YASKAWA ELECTRIC

TSE-S800-2-3B
BULLETIN

VS-800 SERIES

# AC Servo Drives

## M, F SERIES FOR POSITIONING CONTROL

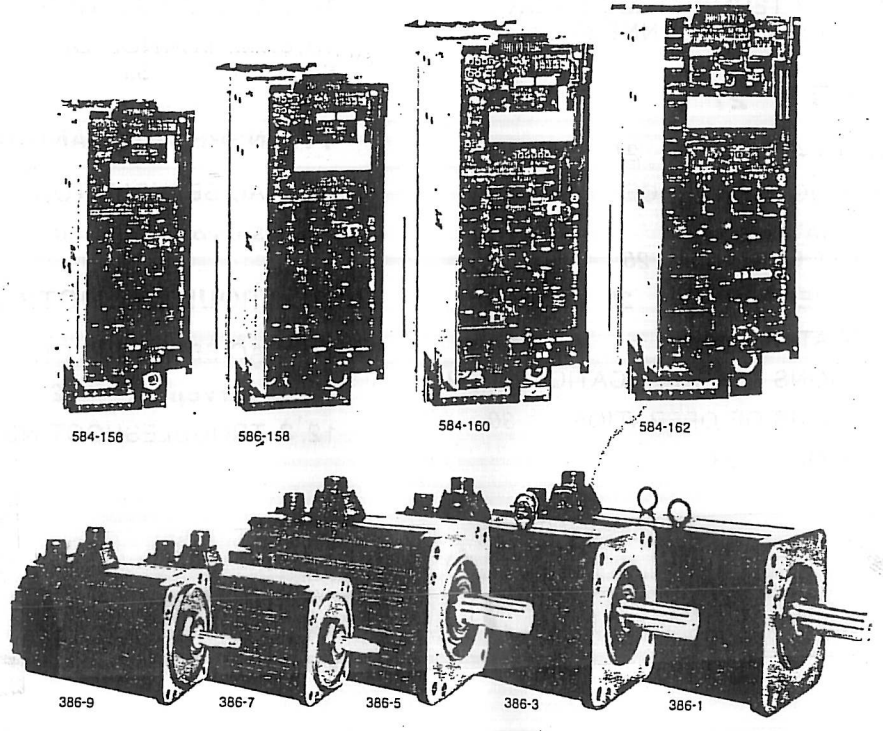
***Servomotor*** TYPES USAM□D, USAFED (With Optical Encoder)
***Servopack***™ TYPES CACR-PR□BB (Base-mounted Type)

Yaskawa AC Servo Drives have been developed as the basic mechatronics drives for the most advanced FA and FMS including robots and machine tools. The extensive servo manufacturing technology accumulated through a half century of servo drive applications has created and nurtured a new phase of AC servo drives.

This bulletin covers AC servo drives M and F series for speed control.
The AC Servo Drives consist primarily of AC servomotors and their controllers, Servopacks. The AC servomotor features a high power rate for achieving quick response. Custom LSI and hybrid ICs packaged in Servopack reduce the unit size and simplify wiring. The additional feature of a highly accurate pluse resolution offers stepless pulse flow.

For your mechatronics systems, the flexible combination of our AC servomotor and Servopack achieves stable control operation with high accuracy, quick response control under any environmental condition, and smooth, powerful operation even at low-speed range. Some outstanding features are as follows.

- High accuracy and quick response for speed control
- Compact design and high reliability
- Light weight and high power
- Highly reliable protective functions
- Selectable drive to meet users' requirements




M Series AC Servo Drives for Positioniog Control
— AC Servomotors and Their Controllers Servopacks

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# 1. RATINGS AND SPECIFICATIONS

## 1.1 RATINGS AND SPECIFICATIONS OF M SERIES AC SERVOMOTORS

### 1.1.1 Ratings

Time Rating: Continuous

Insulation: Class F

Isolation Voltage: 1500 VAC, one minute

Insulation Resistance: 500 VDC, 10MΩ or more

Enclosure: Totally-enclosed, self-cooled: totally-enclosed, externally fan-cooled for type USAMKD-60MA2 (Equivalent to IP-55 exclusive shaft opening)

Ambient Temperature: 0 to +40°C

Ambient Humidity: 20% to 80% (non-condensing)

Vibration: 15 μm or below

Finish in Munsell Notation: N1.5 (Gray)

Excitation: Permanent magnet

Mounting: Flange mounted

Drive Method: Direct drive

Table 1.1 Ratings and Specifications of M Series AC Servomotors

| Item \ Motor Type | | | USAMED -03M□1 | USAMED -06M□1 | USAMED -09M□2 | USAMED -12M□2 | USAMED -20M□2 | USAMED -30M□2 | USAMED -44M□2 | USAMKD -60M□2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Rated Output* | | kW (HP) | 0.3 (0.4) | 0.6 (0.8) | 0.9 (1.2) | 1.2 (1.6) | 2.0 (2.7) | 3.0 (4.1) | 4.4 (6.0) | 6.0 (8.2) |
| Rated Torque* | | kg·cm (lb·in) | 29 (25) | 58 (50) | 88 (76) | 117 (102) | 195 (169) | 290 (252) | 428 (372) | 584 (507) |
| Continuous Max Torque* | | kg·cm (lb·in) | 30 (26) | 60 (52) | 90 (78) | 120 (104) | 220 (191) | 330 (286) | 470 (408) | 642 (557) |
| Instantaneous Max Torque* | | kg·cm (lb·in) | 73 (63) | 144 (125) | 197 (171) | 286 (248) | 449 (390) | 650 (564) | 930 (807) | 1080 (938) |
| Rated Current* | | A | 3.0 | 5.8 | 7.6 | 11.7 | 18.8 | 26 | 33 | 45 |
| Rated Speed* | | rpm | 1000 | | | | | | | |
| Instantaneous Max Speed* | | rpm | 2000 | | | | | | 1500 | |
| Torque Constant | | kg·cm/A (lb·in/A) | 10.3 (8.9) | 10.6 (9.2) | 12.3 (10.7) | 10.4 (9.0) | 10.9 (9.5) | 11.8 (10.2) | 13.6 (11.8) | 13.6 (11.8) |
| Inertia | J | g·cm·s² (lb·in·s²×10⁻³) | 13.8 (12.0) | 24.8 (21.5) | 37.4 (32.5) | 68.2 (59.2) | 112 (97.2) | 146 (126.7) | 245 (212.6) | 245 (212.6) |
| | (GD²/4) | kg·cm² (lb·in²) | 13.5 (4.61) | 24.3 (8.31) | 36.7 (12.5) | 66.8 (22.8) | 110 (37.6) | 143 (48.9) | 240 (82.0) | 240 (82.0) |
| Power Rate* | | kW/s | 6.1 | 13.3 | 20.3 | 19.7 | 33.2 | 57.0 | 74.0 | 138 |
| Inertia Time Constant | | ms | 8.3 | 5.9 | 4.6 | 6.9 | 5.2 | 4.1 | 4.0 | 4.0 |
| Inductive Time Constant | | ms | 4.2 | 5.4 | 6.5 | 10.4 | 12.9 | 15.3 | 16.2 | 16.2 |
| Insulation | | | Class F | | | | | | | |

* Values when servomotor is combined with Servopack and the armature winding temperature is 20°C. Shown are normal (TYP) values above.

Note:

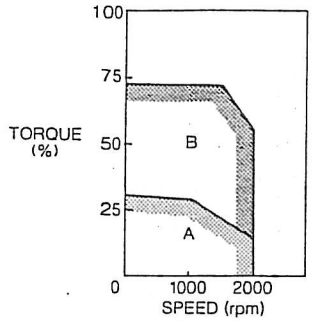
1. □ in type designation is determined by output pulses (pulses/rev) of optical encoder as follows:
   - Standard: A (6000 pulses/rev)
   - Optional: B (5000 pulses/rev), D (4000 pulses/rev)

2. Power supply unit for brake has two types:
   - Type OPR109F (Input 100 VAC, Output 90 VDC)
   - Type OPR109A (Input 200 VAC, Output 90 VDC)

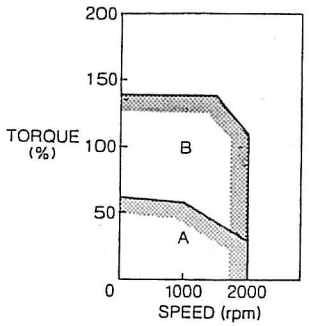
   For details, see par. 8.5 (3) on page 45.

### 1.1.2 Torque-Speed Characteristics

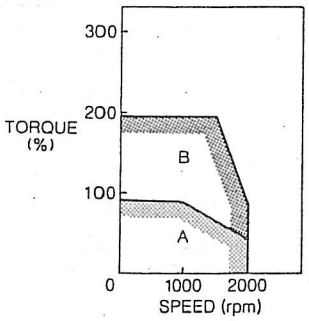
• TYPE USAMED-03M



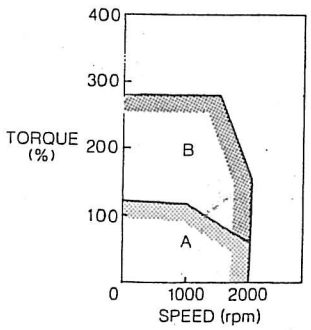

• TYPE USAMED-06M



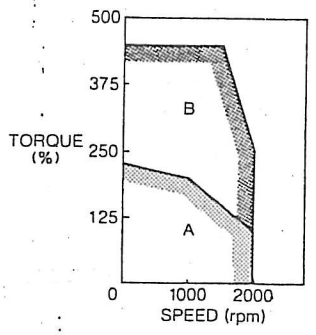

• TYPE USAMED-09M



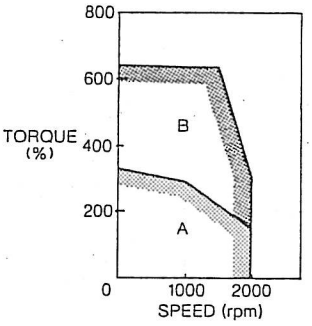

• TYPE USAMED-12M



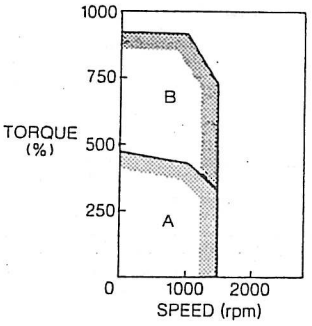

• TYPE USAMED-20M



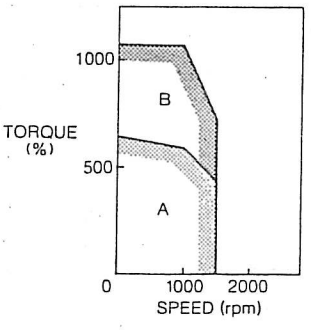

• TYPE USAMED-30M




• TYPE USAMED-44M




• TYPE USAMKD-60M




A: CONTINUOUS DUTY ZONE
B: INTERMITTENT DUTY ZONE
POWER SUPPLY: 200 V

## 1.2 RATINGS AND SPECIFICATIONS OF F SERIES AC SERVOMOTORS

### 1.2.1 Ratings

Time Rating: Continuous
Insulation: Class F
Isolation Voltage: 1500 VAC, one minute
Insulation Resistance: 500 VDC, 10MΩ or more
Enclosure: Totally-enclosed, self-cooled
(Equivalent to IP-55 exclusive shaft opening)

Ambient Temperature: 0 to +40°C
Ambient Humidity: 20% to 80% (non-condensing)
Vibration: 15 μm or below
Finish in Munsell Notation: N1.5 (Gray)
Excitation: Permanent magnet
Mounting: Flange mounted
Drive Method: Direct drive

Table 1.2 Ratings and Specifications of F Series AC Servomotors

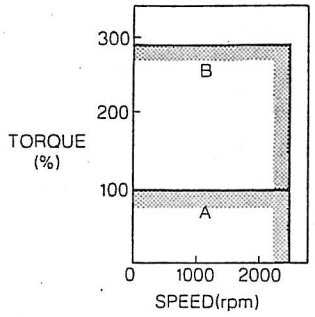
| Item | | Motor Type USAFED- | 02F□1 | 03F□1 | 05F□1 | 09F□1 | 13F□2 | 20F□2 | 30F□2 | 44F□2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Rated Output* | | kW (HP) | 0.15 (0.2) | 0.3 (0.4) | 0.45 (0.6) | 0.85 (1.2) | 1.3 (1.8) | 1.8 (2.4) | 2.9 (3.9) | 4.4 (6.0) |
| Rated Torque* | | kg·cm (lb·in) | 10 (8.7) | 20 (17) | 29 (25) | 55 (48) | 85 (74) | 117 (102) | 190 (165) | 290 (252) |
| Continuous Max Torque* | | kg·cm (lb·in) | 11 (10) | 22 (19) | 30 (26) | 60 (52) | 90 (78) | 120 (104) | 230 (200) | 380 (330) |
| Instantaneous Max Torque* | | kg·cm (lb·in) | 29.7 (26) | 59.4 (52) | 91 (79) | 155 (135) | 252 (219) | 347 (301) | 552 (479) | 778 (675) |
| Rated Current* | | A | 3 | 3 | 3.8 | 6.2 | 9.7 | 15 | 20 | 30 |
| Rated Speed* | | rpm | 1500 | | | | | | | |
| Instantaneous Max Speed* | | rpm | 2500 | | | | | | | |
| Torque Constant | | kg·cm/A (lb·in/A) | 3.7 (3.2) | 7.3 (6.3) | 8.2 (7.1) | 9.4 (8.2) | 9.4 (8.2) | 8.4 (7.3) | 10.0 (8.7) | 10.4 (9.0) |
| Inertia | J | g·cm·s² (lb·in·s²×13⁻³) | 1.33 (1.1) | 2.1 (1.8) | 13.8 (12.0) | 24.8 (21.5) | 37.4 (32.5) | 68.2 (59.2) | 112 (97.2) | 146 (126.7) |
| | (GD²/4) | kg·cm² (lb·in²) | 1.3 (0.44) | 2.06 (0.70) | 13.5 (4.61) | 24.3 (8.31) | 36.7 (12.5) | 66.8 (22.8) | 110 (37.6) | 143 (48.9) |
| Power Rate* | | kW/s | 7.4 | 18.3 | 6.0 | 12 | 18.9 | 19.7 | 31.5 | 57.0 |
| Inertia Time Constant | | ms | 4.5 | 2.5 | 8.3 | 5.7 | 4.7 | 6.8 | 5.1 | 4.1 |
| Inductive Time Constant | | ms | 3.4 | 4.3 | 4.2 | 5.5 | 6.4 | 10.4 | 13.0 | 15.2 |
| Insulation | | | Class F | | | | | | | |

* Values when servomotor is combined with Servopack and the armature winding temperature is 20°C. Shown are normal (TYP) values above.

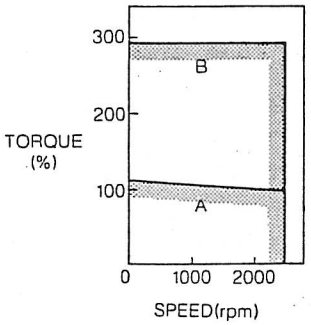
Note:
1. □ in type designation is determined by output pulses (pulses/rev) of optical encoder as follows:
   - Standard: A (6000 pulses/rev)
   - Optional: B (5000 pulses/rev), D (4000 pulses/rev)
2. Power supply unit for brake has two types:
   - Type OPR109F (Input 100 VAC, Output 90 VDC)
   - Type OPR109A (Input 200 VAC, Output 90 VDC)

## 1. 2. 2 Torque-Speed Characteristics

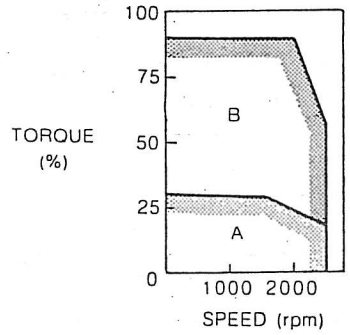
• TYPE USAFED-02F



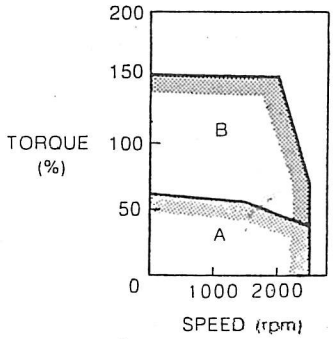

• TYPE USAFED-03F



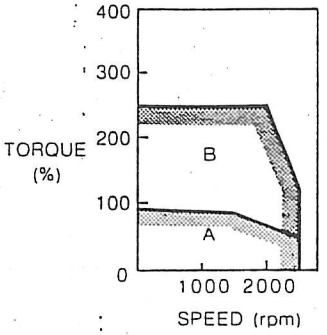

• TYPE USAFED-05F



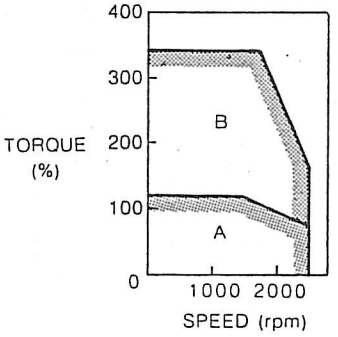

• TYPE USAFED-09F



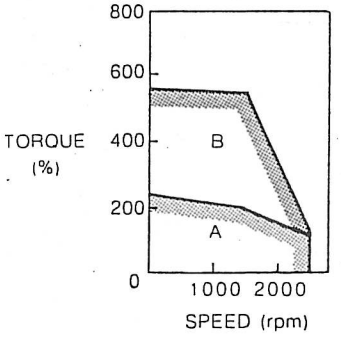

• TYPE USAFED-13F



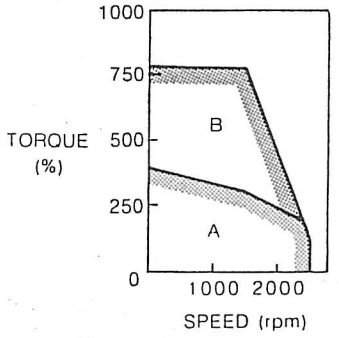

• TYPE USAFED-20F




• TYPE USAFED-30F




• TYPE USAFED-44F




A: CONTINUOUS DUTY ZONE
B: INTERMITTENT DUTY ZONE
POWER SUPPLY: 200 V

## 1.3 RATINGS AND SPECIFICATIONS OF *Servopack*

Table 1.3 Ratings and Specifications of *Servopack*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| servopack Type CACR- | | | | PR03BB | PR05BB | PR07BB | PR10BB | PR15BB | PR20BB | PR30BB | PR44BB | PR60BB |
| Max Motor Output | | | kW (HP) | 0.3 (0.4) | 0.5 (0.67) | 0.7 (0.94) | 1.0 (1.34) | 1.5 (2.01) | 2.0 (2.7) | 3.0 (4.1) | 4.4 (6.0) | 6.0 (8.2) |
| M Series | Applicable Optical Encoder | | | A: 6000 pulses/rev(B: 5000 pulses/rev. D: 4000 pulses/rev) | | | | | | | | |
| | AC Servomotor | Type USAMED- | | 03MA | – | 06MA | 09MA | 12MA | 20MA | 30MA | 44MA | 60M |
| | | Output | kW (HP) | 0.3 (0.4) | – | 0.6 (0.8) | 0.9 (1.2) | 1.2 (1.6) | 2.0 (2.7) | 3.0 (4.1) | 4.4 (6.0) | 6.0 (8.2) |
| | | Rated Speed | rpm | 1000 | | | | | | | | |
| | Servopack Type CACR- | | | PR03BB3AM | – | PR07BB3AM | PR10BB3AM | PR15BB3AM | PR20BB3AM | PR30BB3AM | PR44BB3AM | PR60BB3AM |
| | Continuous Output Current | | Arms | 3.0 | – | 5.8 | 7.6 | 11.7 | 18.8 | 26.0 | 33.0 | 45.0 |
| | Max Output Current | | Arms | 7.3 | – | 13.9 | 16.6 | 28.0 | 42.0 | 56.5 | 70.0 | 80.6 |
| | Allowable GD²‡ | | kg·cm² (lb·in²) | 270 (92.3) | – | 486 (166.1) | 734 (250.8) | 1336 (456.5) | 2200 (751.7) | 2860 (977.2) | 4800 (1640.2) | 4800 (1640.2) |
| F Series | Applicable Optical Encoder | | | A: 6000 pulses/rev(B: 5000 pulses/rev. D: 4000 pulses/rev) | | | | | | | | |
| | AC Servomotor | Type USAFED— | | 02FA | 03FA | 05FA | – | 09FA | 13FA | 20FA | 30FA | 44FA | – |
| | | Output | kW (HP) | 0.15 (0.2) | 0.3 (0.4) | 0.45 (0.6) | – | 0.85 (1.2) | 1.3 (1.8) | 1.8 (2.4) | 2.9 (3.9) | 4.4 (6.0) | – |
| | | Rated Speed | rpm | 1500 | | | | | | | | |
| | Servopack Type CACR— | | | PR03BB3AF | PR05BB3AF | – | PR10BB3AF | PR15BB3AF | PR20BB3AF | PR30BB3AF | PR44BB3AF | – |
| | Continuous Output Current | | Arms | 3.0 | 3.8 | – | 6.2 | 9.7 | 15.0 | 20.0 | 30.0 | – |
| | Max Output Current | | Arms | 8.5 | 11.0 | – | 17.0 | 27.6 | 42.0 | 56.5 | 77.0 | – |
| | Allowable GD²‡ | | kg·cm² (lb·in²) | 40 (13.7) | 270 (92.3) | – | 486 (166.1) | 734 (250.8) | 1336 (456.5) | 2200 (751.7) | 2860 (977.2) | – |
| Basic Specifications | Power* Supply | Main Circuit | | Three-phase 200 to 230 VAC $^{+10}_{-15}$ %, 50/60 Hz | | | | | | | | |
| | | Control Circuit | | Single-phase 200 to 230 VAC $^{+10}_{-15}$ %, 50/60Hz | | | | | | | | |
| | Control Method | | | Transistorized PWM Control | | | | | | | | |
| | Feedback | | | Optical encoder (A: 6000 pulses/rev, B: 5000 pulses/rev, D: 4000 pulses/rev) | | | | | | | | |
| | Ambient Temperature† | | | 0 to +55 °C | | | | | | | | |
| | Storage Temperature | | | −20 °C to +85 °C | | | | | | | | |
| | Ambient and Storage Humidity | | | 90 % or less(non-condensing) | | | | | | | | |
| | Mounting Structure | | | Base mounted | | | | | | | | |
| | Approx Weight | | kg (lb) | 8 (18) | 8 (18) | 8 (18) | 10.5 (23) | 10.5 (23) | 11 (24) | 11.5 (25) | 15 (33) | 23 (51) |
| Performance | Max Input Pulse Frequency | | | 200Kpps(Max motor speed or below)12V/5V changeable | | | | | | | | |
| | Input Pulse Form | | | +12V level(sign + pulse input) | | | | | | | | |
| | Positioning Completion | | | Output transistor ON if No. of error counter lag | | | | | | | | |
| | Signal Output | | | Pulses reaches the set value(±1 to ±70 pulses) | | | | | | | | |
| | Reference Pulse Block Signal | | | Block input reference pulses | | | | | | | | |
| | Clear Signal | | | Clears error counter lag pulses | | | | | | | | |
| | Sequence Input Signal | | | Servo ON, P drive, forward run inhibit, reverse run inhibit | | | | | | | | |
| | Sequence Output Signal | | | Servo alarm, positioning completion signal , overflow | | | | | | | | |
| | Positioning Signal Output | | | 1/N time(N = 1 to 32) of PG pulses or 2/N time(N 2 to 32) | | | | | | | | |
| Built-in Functions | Protection | | | Overvoltage, overload, overcurrent, overspeed, overrun, open phase detection , fuse blown, heatsink overheat. | | | | | | | | |
| | Indication | | | Power supply, alarm, status indications | | | | | | | | |
| | Dynamic Brake | | | Built-in(non-contact dynamic brake) | | | | | | | | |
| | Regenerative Resistor | | | Built-in | | | | | | | | Separately installed |
| | Applicable Load Inertia‡ | | | Up to 5 times motor inertia | | | | | | | | |
| | Monitor Output | | | Speed monitor: 2.0 V ±5 % at 1000 rpm(M, F series) | | | | | | | | |

* Supply voltage shoud not exceed 230 V + 10 % (253 V). If the voltage should exceed this value, a step down transformer is required.

† When housed in a panel, the inside temperature must not exceed ambient temperature range.

‡ When load GD² exceeds applicable range, be sure to refer to 6.7.2, Load Inertia.

## 2. TYPE DESIGNATION

• AC Servomotor

USAFED-05FA1□□

- AC SERVOMOTOR
- SERIES
  - AM: M Series
  - AF: F Series
- ENCLOSURE
  - E: Totally-enclosed, Self-cooled Type
  - K: Totally-enclosed, Externally Fan-cooled Type
- MAGNET TYPE
  - D: Ferrite
  - M: Rare Earth
- MOTOR OUTPUT (Table 2.1)
- DESIGN REVISION ORDER
- DETECTOR (Table 2.3)
- SHAFT TYPE
  - 1: Taper
  - 2: Straight
- DRIVE END SPECIFICATION
  - Blank: Standard
  - O: Standard (With Brake)
  - K: With Keyway
  - S: With Oil Seal
  - T: With Keyway & Oil Seal
- OPPOSITE DRIVE END SPECIFICATION
  - Blank: Standard
  - E: With Brake

• ***Servopack***

CACR-PR05BB3AF

- *Servopack* SERIES
- CONTROL TYPE
  - PR: POSITIONING CONTROL
- MOTOR OUTPUT (Table 2.2)
- APPLICATION
  - B: M, F Series
- DESIGN REVISION ORDER
- INPUT FORM
  - 3: 200V, Pulse input
- DETECTOR (Table 2.3)
- APPLICABLE MOTOR SERIES
  - M: M Series
  - F: F Series

Table 2.1

| | Motor Output | |
|---|---|---|
| | M Series | F Series |
| 02 | — | 0.15kW (0.2HP) |
| 03 | 0.3kW (0.4HP) | 0.3kW (0.4HP) |
| 05 | — | 0.45kW (0.6HP) |
| 06 | 0.6kW (0.8HP) | — |
| 08 | — | — |
| 09 | 0.9kW (1.2HP) | 0.85kW (1.2HP) |
| 12 | 1.2kW (1.6HP) | — |
| 13 | — | 1.3kW (1.8HP) |
| 15 | — | — |
| 20 | 2.0kW (2.7HP) | 1.8kW (2.4HP) |
| 30 | 3.0kW (4.1HP) | 2.9kW (3.9HP) |
| 44 | 4.4kW (6.0HP) | 4.4kW (6.0HP) |
| 60 | 6.0kW (8.2HP) | — |

Table 2.2

| | Motor Output | |
|---|---|---|
| | M Series | F Series |
| 03 | 0.3kW (0.4HP) | 0.15kW (0.2HP) |
| | | 0.3kW (0.4HP) |
| 05 | — | 0.45kW (0.6HP) |
| 07 | 0.6kW (0.8HP) | — |
| 10 | 0.9kW (1.2HP) | 0.85kW (1.2HP) |
| 15 | 1.2kW (1.6HP) | 1.3kW (1.8HP) |
| 20 | 2.0kW (2.7HP) | 1.8kW (2.4HP) |
| 30 | 3.0kW (4.1HP) | 2.9kW (3.9HP) |
| 44 | 4.4kW (6.0HP) | 4.4kW (6.0HP) |
| 60 | 6.0kW (8.2HP) | — |

Table 2.3

| Models | Standard pulses/rev | | Optional pulses/rev | | | |
|---|---|---|---|---|---|---|
| M Series | A | 6000 | B | 5000 | D | 4000 |
| F Series | A | 6000 | B | 5000 | D | 4000 |

# 3. LIST OF STANDARD COMBINATION

Table 3.1 Combination of ***Servopack***, AC Servomotors and Associate Units

• M SERIES

| Servopack Type CACR- | AC Servomotor Type | AC Servomotor Optical Encoder pulses/rev | Power Capacity* per Servopack kVA | Current Capacity per MCCB or Fuse A | Applicable Noise Filter | Recommended Noise Filter† Type | Recommended Noise Filter† Specifications | Power ON/OFF SwitCh |
|---|---|---|---|---|---|---|---|---|
| PR03BB3AM | USAMED-03MA1 | 6000 | 0.65 | 5 | Good | LF-305 | 3-phase 200 VAC class, 5A | Yaskawa type HI-15E$_2$ rated 30A or equivalent |
| PR03BB3BM | USAMED-03MB1 | 5000 | | | | | | |
| PR03BB3DM | USAMED-03MD1 | 4000 | | | | | | |
| PR07BB3AM | USAMED-06MA1 | 6000 | 1.5 | 8 | | LF-310 | 3-phase 200 VAC class, 10A | |
| PR07BB3BM | USAMED-06MB1 | 5000 | | | | | | |
| PR07BB3DM | USAMED-06MD1 | 4000 | | | | | | |
| PR10BB3AM | USAMED-09MA2 | 6000 | 2.1 | 8 | | LF-315 | 3-phase 200 VAC class, 15A | |
| PR10BB3BM | USAMED-09MB2 | 5000 | | | | | | |
| PR10BB3DM | USAMED-09MD2 | 4000 | | | | | | |
| PR15BB3AM | USAMED-12MA2 | 6000 | 3.1 | 10 | | LF-315 | 3-phase 200 VAC class, 15A | |
| PR15BB3BM | USAMED-12MB2 | 5000 | | | | | | |
| PR15BB3DM | USAMED-12MD2 | 4000 | | | | | | |
| PR20BB3AM | USAMED-20MA2 | 6000 | 4.1 | 12 | | LF-320 | 3-phase 200 VAC class, 20A | Yaskawa type HI-18E rated 35A or equivalent |
| PR20BB3BM | USAMED-20MB2 | 5000 | | | | | | |
| PR20BB3DM | USAMED-20MD2 | 4000 | | | | | | |
| PR30BB3AM | USAMED-30MA2 | 6000 | 6.0 | 18 | | LF-330 | 3-phase 200 VAC class, 30A | |
| PR30BB3BM | USAMED-30MB2 | 5000 | | | | | | |
| PR30BB3DM | USAMED-30MD2 | 4000 | | | | | | |
| PR44BB3AM | USAMED-44MA2 | 6000 | 8.0 | 24 | Poor | LF-340 | 3-phase 200 VAC class, 40A | |
| PR44BB3BM | USAMED-44MB2 | 5000 | | | | | | |
| PR44BB3DM | USAMED-44MD2 | 4000 | | | | | | |
| PR60BB3AM | USAMKD-60MA2 | 6000 | 11 | 32 | | LF-350 | 3-phase 200 VAC class, 50A | Yaskawa type HI-25E rated 50A or equivalent |
| PR60BB3BM | USAMKD-60MB2 | 5000 | | | | | | |
| PR60BB3DM | USAMKD-60MD2 | 4000 | | | | | | |

• F SERIES

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PR03BB3AF | USAFED-02FA1 | 6000 | 0.65 | 5 | Good | LF-305 | 3-phase 200 VAC class, 5A | Yaskawa type HI-15E$_2$ rated 30A or equivalent |
| PR03BB3BF | USAFED-02FB1 | 5000 | | | | | | |
| PR03BB3DF | USAFED-02FD1 | 4000 | | | | | | |
| PR03BB3AF | USAFED-03FA1 | 6000 | | | | | | |
| PR03BB3BF | USAFED-03FB1 | 5000 | | | | | | |
| PR03BB3DF | USAFED-03FD1 | 4000 | | | | | | |
| PR05BB3AF | USAFED-05FA1 | 6000 | 1.1 | | | | | |
| PR05BB3BF | USAFED-05FB1 | 5000 | | | | | | |
| PR05BB3DF | USAFED-05FD1 | 4000 | | | | | | |
| PR10BB3AF | USAFED-09FA1 | 6000 | 2.1 | 8 | | LF-315 | 3-phase 200 VAC class, 15A | |
| PR10BB3BF | USAFED-09FB1 | 5000 | | | | | | |
| PR10BB3DF | USAFED-09FD1 | 4000 | | | | | | |
| PR15BB3AF | USAFED-13FA2 | 6000 | 3.1 | 10 | | LF-315 | 3-phase 200 VAC class, 15A | |
| PR15BB3BF | USAFED-13FB2 | 5000 | | | | | | |
| PR15BB3DF | USAFED-13FD2 | 4000 | | | | | | |
| PR20BB3AF | USAFED-20FA2 | 6000 | 4.1 | 12 | Poor | LF-320 | 3-phase 200 VAC class, 20A | Yaskawa type HI-18E rated 35A or equivalent |
| PR20BB3BF | USAFED-20FB2 | 5000 | | | | | | |
| PR20BB3DF | USAFED-20FD2 | 4000 | | | | | | |
| PR30BB3AF | USAFED-30FA2 | 6000 | 6.0 | 18 | | LF-330 | 3-phase 200 VAC class, 30A | |
| PR30BB3BF | USAFED-30FB2 | 5000 | | | | | | |
| PR30BB3DF | USAFED-30FD2 | 4000 | | | | | | |
| PR44BB3AF | USAFED-44FA2 | 6000 | 8.0 | 24 | | LF-340 | 3-phase 200 VAC class, 40A | |
| PR44BB3BF | USAFED-44FB2 | 5000 | | | | | | |
| PR44BB3DF | USAFED-44FD2 | 4000 | | | | | | |

*Values at rated load.
Made by Tokin Corp.

