Outline

The BPM Energy-Saving Power Module Series is a series of energy-saving switching power modules with built-in switching transformers, control ICs, control circuits and switching elements (FET).
Attaching the input noise filter, the input rectifier diode and the output smoothing capacitor externally enables the easy creation of power switching with high-efficiency, low-standby power.

Features

・Quasi-resonant operations for high efficiency.
・Operations using both frequency reduction and bursts for generation of low-standby power.
・Supports worldwide input and PFC output voltages (Vin: DC100V to 420V)
・Reinforced insulation between Primary and Secondary (AC3000V guaranteed for one minute).
・Resin filling is available to reduce audible noise.
・Compliant with all required safety standards for information equipment, AV equipment, industrial equipment, and home appliance equipment.
・Various built-in protection functions (overcurrent, overvoltage and overheating protection).

1. Selecting Externally Connected Equipment

The example of application circuits and parts value which are indicated to this application note aim at assistance of a design. Therefore, external parts variation or user operating conditions are not fully taken into consideration. Please take parts variation, operating conditions into consideration when designing.

1.1 Application Circuits

●With FG (Class I Power Supply)

Vin=85Vac～276Vac
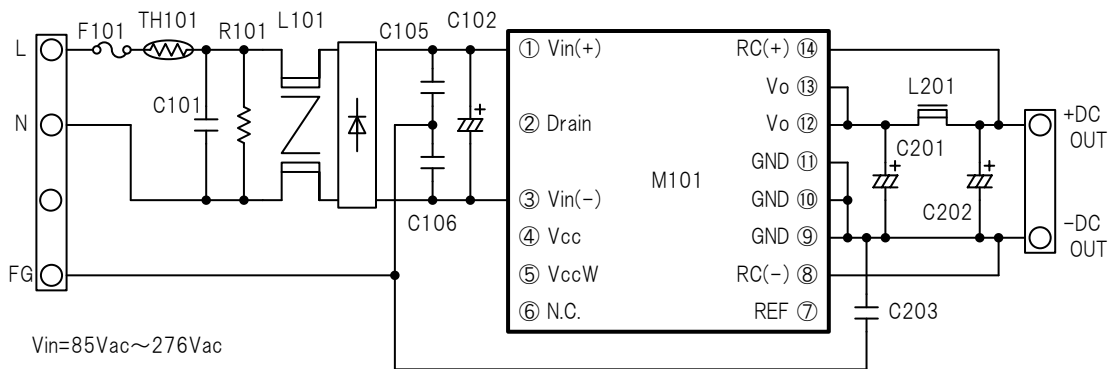
●Without FG (Class II Power Supply)

