Applications Manual
for TUNS300/500/700

Rev. 1.8E   02-Apr-2024

Contents

Note : Information contained in this document is subject to change without notice for improvement.
The materials are intended as a reference design, component values and circuit examples described in this document varies depending on operating conditions and component variations.
Please select the components and design under consideration of usage condition etc.

1. Pin Assignment

1.1 Pin Assignment

Fig.1.1
Pin Assignment

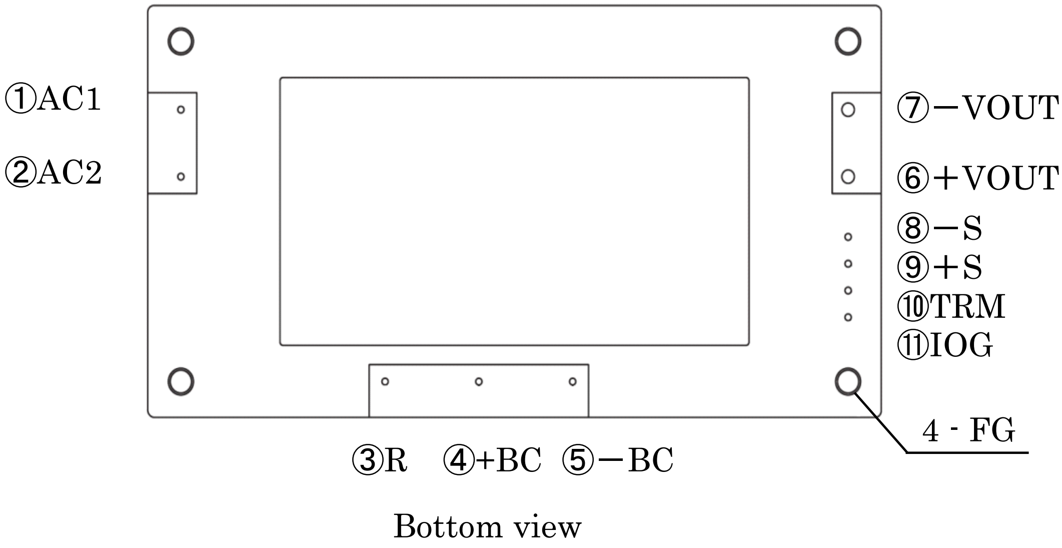


Table 1.1
Pin configuration
and function

No.	Pin Connection	Function
①	AC1	AC input
②	AC2	
③	R	External resistor for inrush current protection
④	+BC	+BC output
⑤	-BC	-BC output
⑥	+VOUT	+DC output
⑦	-VOUT	-DC output
⑧	-S	Remote sensing(-)
⑨	+S	Remote sensing(+)
⑩	TRM	Adjustment of output voltage
⑪	IOG	Inverter operation monitor
-	FG	Mounting hole(FG)

2. Connecrion for Standard Use

2.1 Connection for standard use

■ To use the TUNS300/500/700 series, external components should be connected as shown in Fig.2.1.

■ The TUNS300/500/700 series should be conduction-cooled. Use a heatsink or fan to dissipate heat.

Fig.2.1
Connection for standard use

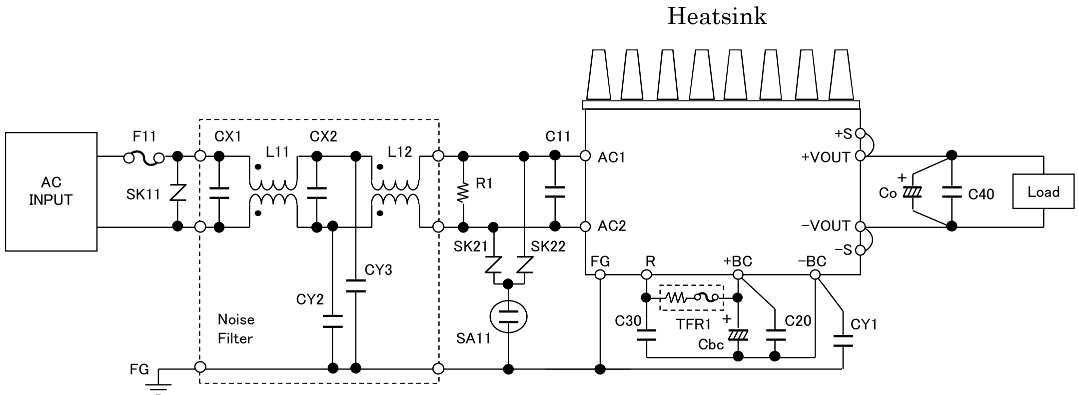


Table 2.1
Components list

No.	Symbol	Item			TUNS300F Rating	TUNS300F Part name	TUNS500F Rating	TUNS500F Part name	TUNS700F Rating	TUNS700F Part name
1	F11	Input fuse			AC250V/10A	0325010 (Littelfuse)	AC250V/15A	0325015 (Littelfuse)	AC250V/15A	0325015 (Littelfuse)
2	C11	Input capacitor			AC275V/2.2uF	ECQUAAF225 (Panasonic)	AC275V/2.2uF	ECQUAAF225 (Panasonic)	AC275V/1.5uF × 2parallel	ECQUAAF155 × 2 (parallel) (Panasonic)
3	CY1	Y capacitor			AC400V/2200pF	CD45-E2GA222M (TDK)	AC400V/2200pF	CD45-E2GA222M (TDK)	AC400V/2200pF	CD45-E2GA222M (TDK)
4	L11 ※	Noise filter	Line Filter		6mH/12A	ADM-25-12-060T (Ueno)	6mH/12A	ADM-25-12-060T (Ueno)	6mH/12A	ADM-25-12-060T (Ueno)
5					2mH/15A	SC-15-200 (TOKIN)	2mH/15A	SC-15-200 (TOKIN)	2mH/15A	SC-15-200 (TOKIN)
6	L12 ※				6mH/12A	ADM-25-12-060T (Ueno)	6mH/12A	ADM-25-12-060T (Ueno)	6mH/12A	ADM-25-12-060T (Ueno)
7					2mH/15A	SC-15-200 (TOKIN)	2mH/15A	SC-15-200 (TOKIN)	2mH/15A	SC-15-200 (TOKIN)
8	CX1		X capacitor		AC275V/1.5uF	ECQUAAF155 (Panasonic)	AC275V/1.5uF	ECQUAAF155 (Panasonic)	AC275V/1.5uF	ECQUAAF155 (Panasonic)
9	CX2				AC275V/1.5uF	ECQUAAF155 (Panasonic)	AC275V/1.5uF	ECQUAAF155 (Panasonic)	AC275V/1.5uF	ECQUAAF155 (Panasonic)
10	CY2		Y capacitor		AC400V/2200pF	CD45-E2GA222M (TDK)	AC400V/2200pF	CD45-E2GA222M (TDK)	AC400V/2200pF	CD45-E2GA222M (TDK)
11	CY3				AC400V/2200pF	CD45-E2GA222M (TDK)	AC400V/2200pF	CD45-E2GA222M (TDK)	AC400V/2200pF	CD45-E2GA222M (TDK)
12	Co	Output capacitor		F12	DC25V/2200uF	ELXZ250ELL222 (Nippon Chemi-Con)	DC25V/2200uF	ELXZ250ELL222 (Nippon Chemi-Con)	DC25V/2200uF	ELXZ250ELL222 (Nippon Chemi-Con)
				F28	DC50V/1000uF	ELXZ500ELL102 (Nippon Chemi-Con)	DC50V/1000uF	ELXZ500ELL102 (Nippon Chemi-Con)	DC50V/1000uF	ELXZ500ELL102 (Nippon Chemi-Con)
				F48	DC63V/470uF	ELXZ630ELL471 (Nippon Chemi-Con)	DC63V/470uF	ELXZ630ELL471 (Nippon Chemi-Con)	DC63V/470uF	ELXZ630ELL471 (Nippon Chemi-Con)
13	C40	Bypass capacitor		F12	DC50V/10uF	C3216X7R1H106KT (TDK)	DC50V/10uF	C3216X7R1H106KT (TDK)	DC50V/10uF	C3216X7R1H106KT (TDK)
				F28	DC50V/10uF	C3216X7R1H106KT (TDK)	DC50V/10uF	C3216X7R1H106KT (TDK)	DC50V/10uF	C3216X7R1H106KT (TDK)
				F48	DC100V/2.2uF	C3216X7S2A225 (TDK)	DC100V/2.2uF	C3216X7S2A225 (TDK)	DC100V/2.2uF	C3216X7S2A225 (TDK)
14	Cbc	Smoothing capacitor			DC450V/470uF	ELXS451VSN471 (Nippon Chemi-Con)	DC450V/390uF ×2parallel	ELXS451VSN391 × 2 (parallel) (Nippon Chemi-Con)	DC450V/390uF ×2parallel	ELXS451VSN391 × 2 (parallel) (Nippon Chemi-Con)
15	C20	Capacitor for boost voltage			DC450V/0.68uF ×2parallel	ECW-F2W684JA × 2parallel (Panasonic Electronic Components)	DC450V/0.68uF ×2parallel	ECW-F2W684JA × 2parallel (Panasonic Electronic Components)	DC450V/0.68uF ×2parallel	ECW-F2W684JA × 2parallel (Panasonic Electronic Components)
16	C30	Capacitor for boost voltage			DC450V/0.68uF ×2parallel	ECW-F2W684JA × 2parallel (Panasonic Electronic Components)	DC450V/0.68uF ×2parallel	ECW-F2W684JA × 2parallel (Panasonic Electronic Components)	DC450V/0.68uF ×2parallel	ECW-F2W684JA × 2parallel (Panasonic Electronic Components)
17	TFR1	Inrush current protection resistor			10Ω	A5MC-100J (Uchihashi Estec)	10Ω	A5MC-100J (Uchihashi Estec)	10Ω	A5MC-100J (Uchihashi Estec)
18	R1	Discharging resistor			68kΩ ×3series 2parallel	CRS32 683 (HOKURIKU ELECTRIC INDUSTRY)	68kΩ ×3series 2parallel	CRS32 683 (HOKURIKU ELECTRIC INDUSTRY)	68kΩ ×3series 2parallel	CRS32 683 (HOKURIKU ELECTRIC INDUSTRY)
19	SK11 SK21 SK22	Varistor			620V	TND14V-621K (Nippon Chemi-Con)	620V	TND14V-621K (Nippon Chemi-Con)	620V	TND14V-621K (Nippon Chemi-Con)
20	SA11	Surge absorber			4kV	DSA-402MA (Mitsubishi Materials)	4kV	DSA-402MA (Mitsubishi Materials)	4kV	DSA-402MA (Mitsubishi Materials)

※Please select one of the parts.The reference PCB layout of 10.2 is mounted ADM-25-12-060T.

- Parts name are shown in Table 2.1 as reference.
- External parts should be changed according to the ambient temperature, and input and output conditions.
  For details, refer to the selection method of individual parts.

2.2 Input fuse: F11

■ No protective fuse is preinstalled on the input side. To protect the unit, install a slow-blow type fuse shown in Table 2.2 in the input circuit.

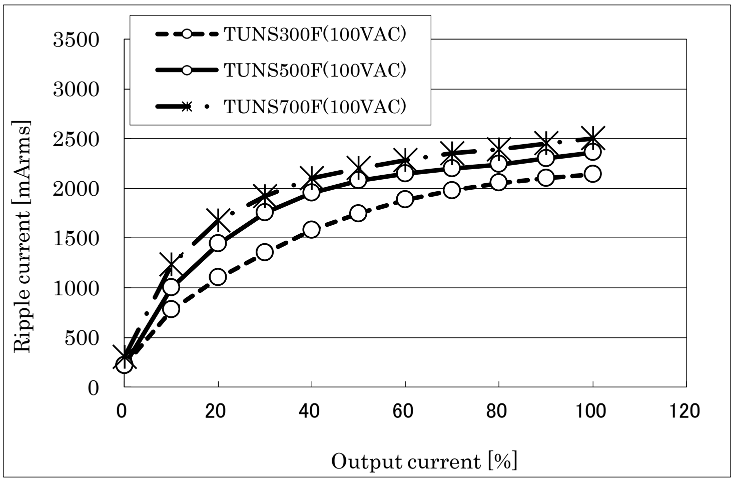
Table 2.2 Recommended fuse

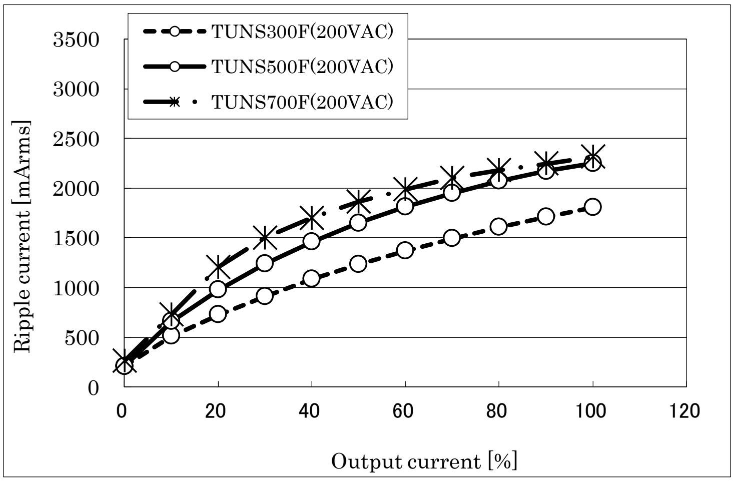
Model	TUNS300F	TUNS500F	TUNS700F
Rated current	10A	15A	15A

2.3 Input capacitor: C11

■ Connect a film capacitor of 2 uF or higher as input capacitor C11.
■ Use a capacitor with a rated voltage of AC250V which complies with the safety standards.
■ If C11 is not connected, the power supply or external components could be damaged.
■ When selecting a capacitor, check the maximum allowable ripple current.
■ Ripple current includes low frequency component (input frequency) and high frequency component (100kHz).
■ Ripple current values flowing into C11 as listed in Table 2.1 are shown in Fig.2.2.
■ The ripple current changes with PCB patterns, external parts, ambient temperature, etc. Check the actual ripple current value flowing through C11.

Fig.2.2 Ripple current values C11





2.4 Y Capacitors and noise filters: CY, CX, L1

- The TUNS300/500/700 series has no internal noise filter.
  Connect external noise filters and capacitors (CY) to reduce conduction noise and stabilize the operation of the power supply.
- Noise filters should be properly designed when the unit must conform to the EMI/EMS standards or when surge voltage may be applied to the unit.
- Install the primary Y capacitor (CY1) as close as possible to the input pins (within 50 mm from the pins).
  A capacitance of 470 pF or more is required.
- When the total capacitance of CYs exceeds 8,800 pF, input-output withstanding voltage may be dropped. In this case, either reduce the capacitance of Y capacitors or install a grounding capacitor between output and FG.
- Use capacitors with a rated voltage of AC250V which comply with the safety standards as CY.