Table 3.2 Specifications of AC Servomotors and Detectors

• M SERIES

| Servopack Type CACR– | AC Servomotor | | | | | | Detector | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Type | Optical Encoder pulses/rev | Receptacle Type | L-type Plug | Straight Plug | Cable Clamp | Receptacle Type | L-type Plug | Straight Plug | *Cable Clamp |
| PR03BB3AM | USAMED-03MA1 | 6000 | MS 3102A18 -10P | MS 3108B18 -10S | MS 3106B18 -10S | MS 3057 -10A | MS 3102A20 -29P | MS 3108B20 -29S | MS 3106B20 -29S | MS 3057 -12A |
| PR03BB3BM | USAMED-03MB1 | 5000 | | | | | | | | |
| PR03BB3DM | USAMED-03MD1 | 4000 | | | | | | | | |
| PR07BB3AM | USAMED-06MA1 | 6000 | | | | | | | | |
| PR07BB3BM | USAMED-06MB1 | 5000 | | | | | | | | |
| PR07BB3DM | USAMED-06MD1 | 4000 | | | | | | | | |
| PR10BB3AM | USAMED-09MA2 | 6000 | | | | | | | | |
| PR10BB3BM | USAMED-09MB2 | 5000 | | | | | | | | |
| PR10BB3DM | USAMED-09MD2 | 4000 | | | | | | | | |
| PR15BB3AM | USAMED-12MA2 | 6000 | MS 3102A22 -22P | MS 3108B22 -22S | MS 3106B22 -22S | MS 3057 -12A | | | | |
| PR15BB3BM | USAMED-12MB2 | 5000 | | | | | | | | |
| PR15BB3DM | USAMED-12MD2 | 4000 | | | | | | | | |
| PR20BB3AM | USAMED-20MA2 | 6000 | | | | | | | | |
| PR20BB3BM | USAMED-20MB2 | 5000 | | | | | | | | |
| PR20BB3DM | USAMED-20MD2 | 4000 | | | | | | | | |
| PR30BB3AM | USAMED-30MA2 | 6000 | | | | | | | | |
| PR30BB3BM | USAMED-30MB2 | 5000 | | | | | | | | |
| PR30BB3DM | USAMED-30MD2 | 4000 | | | | | | | | |
| PR44BB3AM | USAMED-44MA2 | 6000 | MS 3102A32 -17P | MS 3108B32 -17S | MS 3106B32 -17S | MS 3057 -20A | | | | |
| PR44BB3BM | USAMED-44MB2 | 5000 | | | | | | | | |
| PR44BB3DM | USAMED-44MD2 | 4000 | | | | | | | | |
| PR60BB3AM | USAMKD-60MA2 | 6000 | | | | | | | | |
| PR60BB3BM | USAMKD-60MB2 | 5000 | | | | | | | | |
| PR60BB3DM | USAMKD-60MD2 | 4000 | | | | | | | | |

• F SERIES

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| PR03BB3AF | USAFED-02FA1 | 6000 | MS 3102A14S -2P | MS 3108B14S -2S | MS 3106B14S -2S | MS 3057 -6A | MS 3102A20 -29P | MS 3108B20 -29S | MS 3106B20 -29S | MS 3057 -12A |
| PR03BB3BF | USAFED-02FB1 | 5000 | | | | | | | | |
| PR03BB3DF | USAFED-02FD1 | 4000 | | | | | | | | |
| PR03BB3AF | USAFED-03FA1 | 6000 | | | | | | | | |
| PR03BB3BF | USAFED-03FB1 | 5000 | | | | | | | | |
| PR03BB3DF | USAFED-03FD1 | 4000 | | | | | | | | |
| PR05BB3AF | USAFED-05FA1 | 6000 | MS 3102A18 -10P | MS 3108B18 -10S | MS 3106B18 -10S | MS 3057 -10A | | | | |
| PR05BB3BF | USAFED-05FB1 | 5000 | | | | | | | | |
| PR05BB3DF | USAFED-05FD1 | 4000 | | | | | | | | |
| PR10BB3AF | USAFED-09FA1 | 6000 | | | | | | | | |
| PR10BB3BF | USAFED-09FB1 | 5000 | | | | | | | | |
| PR10BB3DF | USAFED-09FD1 | 4000 | | | | | | | | |
| PR15BB3AF | USAFED-13FA2 | 6000 | | | | | | | | |
| PR15BB3BF | USAFED-13FB2 | 5000 | | | | | | | | |
| PR15BB3DF | USAFED-13FD2 | 4000 | | | | | | | | |
| PR20BB3AF | USAFED-20FA2 | 6000 | MS 3102A22 -22P | MS 3108B22 -22S | MS 3106B22 -22S | MS 3057 -12A | | | | |
| PR20BB3BF | USAFED-20FB2 | 5000 | | | | | | | | |
| PR20BB3DF | USAFED-20FD2 | 4000 | | | | | | | | |
| PR30BB3AF | USAFED-30FA2 | 6000 | | | | | | | | |
| PR30BB3BF | USAFED-30FB2 | 5000 | | | | | | | | |
| PR30BB3BF | USAFED-30FD2 | 4000 | | | | | | | | |
| PR44BB3AF | USAFED-44FA2 | 6000 | | | | | | | | |
| PR44BB3BF | USAFED-44FB2 | 5000 | | | | | | | | |
| PR44BB3DF | USAFED-44FD2 | 4000 | | | | | | | | |

Note: When plugs or clamps are required, contact Yaskawa representative. The following connections are provided: soldered type (type MS) and solderless type (type JA).

Table 3.3 Specifications of Holding Brake

• M SERIES

| Servopack Type CACR– | AC Servomotor | | Holding Brake | | | |
|---|---|---|---|---|---|---|
| | Type | Optical Encoder pulses/rev | Receptacle Type | L–type Plug | Straight Plug | Cable Clamp |
| PR03BB3AM | USAMED–03MA1 | 6000 | MS3102A20 –15P | MS3108B20 –15S | MS3106B20 –15S | MS3057 –12A |
| PR03BB3BM | USAMED–03MB1 | 5000 | | | | |
| PR03BB3DM | USAMED–03MD1 | 4000 | | | | |
| PR07BB3AM | USAMED–06MA1 | 6000 | | | | |
| PR07BB3BM | USAMED–06MB1 | 5000 | | | | |
| PR07BB3DM | USAMED–06MD1 | 4000 | | | | |
| PR10BB3AM | USAMED–09MA2 | 6000 | | | | |
| PR10BB3BM | USAMED–09MB2 | 5000 | | | | |
| PR10BB3DM | USAMED–09MD2 | 4000 | | | | |
| PR15BB3AM | USAMED–12MA2 | 6000 | MS3102A24 –10P | MS3108B24 –10S | MS3106B24 –10S | MS3057 –16A |
| PR15BB3BM | USAMED–12MB2 | 5000 | | | | |
| PR15BB3DM | USAMED–12MD2 | 4000 | | | | |
| PR20BB3AM | USAMED–20MA2 | 6000 | | | | |
| PR20BB3BM | USAMED–20MB2 | 5000 | | | | |
| PR20BB3DM | USAMED–20MD2 | 4000 | | | | |
| PR30BB3AM | USAMED–30MA2 | 6000 | | | | |
| PR30BB3BM | USAMED–30MB2 | 5000 | | | | |
| PR30BB3DM | USAMED–30MD2 | 4000 | | | | |
| PR44BB3AM | USAMED–44MA2 | 6000 | – | – | – | – |
| PR44BB3BM | USAMED–44MB2 | 5000 | | | | |
| PR44BB3DM | USAMED–44MD2 | 4000 | | | | |
| PR60BB3AM | USAMKD–60MA2 | 6000 | | | | |
| PR60BB3BM | USAMKD–60MB2 | 5000 | | | | |
| PR60BB3DM | USAMKD–60MD2 | 4000 | | | | |

• F SERIES

| | | | | | | |
|---|---|---|---|---|---|---|
| PR03BB3AF | USAFED–02FA1 | 6000 | MS3102A14S –6P | MS3108B14S –6S | MS3106B14S –6S | MS3057 –6A |
| PR03BB3BF | USAFED–02FB1 | 5000 | | | | |
| PR03BB3DF | USAFED–02FD1 | 4000 | | | | |
| PR03BB3AF | USAFED–03FA1 | 6000 | | | | |
| PR03BB3BF | USAFED–03FB1 | 5000 | | | | |
| PR03BB3DF | USAFED–03FD1 | 4000 | | | | |
| PR05BB3FA | USAFED–05FA1 | 6000 | MS3102A20 –15P | MS3108B20 –15S | MS3106B20 –15S | MS3057 –12A |
| PR05BB3BF | USAFED–05FB1 | 5000 | | | | |
| PR05BB3DF | USAFED–05FD1 | 4000 | | | | |
| PR10BB3AF | USAFED–09FA1 | 6000 | | | | |
| PR10BB3BF | USAFED–09FB1 | 5000 | | | | |
| PR10BB3DF | USAFED–09FD1 | 4000 | | | | |
| PR15BB3AF | USAFED–13FA2 | 6000 | | | | |
| PR15BB3BF | USAFED–13FB2 | 5000 | | | | |
| PR15BB3DF | USAFED–13FD2 | 4000 | | | | |
| PR20BB3AF | USAFED–20FA2 | 6000 | MS3102A24 –10P | MS3108B24 –10S | MS3106B24 –10S | MS3057 –16A |
| PR20BB3BF | USAFED–20FB2 | 5000 | | | | |
| PR20BB3DF | USAFED–20FD2 | 4000 | | | | |
| PR30BB3AF | USAFED–30FA2 | 6000 | | | | |
| PR30BB3BF | USAFED–30FB2 | 5000 | | | | |
| PR30BB3DF | USAFED–30FD2 | 4000 | | | | |
| PR44BB3AF | USAFED–44FA2 | 6000 | | | | |
| PR44BB3BF | USAFED–44FB2 | 5000 | | | | |
| PR44BB3DF | USAFED–44FD2 | 4000 | | | | |

# 4. CHARACTERISTICS

## 4.1 OVERLOAD CHARACTERISTICS

The overload protective circuit built in Servopack prevents the motor and Servopack from overload and restricts the allowable conduction time of Servopack. (See Figs. 4.1 and 4.2.)

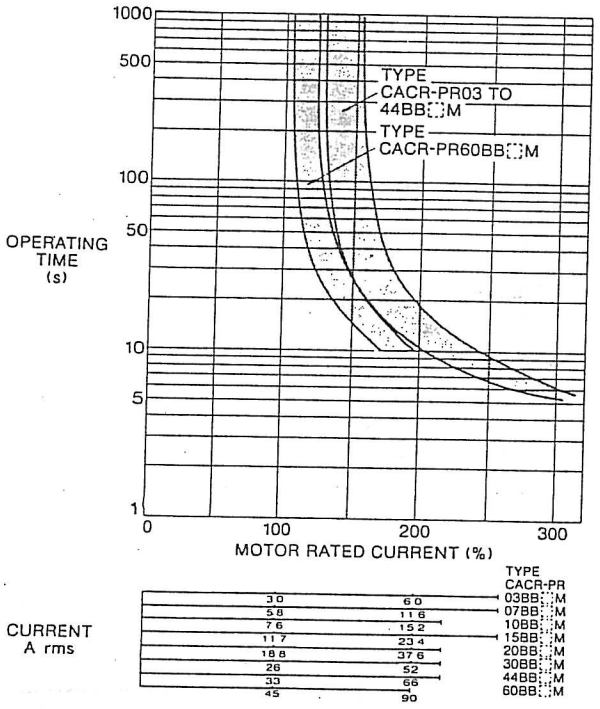



Fig. 4.1 Overload Characteristics of M Series Motors

The overload detection level is set precisely by the hot start conditions at an ambient temperature of 55°C and cannot be changed.

**NOTE**

Hot start is the overload characteristics when the Servopack is running at the rated load and thermally saturated.

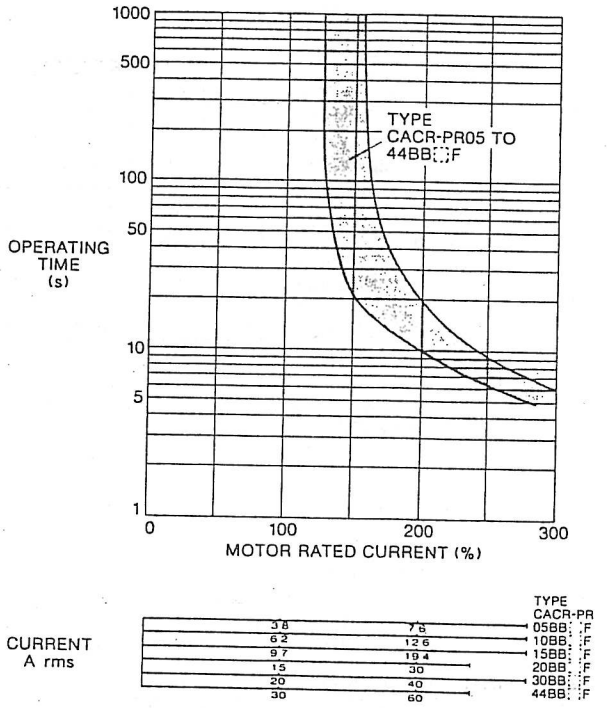



Fig. 4.2 Overload Characteristics of F Series Motors

## 4.2 STARTING AND STOPPING TIME

The starting time and stopping time of servomotor under a constant load is shown by the formula below. Viscous or friction torque of the motor is neglected.

Starting Time:

$$t_r = 26.8 \times 10^{-3} \times \frac{N_R\ (GD_M^2 + GD_L^2)}{Kt\ I_R\ (\alpha - \beta)} \text{(ms)}$$

Stopping Time:

$$t_f = 26.8 \times 10^{-3} \times \frac{N_R\ (GD_M^2 + GD_L^2)}{Kt\ I_R\ (\alpha + \beta)} \text{(ms)}$$

Where,

$N_R$ : Rated motor speed (rpm)

$GD^2_M$ : Motor $GD^2$ (kg·cm² = lb.in²)

$GD^2_L$ : Moment of inertia of motor (kg·cm² = lb.in²)

$Kt$ : Torque constant of motor (kg·cm/A = lb.in/A)

$I_R$ : Motor rated current (A)

$\alpha = I_P / I_R$ : Acceleration/deceleration current constant

$I_P$ : Acceleration/deceleration current (Acceleration/deceleration current $\alpha$ times the motor rated current) (A)

$\beta = I_L / I_R$ : Load current constant

$I_L$ : Current equivalent to load torque (Load current $\beta$ times the motor rated current) (A)

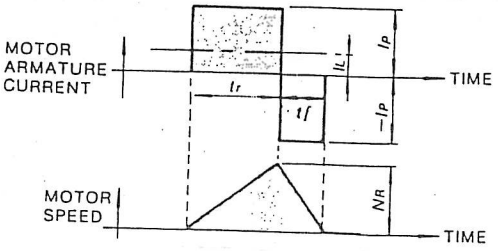



Fig. 4.3 Timing Chart of Motor Armature Current and Speed

## 4.3 ALLOWABLE FREQUENCY OF OPERATION

The allowable frequency of operation is restricted by the servomotor and Servopack, and both the conditions must be considered for satisfactory operation.

- Allowable frequency of operation restricted by the ***Servopack***

  The allowable frequency of operation is restricted by the heat generated in the regenerative resistor in the Servopack, and varies depending on the motor types, capacity, load $GD^2$, acceleration/deceleration current values, and motor speed. If the frequency of operation exceeds 60 times/min when load $GD^2 = 0$ before the rated speed is reached, or if it exceeds $\frac{60}{m+1}$ cycles/min when load $GD^2$ = motor $GD^2 \times m$, contact Yaskawa representative.

- Allowable frequency of operation restricted by the Servomotor

  The allowable frequency of operation varies depending on the load conditions, motor running time and the operating conditions. Typical examples are shown below. See par. 4.2 Starting and Stopping Time for symbols.

- When the motor repeats rated-speed operation and being at standstill (Fig. 4.4).

  Cycle time(T) should be determined so that RMS value of motor armature current is lower than the motor rated current:

$$T \geqq \frac{Ip^2\ (tr+tf)+I_L^2 ts}{I_R^2}\ (s)$$

  Where cycle time(T) is determined, values $Ip$, $tr$, $tf$ satisfying the formula above, should be specified.

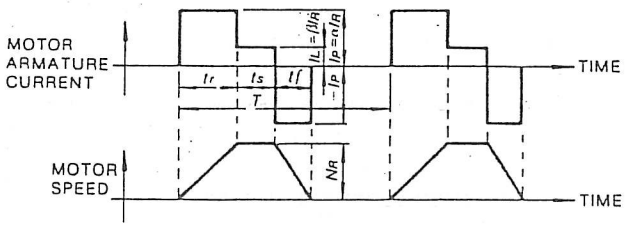



Fig. 4.4 Timing Chart of Motor Armature Current and Speed

- When the motor remains at standstill between cycles of acceleration and deceleration without continuous rated speed running (Fig. 4.5).

  The timing chart of the motor armature current and speed is as shown in Fig.4.5. The allowable frequency of operation "n" can be calculated as follows:

$$n=1.12 \times 10^6 \times \frac{Kt \cdot I_R}{N_R(GD_M^2 + GD_L^2)}\left(\frac{1}{\alpha} - \frac{\beta^2}{\alpha^3}\right)$$

(times/min)

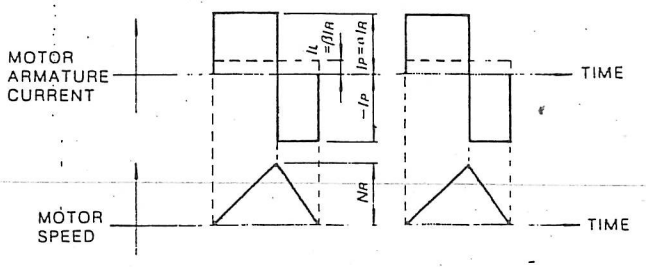



Fig. 4.5 Timing Chart of Motor Armature Current and Speed

- When the motor accelerates, runs at constant speed, and decelerates in a continuing cycle without being at standstill (Fig. 4.6).

  The timing chart of the motor armature current and speed is as shown in Fig. 4.6. The allowable frequency of operation "n" can be calculated as follows.

$$n=1.12 \times 10^6 \times \frac{Kt \cdot I_R}{N_R(GD_M^2 + GD_L^2)}\left(\frac{1}{\alpha} - \frac{\beta^2}{\alpha}\right)$$

(times/min)

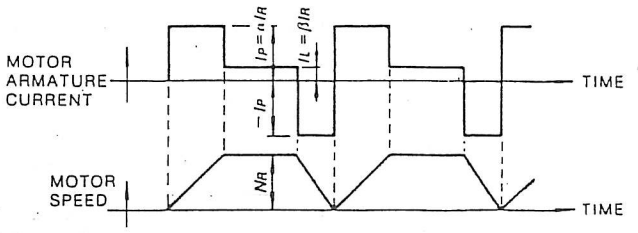



Fig. 4.6 Timing Chart of Motor Armature Current and Speed

## 4.4 MOTOR MECHANICAL CHARACTERISTICS

### 4.4.1 Mechanical Strength

AC servomotors can carry up to 300% of the rated momentary maximum torque at output shaft.

### 4.4.2 Allowable Radial Load and Thrust Load

Table 4.1 shows allowable loads according to AC servomotor types.

Table 4.1 M Series Allowable Radial Load and Thrust Load

| Motor Type USAMED- | Allowable Radial Load* kg (lb) | Allowable Thrust Load kg (lb) |
|---|---|---|
| 03MA1, 06MA1 | 50 (110) | 10 ( 22)† |
| 09MA2 | 70 (154) | 35 ( 77) |
| 12MA2, 20MA2, 30MA2 | 150 (330) | 50 (110) |
| 44MA2 (USAMKD-) 60MA2 | 180 (397) | 60 (132) |

*Maximum values of the load applying to the shaft extension.
†Do not apply the exceeding load because motor cannot be rotated

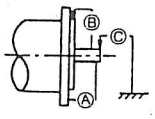
Table 4.2 F Series Allowable Radial Load and Thrust Load

| Motor Type USAFED- | Allowable Radial Load * kg (lb) | Allowable Thrust Load kg (lb) |
|---|---|---|
| 02F□, 03F□ | 15 ( 33) | 5 ( 11)† |
| 05F□, 09F□ | 50 (110) | 10 ( 22)† |
| 13F□ | 70 (154) | 35 ( 77) |
| 20F□, 30F□, 44F□ | 150 (330) | 50 (110) |

*Maximum values of the load applying to the shaft extension.
†Do not apply the exceeding load because motor cannot be rotated.

### 4.4.3 Mechanical Specifications (M and F series)

Table 4.3 Mechanical Specifications in mm

| Accuracy (T.I.R.)† | | Reference Diagram |
|---|---|---|
| Flange surface perpendicular to shaft Ⓐ | 0.04 |  |
| Flange diameter concentric to shaft Ⓑ | 0.04 | |
| Shaft run out Ⓒ | 0.02 (0.04)† | |

†T.I.R. (Total Indicator Reading)
‡Accuray for motor types USAMED-44MA2 and USAMKD-60MA2.

### 4.4.4 Direction of Rotation

AC servomotors rotate counterclockwise viewed from drive end when motor and detector leads are connected as shown below.

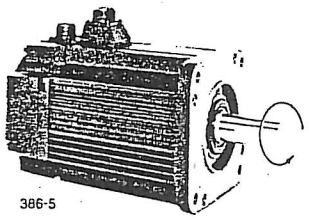
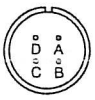



Fig. 4.7 AC Servomotor

(1) Connector Specifications

· Motor receptacle (Standard)



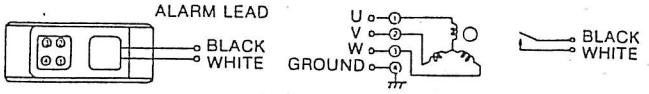

| | |
|---|---|
| A | Phase U |
| B | Phase V |
| C | Phase W |
| D | Ground |

· Detector Receptacle

| | | | |
|---|---|---|---|
| A | Channel A output | K | Channel U output |
| B | Channel $\overline{A}$ output | L | Channel $\overline{U}$ output |
| C | Channel B output | M | Channel V output |
| D | Channel $\overline{B}$ output | N | Channel $\overline{V}$ output |
| E | Channel Z output | P | Channel W output |
| F | Channel $\overline{Z}$ output | R | Channel $\overline{W}$ output |
| G | 0 V | S | — |
| H | +5 VDC | T | — |
| J | Frame ground | – | — |

(2) Fan Terminal Connection (for only type USAMKD-60MA2)

The cooling fan is not of dripproof protected construction.




ALARM CONTACT: ON AT 1800 ± 150rpm OR LESS
CONTACT CAPACITY: RESISTIVE LOAD 10VA MAX (100 V MAX, 0.5 A MAX)

If the alarm for cooling fan occurs, perform the following action.

· Close terminal No.3 "amplifier ON" of 15CN in Servopack by alarm signal. The built-in contactor becomes OFF status, and conducting to the main motor and fan motor stops.
The action from alarm signal output to nonconducting state should be executed within five minutes, because the self-cooled protection of main motor lasts for five minutes.

· When the cooling fan is started, error detection signal becomes ON state for one second. Therefore, delay relay is included in the circuit.

### 4.4.5 Impact Resistance

When mounted horizontally and exposed to vertical shock impulses, the motor can withstand up to two impacts with impact acceleration of 10 G (Fig.4.8).

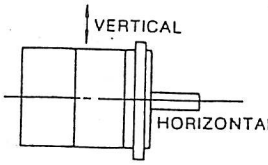



Fig. 4.8 Impact Resistance

**NOTE**

A precision detector is mounted on the opposite-drive end of AC servomotor. Care should be taken to protect the shaft from directly impacts that could damage the detector.

### 4.4.6 Vibration Resistance

When mounted horizontally, the motor can withstand vibration (vertical, lateral, axial) of 2.5 G (Fig.4.9).

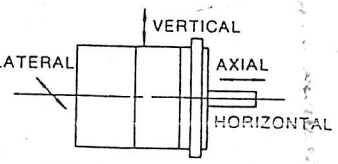



Fig. 4.9 Vibration Resistance

### 4.4.7 Vibration Class

Vibration of the motor running at rated speed is 15$\mu$m or below (Fig.4.10).

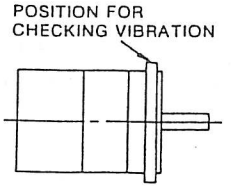



Fig. 4.10 Vibration Checking

# 5. CONFIGURATION

## 5.1 CONNECTION DIAGRAM

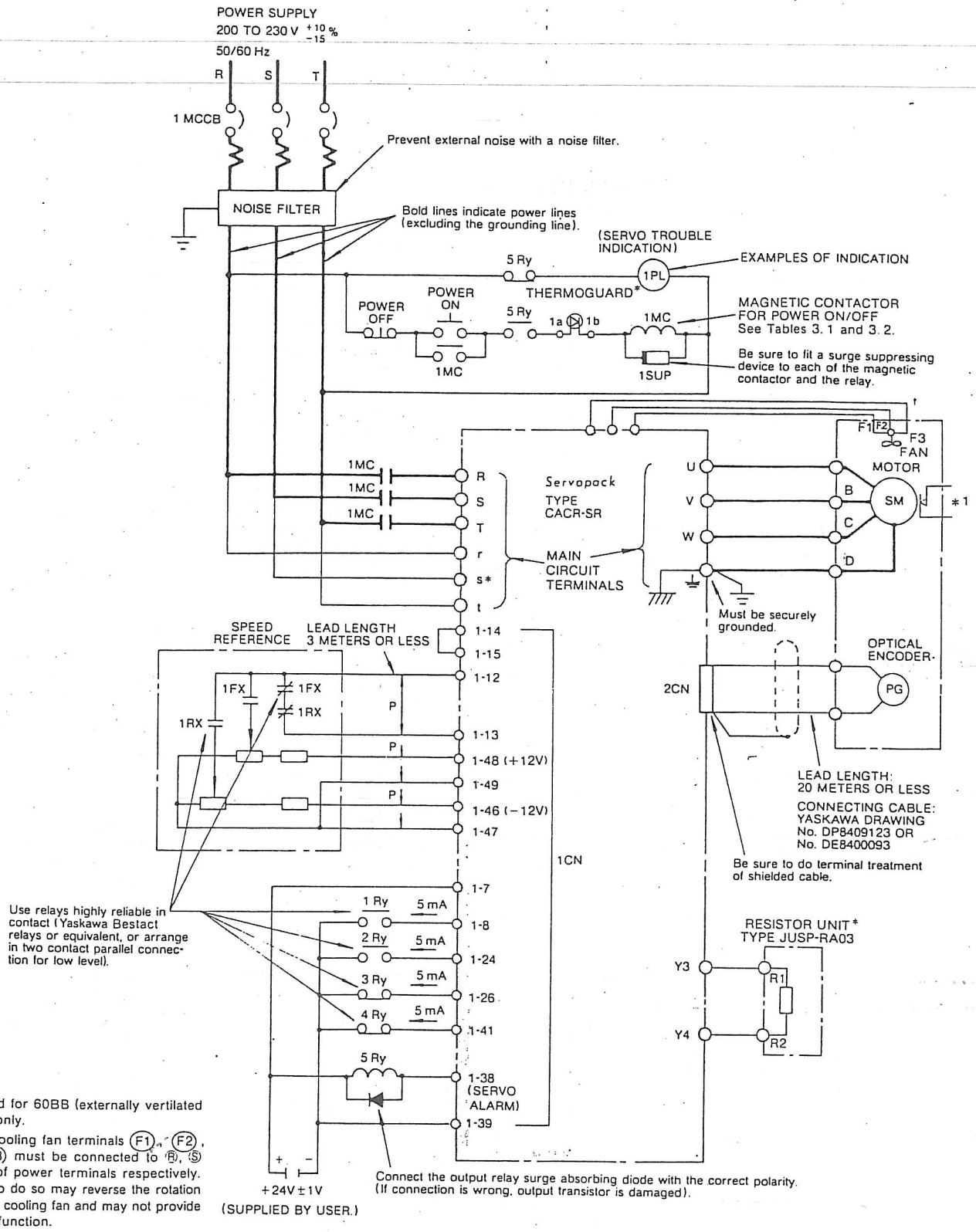
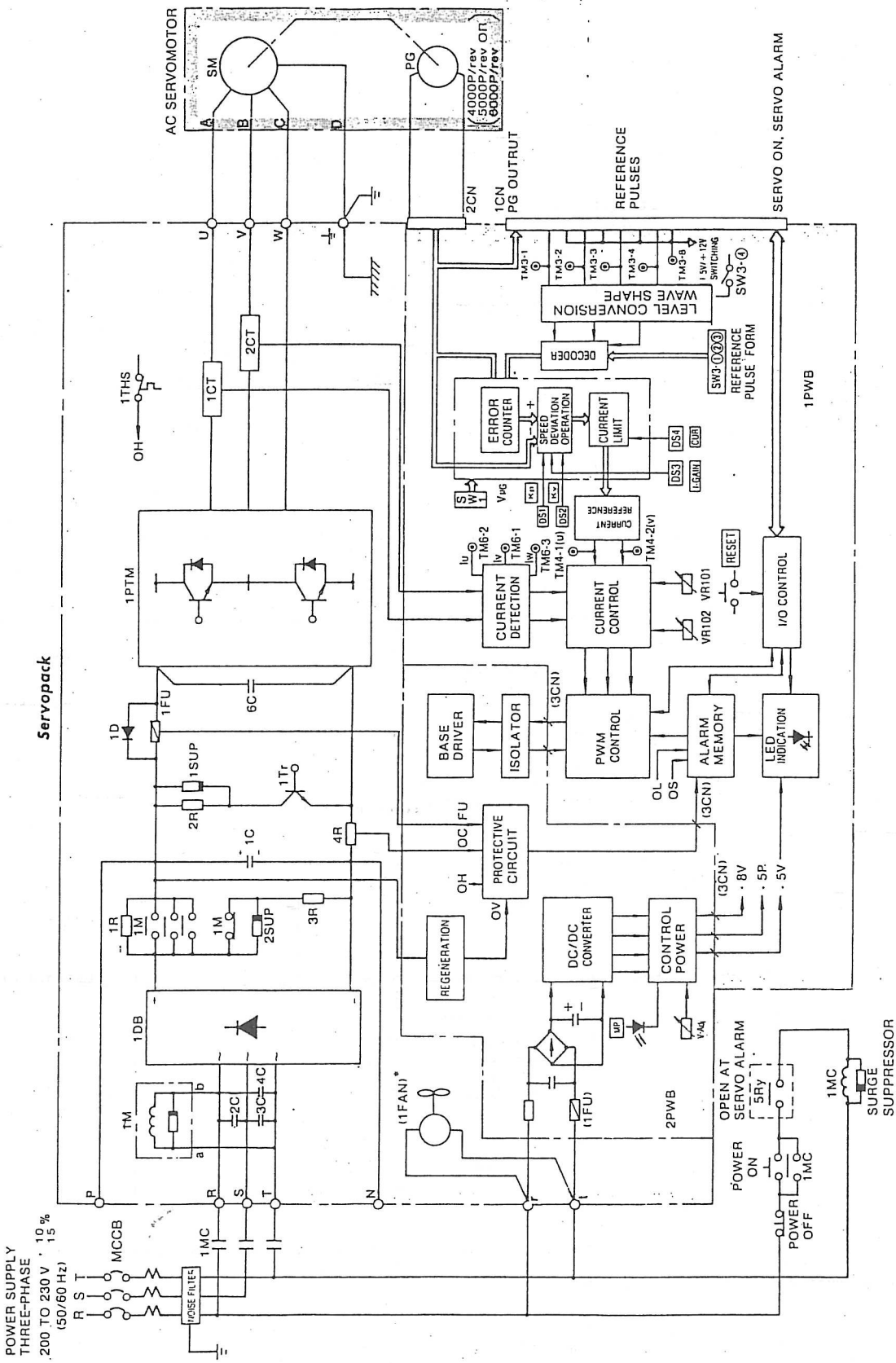



Fig. 5.1 Example of Connection Diagram of *Servopack* with a Servomotor and Peripherals

## 5. 2 INTERNAL BLOCK DIAGRAM

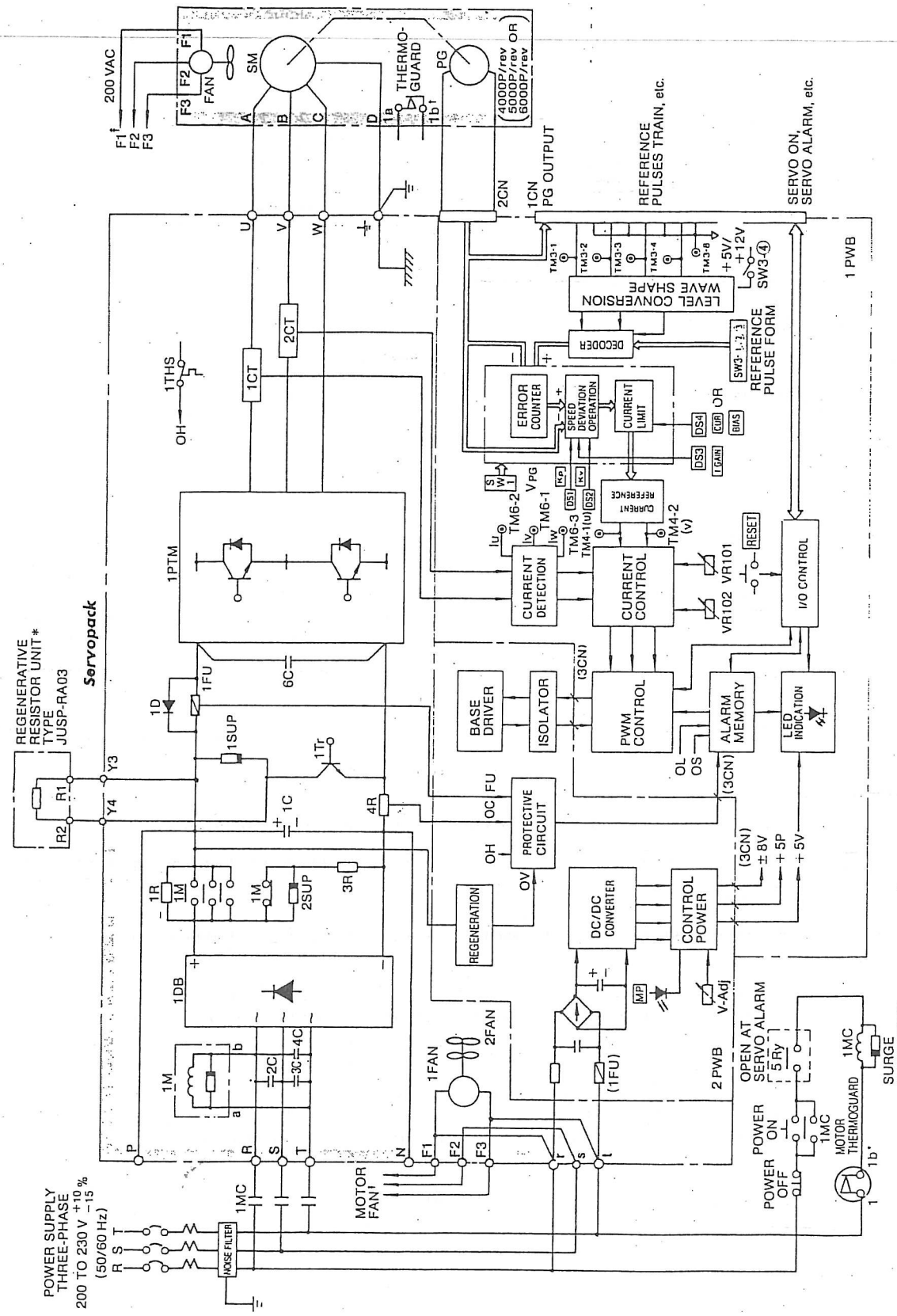
(1) Types CACR-PR03BB to -PR44BB (Fig. 5.2)




*Not furnished with types CACR-PR03BB, -PR05BB and -PR07BB.

