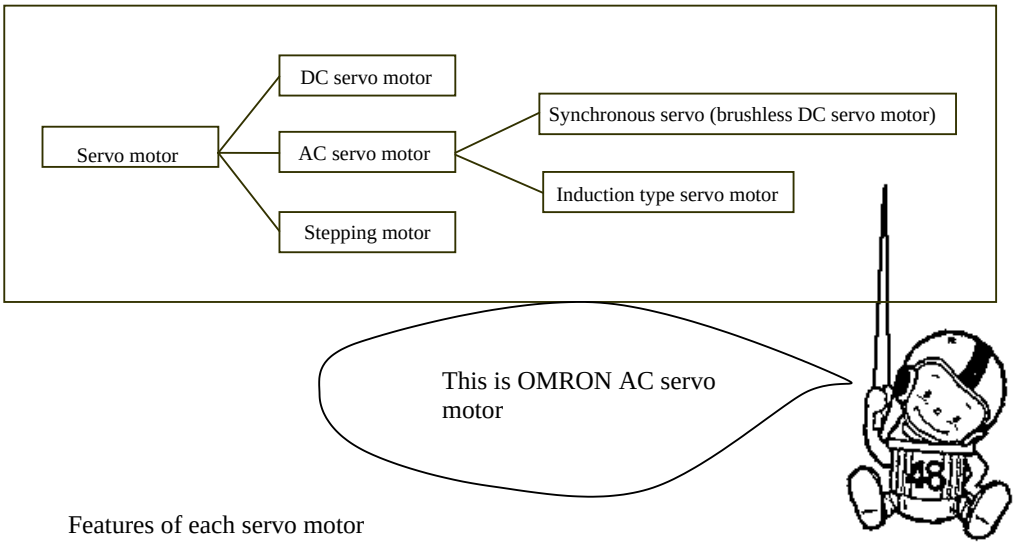
1. Difference with Other Conventional Motor

   Basic construction and operation principles of the servo motor are the same as general conventional induction motors. But they have been redesigned to meet high precision, high speed, high frequency positioning and speed control of mechanical facilities.

2. Types and Features of Servo motors

   Servo motors are classified into DC servo motors, and stepping motors. There are two varieties of AC servo motors; synchronous servo motor and induction type servo motor.

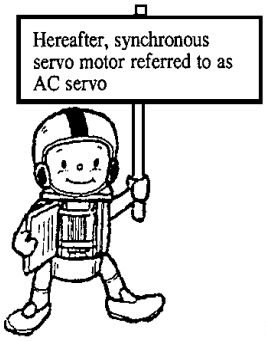
   Classification of servo motor

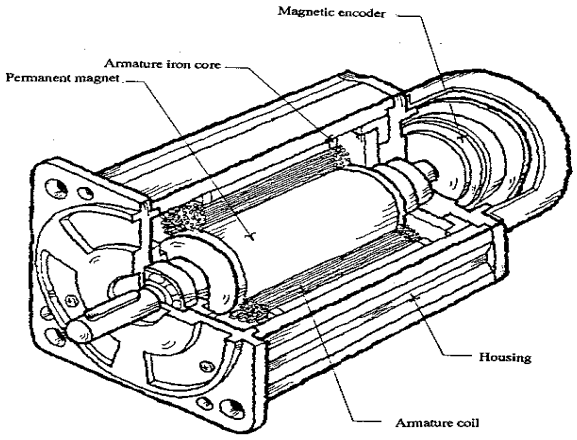


   Features of each servo motor

	Stepping motor	DC servo motor	Synchronous servo motor	Induction type servo motor
Capacity (watt)	Less than 100W	Less than 500W	100 to 2kW	2kW or up
Advantages	Compact and high output. Cheap.	Smaller outside dimensions and large torque. Good operation efficiency. Good controllability. Cheap.	High speed and high torque. Good operation efficiency. No maintenance required.	High speed and high torque. No need maintenance. Durable. Large peak torque.
Disadvantages	Out-of-step and magnet noise at low speed operation.	Limit at rectification. Low reliability. Requires maintenance.	Expensive.	Bad operation efficiency with medium capacity models. Complicated control circuit. Expensive.