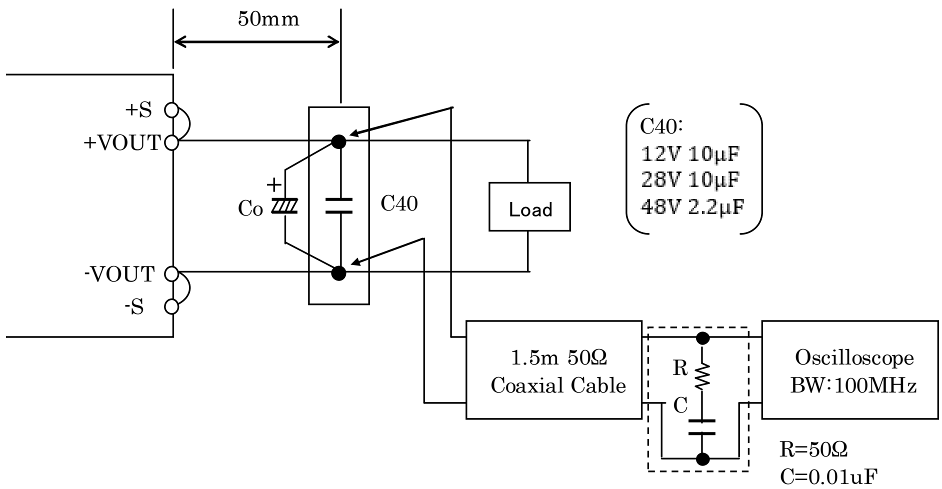
2.5 Output capacitors: Co, C40

- Install an external capacitor, Co, between +VOUT and -VOUT pins for stable operation of the power supply. Recommended capacitance of Co is shown in Table 2.3.
- Use low impedance electrolytic capacitors with excellent temperature characteristics.
- When Using at ambient temperatures below 0 ºC, the output ripple voltage increases due to the characteristics of equivalent series resistor (ESR). In this case, connect three capacitors, Co, of recommended capacitance in parallel connection.
- Specifications, output ripple and ripple noise as evaluation data values are measured according to Fig.2.3.

Table 2.3 Recommended capacitance Co

Output Voltage	TUNS300F	TUNS500F	TUNS700F
12V	2,200uF	2,200uF	2,200uF
28V	1,000uF	1,000uF	1,000uF
48V	470uF	470uF	470uF

Fig.2.3 Measuring environment



2.6 Smoothing capacitor for boost voltage: Cbc

■ In order to smooth boost voltage, connect Cbc between +BC and -BC.
Recommended capacitance of Cbc is shown in Table 2.4.

■ Install a capacitor Cbc with a rated voltage of DC420 V or higher within the allowable capacitance.

■ When operated below 0ºC, operation may become unstable as boost ripple voltage increases due to ESR characteristics. Choose a capacitor which has higher capacitance than recommended.
Select a capacitor so that the ripple voltage of the boost voltage is 30 Vp-p or below.

■ If the ripple voltage of the boost voltage increases, the ripple current rating of the smoothing capacitor may be exceeded. Check the maximum allowable ripple current of the capacitor.

■ The ripple current changes with PCB patterns, external parts, ambient temperature, etc. Check the actual ripple current value flowing through Cbc.

Table 2.4 Recommended capacitance Cbc

Model	Recommended capacitance	Allowable capacitance range
TUNS300F	470uF	390uF ~ 2,200uF
TUNS500F	390uF × 2 parallel	390uF ~ 2,200uF
TUNS700F	390uF × 2 parallel	470uF ~ 2,200uF

※Refer to item 6 and 7 for selection method of Cbc.

2.7 Capacitor for boost voltage :C20,C30

■ Install film capacitors with a rating of 1uF/DC450V or higher as C20 and C30.

■ If C20 and C30 are not connected, the power supply or external components could be damaged.

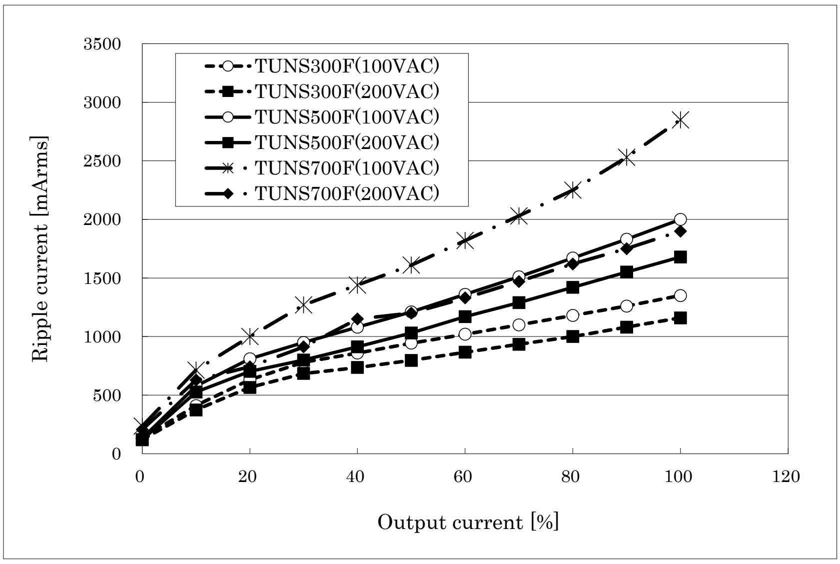
■ The ripple current flows into these capacitors. Check the maximum allowable ripple current of the capacitor while selecting.

■ The frequency of the ripple current is 100 kHz to 200 kHz.

■ Ripple current values flowing into C20 and C30 as listed in Table 2.1 are shown in Fig.2.4 and Fig.2.5.

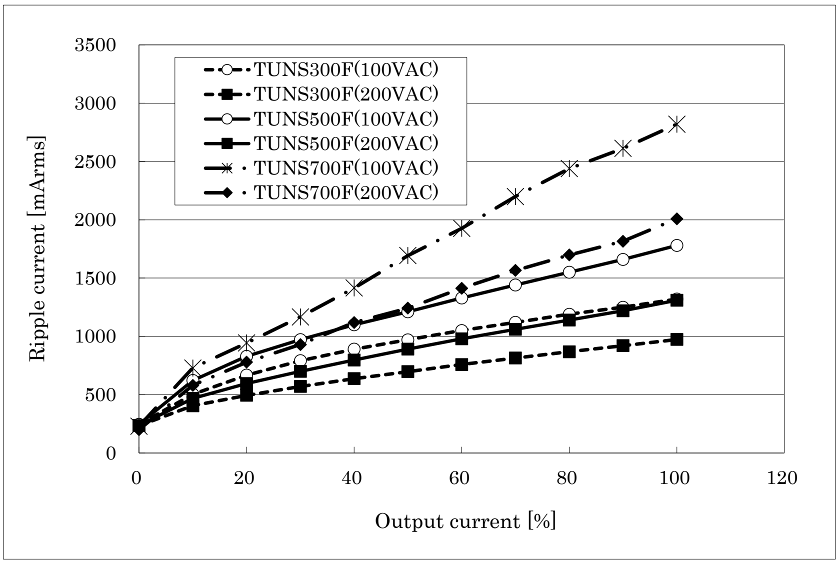
■ The ripple current changes with PCB patterns, external parts, ambient temperature, etc. Check the actual ripple current values flowing through C20 and C30.

Fig.2.4 Ripple current values C20



※Ripple current value is total of 2 paralleled capacitors.

Fig.2.5
Ripple current values
C30



※Ripple current value is total of 2 paralleled capacitors.

2.8 Inrush current limiting resistor: TFR1

■ The TUNS300/500/700 must connect TFR1.
■ If TFR1 is not connected, the power supply will not operate.
■ Connect TFR1 between R and +BC.
Recommended resistance of TFR1 is shown in Table 2.5.
■ The surge capacity is required for TFR1.
■ Wirewound resistor with thermal cut-offs type is required.
■ Inrush current limiting resistor can be used to limit the primary inrush current. However, the secondary inrush current can't be limited by increasing the resistor value of inrush current limiting resistor. The secondary inrush current is approx. 25 ~ 30A.
Therefore, we don't recommend connecting a large resistance as TFR1.
■ The inrush current changes by PCB pattern, parts characteristic etc.
Check the actual inrush current value flowing through the AC line.

Table 2.5
Recommended resistor
TFR1

Model	Recommended resistance
TUNS300F	4.7Ω ~ 22Ω
TUNS500F	4.7Ω ~ 22Ω
TUNS700F	4.7Ω ~ 22Ω

■ The selection method of TFR1 is shown below.
・ Calculation of resistance
Resistance can be calculated using the following formula.

$$TFR1 = \frac{Vin \times \sqrt{2}}{Ip} - R_L [\Omega]$$

TFR1 : Inrush current limiting resistor
RL : Line impedance
Vin : Input voltage (rms)
Ip : Primary Inrush current (peak)

・ Calculation of required surge capacity
Required surge capacity can be calculated using the following formula.
Please contact to the component manufacturer regarding the surge current withstanding capability.

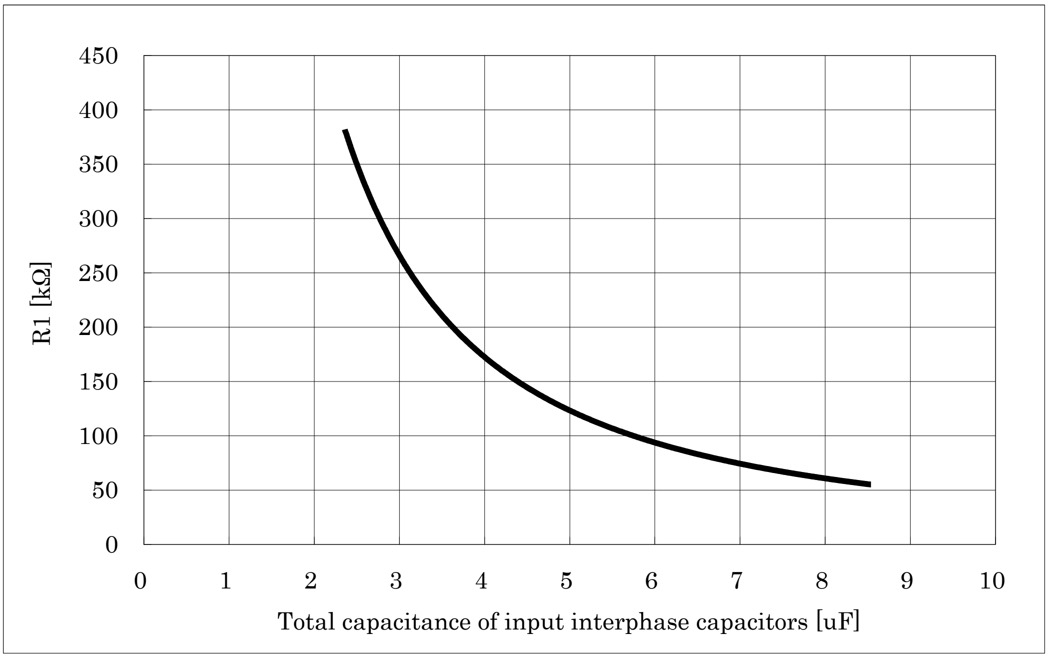
$$I^2 t = \frac{Cbc \times Vin^2}{TFR1} [A^2 s]$$

I2t : Current squared times
TFR1 : Inrush current limiting resistor
Cbc : Smoothing capacitor for boost voltage
Vin : Input voltage (rms)

2.9 Discharging resistor: R1

■ If you need to meet the safety standards, connect a discharging resistor R1 at input interphase.
■ Please select a resistor so that the input interphase voltage decreases in 42.4V or less at 1 second after turn off the input.
■ Fig.2.6 shows the relationship between a necessary resistance of R1 and total capacitance of input interphase capacitors.
And the data of Fig.2.6 is the values that assumed the worst condition.
■ Please keep margin for rated voltage and power of R1.

Fig.2.6
TUNS500F
Relationship between a necessary resistance of R1 and total capacitance of input interphase capacitors



3. Derating

3.1 Output current derating

■ The TUNS300/500/700 series should be conduction-cooled.

■ Fig.3.1, Fig.3.2 and Fig.3.3 show the derating curve in relation to the temperature of the aluminum base plate.
Note that operation within the shaded area will cause a significant level of ripple and ripple noise.

■ Please measure the temperature of the aluminum base plate at the center.
Please measure the temperature on the aluminum base plate edge side when you cannot measure the temperature of the center part of the aluminum base plate.
In this case, please take 5deg temperature margin from the derating characteristics shown in Fig.3.1, Fig.3.2 and Fig.3.3.

■ In the case of forced air cooling, please measure the temperature on the aluminum base plate edge side of the leeward side. Especially in the case of small heat sink, the temperature difference between the base plate center and the base plate edge side will increase. In this case, the temperature margin of 5deg is not required.

■ Attention should be paid to thermal fatigue life due to temperature fluctuations by self-heating. Make the range of temperature fluctuations as narrow as possible if temperature often fluctuates.

