

# PFE500F · 1000F SERIES

## Instruction Manual

### BEFORE USING THE POWER SUPPLY UNIT

Be sure to read this instruction manual thoroughly before using this product. Pay attention to all cautions and warnings before using this product. Incorrect usage could lead to an electrical shock, damage to the unit or a fire hazard.

#### DANGER

- Never use this product in locations where flammable gas or ignitable substances are present.

#### WARNING


- Do not make unauthorized changes to power supply unit, otherwise you might have electric shock and void your warranty.
- Do not touch this unit and the internal components in operation or shortly after shut down. They might have high voltage or high temperature and as the unit dissipates its heat so the surface of the unit is hot. You might receive electric shock or burn.
- When the unit is operating, keep your hands and face away from it; you might be injured by an accident.
- Do not use unit under unusual condition such as emission of smoke or abnormal smell and sound etc. It might cause fire and electric shock. In such case, please contact us; do not repair by yourself, as it is dangerous for the user.
- Do not drop or insert anything into unit. It might cause failure and fire.
- Do not operate these units under condensation condition. It might cause fire and electric shock.

#### CAUTION

- As a component part, compliance with the standard will be based upon installation in the final application. This product must be installed in a restricted access location, accessible to authorized competent personnel only. These AC to DC converters have reinforced insulation between the input and the output. The outputs of these products are energy hazards. All models with an output greater than 28V model are considered to be non-SELV. As such, the instructions for use must refer to these energy hazardous outputs and Non-SELV outputs in that the outputs must not be accessible to the operator. The installer must also provide protection against inadvertent contact by a service engineer.
- The equipment has been evaluated for use in a Pollution Degree 2 environment.
- This power supply is primarily designed and manufactured to be used and enclosed in other equipment.
- Confirm connections to input/output terminals and signal terminals are correct as indicated in the instruction manual.
- Attach a fast acting external fuse to each module to ensure safety operation and compliance to each safety standard approval. The recommended input fuse rating within the instructions manual. The breaking capacity and voltage rating of this fuse might be subject to the end use application.
- Input voltage, Output current, Output power, ambient temperature and ambient humidity should be used within specifications, otherwise the unit will be damaged.
- For application equipment, which requires very high reliability (Nuclear related equipment, traffic control equipment, medical equipment, etc.), please provide fail safety function in the equipment.
- Do not use the product in environment with strong electromagnetic field, corrosive gas and conductive substance.
- Do not operate and store this unit at an environment where condensation occurs. In such case, waterproof treatment is necessary
- Never operate the unit under over current or shorted conditions for 30 seconds or more and out of Input Voltage Range as specification. Insulation failure, smoking, burning or other damage might occur to the unit.
- The output voltage of this power supply unit is considered to be a hazardous energy level (The voltage is 2V or more and the electric power is 240VA or more). Prevention from direct contact with output terminal is highly necessary. While installing or servicing this power supply unit, avoid dropping tools by mistake or direct contact with output terminal. This might cause an electrical shock. While repairing this power supply unit, the AC input power must be switched off and the input and output voltage should be level.
- To maintain the SELV output for outputs less than 28VDC, under fault conditions, the output must be connected to earth in the final application.
- The application circuits and their parameter are for reference only. Be sure to verify effectiveness of application circuits and their parameters before finalizing circuit design.
- Do not inject abnormal voltage to output terminal and signal terminal from the outside. The injection of reverse voltage or over voltage exceeding nominal output voltage to output terminals might cause damage to internal components.
- This information in this document is subject to change without prior notice. For actual design-in, please refer to the latest publications of data sheet, etc., for the most up-to date specifications of the unit.
- Design the board of an application circuit implementing this product in consideration of components layout, pattern layout and pattern width.
- No part of this document might be copied or reproduced in any form without prior written consent of Densai-Lambda.

### Note : CE MARKING

CE Marking when applied to a product covered by this handbook indicates compliance with the low voltage directive (2006/95/EC) in that it complies with EN60950-1.

DWG. No. : C250-04-11A		
APPD	CHK	DWG
	H. Kawagoe	Hirokawa
19. Sep. '08	19, Sep, '08	19. Sep. '08

## Table of Contents

### ■ Block Diagram

### ■ Sequence Time Chart

### ■ Terminal Explanation

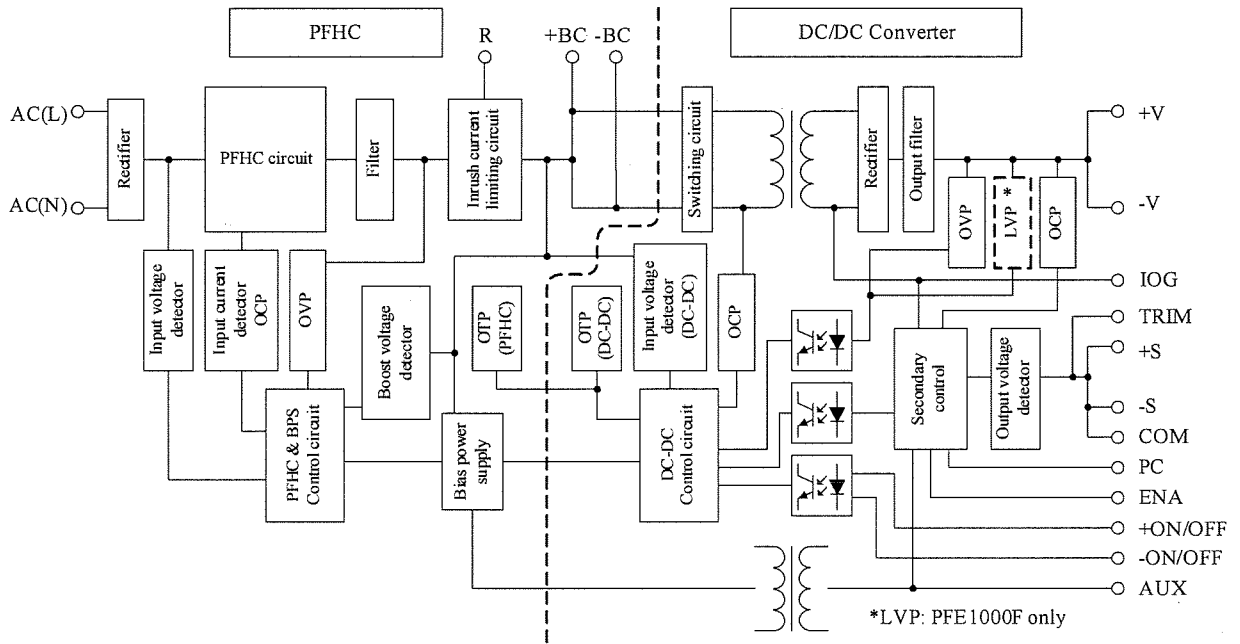
### ■ Explanation on Specifications

1. Input Voltage Range
2. Output Voltage Adjustment Range (TRIM terminal)
3. Maximum Output Ripple and Noise
4. Maximum Line Regulation
5. Maximum Load Regulation
6. Over Current Protection (OCP)
7. Over Voltage Protection (OVP)
8. Over Temperature Protection (OTP)
9. Remote Sensing (+S, -S terminals)
10. ON/OFF Control (+ON/OFF, -ON/OFF terminals)
11. Series Operation
12. Parallel Operation (PC terminal)
13. Power ON Signal (ENA terminal)
14. I.O.G Signal (IOG terminal)
15. Auxiliary Power Supply for External Circuits (AUX terminal)
16. Operating Temperature Range
17. Operating Humidity
18. Storage Temperature
19. Storage Humidity
20. Cooling Method
21. Withstand Voltage
22. Insulation Resistance
23. Recommended Soldering Conditions