Fig. 5.2 Internal Block Diagram of Types CACR-PR03BB to 44BB

(2) Type CACR-PR60BB (Fig. 5.3)




*A separately installed regenerative resistor unit (type JUSP-RA03) is required.
†A normally-closed contact of a thermoguard is output.
‡Motor cooling fan terminals (F1), (F2) and (F3) must be connected to R, S and T of power terminals, respectively.

Fig. 5.3 Internal Block Diagram of Type CACR-PR60BB

## 5.3 EXTERNAL TERMINALS

Table 5.1 shows the specifications of external terminals for Servopack.

Table 5.1 External Terminals for ***Servopack***

| Terminal Symbol | Name | Description |
|---|---|---|
| Ⓡ Ⓢ Ⓣ | Main-circuit AC input | Three-phase 200 to 230 VAC $^{+10}_{-15}$%, 50/60 Hz. |
| Ⓤ Ⓥ Ⓦ | Motor connection | Connects terminal Ⓤ to motor terminal A, Ⓥ to B and Ⓦ to C. |
| ⓡ Ⓢ* ⓣ | Control power input | Single-phase 200 to 230 VAC $^{+10}_{-15}$%, 50/60 Hz |
| ⏚ | Ground | Connects to motor terminal D. Must be securely grounded. |
| Ⓨ3 Ⓨ4 | Regenerative resistor | External connection not usually required only for Type PR60BB. |
| Ⓕ1 Ⓕ2 Ⓕ3 | Motor cooling fan connection | Motor cooling fan driving power: 200 VAC only for Type PR60BB. |
| Ⓟ Ⓝ | Main-circuit DC power terminal | Normally not used. |

*Terminal Ⓢ provided for Type 60BB only. (3-phase AC)

## 5.4 CONNECTOR TERMINAL (1 CN) FOR INPUT/OUTPUT SIGNAL

### 5.4.1 Specifications of Applicable Receptacles

Table 5.2 Specifications of Applicable Receptacles for ***Servopack*** Input/Output Signal

| Connector Type* used in ***Servopack*** | Applicable Receptacle Type | | | |
|---|---|---|---|---|
| | Manufacturer | Soldered Type | Caulking Type | Case |
| MR-50RMA (Right angle 50 P) | Honda Tsushin Co., Ltd. | MR-50F† | MRP-50F01 | MR-50L† |

*The connectors for input/output signals used are type MR-50RMA made by Honda Tsushin Co.
†Attached to *Servopack* when shipping.

### 5.4.2 Connector 1CN Layout and Connection of ***Servopack***

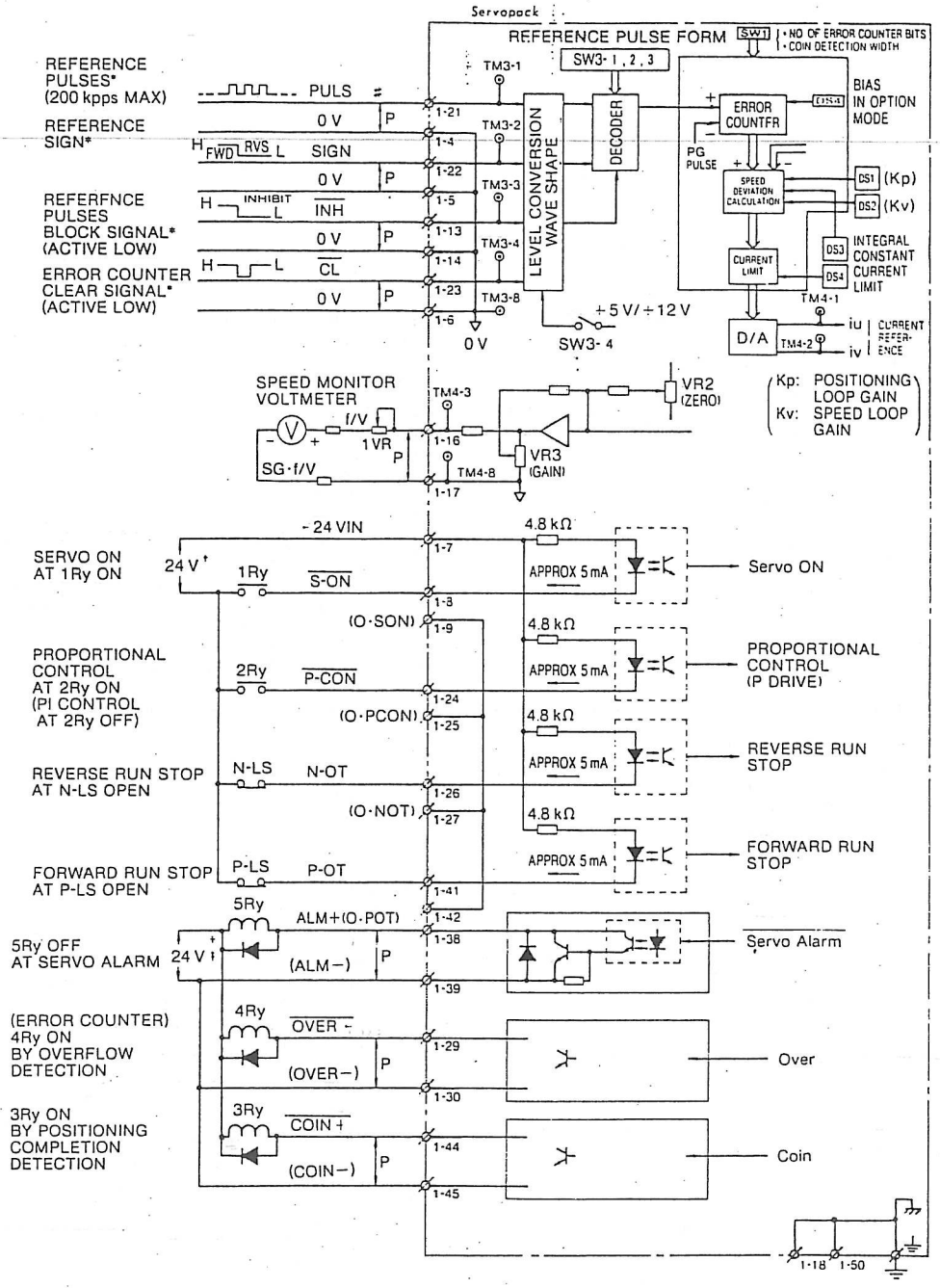
The terminal layout of the Servopack input/output signal connectors (1CN) is shown in Table 5.3. The external connection and external signal processing are shown in Fig. 5.4 on page 17.

Table 5.3 Connector 1CN Layout of ***Servopack***

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 V | 0 V | 0 V | 0 V | 0 V | 0 V | + 24 VIN | $\overline{\text{S-ON}}$ | O-SON | | | | $\overline{\text{INH}}$ | 0 V | | f /V | SG | FG |
| 0 V for PG Output Signal | | | PULS 0 V | SIGN 0 V | $\overline{\text{CL}}$ 0 V | Ext. Input Power | Servo ON Input | | | | | inhibit input | $\overline{\text{INH}}$ 0 V | | Speed Monitor | | Frame Ground |

| | | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PCO | *PCO | PULS | SIGN | $\overline{\text{CL}}$ | $\overline{\text{P-CON}}$ | O-PCON | N-OT | O-NOT | | $\overline{\text{OVER+}}$ | OVER− | | | | |
| | | Output Signal | | Ref. Pulse Input | Ref. Sign Input | Clear Input | P Drive Input | | Rev. inhb. input | | | Overflow Output | | | | | |

| 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PAO | *PAO | PBO | *PBO | | ALM+ | ALM− | | P-OT | O-POT | | $\overline{\text{COIN+}}$ | COIN− | | | | | FG |
| Output Signal | | Output Signal | | | Servo Alarm Output | Servo Alarm 0 V | | Fwd. Inhb. Input | | | Positioning Compl. Detection | | | | | | Frame Ground |




*The reference pulses and CLEAR signals should be input either at +5 V (TTL) or +12 V level.

†24 V power should be provided by customer.

‡Each capacity of output circuits is 30 VDC, 100 mA or less.

≠ ⊥P⊥: Twisted cable.

Note: Maximum frequency of reference pulses of 200 kpps can be given. If input pulses exceeding motor maximum speed (2000 rpm for M series; 2500 rpm for F series) are added, OS (Overspeed) will activate even if reference pulses are 200 kpps or below.

Fig. 5.4 Connection of 1CN I/O Signals and External Signal Processing

Table 5.4 Input Signals of Connector 1CN

| Signal Name | Connector 1CN No. | Function | Description |
|---|---|---|---|
| $\overline{\text{S-ON}}$ | 8 | Servo ON | Inputting this signal makes the Servopack ready to receive pulse reference input.<br>Base block is cleared. |
| $\overline{\text{P-CON}}$ | 24 | Proportional drive reference | Proportional control command applies friction torque to the motor to prevent drifting when the motor is left motionless without command input.<br>While the main circuit kept energized. |
| N-OT | 26 | Reverse runing inhibit | In the case of linear drive, etc., connect limit switch signal according to the run direction. Since it is a bar signal (reverse signal), it is "closed" during normal run. When limit switch is tripped, it becomes "open". |
| P-OT | 41 | Forward runing inhibit | |
| 24 V | 7 | 24 V | External power supply to 1CN-8, 24, 26 and 41. Prepare a 24 VDC (20 mA min.) power supply. |
| PULS | 21<br>(4) | Speed command input | Pulse train frequency = $\frac{\text{Motor speed(rpm)}}{60} \times$ Dividing ratio $\times$ No. of PG pulses(pulse/rev) $\times$ M $\leqq$ 200 kpps. (M: PG multiplication factor ···1,2,4)<br>Pulse width = Duty must be 50% at the maximum frequency used ··· 2.5 $\mu$s. |
| SIGN | 22<br>(5) | command sign input | Forward rotation command: H-level<br>Reverse rotation command: L-level |
| $\overline{\text{INH}}$ | 13<br>(14) | Reference pulse block signal | Blocks input command pulses.<br>Blocks command pulses at L-level. |
| $\overline{\text{CL}}$ | 23<br>(6) | Deviation counter Clear signal | Blocks command and feedback pulses and clears the deviation counter.<br>Clears the deviation counter L-level. |

Table 5.5 Output Signals of Connector 1CN

| Signal Name | Connector 1CN No. | Function | Description |
|---|---|---|---|
| $\overline{\text{COIN}}$ | 44<br>(45) | Positioning completion signal | Output when No. of lag pulses of the error counter reaches the range of the set value (±1 to ±70 Pulses). |
| $\overline{\text{OVER}}$ | 29<br>(30) | Over flow detection Signal | Outputs when No. of lag pulses of the error counter exceeds the specified value.<br>No. of lag pulses = $\frac{4}{\text{Kp}} \times \frac{\text{Motor speed(rpm)}}{60} \times 1.05 \times$ (Dividing ratio) $\times$<br>No. of pulses(pulse/rev) $\times$ M $\leqq 2^{20}$ pulses<br>(M: PG multiplication factor··· 1, 2, 4) |
| ALM | 38<br>(39) | Servo alarm | Turns OFF if malfunction is detected.<br>For details, refer to par. 6.7. |
| F/V | 16<br>(17) | Speed monitor | M-F Series (±2.0 V/1000 rpm) ± 5 %<br>Load: Less than 1mA |
| PAO<br>*PAO | 33<br>34 | Position signal output-1 Phase A | Output by the pulse line driver (manufactured by TI SN75113) after dividing. |
| PBO<br>*PBO | 35<br>36 | Position signal output-1 Phase B | Receive with the line receiver (manufactured by TI SN75115). |
| PCO<br>*PCO | 19<br>20 | Position signal output-1 Phase C | |

## 5.5 CONNECTOR TERMINAL (2CN) FOR OPTICAL ENCODER (PG) CONNECTION

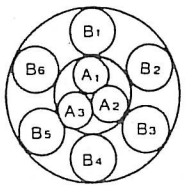
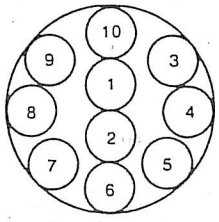
### 5.5.1 Specifications of Applicable Receptacles and Cables (Table 5.6)

Table 5.6 Specifications of Applicable Receptacles and Cables

| Connector Type* used in Servopack | Applicable Receptacle Type | | | | Connection Cable= |
|---|---|---|---|---|---|
| | Manufacturer | Soldered Type | Caulking Type | Case† | |
| MR-20RMA, right angle 20P | Honda Tsushin Co., Ltd. | MR-20F‡ | MRP-20F01 | MR-20L‡ | DP8409123 or DE8400093 |

*Made by Honda Tsushin Co., Ltd.
†Attached to each applicable receptacle (soldered and caulking types).
‡Attached to Servopack when shipping.
=The cables listed in Table 5.7 are available on request. If required, purchase in units of standard length as shown in Table 5.7.

Table 5.7 Details of Specifications of Applicable Cables

| Connection | Soldered Type | Caulking Type |
|---|---|---|
| Yaskawa Drawing No. | DP 8409123 | DE 8400093 |
| Manufacturer | Fujikura Cable Co. | |
| Approx Specifications | Double, KQVV-SW AWG 22 × 3 C AWG 26 × 6 P | KQVV-SB AWG 26 × 10 P |
| Internal Composition and Lead Color | For Soldered Type   | For Caulking Type   |
| | A1 Red<br>A2 Black<br>A3 Green yellow<br>B1 Blue-White/blue<br>B2 Yellow-White/yellow<br>B3 Green-White/green<br>B4 orange-White/orange<br>B5 Purple-White/purple<br>B6 Grey-White-grey<br>Twisted cable | 1 Blue-White-<br>2 Yellow-White<br>3 Green-White<br>4 Red-White<br>5 Purple-White<br>6 Blue-Brown<br>7 Yellow-Brown<br>8 Green-Brown<br>9 Red-Brown<br>10 Purple-Brown<br>Twisted Cable |
| Yaskawa Standard Specifications | Standard length: 5 m, 10 m, 20 m<br>Terminal ends are not provided with connectors. | |

**NOTE**

1. When applicable cables listed in Table 5.7 are used, allowable wiring distance between Servopack and motor is a maximum of 20 meters.
2. The cable applied for 50 m wiring distance is available on order (Yaskawa drawing No. DP8409179). If wiring distance is 20 m or more, contact your Yaskawa representative.

### 5.5.2 *Servopack* Connector (2CN) Terminal Layout and Connection

The terminal layout for the Servopack connectors (2CN) for connecting the optical encoder is shown in Table 5.8, and the connection method of 2CN and the optical encoder, in Figs. 5.5 and 5.6.

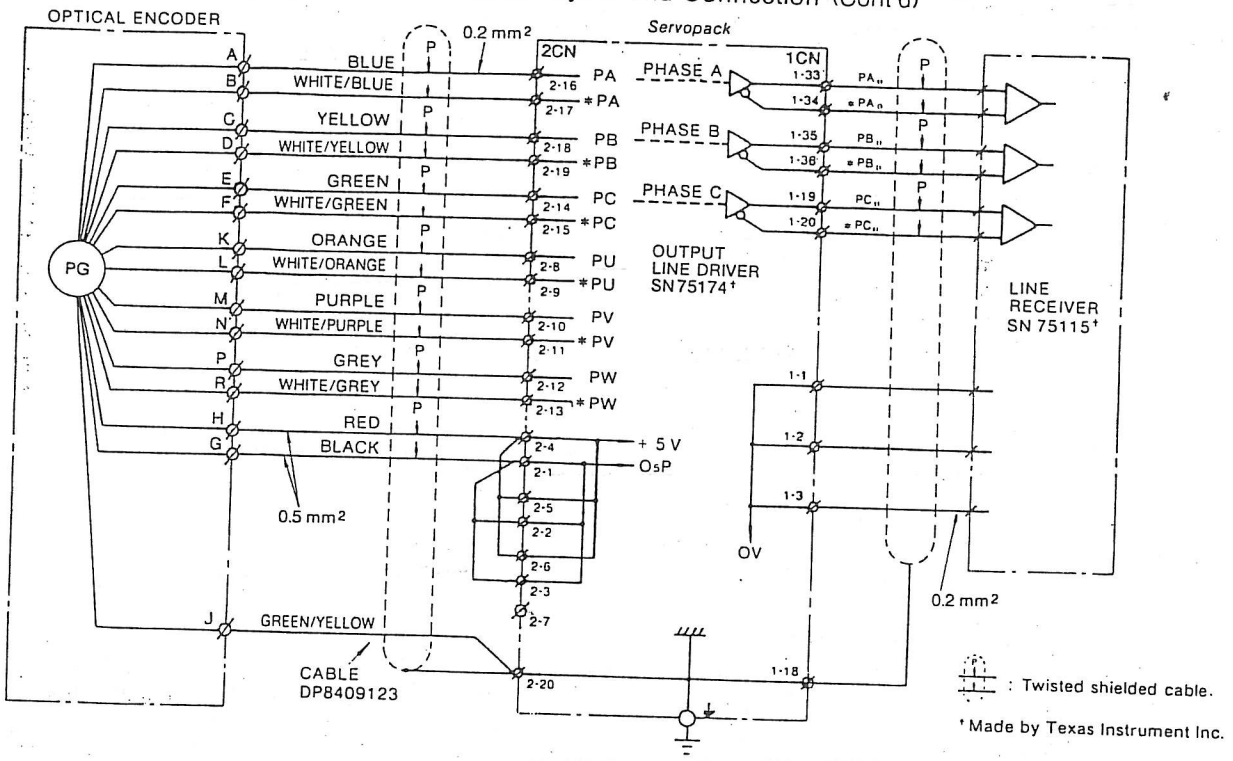
Table 5.8 Connector 2CN Layout of *Servopack*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| O5P | O5P | O5P | +5P | +5P | +5P | DIR |

| 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|
| PU | *PU | PV | *PV | PW | *PW |

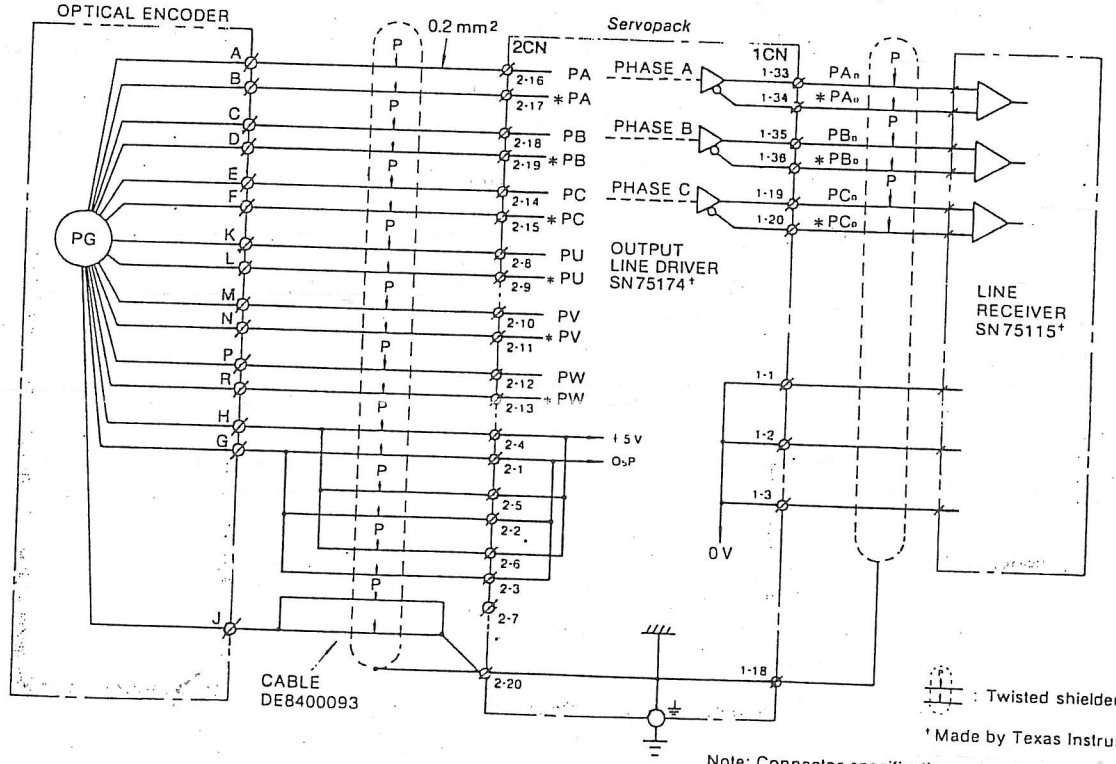
| 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|
| PC | *PC | PA | *PA | PB | *PB | FG |

## 5.5.2 *Servopack* Connector (2CN) Terminal Layout and Connection (Cont'd)




Note: Connector specifications of optical encoders are as follows.
Connector — Type MS3102A20-29P (Receptacle)
Accessory (not attached) — Type MS3108B20-29S (Angle plug)
Type MS3057-12A (Cable clamp)

Fig. 5.5 Soldered Type Connector 2CN Connection and 1CN Output Processing (when using Connection Cable DP8401923)




Note: Connector specifications of optical encoder are as follows.
Connector — Type MS3102A20-29P (Receptacle)
Accessory (not attached) — Type MS3108B20-29S (Angle plug)
Type MS3057-12A (Cable clamp)

Fig. 5.6 Caulking Type Connector 2CN Connection and 1CN Output Processing (when using Connection Cable DE8400093)

## 6. 2 POSITIONING REFERENCE

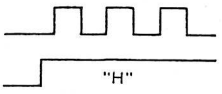
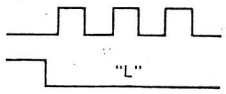
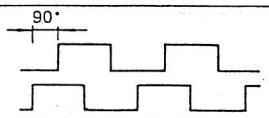
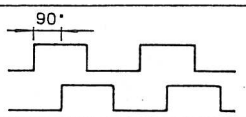
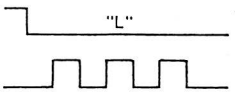
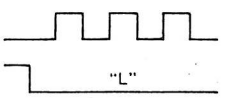
### 6. 2. 1 Input Reference Pulse

"H" level is effective for input $\overline{\text{INH}}$($\overline{\text{INHIBIT}}$) and $\overline{\text{CL}}$ ($\overline{\text{CLEAR}}$) signals. Three types of signals can be input as reference pulses.

(1) Reference pulse mode

Only for 2-phase signals as shown in Table 6.1, set switches SW3-nos. 1, 2 and 3 according to the reference pulse modes and the multipliers.

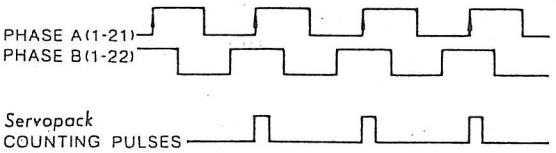
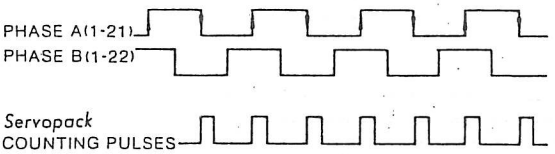
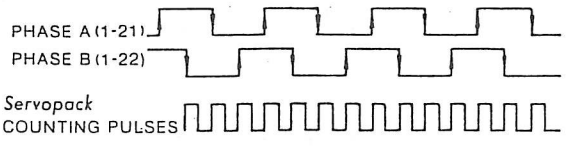
Table 6. 1 Reference Pulse Mode

| Reference Pulse Mode | Input Pin No. | Forward Running Reference of Motor | Reverse Running Reference of Motor | Input Multiplier* | SW3 ① | SW3 ② | SW3 ③ |
|---|---|---|---|---|---|---|---|
| Sign + Pulses | 1CN-㉑<br>1CN-㉒ |  |  | — | | ○ | ○ |
| 90° Phase Difference 2-phase Pulses (1, 2 or 4 Times) | 1CN-㉑<br>1CN-㉒ |  |  | × 1<br>× 2<br>× 4 | ○<br>○<br>○ | ○<br>○<br> | ○<br> <br>○ |
| CW Pulses + CCW Pulses | 1CN-㉑<br>1CN-㉒ |  |  | — | | ○ | |

* Defines the method of counting the input pulse waves in Servopack. Table 6.2 shows the forward running reference for 90° phase difference 2-phase pulses when phase A = phase B = f(pps).

Note:
1. Circles in SW3 show the positions for installing the setting plugs on the pins.
2. The multiplier can be set for 90° phase difference, 2-phase pulse input.

Table 6. 2 Counting Method of Reference Pulse

| Multiplier | Content of Pulse Counting of *Servopack* | Reference Pulse Frequency of *Servopack* |
|---|---|---|
| × 1 | Counts only the leading edge of phase-A pulse input (1CN-㉑).<br>  | *f* (pps)<br>[Nrpm*] |
| × 2 | Counts the leading and trailing edges of phase-A pulse input (1CN-㉑).<br>  | 2 × *f* (pps)<br>[2 × Nrpm] |
| × 4 | Counts the leading and trailing edges of phase-A pulse input (1CN-㉑) and phase-B pulse input (1CN-㉒).<br>  | 4 × *f* (pps)<br>[4 × Nrpm] |

* Motor speed

# 6. OPERATION

## 6.1 POWER ON AND OFF

Arrange the sequence so that the power is simultaneously supplied to the main circuit (R.S.T) and the control circuit (r,t), or supplied to the control circuit first, then the main circuit (Figs. 6.1 and 6.2).

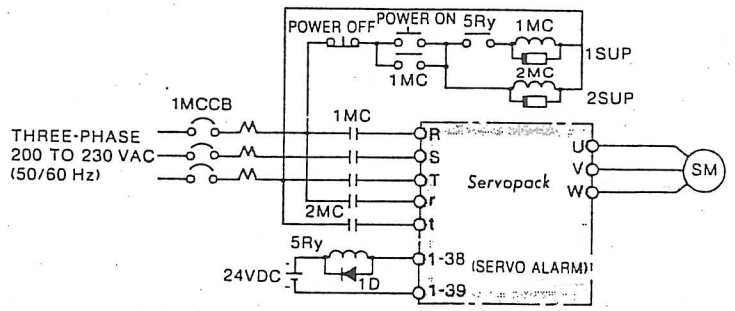
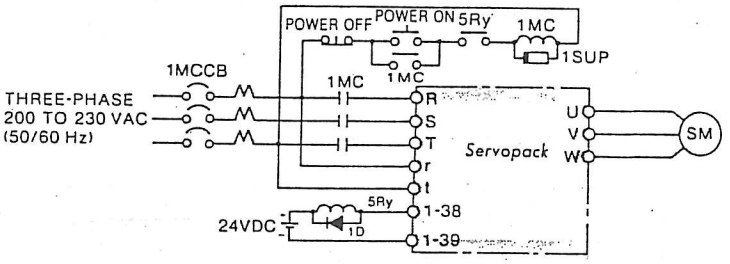



Fig. 6.1 Connection Example for Simultaneous Control Power ON/OFF




1SUP, 2SUP: Surge suppressor CR50500BA or equivalent (made by Okaya Electric Industries Co., Ltd.)
1D: Flywheel diode (to prevent spike of 5Ry)

Fig. 6.2 Connection Example for Main-circuit Power ON/OFF

Arrange the sequence so that the power is simultaneously cut (including momentary power failure) (Fig. 6.1), or the power to the main circuit is cut first, then the control circuit (Fig. 6.2). The order is the reverse of the power ON sequence. Precautions for connections in Figs. 6.1 and 6.2 are as follows.

- Make sequence to assure that the main-circuit power will be cut off by a servo alarm signal.

  If the control circuit is turned off, the LED indicating the kind of servo alarm also goes off.

- When power is supplied to the power ON/OFF sequence shown in Fig. 6.1, the normal signal is set (5Ry is turned on) in the control circuit after a maximum delay of 1 second.

**NOTE**

When the power is turned on, a servo alarm signal continues for approximately 1 second (normally 200 to 300 ms) to initialize the ***Servopack***.

Hold the main-circuit power ON signal for approximately 1 second. However, this is unnecessary in the sequence in Fig. 6.2, because the control power is always turned on.

- Since Servopack is of a capacitor input type, large recharging current flows when the main-circuit power is turned on (recharging time: 0.5s). If the power is turned on and off frequently, the main circuit element may be degraded and a malfunction may occur.

  When the motor starts, turn ON the reference pulse train and turn it OFF when the motor stops. Do not turn the power ON or OFF.

- Before power on or off, turn off the "Servo-ON" switch to avoid transient troubles.

(2) Reference pulse voltage and timing

The applicable voltage level of reference pulse is +12 V and +5 V and set as follows, using switch SW3-no.4.

SW3-④, without short-circuit pin(open): +5 V level

SW3-④, with short-circuit pin (shorted): +12 V level

The applicable voltage level and timing are detailed in Table 6.3

(3) Input circuit

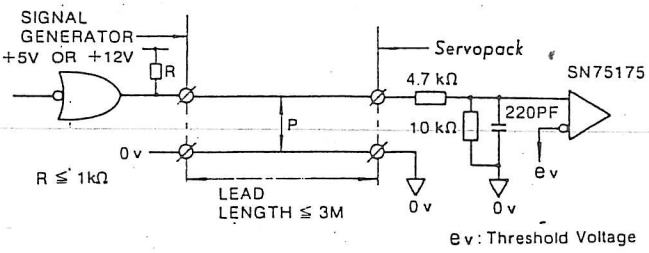
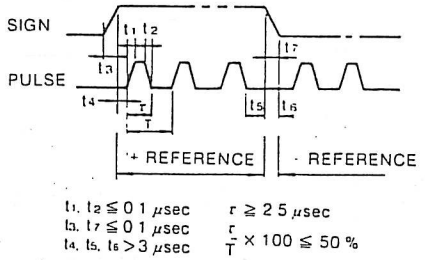
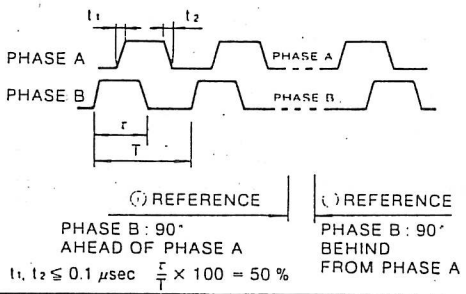
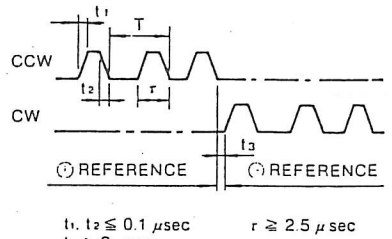



Fig. 6.3 Input Circuit

Table 6.3 Applicable Voltage Level and Timing

| Item | | | Electrical Specifications | | Remarks |
|---|---|---|---|---|---|
| Voltage Level of Signal | | ÷12 V Level | H Level | + 10.8 V to + 12 V | ÷ 5 V level or ÷ 12 V level is set by internal switch SW3. |
| | | | L Level | 0 V to ÷ 1.2 V | |
| | | ÷ 5 V Level | H Level | + 4.2 V to + 5 V | |
| | | | L Level | 0 V to ÷ 0.8 V | |
| Reference Pulse Signal Mode | Sign ÷ Pulse Input (SIGN ÷ PULSE Signal) | |   $t_1, t_2 \leqq 0.1\ \mu sec$ $t_3, t_7 \leqq 0.1\ \mu sec$ $t_4, t_5, t_6 > 3\ \mu sec$ $\tau \geqq 2.5\ \mu sec$ $\frac{\tau}{T} \times 100 \leqq 50\ \%$ | SIGN : H — · Reference L — · Reference |
| | 90° Phase Difference 2-phase Pulse (Phase A + Phase B) | |   $t_1, t_2 \leqq 0.1\ \mu sec$ $\frac{\tau}{T} \times 100 = 50\ \%$ | Multiplier mode is set by the internal switch SW3. |
| | CCW Pulses + CW Pulses | |   $t_1, t_2 \leqq 0.1\ \mu sec$ $t_3 > 3\ \mu sec$ $\tau \geqq 2.5\ \mu sec$ $\frac{\tau}{T} \times 100 \leqq 50\ \%$ | — |

Note: Maximum reference frequency is 200 kpps.

### 6.2.2 Other Input Signals

Other input signals are $\overline{CL}$ (abbreviation of $\overline{CLEAR}$) and $\overline{INH}$. The voltage level of these signals are the same as that of the reference pulse (the voltage level set by SW3-no.4 can operate $\overline{CL}$ and $\overline{INH}$).

(1) $\overline{CL}$ signal

When $\overline{CL}$ signal goes "L", the content of the positioning error counter is cleared and returns to 0, and positioning loop does not function. This signal is usually held at H level during operation.

(2) $\overline{INH}$ signal

When $\overline{INH}$ signal goes L, the reference puise input gate closes, and the error counter does not count, but the positioning error counter is not cleared, so the servo is clamped. This signal is usually held at H level during operation.

### 6.2.3 Other Output Signals

See par.6.3.2 Output Circuit for the output circuit configuration.

(1) Overflow detection signal($\overline{OVER}$)

This signal is output when No. of lag pulses in error counter becomes abnormally large.