3. Construction of AC servo motor





- Features of AC servo motor compared with DC servo motor
  Permanent magnet is built-in the motor…Rotating field type.
  Coils are provided on the stator……Static armature.
  In other words, electrical functions of rotor and stator are reversed.

  AC servo motor does not have the commutator and brushes which DC servo motor has.

4. Comparison Between AC & DC Servo Motor

	AC servo	DC servo
Life	<Bearing life> 20,000 h or up.	<Brush life> Normally, 3,000 to 5,000 h Varies considerably due to load and environmental conditions.
Maintenance	<Not required> No mechanical contact. (No brushes, commutators)	<Required> Required periodical check and replacement of brushes.
Sound noise	<Quiet>	<Noisy> Due to brush contacting noise.
Electrical noise	<None> No noise as no brushes.	<Exist> Noise occurs due to actuation of brushes.
Efficiency	<Excellent> Good cooling efficiency as heat radiates from stator.	<Good> Rectification loss occurs. Bad cooling efficiency due to rotor heat.
Against overload	<Good> Large thermal time constant. High speed and large torque.	<Medium> Small thermal time constant. Limited current due to brush flashover.
Response characteristics	<Very quick> Large power rate. (Small rotor inertia and large torque until high speed range.	<Quick> Small power rate. (Large rotor inertia. Decrease torque at high speed range.)
Cleanness	<Good> Clean as no brush powder occurs.	<Bad> Brush powder occurs.

14-6 Servo Driver

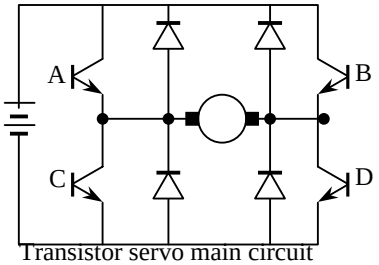
A Servo Driver is a power device use to drive a Servo Motor. It consists mainly of Power Transistors & Diodes that are constructed in a Dartington Power Transistor Bridge Configuration.

Transistors are turned on/off in pair, that means either Transistor A & D are on for the Clockwise direction or Transistor B & C are on for the counter-clockwise direction.

1 Typical Servo Driver

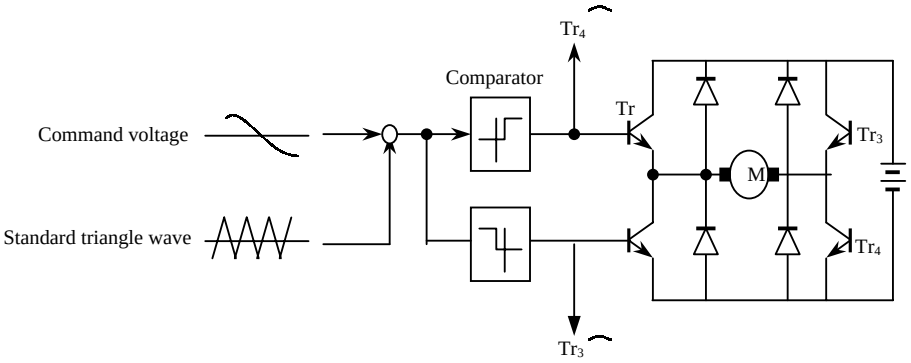
Let us become familiarized with the circuit and operation of PWM transistor driver, which is one of major drives for servo motors.

