FANUC AC SPINDLE SERVO UNIT

MAINTENANCE MANUAL

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1. GENERAL

This instruction manual applies to the maintenance work of 18 AC spindle servo unit and its options. (For applicable units refer to Table 1.2)

Owing to its unique driving method using a microcomputer, the FANUC AC spindle servo unit controls AC spindle motors smoothly and stably without any noticeable noise.

The characteristic regenerative braking system of this FANUC AC spindle servo unit feeds back the regenerative energy to the power supply efficiently to economize power during the deceleration of AC spindle motor.

1.1 Structure

The FANUC AC spindle servo unit consists of the following units and parts.

(1) Spindle control unit (Basic) --------
- ① Unit
- ② PCB
- ③ ROM

(2) Fuses (for spare) (Basic)
(3) Connectors (for connections) (Basic)
(4) D/A converter (Option)
(5) Power transformer (Option)
(6) Spindle orientation control circuit (Option)
(7) Unit cover (Option)*
(8) Unit adapter (Option)*

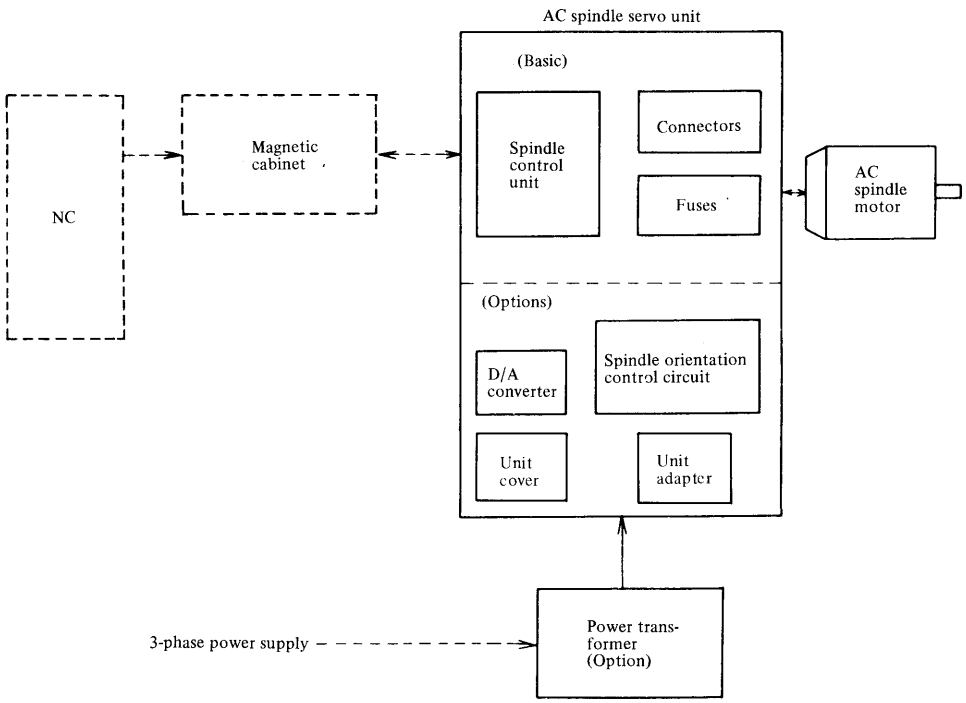


Fig. 1.1 Block Diagram

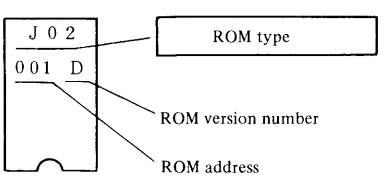
1.

Applicable motor or name	Specification drawing numbers	Unit drawing numbers	PCB drawing numbers	ROM		Specification drawing numbers of applicable AC spindle motor
				Specification drawing numbers	Classification	
Spindle servo unit for model 3	A06B-6044-H007	A06B-6044-C008	A20B-0009-0530	A06B-6044-C507 #J10	J10	A06B-0704-B001,2
Spindle servo unit for model 6	A06B-6044-H008	A06B-6044-C008	A20B-0009-0531	A06B-6044-C508 #J11	J11	A06B-0707-B001,2
Spindle servo unit for model 8	A06B-6044-H009	A06B-6044-C009	A20B-0009-0532	A06B-6044-C509	J02	A06B-0706-B001,2
	A06B-6044-H108	A06B-6044-C108	A20B-1000-0692			
Spindle servo unit for model 12	A06B-6044-H010	A06B-6044-C010	A20B-0009-0533	A06B-6044-C510	J03	A06B-0705-B001,2
	A06B-6044-H112	A06B-6044-C112	A20B-1000-0693			
Spindle servo unit for model 15	A06B-6044-H011	A06B-6044-C011	A20B-0009-0534	A06B-6044-C511	J04	A06B-0708-B001,2
Spindle servo unit for model 18	A06B-6044-H016	A06B-6044-C012	A20B-0009-0538	A06B-6044-C516	J05	A06B-0709-B001,2
Spindle servo unit for model 22	A06B-6044-H017	A06B-6044-C013	A20B-0009-0539	A06B-6044-C517	J06	A06B-0710-B001,2
D/A converter (BCD)	A06B-6041-J031					
D/A converter (BINARY)	A06B-6041-J032					
Orientation A (Position coder system, 2-step speed change)	A06B-6041-J110		A20B-0008-0240			
Orientation B (Position coder system, 2-step speed change)	A06B-6041-J111		A20B-0008-0241			
Orientation C (Magnetic sensor system 2-step speed change)	A06B-6041-J120		A20B-0008-0030			
Orientation D (Magnetic sensor system 3-step speed change)	A06B-6041-J121		A20B-0009-0520			
Orientation E (Position coder system, 4-step speed change)	A06B-6041-J130		A20B-1000-0460			
Orientation F (Position coder system, 4-step speed change)	A06B-6041-J131		A20B-1000-0461			
Orientation G (Magnetic sensor system 2-step speed change)	A06B-6041-J112		A20B-0008-0031			

Note 1) For PCBs A20B-0009-0530 ~ 0539, their components parts other than ROM are the same, but their setting and adjustments differ from each other.

Note 2) ROM is mounted at MD25. (See appendix 6 PCB wiring diagram)

Note 3) The ROM type is indicated as shown in the right figure.



1.2 Maintenance Tools

1.2.1 Tools for adjustment

Use tools shown in Table 1.2(a) for adjustment and tools shown in Table 1.2(b) for repair.

Table 1.2(a) Tools for Adjustment

Name	Specification	Use
AC voltmeter	1V ~ 300V (Accuracy: Better than ±2%)	AC power voltage measurement
Cross-recessed (+) and conventional screwdrivers	(+): Large, and medium sizes (-): Large, medium, and small sizes	————

Table 1.2(b) Tools for Repair

Name	Specification	Use
DC voltmeter	1V ~ 300V (Accuracy: Better than ±1%)	AC power voltage measurement
DC voltmeter	1mV ~ 500V (Accuracy: Better than ±1%)	DC power voltage and offset voltage check
Circuit tester		Resistance value check
Cross-recessed (+) and conventional screwdrivers	(+): Large, and medium sizes (-): Large, medium, and small sizes	————

1.3 Installation Procedure

Check the AC spindle servo unit at the installation time according to the items shown in Table 1.3.

2.

Table 1.3 Check Procedure at Installation Time

Item	Procedure	Remarks
1	Check if the specifications of motor, servo unit, and options are correct.	Check if the motor correctly corresponds to to the unit, PCB, and ROM, referring to Table 1.1.
2	Check the unit for external damage.	Check upper power resistors and PCB parts for damage.
3	Check the AC power voltage, voltage fluctuation, power capacity (kVA) and frequency employed.	See Table 2.1.1.
4.	Connect the grounding wire, power cable, drive power cable, and signal cables.	See para. 2.1, 2.2, 2.3 and appendix 1.
5.	Check setting and adjusting results.	See para. 3.1.
6.	Turn on AC power supply, and check if the green PIL lamp lights on PCB.	
7.	Check if motor rotates in normal and reverse directions correctly by giving rotation commands.	
8.	Check the motor operation for all speed ranges.	
9.	Adjust the spindle orientation circuit.	See Chapter 7.

2. CONNECTIONS

Check connections according to the connection diagram (APPENDIX 1) and cable layout (APPENDIX 2).

For conductor sectional areas and other details of cables, see cable specifications (APPENDIX 3).

2.1 Connection of Power Supply

2.1.1 Power voltage and capacity check

Measure the AC power voltage before connecting the power supply, and observe the following procedure according to the power voltage.

Table 2.1.1(a) Procedure to AC Power Voltage

AC power voltage	Nominal voltage	Procedure
170V ~ 220V	200V	Set toggle switch to 200V.
210V ~ 242V	220V	Set toggle switch to 220V.
230V ~ 253V	230V	Reduce the input voltage to 200V by using an autotransformer or the like.
254V or more	380V ~ 550V	Reduce the input voltage to 200V by using an insulation transformer.

The input power specifications of AC spindle servo unit are shown in Table 2.1.1(a).

Use the power supply having the capacity enough to avoid any trouble due to the voltage drop with the maximum load.

Table 2.1.1(b) Input power specifications of AC spindle servo unit

Nominal rated voltage		AC200V/220V (Switchable, 3-phase)						
Allowable voltage fluctuation		-15% ~ +10%						
Frequency		50Hz/60Hz ±1Hz (Not switchable)						
Power capacity	Motor model	3	6	8	12	15	18	22
	Capacity at 30 min. rating (KVA)	9	12	17	22	26	32	37

2.1.2 Connection of protective grounding wire

Connect a protective grounding wire to ground terminal "G" before connecting the power cable. Use a grounding wire having the capacity enought to meet the feeder breaker capacity.

2.1.3 Connection of power cable

Connect the power cable after connecting the grounding wire. The phase rotation of power supply is not specified for the AC spindle servo unit.

2.2 Connection of AC Spindle Motor

Connect the AC spindle motor according to the connection diagram. (APPENDIX 1).

Be careful not to connect the drive power cable in a wrong connecting order, otherwise the motor vibrates or it stops with alarm No. 2. Connect protective grounding wire "G" without fail.

2.3 Connection of Signal Cables

Connect signal cables according to the connection diagram, (APPENDIX 1).

3. SETTING AND ADJUSTMENTS

3.1 Setting of Unit and PCB

For the parts on the unit and PCBs, refer to mounting layout of parts (APPENDIX 5 and 6). Confirm the following setting before turning on the power switch.

Table 3.1(a) Setting to be Confirmed before Turning on the Power Switch

No.	Check items	Remarks
1	Setting of voltage selection	See para. 2.1
2	Setting (short bars) check	See Table 3.1(b)

Table 3.1(b) Setting

Setting terminal No.	Contents		Setting	Setting at shipment from FANUC
S1	Machine ready signal (MRDY)	Used	OFF 	OFF
		Not used	ON 	
S2 (Note 1)	Analog override	Used	OFF 	OFF
		Not used	ON 	
S3 (Note 1)	Same as the above	Used	ON 	ON
		Not used	OFF 	
S4	Velocity command signal	Use of external analog voltage command	OFF 	OFF
		Use of R01 ~ R12 commands	ON 	

3.1

Setting terminal No.	Contents		Setting	Setting at shipment from FANUC
S5	Setting of velocity feedback amount to rated command	4500 rpm	B: Shorted 	Set to the rating of the motor employed
		6000 rpm	A: Shorted 	
		8000 rpm	A and B: opened 	
S6	Velocity control phase compensation	S6	Depends on motor and PPW version numbers. See Table 3.1(c)	
S7		S7		
S8	Delay time required until motor is de-energized	0 sec/option	OFF 	ON (Note 1)
		0.2 sec/standard	ON 	
S9	Machine ready signal function	MCC is turned off	OFF 	OFF
		MCC is not turned off	ON 	
S10	Overcurrent detection level	Labeled	OFF 	Determined as specified on the unit label (Note 2)
		Not labeled	ON 	

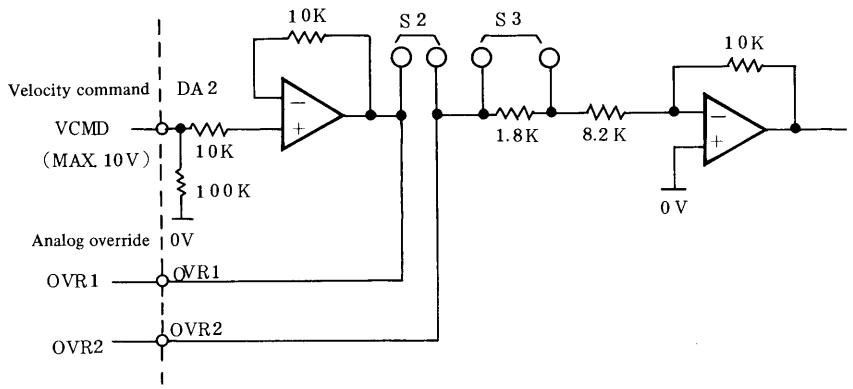
Note 1) Insert a short bar without fail even when setting is turned off.

Note 2) Turn on S10 only when the label at the upper part of the PCB mounting plate represents that S10 is turned on.

Variable resistors RV1 ~ RV19 of the spindle control circuit PCB have been adjusted at factory before shipment, and their adjustments are no longer necessary, in principle.

However, the set values of variable resistors shown in Table 3.1(d) are changeable as required. Readjust variable resistors shown in Table 3.1(c) after turning on the power supply, if fine adjustment is required for offset, rotating speed, etc.

Note 1) Setting terminals S2 and S3 shown in Fig. 3.1(a) are mounted on the circuit in the vicinity of the analog override circuit in spindle control PCB.



Setting	Use of override		Unuse of override
	Override range Max 120%	Override range Max 100%	
S2	OFF	OFF	ON
S3	ON	OFF	OFF

Fig. 3.1(a) Analog Override Circuit

Table 3.1(c) Setting of S6 and S7

(i) PCB A20B-0009-0530 ∿ 539

Applicable motor	ROM		Overall version number of PCB	Setting	
	Type	Version number		S6	S7
Model 3	J10	Refore 001D	Refore 12E	ON	OFF
		After 001E	After 14F	OFF	ON
Model 6	J11	Before 001D	Before 12E	ON	OFF
		After 001E	After 14F	OFF	ON
Model 8	J02	Before 001F	Before 12E	ON	ON
		After 001G	After 14F	OFF	ON
Model 12	J03	Before 001F	Before 12E	ON	ON
		Before 001G	After 14F	OFF	ON

3.1

Applicable motor	R O M		Overall version number of PCB	Setting	
Model 15	J04	Before 001E	Before 12E	ON	ON
		After 001F	After 14F	OFF	ON
Model 18	J05	Before 001B	Before 12E	ON	ON
		After 001C	After 14F	OFF	ON
Model 22	J06	After 001A	After 14F	OFF	ON

(ii) PCB A20B-1000-0692, 0693

Applicable motor	R O M		Setting	
	Type	Version number	S6	S7
Model 8	J02	After 001G	OFF	ON
Model 12	J03	After 001G	OFF	ON

(1) Variable resistors whose set values are changeable.

Table 3.1(d)

Variable resistor No.	Use	Standard adjustment at shipment from FANUC	Setting change method
RV3	Set speed arrival level	Sends speed arrival signal when the motor speed reaches 85 ~ 115% of the command speed.	See appendix 8.
RV4	Speed detection level	3% of the maximum speed is detected.	"
RV5	Torque limit value		"

(2) Variable resistors for fine adjustment of offset and rated speed.

Table 3.1(e)

Variable resistor No.	Use	Adjusting method
RV1	Adjusts the velocity command voltage level.	See appendix 8.
RV2	Adjusts the velocity command voltage offset.	"
RV9	Finely adjusts the rated speed in normal rotation (SFR).	"
RV11	Finely adjusts the rated speed in reverse rotation (SRV).	"
RV13	Adjusts the offset when zero speed is commanded.	"

Note 1) Don't change the setting of variable resistors other than specified in Table 3.1(d) and Table 3.1(e), since these variable resistors have been adjusted at factory before shipment from FANUC.
For adjustments of variable resistors, see APPENDIX 8.

3.2 Setting and Adjustment of Spindle Orientation Control Circuit

Refer to spindle orientation control circuit, in chapter 7.

4.

4. ROUTINE MAINTENANCE

Check and clean AC spindle motor and servo unit about the following items once every 6 months so that they can be operated under a good operating condition for a long time. Change the check intervals as required according to the contamination degrees.

4.1 AC Spindle Motor

If the ventilation hole, cooling fan, and finger guard of the AC spindle motor are dirty, the radiation efficiency of the motor will be lowered. Clean them using compressed air or a vacuum cleaner.

4.2 AC Spindle Servo Unit

Since a cooling fan is mounted at the upper part of the servo unit, nearby resistors and other parts may become dirty. If these parts are dirty, clean them with a vacuum cleaner.

5. TROUBLESHOOTING

If a trouble occurs, locate its cause, and take a remedial action referring to each item in Table 5(b) according to symptoms after checking the AC power voltage and DC power voltage on PCB shown in Table 5(a).

Table 5(a) Power Voltage Check

AC power voltage check	Check AC power voltage at INPUT terminals R, S, T, G (see par. 2.1)
DC power voltage check on PCB	

Voltage	Check terminals	Standard values
+24V	+24 — 0V	About 25V±10%, Ripple: About 0.5V
+15V	+15 — 0V	+15V±4% (Not adjustable)
+ 5V	+ 5 — 0V	+ 5V±1% (Adjustable by RV15)
-15V	-15 — 0V	-15V±4% (Not adjustable)

Table(b) Classification of Symptoms

Item	Symptoms	Reference items
1	POWER ON indicator lamp PIL does not light.	5.1
2	Alarm lamp lights on PCB.	5.2
3	The motor does not rotate at the specified revolutions.	5.3
4	The motor does not rotate.	5.3
5	Noticeable vibrations or noises are produced during rotation.	5.4
6	An abnormal noise is produced from motor during deceleration.	5.5
7	Speed overshooting or hunting occurs.	5.6
8	Cutting power is low.	5.7

5.1

Item	Symptoms	Reference items
9	Spindle orientation is not correct.	5.8
10	Acceleration/deceleration time is longer than specified.	5.9
11	DC power voltage of PCB is not correct.	5.1

5.1 Power ON Indicator Lamp PIL does not Light

Table 5.1 Check Procedure and Remedy

Item	Causes	Check procedure	Remedy
1	AC power is not supplied.	Check it at power input terminals R,S,T.	
2	Fuse F4 is blown out.	See appendix 5.	Replace F4 (5A).
3	Fuses AF1, AF2, and AF3 are blown out.	Check if alarm indications of fuses AF1, AF2, AF3 appear. See appendix 5.	Replace fuses AF1, AF2, AF3. Replace PCB, if these fuses are blown out again soon after replacing them.
4	PCB connectors CN6 and CN7 are not plugged correctly.	Check if the connector guide groove appears on the PCB connector surface.	Insert connectors correctly.
5	Neither 19A nor 19B is output because of defective transformer TF.	Check voltage at check terminals 19A-CT and 19B-CT of PCB. Measuring voltage values should be about AC 19V between these terminals.	Replace transformer TF.
6	PCB power circuit is defective.	Lamp PIL is lit by +5V and -15V. Check power voltage according to Table 5(a).	Replace PCB.

5.2 Alarm Lamp Lights on PCB

An alarm is displayed by four hexadecimal codes using LEDs mounted on PCB as shown in Table 5.2.

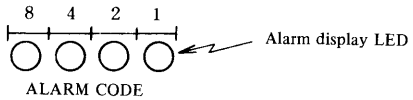


Fig. 5.2(a)

Table 5.2(a) Contents of Alarms

No.	Alarm display (O: Light)				Contents of alarms
	8	4	2	1	
1				O	Motor is overheated (thermostat operates).
2			O		Speed is deviated from the command value due to overload and others.
3			O	O	Fuse F7 in DC link is blown out.
4		O			Fuses F1, F2, or F3 in AC input circuit are blown out.
5		O		O	Fuses AF2 or AF3 on PCB is blown out.
6		O	O		The motor speed exceeds the maximum rated speed (analog system detection).
7		O	O	O	The motor speed exceeds the maximum rated speed (digital system detection).
8	O				Power voltage (+24V) is higher than specified.
9	O			O	Radiator for power semiconductors is overheated.
10	O		O		+15V power voltage is abnormally low.
11	O		O	O	DC link voltage is abnormally high.
12	O	O			DC link current is flows excessively.
13	O	O		O	CPU and peripheral parts are defective.
14	O	O	O		ROM is defective.

5.2

5.2

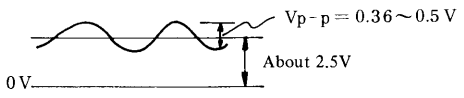
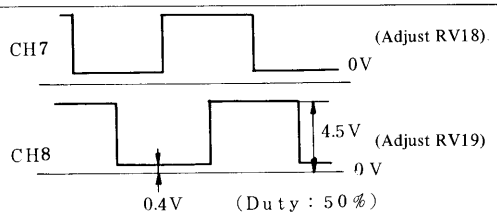
(1) Alarm No. 1 Motor is overheated.

Item	Causes	Check procedure	Remedy
1	Built-in fan motor of spindle motor is defective.		Replace fan motor.
2	Overload operation	Check it using a load meter.	Re-examine cutting conditions and tools.
3	Motor cooling system is dirty.		Clean it using compressed air or vacuum cleaner.
4	Disconnection or poor contact of wiring	Check connections between motor and servo unit.	

(2) Alarm No. 2 Speed is deviated from the command value.

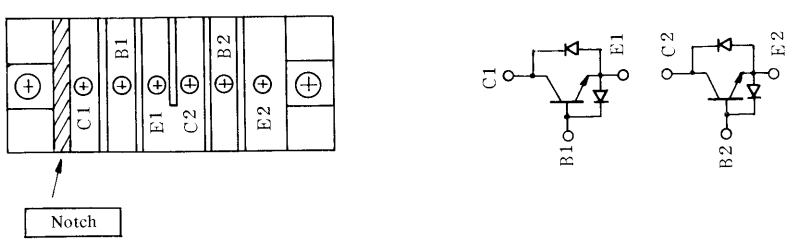
Item	Causes	Check procedure	Remedy
1	Overload	Check it using a load meter.	Re-examine cutting conditions and tools.
2	Wrong operation of torque limiter	Check it using a load meter.	Replace PCB.
3	Blow out of fuse in regeneration circuit	Check fuses F5 and F6 for continuity by using a circuit tester.	Check if the acceleration /deceleration on cycle is to frequent. Replace fuses.
4	Blow out or poor connection of the driver protective fuse on PCB	Check fuses FA, FB, ... FG for blown out or missing.	Connect fuses securely, and replace blown out fuses, if any.
5	Speed feedback signal is defective.	Check the speed feedback signal level.	Adjust RV18 and RV19.

Note 1) Speed feedback signal check
Observe the speed feedback signal using an oscilloscope under the rotation command off (motor stop, drive power off) condition after turning on the power supply.
Observe it at the following check terminals, while slowly turning the motor by hand.

Check terminals	Normal wave forms
CH3-0V (PA)	
CH4-0V (PB)	Same as shown above
CH5-0V (RA)	DC 2.5V±0.2V
CH6-0V (RB)	Same as shown above
CH7-0V CH8-0V (In case of CW rotation)	 (CH7 and CH8 signals are inverted in CCW direction.)

(3) Alarm No. 3 DC link fuse (F7) is blown out.

Blown out DC link fuse (F7) is presumed to have been caused by detective transistor module. Replace defective elements according to the following procedure.
If the transistor module is judged to be defective due to a trouble of the control PCB, replace PCB at a time. If this trouble cannot be repaired easily, please contact FANUC's service center.

Step	Procedure
1	After turning off AC power supply (turning off the magnetic cabinet breaker), disconnect the motor power cable.
2	Remove PCB and check resistance values across collectors C1, C2) - emitters (E1, E2), collectors (C1, C2) - bases (B1, B2) and bases (B1, B2) - emitters (E1, E2) of the transistor module by using a circuit tester. 

5.2

<table>
<tr><th>Step</th><th>Procedure</th></tr>
<tr><td></td><td>
Criteria (When circuit tester is set to x 10 Ω range)
<table>
<tr><th>Check terminals</th><th>Circuit tester terminals</th><th>Normal</th><th>Defective</th></tr>
<tr><td rowspan="2">C-E</td><td>Connect C to - terminal</td><td>About several hundred ohms</td><td>Short-circuit, infinite</td></tr>
<tr><td>Connect C to - terminal</td><td>Infinite</td><td>Short-circuit, about several hundred ohms</td></tr>
<tr><td rowspan="2">C-B</td><td>Connect C to + terminal</td><td>About several hundred ohms</td><td>Short-circuit, infinite</td></tr>
<tr><td>Connect C to - terminal</td><td>Infinite</td><td>Short-circuit, about several hundred ohms</td></tr>
<tr><td rowspan="2">B-E</td><td>Connect B to + terminal</td><td>About several hundred ohms</td><td>Short-circuit, infinite</td></tr>
<tr><td>Connect B to - terminal</td><td>About several hundred ohms</td><td>Short-circuit, infinite</td></tr>
</table>
When the transistor module is broken, the collector - emitter and collector - base are shorted (0 Ω) usually.
</td></tr>
<tr><td>3</td><td>Replace defective parts. Apply silicon grease without fail when replacing these parts.</td></tr>
<tr><td>4</td><td>After replacement, recheck transistor module by using the circuit tester in step 2.</td></tr>
</table>

5 Check the transistor drive circuit of PCB.

① After detaching DC link fuse F7, turn on AC input power supply. Don't apply the rotation commands (SFR, SRV).