Fig.3.1
TUNS300F
Output current
derating

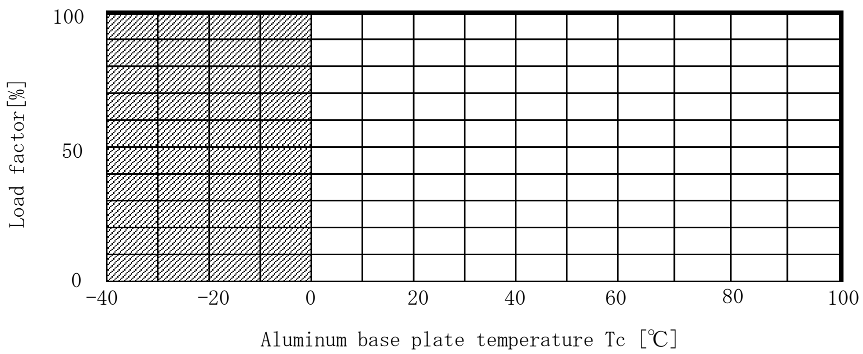


Fig.3.2
TUNS500F
Output current
derating

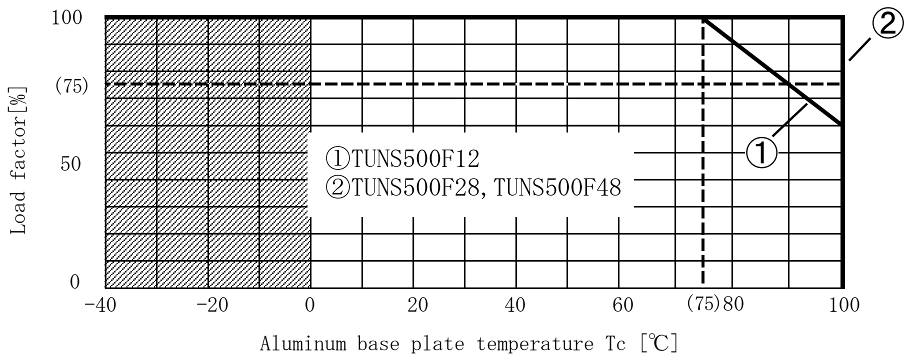
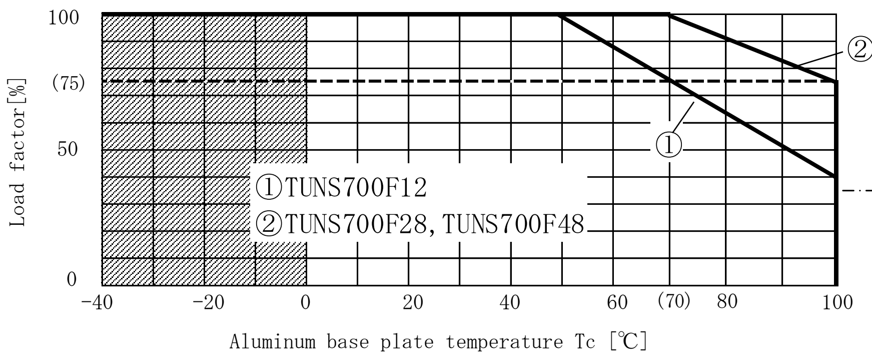
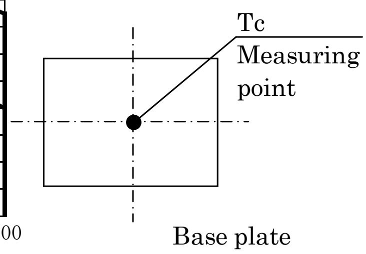


Fig.3.3
TUNS700F
Output current
derating





3.2 Input voltage derating

■ Fig.3.4 shows the input voltage derating curve of TUNS700F.
In case of both Input voltage derating and load derating are required, please multiply respective mitigation rate (see Fig.3.5, Fig.3.6).

Fig.3.4
TUNS700F
Input voltage derating

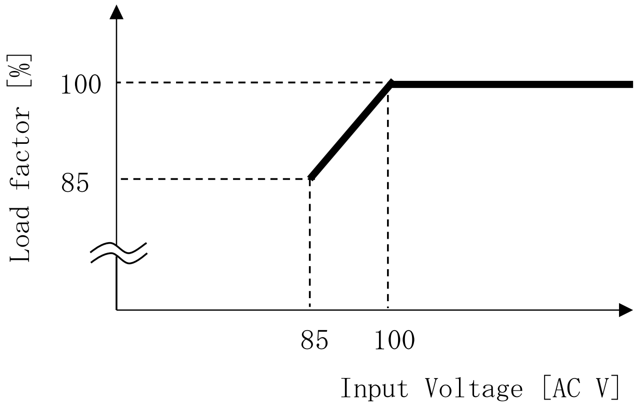
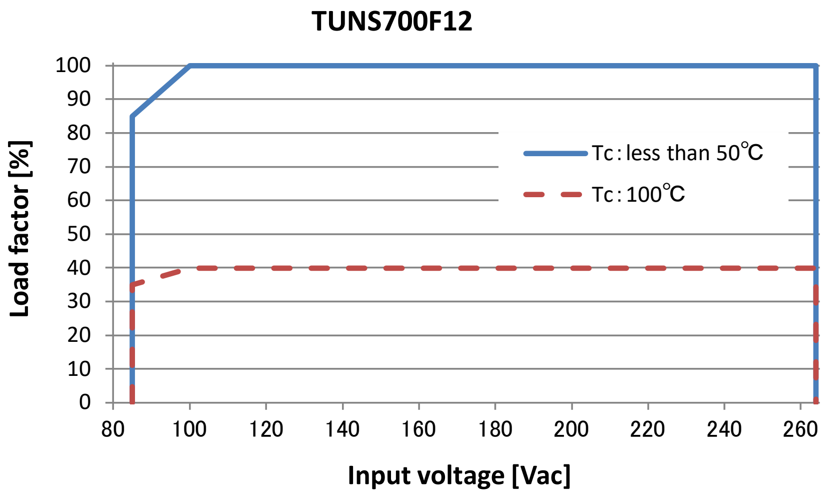
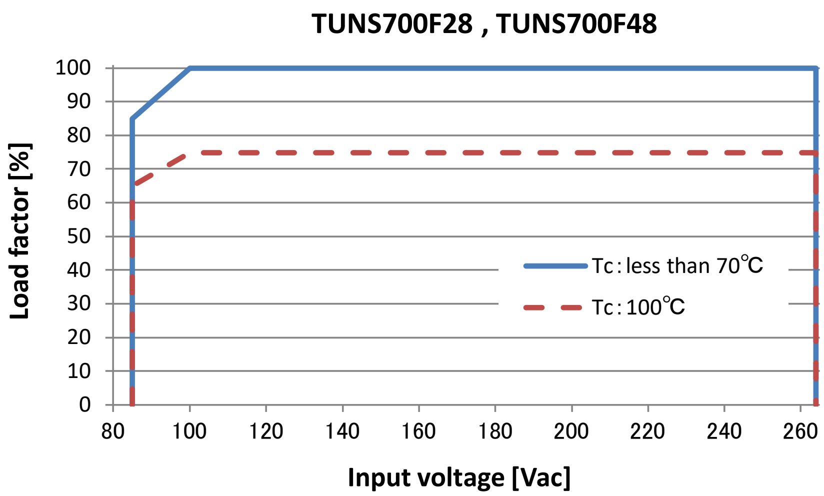


Fig.3.5
TUNS700F12
Output current and Input voltage derating



Tc : Aluminum base plate temperature

Fig.3.6
TUNS700F28/48
Output current and Input voltage derating



Tc : Aluminum base plate temperature

4. Output voltage adjustment

4.1 Output voltage adjustment

■The output voltage is adjustable in the output voltage variable range (Table 4.1).
■Overvoltage protection may be activated if output voltage is set up over the certain level.
■Variable range upper limit in the standard of 48V output is 52.8V (rated voltage + 10%). Please use the option -Y1 if up to +20% output voltage adjustment is necessary.
■About -Y1 options (48V output only)

1) On the safety standards, the output of the options -Y1 are treated with the ELV. The manufacturer must provide protection against inadvertent contact to the operator.
2) Overvoltage protection operation value will be changed to the value shown in Table 3.1.
3) Boost terminal (BC terminal) voltage will be changed to DC390Vtyp.

Table 4.1
Output voltage variable range

Output voltage	12V	28V	48V	
	Standard	Standard	Standard	Option：-Y1
Output voltage variable range	9.6～14.4V (80%～120%)	22.4～33.6V (80%～120%)	38.4～52.8V (80%～110%)	38.4～57.6V (80%～120%)
Overvoltage protection operation value	15.0～16.8V (125～140%)	35.0～39.2V (125～140%)	55.2～64.8V (115～135%)	60.0～67.2V (125%～140%)
Boost terminal voltage	DC380Vtyp	DC380Vtyp	DC380Vtyp	DC390Vtyp

4.2 Output voltage adjustment by potentiometer

■The output voltage is adjustable by external potentiometer as shown in Fig.4.1.
■When the output voltage is increased, the maximum output current must be reduced not to exceed the rated power. When the output voltage is reduced, the maximum output current must be kept within its rated current.
■The potentiometer(VR) and resistor (R1, R2) might not meet requirements of fluctuation characteristics of ambient temperature; therefore, cermet type potentiometer (≦±300ppm/℃) and metallic film resistor (≦±100ppm/℃) are recommended.

Fig.4.1
Connection devices outside the power supply

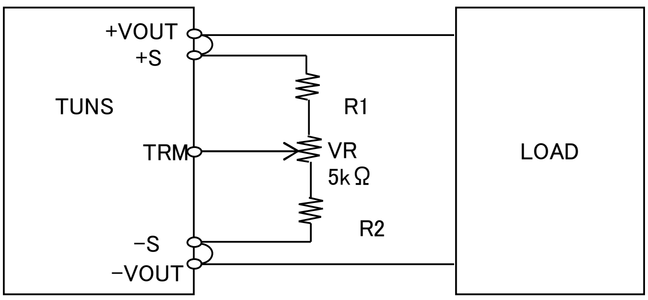
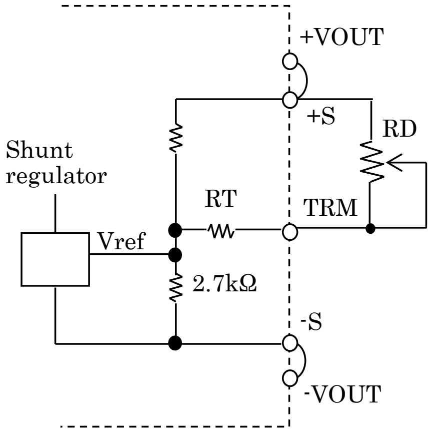


Table 4.2
Output voltage adjustment Recommended component values

Output voltage		12V	28V	48V	
		Standard	Standard	Standard	Option：-Y1
±5%	R1[kΩ]	12	39	68	68
	R2[kΩ]	2.2	2.2	2.2	2.2
	VR[kΩ]	5	5	5	5
±10%	R1[kΩ]	6.8	27	47	47
	R2[kΩ]	1	1	1	1
	VR[kΩ]	5	5	5	5
±20%	R1[kΩ]	3.3	12	27	27
	R2[kΩ]	0.15	0.15	0.15	0.15
	VR[kΩ]	5	5	5	5

■ When variable only in one side direction of the output voltage from the rated voltage, please do the connection shown in Fig.4.2 or Fig.4.3.
The resistance can be calculated by the following equation. In addition, because there is that it is not a calculated value as in the variations of the internal components, it is recommended that you adjust the potentiometer.

Fig.4.2
Output voltage decreasing



<Output voltage decreasing>

$$RD = \frac{2.7}{B - A} - RT\ [k\Omega]$$

$$A = \frac{Vref}{V_{OR} - Vref} \qquad B = \frac{Vref}{V_{OD} - Vref}$$

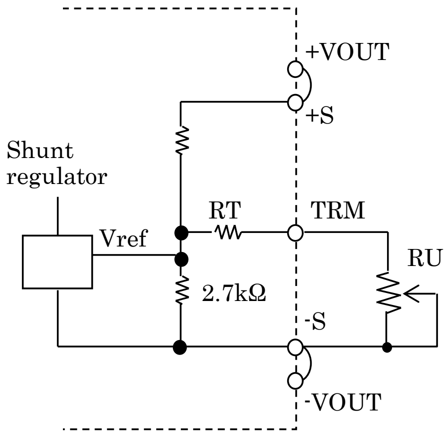
V_{OR} : Rated output voltage[V]

V_{OD} : Output voltage needed to set up[V]

V_{ref} : Reference voltage [V]
Vref = 2.495 [V]

RT : Resistor of TRM[kΩ]
12V : 6.8 [kΩ]
28V : 8.2 [kΩ]
48V : 8.2 [kΩ]

Fig.4.3
Output voltage increasing



<Output voltage increasing>

$$RU = \frac{2.7}{\frac{A}{C} - 1} - RT\ [k\Omega]$$

$$A = \frac{Vref}{V_{OR} - Vref} \qquad C = \frac{Vref}{V_{OU} - Vref}$$

V_{OR} : Rated output voltage[V]

V_{OU} : Output voltage needed to set up[V]

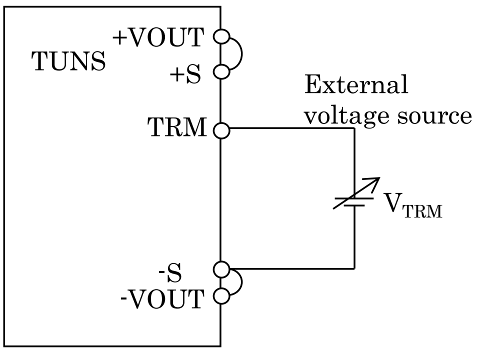
V_{ref} : Reference voltage [V]
Vref = 2.495 [V]

RT : Resistor of TRM[kΩ]
12V : 6.8 [kΩ]
28V : 8.2 [kΩ]
48V : 8.2 [kΩ]

4.3 Output voltage adjustment by external voltage

■ The output voltage can be adjustable by applying voltage between the TRM terminal and -S terminal.
■ Overvoltage protection will be activated if output voltage is adjusted over the certain level.
■ During startup , VTRM should be applied before input voltage.
■ Please use low impedance for VTRM as current will flow through TRM terminal.

Fig.4.4
Output voltage adjustment by external voltage

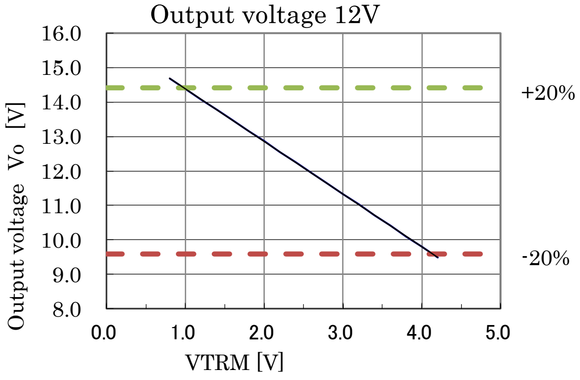


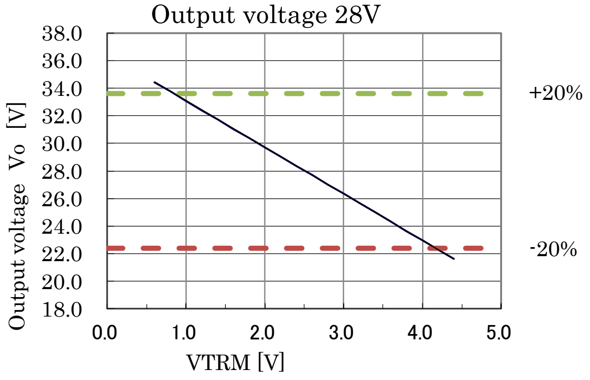
<V_{TRM} → Output voltage Calculating formula>

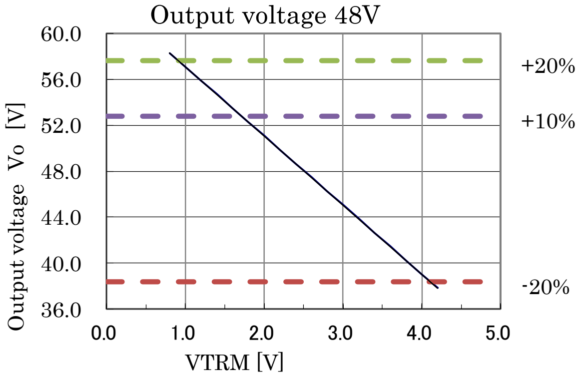
(1) Output voltage 12V
$Vo = -1.526 \times V_{TRM} + 15.91$

(2) Output voltage 28V
$Vo = -3.367 \times V_{TRM} + 36.44$

(3) Output voltage 48V
$Vo = -6.010 \times V_{TRM} + 63.09$







5. Parallel operation (option: - P)

5.1 Parallel operation

■ Option:-P is for parallel operation (TUNS700F only).
The output current can be balanced by static load regulation the power supply. Output voltage - output current characteristic is shown in Fig.5.1.