Transistor PWM
An example of main circuit



Transistor servo main circuit

Operation



■ AC Servomotors Conforming to EC Directives (Incremental Encoder)

Specifications				Model
U Series	With no brake	200-VAC input	30W	R88M-U03030VA-S1
			50W	R88M-U05030VA-S1
			100W	R88M-U10030VA-S1
			200W	R88M-U20030VA-S1
			400W	R88M-U40030VA-S1
			750W	R88M-U75030VA-S1
			1kW	R88M-U1K030V-S1
			1.5kW	R88M-U1K530V-S1
			2kW	R88M-U2K030V-S1
			3kW	R88M-U3K030V-S1
			4kW	R88M-U4K030V-S1
			5kW	R88M-U5K030V-S1
		100-VAC input	30W	R88M-U03030WA-S1
			50W	R88M-U05030WA-S1
			100W	R88M-U10030WA-S1
			200W	R88M-U20030WA-S1
			300W	R88M-U30030WA-S1
	With brake	200-VAC input	30W	R88M-U03030VA-BS1
			50W	R88M-U05030VA-BS1
			100W	R88M-U10030VA-BS1
			200W	R88M-U20030VA-BS1
			400W	R88M-U40030VA-BS1
			750W	R88M-U75030VA-BS1
			1kW	R88M-U1K030V-BS1
			1.5kW	R88M-U1K530V-BS1
			2kW	R88M-U2K030V-BS1
			3kW	R88M-U3K030V-BS1
			4kW	R88M-U4K030V-BS1
			5kW	R88M-U5K030V-BS1
		100-VAC input	30W	R88M-U03030WA-BS1
			50W	R88M-U05030WA-BS1
			100W	R88M-U10030WA-BS1
			200W	R88M-U20030WA-BS1
			300W	R88M-U30030WA-BS1
U-series UE Models	With no brake	200-VAC input	100W	R88M-UE10030V-S1
			200W	R88M-UE20030V-S1
			400W	R88M-UE40030V-S1
			750W	R88M-UE75030V-S1
		100-VAC input	100W	R88M-UE10030W-S1
			200W	R88M-UE20030W-S1
			300W	R88M-UE30030W-S1
	With brake	200-VAC input	100W	R88M-UE10030V-BS1
			200W	R88M-UE20030V-BS1
			400W	R88M-UE40030V-BS1
			750W	R88M-UE75030V-BS1
		100-VAC input	100W	R88M-UE10030W-BS1
			200W	R88M-UE20030W-BS1
			300W	R88M-UE30030W-BS1

■ AC Servomotor Conforming to EC Directives (Absolute Encoder)

Specifications				Model
U Series	With no brake	200-VAC input	30W	R88M-U03030XA-S1
			50W	R88M-U05030XA-S1
			100W	R88M-U10030XA-S1
			200W	R88M-U20030XA-S1
			400W	R88M-U40030XA-S1
			750W	R88M-U75030XA-S1
			1kW	R88M-U1K030X-S1
			1.5kW	R88M-U1K530X-S1
			2kW	R88M-U2K030X-S1
			3kW	R88M-U3K030X-S1
			4kW	R88M-U4K030X-S1
			5kW	R88M-U5K030X-S1
		100-VAC input	30W	R88M-U03030YA-S1
			50W	R88M-U05030YA-S1
			100W	R88M-U10030YA-S1
			200W	R88M-U20030YA-S1
			300W	R88M-U30030YA-S1
	With brake	200-VAC input	30W	R88M-U03030XA-BS1
			50W	R88M-U05030XA-BS1
			100W	R88M-U10030XA-BS1
			200W	R88M-U20030XA-BS1
			400W	R88M-U40030XA-BS1
			750W	R88M-U75030XA-BS1
			1kW	R88M-U1K030X-BS1
			1.5kW	R88M-U1K530X-BS1
			2kW	R88M-U2K030X-BS1
			3kW	R88M-U3K030X-BS1
			4kW	R88M-U4K030X-BS1
			5kW	R88M-U5K030X-BS1
		100-VAC input	30W	R88M-U03030YA-BS1
			50W	R88M-U05030YA-BS1
			100W	R88M-U10030YA-BS1
			200W	R88M-U20030YA-BS1
			300W	R88M-U30030YA-BS1

*1. The motor shaft must be straight with a key groove.

