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FSP Amplifier

(FSP-) **SERIES**

AC SERVO DRIVE Safety Precautions
Short Form Installation Guide

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FSP Amplifier Safety Precautions, Installation Guide (Short Form)
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Every effort has been made to make this guide complete and as accurate as possible.
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1. Introduction

This guide describes the FSP- series AC servo drive (FSP Amplifier) that controls Yaskawa Sigma II series or any compatible AC servomotor.

This product conforms to the following standards:

- EN61000-6-2: 1999
- EN55011: 1998, Group 1 Class A

However, because this product is a built-in type, reconfirmation of the above standards is required after being installed in the final product.

Upon receipt of the product and prior to installing the product, read these instructions carefully and retain for future reference. This will enable you to properly use the FSP Amplifier and carry out periodic inspection, maintenance, etc.

Related documents:

Title	Catalog No.
Sigma FSP Servo System User's Manual	YEA-SIA-FSP-3
AC Servo Motor Instructions for Yaskawa Sigma II series motors or documentation for other compatible motors	TOE-C231-2 (for Sigma II) Manufacturer's motor specification
FlexWorks User's Manual	YEA-SIA-FSP-4

This guide and other related documents can be downloaded from our website:

www.yaskawa.com

Note: YEA is not responsible for accidents or damages resulting from product modifications made by the user.

1.1. Safety Precautions

In this guide, safety precautions are classified as WARNING or CAUTION. It is extremely important that you pay close attention to these precautions.

The following symbols are used:



Indicates a potentially hazardous situation, which, if not avoided, could result in death or serious personal injury.



Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate personal injury and/or damage to the equipment. In some instances, items described in CAUTION could also result in a serious accident.

Read the following safety precautions thoroughly before installation, operation, maintenance or inspection of the FSP Amplifier.

1.2. Notes for Safe Operation

⚠ WARNING

- **Never touch any rotating motor parts while the motor is running.**
  Failure to observe this warning may result in injury.
- **Before starting operation with a machine connected, make sure that an emergency stop can be applied at any time.**
  Failure to observe this warning may result in injury.
- **Never touch the inside of the FSP Amplifier.**
  Failure to observe this warning may result in electric shock.
- **Do not remove the terminal cover while the power is ON.**
  Failure to observe this warning may result in electric shock.
- **Do not touch terminals for five minutes after the power is turned OFF.**
  Residual voltage may cause electric shock.
- **Do not touch terminals for five minutes after voltage resistance test.**
  Residual voltage may cause electric shock.
- **Follow the procedures and instructions for trial operation precisely as notedin the relevant User's Manual.**
  Malfunctions that occur after the servomotor is connected to the equipment not only damage the equipment, but may also cause an accident resulting in death or injury.
- **The multi-turn limit value must be changed only for special applications.**
  Changing it inappropriately or unintentionally can be dangerous.
- **If the Multi-turn Limit Disagreement alarm occurs, check the setting of parameter Pn205 in the FSP Amplifier to be sure that it is correct.**
  If Fn013 is executed when an incorrect value is set in Pn205, an incorrect value will be set in the encoder. The alarm will disappear even if an incorrect value is set, but incorrect positions will be detected, resulting in a dangerous situation where the machine will move to unexpected positions.
- **Do not remove the terminal cover, cables, connectors, or optional items while the power is ON.**
  Failure to observe this warning may result in electric shock.
- **Connect the ground terminal to electrical codes (ground resistance: 100 Ω or less).**
  Improper grounding may result in electric shock or fire.
- **Only authorized personnel must perform installation, disassembly, or repair.**
  Failure to observe this warning may result in electric shock or injury.

⚠ WARNING

- **Do not damage, press and exert excessive force or place heavy objects on the cables.**

  Failure to observe this warning may result in electric shock, stoppage of operation, or burning.
- **Do not modify the product.**

  Failure to observe this warning may result in injury or damage to the product.
- **Provide an appropriate stopping device on the machine side to ensure safety. A holding brake for a servomotor with brake is not a stopping device for ensuring safety.**

  Failure to observe this warning may result in injury.
- **Do not come close to the machine immediately after resetting momentary power loss to avoid an unexpected restart. Take appropriate measures to ensure safety against an unexpected restart.**

  Failure to observe this warning may result in injury.

■ Checking on Delivery

⚠ CAUTION

- **Always use the servomotor and the FSP Amplifier in one of the specified combinations.**

  Failure to observe this caution may result in fire or malfunction.

■ Storage and Transportation

⚠ CAUTION

- **Do not store or install the product in the following locations.**
  - ❖ **Locations subject to direct sunlight.**
  - ❖ **Locations subject to temperatures outside the range specified in the storage/installation temperature conditions.**
  - ❖ **Locations subject to humidity outside the range specified in the storage/installation humidity conditions.**
  - ❖ **Locations subject to condensation as the result of extreme changes in temperature.**
  - ❖ **Locations subject to corrosive or flammable gases.**
  - ❖ **Locations subject to dust, salts or iron dust.**
  - ❖ **Locations subject to exposure to water, oil or chemicals.**
  - ❖ **Locations subject to shock or vibration.**

  Failure to observe this caution may result in fire, electric shock, or damage to the product.

- **Do not hold the product by the cables or motor shaft while transporting it.**
  Failure to observe this caution may result in injury or malfunction.
- **Do not place any load exceeding the limit specified on the packing box.**
  Failure to observe this caution may result in injury or malfunction.
- **Do not hold the product by the eyebolt of motor while transporting it.**
  Failure to observe this caution may result in injury or malfunction.

■ Installation

⚠ CAUTION

- **Never use the products in an environment subject to water, corrosive gases, inflammable gases, or combustibles.**
  Failure to observe this caution may result in electric shock or fire.
- **Do not step on or place a heavy object on the product.**
  Failure to observe this caution may result in injury.
- **Do not cover the inlet or outlet ports and prevent any foreign objects from entering the product.**
  Failure to observe this caution may cause internal elements to deteriorate resulting in malfunction or fire.
- **Be sure to install the product in the correct direction.**
  Failure to observe this caution may result in malfunction.
- **Provide the specified clearance between the FSP Amplifier and the control panel or other device.**
  Failure to observe this caution may result in fire or malfunction.
- **Do not apply any strong impact.**
  Failure to observe this caution may result in malfunction.

■ Wiring

⚠ CAUTION

- **Do not connect a three-phase power supply to the U, V, or W output terminals.**
  Failure to observe this caution may result in injury or fire.
- **Securely connect the power supply terminal screws and motor output terminal screws.**
  Failure to observe this caution may result in fire.
- **Do not bundle or run power and signal lines together in the same duct. Keep power and signal lines separated by at least 30 cm (11.81 in).**
  Failure to observe this caution may result in fire.
- **Use twisted-pair shielded wires or multi-core twisted pair shielded wires for signal and encoder (PG) feedback lines.**
  The maximum length is 3 m (118. 11 in) for reference input lines and is 20 m (787.40 in) for PG feedback lines. If feedback lines are longer than 20 m (787.40 in), use the 50 m (1968.50 in) cable.
- **Do not touch the power terminals for 5 minutes after turning power OFF because high voltage may still remain in the FSP Amplifier.**
  Make sure the charge indicator is out first before starting an inspection.
- **Avoid frequently turning power ON and OFF. Do not turn power ON or OFF more than once per minute.**
  Since the FSP Amplifier has a capacitor in the power supply, a high charging current flows for 0.2 seconds when power is turned ON. Frequently turning power ON and OFF causes main power devices like capacitors and fuses to deteriorate, resulting in unexpected problems.
- **Observe the following precautions when wiring main circuit terminal blocks.**
  Failure to observe this caution may result in injury, fire, or malfunction.
  - ❖ Remove the terminal block from the FSP Amplifier prior to wiring.
  - ❖ Insert only one wire per terminal on the terminal block.
  - ❖ Make sure that the core wire is not electrically shorted to adjacent core wires.
  - ❖ The leakage from the power lines may be extremely large for 400 V FSP Amplifier. Be sure to secure the wiring of the power lines.
- **Do not connect the FSP Amplifier for 100 V and 200 V directly to a voltage of 400 V.**
  The FSP Amplifier will be destroyed.
- **Be sure to wire correctly and securely.**
  Failure to observe this caution may result in motor overrun, injury, or malfunction.
- **Always use the specified power supply voltage.**
  An incorrect voltage may result in burning.
- **Take appropriate measures to ensure that the input power supply is supplied within the specified voltage fluctuation range. Be particularly careful in places where the power supply is unstable.**
  An incorrect power supply may result in damage to the product.
- **Install external breakers or other safety devices against short-circuiting in external wiring.**
  Failure to observe this caution may result in fire.

⚠ CAUTION

- **Take appropriate and sufficient countermeasures for each when installing systems in the following locations.**

  Failure to observe this caution may result in damage to the product.

  ❖ Locations subject to static electricity or other forms of noise.
  ❖ Locations subject to strong electromagnetic fields and magnetic fields.
  ❖ Locations subject to possible exposure to radioactivity.
  ❖ Locations close to power supplies.

- **Do not reverse the polarity of the battery when connecting it.**

  Failure to observe this caution may damage the battery or cause it to explode.

■ Operation

⚠ CAUTION

- **Conduct trial operation on the servomotor alone with the motor shaft disconnected from machine to avoid any unexpected accidents.**

  Failure to observe this caution may result in injury.

- **Before starting operation with a machine connected, change the settings to match the parameters of the machine.**

  Starting operation without matching the proper settings may cause the machine to run out of control or malfunction.

- **Forward run prohibited (P-OT) and reverse run prohibited (N-OT) signals are not effective during zero point search mode using parameter Fn003.**

  Failure to observe this caution may result in injury.

- **When using the servomotor for a vertical axis, install the safety devices to prevent workpieces to fall off due to occurrence of alarm or overtravel. Set the servomotor so that it will stop in the zero clamp state at occurrence of overtravel.**

  Failure to observe this caution may cause workpieces to fall off due to overtravel.

- **When not using the online autotuning set to the correct moment of inertia ratio.**

  Setting to an incorrect moment of inertia ratio may cause vibration.

- **Do not touch the FSP Amplifier's heat sink, regenerative resistor, or servomotor while power is ON or soon after the power is turned OFF.**

  Failure to observe this caution may result in burns due to high temperatures.

- **Do not make any extreme adjustments or setting changes of parameters.**

  Failure to observe this caution may result in injury due to unstable operation.

- **When an alarm occurs, remove the cause, reset the alarm after confirming safety, and then resume operation.**

  Failure to observe this caution may result in injury.

- **Do not use the servo brake of the servomotor for ordinary braking.**

  Failure to observe this caution may result in malfunction.

■ Maintenance and Inspection

⚠ CAUTION

- **Do not disassemble the FSP Amplifier.**
  Failure to observe this caution may result in electric shock or injury.
- **Do not attempt to change wiring while the power is ON.**
  Failure to observe this caution may result in electric shock or injury.
- **When replacing the FSP Amplifier, resume operation only after transferring the previous FSP Amplifier parameters to the new FSP Amplifier.**
  Failure to observe this caution may result in damage to the product.

■ Disposal

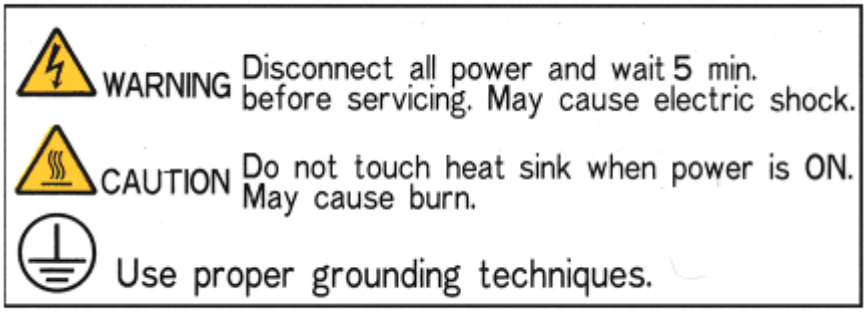
⚠ CAUTION

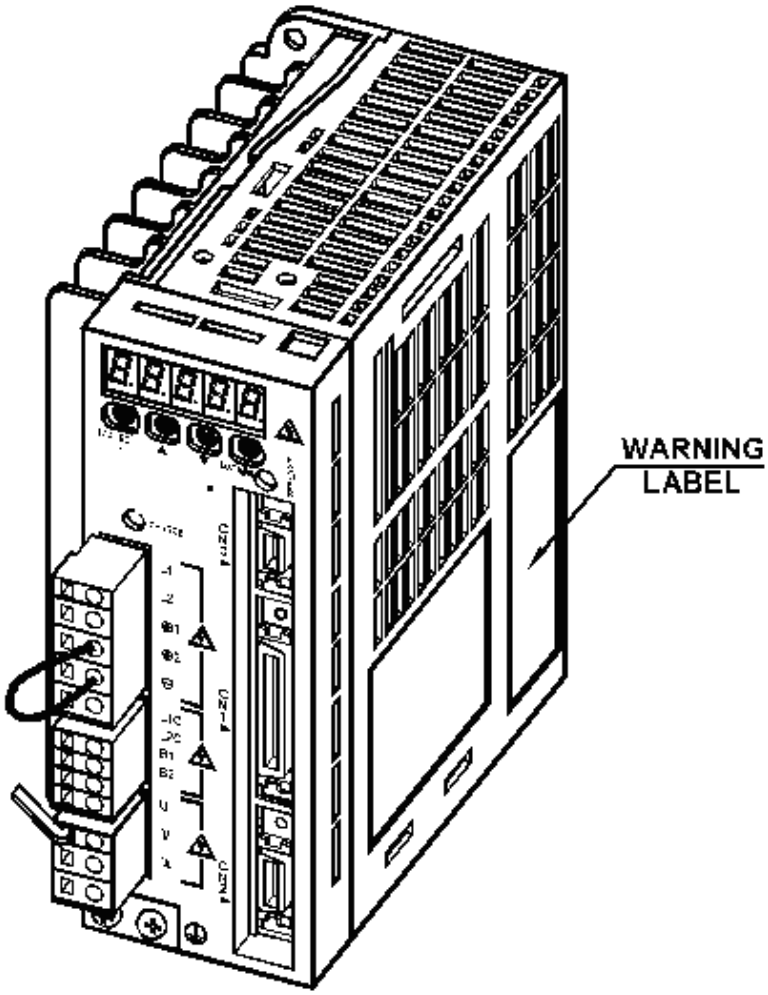
- **When disposing of the products, treat them as ordinary industrial waste.**
  Failure to observe this caution may result in injury.

