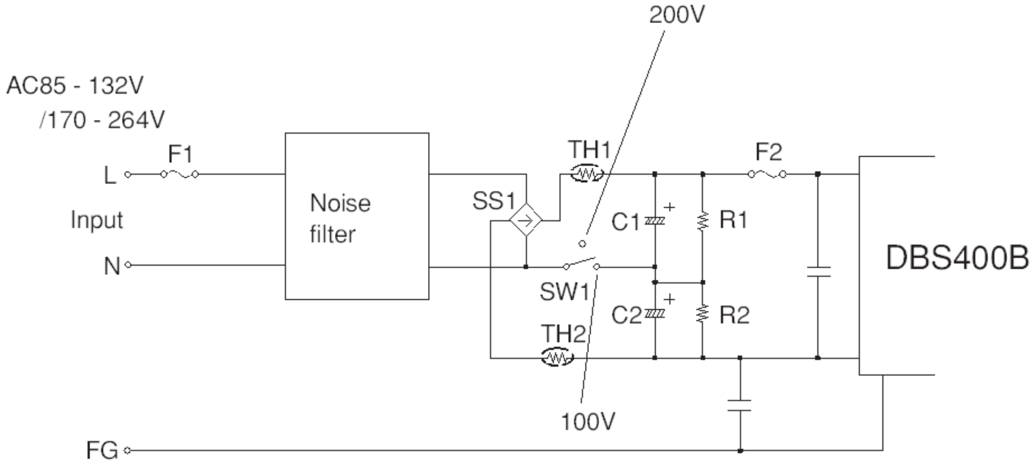
5. Input Rectifier Circuit

Input Rectifier Circuit

5.1 Single phase input rectifier circuit

[Example]

Fig.5.1.1
Single phase input filter
+ rectifier circuit



Voltage doubler circuit : 100V : SW1 is ON
200V : SW1 is OFF

5.1.1 Input fuse

- To avoid any damage or failure, install either an input circuit breaker or a fuse. When selecting these parts, consider the continuous current and the inrush current. Use a normal-blow or slow-blow type fuse.

(1) AC fuse (F1)

Table 5.1.1
Recommended value
of AC fuse

Input Voltage	Output power of module			
	200W	400W	600W	800W
100V	10A	15A	20A	25A
200V	5A	8A	10A	15A

(2) DC fuse (F2)

Table 5.1.2
Recommended value
of DC fuse

	Output power of module	
	200W	400W
200V	3.15A	5A

5.1.2 Noise filters

- In order to reduce the conducted noise from the unit to the AC line and to increase the immunity level against the external noises, a noise filter should be installed. Refer to "Section 12 Noise Filter Design" for details.

Input Rectifier Circuit

5.1.3 Rectifier (SS1)

- It rectifies the AC input to DC. The rated voltage is 600V and the rated current is as follows.

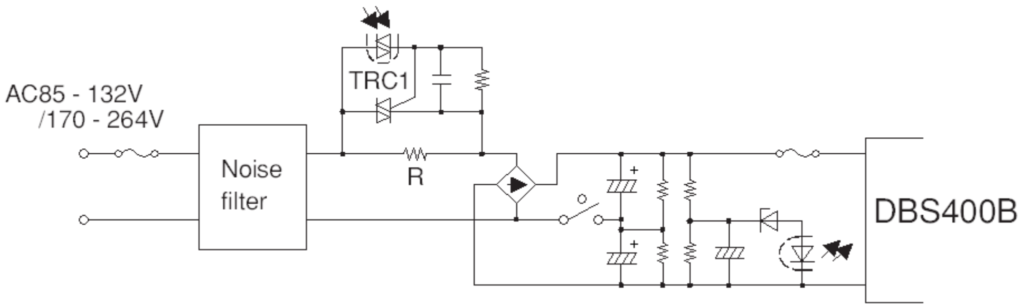
Table 5.1.3
Recommendation rectifier

Output Power	The example of combination of a power supply	Current of Rectifier
200W	DBS200B	4 - 6A type
400W	DBS200B x 2	8 - 10A type
600W	DBS200B + DBS400B	12 - 15A type
800W	DBS400B x 2	18 - 20A type

5.1.4 Inrush current limiting

- This rectification filtering circuit employs a capacitor input type. When input voltage is applied, an inrush current flows to charge the capacitor. To avoid the damage, an inrush current limiting is required. This resistance limits inrush current by the thermistor when the input is turned on, and resistance usually suppresses the lower loss due to the characteristic of thermistor (thermistor method).
- When temperature is low, the start-up time is getting longer due to characteristic of thermistor. Please select thermistor which can be used at actual.
- When the output power grows, inrush current protection circuit used to be build-in (SCR method and TRC method) using the thyristor or triac. Inrush current is limited by the resistance connected with thyristor or triac in parallel when the input is turned on. Then once input current goes to continuously, thyristor or triac is turned on to reduce power loss of resistor. In this circuit needed consideration about serge capacity of thyristor and add thermal fuse or use resistor which includes thermal fuse inside.

