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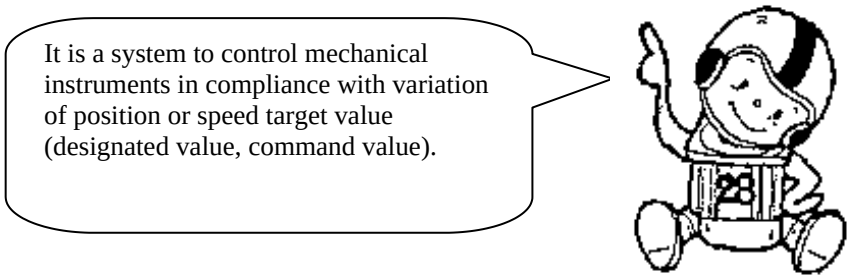
CONTENTS

Servo
Section 1

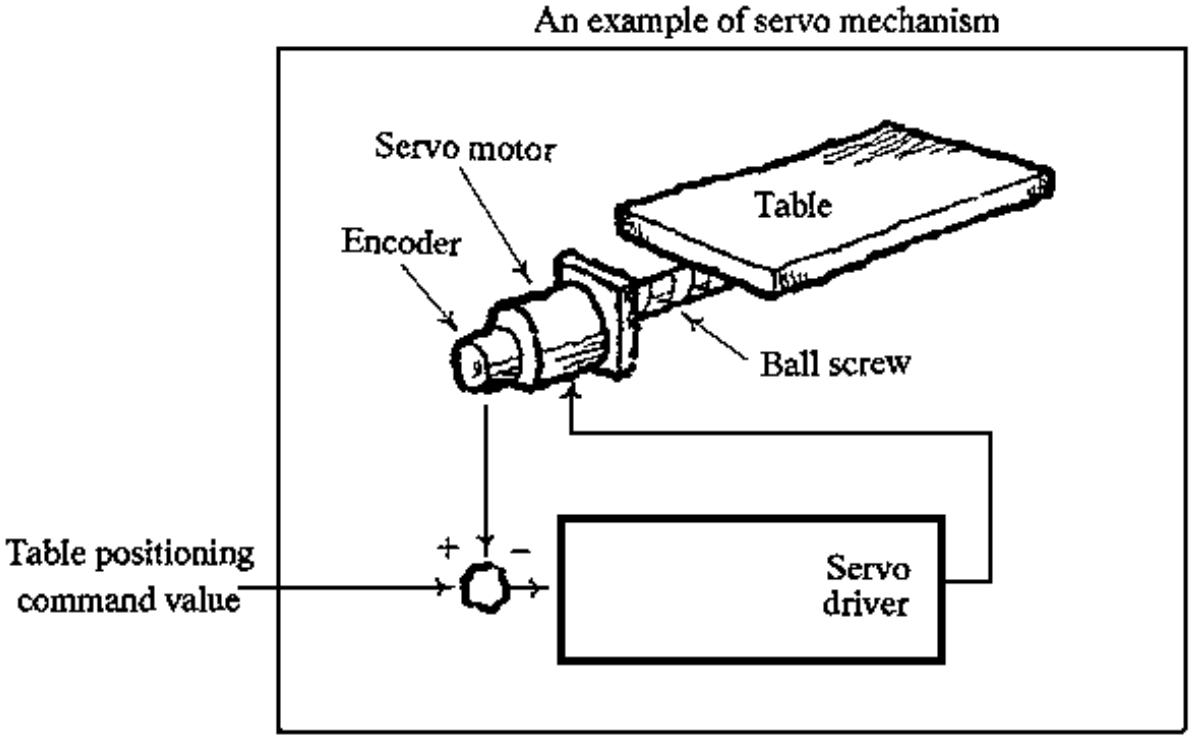
1 About Servo System

1. What is “Servo System”

“Servo” derives from the Greek “Servus (servant).” The system is called “Servo System” as it responds faithfully to a command.

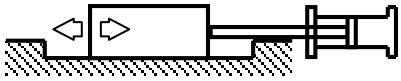


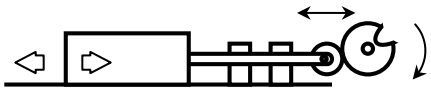
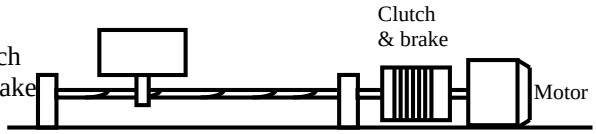
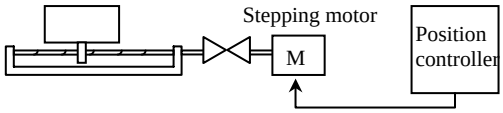
An example of servo mechanism

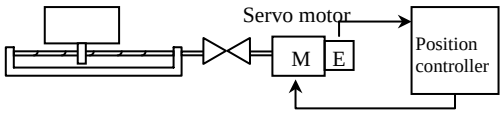


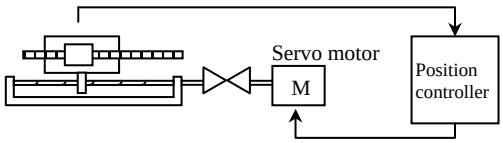
2. Positioning Mechanisms

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.

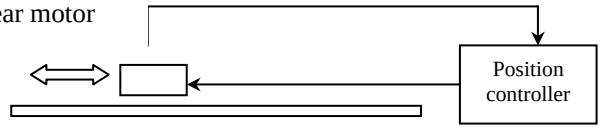
<table>
<tr>
<td>Simple positioning</td>
<td>Cylinder
 

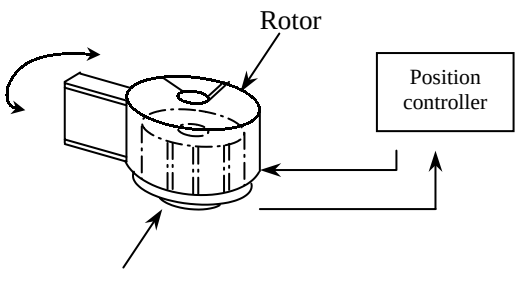
Cam system
 
Clutch & brake
 
</td>
<td>Simple.
Low cost.
Available high speed operation.</td>
</tr>
<tr>
<td>Flexible positioning by servo motor</td>
<td>Open loop
 

Semi-closed loop
 

Full-closed loop
 

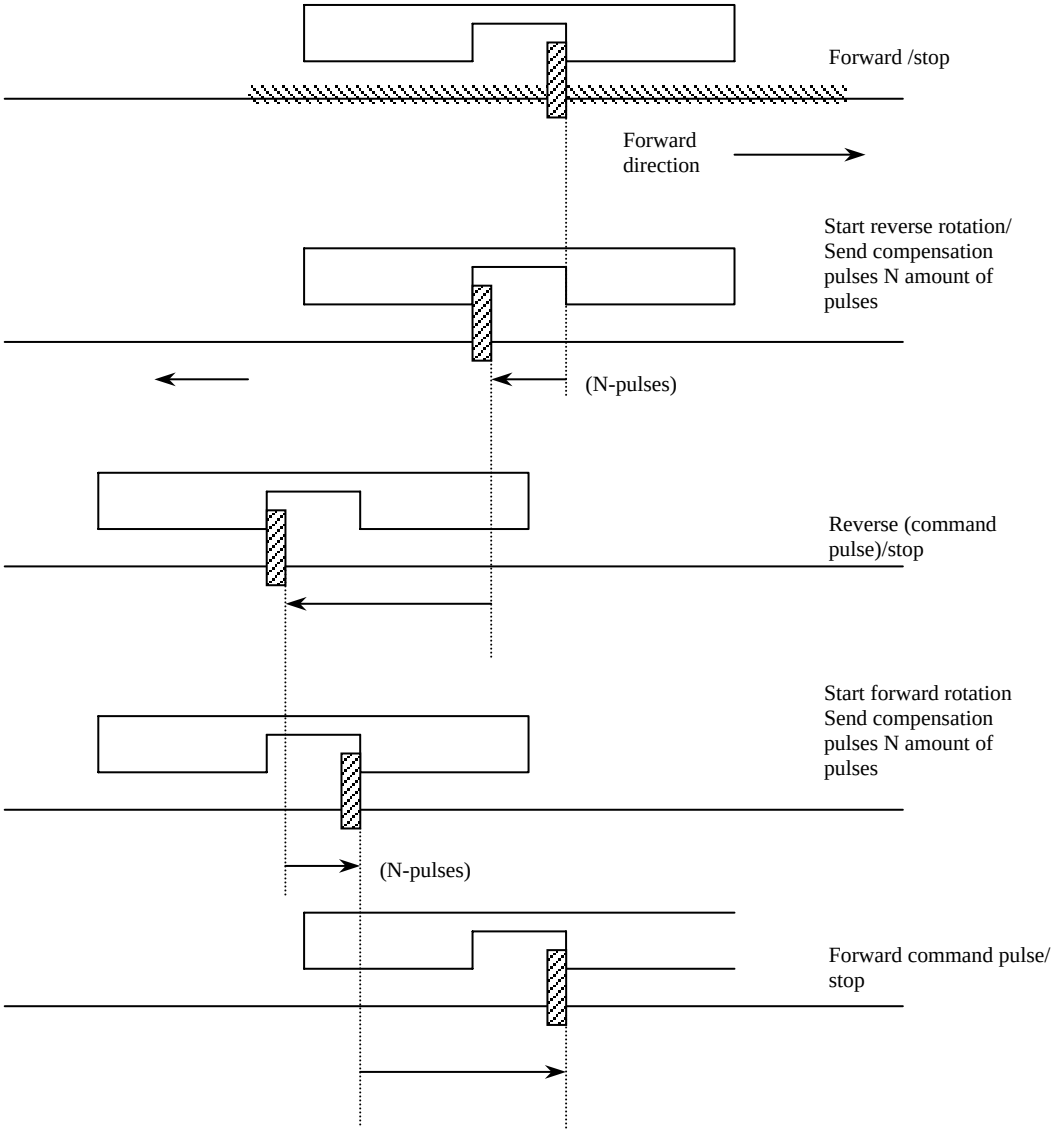
 
Change to AC servo motor</td>
<td>Precise.
High speed.
Easy to change target position and feed speed.

No maintenance.
High speed response</td>
</tr>
<tr>
<td>Direct driving system</td>
<td>Linear motor
 

Direct drive
 
</td>
<td>Simple mechanism.
No backlash.
No trouble bout gear life.</td>
</tr>
</table>

Mechanical backlash and its correction

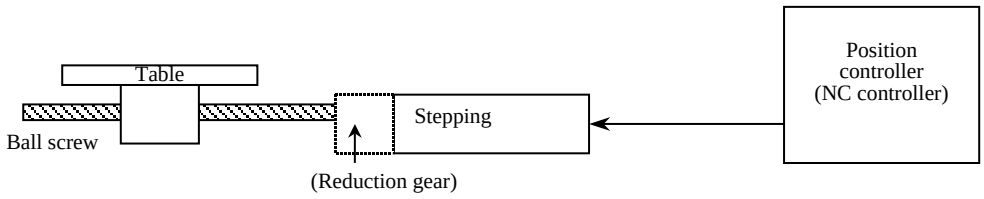
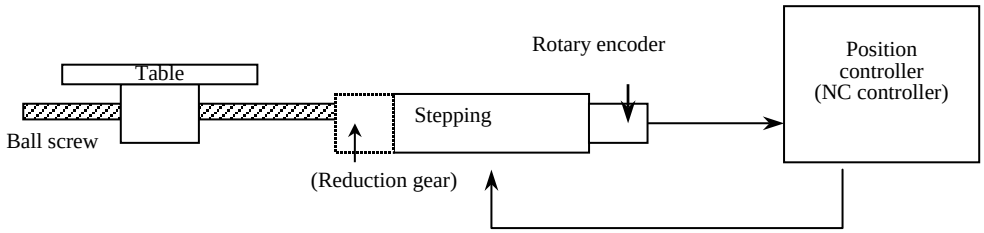
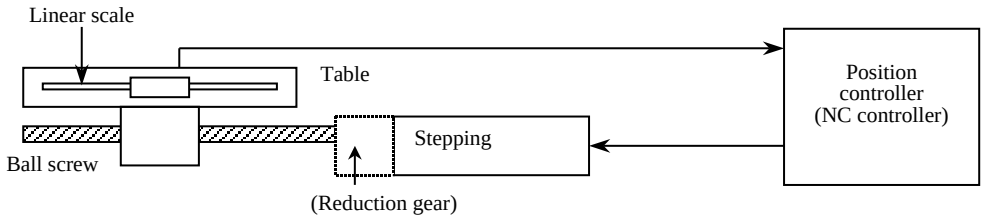
Almost all mechanical devices have neutral zone between forward and reverse rotations. For example, when you change rotation direction of a mechanism from forward to reverse, an additional amount of rotation is required to cover a gap (free zone) between forward and reverse rotations. This gap or allowance is called “backlash”. The servo system has a function to compensate for this backlash.



As shown above, the servo system sends command pulse adding correction amount of pulses. In this case, a current position value counter does not count this correction amount.

3. Three Types of Control System

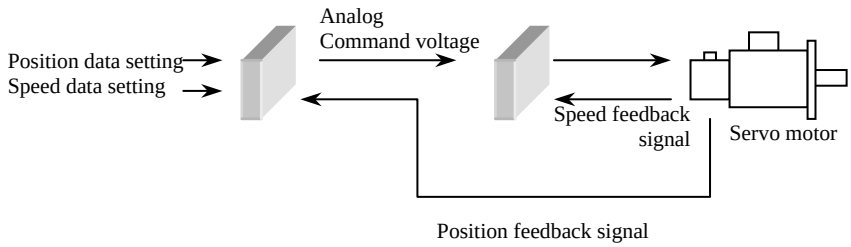
At present, there are three major control system: 1) open loop, 2) semi-closed loop, and 3) full-closed loop systems

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

Features of each system

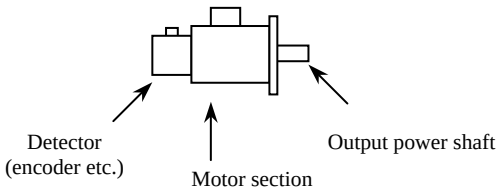
	Open loop	Semi-closed loop	Full-closed loop
Control system	Simple	Little complicated	Complicated
Detection method	None	Not required as installed in motor	Required
Against load fluctuation	Week	Strong	Strong
Precision	Mechanical difference	Mechanical difference	By precision of detector
Difference (backlash 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

Configuration example of servo system



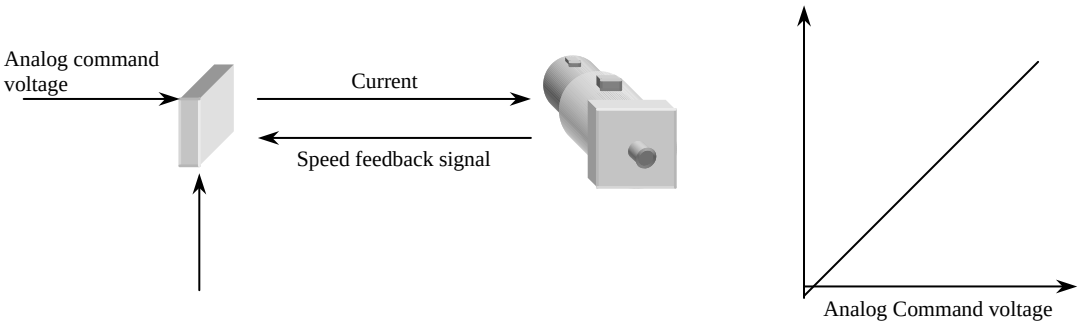
- **Servo motor**

Major difference of the servo motor compared with general use induction motors is that it has a detector to detect rotation speed and position



- **Driver (analog input type)**

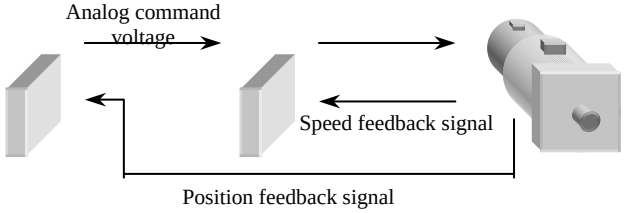
The driver controls servo motor rotation speed to rotate with a designated number of rotations in proportion to analog speed command voltage. Thus, it monitors motor rotation speed all the time



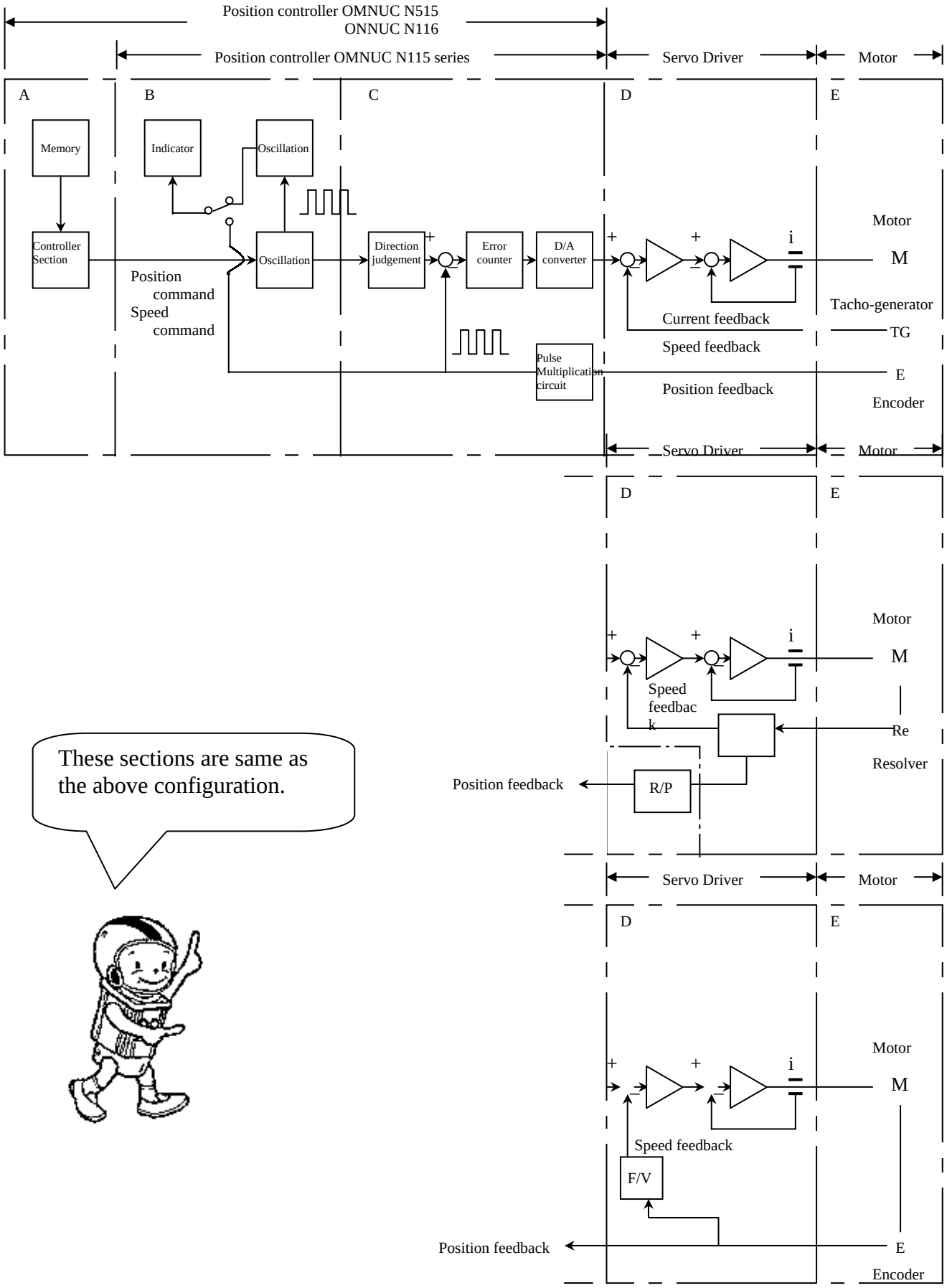
(Ex.)	Analog command		Number of rotation
	Voltage		
	+10V	Forward direction	3,000 rpm
	-5V	Reverse direction	1,500 rpm