1.3. Warning Label

The following illustration shows an example of the FSP Amplifier's warning label.

The mounting position of the label differs depending on the model and capacity of the FSP Amplifier.

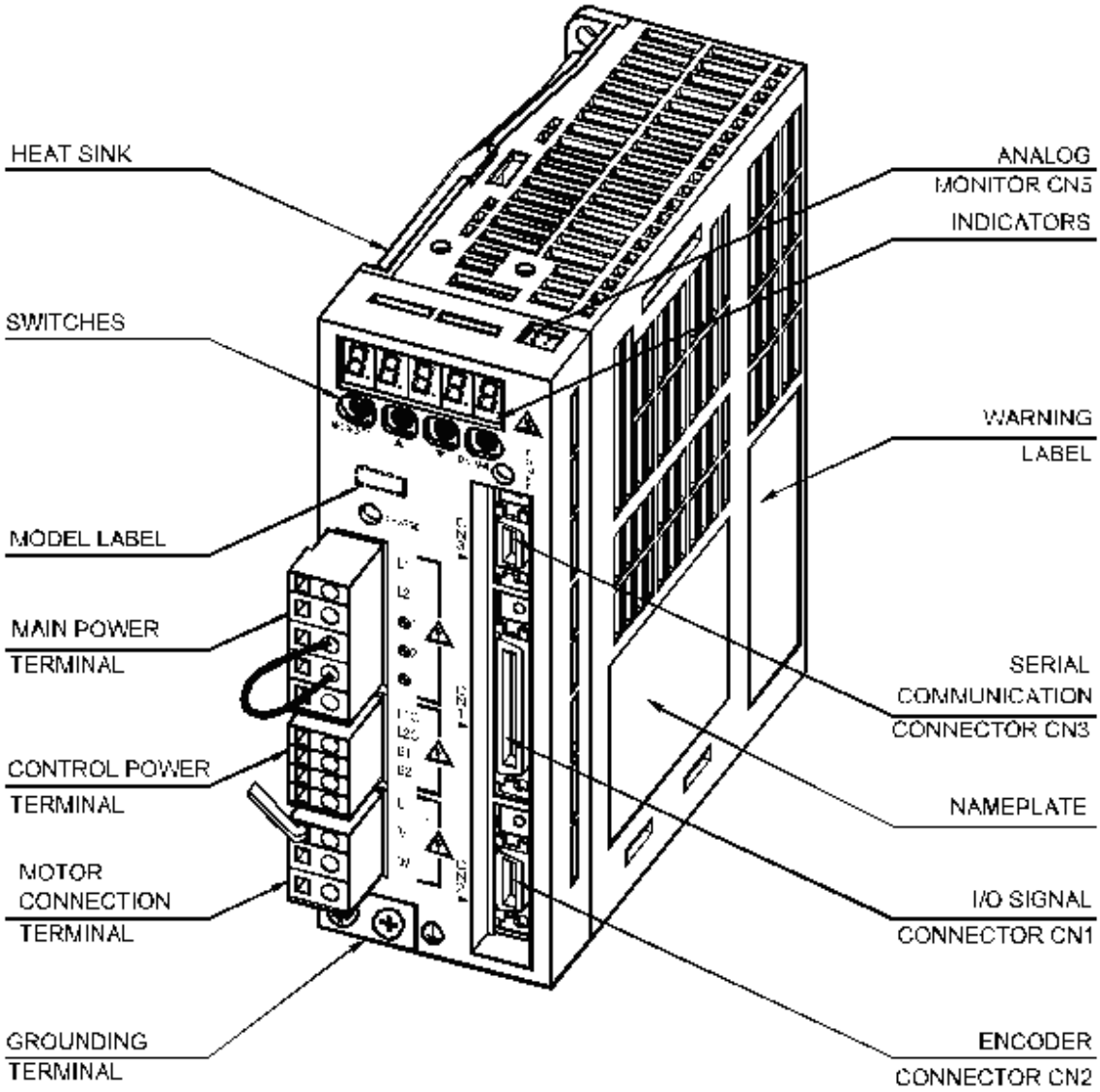




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1.4. Parts

The part names of the FSP Amplifier are shown in the following diagram:



2. Checking Products On Delivery

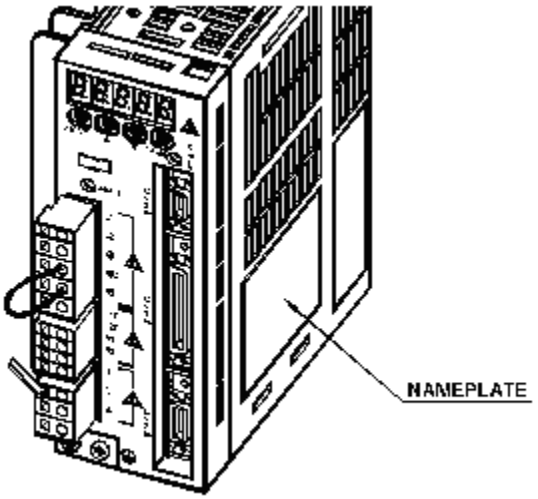
The following procedure is used to check FSP- series products upon delivery.

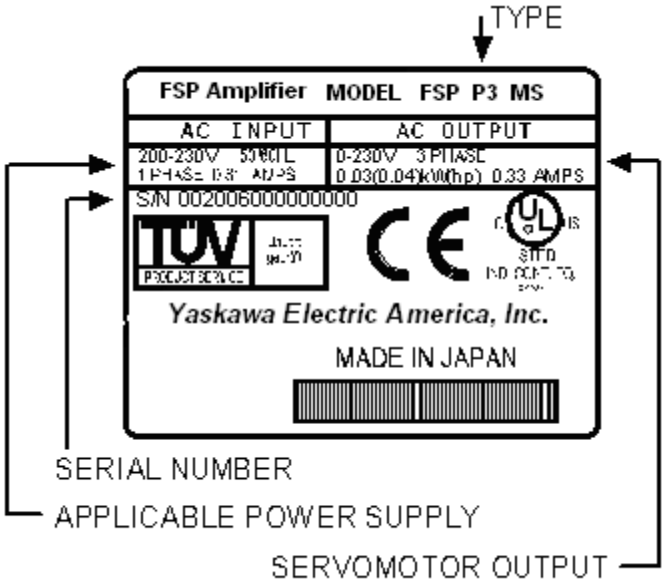
Check Item	Comments
Are the delivered products the ones you ordered?	Check the model numbers marked on the nameplates of the FSP Amplifier.
Is there any visible damage?	Check the overall appearance and check for damage or scratches that may have occurred during transportation.
Are there any loose screws?	Tighten any loose screws with a screwdriver.

If any of the above items are faulty or incorrect, contact your local sales representative or the dealer from whom you purchased the product(s).

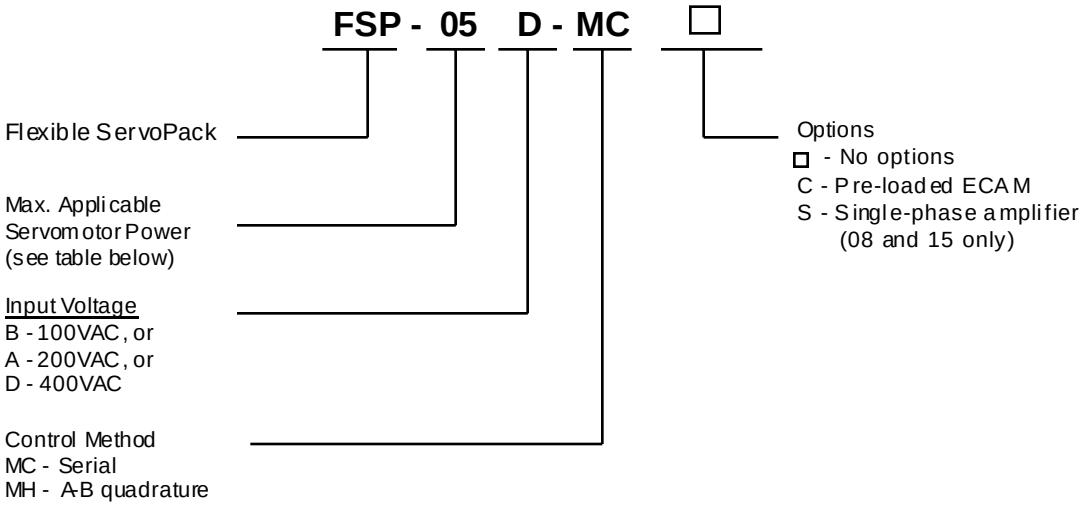
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3. Appearance and Nameplate





3.1. Type Designation



Output Capacity Code	Max. Applicable Servomotor Power (kW)
A3	0.03
A5	0.05
01	0.10
02	0.20
04	0.40
05	0.50
08	0.75
10	1.00
15	1.50
20	2.00
30	3.00
50	5.00

4. Installation

The FSP Amplifier is a base-mount type servo controller. Incorrect installation will cause problems. Always observe the installation instructions provided below.

4.1. Operating Conditions

Ensure the following operating conditions for the FSP Amplifier use:

Installation category (Overvoltage category)*: II
Pollution degree*: 2
Protection class*: 1X
Maximum altitude: 1000 m

* Conforming to the following standards:

EN55011: 1198 Group 1 Class A
EN61000-6-2: 1999

4.2. Installation Sites

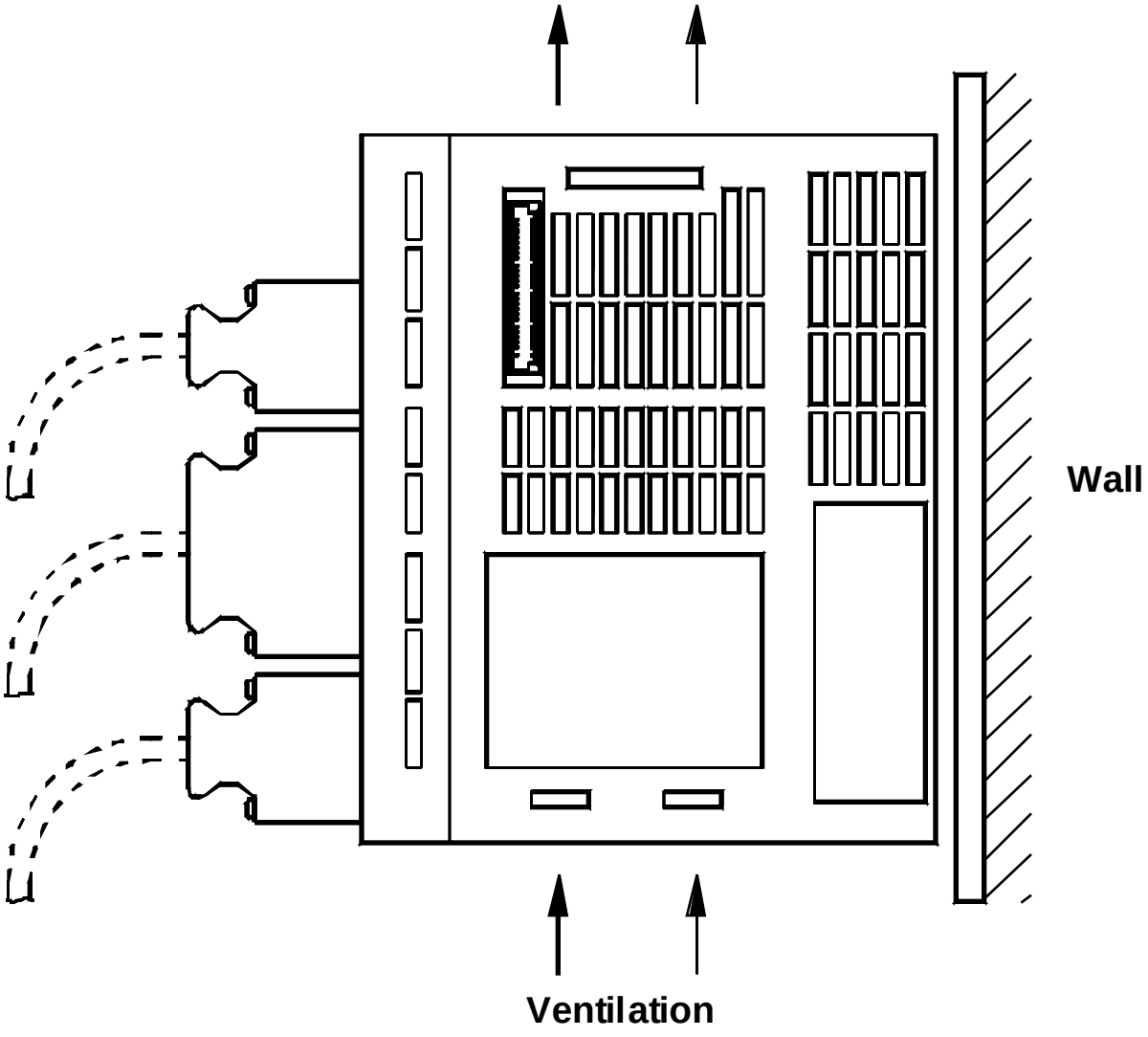
For installation sites, use proper care with the following notes.

Situation	Notes on Installation
When installed inside a control panel	• Design the control panel size, unit layout, and cooling method so that temperature around the periphery of the FSP Amplifier does not exceed 55°C. • When installing multiple FSP Amplifiers side by side in a control panel, install cooling fans and provide sufficient space around each FSP Amplifier to allow cooling by fan and natural convection.
When installed near a heating unit	Suppress radiated heat from the heating unit and temperature rise caused by convection so that the temperature around the periphery of the FSP Amplifier does not exceeds 55°C.
When installed near a vibration source	Install a vibration isolator underneath the FSP Amplifier to prevent it from receiving vibration.
When installed in a corrosive gases area	Corrosive gases do not immediately affect the FSP Amplifier but will eventually cause contactor-related devices to malfunction. Take appropriate action to protect against corrosive gases.
Others	• Avoid installation in a hot and humid place or where excessive dust or iron powder is present in the air. • Be sure there is no condensation or freezing. • Keep the ambient temperature 45°C or less to ensure long-term reliability.