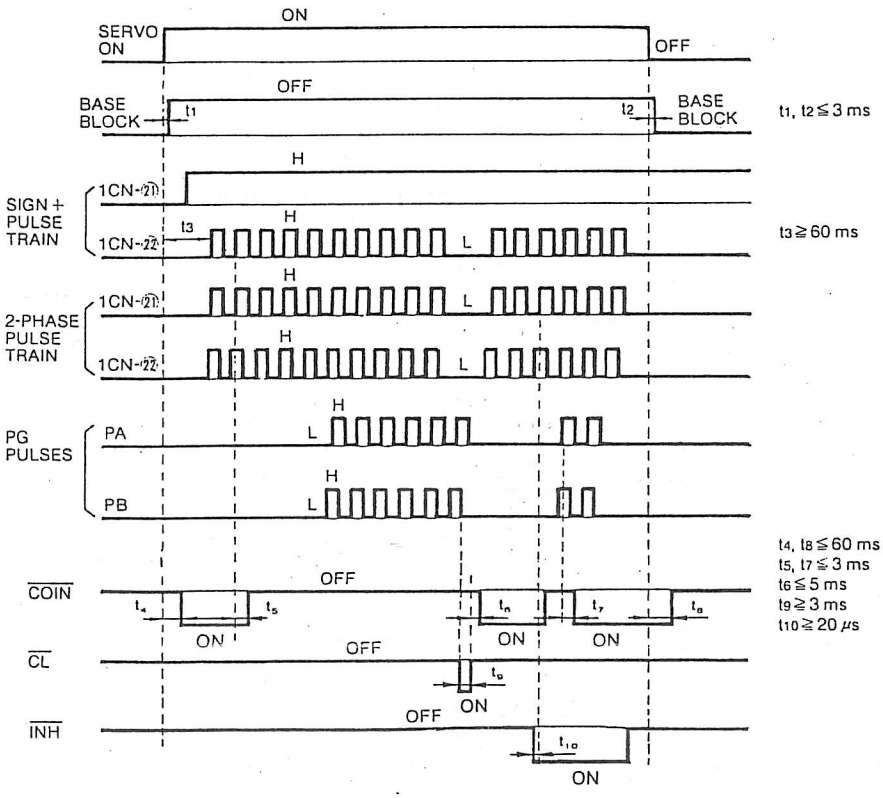
When No. of lag pulses in error counter exceec 20 bits, the servo alarm is output and $\overline{OVER}$ wi not be output.

(2) Positioning completion signal($\overline{COIN}$)

This signal is output when the lag pulses in erro counter fall within the set values. The lag pulse in error counter are set by switch SW3-nos. 5, 6, and 8.

### 6.2.4 Input/Output Signal Timing

An example of the timing of the input/output sign is shown in Fig. 6.4.




t1, t2 ≦ 3 ms
t3 ≧ 60 ms
t4, t8 ≦ 60 ms
t5, t7 ≦ 3 ms
t6 ≦ 5 ms
t9 ≧ 3 ms
t10 ≧ 20 μs

. PG pulse frequency dividing ratio = 1
. Output maltiplier = 1
. Width of positioning completion = ±1 pul

Note:
1. Allow at least a 60 ms interval after setting the servo on signal "ON" until inputting the command pulse If the command pulse is input within less than 60 m the command pulse may not be correctly input.
2. The clear signal must be kept on for at least 3 ms It may not be input if it is less than 3 ms.
3. It takes approximately 20 sec. after turning "ON" th command pulse block signal until the command puls is actually blocked.

Fig. 6.4 Timing Chart of Input/Outpu

Table 6.4 Setting of Lag Pulses

| Item | SW3 ⑤ | SW3 ⑥ | SW3 ⑦ | SW3 ⑧ | Remarks |
|---|---|---|---|---|---|
| Data | $D_0$ | $D_1$ | $D_2$ | $D_3$ | |
| Without Short-circuit Pin | 1 | 1 | 2 | 4 | Setting of lag pulses |
| With Short-circuit Pin | 10 | 0 | 0 | 0 | |

Note: When all switches above are short-circuited with pins ⑥ to ⑧, setting value is ±1 pulse.

No. of lag pulses = $\left(\sum_{N=1}^{3} D_N\right) \times D_0$

No. of lag pulses is converted to angle of rotatio

$$\frac{N}{P \times M} \times \left(\sum_{N=1}^{3} D_N\right) \times D_0 \text{ (rev)}$$

P: No. of pulses from optical encoder (pulse/rev)

N: Pulse frequency dividing ratio

M: Multiplier ratio

## 6.3 CONFIGURATION OF INPUT/OUTPUT CIRCUIT

For proportional drive, overtravel, servo ON, servo alarm output, $\overline{\text{OVER}}$ output, $\overline{\text{COIN}}$ output, each input/output circuit is a non-contact circuit insulated with optical couplers. The external circuit, therefore, must be constructed with the specified voltage and current.

### 6.3.1 Input Circuit

There are four types of protective functions to prevent continued rotation of the motor in forward and reverse direction: Servo ON inputs, proportional drive circuits, and overtravel protection circuits. Construct the input circuit using 24 V power supply (Fig.6.5). Typical circuits are shown in Fig.5.3.

**NOTE**

The user must provide the 24 V power supply: 24VDC ±1V, 20mA or more (approx 5mA/circuit)

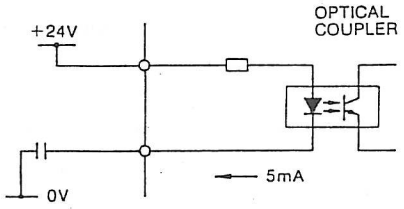



Fig. 6.5 Configuration of Input/Output Circuit

(1) Proportional Drive Reference [$\overline{\text{P-CON}}$]

The speed control operation is normally performed under PI operation mode, but P operation mode can be called by turning this command input ON.

(2) Forward and reverse running inhibit [P-OT, N-OT]

These circuits are used to stop the forward running of the motor(counterclockwise when viewed from the drive end of the motor) and reverse running. This circuit reduced output current to 0 (torque reference to 0). Therefore, the motor will coast to a stop. If braking is required, set the speed reference voltage to 0V or set the dynamic braking circuit (generator contol) by turning OFF "SERVO ON."

**NOTE**

When the overtravel prevention circuit is not used, connect 1CN-㉖ and ㊶ to the 0 V terminal of the external 24 V power supply.

(3) Servo ON [$\overline{\text{S-ON}}$]

This circuit is used to turn on the main-circuit power-drive circuit of the Servopack. When the signal of the circuit is not input(Servo OFF state), the motor cannot be diriven. And error counter will be in clear state. If this signal is applied during motor running, the motor will coast to stop.

**NOTE**

Before turning power on or off, turn off the "Servo-ON" switch to avoid troubles resulting from transient current. Allow 60 ms for the command pulse to be accepted after servo-on.

### 6.3.2 Output Circuit

There are three output signals: Over flow detection (OVER), positioning completion (COIN), Servo alarm.

These output circuits are non-contact, employing transistors. Voltage and current specifications are:

Applied Voltage(Vmax) ≦ 30 V

Conduction Current (Ip) ≦ 100 mA

**NOTE**

The output circuit requires a separate power supply. It is recommended to use the same 24 V power supply used for the input circuit (Fig. 6.6).

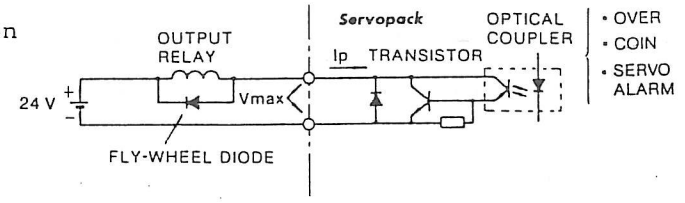



Fig. 6.6 Output Circuit

### 6.3.3 Optical Encoder (PG) Output Circuit [PAo. *PAo, PBo, *PBo, PCo, *PCo]

Phses A, B, and C(original point) signals for for the optical encoder, PG(6000 pulses/rev, 5000 pulses/rev, or 4000 pulses/rev) are output.

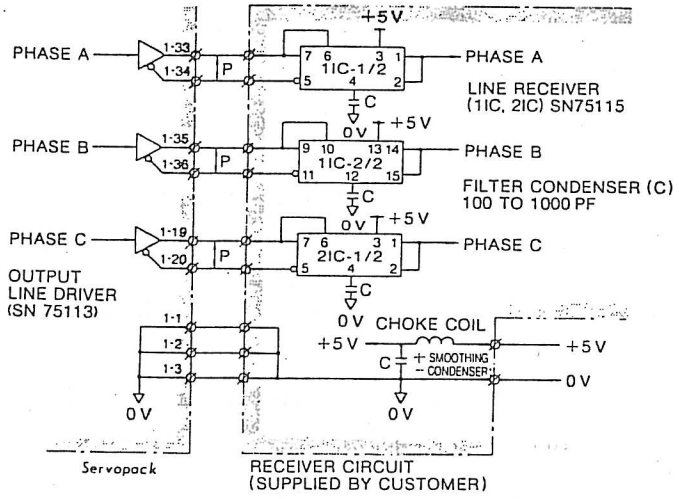
Use these signals as positioning signals. The output signal specifications are as follows:

(1) Signal form

- Two-phase pulse with 90° pulse difference (phases A and B)
- Original point pulse(phase C)

(2) Output circuit and receiver circuit

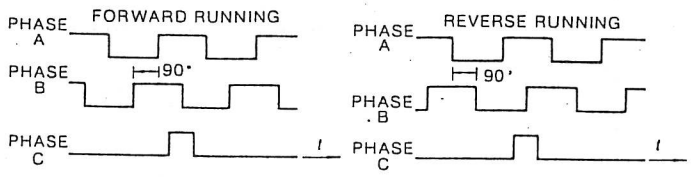
Two types of output circuits are provided: line driver output and open collector output. Fig. 6.7. shows an example of line driver output.




PT : Twisted cable

Fig. 6.7 Output Circuit and Receiver Circuit

(3) Output phase




Note: Phase C (original point pulse) is synchronized with phase A.

Fig. 6.8 Output Phase

(4) Pulse resolution

The pulse frequency of the PG can be further divided into 1/N (N=1 to 32) or 2/N(N=2 to 32) by using the divider in the Servopack. The phase relation is the same as in (3), above. Set the pulse frequency dividing ratio according to Table 6.6.

The dividing ratio must be able to divide the pulses of the optical encoder. For example, in an optical encoder of 5000 pulses/rev, 1/3, 1/6, or 1/7 cannot be used. Fig. 6.9 shows the optical encoder output waveform under the dividing pulse frequency.

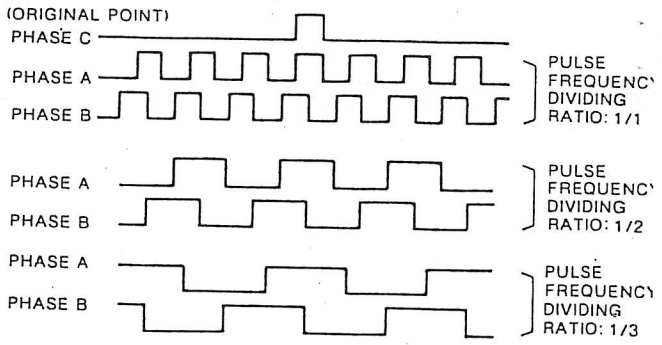



Fig. 6.9 Output Waveform of Optical Encoder

(5) Output multiplier circuit

According to the combination of switch SW2-nos. 7 and 8 in the Servopack, the number of optical encoder frequency(output) can be multiplied by the user. See Table 6.5.

Four multiplier should be set when all edges of 2 phases of the PG output are used; 2-multiplier when all edges of 1 phase are used; and 1-multiplier when one edge of 1 phase is use

Table 6.5 Setting of Output Multiplier Circuit

| SW 2 | | Multiplier |
|---|---|---|
| (7) | (8) | |
| ( ) | ( ) | × 1 |
| | ( ) | × 1 |
| ( ) | | × 2 |
| | | × 4 |

Note:
1. Circles indicate the positions of short-circuit pins.
2. For type CACR-SR, spare short-circuit pins are inserted in SW2-nos. 7 and 8.
3. The relationship of pulse frequency dividing ratio(N), multiplier (M) and rotation angle per pulse are as follows:

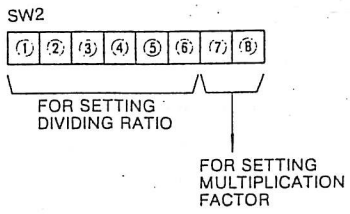
$$\text{Rotation angle per pulse} = \frac{N}{P \times M} \text{ (rev)}$$

N: Pulse frequency dividing ratio
M: Multiplier
P: Number of PG pulses (pulses/rev)

Table 6.6 Setting of PG Pulse Frequency Dividing Ratio

| Setting | | | | | | | | PG Pulse Frequency Dividing Ratio(I/O) | Pulse Frequency Dividing Output (pulses/rev) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | PG=6000 | PG=5000 | PG=4000 |
| ○ | ○ | ○ | ○ | ○ | ○ | | | 1/1 | 6000 | 5000 | 4000 |
| | ○ | ○ | ○ | ○ | ○ | | | 1/2 | 3000 | 2500 | 2000 |
| ○ | | ○ | ○ | ○ | ○ | | | 1/3 | 2000 | — | — |
| | | ○ | ○ | ○ | ○ | | | 1/4 | 1500 | 1250 | 1000 |
| ○ | ○ | | ○ | ○ | ○ | | | 1/5 | 1200 | 1000 | 800 |
| | ○ | | ○ | ○ | ○ | | | 1/6 | 1000 | — | — |
| | | | ○ | ○ | ○ | | | 1/8 | 750 | 625 | 500 |
| | ○ | ○ | | ○ | ○ | | | 1/10 | 600 | 500 | 400 |
| | | ○ | | ○ | ○ | | | 1/12 | 500 | — | — |
| ○ | | | | ○ | ○ | | | 1/15 | 400 | — | — |
| | | | | ○ | ○ | | | 1/16 | 375 | — | 250 |
| | | ○ | ○ | | ○ | | | 1/20 | 300 | 250 | 200 |
| | | | ○ | | ○ | | | 1/24 | 250 | — | — |
| ○ | ○ | ○ | | | ○ | | | 1/25 | 240 | 200 | 160 |
| | ○ | | | | ○ | | | 1/30 | 200 | — | — |
| | ○ | ○ | ○ | ○ | | | | 2/2 | 6000 | 5000 | 4000 |
| ○ | | ○ | ○ | ○ | | | | 2/3 | 4000 | — | — |
| | | ○ | ○ | ○ | | | | 2/4 | 3000 | 2500 | 2000 |
| ○ | ○ | | ○ | ○ | | | | 2/5 | 2400 | 2000 | 1600 |
| | ○ | | ○ | ○ | | | | 2/6 | 2000 | — | — |
| | | | ○ | ○ | | | | 2/8 | 1500 | 1250 | 1000 |
| | ○ | ○ | | ○ | | | | 2/10 | 1200 | 1000 | 800 |
| | | ○ | | ○ | | | | 2/12 | 1000 | — | — |
| ○ | | | | ○ | | | | 2/15 | 800 | — | — |
| | | | | ○ | | | | 2/16 | 750 | — | 500 |
| | | ○ | ○ | | | | | 2/20 | 600 | 500 | 400 |
| | | | ○ | | | | | 2/24 | 500 | — | — |
| ○ | ○ | ○ | | | | | | 2/25 | 480 | 400 | 320 |
| | ○ | | | | | | | 2/30 | 400 | — | — |

Note:
1. Insert short-circuit pins in switches marked ○.
2. 6000 pulses/rev is the standard.



## 6.4 PROTECTIVE CIRCUIT

Servopack provides functions to protect the body and motor from malfunctions.

(1) Malfunction detecting functions

Table 6.7 Malfunction Detection Function

| Malfunction Detection Function | Protection and Detection |
|---|---|
| Over-run (Prevention of over-run) OS | When operation is performed with wrong connection of the phase sequence, without connection (1-phase connection), or with wrong PG signal connection, the motor may rotate at excessively high speed. This type of malfunction is detected. |
| Overspeed OS | Detected when the motor speed exceeds approximately 2400 rpm. |
| Overcurrent OC | Detects overcurrent in the main circuit caused by wrong operation by defective motor insulation or trouble in the current detection circuit. |
| Overvoltage OV | Detects excessively high direct current voltage in the main circuit . For example, the $GD^2$ is too large during deceleration. |
| Heat sink Overheat OH | Detected when the heat sink is excessively heated , for example, by an increase of generation loss caused by trouble in the main circuit element or by deterioration of the cooling conditions. |
| Overload OL | Detects excess load on the Servopack. |
| Blown fuse FU | Detects that the fuse of the Servopack has blown. |
| Regenerative Malfunction REGE | Detects malfunction in the regenerative processing circuit (short-circuit of the regenerative transistor, regenerative resistance is broken, etc.) of the Servopack. |
| Overflow OVER | Detects the storage pulse in the Servopack deviation counter when it becomes 20 bits or more. |

(2) Overload (OL) detection level

Fig. 6.10 shows the setting of overload detection level at 100% rated motor current.

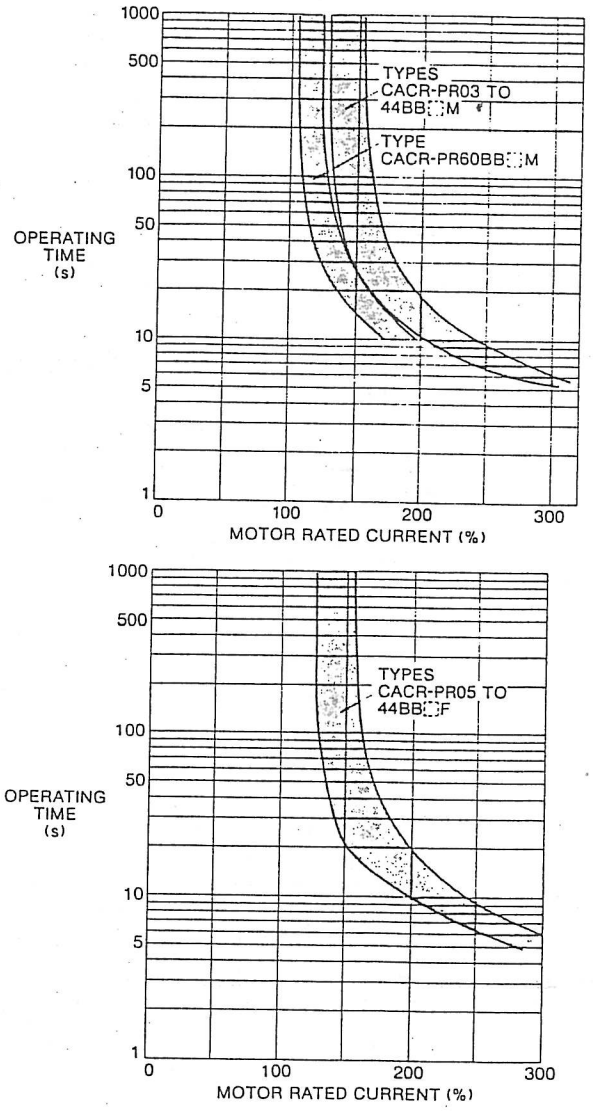



Fig. 6.10 Overload Characteristics

(3) Servo alarm output [ALM+, ALM-]

If any trouble detection circuits in Table 6.7. functions, the power drive circuit in the Servopack goes off, 8-segment LEDs indicate the operation condition and a servo alarm signal is output.

Note that the overflow is detected by;

Number of storage pulses of the deviation counter = $4/Kp \times (\text{Maximum motor revolution}/60 \times 1.05 \times S \times M/D)$

S: Number of PG pulses

M: Multiplication factor

D: Dividing ratio

Then, the overflow output turns 'ON'. When it becomes 20 bits or more, the overflow output turns 'OFF', and at the same time, outputs an external servo alarm signal. This state continues until it is reset.

(4) Protective circuit operation

An alarm signal indicates some trouble. Check the cause and correct the trouble, and restart the operation. Before checking the cause, turn off the power to the main circuit to avoid danger. Apply the sequence so that the alarm signal turns off only the main circuit (Ⓡ, Ⓢ, Ⓣ), as shown in Figs. 6.1 and 6.2. This allows rapid reaction in the event of a malfunction.

If the power to the control circuit (Ⓡ, Ⓣ) is simultaneously turned off, this also turns off the LED in the Servopack indicating the cause of the alarm signal.

**CAUTION**

When an alarm signal cuts off only the main circuit, set the speed reference to 0 V and turn on $\overline{CL}$ to clear the internal counter before supplying power to the main circuit to resume the operation.

(5) Resetting servo alarm

To reset the servo alarm, depress the RESET PB (blue pushbutton switch) on the printed circuit board in the Servopack. Error counter will not be reset.

If OL is on (e.g., Servopack is over loaded or the heat sink is overheated), the reset alarm is not immediate and occurs a few minutes later.

(1) f/V output circuit [f/V]

The f/V output circuit is for monitoring the number of revolutions. A minus signal is output with 2V/1000rpm forward rotation, and a plus signal is output with reverse rotation. (See par. 6.8.3 for details on connection of the tachometer.)

## 6.6 PRECAUTIONS FOR APPLICATION

### 6.6.1 Minus Load

The motor is rotated by the load; it is impossible to apply brake (regenerative brake) against this rotation and achieve continuous running.

Example: Driving a motor to lower objects (with no counterweight)

Since Servopack has the regenerative brake capability of short time (corresponding to the motor stopping time), for application to a minus load, contact Yaskawa representative.

### 6.6.2 Load Inertia ($GD^2$)

The allowable load inertia $GD^2$ converted to the motor shaft must be within five times the inertia of the applicable AC servomotor. If the allowable inertia is exceeded, an overvoltage alarm may be given during deceleration. If this occurs, take the following actions:

- Reduce the current limit.
- Slow down the deceleration curve.
- Decrease the maximum speed.

For details, contact Yaskawa representative.

## 6.5 LED INDICATION

Table 6.8 LED Indication Specifications

| Indication | LED* | Color | Conditions |
|---|---|---|---|
| Power | MP<br>P | Green<br>Green | Main circuit voltage (200 VDC or more) in the Servopack is normal.<br>Control power supply (±5 V) in the Servopack is normal. |
| Base OFF | BL | White-red | Power circuit of the Servopack is OFF.<br>When it is servo-OFF<br>When main circuit power is OFF<br>When the servo is abnormal |
| Over-run prevention | OS | Red | When the over-run detection circuit or the overspeed detection circuit operates. |
| Overcurrent | OC | Red | When the overcurrent detection circuit operates. |
| Overvoltage | OV | Red | When the overvoltage detection circuit operates. |
| Overload | OL | Red | When the overload detection circuit or the heat sink overheat detection circuit operates. |
| Blown Fuse | FU | Red | When the blown fuse detection circuit operates. |

* When a single LED is used to indicate two types of malfunctions, the causes of both types of trouble must be determined. The fuse element incorporated in the Servopack indicates that it is blown (Fig. 6.11)

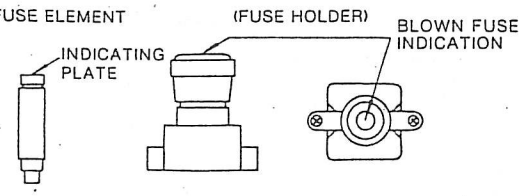



Fig. 6.11 Indication of Blown-fuse of Incorporated Fuse

### 6.6.3 High Voltage Line

If the supply voltage is 400/440 V, the voltage must be dropped three-phase, 400/440V to 200 V by using a power transformer. Table 6.10 shows the transformer selection. Connection should be made so that the power is supplied and cut through the primary side of the transformer. Single-phase 100 V class power supply should not be used.

## 6.7 PRECAUTIONS OF OPERATION

### 6.7.1 Noise Treatment

Servopack uses is a power transistor in the main circuit. When these transistors are switched, the effect of $\frac{di}{dt}$ or $\frac{dv}{dt}$ (switching noise) may sometimes occur depending on the wiring or grounding method.

The Servopack incorporates CPU. This requires wiring and treatment to prevent noise interference. To reduce switching noise as much as possible, the recommended method of wiring and grounding is shown in Fig. 6.12.

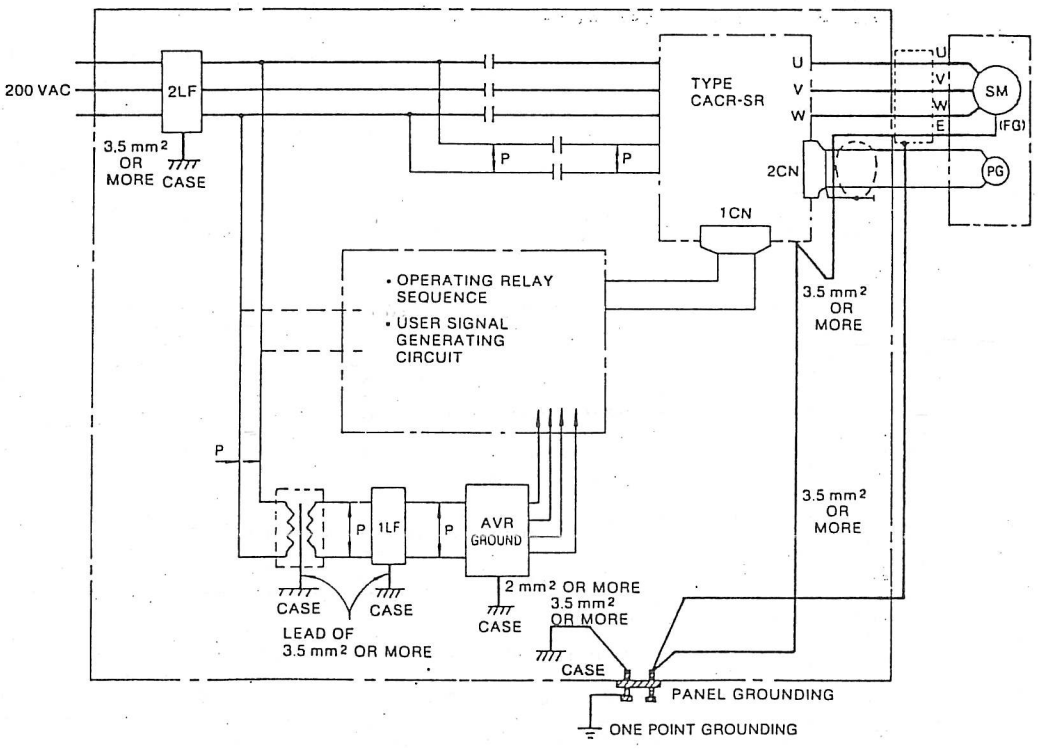
(1) Grounding method (Fig. 6.12)

- Motor frame grounding

  When the motor is at the machine side and grounded through the frame, Cf $\frac{dv}{dt}$ current flows from the PWM power through the floating capacity of the motor. To prevent this effect of current, motor ground terminal Ⓔ (motor frame) should be connected to terminal ⏚ of Servopack. (Terminal ⏚ of Servopack should be directly grounded.)

- Servopack SG 0 V

  Noise may remain in the input signal line, so make sure to ground SG 0 V. When motor wiring is contained in metal conduits, the conduits and boxes must be grounded. The above grounding uses one-point grounding.




P — Twisted cable

Note:
1. Use wires of 3.5 mm² or more for grounding to the case (preferably flat-woven copper wire).
2. Connect line filters observing the precautions as shown in (2) Noise filter installation.

Fig. 6.12 Grounding Method

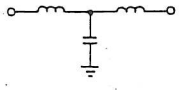
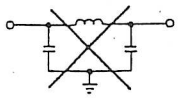
(2) Noise filter installation

When noise filters are installed to prevent noise from the power line, the block type must be used. The recommended noise filter is shown in Table 6.9. The power supply to peripherals also needs noise filters.

**NOTE**

If the noise filter connection is wrong, the effect decreases greatly. Observing the precautions, carefully connect them as shown in Fig. 6.13.

Table 6.9 Recommended Noise Filter

| *Servopack* Type CACR- | Applicable Noise Filter | Recommended Noise Filter | |
|---|---|---|---|
| | | Type | Specifications |
| PR03BB PR05BB |  CORRECT | LF-305 | Three-phase 200 VAC class, 5 A |
| PR07BB | | LF-310 | Three-phase 200 VAC class, 10 A |
| PR10BB PR15BB | | LF-315 | Three-phase 200 VAC class, 15 A |
| PR20BB | | LF-320 | Three-phase 200 VAC class, 20 A |
| PR30BB |  WRONG | LF-330 | Three-phase 200 VAC class, 30 A |
| PR44BB | | LF-340 | Three-phase 200 VAC class, 40 A |
| PR60BB | | LF-350 | Three-phase 200 VAC class, 50 A |

Note: Noise filter made by Tohoku Kinzoku Ind., Co.

(a) Separate the input and output leads. Do not bundle or run them in the same duct.

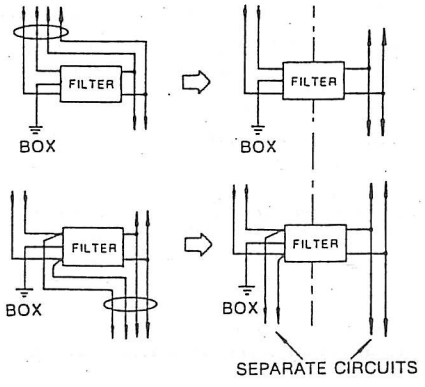



Fig. 6.13 (a)

(b) Do not bundle the ground lead with the filter output line or other signal lines or run them in the same duct.

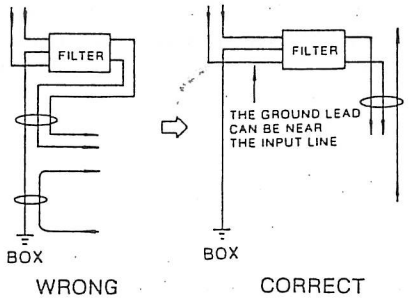



Fig. 6.13 (b)

(c) Connect the ground lead singly to the box or the ground panel.

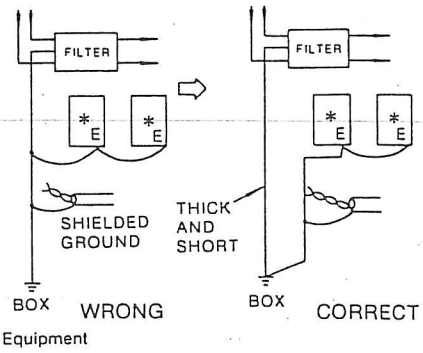



Fig. 6.13 (c)

(d) If the control panel contains the filter, connect the filter ground and the equipment ground to the base of the control unit.

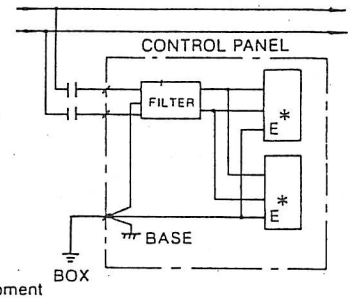



Fig. 6.13 (d)

### 6.7.2 Power Line Protection

The Servopack is operated through the commercial power line(200 V). To prevent the power line accidents due to grounding error, contact error, or to protect the system from a fire, circuit breakers(MCCB) or fuses must be installed according to the number of Servopacks used (Table 6.10).

A quick-melting fuse cannot be used, because the Servopack uses the capacitor-input power supply and the charging current might melt such a fuse.

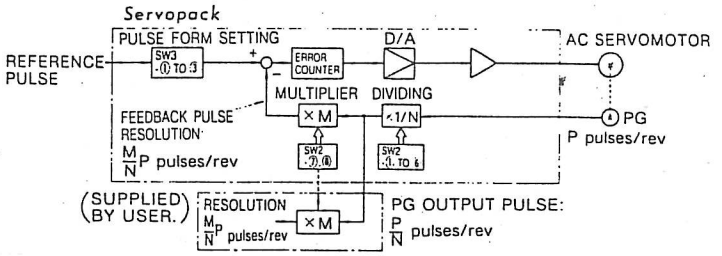
Table 6.10 Power Supply Capacity and MCCB or Fuse Capacity

| *Servopack* Type CACR- | Power Capacity* per *Servopack* | Current Capacity per MCCB or Fuse |
|---|---|---|
| PR03BB | 0.65 kVA | 5 A |
| PR05BB | 1.1 kVA | 5 A |
| PR07BB | 1.5 kVA | 8 A |
| PR10BB | 2.1 kVA | 8 A |
| PR15BB | 3.1 kVA | 10 A |
| PR20BB | 4.1 kVA | 12 A |
| PR30BB | 6.0 kVA | 18 A |
| PR44BB | 8.0 kVA | 24 A |
| PR60BB | 11 kVA | 32 A |

*Values at rated load.

### 6.7.3 Input and Output Pulses

Servopack multiplies the reference input pulses and divides and multiplies the PG output. Table 6.11 shows a typical relationship between these functions when the reference input pulses and PG output pulses are combined.




Note: When the same number of pulses obtained from feedback pulse resolution is required, multiply the PG output pulses by the number (M) set by switches SW2-⑦ and -⑧ in the Servopack.

Fig. 6.14 Block Diagram of Pulse Setting in Type CACR-PR

Table 6.11 Input and Output Pulses

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Input Multiplier (SW 3 - ①, ②, ③) | | 1 | 1 | 4 | 4 | 4 | 1 |
| PG Pulse Frequency Dividing (SW 2-① to ⑥) | | 1 | 1 | 1 | 2 | 3 | 3 |
| Output Multiplier (SW 2-⑦, ⑧) | | 1 | 4 | 4 | 4 | 1 | 1 |
| Reference Pulse Train | For 2-phase Pulse Train Input | | | | | | |
| | For Sign + Pulse Train Input | | | | | | |
| PG, FB Pulse | PA<br>PB | | | | | | |
| PG Output | PAo<br>PBo | | | | | | |
| Pulse Resolution | | 6000 | 24000 | 24000 | 12000 | 2000 | 2000 |

Note:
1. When the input multiplier is 4, 2-phase pulse train can be input. Inputting the sign and pulse train indicates that the condition is the same as when four times of reference frequency is input.
2. The pulse resolution is calculated from PG 6000 pulses/rev.

### 6.7.4 Setting Number of Optical Encoder Pulses

The optical encoder issues numbers of pulses, 4000, 5000, or 6000 pulses/rev. These pulses are set by the short switch(SW1) in the Servopack.