■ Terminal is different from the standard. See Figure 5.2.Position is the same as standard.

■ There is no remote sensing function and the output voltage variable function.

■ As variance of output current drawn from each power supply is 10% maximum, the total output current must not exceed the value determined by the following equation.

(Output current in parallel operation)
=(the rated current per unit) × (number of unit) × 0.9

■ Total number of units should be 5 pieces or less.

■ Input capacitor C11, Boost voltage capacitor (Cbc, C20, C30), Inrush current protection resistor RFR1, Output capacitor (Co) can not be shared. Please connect them to each power supply for parallel operation. In addition, To avoid startup time difference, please use same value for Cbc and RFR1 for each power supply.

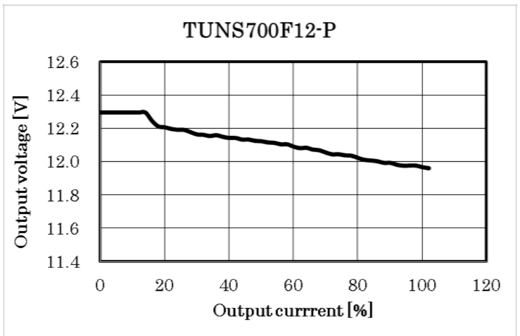
■ The length and width of output should be as same as possible to optimize the current sharing.

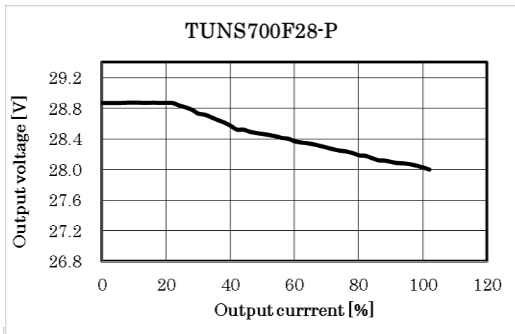
■ Connect each input pin with as low impedance possible. When the number of the units in parallel operation increases, input current increases. Adequate wiring design for input circuitry such as circuit pattern, wiring and current for equipment is required.

■ If temperatures of aluminum base plates are different during among the power supplies for parallel operation, voltage will vary significantly. balancing between module will not good. Please consider the designing of heat dissipation to equalize the aluminum base plate temperature.

■ + M / -M terminal is the output voltage monitor terminal. Please do not take the current from + M / -M terminal. Also, please do not connect the + M / -M each other parallel to the power supply.

Fig.5.1
TUNS700F□□-P
Load characteristic





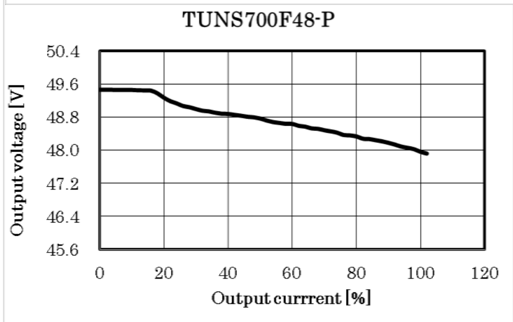
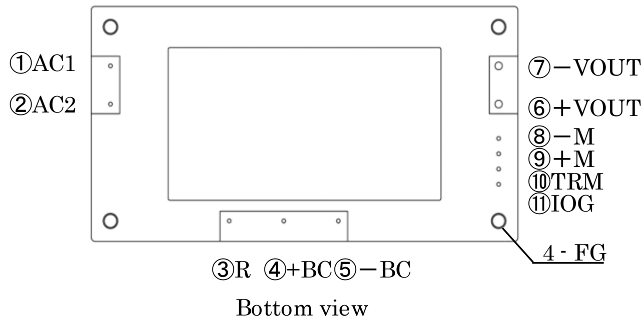


Fig.5.2
TUNS700F□□-P
Pin Assignment

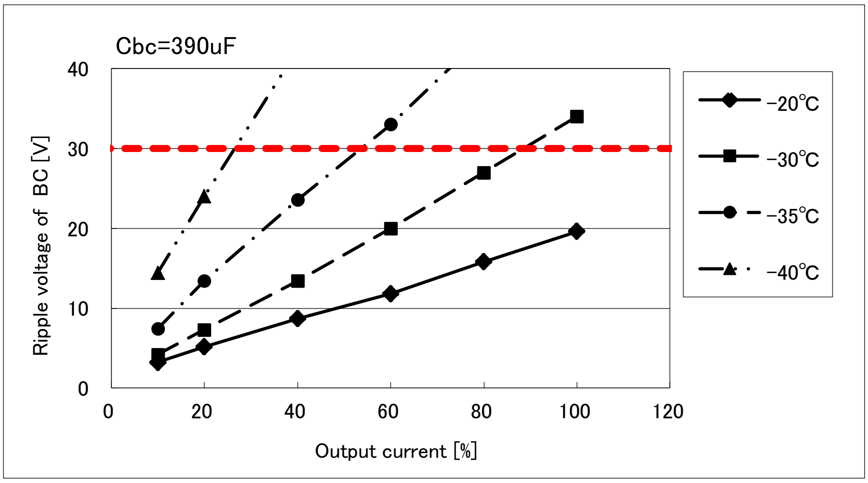


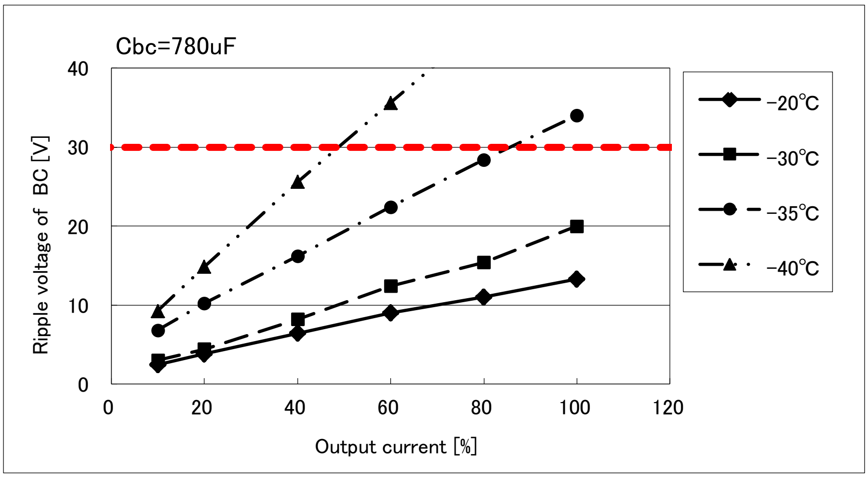
6. Operation Under Low Temperature Conditions

6.1 Ripple voltage of boost voltage

- At low temperature, ripple voltage of boost voltage increases due to Cbc freezes.
- Select a capacitor of which ripple voltage of boost voltage does not exceed 30Vp-p on an actual operating condition.
  And check the maximum allowable ripple current of the capacitor.
- Fig.6.1 and Fig.6.2 shows the relationship between ripple voltage of boost voltage and temperature(Vin=AC85V).

Fig.6.1 TUNS500F Relationship between ripple voltage of boost voltage and temperature (Vin=AC85V)





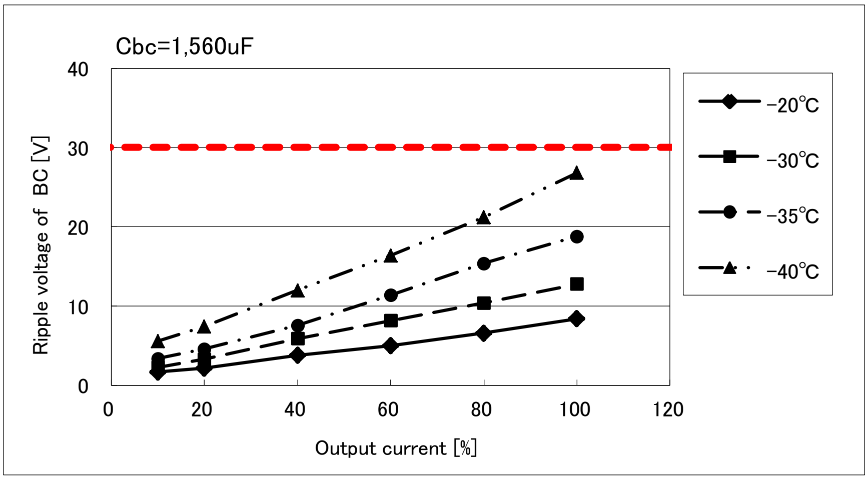
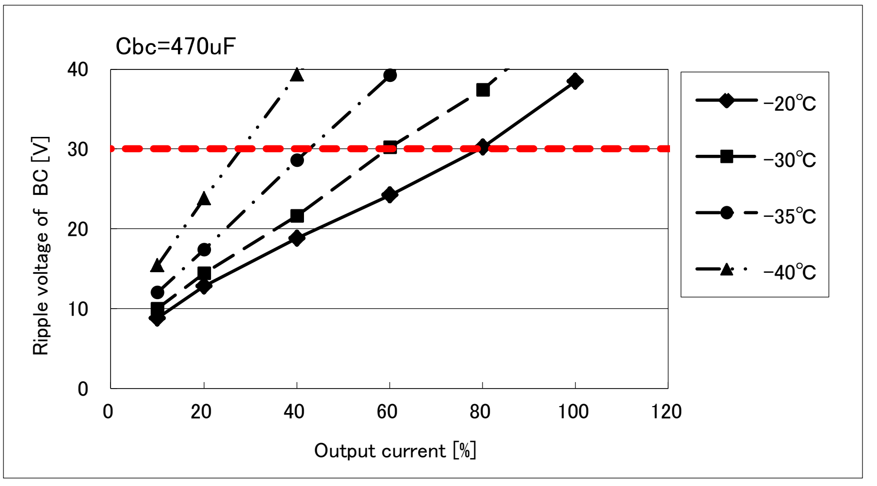
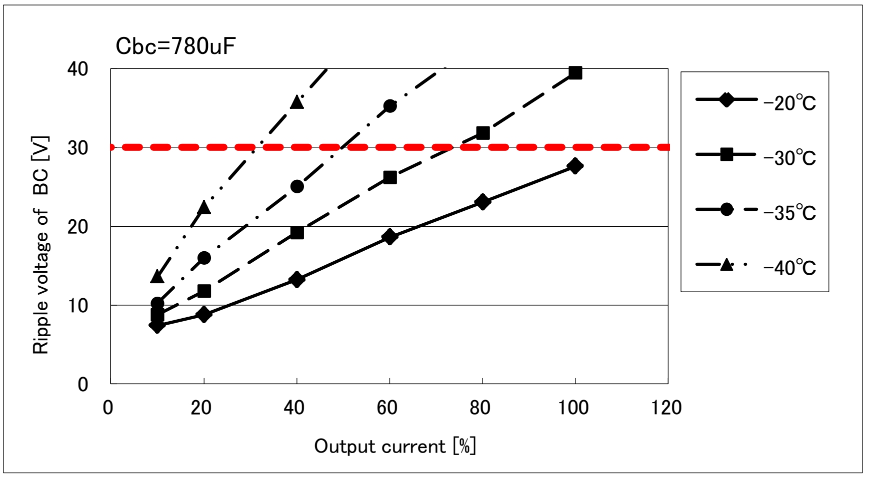
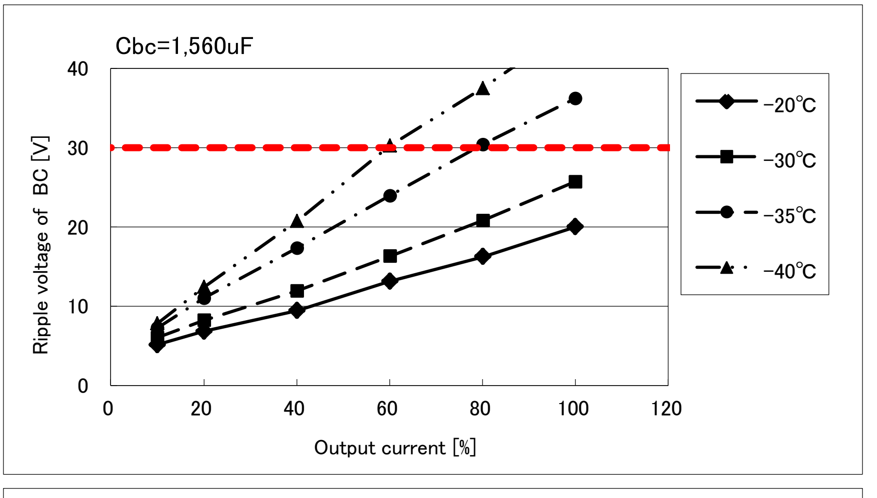
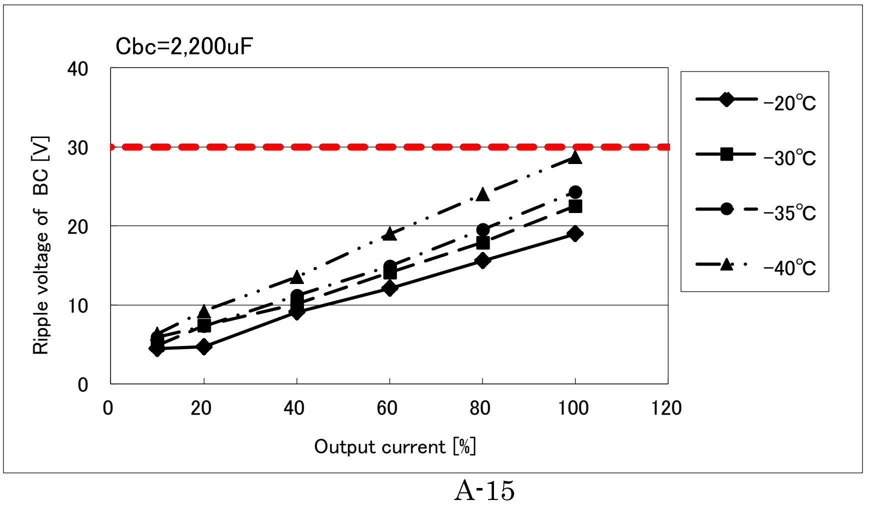


Fig.6.2
TUNS700F
Relationship between ripple voltage of boost voltage and temperature
(Vin=AC85V)









7. Holdup Time

7.1 Holdup time

■ Holdup time is determined by the capacitance of Cbc.
Fig.7.1, Fig.7.2 and Fig.7.3 show the relationship between holdup time and output current within the allowable capacitance of Cbc.