4.3. Orientation

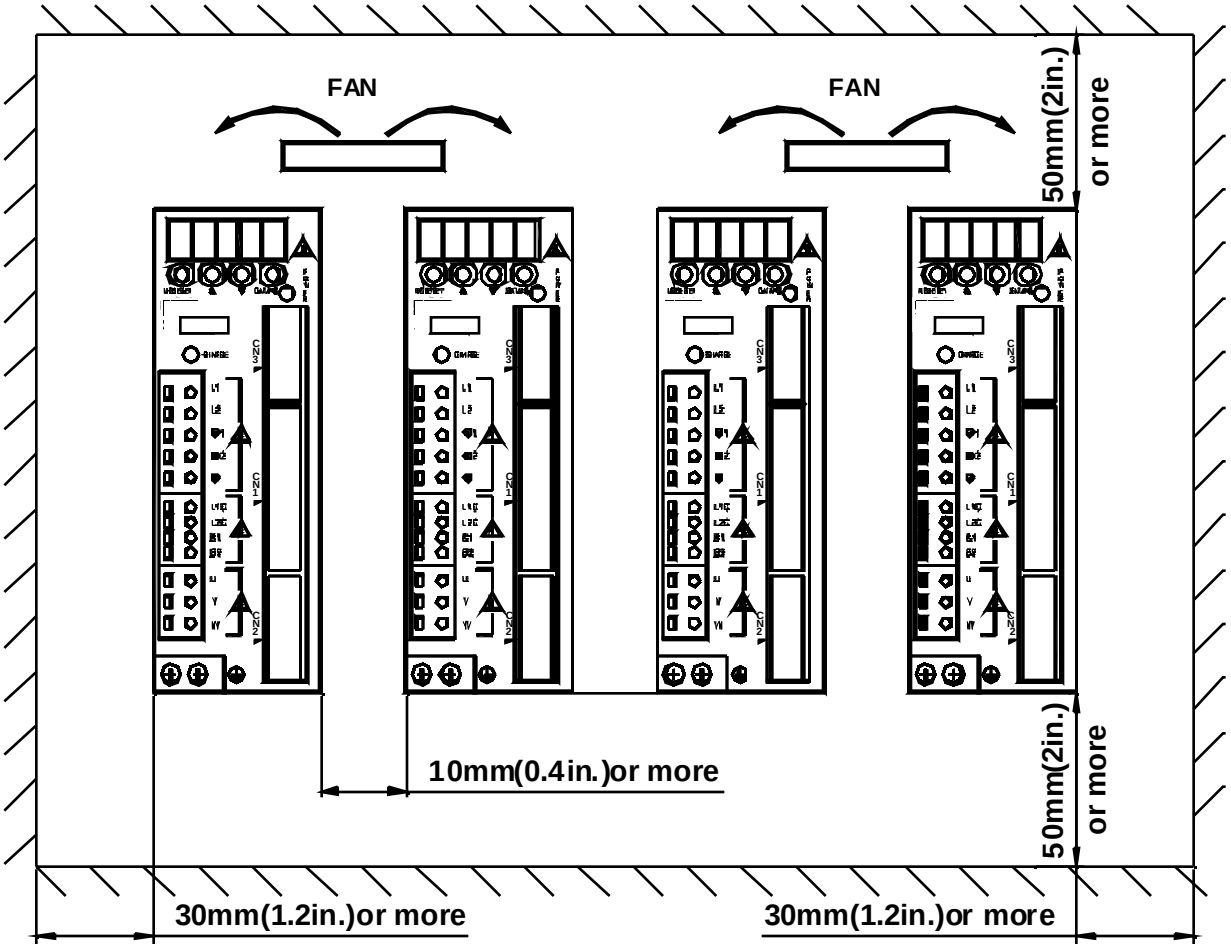
Install the FSP Amplifier perpendicular to the wall and orientate it as shown in the figure below.

Firmly secure the FSP Amplifier through two or four mounting holes (depending on the FSP Amplifier capacity).



4.4. Multiple FSP Amplifier Installation

When installing multiple FSP Amplifiers side by side in a control panel, observe the following:



4.4.1 Where Mounted Side by Side

When installing FSP Amplifiers side by side, provide at least 10 mm (0.4 in) space between them and at least 50 mm (2 in) space above and below them as shown in the figure above. Install cooling fans above the FSP Amplifiers to prevent the temperature around each FSP Amplifier from increasing excessively and also to maintain the temperature inside the control panel evenly.

4.4.2 Environment Inside Control Box

Maintain the following conditions inside the control box:

Ambient temperature for FSP Amplifier: 0 to 55^{o}C
Humidity: 90% RH or less, no condensing.
Vibration: 4.9 m/s^{2}
No freezing.
Ambient temperature to ensure long-term reliability: 45^{o}C or less

5. Wiring

5.1. Molded-case Circuit Breaker and Fuse Capacity

Main circuit Power Supply	FSP Amplifier model		Power Supply Capacity per FSP Amplifier (kVA)	Current Capacity of the Molded-case Circuit Breaker and the Fuse (A_{rms})*1, *2		Inrush current	
	Capacity (kW)	FSP-		Main circuit Power Supply	Control circuit Power Supply	Main circuit Power Supply	Control circuit Power Supply
Single-phase 100V	0.03	A3B*	0.15	4	0.26	32 A	30 A
	0.05	A5B*	0.25				
	0.10	01B*	0.40				
	0.20	02B*	0.60	6			
Single-phase 200V	0.03	A3A*	0.20	4	0.13	63 A	60 A
	0.05	A5A*	0.25				
	0.10	01A*	0.40				
	0.20	02A*	0.75				
	0.40	04A*	1.2	8			
Single-phase 220V	0.75	08A*	2.1	11	0.13*4	130 A	66 A
	1.50	15A*	4.0	19			
Three-phase 200V	2.00	20A*	4.3	13	0.13*4	63 A	60 A
	3.00	30A*	5.9	17			
Three-phase 400V	0.50	05D*	1.1	1.6	0.7*4	10 A	--*3
	1.00	10D*	2.3	3.4			
	1.50	15D*	3.2	4.6			
	2.00	20D*	4.9	7.1		20 A	
	3.00	30D*	6.7	9.7			
	5.00	50D*	10.3	14.9		78 A	

*1. Nominal value at rated load. The specified derating is required to select an appropriate fuse capacity.
*2. Cutoff characteristics (25°C): 300% five seconds min. and inrush current of 20ms.
*3. A preventive circuit for inrush current is not built in the 24 VDC control power supply. Customer must design the protective circuit.
*4. Make sure the current capacity is accurate. For an FSP Amplifier with cooling fan built-in, an inrush current flows; 200% of the current capacity (in the table above) for two seconds, when turning ON the control circuit.

5.2. Main Circuit Wiring

FSP Amplifiers are suitable under the following conditions.

With 100 V class: Less than 5000 A_{rms}, 120 V maximum.

With 200 V class: Less than 5000 A_{rms}, 240 V maximum.

With 400 V class: Less than 5000 A_{rms}, 480 V maximum.

FSP Amplifiers must be used with UL-listed fuses or circuit breakers, in accordance with the National Electrical Code (NEC).

Use 75°C heat-resistant copper wires or an equivalent.

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5.3. Main Circuit Wire Size

■ Cable Types

Cable Types		Allowable Conductor Temperature ºC (ºF)
Symbol	Name	
PVC	Normal vinyl cable	—
IV	600V vinyl cable	60 (140)
HIV	Temperature-resistant vinyl cable	75 (167)

- **Wire sizes are selected for three cables per bundle at 40°C (104°F) ambient temperature with the rated current.**
- **Use cable with a minimum withstand voltage of 600V for main circuits.**
- **If cables are bundled in PVC or metal ducts, consider the reduction ratio of the allowable current.**
- **Use heat-resistant cables under high ambient or panel temperatures where normal vinyl cables will rapidly deteriorate.**
- **Use cables within the allowable moment of inertia.**
- **Do not use cables under continuous regenerative state.**

The following table shows the wire size and allowable current for three cables. Use a cable whose specifications meet or are less than the values in the table.

■ 600-V Heat-resistant Vinyl Cables (HIV)

AWG Size	Nominal Cross Section Diameter mm^2 (in^2)	Configuration Number of wires/mm^2 (in^2)	Conductive Resistance Ω/km	Allowable Current at Ambient Temperature		
				30°C (86°F)	40°C (104°F)	50°C (122°F)
20	0.5 (0.00078)	19/0.18 (0.00028)	39.5	6.6	5.6	4.5
—	0.75 (0.00116)	30/0.18 (0.00028)	26.0	8.8	7.0	5.5
18	0.9 (0.00140)	37/0.18 (0.00028)	24.4	9.0	7.7	6.0
16	1.25 (0.00193)	50/0.18 (0.00028)	15.6	12.0	11.0	8.5
14	2.0 (0.00310)	7/0.6 (0.00093)	9.53	23	20	16
12	3.5 (0.00543)	7/0.8 (0.00124)	5.41	33	29	24
10	5.5 (0.00853)	7/1.0 (0.00155)	3.47	43	38	31
8	8.0 (0.01240)	7/1.2 (0.00186)	2.41	55	49	40
6	14.0 (0.02170)	7/1.6 (0.00248)	1.35	79	70	57
4	22.0 (0.03410)	7/2.0 (0.00310)	0.85	91	81	66

Note: The values in the table are for reference only.

■ Main Circuit Input Terminals (L1, L2, L3), Servomotor Connection Terminals (U, V, W)

Main Circuit Power Supply	Capacity (kW)	Model	Main Circuit Input Terminals (L1, L2, L3)*1			Servomotor Connection Terminals (U, V, W)		
		FSP-	Wire Type & Size (mm^2)	Terminal Screw Size	Tightening Torque (N·m)	Wire Type & Size (mm^2)	Terminal Screw Size	Tightening Torque (N·m)
Single-phase 100V	0.03	A3B*	HIV 1.25	—	—	HIV 1.25	—	—
	0.05	A5B*						
	0.10	01B*						
	0.20	02B*	HIV 2.0					
Single-phase 200V	0.03	A3A*	HIV 1.25	—	—	HIV 1.25	—	—
	0.05	A5A*						
	0.10	01A*						
	0.20	02A*						
	0.40	04A*	HIV 2.0					
Single-phase 220V	0.75	08A*	HIV 2.0	—	—	HIV 1.25	—	—
	1.50	15A*	HIV 3.5	M4	1.2 to 1.4	HIV 2.0	M4	1.2 to 1.4
Three-phase 200V	2.00	20A*	HIV 3.5	M4	1.2 to 1.4	HIV 3.5	M4	1.2 to 1.4
	3.00	30A*				HIV 5.5		
Three-phase 400V	0.50	05D*	HIV 1.25	—	—	HIV 1.25	—	—
	1.00	10D*						
	1.50	15D*						
	2.00	20D*	HIV 2.0	M4	1.2 to 1.4	HIV 2.0	M4	1.2 to 1.4
	3.00	30D*						
	5.00	50D*	HIV 3.5	M5	1.6 to 2.4	HIV 3.5	M5	1.6 to 2.4

1. Connect the main power supply to terminals L1 and L3 for FSP-08A-S and FSP-15A*-S. Do not connect to the L2 terminal.

■ Control Power Input Terminals (L1C, L2C), External Regenerative Resistor Terminals (B1, B2)

Main Circuit Power Supply	Capacity (kW)	Model	Main Circuit Input Terminals (L1C, L2C)*1			External Regeneration Resistor Terminals (B1, B2)		
		FSP-	Wire Type & Size (mm^2)	Terminal Screw Size	Tightening Torque (N·m)	Wire Type & Size (mm^2)	Terminal Screw Size	Tightening Torque (N·m)
Single-phase 100V	0.03	A3B*	HIV 1.25	—	—	HIV1.25	—	—
	0.05	A5B*						
	0.10	01B*						
	0.20	02B*						
Single-phase 200V	0.03	A3A*	HIV 1.25	—	—	HIV1.25	—	—
	0.05	A5A*						
	0.10	01A*						
	0.20	02A*						
	0.40	04A*						
Single-phase 220V	0.75	08A*	HIV 1.25	—	—	HIV1.25	—	—
	1.50	15A*		M4	1.2 to 1.4		M4	1.2 to 1.4
Three-phase 200V	2.00	20A*	HIV 1.25	M4	1.2 to 1.4	HIV2.0	M4	1.2 to 1.4
	3.00	30A*				HIV3.5		
Three-phase 400V	0.50	05D*	HIV 1.25	—	—	HIV1.25	—	—
	1.00	10D*						
	1.50	15D*						
	2.00	20D*		M4	1.2 to 1.4		M4	1.2 to 1.4
	3.00	30D*						
	5.00	50D*				HIV2.0		

*1. Terminal symbols +24 V and 0 V are for 3-phase 400V FSP Amplifiers only.

- **Ground Terminal** ⏚

Main Circuit Power Supply	Capacity (kW)	Model	Ground Terminal		
		FSP-	Wire Type & Size (mm^2)	Terminal Screw Size	Tightening Torque (N·m)
Single-phase 100V	0.03	A3B*	HIV 2.0 or larger	M4	1.2 to 1.4
	0.05	A5B*			
	0.10	01B*			
	0.20	02B*			
Single-phase 200V	0.03	A3A*	HIV 2.0 or larger	M4	1.2 to 1.4
	0.05	A5A*			
	0.10	01A*			
	0.20	02A*			
	0.40	04A*			
Single-phase 220V	0.75	08A*	HIV 2.0 or larger	M4	1.2 to 1.4
	1.50	15A*			
Three-phase 200V	2.00	20A*	HIV 2.0 or larger	M4	1.2 to 1.4
	3.00	30A*			
Three-phase 400V	0.50	05D*	HIV 2.0 or larger	M4	1.2 to 1.4
	1.00	10D*			
	1.50	15D*			
	2.00	20D*			
	3.00	30D*			
	5.00	50D*		M5	1.6 to 2.4

- **Signal Line Wire Sizes**

  The following table shows appropriate cables for CN1 and CN2 FSP Amplifier connectors.