② Measure the base to emitter voltage of 8 transistors (U, V, W phase, regenerative control circuit) at connectors CN6, CN7, by using a circuit tester (2 ~ 5V range).
Be careful not to receive an electric shock, since high voltage (DC 300V) is applied to CN6 and CN7.
Be careful not to damage the connector when applying the probes to the connector.

Criteria	A defective circuit can be easily identified from other normal circuits.

	Base to emitter voltage (with reference to emitter)
Normal	About - 0.8V ~ -1.3V
Abnormal	About - 0.0V ~ -0.8V

Connector CN6 terminals

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	5C	5B	5E	6C	6B	6E	7C	7B	7E	8C	8B	8E		

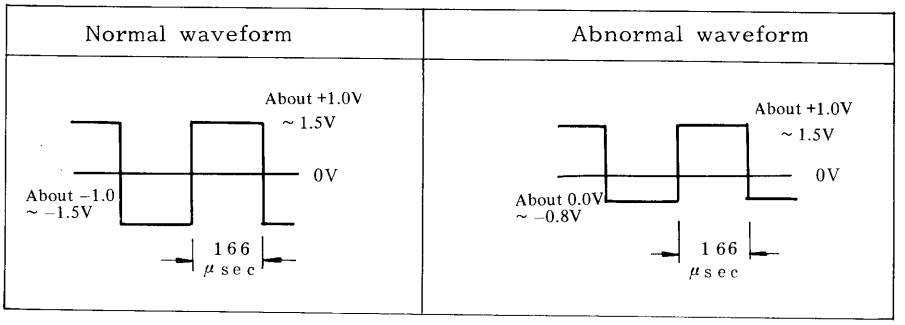
Connector CN7 terminals

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1C	1B	1E	2C	2B	2E	3C	3B	3E	4C	4B	4E			

(Reference)
The following figure indicates normal and abnormal waveforms. Refer to these waveforms, if it is difficult to judge symptoms by using a circuit tester.

Particularly be careful since high voltage (about DC 300V) is applied to CN6 and CN7.

5.2

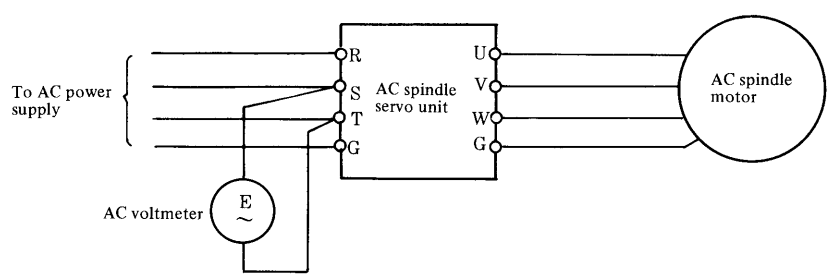
Step	Procedure
5	Apply the normal rotation or reverse rotation command. (Send velocity command 0rpm) Observe the base to emitter waveform of transistors (U, V, W phase, regenerative control circuit) at connectors CN6, CN7 by using an insulated oscilloscope. When F7 is removed, alarm No. 3 occurs. Short check terminal (AR7) with 0V by using a clip. After observation, disconnect this clip without fail.  Observe the following procedure, if a PCB was confirmed to be defective. (i) Fuses FA, FB ... FG are mounted on the driver circuit in and after PCB version number 17H. Check if these fuses are blown out by using a circuit tester. Replace blown out fuses if any, and check 1 and 2 again to confirm that the unit has been recovered. (ii) Replace PCB, if it does not correspond to (i) or if no fuse is blown out in (i).
6	Connect the motor power cable, replace fuse F7, and restart operation.

(4) Alarm No. 4 AC input fuses (F1, F2, F3) are blown out.

Item	Causes	Check procedure	Remedy
1	High impedance on AC power supply side. (Note 1) (Example) Two transformers are connected in series or when a variable autotransformet is connected.	° Alarm No.4 lights only when the motor speed is reduced from high speed. ° Alarm No.4 may also light, irrespective of normal condition of F1 ~ F3.	° Replace the power supply having low power impedance. ° Looseness of input cable connector. Example: Open phase due to loosened screws.
2	Transistor module is defective.	See alarm No.3.	See alarm No.3. Replace transistor module and fuse.

Item	Causes	Check procedure	Remedy
3	Diode module or thyristor module is defective.	After disconnecting cables of diode modules DM1 ~ 3 and thyristor modules SM1 ~ 3, check A-k by using a circuit tester. (Defective parts are generally shorted.)	Replace defective parts and fuses.
4	Surge absorbers or capacitors are defective.	Check surge absorbers Z1 ~ 3 and capacitors C4 ~ 6.	Replace defective parts and and fuses.
5	Input fuses not blown out.	Check if it is not applicable to item 1.	Replace the PCB if not applicable to item 1.

Note 1) Power impedance checking method.



1 Calculation formula

$$\frac{E_0 - E_1}{E_0} \times 100\ (\%) < 7\ (\%)$$

where E0: Voltage when the motor stops oerating.

E1: Voltage during acceleration of motor or voltage just before the motor speed begins lowering with a load applied.

5.2

2 Input power specifications

Name	Specifications
Nominal rated voltage	AC200/220V
Allowable voltage fluctuation width	-15% ~ +10%
Power frequency	50/60Hz
Power impedance	Voltage fluctuation due to load (120% load at 30 minute rating): Less than 7%

(5) Alarm No. [5] Fuses AF2 or AF3 on PCB are blown out.

Item	Causes	Check procedure	Remedy
1	PCB is defective	Check AC input voltage. See 5 in para. 5.1.	Replace PCB.
2	Power voltage is abnormal.		

(6) Alarm No. [6] Overspeed (analog detection)

Item	Causes	Check procedure	Remedy
1	PCB setting failure or adjusting failure	Check PCB for normal setting and adjustment (S2, S3, S5).	Change S5 setting.
2	Wrong specification of ROM (memory IC)	Check specification referring to Table 1.1.	Replace ROM.
3	PCB is defective.		Replace PCB.

(7) Alarm No. [7] Overspeed (Digital detection)
Alarm No. [6] Same as in alarm No.6

(8) Alarm No. 8 +24V overvoltage

Item	Causes	Check procedure	Remedy
1	AC power voltage exceeds +10% of the rated value.	Check power voltage.	
2	Setting failure of voltage selection toggle switch.	Check power voltage.	Setting from 200V to 220V.

(9) Alarm No. 9 Radiator is overheated.

Item	Causes	Check procedure	Remedy
1	Cooling fan is defective.	Check if fan is stopping.	Replace fan.
2	Overload operation.	Check load by using a load meter.	Re-examine the cutting condition.
3	Dusty and dirty.		Clean using compressed air or vacuum cleaner.

(10) Alarm No. 10 +15V voltage drop.

This alarm indicates abnormally low AC power voltage (-15% or less).

(11) Alarm No. 11 Overvoltage of DC link circuit.

Item	Causes	Check procedure	Remedy
1	Fuses F5 and F6 are blown out.	Check fuses F5, F6 by using a circuit tester. If these fuses are blown out. Check transistor module by the same procedure as in alarm No.3.	Replace fuses.
2	High power impedance.		Examine AC power specification.
3	PCB is defective.		Replace PCB.

(12) Alarm No. 12 Overcurrent flows to DC link circuit.

Item	Causes	Check procedure	Remedy
1	Output terminals or internal circuit of motor is shorted.	Check connections.	
2	Transistor module is defective.	Check it by the same procedure as in alarm No.3.	Replace defective parts.
3	PCB is defective.		Replace PCB.

(13) Alarm No. 13 CPU alarm.
Replace PCB.

(14) Alarm No. 14 ROM is defective.

Item	Causes	Check procedure	Remedy
1	ROM is not mounted at all or not properly mounted.	Check if ROM is unplugged from the socket or if its leads are broken.	Mount ROM properly.
2	ROM is defective		Replace ROM having correct specification. (see Table 1.1)

5.3 Motor does not Rotate, or Motor does not Rotate at the Specified Revolutions

Item	Causes	Check procedure	Remedy
1	Fault analysis	Alarm lamp lights on spindle servo unit when rotation command is given.	Proceed to 5.2.
		Alarm lamp does not light.	Proceed to item 2 or 3.
2	Command signal connection failure.	Check signal cable connection.	
3	PCB is defective.		Replace PCB.

5.4 Vibrations or Noises are Noticeable during Rotation

Item	Causes	Check procedure	Remedy
1	Motor is defective.		Replace motor.
2	PCB is defective.	Run the motor idly. When the connector CN2 from AC spindle servo unit while rotating the motor, overheat alarm occurs, and the motor runs idly. If vibrations and noises.are reduced duting idle run as compared with normal rotation time, the control circuit is defective.	Replace PCB.

5.5 Abnormal Noise is Produced from Motor during Deceleration

During deceleration of the motor, energy is regenerated to the power supply through the regenerative control circuit.

If the regenerative energy is excessive, the regeneration limiter circuit operates to change the motor current waveform, causing an abnormal noise to be produced from the motor.

If such a case, turn RV6 (this is normally set to division 3) counterclockwise untill no abnormal noise is produced. When RV6 is turned counterclockwise, the deceleration time increases.

5.6 Speed Overshooting or Hunting Occurs

Item	Causes	Check procedure	Remedy
1	PCB setting or adjustment failure.	Increase gain by turning RV12 (standard division 5) clockwise.	Readjust RV12.
2	Spindle hunting occurs.	Decrease gain by turning RV12 counterclockwise.	Readjust RV12.

5.7 Cutting Power is Low

Item	Causes	Check procedure	Remedy
1	ROM specification is wrong.	Check it referring to Table 1.1.	Replace ROM.
2	Torque limitation command is applied.	Check signal.	
3	Loosened belt.	Check belt for proper tension.	

5.8 Orientation is not Correct

Item	Causes	Check procedure	Remedy
1	Setting or adjusting failure of orientation control circuit.	Check if circuit is set and adjusted as specified in data sheet.	Refer to setting and adjustment of spindle orientation control circuit in chapter 7.
2	Orientation control circuit PCB is defective.		Replace PCB.
3	Spindle control PCB is maladjusted.		Adjust PCB.
4	Position detection (position coder or magnetic sensor) is defective.	Check the output signal waveform of the position detector. (For the magnetic sensor, refer to appendix 10.)	Replace the position coder or magnetic sensor.

5.9 Acceleration/Deceleration Time is Long

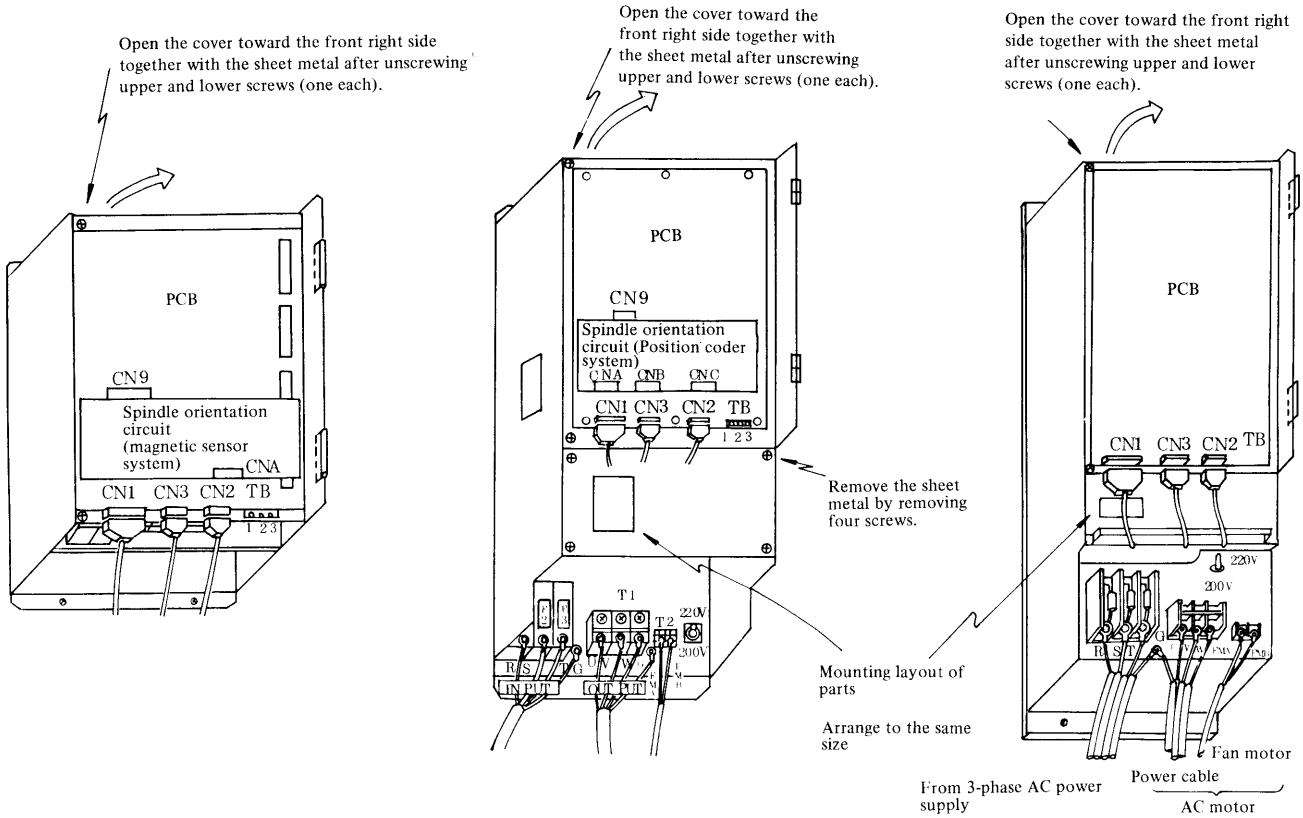
Item	Causes	Check procedure	Remedy
1	Torque limitation command is applied.	Check signal.	
2	ROM specification is wrong.	Check if referring to Table 1.1.	Replace ROM.
3	Defection of the regenerative circuit.	See alarm No. 2 item 3.4.	
4	PCB is maladjusted.	If RV6 is set lower than necessary, the deceleration time increases (see para. 5.5).	Readjust RV6.

6.

6. EXCHANGE METHODS OF FUSES AND PCB

6.1 Exchange of Fuses

Replace fuses F1 ~ F7 in AC spindle servo unit after opening the unit cover as shown in 6.1.



(i) • Spindle servo unit for AC spindle motor models 3 and 6,
• Small type spindle servo unit for AC spindle motor models 8 and 12.

(ii) Spindle servo unit for AC spindle motor models 8, 12 and 15

(iii) Spindle servo unit for AC spindle motor models 18 and 22

Fig. 6.1 How to open the AC spindle servo unit cover

6.2 Exchange of PCB

Table 6.2(a) How to Remove PCB

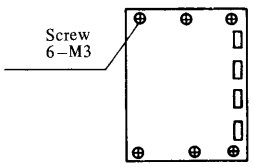
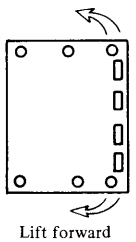
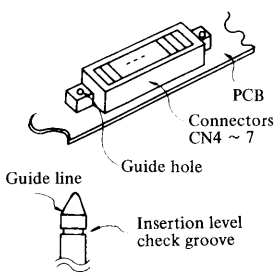
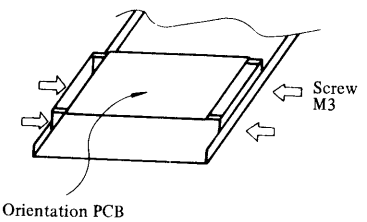
Step	Procedure
1	Disconnect cables from PCB after turning off power supply. Record the correspondence between cables and connector No.
2	Remove six screws fixing PCB. 
3	Gradually lift the upper right and lower right part of PCB forward at a time, and remove PCB by disconnecting connectors CN4 ~ 7 (pins are inserted from the rear side). 

Table 6.2(b) How to mount PCB

Step	Procedure
1	After setting the guide holes of PCB connectors CN4 ~ 7 to the guide pins on the unit side and insert CN4 ~ 7 until check groove (see right figure) appears on the PCB connector surface. 
2	Fix PCB on the unit by using six screws. See step 2 in Table 6.2(a).
3	Connect cables to the connectors.
4	Start operating the unit after confirming the ROM specification and PCB setting.

6.3 Exchange of Spindle Orientation Control Circuit PCB

Table 6.3 How to Remove PCB

Step	Procedure
1	Remove the entire PCB from the spindle control unit according to Table 6.2(a) disconnect cables connecting PCB.
2	Remove 4 screws which fix the stays of spindle orientation control circuit PCB. 

Mount PCB by reversing the procedure specified in Table 6.3.

7. SPINDLE ORIENTATION CONTROL CIRCUIT

This chapter describes instructions for maintenance, installation, and adjustment when a pure electric orientation (constant position stop) function is attached to the spindle of an NC machine tool.

7.1 Configuration

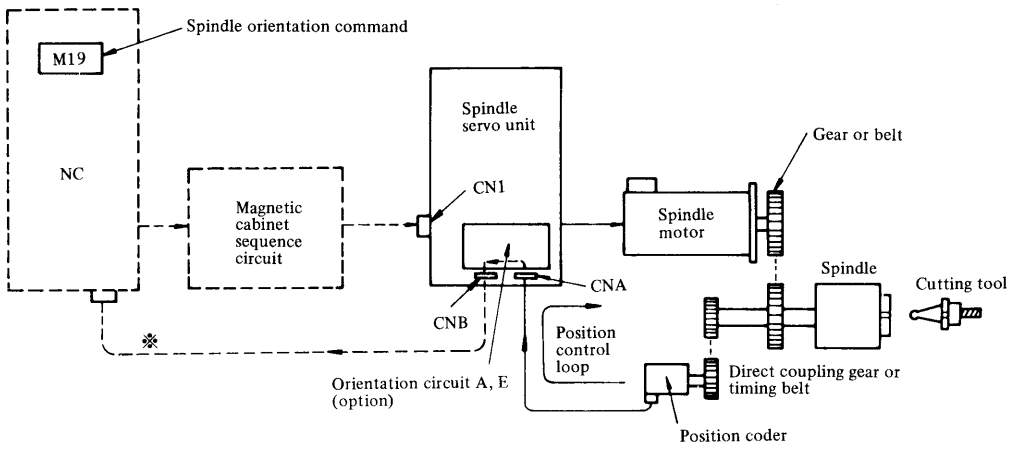


Fig. 7.1(a) Configuration of spindle orientation using position coder (Internal stop position setting type)

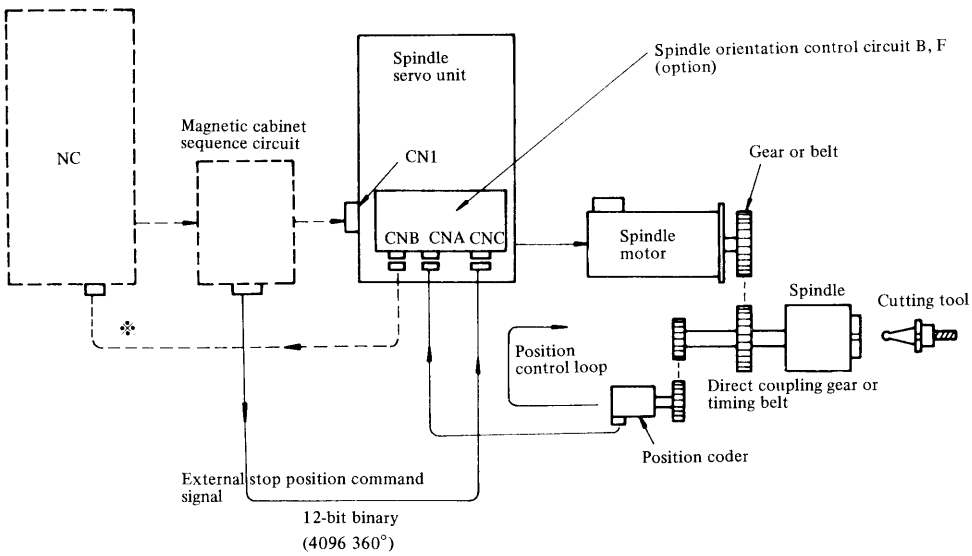


Fig. 7.1(b) Configuration of spindle orientation using position coder (External stop position setting type)

Note 1) If a position coder is mounted on a lathe, etc., it is applicable to this system.

Note 2) Asterisked cable route is employed when the position coder of the lathe or sync. feed position coder in machining center is combined.

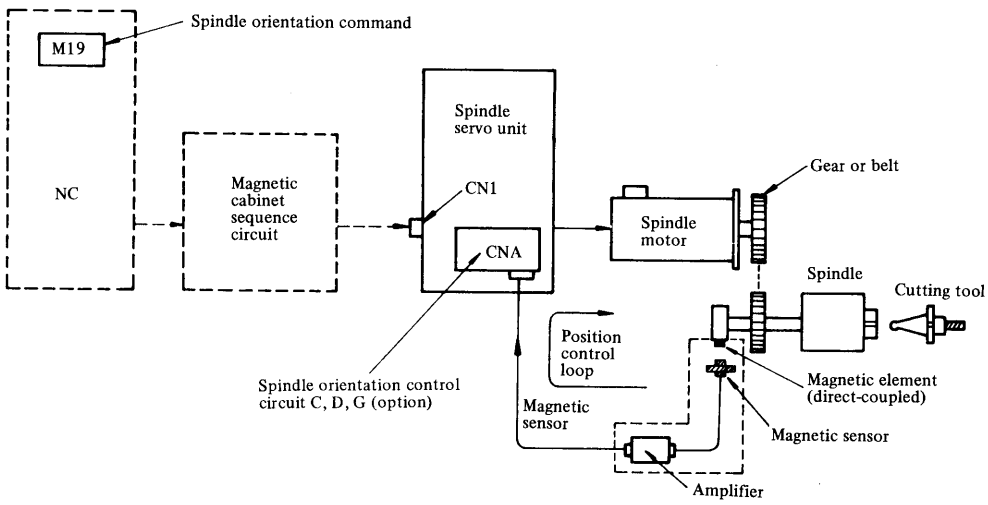


Fig. 7.1(c) Configuration of spindle orientation using magnetic sensor

7.2 Adjustment of Position Coder System Spindle Orientation Control Circuit

7.2.1 Specifications of PCB

Type	Speed change step corresponding to the spindle axis	Stop position	PCB drawing number
Orientation A	2 or less speed change steps	Internal setting type (fixed)	A20B-0008-0240
Orientation B		External setting type (variable)	A20B-0008-0241
Orientation C	3 or 4 speed change steps	Internal setting type (fixed)	A20B-1000-0460
Orientation D		External setting type (variable)	A20B-1000-0461

7.2.2 Setting and adjustment of spindle orientation control circuit in 2-step spindle speed change

Orientation A, B (A06B-6041-J110, J111) are required. Setting and adjustment for PCB A20B-0008-0240, 0241 are described in the followings.

(1) Display contents

The following display is done using LED.

LED No.	Symbol	Lighting color	Description
LED 1	ORIENTATION	Green	Lights when orientation command (ORCM1, 2 ON) is input.
LED 2	LOW	Green	Lights when cluth switching signal *CTH contact is closed. It means that cluth LOW is selected.
LED 3	IN-POSITION OUT	Green	Light when orientation end signal ORAR1-2 is sent.
LED 4	IN-POSITION ADJUST	Green	Lights when spindle enters within 1 pulse width of orientation command position. Adjust OFFSET adjusting RV3/RV5 so that this LED lights at gear HIGH/LOW, and the stop positions at gear HIGH and LOW coincide with each other.

(2) Setting

(a) Setting position coder power supply

If the position coder power supply +5V is supplied from the spindle amplifier, short the circuit between +5V-5H and 0G-0V. Open the circuit between +5V-5H and 0G-0V when +5V is supplied from NC machine tool.

(b) Setting of SW4 and SW5

Position coder	Type	SW4	SW5
Balanced type	Type A	Right	Right
Unbalanced type	Type B	Left	Left

(c) Setting of SH01, SH02, SH03

Set SH01, SH02, and SH03 according to the following table.

Table 7.2.2 Setting of SH01, SH02 and SH03

O indicates short-circuit, while
× indicates opening.

No.	Setting contents		SH01								SH02								SH03		Remarks
			1 | 16	2 | 15	3 | 14	4 | 13	5 | 12	6 | 11	7 | 10	8 | 9	1 | 16	2 | 15	3 | 14	4 | 13	5 | 12	6 | 11	7 | 10	8 | 9	1 | 2	2 | 3	
1	Setting of rotating direction in the first orientation after turning on the power switch.	CCW	O	×																	(Standard)
		CW	×	O																	
2	Setting of rotating direction in the second and subsequent orientation.	CCW direction only			×	O															(Standard)
		CW direction only			×	×															
		Same as rotating direction			O	×															(Standard)
3	Setting to clamp the orientation speed determined by position gain to 1, 2/3 and 1/3.	1					×	×													
		2/3					O	×													
		1/3					×	O													
4	Setting by spindle rotation and rotating direction of position coder.	Same direction							O	×											Depens upon machine tools. Hunting occurs, if this setting is inverted.
		Opposite direction							×	O											
5	Setting of the in-position width when orientation end signals (ORAR1, 2) are output.	±2 pulse									O	O	O	O	O	O					(±16 pulse corresponds to ±1.3°)
		±4										O	O	O	O	O					
		±8											O	O	O	O					
		±16												O	O	O					
		±32													O	O					
		±64														O					
6	Setting by hysteresis of position coder	No compensation															×	×			(Standard)
		+1 pulse															O	×			
		-1 pulse															×	O			
7	Setting according to the types of spindle servo unit.	DC																	O	×	When DC spindle servo unit is used.
		AC																	×	O	When AC spindle servo unit is used.