### ■ Before concluding module damage

# PFE500F · 1000F SERIES

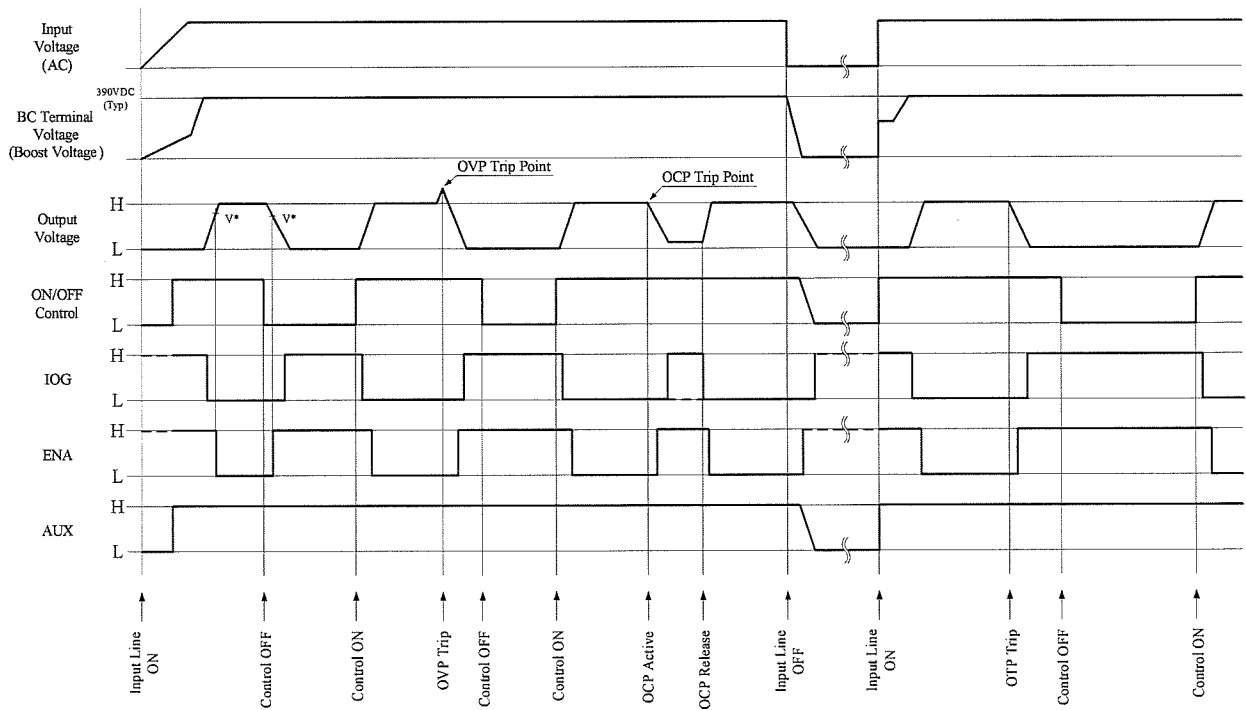
## ■ Block Diagram



**Switching Frequency**  
**PFHC circuit (fixed) :100kHz**  
**DC/DC converter (fixed) :230kHz (primary), 460kHz (secondary)**

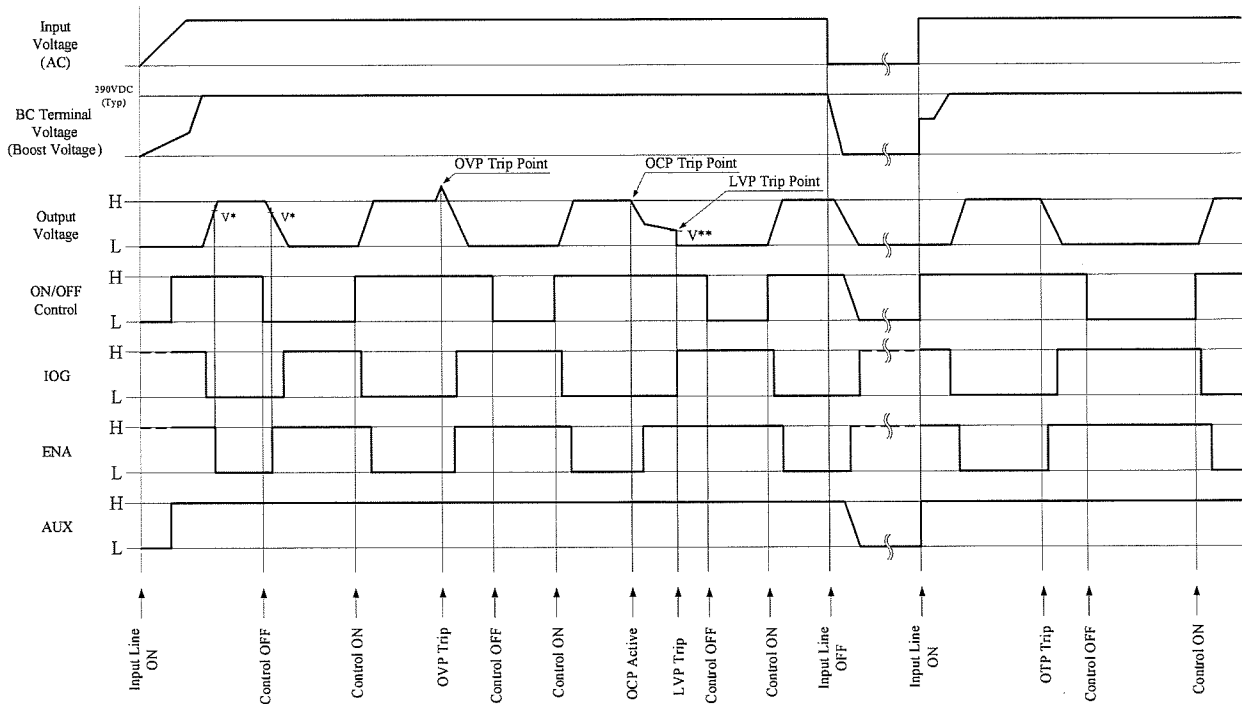
## Sequence Time Chart

### PFE500F Series



$V^*$  voltage level: Refer to Application Notes "13.Power ON Signal" section.

### PFE1000F Series

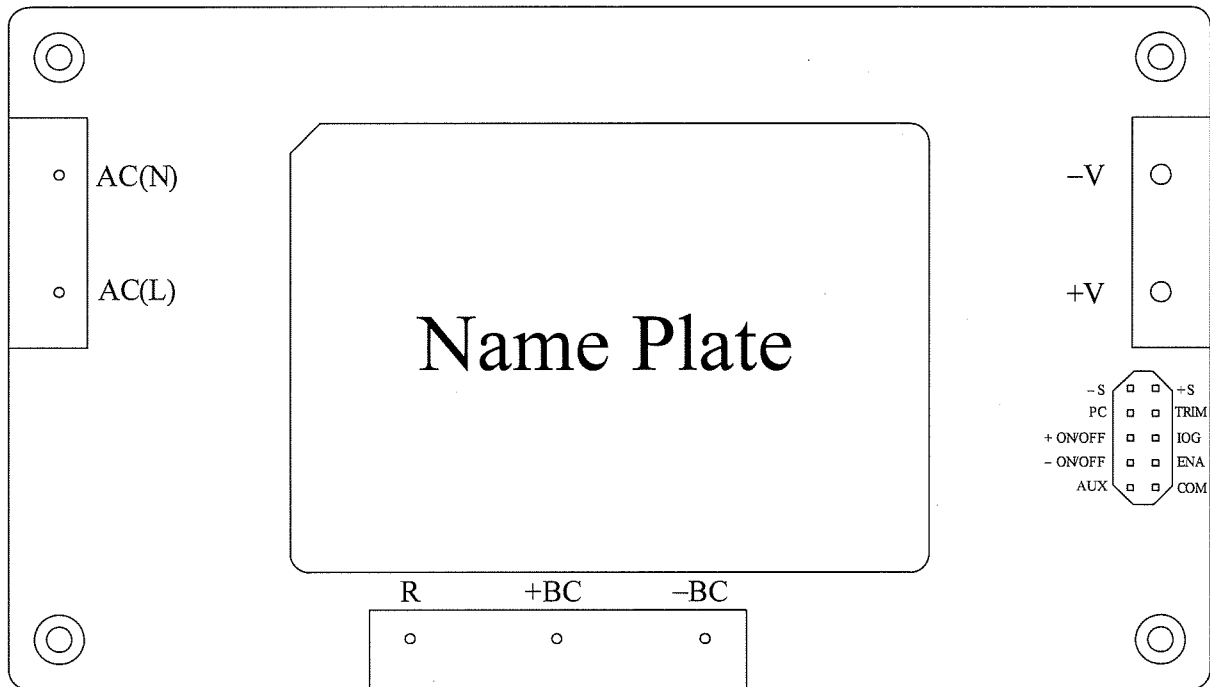


$V^*$  voltage level: Refer to Application Notes "13.Power ON Signal" section.