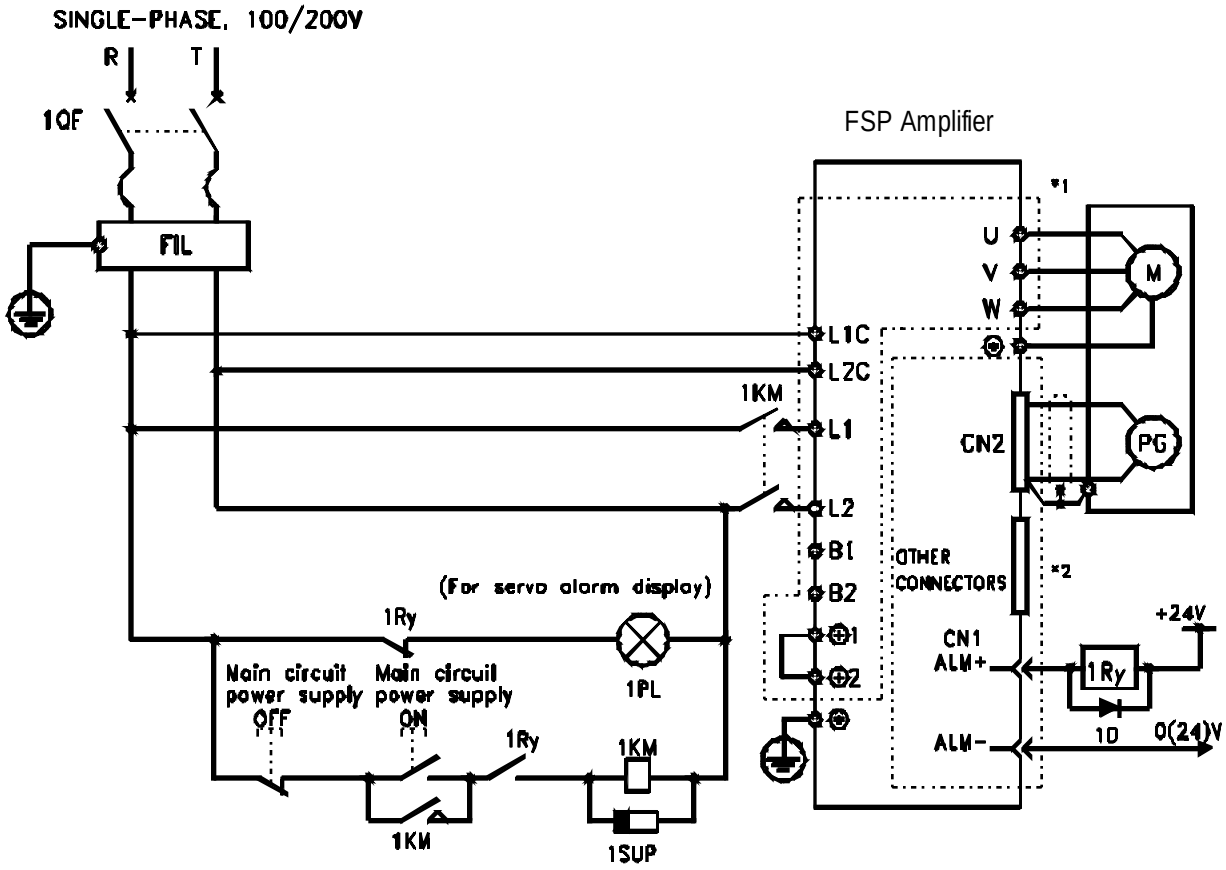
  Wire sizes were selected for three cables per bundle at 40ºC ambient temperature with the rated current.

Connector Name and Signal		Item	Specification
Control I/O Signal Connector	CN1	Cable	Twisted-pair or shielded twisted-pair wire.
		Applicable wire	AWG24 (0.2 mm^2), AWG26 (0.12 mm^2), AWG28 (0.08 mm^2), AWG30 (0.05 mm^2).
		Finished cable dimension	Ø 16.0 mm (Ø 0.63 in) MAX.
PG Signal Connector	CN2	Cable	Shielded twisted-pair wire.
		Applicable wire	AWG 24 (0.2 mm^2), AWG 26 (0.12 mm^2), AWG 28 (0.08 mm^2), AWG 30 (0.05 mm^2). Use AWG 22 (0.33 mm^2) for encoder power supply and AWG 26 (0.12 mm^2) for other signals. These conditions permit wiring distances up to 20 m (65.6 ft).
		Finished cable dimension	Ø 6.8 mm (Ø 0.27 in) MAX.

5.4. Typical Main Circuit Wiring Examples

Only qualified personnel should perform the wiring. Design the circuit so that the main circuit power supply turns OFF at emergency stop.

5.4.1. Single-phase 100V/200V Main Circuit



1QF	: Molded-case circuit breaker	1Ry	: Relay
FIL	: Noise filter	1PL	: Indicator lamp
1KM	: Magnetic contactor	1SUP	: Surge suppressor
		1D	: Flywheel diode

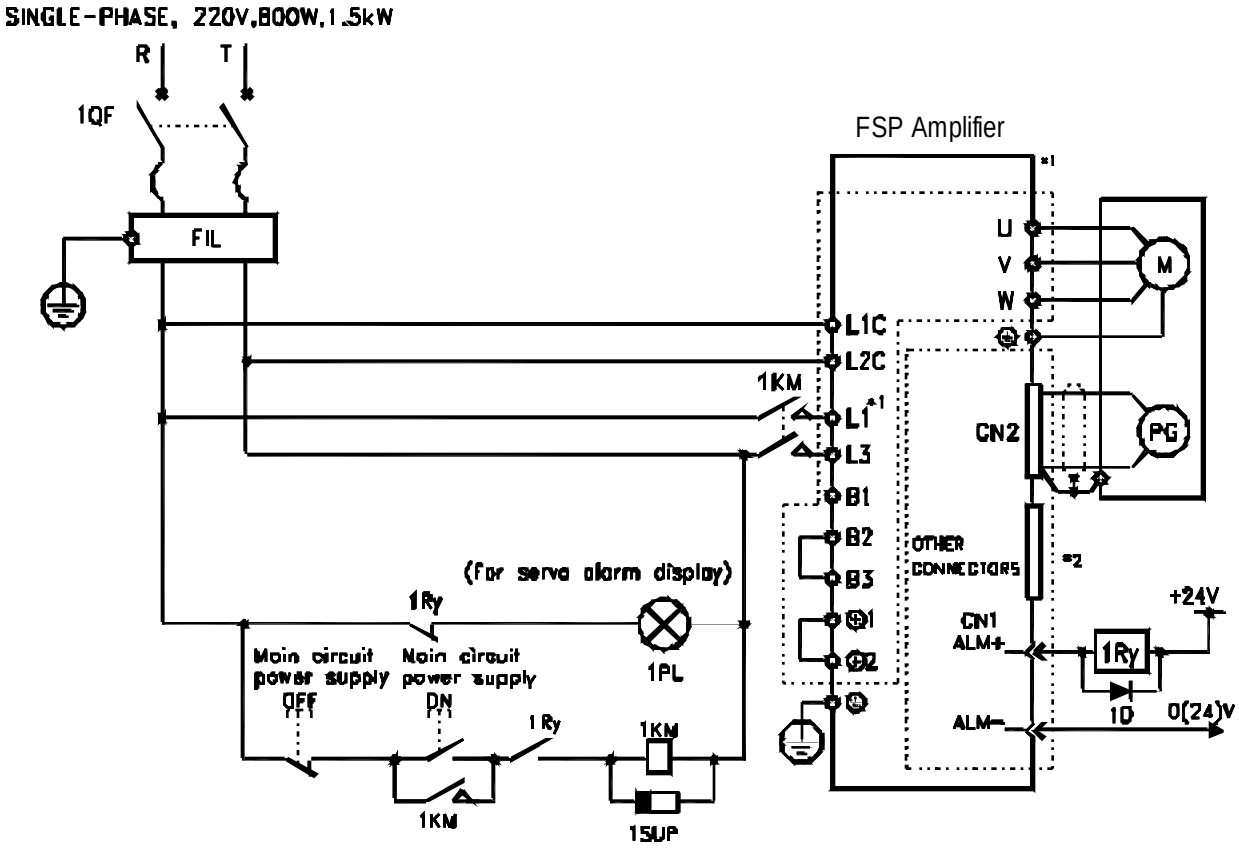
*1. These circuits are power lines. Do not touch these terminals when the power is ON to avoid electric shock.

*2. These circuits are SELV circuits and are separated from all other circuits by double and reinforced insulation. The CN1 input signal is available for sink or source circuits.

Note: Customers must purchase a 24VDC power supply with a double-shielded enclosure.

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5.4.2. Single-phase 200V 0.8kW and 1.5kW Main Circuit



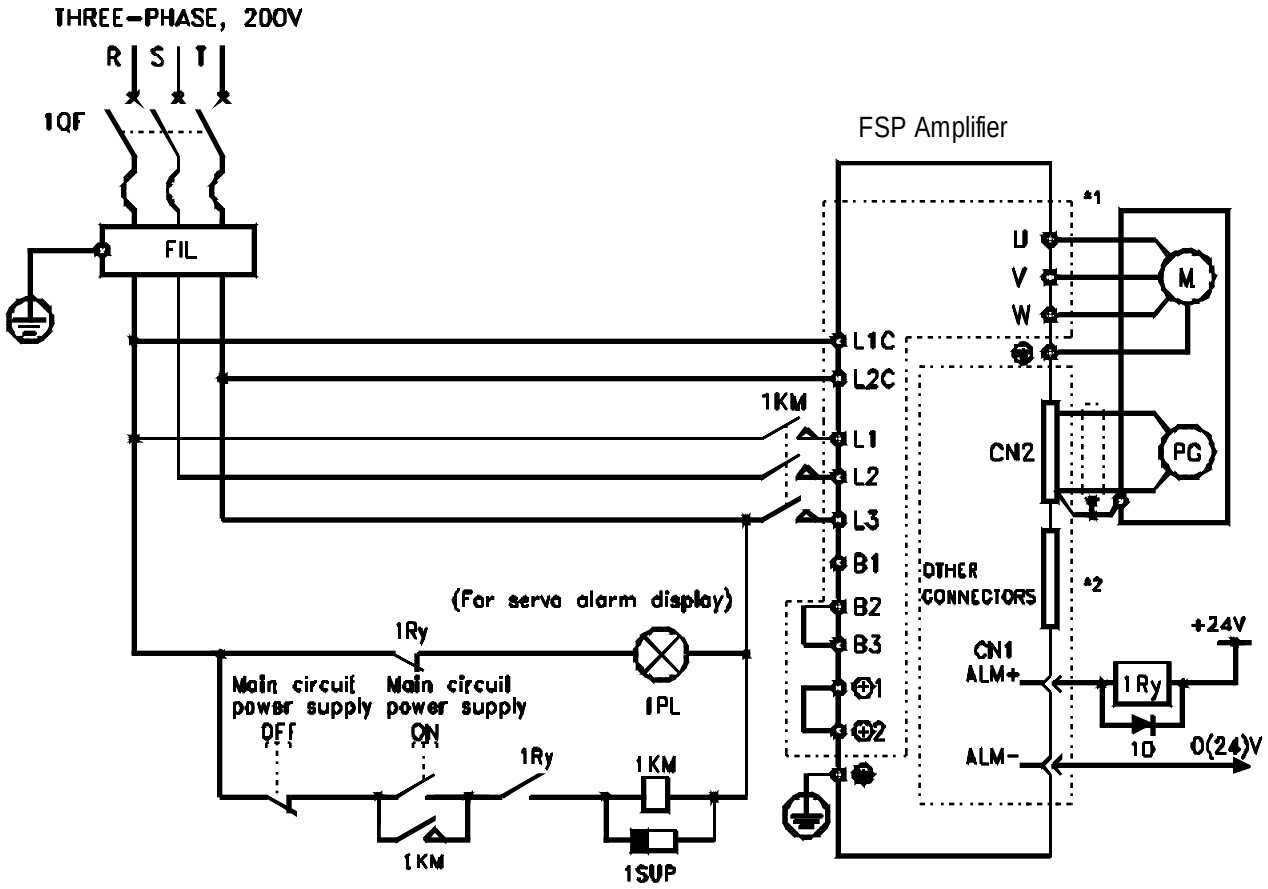
1QF : Molded-case circuit breaker
FIL : Noise filter
1KM : Magnetic contactor
1Ry : Relay
1PL : Indicator lamp
1SUP : Surge suppressor
1D : Flywheel diode

*1. These circuits are power lines. Do not touch these terminals when the power is ON to avoid electric shock.

*2. These circuits are SELV circuits and are separated from all other circuits by double and reinforced insulation. The CN1 input signal is available for sink or source circuits.

Note: Customers must purchase a 24 VDC power supply with a double-shielded enclosure.

5.4.3. Three-phase 200V Main Circuit

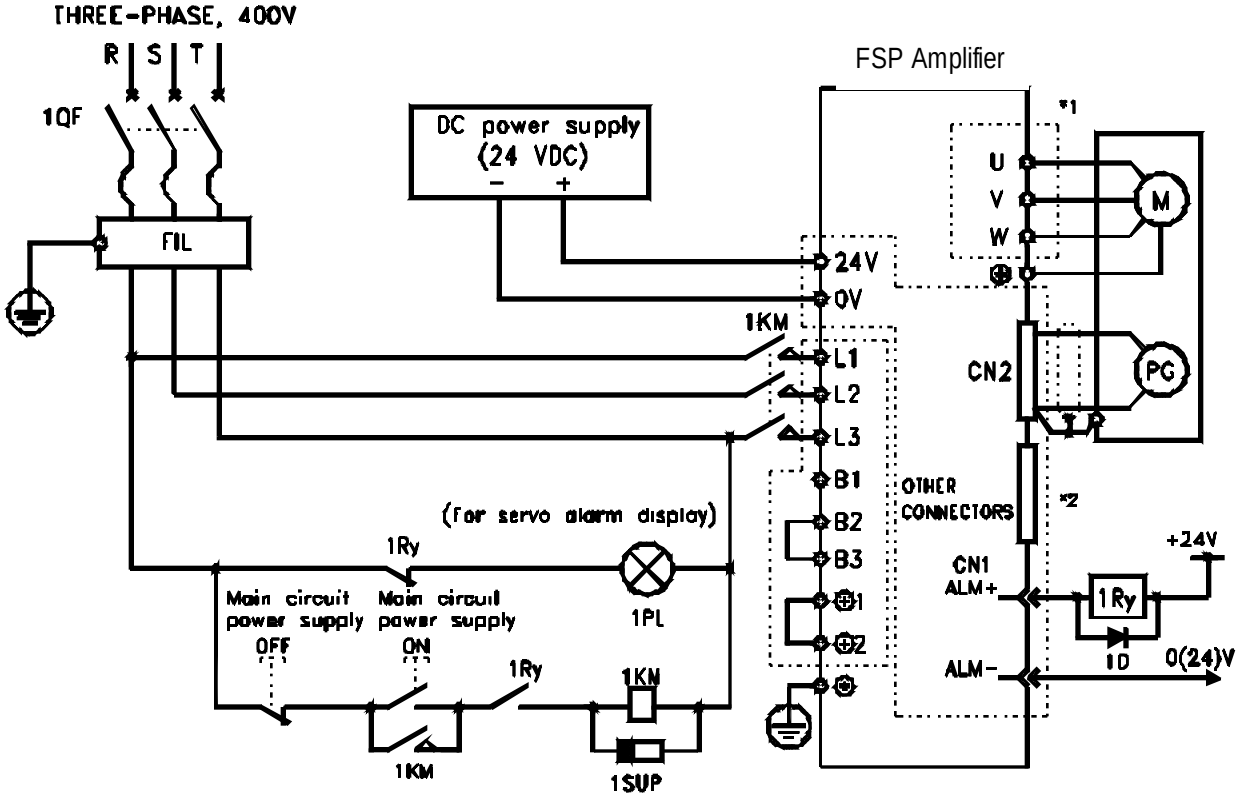


1QF : Molded-case circuit breaker
FIL : Noise filter
1KM : Magnetic contactor
1Ry : Relay
1PL : Indicator lamp
1SUP : Surge suppressor
1D : Flywheel diode

*1. These circuits are power lines. Do not touch these terminals when the power is ON to avoid electric shock.
*2. These circuits are SELV circuits and are separated from all other circuits by double and reinforced insulation. The CN1 input signal is available for sink or source circuits.