(Note) Send condition (C) of orientation end signal.

* The angle position is located with the in-position setting pulse range.

* Velocity zero signal is turned on.

* ORCM is turned on.

(d) Setting of position switches (SW1, 2, 3)

Setting switch	Description
SW1	16 divisions every 22.5° 4096/16=256 pulses 1 division Inching
SW2	16 divisions every 1.4° 256/16=16 pulses 1 division Inching
SW3	16 divisions every 0.088° 16/16=1 pulses 1 division Inching

The spindle can be stopped at an optional point during one rotation in the unit of 1/4096 360°=0.088° by setting these switches in the order of SW1, SW2, SW3.

(3) Adjustments

No.	Item	Name of variable resister	Standard adjustment	Measuring point	Description
1	Speed feedback voltage OFFSET	RV1	5 divisions	TSA2 CH14 (TSA2)	Adjust RV1 until TSA2 voltage becomes 0 ±1 mV.
2	Gear HIGH position gain	RV2	3 ~ 4 divisions	Spindle motion or CH14	Set the gain to the maximum within a range where the spindle does not overshoot.
3	Gear HIGH offset	RV3	About 5 divisions	LED 4 (ADJUST)	Adjust RV3 until LED4 lights or flickers.
4	Gear LOW position gain	RV4	3 ~ 6 divisions	Spindle motion or CH14	Set the gain to the maximum within a range where the spindle does not overshoot.

No.	Item	Name of variable resister	Standard adjustment	Measuring point	Description
5	Gear LOW offset	RV5	About 5 divisions	LED4 (ADJUST)	Adjust RV3 until LED4 lights or flickers.
6	Speed loop gain (in case of DC spindle motor)	RV6DC	0 division	CH14	Make sure that motor not hunting. The rigidity increases during stop by turning these RV clockwise.
7	Speed loop gain (in case of AC spindle motor)	RV6AC	7 divisions	CH14	

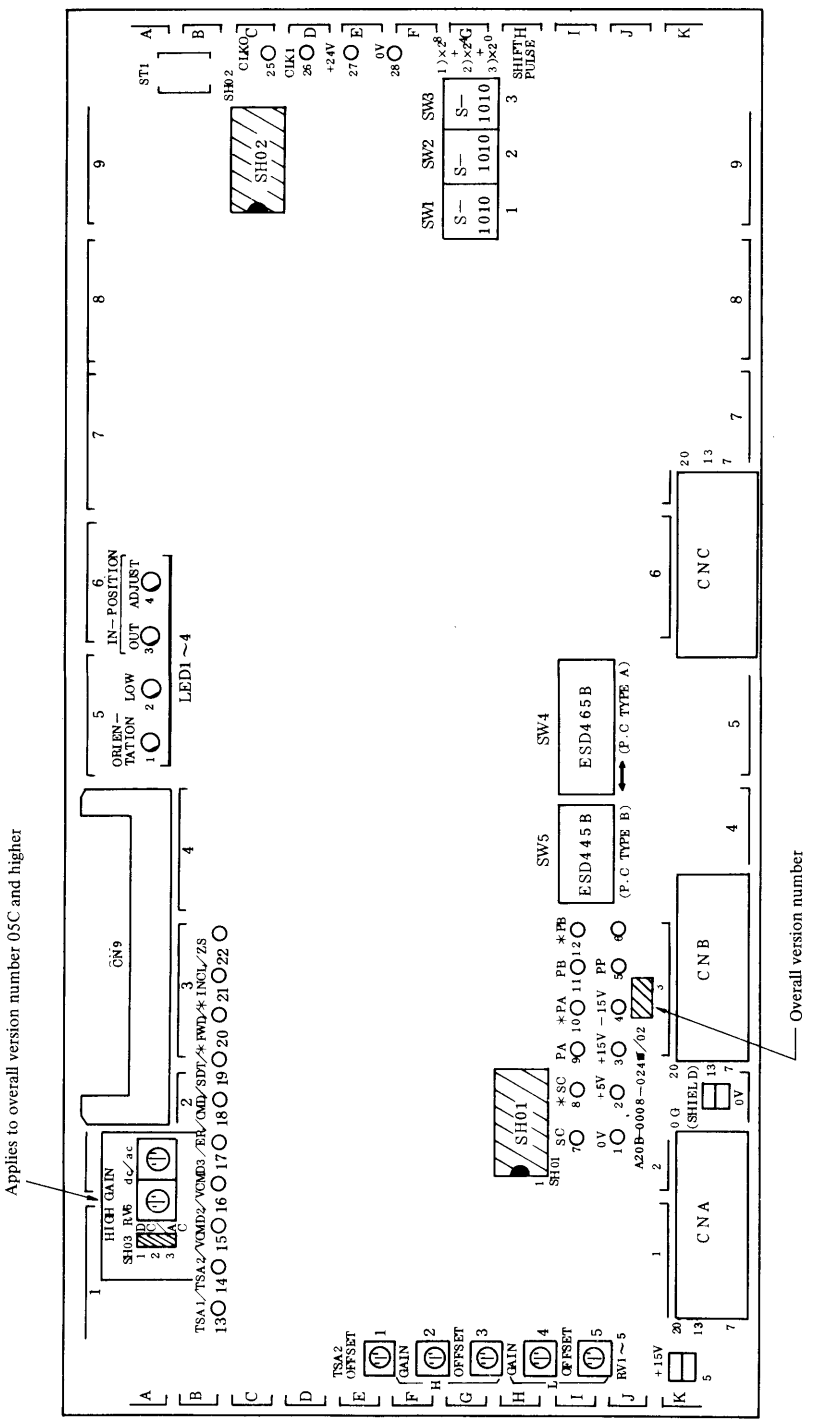


Fig. 7.2.2(1) Mounting positions of check terminals, variable resistors, setting pins, and light-emitting diodes (LED) (PCB A20B-0008-0240, 0241)

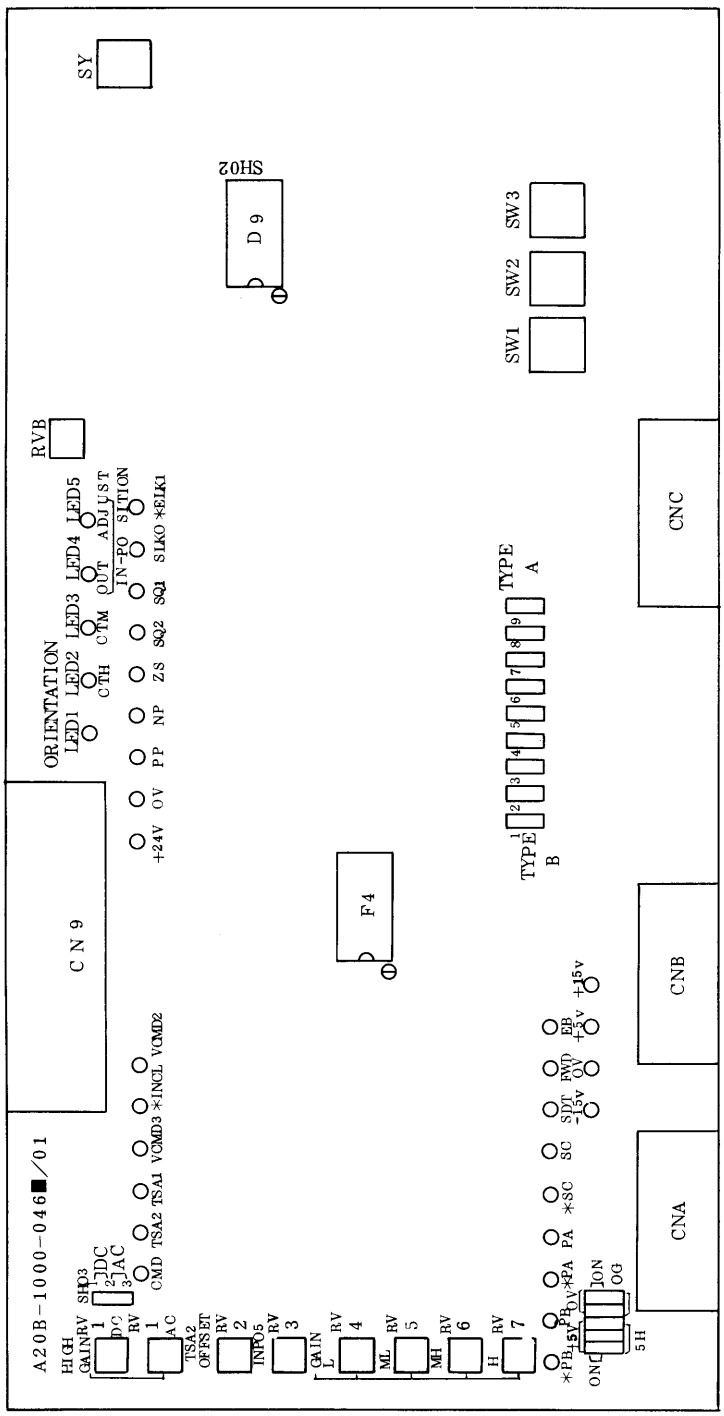


Fig. 7.2.2(2) Mounting place of check terminal, variable register, setting pin, LED

7.2.3 Setting and adjustment for spindle orientation control circuit in 3 or 4 step spindle speed change

Orientation E, F (A06B-6041-J130, J131) are required. Setting and adjustments for the PCB A20B-1000-0460, 0461 are described in the followings.

(1) Display contents

LED No.	Symbol	Description
LED1	ORIENTATION	Lights when orientation command is input.
LED2	CTH	Lights when CTH signal (spindle speed change) is input.
LED3	CTM	Lights when CTM signal (spindle speed change) is input.
LED4	IN-POSITION OUT	Lights when the machine is positioned within the setting pulse width of the stop position after orientation motion. The stop position width is set by SH02 01-06 pins.
LED5	IN-POSITION AJUST	Lights when the machine is positioned within ±2 pulses of the specified stop position. Adjust RV3 so that LED5 lights when the orientation has been completed.

(2) Setting

(a) Setting position coder power supply

If the position coder power supply +5V is supplied from the spindle amplifier, short the circuit between +5V-5H and 0G-0V. Open the circuit between +5V-5H and 0G-0V when +5V is supplied from NC machine tool.

(b) Setting of SW4 and SW 5

Position coder	Setting for setting terminal 1 ~ 9
Balanced type	Insert short-circuit bars on the type A side (9 positions)
Unbalanced type	Insert short-circuit bars on the type B side (9 positions)

(c) Setting of SH01, SH02, SH03

Set SH01, SH02, and SH03 according to the following table.

Table 7.2.3 Setting of SH01, SH02 and SH03

O indicates short-circuit, while
× indicates opening.

No.	Setting contents		SH01								SH02								SH03		Remarks
			1 | 16	2 | 15	3 | 14	4 | 13	5 | 12	6 | 11	7 | 10	8 | 9	1 | 16	2 | 15	3 | 14	4 | 13	5 | 12	6 | 11	7 | 10	8 | 9	1 | 2	2 | 3	
1	Setting of rotating direction in the first orientation after turning on the power switch.	CCW	O	×																	(Standard)
		CW	×	O																	
2	Setting of rotating direction in the second and subsequent orientation.	CCW direction only			×	O															(Standard)
		CW direction only			×	×															
		Same as rotating direction			O	×															(Standard)
3	Setting to clamp the orientation speed determined by position gain to 1, 2/3 and 1/3.	1					×	×													
		2/3					O	×													
		1/3					×	O													
4	Setting by spindle rotation and rotating direction of position coder.	Same direction							O	×											Depens upon machine tools. Hunting occurs, if this setting is inverted.
		Opposite direction							×	O											
5	Setting of the in-position width when orientation end signals (ORAR1, 2) are output.	±2 pulse									O	O	O	O	O	O					(±16 pulse corresponds to ±1.3°)
		±4										O	O	O	O	O					
		±8											O	O	O	O					
		±16												O	O	O					
		±32													O	O					
		±64														O					
6	Setting by hysteresis of position coder	No compensation															×	×			(Standard)
		+1 pulse															O	×			
		-1 pulse															×	O			
7	Setting according to the types of spindle servo unit.	DC																	O	×	When DC spindle servo unit is used.
		AC																	×	O	When AC spindle servo unit is used.

(Note) Send condition (C) of orientation end signal.

* The angle position is located with the in-position setting pulse range.

* Velocity zero signal is turned on.

* ORCM is turned on.

(d) Setting of position switches (SW1, 2, 3)

Setting switch	Description
SW1	16 divisions every 22.5° 4096/16=256 pulses 1 division Inching
SW2	16 divisions every 1.4° 256/16=16 pulses 1 division Inching
SW3	16 divisions every 0.088° 16/16=1 pulses 1 division Inching

The spindle can be stopped at an optional point during one rotation in the unit of 1/4096 × 360° = 0.088° by setting these switches in the order of SW1, SW2, SW3.

(3) Adjustment

No.	Item	Name of variable resister	Measuring point	Standard adjusting value	Description
1	Orientation high gain	RV1 DC (for DC motor)		0 division	Rigidity increases when turning clockwise during stop.
2	Orientation high gain	RV1A AC (for AC motor)		7 divisions	
3	Velocity feedback voltage offset	RV2	TSA2	5 divisions	Adjust until the voltage becomes 0 ±1 mV when the spindle is stopping.
4	Fine position adjustment	RV3	VCMD3	5 divisions	Adjust so that LED5 (ADJST) lights at high gear position gain.
5	Low gear position gain CTH-ON. CTM-ON	RV4	Spindle motion (TSA2)	2 divisions	Set the gain to the maximum within a range where the spindle does not overshoot.
6	M.Low gear position gain CTH-ON.CTM-OFF	RV5	Spindle motion (TSA2)	2 division	Set the gain to the maximum within a range where the spindle does not overshoot.
7	M.Low gear position gain CTH-OFF.CTM-ON	RV6	Spindle motion (TSA2)	2 division	Set the gain to the maximum within a range where the spindle does not overshoot.

No.	Item	Name of variable resister	Measuring point	Standard adjusting value	Description
8	High gear position gain CTH-OFF. CTM-OFF	RV7	Spindle (TSA2)	2 division	Set the gain to the maximum within a range where the spindle does not overshoot.
9	ER voltage offset adjustment	RV8	ER	0 ±1 mV	Adjusted before delivery.
			Note) 1. Set SW1 ~ 3 as follows. SW1 ... 8 divisions, SW2, SW3 ... 0 division 2. Set No. 1 ~ 4 setting pins (type A/B) to OFF. 3. Perform the above adjustments after motor has been rotating with the orientation command turned on.		

7.3 Adjustment of Magnetic Sensor Type Spindle Orientation Control Circuit

7.3.1 Mounting method of magnetizing element and magnetic sensor

Determine the mounting directions of the magnetizing element and magnetic sensor according to the following procedure. If they are not mounted correctly, the spindle may repeat normal rotation and reverse rotation without being stopped, the hunting occurs, or the spindle stops at the position where the magnetizing element end is opposite to the sensor head.

Mounting procedure of magnetizing element and magnetic sensor

Item	Procedure
1	Mount the magnetizing element is such a way as the reference hole moves and faces as shown in Fig. 1 when the spindle is turned by the spindle motor normal rotation command (SFR, VCMD: Positive).
2	Mount the magnetic sensor head so that the pin hole of the flange is opposite to the reference hole.
3	Adjust the gap between the magnetizing element and the sensor head, so that the minimum gap value L becomes L=1.5±0.5mm.

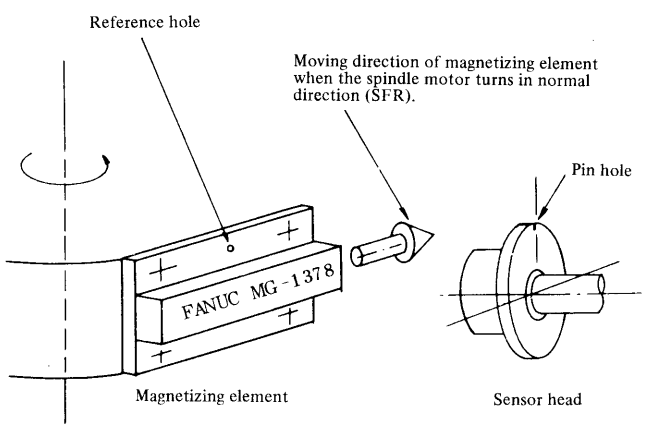


Fig. 7.3.1(a) Mounting direction of magnetizing element (Reference drawing)

7.3.2 Setting and adjustment of spindle orientation control circuit in 2-step speed change spindle for standard type for standard type

The orientation C (A06B-6041-J120), (PCB A20B-0008-0030) is required. This circuit is set and adjusted as follows.

(1) Setting and adjustment of setting terminals (SH)

Table 7.3.2 (1) shows the setting and functions of setting terminals (SH). Select these terminals by user.
Terminal SH01 is provided for adjustment and testing at site. Set this SH01 terminal after turning on the power supply, and disconnect it after adjustment without fail.
(Make sure that LED7 goes out)

Table 7.3.2 (1) Setting and Functions of Setting Terminals (SH)

Setting and functions of setting terminals (SH) (The double frame indicates standard setting)				
Setting (Note 1)			Function	Remarks
SH	1-2	2-3		
01		O	Sets the test mode. (Note 2)	Set for adjustment only.
02	O	X	Rotates the motor shaft end clockwise when the orientation command is given before operating the spindle after turning on the power supply.	SH03 setting takes precedence of SH02. This is effective only when SH03: 1-2 are shorted.
	X	O	Rotates -------- counterclockwise	
03	O	X	Orients in the direction the spindle was turning just before the orientation command was given.	SH02 setting becomes effective.
	X	O	Orients the spindle counterclockwise at all times.	
	X	X	Orients the spindle clockwise at all times.	

7.3

Setting (Note 1)			Function	Remarks
SH	1-2	2-3		
04	X	X	Sets the initial orientation speed to about 60 (spindle position loop gain sec^{-1}) of the spindle.	Since the position loop gain of spindle is 5 sec^{-1} in general, the initial speed is about 300 rpm without limitation.
	O	X	Limits the initial orientation speed to 1/3.	
	X	O	Limits the initial orientation speed to 2/3.	
05	O	X	For DC spindle servo unit.	
	X	O	For AC spindle servo unit.	

Note 1) O indicates short-circuit, while X indicates opening.

Note 2) Method of setting the TEST MODE.

(1) Turn on spindle orientation command.

(2) Spindle orientation end signal (ORAR1, 2) is not sent.

(3) The spindle turns at the initial orientation speed, while the SW1 (INITIALIZING BUTTON) is being depressed and the spindle stops at the fixed position when SW1 is released.

(4) Red LED7 lights in this mode.

(2) LED display contents

Seven indicator lamps LED1 ~ 7 are mounted on spindle orientation control circuit C PCB. The following table shows their display contents.
Neither LED1 nor LED2 is mounted on PCB of 01A version.

LED display contents			
LED	Display contents	Lighting color	Description
1	ORIENTATION (Orientation in progress)	Green	Lights when spindle orientation command is given (ORCM1 and 2 are shorted).
2	LOW (Clutch (gear) LOW)	Green	Lights when clutch (gear) LOW signal is turned on (*CTH1 and 2 are shorted).
3	MS PEAK LEVEL (Magnetic flux detection signal peak value adjusting indicator)	Green	This adjusting indicator lights when the peak value of the magnetic flux detection signal (MS) exceeds ±10V.
4	SLOWDOWN PERIOD (Low-speed rotation period adjusting indicator)	Green	Lights when the spindle approaches the stop position and enters the low speed rotation area during spindle orientation motion.
5	IN POSITION FINE (In-position adjusting indicator)	Green	Lights when the magnetic flux signal (output) value is within the setting range of 0.1° as a converted spindle angle. This LED5 may also light when the sensor is not positioned on the magnetizing element.
6	IN-POSITION (In-position in progress)	Green	Lights when the spindle is within ±1° of the aimed adjusting position after completion of spindle orientation. The spindle orientation end signal (ORAR1 and 2 are shorted) is sent whenthis LED is lighting in a mode other than TEST mode.
7	TEST MODE (Test mode in progress)	Red	Lights when setting terminal SH01 pins are shorted. The orientation end signal is not sent in this mode even if the orientation motion is executed.

7.3

(3) Setting of variable resistors

Set the variable resistor groove direction as shown in the following table before starting adjustments.
Asterisked items are readjusted during adjustment procedure described later. Set these items also as the preliminary setting.

Setting and preparation of variable resistors

Name of variable resistor	RV	1*	2*	3	4	5	6*	7*	8	9*	10*	11*	12DC	12AC
Variable resistor scale position		5.0	6.0	①	①	②	2.0	5.0	③	2.0	5.0	5.0	0	7.0

① Setting of RV3 and RV4

Set RV3 and RV4 according to the distance H between the rotation center line of magnetizing element and the center of the sensor head face.

H (mm)	60~65	~70	~75	~80	~85	~90	~95	~100	~105	~110
Scale position	7.0	6.0	5.0	4.0	3.0	2.5	2.0	1.5	1.0	0.5

② Setting of RV5

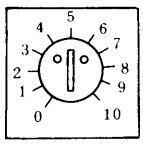
Set RV5 according to the spindle HIGH revolutions N_{HM} when the spindle motor turns at the rated revolutions.

N_{HM} (rpm)	2,000 ~ 2,200	~ 2,500	~ 2,700	~ 3,100	~ 3,500	~ 4,000	~ 4,500	~ 5,000	~ 5,500	~ 6,000
Scale position	7.5	6.5	5.5	4.5	3.5	2.5	2.0	1.5	1.0	0.5

③ Setting of RV8

Set RV8 according to the spindle HIGH/LOW reduction gear ratio $R_{H/L}$.

$R_{H/L}$	-2.0	-2.2	-2.5	-2.8	-3.2	-3.7	-4.4	-5.3	-6.0	-7.0
Scale position	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	9.5	10



Variable resistor scale

(4) Adjustment of variable resistors

Adjust RV1 - 12, 12DC, and 12AC according to the following table. Adjust the offset and gain of spindle control circuit PCB before adjusting the orientation circuit. When RV12 and RV13 of the spindle control circuit PCB are changed, the stop position may be deviated.

Table 7.3.2 Adjustments of variable resistors

Set the test mode for the following adjustments by shorting SH01 pins.

Item	Name of variable resistor	Item to be adjusted	Conditions	Adjusting method (specification)
1	RV1	TS OFFSET Tachogenerator offset. (Compensation for the difference of the slow down time in normal and reverse rotating direction)	Compare the slow down time during the orientation in normal and reverse directions after completion of this adjustments.	The standard setting value is 5 divisions. Adjust RV1 until the difference of the slow down time between normal and reverse rotation become shorter than 0.1 sec.
2	RV2	MS PEAK LEVEL MS signal amplitude value.	Keep depressing SW1 (initializing button).	Set VR2 to the position where LED3 (MS PEAK LEVEL) starts flickering.
3	RV3	SLOWDOWN REFERENCE Slowdown speed reference.		See 7.3.2.(3) ①
4	RV4	AMS PEAK LEVEL AMS signal amplitude value.		See 7.3.2.(3) ①

7.3

Item	Name of variable resistor	Item to be adjusted	Conditions	Adjusting method (specification)
5	RV5	SLOWDOWN TIME IN HIGH MODE Slowdown time in clutch (gear) high high mode.	Set the clutch (gear) HIGH mode. Stop the spindle at the fixed position by depressing SW1 once. *CTH signal is OFF (option).	LED4 (SLOWDOWN PERIOD) should clearly light at a moment just before the spindle stops.
6	RV6	GAIN (H) Position loop gain.	Same as specified above.	Turn RV6 clockwise to such an extent as does not cause any overshoot when the spindle stops.
7	RV7	IN-POSITION (H) Spindle stop position (H).	Same as specified above.	LED5 (IN-POS FINE) should light during lighting of LED6 (IN-POSITION).
8	RV8	SLOWDOWN TIME IN LOW MODE Slowdown the in clutch (gear) low mode.	Set the clutch (gear) LOW mode. Stop the spindle at the fixed position by depressing SW1 once. *CTH signal is turned on (closed).	LED (SLOWDOWN PERIOD) should clearly light at a moment just before the spindle stops. (See item 5 in this table)
9	RV9	GAIN (L) Position loop gain	Same as specified above.	Turn RV9 clockwise to such an extent as does not cause any overshoot when the spindle stops.
10	RV10	IN-POSITION (L) Spindle stop position (L).	Same as specified above.	LED5 (IN-POS FINE) should light during lighting of LED6 (IN-POSITION).
11	RV11	POSITION SHIFT Spindle stop position shift.		The spindle stop position can be finely adjusted within a range $\pm 1^{\circ}$ the spindle angle.
12	RV12 DC	HIGH GAIN DC High gain	Adjust RV12 when DC spindle servo unit is used.	Standard adjusting value: 7 divisions.

Item	Name of variable resistor	Item to be adjusted	Conditions	Adjusting method (specification)
13	RV12 AC	HIGH GAIN AC High gain	Adjust RV12 when AC spindle servo unit is used.	Standard adjusting value: 7 divisions.