- **Positioner**

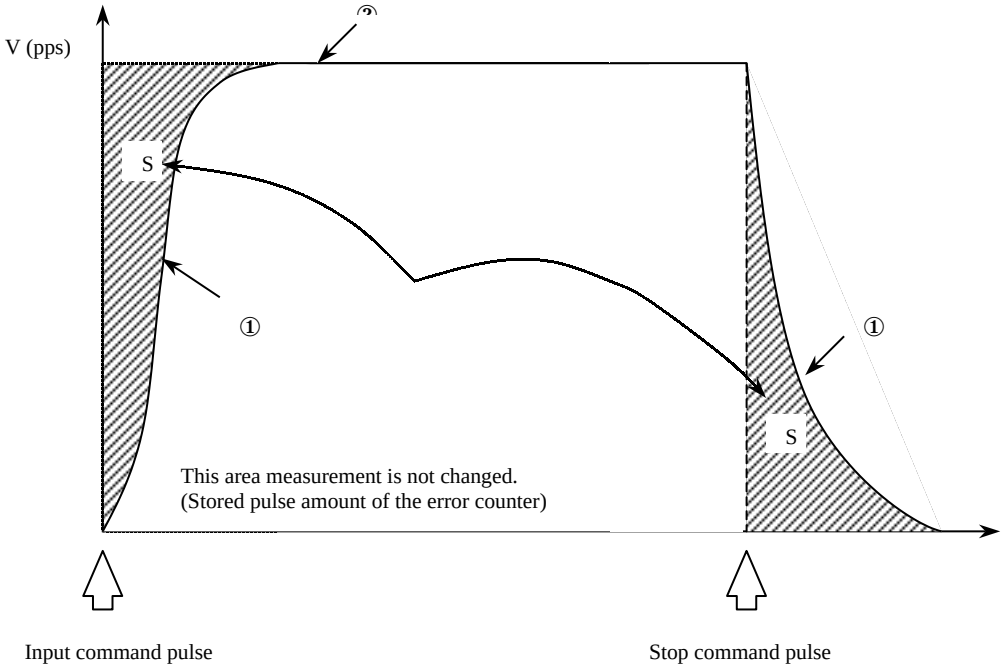
The positioner controls servo motor positioning. Thus, it monitors motor rotation position all the time



4. Configuration of the Servo System and Its Operation



Error counter operation and response characteristics



1) When an amount of command pulse is supplied with equivalent to command speed, the servo driver receives square shaped input. The motor, however, takes some interval to reach to the command speed as it has to overcome inertia.
2) When the motor reaches the command speed, command pulse frequency becomes return pulse frequency. The motor speed stays in the rated level.
3) When the driver stops supply of command pulse by ending number of pulse equivalent to the command position, the error counter and D/ A converter output power until stored pulses (an amount equivalent to delay pulse amount S1 at start) in the error counter are discharged, and the motor keeps rotation with this output.
   The motor stops rotation when number of position command pulse is equal to number of return pulses.
   Stored pulse amount S1 equals S2 in the figure above

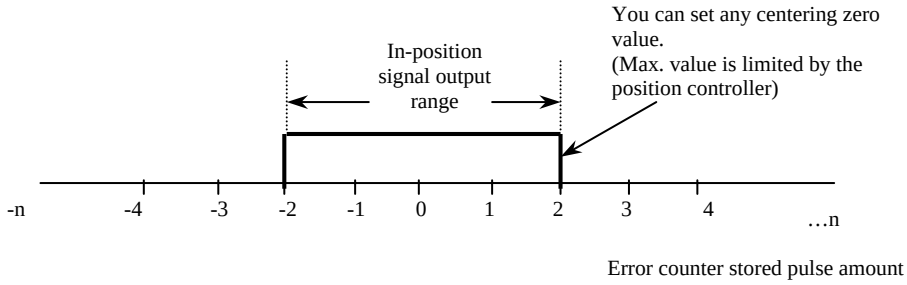
Note 1: Error counter (also called “deviation counter”)
Command pulses are temporarily stored inside the servo driver until they turn to command voltage by the D/A converter. These pulses are called error pulses or deviation pulses. Stored section is called “error counter” or “deviation counter.”

Difference after completion of positioning should theoretically become zero. However, this may vary by total amount of allowance of position detector (ex: one pulse of the encoder), allowance of the servo driver, and mechanical static friction torque.

In-position (nearly zero)

When the servo system completes positioning, it goes to next step after receiving positioning completion signal. This positioning completion signal is called “in-position.”
This in-position function enables the position control device (position controller or NC) to adjust its sensing width.
By adjusting this in-position range and using this in-position signal, the system is able to go to next step in advance of completion of positioning or to shorten total cycle time
The servo system, however, executes positioning regardless of in–position range and its output, and completes positioning until the error counter becomes zero.

<Setting example of in-position range>



This in-position is also called “nearly zero” as the error counter becomes almost zero.

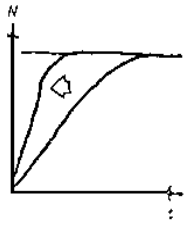
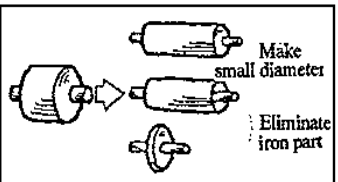
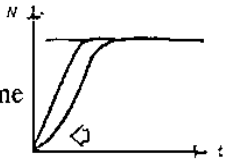
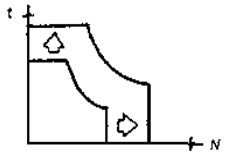
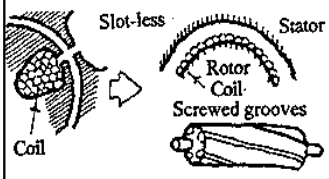
Servo
Section 2

2. About 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.

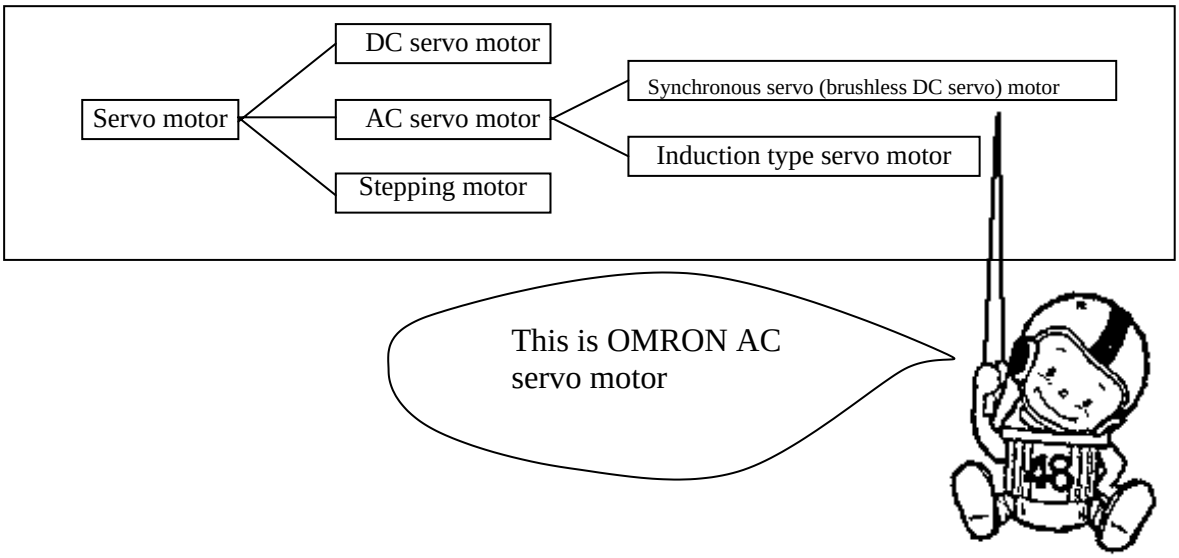
Features of servo motor

Acceleration (Shortens reaction interval to command speed.) 	Minimized rotor inertia.	
	Makes possible increased supply current. (Improve demagnetization preventive characteristics of permanent magnet.)	Uses rare earth magnet, or ferrite magnet. Design armature and magnet shapes.
Response (Shorts delay time of acceleration) 	Minimize armature inductance.	Decreased number of coiling. Shorten magnet circuit clearance.
Enlarge control range. 	Improved withstand voltage. Improved magnet saturation.	Improved insulation. Uses rare earth or ferrite magnet.
Stabilize rotation speed. (Decrease torque ripple and rotation ripple) 	Improve magnet circuit and magnet pole.	
Designed to endure sudden acceleration and high frequency operation.		Long life, wear-free bearings, motor brushes.

2. Types and Features of Servo Motors

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

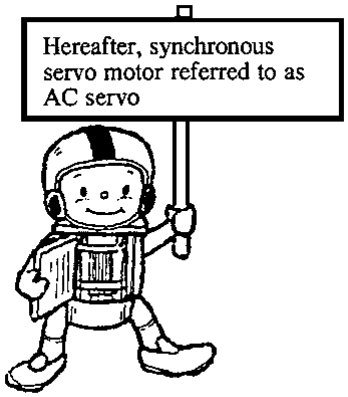
Classification of servo motor

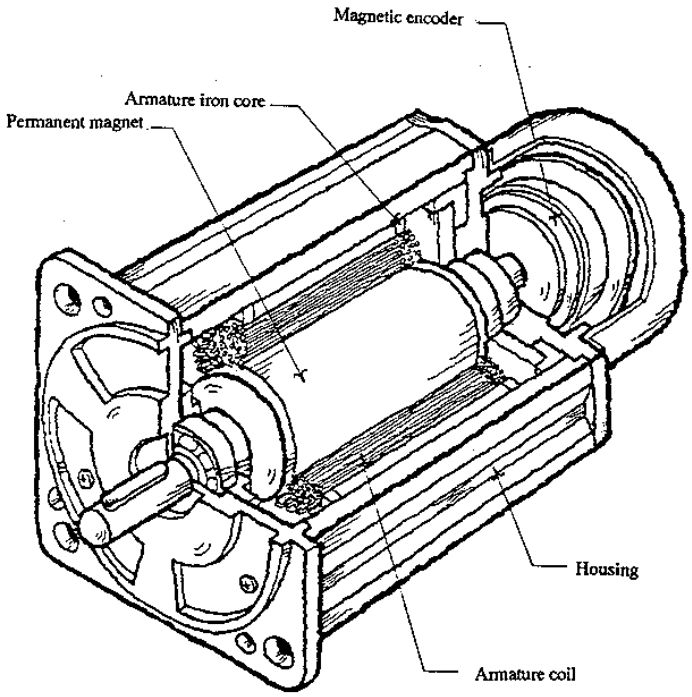


Features of each servo motor

	Stepping motor	DC servo motor	Synchronous servo motor	Induction type servo motor
Capacity (watt)	Less than 100 W	Less than 500 W	100 to 2 kW	2 kW 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

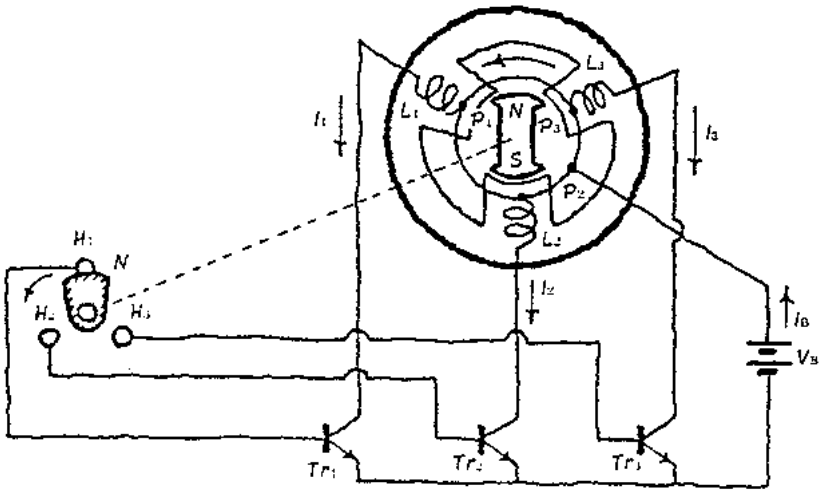




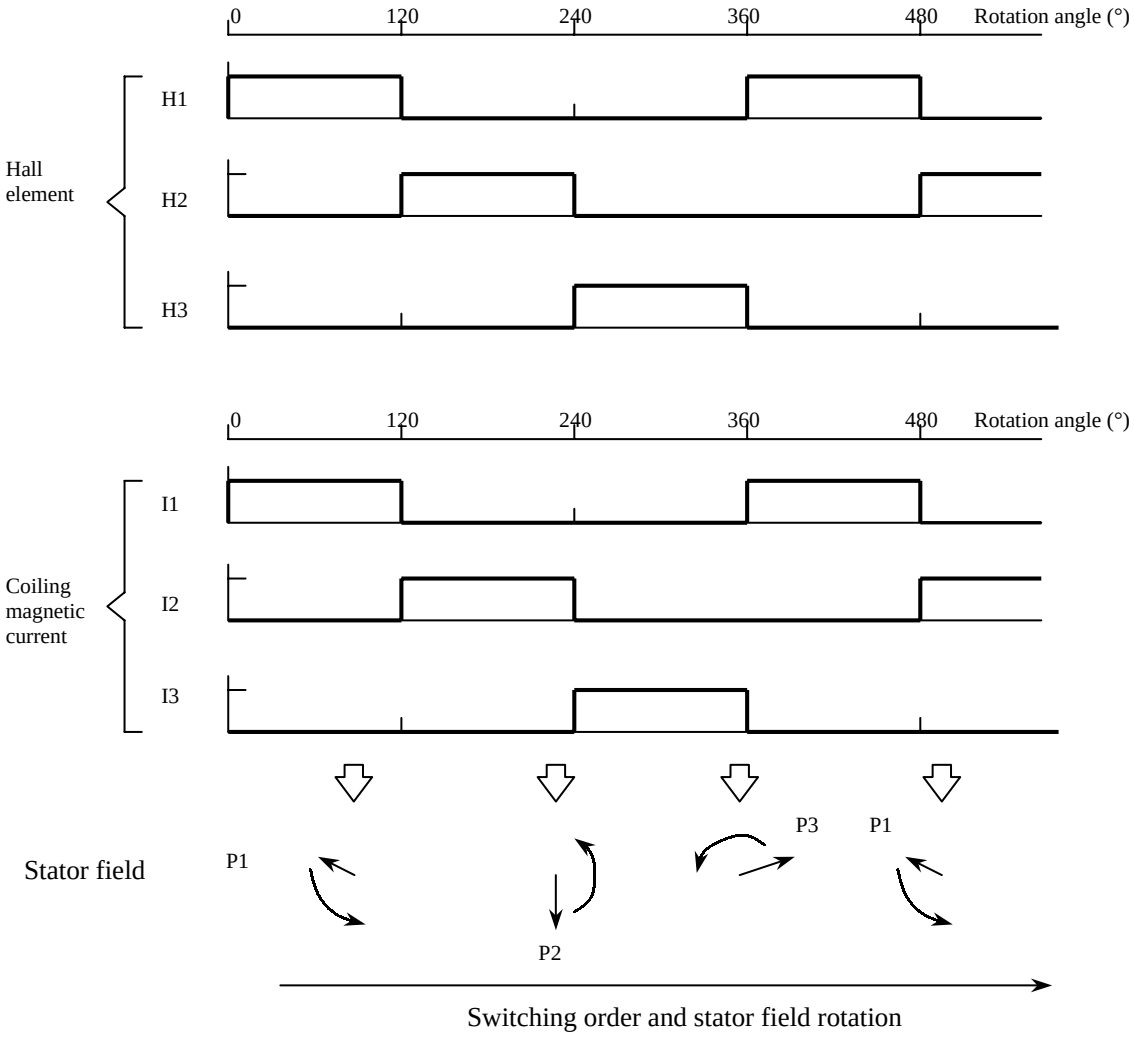
- Features of AC servo motor compared with DC servo motor
  Permanent magnet is built-in the rotor….Rotating field type
  Coils are provided on the stator……Static armature.
  In other word, electrical functions of rotor an stator are reversed.

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

Operation principle of AC servo motor



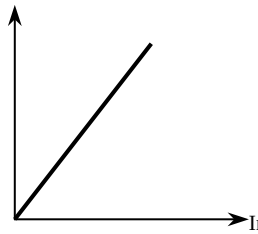
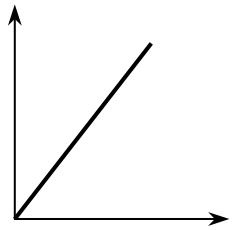
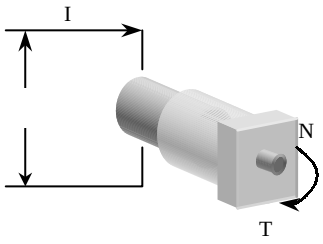
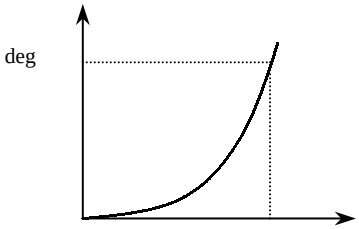
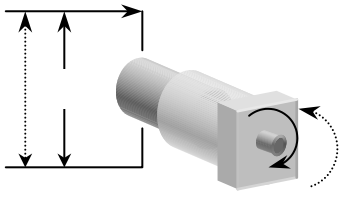
Principle of 3-pole uni-polar type motor



Switching order and stator field rotation

(1).....Features of Servo motor

Characteristics of servo motor

 N ∝ V	Motor speed: N varies in proportion to impressed voltage: V
 T ∝ I	Motor torque: T varies in proportion to supplied current : I
 P ∝ N • T output ∝ V • I input	Motor output power is nearly proportionate to product multiplied speed by torque, and product multiplied impressed voltage by current.
$T \propto \frac{N \bullet J}{T}$	Acceleration and deceleration time: t is in proportion to inertia moment: J of the whole mechanism and arriving speed: N, and in inverse proportion to torque: T.
 Th ∝ I^2 rms	Operation limit of the motor is determined by temperature rise. Rising temperature is in proportion to square of effective value of current
	Motor rotation direction is determined by polarity of impressed voltage

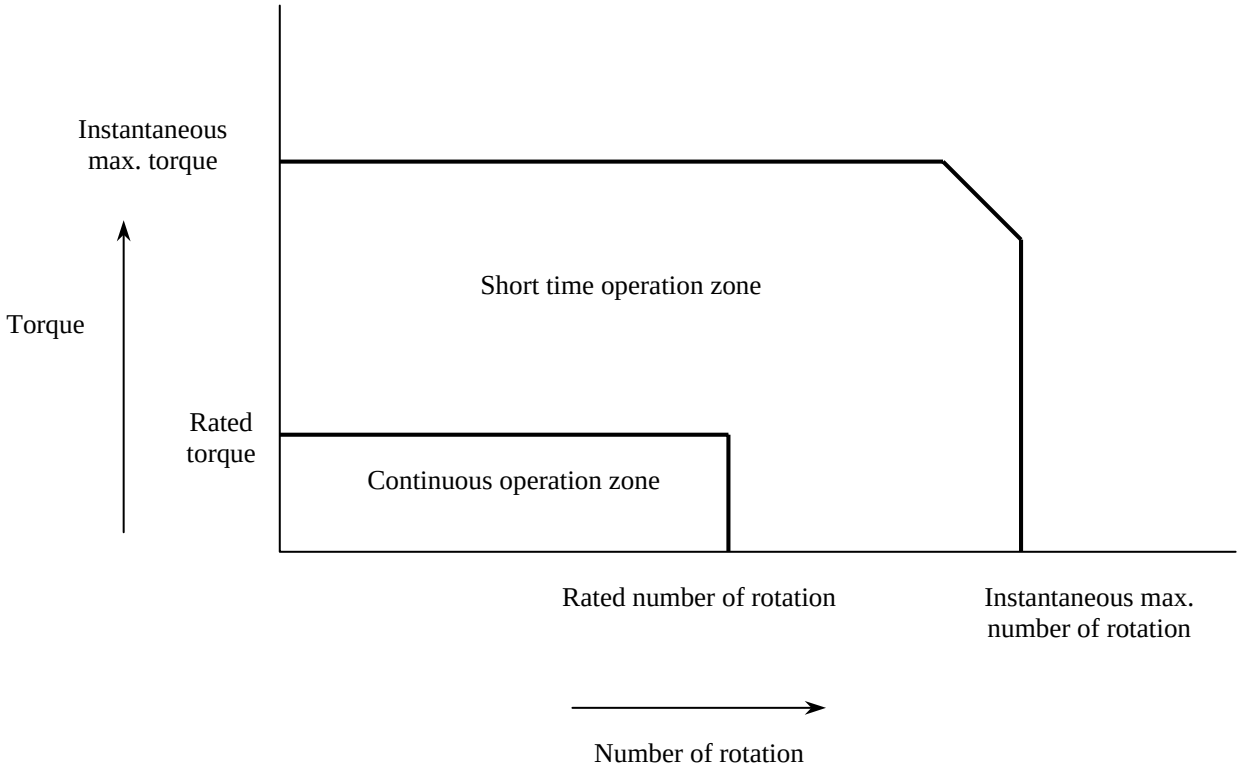
(2) Comparison Between AC & DC Servo

	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.