*2. Refer to the Catalogs for OMNUC U Series or U-series UE Models for specifications and functions of the above models.

■ AC Servo Drivers Conforming to EC Directives

Specifications				Model
U Series	Analog input	Single-phase 200-VAC input	30W	R88D-UA02V
			50W	R88D-UA03V
			100W	R88D-UA04V
			200W	R88D-UA08V
			400W	R88D-UA12V
			750W	R88D-UA20V
		Single-phase 100-VAC input	30W	R88D-UA03W
			50W	R88D-UA04W
			100W	R88D-UA10W
			200W	R88D-UA12W
			300W	R88D-UA15W
	Pulse-train input	Single-phase 200-VAC input	30W	R88D-UP02V
			50W	R88D-UP03V
			100W	R88D-UP04V
			200W	R88D-UP08V
			400W	R88D-UP12V
			750W	R88D-UP20V
		Single-phase 100-VAC input	30W	R88D-UP03W
			50W	R88D-UP04W
			100W	R88D-UP10W
			200W	R88D-UP12W
			300W	R88D-UP15W
	Common to analog and pulse train inputs	Single-phase 200-VAC input	1kW	R88D-UT24V
			1.5kW	R88D-UT40V
			2kW	R88D-UT60V
			3kW	R88D-UT80V
			4kW 5kW	R88D-UT110V (see notes 1 and 2)
			1kW	R88D-UT24V-RG (see note 1)
			1.5kW	R88D-UT40V-RG (see note 1)
			2kW	R88D-UT60V-RG (see note 1)
			3kW	R88D-UT80V-RG (see note 1)
U-series UE Models	Pulse-train input	Single-phase 200-VAC input	100W	R88D-UEP04V
			200W	R88D-UEP08V
			400W	R88D-UEP12V
			750W	R88D-UEP20V
		Single-phase 100-VAC input	100W	R88D-UEP10W
			200W	R88D-UEP12W
			300W	R88D-UEP15W

Note 1: Models requiring external regenerative resistors. Be sure to connect external regenerative resistors.

Note 2: The initial parameters of the R88D-UT110V are set to the settings for the 4-kW motors.

■ External Regenerative Resistor Conforming to EC Directives

Specifications	Model
70 W	R88A-RR22047S

■ Encoder Cables Conforming to EC Directives (For 30- to 750-W Models)

Specifications		Model
For motors with incremental encoders	3m	R88A-CRUD003C
	5m	R88A-CRUD005C
	10m	R88A-CRUD010C
	15m	R88A-CRUD015C
	20m	R88A-CRUD020C
For motors with absolute encoders	3m	R88A-CSUD003C
	5m	R88A-CSUD005C
	10m	R88A-CSUD010C
	15m	R88A-CSUD015C
	20m	R88A-CSUD020C

Conform to EC Directives

The following EMC (electromagnetic compatibility) directives and low-voltage directives (LVD) have been met.

- Servodrivers — EMC directives: EN55011 and EN50082-2; LVD: EN61010-1
- Servomotors — EMC directives: EN55011 and EN50082-2; LVD: IEC34-1, IEC34-5, IEC34-8, and IEC34-9

A Wide Variety of Models

The U series and U-series UE Models include a total of 87 models.

Series	Supply voltage	Driver	Servomotor
U Series	200 VAC	12 models	12 models
	100 VAC	10 models	10 models
U-series UE Models	200 VAC	4 models	8 models
	100 VAC	3 models	6 models

System Configuration

*1. We recommend using the Okaya Electric noise filters in the table so that the system will satisfy EMC directives.
*2. The noise filter is required for reducing noise transmission.

■ Noise Filter Meeting EC Directives (Okaya Electric Industries Co., Ltd.)

Specifications	Model
200 V: For 30 to 100 W 100 V: For 30 and 50 W	SUP-P5H-EPR-4
For brake power supply.	
200 V: For 200 and 400 W 100 V: For 100 W	SUP-P8H-EPR-4
200 V: For 750 W 100 V: For 200 and 300 W	SUP-P10H-EPR-4

Noise filters have screw terminals.