Vin=85Vac～276Vac
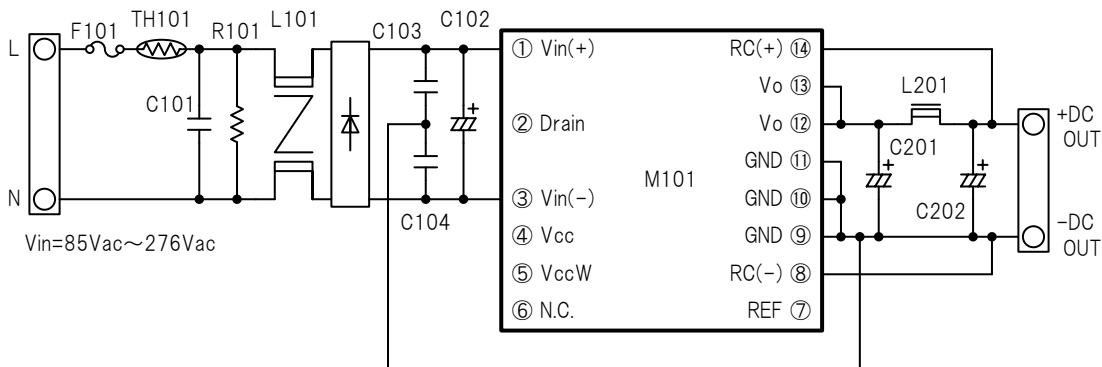
1.2 Parts example

Part	Output Specifications				
	3.3V **A	5V 8A	12V 3.4A	15 2.7A	24 1.7A
M101		BPM0580SJ	BPM1234SJ	BPM1527SJ	BPM2417SJ
F101		250V 2.0A time lag	250V 2.0A time lag	250V 2.0A time lag	250V 2.0A time lag
TH101		5Ω～10Ω	5Ω～10Ω	5Ω～10Ω	5Ω～10Ω
L101		22mH～47mH/ 1A	22mH～47mH/ 1A	22mH～47mH/ 1A	22mH～47mH/ 1A
L201		2.2uH～10uH / 12A	2.2uH～10uH / 6.8A	2.2uH～10uH / 5.4A	2.2uH～10uH / 3.4A
L202		2.2uH～10uH / 8A	2.2uH～10uH / 3.4A	2.2uH～10uH / 2.7A	2.2uH～10uH / 1.7A
C101		0.1uH～0.22uH / 250V	0.1uH～0.22uH / 250V	0.1uH～0.22uH / 250V	0.1uH～0.22uH / 250V
C102		450V 100uF	450V 100uF	450V 100uF	450V 100uF
C103		100pF～2200pF class Ⅱ	100pF～2200pF class Ⅱ	100pF～2200pF class Ⅱ	100pF～2200pF class Ⅱ
C104		100pF～2200pF class Ⅱ	100pF～2200pF class Ⅱ	100pF～2200pF class Ⅱ	100pF～2200pF class Ⅱ
C105、C106		470pF～2200pF class Ⅰ	470pF～2200pF class Ⅰ	470pF～2200pF class Ⅰ	470pF～2200pF class Ⅰ
C201		10V 2200uF × 4	25V 1500uF × 2	25V 1500uF × 2	35V 680uF
C202		10V 1000uF	25V 820uF	25V 820uF	35V 220uF
C203		1kV 0.022uF	1kV 0.022uF	1kV 0.022uF	1kV 0.022uF
R101		3.3MΩ 500V	3.3MΩ 500V	3.3MΩ 500V	3.3MΩ 500V

(Comming soon — in the 3.3V **A column)

※C102 is calculated based on rated output power equal maximum power.

1.3　AC input　DC output

When using an AC input connector and DC output connector, pay attention to　the rated voltage　and rated current of　the connector.
Consider the input voltage, withstand voltage and safety standard demanded values and provide a clearance between AC input connector pins.

1.4　Fuse (F101)

Since a fuse is not built into the module (M101), always install a fuse at the Live　side to ensure safety.
Select the fuse by considering the normal current, in-rush current, ambient temperature, and other conditions.
(Discharge the capacitors in the circuit fully and consider the conditions at which　the circuit impedance is lowest when there is a thermistor or other element whose resistance value changes with temperature.)

①Select a rated current of 2 or more times the normal current.
②Consider the rated current rate of change by ambient temperature.(At high temperature: Rated voltage drops)
③Check that the in-rush current and normal current are within the blowout characteristic curve of the fuse.
④Select a fuse so that in-rush current and normal current can take sufficient margin to a fuse permission I^2t curve.
　A required margin is subject to the influence by temperature conditions, and the influence of the number of times of incoming current which occurs in an expected life. We recommend you to ask a fuse maker a proper margin.

In order to share an input line and an input electrolytic capacitor with another converter, when selecting a fuse with the high fusing current characteristic, and a high-capacity electrolytic capacitor, there is a case which a fuse does not blow out at the time of abnormalities.
Please perform a safety check enough in such a case.

1.5　Noise filter　(C101,C103,C104,C105,C106,C203,L101)

1.5.1　C101:X capacitor (Across-the-line capacitor)
　・Select the rated voltage matched to the input voltage specifications.
　・Use a safety standard approved product of each country.

1.5.2　C103,C104,C105,C106,C203：Y capacitor (Line bypass capacitor)
・　Use a safety standard approved product of each country.
・　Be careful of the leakage current specified by each safety standard.
・　With a Class Ⅱ power supply, when connecting directly between the primary and secondary, use a reinforced insulation product(Y1 class approved).
・　C203 does not require a safety standard approved product, but since the withstand test voltage applied between the primary and secondary is divided and applied according to the overall capacitance of C105 and C106 and the capacitance of C203, pay careful attention to the rated voltage.
・
1.5.3　L101：Common mode choke coil
　・Be careful to confirm the rated temperature specified by the wire type and the bobbin insulation used in the common choke coil

1.6 X capacitor discharge resistance (R101)

The voltage immediately before cutoff is charged in the X capacitor even when the input line is in cutoff status. With a device at which parts of the same voltage as the X capacitor may be touched, a discharge resistor is necessary according to the capacity of the X capacitor.