AC servomotor is more suitable for high speed, high response, and high acceleration/ deceleration control than DC servomotor. It also does not require maintenance.

(3) Torque – number of rotation characteristics

AC servo motor



Servo
Section 3

3. About detector

1. Detector Classification According to Their Detection Method

Detectors installed on servo motors are classified into three categories according to their detection method. Now, detectors are intended to carry out signal treatment of encoders' and resolvers' outputs, and function as both speed an position detectors.

Classification of detectors

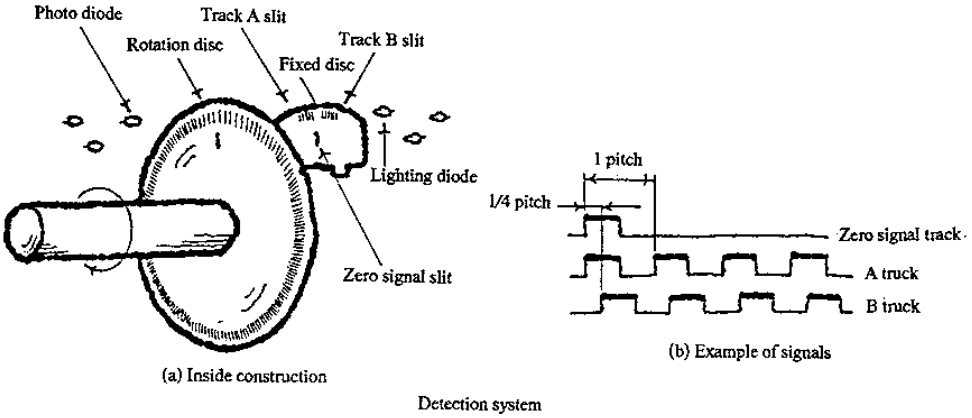
Detection method		Linear type	Rotary type	Detector	Speed	Position
Use seed generated power		○	○ ○ ○	Induction type speed detector. DC tacho generator. • Permanent magnet type • Other excited type AC tacho-generated Brushless DC tacho-generator • Permanent magnet type • Drag cup type		
Use pulse or phase equivalent to position and angle	Photo type Magnetic type Electro-magnetic induction type Contact type	○ ○	○	Linear encoder Rotary encoder Magnet scale Rotary magnet scale Linear inductsyn Rotary inductsyn Sunchro Resolver • Brush type • Brushless type Contact type linear encoder Contact type rotary encoder		

2. Typical Detector

Rotary encoder, and resolver are examples of present day detectors for AC servo

(1) Rotary Encoder

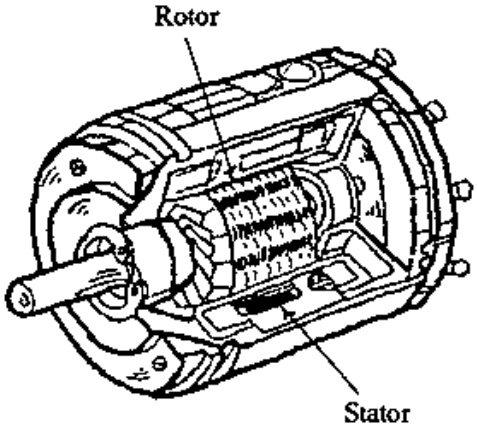
Increment rotary encoder



Detection system

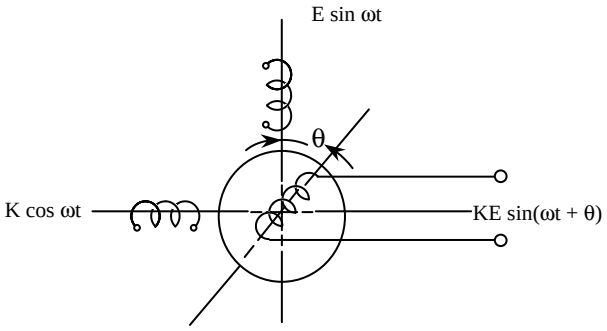
- Basic principle of rotary encoder
  Incremental rotary encoder
  The above figure shows detection system. A beam of light is directed at the rotation disc, which is installed on the fixed disc and the rotation disc installed on the input shaft. As the slits on both discs pass in rotation, this beam shuts off and on. This pulse is converted into electric signal by the photo diode. Both A and B slits on the fixed disc have phase difference of 90°. Thus, smoothed waveform output has two short waves having 90° phase difference. Counting this pulse output makes it possible to detect rotation angle. The outputs of both A and B enable detection of rotation direction when they pass through the direction judgement circuit, and are used to add or deduct measuring value. In addition, some rotary encoders have a slit per rotation to get zero position standard signal.
  Incremental type rotary encoder has simple construction and is cheap so that only a few output lines are required. On the contrary, it may accumulate differences generated by electrical noise at signal transportation. When power is OFF, the display disappears and does not store its data so that a separate counter is required.

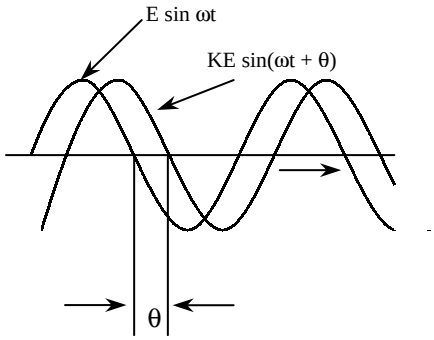
(2) Resolver



Construction of synchronous resolver

The resolver is a rotation angle detection sensor to detect mechanical rotation angle as rotor electro-magnetic induction voltage.
Two stator coils are arranged to have a 90° angle to each other around the rotor coil. While AC voltage is charged with a rated frequency to the rotor coil, the rotor coil generates induction voltage waveform output relative to angle variation with the rotor.





- **Features of the resolver compared with the photo type rotary encoder are as follows:**

1) Durable against environmental conditions like vibration, shock, and electrical noise as simple construction, no semiconductors are used.
2) Durable against power fluctuation and ambient temperature variation as no semiconductors are used.
3) Number of division per rotation can be selected by preparing an external circuit.
4) Complicated convert circuit from excitation voltage to digital, and increase peripheral circuit.

3. Features of Each Detector and Its Application.

Each detector has constructional, functional features and need required conditions to use it in compliance with those features.

Item	Photo type encoder	Magnetic type encoder	Resolver
Features	• Simple processing circuit. • Durable against electrical noise as it is digital signal. • Easy to get high resolution. • Weak against vibration and shock. • Not suitable for high temperature operation.	• Simple processing circuit. • Durable against electrical noise as it is digital signal. • Relatively strong against vibration and shock. • Not suitable for high temperature operation.	• Rugged • Strong against vibration and shock. • Available high temperature operation. • Adjustable resolution change by processing circuit. • Complex processing circuit.
Speed Detection	• By F/V converter • Usable as digital data	• By F/V converter. • Usable as digital data	• Uses phase variation by phase change at a rated interval as speed data.
Position Detection	• Use incremental pulse. • Easy to apply zero position pulse.	• Use incremental pulse. • Easy to apply zero position pulse.	• Two pole resolver has the same function as absolute encoder. • Incremental data is available by processing circuit
Magnet pole sensor	• Available by adding slit for magnetic pole sensor on rotation disc.	• Available by adding track for magnetic pole sensor on magnetic drum.	• Available by using same pole of motor or two pole resolver

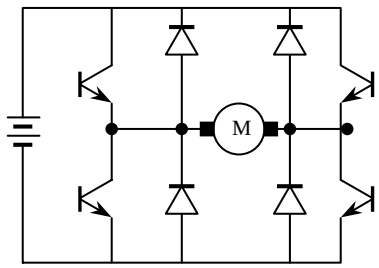
4. About Servo Driver

1. Typical Servo Driver

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

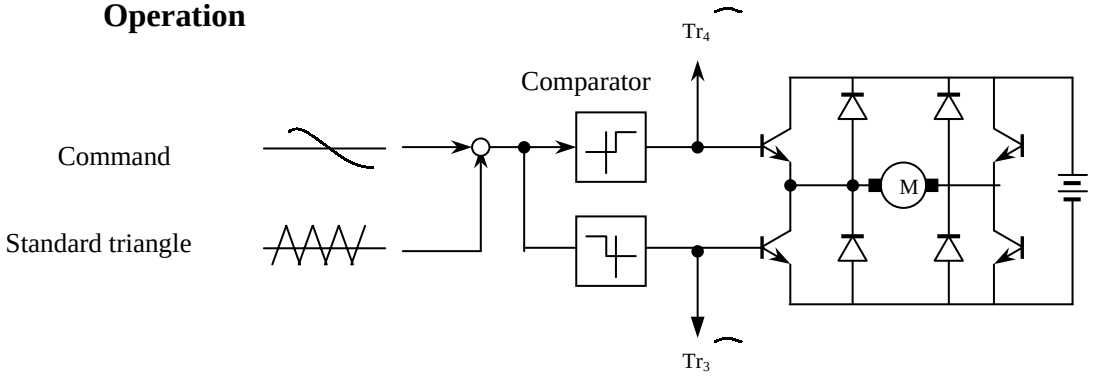
Transistor PWM

An example of main circuit



Transistor servo main circuit

Operation



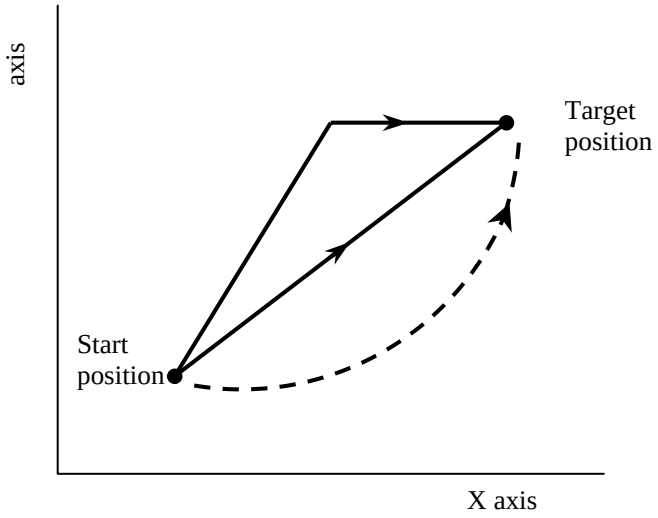
5 About position Control

1 Two types of Positioning Systems

There are two types of positioning systems: PTP (Point to Point) system and CP (Continuous Path) system. Each system is used in compliance with specific applications.

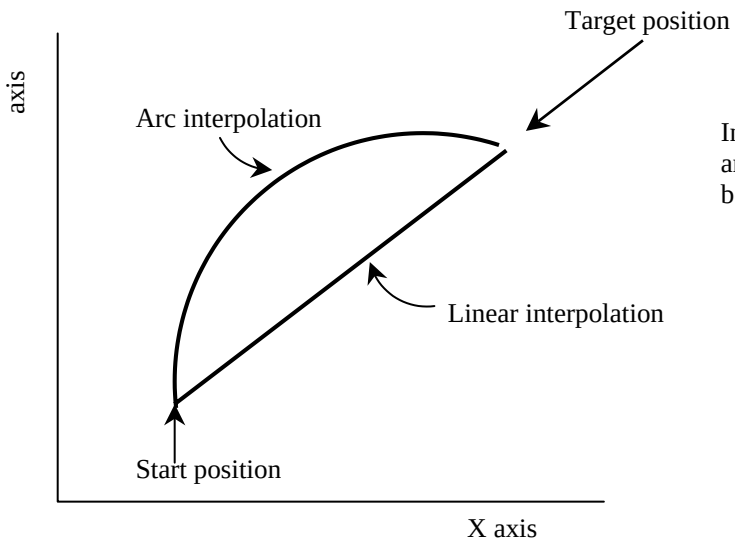
PTP system and CP system

- **PTP (Point to Point) system**



Designate only target position. Do not designate route to arrive.
Route may change in compliance with driving mechanism and speed of each axis.

- **CP (Continuous Path) system**



In addition to designating start position and target position, also designate route between two points.

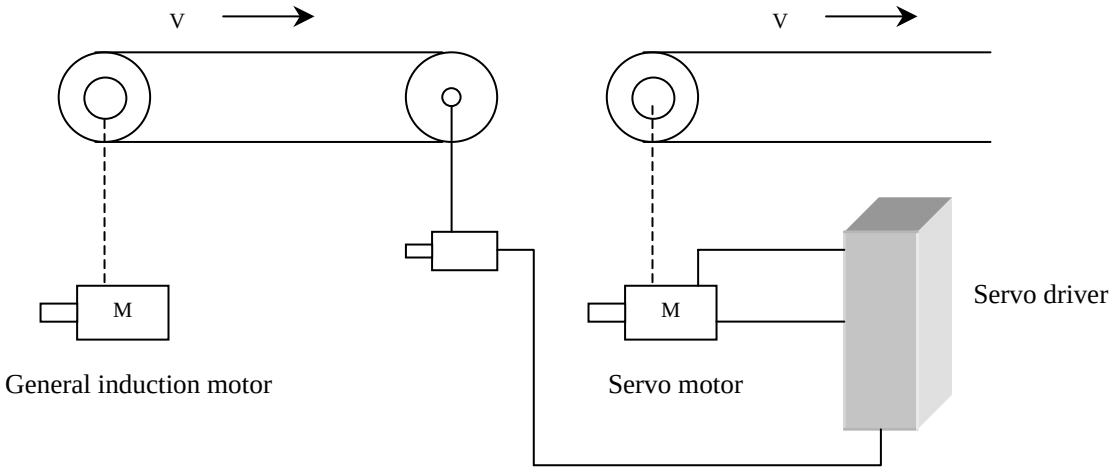
2. Speed Control and Torque Control

Beside position control, the system is also used to control motor speed by command voltage and torque by limiting current to the servo motor.

Speed control (approx. 20%)

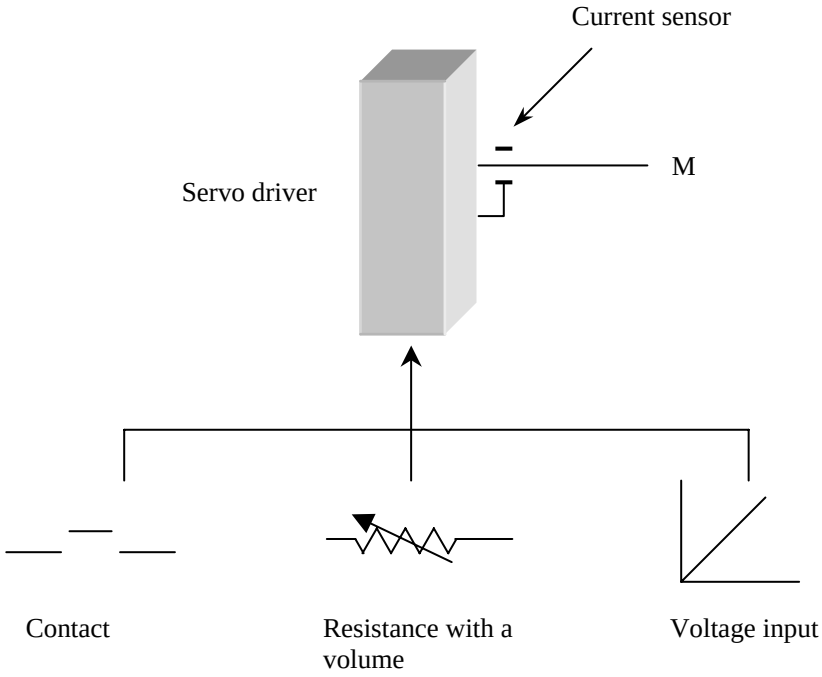
(1) Rotate the motor with the rated speed (constant speed operation).
(2) Match the motor speed with the standard speed of other feed mechanism (synchronous operation).

Ex.)



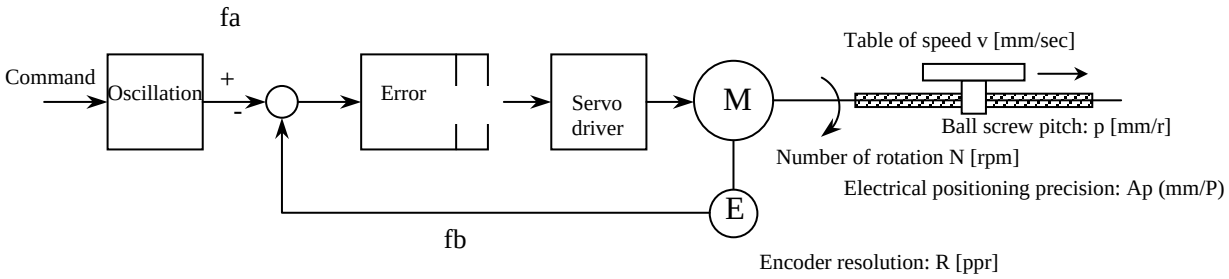
Torque control (approx. 5%)

Motor torque changes in proportion to supply current. To limit motor torque, control current value to the motor



3. Response Frequency of Position Controllers

One of the most important specifics required for position control is response frequency characteristics."
Now, higher speed and higher resolution are required for servo systems so that servo systems meet response prior to constructing a servo system.