$V^{**}$  voltage level: Refer to Application Notes "6.Over Current Protection" section.

## Terminal Explanation

### PFE500F Series



[Input side terminals]  
 AC (L) : Input terminal live line  
 AC (N) : Input terminal neutral line

+BC : +Boost voltage terminal  
 -BC : -Boost voltage terminal  
 R : External inrush current limiting resistor terminal

[Output side terminals]  
 +V : +Output terminal  
 -V : -Output terminal

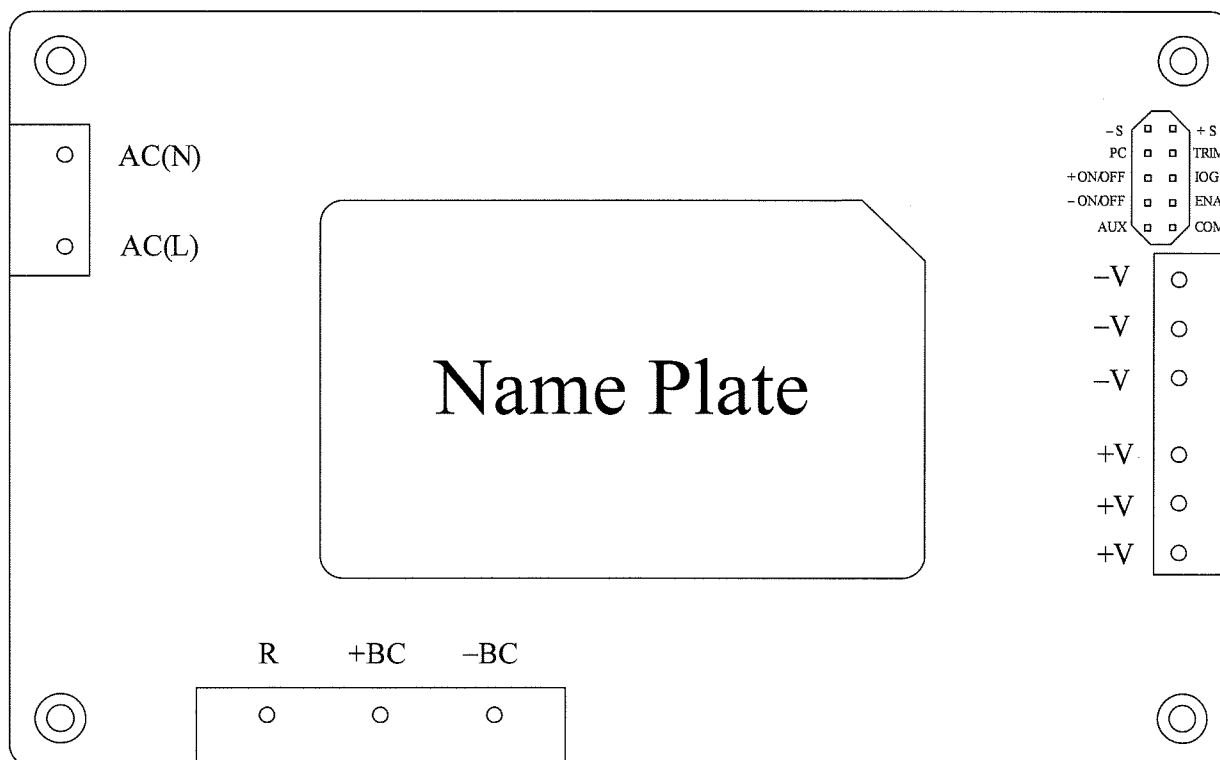
+S : +Remote sensing terminal  
 -S : -Remote sensing terminal  
 PC : Output current balance terminal  
 TRIM : Output voltage trimming terminal  
 IOG : Inverter operation good terminal  
 ENA : Power on signal terminal  
 +ON/OFF : +ON/OFF control terminal  
 -ON/OFF : -ON/OFF control terminal  
 AUX : Auxiliary power supply terminal for external circuits  
 COM : Common ground terminal

- Baseplate can be connected to FG through M3 mounting tapped holes.
- Consider contact resistance when connecting AC (L), AC (N), R, +BC, -BC, +V, -V.
- Note that +BC and -BC terminals is a primary voltage with high voltage (390VDC). Do not connect load to these terminals. It might result in power module damage.

# PFE500F · 1000F SERIES

## Terminal Explanation

### PFE1000F Series



#### [Input side terminals]

AC (L)	: Input terminal live line
AC (N)	: Input terminal neutral line
+BC	: +Boost voltage terminal
-BC	: -Boost voltage terminal
R	: External inrush current limiting resistor terminal

#### [Output side terminals]

+V	: +Output terminal
-V	: -Output terminal
+S	: +Remote sensing terminal
-S	: -Remote sensing terminal
PC	: Output current balance terminal
TRIM	: Output voltage trimming terminal
IOG	: Inverter operation good terminal
ENA	: Power on signal terminal
+ON/OFF	: +ON/OFF control terminal
-ON/OFF	: -ON/OFF control terminal
AUX	: Auxiliary power supply terminal for external circuits
COM	: Common ground terminal

- Baseplate can be connected to FG through M3 mounting tapped holes.
- Consider contact resistance when connecting AC (L), AC (N), R, +BC, -BC, +V, -V.
- Note that +BC and -BC terminals is a primary voltage with high voltage (390VDC).  
Do not connect load to these terminals. It might result in power module damage.

## ■ Explanations on Specifications

### 1. Input Voltage Range

Input voltage range is indicated below. Take care not to apply input voltage which is above this specified range or under this specified range for more than 30 seconds. Nor should a DC input voltage be applied as this would result into power module damage.

Input Voltage Range : Single Phase 85 to 265VAC    Line Frequency Range : 47 to 63Hz

