PFE SERIES


PFE500-48
INPUT : 100-240VAC 8A
50/60Hz
OUTPUT : 48V ⎓ 10.5A
Power Module
AC-DC
TDK·Lambda
MADE IN MALAYSIA
-V
+V
-S
+S
TRIM
ENA
-BC
+BC
AC (N)
AC (L)

(Full-scale)

TDK·Lambda

Make it smaller.

Large size performance in a small size package

Makes your products smaller and your market share larger

From Japan to the world:

Launching new standard in power supplies today.

The World's first two-in-one full-brick AC-DC power supply. Halving the total package size.

One module now contains the functionality previously only obtainable by combining a front-end module with a high voltage input DC-DC converter.
The product is made using a wide range input AC/DC front-end function (harmonic current control and power factor correction) and a DC/DC back-end function (voltage conversion and isolation) in full-brick size. The package size is greatly reduced compared to our previous products - the PFE500 series approximately half the size and the PFE700 series one-third the size.

A 2% efficiency improvement. Significant energy savings.

With power supply efficiency increased by 2%, you can achieve significant energy savings. Power supplies are producers of heat. Reducing the amount of that heat is always a challenge for designers. The PFE500 series realizes an improvement of 2%. Its groundbreaking design reduces heat losses and hence power consumption. An efficiency improvement of 2% is in fact equivalent to the power used by 100,000 computers in standby mode. Thus adopting the PFE series will decrease your product running costs.

Good for use in harsh environments. -40˚C to +100˚C base-plate temperatures.

The PFE is suitable for use in outdoor equipment subject to heating from direct sunlight, making it ideal for designers of projects requiring advanced thermal management. Reliability has not been compromised with such base-plate temperature ratings, from -40˚C to +100˚C; PFE500-12 is from -40˚C to +85˚C.

AC/DC power module

PFE SERIES

Ideally, use the right power supplies in the right products.
The key is in the application - making use of power modules' advantage.

To maximize reliability, power supplies should always be used in applications for which they were designed for. Traditional unit type power supplies have their advantages and disadvantages. Now Designers can choose the type of power supply to best match their product concept. Just like an air-cooled engine, a power module provides simplicity of operation, ease of thermal management and an excellent value for money.

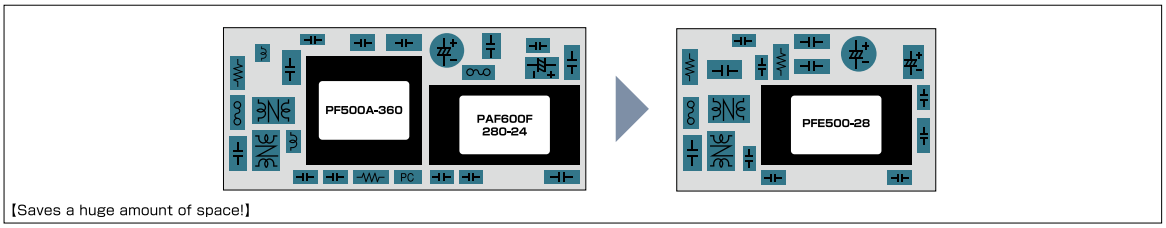
	Power module type	Unit type
Size	Small	Large
Cooling	Conduction	Convection or forced air with an internal fan
Mounting	Form factor can be freely decided	Restricted by case size
Design restriction	Possible to optimize the design according to the application	Determined by the manufacturer1s setting
Application design	Skill is required	Simple

Stimulating design creativity
Can be applied to variety of industrial fields.

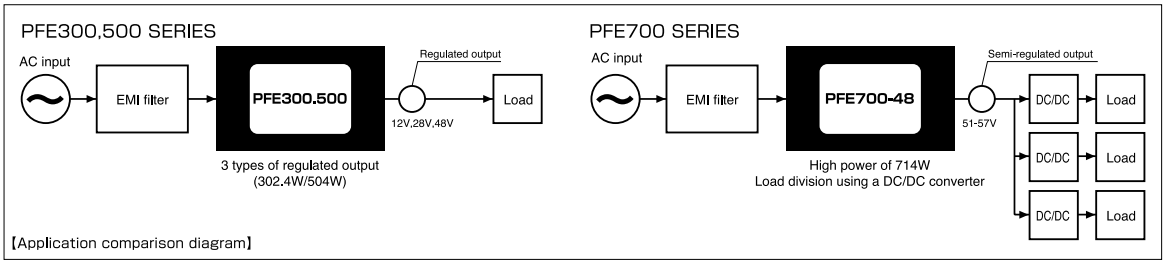
Rather than being faced with the daunting task of designing a custom power supply from the very basic fundamentals, we can provide you a module containing all the power components and control circuitry. It is then possible to create the optimal power supply, with only a basic knowledge of power supply operation. Our keywords are customization and personalization. By combining a few standard parts, you can create a power supply uniquely suited to your needs.

We welcome your application questions.
The leading provider of power supplies will support you through every step.

Even Designers new to using a power module for the first time need not be concerned; we can help you through every stage. We have sales outlets in 15 countries worldwide. If you just want to have a look at a PFE series product, please don't hesitate to give us a phone call.



【Saves a huge amount of space!】



【Application comparison diagram】

Select by output voltage

PFE300/500

Select by high power

PFE700 SERIES

* The comparison of properties are our company's comparisons. * The PFE series is developed and manufactured by Densei-Lambda K.K.

PFE SERIES

Single Output AC-DC Power Module

UL60950-1/ CSA C22.2 No.60950-1 | EN60950 | Low Voltage Directive | 2 YEARS warranty

■ Features

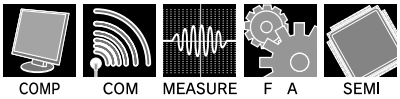
- PFHC and DC/DC conversion integrated into a full brick package
- Wide input voltage range: 85-265VAC
- High power factor: 0.95, meeting PFHC standard (EN61000-3-2)
- High efficiency: 86% max (PFE300,500), 89% max (PFE700)
- Wide operating temperature
  Baseplace temperature: -40℃ to +100℃
- Stable output voltage type (PFE300,500) and high power semi-regulated type (PFE700) in the line-up
- Parallel operation supported (PFE700 only)
- Built-in capacitor: Ceramic type only (high reliability)

■ Model naming method

PFE 500-12 / □

- Option
  None: Standard type
  T: Mounting stand ϕ3.3 (Non-thread, Through hole)
- Output voltage
- Output power
- Series name

■ Applications



■ Conformity to RoHS Directive

This means that, in conformity with EU Directive 2002/95/EC, lead, cadmium, mercury, hexavalent chromium, and specific bromine-based flame retardants, PBB and PBDE, have not been used, except for exempted applications.

■ Product Line up

PFE(AC85-265Vin)

Output Voltage	300W		500W		700W	
	Output Current	Model	Output Current	Model	Output Current	Model
12V	25A	PFE300-12	33A	PFE500-12	—	—
28V	10.8A	PFE300-28	18A	PFE500-28	—	—
48V	6.3A	PFE300-48	10.5A	PFE500-48	—	—
50-57V (Semi-regulated)	—	—	—	—	14A	PFE700-48

Note) PFE300/PFE500 are of the stable output voltage type, and they are constant-voltage power supplies as they are. PFE700 is of the semi-regulated type, and a multiple-output power supply can be configured by connecting other multiple DC/DC converters on the back of PFE700.

PFE300 Specifications

ITEMS/UNITS \ MODEL				PFE300-12	PFE300-28	PFE300-48
Input	Voltage Range	(*2)(*5)	V	AC85 - 265		
	Frequency	(*2)	Hz	47 - 63		
	Power Factor (min)	(*1)(*5)		0.95		
	Efficiency (typ)	(*1)	%	81 / 83	83 / 85	
	Current	(*1)	A	4.0 / 2.0		
	Inrush Current (typ)	(*1)(*5)	A	20 / 40 peak		
Output	Nominal Voltage	(*1)	VDC	12	28	48
	Maximum Current		A	25	10.8	6.3
	Maximum Power		W	300	302.4	
	Voltage Setting Accuracy		%	±2		
	Maximum Line Regulation		mV	48	56	96
	Maximum Load Regulation		mV	48	56	96
	Maximum Ripple Voltage	(*5)	mVp-p	120	280	480
	Voltage Adjustable Range			-20% / +20%		
Function	Over Current Protection			105% - 140% (Automatic recovery method)		
	Over Voltage Protection			125% - 145% (Inverter shutdown method)		
	Parallel Operation			-		
	Series Operation	(*6)		Possible		
Environment	Operating Temperature	(*3)(*7)	℃	-40 to +100 (Baseplate)		
	Storage Temperature		℃	-40 to +100		
	Operating Humidity		%RH	20 - 95 (No dewdrop)		
	Storage Humidity		%RH	10 - 95 (No dewdrop)		
	Vibration			At no operating, 10-55Hz (sweep for 1min.) Amplitude 0.825mm constant (maximum 49.0m/s²) X, Y, Z 1 hour each		
	Shock			196.1m/s²		
	Cooling	(*4)		Conduction cooled		
Isolation	Withstand Voltage			Input-Baseplate : 2.5kVAC, Input-Output : 3.0kVAC for 1min. Output-Baseplate : 1.5kVDC for 1min.		
	Isolation Resistance			Output to Baseplate 500VDC more than 100MΩ (25℃, 70%RH)		
	Safety Standards			Approved by UL60950-1, CSA C22.2 No.60950-1, EN60950-1		
Mechanical	Weight (typ)		g	250		
	Size (W x H x D)		mm	61 x 12.7 x 116.8 (Refer to outline drawing.)		

(*1) At 100VAC/200VAC and maximum output power. (Baseplate temperature = +25℃.)

(*2) For cases where conformance to various safety specs (UL, CSA, EN) are required, input voltage range will be 100 - 240VAC (50/60Hz).

(*3) Ratings - refer to derating curve below.