Fig.7.1
TUNS300F
Relationship between holdup time and Cbc

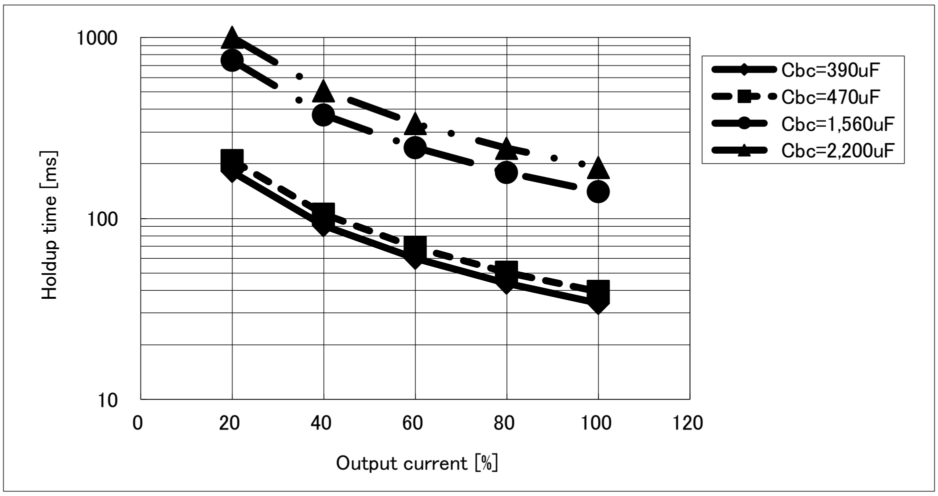


Fig.7.2
TUNS500F
Relationship between holdup time and Cbc

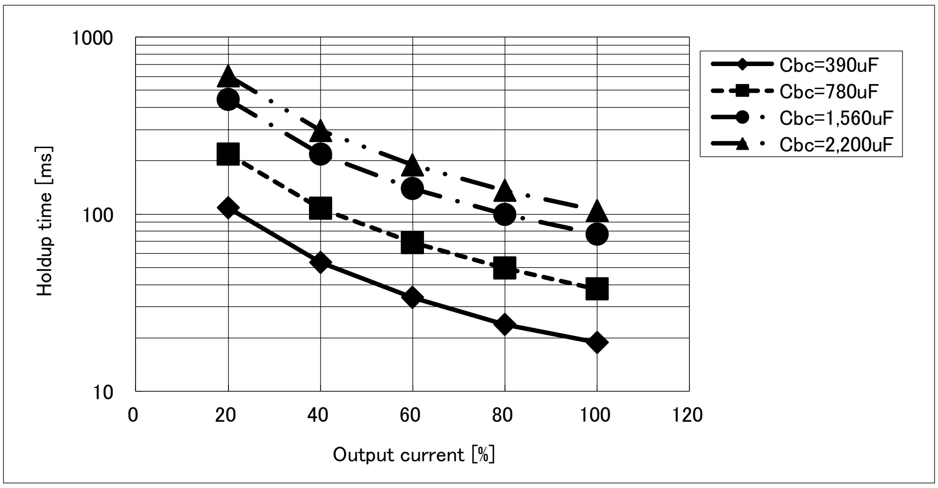
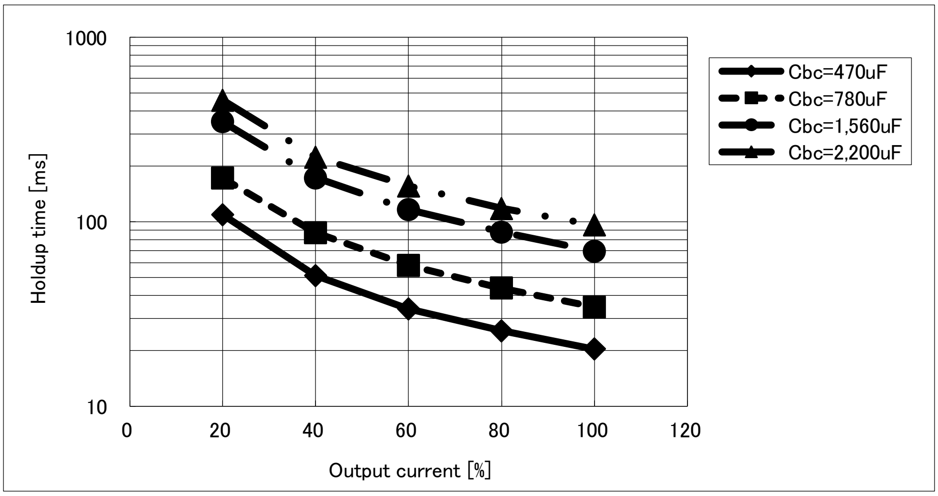


Fig.7.3
TUNS700F
Relationship between holdup time and Cbc

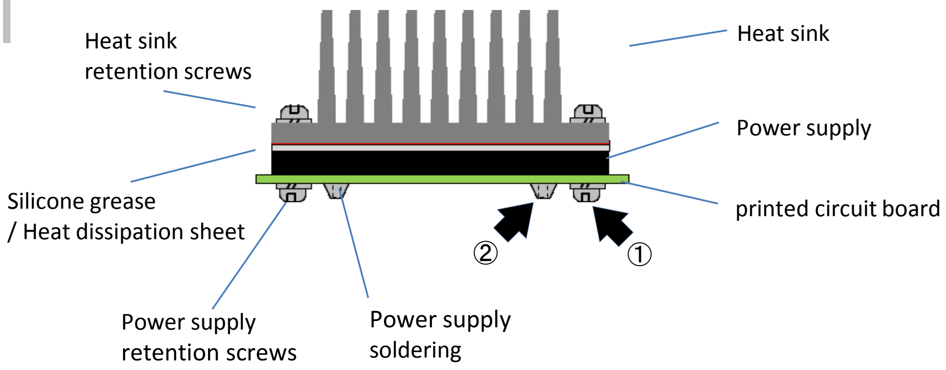


8. Mounting method

8.1 Mounting method

■ When implementing the power supply to the printed circuit board, please fix the power supply to the printed circuit board by screw before the soldering.
If it is screwed to the substrate after soldering, there is a possibility of failure by adding mechanical stress to the soldering point and the internal connections of power supply.

Fig.8.1
Mounting method



9. Thermal Design

9.1 Thermal Design

■ Please refer to the applications manual "9.Thermal Considerations" on our website.

Home> Technical Data> Application Manual
♦Power Module Type
9.Thermal Considerations

http://www.cosel.co.jp/en/data/pdf/thermal_considerations.pdf

9.2 Examples of Convection cooling

■ Here is an example of convection cooling with heatsink.
■ Please consider this example as a design guideline because it changes by the heat dissipation environment. Please measure the temperature of the actual equipment eventually.

Fig.9.1
Convection cooling
Heatsink example

237.5×150×45mm
(EX239-150-DE MIZUTANI ELECTRIC IND.CO.,LTD)
Thermal resistance : 0.39℃/W

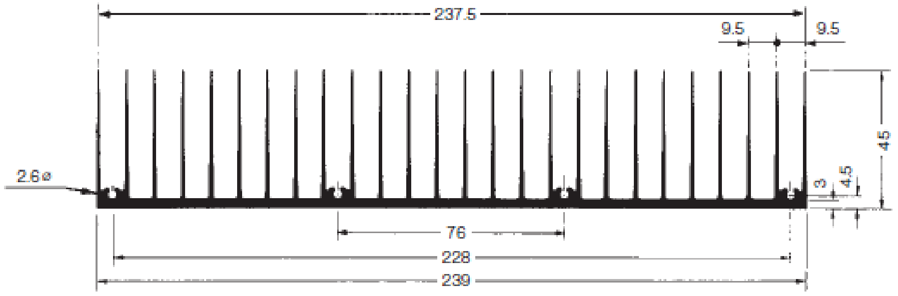
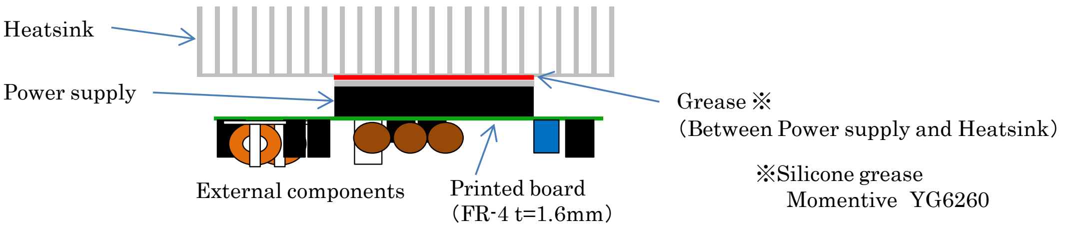


Fig.9.2
Environment



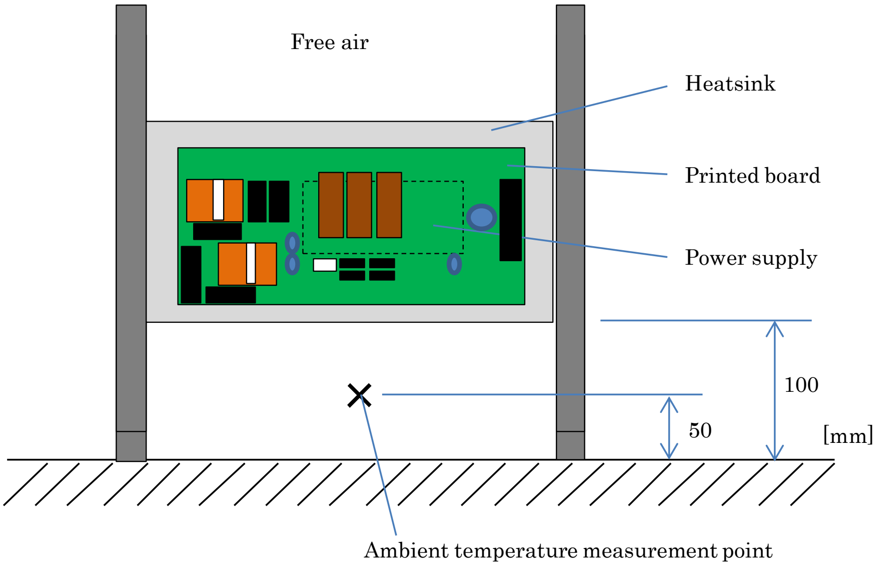


Fig.9.3
TUNS300F
result

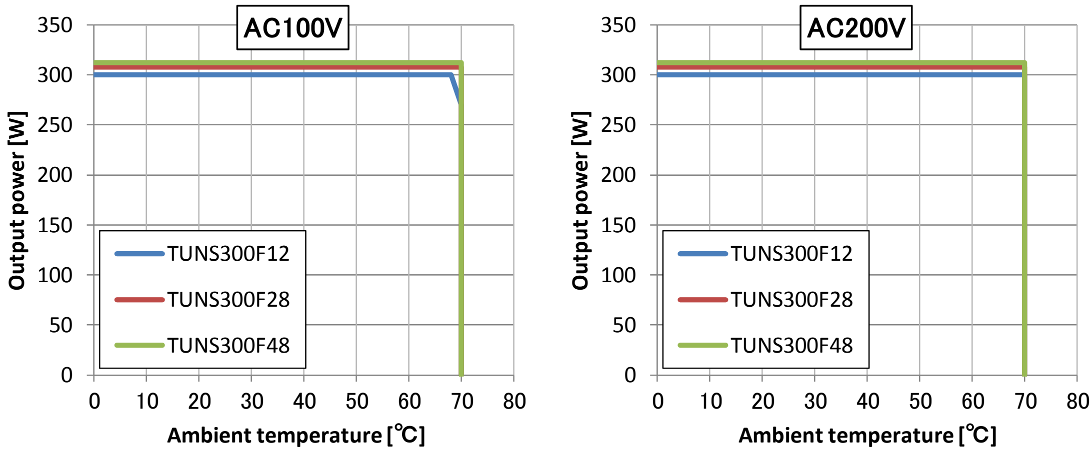


Fig.9.4
TUNS500F
result

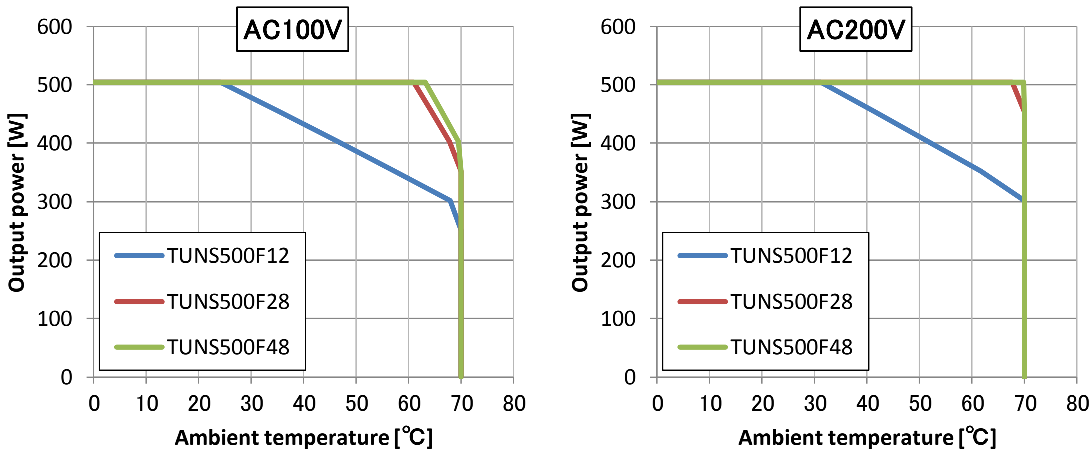
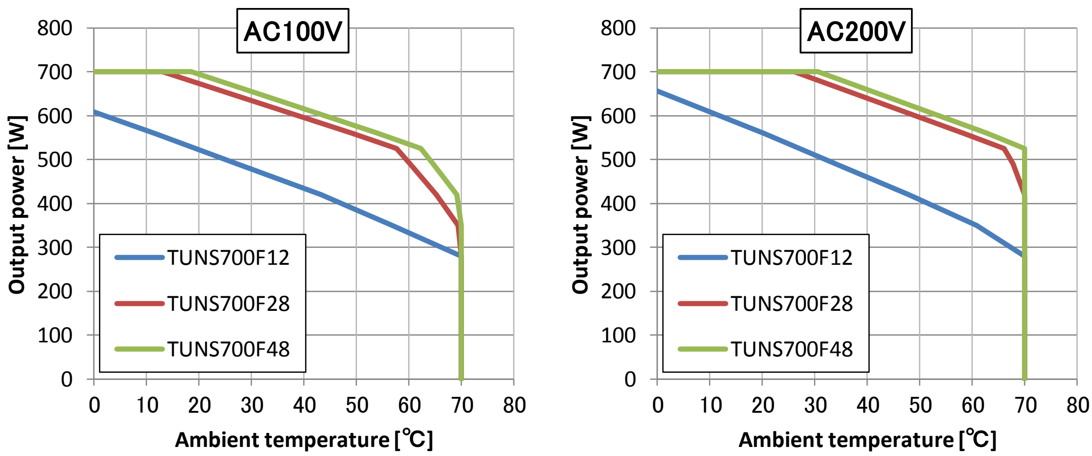


Fig.9.5
TUNS700F
result



※ Maximum ambient temperature is limited at 70 ℃ MAX to be considered the life of the electrolytic capacitor.