Note that if wrong number of pulses is set for the servomotor and Servopack, the motor cannot run.

- The number of pulses of the optical encoder is indicated with the type of the servomotor.
- The number of pulses of the Servopack's optical encoder set at the factory is indicated with the type of the Servopack. (The factory setting is A:6000 pulses/rev.)

If the number of pulses of the Servopack's optical encoder set at the factory is different from the number of motor pulses, change the setting switches in the Servopack according to Tables 10.2 and 10.5 and 6.7.2 Operation of Setting Switches.

### 6.7.5 Positioning Signal when Power is Supplied

When the power is supplied to the control circuit, a positioning signal(COIN output) continues for approximately 150 ms to initialize the Servopack. Note that this is an invalied signal and should not be taken this into the unit to be used.

Example: Take interlock with a servo alarm output.

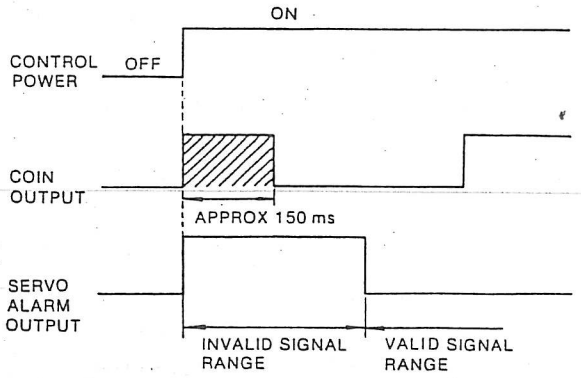


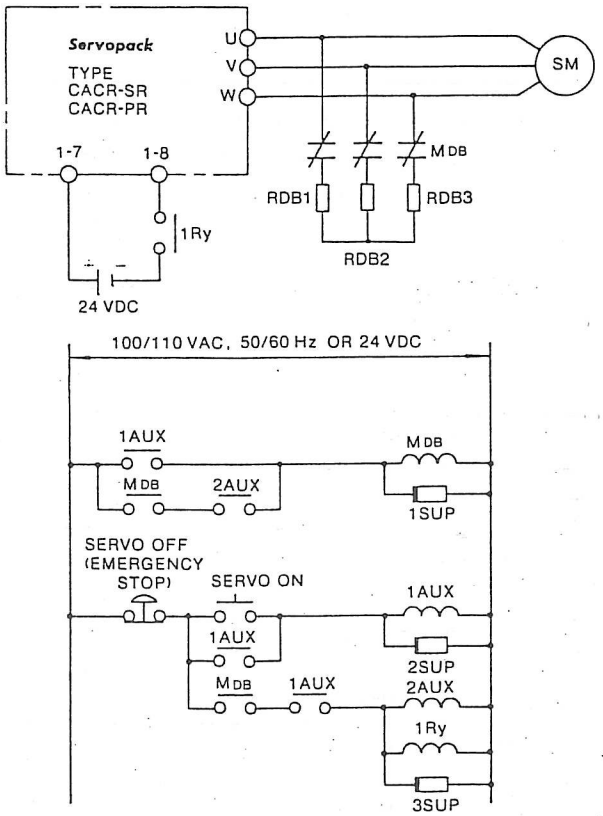

Fig. 6.15 Positioning Signal COIN Output

## 6.8 APPLICATION

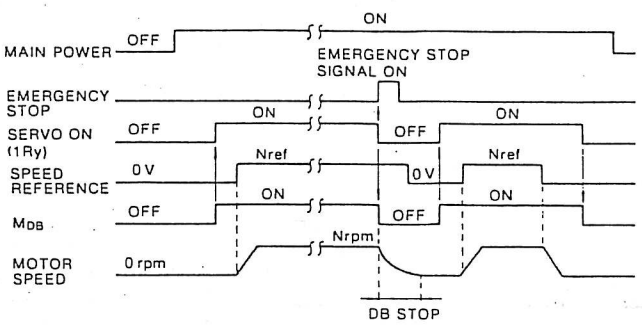
### 6.8.1 Emergency Stop Dynamic Braking (DB) Circuit

When an external DB circuit for emergency stop is used, make and break the DB circuit in the sequence shown below.

(1) DB circuit and closing timing(Fig. 6.16)




1 SUP to 3 SUP: Surge absorber CR 50500 BA or equivalent (made by Okaya Electric Industries Co., Ltd.)
$M_{DB}$: Magnetic contactor
$R_{DB1}$ to $R_{DB3}$: DB resistor
1 AUX, 2 AUX: Auxirialy relay MY-4Z or equivalent (made by Omron Tateisi Electronics Co.)
1 Ry: Servo ON reference relay MY-4Z or equivalent (made by Omron Tateisi Electronics Co.)




Note:
1. $M_{DB}$ OFF: Break state, $M_{DB}$ ON: make state
2. Arrows ↑ ↓ show delay time greater than the operating time of one relay.
3. Although the emergency stop signal is indicated by pulses, it is the same as a status signal (solid line).
4. Before restarting (Servo ON), or stop the reference pulse and turn on $\overline{CL}$ to clear the internal counter.

- Operation at emergency stop

Emergency stop ON
↓
1AUX OFF
↓
1Ry, 2AUX OFF(Servo OFF)
↓
$M_{DB}$ OFF(Break)
↓
DB stop

- Operation at restarting

Emergency stop OFF
↓
Restart(Servo ON SW ON)
↓
1AUX ON
↓
$M_{DB}$ ON(Make)
↓
1Ry, 2AUX ON(Servo ON)
↓
Preparation completion for operation

Fig. 6.16 DB Circuit and Closing Timing

6.8.1 Emergency Stop Dynamic Braking (DB) Circuit (Cont'd)

(2) DB Resistor

Depending on the motor speed, select the standard value shown in Table 6.12.

Table 6.12 DB Resistor for AC Servomotor

| Motor Type | DB Resistance(RDB1 to RDB3) | | Magnetic Contactor(MDB) |
|---|---|---|---|
| | DB stop at Reted Speed | DB stop at Max Rated Speed | |
| USAMED-03M | 0 Ω | 40 W, 2 Ω | Yaskawa Type RA-6E3(3N03NC)or equivalent |
| USAMED-06M | 40 W, 0.5 Ω | 40 W, 1 Ω | |
| USAMED-09M | 40 W, 0.5 Ω | 40 W, 1 Ω | Fuji Electric Co., Ltd. Type SRC50-4 or equivalent (2N03NC, 1N04NC or 5NC) |
| USAMED-12M | 40 W, 0.5 Ω | 40 W, 1 Ω | |
| USAMED-20M | 40 W, 0.5 Ω | 40 W, 1 Ω | |
| USAMED-30M | 60 W, 0.3 Ω | 60 W, 0.5 Ω | Mitsubishi Electric Corporation Type BA-65 |
| USAMED-44M | 60 W, 0.3 Ω | 60 W, 0.5 Ω | |
| USAMKD-60M | 60 W, 0.3 Ω | 60 W, 0.5 Ω | |
| USAFED-05F | 40 W, 0.5 Ω | 40 W, 2 Ω | Yaskawa Type RA-6E3(3N03NC)or equivalent |
| USAFED-09F | 40 W, 0.5 Ω | 40 W, 3 Ω | |
| USAFED-13F | 40 W, 0.5 Ω | 40 W, 1 Ω | Fuji Electric Co., Ltd. Type SRC50-4 (2N03NC, 1N04NC or 5NC) |
| USAFED-20F | 40 W, 1 Ω | 40 W, 2 Ω | |
| USAFED-30F | 40 W, 0.5 Ω | 40 W, 1 Ω | Mitsubishi Electric Corporation Type BA-65 |
| USAFED-44F | 60 W, 0.3 Ω | 60 W, 0.5 Ω | |

Note:
1. The value of the DB resistance is the value in which the motor inertia is the minimum on DB-stop, at the rated and maximum rpm. If the conditions for DB-stop are not clear, use the value for the maximum rpm.
2. The capacity of the DB resistance in the above table is the capacity when frequency of the DB-stop is very small(DB-stop for emergency stops: 10 times or less/hour). The capacity of the DB resistance must be increased if the frequency of the DB-stop increases.

Table 6.13 Dynamic Braking Torque

| Motur Type | Average Braking Torque under Rated Motor Speed kg·cm | Average Braking Torque under Max Motor Speed kg·cm |
|---|---|---|
| USAMED-03M | 26.2 | 24.0 |
| USAMED-06M | 43.9 | 48.4 |
| USAMED-09M | 69.9 | 76.0 |
| USAMED-12M | 60.4 | 60.6 |
| USAMED-20M | 88.9 | 87.9 |
| USAMED-30M | 159.5 | 166.3 |
| USAMED-44M | 228.1 | 241.8 |
| USAMED-60M | 228.1 | 241.8 |
| USAFED-05F | 25.7 | 23.1 |
| USAFED-09F | 48.6 | 31.2 |
| USEFED-13F | 69.9 | 67.5 |
| USAFED-20F | 52.9 | 48.0 |
| USAFED-30F | 97.8 | 88.6 |
| USAFED-44F | 166.0 | 161.6 |

Note:
The average brake torque is calculated as follows.
(formula)

$$T_{Bave} = \frac{(GD^2_M + GD^2_L) \times N}{375 \times tf} - T_L$$

Where:
$T_{Bave}$: Average brake torque[kg·m] at DB-stop of rated rpm or maximum rpm.
$GD^2_M$: Motor $GD^2$ [kg·m²]
$GD^2_L$: Motor shaft conversion load $GD^2$ [kg·m²]
N: Rpm when DB is commanded 1000 rpm or 2000 (1500) rpm
tf: Time for the motor to stop [s]
TL: Load torque [kg·m]

### 6.8.2 Connection for Reverse Motor Running

If the machine construction requires that the normal forward reference is used for reverse motor running and the normal reverse reference for forward running, the following connection should be provided. The phase(PAo, PBo) of PG output for this connection is shown below.

(1) Lead change

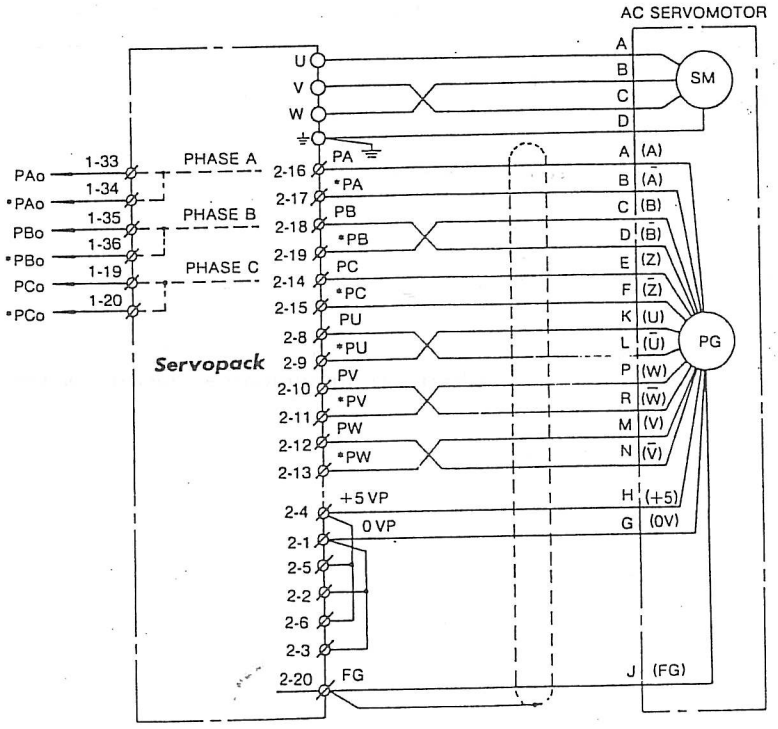
| Motor Lead | Optical Encoder Lead |
|---|---|
| B ⟷ C | PU ⟷ *PU |
| | PV ⟷ *PW |
| | PW ⟷ *PV |
| | PB ⟷ *PB |

⇩

PG Output Phase

| Reverse Motor Running (PBo Ahead) | Forward Motor Running (PAo Ahead) |
|---|---|
| PAo  | PAo  |
| PBo  | PBo  |

(2) Typical Connection Example (Fig. 6.17)




Note: Signal PCo is synchronized with PAo.

Fig. 6.17 Typical Connection Example

### 6.8.3 Tachometer Connection

When a tachometer is connected to f/V output, make the connection as shown in Fig. 6.18, using a DC ammeter of ±1 mA(both swing).

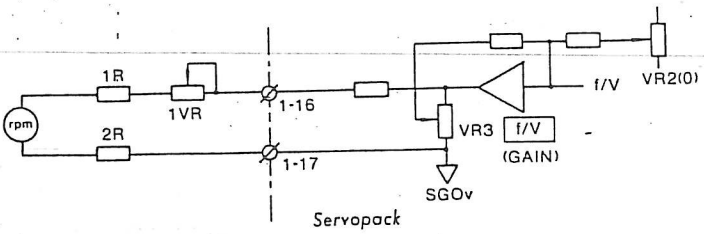



Fig. 6.18 Tachometer Connection

- Instrument: ±1 mA(both swing) ammeter. Use ammeter of DCF-6 or DCF-12N by Toyo Instrument or equivalent.

f/V output in Servopack is set at 2V/1000rpm. Using resistances 1R and 2R and a potentiometer 1VR, set the maximum speed per full scale. (Select 1R=2R; 1VR is for fine adjustment.)

**NOTE**

***Servopack*** potentiometer VR3 f/V can be adjustable. It has been preset at 2 V/1000 rpm at the factory. Readjusting it will change the monitor of motor speed. Meter adjustment at full scale should be performed as shown in Fig. 6.18.

# 7. INSTALLATION AND WIRING

## 7.1 RECEIVING

This motor has been put through severe tests at the factory before shipped. After unpacking, however, check and see the following.

- Its nameplate ratings meet your requirements.
- It has sustained no damage while in transit.
- The output shaft should be hand-rotated freely. However, the brake-mounted motor does not rotate as it is shipped with the shaft locked.
- Fastening bolts and screws are not loose.

If any part of the motor is damaged or lost, immediately notify us giving full details and nameplate data.

## 7.2 INSTALLATION

### 7.2.1 Servomotor

AC Servomotor can be installed either horizontally or vertically.

(1) Before mounting

Wash out anticorrosive paint on shaft extension and flange surface with thinner before connecting the motor to the driven machine. See Fig. 7.1.

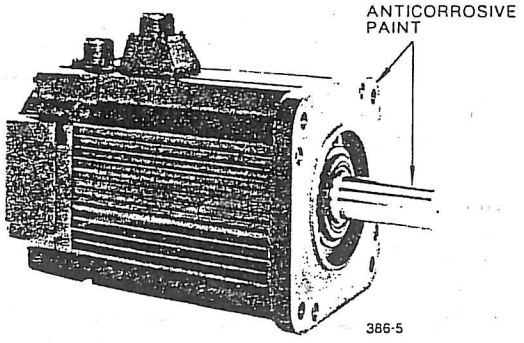



Fig. 7.1 Anticorrosive Paint to be Removed

(2) Location

Use the motor under the following conditions.

- Indoors
- Free from corrosive and/or explosive gases or liquids
- Ambient temperature: -10 to +40°C
- Clean and dry
- Accessible for inspection and cleaning

If the AC servomotor is subject to excessive water or oil droplets, protect the motor with a cover. The motor can withstand a small amount of splashed water or oil.

(3) Environmental conditions

Ambient Temperature: 0 to +40°C

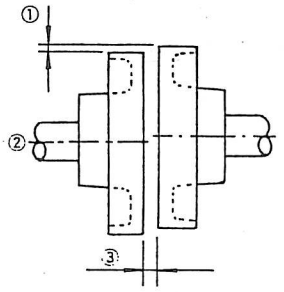
Storage Temperature: -20 to +80°C

Humidity: 20% to 80% RH (non-condensing)

(4) Load coupling

True alignment of motor and driven machine is essential to prevent vibration, reduced bearing and coupling life, or shaft and bearing failures.

Use flexible coupling with direct drive. The alignment should be made in accordance with Fig. 7.2.




① Measure the gap between the straightedge and coupling halves at four equidistant points of the coupling. The each reading should not exceed 0.03 mm.

② Align the shafts.

③ Measure the gap between the coupling faces at four equidistant points around the coupling rim with thickness gage. The maximum variation between any two readings should not exceed 0.03 mm.

Fig. 7.2 Alignment of Coupling

(5) Allowable bearing load

Avoid both thrust and radial loads to the motor shaft. If unavoidable, never exceed the values in Tables 4.1 to 4.3.

### 7.2.2 *Servopack*

(1) Installation

The Servopack type CACR-PR is mounted on the base as standard.

(2) Location

- When installed in a panel:

  Keep the temperature around Servopack at 55°C or below. (Fig. 7.3)

- When installed near a heat source:

  Keep the temperature around Servopack below 55°C. (Fig. 7.4)

- If subjected to vibration:

  Mount the unit on shock absorbing material.

- If corrosive gases are present:

  Avoid locations where corrosive gases exist as it may cause extensive damage over long use. Especially vulnerable are switching operation of contactors and relays.

- Unfavorable atmospheric conditions:

  Select a location with minimum exposure to oil, water, hot air, high humidity, excessive dust or metallic particles.

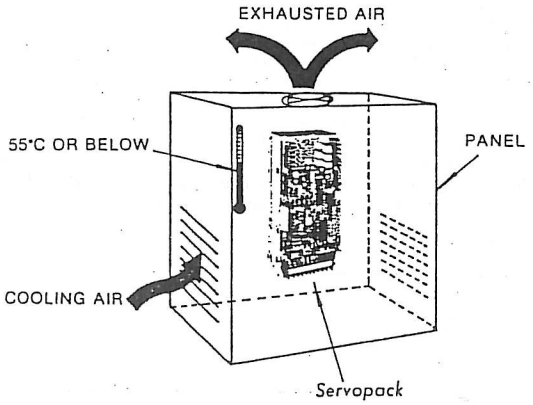



Fig. 7.3 Typical Layout for Panel Mounting

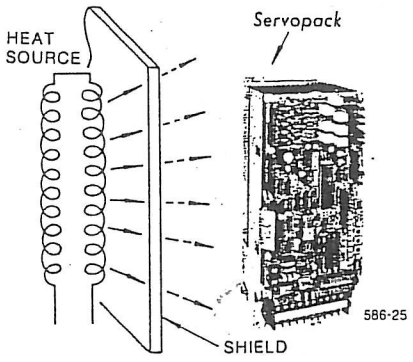



Fig. 7.4 Protection against Heat Radiation

(3) Mounting Direction

Mount the unit vertically on the wall using the mounting holes (4) on the base plate, with main terminals at the bottom. (Fig. 7.5)

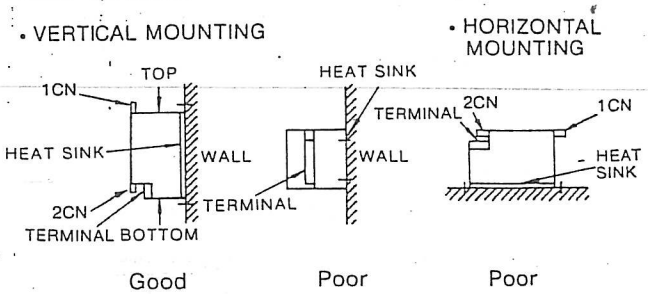



Fig. 7.5 Mounting Direction of *Servopack*

## 7.3 WIRING

### 7.3.1 Rated Current and Cable Size

Tables 7.1 and 7.2 show external terminals, rated current, and cable sizes of the power unit and Servopack, respectively. Select the type and size of cables to meet ambient conditions and current capacity. The cable size is determined so that a bundle of three cables can bear the rated current at an ambient temperature of 40°C. Table 7.3 lists the type of cables.

Table 7.1 Rated Current

| External Terminal | | Type CACR- / Symbol | Rated Current A (Effective Current) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | PR 03BB | PR 05BB | PR 07BB | PR 10BB | PR 15BB | PR 20BB | PR 30BB | PR 44BB | PR 60BB |
| On Line | Main Circuit Power Input | R, S, T | 2 | 5 | 6 | 8 | 10 | 12 | 18 | 24 | 32 |
| On Line | Motor Connection | U, V, W | 3.0 | 3.8 | 5.8 | 7.6 | 11.7 | 18.8 | 26.0 | 33.0 | 45 |
| On Line | Control Power Input | r, t | 0.5A | | | | | | | | |
| Off Line | Control I/O Signal Connector | 1CN | 100mA DC max | | | | | | | | |
| Off Line | PG Signal Connector | 2CN | 100mA DC max (500mA DC for power line only) | | | | | | | | |
| | Ground | ⏚ | — | | | | | | | | |

Table 7.2 Recommended Cable Size of *Servopack*

| External Terminal | | Type CACR- / Symbol | Cable Size mm² | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | PR 03BB | PR 05BB | PR 07BB | PR 10BB | PR 15BB | PR 20BB | PR 30BB | PR 44BB | PR 60BB |
| On Line | Main Circuit Power Input | R, S, T | HIV 2.0 or more | | | | HIV 3.5 or more | | HIV 5.5 or more | HIV 5.5 or more | HIV 8 or more |
| On Line | Motor Connection | U, V, W | HIV 2.0 or more | | | HIV 3.5 or more | | | | | |
| On Line | Control Power Input | r, t | HIV 1.25 or more | | | | | | | | |
| Off Line | Control I/O Signal Connector | 1CN | • Two-core twisted shielded cable<br>• Core must be 0.2 mm² or more<br>• Tin-plated soft-copper twisted cable<br>• Finished cable dimension: 16 dia or less for 1CN, 11 dia or less for 2CN | | | | | | | | |
| Off Line | PG Signal Connector | 2CN | | | | | | | | | |
| | Ground | ⏚ | HIV 2.0 or more | | | | | | | | |

Note: Terminal (Y3) and (Y4) of resistor unit should be used wire HIV 3.5 or more. Fan terminal (F1), (F2) and (F3) should be used wire HIV 2.0 or more.

### 7.3.1 Rated Current and Cable Size (Cont'd)

Table 7.3 Cable

| Type of Lead | Allowable Conductor Temperature |
|---|---|
| Vinyl Cable (PVC) | — |
| 600 V Vinyl Cable (IV) | 60 |
| Special Heat-Resistant Cable (HIV) | 75 |

Note:
1. For main circuits, use cables of 600 V or more.
2. Where cables are bundled or run through a duct (unplasticized polyvinyl chloride conduit or metalic conduit), select the larger cable size than listed considering the current drop rate of the cables.
3. Where the ambient (panel inside) temperature is high (40°C to 60°C), use heat-resistant cables.

### 7.3.2 Wiring Precautions

The following precautions should be taken for wiring.

(1) For signal lines and PG feedback lines, use twisted cables or multi-core shielded twisted-pair cables(Yaskawa Drawing No. DP8409123 or DE8400093).

Cable length is a maximum of 3 m for reference input lines and a maximum of 20 m for PG feedback lines. Use the shortest possible length.

(2) For ground line, cable should be as heavy as possible to provide class 3 ground (ground resistance 100 Ω or less). Make sure to ground at one point. If the motor and machine are insulated, ground the motor.

(3) To prevent malfunction due to noise, take the following precautions:

- Place the noise filter, Servopack and I/O reference as near as possible to each other.
- Make sure to insert a surge absorbing circuit into the relay, electromagnetic contact, and solenoid coils.
- Run the power line and signal line, holding the distance to 30 cm or more; do not run them in the same duct or in a bundle.
- When the same power is used for Servopack, as for an electric welder or electrical discharge machine or when a high-frequency noise source is present in the vicinity, use filters in the power and input circuits.
- The Servopack uses a switching amplifier, and spurious noise may be present in the signal line. Never leave the termination of the analog input wiring open.

(4) Remedy for Radio Frequency Interference (R.F.I).

Servopack is not provided with protected from radio frequency interference. If the controller is adversely affected by radio waves, connect a noise filter to power supply.

(5) The signal line uses cables whose core is extremely fine (0.2 to 0.3 $mm^2$). Avoid using excessive force which may damage these cables.

### 7.3.3 Power Loss

The power loss of Servopack is shown in Table 7.4.

Table 7.4 Power Loss at Rated Output

| Servopack Type CACR- | Output Current A | Power Loss | | | |
|---|---|---|---|---|---|
| | | Main Circuit W | Regenerative Resistance W | Control Circuit W | Total W |
| PR03BB | 3.0 | 20 | 10 | 60 | 90 |
| PR05BB | 3.8 | 40 | | | 110 |
| PR07BB | 5.8 | 60 | 20 | | 140 |
| PR10BB | 7.6 | 70 | | | 150 |
| PR15BB | 11.7 | 80 | | | 160 |
| PR20BB | 18.8 | 100 | 40 | | 200 |
| PR30BB | 26.0 | 160 | 80 | | 300 |
| PR44BB | 33.0 | 210 | 100 | | 370 |
| PR60BB | 45.0 | 300 | 120 | | 480 |

Note: The regenerative resistor causes power loss when the motor is decelerated, but is negligible if the motor is not started and stopped frequently.

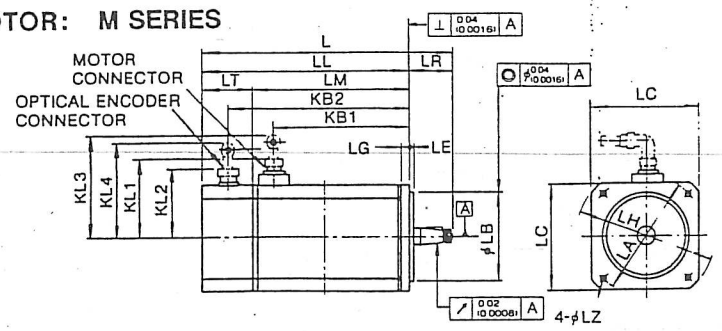
# 8. DIMENSIONS in mm (inches)

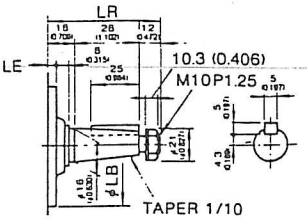
## 8.1 SERVOMOTOR: M SERIES

(1) Standard

(Taper Shaft)

Drawing 1

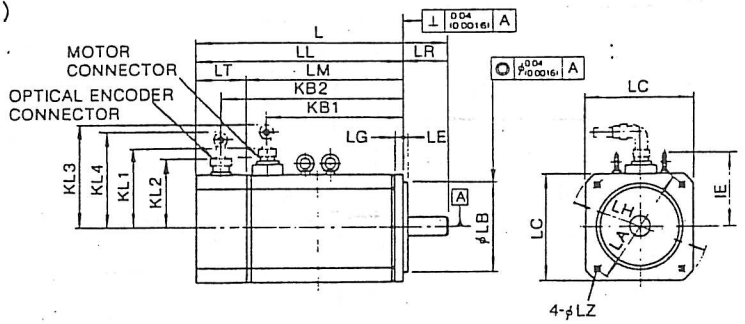


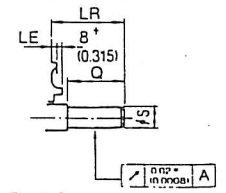




Detail of Shaft Extension

(Straight Shaft)

Drawing 2



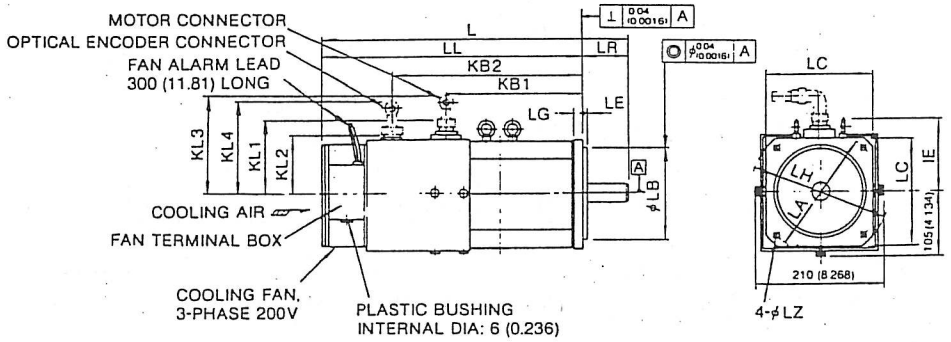



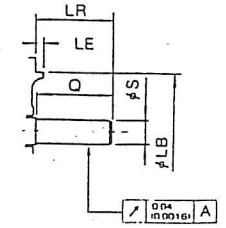

* For USAMED-44MA2, 0.04 (0.0016).

† Only for USAMED-09MA2.

Detail of Shaft Extension

Drawing 3




Detail of Shaft Extension

| AC Servomotor Type | Dwg No. | L | LL | LM | LR | LT | KB1 | KB2 | IE | KL1 | KL2 | KL3 | KL4 | Flange Surface LA | LB | LC | LE | LG | LH | LZ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USAMED-03MA1* | 1 | 261 (10.276) | 203 (7.992) | 157 (6.181) | 58 (2.283) | 46 (1.811) | 124 (4.882) | 176 (69.29) | — | 112 (4.409) | 93 (3.661) | 168 (6.614) | 158 (6.22) | 145 (5.709) | 110 $^{0}_{-0.035}$ (4.331 $^{0}_{-0.0014}$) | 130 (5.118) | 6 (0.236) | 12 (0.472) | 165 (6.496) | 9 (0.354) |
| USAMED-06MA1* | 1 | 318 (12.52) | 260 (10.236) | 214 (8.425) | | | 181 (7.126) | 233 (9.173) | | | | | | | | | | | | |
| USAMED-09MA2* | 2 | 406 (15.984) | 348 (13.701) | 302 (11.890) | | | 250 (9.843) | 322 (12.677) | | | | | | | | | | | | |
| USAMED-12MA2* | 2 | 350 (13.78) | 271 (10.669) | 213 (8.386) | 79 (3.11) | 58 (2.283) | 171 (6.732) | 232 (9.134) | 124 (4.882) | 137 (5.394) | 110 (4.331) | 202 (7.953) | 175 (6.89) | 200 (7.874) | 114.3 $^{0}_{-0.025}$ ( 4.5 $^{0}_{-0.0009}$ ) | 180 (7.087) | 3.2 (0.126) | 18 (0.709) | 230 (9.055) | 13.5 (0.531) |
| USAMED-20MA2 | 2 | 408 (16.063) | 329 (12.953) | 271 (10.669) | | | 229 (9.016) | 290 (11.417) | | | | | | | | | | | | |
| USAMED-30MA2 | 2 | 493 (19.409) | 414 (16.299) | 356 (14.016) | | | 314 (12.362) | 375 (14.764) | | | | | | | | | | | | |
| USAMED-44MA2 | 2 | 725 (28.543) | 615 (24.213) | 557 (21.929) | 110 (4.331) | — | 482 (18.976) | 587 (23.11) | | 150 (5.906) | 100 (3.937) | 235 (9.252) | 165 (6.496) | | | | | | | |
| USAMKD-60MA2 | 3 | 820 (32.283) | 710 (27.953) | — | | | | | | | | | | | | | | | | |

| AC Servomotor Type | Dwg No. | Shaft Extension S | Shaft Extension Q | Approx Weight kg (lb) | Motor Connector Types: Receptacle | L-type Plug | Straight Plug | Cable Clamp | Optical Encoder Connector Types: Receptacle | L-type Plug | Straight Plug | Cable Clamp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USAMED-03MA1* | 1 | See Drawing 1. | | 10 (22) | MS 3102 A 18 -10 P | MS 3108 B 18 -10 S | MS 3106 B 18 -10 S | MS 3057 -10 A | MS 3102 A 20 -29 P | MS 3108 B 20 -29 S | MS 3106 B 20 -29 S | MS 3057 -12 A |
| USAMED-06MA1* | 1 | | | 15 (33) | | | | | | | | |
| USAMED-09MA2* | 2 | 22 $^{0}_{-0.013}$ (0.866 $^{0}_{-0.0005}$) | 40 (1.575) | 21 (46) | | | | | | | | |
| USAMED-12MA2* | 2 | 35 $^{0}_{-0.016}$ (1.378 $^{0}_{-0.0006}$) | 76 (2.992) | 24 (53) | MS 3102 A 22 -22 P | MS 3108 B 22 -22 S | MS 3106 B 22 -22 S | MS 3057 -12 A | | | | |
| USAMED-20MA2 | 2 | | | 32 (71) | | | | | | | | |
| USAMED-30MA2 | 2 | | | 43 (95) | | | | | | | | |
| USAMED-44MA2 | 2 | 42 $^{0}_{-0.016}$ (1.654 $^{0}_{-0.0006}$) | 110 (4.331) | 70 (154) | MS 3102 A 32 -17 P | MS 3108 B 32 -17 S | MS 3106 B 32 -17 S | MS 3057 -16 A | | | | |
| USAMKD-60MA2 | 3 | | | 75 (165) | | | | | | | | |

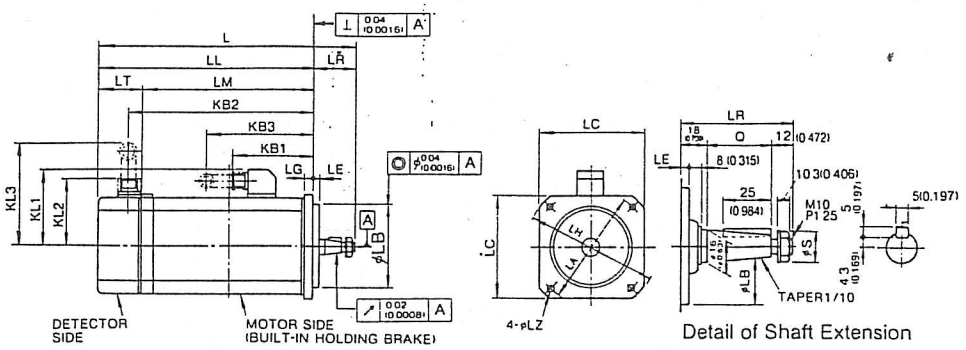
*Not provided with an eyebolt.

Note :
1. Optical encoder (6000 pulses/rev) is used as a detector.
2. Vibration : 15$\mu$m or below.
3. Plug and clamp are not attached for receptacle connection.
4. Fan terminal connection (for only type USAMKD-60MA2).