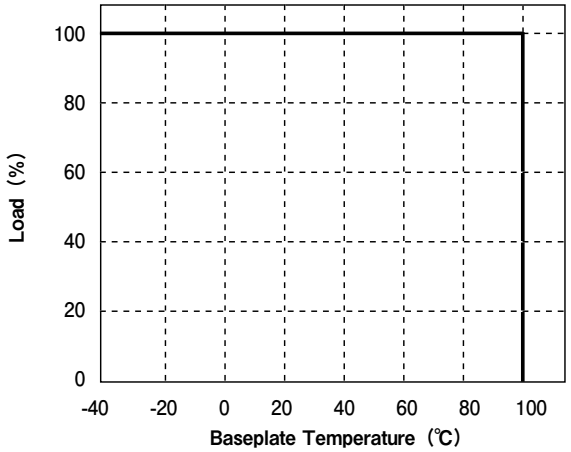
(*4) Heatsink has to be chosen according to instruction manual.

(*5) External components are needed for operation. (Refer to basic connection and instruction manual.)

(*6) Refer to instruction manual.

(*7) Ambient temperature min=-40℃

Derating Curve



PFE500 Specifications

ITEMS/UNITS		MODEL	PFE500-12	PFE500-28	PFE500-48
Input	Voltage Range (*2)(*5)	V	AC85 - 265		
	Frequency (*2)	Hz	47 - 63		
	Power Factor (min) (*1)(*5)		0.95		
	Efficiency (typ) (*1)	%	82 / 83	84 / 86	
	Current (*1)	A	5.0 / 3.0	6.2 / 3.2	
	Inrush Current (typ) (*1)(*5)	A	20 / 40 peak		
Output	Nominal Voltage (*1)	VDC	12	28	48
	Maximum Current	A	33	18	10.5
	Maximum Power	W	396	504	
	Voltage Setting Accuracy	%	±2		
	Maximum Line Regulation	mV	48	56	96
	Maximum Load Regulation	mV	48	56	96
	Maximum Ripple & Noise (*5)	mVp-p	120	280	480
	Voltage Adjustable Range		-20% / +20%		
Function	Over Current Protection		105% - 140% (Automatic recovery method)		
	Over Voltage Protection		125% - 145% (Inverter shutdown method)		
	Parallel Operation		-		
	Series Operation (*6)		Possible		
Environment	Operating Temperature (*3)(*7)	℃	-40 to +85 (Baseplate)	-40 to +100 (Baseplate)	
	Storage Temperature	℃	-40 to +100		
	Operating Humidity	%RH	20 - 95 (No dewdrop)		
	Storage Humidity	%RH	10 - 95 (No dewdrop)		
	Vibration		At no operating, 10-55Hz (sweep for 1min.) Amplitude 0.825mm constant (maximum 49.0m/s²) X, Y, Z 1 hour each		
	Shock		196.1m/s²		
	Cooling (*4)		Conduction cooled		
Isolation	Withstand Voltage		Input-Baseplate : 2.5kVAC, Input-Output : 3.0kVAC for 1min. Output-Baseplate : 1.5kVDC for 1min.		
	Isolation Resistance		Output to Baseplate 500VDC more than 100MΩ (25℃, 70%RH)		
	Safety Standards		Approved by UL60950-1, CSA C22.2 No.60950-1, EN60950-1		
Mechanical	Weight (typ)	g	250		
	Size (W x H x D)	mm	61 x 12.7 x 116.8 (Refer to outline drawing.)		

(*1) At 100VAC/200VAC and maximum output power. (Baseplate temperature = +25℃.)

(*2) For cases where conformance to various safety specs (UL, CSA, EN) are required, input voltage range will be 100 ~ 240VAC (50/60Hz).

(*3) Ratings - refer to derating curve on the right.

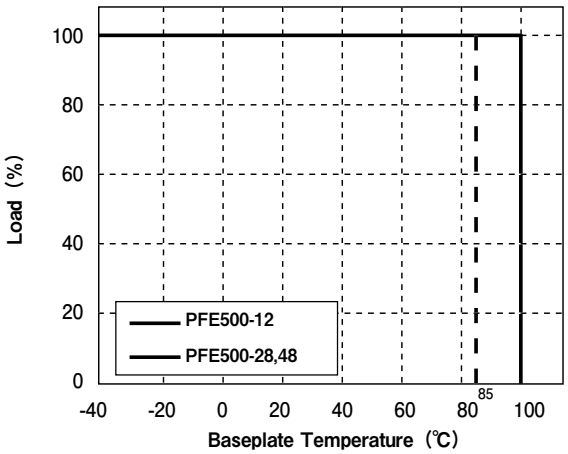
(*4) Heatsink has to be chosen according to instruction manual.

(*5) External components are needed for operation. (Refer to basic connection and instruction manual.)

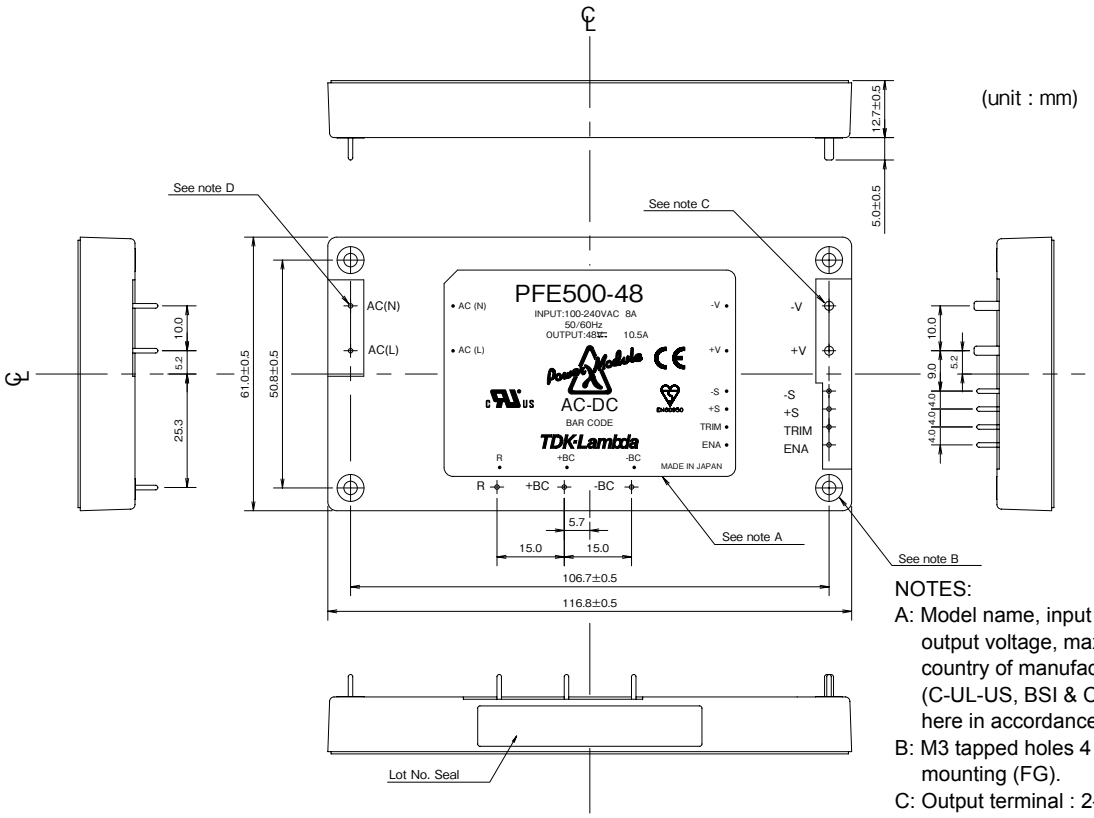
(*6) Refer to instruction manual.

(*7) Ambient temperature min=-40℃

Derating Curve



Outline Drawing



NOTES:

A: Model name, input voltage range, nominal output voltage, maximum output current, country of manufacture and safety marking (C-UL-US, BSI & CE marking) are shown here in accordance with the specifications.

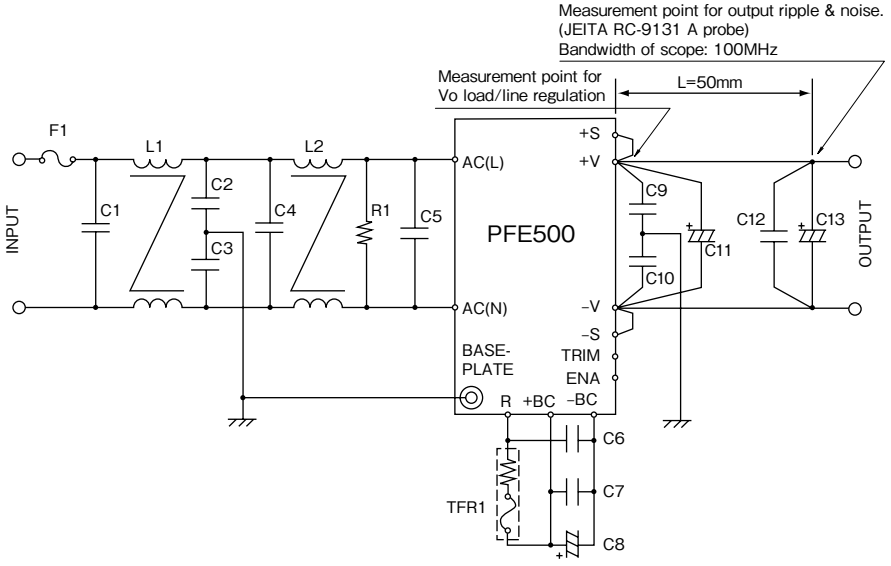
B: M3 tapped holes 4 for customer chassis mounting (FG).