Fig.5.1.2
Inrush current limiting with TRC



PC1 is the extra low trigger current opto coupler.

The inrush current can be calculated at the following formula.

$$\text{Inrush current value (at AC200V)} = \frac{200 \times \sqrt{2}}{R}$$

* Please note, input current protection might not be activated, if input ON/OFF interval is short.

5.1.5 Filtering circuit (Filtering capacitor) (C1, C2)

- The selection of the filtering capacitor depends on the output hold-up time and the ripple current flowing in the capacitor.

(1) Obtain the capacitance (Ch) from the output hold-up time as follows

$$Ch = \frac{2 \times Po \times Th}{(V1^2 - V2^2) \times \eta}$$

Ch : Capacity of the filtering capacitor
Po : Output power of module
Th : Hold-up time
V1 : Input DC voltage = Input AC voltage (rms) x √2
V2 : Input DC voltage which can hold output voltage
η : Efficiency

[Calculation example]

(1) DBS400B is used with AC200V.
(2) The hold-up time is 20ms at AC200V.
(3) The efficiency of DBS400B is 85%.

$$Ch = \frac{2 \times 400W \times (20ms + 5ms)}{\{(200 \times \sqrt{2})^2 - (165V)^2\} \times 0.85} = 446\ \mu F$$

* 5ms in the formula above is added considering the ripple voltage of the filtering capacitor.

(2) Obtain the ripple current for selection of the capacitor as follows

[Calculation example]

$$\text{Ripple current} = \frac{2.5 \times 400W}{200V} = 5\ A$$

Po : Output power of module
Vin : Input voltage

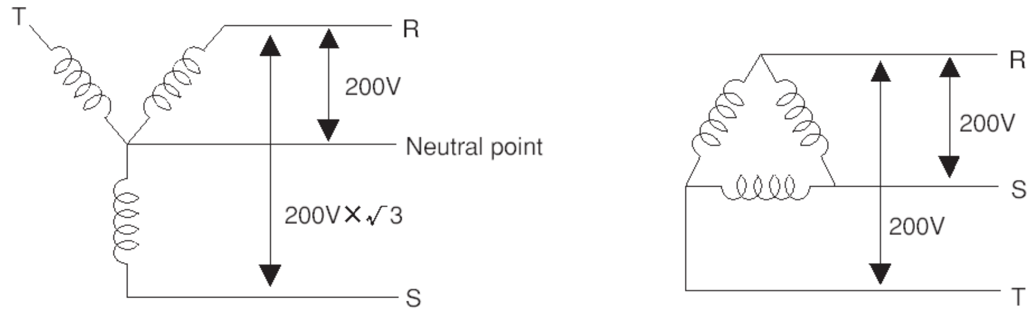
Table 5.1.4
Ripple current value

Output power of module	Input voltage	
	AC 100V	AC 200V
50W	1.25A	0.625A
100W	2.5A	1.25A
150W	3.75A	1.875A
200W	5.0A	2.5A
400W	10.0A	5.0A
600W	15.0A	7.5A
800W	20.0A	10.0A

5.2 Three phase input rectifier circuit

5.2.1 Three phase Y-connection and Δ connecting wires

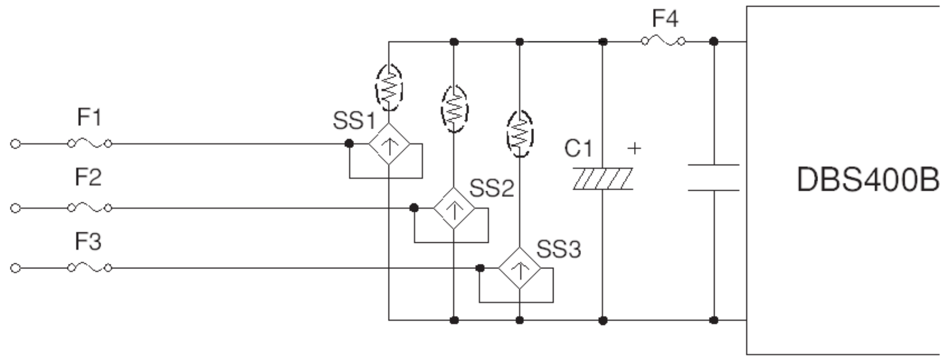
Fig.5.2.1
Y-connection (three phase four line type) and Δ connecting wires (three phase three line type)



- Do not use Y-connection (three phase four line type), because the peak rectified line voltage exceeds the maximum input voltage range of module.
  The example of connection for "Three phase input rectifier circuit" is shown on Fig.5.2.2.

[example]

Fig.5.2.2
Three phase input circuit



5.2.2 Input fuse

- To avoid any damage or failure, install either an input circuit breaker a fuse. When selecting these parts, consider the continuous current and the inrush current. Use a normal-blow or slow-blow type fuse.