## 8.1 SERVOMOTOR: M SERIES (Cont'd)

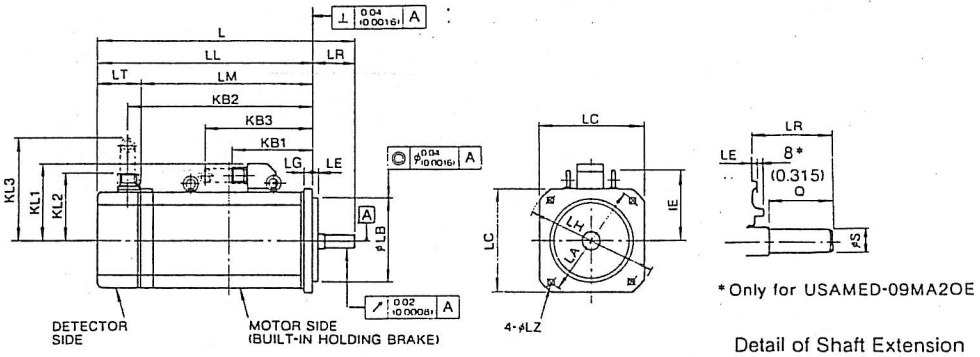
(2) With Brake

(Taper Shaft)
Drawing 1




Detail of Shaft Extension

(Straight Shaft)
Drawing 2




* Only for USAMED-09MA2OE

Detail of Shaft Extension

| AC Servomotor Type USAMED- | Dwg No. | L | LL | LM | LR | LT | KB1 | KB2 | KB3 | IE | KL1 | KL2 | KL3 | Flange Surface | | | | | | | Shaft Extension | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | LA | LB | LC | LE | LG | LH | LZ | S | Q |
| 03MA1OE* | 1 | 316 (12.441) | 258 (10.157) | 214 (8.425) | 58 (2.283) | 44 (1.732) | 116 (4.567) | 233 (9.173) | 158 (6.220) | — | 113 (4.449) | 93 (3.661) | 147 (5.787) | 145 (5.709) | 110 $^{0}_{-0.035}$ (4.331 $^{0}_{-0.0014}$) | 130 (5.118) | 6 (0.236) | 12 (0.472) | 165 (6.496) | 9 (0.354) | 21 $^{+0.021}_{0}$ | 28 (1.102) |
| 06MA1OE* | 1 | 362 (14.252) | 304 (11.969) | 260 (10.236) | | | | 279 (10.984) | | | | | | | | | | | | | | |
| 09MA2OE* | 2 | 452 (17.795) | 394 (15.512) | 350 (13.780) | | | | 369 (14.528) | | | | | | | | | | | | | 22 $^{+0.021}_{0}$ (0.866 $^{+0.00083}_{0}$) | 40 (1.575) |
| 12MA2OE | 2 | 426 (16.772) | 347 (13.661) | 292 (11.496) | 79 (3.110) | 55 (2.165) | 165 (6.496) | 311 (12.244) | 220 (8.661) | 124 (4.882) | 143 (5.630) | 110 (4.331) | 171 (6.732) | 200 (7.874) | 114.3 $^{0}_{-0.025}$ ( 4.5 $^{0}_{-0.0010}$) | 180 (7.087) | 3.2 (0.126) | 18 (0.709) | 230 (9.055) | 13.5 (0.531) | 35 $^{+0.01}_{0}$ (1.378 $^{+0.00039}_{0}$) | 76 (2.992) |
| 20MA2OE | 2 | 490 (19.291) | 411 (16.181) | 356 (14.016) | | | | 375 (14.764) | | | | | | | | | | | | | | |
| 30MA2OE | 2 | 571 (22.480) | 492 (19.370) | 437 (17.205) | | | | 456 (17.953) | | | | | | | | | | | | | | |

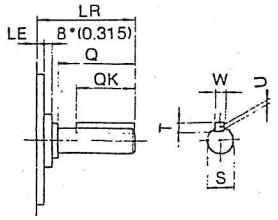
| AC Servomotor Type USAMED- | Dwg No. | Approx Weight kg (lb) | Brake Torque kg·m (lb·in) | Connector Types for Motor and Brake | | | | Optical Encoder Connector Types | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Receptacle | L-type Plug | Straight Plug | Cable Clamp | Receptacle | L-type Plug | Straight Plug | Cable Clamp |
| 03MA10E* | 1 | 13 (29) | 0.6 (52.1) | MS 3102 A 20 -15 P | MS 3108 B 20 -15 S | MS 3106 B 20 -15 S | MS 3057 -12 A | MS 3102 A 20 -29 P | MS 3108 B 20 -29 S | MS 3106 B 20 -29 S | MS 3057 -12 A |
| 06MA10E* | 1 | 17 (37) | | | | | | | | | |
| 09MA20E* | 2 | 24 (53) | | | | | | | | | |
| 12MA20E | 2 | 32 (71) | 3.6 (312.5) | MS 3102 A 24 -10 P | MS 3108 B 24 -10 S | MS 3106 B 24 -10 S | MS 3057 -16 A | | | | |
| 20MA20E | 2 | 40 (88) | | | | | | | | | |
| 30MA20E | 2 | 51 (112) | | | | | | | | | |

* Not provided with an eyebolt.

Note:
1. Optical encoder (6000 pulses/rev) is used as a detector.
2. Vibration: 15 μm or below.
3. Plug and clamp are not attached for receptacle connection.
4. Power supply for brake is 90 VDC.
5. For type USAMED-44MA20E and USAMKD-60MA2E, contact your Yaskawa representative.

(3) Shaft Extension of Straight Shaft with Keyway

Both Servomotors without brake and with brake have the same dimensions except for shaft extension. Shaft extensions are shown below:



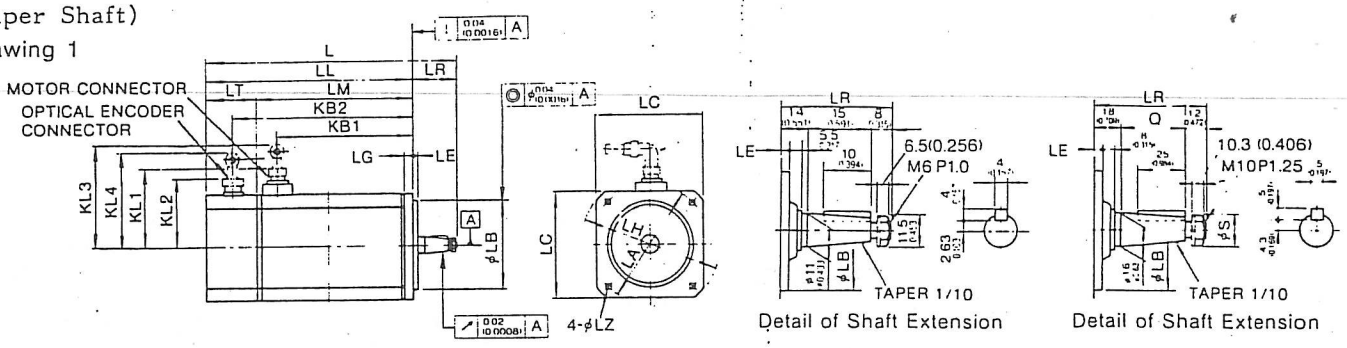

| AC Servomotor Type USAMED- | | LR | LE | Shaft Extension | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Without Brake | With Brake | | | S | Q | QK | T | U | W |
| 03MA2K | 03MA2KE | 58 (2.283) | 6 (0.236) | 19 $^{0}_{-0.013}$ (0.748 $^{0}_{-0.00051}$) | 40 (1.575) | 25 (0.984) | 5 (0.197) | 3 (0.118) | 5 (0.197) |
| 06MA2K | 06MA2KE | | | | | | | | |
| 09MA2K | 09MA2KE | | | 22 $^{0}_{-0.013}$ (0.866 $^{0}_{-0.00051}$) | | | 6 (0.236) | 3.5 (0.138) | 6 (0.236) |
| 12MA2K | 12MA2KE | 79 (3.11) | 3.2 (0.126) | 35 $^{+0.01}_{0}$ (1.378 $^{+0.00039}_{0}$) | 76 (2.992) | 60 (2.362) | 8 (0.315) | 5 (0.197) | 10 (0.394) |
| 20MA2K | 20MA2KE | | | | | | | | |
| 30MA2K | 30MA2KE | | | | | | | | |
| 44MA2K | 44MA2KB | 110 (4.331) | | 42 $^{0}_{-0.016}$ (1.654 $^{0}_{-0.00063}$) | 110 (4.331) | 90 (3.543) | | | 12 (0.472) |
| 44MA2K | 44MA2KB | | | | | | | | |

## 8. 2 SERVOMOTOR: F SERIES

### (1) Standard

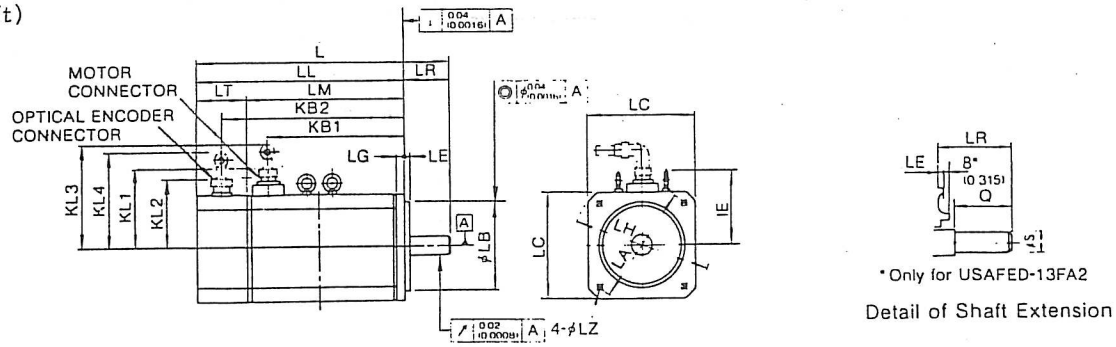
### (Taper Shaft)

Drawing 1




### (Straight Shaft)

Drawing 2




| AC Servomotor Type USAFED- | Dwg No. | L | LL | LM | LR | LT | KB1 | KB2 | IE | KL1 | KL2 | KL3 | KL4 | Flange Surface LA | LB | LC | LE | LG | LH | LZ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02FA1 | 1 | 190 (7.480) | 153 (6.024) | 113 (4.449) | 37 (1.457) | 40 (1.575) | 89.5 (3.524) | 132 (5.197) | — | 76 (2.992) | 89 (3.543) | 126 (4.961) | 139 (5.472) | 100 (3.937) | 80 $^{0}_{-0.030}$ (3.150 $^{0}_{-0.0012}$) | 90 (3.543) | 4 (0.157) | 7 (0.276) | 120 (4.724) | 6.6 (0.260) |
| 03FA1 | 1 | 236 (9.291) | 199 (7.835) | 159 (6.260) | | | 135.5 (5.335) | 178 (7.001) | | | | | | | | | | | | |
| 05FA1* | 1 | 261 (10.276) | 203 (7.992) | 157 (6.181) | 58 (2.283) | 46 (1.811) | 124 (4.882) | 176 (6.929) | | 112 (4.409) | 93 (3.661) | 168 (6.614) | 158 (6.22) | 145 (5.709) | 110 $^{0}_{-0.035}$ (4.331 $^{0}_{-0.0014}$) | 130 (5.118) | 6 (0.236) | 12 (0.472) | 165 (6.496) | 9 (0.354) |
| 09FA1* | 1 | 318 (12.52) | 260 (10.236) | 214 (8.425) | | | 181 (7.126) | 233 (9.137) | | | | | | | | | | | | |
| 13FA2* | 2 | 406 (15.984) | 348 (13.701) | 302 (11.890) | | | 250 (9.843) | 322 (12.677) | | | | | | | | | | | | |
| 20FA2* | 2 | 350 (13.78) | 271 (10.669) | 213 (8.386) | 79 (3.11) | 58 (2.283) | 171 (6.732) | 232 (9.134) | | 137 (5.394) | 110 (4.331) | 202 (7.953) | 175 (6.89) | 200 (7.874) | 114.3 $^{0}_{-0.025}$ ( 4.5 $^{0}_{-0.0010}$) | 180 (7.087) | 3.2 (0.126) | 18 (0.709) | 230 (9.055) | 13.5 (0.531) |
| 30FA2 | 2 | 408 (16.063) | 329 (12.953) | 271 (10.669) | | | 229 (9.016) | 290 (11.417) | 124 (4.882) | | | | | | | | | | | |
| 44FA2 | 2 | 493 (19.409) | 414 (16.299) | 356 (14.016) | | | 314 (12.362) | 375 (14.764) | | | | | | | | | | | | |

| AC Servomotor Type USAFED- | Dwg No. | Shaft Extension S | Shaft Extension Q | Approx Weight kg (lb) | Motor Connector Types: Receptacle | L-type Plug | Straight Plug | Cable Clamp | Optical Encoder Types: Receptacle | L-type Plug | Straight Plug | Cable Clamp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02FA1 | 1 | 11.5 (0.453) | 15 (0.591) | 3.5 (8) | MS 3102 A 14 S -2 P | MS 3108 B 14 S -2 S | MS 3106 B 14 S -2 S | MS 3057 -6 A | MS 3102 A 20 -29 P | MS 3108 B 20 -29 S | MS 3106 B 20 -29 S | MS 3057 -12 A |
| 03FA1 | 1 | | | 4 (9) | | | | | | | | |
| 05FA1* | 1 | 21 (0.827) | 28 (1.102) | 10 (22) | MS 3102 A 18 -10 P | MS 3108 B 18 -10 S | MS 3106 B 18 -10 S | MS 3057 -10 A | | | | |
| 09FA1* | 1 | | | 15 (33) | | | | | | | | |
| 13FA2* | 2 | 22 $^{0}_{-0.013}$ (0.866 $^{0}_{-0.0005}$) | 40 (1.575) | 21 (46) | | | | | | | | |
| 20FA2* | 2 | 35 $^{+0.01}_{0}$ (1.378 $^{+0.0004}_{0}$) | 76 (2.992) | 24 (53) | MS 3102 A 22 -22 P | MS 3108 B 22 -22 S | MS 3106 B 22 -22 S | MS 3057 -12 A | | | | |
| 30FA2 | 2 | | | 32 (71) | | | | | | | | |
| 44FA2 | 2 | | | 43 (95) | | | | | | | | |

* Not provided with an eyebolt.

Note:

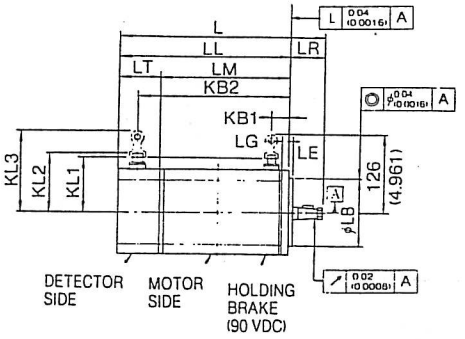
1. Optical encoder (6000 pulses/rev) is used as a detector.
2. Vibration: 15 $\mu$m or below.
3. Plug and clamp are not attached for receptacle connection.

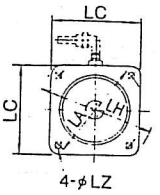
## 8. 2 SERVOMOTOR: F SERIES (Cont'd)

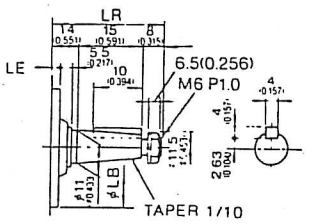
(2) With Brake

(Taper Shaft)

Drawing 1

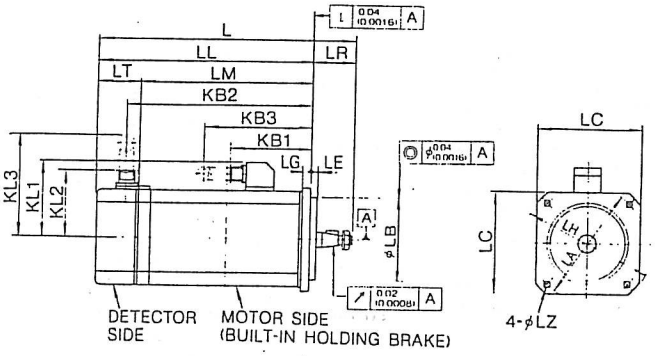


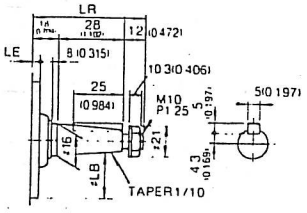




Detail of Shaft Extension

Drawing 2

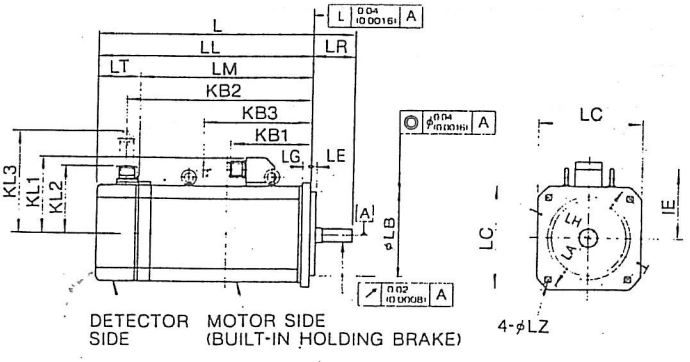


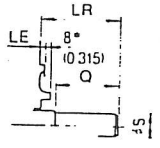




Detail of Shaft Extension

(Straight Shaft)

Drawing 3




*Only for USAFED-13FA2OE

Detail of Shaft Extension

| AC Servomotor Type USAFED- | Dwg No. | L | LL | LM | LR | LT | KB1 | KB2 | KB3 | IE | KL1 | KL2 | KL3 | Flange Surface | | | | | | Shaft Extension | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | LA | LB | LC | LE | LG | LH | LZ | S | Q |
| 02FA10E | 1 | 236 (9.291) | 199 (7.835) | 159 (6.260) | 37 (1.457) | 40 (1.575) | 24 (0.945) | 178 (7.008) | — | | 76 (2.992) | 89 (3.504) | 154 (6.063) | 100 (3.937) | 80 $^{0}_{-0.030}$ (3.150 $^{0}_{-0.0012}$) | 90 (3.543) | 4 (0.157) | 7 (0.276) | 120 (4.724) | 6.6 (0.260) | — | — |
| 03FA10E | 1 | 286 (11.260) | 249 (9.803) | 209 (8.228) | | | | 228 (8.976) | | | | | | | | | | | | | |
| 05FA10E* | 2 | 316 (12.441) | 258 (10.157) | 214 (8.125) | 58 (2.283) | 44 (1.732) | 116 (4.567) | 233 (9.173) | 158 (6.220) | — | 113 (4.449) | 93 (3.661) | 147 (5.787) | 145 (5.709) | 110 $^{0}_{-0.035}$ (4.331 $^{0}_{-0.0014}$) | 130 (5.118) | 6 (0.236) | 12 (0.472) | 165 (6.496) | 9 (0.354) | | |
| 09FA10E* | 2 | 362 (14.252) | 304 (11.969) | 260 (10.236) | | | | 279 (10.984) | | | | | | | | | | | | | |
| 13FA20E* | 3 | 452 (17.780) | 394 (15.512) | 350 (13.780) | | | | 369 (14.528) | | | | | | | | | | | | | 22 $^{0}_{-0.013}$ (0.866 $^{0}_{-0.0005}$) | 40 (1.575) |
| 20FA20E | 3 | 426 (16.772) | 347 (13.661) | 292 (11.496) | 79 (3.110) | 55 (2.165) | 165 (6.496) | 311 (12.244) | 220 (8.661) | 124 (4.882) | 143 (5.630) | 110 (4.331) | 171 (6.732) | 200 (7.874) | 114.3 $^{0}_{-0.035}$ ( 4.5 $^{0}_{-0.0014}$) | 180 (7.087) | 3.2 (0.126) | 18 (0.709) | 230 (9.055) | 13.5 (0.531) | 35 $^{+0.018}_{0}$ (1.378 $^{+0.0007}_{0}$) | 76 (2.992) |
| 30FA20E | 3 | 490 (19.291) | 411 (16.181) | 356 (14.016) | | | | 375 (14.764) | | | | | | | | | | | | | | |
| 44FA20E | 3 | 571 (22.48) | 492 (19.37) | 437 (17.205) | | | | 456 (17.953) | | | | | | | | | | | | | | |

| AC Servomotr Type USAFED- | Dwg No. | Approx Weight kg (lb) | Brake Torque kg·m(lb·in) | Connector Types for Motor and Brake | | | | Optical Encoder Connector Types | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Receptacle | L-type Plug | Straight Plug | Cable Clamp | Receptacle | L-type Plug | Straight Plug | Cable Clamp |
| 02FA10E | 1 | 4.4 (10) | 0.1 (8.7) | MS 3102 A 14 S -6 P | MS 3108 B 14 S -6 S | MS 3106 B 14 S -6 S | MS 3037 -6 A | MS 3102 A 20 -29 P | MS 3108 B 20 -29 S | MS 3106 B 20 -29 S | MS 3057 -12 A |
| 03FA10E | 1 | 5 (11) | | | | | | | | | |
| 05FA10E* | 2 | 13 (29) | 0.6 (52.1) | MS 3102 A 20 -15 P | MS 3108 B 20 -15 S | MS 3106 B 20 -15 S | MS 3057 -12 A | | | | |
| 09FA10E* | 2 | 17 (37) | | | | | | | | | |
| 13FA20E* | 3 | 24 (53) | | | | | | | | | |
| 20FA20E | 3 | 32 (71) | 3.6 (312.5) | MS 3102 A 24 -10 P | MS 3108 A 24 -10 S | MS 3106 B 24 -10 S | MS 3057 -16 A | | | | |
| 30FA20E | 3 | 40 (88) | | | | | | | | | |
| 44FA20E | 3 | 51 (112) | | | | | | | | | |

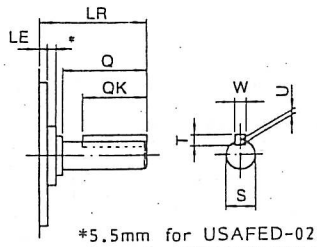
* Not provided with an eyebolt.

Note:

1. Optical encoder (6000 pulses/rev) is used as a detector.
2. Vibration: 15 $\mu$m or below.
3. Plug and clamp are not attached for receptacle connection.
4. Power supply for brake is 90 VDC.

### (3) Shaft Extension of Straight Shaft with Keyway

Both Servomotors with brake and without brake have the same dimensions except for shaft extension. Shaft extensions are shown below:

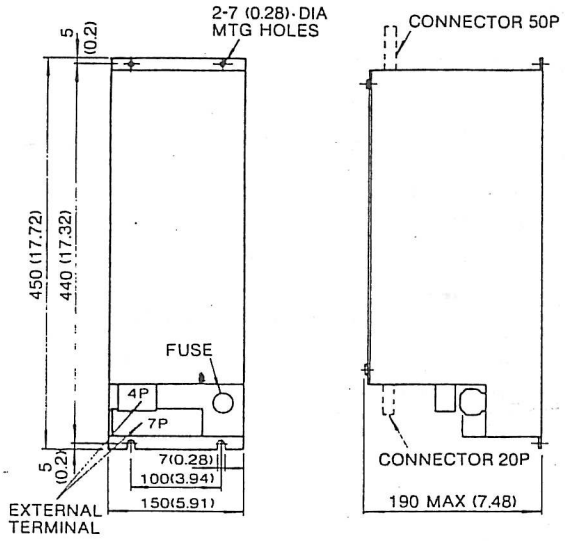



*5.5mm for USAFED-02FA2[] and 03FA2[]
8mm for USAFED-05FA2[] to 13FA2[]

| AC Servomotr Type USAFED- | | LR | LE | Shaft Extension | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Without Brake | With Brake | | | S | Q | QK | T | U | W |
| 02FA2K | 02FA2KE | 37 (1.457) | 4 (0.157) | 14 $^{0}_{-0.011}$ (0.551 $^{0}_{-0.0004}$) | 25 (0.984) | 15 (0.591) | 5 (0.197) | 3 (0.118) | |
| 03FA2K | 03FA2KE | | | | | | | | |
| 05FA2K | 05FA2KE | 58 (2.283) | 6 (0.236) | 19 $^{0}_{-0.013}$ (0.748 $^{0}_{-0.0005}$) | 40 (1.575) | 25 (0.984) | | | |
| 09FA2K | 09FA2KE | | | | | | | | |
| 13FA2K | 13FA2KE | | | 22 $^{0}_{-0.013}$ (0.866 $^{0}_{-0.0005}$) | | | 6 (0.236) | 3.5 (0.138) | |
| 20FA2K | 20FA2KE | 79 (3.11) | 3.2 (0.126) | 35 $^{+0.018}_{0}$ (1.378 $^{+0.0007}_{0}$) | 76 (2.992) | 60 (2.362) | 8 (0.315) | 5 (0.197) | |
| 30FA2K | 30FA2KE | | | | | | | | |
| 44FA2K | 44FA2KE | | | | | | | | |

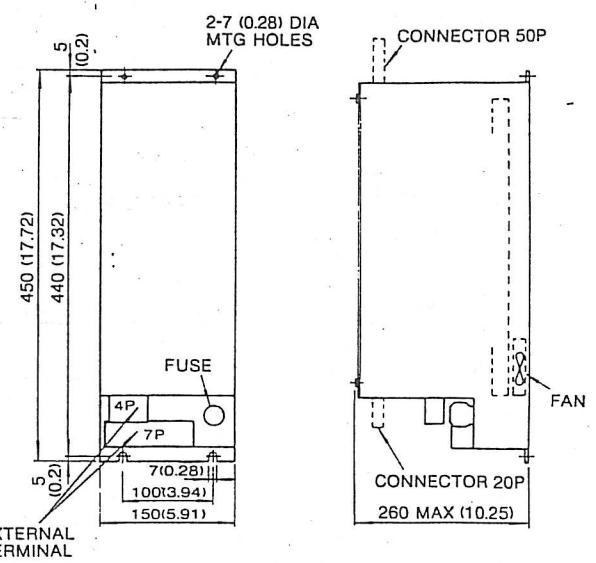
## 8.3 *Servopack*

(1) Types CACR-PR03BB, -PR05BB and -PR07BB



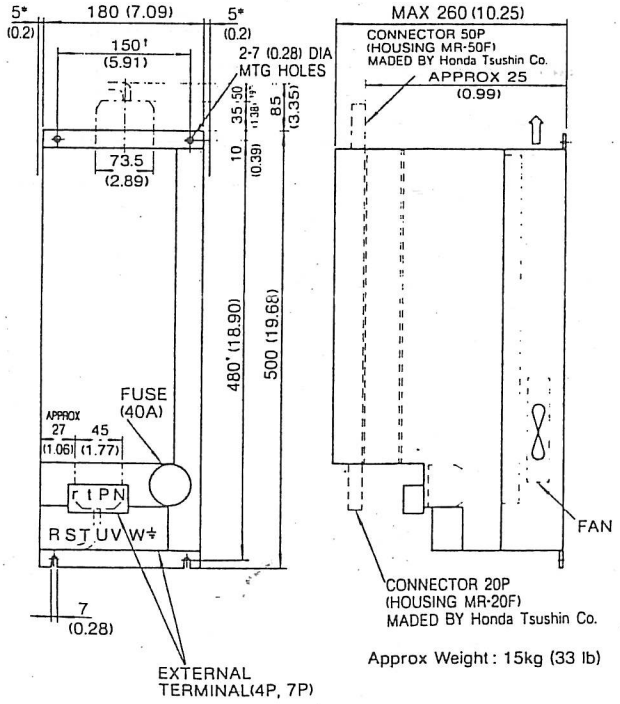

Approx Weight: 8kg (18 lb)

(2) Types CACR-PR01BB, PR15BB, -PR20BB and -PR30BB




| *Servopack* Type CACR- | Approx Weight kg (lb) |
|---|---|
| PR10BB, PR15BB | 10.5 (23) |
| PR20BB | 11 (24) |
| PR30BB | 11.5 (25) |

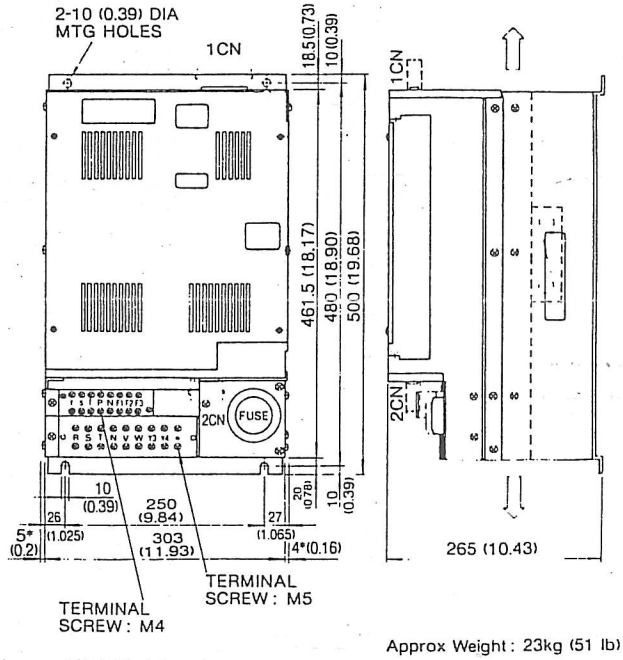
(3) Type CACR-PR44BB




Approx Weight: 15kg (33 lb)

*Height of thread
†Mounting pitch

(4) Type CACR-PR60BB

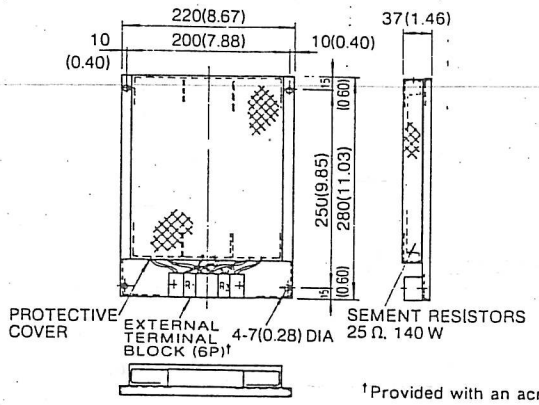



Approx Weight: 23kg (51 lb)

*Height of thread

## 8.4 PERIPHERAL EQUIPMENT

(1) Regenerative Resistor Type JUSP-RA03



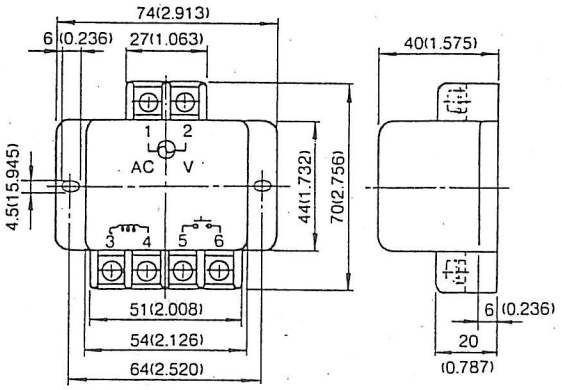

†Provided with an acrylic resin cover.

(2) Power Supply for Brake

According to the motor, select either M and F series.

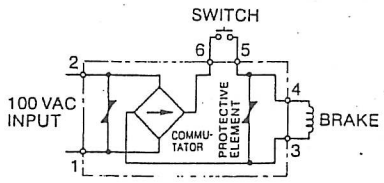
(a) Power supply unit for M and F series

- Input 100 VAC, output 90 VDC 1A ...Type OPR109F
- Input 200 VAC, output 90 VDC 1A ...Type OPR109A

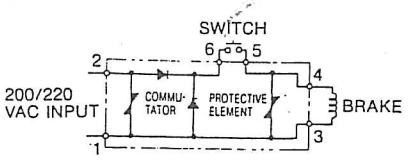



Approx Weight: 0.1 kg (0.2 lb)

Type OPR109F Circuit




Type OPR109F Circuit




Note:

1. Do not short-circuit output terminals Nos. 3 and 4.
2. The open/close value of the contact used for Nos. 5 and 6 is 5 to 10 times the rated current of the brake used. Direct current open/close contacts must be used.
3. Insert a fuse in the input or output side to protect the power unit.

# 9. TEST RUN

Before test run, check the following. Correct any deficiency.

## 9.1 CHECK ITEMS BEFORE TEST RUN

### 9.1.1 Servomotor

Before test run, check the following. If the test run is performed after long storage, see par. 11. Inspection and Maintenance.

- Connection to machines or devices, wiring, fuse connection, and grounding are correct.
- Bolts and nuts are not loose.
- For motors with oil seals, the seals are not damaged and oil is properly lubricated.

### 9.1.2 *Servopack*

- Setting switches are correctly set to satisfy the specifications for the applicable servomotor and optical encoder.
- Connection and wiring leads are firmly connected to terminals or inserted into the connectors.
- The power supply is turned off if servo alarm outputs.
- Voltage supplied to Servopack is 200 to 230V $^{+10}_{-15}$%. (If a voltage line other than 200V is used, the voltage should be dropped to 200V through a power transformer.)
- Reference pulses should not be applied.

## 9.2 TEST RUN PROCEDURES

### 9.2.1 Preparation of Operation

During test run, loads should not be applied to the servomotor. If it is necessary to start with the driven machine connected to the motor, confirm that the driven system has been ready for emergency stop at any time.

(1) Power ON

- After checking items in par. 9.1, turn on the power supply. When the power on sequence is correct, according to par. 6.1, the power is turned on by pressing the POWER pushbutton for approximately 1 second.
- When the power is correctly supplied, the following green LEDs light: P and MP .
- When a Servo ON signal is input (contact is on), the power circuit in the Servopack operates and the motor is ready to run.

### 9.2.2 Operation

The operation is possible only while Servo ON signal is on.

- The motor speed is proportional to the reference pulse frequency and the motor rotation angle is proportional to the number of input reference pulses.
- Run the motor at a low speed, by continuously inputting low-frequency reference pulses.

  Check that the motor rotates in the correct direction according to the forward or reverse reference (depending on the input form of the reference pulses).

  The forward rotation of motor is counterclockwise viewed from drive end (output shaft) See Fig. 9.1.
- The motor is stopped by cutting the reference pulse.