C: Output terminal : 2-Φ2

D: Input, Intermediate terminal and signal pin: 9-Φ1

E: Unless otherwise specified dimensional tolerance : ±0.3

Basic Connection



F1	AC250V 15A	C11	12V: 25V 1000uF (Elec.)
C1	AC250V 1uF (Film)		28V: 50V 470uF (Elec.)
C2	4700pF		48V: 100V 220uF (Elec.)
C3	4700pF	C12	100V 2.2uF (Ceramic)
C4	AC250V 1uF (Film)	C13	12V: 25V 1000uF (Elec.)
C5	AC250V 1uF (Film)		28V: 50V 470uF (Elec.)
C6	450V 1uF (Film)		48V: 100V 220uF (Elec.)
C7	450V 1uF (Film)	R1	2W 470kΩ
C8	450V 390uF x2 Parallel (Elec.)	TFR1	10Ω 139℃ (Res., Thermal fuse)
C9	0.033uF	L1	6mH
C10	0.033uF	L2	6mH

PFE700 Specifications

ITEMS/UNITaS		MODEL	PFE700-48
Input	Voltage Range (*2)(*5)	V	AC 85 - 265
	Frequency (*2)	Hz	47 - 63
	Power Factor (min) (*1)(*5)		0.95
	Efficiency (typ) (*1)	%	86 / 89
	Current (*1)	A	8.8 / 4.4
	Inrush Current (typ) (*1)(*5)	A	20 / 40 peak
Output	Nominal Voltage (*1)	VDC	51
	Voltage Regulation Range (*7)	V	50 - 57
	Maximum Current	A	14
	Maximum Power	W	714
	Voltage Setting Accuracy (*1)	%	±1
	Maximum Ripple & Noise (*5)	mVp-p	4
Function	Over Current Protection		105% - 140% (Automatic recovery method)
	Over Voltage Protection	VDC	60.0 - 69.6 (Inverter shutdown method)
	Parallel Operation (*6)		Possible
	Series Operation (*6)		Possible
Environment	Operating Temperature (*3)	℃	-40 to +100 (Baseplate), Ambient temperature min=-40℃
	Storage Temperature	℃	-40 to +100
	Operating Humidity	%RH	20 - 95 (No dewdrop)
	Storage Humidity	%RH	10 - 95 (No dewdrop)
	Vibration		At no operating, 10-55Hz (sweep for 1min.) Amplitude 0.825mm constant (maximum 49.0m/s²) X, Y, Z 1 hour each
	Shock		196.1m/s²
	Cooling (*4)		Conduction cooled
Isolation	Withstand Voltage		Input-Baseplate : 2.5kVAC, Input-Output : 3.0kVAC for 1min. Output-Baseplate : 1.5kVDC for 1min.
	Isolation Resistance		Output to baseplate 500VDC more than 100MΩ (25℃, 70%RH)
Standards	Safety Standards		Approved by UL60950-1, CSA C22 : 2 No.60950-1, EN60950-1
Mechanical	Weight (typ)	g	250
	Size (W x H x D)	mm	61 x 12.7 x 116.8 (Refer to outline drawing.)

(*1) At 100VAC/200VAC and maximum output power. (Baseplate temperature = +25℃.)

(*2) For cases where conformance to various safety specs (UL, CSA, EN) are required, input voltage range will be 100 ~ 240VAC (50/60Hz).

(*3) Ratings - refer to Derating Curve on the right.

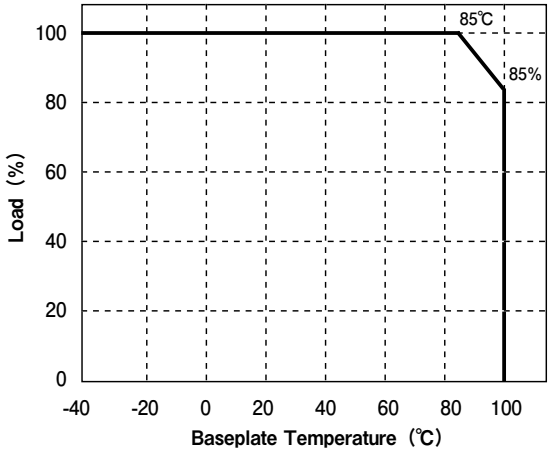
(*4) Heatsink has to be chosen according to Instruction manual.

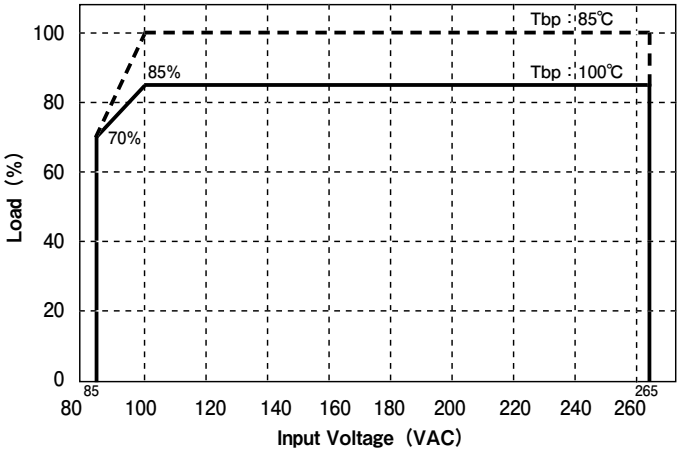
(*5) External components are needed for operation. (Refer to basic connection and instruction manual.)

(*6) Refer to Instruction manual.

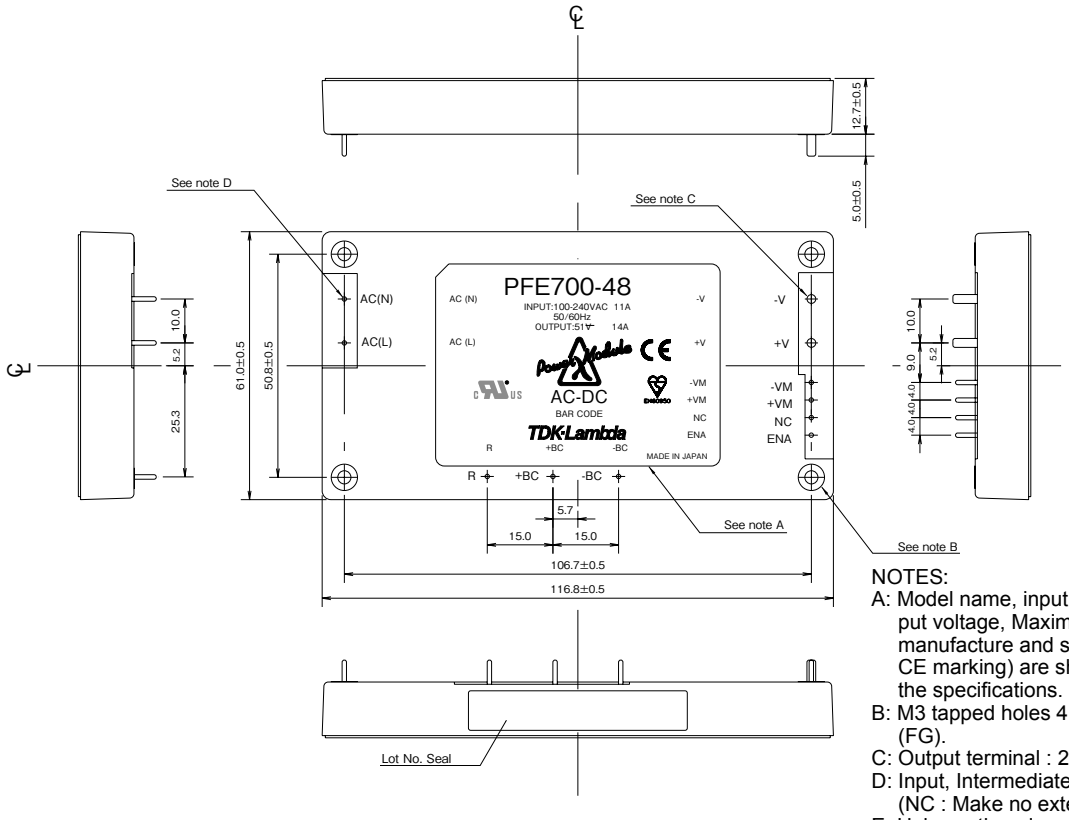
(*7) For all input voltage, output load and temperature range.