1) When the following specifications are required for positioning:
   Positioning resolution: Ap [mm/p]……1 x 10^{-2} [mm/p] → 10 [μm/p]
   Max. positioning speed: Vmax [mm/sec]…… 500 [mm/sec]
   Ball screw pitch: p[mm/r ……10 [mm/r]

2) First, get number of motor rotation.

$$N = \frac{60}{P} Vmax = \frac{60 \times 500}{10} = 3{,}000 \text{ [rpm]}$$

3) Get resolution of the encoder.

$$R = \frac{P}{Ap} = \frac{10}{1 \times 10^{-2}} = 1{,}000 \text{ [ppr] Note1}$$

4) Get oscillation frequency of the encoder and oscillation circuit.

$$fa = fb = R \times \frac{N}{60} = 1{,}000 \times \frac{3{,}000}{60} = 50{,}000 \text{ [pps]} = 50 \text{ [Kpps]}$$

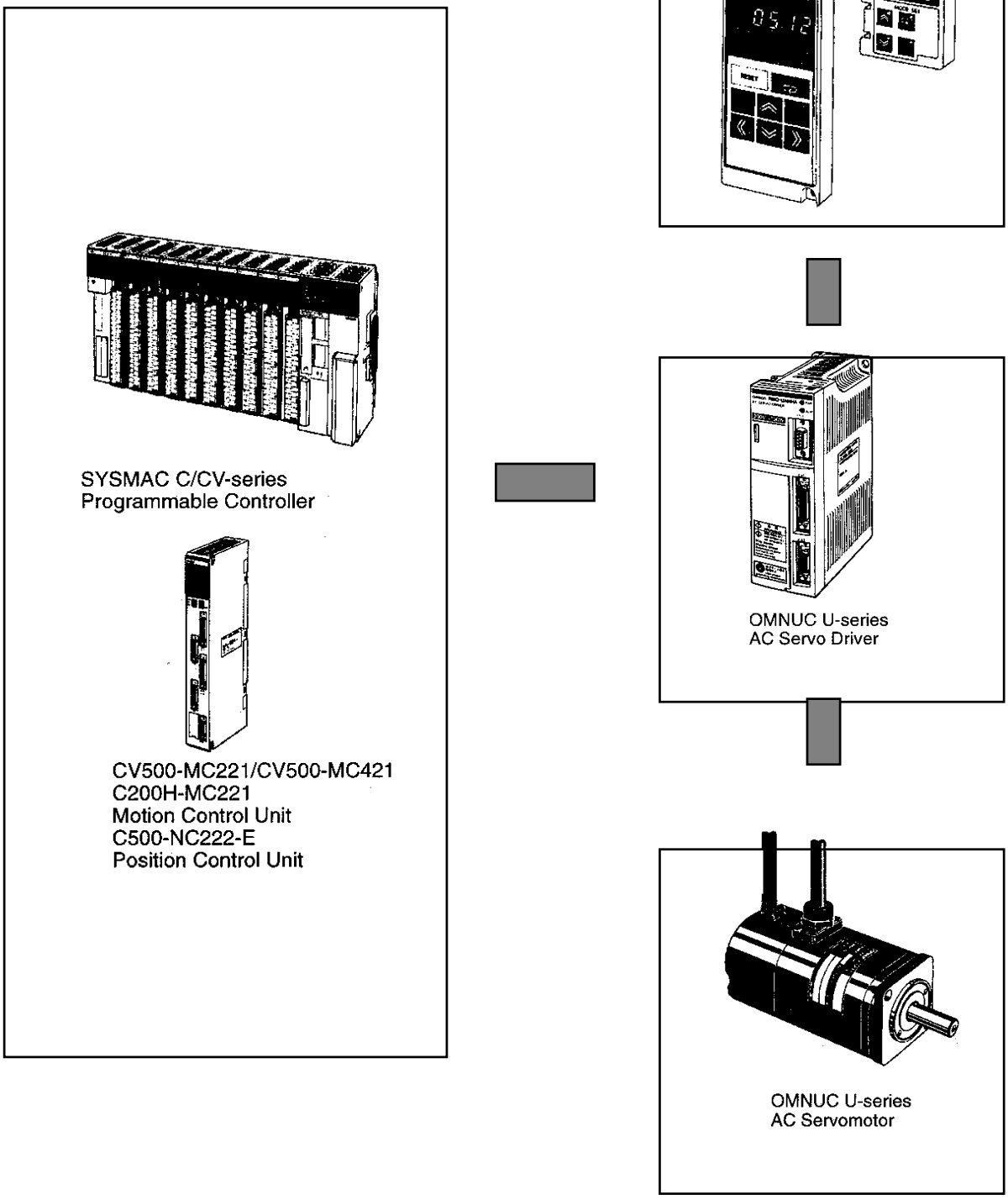
Thus, the error counter and oscillation circuit require 50 Kpps of response frequency. In order to get higher speed and higher resolution, higher response frequency circuit is required. As shown above, 50 Kpps is an inevitable pre-condition to constructing the servo system in order to meet the required specifications.

Note 1: When multiplication function of the encoder is used, number of encoder resolution is enough with $\frac{1}{(\text{multiplication figure})}$. In this case, response frequency of command value oscillation circuit and the error counter should be calculated after multiplication by this figure.

Servo
Section 6

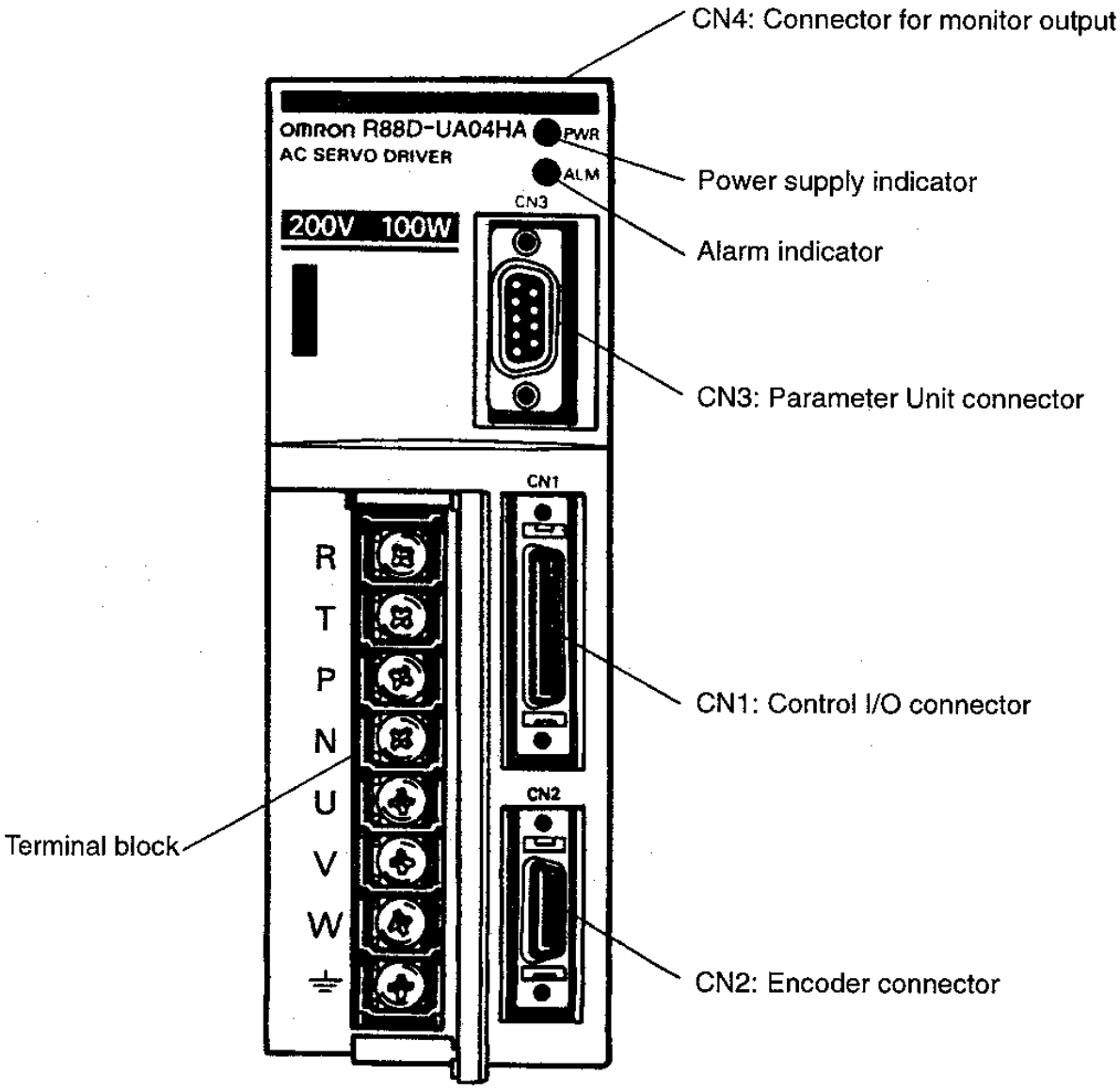
6 Introduction to OMRON Servo

6-1 System configuration and Model



6-2 Servo driver Nomenclature

- **Front View**



6-3 Applicable Standards and Models

6-3-1 UL/ cUL Standards

- **Applicable Standards**

Standard	Product	Applicable Standard	File No.	Remarks
	AC Servo Driver	UL508C	E179149	Power conversion equipment
	AC Servomotor	UL 1004	E179189	Electric motors
CUL	AC Servo Driver	cUL C22.2 No. 1	E179149	Industrial equipment
	AC Servomotor	cUL C22.2 No. 100	E179189	Motor and generators

- **Applicable Models**

Power supply	AC Servo Drivers	AC Servo motors	
		With incremental encoder	With absolute encoder
200 VAC	R88D-UA HA	R88M-U 30HA-	R88M-U 30TA-
100 VAC	R88D-UA LA	R88M-U 30LA-	R88M-U 30SA-

Note: UL/ cUL Standards apply to models manufactured after May 1998

6-3-2 EC Directives

- **Applicable Standards**

EC Directive	Product	Directive	Remarks
Low voltage	AC Servo Driver	EN61010-1	Safety requirements for electrical equipment for measurement, control, and laboratory use.
	AC Servomotor	IEC34-1, -5, -8, -9	Rotating electrical machines
EMC	AC Servo Driver AC Servo motor	EN55011 class A group 1	Limits and methods of measurement of radio disturbance characteristics of industrial, scientific, and medical (ISM) radio-frequency
		EN50082-2	Electromagnetic compatibility generic immunity standard, Part2 Industrial Environment

- **Applicable Models**

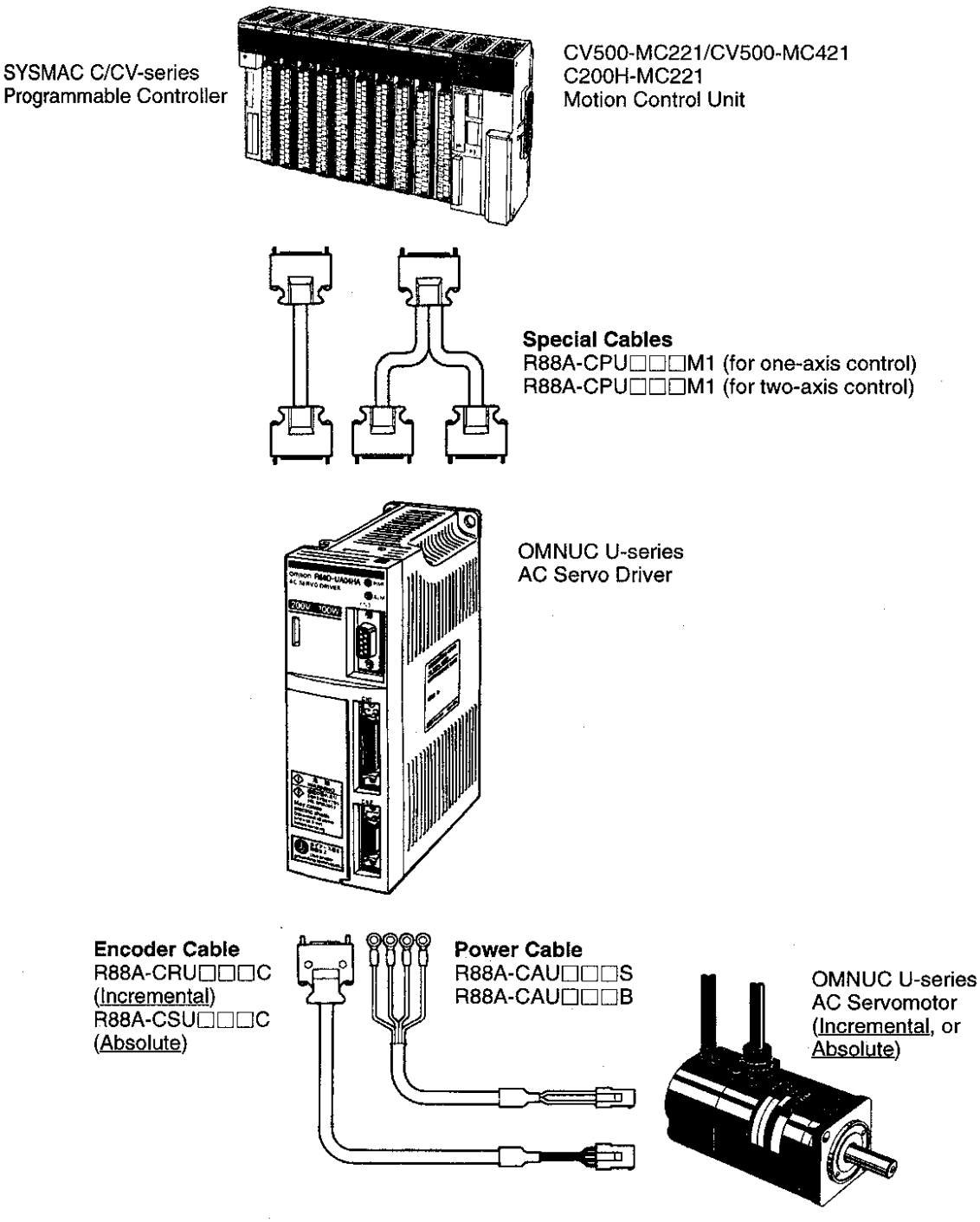
Power Supply	AC Servo Drivers	AC Servomotors	
		With increment encoder	With absolute encoder
200 VAC	R88D-UA V	R88M-U 30VA-	R88M-U 30XA-
100 VAC	R88-UA W	R88-U 30WA	R88M-U 30YA-

6-4 Wiring products conforming to UL/ cUL and Wiring Products Not Conforming to Any standards

6-4-1 Wiring to an OMRON Controller

Use the dedicated control cables and a general-purpose control cable (purchased separately) to connect U-series AC servomotors and Servo Drivers to Position Units

- **SYSMAC CV-series C-Series Motion Control Units**

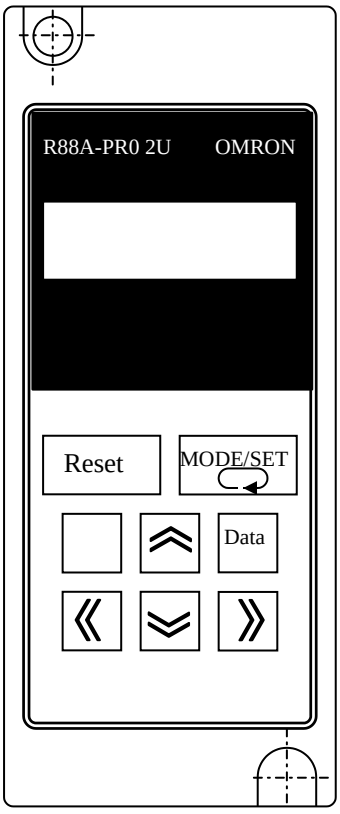


6-5 Using Parameter Units

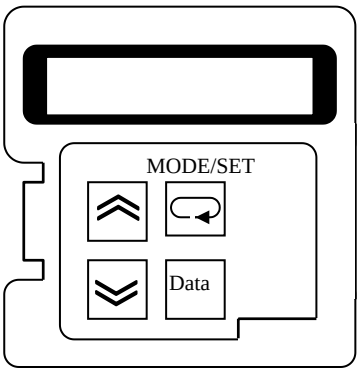
The key operations for the Handy-type R88APR02U and the Mounted-type R88A-PR03U vary depending on the functions used.

6-5-1 Parameter Unit Keys and Functions

Handy-type
R88A-PR02U



Mounted-type
R88-PR033U



PR02U	PR03U	Function
Reset	^^ + vv	Alarm reset
↩	↩	Mode switching Data memory
Servo	Data	Servo ON/ OFF during jog operations
Data	Servo	Switching between parameter display and data display; data memory
^^	vv	Increment parameter numbers and data values
vv	^^	Decrement parameter numbers and data values.
<<		Left shift for operation digits
>>		Right shift for operation digits

6-5-2 Modes and Changing Modes

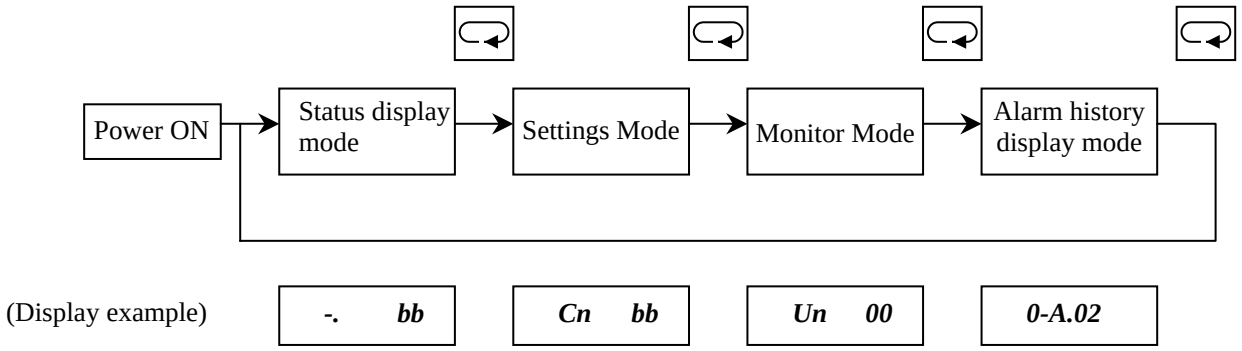
▪ Modes

OMNUC U series AC Servo Drivers have four operating modes, as described in the following table. For example, the Setting Mode is to set parameters.

Mode	Function
Status display mode	Bit display (indicating internal status via indicators): Power supply ON display, baseblock, speed conformity, rotation detection and current limit detection , speed command being input, torque command being input Symbol display (indicating internal status via 3-digit 7-segment display): Baseblock, operating, forward rotation prohibited, reverse rotation prohibited, alarm display
Setting mode	System check: Jog operations, command offset automatic adjustment, alarm history data clear, command offset manual adjustment, motor parameters check, auto-tuning Setting and checking setup parameters Setting and checking user parameters
Monitor mode	Speed feedback, speed commands, torque commands, number of pulses from U-phase, electrical angle, internal status bit display
Alarm history display mode	Displays contents of alarms that have been previously generated (up to a maximum of 10).

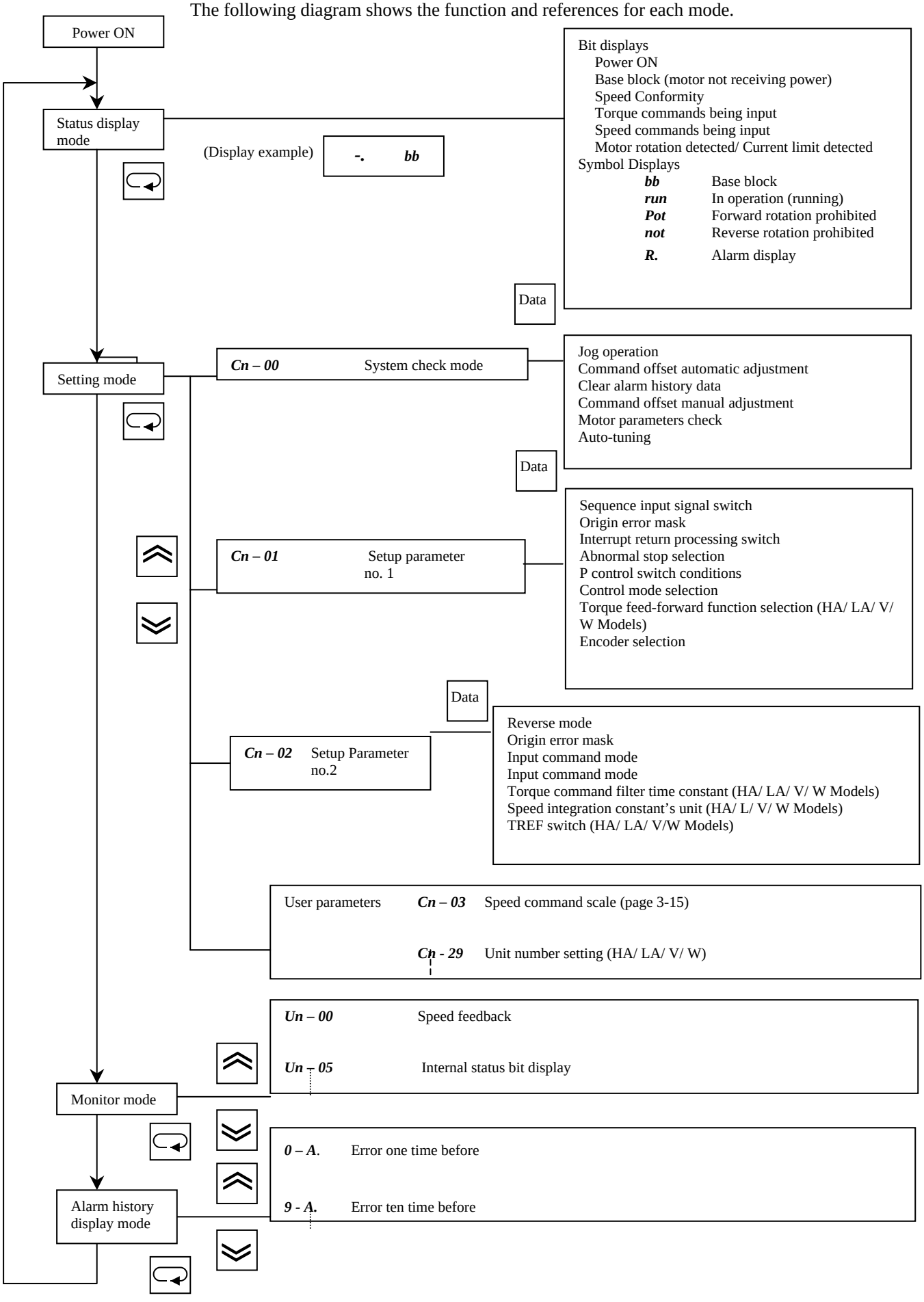
▪ Changing Modes

To change mode, press MODE/ SET Key.