Applicable Series

OMNUC U Series

- Compact models with powerful functions.
- High-speed, high-precision control.

OMNUC U-series UE Models

- Easy-to-use with simplified functions.
- Excellent cost performance.

Series	Supply voltage	Max. applicable motor capacity (W) (30 / 100 / 300 / 750)	Servodriver command input	Servomotor encoder
U Series	200 VAC		Analog, pulse train	Incremental
	100 VAC		Analog, pulse train	Incremental
U-series UE Models	200 VAC		Pulse train	Incremental
	100 VAC		Pulse train	Incremental

14-7 Omron Models

- **AC Servomotors and Servo Drivers**
  Omron Mechatronic System Components

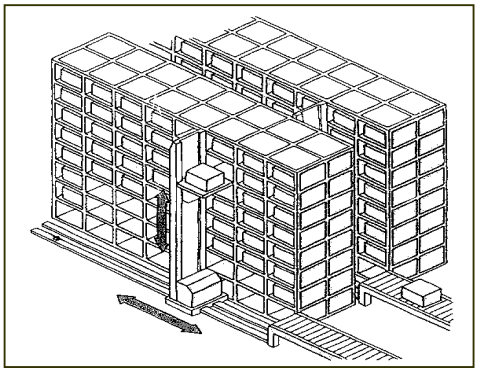
  OMNUC U Series and U-series UE Models

  New Models Conforming to EC Directives for OMRON's Popular AC Servomotors and Servo Drive 1- to 5-kW models have also been added.

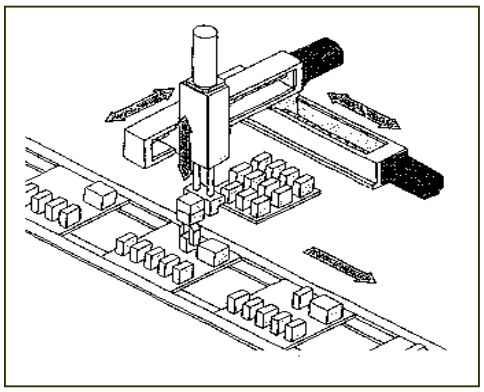
14-8 Application

OMRON Servo Drivers & Servo Motors are used in various precision demanding Applications. There are some examples listed below.

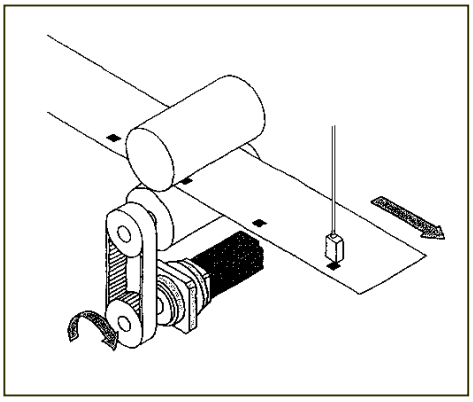
1. Automatic Storage & Retrieval System (ASRS)



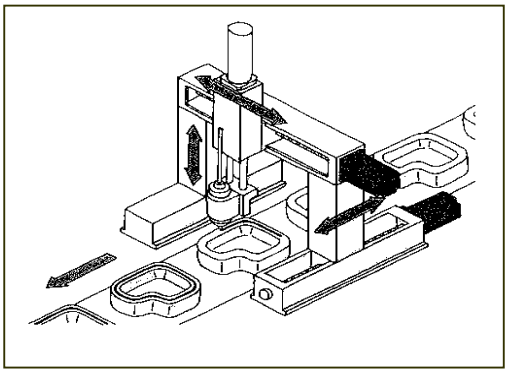
2. Auto Assembly Line



3. Feeding System



4. Glue Dispensing System



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General Basic Component And FA Electricity Course

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