Derating Curve



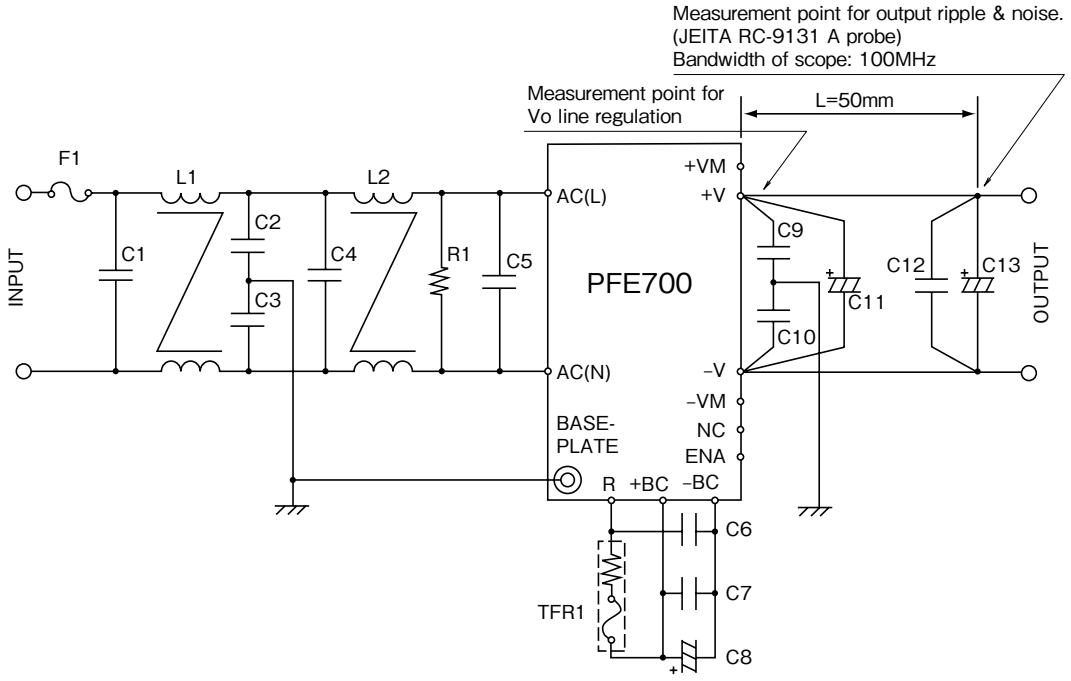


Outline Drawing



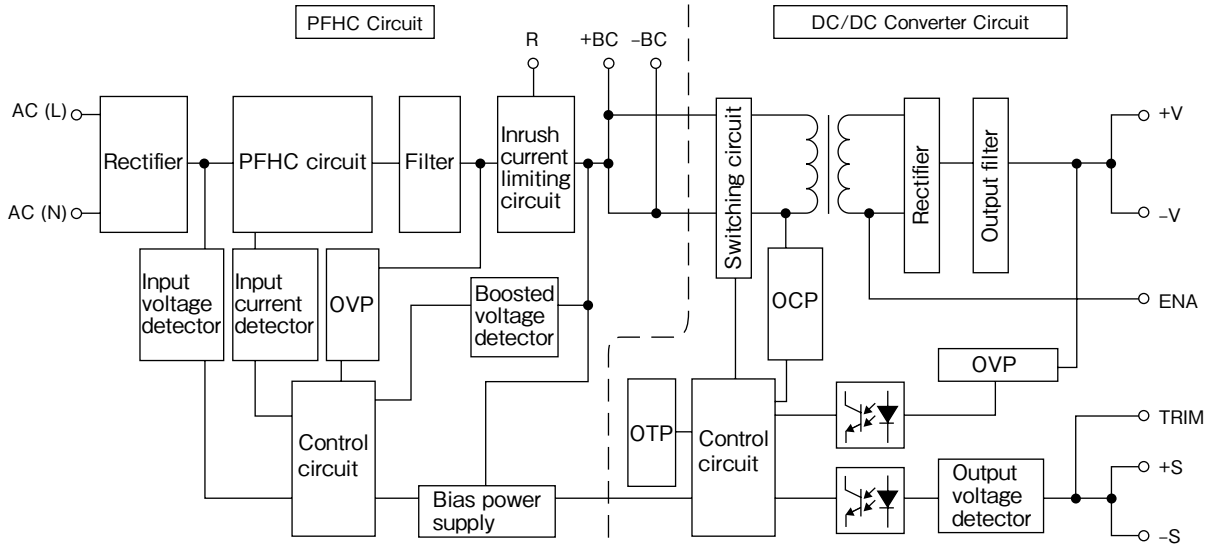
NOTES:
A: Model name, input voltage range, Nominal output voltage, Maximum output current, country of manufacture and safety marking (C-UL-US, BSI & CE marking) are shown here in accordance with the specifications.
B: M3 tapped holes 4 for customer chassis mounting (FG).
C: Output terminal : 2-Φ2
D: Input, Intermediate terminal and signal pin: 9-Φ1 (NC : Make no external connection)
E: Unless otherwise specified dimensional tolerance : ±0.3

Basic Connection



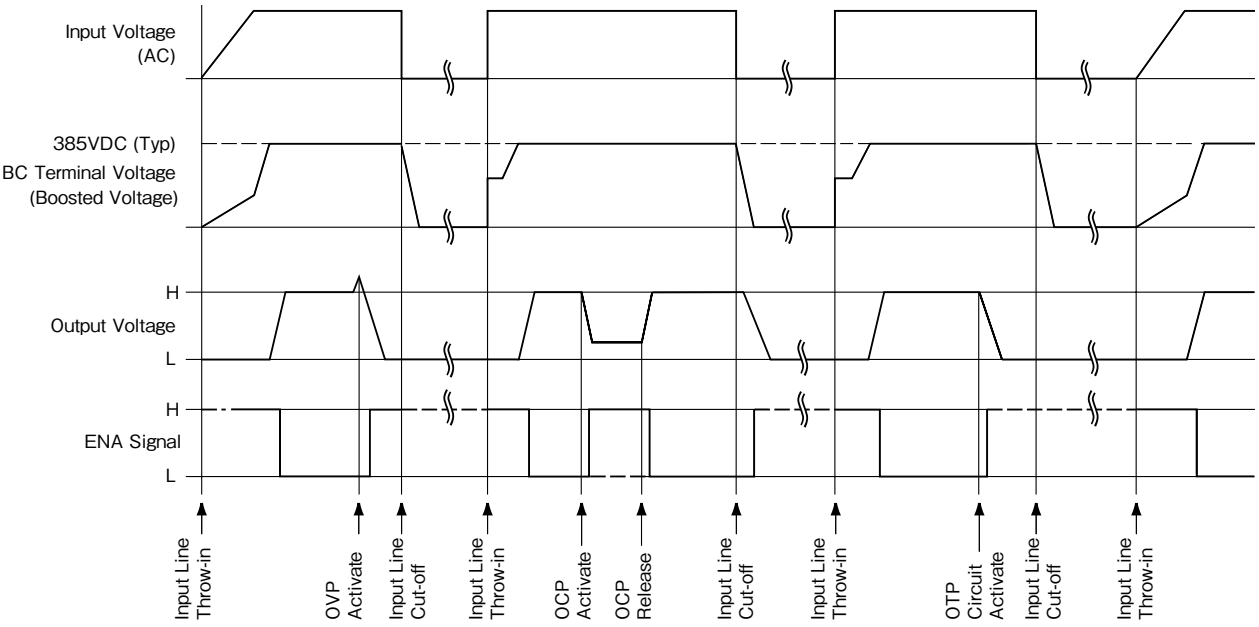
F1	AC250V 15A	C9	0.033uF
C1	AC250V 1uF(Film)	C10	0.033uF
C2	4700pF	C11	100V 220uF(Elec.)
C3	4700pF	C12	100V 2.2uF(Ceramic)
C4	AC250V 1uF(Film)	C13	100V 220uF(Elec.)
C5	AC250V 1uF(Film)	R1	2W 470k Ω
C6	450V 1uF(Film)	TFR1	10 Ω 139℃ (Res.,Thermal fuse)
C7	450V 1uF(Film)	L1	6mH
C8	450V 390uF x2 Parallel(Elec.)	L2	6mH

Block Diagram



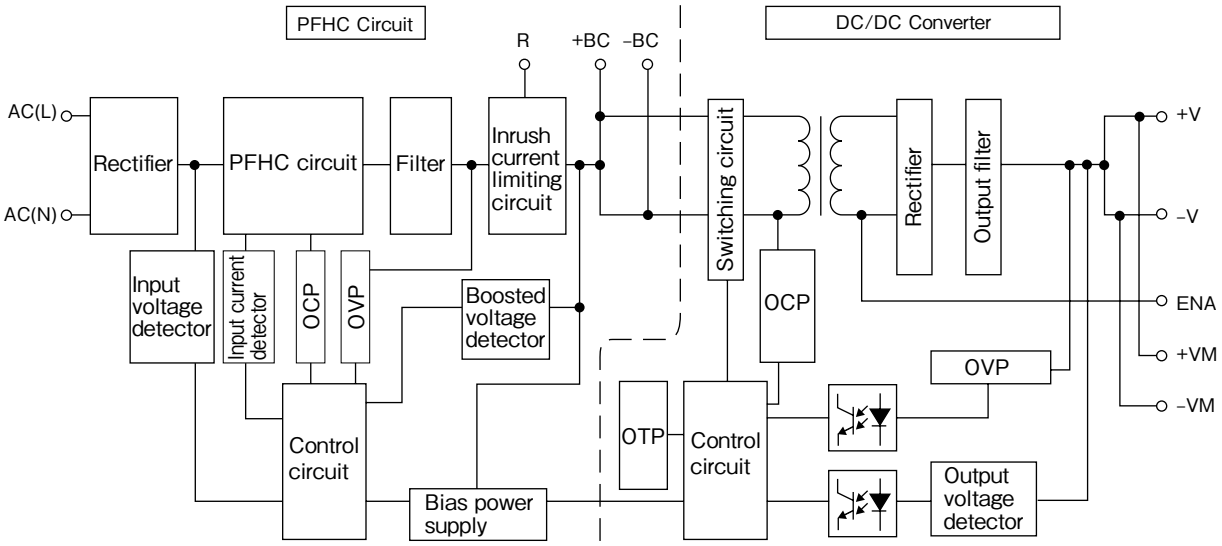
Switching Frequency
PFHC circuit (fixed) : 100kHz
DC/DC converter (fixed) : 230kHz (primary),460kHz (secondary)

Sequence Time Chart



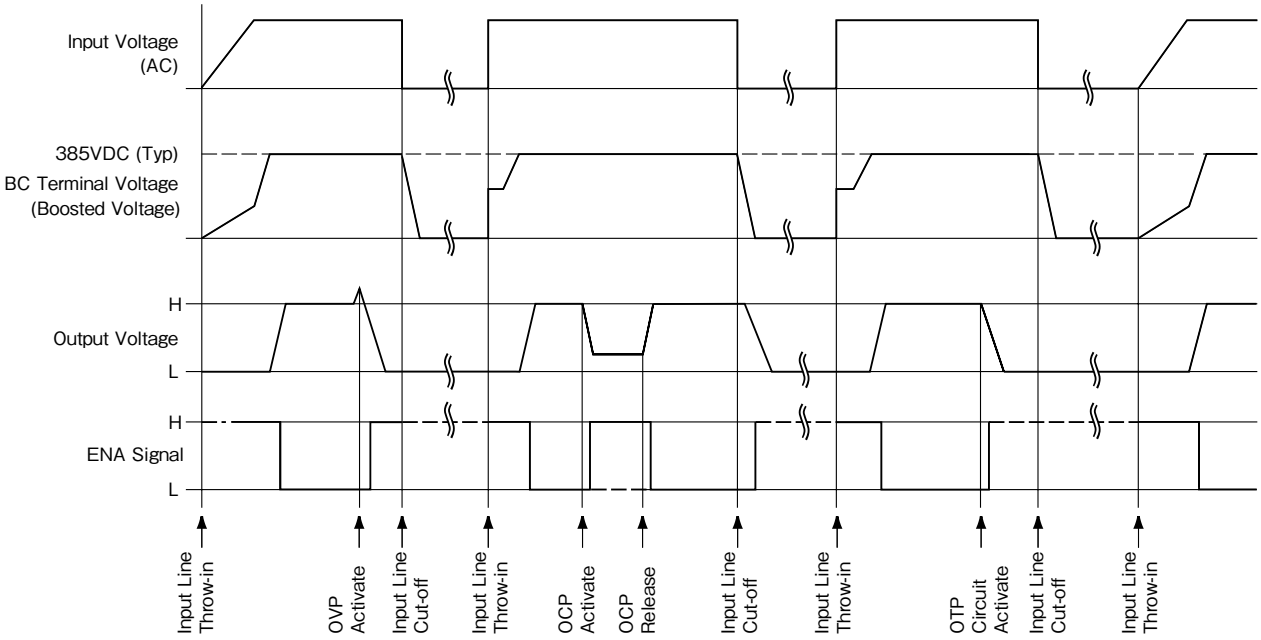
Note : This product has no remote ON/OFF function.