6-5-3 Mode Changes and Display Contents

The following diagram shows the function and references for each mode.



6-6 Initial Settings: Setup Parameters

Setup parameters are parameters that are essential or starting up the system. They include I/O signal function changes, selection of processing for momentary stops and errors, control mode changes, and so on. Set them to match the user system.
Once the parameter have been set, they become effective when the power supply is turned on again after having been turned off. (Check to see that the LED display has gone off.)

6-6-1 Setting and Checking Setup Parameter (Cn-01, 02)

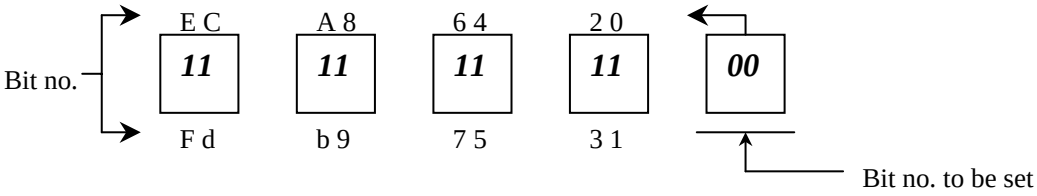
- **Displaying Setup Parameter**

There are two setup parameters: No.1 (Cn-01) and No. 2 (Cn-02).
To display the contents of setup parameters, execute the following key operations.

1. Press the MODE/ SET Key to go into setting mode ***(Cn-00).***
2. Press the Up Key to display the setup parameter No.1 ***(Cn-01).***
3. Press the DATA key to display the setting of the setup parameter.

To display the setting of setup parameter 2, press the Up Key twice at step 2. Before pressing the DATA Key.

The setting of the setup parameters are displayed as follows:



In the leftmost four digits, 16 bits of information are displayed. In the rightmost digit, the bit number that can be set is displayed. It can be checked whether the bit information is “0” (not lit) or “1” (lit), according to the 7-segment LED vertical bar. To change the set value, first set the bit number in the rightmost digit, and then set the appropriate bit to “0” or “1”.

- **Setting up Parameters**

First, display the setting of the setup parameter (No.1 or No.2) using the procedure given above. To change a setting, specify the bit to be changed and then set it to “1” or “0.”

- **Making Settings with Handy-type (R88A-PR02U)**

1. Use the Right and Left Keys to display in the rightmost digit the bit number that is to be set.
2. Using the Up (or Down) Key, reverse the lit/not lit status of the appropriate bit number. For “lit”, set the bit number to “1.” For “not lit,” set it to “0”
3. Repeat step 1 and 2 above as required.
4. Save the data in memory by pressing the MODE/ SET Key (or the DATA Key).
5. With this, the parameter setting operation is complete. Pressing the DATA Key at this point will bring back the parameter number display.

- **Making Setting with Mounted-type (R88-PR03U)**

1. Use the Up and Down Keys to display in the right most digit the bit umber that is to be set.
2. Using the MODE/ SET Key, reverse the lit/not lit status of the appropriate bit number. For “lit,” set the bit number to “1.” For “not lit,” set it to “0.”

3. Repeat steps 1 and 2 above as required.
4. Save the data in memory by pressing the DATA Key.
5. With this, the parameter setting operation is complete. Pressing the DATA at this point will bring back the parameter number display.

6-6-2 Setup Parameter Contents (Cn-01, 02)

▪ Setup Parameters No. 1 (Cn-01)

Item	Bit no.	Factory setting	Setting	Explanation
Sequence input signal switching	0	0	0	Servo turned ON or OFF by Run command (externally input)
			1	Servo always ON
	ABS 1	0	0	Valid on the sensor ON input (externally input)
			1	Always regarded as high level internally regardless of the sensor ON input signal
	2	1	0	Enables forward drive prohibit input (POT))
			1	Permits always-forward drive
	3	1	0	Enables reverse drive prohibit input (NOT)
			1	Permits always –reverse drive.
Sequence output signal switching	4	0	0	Takes TGON/CLIMT signal as motor rotation detection output
			1	Takes TGON/CLIMT signal as current limit detection output
Processing at time of recovery from momentary stop	5(see note 1)	1	0	Servo alarm set at time of recovery from momentary stop.
			1	Servo alarm automatically cleared at time of recovery from momentary stop/
Abnormal stop	6	1	0	Motor Stopped by dynamic brake
			1	Motor stopped with free run.
	7(see note 2)	1	0	Dynamic brake OFF after motor stopped.
			1	Dynamic brake ON after motor stopped.
	8	0	0	Method for stopping when over-travel occurs depends on bit no. 6 setting
			1	When over-travel occurs, motor is stopped at the torque set by user parameter Cn-06
	9	0	0	When over-travel occurs, motor comes to deceleration stop and servo turns OFF.
			1	When over – travel occurs, motor comes to deceleration stop and position is locked

Item	Bit no.	Factory setting	Setting	Explanation
Control mode selection	b, A (see note 5)	0,0	0,0	Speed control • Speed controlled by speed command input (REF) • CN1-15 is for gain reduction (MING); when ON, P control is set and when OFF, Pl is set.
			0,1	Speed Control with Position Lock Function • Speed controlled by speed command input (REF) • CN1-15 is for the position lock command (PLOCK) is ON, if the motor speed is below the setting of user parameter CN-0f (number of position lock rotations), the control mode changes from speed control to position control an d the motor is servo-locked
			1,0	Torque Control I • Torque control depends on torque command input (TREF) • CN1-15 and speed command input (REF) are disabled.
			1,1	Torque Control II • Control mode for using an external signal to switch between torque control via the torque command (TREF) and speed control via the speed command (REF). • CN1-15 is for torque control switching (TVSEL); when OFF, torque control is set, and when ON, speed control is set. • When set for torque control, if the speed command input (REF) is for +voltage , it becomes the speed limit value for forward or reverse rotation.(See note 4)
P control	d, C (see note 6)	1,1	0,0	The torque command value (Cn-0C) is taken as the condition.
			0,1	The speed command value (Cn-0d) is taken as the condition
			1,0	The acceleration value (Cn-0E) is taken as the condition
			1,1	No P control switching function.
Encoder	ABSE	0	0	Incremental encoder
			1	Absolute encoder
Torque feed-forward function selection (HA/ LA/ V/W Models)	F	0	0	Torque feed-forward function disabled.
			1	Torque feed-forward function enabled.

Note 1. If power is immediately turned back on after having been cut off, a momentary stop alarm may be generated. If bit no. 5 is set to "1," the alarm will be cleared automatically even if it is generated, and operation will resume

Note 2. If set bit 6 to "1" and bit 8 to "0," the dynamic brake relay will turn OFF after the Servomotor stops, regardless of setting of bit no.7.

Note 3. In the torque control mode, the method of stopping for errors depend on the setting of bit no 6. The setting of bit no. 8 has no effect.

Note 4. Outside of the speed limit range, a torque is generated in proportion to the difference with the speed limit value, in order to bring down the Servomotor rotation speed. At this time, the Servomotor rotation speed will not necessarily match the speed limit. (The Servomotor rotation speed varies depending on the load.)

Note 5. The function of bits b and A is different when the input command mode is set for internal speed control settings (i.e., bit 2 of Cn-02 is 1).

Note 6. With P control switch conditions, a change from PI control to P control is selected. This function is only valid for speed control.

Note 7. Do not change the setting of bits 1 and E of setup parameter no.1 (Cn-01) when a Servomotor with an incremental encode is being used. Change the setting of bit E of setup parameter no. 1 (Cn-01) when a Servomotor with an absolute encoder is being used.

Note 8. These parameters become effective only after power is reset. Confirm that the indicators go out before turning power back on. (Check to see that the LED display has gone off.)

Item	Bit no.	Factory setting	Setting	Explanation
Reverse rotation mode	0	0	0	Rotates in the CCW direction with a + analog command. (See note 5.)
			1	Rotates in the CW direction with a +analog command.
Origin error mask (ABS)	1	0	0	Origin errors are detected.
			1	Origin errors are not detected
Input command mode (see note 2)	2	0	0	CN1-11 and 12 are used as forward and reverse current commands inputs (PCL, NCL).
			1	[Internal speed control settings]. CN1-11 and 12 are used as speed selection command 1 and 2 inputs (SPD1, SPD2). CN1-15 is used as rotation direction command (RDIR)
	3	0	.....	Not used
	4	0	.....	Not used
	5	0	.....	Not used
	6	0	.....	Not used
	7	0	.....	Not used
	8	0	.....	Not used
	9	0	.....	Not used
	A	0	.....	Not used
Speed integration	b	0	0	1 ms
			1	0.01 ms
Torque command filter time constant (HA/ LA/ V/ W Models)	C	0	0	Primary filter
			1	Secondary filter
	d	0	.....	Not used
	E	0	.....	Not used
TREF switch (see note 3) (HA/ LA/ V/ W Models)	F	0	0	Terminal TREF (CN1-1) isn't the analog current control.
			1	Terminal TREF (CN1-1) is the analog current control

Note 1. Do not set bit nos. 1,2 to A, d, and E of setup parameter no.2 (Cn-02).

Note 2. The function of bits b and A is different when the input command mode is set for internal speed control settings (i.e., bit 2 of Cn-02 is 1).

Note 3. The TREF switch setting (bit F) is valid only for speed control. When this bit is set to "1," the voltage applied to TREF determines the current limit. (HA/ LA/ V/ W Models)

Note 4. These parameters become effective only after power is reset. Confirm that the indicators go out before turning power back on. (Check to see that the LED display has gone off.)

Note 5. Counterclockwise direction when viewed from the motor output shaft is CCW and clockwise for CW.

6-6-3 Important Setup Parameters (Cn-01 and Cn-02)

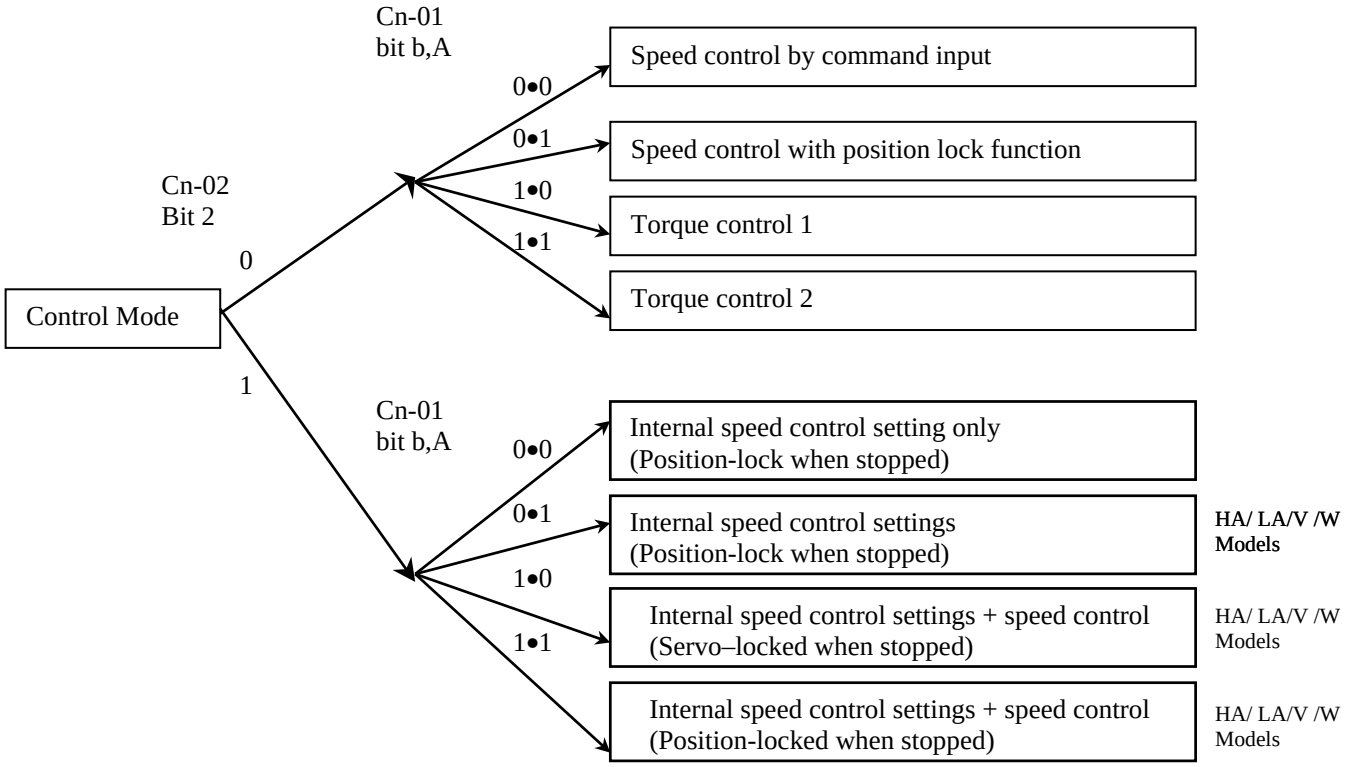
This section explains the particularly important setup parameters. If these parameters aren't set properly, the motor might not operate or might operate unpredictably, Set these parameters appropriately for the system being used.

▪ Control Mode Settings

The control mode is determined by the following setup parameters;

- Input command mode: Cn-02 bit 2 Switches between external analog input control and internal speed control settings.
- Control mode selector: Cn-01 bit b, A (The function of this it depends on the setting of Cn-02 bit 2.)

The following diagram shows the function of these two bits:



Cn-02 bit 2	Cn-01 Bits b, A	Control Mode
0	0,0	Speed control by speed command inputs (factory setting)
	0,1	Speed control with position lock
	1,0	Torque control 1: torque control by torque command
	1,1	Torque control 2: switchable between torque control and speed control
1	0,0	Internal speed control settings only (servo-lock when stopped)
	0,1	Internal speed control settings only (position-lock when stopped)
	1,0	Internal speed control settings + speed control (servo - lock when stopped)
	1,1	Internal speed control settings + speed control (position – locked when stopped)

7 Hands-On

7-1 Preparations for Operation

• Power Off

The power supply must be toggled to apply some of the parameter settings. Always turn off the power supply before starting.

• No Motor Load

Do not connect a load to the motor shaft during trail operation, just in case the motor runs out of control.

• Stopping the Motor

Make sure that the power switch can be turned off or the Run command used to stop the motor immediately in case of trouble.

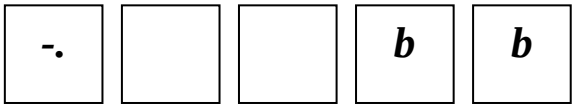
• Connecting a Parameter

Connect a Parameter Unit to the CN3 connector on the front of the Servo Driver if one is not already connected.

▪ Actual Operation

(1) Powering Up

- With the run command (RUN) OFF, apply an AC voltage.
- After internal initialization, the mode will be the status displa mode.

Display example: 

- Set the speed loop gain (Cn-04) to 20 or less. (Match the gain with no load.)

1. Confirm the initial display shown above.
2. Press the MODE/ SET Key to enter setting mode.
3. Press the Up Key to specify user parameter Cn-04.
4. Press the DATA Key to display the setting of Cn-04
5. Press the Down Key to change the setting to 20.
6. Press the DATA Key to record the new setting in memory.
7. Press the DATA Key again to return to the parameter number display.

(2) Jog Operation (See 7-1-2 Jog Operation)

- Perform jog operations sing the Parameter Unit and confirm the following:
  Does the motor turn in the correct direction?
  Is there any unusual sound or vibration
  Do any error occur?

(3) Connect a load and auto-tune (See 7-2 Making Adjustments.)

- Connect the motor shaft to the load (mechanical system) securely, being sure to tighten screws so that they will not become loose.
- Perform auto-tuning with Parameter Unit.
- Automatically adjust the offset.

(4) Turning ON the Run command Input

- Turn ON the run command input. The Servomotor will go into servo-ON status.
- Give a speed command, or carry out the following check with a jogging operation.

(5) Low Speed Operation

- Operate at low speed.
  For speed control, apply a low-voltage speed command.
  For torque control, apply a low-voltage torque command.
  The meaning of “low speed” can vary with the mechanical system. Here, “low speed” means approximately 10% to 20 % of the actual operating speed.

(6) Operation Under Actual Load Conditions

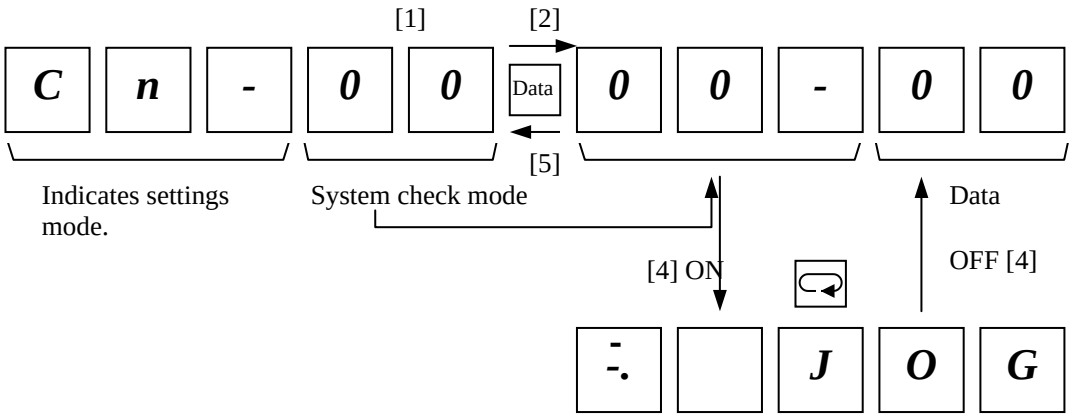
- Operate the Servomotor in a regular pattern and check the following items.
  Is the speed correct? (Use the speed display)
  Is the load torque roughly equivalent to the measured value? (Use the torque command display.)
  Are the positioning points correct?
  When an operation is repeated, is there any discrepancy in positioning?
  Are there any abnormal sounds or vibration?
  Is either the Servomotor or the Servo Driver abnormally overheating
  Is anything abnormal occurring?

(7) Readjust the gain.

- If the gain could not be adjusted completely using auto-tuning, perform the procedure in 7-2 Making Adjustments to adjust the gain.

7-1-1 Jog Operations

Jog operations rotate the Servomotor in a forward or reverse direction using the Parameter Unit. Jog operations are made possible when system check mode Cn-00 is set to “00.” The items in parentheses in the following explanation indicate operations using the Handy-type Parameter Unit.



▪ Operating Procedure

1. Confirm that the initial display is shown (-,bb).
2. Press the MODE/ SET Key to enter the settings mode.
3. Using the Up and Down Keys, set parameter number “00.” (System check mode)
4. Press the DATA Key to display the setting of Cn-00.
5. Using the Up and Down Keys, set the parameter to “00.” (Jog operation)
6. Press the MODE/ SET Key to shift to the jog display.
7. Press the SERVO (DATA) Key to turn on the servo.
8. Press the Up Key to jog forward. Forward operation will continue as long as the key is held down.
9. Press the Down Key to Jog in reverse. Reverse operation will continue as long as the key is held down
10. Press the SERVO (DATA) Key to turn off the servo.
11. Press the MODE/ SET Key to return to the data display.
12. Press the DATA Key to return to the setting mode.

▪ User Parameter Settings

The rotational speed during jog operation can be set with user parameter Cn-10, as shown in the following table.