(1) AC fuse (F1, F2, F3)

Table 5.2.1
Recommended value of AC fuse

	Output power of module			
	200W	400W	600W	800W
Current	2A	3.15A	4A	6.3A

(2) DC fuse (F4)

Table 5.2.2
Recommended value of DC fuse

	Output power of module	
	200W	400W
Current	3.15A	5A

Input Rectifier Circuit

5.2.3 Rectifier (SS1, SS2, SS3)

■ It rectifies the AC input to DC. The rated voltage is 600V and the rated current is as follows.

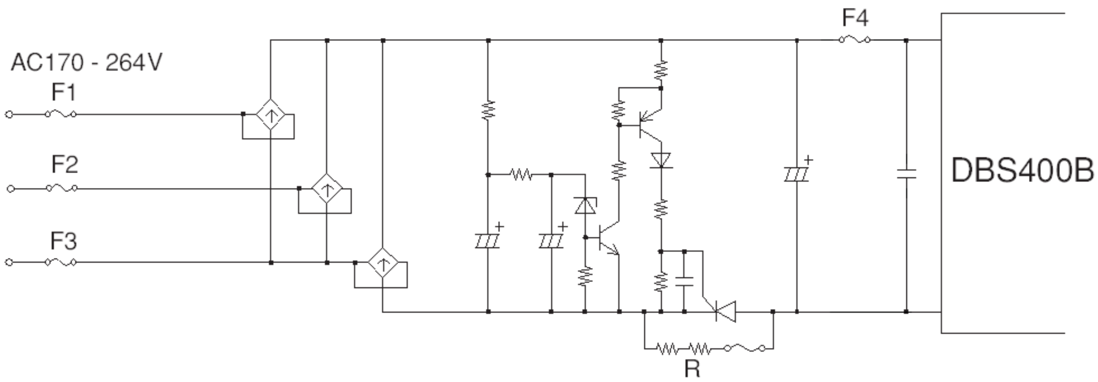
Table 5.2.3
Recommendation rectifier

Output Power	The example of combination of a power supply	Current of Rectifier
200W	DBS200B	1 - 2A type
400W	DBS200B x 2	3 - 4A type
600W	DBS200B + DBS400B	4 - 5A type
800W	DBS400B x 2	6 - 7A type

5.2.4 Inrush current limiting

■ When the output power grows, inrush current protection circuit used to be build-in (SCR method and TRC method) using the thyristor or triac. Inrush current is limited by the resistance connected with thyristor or triac in parallel when the input is turned on. Then once input current goes to continuously, thyristor or triac is turned on to reduce power loss of resistor. In this circuit needed consideration about serge capacity of thyristor and add thermal fuse or use resistor which includes thermal fuse inside.

Fig.5.2.3
Inrush current limiting with SCR



■ The inrush current can be calculated from the following type.

$$\text{Inrush current value (at AC200V)} = \frac{200 \times \sqrt{2}}{R}$$

* Please note, input current protection might not be activated, if input ON/OFF interval is short.

5.2.5 Filtering circuit (Filtering capacitor) (C1)

■ Becomes a calculation type same as the single phase input at three aspect input.
The expression is shown in the following.

■ The selection of the filtering capacitor depends on the output hold-up time and the ripple current flowing in the capacitor.

■ The hold-up time of three phase input is almost the same as the single phase input. The expression in the single phase input is used this time.

(1) Obtain the capacitance (Ch) from the output hold-up time as follows

$$Ch = \frac{2 \times Po \times Th}{(V1^2 - V2^2) \times \eta}$$

Ch : Capacity of the filtering capacitor
Po : Output power of module
Th : Hold-up time
V1 : Input DC voltage = Input AC voltage (rms) x √2
V2 : Input DC voltage which can hold output voltage
η : Efficiency

[Calculation example]

(1) DBS400B is used with AC200V.
(2) The hold-up time is 20ms at AC200V.
(3) The efficiency of DBS400B is 85%.

$$Ch = \frac{2 \times 400W \times (20ms + 5ms)}{\{(200 \times \sqrt{2})^2 - (165V)^2\} \times 0.85}$$
$$= 446\ \mu F$$

* 5ms in the formula above is added considering the ripple voltage of the filtering capacitor.

(2) Obtain the ripple current for selection of the capacitor as follows

[Calculation example]

$$\text{Ripple current} = \frac{2.5 \times 400W}{200V}$$
$$= 5\ A$$

Po : Output power of module
Vin : Input voltage

Table 5.2.4
Ripple current value

Output power of module	Input voltage	
	AC 100V	AC 200V
50W	1.25A	0.625A
100W	2.5A	1.25A
150W	3.75A	1.875A
200W	5.0A	2.5A
400W	10.0A	5.0A
600W	15.0A	7.5A
800W	20.0A	10.0A