Block Diagram



Switching Frequency
PFHC circuit (fixed) : 100kHz
DC/DC converter (fixed) : 180kHz (primary), 360kHz (secondary)

Sequence Time Chart



Note : This product has no remote ON/OFF function.

PFE300, 500 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.

⚠ WARNING

- Do not make unauthorized changes to power supply unit, otherwise you may have electric shock and void your warranty.
- Do not touch this unit and the internal components in operation or shortly after shut down. They may have high voltage or high temperature and as the unit dissipates its heat so the surface of the unit is hot. You may receive electric shock or burn.
- When the unit is operating, keep your hands and face away from it; you may 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 may cause fire and electric shock.

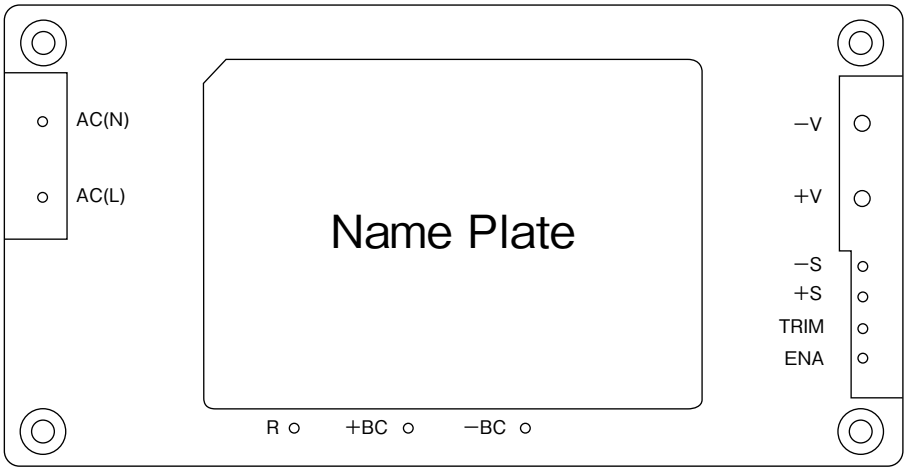
⚠ CAUTION

- 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 an HBC external fuse to each module to ensure safety operation and compliance to each safety standard approval. The recommended input fuse rating within the instructions is as follows: -15AHBC, 250V fast acting fuse. The breaking capacity and voltage rating of this fuse may 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 may 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 electric 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 date specifications of the unit.
- No part of this document may be copied or reproduced in any form without prior written consent of Densei-Lambda.

Note : CE MARKING

CE Marking, when applied to a product covered by this handbook, indicates compliance with the low voltage directive (73/23/EEC) as modified by the CE Marking Directive (93/68/EEC) which complies with EN60950.

1. Terminal Explanation



[Input side terminals]

AC(L) : Input terminal live line
AC(N) : Input terminal neutral line

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

[Output side terminals]

+V : +Output terminal
-V : -Output terminal

+S : +Remote sensing terminal
-S : -Remote sensing terminal
TRIM : Output voltage trimming terminal
ENA : Power on signal 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 (385VDC).
Do not connect load from these terminals.

2. Explanations on Specifications

This manual explains based on "Fig.1-1 Basic Connection".
Please do actual evaluation when changing circuit from Fig.1-1.

1 Input Voltage Range

Input voltage range is indicated below. Take care not to apply input voltage which is out of this specified range 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

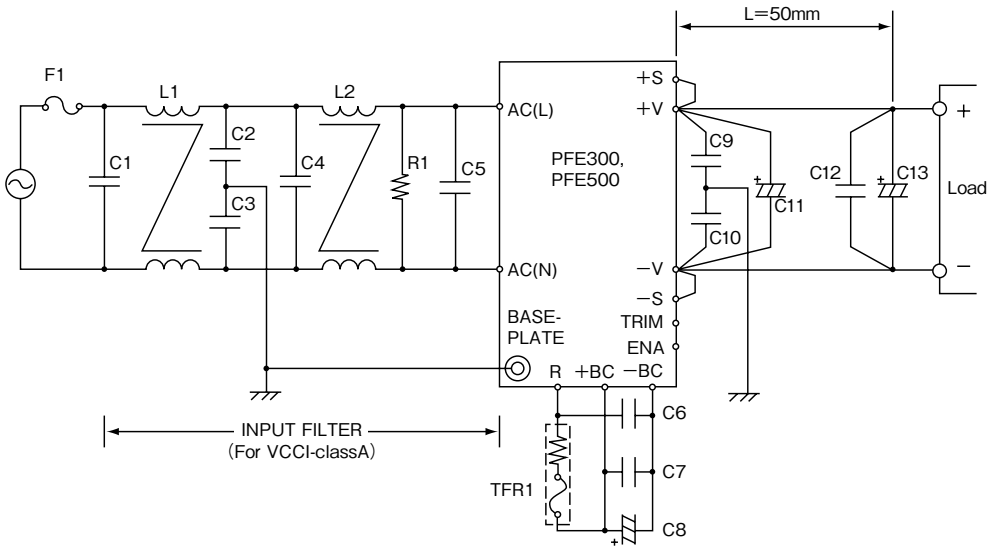


Fig. 1-1 Basic Connection

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^2t rating of external switch and external fuse.

Recommended External Fuse: 15A

Select fuse based on rated voltage, rated current and surge current capability.

(1) Voltage Ratings
100VAC line: AC125V
200VAC line: AC250V

(2) Current Ratings
Rated current is determined by the maximum input current based on operating conditions and can be calculated by the following formula.

$$Iin(max) = \frac{Pout}{Vin \times Eff \times PF} \quad (Arms) \text{ (Formula 1-1)}$$

Iin (max): Maximum Input Current
Pout: Maximum Output Power
Vin: Minimum Input Voltage
Eff: Efficiency
PF: Power Factor

For efficiency and power factor values, refer to separate "Evaluation Data of each product".

C1, C4, C5: 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 as near as possible towards the input terminals of this power module.

L1, L2: 6mH

Add common mode choke coil as EMI/EMS counter-measure. 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: 4,700pF (Ceramic Capacitor)

Add ceramic capacitor as EMI/EMS countermeasure. Be sure to consider leakage current of your equipment when adding this capacitor.

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

R1: 470kΩ

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

C6, C7: 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 C6, C7 as near as possible towards the output terminals of this power module.

C8: Electrolytic Capacitor
PFE300: 470μF×1
PFE500: 390μF×2 pcs in parallel

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

Allowable External Capacitance at nominal capacitor value is shown below.

Recommended Voltage Rating: 450VDC
Recommended Total Capacitor: 390uF to 1,200uF

Note) 1. Do not connect capacitors with more than the above capacitance value as this would result into power module damage.
2. When using module below -20℃ ambient temperature, AC ripple of boost voltage, output ripple voltage and stand up characteristics might be affected by ESR characteristics of the bulk capacitor.
Therefore, be sure to verify characteristics by actual evaluation.

C9, C10: 0.033uF

Connect ceramic or film capacitor as EMI/EMS countermeasure and to reduce spike noise.

Note) High Voltage is applied across this capacitor during withstand voltage test depending on the application.
Connect C9, C10 as near as possible towards the output terminals of this power module.

C11: Refer to Table 1-1

To reduce output ripple noise voltage, connect electrolytic capacitors across +V and -V.

Note) Connect C11 as near as possible to the +V and -V output terminals of this power module.

Vout	C11
12V	25V 1,000uF
28V	50V 470uF
48V	100V 220uF

Table 1-1 C11 : Recommended external capacitance

C12: 2.2uF

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

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

C13 : Refer to Table 1-2

Connect C13 within 50mm from the output terminals +V and -V of the power module to stabilize operation.

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 may vary depending on the wiring pattern of the printed circuit board.

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

Vout	C13
12V	25V 1,000uF
28V	50V 470uF
48V	100V 220uF

Table 1-2 C13 : Recommended external capacitance

Note) 1. Use low-impedance electrolytic capacitors with excellent temperature characteristics.
(Nihon Chemi-con LXY Series or equivalent)
(Nichicon PM Series or equivalent)

2. For module operation at ambient temperature -20℃ 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	C11, C13
12V	25V 1,000uF x 2parallel
28V	50V 470uF x 2parallel
48V	100V 220uF x 2parallel

Table 1-3 C11, C13 : Recommended external capacitance

(Ambient Temperature < -20 deg C)

3. Take note of the maximum allowable 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 be exceeded.

● Selection Method of External Bulk Capacitor for Boost Voltage

Boost voltage bulk capacitor is determined by boost voltage ripple voltage, ripple current and hold-up time.

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

Note) When ambient temperature is -20℃ or less,
Boost voltage might increase due to ESR characteristics. Therefore, verify above characteristics by actual evaluation.

For output hold-up time, refer to separate document "PFE 300 Series Evaluation Data" or "PFE500 Series Evaluation Data" and use appropriate capacitor up to 1,200uF maximum. (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.