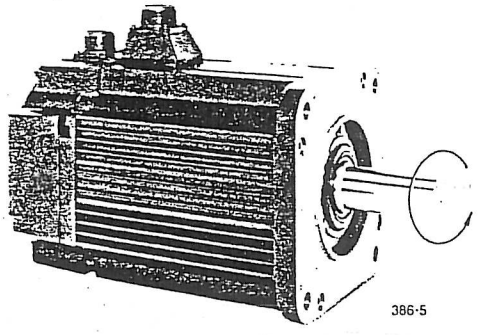



Fig. 9.1 Motor Forward Running

### 9.2.3 Inspection during Test Run

The following items should be checked during the test run.

- Unusual vibration
- Abnormal noise
- Excessive temperature rise

If any abnormality is found, take corrective actions according to par. 12. At a test operation, the load and machine may not fit well at first and result in overload.

# 10. ADJUSTMENT

## 10.1 SETTINGS AT THE TIME OF DELIVERY

The Servopack has been factory-adjusted as follows:

(1) M series

Table 10.1 Standard Adjustment and Setting Specifications

| *Servopack* Type CACR— | Applicable Servomotor | | | *Servopack* Adjusting Specifications | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Type USAMED— | Optical Encoder pulses/rev | Rated Current* A | Reference Mode | Reference Pulse Frequency kpps | Speed Setting rpm | PG Pulse Frequency Dividing Ratio | PG Multi-plier | Pulse Resolution per Motor Revolution | f/V Output rpm | Start Current Setting A |
| PR03BB3AM | 03MA1 | 6000 | 3.0 | Sign + pulse train | 200 | 2000 | ×1 | ×1 | 6000 | 2V/1000 | 7.3 |
| PR03BB3BM | 03MB1 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR03BB3DM | 03MD1 | 4000 | | | 100 | 1500 | | | 4000 | | |
| PR07BB3AM | 06MA1 | 6000 | 5.8 | | 200 | 2000 | | | 6000 | | 13.9 |
| PR07BB3BM | 06MB1 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR07BB3DM | 06MD1 | 4000 | | | 100 | 1500 | | | 4000 | | |
| PR10BB3AM | 09MA2 | 6000 | 7.6 | | 200 | 2000 | | | 6000 | | 16.6 |
| PR10BB3BM | 09MB2 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR10BB3DM | 09MD2 | 4000 | | | 100 | 1500 | | | 4000 | | |
| PR15BB3AM | 12MA2 | 6000 | 11.7 | | 200 | 2000 | | | 6000 | | 28.0 |
| PR15BB3BM | 12MB2 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR15BB3DM | 12MD2 | 4000 | | | 100 | 1500 | | | 4000 | | |
| PR20BB3AM | 20MA2 | 6000 | 18.8 | | 200 | 2000 | | | 6000 | | 42.0 |
| SR20BB3BM | 20MB2 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR20BB3DM | 20MD2 | 4000 | | | 100 | 1500 | | | 4000 | | |
| PR30BB3AM | 30MA2 | 6000 | 26.0 | | 200 | 2000 | | | 6000 | | 56.5 |
| PR30BB3BM | 30MB2 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR30BB3DM | 30MD2 | 4000 | | | 100 | 1500 | | | 4000 | | |
| PR44BB3AM | 44MA2 | 6000 | 33.0 | | 200 | 2000 | | | 6000 | | 70.0 |
| PR44BB3BM | 44MB2 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR44BB3DM | 44MD2 | 4000 | | | 100 | 1500 | | | 4000 | | |
| PR60BB3AM | (USAMKD-) 60MA2 | 6000 | 45.0 | | 200 | 2000 | | | 6000 | | 80.6 |
| PR60BB3BM | (USAMKD-) 60MB2 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR60BB3DM | (USAMKD-) 60MD2 | 4000 | | | 100 | 1500 | | | 4000 | | |

*Effective value

Note:

1. At the factory, the *Servopacks* are preset and adjusted as shown in ☐.
2. The pulse resolution per rotation of the motor shaft processed in the Servopack is calculated as follows:
   Pulse resolution P × M/N
   P: Numder of optical encoder pulses/rev
   N: Dividing ratio
   M: Multiplication factor (1, 2, or 4)
   The following relation is also observed.
   Reference pulse frequency [pps]
   = Motor speed [rpm] /60 × pulse resolution
3. The PG pulse output from the *Servopack* is the number of pulses generated from the optical encoder multiplied by the PG dividing ratio.
   *Servopack* PG output pulses = P/N
   (per rotation of motor)

## 10.1 SETTING AT THE TIME OF DELIVERY (Cont'd)

Table 10.2 Setting Switch Position at the Time of Delivery (SW1, SW2, SW3)

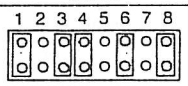
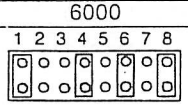
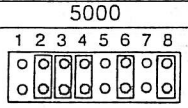
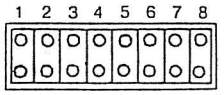
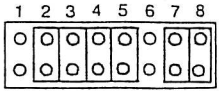
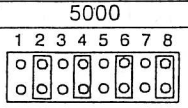
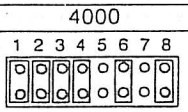
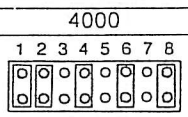
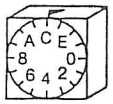
| *Servopack* Type CACR- | SW1 | SW2 | | SW3 | | |
|---|---|---|---|---|---|---|
| | Motor Characteristics Parameter Setting | Pulse Resolution Setting | | Reference Input Specification Setting | | |
| | No. of PG Pulses P/R | PG Frequency Dividing Ratio | PG Multiplier | Pulse Mode | Voltage Level | COIN Width |
| PR03BB3AM<br>PR07BB3AM<br>PR15BB3AM | 6000<br>  | ×1 | ×1 | Sign + Pulse Train | +12V | ± 10 Pulses |
| PR10BB3AM<br>PR20BB3AM<br>PR30BB3AM<br>PR44BB3AM<br>PR60BB3AM | 6000<br>  | | | | | |
| PR03BB3BM<br>PR07BB3BM<br>PR15BB3BM | 5000<br>  |  | |  | | |
| PR10BB3BM<br>PR20BB3BM<br>PR30BB3BM<br>PR44BB3BM<br>PR60BB3BM | 5000<br>  | | | | | |
| PR03BB3DM<br>PR07BB3DM<br>PR15BB3DM | 4000<br>  | | | | | |
| PR10BB3DM<br>PR20BB3DM<br>PR30BB3DM<br>PR44BB3DM<br>PR60BB3DM | 4000<br>  | | | | | |

Table 10.3 Digital Switch and Potentiometer Setting Position at the Time of Delivery

| Digital Switch / *Servopack* Type CACR- | DS1 Kp | DS2 Kv | DS3 I-GAIN | DS4 CUR/BIAS | VR2 f/V ZERO | VR3 f/V GAIN |
|---|---|---|---|---|---|---|
| PR03BB3⬚M | 0 | 4 | 9 | F | Approx 5/10 scale | Approx 3/10 scale |
| PR07BB3⬚M | 1 | 5 | 7 | | | |
| PR10BB3⬚M | 1 | 4 | 8 | | | |
| PR15BB3⬚M | 0 | 4 | 7 | | | |
| PR20BB3⬚M | 0 | 4 | 9 | | | |
| PR30BB3⬚M | 0 | 5 | A | | | |
| PR44BB3⬚M | 0 | 4 | A | | | |
| PR60BB3⬚M | 0 | 4 | A | | | |

Note: The *Servopack* also has VR1, and VR101 to VR106 besides the digital switches (DS) and potentiometers (VR) in the above table. These have been adjusted at the factory before delivery and must not be tampered with. In special cases, contact your Yaskawa representative before attempting any adjustment. The digital switch is read as follows.

For example,  indicates scale "C".

(2) F series

Table 10.4 Standard Adjustment and Setting Specifications

| *Servopack* Type CACR- | Applicable Servomotor | | | *Servopack* Adjusting Specifications | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Type USAFED- | Optical Encoder pulses/rev | Rated Current* A | Reference Mode | Reference Pulse Frequency kpps | Speed Setting rpm | PG Pulse Frequency Dividing Ratio | PG Multi-plier | Pulse Resolution per Motor Revolution | f/V Output rpm | Start Current Setting A |
| **PR03BB3AF** | 02FA1 | 6000 | 3.0 | Sign + pulse train | 200 | 2000 | ×1 | ×1 | 6000 | 2V/1000 | 8.5 |
| PR03BB3BF | 02FB1 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR03BB3DF | 02FD1 | 4000 | | | 100 | 1500 | | | 4000 | | |
| **PR03BB3AF** | 03FA1 | 6000 | | | 200 | 2000 | | | 6000 | | |
| PR03BB3BF | 03FB1 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR03BB3DF | 03FD1 | 4000 | | | 100 | 1500 | | | 4000 | | |
| **PR05BB3AF** | 05FA2 | 6000 | 3.8 | | 200 | 2000 | | | 6000 | | 11.0 |
| PR05BB3BF | 05FB2 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR05BB3DF | 05FD2 | 4000 | | | 100 | 1500 | | | 4000 | | |
| **PR10BB3AF** | 09FA2 | 6000 | 6.2 | | 200 | 2000 | | | 6000 | | 17.0 |
| PR10BB3BF | 09FB2 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR10BB3DF | 09FD2 | 4000 | | | 100 | 1500 | | | 4000 | | |
| **PR15BB3AF** | 13FA2 | 6000 | 9.7 | | 200 | 2000 | | | 6000 | | 27.6 |
| PR15BB3BF | 13FB2 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR15BB3DF | 13FD2 | 4000 | | | 100 | 1500 | | | 4000 | | |
| **PR20BB3AF** | 20FA2 | 6000 | 15.0 | | 200 | 2000 | | | 6000 | | 42.0 |
| PR20BB3BF | 20FB2 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR20BB3DF | 20FD2 | 4000 | | | 100 | 1500 | | | 4000 | | |
| **PR30BB3AF** | 30FA2 | 6000 | 20.0 | | 200 | 2000 | | | 6000 | | 56.5 |
| PR30BB3BF | 30FB2 | 5000 | | | 250 | 1800 | | | 5000 | | |
| PR30BB3DF | 30FD2 | 4000 | | | 100 | 1500 | | | 4000 | | |
| **PR44BB3AF** | 44FA2 | 6000 | 30.0 | | 200 | 2000 | | | 6000 | | 77.0 |
| PR44BB3BF | 44FB2 | 5000 | | | 150 | 1800 | | | 5000 | | |
| PR44BB3DF | 44FD2 | 4000 | | | 100 | 1500 | | | 4000 | | |

*Effective value

Note:

1. At the factory, the *Servopacks* are preset and adjusted as shown in ☐.
2. The pulse resolution per rotation of the motor shaft processed in the Servopack is calculated as follows:
   Pulse resolution P × M/N
   P: Numder of optical encoder pulses/rev
   N: Dividing ratio
   M: Multiplication factor (1, 2, or 4)
   The following relation is also observed.
   Reference pulse frequency [pps]
   = Motor speed [rpm] /60 × pulse resolution
3. The PG pulse output from the *Servopack* is the number of pulses generated from the optical encoder multiplied by the PG dividing ratio.
   *Servopack* PG output pulses = P/N
   (per rotation of motor)

## 10.1 SETTINGS AT THE TIME OF DELIVERY (Cont'd)

Table 10.5 Setting Switch Position at the Time of Delivery (SW1, SW2, SW3)

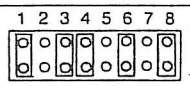
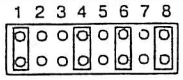
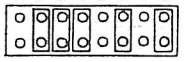
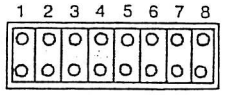
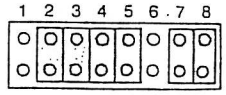
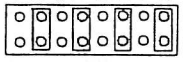
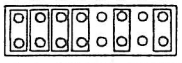
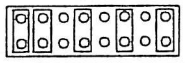
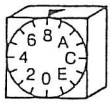
| Servopack Type CACR- | SW1 | SW2 | | SW3 | | |
|---|---|---|---|---|---|---|
| | Motor Characteristics Parameter Setting | Pulse Resolution Setting | | Reference Input Specification Setting | | |
| | No. of PG Pulses P/R | PG Frequency Dividing Ratio | PG Multiplier | Pulse Mode | Voltage Level | COIN Width |
| PR05BB3AF<br>PR10BB3AF<br>PR15BB3AF<br>PR30BB3AF | 6000<br>  | ×1 | ×1 | Sign + Pulse Train | +12V | ±10 pulses |
| PR20BB3AF<br>PR44BB3AF | 6000<br>  | | | | | |
| PR05BB3AF<br>PR10BB3AF<br>PR15BB3AF<br>PR30BB3AF | 5000<br>  |  | |  | | |
| PR20BB3AF<br>PR44BB3AF | 5000<br>  | | | | | |
| PR05BB3AF<br>PR10BB3AF<br>PR15BB3AF<br>PR30BB3AF | 4000<br>  | | | | | |
| PR20BB3AF<br>PR44BB3AF | 4000<br>  | | | | | |

Table 10.6 Digital Switch and Potentiometer Setting Position at the Time of Delivery

| Digital Switch / Servopack Type CACR- | DS1 Kp | DS2 Kv | DS3 I-GAIN | DS4 CUR | VR2 f/V ZERO | VR3 f/V GAI |
|---|---|---|---|---|---|---|
| PR05BB3AF | 1 | 5 | 8 | F | Approx 5/10 scale | Approx 3/10 scal |
| PR10BB3AF | 2 | 4 | 8 | | | |
| PR15BB3AF | 2 | 5 | 8 | | | |
| PR20BB3AF | 0 | 4 | 9 | | | |
| PR30BB3AF | 0 | 4 | A | | | |
| PR44BB3AF | 0 | 4 | A | | | |

Note: The Servopack also has VR1, and VR101 to VR106 besides the digital switches (DS) and potentiometers (VR) in the above table. These have been adjusted at the factory before delivery and must not be tampered with. In special cases, contact your Yaskawa representative before attempting any adjustment. The digital switch is read as follows.

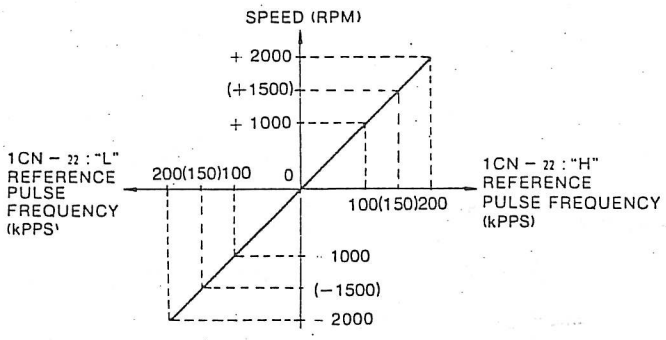
For example,  indicates scale "8".

## 10.2 CHARACTERISTICS AT THE TIME OF DELIVERY

The equipment has been adjusted prior to shipping as follows.

(a) Speed reference input and servomotor speed ratio (Fig. 10.1)

(No load and continuous pulses)

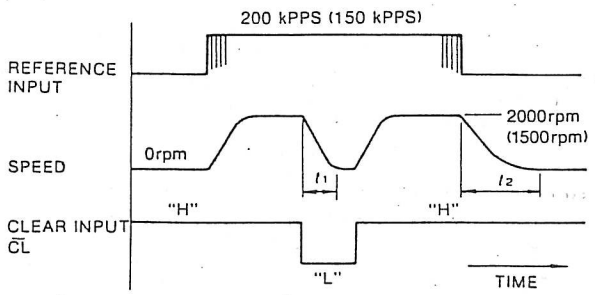



Note: The values in ( ) apply to PR44BB3AM and PR60BB3AM.

Fig. 10.1 Reference Input Frequency — Motor Speed Characteristics

(2) Start-stop characteristics

(· Load $GD^2_L = GD^2_M$
· No load $t_2 \fallingdotseq 3 \times t_1$)




Note: The values in ( )apply to PR44BB3AM and PR60BB3AM.

Fig. 10.2 Start-stop Response Characteristics

## 10.3 READJUSTMENT

- The Servopack with the motor applied is adjusted for optimum characteristics before shipment from the factory and no further adjustment is required.
- In case adjustment is required to meet a specific application, follow the instructions given in the next section.

## 10.4 ADJUSTMENT PROCEDURES

The position of the setting digital switch, adjustment of the potentiometer, and waveform observer check terminals are shown in Fig. 10.3.
A general adjustment of the potentiometer is shown in Table 10.11 and an explanation of each check terminal is given in Table 10.12.

There are two types mode selection switches in SW1 ( SW1 ⑦ ) normal mode and optional mode. Servopack functions or the digital switch contents can be changed by switching the SW1 . Table 10.7 shows the scale of the digital switch at normal mode setting. Table 10.8 shows the scale of the digital switch at optional mode setting. For the function of SW1 , see par.10.7.

Adjust the digital switch and potentiometers while observing the waveform of the check terminals. (Do not tamper with them unnecessarily.)

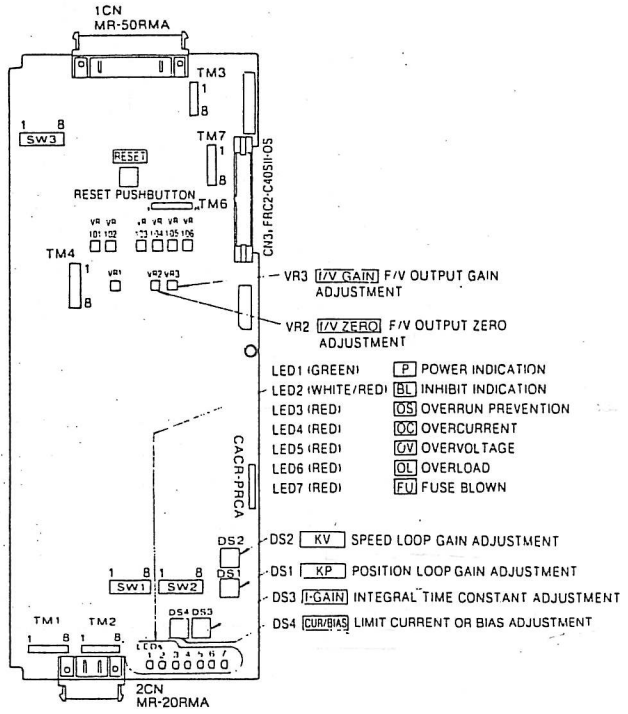



Fig. 10.3 Arrangement of Potentiometers (VR), Reset Pushbuttons (PB), Switches (SW) and Digital Switches (DS)

(Printed Circuit Board CACR-PRCA for *Servopack* Type CACR-RR□BB□)

## 10. 4 ADJUSTMENT PROCEDURES (Cont'd)

Table 10. 7 Contents of Setting Digital Switch (Normal Mode Setting)

| Digital Switch \ Scale | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kp Position Loop Gain | | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 | 46.0 | 52.0 | 60.0 | 70.0 | 80.0 | 90.0 | 100.0 | 110.0 | 120.0 | 130.0 | 140.0 | |
| Kv Speed Loop Gain | | 1.00 | 1.24 | 1.55 | 1.93 | 2.40 | 2.99 | 3.72 | 4.63 | 5.76 | 7.17 | 8.93 | 11.12 | 13.84 | 17.23 | 21.44 | 26.70 | 1 at scale "0" |
| I Gain Integration Constant | | ∞ | 192 | 128 | 96 | 64 | 48 | 32 | 24 | 20 | 16 | 12 | 8 | 6 | 4 | 3 | 2 | (ms) |
| CUR Current Limit* | PR03BB□M | 4.3A 101% | 4.7A 111% | 5.2A 122% | 5.6A 132% | 6.0A 142% | 6.4A 152% | 6.9A 162% | 7.3A 172% | 7.7A 182% | 8.2A 192% | 8.6A 203% | 9.0A 213% | 9.4A 223% | 9.9A 233% | 10.1A 238% | 10.3A 243% | |
| | PR07BB□M | 8.2A 100% | 9.0A 110% | 9.9A 120% | 10.7A 130% | 11.5A 140% | 12.3A 150% | 13.1A 160% | 14.0A 170% | 14.8A 180% | 15.6A 190% | 16.4A 200% | 17.2A 210% | 18.1A 220% | 18.9A 230% | 19.3A 235% | 19.7A 240% | |
| | PR10BB□M | 11.2A 104% | 12.3A 114% | 13.4A 125% | 14.5A 135% | 15.7A 145% | 16.8A 156% | 17.9A 166% | 19.0A 176% | 19.6A 182% | 20.1A 187% | 20.7A 192% | 21.3A 197% | 21.8A 202% | 22.4A 208% | 22.9A 213% | 23.5A 218% | |
| | PR15BB□M | 16.5A 100% | 18.1A 110% | 19.8A 120% | 21.4A 129% | 23.0A 139% | 24.7A 149% | 16.4A 159% | 28.1A 169% | 29.7A 179% | 31.4A 189% | 33.0A 199% | 34.7A 209% | 36.3A 219% | 38.0A 229% | 38.8A 234% | 39.6A 239% | |
| | PR20BB□M | 28.3A 106% | 31.1A 117% | 33.9A 127% | 36.8A 138% | 39.6A 149% | 42.4A 159% | 45.3A 170% | 48.1A 181% | 49.5A 186% | 50.9A 191% | 52.3A 196% | 53.7A 202% | 55.2A 207% | 56.6A 212% | 58.0A 218% | 59.4A 223% | |
| | PR30BB□M | 39.0A 103% | 41.9A 114% | 45.7A 124% | 49.5A 134% | 52.3A 145% | 57.1A 155% | 60.9A 165% | 64.7A 176% | 66.6A 181% | 68.5A 186% | 70.4A 191% | 72.3A 196% | 74.2A 202% | 76.1A 207% | 78.0A 212% | 79.9A 217% | |
| | PR44BB□M | 47.1A 101% | 51.9A 111% | 56.6A 121% | 61.3A 131% | 66.0A 141% | 70.7A 151% | 75.4A 162% | 80.1A 172% | 82.5A 177% | 84.9A 182% | 87.2A 187% | 89.6A 192% | 91.9A 197% | 94.3A 202% | 96.6A 207% | 99.0A 212% | |
| | PR60BB□M | 54.3A 85% | 59.7A 94% | 65.1A 102% | 70.6A 111% | 76.0A 119% | 81.4A 128% | 86.9A 136% | 92.3A 145% | 95.0A 149% | 97.7A 153% | 100.4A 158% | 103.1A 162% | 105.9A 166% | 108.6A 170% | 111.3A 175% | 114.0A 179% | |
| | PR05BB□F | 5.6A 103% | 6.7A 124% | 7.8A 145% | 8.9A 165% | 9.5A 175% | 10.0A 186% | 10.6A 196% | 11.1A 206% | 11.7A 217% | 12.3A 227% | 12.8A 237% | 13.4A 248% | 13.9A 258% | 14.5A 268% | 15.0A 279% | 15.6A 289% | |
| | PR10BB□F | 8.6A 98% | 10.3A 117% | 12.0A 137% | 13.7A 157% | 14.6A 166% | 15.4A 176% | 16.3A 186% | 17.1A 196% | 18.0A 206% | 18.9A 215% | 19.7A 225% | 20.6A 235% | 21.4A 245% | 22.3A 254% | 23.1A 264% | 24.0A 274% | |
| | PR15BB□F | 13.9A 102% | 16.7A 123% | 19.5A 143% | 22.3A 163% | 23.7A 174% | 25.1A 184% | 26.5A 194% | 27.9A 204% | 29.3A 214% | 30.6A 225% | 32.0A 235% | 33.4A 245% | 34.8A 256% | 36.2A 266% | 37.6A 276% | 39.0A 286% | |
| | PR20BB□F | 21.0A 99% | 23.1A 109% | 25.3A 119% | 27.4A 129% | 29.5A 139% | 31.6A 149% | 33.7A 159% | 35.8A 169% | 37.9A 179% | 40.0A 188% | 42.1A 198% | 44.2A 208% | 46.3A 218% | 48.4A 228% | 49.4A 233% | 50.5A 238% | |
| | PR30BB□F | 28.5A 101% | 34.2A 121% | 40.0A 142% | 45.7A 162% | 48.5A 172% | 51.4A 182% | 54.2A 192% | 57.1A 202% | 59.9A 212% | 62.8A 222% | 65.6A 232% | 68.5A 243% | 71.3A 253% | 74.2A 263% | 77.0A 273% | 79.9A 283% | |
| | PR44BB□F | 45.4A 107% | 49.9A 118% | 54.5A 129% | 59.0A 139% | 63.5A 150% | 68.1A 161% | 72.6A 171% | 77.1A 182% | 81.7A 193% | 86.2A 203% | 90.8A 214% | 95.3A 225% | 99.8A 236% | 104.4A 246% | 106.6A 252% | 108.9A 257% | |

*Percent indicates values when the rated current of the motor used is 100%. The current value in the above table is Ao-p value. Its accuracy is ± 5% of the actual current value.

Table 10.8 Contents of Setting Digital Switch (Optional Mode Setting)

| Digital Switch \ Scale | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kp Position Loop Gain | | 40.0 | 50.0 | 60.0 | 70.0 | 80.0 | 92.0 | 104.0 | 120.0 | 140.0 | 160.0 | 180.0 | 200.0 | 220.0 | 240.0 | 260.0 | 280.0 | — |
| Kv Speed Loop Gain | | 1.00 | 1.24 | 1.55 | 1.93 | 2.40 | 2.99 | 3.72 | 4.63 | 5.76 | 7.17 | 8.93 | 11.12 | 13.84 | 17.23 | 21.44 | 26.70 | 1 at scale "0" |
| I Gain Integration Constant | | ∞ | 192 | 128 | 96 | 64 | 48 | 32 | 24 | 20 | 16 | 12 | 8 | 6 | 4 | 3 | 2 | (ms) |
| CUR Current Limit* | PR□ BB3A□ | 0 | 17 | 21 | 26 | 30 | 34 | 43 | 51 | 60 | 68 | 85 | 102 | 119 | 136 | 153 | 167 | PG6000P/rev - (rpm) |
| | PR□ BB3B□ | 0 | 20 | 25 | 30 | 35 | 40 | 50 | 60 | 70 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | PG5000P/rev (rpm) |
| | PR□ BB3D□ | 0 | 25 | 31 | 38 | 44 | 50 | 63 | 75 | 88 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | PG4000P/rev (rpm) |

* Percent indicates values when the rated current of the motor used is 100%. The current value in the above table is Ao-p value. Its accuracy is ±5% of the actual current value.

Table 10.9 Current Limit

| Motor Type CACR- | Current % |
|---|---|
| PR03BB□M | 10.3 A, 243 % |
| PR07BB□M | 19.7 A, 240 % |
| PR10BB□M | 23.5 A, 218 % |
| PR15BB□M | 39.6 A, 239 % |
| PR20BB□M | 59.4 A, 223 % |
| PR30BB□M | 79.9 A, 217 % |
| PR44BB□M | 99.0 A, 212 % |
| PR60BB□M | 114.0 A, 179 % |
| PR05BB□F | 15.6 A, 289 % |
| PR10BB□F | 24.0 A, 274 % |
| PR15BB□F | 39.0 A, 286 % |
| PR20BB□F | 50.5 A, 238 % |
| PR30BB□F | 79.9 A, 283 % |
| PR44BB□F | 108.9 A, 257 % |

· Estimation of position loop gain (Kp)

For stepping input of reference pulses, the approximate value is obtained from the following formula. Motor, controller and machine specifications are shown in Table 10.10.

Table 10.10 Specifications of Motor, *Servopack* and Machine

| Motor | | *Servopack* | | Machine | |
|---|---|---|---|---|---|
| Rated Speed (N) | rpm | Max Set Current (Ip) | A | Load Torque at Motor Shaft ($T_L$) | kg·cm (lb·in) |
| Rated Motor Torque ($T_M$) | kg·cm (lb·in) | | | | |
| Rotor Inertia ($GD^2_M$) | kg·cm² (lb·in²) | Adjust Ip according to machine specifications. | | Load Inertia at Motnr Shaft ($GD^2_L$) | kg·cm² (lb·in²) |
| Rated Motor Current (Ia) | A | | | | |

(a) Starting time

$$t_a = \frac{(GD^2_M + GD^2_L) \times N \times 10^{-2}}{375 \times (I_P / I_a \times T_M - T_L)} \quad [s]$$

(b) Position loop gain

$$K_P \approx \frac{1.4}{t_a} \quad [s^{-1}]$$

(c) No. of lag pulses in error counter

$$\varepsilon = \frac{fin}{K_P} \quad [pulses]$$

$fin$: Reference pulse frequency (pps)

## 10. 5 DIGITAL SWITCH ADJUSTMENT

Digital switches should be adjusted with servomotor and driven machine combined.

(1) CUR/BIAS (DS4) (current limit or bias setting)

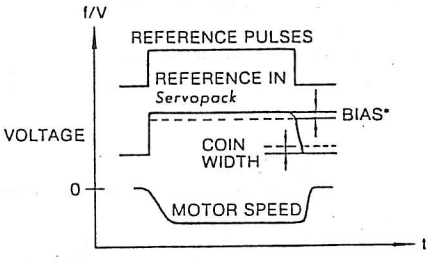
This is current limit under normal mode setting, and bias setting under optional mode setting.

(a) Current limit .... Check terminal : TM6 -1 to TM6-3

The maximum current of the Servopack is adjusted.

(b) Bias setting .... Check terminal : TM4-3

The motor must not vibrate or oscillate.
The bias is used according to the load conditions to shorten the positioning time.
This is used to shorten the positioning time when Kp cannot be increased. (Fig. 10.4).




* Amount for 0 to 167 rpm can be set when it is PG6000 pulses/rev. When the dividing ratio is 1/1 and multiplication 1, it is 0 to 16.7 Kpps equivalent. (setting value: Table 8).

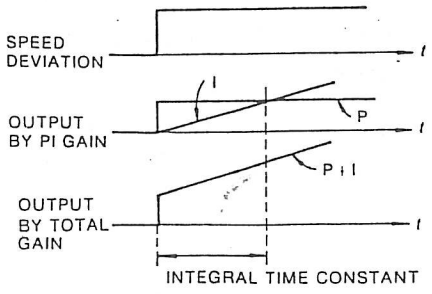
Fig. 10. 4 Bias Setting

(2) [1-GAIN] (Integral time constant):

Check locations—Motor movement (the motor should not cause vibration or oscillation.)

Adjust [1-GAIN] of the speed loop. When speed deviations are applied in steps, the proportional gain becomes equal to the integral gain after this integral time constant.

The sum of the proportional gain and the integral gain is the total gain. The output by the total gain is proportional to the current reference.




Note: If the integral time is shortened, oscillation occurs. It is recommended not to change the condition (10 ms or more) preset at the factory.

Fig. 10. 5 Integral Gain

(3) [Kv] (Speed loop gain):

Check terminal— TM4-3 (the motor should not cause vibration or oscillation.)

Adjust the loop gain of the speed loop. Assuming the speed deviation to be $\varepsilon_v$, the relation ship between the speed loop gain and the integral gain is defined by the following formula which becomes proportional to the current reference:

$$Kv\left[\varepsilon_v + \int \frac{\varepsilon_v}{Ti}\, dt\right]$$

$Ti$: Integral time constant

### NOTE

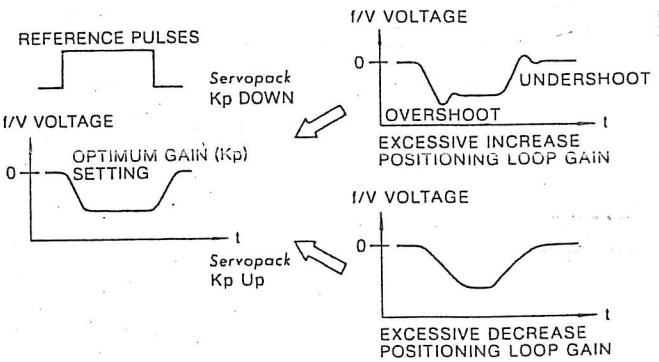
If the rigidity of the mechanical system is poor, Kv cannot be increased. If Kv is increased, oscillation occurs. Adjust the Kv when the $\overline{CL}$ is turned on and the position error counter is cleared to 0, then the effect of the position loop gain Kp can be removed.

(4) [Kp] (Position loop gain):

Check terminal—TM4-3 (the motor should not cause overshoot, undershoot, or oscillation.)

Adjust the loop gain of the position loop, after the speed loop has been adjusted. Input the maximum pulse frequency while observing the speed monitoring f/V output with an oscilloscope. The optimum Kp value is at the point and undershoot disappear.

If relatively high Kp value is needed while overshoot and undershoot are undesirable, then gradually speed up and slow down the pulse frequency. (Fig. 10.7)

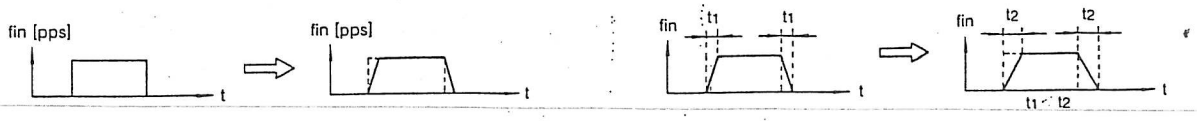



Note: If Kp is increased too much, the over-shoot and/or undershoot becomes too large. It may even oscillate without commands.

Fig. 10. 6 Positioning Loop Gain Adjustment

① Acceleration/deceleration speed control is performed on the command pulse serial input, and the mode is set at ramp input.

② When it is currently ramp input, prolong the acceleration/deceleration time.