#### ● Basic Connection

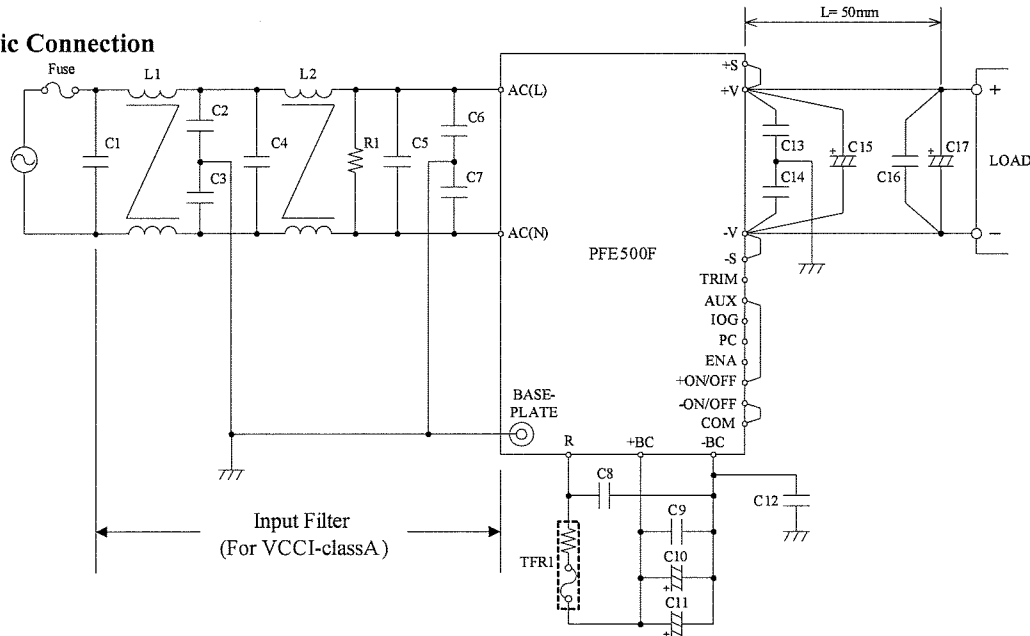


Fig. 1-1-(1) Basic Connection for PFE500F Series

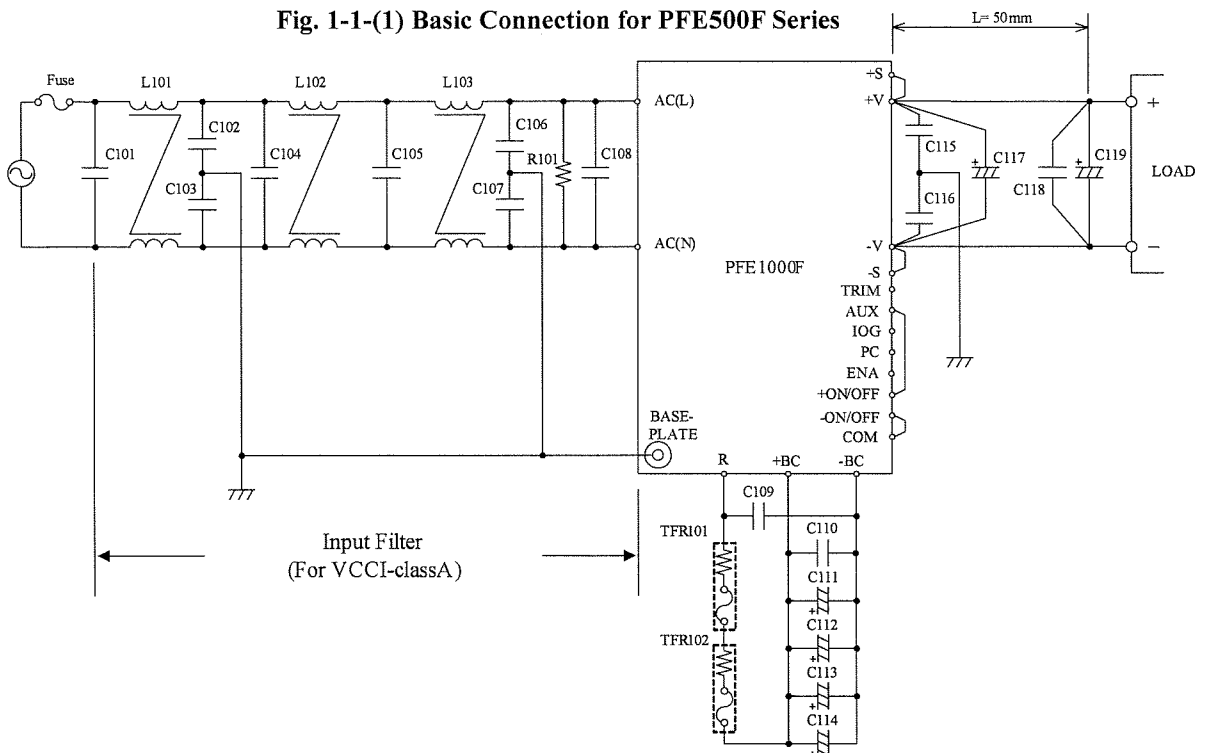


Fig. 1-1-(2) Basic Connection for PFE1000F Series

Note) To meet the surge immunity, evaluate the addition of the surge protection components. Refer to separate document "PFE500F Series IEC Data" and "PFE1000F Series IEC Data".

# PFE500F · 1000F SERIES

## External Input Fuse

This power module has no internal fuse. Use external fuse to acquire each Safety Standard and to further improve safety. Further, Fast-Blow type fuse must be used per one module. Also, in-rush surge current flows during line throw-in. Be sure to check I<sup>2</sup>t capability of external switch and fuse.

### Recommended External Fuse

**PFE500F : F15AH, 250V**

**PFE1000F : F25AH, 250V**

Note) Select fuse based on rated voltage, rated current and breaking capacity.

#### (1) Voltage Ratings

100VAC line : AC125V

200VAC line : AC250V

#### (2) Current Ratings

Rated current is selected by the maximum input current based on operating conditions and can be calculated by the following formula.

$$I_{in(max)} = \frac{P_{out}}{V_{in} \times \text{Eff} \times \text{PF}} \text{ (Arms)} \quad \text{(Formula 1-1)}$$

I<sub>in</sub> (max) : Maximum Input Current

P<sub>out</sub> : Maximum Output Power

V<sub>in</sub> : Minimum Input Voltage

Eff : Efficiency

PF : Power Factor

#### (3) Breaking Capacity

The breaking capacity may be subject to the end use application. Please select a suitably rated breaking capacity fuse for end use application.

For Efficiency and Power Factor values, refer to separate document "PFE500F Series Evaluation Data" and "PFE1000F Series Evaluation Data".

**C1, C4, C5 : 1uF (Film Capacitor)**

**C101, C104, C105, C108 : 1uF (Film Capacitor)**

Ripple current flows through this capacitor. When selecting capacitor, be sure to check the allowable maximum ripple current rating of this capacitor. Verify the actual ripple current flowing through this capacitor by doing actual measurement.

**Recommended Voltage Rating : 250VAC**

Note) Connect C5, C108 as near as possible towards the input terminals of this power module.

Audible noise may occur depending on type of film capacitor.

**L1, L2 : 6mH**

**L101, L102, L103 : 2mH**

Add common mode choke coil to conform to EMI/EMS standard. When using multiple modules, connect coil to each module.

Note) Depending on the input filter used, noise might increase or power module might malfunction due to filter resonance.

**C2, C3, C6, C7, C12: 2,200pF (Ceramic Capacitor)**

**C102, C103 : 470pF (Ceramic Capacitor)**

**C106, C107 : 4,700pF (Ceramic Capacitor)**

Connect ceramic capacitor to conform to EMI/EMS standard. Be sure to note the leakage current of your equipment when connecting this capacitor.

High withstand voltage are applied across this capacitor depending on the application. Select capacitors with high withstand voltage rating.

**R1, R101 : 470kohm**

Connect bleeder resistor across AC(L) and AC(N) terminals.

**C8, C9 : 1uF (Film Capacitor)**

**C109, C110 : 1uF (Film Capacitor)**

Ripple current flows through this capacitor. When selecting capacitor, be sure to check the allowable maximum ripple current rating of this capacitor. Verify the actual ripple current flowing through this capacitor by doing actual measurement.

**Recommended Voltage Rating : 450VDC**

Note) Select Capacitor with more than 3A (rms) rating. Connect C8, C9, C109, C110 as near as possible towards the terminals of this power module.

**C10, C11: 390uF (Electrolytic Capacitor)**

**C111, C112, C113, C114 : 390uF (Electrolytic Capacitor)**

Refer to "Selection Method of External Bulk Capacitor for Boost Voltage".

Allowable External Capacitance at nominal capacitor value is shown below.

**Recommended Voltage Rating : 450VDC**

**Recommended Total Capacitor :**

**390uF to 1,200uF (PFE500F Series)**

**780uF to 2,300uF (PFE1000F Series)**

- Note) 1. Do not connect capacitors with more than the above capacitance value as this might result in power module damage.
2. When using module between 390uF – 600uF for PFE500F Series, 780uF – 1,200uF for PFE1000F Series total capacitor value, it is necessary to reduce output power as shown in Fig1-3.
3. When using module below -20 deg C ambient temperature, AC ripple of boost voltage, output ripple voltage and start up characteristics might be affected by ESR characteristics of the bulk capacitors. Therefore, be sure to verify characteristics by actual evaluation.



# PFE500F · 1000F SERIES

## C13, C14, C115, C116 : 0.033uF

Connect ceramic or film capacitor to conform to EMI/EMS standard and to reduce output spike noise voltage.

Note) High Voltage is applied across this capacitor during withstand voltage test depending on the application.

Connect C13, C14, C115, C116 as near as possible towards the terminals of this power module.

## C15, C117 : Refer to Table 1-1

To reduce output ripple voltage and to stabilize operation, connect electrolytic capacitors across +V and -V terminals.

Note) Connect C15, C117 as near as possible to the +V and -V terminals of this power module.

Vout	C15, C117
12V	25V 1,000uF
28V	50V 470uF
48V	100V 220uF

Table 1-1 C15, C117:Recommended external capacitance

## C16, C118 : 2.2uF (Ceramic Capacitor)

Connect ceramic capacitor within 50mm from the output terminals +V and -V of the power module to reduce output spike noise voltage.

Also, note that output spike noise voltage might vary depending on the wiring pattern of the printed circuit board.

## C17, C119 : Refer to Table 1-2

Connect C17, C119 within 50mm from the output terminals +V and -V of the power module to stabilize operation and to reduce output ripple noise voltage.

Note that the output ripple and line turn off characteristics of the power module might be affected by the ESR and ESL of the electrolytic capacitor.