After adjustments, cancel the test mode, and make sure that the LED7 (red) goes out.

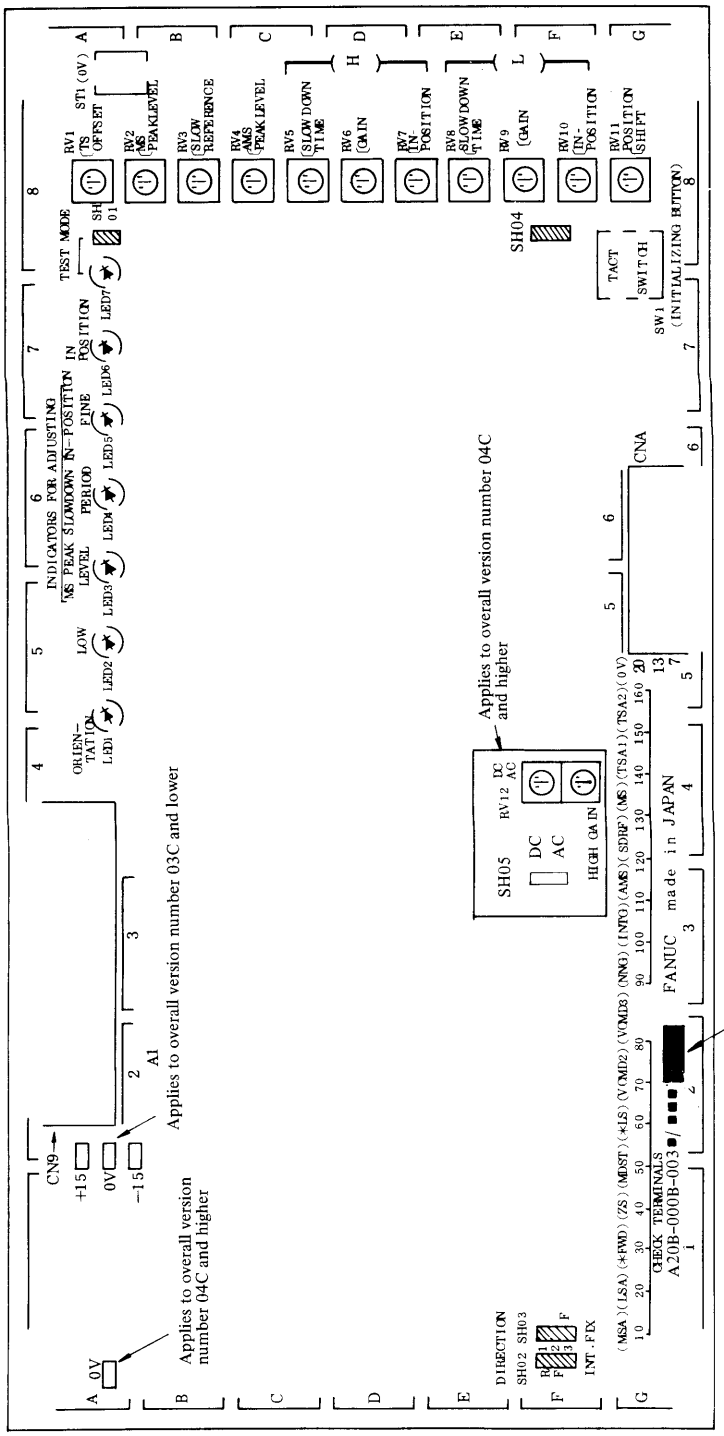


Fig. 7.3.2 Mounting positions of check terminals, variable resistors, setting pins and light-emitting diodes (LED) (PCB A20B-0008-0030)

7.3.3 Setting and adjustment of spindle orientation control circuit in 2-step spindle speed for high speed

The orientation G (A06B-6041-J122), (PCB A20B-0008-0031) is required. This circuit is set and adjusted as follows.

(1) Setting and adjustment of setting terminals (SH)

Table 1 shows the setting and functions of setting terminals (SH). Select these terminals by user.
Terminal SH01 is provided for adjustment and testing at site. Set this SH01 terminal after turning on the power supply, and disconnect it after adjustment without fail.
(Make sure that LED7 goes out)

Table 1 Setting and Functions of Setting Terminals (SH)

Setting and functions of setting terminals (SH) (The double frame indicates standard setting)				
Setting (Note 1)			Function	Remarks
SH	1-2	2-3		
01		O	Sets the test mode. (Note 2)	Set for adjustment only.
02	O	X	Rotates the motor shaft end clockwise when the orientation command is given before operating the spindle after turning on the power supply.	SH03 setting takes precedence of SH02. This is effective only when SH03: 1-2 are shorted.
	X	O	Rotates -------- counterclockwise	
03	O	X	Orients in the direction the spindle was turning just before the orientation command was given.	SH02 setting becomes effective.
	X	O	Orients the spindle counterclockwise at all times.	
	X	X	Orients the spindle clockwise at all times.	

7.3

Setting (Note 1)			Function	Remarks
SH	1-2	2-3		
04	X	X	Sets the initial orientation speed to about 60 (spindle position loop gain sec^{-1}) of the spindle.	Since the position loop gain of spindle is 5 sec^{-1} in general, the initial speed is about 300 rpm without limitation.
	O	X	Limits the initial orientation speed to 1/3.	
	X	O	Limits the initial orientation speed to 2/3.	
05	O	X	For DC spindle servo unit.	
	X	O	For AC spindle servo unit.	

Note 1) O indicates short-circuit, while X indicates opening.

Note 2) Method of setting the TEST MODE.

(1) Turn on spindle orientation command.

(2) Spindle orientation end signal (ORAR1, 2) is not sent.

(3) The spindle turns at the initial orientation speed, while the SW1 (INITIALIZING BUTTON) is being depressed and the spindle stops at the fixed position when SW1 is released.

(4) Red LED7 lights in this mode.

(2) LED display contents

Seven indicator lamps LED1 ~ 7 are mounted on spindle orientation control circuit C PCB. The following table shows their display contents.

LED display contents			
LED	Display contents	Lighting color	Description
1	ORIENTATION (Orientation in progress)	Green	Lights when spindle orientation command is given (ORCM1 and 2 are shorted).
2	LOW (Clutch (gear) LOW)	Green	Lights when clutch (gear) LOW signal is turned on (*CTH1 and 2 are shorted).
3	MS PEAK LEVEL (Magnetic flux detection signal peak value adjusting indicator)	Green	This adjusting indicator lights when the peak value of the magnetic flux detection signal (MS) exceeds ±10V.
4	SLOWDOWN PERIOD (Low-speed rotation period adjusting indicator)	Green	Lights when the spindle approaches the stop position and enters the low speed rotation area during spindle orientation motion.
5	IN POSITION FINE (In-position adjusting indicator)	Green	Lights when the magnetic flux signal (output) value is within the setting range of 0.1° as a converted spindle angle. This LED5 may also light when the sensor is not positioned on the magnetizing element.
6	IN-POSITION (In-position in progress)	Green	Lights when the spindle is within ±1° of the aimed adjusting position after completion of spindle orientation. The spindle orientation end signal (ORAR1 and 2 are shorted) is sent whenthis LED is lighting in a mode other than TEST mode.
7	TEST MODE (Test mode in progress)	Red	Lights when setting terminal SH01 pins are shorted. The orientation end signal is not sent in this mode even if the orientation motion is executed.

7.3

(3) Setting of variable resistors

Set the variable resistor groove direction as shown in the following table before starting adjustments.
Asterisked items are readjusted during adjustment procedure described later. Set these items also as the preliminary setting.

Setting and preparation of variable resistors

Name of variable resistor	RV	1*	2*	3	4	5	6*	7*	8	9*	10*	11*	12DC	12AC
Variable resistor scale position		5.0	5.0	①	①	②	5.0	5.0	③	5.0	5.0	5.0	0	8.0

① Setting of RV3 and RV4

Set RV3 and RV4 according to the distance H between the rotation center line of magnetizing element and the center of the sensor head face.

H (mm)	40~45	~50	~55	~60	~65	~70	~80	~90	~100	~110
Scale position	9.5	7.0	5.0	4.0	3.0	2.5	2.0	1.5	1.0	1.0

② Setting of RV5

Set RV5 according to the spindle HIGH revolutions N_{HM} when the spindle motor turns at the rated revolutions.

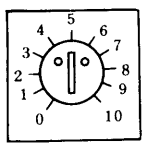
N_{HM} (rpm)	6,000 ~ 6,500	~ 7,000	~ 7,500	~ 8,000	~ 8,500	~ 9,000	~ 9,500	~ 10,000	~ 11,000	~ 12,000
Scale position	6.0	5.0	4.5	4.0	3.5	3.0	2.5	2.5	2.0	1.0

③ Setting of RV8

Set RV8 according to the spindle HIGH/LOW reduction gear ratio $R_{H/L}$.

$R_{H/L}$	~2.2	~2.5	~2.8	~3.2	~3.7	~4.5	~5.0	~6.0	~7.0	~
Scale position	2.0	3.0	4.0	5.0	6.0	7.0	8.0	8.0	9.0	

(4) Adjustment of variable resistors



Variable resistor scale

Adjust RV1 ~ 12, 12DC, and 12AC according to the following table. Adjust the offset and gain of spindle control circuit PCB before adjusting the orientation circuit. When RV12 and RV13 of the spindle control circuit PCB are changed, the stop position may be deviated.

Table 7.3.2 Adjustments of variable resistors

Set the test mode for the following adjustments by shorting SH01 pins.

Item	Name of variable resistor	Item to be adjusted	Conditions	Adjusting method (specification)
1	RV1	TS OFFSET Tachogenerator offset. (Compensation for the difference of the slow down time in normal and reverse rotating direction)	Compare the slow down time during the orientation in normal and reverse directions after completion of this adjustments.	The standard setting value is 5 divisions. Adjust RV1 until the difference of the slow down time between normal and reverse rotation become shorter than 0.1 sec.
2	RV2	MS PEAK LEVEL MS signal amplitude value.	Keep depressing SW1 (initializing button).	Set VR2 to the position where LED3 (MS PEAK LEVEL) starts flickering.
3	RV3	SLOWDOWN REFERENCE Slowdown speed reference.		See 7.3.3(3) 1
4	RV4	AMS PEAK LEVEL AMS signal amplitude value.		See 7.3.3(3) 1

7.3

Item	Name of variable resistor	Item to be adjusted	Conditions	Adjusting method (specification)
5	RV5	SLOWDOWN TIME IN HIGH MODE Slowdown time in clutch (gear) high high mode.	Set the clutch (gear) HIGH mode. Stop the spindle at the fixed position by depressing SW1 once. *CTH signal is OFF (option).	LED4 (SLOWDOWN PERIOD) should clearly light at a moment just before the spindle stops.
6	RV6	GAIN (H) Position loop gain.	Same as specified above.	Turn RV6 clockwise to such an extent as does not cause any overshoot when the spindle stops.
7	RV7	IN-POSITION (H) Spindle stop position (H).	Same as specified above.	LED5 (IN-POS FINE) should light during lighting of LED6 (IN-POSITION).
8	RV8	SLOWDOWN TIME IN LOW MODE Slowdown the in clutch (gear) low mode.	Set the clutch (gear) LOW mode. Stop the spindle at the fixed position by depressing SW1 once. *CTH signal is turned on (closed).	LED (SLOWDOWN PERIOD) should clearly light at a moment just before the spindle stops. (See item 5 in this table)
9	RV9	GAIN (L) Position loop gain	Same as specified above.	Turn RV9 clockwise to such an extent as does not cause any overshoot when the spindle stops.
10	RV10	IN-POSITION (L) Spindle stop position (L).	Same as specified above.	LED5 (IN-POS FINE) should light during lighting of LED6 (IN-POSITION).
11	RV11	POSITION SHIFT Spindle stop position shift.		The spindle stop position can be finely adjusted within a range $\pm 1^{\circ}$ the spindle angle.
12	RV12 DC	HIGH GAIN DC High gain	Adjust RV12 when DC spindle servo unit is used.	Standard adjusting value: 7 divisions.

Item	Name of variable resistor	Item to be adjusted	Conditions	Adjusting method (specification)
13	RV12 AC	HIGH GAIN AC High gain	Adjust RV12 when AC spindle servo unit is used.	Standard adjusting value: 7 divisions.

After adjustments, cancel the test mode, and make sure that the LED7 (red) goes out.

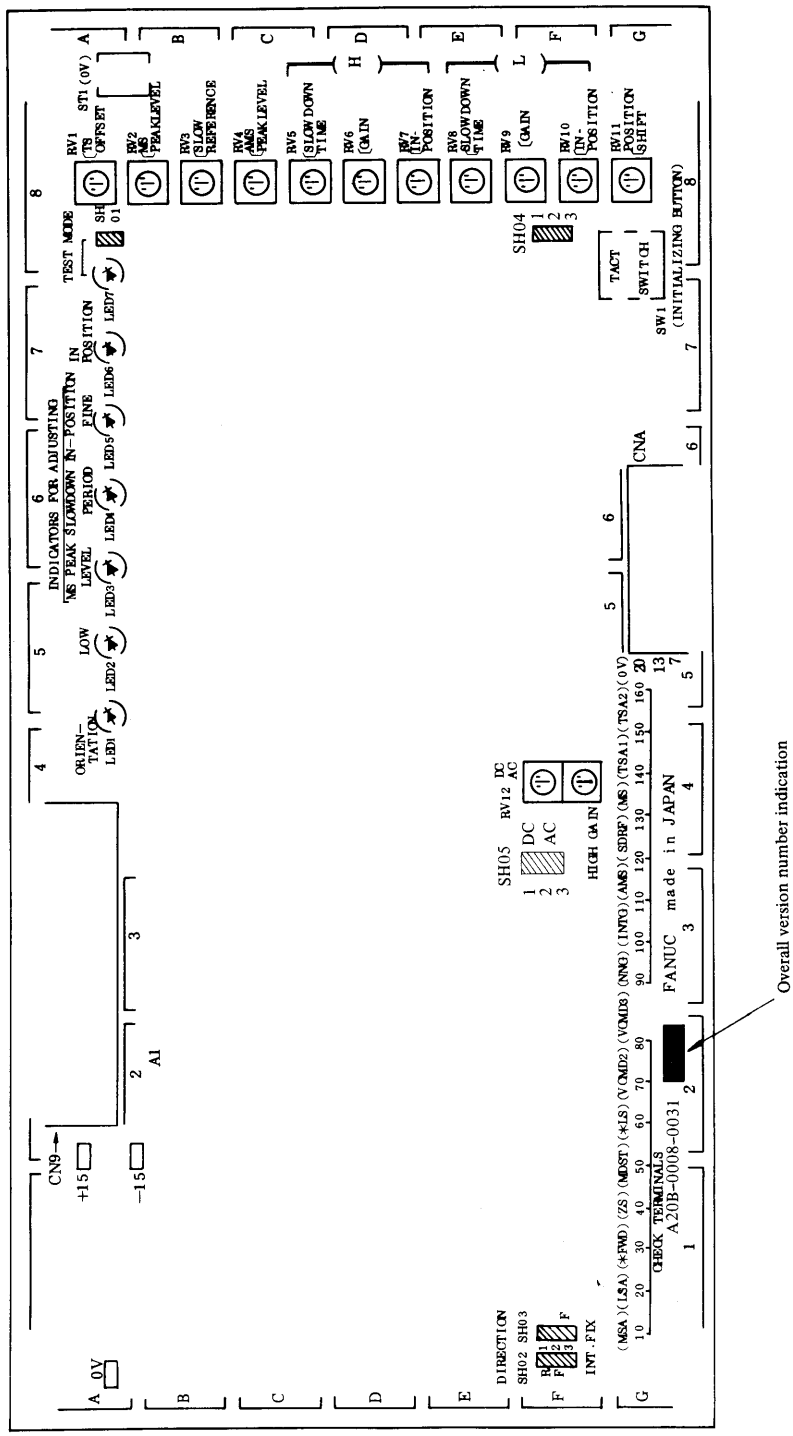


Fig. 7.3.3 Mounting positions of check terminals, variable resistors, setting pins and light-emitting diodes (LED) (PCB A20B-0008-0031)

7.3.4 Setting and adjustment of spindle orientation control circuit in case of 3-step spindle speed change

PCB A20B-0009-0520 is employed as spindle orientation control circuit D (A06B-6041-J121). This paragraph describes the setting and adjusting methods of this circuit.

Note) Be careful since the maximum spindle revolution range is limited at each speed change step.

	Maximum spindle revolution range
High speed	4000 ~ 8000 rpm
Medium speed	1000 ~ 2000 rpm
Low speed	250 ~ 667 rpm

(1) Setting and functions of setting terminals (SH) same as in 3.2.1

(2) LED display contents

LED No.	Symbols	Lighting color	Description
LED 1	ORIENTATION	Green	Lights when orientation command is input.
LED2H	GEAR/CLUTCH	Green	Lights when gear/clutch is set to high positions.
LED2M			Lights when gear/clutch is set to medium position.
LED2L			Lights when gear/clutch is set to low position.
LED 3	MS PEAK LEVEL	Green	Lights when the peak value of MS signal from magnetic sensor is higher than ±10V.
LED 4	SLOWDOWN PERIOD	Green	Lights during the period from the constant low speed just before completion of orientation to the arrival of magnetizing sensor at the sensor position.
LED 5	IN-POSITION FINE	Green	Lights when the spindle is positioned within ±0.1° of the stop position after completion of orientation.

LED No.	Symbols	Lighting color	Description
LED 6	IN-POSITION	Green	Lights when the spindle is positioned within ±1.0° of the stop position after completion of orientation. Orientation end signal is sent when this LED is lighting in a mode other than TEST mode.
LED 7	TEST MODE	Red	Lights when setting terminal SH01 is shorted across 01 and 02.

(3) Adjustments

Observe the following procedure in the test mode after turning on the power supply.

Item	Variable resistor	Adjustment item	Conditions	Adjusting method
1	RV1	TS OFFSET Tachogenerator offset. (Compensation for the difference of the slow down time in normal and reverse rotating direction)	Compare the slow down time during the orientation in normal and reverse directions after completion of this adjustments.	The standard setting value is 5 divisions. Adjust RV1 until the difference of the slow down time between normal and reverse rotation become shorter than 0.1 sec.
2	RV2	MS PEAK LEVEL MS signal amplitude adjustment.	Keep depressing SW1.	Set VR2 at the position where LED3 begins flickering.
3	RV3	SLOW DOWN REFERENCE (Slowdown speed reference)	Check the distance from the spindle center to the sensor head.	Set RV3 and RV4 according to (Note 1).
4	RV4	AMS PEAK LEVEL (AMS signal amplitude value).		
5	RV5	SLOWDOWN TIME (HIGH) (Slowdown time)	Repeat turning on and off SW1 while LED2H (clutch (gear) HIGH) is lighting.	LED4 should clearly light for a moment (about 0.2 sec) just before stopping.
6	RV6	GAIN (HIGH) (Position loop gain)		Turn RV6 clockwise to such an extent as does not cause any overshoot when the spindle stops.

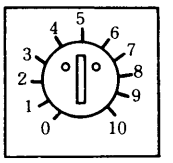
Item	Variable resistor	Adjustment item	Conditions	Adjusting method
7	RV7	IN-POSITION (H) (Spindle stop position adjustment)	Same as above	Adjust RV7 so that LED5 lights concurrently while LED6 is lighting. LED5 may flicker.
8	RV8	SLOWDOWN TIME (LOW) (Slowdown time)	Repeat turning on and off SW1, while LED2L (clutch (gear) LOW) is lighting.	Same as in item 5 in this table.
9	RV9	GAIN (LOW) (Position loop gain)		Same as in item 6 in this table.
10	RV10	IN-POSITION (LOW) (Spindle stop position adjustment)		Same as in item 7 in this table.
11	RV12	SLOWDOWN TIME (MEDIUM) (Slowdown time)	Repeat turning on and off SW1 while LED2M (clutch (gear) MEDIUM) is lighting.	Same as in item 5 in this table.
12	RV13	GAIN (MEDIUM) (Position loop gain)		Same as in item 6 in this table.
13	RV14	IN-POSITION (MEDIUM) (Spindle stop position adjustment)		Same as in item 7 in this table.
14	RV11	POSITION SHIFT (Spindle stop position shift)	The spindle stop position can be finely adjusted down to $\pm 1^{\circ}$ at spindle angle.	Set the key position of ATC arm to the keyway position of spindle.
15	RV15DC	HIGH GAIN DC High gain	Adjustment using DC spindle servo unit.	Standard adjusting value: 0 division.
16	RV15AC	HIGH GAIN AC High gain	Adjustment using AC spindle servo unit.	Standard adjusting value: 7 divisions.

7.3

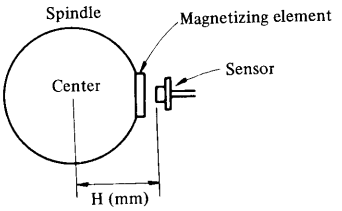
Reset the test mode after adjustments.

Note 1) Adjust RV3 and RV4 according to the distance (H) from the spindle center to the sensor as follows.

H (mm)	50	60	70	80	90	100	110	120
RV3, 4 scale	9.5	6.5	4.5	3.0	2.2	1.5	1.0	0.5



Variable resistor scale divisions



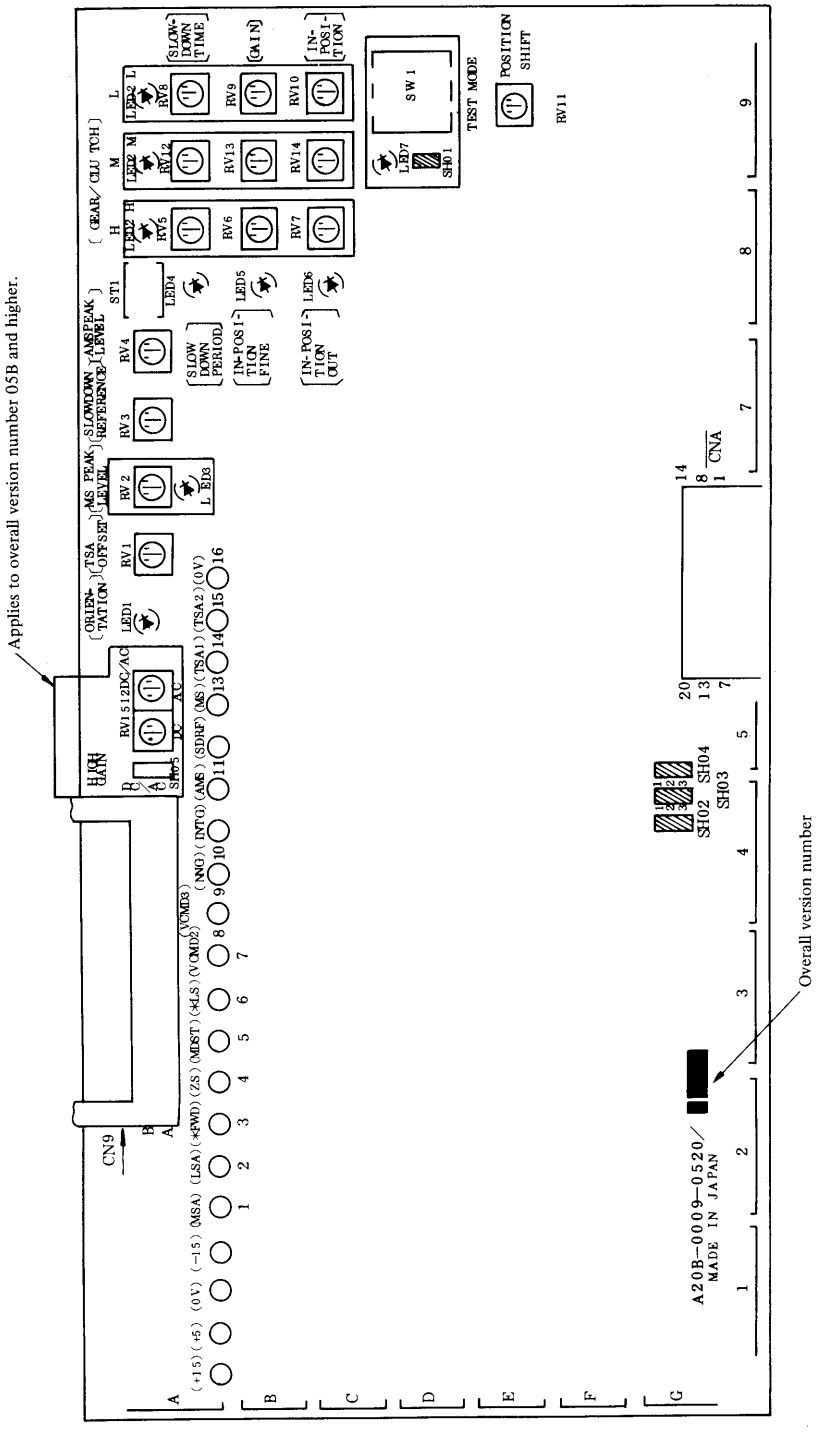


Fig. 7.3.4 Mounting positions of check terminals, variable resistors, setting pins, and light-emitting diodes (LED) (PCB A20B-0009-0520)

7.3.5 Method of checking the spindle position loop gain

The spindle position loop gain can be checked according to the following procedure. Check it after adjusting the spindle orientation control circuit.