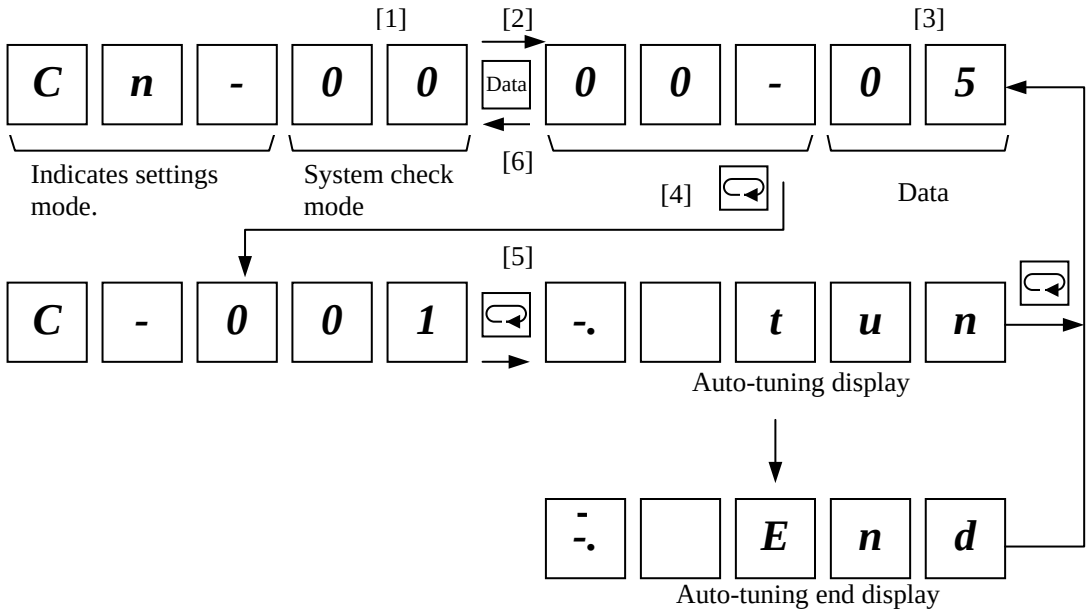
PRM No.	Parameter name	Factory setting	Unit	Setting range	Explanation
Cn-10	Jog speed	500	R/min	0 to 4,500	Speed setting for jog operation

7-2 Auto-tuning

Auto-tuning rotates the Servomotor with a load connected (mechanical system), and automatically adjusts the position loop gain, the speed loop gain, and the speed loop integration time constant.

▪ Executing Auto-tuning

Make sure that Cn-28 for compensation gain adjustment is set to 0 before performing auto-tuning. Proper gain adjustment may not be possible with auto-tuning if the parameter is not set to 0. This parameter is factory-set to 0.



1. Confirm that the initial display is shown (-, bb).
2. Press the MODE/ SET Key to enter the setting mode.
3. Using the Up and Down Keys, set parameter number ”00.” (System check mode)
4. Press the DATA key to display the setting of Cn-00.
5. Using the Up and Down Keys, set the parameter to “05.” (Auto-tuning)
6. Press the MODE/ SET Key to switch to the mechanical rigidity selection display
7. Using the Up and Downs Keys, adjust the rigidity to the mechanical system. (Refer to Selecting Mechanical Rigidity on the next page.)
8. Press the MODE/ SET Key to switch to the auto-tuning display.
9. Press the SERVO (DATA) Key to turn on the servo. (This step is not required if the Run Command Input is ON.)
10. Perform auto tuning, using the Up Key for forward operation and Down Key for reverse operation. Continue pressing the key until ”End” is displayed, indicating that auto-tuning has been completed.
11. Release the key. The data display will return.
12. Press the DATA Key to return to the setting mode.

- **Selecting Mechanical Rigidity**

Select the set value to match the rigidity of the mechanical system.

HA/ LA/ V/ W Models

Respons e	Set value	Position loop gain (1/s)	Representative applications
Low	001	16	Articulated robots, harmonic drives, chain drives, belt drives, rack and pinion drives, etc.
	002	28	
Medium	003	40	XY tables, Cartesian-coordinate robots, general-purpose machinery, etc.
High	004	56	Ball screws (direct coupling), feeders, etc.
	005	78	
	006	108	
	007	130	

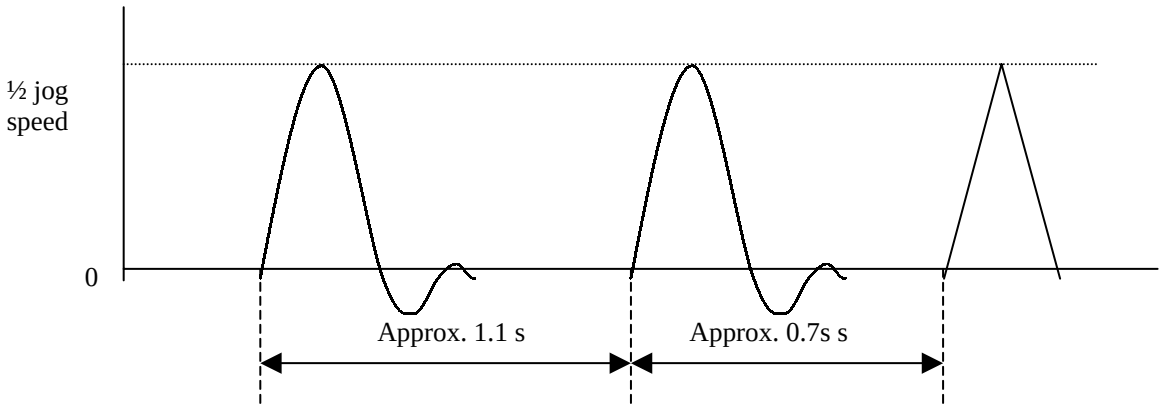
H/ L Models

Respons e	Set value	Position loop gain (1/s)	Representative applications
Low	001	20	Articulated robots, harmonic drives, chain drives, belt drives, rack and pinion drives, etc.
Medium	002	40	XY tables, Cartesian-coordinate robots, general-purpose machinery, etc.
High	003	60	Ball screws, (direct coupling), feeders, etc.

Note: The higher the rigidity of the mechanical system is, the higher the response becomes

- **Auto-tuning**

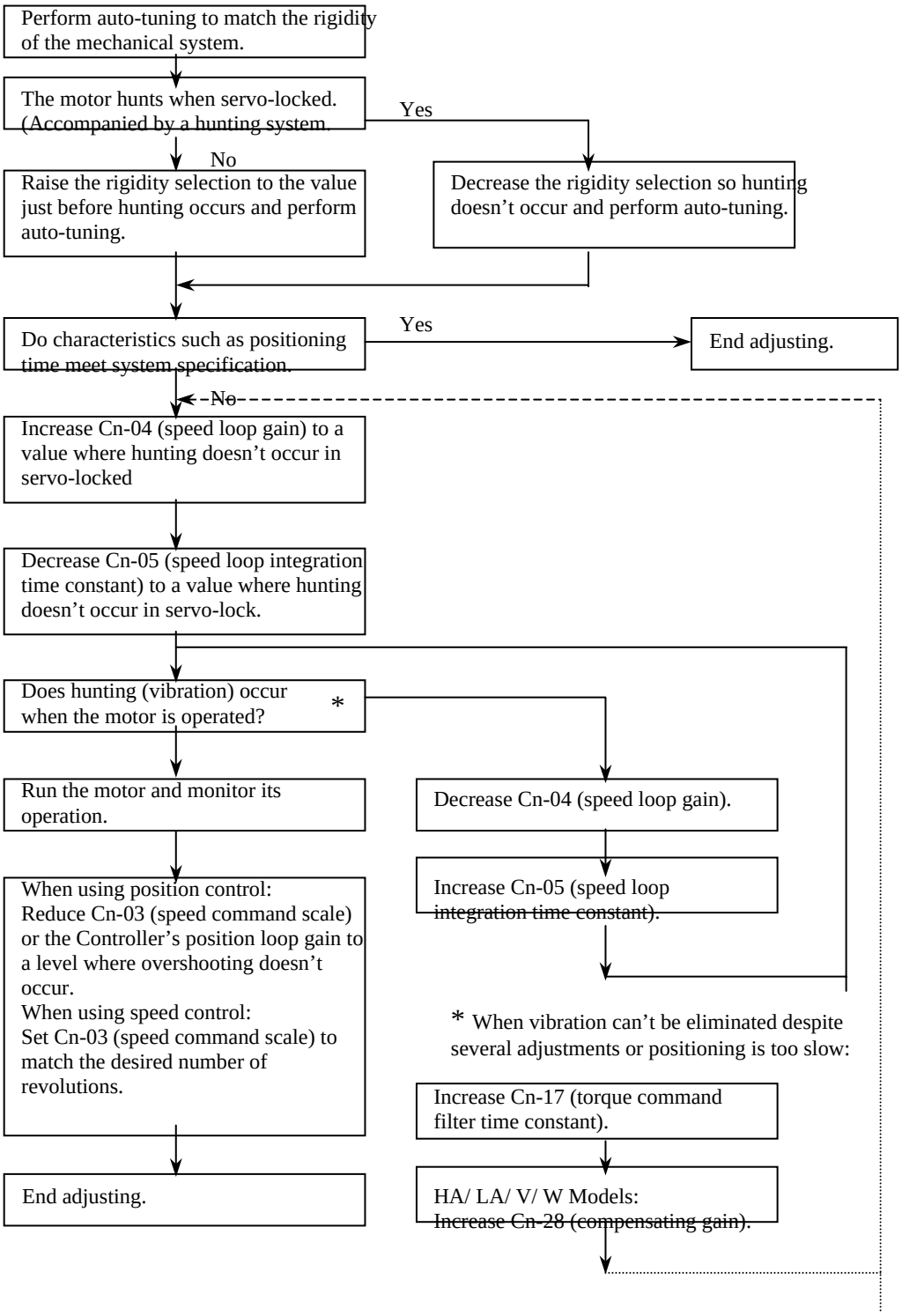
- Auto-tuning will not be complete until at least three operations have been completed. Be sure there is plenty of room for the machine to operate.
- If the auto-tuning is not complete after three operation, operations will be repeat as long as the key is held down.
- The Servomotor rotation speed will be approximately ½ that of the jog speed (Cn-10).
- Auto-tuning will automatically change the setting of the user parameter position loop gain (Cn-1A), speed loop gain (Cn-04), and speed loop integration time constant (Cn-05). These values will not be changed, however, until the auto-tuning operation has been completed.
- If auto-tuning does not complete or if the an set via auto-tuning is not sufficient, adjust the gain manually using the procedure in 7-3 Manually Adjusting Gain.



7-3 Manually Adjusting Gain

Make sure that Cn-28 for compensation gain adjustment is set to 0 before performing auto-tuning. This parameter is factory-set to 0.

- **Gain Adjustment Flowchart**



Sensor
Section 8

8 Servo Driver Specifications.

8-1 General Specifications

Item	Specifications
Operating ambient temperature	0°C to 55°C
Operating ambient humidity	35 % to 85 % RH (with no condensation)
Storage ambient temperature	-10°C to 75°C
Storage ambient humidity	35% to 85% RH (with no condensation)
Storage and operating atmosphere	No corrosive gases.
Vibration resistance	10 to 55 Hz in X, Y and Z directions with 0.10-mm double amplitude; acceleration 4.9m/s² {0.5 G} max.; time coefficient: 8 min; 4 sweeps
Impact resistance	Acceleration 19.6 m/s² {2G} max., in X, Y,Z directions, three times
Insulation resistance	Between power line terminals and case: 5 MΩ min. (at 1000 VDC)
Dielectric strength	Models Conforming to UL/ cUL standards and Models Not Conforming to any Standards Between power line terminals and case: 1,000 VAC for 1 min (20 mA max) at 50/60 Hz Models Conforming to EC Directives Between power line terminals and case: 1,500 VAC for 1 min at 50/60 Hz
Protective structure	Built into panel.

8-2 Specifications

- **200-VAC Input Servo Drivers Conforming to UL/ cUL Standard and 200-VAC Input Servo Drivers Not Conforming to Any standards**

Item			R88D-UA02H(A)	R88D-UA03H(A)	R88D-UA04H(A)	R88D-UA08H(A)	R88D-UA12H(A)	R88D-UA20H(A)
Continuous output current (0-p)			0.6 A	0.85 A	1.2 A	2.8 A	3.7 A	3.2 A
Momentary max. output current (0-P)			1.8 A	2.7 A	4.0 A	8.5 A	11.3 A	19.7 A
Input power supply			Single-phase 200/ 230 VAC (170 to 253V) 50/ 60 Hz					
Control method			All digital servo					
Speed feedback		INC	Optical encoder, 2,048 pulses/ revolution					
		ABC	Optical encoder, 1,024 pulses/ revolution					
Applicable load inertia		INC	Maximum of 30 times motor's rotor inertia.				Maximum of 20 times motor's rotor inertia	
		ABS	Maximum of 20 times motor's rotor inertia.			Maximum of 25 times motor's rotor inertia	Maximum of 20 times motor's rotor inertia	Maximum of 18 times motor's rotor inertia
Inverter method			PWM method based on IGBT					
PWM Frequency			11 kHz					7.8 kHz
Applicable Servomotor		INC	R88M-U03030H(A)	R88M-U05030H(A)	R88M-U10030H(A)	R88M-U20030H(A)	R88M-U40030H(A)	R88M-U75030H(A)
		ABS	R88M-U03030T(A)	R88M-U05030T(A)	R88M-U10030T(A)	R88M-U20030T(A)	R88M-U40030T(A)	R88M-U75030T(A)
Applicable Servomotor wattage			30 W	50 W	100 W	200 W	400 W	750 W
Weight			Approx. 0.9 kg				Approx. 1.2 kg	Approx. 1.5 kg
Heating value			15 W	18 W	20 W	35 W	45 W	60 W
Capacity	Speed control range		1:5,000					
	Load fluctuation rate		0.1% at 0 to100% (at rated rotation speed)					
	Voltage fluctuation rate.		0% at input voltage of 170 to253 VAC					
	Temperature fluctuation rate		± 0.2% max. at 0 to +50°C					
	Frequency characteristics		250 Hz (HA/ LA/ V/ W Models), 150 Hz (H/L Models) (at the same load as the rotor inertia)					
	Torque control reproducibility		± 2.0%					
	Acceleration/ deceleration time settings		0 to 10 s (Set separately for acceleration and deceleration.)					
Input signal	Speed command voltage		± 2 to 10 VDC (Forward motor rotation by +command)/ rated rotation speed Input impedance; Approx. 30 kΩ; circuit time constant: Approx. 47 μs					
	Torque command voltage		± 1 to 10 VDC /raged torque Input impedance: Approx. 30 kΩ; circuit time constant: Approx. 47 μs					
	Sequence input		24-VDC, 5-mA photocoupler input, external power supply: 24 ± 1 VDC, 50mA min.					
Output signal	Position feedback output		A-, B-, Z-phase line driver output (EIA RS-422A) INC: A-phase and B-phase (dividing rate setting): 16 to 2,048 pulses/ revolution ABS: A-phase and B-phase (dividing rate setting): 16 to 1,024 pulses/ revolution Z-phase: 1 pulse/ revolution					
	Speed monitor output		0.5 V/ 1000 r/min					
	Current monitor output		0.5 V/ 100%					
	Sequence output		Alarm output, alarm code output, motor rotation detection, brake interlock, speed conformity, open collector output, 30 VDC, 50 mA (except for alarm code output, which is 30 VDC, 20mA)					

8-3 I/ O Specifications

- **Terminal Block Specifications, Models Conforming to UL/ cUL Standards and Models Not Conforming to Any Standards.**

Signal	Function	Conditions	
R T	Power supply input	R88D-UA H(A) (200-VAC Units): Single–phase 200/ 300 VAC (170 to 253 VAC) 50/ 60 HZ R88D-UA L(A) (100-VAC Units): Single-phase 100/ 11 VAC (85 to 127 VAC) 50/ 60 Hz	
P N	Main circuit DC output	These are the connection terminals for the Regeneration Unit (R88A-RG08UA). Connect these when the regeneration energy is high.	
U	Servomotor U-phase output	Red	These are the terminals for outputs to the Servomotor.
V	Servomotor V-phase output	White	
W	Servomotor W-phase output	Blue	
⏚	Frame ground	Green	This is the connection terminal. Use a 100 Ω or less (class-3) or better ground. It is used in common for Servomotor output and power supply.

- **Terminal Block Specifications, Models Conforming to EC Directives**

Signal	Function	Condition	
L1 L2	Power supply input	R88D-UA V (200-VAC Units): Single-phase 200/ 230 VAC (170 to 253 VAC) 50/ 60 Hz R88D-UA W (100-VAC Units): Single-phase 100/ 115 VAC (85 to 127 VAC) 50/ 60 Hz	
+ –	Main circuit DC output	When using multiple axes and there is excessive regenerative energy, the +terminals can be connected together and the – terminals can be connected together to increase the regeneration absorption capacity.	
U	Servomotor U-phase output	Red	These are the terminals for outputs to the Servomotor.
V	Servomotor V-phase output	White	
W	Servomotor W-phase output	Blue	
⏚	Protective earth terminal	Green	This is the connection. Terminal. Use a 100 Ω or less (class-3) or better ground.

- **CN1: Control I/ O Specifications (Same for all Models)**

- **CN1: Control Input**

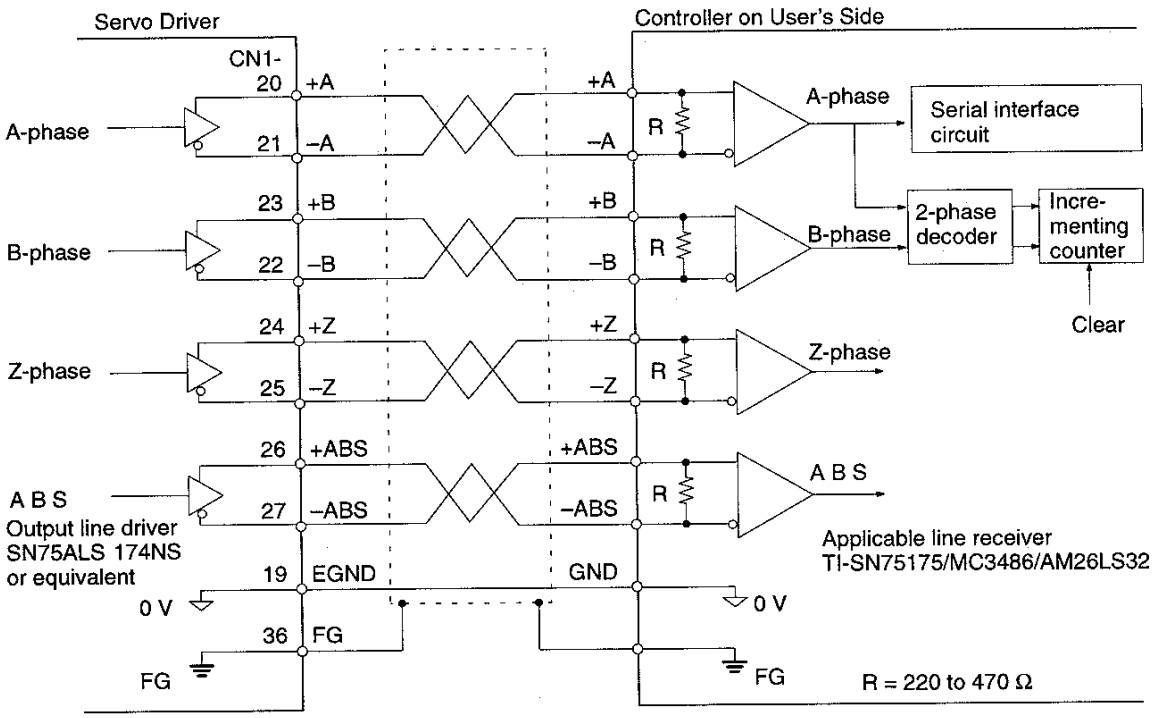
Pin No.	Signal name	Function	Contents
1	TREF	Torque command input	±1 to ±10V/ rated torque Changeable by means of user parameter Cn-13 torque command scale.
2	AGND	Torque command input	

Pin No.	Signal name	Function	Contents
3	REF	Speed command input	±2 to ±10V/ rated torque Changeable by means of user parameter Cn-03 speed command scale
4	AGND	Speed command input ground	
5	SEN (ABS) (see note)	Sensor ON input	ON: Supplies 5 V to the absolute encoder. This signal is not used when setup parameter Cn-01 bit no. 1=1.
6	SENGND (ABS) (see note)	Sensor On input ground	
11	PCL/ SPD1	Forward rotation current limit input/ Speed selection command 1 input	Forward/ reverse rotation current limit (PCL/NCL) when setup parameter Cn-02 bit no. 2=0. (ON: Current limit) Internal setting speed (Cn-1F, 20,21) selector switch when setup parameter Cn-02 bit no.2=1
12	NCL/ SPD2	Reverse rotation current limit input/ Speed selection command 2 input.	
13	+24 VIN	+24-V power supply input for control DC	Power supply for pin nos. 11, 12, 14, 15, 16, 17, 18; +24-V input.
14	RUN	Run command input	ON: Servo ON, when setup parameter Cn-01 bit no. 0=0. When setup parameter Cn-01 bit no. 0=1, this signal is not used. (Automatically set to Servo ON)
15	MING	Gain deceleration input	ON: Servo ON, when
	PLOCK	Position lock command input	When setup parameter Cn-01 bit nos. b, A=0, 1, 2 then, when this bit is ON, position lock goes in effect if the motor rotation speed is no more than the position lock rotation speed (Cn-0F)
	TVSEL	Torque/ Speed control switch input	When setup parameter Cn-01 bit nos. b, A= 1, 1, then, when this bit is ON, the mode changes from the torque command (TREF) mode to the speed command (REF) mode. When in torque command mode, speed command (REF) inputs become forward/ reverse rotation speed limits
	RDIR	Rotation direction command inputs	When setup parameter Cn-02 bit no. 2=1, this is the rotation direction command for internal speed setting 1 to 3. (OFF: Forward rotation, ON: Reverse rotation)
16	POT	Forward drive prohibit input	Forward rotation overtravel input (OFF when prohibited). When setup parameter Cn-01 bit no.2=1, this signal is not used.
17	NOT	Reverse drive prohibit input	Reverse rotation overtravel input (OFF when prohibited). When setup parameter Cn-01 bit no.3 =1, this signal is not used.
18	RESET	Alarm reset input	ON: Servo alarm status is reset.
28	BAT (ABS see note)	Backup battery + input	The backup battery connection terminals used when power is not supplied to an absolute encoder.
29	BATGND (ABS see note)	Backup battery – input	

Note Do not connect pins 5, 6, 26, 27, 28, and 29 unless a motor with an absolute encoder is used.