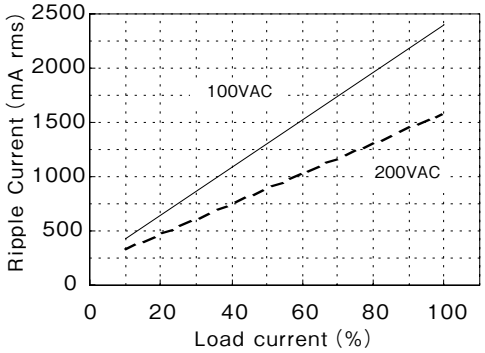


Fig. 1-2 Allowable ripple current value

TFR1 : 10 to 100Ω

By connecting thermal fuse 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) can occur. Therefore, be sure to connect this external thermal fuse resistor.

Note that this module will not operate without this external resistor.

● Selection Method of External Resistor

(1) Calculating Resistance Value for TFR1

Resistance can be calculated by the formula below.

$$R = \frac{Vin}{Irush} (\Omega) \text{ (Formula 1-2)}$$

R: Resistance Value for External TFR1
Vin: Input Voltage converted to DC value
=Input Votlage (rms) $\times\sqrt{2}$
Irush: Input surge current value

(2) Required Surge Current Rating

Sufficient surge current withstand capability is required for external TFR1.

Required Surge Current Rating can be selected by I^2t. (Current squared multiplied by time).

$$I^2t = \frac{Co \times Vin^2}{2 \times R} (A^2s) \text{ (Formula 1-3)}$$

I^2t: Current-squared multiplied by time
Co: Booster Voltage Bulk Capacitance
Vin: Input Voltage converted to DC value
= Input Voltage (rms) x $\sqrt{2}$
R: Resistance Value for External TFR1

2 Output Voltage Adjustment Range

Output Voltage can be adjusted within the range below by connecting fixed and variable resistors. However, take care not to exceed the output voltage range shown below because OVP function will activate.

Output Voltage Adjustment Range :
±20% of the typical voltage rating

When increasing output voltage, reduce output current so as not to exceed maximum output 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	10k	47k	100k
VR	10k	20k	30k

unit: [Ω]

External Resistor: Tolerance ±5% or less
Variable Resistor: Total Tolerance ±20% or less
End Resistance 1% or less

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

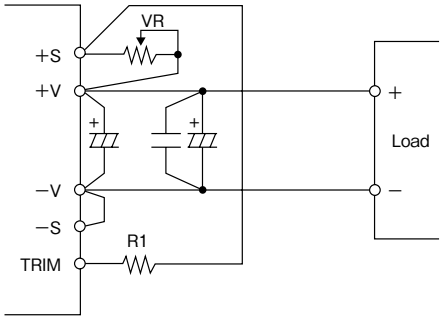


Fig. 2-1 External Resistor Connection Example

3 Maximum Ripple and Noise

This value is measured according to the description below in accordance with JEITA-9131A (Section 7.12 and Section 7.13).

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 may vary depending on the wiring pattern of the printed circuit board.

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

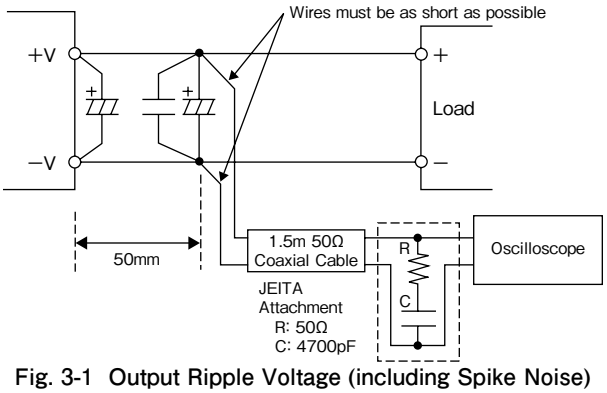


Fig. 3-1 Output Ripple Voltage (including Spike Noise) Measurement Method

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 can occur. Make prior evaluation thoroughly before using this power module.

6 Over Current Protection (OCP)

This module is equipped with OCP function.

Output will automatically recover when short circuit or overload condition is removed. OCP value is fixed and cannot be adjusted externally.

Note that continuous short circuit or overload condition 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.

OVP value is fixed and cannot be set externally.

8 Over Temperature Protection (OTP)

This module is equipped with OTP function. This function will activate and shutdown the output when ambient temperature or internal temperature abnormally rises. OTP activates at following baseplate temperature.

PFE300-12, 28, 48: 105 to 130℃
PFE500-12: 90 to 115℃
PFE500-28, 48: 105 to 130℃

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.

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 2V.
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.

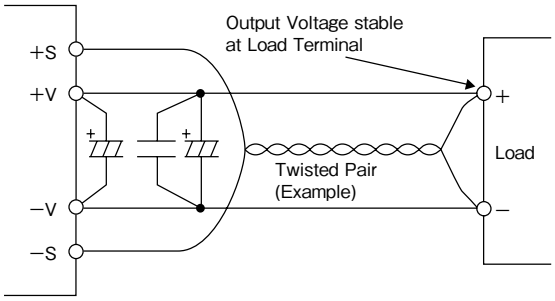


Fig. 9-1 Remote Sensing is used

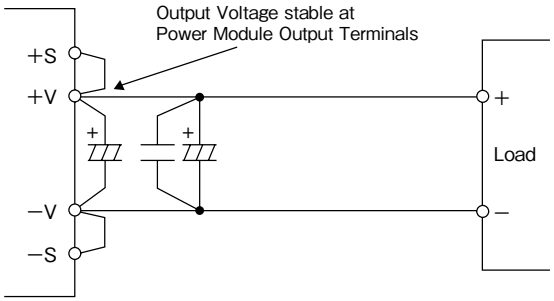


Fig. 9-2 Remote Sensing is not used (Local Sensing)

10 Series Operation

Series operation is possible for PFE300, 500 Series.
Connections shown in Fig.10-1 and Fig.10-2 are possible.

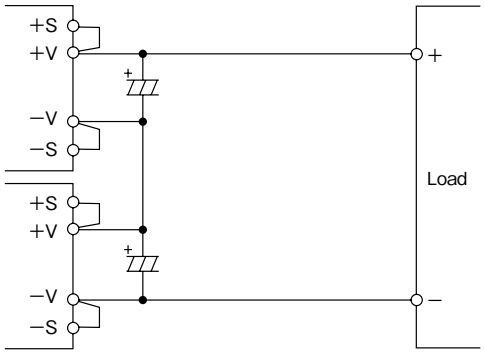


Fig. 10-1 Series Operation for High Output Voltage Applications

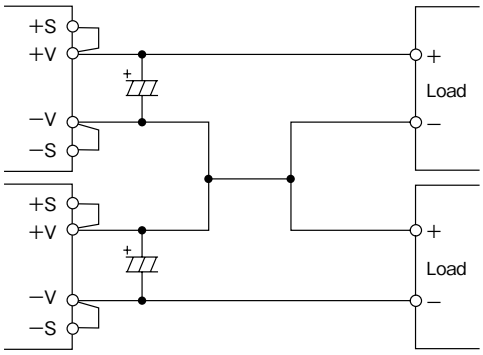


Fig. 10-2 ±Output Series Applications

11 Power ON Signal (ENA Terminal)

This signal is located at the secondary side (output side) and is an open collector output.
(Maximum sink current is 10mA and maximum applied voltage is 75V.)
Return line for ENA terminal is the -V terminal.
When output voltage goes over a specified voltage level at start up, Power ON signal is "Low level".
Output voltage threshold level is as follows.

PFE300 or PFE500-12 : 9V (TYP)
PFE300 or PFE500-28 : 21V (TYP)
PFE300 or PFE500-48 : 37V (TYP)

On the other hand, output voltage threshold level for Power ON signal to turn high level at shutdown varies according to output condition. Therefore, be sure to do actual verification.

12 Operating Ambient Temperature Range

These products can be used in any orientation 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:

PFE300-12, 28, 48: 100℃
PFE500-12: 85℃
PFE500-28, 48: 100℃

Verify baseplate temperature at worst case operating condition at the measuring point shown in Fig. 12-1.
For Thermal Design details, refer to Application Notes "Thermal Design" section.

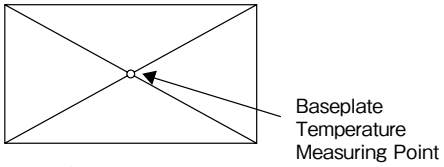


Fig. 12-1 Baseplate Measuring Point

Baseplate temperature range is limited according to Fig. 12-2.

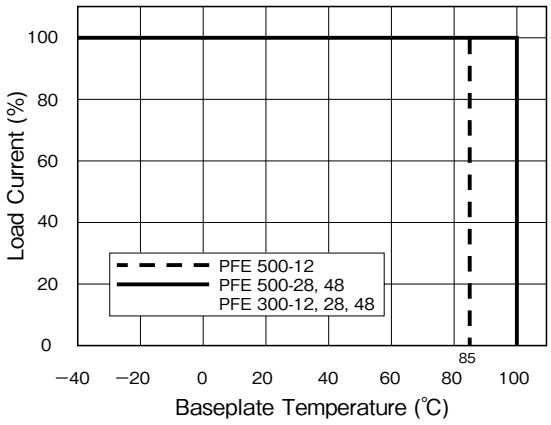


Fig. 12-2 Derating Curve

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

13 Operating Ambient Humidity

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

14 Storage Ambient Temperature

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

15 Storage Ambient 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.

16 Cooling Method

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

17 Withstand Voltage

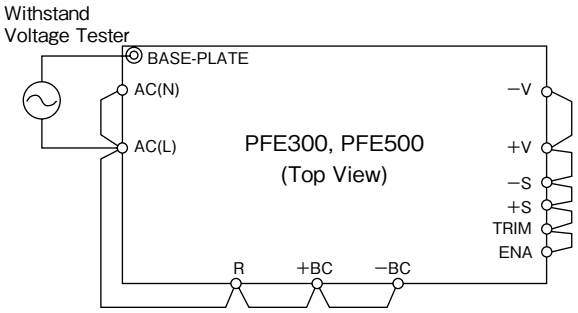
This module is designed to withstand applied voltage 2.5kVAC between input and baseplate, 3kVAC between input and output for a duration of 1 minute. When doing this test during incoming inspection, set the current limit of test equipment to 20mA.