Procedure of checking the spindle position loop gain

1	Set the mode to TEST mode (LED7 ON) after shorting setting terminal SH01 pins.
2	Release setting terminal SH04 1-2 and 2-3 pins to release the speed limitation of orientation.
3	Measure spindle revolutions Ns(H), Ns(L) rpm when SW1 (INITIALIZING button) is depressed (turned on) and the spindle clutch (gear) is set to HIGH (*CT *CTH1, 2: Open) and LOW (*CTH1, 2: Closed), respectively.
4	The spindle position loop gain can be obtained by the following formula. K_p (H or L) $\fallingdotseq N_s$ (H or L) ÷ 55 (sec^{-1}) where K_p(H): Position loop gain when the spindle is set to HIGH gear (clutch). K_p(L): Position loop gain when the spindle is set to LOW gear (clutch).

APPENDIX

APPENDIX 1. Connection Diagrams

Fig. 1(a) Connection diagram of AC spindle servo unit (without spindle orientation function combined)

Fig. 1(b) Detailed connection diagram of AC spindle servo unit (without spindle orientation function combined)

Fig. 1(c) Connection diagram of spindle orientation (with position coder employed)

Fig. 1(d) Detailed connection diagram of spindle orientation with position coder employed (when synchronous feed position coder is concurrently used for lathes and machining centers)

Fig. 1(e) Detailed connection diagram of spindle orientation using position coder (when spindle orientation only is used for machining centers)

Fig. 1(f) Detailed connection diagram of spindle orientation using position coder (when the stop position is externally set)

Fig. 1(g) Connection diagram of spindle orientation (when magnetic sensor is used)

Fig. 1(h) Detailed connection diagram of spindle orientation (when magnetic sensor is used)

APPENDIX 1.

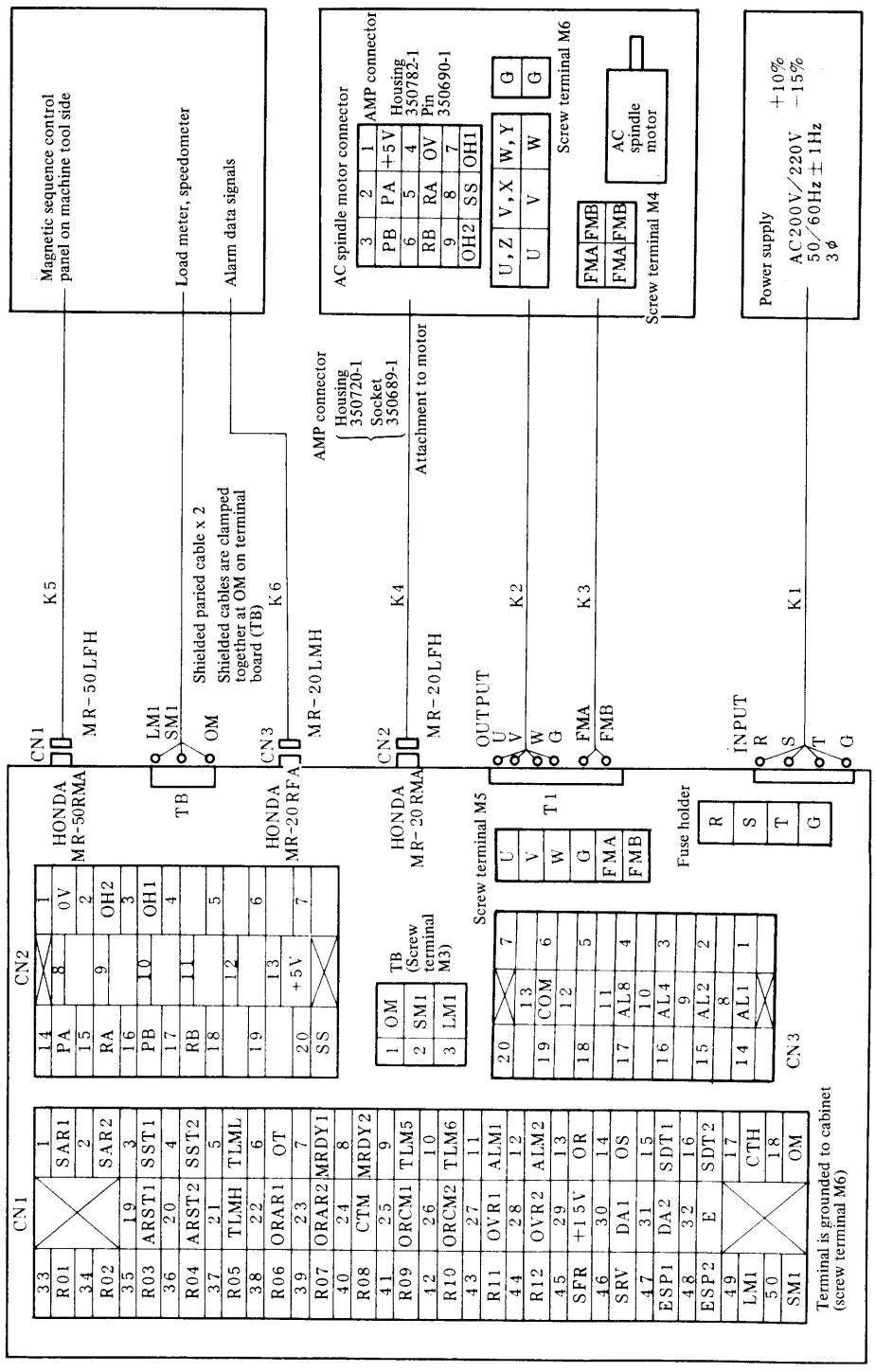
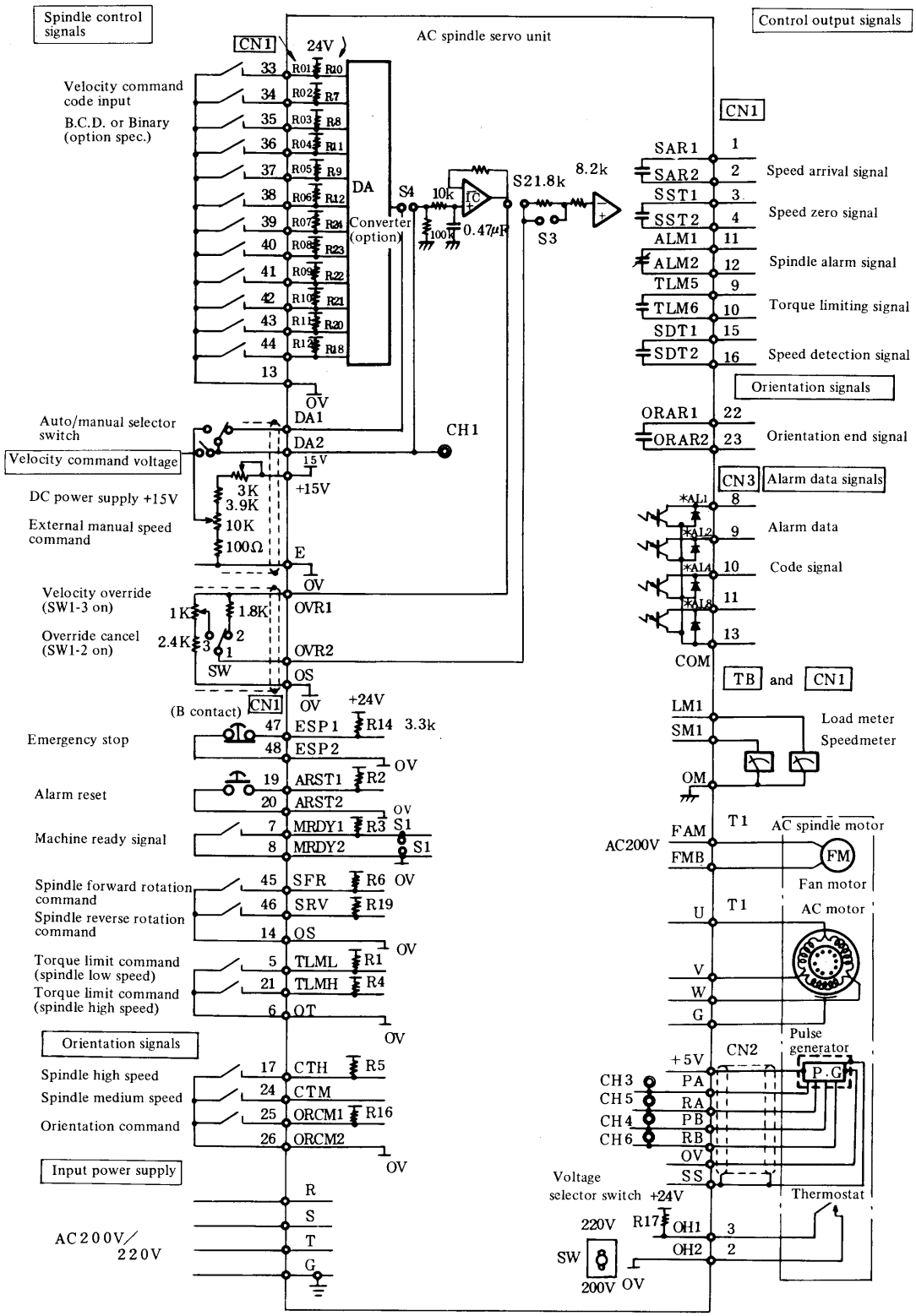


Fig. 1(a) Connection diagram of AC spindle servo unit
(without spindle orientation function combined)



Note) For the mounting position of the input part resister, refer to Appendix 6.

Fig. 1(b) Detailed connection diagram of AC spindle servo unit (without spindle orientation function combined)

APPENDIX 1.

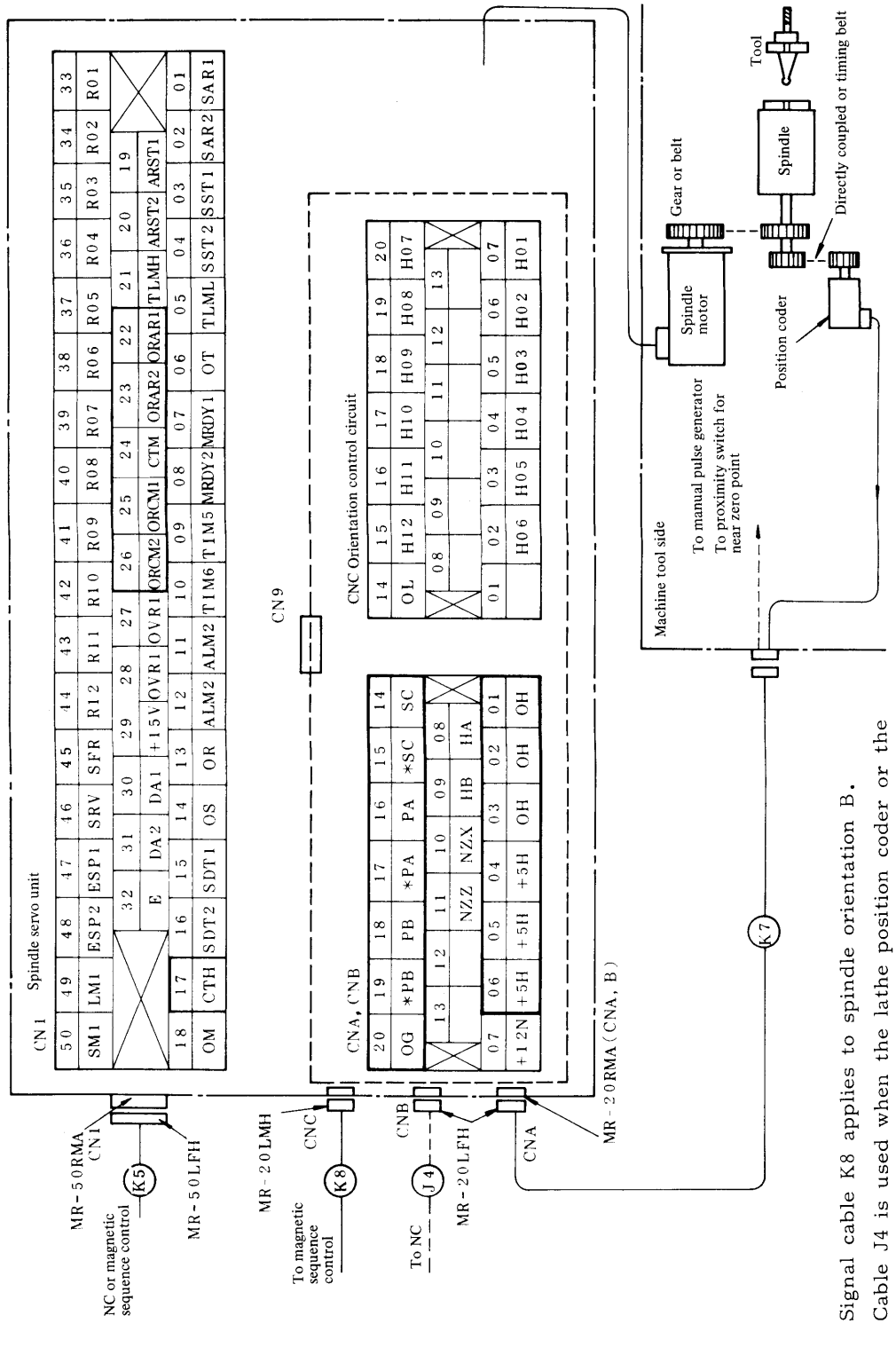


Fig. 1(c) Connection diagram of spindle orientation (with position coder employed)

Note 1) Signal cable K8 applies to spindle orientation B.

Note 2) Cable J4 is used when the lathe position coder or the synchronous feed position coder for machining center is used concurrently.

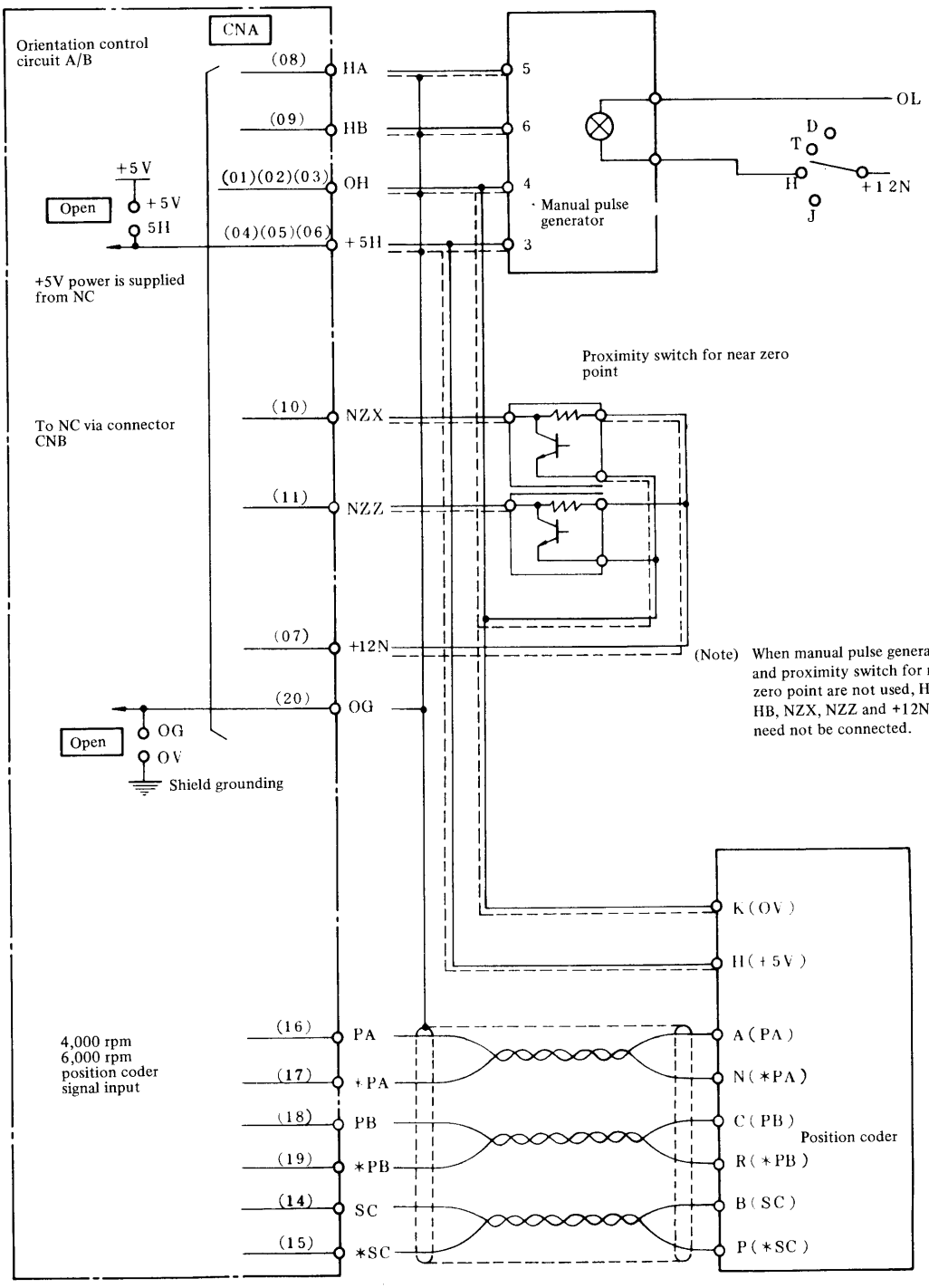
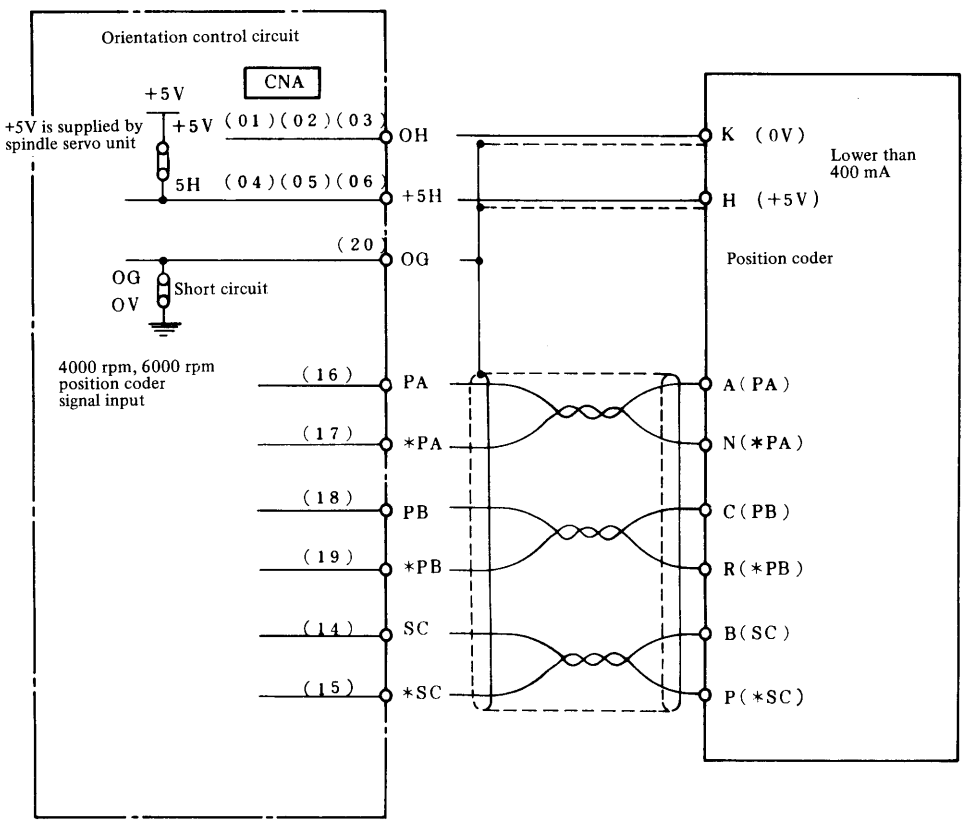


Fig. 1(d) Detailed connection diagram of spindle orientation with position coder employed (when synchronous feed position coder is concurrently used for lathes and machining centers)

APPENDIX 1.



Note) The cable length should be shorter than 20m between the servo unit and the position coder.

Fig. 1(e) Detailed connection diagram of spindle orientation using position coder (when spindle orientation only is used for machining centers)

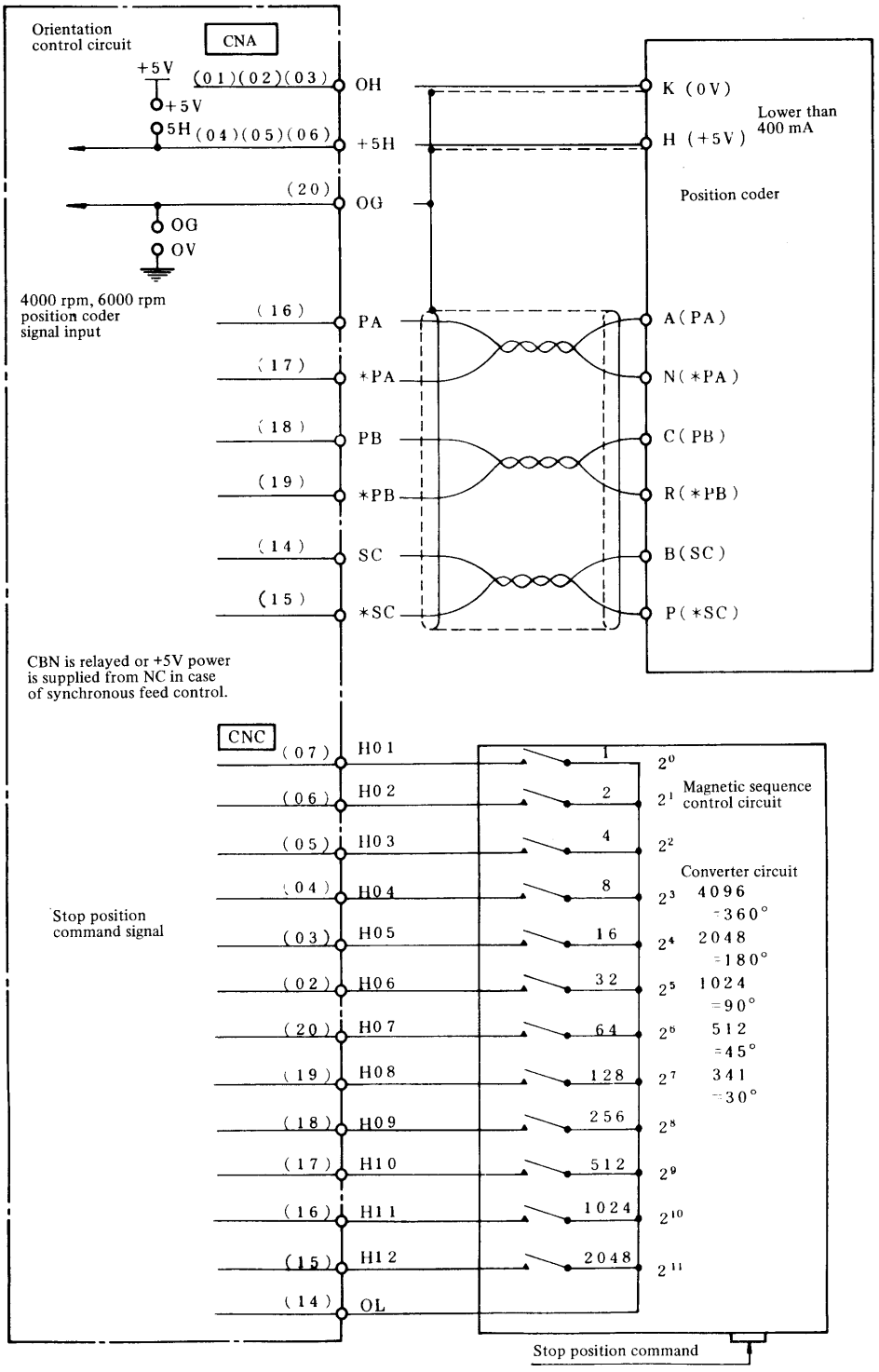


Fig. 1(f) Detailed connection diagram of spindle orientation using position coder (when the stop position is externally set)

APPENDIX 1.