Example) IEC60950: When the X capacitor capacitance 0.1µF is exceeded; the time constant shall be 1 or less.

X capacitor capacitance：0.22uF $1 \geqq R101 \cdot 0.22 \times 10^{-6}$
$R \leqq 4.5 M\Omega$

In addition, calculate the X capacitor voltage after t seconds from input line cutoff from the following expression and check that there is no problem.

$Vt = Vo(1 - e^{-t/CR})$ Vt： X capacitor voltage t seconds from input cutoff
Vo： Effective input voltage $X\sqrt{2}$
C： X capacitor capacitance
R： Discharge resistor value
e： Base of natural logarithm （≒2.71828）

1.7 Rectifying diode(D101)

Always perform full-wave rectification using a bridge diode or general rectifying diodes (use 4 diodes).
When selecting parts, pay attention to the rated voltage, rated current, and temperature rise.

Check that the in-rush current does not exceed the peak surge current and I^2t specification of the rectifying diode.
(Discharge the capacitors in the circuit fully and consider the conditions at which the circuit impedance is lowest when there is a thermistor or other element whose resistance value changes with temperature.)

1.8 Surge current prevention(TH101)

When input power is applied, an in-rush current which charges the input smoothing electrolytic capacitor flows. An in-rush current that is too large will cause the power supply voltage to become unstable and may affect the devices which share the power supply. The fuse and rectifying diodes used may also be damaged.
When using a power thermistor to suppress the surge current, select it by paying attention to the following:

①Be sure that the temperature is within the operating temperature range of the thermistor.
②Since the characteristic is such that a rated current drop accompanies a temperature rise, check the highest temperature of the thermistor and that the load current (power supply input current) is the rated current or less at the highest temperature.
③With a power thermistor, the relationship between the maximum value of the usable input voltage (rms) and the capacitance of the input smoothing electrolytic capacitor are set. Check that the relationship between the input voltage (rms) and input smoothing electrolytic capacitor is not a problem with the thermistor used.
④Since a power thermistor has a large thermal time constant and its resistance value remains low after the input is tripped, when the input is repeatedly turned on and off,   the surge current cannot be controlled. When using under this condition, check that the effect, etc. on the fuse, bridge diode, and input power supply are no problem.

The surge current calculation expression is:
As the calculation result is only a reference, conduct a thorough check using actual equipment.

・AC input ：

$$\text{Inrush Current(peak value)} ： \text{Vin(rms)} \cdot \sqrt{2} / (R_{TH101} + R_L)$$

$$I^2t ： \text{Vin(rms)}^2 \cdot C102 / (R_{TH101} + R_L)$$

・DC input

$$\text{Inrush Current(peak value)} ： \text{Vin(dc)} / (R_{TH101} + R_L)$$

$$I^2t ： \text{Vin(dc)}^2 \cdot C102 / 2(R_{TH101} + R_L)$$

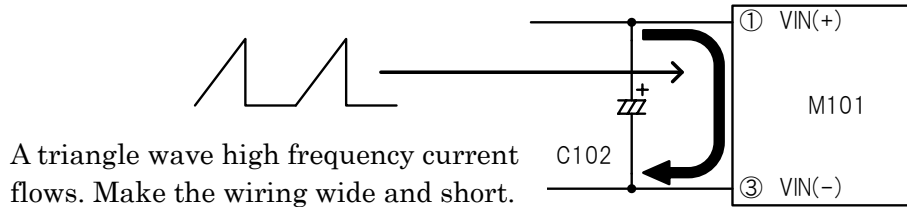R_L：Line impedance (Ω)
R_{TH101}：Thermistor resistance (Ω) at 25℃
C102：electrolytic capacitor(F)

1.9 Input smoothing electrolytic capacitor(C102)

The input smoothing electrolytic capacitor has a large effect on the characteristics and life of the product.
Select the capacitor by paying attention to the following:

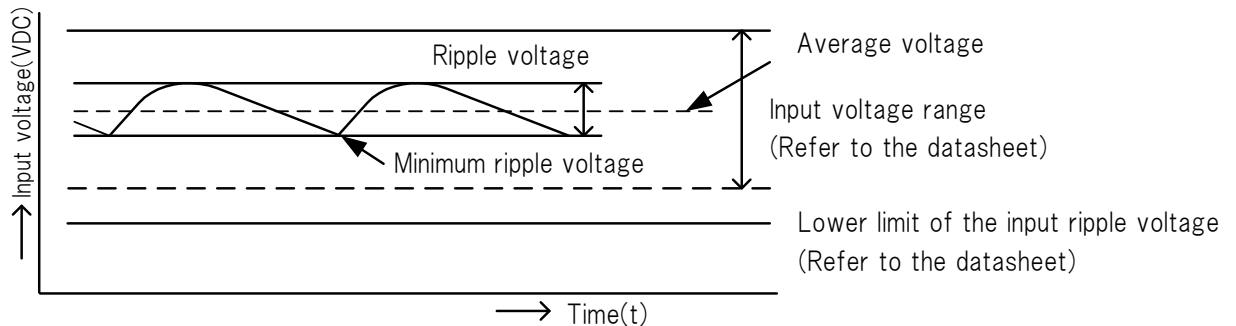①Install the capacitor very close to the module (M101) and use a wide pattern to connect M101.

A triangle wave high frequency current
flows. Make the wiring wide and short.

C102

① VIN(+)

M101

③ VIN(−)

②Follow the instructions below to determine the capacitance of the electrolytic capacitors according to the input
voltage to be used.
1) AC 100 V input, worldwide input

Determine the capacitance of the electrolytic capacitors so that the average voltage is equal to or higher than the
lower limit of the input voltage, and so that the minimum ripple voltage is equal to or higher than the lower limit of
the input ripple voltage.
Make sure that the peak voltage of the ripple voltage does not exceed the input voltage range. Take the variation
in capacitance and the capacitance reduction due to aging into consideration when selecting the capacitance.
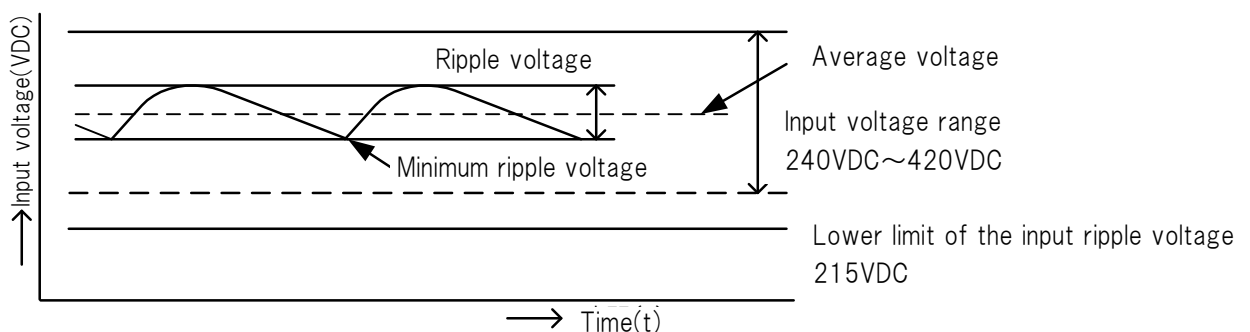
Input voltage(VDC)

Ripple voltage

Minimum ripple voltage

Time(t)

Average voltage

Input voltage range
(Refer to the datasheet)

Lower limit of the input ripple voltage
(Refer to the datasheet)

Datesheet···「http://www.tamura−ss.co.jp/electronics/en/powermodule/ 」

2) AC 200 V input

Determine the capacitance of the electrolytic capacitors so that the average voltage is equal to or higher than
240 V, and so that the minimum ripple voltage is equal to or higher than 215 V.
Make sure that the peak voltage of the ripple voltage does not exceed the input voltage range.
Take the variation in capacitance and the capacitance reduction due to aging into consideration when selecting the
capacitance.