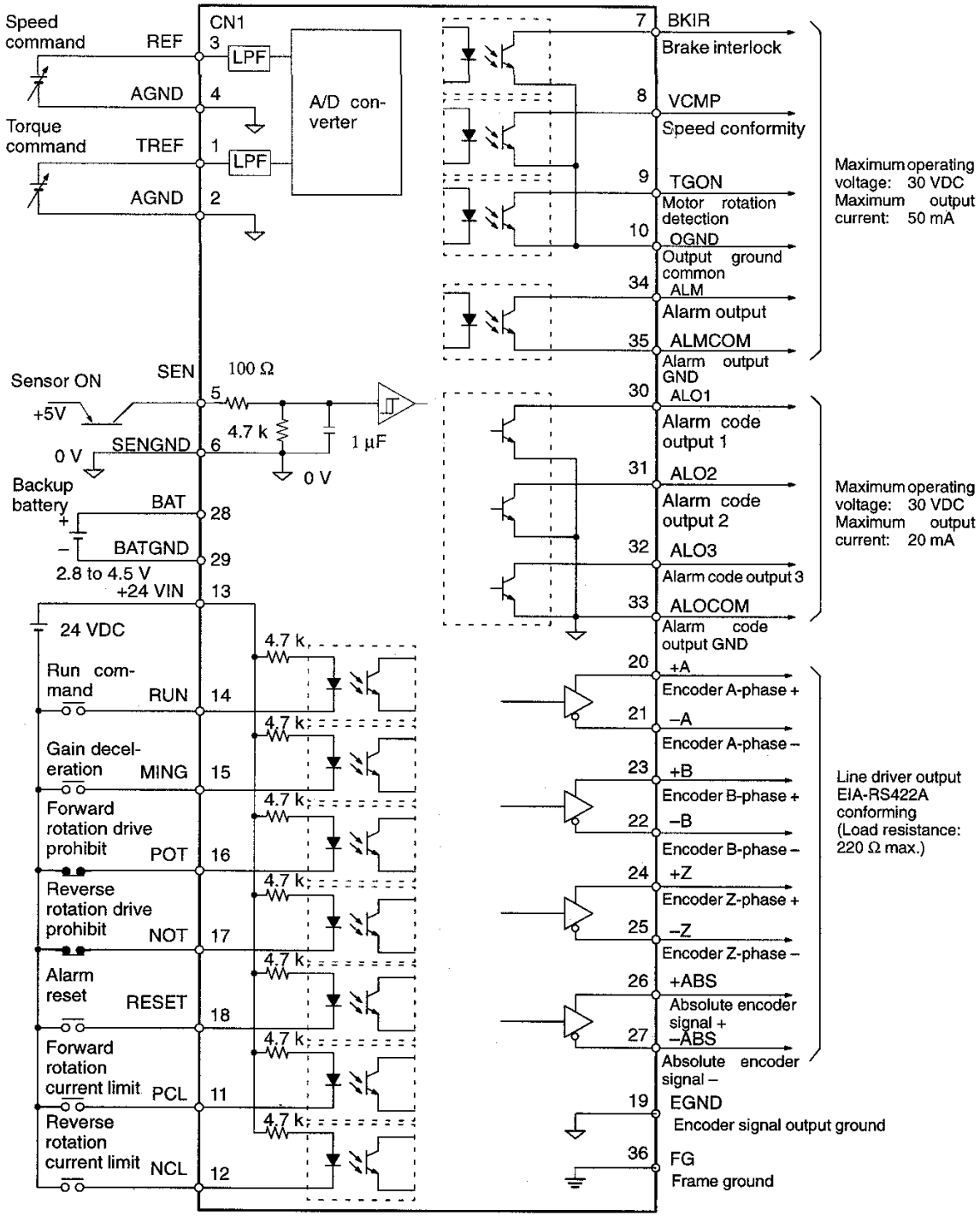
- **Output Circuit and Receiving Circuit**

• Output Circuit and Receiving Circuit



- **Control I/O Signal Connections and External Signal Processing**

■ Control I/O Signal Connections and External Signal Processing



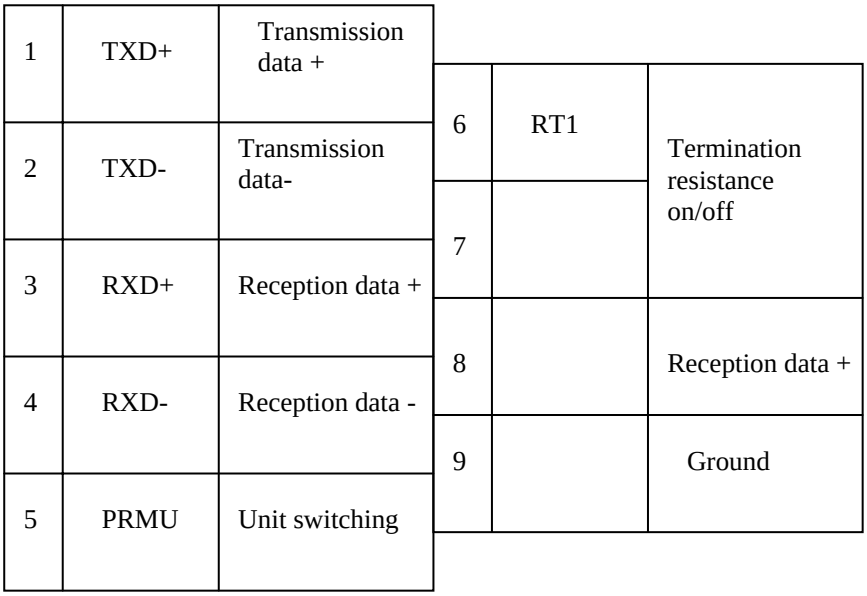
Note 1. Pins 5, 6, 26, 27, 28, and 29 are used with an absolute encoder.

Note 2. Pin 36 is not used with models conforming to EC Directives.

▪ CN3: Parameter Unit Input Specifications

Pin No.	Signal	Function	I/O interface
1	TXD +	Transmission data +	This is data transmitted to a Parameter Unit (or a personal computer)
2	TXD-	Transmission data -	
3	RXD+	Reception data +	This is data received from a Parameter Unit (or a personal computer.
4	RXD-	Reception data -	
5	PRMU	Unit switching	This is the switching terminal for a Parameter Unit or personal computer. If the pin is open, it is for a personal computer. If connected to +5V, it is for a Parameter Unit.
6	RT1	Termination resistance enabled/ disabled	This is the termination resistance terminal for the line receiver. For 1-to-1 communications or for the final Servo Driver, short-circuit RT1-RT2.
7	RT2		
8	+5V	+5 V output	This is the + 5 V output to the Parameter Unit.
9	GND	Ground	

• Pin Arrangement



• Connectors Used (D-sub Connector, 9P)

Dai-ichi Denshi Kogyo	Socket at servo Driver	17LE-13090-27(D2BC)
	Soldered plug at cable side	17JE-23090-02 (D1)
	Cover at cable side	17JE-09H-15
OMRON	Soldered plug at cable side	XM2A-0901
	Cover at cable side	XM2S-0912

- **CN4: Speed/ Current Monitor Specifications**

Pin No.	Signal Name	Function	I/O interface
1	NM	Speed monitor output	Voltage output with a ratio of ±0.5V/(1,000 r/min), centered at 0V. (-) voltage is forward, (+) voltage is reverse, and output accuracy is about ±10%.
2	AM	Current monitor output	Voltage output with a ratio of ±0.5V /(rated torque), centered at 0V. (-) Voltage is forward acceleration, (+) voltage is reverse acceleration. Output accuracy is about ±10%.
3, 4	GND	Output ground	This is the output ground mentioned above

- **Connectors Used (4)**

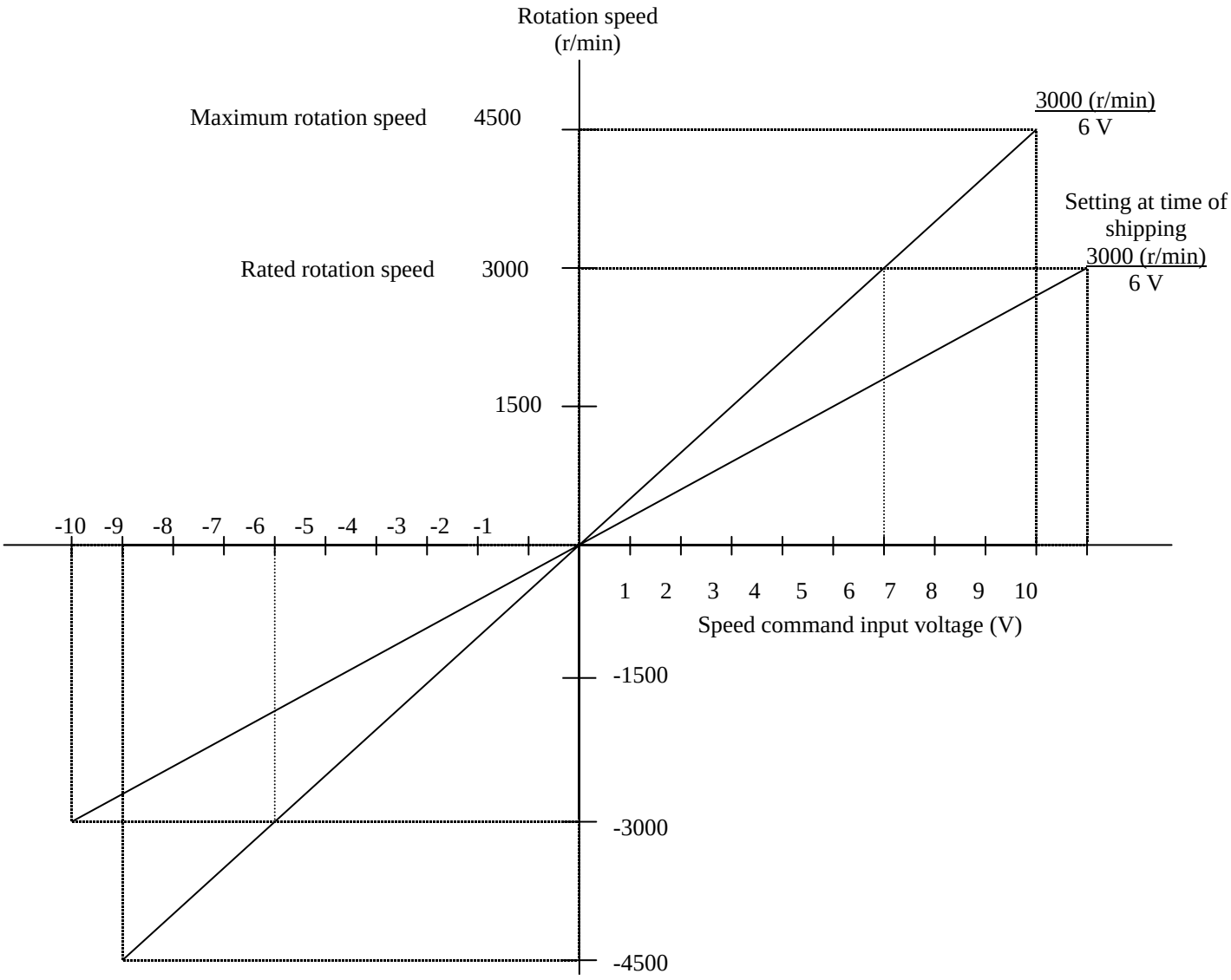
Hirose Electric	Pin header at Servo Driver	DF11-4DP-2DS
	Socket at cable side	DF11-4DS-2C
	Socket crimp terminal at cable side	DF11-2428 SC

8-4 Parameter Specifications

User Parameter Details

- **Speed Command Scale: Cn-03**

This is a constant for adjusting the motor rotation speed for the speed command input. The adjustable range is 0 to 2,162 (r/min/V). The factory setting is for 300 (r/min/V), with an input voltage of 10V at 3,000 r/min. This parameter is used as the positioning loop gain if a position controller is connected as the host.



- **Speed loop Gain: Cn-04**

  This is the proportional gain for the speed controller. The adjustable range is 1 to 2,000 Hz (the response frequency when equivalent inertia used). As he number is increased, the gain is increased. The factory setting is for 80(Hz). Using the factory setting for the Servomotor alone or with a small load inertia will cause vibration to occur, so set the value to a maximum of 20(Hz) for operation.

- **Speed Loop Integration Time Constant: Cn-05**

  This is the integration time for the speed controller. The adjustable range is 2 to 10,000 (ms), and it is factory set to 20 (ms). As the number is increased, the gain decreased. The units for the time constant (1ms or 0.01ms) can be changed with bit b of Cn-02 (the speed integration constant's units). (HA/LA/V/W Models)

- **Emergency Stop Torque: Cn-06**

  When setup parameter Cn-01 bit no.8=1, this sets the braking torque for over-travel stopping (forward/ reverse drive prohibit input operation). The setting range is 0 to the maximum torque (a percentage of the braking torque as 100% of the Servomotor rated torque. The factory setting is for the maximum torque.

- **Software Start Acceleration Time: Cn-07**
  Software Start Deceleration Time: Cn-23

  The Servomotor rotation acceleration time from 0 r/min to 4,500 r/min is set in Cn-07, and the deceleration time from 4,500 r/min to 0 r/min is set in Cn-23. The factory setting is for 0 (ms). When positioning is controlled by connecting a position controller, set it to 0 (ms).

- **Forward Rotation Torque Control: Cn-08**
  Reverse Rotation Torque Control: Cn-09

  The Servomotor output torque control value for forward rotation is set in Cn-08, and the value for reverse rotation is set in Cn-09. The setting range is 0 to the maximum torque, and the factory setting is for the maximum torque.

- **Encoder Dividing Rate Setting: Cn-0A**

  The number of pulses detected (A- and B-pulses) per encoder revolution is converted to the number of pulses set for this parameter and output from the Servo Driver, The setting range is 16 to 2,048 pulses revolution for incremental encoders and 16 to 1,024 pulses/ revolution for absolute encoders. The factory setting is for 1,000 (pulses/revolution).

- **Rotation Speed for Servomotor Rotation Detection: Cn=0b**

  This sets the rotation speed for detecting whether or not the Servomotor is rotating. The setting range is 1 to 4,500 r/min. When the rotation detection has been set for the sequence output signal switch (Cn-01 bit 4=0), the Servomotor rotation detection output (TGON) is turned ON if the Servomotor rotational speed meets or exceeds this set value. The factory setting is for 20 (r/min).

- **P Control Switching (torque Command): Cn-0C**
  P Control Switching (Speed Command): Cn-0d
  P Control Switching (Acceleration Command): Cn-0E

  These set the various points for switching the speed controller from PI control to P control in order to moderate excessive characteristics when an operation such as acceleration or deceleration is executed accompanied by output saturation of the controller. These selections are made by setting the setup parameter Cn-0 bit nos. d and C

- **Position Lock Rotation Speed: Cn-0F**

  This sets the rotation speed for inducing position lock, The setting range is 0 to 4,500 r/min. This setting is used in the “speed control with position lock” control mode (bit 2 of Cn-02=0 and bits b and A of Cn-01=0 and 1) for all models. It is also used in the “internal speed control settings (position-lock when stopped)” control mode (bit 2 of Cn-02=1 and bit A of Cn-01=1) with HA/ LA/ V/ W models. When the position lock command input (PLOCK) is ON and the motor’s speed falls below this set value, operation switches from speed control to position control and the motor goes into position lock. (Operation automatically switches to position control and goes into position lock when the control mode is “internal speed control settings” and the motor’s speed falls below this set value.) Position lock force is adjusted b means of position loop gain (Cn-1A). The factory setting is for 10 (r/min)

- **Jog Speed: Cn-10**

  This sets the speed for manual operation. The setting range is 0 to 4,500 r/min. During manual operation, operating commands are given from the Parameter Unit. The factory setting is for 500 (r/min).

- **Number of Encoder Pulses: Cn-11**

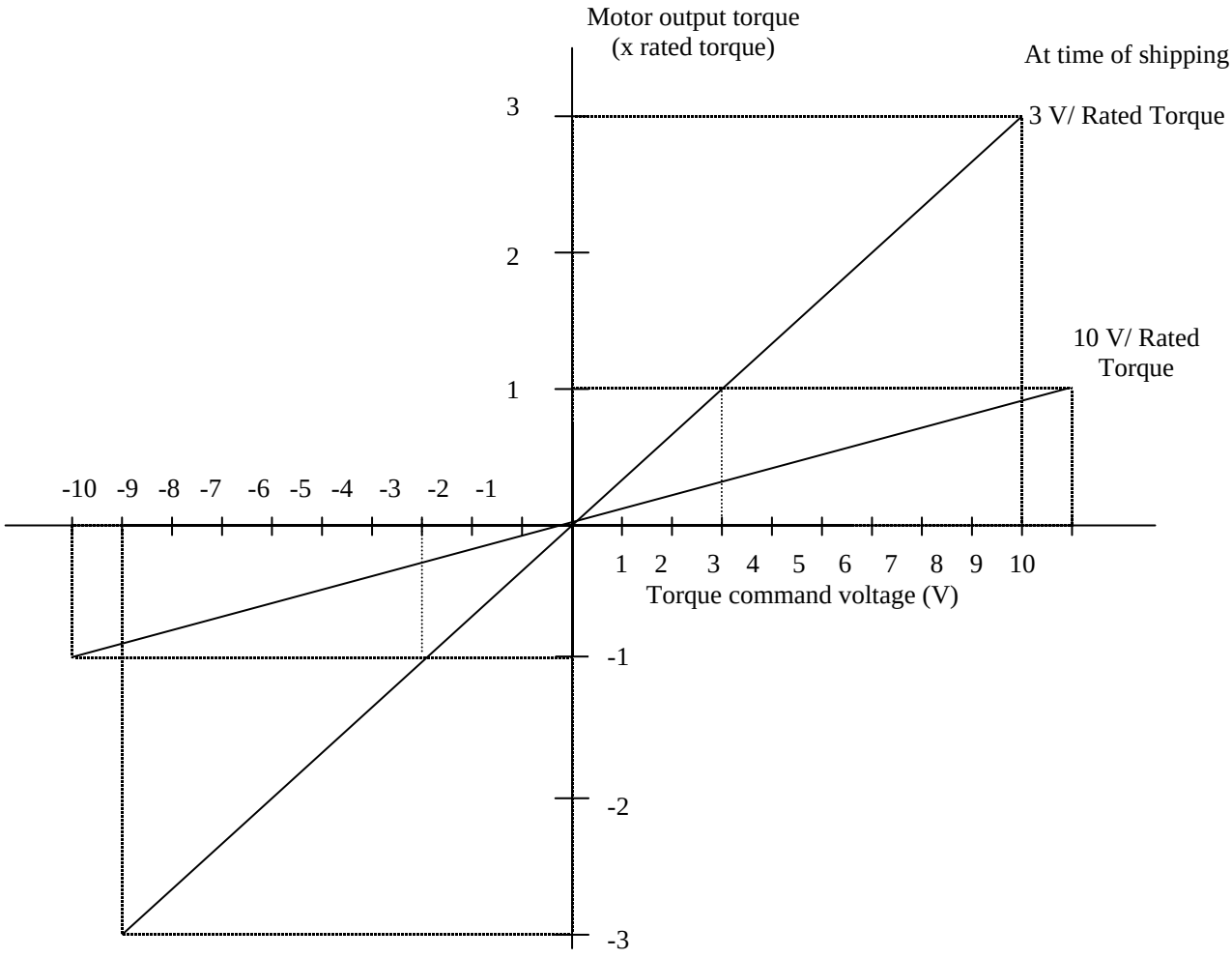
  This sets the number of pulses per revolution of a connected encoder. Set 2,048 for incremental encoders and 1,024 for absolute encoder. The Servomotor will not operate correctly if the setting is incorrect. The factory setting is for 2,048 (pulses/ revolution).