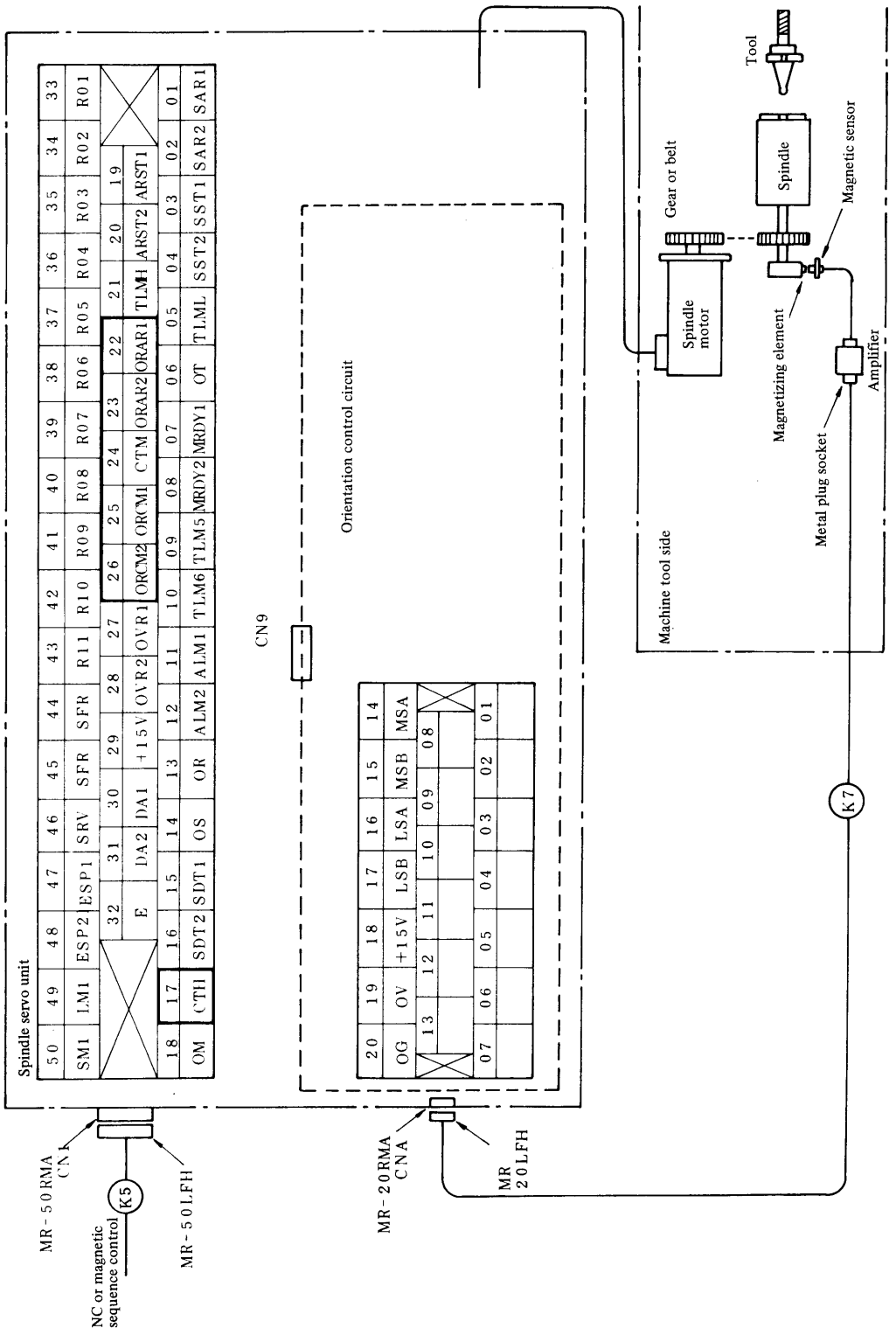
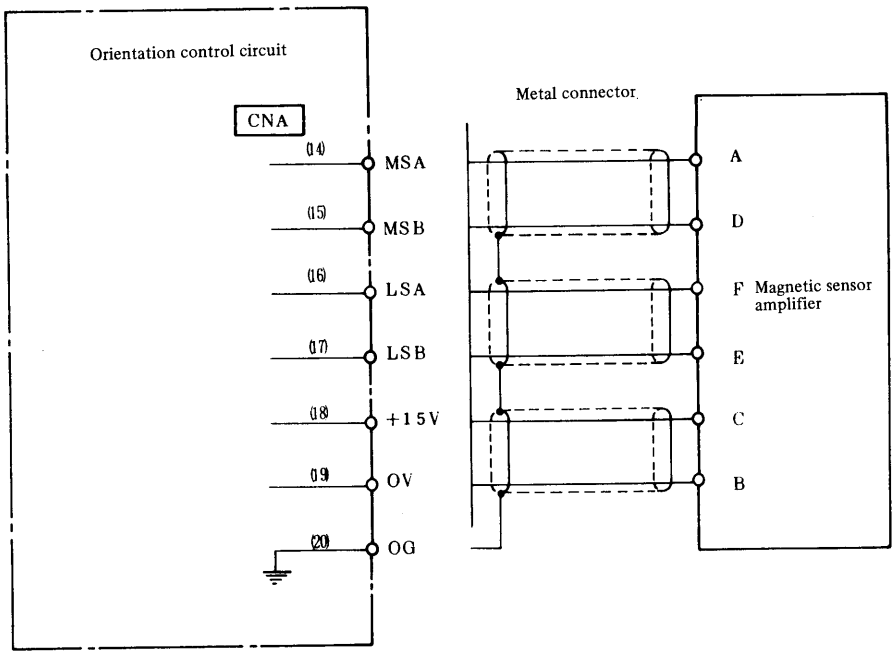


Fig. 1(g) Connection diagram of spindle orientation (when magnetic sensor is used)

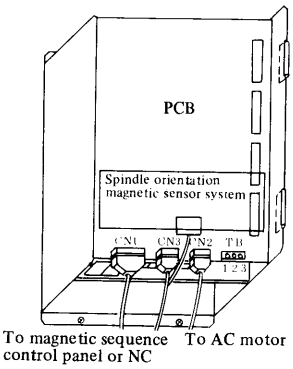


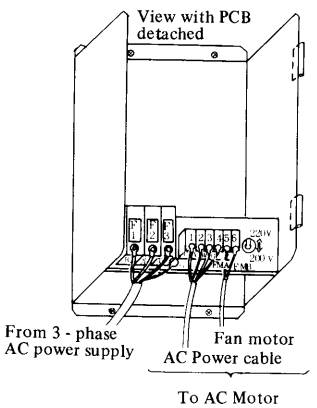
(Note) The cable length should be shorter than 20m between the servo unit and the magnetic sensor amplifier.

Fig. 1(h) Detailed connection diagram of spindle orientation (when magnetic sensor is used)

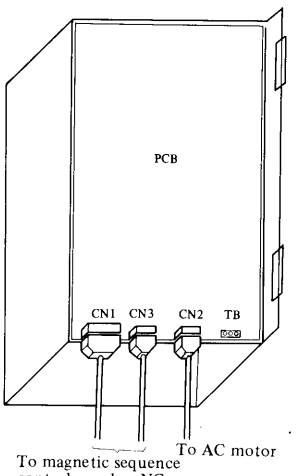
APPENDIX 2. Cable Service Entrance

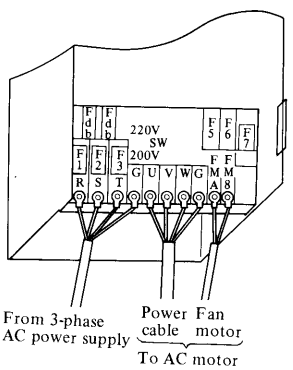
(1) Cable service entrance for models 3 and 6



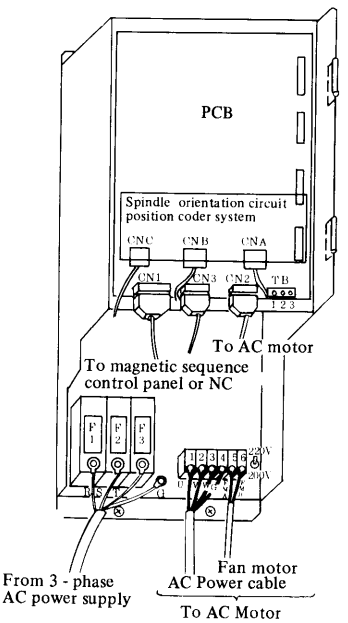


(2) Cable service entrance for model 8 and 12 (A06B-6044-H108, H112)

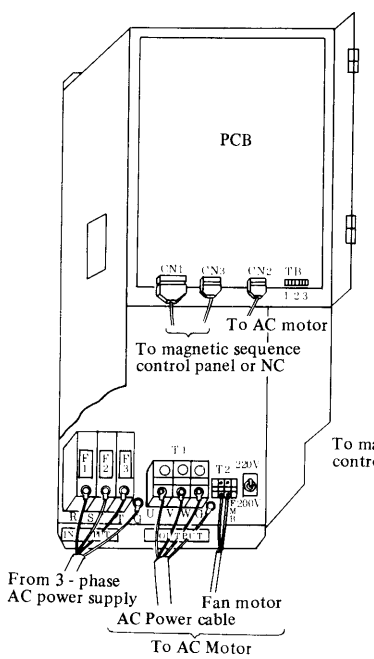




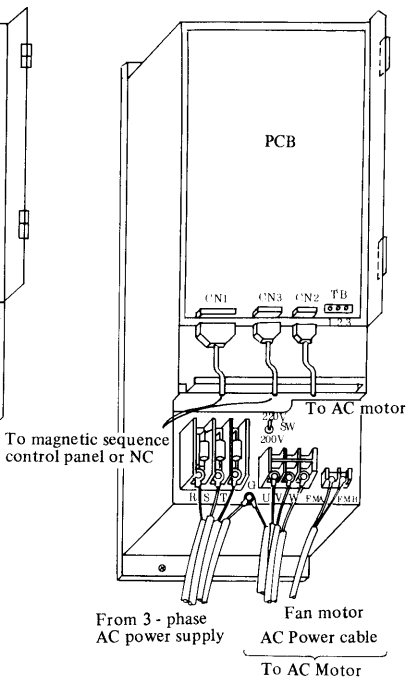
(3) Cable service entrance for models 8 and 12 (A06B-6044-H009, H010)



(4) Cable service entrance for model 15



(5) Cable service entrance for models 18 and 22

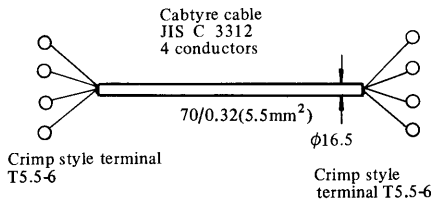
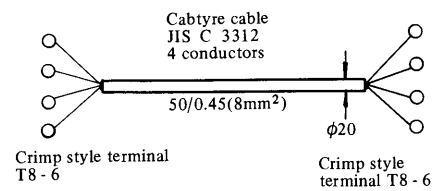
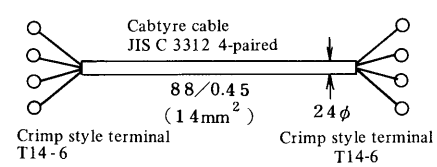
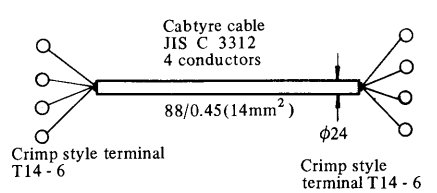


APPENDIX 3. Cable Specifications

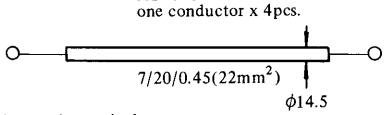
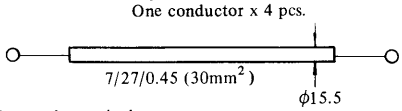
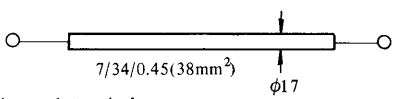
The cable specifications are as described below.

Prepare cables by users.

(1) Power cable and drive power cables to be selected according to motor models.

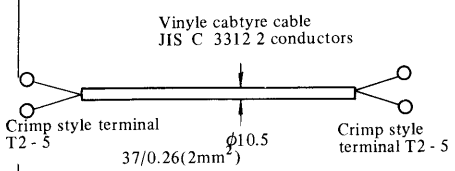
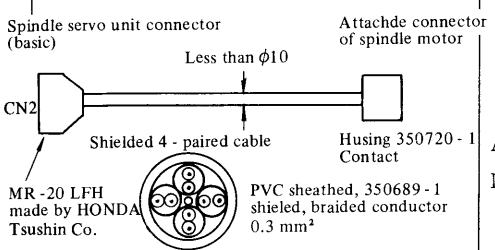
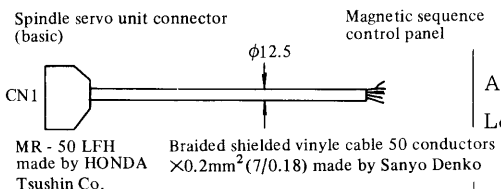
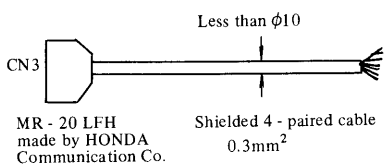
Use	Symbol	Specifications	Remarks
For model 3 (Lower than 12 kVA) Power cable Drive power cable	 K1 K2		A02B-0008-K853 Length: 7m
For model 6 (Lower than 16kVA) Power cable Drive power cable	 K1 K2		A06B-6044-K018 Length: 7m
For model 8, 12 Power cable	 K1		A06B-6044-K017 Length: 7m
For models 8 and 12 Drive power cable	 K2		A02B-0008-K018 Length: 7m

APPENDIX 3

Use	Symbol	Specifications	Remarks
For model 15 (Lower than 30kVA) Power cable Drive power cable	K1 K2	Cabtyre cable JIS C 3312 one conductor x 4pcs.  7/20/0.45(22mm^2) ϕ14.5 Crimp style terminal T22 - 8 Crimp style terminal T22 - 6	A06B-6044-K019 Length: 7m
For model 18 (Lower than 38 kVA)	K1 K2	Cabtyre cable JIS C 3312 One conductor x 4 pcs.  7/27/0.45 (30mm^2) ϕ15.5 Crimp style terminal T38-8 Crimp style terminal T38-8	A06B-6044-K020 Length: 7m
For model 22 (Lower than 45 kVA)	K1 K2	Cabtyre cable JIS C 3312 One conductor x 4 pcs.  7/34/0.45(38mm^2) ϕ17 Crimp style terminal T38 - 8 Crimp style terminal T38 - 8	A06B-6044-K021 Length: 7m

(2) Common cables

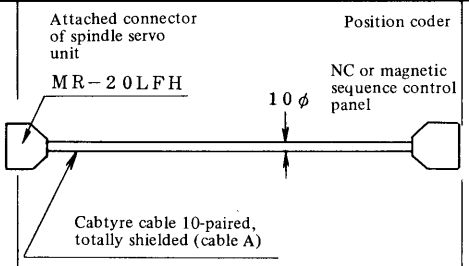
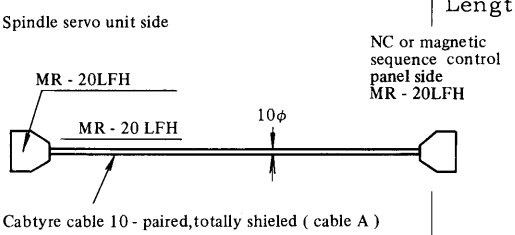
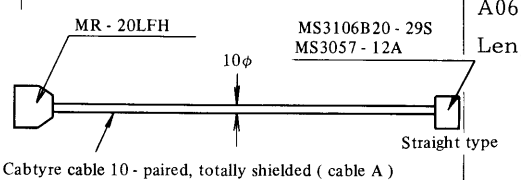
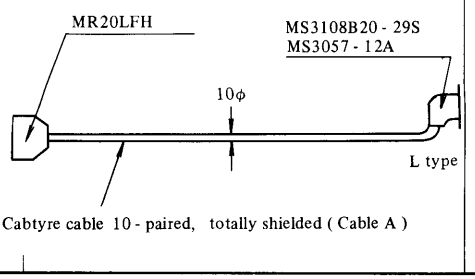
The following cables are common to all lmodels.

Use	Symbol	Specifications	Remarks
Spindle servo unit AC spindle motor (cooling fan)	K3		A06B-6044-K022 Length: 7m
Spindle servo unit AC spindle motor (for signals)	K4		A06B-6044-K200 Length: 7m
Spindle servo unit Magnetic sequence control panel (for signals)	K5		A06B-6044-K023 Length: 7m
Spindle servo unit Magnetic sequence control panel (for signals)	K6		A06B-6044-K024 Length: 7m

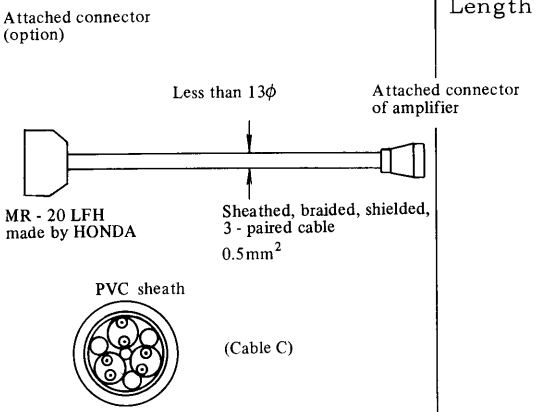
APPENDIX 3

(3) Spindle orientation cables

(a) For position coder

Use	Symbol	Specifications	Remarks
Spindle servo unit Magnetic sequence control panel	J4 K7		A06B-6041-K202 Length: 7m
Spindle servo unit NC or magnetic sequence control panel	K8		A06B-6041-K205 Length: 7m
Spindle servo unit Position coder	K7		A06B-6041-K201 Length: 7m
Spindle servo unit Position coder	K7		A06B-6041-K204 Length: 7m

(b) For magnetic sensor

Use	Symbol	Specifications	Remarks
Spindle servo unit Magnetic sensor	K7		A06B-6041-K203 Length: 7m

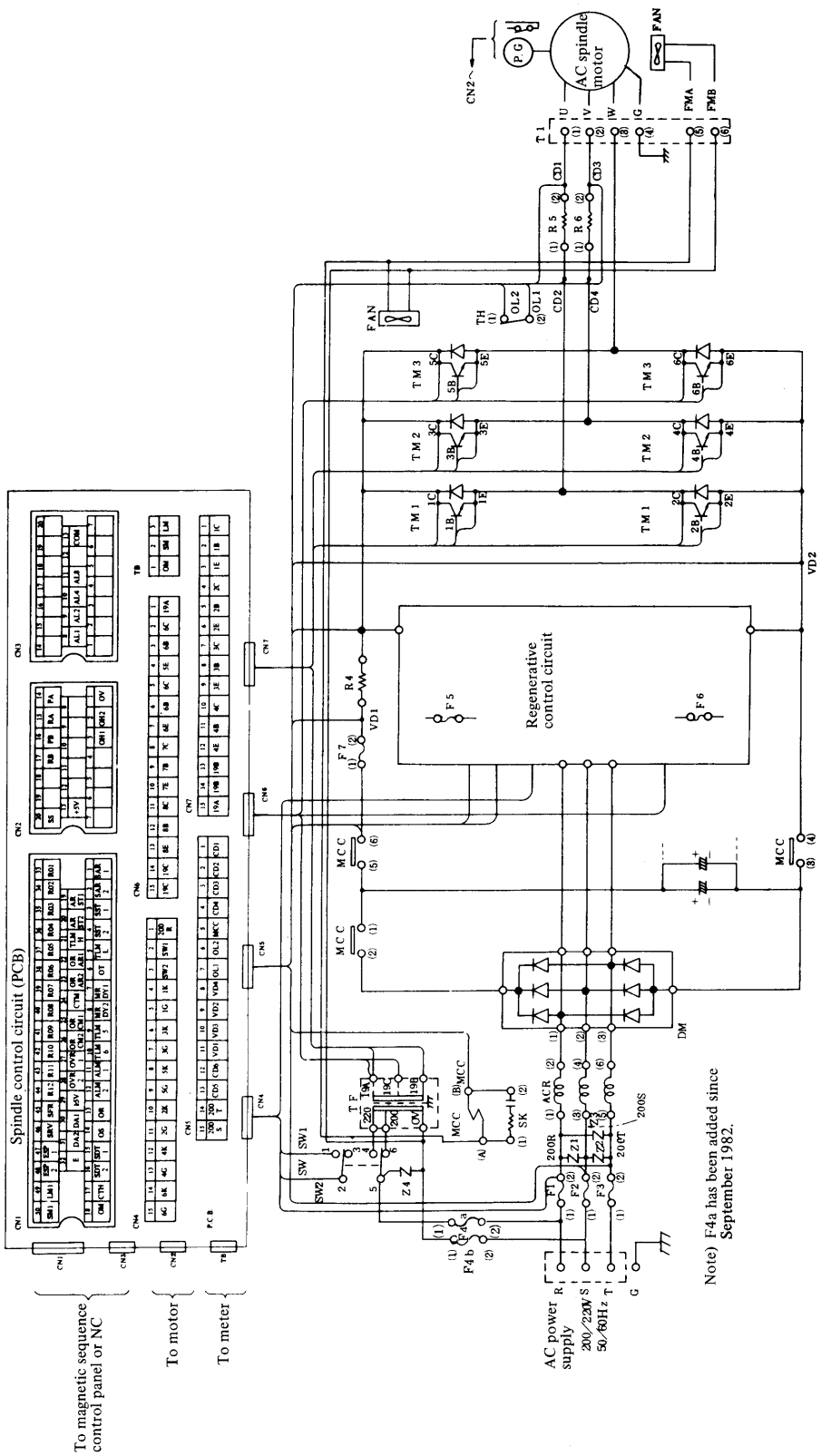
Note) For the specification of K5, see (2) common cables.

(c) Cable specifications

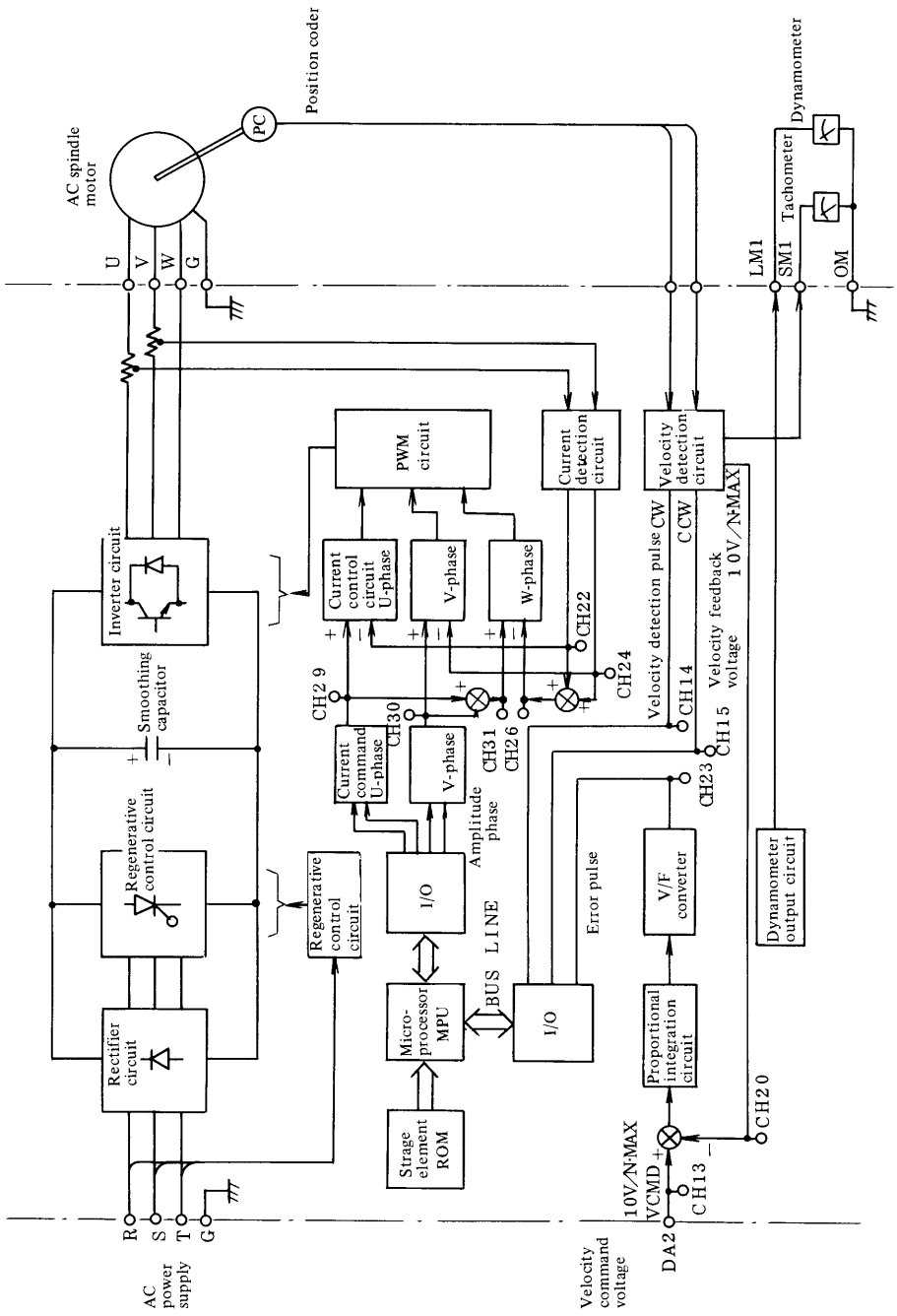
Name	Conductor		Thickness of sheath	Finished outer diameter	Electric characteristics	
	Diameter	Composition			Conductor resistance	Allowable current
Cable A (10-paired)	φ1.05 mm	7/0.18	1.4 mm	φ10.0 mm	110 Ω/km	1.6A
Cable B (50-paired)	φ1.05 mm	7/0.18	1.5 mm	φ12.5 mm	106 Ω/km	1.6A
Cable C (3-paired)	φ0.93 mm	45/0.12	1.0 mm	φ10.6 mm	38.7 Ω/km	1.6A

APPENDIX 4. Main Circuit Diagram

4.1 Main Circuit

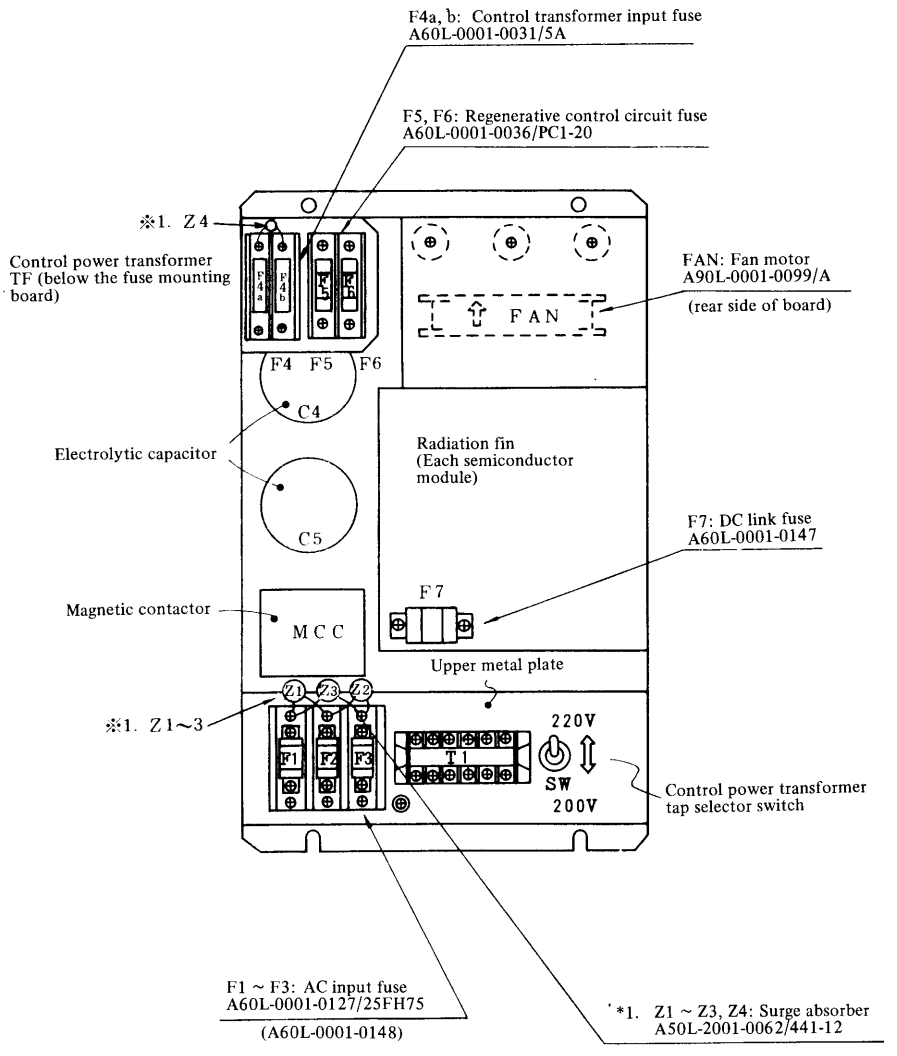


(Note) F4a has been added since September 1982.