9.3 Examples of Forced air cooling

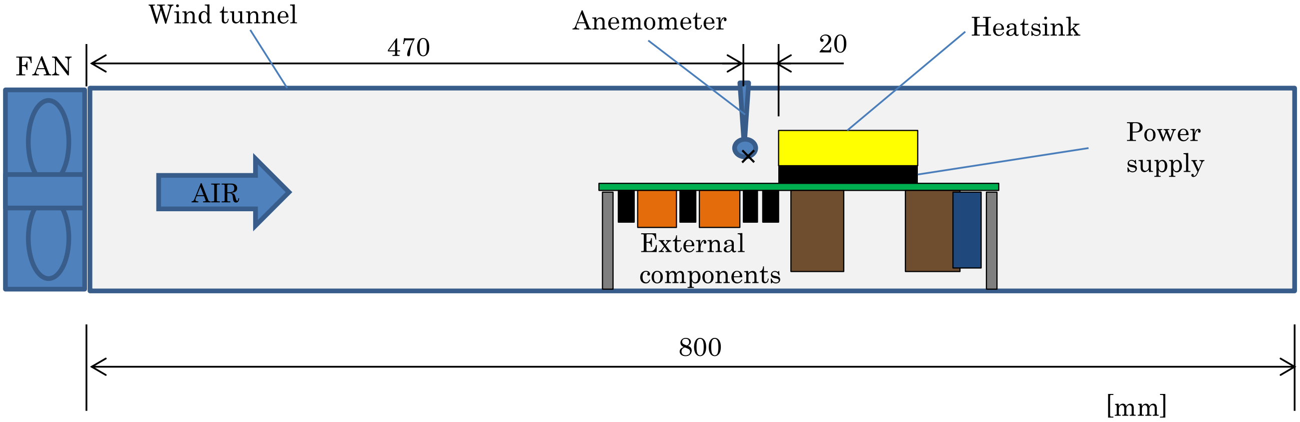
- Here is an example of forced air cooling with heatsink.
- Please consider this example as a design guideline because it changes by the heat dissipation environment. Please measure the temperature of the actual equipment eventually.
- If it is difficult to measure the center of the baseplate, please measure the leeward side of the baseplate edge.

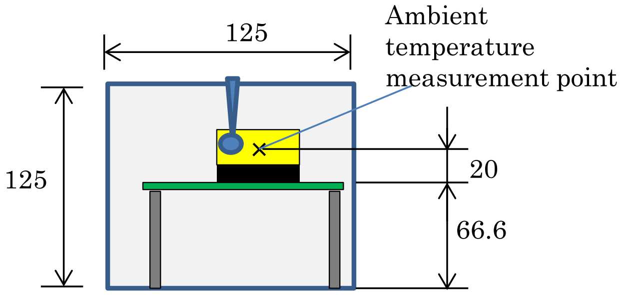
Fig.9.6
Forced air cooling
Heat sink example

Full brick size heatsink (Mounting surface with heat dissipation sheet)
117×61×23mm
(ATS-1111-C1-R0 Advanced Thermal Solutions, Inc.)

AIR VELOCITY [m/s]	THERMAL RESISTANCE [°C/W]
1.0	1.82
1.5	0.98
2.0	0.65
2.5	0.50
3.0	0.41
3.5	0.35
4.0	0.32

Fig.9.7
Environment





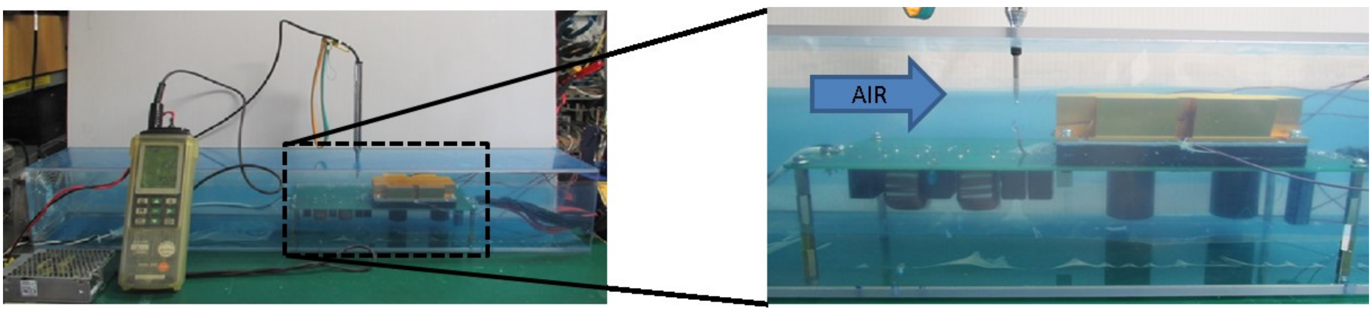
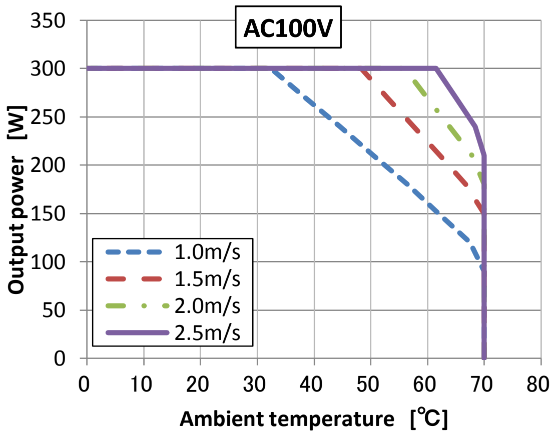


Fig.9.8
TUNS300F12
result



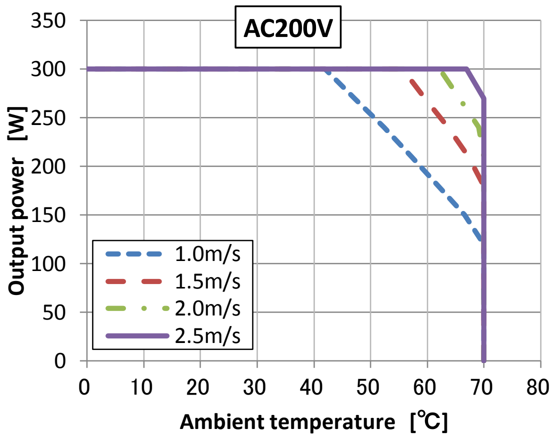
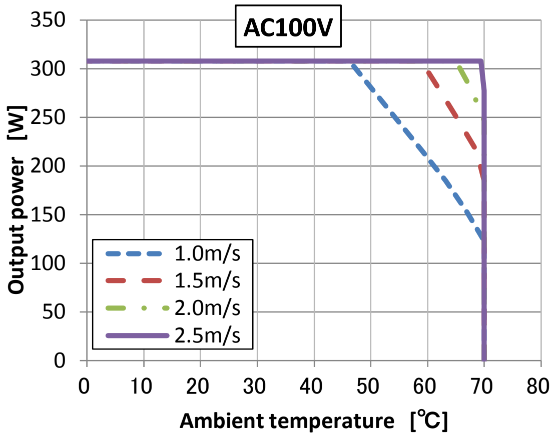


Fig.9.9
TUNS300F28
result



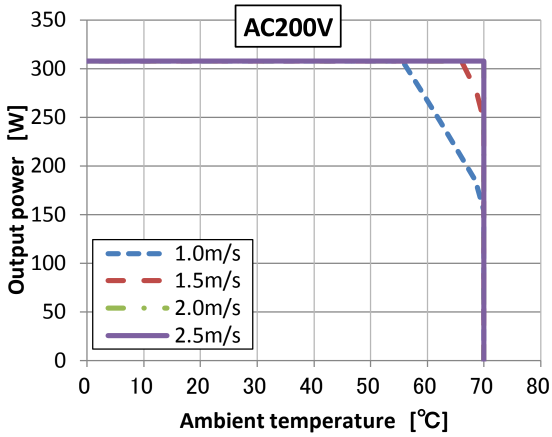
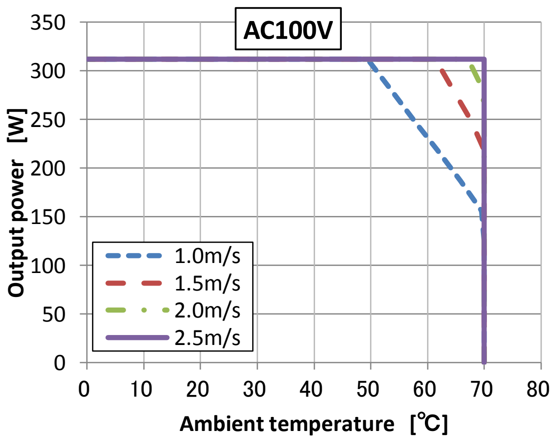
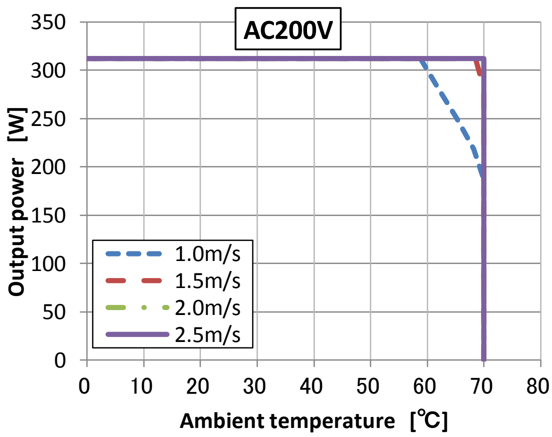


Fig.9.10
TUNS300F48
result





※ Maximum ambient temperature is limited at 70 ℃ MAX to be considered the life of the electrolytic capacitor.

Fig.9.11
TUNS500F12
result

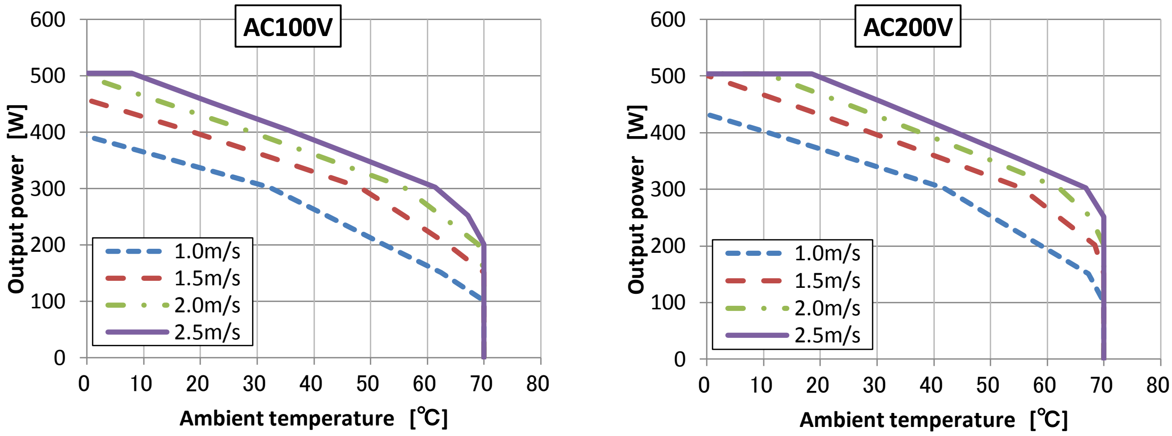


Fig.9.12
TUNS500F28
result

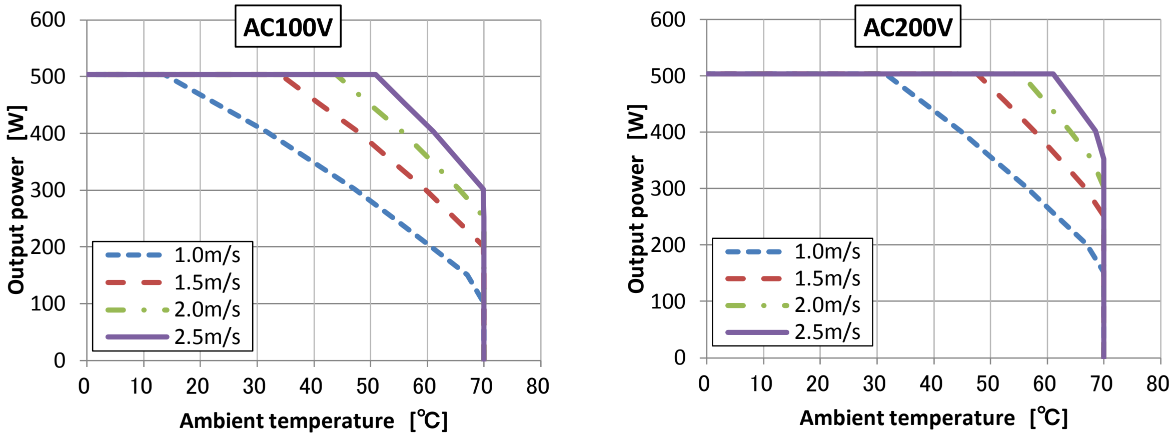
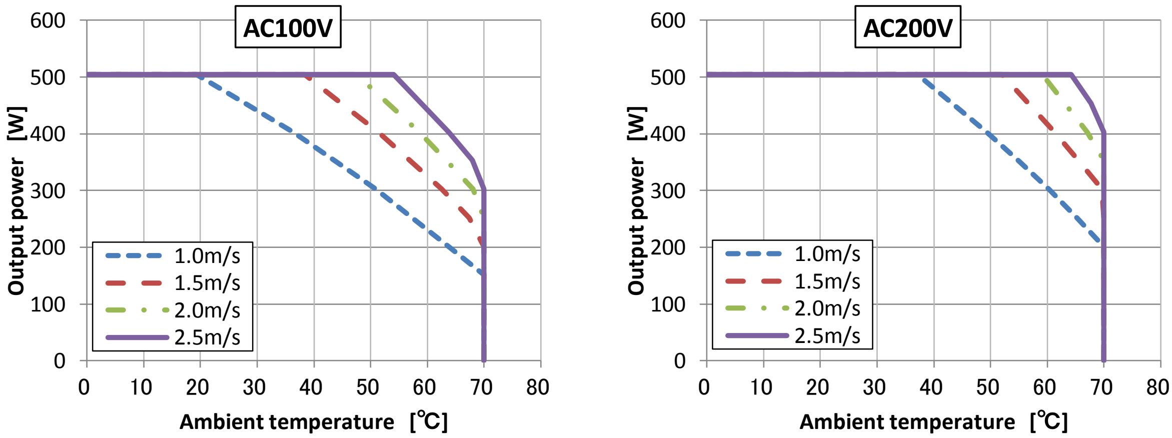


Fig.9.13
TUNS500F48
result



※ Maximum ambient temperature is limited at 70 ℃ MAX to be considered the life of the electrolytic capacitor.