Note: Customers must purchase a 24VDC power supply with a double-shielded enclosure.

5.4.4. Three-phase 400V Main Circuit



1QF : Molded-case circuit breaker	1Ry : Relay
FIL : Noise filter	1PL : Indicator lamp
1KM : Magnetic contactor	1SUP : Surge suppressor
	1D : Flywheel diode

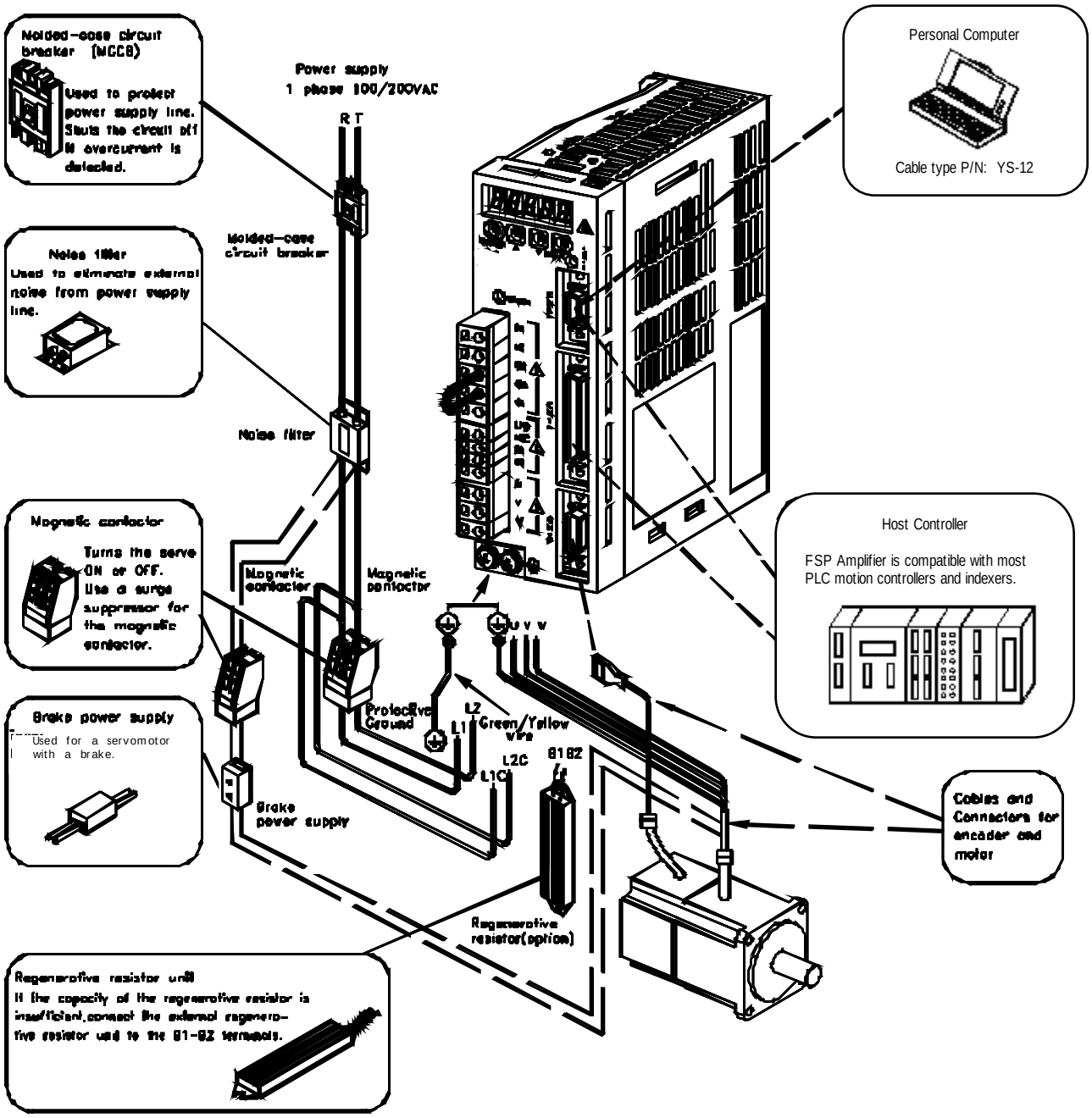
*1. These circuits are power lines. Do not touch these terminals when the power is ON to avoid electric shock.

*2. These circuits are SELV circuits and are separated from all other circuits by double and reinforced insulation. The CN1 input signal is available for sink or source circuits.

Note: Customers must purchase a 24VDC power supply with a double-shielded enclosure.

5.5. Main Circuit Wiring Graphic Diagrams

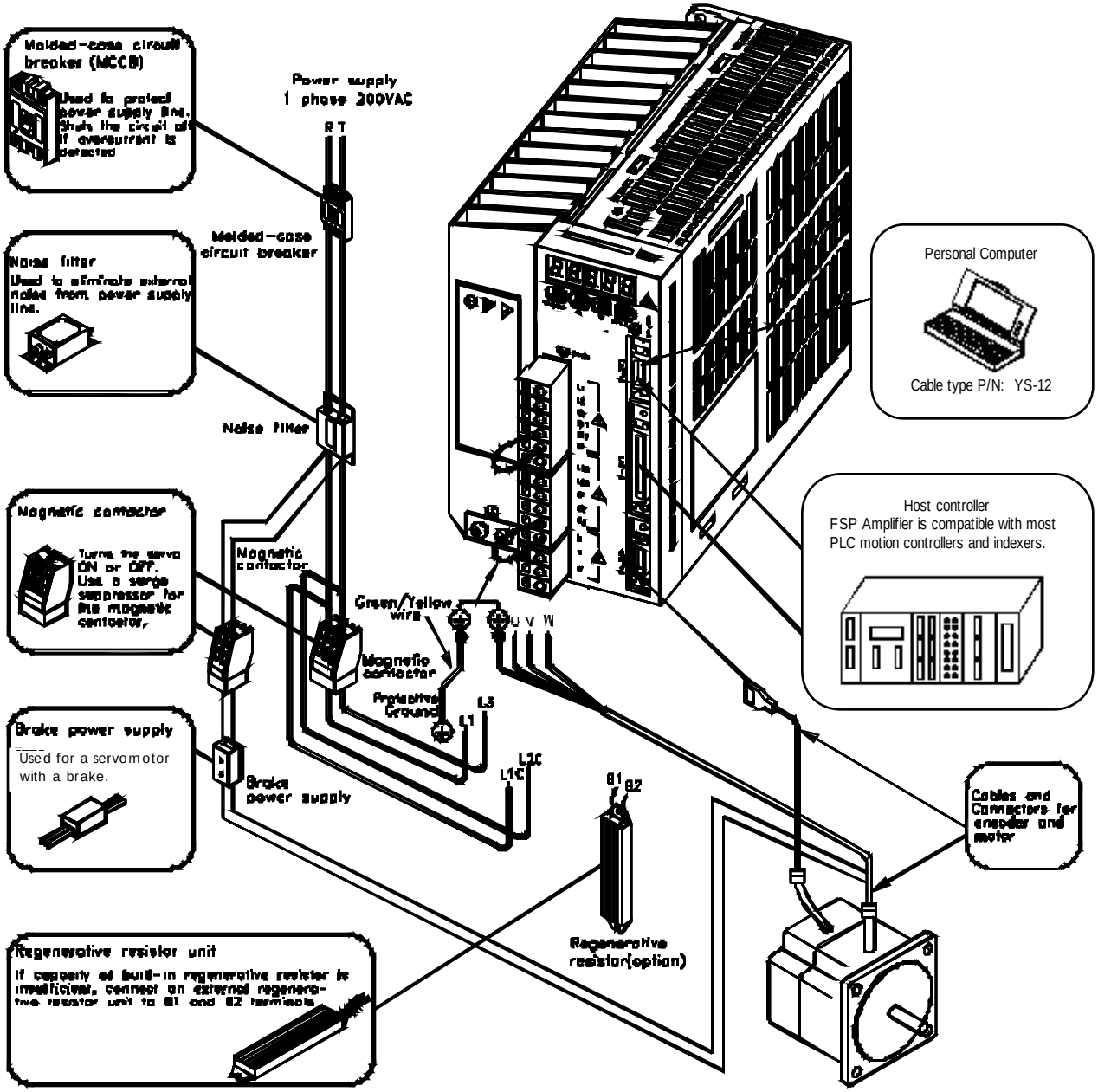
5.5.1. Single-phase 100V/200V Main Circuit



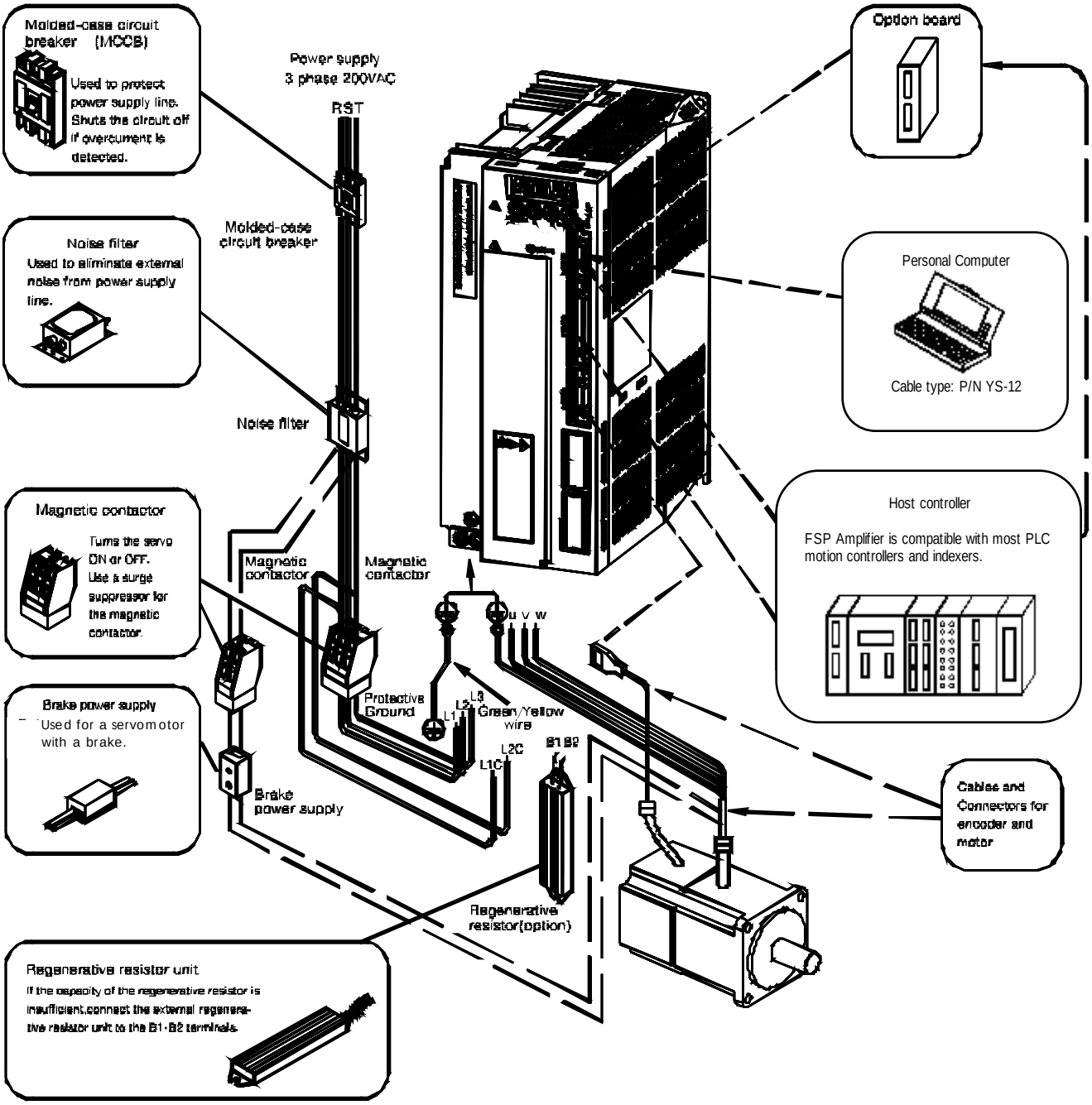
5.5.2. Single-phase 200V 0.8kW and 1.5kW Main Circuit

Observe the following points.