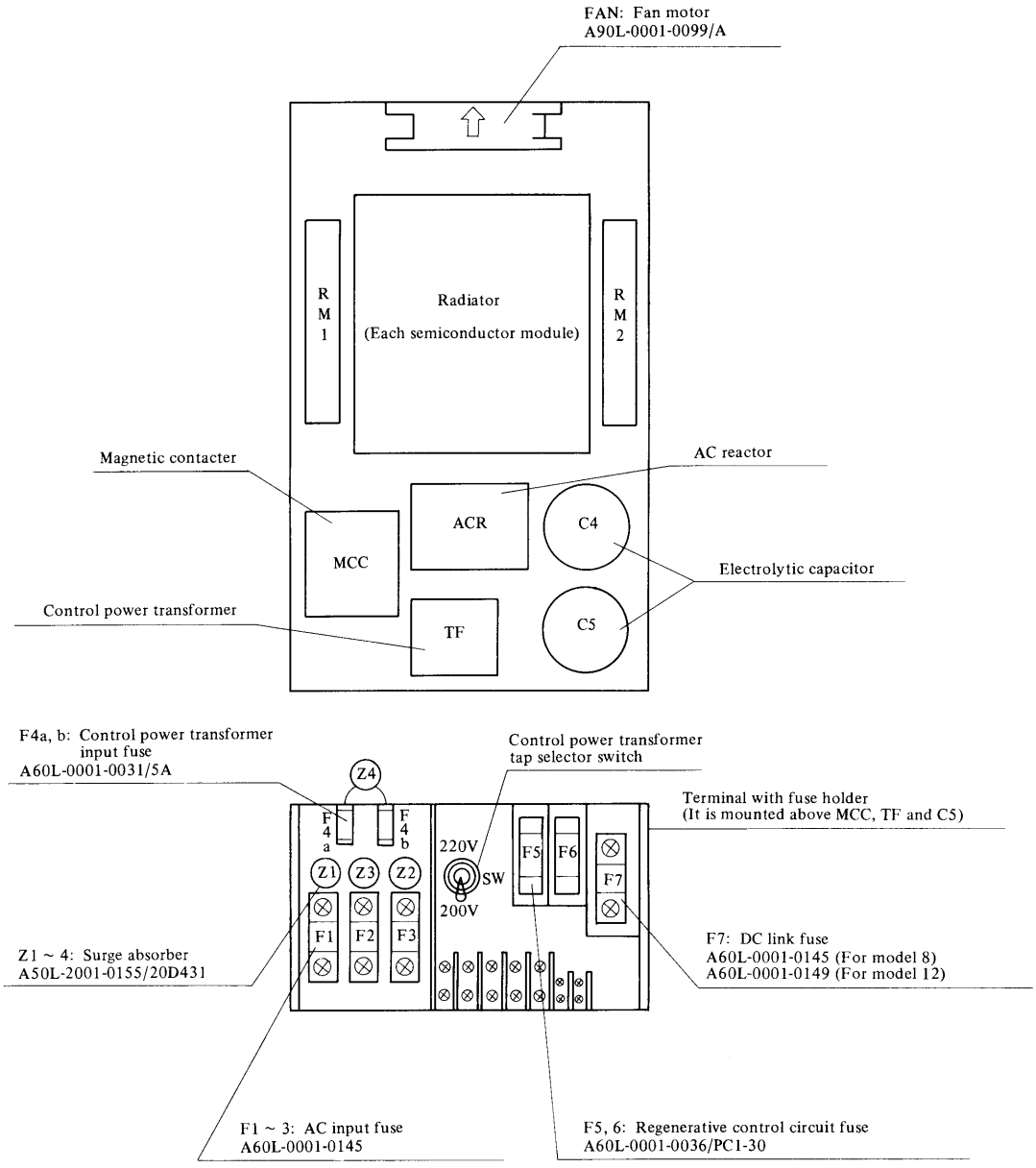

AC spindle motor
Position coder
PC
U
V
W
G
Dynamometer
Tachometer
LM1
SM1
OM
Inverter circuit
Smoothing capacitor
Regenerative control circuit
Rectifier circuit
PWM circuit
Current control circuit U-phase
V-phase
W-phase
Current detection circuit
Velocity detection circuit
CH22
CH24
CH29
CH30
CH31
CH26
CH23
CH14
CH15
Velocity detection pulse CW
CCW
Velocity feedback voltage
10V/N·MAX
Current command U-phase
Amplitude phase
Regenerative control circuit
I/O
BUS LINE
Micro-processor MPU
Strage element ROM
Error pulse
V/F converter
Dynamometer output circuit
Proportional integration circuit
CH20
10V/N·MAX
VCMD+
CH13 −
DA2
R
S
T
G
AC power supply
Velocity command voltage

APPENDIX 5. Mounting Layout of Spindle Servo Unit Parts (other than PCB)

(1) Spindle servo unit for AC spindle motor models 3 and 6. (A06B-6044-C008)

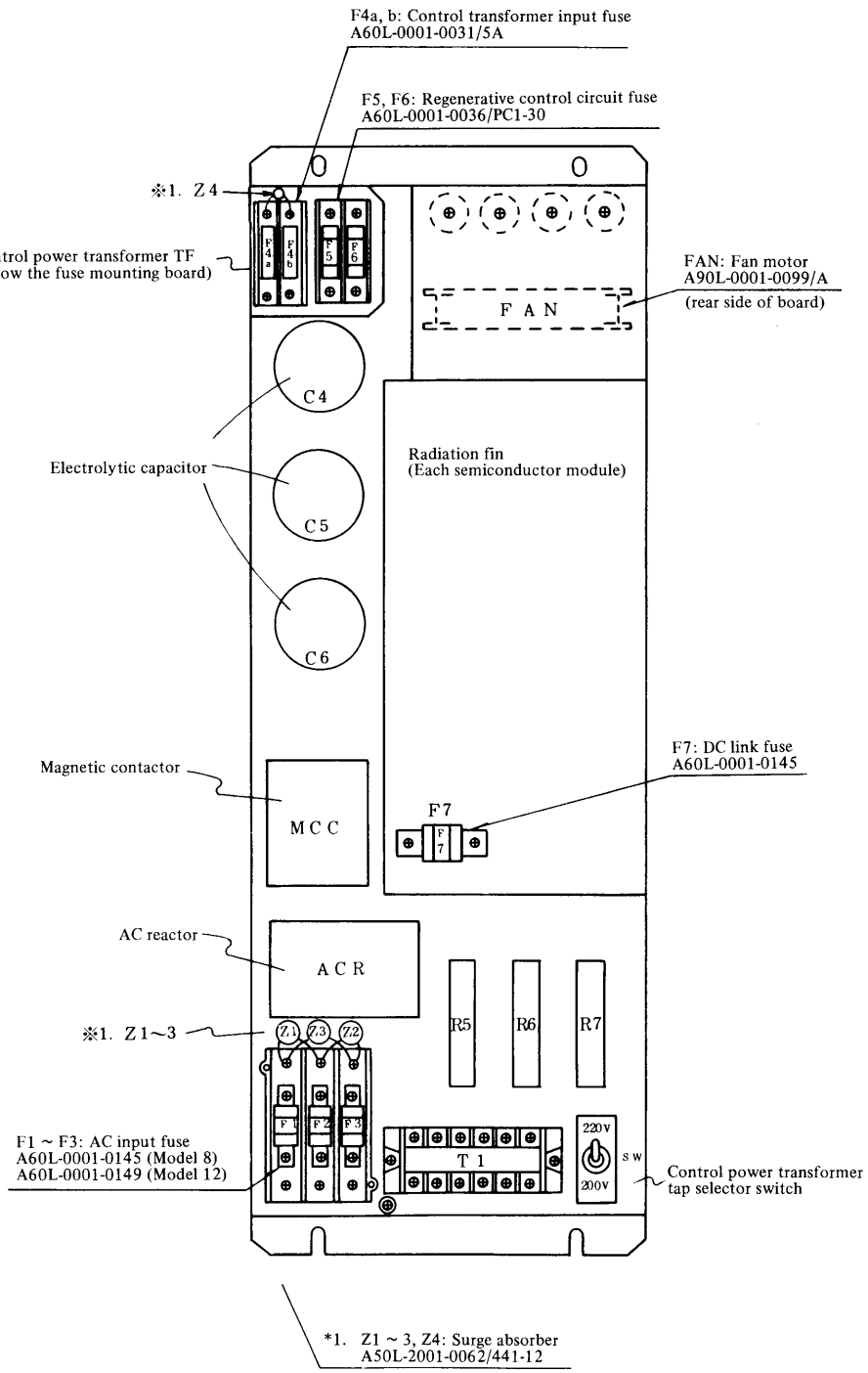


(2) Small type spindle servo unit for spindle motor models 8 and 12 (A06B-6044-C108, C112)

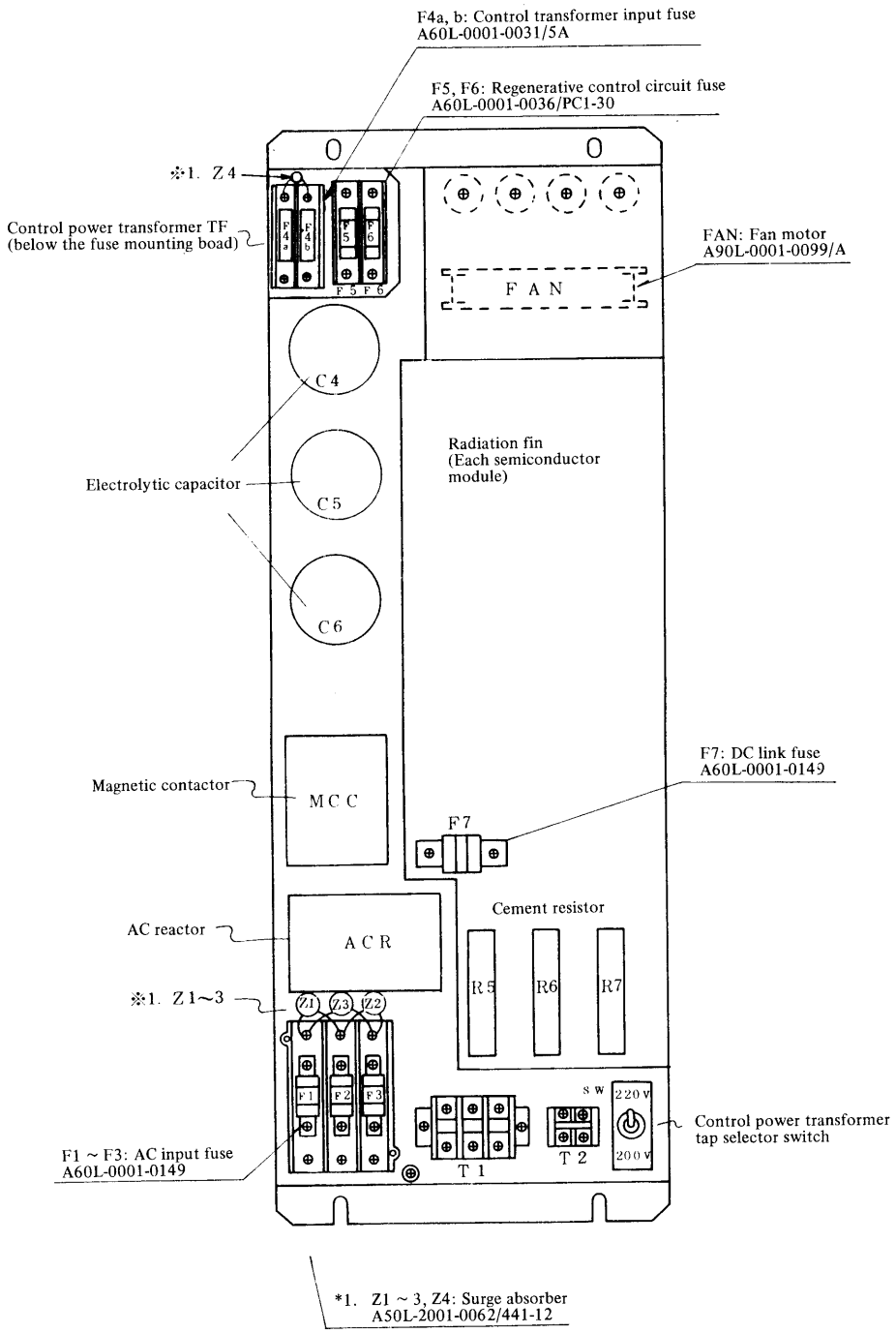


APPENDIX 5.

(3) Spindle servo unit for AC spindle motor models 8 and 12 (A06B-6044-C009, C010)

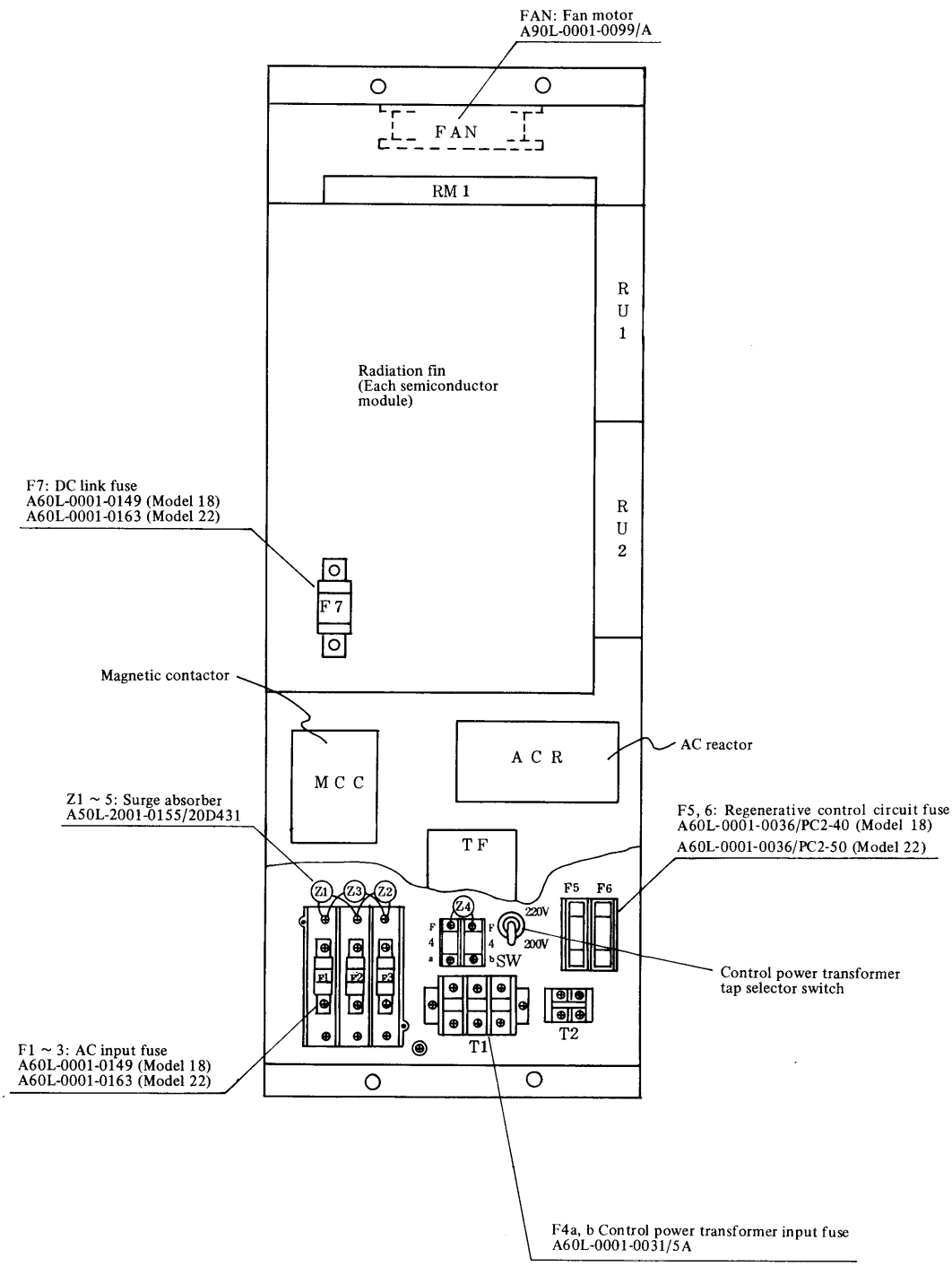


(4) Spindle servo unit for AC spindle motor model 15. (A06B-6044-C011)

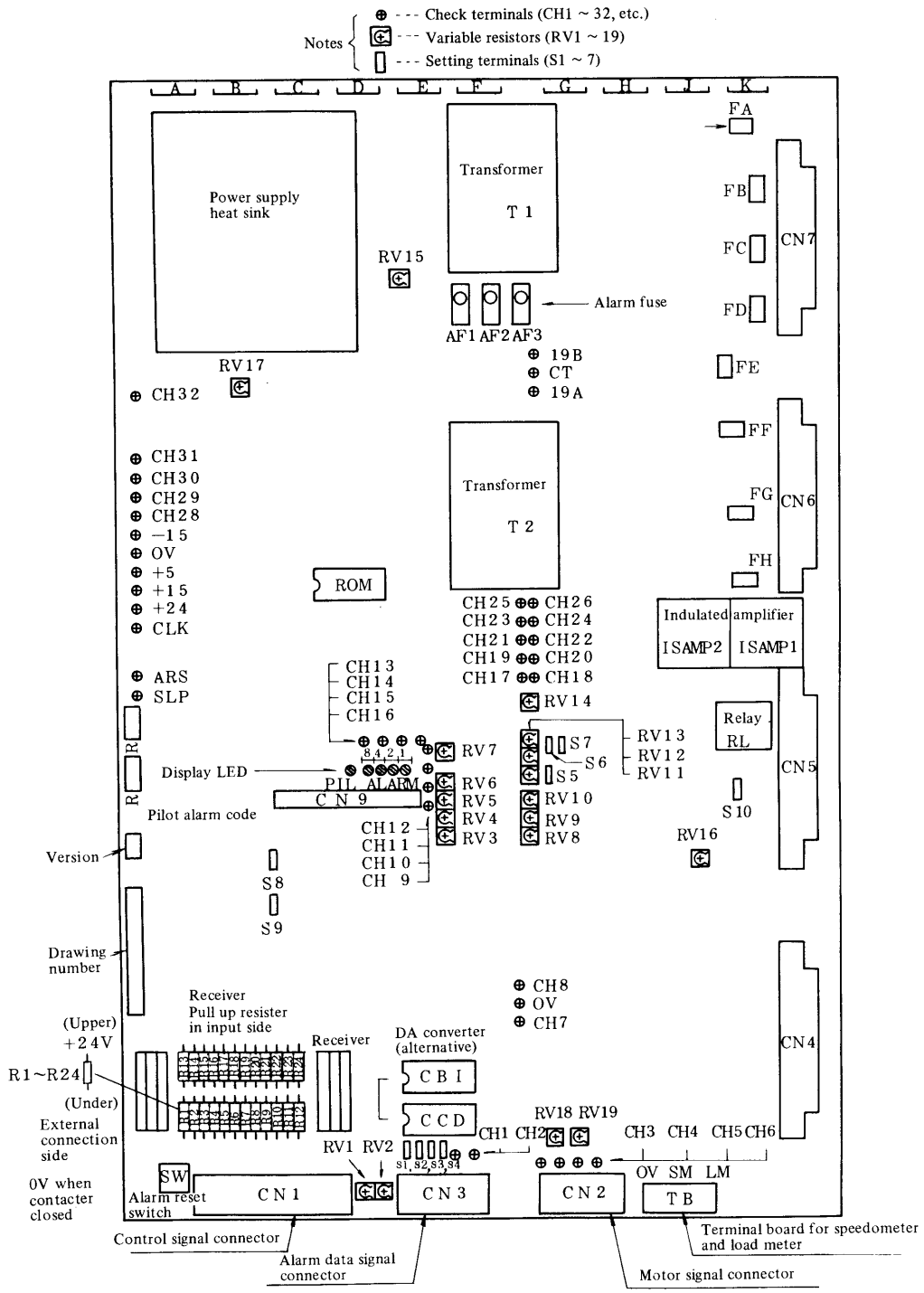


APPENDIX 5.

(5) Spindle servo unit for AC spindle motor models 18 and 22. (A06B-6044-C012, C013)



APPENDIX 6. Mounting Layout of Spindle Control Circuit PCB



APPENDIX 7. Major Parts List

(1) Fuse and surge absorber

Item	Symbol	Name	Specifications								
			For AC spindle motor model 3	For AC spindle motor model 6	For AC spindle motor model 8	For AC spindle motor model 12	For AC spindle motor model 15	For AC spindle motor model 18	For AC spindle motor model 22	For AC spindle motor model 8 (small type)	For AC spindle motor model 12 (small type)
1	F1 ∿ 3	Fuse	A60L-0001-0127/25FH75		A60L-0001-0145	A60L-0001-0149			A60L-0001-0163	A60L-0001-0145	
2	F4a, b	Fuse	A60L-0001-0031/5A								
3	F5, 6	Fuse	A60L-0001-0036/PC1-20		A60L-0001-0036/PC1-30			A60L-0001-0036 /PC2-40	A60L-0001-0036 /PC2-50	A60L-0001-0036/PC1-30	
4	F7	Fuse	A60L-0001-0147		A60L-0001-0145		A60L-0001-0149		A60L-0001-0163	A60L-0001-0145	A60L-0001-0149
5	Z1 ∿ 4	Surge absorber	A50L-2001-0062/441-12					A50L-2001-0155/20D431			
6	AF1	PCB fuse	A60L-0001-0046/32(3.2A)								
7	AF2, 3	PCB fuse	A60L-0001-0075/32(3.2AS)								
8	Fa ∿ h	PCB fuse	A60L-0001-0175(0.3A)								

(2) Main parts

Item	Symbol *	Name	Specifications								
			For AC spindle motor model 3	For AC spindle motor model 6	For AC spindle motor model 8	For AC spindle motor model 12	For AC spindle motor model 15	For AC spindle motor model 18	For AC spindle motor model 22	For AC spindle motor model 8 (small type)	For AC spindle motor model 12 (small type)
1	P.C.B.	PCB	A20B-0009-0530	A20B-0009-0531	A20B-0009-0532	A20B-0009-0533	A20-0009-0534	A20-B-0009-0588	A20B-0009-0589	A20B-1000-0692	A20B-1000-0693
2	ROM	Memory element	J10	J11	J02	J03	J04	J05	J06	J02	J03
3	TM(1 ∿ 11)	Transistor module	A50L-0001-0096					A50L-0001-0103		A50L-0001-0109	
4	SM(1 ∿ 3)	SCR module	A50L-5000-0029/30		A50L-5000-0029/50			A50L-5000-0029/80		A50L-5000-0029/50	
5	DM(1 ∿ 3)	Diode module	A50L-2001-0138		A50L-2001-0146					A50L-2001-0168	A50L-2001-0146
6	D(1 ∿ 3)	Diode	A50L-2001-0103/12JH11								
7	D(4 ∿ 6)	Diode	A50L-2001-0103/12JG11								
8	D(7)	Diode	A50L-2001-0081/60					A50L-2001-0097/U06G			
9	D(8)	Diode	A50L-2001-0097/U06G								
10	C(1 ∿ 3)	Capacitor	A42L-0001-0103								
11	MCC	Contactor	A58L-0001-0094/200V1A1B		A58L-0001-0092/A		A58L-0001-0146	A58L-0001-0165	A58L-0001-0166	A58L-0001-0092/A	
12	TF	Transformer	A80L-0001-0276								
13	FAM	Fan	A90L-0001-0099/A								
14	TH	Thermostat	A57L-0001-0028					A57L-0001-0046/90		A57L-0001-0051	
15	SW	Switch	A57L-0001-0030/2					A56L-0001-0048		A57L-0001-0048/A	

* Parts number in parenthesis are different depend on unit models. Refer to the parts mounting label in the unit for the details.