Also, note that output ripple voltage might vary depending on the wiring pattern of the printed circuit board.

Fluctuation in output voltage due to sudden load change or sudden input voltage change can be reduced by increasing external output capacitor value.

Vout	C17, C119
12V	25V 1,000uF
28V	50V 470uF
48V	100V 220uF

Table 1-2 C17, C119:Recommended external capacitance

- Note) 1. Use low-impedance electrolytic capacitors with excellent temperature characteristics.  
(Nippon Chemi-con LXY Series or equivalent)  
(Nichicon PM Series or equivalent)
2. For module operation at ambient temperature -20 deg C or less, output ripple voltage might be affected by ESR characteristics of the electrolytic capacitors. Increase the capacitor values shown in Table 1-1 and 1-2 according to the table below.

Vout	C15, C17, C117, C119
12V	25V 1,000uF x 2 parallel
28V	50V 470uF x 2 parallel
48V	100V 220uF x 2 parallel

Table 1-3 C15, C17, C117, C119 :  
Recommended external capacitance  
(Ambient Temperature < -20 deg C)

3. Take note of the allowable maximum ripple current of the electrolytic capacitor used. Especially, for sudden load current changes, verify actual ripple current and make sure that allowable maximum ripple current is not exceeded.

## ● Selection Method of External Bulk Capacitor for Boost Voltage

Boost voltage bulk capacitor is selected by ripple voltage, ripple current and output hold-up time.

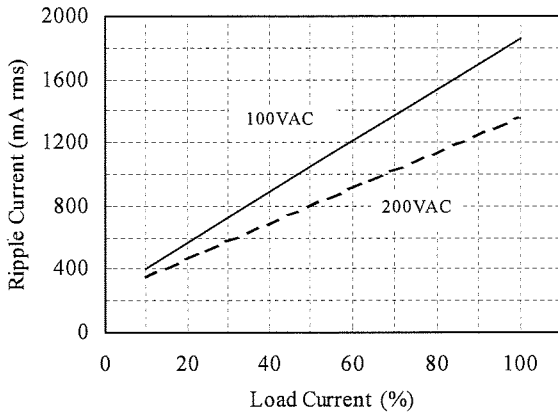
Select capacitor value such that boost voltage ripple voltage does not exceed 15Vp-p.

Note) When ambient temperature is -20 deg C or less, ripple voltage of the boost voltage might increase due to ESR characteristics. Therefore, verify above characteristics by actual evaluation.

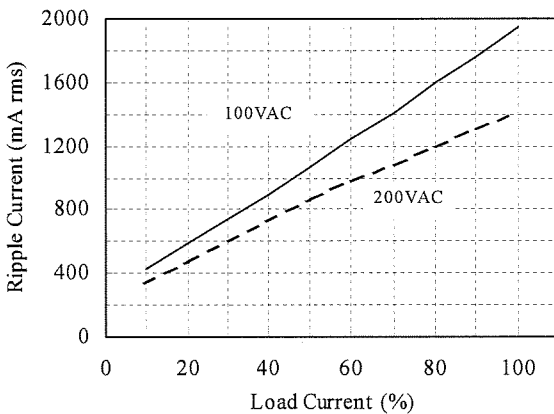
For output hold-up time, refer to separate document "PFE500F Series Evaluation Data" or "PFE1000F Series Evaluation Data" and use appropriate capacitor up to 1,200uF maximum for PFE500F Series, 2,300uF maximum for PFE1000F Series. (It is recommended that verification should be done through actual evaluation).

For allowable ripple current value, refer to Fig. 1-2 and select a capacitor with higher ripple current rating.

# PFE500F · 1000F SERIES



**Fig. 1-2-(1) Ripple current value for PFE500F Series**  
(A value per one of Fig. 1-1-(1) connection)



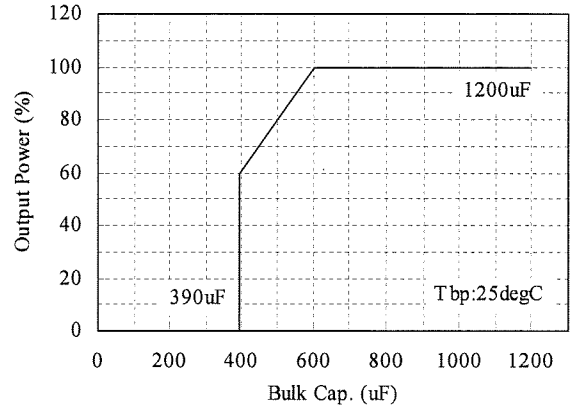
**Fig. 1-2-(2) Ripple current value for PFE1000F Series**  
(A value per one of Fig. 1-1-(2) connection)

The recommended boost voltage bulk capacitor value range is 390uF-1,200uF for PFE500F Series, 780uF-2,300uF for PFE1000F Series.

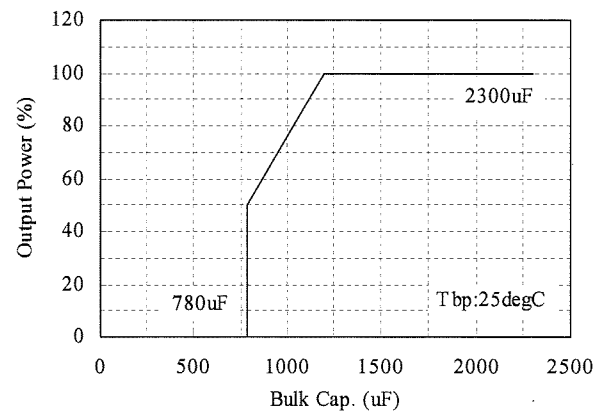
When using with reduced the bulk capacitor value, it is necessary to reduce output power as shown in Fig1-3.

Note that reducing the bulk capacitance affects output hold-up time, dynamic line response and dynamic load response characteristics.

It is recommended that verification should be done through actual evaluation.



**Fig. 1-3-(1) Output Power v.s. Boost Voltage Bulk Capacitance For PFE500F Series**



**Fig. 1-3-(2) Output Power v.s. Boost Voltage Bulk Capacitance For PFE1000F Series**

**TFR1 : 10 to 100 ohm**

**TFR101, TFR102 : 10 to 50 ohm (Total value)**

By connecting resistor across R and +BC terminals as shown in Fig. 1-1, in-rush current during line throw-in can be suppressed. Failures due to in-rush current such as melting of external fuse, welding of relay or switch connecting joints or shutdown of No-Fuse Breakers (NFB) might occur. Therefore, select TFR1, TFR101, TFR102 in consideration of the surge current capability of the external components. (TFR1, TFR101, TFR102 are recommended to use the Thermal Fuse Resistor.)

- Note) 1. Do not connect resistors that is out of range from the values shown above as this might result in power module damage.  
2. Note that this module will not operate without this external resistor.

# PFE500F · 1000F SERIES

## ● Selection Method of External Resistor

- (1) Calculating Resistance Value for External Resistor  
Resistance can be calculated by the formula below.

$$R = \frac{V_{in}}{I_{rush}} (\Omega) \quad (\text{Formula 1-2})$$

R : Resistance Value for External resistor  
V<sub>in</sub> : Input Voltage converted to DC value  
= Input Voltage (rms) × √2  
I<sub>rush</sub> : Input surge current value

- (2) Required Surge Current Rating

Sufficient surge current withstand capability is required for external resistor.

Required Surge Current Rating can be selected by I<sup>2</sup>t. (Current squared multiplied by time)

$$I^2t = \frac{C_o \times V_{in}^2}{2 \times R} (A^2s) \quad (\text{Formula 1-3})$$

I<sup>2</sup>t : Current-squared multiplied by time  
C<sub>o</sub> : Boost Voltage Bulk Capacitance  
V<sub>in</sub> : Input Voltage converted to DC value  
= Input Voltage (rms) × √2  
R : Resistance Value for External Resistor

## 2. Output Voltage Adjustment Range (TRIM terminal)

Output voltage can be adjusted within the range below by connecting fixed and variable resistors or applying external voltage.

However, take care not to exceed the output voltage range shown below because OVP function will activate.

In the PFE1000F Series, be careful not to drop from the following range, because a Low Voltage Protection (LVP) function will be activate.