Fig.9.14
TUNS700F12
result

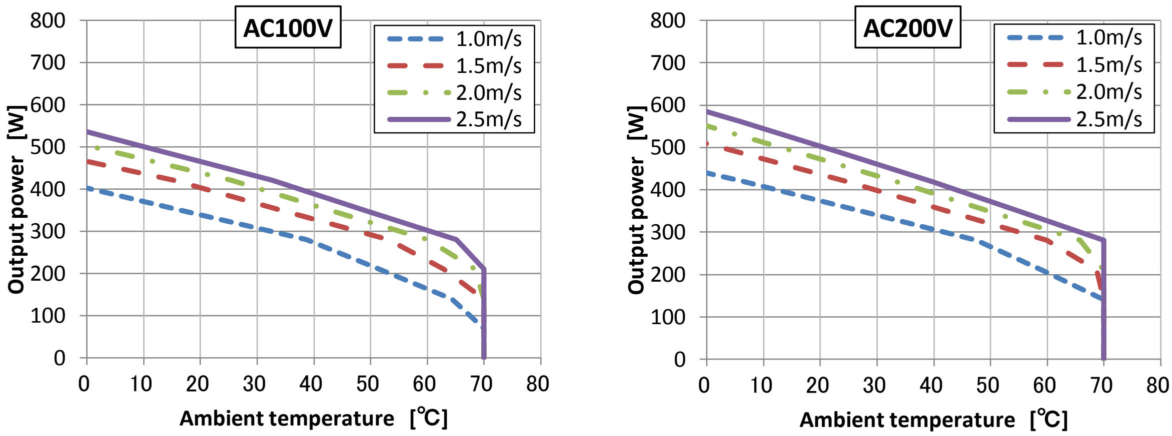


Fig.9.15
TUNS700F28
result

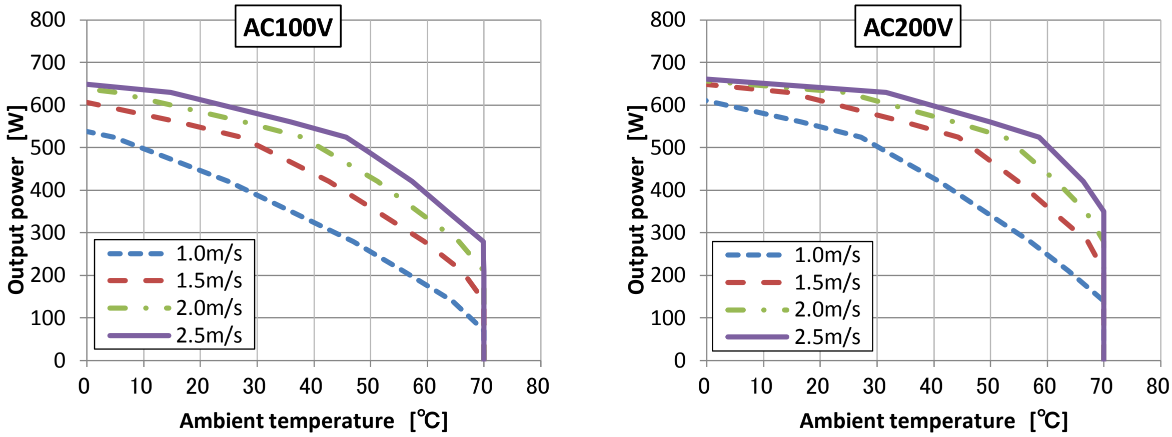
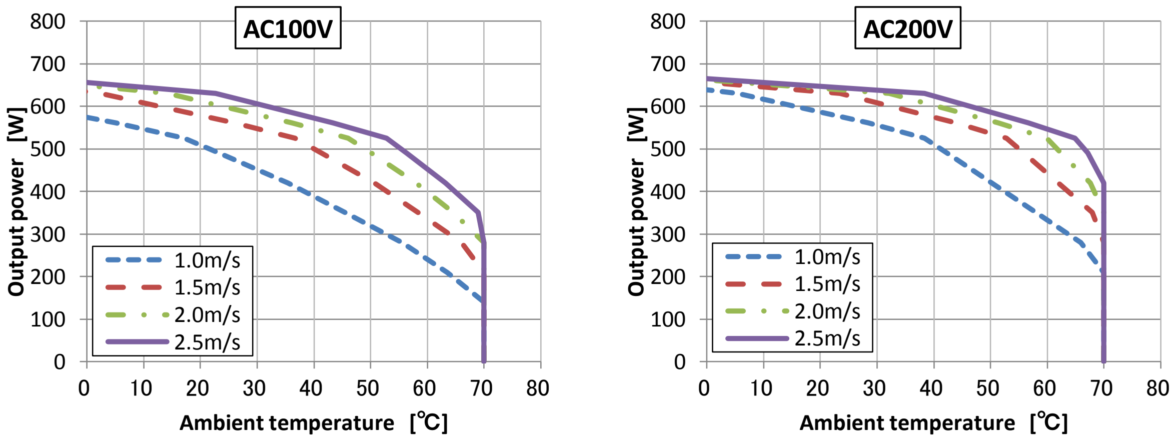


Fig.9.16
TUNS700F48
result



※ Maximum ambient temperature is limited at 70 ℃ MAX to be considered the life of the electrolytic capacitor.

10. Board layout

10.1 Consideration for board layout

■ The potential voltage of each terminal is given below. External components that are connected to these terminals should be at same potential voltage.

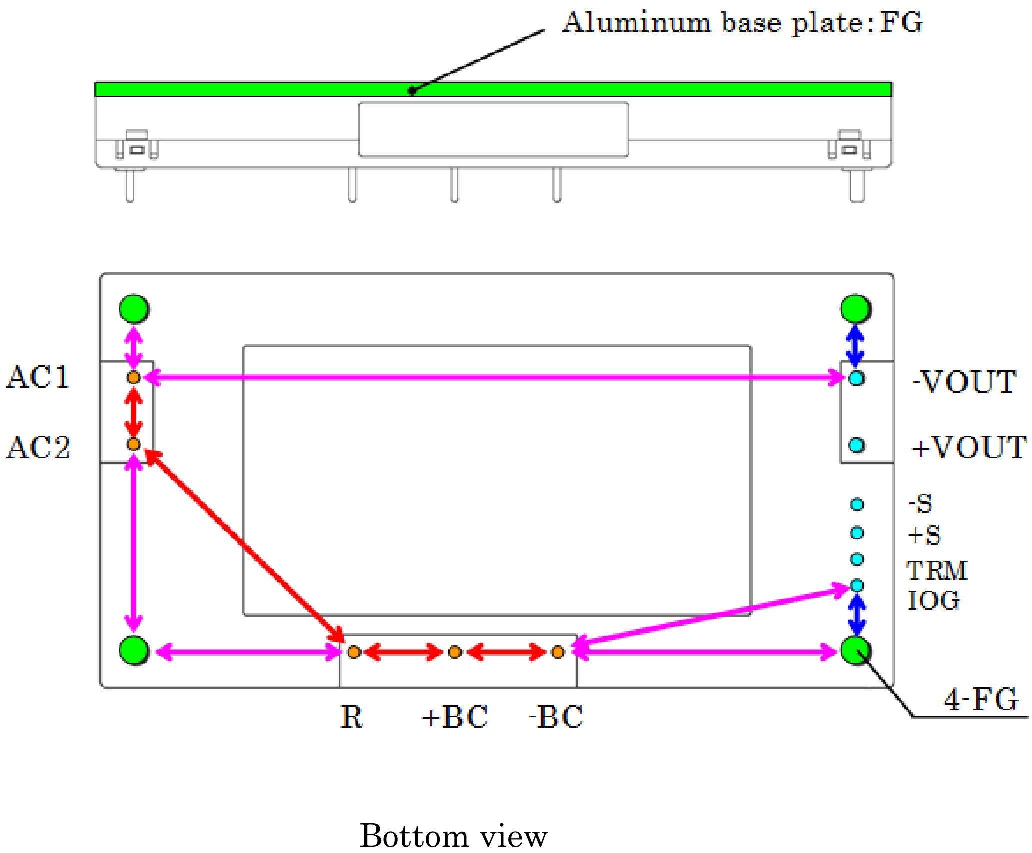
Primary (input side)	(orange)	: AC, BC, R pin
Secondary (output side)	(light blue)	: VOUT, S, TRM, IOG pin
FG (base plate)	(green)	: Nut (4 places), Aluminum base plate, Heat sink

■ In order to meet the breakdown voltage specification of products, insulation distance between components and between patterns is recommended to ensure the following.

Primary - Secondary	↔ (magenta)	: 5mm or more
Primary -FG	↔ (magenta)	: 5mm or more
Secondary - FG	↔ (blue)	: 1.6mm or more
Primary interphase	↔ (red)	: 3mm or more
Wiring of AC pin - BC pin	↔ (red)	: 3mm or more

■ Clearance and creepage requirements vary based on different safety standards and conditions of usage. Please place the components and wiring pattern according to those safety standards.

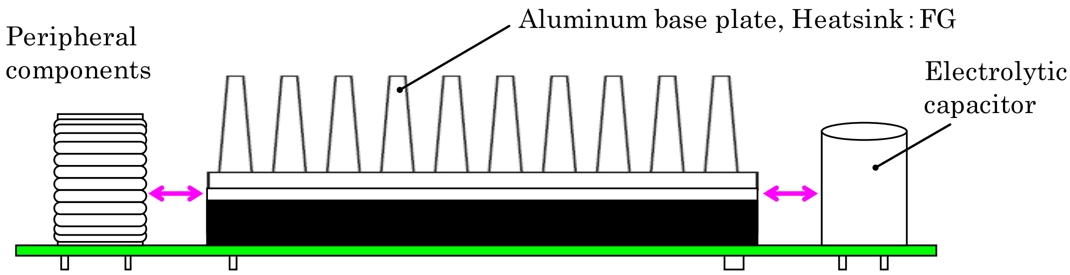
Fig.10.1 Insulation distance



■ When installing the electrolytic capacitor and the power supply on the same surface of the printed circuit board, please pay attention to the distance between the base plate and electrolytic capacitor. Exterior of the electrolytic capacitor is assumed to be the same potential as the negative electrode.

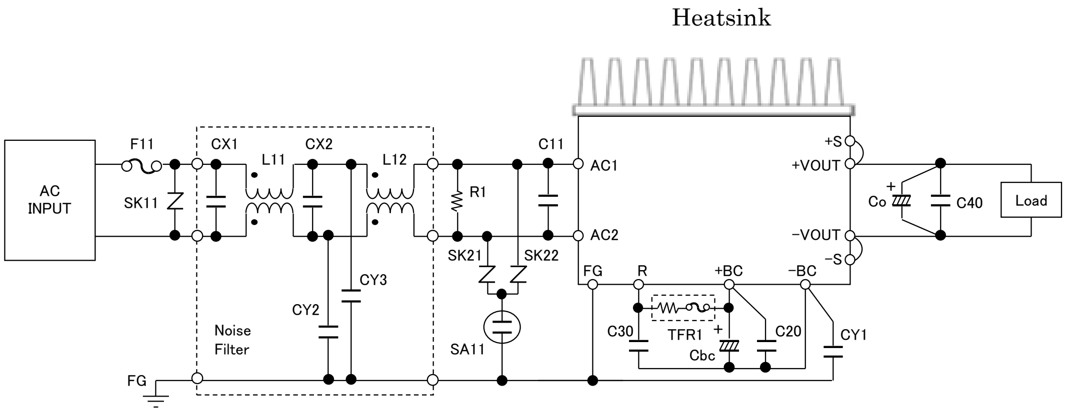
■ High-frequency noise radiates directly from the unit to the atmosphere. Therefore, design the shield pattern on the printed circuit board and connect to FG. The shield pattern prevents noise radiation.

Fig.10.2
Same Surface
Mount



■ There are notes for printed circuit board design at recommended circuit in this applications manual. Please see below.

Fig.10.3
Recommended
external circuit



① Input fuse：F11
② Noise filters
  Line filter ：L11、L12
  Interphase capacitor ：CX1、CX2
  Y capacitor ：CY2、CY3
③ Input capacitor：C11
④ Inrush current limiting resistor：TFR1
⑤ Capacitor for boost voltage
  Electrolytic capacitor ：Cbc
  Film Capacitors ：C20、C30
⑥ Y Capacitors ：CY1
⑦ Output capacitors
  Electrolytic capacitor ：Co
  Ceramic capacitor ：C40
⑧ FG terminals
⑨ Surge Suppression
  Varistor ：SK11、SK21、SK22
  Surge absorber ：SA11
⑩ Discharging resistor：R1

① Input fuse：F11

When the fuse is blown out, input voltage would be applied between the terminals of the fuse F11.

Please keep the distance of the pattern between the terminals of the fuse more than 2.5mm if you must be complied safety approvals.

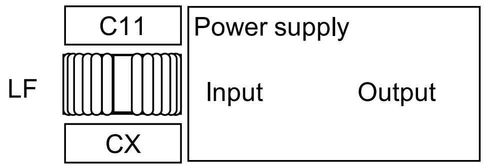
② Noise filter

Noise filter is build by Line filters (L11, L12), X capacitor (CX1, CX2) and Y capacitor (CY2,CY3). And the Noise filter is used to reduce conduction noise from power supply.

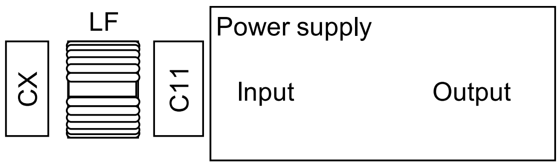
Off-the-shelf Noise filter is also available.