APPENDIX 8. PCB Adjustments

Adjustments of A20B-0009-0530 - 4 PCBs are shown in the following table. Don't change RV7, 8, 14 - 19, since these variable resistors have been adjusted at FANUC factory before shipment.

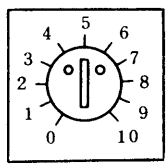
No.	Symbol	Adjustment items	Standard setting	Measuring terminals	Adjusting methods
1	RV1	Velocity command voltage level		CH13-0V	See subsection (1).
2	RV2	Velocity command voltage offset		CH13-0V	"
3	RV3	Speed arrival detection level		CH10-0V	See subsection (4).
4	RV4	Speed detection level		CH9-0V	See subsection (5).
5	RV5	Torque limitation level			See subsection (6).
6	RV6	Regenerative power limitation	3 divisions		
7	RV7	VF conversion level (1)		CH23-0V	200 ±2kHz when voltage is 10V between LM and OM.
8	RV8	Speed detection circuit setting		CH18-0V	1.38 ±0.03V at forward rotation of motor in 4.5 rpm.
9	RV9	Forward motor speed adjustment		Number of motor revolutions	See subsection (2).
10	RV10	Speed detection offset		CH17-0V	Lower than ±2V when the spindle stops.
11	RV11	Reverse motion speed adjustment		Number of motor revolutions	See subsection (2).
12	RV12	Velocity loop gain	3 divisions		

APPENDIX 8.

No.	Symbol	Adjustment items	Standard setting	Measuring terminals	Adjusting methods
13	RV13	Velocity loop offset		No. of spindle revolutions	See subsection (3).
14	RV14	Load meter amplitude adjustment		LM-0M	10+0.1V at acceleration.
15	RV15	+5V voltage adjustment		+5V-0V	5±0.05V
16	RV16	Regenerative voltage limitation level	4 divisions		
17	RV17	VF conversion level (2)		CH32-0V	24±0.2kHz at input AC 200V
18	RV18	RA offset adjustment		CH5-0V	The rate of ON time at CH7 waveform to be 50%.
19	RV19	RB offset adjustment		CH6-0V	The rate of ON time at CH8 wave form to be 50%.

Note) How to read the variable resistor scale.

(Note) How to read the variable resistor scale

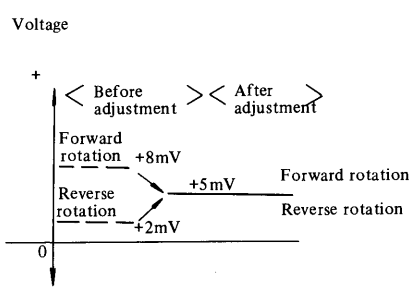


(1) Velocity command voltage (RV1, RV2)

When the velocity command voltage is 10V, the motor rotates at the rated speed.

Item	Measuring terminal	Adjusting procedure
Offset	CH13-0V	Give velocity command voltage 0V (equivalent to S00) after setting the motor to be ready for operation. Adjust RV2 while alternately giving the forward rotation and reverse rotation commands, until the voltage remains unchanged at measuring terminals. (Note)
Level	CH13-0V	Give the rated rotation command 10V to the motor, and adjust RV1 until the measuring terminal voltage becomes +10V±0.05V when the spindle forward rotation command is sent.

(Note) If the voltage at CH13 is +5.0 mV when the spindle rotates forward and ±5.0 mV ±1.0 mV when the spindle rotates reversely, the offset error becomes ±1.0 mV when the velocity command voltage directions are inverted.

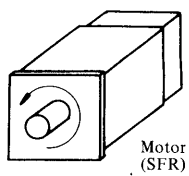


(2) Rotation speed adjustment (RV9, RV11)

The number of spindle revolutions can be finely adjusted according to the following procedure.
Measure the number of spindle revolutions directly by using a stroboscope or a tachometer.

Item	Measuring terminal	Adjusting procedure
Number of forward revolutions	Spindle	Give the specified motor rotation command voltage. Adjust RV9 so that the motor rotates at the specified speed when the forward rotation (SFR) command is given.
Number of reverse revolutions	Spindle	Adjust RV11 so that the motor rotates at the specified speed when the reverse rotation (SRV) command is given.

Note) The forward rotation means that the AC spindle motor rotates counterlockwise as viewed from the motor shaft direction and this forward rotation (SFR) does not always correspond to the forward rotation of the machine tool spindle.



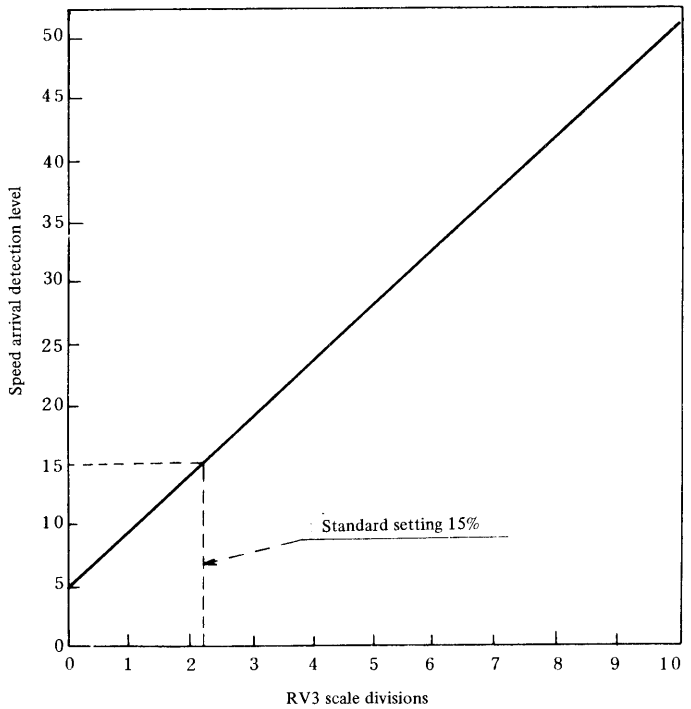
(3) Velocity offset (RV13)

Adjust RV13 after completion of the previous adjustments so that the spindle does not rotate at low speed when the velocity command voltage 0V is given.

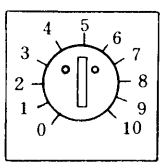
Item	Measuring point	Adjusting procedure
Velocity offset	Spindle (or motor)	Adjust RV13 so that the spindle does not rotate when the velocity command voltage 0V and either forward or reverse rotation command are given.

(4) Speed arrival detection level (RV3)

The speed arrival detection level can be set according to the following graph. The coordinate indicates percentage to the rated revolutions of motor.



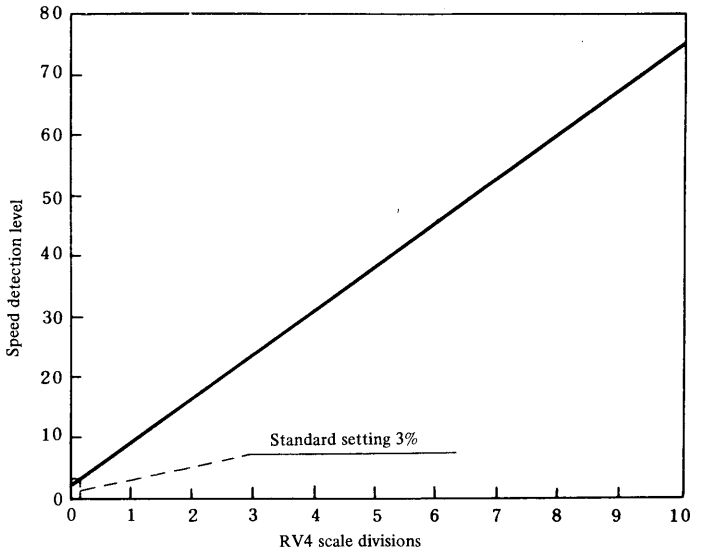
Note) Now to read the variable resistor scale divisions.



APPENDIX 8.

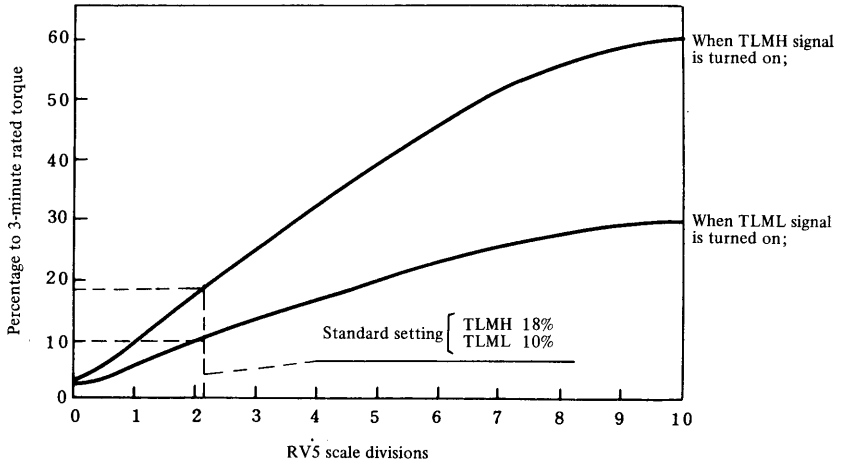
(5) Speed detection level (RV4)

The coordinate indicates percentage to the rated revolutions of the motor. This signal is used as a check signal when the clutch or gear is changed.



(6) Torque limitation level (RV5)

The coordinate indicates percentage to the 30-minute rated torque.



APPENDIX 9. Checking Method for PCB

9.1 Check Terminal

Name of terminal	Name of signal	Signal data	Remarks
CH1	DA2	Analog command voltage	0 ~ 10.0V
CH2	DA1	D/A converter output voltage	0 ~ 10.0V
CH3	PA	Pulse generator output A phase	
CH4	PB	Pulse generator output B phase	PA leads PB by 90° in CW rotation
CH5	RA	A-phase reference voltage	PA DC ±25mV
CH6	RB	B-phase reference voltage	PB DC ±25mV
CH7	PSA	A-phase square wave	Duty 50% (at constant speed) ±10%
0V	0V	PCB 0V	
CH8	PSB	B-phase square wave	Duty 50% (at constant speed) ±10%
CH9	SDTRF	Speed detection level	Variable over a range of 0.14 ~ 7.4V by RV4
CH10	SARRF	Speed arrival level	Variable by RV3
CH11	VCMD	Acceleration/deceleration in progress	 "1" level during acc./dcc.
CH13	VCMD	Velocity command voltage	0 ~ ±10.0V ⊕ ; CCW, ⊖ ; CW
CH14	RVP	Reverse rotation speed level	Pulse width 3.2 s generated during reverse rotation only.
CH15	FWP	Forward rotation speed level	Pulse width 3.2 s generated during forward rotation only.
CH16	0V	PCB 0V	
CH17	TS1	Velocity feedback F/V output	-8V at 6000 rpm in CCW (forward) rotation.

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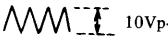
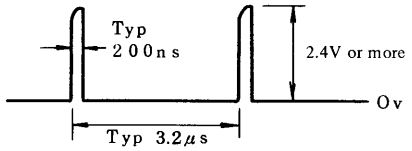
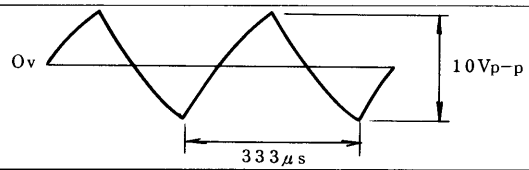
Name of terminal	Name of signal	Signal data	Remarks
CH18	TS2	Low speed detection signal	-1.38 ±0.03V at 45 rpm in CCW (forward) rotation.
CH20	TSA	Velocity feedback signal	±10V at rated rotation speed and (-) in CCW rotation.
CH21	LTRF	Output torque limitation voltage	Output=-(C|V_{CH21}|+1.8)/10x maximum output
CH22	CRU	U-phase current detection signal	Current/V: M3.6 16.7A; M8 25A; M12 35.7A; M15 50A; M18 50A; M22 62.5A
CH23	ERP	VF conversion output	200 kHz when L_M-0V is 10V, 0.4 µs width
CH24	CRV	V-phase current detection signal	See CH22
CH25	TRWF	Triangular wave signal	 10Vp-p
CH26	CRW	W-phase current detection signal	See CH22
CLK	CLK	Clock signal	312.5 kHz, 200 ns typ.
+24	24V	+24V power voltage	
+15	15V	+15V power voltage	
+5	5V	+5V power voltage	+5V±1% (Already adjusted by RV15)
0V	0V	PCB 0V	Same as the 0V and CH16
-15	-15V	-15V power voltage	-15V±4%
CH28	ER	Error voltage	0 ~ 10V
CH29	UCM	U-phase command voltage	
CH30	VCM	V-phase command voltage	
CH31	WCM	W-phase command voltage	
CH32	24VP		

Name of terminal	Name of signal	Signal data	Remarks
19A	19A	AC 19V input voltage	For PCB control power supply
CT	CT	0V	For PCB control power supply
19B	19B	AC 19V input voltage	For PCB control power supply
SLP	Slip	Slip frequency	

9.2 Check Terminal Data Confirmation Method

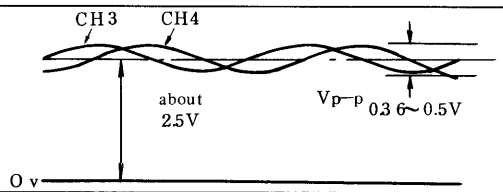
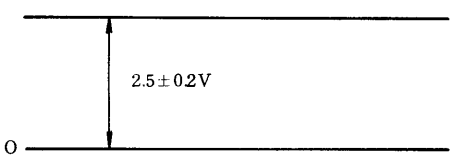
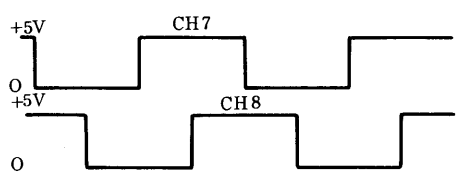
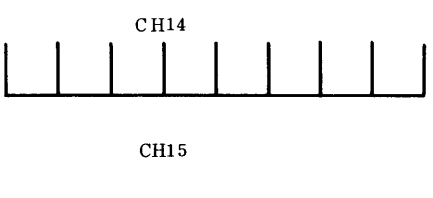
Terminal	Voltage check by a circuit tester or the like, or frequency check by a counter or the like	Wareform check during stop	Wareform check during low-speed rotation	Wareform check during acceleration /deceleration
CH1	0 ~ ±10V by velocity command voltage input			
CH2	0 ~ +10V by velocity command			
CH3 CH4 CH5 CH6 CH7 CH8			See (2)	
CH9	0.3V by standard adjustment			
CH10	1.5V (standard) when velocity command voltage is 10V			
CH11				See (3)
CH13	0 ~ ±10V by velocity command voltage input			See (3)
CH14 CH15			See (2)	
CH17 CH18 CH19 CH20 CH28	±1.38 ±0.03V at motor rotation ±4.5 rpm 0 ~ ±10V by rotation speed			See (3)
CH21	Standard -8.2V (during low-speed rotation)			
CH22 CH24 CH26 CH29 CH30 CH31 CH23 SLP			See (2)	
CH25 CLK		See (1)		
+24 +15 + 5 -15	At AC200V input, +24.7 ±1V +15.0 ±0.45V + 5.0 ±0.05V -15.0 ±0.45V			
19A CT 19B	AC19V at AC200V input between 19A and CT AC19V at AC200V input between 19B and CT			
CH32	24 KHz at AC200V input			

(1) Waveform at stopping

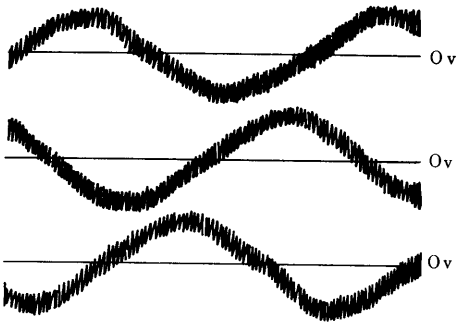
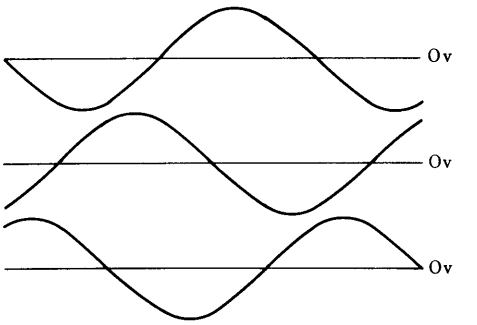
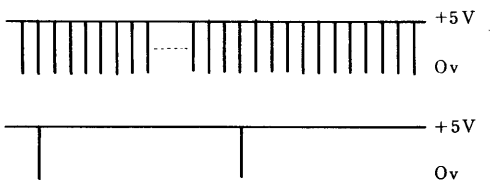
Check terminal	Waveform	Remarks
CLK		
CH25		

(2) Waveform during low speed

Condition: Motor rpm. 45 ∿ 1000 rpm
Spindle reverse rotation command signal SRV ON

Check terminal	Waveform	Remarks
CH3 CH4		
CH5 CH6		
CH7 CH8		Set the ON/OFF duty of CH7 and CH8 waveform 1 to 1 by RV18 and RV19 at 1000 rpm.
CH14 CH15		When spindle rotation direction is reverse, waveform appears at CH15 and not appears at CH14.

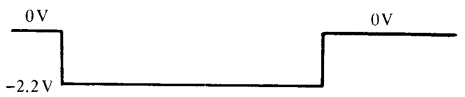
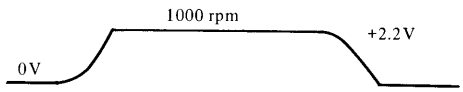
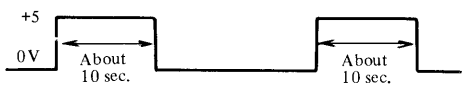
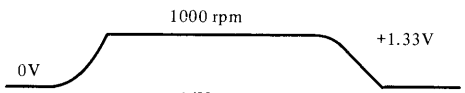
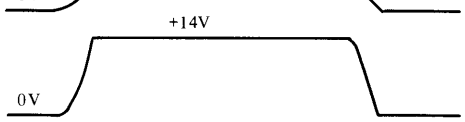
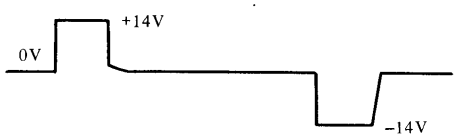
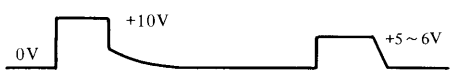
APPENDIX 9.

Check terminal	Waveform	Remarks
CH22 CH24 CH26		If spindle rotation direction is reverse, phase of CH24 and CH26 are replaced.
CH29 CH30 CH31		If spindle rotation direction is reverse, phase of CH30 and CH31 are replaced. Frequency is in proportion to spindle rotation. When unit and motor is normal, Sine-wave appears at check point.
CH23 SLP		Pulse number are changed in proportion to voltage of CH28 terminal.

(3) Waveform during acceleration/deceleration

Conditions: Motor revolutions 0 → 1000 rpm → 0 rpm

Spindle reverse rotation command signal (SRV) OFF → ON → OFF

Check terminal	Waveform	Remarks
CH13		
CH20		
CH11		
CH17		
CH18		
CH19		
CH28		

APPENDIX 10 Magnetic Sensor Signals Checking Method

10.1 Application

This document applies to the following check procedure by observing output signals of the magnetic sensor (specification: A57L-0001-0037) employed for magnetic sensor system spindle orientation.

Item	Check item
1	Whether magnetizer, magnetic sensor head, and magnetic sensor amplifier are defective or not.
2	Whether magnetizer and magnetic sensor head are properly mounted or not;
3	Whether magnetic sensor signal cables are properly connected without any connection failure and short-circuit.

10.2 Check Procedure

(1) Preparation

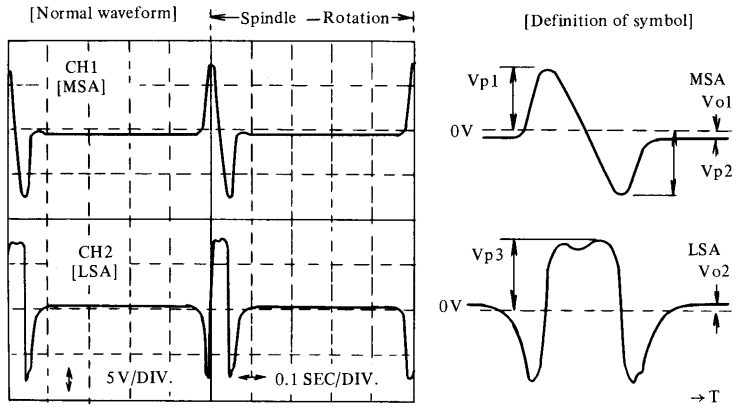
① Rotate the spindle at about 120 rpm. Select the counterclockwise rotating direction as viewed from the AC spindle motor shaft (in such a direction as the voltage at check terminal CH13 (VCMD) of AC spindle control circuit PCB (drawing: A20B-0009-0530 - 9) becomes positive (+) to CH16 (OV)).

② Check the peak voltage and offset voltage levels of the following signal waveforms at the check terminals of the orientation circuit (drawing: A20B-0008-0030 - 1 or A20B-0009-0520) using an oscilloscope. The names of check terminals and signal contents are common, irrespective of the kinds of orientation circuit.

Check terminal No.	Signal name	Symbol	Prove common terminal
CH1	Magnetic sensor output signal A	MSA	CH16 (0V)
CH2	Magnetic sensor output signal B	LSA	

(2) Decision method

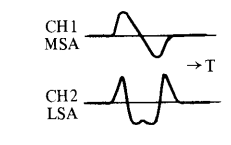
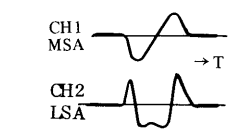
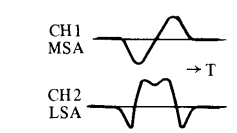
① Examples of normal waveforms and their criteria are as shown below.
If a trouble occurred, refer to the causes and remedy shown in the following table.



(Criteria table)

Item	Criteria (normal, if these conditions are satisfied.)
Offset voltage	$V_{o}1 \sim 2 < 0.5V$
Peak voltage	$3V < V_{p}1 \sim 3 \quad 10V$

② Remedy to be observed when the above criteria are not satisfied.

Item	Symptoms	Causes	Remedy
1	Offset voltage of either or both signals is high. Offset voltage is normal. Peak voltage of either signal only is low.	a. Magnetic sensor head or magnetic sensor amplifier is defective.	Replace defective parts.
	Waveform of either signal does not appear, or waveform of both signals don't appear.	a. Magnetic sensor head, amplifier, or magnetic sensor amplifier is defective. b. Poor connection or short-circuit of cables or connectors.	a. Replace defective parts. b. Repair defective parts.
3	Offset voltage is normal, but the entire peak voltage is low.	a. Mounting gap of the magnetic sensor head and the magnetizer is wider than specified.	Readjust the gap.
4	Offset voltage and peak voltage levels are normal, but waveforms are different from specified ones.	Ovserve the following procedure according to waveforms.	
	Observation waveform: 	a. Magnetic sensor head is not mountd properly. b. Wrong cable connection.	a. Reverse the pin groove direction of the magnetic sensor head. b. Replace LSA and LSB with each other.
		a. Magnetizer is not properly mounted. b. Wrong cable connection.	a. Reverse the direction of the reference hole of magnetizer. b. Replace MSA and MSB with each other. Replace LSA and LSB with each other.
		a. Magnetizer and magnetic sensor head are not properly mounted. b. Wrong cable connection.	a. Reverse the mounting directions of both magnetizer and magnetic sensor head. b. Replace MSA and MSB with each other.

(Reference) For normal mounting methods and connection methods of signal cables of the magnetizer and magnetic sensor head, refer to 7.3.1 in text and appendix 1 "Connections".

Revision Record

FANUC AC SPINDLE SERVO UNIT MAINTENANCE MANUAL (B–53425E)

Edition	Date	Contents	Edition	Date	Contents
05	1, '84	Adding of small type servo unit (A06B-6044-H108, H112) for motor model 8 and 12.			
04	11, '83	All contents are changed.			
03	8, '82	All contents are changed.			
02	11, '81	Correction of errata			
01	9, '81				

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(Y540)

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