This module is designed to withstand applied voltage 1.5kVDC 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 withstand voltage during testing and gradually reduce the voltage after the test.

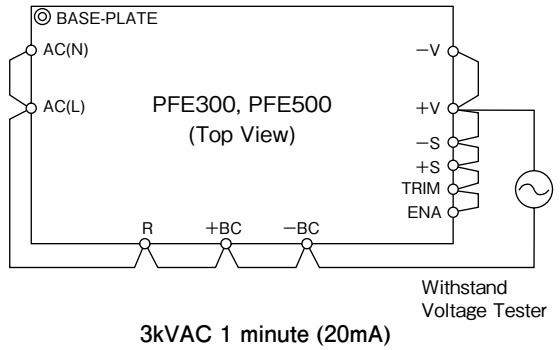
Especially, when using timer switch of the test equipment, impulse voltage which is higher than the applied set voltage, is generated when the timer switch is cut off. This causes damage to the power module. Connect each terminal according to the circuit diagram shown below.

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



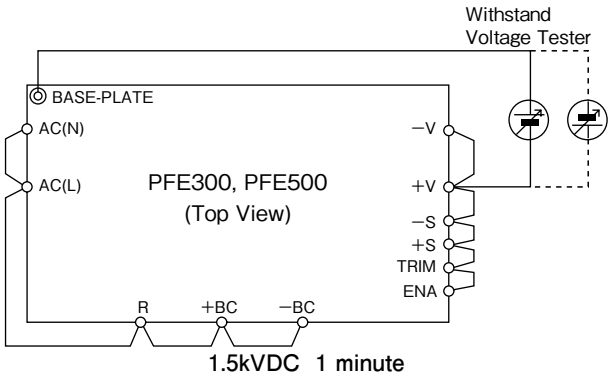
2.5kVAC 1 minute (20mA)

Fig. 17-1 Input to Baseplate Withstand Voltage Test Method



3kVAC 1 minute (20mA)

Fig.17-2 Input to Output Withstand Voltage Test Method

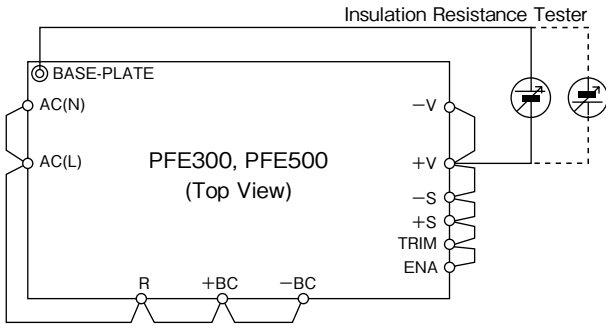


1.5kVDC 1 minute

Fig.17-3 Output to Baseplate Withstand Voltage Test Method

18 Insulation Resistance

Use DC Insulation Resistance test equipment (MAX.500V) between output and baseplate.
Insulation Resistance must be 100MΩ 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.



100MΩ or more at 500VDC
Fig. 18-1 Insulation Resistance Test Method

4. Before Concluding Power Module Damage

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?

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 equiva lent method?

PFE700 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 electric shock, damage to the unit or a fire hazard.

⚠ WARNING

- Do not make unauthorized changes to power supply unit, otherwise you may have electric shock and void your warranty.
- Do not touch this unit and the internal components in operation or shortly after shut down. They may have high voltage or high temperature and as the unit dissipates its heat so the surface of the unit is hot. You may receive electric shock or burn.
- When the unit is operating, keep your hands and face away from it; you may 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 may cause fire and electric shock.

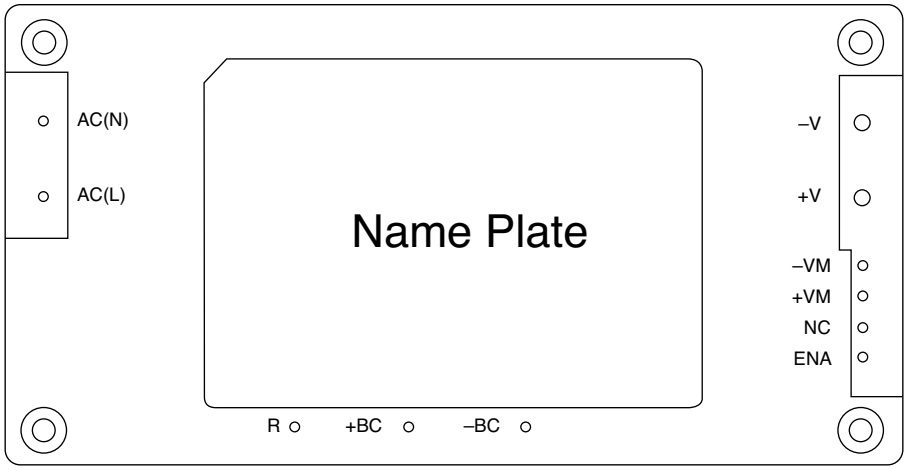
⚠ CAUTION

- 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. This model is 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 an HBC external fuse to each module to ensure safety operation and compliance to each safety standard approval. The recommended input fuse rating within the instructions is as follows: -15AHBC, 250V fast acting fuse. The breaking capacity and voltage rating of this fuse may 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 may 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 electric 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.
- No part of this document may be copied or reproduced in any form without prior written consent of Densei-Lambda.

Note : CE MARKING

CE Marking, when applied to a product covered by this handbook, indicates compliance with the low voltage directive (73/23/EEC) as modified by the CE Marking Directive (93/68/EEC) which complies with EN60950.

1. Terminal Explanation



[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

[Output side terminals]

+V : +Output terminal
−V : −Output terminal

+VM : +VOutput monitor terminal
−VM : −VOutput monitor terminal
NC : Make no external connection
ENA : Power on signal 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 are primary voltage with high voltage (385VDC). Do not connect load from these terminals.
- Do not make external connection to NC terminal.

2. Explanations on Specifications

This manual explains based on "Fig. 1-1 Basic Connection." Please do actual evaluation when changing circuit from Fig.1-1.

1 Input Voltage Range

Input voltage range is indicated below. Take care not to apply input voltage which is out of this specified range 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

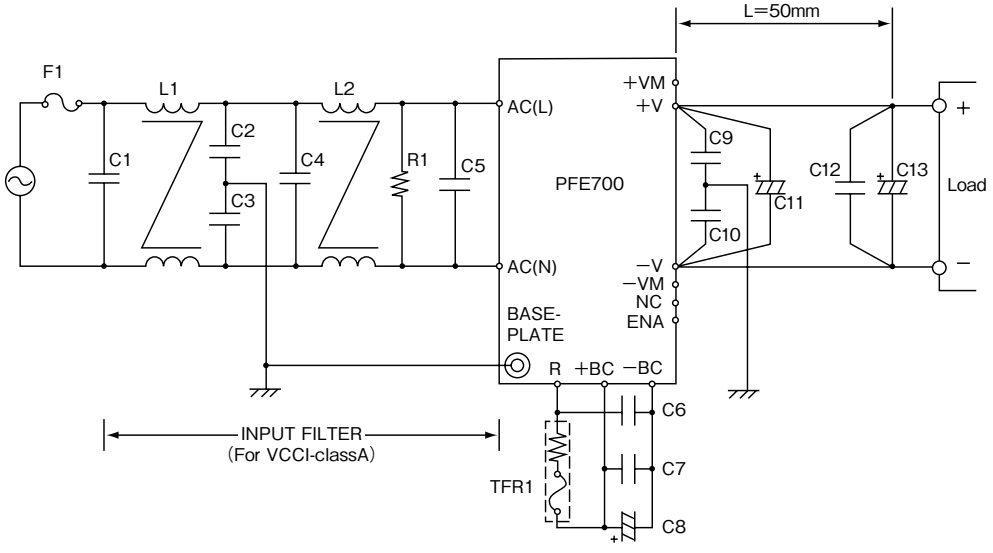


Fig. 1-1 Basic Connection

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^2t rating of external switch and external fuse.

Recommended External Fuse: 15A

Select fuse based on rated voltage, rated current and surge current capability.

(1) Voltage Ratings
100VAC line: AC125V
200VAC line: AC250V

(2) Current Ratings
Rated current is determined by the maximum input current based on operating conditions and can be calculated by the following formula.

$$Iin(max) = \frac{Pout}{Vin \times Eff \times PF} \text{ (Arms) (Formula 1-1)}$$

Iin (max): Maximum Input Current
Pout: Maximum Output Power
Vin: Minimum Input Voltage
Eff: Efficiency
PF: Power Factor

For efficiency and power factor values, refer to separate document "PFE700 Series Evaluation Data".

C1, C4, C5: 1μF (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 as near as possible towards the input terminals of this power module.

L1, L2: 6mH

Add common mode choke coil as EMI/EMS counter-measure. 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: 4,700pF (Ceramic Capacitor)

Add ceramic capacitor as EMI/EMS countermeasure. Be sure to consider leakage current of your equipment when adding this capacitor.

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

R1: 470kΩ

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

C6, C7: 1μF (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 C6, C7 as near as possible towards the output terminals of this power module.

C8: 780μF (390μF×2 pcs. in parallel) (Electrolytic Capacitor)

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

Allowable external capacitance at nominal capacitor value is shown below.

Recommended Voltage Rating: 450VDC
Recommended Total Capacitor: 390uF to 1,200uF

Note) 1. Do not connect capacitors with more than the above capacitance value as this would result into power module damage.
2. 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.

C9, C10: 0.033μF

Connect ceramic or film capacitor as EMI/EMS countermeasure and to reduce spike noise.

Note) High voltage is applied across this capacitor during withstand voltage test depending on the application.
Connect C9, C10 as near as possible towards the output terminals of this power module.

C11: 220μF

To reduce output ripple noise voltage, connect electrolytic capacitors across +V and −V.

Note) Connect C11 as near as possible to the +V and −V output terminals of this power module.

Recommended Voltage Rating: 100VDC

C12: 2.2μF

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

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

C13: 220μF

Connect C13 within 50mm from the output terminals +V and −V of the power module to stabilize operation.