**Output Voltage Adjustment Range :**  
+/-20% of the typical voltage rating

When increasing or decreasing output voltage, it must not exceed maximum output current and power.

Even if the output voltage is adjusted using external circuit shown in Fig. 2-1, remote sensing can be done. For details on Remote Sensing function, refer to "9. Remote Sensing".

### Output Voltage Adjustment using Fixed and Variable Resistors

External resistor (R1) and variable resistor (VR) values, as well as, circuit connection is shown below.

For this case, remote programming of the output voltage can be done through the remote programming resistor VR.

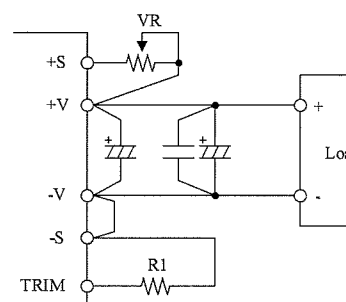
Be sure to connect the remote programming resistor between +S and +V terminals.

	12V	28V	48V
R1	18k	18k	18k
VR	10k	20k	50k

unit : [ohm]

External Resistor : Tolerance +/-5% or less  
Variable Resistor : Total Tolerance +/-20% or less  
Remain Resistance 1% or less

**Table 2-1**  
**External Resistor and Variable Resistor Value**  
(For +/-20% Output Adjustment)

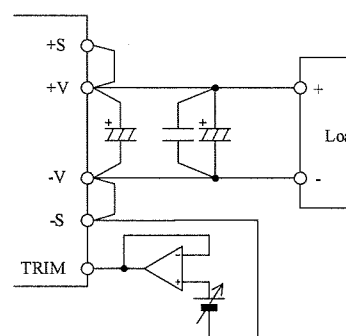


**Fig. 2-1 External Resistor Connection Example**

### Output Voltage Adjustment by applying external voltage

By applying external voltage at the TRIM terminal, output voltage can be adjusted within the same output voltage adjustment range as the output voltage adjustment by external resistor or variable resistor. For this case, output voltage can be determined by the formula shown below.

**Output Voltage = TRIM Terminal Voltage**  
**x Nominal Output Voltage**



**Fig. 2-2 Output Voltage Adjustment**  
**by applying external voltage**

For applications other than the above, refer to the TRIM circuit as shown in fig.2-3 and determine external circuit and components values.

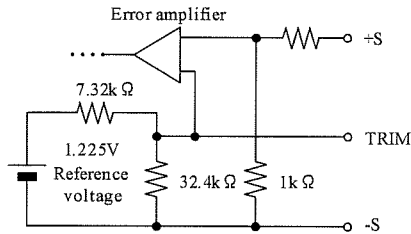


Fig.2-3 Internal TRIM Circuit (For the Reference)

### 3. Maximum Ripple and Noise

This value is measured according to the description below in accordance with JEITA-9131B(Section 7.16, 7.17 and 7.18).

In the basic connection shown in Fig. 1-1, additional connection shown in Fig. 3-1 is done for measurement. Capacitor (Ceramic Capacitor : 2.2μF and Electrolytic Capacitor : Refer to Table 1-2) must be connected within 50mm from the output terminals. Then, connect coaxial cable with JEITA attachment across the ceramic capacitor electrodes. Use 100MHz bandwidth oscilloscope or equivalent.

Also, note that output ripple voltage and output spike noise voltage might vary depending on the wiring pattern of the printed circuit board.

In general, output ripple voltage and output spike noise voltage can be reduced by increasing external capacitance.

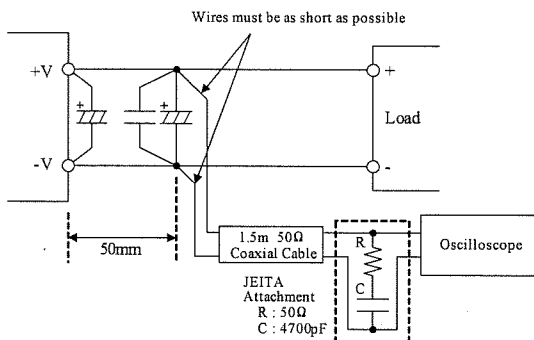


Fig. 3-1  
Output Ripple Voltage (including Spike Noise)  
Measurement Method

### 4. Maximum Line Regulation

Maximum line regulation is defined as the maximum output voltage change when input voltage is gradually changed (Steady-State) within specification range.

### 5. Maximum Load Regulation

Maximum load regulation is defined as the maximum output voltage change when output load current is gradually changed (Steady-State) within specification range.

When using power module in dynamic load mode, audible sound could be heard from the power module or large output voltage change might occur. Make prior evaluation thoroughly before using this power module.

### 6. Over Current Protection (OCP)

This module is equipped with OCP function.

Constant current limiting with automatic recovery for PFE500F Series. Output will automatically recover when short circuit or overload condition is released.

Constant current limiting with delay shutdown for PFE1000F Series. Output will be shutdown when output about under 70% by short circuit or overload condition that continue about 0.5s. When the shutdown function activates, first cut off input line and verify that boost voltage has dropped down to 20V or less. Then, recover output by recycling input line. In other method, reset to ON/OFF control. OCP value is fixed and cannot be adjusted externally.

Note that continuous short circuit or overload condition more than 30s, might result in power module damage.

### 7. Over Voltage Protection (OVP)

This module is equipped with OVP function. This value is set between 125% to 145% of nominal output voltage.

When the OVP function activates, first cut off input line and verify that boost voltage has dropped down to 20V or less. Then, recover output by recycling input line. In other method, reset to ON/OFF control. OVP value is fixed and cannot be set externally.

### 8. Over Temperature Protection (OTP)

This module is equipped with OTP function. This function activates and shuts down the output when ambient temperature or internal temperature abnormal rises. OTP activates at following baseplate temperature.

PFE500F-12	:	90 to 115 deg C
PFE500F-28, 48	:	105 to 130 deg C
PFE1000F-*	:	105 to 130 deg C

When OTP function operates, output can be recovered by cooling down the baseplate sufficiently and letting the boost voltage drop down to 20V or less before recycling the input line. In other method, reset to ON/OFF control.

# PFE500F · 1000F SERIES

## 9. Remote Sensing (+S, -S terminals)

This module has remote sensing terminals to compensate for voltage line drop from the output terminals to the output load. When remote sensing is not required, (local sensing) short +S to +V and -S to -V terminals respectively.

Note that line drop (voltage drop due to wiring ) compensation voltage range must be such that the output voltage is within the output voltage adjustment range and that the voltage between -V and -S must be within 0.5V.

Consider power loss due to line drop and use power module within the maximum allowable output power. Reduce the effect of noise to the remote sensing line by using a shield line, a twist pair, or a parallel pattern, etc.

When remote sensing line is long, add the electrolytic capacitor as shown in Fig 9-1.

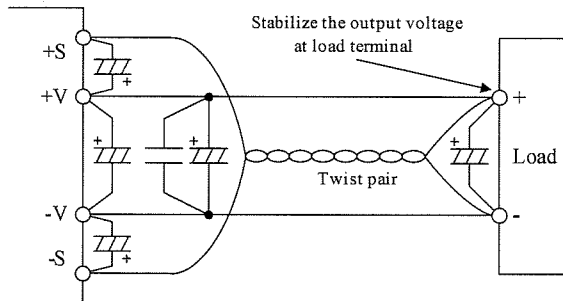


Fig. 9-1 Remote Sensing is used

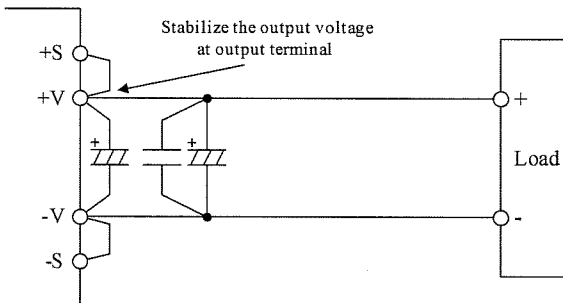


Fig. 9-2 Remote Sensing is not used (Local Sensing)

## 10. ON/OFF Control

### (+ON/OFF, -ON/OFF terminal)

This module is equipped with ON/OFF control function. Without turning the input supply on and off, the output can be enabled and disabled using this function.

The ON/OFF control circuit is isolated from input circuit of the power supply by photo-coupler.