- **Brake Timing 1: Cn-12**
  Brake Command Speed: Cn-15
  Brake Timing 2: Cn-16

  These parameters determine the output timing of the brake interlock signal (BKIR), which controls the electromagnetic brake.
  Brake timings 1 sets the delay time from the time of brake interlock goes OFF until the servo tuns off. The setting range is 0 to 50 (x 10 ms), and the factory setting is for 0 (x 10 ms).
  The brake command speed is the speed (r/m) used to turn OFF the brake interlock. The setting is 0 to 4,500 (r/m) and the factory setting is for 100 (r/m).
  Brake timing 2 sets the wait time from when the servo goes OFF until the brake interlock goes OFF. The setting range is 10 to 100 (x 10 ms), and the factory setting is for (x 10 ms).
  If the run command turns off, a servo error occurs, or the main-circuit power supply turns off during operation of a Servomotor with a brake, the dynamic brake comes on (setup parameter Cn-02 bit 6=1) and the Servomotor rotation speed is decreased. When the speed drops to the level of the value set for the brake command speed (Cn15), the brake interlock output (BKIR: CN1-7) turns OFF.
  Even if the speed does not drop to the level of the value set for the brake command (Cn-15), the brake interlock output (BKIR: Cn1-7) turns OFF after the time set for brake timing 2 has elapsed. (This time setting is made for the purpose of preventing damage to machinery or the Servomotor holding brake.)

- **Torque command Scale: Cn-13**

  This sets the input voltage per rated torque for the torque command scale (TREF: Cn1-1). The setting range is 10 to 100 (x0.1 V/rated), and the factory setting is 30(x 0.1 V/ rated torque, for a setting of 3 V/rated torque).



- **Speed Limit: Cn-14**

  This limits the Servo motor rotation speed for torque control (bit nos. b, A of Cn-01=1, 0 and bit no.2 of Cn-02=0) of the setup parameter no. 1 control mode selection. The setting range is 0 to 4,500 (r/min), and the factory setting is for 3,000 (r/min).

- **Torque Command Filter Time Constant: Cn-17**

  This sets the low-pass filter time constant for the torque command. The setting range is 0 to 250 (x 100 μs), and the factory setting is 4 (x 100 μs).
  The relationship between the filter time constant and the cut-off frequency can be found by means of the following formula:

  $fc\ (Hz) = 1 / (2\pi T)$: T = Filter time constant

  If T = 400 (μs), fc will be approximately 400 (Hz)

  When the characteristic vibration of the machinery is within the response frequency of the servo loop, Servomotor vibration will occur. In order to prevent this sympathetic vibration based on the characteristic vibration of the machinery, set the torque filter time constant to a value that will eliminate the vibration (i.e., set it to a high value).

- **Forward Rotation External Current Limit: Cn-18**
  Reverse Rotation External Current Limit: Cn-19

  These set the Servomotor output torque limits for the forward and reverse directions. They are valid when the forward/ reverse currents limits (PCL/ NCL) are input. This function can't be used when the control mode is "internal speed control settings." The setting range is 0 to the maximum torque, and the factory setting is for the 100 (%).

- **Position Loop Gain: Cn-1A33**

  Set this parameter according to the rigidity of the mechanical system.
  This adjusts the servo-lock force for position lock. The setting range is 1 to 500 (l/s), and the factory setting is 40 (l/s). If the value is set too high, the servo lock will be too strong. Set a small value if there is vibration during position lock.

- **No. 1 Internal Speed Setting: Cn-1F (Factory Setting: 100 r/min)**
  No. 2 Internal Speed Setting: Cn-20 (Factory Setting: 200 r/min)
  No. 3 Internal Speed Setting: Cn-21 (Factory Setting: 300 r/min)

  Make these settings to control speeds by means of internal settings. The setting range is 0 to 4,500 (r/min).

- **Speed Conformity Signal Output Range: Cn-22**

  When the absolute value of the difference between the speed command and the Servomotor rotation speed (the speed deviation) is equal to or less than the set value, the speed conformity output (VCMP: CN1-8) turns ON. If the speed command is for 2,000 (r/min) and the speed conformity signal output range is 100 (r/min), then the speed conformity output (VCMP) turns ON when the Servomotor rotation speed is between 1,900 (r/min) and 2,100 (r/min). The setting range is 0 to 100 (r/min), and the factory setting is for 10 (r/min).

- **Compensating Gain: Cn-28 (HA/ LA/ V/ W Models)**

  This parameter is used to lower the speed loop gain according to the set value to output a large torque for motor deceleration or acceleration.

Servo
Section 9

9 Performance Specifications

▪ 200 VAC Specifications

Item		Unit	R88M –U03030H(A) -U03030T(A) -U03030VA -U03030XA	R88M –U05030H(A) -U05030T(A) -U05030VA -U05030XA	R88M –U10030H(A) -U10030T(A) -U10030VA -U10030XA	R88M –U20030H(A) -U20030T(A) -U20030VA -U20030XA	R88M –U40030H(A) -U40030T(A) -U40030VA -U40030XA	R88M –U75030H(A) -U75030T(A) -U75030VA -U75030XA
Rated output (See note)		W	30	50	100	200	400	750
Rated torque (see note)		N•m	0.095	0.159	0.318	0.637	1.27	2.39
		kgf•cm	0.974	1.62	3.25	6.49	13.0	24.3
Rated rotation speed		r/min	3,000	3,000	3,000	3,000	3,000	3,000
Momentary maximum rotation speed		r/min	4,500	4,500	4,500	4,500	4,500	4,500
Momentary maximum torque (see note)		N•m	0.29	0.48	0.96	1.91	3.82	7.10
		kgf•cm	2.92	4.87	9.75	19.5	39.0	72.9
Momentary maximum/ rated current ratio		%	310	317	322	300	308	316
Rated current (see note)		A (rms)	0.42	0.60	0.87	2.0	2.6	4.4
Momentary maximum current (see note)		A (rms)	1.3	1.9	2.8	6.0	8.0	13.9
Rotor inertia	INC	kg•m² (GD²/4)	0.21 x 10^{-5}	0.26 x 10^{-5}	0.40 x 10^{-5}	1.23 x 10^{-5}	1.91x 10^{-5}	6.71x 10^{-5}
		kgf•cm•s²	0.21 x 10^{-}□	0.27 x 10^{-}□	0.41 x 10^{-}□	1.26 x 10^{-}□	1.95 x 10^{-}□	6.85 x 10^{-}□
	ABS	kg•m² (GD²/4)	0.46 x 10^{-5}	0.51 x 10^{-5}	0.65 x 10^{-5}	1.48 x 10^{-5}	2.16 x 10^{-5}	6.96 x 10^{-5}
		kgf•cm•s²	0.47 x 10^{-}□	0.53 x 10^{-}□	0.67 x 10^{-}□	1.52 x 10^{-}□	2.21 x 10^{-}□	7.11 x 10^{-}□
Torque constant (see note)		N•m/A	0.255	0.286	0.408	0.355	0.533	0.590
		kgf•cm•s²	2.60	2.92	4.16	3.62	5.44	6.01
Induced voltage constant (see note)		mV/(r/min)	8.89	9.98	14.0	12.4	18.6	20.6
Power rate (see note)		kW/s	4.36	9.63	25.4	32.8	84.6	85.1
Mechanical time constant		Ms	1.5	0.9	0.5	0.4	0.3	0.3
Winding Resistance		Ω	15.8	9.64	6.99	1.34	1.23	0.45
Winding Impedance		mH	23.1	16.9	13.2	7.2	7.9	5.7
Electrical time constant		ms	1.5	1.8	1.9	5.4	6.4	13
	INC	kg	Approx. 0.3	Approx. 0.4	Approx. 0.5	Approx. 1.1	Approx. 1.7	Approx. 3.4
	ABS	kg	Approx. 0.45	Approx. 0.55	Approx. 0.65	Approx. 1.2	Approx.1.8	Approx. 3.5
Corresponding Servo Driver			R88D -UA02H(A) -UA02V	R88D -UA03H(A) -UA03V	R88D -UA04H(A) -UA04V	R88D -UA08H(A) -UA08V	R88D -UA12H(A) -UA12V	R88D -UA20H(A) -UA20V

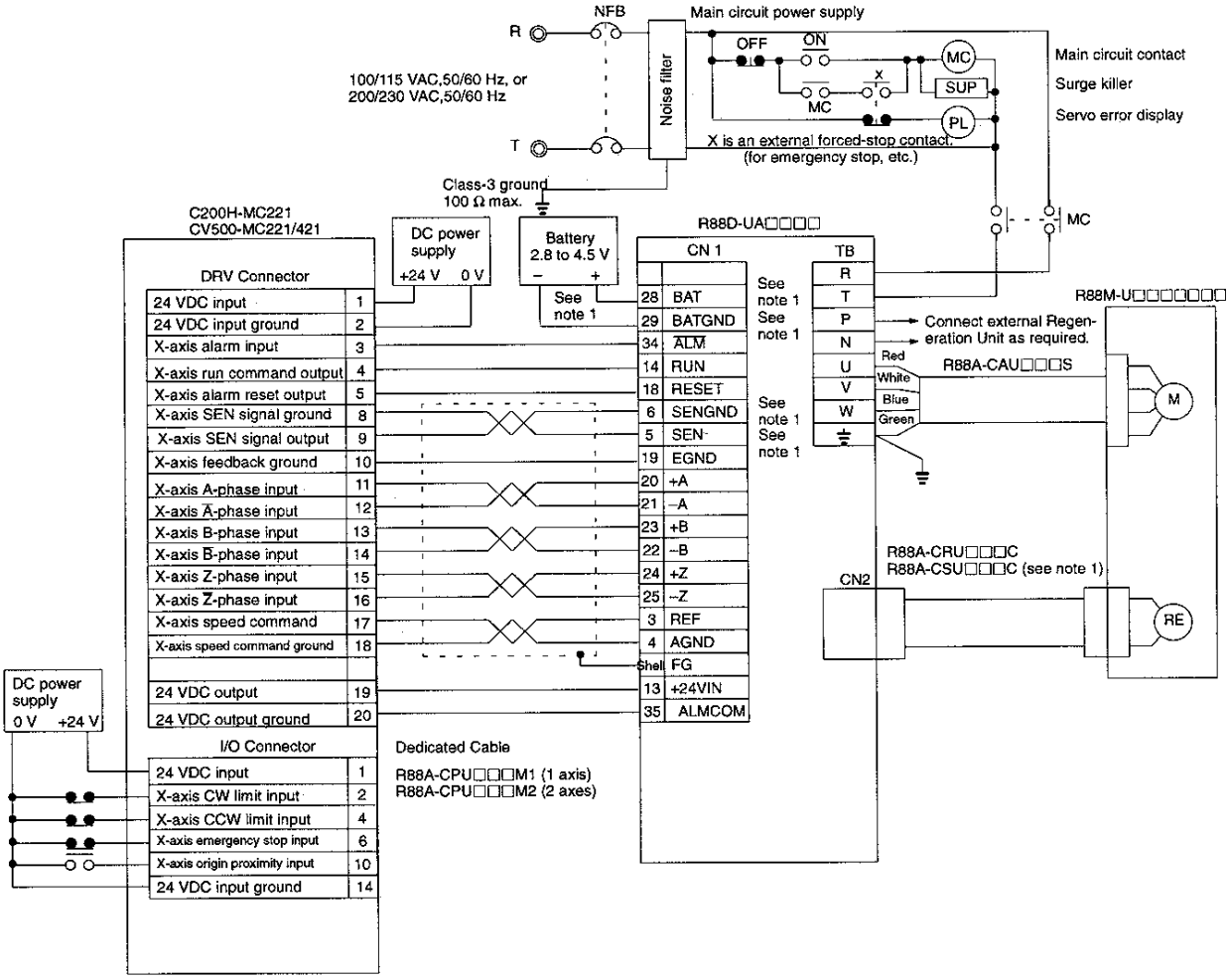
Note The values for torque and rotation speed characteristics, are the values at an armature winding temperature of 100 C, combined with the Servo Driver. Other values are at normal conditions (20 C, 65%). The maximum momentary torque is a reference value.

• AC Servomotor Heat Radiation Conditions

When an AC Servomotor is continuously operated at the rated conditions, a heat radiation plate equivalent to a rectangle aluminum plate of t6x250 mm is required at the Servomotor flange mounting area. (This is for horizontal mounting, with nothing around the Servomotor and no interference from heat convection currents.)

10 Connection Examples of C200H-MC221 & R88D-UA

- **Connection Example 1: Connecting to SYS MAC CV500-MC221/421 or C200H-MC221 Control Unit, Models (Incremental and Absolute Encoders) conforming to UL/ cUL Standards**



Encoders Dividing Ratios and Speeds when Connected to OMRON Controllers

The encoder output pulses can be changed for OMNUC U-series AC Servo Driver by setting encoder dividing ratio. The maximum speed, however, is limited by the maximum response frequency of the encoder input to the controller as listed in the following table.

- **Encoder Dividing Ratio (Cn-0A) and Maximum Motor Speed**

Controller	Dividing ratio					
	2,048 to 1,025		1,024 to 683		2,048/ n ≥ Cn-0A> 2,048/ n+1	
	4x	2x/ 1x	4x	2x/ 1x	4x	2x/ 1x
CV500-MC221/421 C200H-MC221	4,500		4,500		4,500	

OMNUC U-Series Standard Models

- **Models with Incremental Encoders Conforming to UL/ cUL Standards and Not Conforming to any Standards**

- **Servomotors**

Specification				Model
Straight shaft with no key	Standard (no brake)	200 VAC	30 W	R88M-U03030HA
			50W	R88M-U05030HA
			100 W	R88M-U10030HA
			200 W	R88M-U20030HA
			400 W	R88M-U40030HA
			750 W	R88M-U75030HA
	With Brake	200 VAC	30 W	R88M-U03030HA-B
			50 W	R88M-U05030HA-B
			100 W	R88M-U10030HA-B
			200 W	R88M-U20030HA-B
			400 W	R88M-U40030HA-B
			750W	R88M-U75030HA-B

Specification				Model
Straight shafts with keys	Standard (no brake)	200 VAC	30 W	R88M-U03030HA-S1
			50W	R88M-U05030HA-S1
			100 W	R88M-U10030HA-S1
			200 W	R88M-U20030HA-S1
			400 W	R88M-U40030HA-S1
			750 W	R88M-U75030HA-S1
	With Brake	200 VAC	30 W	R88M-U03030HA-BS1
			50 W	R88M-U05030HA-BS1
			100 W	R88M-U10030HA-BS1
			200 W	R88M-U20030HA-BS1
			400 W	R88M-U40030HA-BS1
			750W	R88M-U75030HA-BS1

- **Servo Drivers with Analog Inputs**

Specification			Model
Analog input	200 VAC	30 W	R88D-UA02HA
		50 W	R88D-UA03HA
		100 W	R88D-UA04HA
		200 W	R88D-UA08HA
		400 W	R88D-UA12HA
		750 W	R88D-UA20HA

- **Parameter Unit**

Specification	Model
Handy type	R88A-PR02U
Mounted type	R88A-PR03U

- **Regeneration Unit**

Specification	Model
Regeneration processing current: 8 A	R88A-RG08UA

- **External Regeneration Resistor**

Specification	Model
Regeneration capacity: 70 W, 47 Ω	R88A-RR22047S

- **Encoder Cables**

Specification		Model
Connectors at both ends	3 m	R88A-CRU003C
	5 m	R88A-CRU005C
	10 m	R88A-CRU010C
	15 m	R88A-CRU015C
	20	R88A-CRU020C
Cable only	1-m units	R88A-CRU001

- **Power cables**

Specification			Model
For standard motors (no brake)	Connector at one end	3 m	R88A-CAU003S
		5 m	R88A-CAU005S
		10 m	R88A-CAU010S
		15 m	R88A-CAU015S
		20 m	R88A-CAU020S
	Cable only	1-m units	R88A-CAU001
For motors with brakes	Connector at one end	3 m	R88A-CAU003B
		5 m	R88A-CAU005B
		10 m	R88A-CAU010B
		15 m	R88A-CAU015B
		20 m	R88A-CAU020B
	Cable only	1-m units	R88A-CAU01B

- **Dedicated Control Cables**

Specification			Model
For Motion Control Units, connectors at both ends	1 axis	1 m	R88A-CPU001M1
		2 m	R88A-CPU002M1
	2 axis	1 m	R88A-CPU001M2
		2 m	R88A-CPU002M2
For N115, N116, U43, or U45, connectors at both ends		1 m	R88A-CPU001N
		2 m	R88A-CPU002N

- **General-purpose Control Cables**

Specification		Model
For general-purpose controllers, connector at one end	1 m	R88A-CPU001S
	2 m	R88A-CPU002S

- **Connectors and Terminal Blocks**

Specification		Model
Control cable connector		R88A-CNU01C
Connector terminal block		XW2B-40F5-P
Connection cable for connector terminal block	1 m	R88A-CTU001N
	2 m	R88A-CTU002N

- **Front-surface Mounting Brackets**

Specification	Model
For the following Servo Drivers 200 VAC: 30 to 400 W 100 VAC: 30 to 200 W	R88A-TK01U
For the following Servo Drivers 200 VAC: 750 W 100 VAC: 300 W	R88ATK02U

Note HA/ LA models: Models manufactured after May 1998 conform to UL/ cUL Standards.

- **Models with Absolute Encoders Conforming to UL/ cUL Standards**

- **Servomotors**

Specification				Model
Straight shafts with no keys	Standard (no brake)	200 VAC	30 W	R88M-U03030TA
			50W	R88M-U05030TA
			100 W	R88M-U10030TA
			200 W	R88M-U20030TA
			400 W	R88M-U40030TA
			750 W	R88M-U75030TA
	With Brake	200 VAC	30 W	R88M-U03030TA-B
			50 W	R88M-U05030TA-B
			100 W	R88M-U10030TA-B
			200 W	R88M-U20030TA-B
			400 W	R88M-U40030TA-B
			750W	R88M-U75030TA-B

Specification				Model
Straight shafts with keys	Standard (no brake)	200 VAC	30 W	R88M-U03030TA-S1
			50W	R88M-U05030TA-S1
			100 W	R88M-U10030TA-S1
			200 W	R88M-U20030TA-S1
			400 W	R88M-U40030TA-S1
			750 W	R88M-U75030TA-S1
	With Brake	200 VAC	30 W	R88M-U03030TA-BS1
			50 W	R88M-U05030TA-BS1
			100 W	R88M-U10030TA-BS1
			200 W	R88M-U20030TA-BS1
			400 W	R88M-U40030TA-BS1
			750W	R88M-U75030TA-BS1

- **Servo Drivers with Analog Inputs**

Specification			Model
Analog input	200 VAC	30 W	R88D-UA02HA
		50 W	R88D-UA03HA
		100 W	R88D-UA04HA
		200 W	R88D-UA08HA
		400 W	R88D-UA12HA
		750 W	R88D-UA20HA

- **Parameter Unit**

Specification	Model
Handy type	R88A-PR02u
Mounted type	R88A-PR03U

- Regeneration Unit

Specification	Model
Regeneration Processing current: 8 A	R88A-R08UA

OMRON

Servo (Basic)

Version 1.0
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