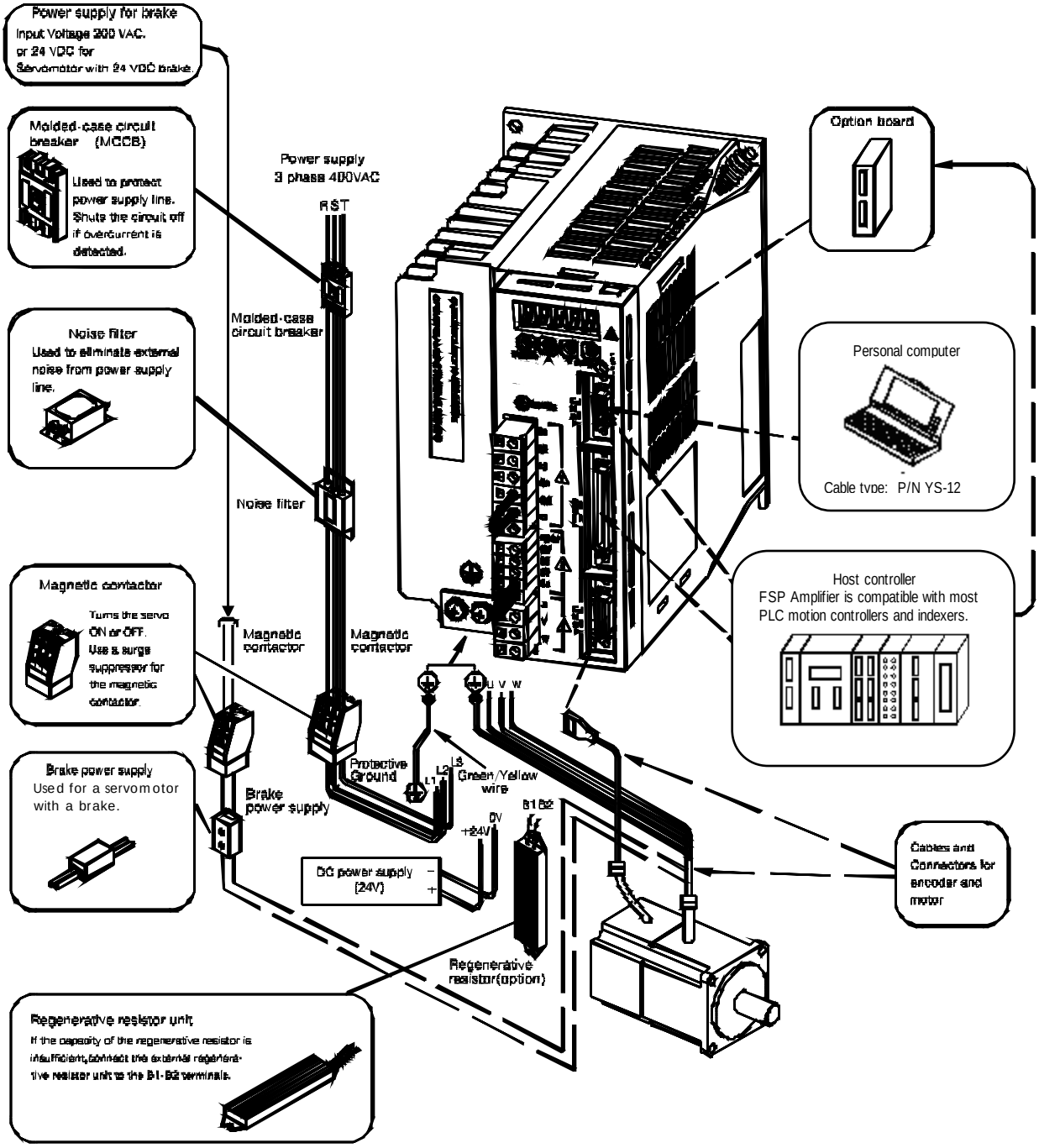
1. Connect main power supply shown below to **L1** and **L3** terminals. Power supply is single-phase, 220 to 230VAC +10% to -15%, 50/60Hz. If power supply of 187 V (-15% of 220V) or less is used, alarm A.41 indicating voltage shortage, may occur when accelerating to max speed with max torque of motor.
2. Short-circuit **B2** and **B3** terminals using the internal regenerative resistor. If capacity of the regenerative resistor is insufficient, remove the lead between **B2** and **B3** terminals and connect an external regenerative resistor unit to **B1** and **B2** terminals.



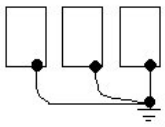
5.5.3. Three-phase 200V Main Circuit



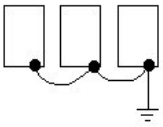
5.5.4. Three-phase 400V Main Circuit



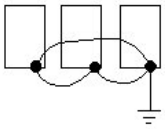
- In conformance with local electrical codes, ground the FSP Amplifier grounding terminal ⏚(grounding resistance: 100 Ω or less).
- Be sure to connect the grounding wire of the servomotor to ⏚ of the FSP Amplifier.
- Never share the grounding cable or main grounding point with welding equipment, power equipment or other high-voltage devices. Separate the grounding cable from wiring of high-voltage equipment.
- Make the grounding wire as short as possible.
- If two or more FSP Amplifiers are used, ground them as shown in (a) below.
- Avoid methods (b) and (c).



GOOD
(a)



POOR
(b)



POOR
(c)

5.6. AC Power Source Supply

Use the FSP Amplifier AC power source supply according to product ratings. See the following table for details.

Power	FSP Amplifier	Motor Output	Specifications	Connection Terminals
Single-Phase 200V	FSP-A3A* to FSP-04A*	30, 50, 100, 200, and 400W	1-phase 200VAC to 230VAC (+10% to -15%), 50/60 Hz	L1, L2 (Main) LIC, L2C (Control)
	FSP-08A* and FSP-15A*	750 W and 1.5kW	1-phase 220VAC to 230VAC*1 (+10% to -15%), 50/60 Hz	L1, **L3** (Main)
			1-phase 200VAC to 230VAC (+10% to -15%), 50/60 Hz	L1C, L2C (Control)
Three-Phase 200V	FSP-10A* to FSP-30A*	1.0, 2.0, and 3.0kW	3-phase 220VAC to 230VAC (+10% to -15%), 50/60 Hz	L1, L2, L3 (Main)
			1-phase 200VAC to 230VAC (+10% to -15%), 50/60 Hz	L1C, L2C (Control)
Three-Phase 400V	FSP-05D* to FSP-50D*	0.5, 1.0, 1.5, 2.0, 3.0 and 5.0kW	3-phase 380VAC to 480VAC (+10% to -15%), 50/60 Hz	L1, L2, L3 (Main)
			DC power supply +24V (±15%) (not provided by YET)	24 V, 0 V (Control)

*1. When a power supply of 187V (-15% of 220V) or less is used, alarm A.41, indicating voltage shortage, may occur when accelerating to max speed with max torque of servomotor.

5.7. DC Power Source Supply

3-Phase 400V FSP Amplifier models require 24VDC for its control circuit. The user must provide a 24VDC ± 15% power supply with a current capacity of at least 1 Amp. This power supply must also be able to withstand a surge of up to 3A for 50ms. It should be connected to the terminals marked 24V and 0V on the FSP Amplifier.

WARNING

- **Do not connect AC voltage to these terminals.**
  Doing so may cause permanent damage to the amplifier.

5.8. Noise Control

- If the signal line is affected by noise, malfunction may result.
- Separate power cables from control cables.
- Make the signal line as short as possible and use twisted-pair wires.
- Never use a line filter (for power input) for servomotor circuit. If peripheral devices malfunction due to the noise from the FSP Amplifier, insert a line filter (for output, type LF-310KA, made by Tokin Corp.) between the servomotor and the FSP Amplifier.

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6. Operation

This section describes precautions that should be taken at test run and during operation. For instructions on test run and operation, refer to the Sigma FSP Servo System User's Manual (Document # YEA-SIA-FSP-3).

6.1. Precautions at Test Run

⚠ CAUTION

- **To avoid accidents, run the servomotor only in test run (without load).**
  Failure to observe this caution could result in personal injury.
- **Before starting operation with a load connected, set up user constants suitable for the machine.**
  Failure to do so could result in overrun failure. When the load moves vertically, incorrect setting of the user constants could cause the load to fall.
- **Before starting operation with a load connected, make sure emergency-stop procedures are in place.**
  Failure to observe this caution could result in personal injury.

6.2. Conducting Test Run for Servomotor Without Load

When the servomotor is operated without a load, set the speed loop gain (user constant Pn100) to 40 or less. (The factory setting is 40.)

The speed loop gain (user constant Pn100) is determined by:
Load inertia ≥ (servomotor inertia × N) where $1 \leq N \leq 3$.

Therefore, if the servomotor is rotated without a load (i.e., without load inertia) or if the load inertia is small, the servomotor may oscillate. To avoid this possibility, set the value of Pn100 (speed loop gain) to 40 or less and then switch servo ON.

6.3. Conducting Test Run with Servomotor Connected to Machine

Initial parameters for the FSP Amplifier are set assuming normal operation conditions. Before conducting a test run, set up user constants suitable for the machine. Failure to do so could result in machine overrun or breakdown.
For the setting procedures and methods, refer to the Sigma FSP Servo System User's Manual (Document # YEA-SIA-FSP-3).

The following items should be checked during the test run:
- Unusual vibration
- Abnormal noise
- Excessive temperature rise

6.4. Precautions During Operation

CAUTION

- **During operation, do not touch the FSP Amplifier's heat sink.**
  Failure to observe this caution could result in burns.
- **Motor overload protection is provided internally.**
  Refer to the Sigma FSP Servo System User's Manual (Document # YEA-SIA-FSP-3) for rating.

7. Inspection and Maintenance

This section describes the basic inspection and maintenance procedures for the FSP Amplifier and battery replacement for absolute encoder. If any failure occurs on the FSP Amplifier, refer to the Sigma FSP Servo System User's Manual (Document # YEA-SIA-FSP-3), *Troubleshooting*.

Contact your YEA representative if the problem persists.

⚠ WARNING

- **Be sure to turn OFF power before inspection or maintenance.**
  Failure to observe this warning could result in electric shock.
- **Never open the terminal cover while power is ON, and never turn ON power when the terminal cover is open.**
  Failure to observe this warning could result in electric shock.
- **After turning OFF power, wait at least five minutes before servicing the product.**
  Otherwise, residual electric charges could result in electric shock.

⚠ CAUTION

- **Never change wiring while power is ON.**
  Failure to observe this caution could result in electric shock or personal injury.

7.1. FSP Amplifier Inspection

The inspection and maintenance procedures listed in the table below should be performed at least once every year.

Item	Frequency	Procedure	Remedy
Clean unit interior and circuit boards	At least once per year	Check for dust, dirt and oil on surfaces.	Clean with compressed air if necessary.
Loose screws	At least once per year	Check for loose terminal block and connector screws.	Tighten any loose screws.
Defective parts in unit or on circuit boards	At least once per year	Check for discoloration or damage due to heating.	Contact your YEA representative.

7.2. Part Replacement Period

The following parts are subject to mechanical wear or deterioration over time. To avoid failure, replace these parts at the frequency indicated.

If the FSP Amplifier has been repaired at YEA, its parameters will be set back to standard settings at shipment. Always check parameters before operating the servomotor.

Part	Standard Replacement Period	Replacement Method	Operating Conditions
Cooling Fan	4 to 5 years	Replace with new part	• Ambient temperature: annual average 30ºC • Load factor: 80% max. • Operation rate: 20 hours/day max.
Smoothing Capacitor	7 to 8 years	Test. Replace with new part if necessary.	
Relays	—	Test. Replace if necessary.	
Fuse	10 years	Replace with new part.	
Electrolytic Capacitor on Circuit Board	5 years	Test. Replace with new circuit board if necessary.	

7.3. Replacing the Battery for an Absolute Encoder

Battery replacement is only required for servo systems using an absolute encoder. When battery voltage is 2.7 V or less, the FSP Amplifier outputs an absolute encoder battery alarm (A.83, when using Yaskawa Sigma II motors with an absolute encoder) only when the FSP Amplifier's power is ON, but not while the FSP Amplifier is operating.

7.3.1. Recommended Battery

Lithium battery: ER3V, manufactured by Toshiba Battery Co. Ltd., 3.6 V 1000 mAh or other compatible lithium battery.

Battery kit (battery with connector) for Absolute Encoder Cable Adapter or wiring into CN1: JZSP-BA01

Battery kit (battery with connector) for wiring into CN1: JZSP-BA01-1
For wiring into CN1, refer to the Sigma FSP Servo System User's Manual (Document # YEA-SIA-FSP-3), *Absolute Encoder Battery*.

Note: The JZSP-BA01-1 has leads 3 cm longer than the JZSP-BA01.

7.3.2. Replacing the Battery

1. With the FSP Amplifier's control power turned ON, replace the old battery with a new one.
2. Turn OFF the FSP Amplifier's control power to clear the absolute encoder battery alarm (A.83).
3. Turn ON the FSP Amplifier's control power.
4. Make sure that FSP Amplifier is operating normally after power is turned on.

Battery replacement is now completed. After replacing the battery, initialize the absolute encoder. Refer to the Sigma FSP Servo System User's Manual (Document # YEA-SIA-FSP-3), *Initializing of Absolute Encoder*.

8. Installation Conditions of EMC Directive

The following conditions must be satisfied for a combination of servomotor and the FSP Amplifier to comply with EMC Directives (EN61000-6-2 and EN55011, Group 1 Class A).

8.1. EMC Installation Conditions

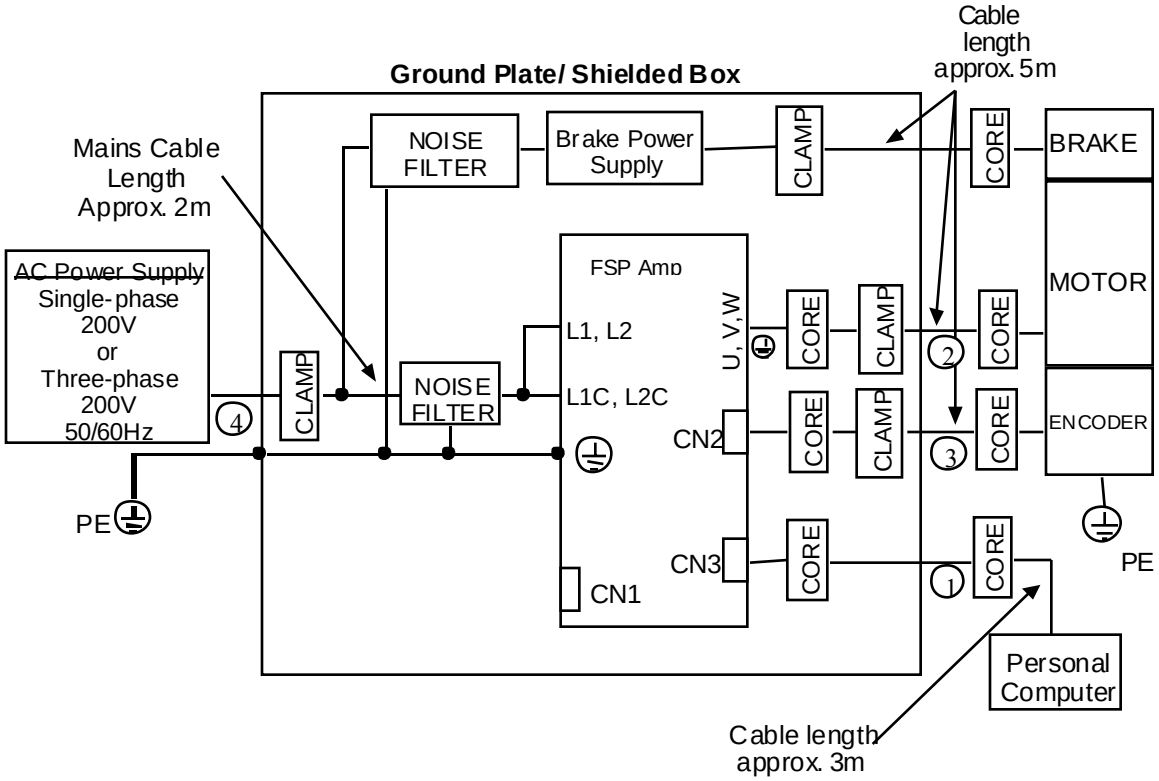
This section describes the test installation conditions prepared by YEA that meet EMC guidelines for all FSP Amplifier models. The actual EMC level may differ depending on the actual system's configuration, wiring and other conditions.