Fig. 10-1 and Fig. 10-2 is connection example of ON/OFF control. When the ON/OFF control is not used, short +ON/OFF to AUX and -ON/OFF to COM terminals respectively.

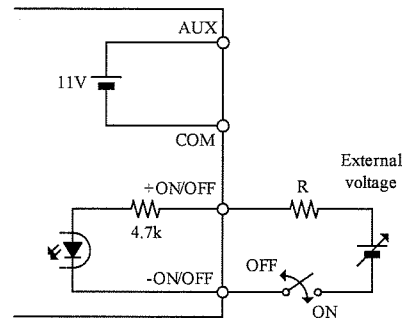


Fig. 10-1 ON/OFF Control Connection Example 1 (ON/OFF Control by External Voltage)

Select the external voltage and external resistance, as the ON/OFF terminals current is shown below.

ON/OFF terminal current	Output Voltage
2.5mA (+/-0.5mA)	ON
Less than 0.15mA	OFF

Table 10-1

Recommended ON/OFF Terminal Current

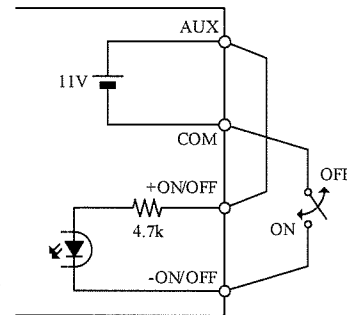


Fig. 10-2 ON/OFF Control Connection Example 2 (ON/OFF Control by Built-in AUX)

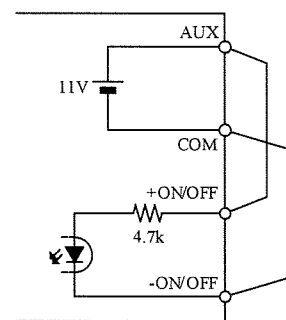
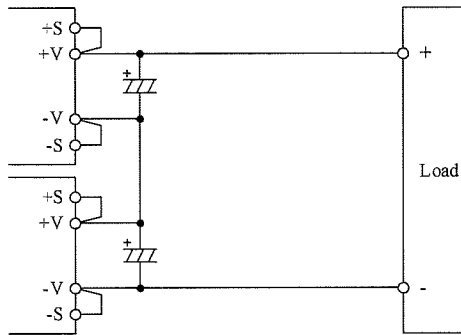


Fig. 10-3 ON/OFF Control Connection Example 3 (ON/OFF Control is not used)

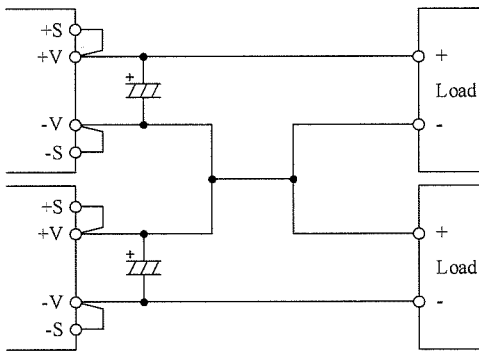
# PFE500F · 1000F SERIES

## 11. Series Operation

Series operation is possible for PFE500F Series and PFE1000F Series. Connections shown in Fig. 11-1 and Fig. 11-2 are possible.



**Fig. 11-1 Series Operation for High Output Voltage Applications**



**Fig. 11-2 +/--Output Series Applications**

## 12. Parallel Operation (PC terminal)

By connecting the PC terminal of each power module, output current can be equally drawn from each module. A maximum of 6 units of the same model can be connected.

However, maximum output current is derated by parallel operation units as shown in Table 12-1.

Note that usage of power module at out-of-rated condition might result in power module temperature abnormal rise or damage.

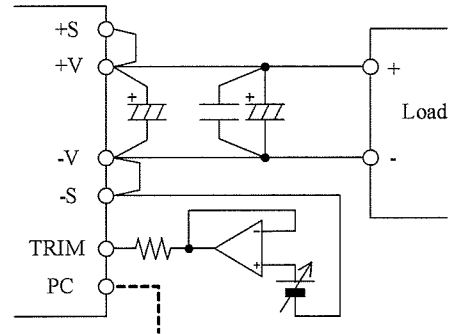
Parallel units	Maximum output current
~3 units	90% of nominal output current
4~6 units	85% of nominal output current

**Table 12-1 Condition for Parallel Operation**

Set the accuracy of the output voltage within +/-1% when adjust the output voltage for parallel operation.

When adjust the output voltage by applying external voltage at the TRIM terminal, insert a about 10k ohm resistor between TRIM terminal and external source.

Moreover, external circuits are necessary for TRIM terminal at each individual module.



**Fig. 12-1 Output Voltage Adjustment by applying external voltage (For parallel operation)**

At parallel operation, +BC, -BC and R terminals must not be connected in parallel with other modules. It might result in power module damage.

Refer to "Parallel Operation" of the PH-Series Application Notes for details.

## 13. Power ON Signal (ENA terminal)

This signal is located at the secondary side (output side) and it is an open collector output. (Maximum sink current is 10mA and maximum applied voltage is 75V.)

Return line for ENA terminal is the COM terminal.

When output voltage goes over a specified voltage level at start up, Power ON signal is LOW.

Output voltage threshold level is as follows.

<b>PFE500F · 1000F-12</b>	<b>: 8V (TYP)</b>
<b>PFE500F · 1000F-28</b>	<b>: 19V (TYP)</b>
<b>PFE500F · 1000F-48</b>	<b>: 33V (TYP)</b>

On the other hand, output voltage threshold level for Power ON signal to turn HIGH is as follows.

<b>PFE500F · 1000F-12</b>	<b>: 6V (TYP)</b>
<b>PFE500F · 1000F-28</b>	<b>: 15V (TYP)</b>
<b>PFE500F · 1000F-48</b>	<b>: 28V (TYP)</b>

## 14. I.O.G signal (IOG terminal)

Normal or abnormal operation of the power module can be monitored by using the IOG terminal. Output of this signal monitor is located at secondary side (output side) and is an open collector output.

This signal is LOW when inverter is normally operating and HIGH when inverter stops or when inverter is operating abnormally. (maximum sink current is 5mA, maximum applied voltage is 35V)

Ground for the IOG terminal is the COM terminal.

Also note that IOG becomes unstable for following conditions:

- Operation of Over Current Protection (OCP)
- Light load conditions at parallel operation
- Dynamic load operation

# PFE500F · 1000F SERIES

## 15. Auxiliary power supply

### for external circuits (AUX terminal)

For AUX terminal, output voltage value is within 10 ~ 14VDC range, maximum output current is 20mA. Ground for the AUX terminal is COM terminal.

Avoid short circuit of AUX terminal with other terminals as this would lead to power module damage.

## 16. Operating Temperature Range

These products can be used in any mounting direction but be sure to consider enough airflow to avoid heat accumulation around the module.

Consider surrounding components layout and set the PCB mounting direction such that air can flow through the heatsink by forced or convection cooling.

This product can operate at actual mounting condition when baseplate temperature is maintained at or below the following baseplate temperature.

- PFE500F-12 : 85 deg C
- PFE500F-28,48 : 100 deg C
- PFE1000F-12 : 100 deg C
- PFE1000F-28,48 : 85 deg C (85VAC ≤ Vin < 170VAC)
- 100 deg C (170VAC ≤ Vin ≤ 265VAC)

Verify baseplate temperature at worst case operating condition at the measuring point as shown in Fig. 16-1.

For Thermal Design details, refer to Power Module Application Notes "Thermal Design" section.

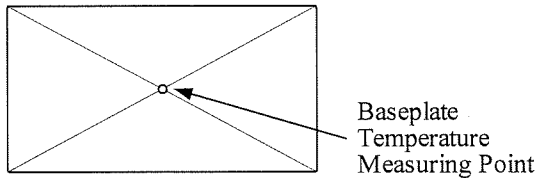


Fig. 16-1 Baseplate Measuring Point

Baseplate temperature range is limited according to Fig. 16-2.