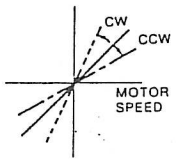



Note: The value of the acceleration/deceleration time $t_{SL}$ must exceed the value of $t_a$ calculated in Table 10.10 (a).
Set Kp at 30 to 280 [$s^{-1}$]
$t_{SL} > t_a$ (a)

Fig. 10.7 Speed Up and Slow Down of Reference Pulse

## 10.6 POTENTIOMETER ADJUSTMENT

Table 10.11 Potentiometer Adjustment

| Potentiometer | VR1 [VREF] | VR2 [f/V ZERO] | VR3 [f/V GAIN] | VR101 | VR102 |
|---|---|---|---|---|---|
| Functions | Reference voltage adjustment | f/V output zero adjustment | f/V output gain adjustment | Phase U current zero adjustment | Phase V current zero adjustment |
| How to Adjust | Adjusted to $V_{REF}$ = 5 V | Adjust so that 0 volt appears while motor is stopped. | Adiust so that required voltage level is reached, when motor runs at the rated speed. | Input overtravel prevention for both forward ahd reverse running and adjust phase U current to 0 ADC. | Input overtravel prevention for both forword and reverse runnings, and adjust phase V current to 0 ADC. |
| Check Terminals | TM4-4 | TM4-3 | TM4-3 | TM6-2 | TM6-1 |
| Characteristics | Adjustment is made at fhe factory. Do not tamper with the potentiometers. | Turning CW indicates output (TM4-3) plus. Turning CCW indicates the output minus. | f/V output(TM4-3)   | If the current zero adjustment is not correct, an offset occurs, ahd motor torque ripple increases. The sine wave current is distorted. | If the current zero adjustment is not correct, an offset occurs, and motor torque ripple increases. The sine wave current is distorted. |
| Adjustment | × | △ | △ | × | × |

## 10. 6 POTENTIOMETER ADJUSTMENT (Cont'd)

Table 10. 11 Potentiometer Adjustment (Cont'd)

| Potentiometer | VR103 | VR104 | VR105 | VR106 | 2PWB 2VR V-ADJ |
|---|---|---|---|---|---|
| Functions | Phase U current detection zero adjustment | Phase V current detection zero adjustment | Phase U current detection gain adjustment | Phase V current detection gain adjustment | PG power supply adjustment |
| How to Adjust | Current detection circuit zero adjustment. Turn off the servo, and adjust the following terminals to give voltage ±1 mV:<br>Phase U: TM6-2<br>Phase V: TM6-1<br>Phase W: TM6-3 | | Adjust the current feedback signal as follows: | | Turning CW increases Voltage .<br>Preset at 5.5 V at the factory. |
| Check Terminals | TM6-2 | TM6-1 | TM6-2 | TM6-1 | Across TM1-8 and TM2-8 |
| Characteristics | Adjustment is made at the factory.<br>Do not tamper with the potentiometers. | | | | If PG long leads should result in voltage drop, increase voltage. Do not tamper with it except for above case. Voltage must be 6V maximum. |
| Adjustment | × | × | × | × | △ |

| Type | Voltage at Check Terminal |
|---|---|
| PR03BB3[ ]M | 76 mV/A |
| PR07BB3[ ]M | 40.2 mV/A |
| PR10BB3[ ]M | 33.7 mV/A |
| PR15BB3[ ]M | 20 mV/A |
| PR20BB3[ ]M | 13.3 mV/A |
| PR30BB3[ ]M | 10 mV/A |
| PR44BB3[ ]M | 7 mV/A |
| PR60BB3[ ]M | 6.1 mV/A |
| PR05BB3[ ]F | 50.8 mV/A |
| PR10BB3[ ]F | 32.9 mV/A |
| PR15BB3[ ]F | 20.3 mV/A |
| PR20BB3[ ]F | 15.7 mV/A |
| PR30BB3[ ]F | 10 mV/A |
| PR44BB3[ ]F | 6.3 mV/A |

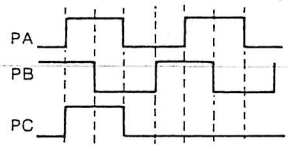
Adjustment Directions
Allowable error is ±3% for current detection gain.
Mark △: Potentiometer should not be adjusted except special cases.
Mark ×: Do not adjust.

Table 10.12 List of Check Terminals

| Equipment Symbol | | Signal Name | Description |
|---|---|---|---|
| TM1 | 1 | PA | Phase A pulse is input from PG. |
| | 2 | * PA | Reverse pulse of PA is input. |
| | 3 | PB | Phase B pulse is input from PG. |
| | 4 | * PB | Reverse pulse of PB is input. |
| | 5 | PC | Phase C pulse is input from PG. |
| | 6 | * PC | Reverse pulse of PC is input. |
| | 8 | 5 VP | PG supply voltage + 5 V |

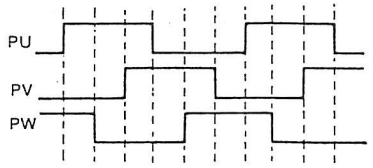
PA and PB are two-phase pulse with 90° phase difference. PC occurs once for each motor rotation, in synchronization with PA.

**Waveform at motor forward rotation**



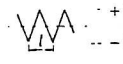

| Equipment Symbol | | Signal Name | Description |
|---|---|---|---|
| TM2 | 1 | PU | Phase U pulse is input from pole sensor. |
| | 2 | * PU | Reverse pulse of PU is input. |
| | 3 | PV | Phase V pulse is input from pole sensor. |
| | 4 | * PV | Reverse pulse of PV is input. |
| | 5 | PW | Phase W pulse is input from pole sensor. |
| | 6 | * PW | Reverse pulse of PW is input. |
| | 8 | 0 VP | 0 V of the PG power supply (PG: common terminal to signals from the pole sensor) |

**Waveform at motor forward rotation**




| Equipment Symbol | | Signal Name | Description |
|---|---|---|---|
| TM3 | 1 | IN-A | Monitors the speed reference input (connector CN1 12 – 13). |
| | 2 | IN-B | Monitors the speed reference auxiliary input (connector CN1 14 – 15). |
| | 3 | $V_{TG}$ | Monitors the motor speed ± 2.0 VDC/± 1000 rpm. |
| | 4 | 8 VR | Terminal to set the mode switch operating level. Set value: 3.5 to 4.0 V |
| | 8 | SG | Signal 0 V |
| TM4 | 1 | Iu | Monitors the phase U reference current ($T_{REF} \times \sin\theta$). |
| | 2 | Iv | Monitors the phase V reference current [$T_{REF} \times \sin(\theta - 120°)$]. |
| | 3 | f/V | f/V output signal |
| | 4 | $V_{REF}$ | Monitors the + 5 V reference voltage of the D/A converter. |
| | 8 | SG | Signal 0 V |
| TM6 | 1 | IV | Phase V current monitor |
| | 2 | IU | Phase U current monitor |
| | 3 | IW | Phase W current monitor |
| | 4 | AV | Phase V current amplification output |
| | 5 | AW | Phase W current amplification output |
| | 6 | AU | Phase U current amplification output |
| | 7 | OSC | Carrier frequency |
| | 8 | SG | Signal 0 V |

| 03BB3□M | 07BB3□M | 10BB3□M | 15BB3□M | 20BB3□M | 30BB3□M | 44BB3□M | 60BB3□M |
|---|---|---|---|---|---|---|---|
| 76 mV/A | 40.2 mV/A | 33.7 mV/A | 20 mV/A | 13.3 mV/A | 10 mV/A | 7 mV/A | 6.1 mV/A |
| | 05BB3□F | 10BB3□F | 15BB3□F | 20BB3□F | 30BB3□F | 44B3□F | |
| | 50.8 mV/A | 32.9 mV/A | 20.3 mV/A | 15.7 mV/A | 10 mV A | 6.3 mV/A | |




$t$ = 200 μs : 03-10BB, 15BB3□F
$t$ = 330 μs : 15BB3□M, 20-60BB

| Equipment Symbol | | Signal Name | Description |
|---|---|---|---|
| TM7 | 1 | MU | Phase U PWM waveform (H: 1Tr valid signal; L: 2Tr valid signal) |
| | 2 | MV | Phase V PWM waveform (H: 3Tr valid signal; L: 4Tr valid signal) |
| | 3 | MW | Phase W PWM waveform (H: 5Tr valid signal; L: 6Tr valid signal) |
| | 4 | RST | Servo alarm reset signal |
| | 5 | DR | Drive ready signal (H: power circuit on) |
| | 6 | BB | Base off signal (L: power circuit off) |
| | 8 | SG | Signal 0 V |

Note:
1. The check terminals allow oscilloscope connection for measurement.
2. Measure waveforms of TM3 and TM4 with TM3-8 or TM4-8 (signal 0V) taken as the reference.
   TM1-8 (PG power 0V) are impedance-connected to TM3-8 and TM4-8 (signal 0V).
3. During measurement, do not short the adjacent two check terminals, as the connected elements may be destroyed by this.
4. TM5 check terminal is for use only by the manufacturer. Do not make any measurement with it.

## 10.7 SWITCH SETTING

The three switches( SW1 , SW2 , SW3 ) have the following functions:

Table 10.3 Switch Setting and Function

| Switch Name | Function | User Adjustment |
|---|---|---|
| SW1 | • Motor type Setting<br>• Motor specifications. motor PG and *Servopack* function settings. | 1 to 3 : Impossible<br>4 to 8 : Possible only for using positioning time reduction function. |
| SW2 | PG frequency dividing setting (Output pulse multiplier setting) | Possible (See Tables 6.5 and 6.6) |
| SW3 | Reference input specifications setting | Possible |

Functions of SW1

(1) Setting of motor model, motor PG (①—③)

As the motor torque characteristics are set for the optimum, do not change the setting, except for the setting of PG. (See Tables 10.2 and 10.5 for setting of the PG.)

(2) Setting of EMF compensation (④ — ⑤)

Effective only under normal mode. [ See (5) on page 59]. Always set as shown below in Table 10.14.

Table 10.14 EMF Compensation

| ④ | ⑤ | EMF Compensation |
|---|---|---|
| Short-circuit | Open | 10% up |

(3) Setting of Kp on stop (④ — ⑤)

Effective only under optional mode. [ See (5) on page 59]. The Kp can be set smaller than during rotation, to avoid vibration and oscillation while the motor is stopping. Used to set Kp with a large value to shorten the positioning time.

Kp during stop = Kp (DS1) * Magnification factor (during rotation)

The Kp during rotation is as shown in Table 10.8.

Table 10.15 Magnification of Kp during Motor Stop

| ④ | ⑤ | Magnification of Kp during Motor Stop |
|---|---|---|
| Short-circuit | Short-circuit | 1.00 |
| Open | Short-circuit | 0.75 |
| Short-circuit | Open | 0.50 |
| Open | Open | 0.25 |

(4) Setting of feed forward compensation (⑥)

Effective only under optional mode.
Used for differential calculus of the command pulse and adding it to the command pulse to shorten the positioning time. If the load is small, it may cause over-shoot or under-shoot. Do not use this setting if over-shoot and under-shoot are to be avoided.

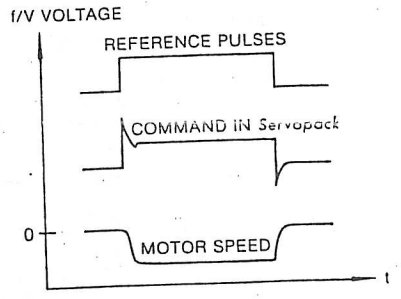



Fig. 10.8 Feed Forward Compensation

(5) Normal mode /optional mode selection (⑦)

This is a switch selection to determine the functions of SW1 ④ —⑥ and Kp DS1, KV (DS2), CUR/BIAS (DS4).

Digital switch 4 (DS4) functions as current limit under normal mode, and bias compensation under optional mode. Normally, use normal mode, except when making the positioning time very short.

(6) Spare short-circuit pin (⑧)

## 10.8 ALTERATION OF INTERNAL SWITCHES

Used when the setting of the internal switches of systems where Model CACR-PR□□ BB is applied must be changed.

Change the setting of the switches according to the order shown in Fig. 10.9.

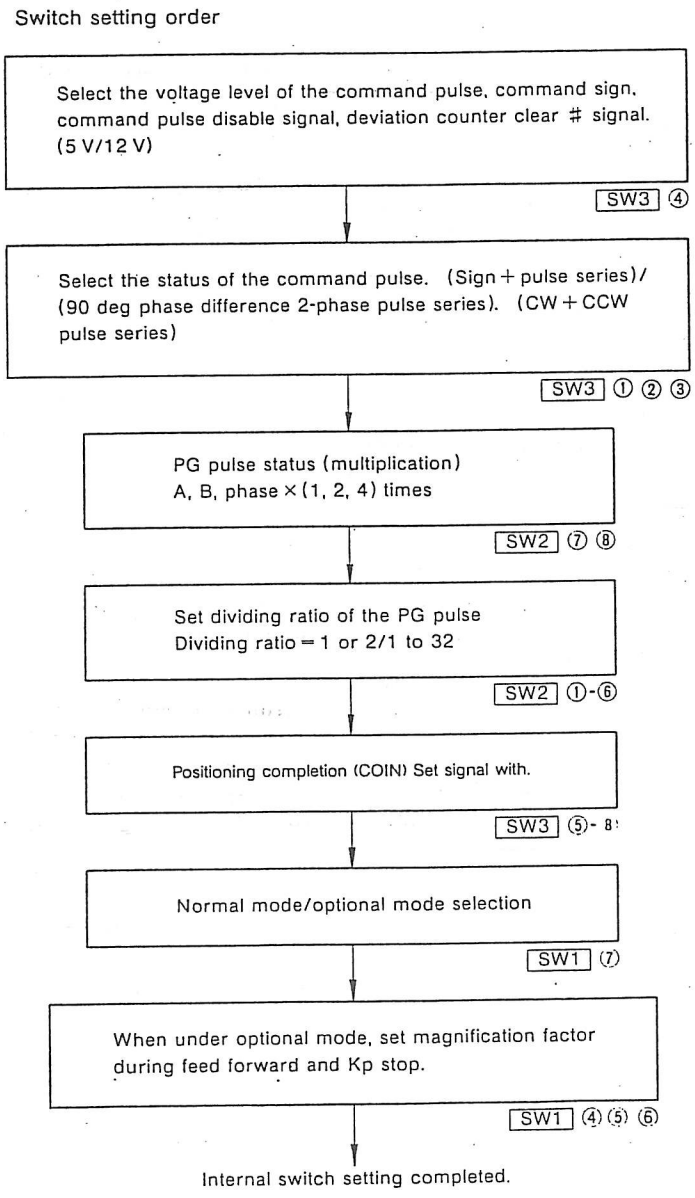



Fig. 10.9 Order of Switch Setting

# 11. INSPECTION AND MAINTENANCE

## 11.1 AC SERVOMOTOR

The AC servomotor has no wearing parts(eg. brushes), so simple daily inspection is sufficient. The inspection schedule for the motor is shown in Table 11.1.

Do not disassemble the motor. If disassembly should become necessary, contact your Yaskawa representative.

Table 11.1 Inspection Schedule for Motors

| Inspection Item | Frequency | Inspection Operation |
|---|---|---|
| Vibration | Daily | Feel manually. |
| Noise | Daily | Aurally |
| Exterior Checking and Cleaning | As required | Clean with dry cloth or compressed air. |
| Insulation Resistance | Yearly | Make sure that it is more than 10MΩ by measuring with a 500V megger after disconnecting the motor from the controller. |
| Oil Seal | Every 5000 hours | If worn or damaged, replace after disconnecting the motor from the driven machine. |
| Total Inspection | Every 20,000 hours | Contact Yaskawa representative. |

## 11.2 *Servopack*

The Servopack is of contactless construction so that no special maintenance is required. Remove dust and tighten screws periodically.
Table 11.2 shows fuse specifications used in Servopack.

Table 11.2 Fuse Specifications

| *Servopack* Type CACR- | | PR03BB | PR05BB PR07BB | PR10BB PR15BB | PR20BB | PR30BB | PR44BB | PR60BB |
|---|---|---|---|---|---|---|---|---|
| Fuse Specifications | Type | C-10 | C-15 | C-20 | C-30 | C-30 | C-40 | C-60 |
| | Capacity | 10A | 15A | 20A | 30A | 30A | 40A | 60A |
| | Manufacture | Fuji Electric Co., Ltd. | | | | | | |

# 12. TROUBLESHOOTING GUIDE

## 12.1 AC SERVOMOTOR

**WARNING**

Remedies in ☐ should be practiced after turning off the power.

Table 12.1 Troubleshooting Guide for AC Servomotor

| Trouble | Cause | What to do |
|---|---|---|
| Motor does not start. | Voltage below rated | Measure voltage across motor terminals U, V, and W with a tester and correct to rated value. |
| | Loose connection | Tighten connection. |
| | Wrong wiring | Correct. |
| | Overload | Reduce load or use a larger motor. |
| | Motor defective | Measure voltage across motor terminals U, V, and W with a tester. When correct, replace motor. |
| Unstable operation | Wrong wiring | Inspect and correct wiring across motor terminals U, V, and W, and PG. |
| Motor overheats. | Excessive ambient temperature. | Reduce below 40 °C. |
| | Motor dirty | Clean motor surface. |
| | Overload | Reduce load or use a larger motor. |
| Unusual noise | Motor loosely mounted | Tighten foundation bolts. |
| | Motor misaligned | Realign. |
| | Coupling out of balance | Balance coupling. |
| | Noisy bearing | Check alignment, loading of bearing, lubrication and contact Yaskawa representative. |
| | Vibration of driven machine | Contact the machine manufacturer. |

## 12.2 *Servopack*

### 12.2.1 LED Indication (8-segment) for Troubleshooting

Table 12.2 LED Indication for Troubleshooting

| LED | Lighting Condition | | Probable Cause | Corrective Action |
|---|---|---|---|---|
| OC | OC goes on when power is supplied to the control circuit. | | • Defective control circuit board (2 PWB). | • Replace the circuit board (*Servopack*). |
| | OC goes on when power is supplied to the main circuit and servo is turned on. | Where the fuse is not blown. | • Defective current feedback circuit<br>• Defective main circuit transistor module. | • Replace the *Servopack*. |
| | | Where the fuse is blown. | • Defective motor grounding<br>• Defective main circuit transistor module. | • Replace the motor.<br>• Replace the *Servopack*. |
| | OC goes on when power is supplied to the main circuit. | | • Defective main circuit transistor module. | • Replace the *Servopack*. |
| | OC goes on when the motor starts or slows down. | | • Incomplete (1 PWB) VR5 adjustment | • See Table 10.11. |
| OV | OV goes on when power is supplied to the control circuit. | | • Defective control circuit board (2 PWB). | • Replace the circuit board (*Servopack*). |
| | OV goes on approximate 0.5 to 1 second after power is supplied to the main circuit. | | • Defective regenerative transistor 1 Tr. | • Replace the *Servopack*. |
| | | | • Regenerative resistor disconnection. | • Check and replace the regenerative resistor. (Replace the *Servopack*.) |
| | OV goes on when the motor starts or slows down. | | • Load inertia ($GD^2$) too large | • Check the inertia of the machine with the value converted to the motor shaft. |
| | | | • Defective regenerative circuit | • Replace the *Servopack*. |
| OL | OL goes on when power is supplied to the control circuit. | | • Defective control circuit board (1 PWB or 2 PWB). | • Replace the circuit board (*Servopack*). |
| | OL goes on during operation.<br>• When power to the control circuit is turned off and then turned on again, the operation starts. | | • Operation with 105% to 130% or more of the rated load. | • Check and correct the load (may be overload). |
| | OL goes on during operation.<br>• When power to the control circuit is turned off and then turned on again, the OL goes on again. When reset later, the operation starts. | | • Fan has stopped. | • Check the fan. (PR 15, 20, 30, 44, 60) |
| | | | • Temperature around the *Servopack* exceeds 55°C. | • Decrease the temperature below 55°C. (The heat sink may be overheated.) |
| | The motor rotates, but the torque is unavailable.<br>When power to the control circuit is turned off and then turned on again, the operation starts, but the torque is still unavailable. | | • Motor circuit error connection, such as U → V, V → W, W → U or single-phase connection. | • Correct the connection. |
| FU | FU goes on when power is supplied to the control circuit. | | • Defective control circuit board (2 PWB). | • Replace the circuit board (*Servopack*). |
| | FU goes on when power is supplied to the main circuit. | | • Fuse is missing or blown. | • Install a fuse.<br>• Replace the fuse. |
| | | | • The fuse is normal. | • Check the wiring leads and joints in the Servopack. |
| OS | OS goes on when power is supplied to the control circuit. | | • Defective control circuit board (1 PWB). | • Replace the circuit board (*Servopack*). |
| | The motor starts momentarily, then OS goes on. | | • Motor connection error | • Correct the motor connection. |
| | | | • Optical encoder connection error | • Check and correct pulses in phases A, B, C, U, V and W with 2CN. |
| | When the reference is input, the motor runs fast and OS goes on. | | • Motor connection error<br>• Optical encoder connection error | • Correct the motor connection.<br>• Check and correct pulses in phases A, B, C, U, V and W with 2CN. |

Table 12.2 LED Indication for Troubleshooting (Cont'd)

| LED or Overflow | Conditions | Cause | Corrective Action |
|---|---|---|---|
| OS | • When the command pulse is input, it operates at high speed and lights. | • Wrong connection in motor.<br>• Wrong connection in optical encoder. | • Correct the motor connection. Check the pulses of phases A, B, C, U, V, and W and correct the connections. |
| | | • Command pulse frequency too high. | • Reduce the command pulse.<br>• Reduce the command pulse frequency (overspeed detection). |
| | • Lights when starting or stopping operation. | • Overshoot or undershoot too large. | • Speed up or slow down the command pulse. |
| | • Lights during operation. | • Motor vibration or current oscillation. | • Reduce the speed loop gain. |
| OVER | • The command pulse is input, but the PG pulse is not returned. | • Wrong connection in motor.<br>• Wrong connection in optical encoder. | • Correct the connection of the motor. Check the pulses of phases A, B, C C, U, V, and W for lead disconnection, short-circuit, no power supply, faulty printed circuit board. Correct the connections. |
| | | • Control board (1PWB or 2PWB) faulty. | • Replace Servopack. |
| | • High-speed operation resulting in overflow. | • Wrong connection in motor.<br>• Wrong connection in optical encoder. | • Correct the motor connection. Check the pulses of phases A, B, C, U, V, W for lead disconnection, short-circuit, no power supply, faulty PC board. Correct the connections. |
| | | • Control board (1PWB or 2PWB) faulty. | • Replace the Servopack. |
| | • The operation is normal, but it overflows if long commands are given. | • Faulty adjustment of the Servopack. | • Increase the speed loop gain. |
| | | • Load capacity too large. | • Check and correct the load ( overload, load inertia too high). |
| | | • Command pulse frequency too high. | • Speed-up or slow-down the command pulse. |

## 12.3 TROUBLESHOOTING

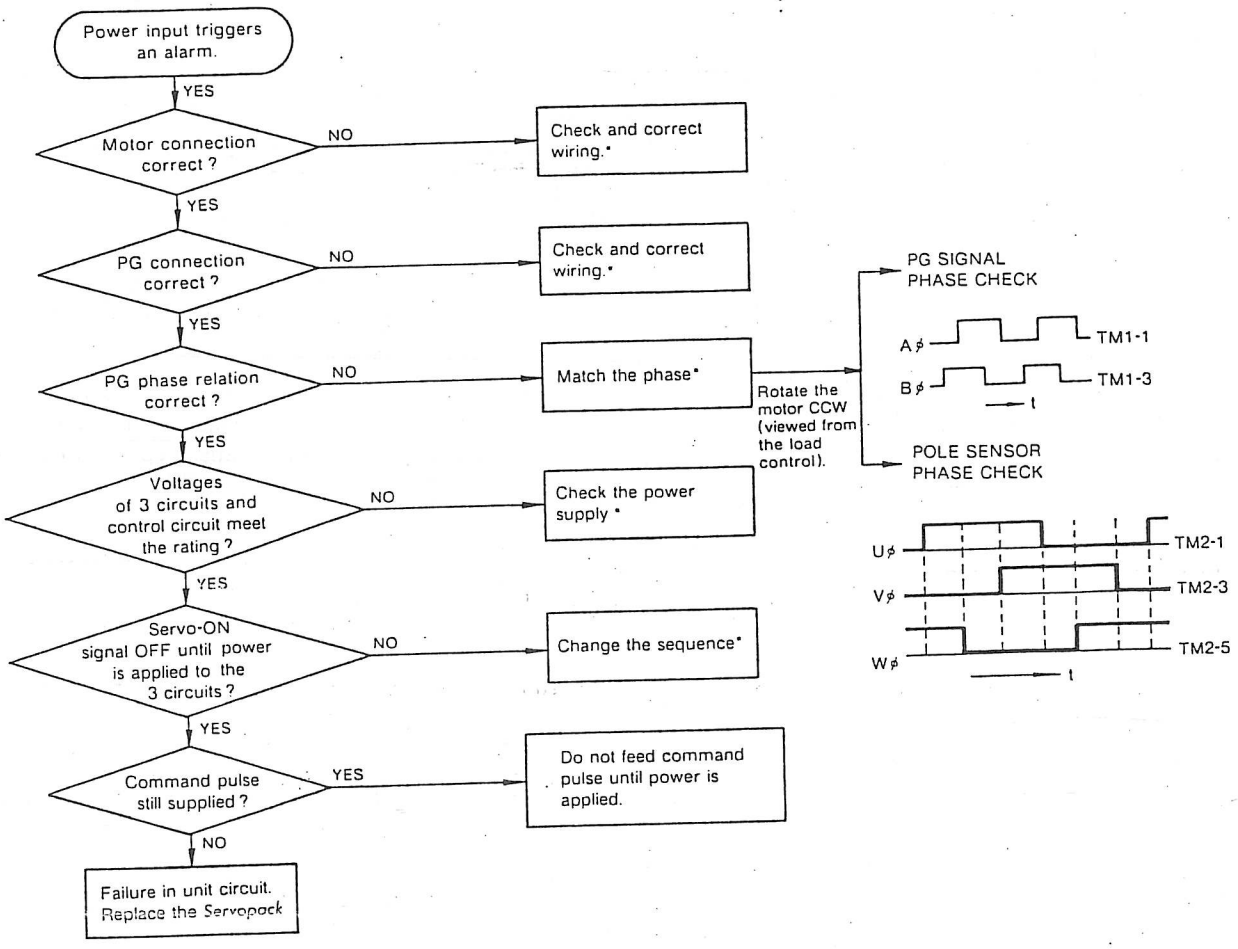
If a malfunction occurs, checking must be started with the assumption that the failure was caused by either erroneous operation or faulty equipment. Condition of the digital control unit is easily checked using LEDs provided on the check panel and input/output terminals. The following charts show typical examples for troubleshooting.

### 12.3.1 DC Power Supply

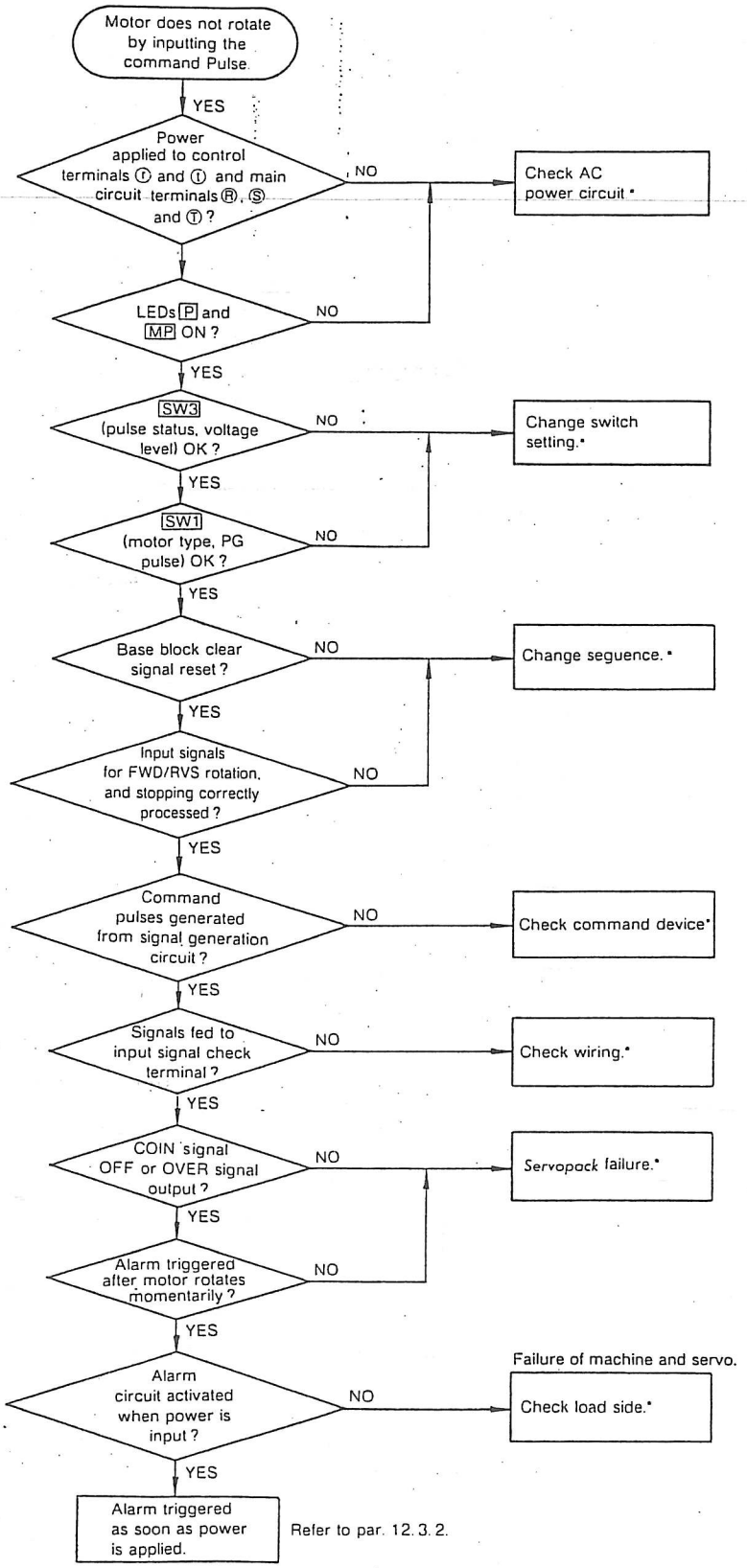
Faulty of control power voltage exceeding following limits may cause overrunning of the motor or inaccurate control. Voltage measured at the following terminals in Servopack should not exceed the limits given below.

Main circuit voltage (Power transformer primary side): 200 to 230 VAC, +10, -15%

Control power voltage: 200 to 230 VAC, +10%, -15%

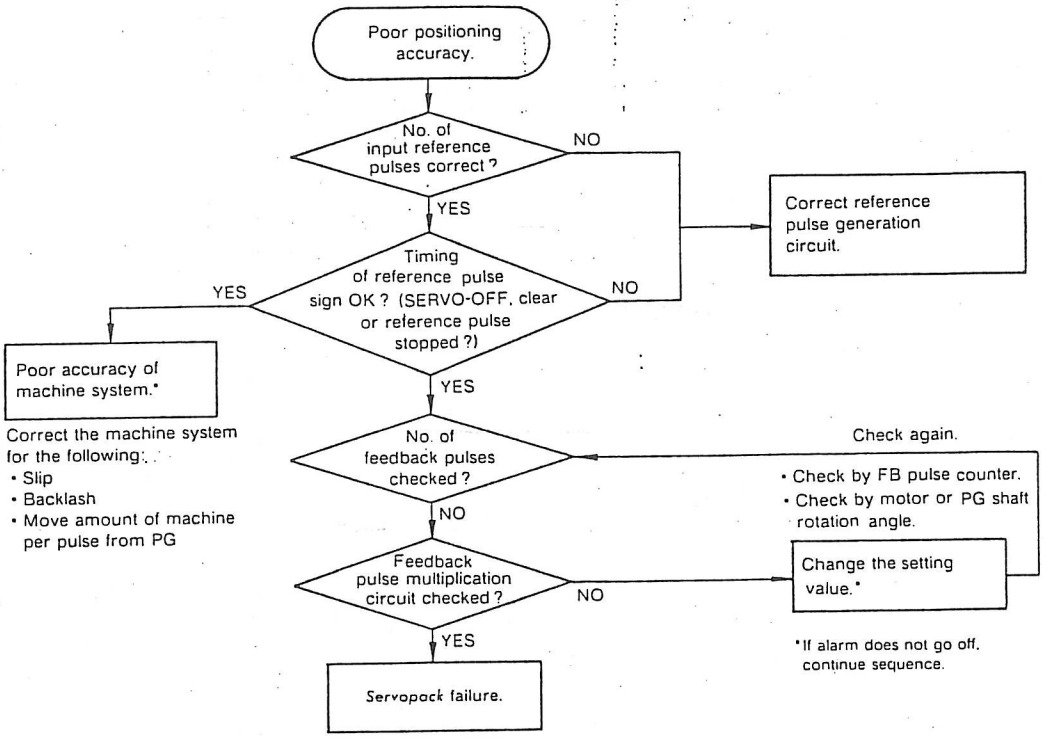



*If alarm does not go off, continue sequence.




*If alarm does not go off, continue sequence.

## 12.3.1 DC Power Supply (Cont'd)




*If alarm does not go off, continue sequence.

### 12.3.2 Examples of Troubleshooting for Defective Wiring or Parts

Table 12.3 Example of Troubleshooting for Defective Wiring or Parts

| Trouble | Check Items | What to do |
|---|---|---|
| • Fuse blows immediately after the power is turned on or Servo ON. | • Fuse capacity<br>• Main circuit wiring (such as the ground of motor) | • Replace the fuse, if defective.<br>• Correct wiring, if wrong. |
| • The motor runs but does not stop (or overruns). | • PG feedback signal of A, B, and C<br>• PG feedback signal phases | • Correct the wiring. |
| • An overflow signal instantly appears | • Reference pulse frequency<br>• Motor lock<br>• Load inertia<br>• PG feedback signal of A, B, and C | • Check that fin $= \frac{\text{Motor speed}}{60} \times$ number of PG pulses.<br>• Release the motor lock.<br>• Recheck the inertia converted to the motor shaft.<br>• Correct the wiring. |

### 12.3.3 Examples of Troubleshooting for Incomplete Adjustment

Table 12.4 Examples of Troubleshootings for Incomplete Adjustment

| Trouble | Check Items | What to do |
|---|---|---|
| Servo performance is improper. | Positioning loop gain too low. | Increase positioning loop gain [Kp]. If hunting, increase the speed loop gain [Kv].<br>(Even if hunting occurs by increasing the speed loop gain, positioning loop gain cannot be increased.<br>This is a limit of Servo performance.) |

VS-800 SERIES

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