8.1.1. Installation: Single & Three-phase 100/200V FSP Amplifier (PC)

FSP-A3A* to -30A*(30W to 3.0kW)

Represents option with PC connected to CN3 connector.

Note: Shielded Box with door closed



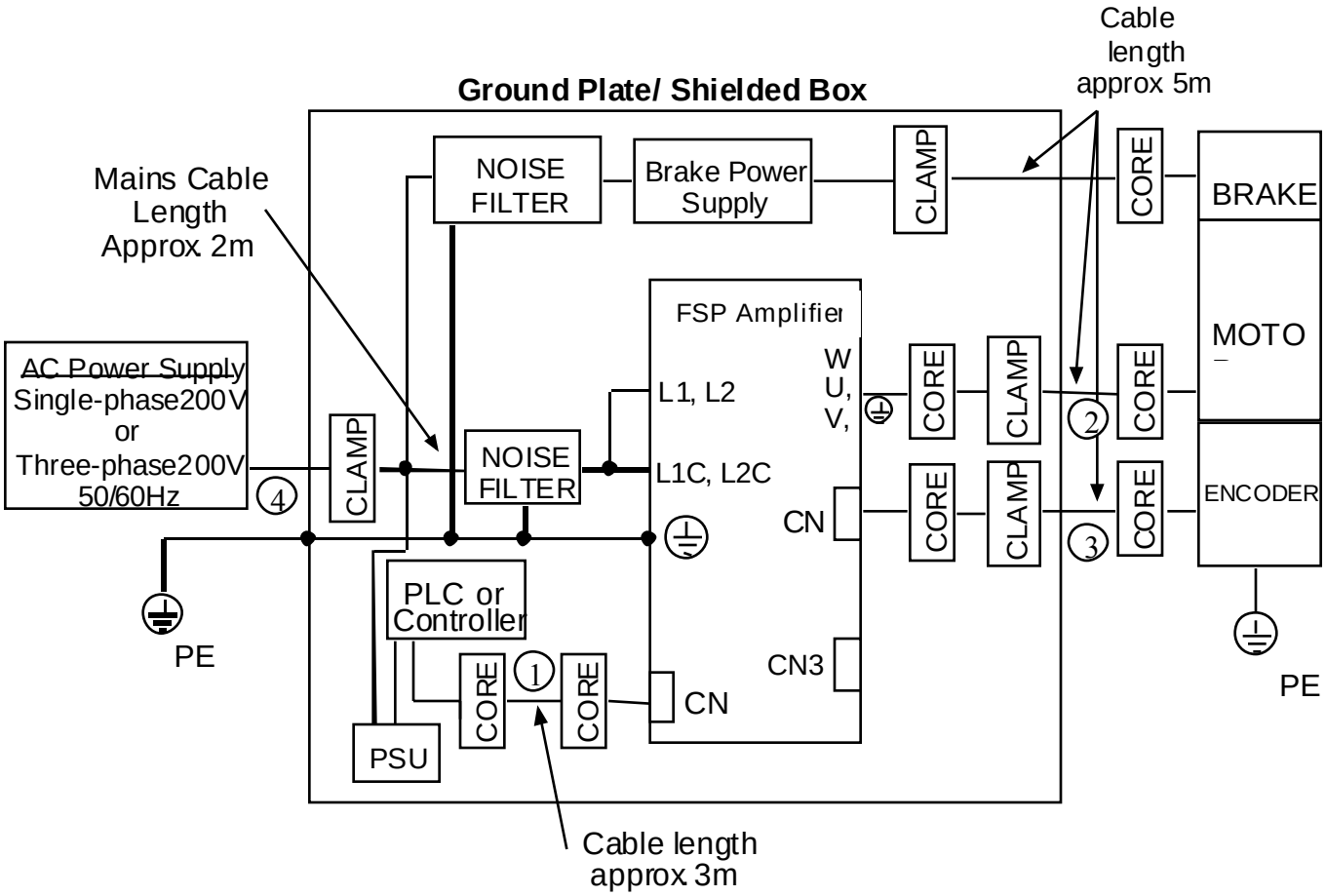
Symbol	Cable Name	Specification
①	PC communication cable	Shielded cable
②	Servomotor cable	Shielded cable
③	Encoder cable	Shielded cable
④	AC line cable	Shielded cable

8.1.2. Installation: Single & Three-phase 100/200V FSP Amplifier (PLC)

FSP-A3A* to -30A*(30W to 3.0kW)

Represents option with PLC or controller connected to CN1 connector.

Note: Shielded Box with door closed



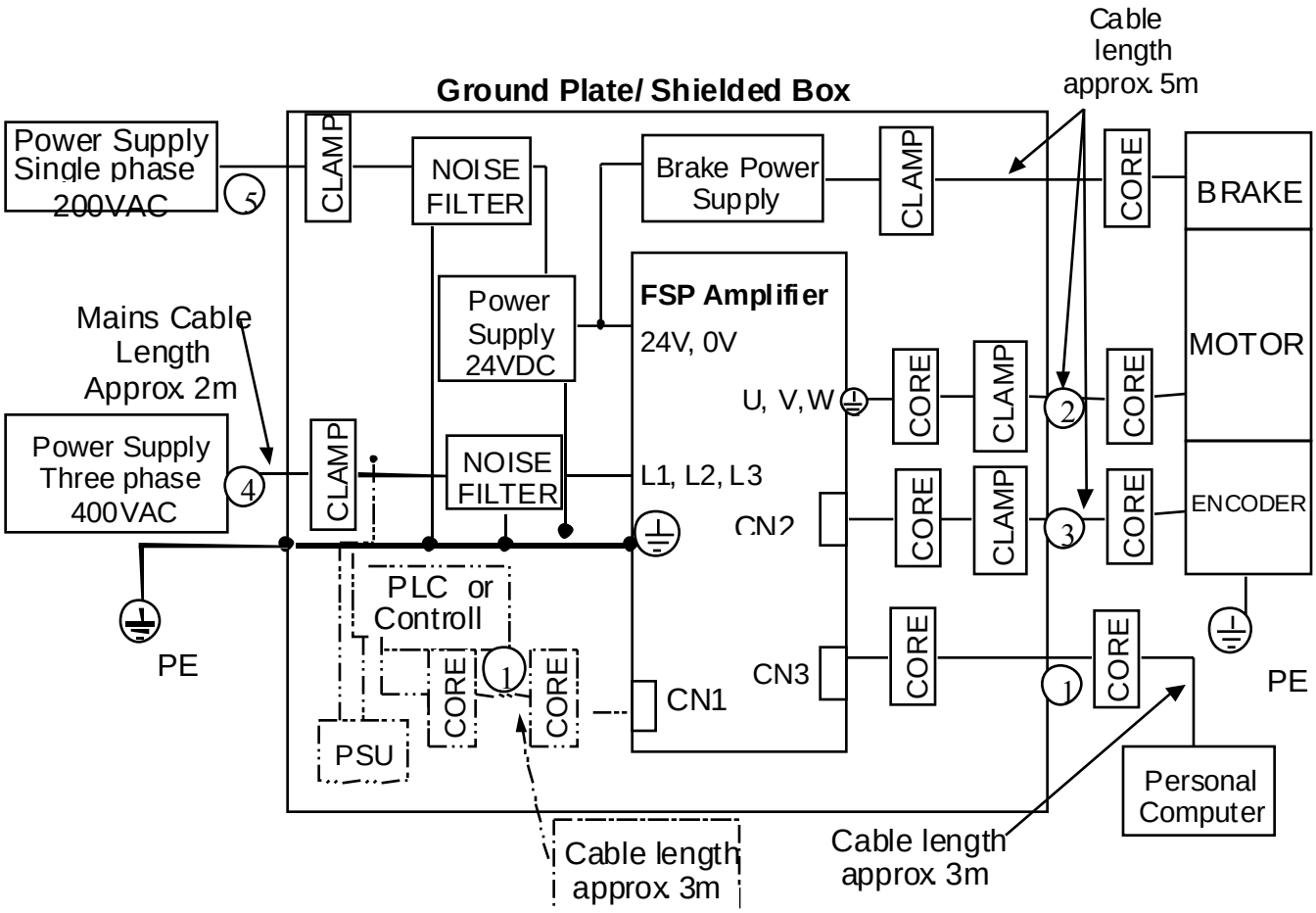
Symbol	Cable Name	Specification
①	PLC communication cable	Shielded cable
②	Servomotor cable	Shielded cable
③	Encoder cable	Shielded cable
④	AC line cable	Shielded cable

8.1.3. Installation: Three-phase 400 V FSP Amplifier

FSP-10D* to -30D* (0.5 kW to 3.0 kW)

Represents option with PLC or controller connected to CN1 connector or PC connected to CN3 connector.

Note: Shielded Box with door closed



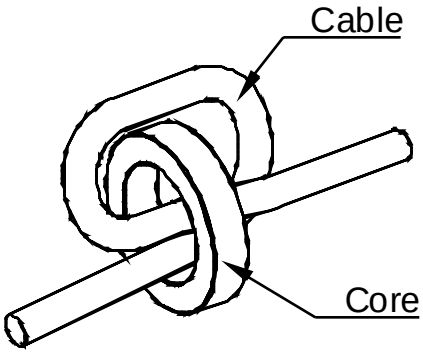
Represents option with PLC or controller connected to CN1 connector.

Symbol	Cable Name	Specification
①	PLC, Controller or PC communication cable	Shielded cable
②	Servomotor cable	Shielded cable
③	Encoder cable	Shielded cable
④	AC line cable	Shielded cable
⑤	AC line cable	Shielded cable

8.2. Cable Core and Cable Clamp

8.2.1. Cable Core

Attach the core on the cable as shown in the diagram below, which shows two turns of the cable:

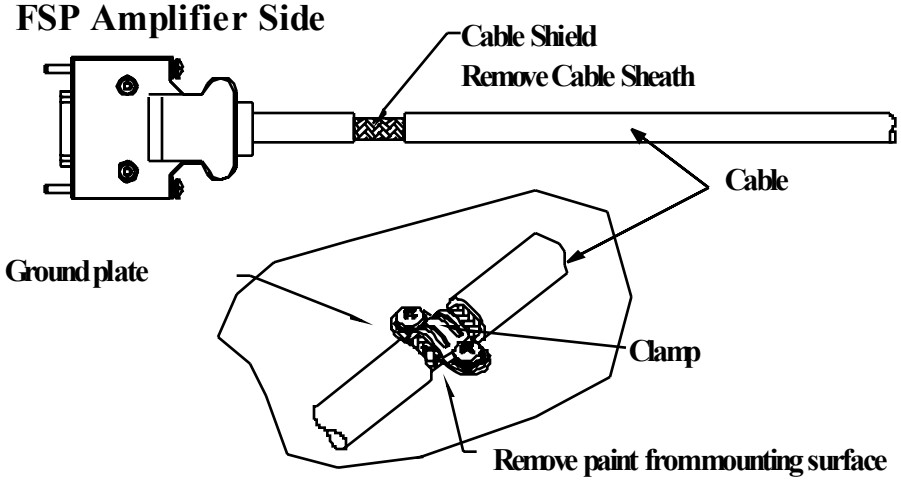


The table below lists the cable names and the mounting positions of the core:

Cable Name	Core Mounting Position
Controller cable	Near the Controller and the FSP Amplifier.
Servomotor cable	Near the FSP Amplifier and the servomotor.
Encoder cable	Near the FSP Amplifier and the servomotor.

8.2.2. Cable Clamp

Fix and ground the cable shield using a piece of conductive metal. The figure below shows an example of a cable clamp, controller side.



9. Peripheral Devices

9.1. Peripheral Device Types and Capacities

The following table gives examples of peripheral devices for use with Yaskawa or other compatible motors.

Main Circuit Power Supply	Model		Power Supply Capacity per FSP Amplifier (kVA)	MCCB or Fuse Capacity *1 (A_{rms})	Recommended Noise Filter *2		Magnetic Contactor Current (A)
	Capacity (kW)	FSP-			Model	Specifications	
Single-phase 100 V	0.03	A3B *	0.15	4	FN2070-6/07	Single-phase 250 VAC, 6A	20
	0.05	A5B *	0.25				
	0.10	01B *	0.40				
	0.20	02B *	0.60	6	FN2070-10/07	Single-phase 250 VAC, 10A	
Single-phase 200 V	0.03	A3A *	0.2	4	FN2070-6/07	Single-phase 250 VAC, 6A	20
	0.05	A5A *	0.25				
	0.10	01A *	0.40				
	0.20	02A *	0.75				
	0.40	04A *	1.2	8	FN2070-10/07	Single-phase 250 VAC, 10A	20
	0.75	08A *	2.1	11	FN2070-16/07	Single-phase 250 VAC, 16 A	35
	1.5	15A *	4.0	19	FN350-30/33	Single-phase 250 VAC, 30 A	
Three-phase 200 V	1.0	10A *	2.3	7	FN258L-16/07	Three-phase 480VAC, 16A	35
	2.0	20A *	4.3	13			
	3.0	30A *	5.9	13	FN258L-30/07	Three-phase 480VAC, 30A	35
Three-phase 400 V	0.45	05D *	1.2	1.7	FN258L-7/07	Three-phase 480 VAC, 7 A	35
	1.0	10D *	2.3	3.4			
	1.5	15D *	3.2	4.6			
	2.0	20D *	4.9	7.1	FN258L-16/07	Three-phase 480 VAC, 16 A	35
	3.0	30D *	6.8	9.8			
	5.0	50D *	10.3	14.9	FS5559-35-33	Three-phase 480 VAC, 35 A	50

*1. This is net value for rated load. When selecting fuses, determine the capacity using the prescribed derating. Braking characteristics at 25°C: 200% for 2 seconds minimum; 700% for 0.01 second minimum.
*2. The FN type noise filter is manufactured by Schaffner.