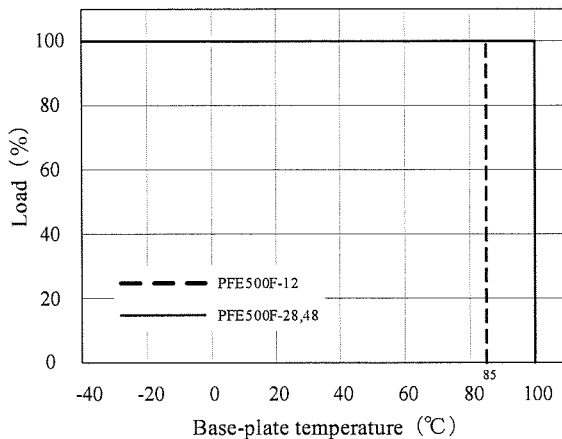


Fig. 16-2(1) PFE500F Series Derating Curve

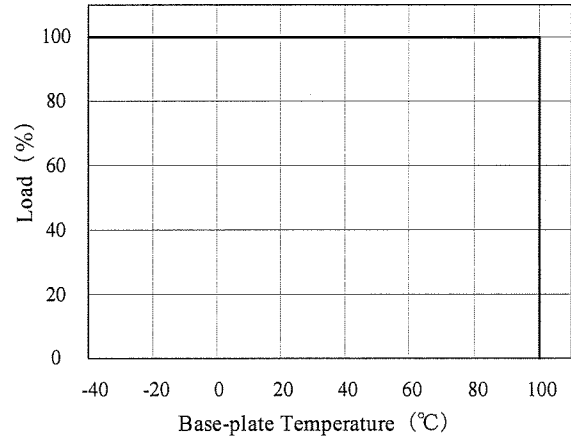


Fig. 16-2(2) PFE1000F-12 Derating Curve

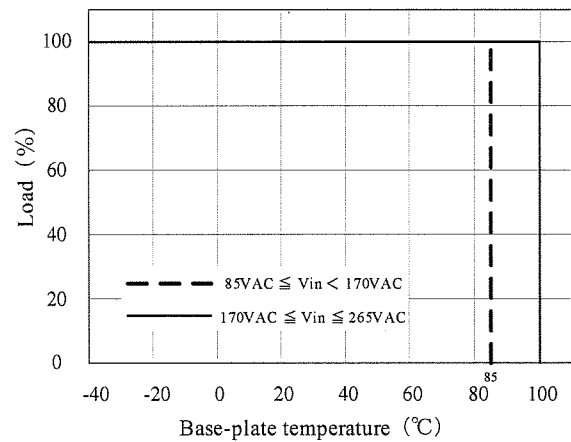


Fig. 16-2(3) PFE1000F-28,48 Derating Curve

To further improve the reliability, it is recommended to use this module with baseplate temperature derating.

## 17. Operating Humidity

Note that dewdrop might cause power module abnormal operation or damage.

## 18. Storage Temperature

Note that rapid temperature change causes dewdrop causing harmful effect on soldering condition of the terminal pins.

## 19. Storage Humidity

Storage under high temperature and high humidity causes rust on terminal pins that causes deterioration of soldering conditions. Take enough caution when storing this module.

## 20. Cooling Method

For details of thermal design, refer to Power Module Application Notes "Thermal Design" section.

# PFE500F · 1000F SERIES

## 21. Withstand Voltage

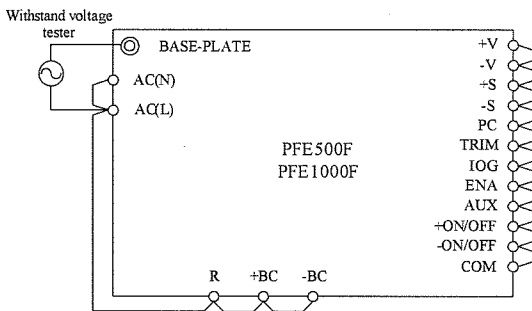
This module is designed to withstand applied voltage 2.5kVAC between input and baseplate, 3kVAC between input and output for a duration of 1 minute. When doing this test during incoming inspection, set the current limit of test equipment to 20mA.

This module is designed to withstand applied voltage 500VDC between output and baseplate for 1 minute. When doing this test during incoming inspection, be sure to apply DC voltage only. Avoid applying AC voltage during this test because this will damage the module.

Refrain from injecting high test voltage suddenly. Be sure to gradually increase the applied voltage during testing and gradually reduce the voltage after the test.

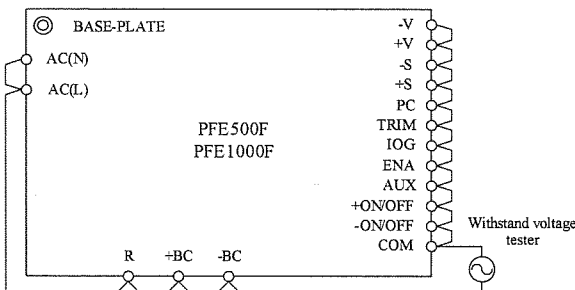
Especially, when using timer switch of the test equipment, impulse voltage which is higher than the applied set voltage, is generated when the timer switch is cut off. This causes damage to the power module. Connect each terminal according to the circuit diagram shown below.

For basic connection shown in Fig. 1-1, do the same terminal connections.



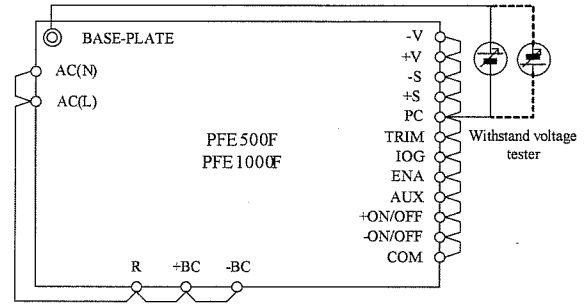
**2.5kVAC 1 minute (20mA)**

**Fig. 21-1 Input to Baseplate Withstand Voltage Test Method**



**3kVAC 1 minute (20mA)**

**Fig.21-2 Input to Output Withstand Voltage Test Method**



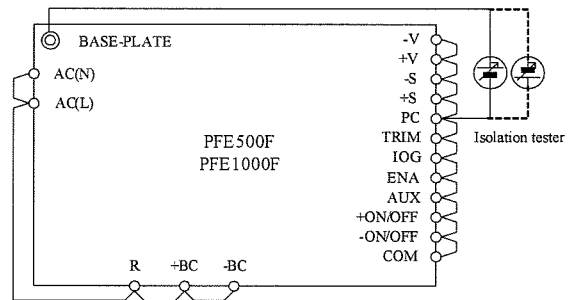
**500VDC 1 minute**

**Fig.21-3 Output to Baseplate Withstand Voltage Test Method**

## 22. Insulation Resistance

Use DC Insulation Resistance test equipment (MAX.500V) between output and baseplate.

Insulation Resistance must be 100Mohm or more at 500VDC. Take caution that some types of test equipment generate high pulse voltage when switching applied voltage. After test, discharge this module using resistor, etc.



**100Mohm or more at 500VDC**

**Fig. 22-1 Insulation Resistance Test Method**

## 23. Recommended Soldering Condition

Recommended soldering temperature is as follows.

(1) Soldering Dip :

**260°C, within 10 seconds**

Preheat :

**130°C, within 60 seconds**

(2) Soldering iron :

**350°C, within 3 seconds**



## ■ Before Concluding Power Module Damage

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Verify following items before concluding power module damage.

1) No output voltage

- Is specified input voltage applied?
- During output voltage adjustment, is the fixed resistor or variable resistor setting correct?
- Is there no abnormality with the output load?
- Is the actual baseplate temperature within the specified operating temperature of this module?
- Are the ON/OFF control terminals (+ON/OFF, -ON/OFF) correctly connected?

2) Output voltage is high

- Are the remote sensing terminals (+S, -S) correctly connected?
- Is the measurement done at the sensing points?
- During output voltage adjustment, is the fixed resistor or variable resistor setting correct?

3) Output voltage is low

- Is specified input voltage applied?
- Are the remote sensing terminals (+S, -S) correctly connected?
- Is the measurement done at the sensing points?
- During output voltage adjustment, is the fixed resistor or variable resistor setting correct?
- Is there no abnormality with the output load?

4) Load regulation or line regulation is large

- Is specified input voltage applied?
- Are the input or output terminals firmly connected?
- Is the measurement done at the sensing points?
- Are the input and output wires too thin?

5) Large output ripple

- Is the measurement done according to methods described Application Notes or is it an equivalent method?