If the Line filter is placed near the components which is switching at high frequency, the conduction noise may be increased because the noise goes into the Line filter.

Therefore, the Line filter should be shielded or keep the distance from the source of noise.



× Not good



O Good

The effect of noise reduction by Y capacitor depends on the place of the FG connection. Recommend connecting Y capacitor to the FG terminal of the power supply as close as possible. Please evaluate before use.

③ Input capacitor：C11

Huge ripple current flows into the capacitor C11.
Place the capacitor C11 near the power supply as close as possible.

④ Inrush current limiting resistor：TFR1

Inrush current will flow through the Cbc TRF1 from the R pin. Please have a pattern width that is not damaged by the inrush current.

⑤ Capacitor for boost voltage：Cbc,C20 R pin connected capacitor ：C30

The high voltage(Approx. 380VDC) is appeared between +BC,R and -BC terminals.
The distance between +BC, R and -BC terminals must be 3mm or more.

Huge ripple current flows into the capacitor C20. Place C20 near the power supply as close as possible.

⑥ Y Capacitors ：CY1

CY1 should be connected to the FG terminal of the power supply as close as possible.

⑦ Output capacitors : Co, C40

Connecting the output capacitor (Co,C40) to the power module as close as possible for stable operation and radiation noise reduction.
The output line impedence could cause unstable output voltage, which can be reduced by adding the output capacitor close to the load.

When the output ripple and ripple noise must be reduced, ceramic capacitor C40 which has good characteristics at high frequency should be used.
If through-hole type ceramic capacitor is used, the effect of the noise reduction would be reduced by the impedance of the lead frame of the components.
Please evaluate before using.

⑧ FG terminals of the power supply

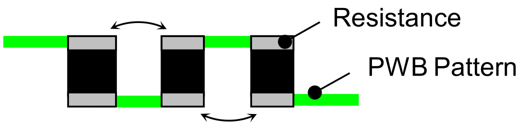
Connect the FG terminal of the power supply to the PWB by screw. If the FG terminals of the power supply is not connected properly, malfunction or failure could happen.
Expose the solder mask around the hole of the FG connection on the PWB to connect FG terminals by screws.

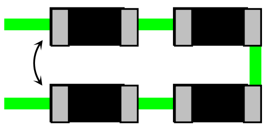
⑨ Surge Suppression Device : SK11,SK21,SK22, and SA11

In isolation test, test voltage is applied to the SA11. When the test voltage beyond the specification of the SA11 is applied, please remove the SA11 during the test, or lower the test voltage.
Note. When conducting isolation test between the primary and the secondary, high voltage is applied to SA11,SK11,SK21, and SK22, by the partial pressure of the Y capacitor.

⑩ Discharging resistor : R1

Please keep distance between electrodes, when using multiple resistors as R1 due to the power loss dispersion.
In the case of obtaining safety standards, please keep insulation distance required by the standards.





10.2 Reference PCB layout

Fig.10.4
Example of
the pattern
layout
(Top view)

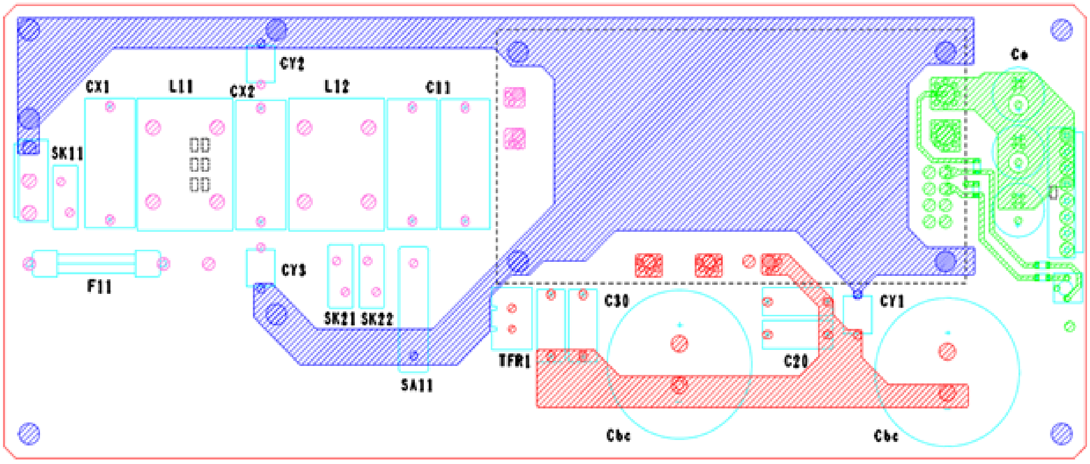


Fig.10.4(a) Example of the pattern and components layout (Top layer)

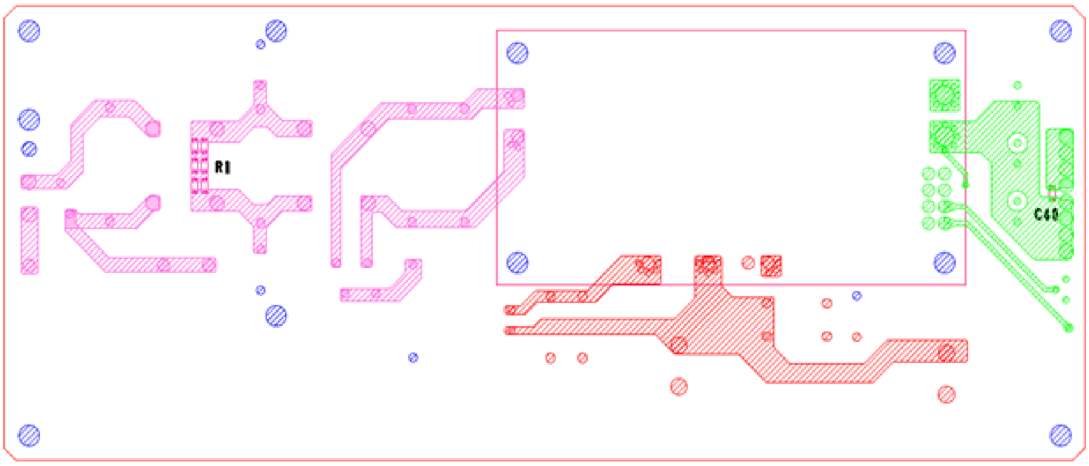


Fig.10.4(b) Example of the pattern and components layout (Bottom layer)

Primary (Input Line) Primary (BC Line) FG Secondary

11. Example of which reduces EMI

11.1 Means of the EMI reduction

■ Fig.2.1 show the recommended circuit example for EN55022 ClassA.
To meet class B or further noise reduction, external components and metal shield should be changed accordingly. Please refer to the circuit showed on section 11.4.

11.2 Switching frequency noise reduction (200kHz)

■ 6dB noise reduction can be achieved either by doubling the values of CY2, CY3 or increase the values ofL11 and L12.
■ When Cy2, Cy3 is increased to 4,700pF, 0.022uF capacitor should be added as Cy4, Cy5 to keep 3kV isolation between primary and secondary.
As another example, if the value of Cy2, Cy3 are 3300pF, each CY4, CY5 value should be 0.01uF
■ Please note that leakage current would become large if Cy2, Cy3 is increased.

11.3 High frequency band noise reduction (more than 10 MHz)

■ EMI noise over 10 MHz varies depending on position of the external components and PC board layout.
■ High frequency noise can be reduced by increasing the value of C20 or Y capacitors at output side (CY4 and CY5).
■ Place the capacitors C20, CY4 and CY5 as close as possible to the power modules.

11.4 EMI measure example

■ Fig.11.1 show the circuit example for EN55022 ClassB.

Fig.11.1
Example of EMI measure circuit

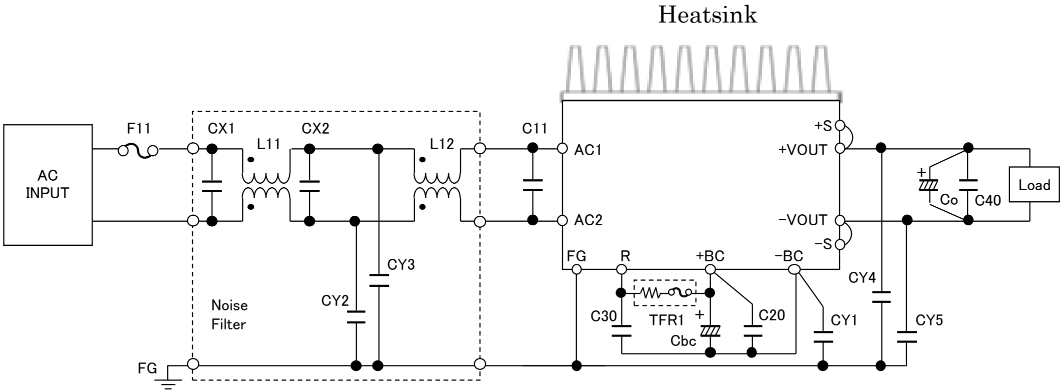


Table 11.1
List of component change for EMI ClassB requirement

No.	Symbol	Item		EN55022 ClassA (Recommended external circuit in Fig. 2.1)		EN55022 ClassB.	
				Rating	Part name	Rating	Part name
1	CY2	Noise filter	Y capacitor	AC400V/2200pF	CD45-E2GA222M (TDK)	AC400V/4700pF	CD45-E2GA472M (TDK)
2	CY3			AC400V/2200pF	CD45-E2GA222M (TDK)	AC400V/4700pF	CD45-E2GA472M (TDK)
3	C20	Capacitor for boost voltage		DC450V/0.68uF ×2parallel	ECW-F2W684JA × 2parallel (Panasonic Electronic Components)	DC450V/0.68uF ×3parallel	ECW-F2W684JA × 3parallel (Panasonic Electronic Components)
4	CY4	Y capacitor		-	-	0.022uF	LE223 (OKAYA ELECTRIC INDUSTRIES)
5	CY5			-	-	0.022uF	LE223 (OKAYA ELECTRIC INDUSTRIES)

Fig.11.2
Line conduction

Model Name	:	TUNE700F48
Power Supply	:	AC Single-Phase 50Hz 230V
Output current	:	Lated Load

<EN55022b>
Limit (QP)
Limit (AV)
<TUNS700F48>
Range (VA,PK)
Range (VB,PK)

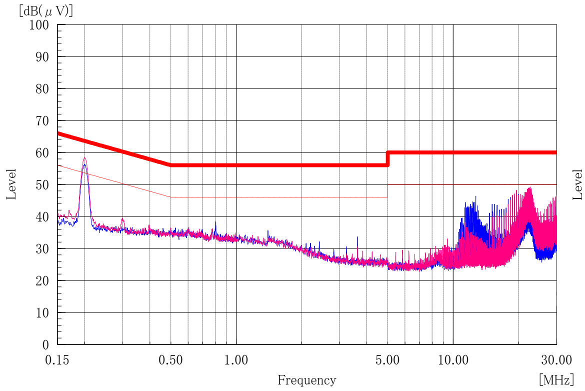


Fig.11.2(a) External circuit on fig.2.1

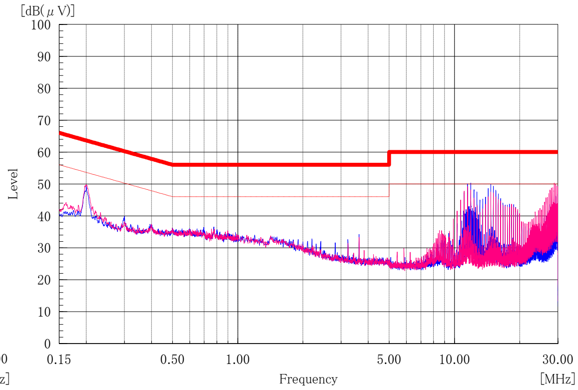


Fig.11.2(b) External circuit on fig.11.1

Fig.11.3
Radiated
emission

Model Name	:	TUNE700F48
Power Supply	:	AC Single-Phase 50Hz 230V
Output current	:	Lated Load

<EN55022b>
Limit (QP)
<TUNS700F48>
Horizontal(PK)
Vertical(PK)

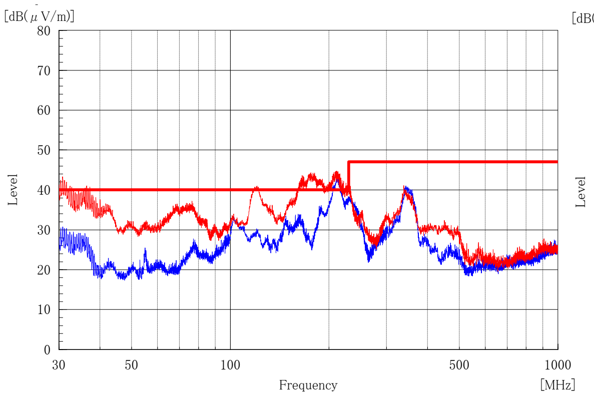


Fig.11.3(a) External circuit on fig.2.1

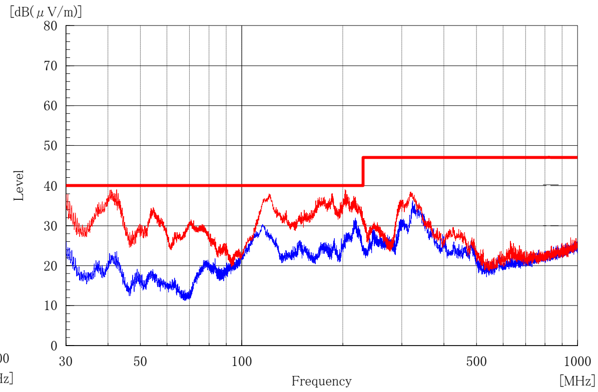


Fig.11.3(b) External circuit on fig.11.1

Revision history

No.	date	Rev.	page	content
1	29-May-2015	1.1E	A-9	[3.2 Input voltage derating] Addition
2	29-May-2015	1.1E	A-10～A-12	[4. Output voltage adjustment] Addition
3	29-May-2015	1.1E	A-13	[5. Parallel operation (option :-P)] Addition
4	29-May-2015	1.1E	A-17	[8. Mounting method] , [9.Thermal Design] Addition
5	10-Aug-2015	1.2E	A-23,A-24	[11.Example of which reduces EMI] Addition
6	3-Dec-2015	1.3E	A-18～A-23	[9.2 Examples of Convection cooling],[9.3 Examples of Forced air cooling] Addition
7	8-Jan-2016	1.4E	A-11	Fig4.3 Calculation formula Correction
8	07 Sep 2018	1.5E	A-2	Table2.1 Components list Change
9	05 Jul 2019	1.6E	A-2,A-29	Table2.1 Components list,Table11.1 Components list Change
10				
11				
12				
13				
14				
15				