9.2. Noise Filter for Brake Power Supply

The table below shows the recommended noise suppression filters models:

Circuit	Filter model	Manufacturer
Brake power circuit	FN2070-6/X[*3] or FMW2-52-6/07	Schaffner or Timonta

*3 Replace X with connection type: 07 = wire, 06 = for soldering or fast-on.

9.3. Cable Specifications

Shield cables should be used for the following cables:

- AC power input line cable (between power supply and noise filter)
- Servomotor cable (between FSP Amplifier and servomotor)
- Encoder cable (between FSP Amplifier and servomotor)
- Controller cable (between FSP Amplifier and controller)

9.4. Recommended Ferrite Cores

Cable	Encoder Cable		Power Cable	
Manufacturer	**Absolute**	**Serial**	**30W to 400W**	**0.8kW to 5kW**
Tokin Corp.	ESD-SR-25	ESD-SR-25	ESD-SR-25	—
Fair-Rite Corp.	0444173551	0444164181	0444173551	—
TDK Corp.	—	—	—	PC40T96x20x70

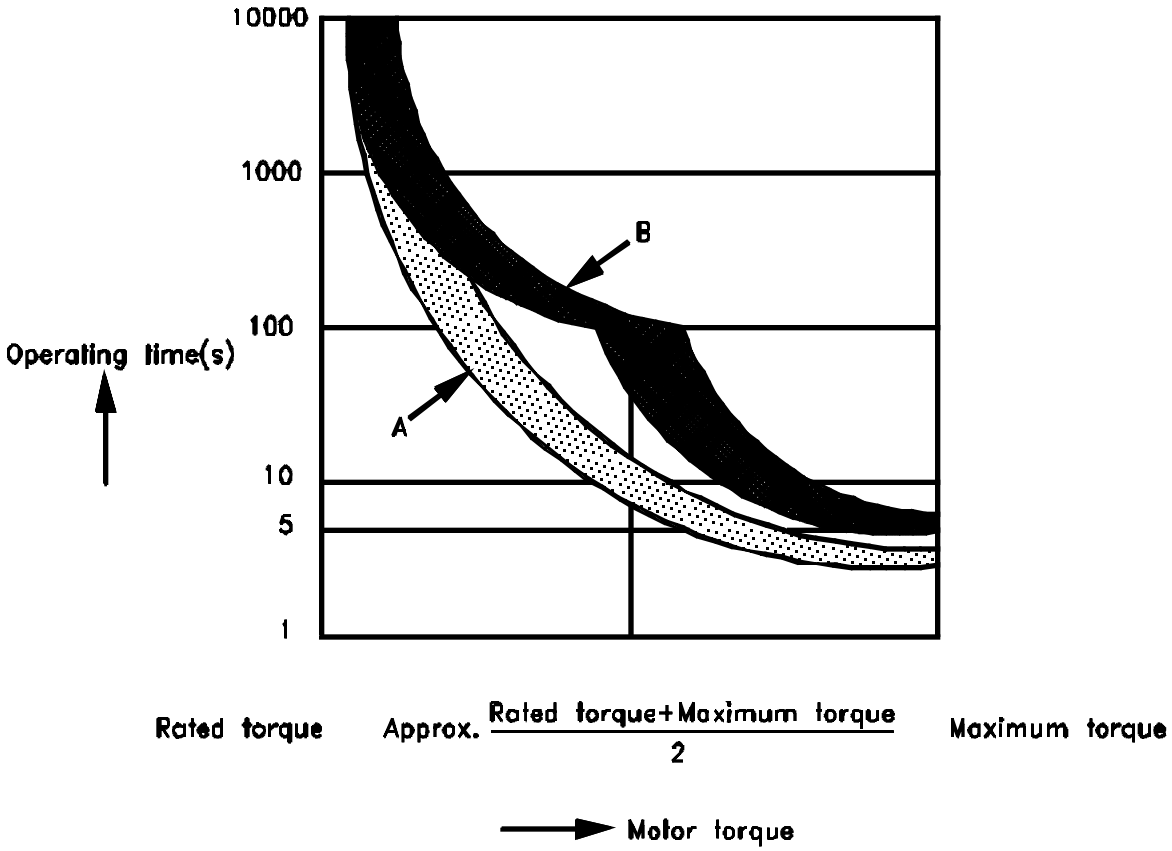
9.5. Shield Box

A shield box, a closed metallic enclosure, should be used for shielding from electromagnetic interference. The structure of the box should allow the main body, door, cooling unit etc. to be attached to the ground. The box opening should be as small as possible.

10. Overload Characteristics

The FSP Amplifier has a built-in overload protective function that protects the amplifier-motor pair from overload. Allowable power for the FSP Amplifier is limited by the overload protective function as shown in the figure below.

The overload detection level is set under hot start* conditions at a servomotor ambient temperature of 40ºC (104ºF).



* A hot start indicates that both the FSP Amplifier and servomotor have run long enough at the rated load to be thermally saturated.

Note: The overload protection characteristics of A and B in the figure are applicable when the FSP Amplifier is combined with one of the following Yaskawa servomotors:

A: SGMAH or SGMPH servomotor with capacity of maximum 400W.

B: SGMAH or SGMPH servomotors with a capacity more than 400W and SGMGH, SGMSH, SGMDH and SGMUH servomotors.

11. Appendix A

11.1. I/O Signals Connector CN1

CN1 connector is required to connect the host controller to the FSP Amplifier. It comprised of a connector and a connector cover.

- **Mating 50-Pin Connector Model (Kit)**

	YEA P/N	Connector Parts
Connector	4J4003	10150-3000VE *
Case		10350-52A0-008 *

* Manufactured by Sumitomo 3M Co.

- **Terminal Layout**

Pin No.	Name	Pin No.	Name
1	Signal Ground	26	/V-CMP- (out 1-)
2	Signal Ground	27	/TGON+ (out 2+)
3	PL1	28	/TGON- (out 2-)
4	SEN	29	/S-RDY+ (out 3+)
5	V-REF	30	/S-RDY- (out 3-)
6	Signal Ground	31	ALM+ (out 4+)
7	PULS	32	ALM- (out 4-)
8	/PULS	33	PAO
9	T-REF	34	/PAO
10	Signal Ground	35	PBO
11	SIGN	36	/PBO
12	/SIGN	37	ALO1
13	PL2	38	ALO2
14	/CLR	39	ALO3
15	CLR	40	/S-ON
16	TMON	41	/P-CON
17	VTG	42	P-OT
18	PL3	43	N-OT
19	PCO	44	/ALM-RST
20	/PCO	45	/P-CL
21	BAT+	46	/N-CL
22	BAT-	47	+24V IN
23	NC*	48	PSO
24	NC*	49	/PSO
25	/V-CMP+ (out 1+)	50	NC*

Note: NC – Leave contact open (Not Connected)

11.2. Encoder Connector CN2

■ Mating 20-Pin Connector Model

	YEA P/N	Connector Parts
Connector	4J4001	10120-3000VE*
Cover	4J0101	10320 - 52A0-008*

* Manufactured by Sumitomo 3M Co.

■ Terminal Layout

Pin No.	Name	Pin No.	Name
1	PG GND	11	Serial PG GND
2	PG GND	12	BAT+
3	PG GND	13	BAT-
4	PG +5V	14	PC
5	PG +5V	15	/PC
6	PG +5V	16	PA
7	NC*	17	/PA
8	PS	18	PB
9	/PS	19	/PB
10	Serial PG +5V	20	NC*

Note: NC – Leave contact open (Not Connected)

■ Terminal Layout for Encoder Connector with Commutation Sensors (Optional)

Pin No.	Name	Pin No.	Name
1	PG GND	11	Serial PG GND
2	PG GND	12	BAT+
3	PG GND	13	BAT-
4	PG +5V	14	PC
5	PG +5V	15	/PC
6	PG +5V	16	PA
7	/UIN	17	/PA
8	NC*	18	PB
9	/VIN	19	/PB
10	Serial PG +5V	20	/WIN

Note: NC – Leave contact open (Not Connected)

11.3. Serial Communication Connector CN3

■ Mating 14-Pin Connector Model

YEA P/N	Connector Parts	
4J4002	**Connector**	10114-3000VE*
4J0102	**Cover**	10314-52A0-008*

* Manufactured by Sumitomo 3M Co.

■ Terminal Layout

Pin No.	Name	Pin No.	Name
1	TXD	8	TXD
2	/TXD	9	/TXD
3	RXD	10	RXD
4	/RXD	11	NC*
5	NC*	12	NC*
6	/RXD	13	+5V
7	RT (termination resistor)	14	GND

Note: NC – Leave contact open (Not Connected)

11.4. Analog Monitor Connector CN5

■ Mating 4-Pin Connector Model

	YEA P/N	Model
Socket	4J7004	DF11-4DS-2C*
Pin	4J0414	DF11-EP2428SCA*

* Manufactured by Hirose Electric Co.

■ Mating Cable Model

YEA P/N	Model
4W1003	DE9404559*

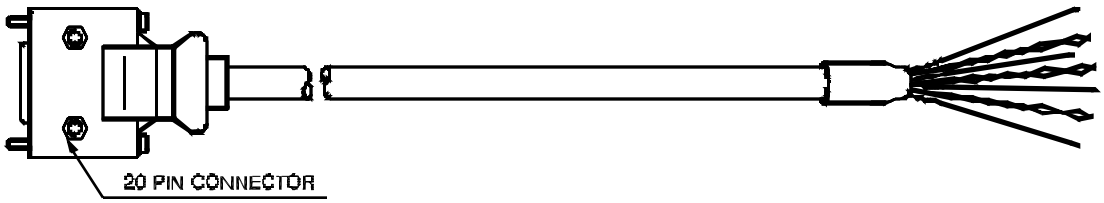
* Manufactured by Yaskawa Electric Co.

■ Terminal Layout

Pin No.	Wire Color	Name
1	Red	Analog Monitor 2
2	White	Analog Monitor 1
3	Black	GND
4	Black	GND

11.5. Connecting NON-Yaskawa Motor with A/B Encoder

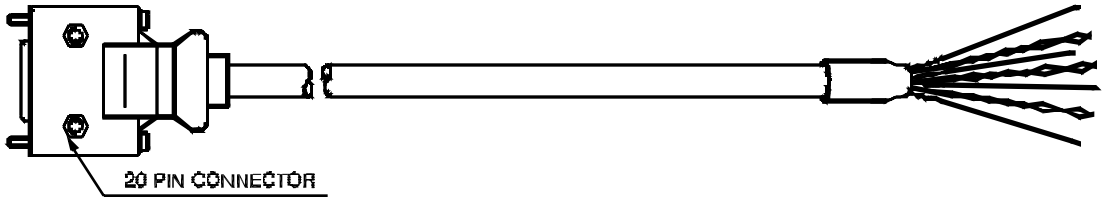
Encoder cable (made by customer)



FSP Amplifier Side Pin Number (20-pin connector)	Signal Name	Remarks
1,2,3	PG GND	—
4,5,6,10	PG +5V	Twisted Pair
14	PC	Twisted Pair
15	/PC	
16	PA	Twisted Pair
17	/PA	
18	PB	Twisted Pair
19	/PB	
FG	Connector Shield	—

11.6. Connecting Pulse A/B Encoder without C Pulse (Index Pulse)

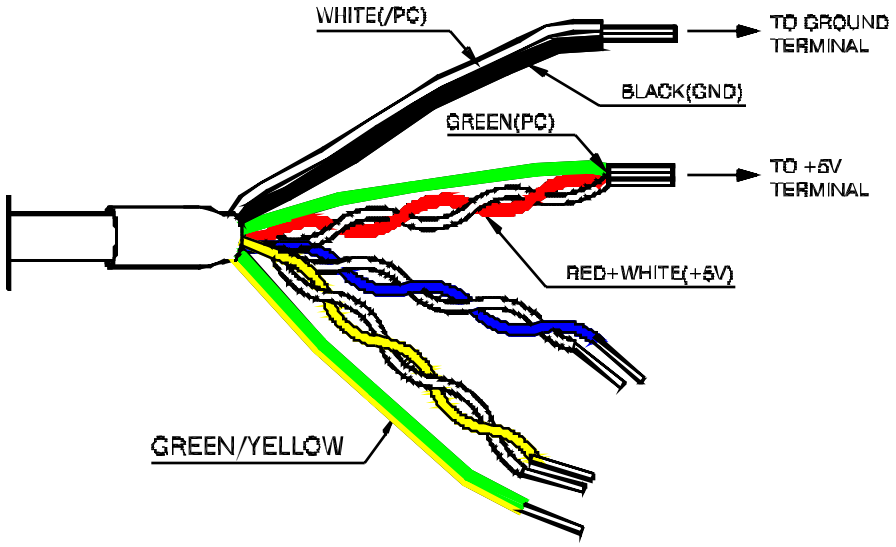
OEM Encoder Cable (made by YEA)



FSP Amplifier Side Pin Number (20-pin connector)	Signal Name	Wire Color	Remarks
1,2,3	PG GND	Black	—
4,5,6,10	PG +5V	Red	Twisted Pair
		White	
14	PC	Green	Twisted Pair
15	/PC	White	
16	PA	Blue	Twisted Pair
17	/PA	White	
18	PB	Yellow	Twisted Pair
19	/PB	White	
FG	Connector Shield	Yellow/Green	—

In case of using an A/B encoder without C pulse:

- Connect signal PC (Green Wire) directly to +5V terminal
  (together with Red-White PG +5V wires)
- Connect signal /PC (White wire from Green-White pair) directly to GND terminal (together with Black wire)



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Specifications are subject to change without notice due to ongoing product modifications and improvements.

YEA-SIA-FSP-2 Rev. C