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 may vary depending

on the wiring pattern of the printed circuit board.
Sudden change in output voltage due to sudden load change or sudden input voltage change can be reduced by increasing external output capacitor value.

Recommended Voltage Rating: 100VDC

Note) 1. Use low-impedance electrolytic capacitors with excellent temperature characteristics.
(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 below.
C11, C13: 100V 220μF x 2 parallel
(Ambient Temperature<−20 deg C)
3. Take note of the maximum allowable 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 be exceeded.

● Selection Method of External Bulk Capacitor for Boost Voltage

Boost voltage bulk capacitor is determined by boost voltage ripple voltage, ripple current and 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, Boost voltage might increase due to ESR characteristics. Therefore, verify above characteristics by actual evaluation.

For output hold-up time, refer to separate document "PFE700 Series Evaluation Data" and use appropriate capacitor up to 1,200uF maximum. (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.

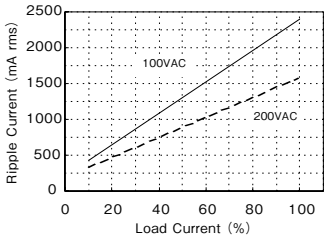


Fig. 1-2 Allowable ripple current value

TFR1: 10 to 100 ohm

By connecting thermal fuse 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, be sure to connect this external thermal fuse resistor.
Note that this module will not operate without this external resistor.

● Selection Method of External Resistor

(1) Calculating Resistance Value for TFR1

Resistance can be calculated by the formula below.

$$R = \frac{Vin}{Irush} (\Omega) \text{ (Formula 1-2)}$$

R : Resistance Value for External TFR1
Vin : Input Voltage converted to DC value
= Input Voltage(rms) $\times\sqrt{2}$
Irush : Input surge current value

(2) Required Surge Current Rating

Sufficient surge current withstand capability is required for external TFR1. Required surge current rating can be selected by I^2t. (Current squared multiplied by time)

$$I^2t = \frac{Co \times Vin^2}{2 \times R} (A^2s) \text{ (Formula 1-3)}$$

I^2t: Current-squared multiplied by time
Co: Boost Voltage Bulk Capacitance
Vin: Input Voltage converted to DC value
= Input Voltage(rms) $\times\sqrt{2}$
R: Resistance Value for External TFR1

2 Maximum Ripple and Noise

This value is measured according to the description below in accordance with JEITA-9131A (Section 7.12 and Section 7.13).
In the basic connection shown in Fig.1-1, additional connection shown in Fig.2-1 is done for measurement. Capacitor (ceramic capacitor 2.2μF and electrolytic capacitor: 220μF) 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 may vary depending on the wiring pattern of the printed circuit board.
In general, output ripple voltage and output spike noise can be reduced by increasing external capacitor value.

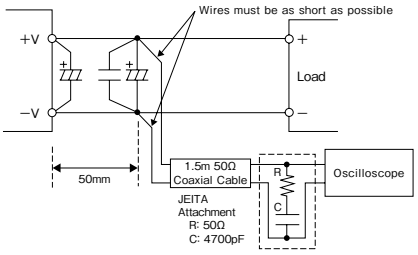


Fig. 2-1 Output Ripple Voltage (including Spike Noise) Measurement Method

3 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.

4 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 can occur. Make prior evaluation thoroughly before using this power module.

5 Over Current Protection (OCP)

This module is equipped with OCP function.
Output will automatically recover when short circuit or overload condition is removed. OCP value is fixed and cannot be adjusted externally.
Note that continuous short circuit or overload condition might result in power module damage.

6 Over Voltage Protection (OVP)

This module is equipped with OVP function. This value is set between 60.0V to 69.6V.
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.
OVP value is fixed and cannot be set externally.

7 Over Temperature Protection (OTP)

This module is equipped with OTP function. This function will activate and shut down the output when ambient temperature or internal temperature abnormally rises. OTP activates at following baseplate temperature.

OTP operating temperature: 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.

8 Parallel Operation

Current share parallel operation is possible for PFE700 Series by connecting the output terminal of each power module. The maximum value of the output current that can be drawn is 85% of the total rated output current. (70% at three phase parallel operation)
Consult us for details when using PFE700 Series at parallel operation.

9 Series Operation

Series operation is possible for PFE700 Series.
Connections shown in Fig.9-1 and Fig.9-2 are possible.

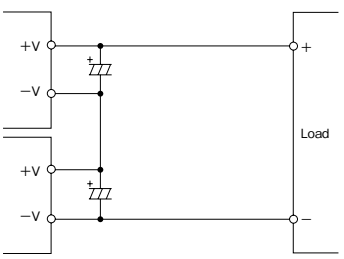


Fig. 9-1 Series Operation for High Output Voltage Applications

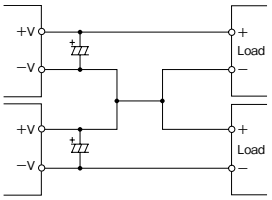


Fig. 9-2 +/−Output Series Applications

10 Power ON Signal (ENA Terminal)

This signal is located at the secondary side (output side) and is an open collector output.
(Maximum sink current is 10mA and maximum applied voltage is 75V.)
When output voltage goes over 46V(TYP) at start up, Power ON signal is "Low Level".
On the other hand, output voltage threshold level for Power ON signal to turn "High Level" at shutdown varies according to output condition.
Therefore, be sure to do actual verification.

11 Operating Ambient Temperature Range

These products can be used in any orientation 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 100 deg C.
Verify baseplate temperature at worst case operating condition at the measuring point shown in Fig.11-1.
For Thermal Design details, refer to Application Notes "Thermal Design" section.

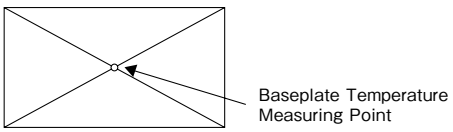


Fig.11-1 Baseplate Measuring Point

Baseplate temperature range is limited according to Fig. 11-2.

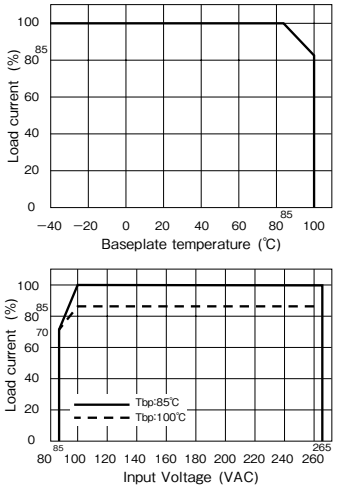


Fig. 11-2 Derating Curve

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

12 Operating Ambient Humidity

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

13 Storage Ambient Temperature

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

14 Storage Ambient 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.

15 Cooling Method

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

16 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.

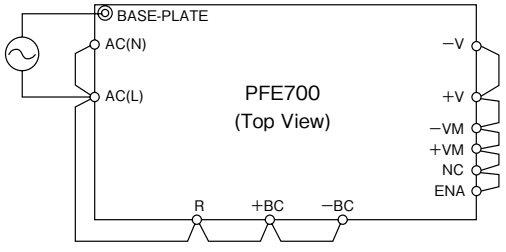
This module is designed to withstand applied voltage 1.5kVDC between output and baseplate for 1 minute. When doing this test during incoming inspection, be sure to apply DC voltage only. Avoid applying AC voltage during this test because this will damage the module.

Refrain from injecting high test voltage suddenly. Be sure to gradually increase the applied withstand 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.

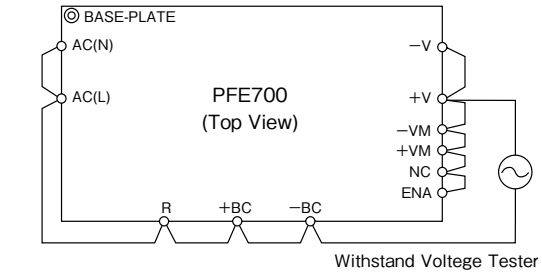
For basic connection shown in Fig.1-1, do the same terminal connections.

Withstand Voltage Tester



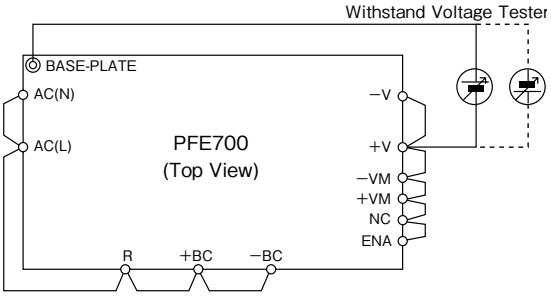
2.5kVAC 1 minute (20mA)

Fig. 16-1 Input to Baseplate Withstand Voltage Test Method



3kVAC 1 minute (20mA)

Fig.16-2 Input to Output Withstand Voltage Test Method



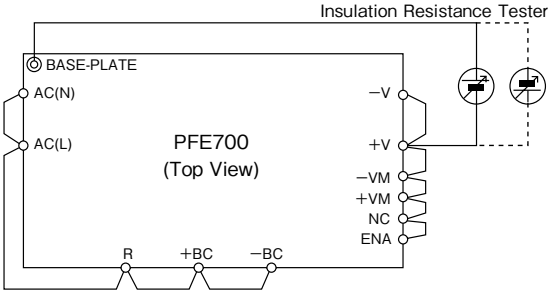
1.5kVDC 1 minute

Fig.16-3 Output to Baseplate Withstand Voltage Test Method

17 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.



100M ohm or more at 500VDC

Fig. 17-1 Insulation Resistance Test Method

4. Before Concluding Power Module Damage

Verify following items before concluding power module damage.

1) No output voltage
- Is specified input voltage applied?
- Is there no abnormality with the output load?
- Is the actual baseplate temperature within the specified operating temperature of this module?

2) Output voltage is low
- Is specified input voltage applied?
- Is there no abnormality with the output load?

3) Load regulation or line regulation is large
- Is specified input voltage applied?
- Are the input or output terminals firmly connected?
- Are the input and output wires too thin?

4) Large output ripple
- Is the measurement done according to methods described Application Notes or is it an equivalent method?

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