Input voltage(VDC)

Ripple voltage

Minimum ripple voltage

Time(t)

Average voltage

Input voltage range
240VDC〜420VDC

Lower limit of the input ripple voltage
215VDC

The capacitance of the electrolytic capacitors can be estimated using the formulae below.
The value calculated using the formulae is the minimum required capacitance. Take into consideration variations in the capacitance of the electrolytic capacitors to be used and reductions in the capacitance due to aging.
As the calculation result is only a reference, conduct a thorough check using actual equipment.

100 V input/WW input $\cdots$

$$C102(\min) \geq 4 \cdot K \cdot Io(\max) \Big/ (5 \cdot f \cdot (2 \cdot Vin\min(rms)^2 - 75^2))$$
(reference for the minimum ripple voltage)

And
$$C102(\min) \geq K \cdot Io(\max) \Big/ (5 \cdot f \cdot 100 \cdot (\sqrt{2} \cdot Vin\min(rms) - 100))$$
(reference for the average voltage)

200 V input $\cdots$

$$C102(\min) \geq 4 \cdot K \cdot Io(\max) \Big/ (5 \cdot f \cdot (2 \cdot Vin\min(rms)^2 - 215^2))$$
(reference for the minimum ripple voltage)

And
$$C102(\min) \geq K \cdot Io(\max) \Big/ (5 \cdot f \cdot 240 \cdot (\sqrt{2} \cdot Vin\min(rms) - 240))$$
(reference for the average voltage)

Vinmin(rms):Minimum effective input voltage(Vrms)

f:Commercial power frequency(Hz)

Io(max):Maximum output current in use(A)

K:Coefficient (varies depending on model. Refer to the following.)
- ·BPM0390SJ : TBD   ·BPM1527SJ : 16.7
- ·BPM0580SJ : 5.88   ·BPM2417SJ : 26.7
- ·BPM1234SJ : 13.3

③Calculate the guaranteed life of the electrolytic capacitor and check that there is no problem.
Since the life calculation expression is different depending on the capacitor manufacturer and type, requesting life calculation by the manufacturer of the capacitor used is recommended.
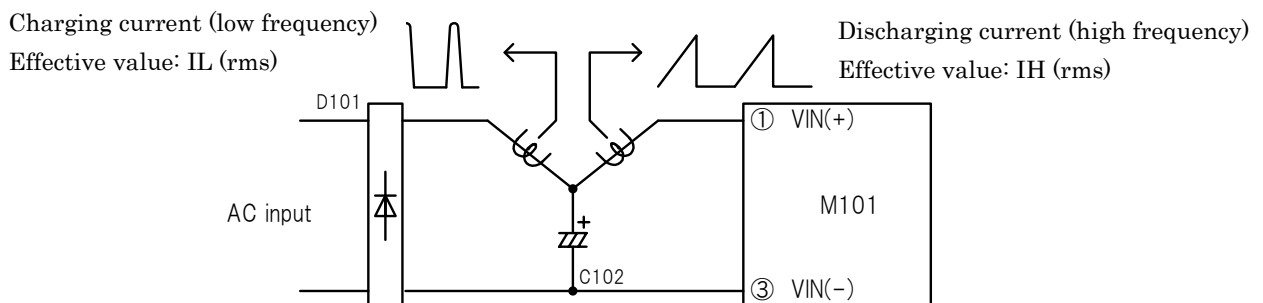Generally, life can be calculated by using the temperature and ripple current of the electrolytic capacitor.
1)Electrolytic capacitor temperature
The temperature at which the temperature on the body of the electrolytic capacitor is maximum is measured and is made a life calculation parameter.

2) Ripple current
For AC input, a charging current (IL) and discharging current (IH) flow in the input smoothing electrolytic capacitor. These currents are measured individually and frequency correction is performed on IH and it is made a life calculation parameter as 120Hz ripple current.

Charging current (low frequency)
Effective value: IL (rms)

Discharging current (high frequency)
Effective value: IH (rms)

D101

AC input

C102

① VIN(+)

M101

③ VIN(−)

The ripple current (I120) frequency corrected to 120Hz is calculated from the following expression:

$$I_{120}(\mathrm{rms}) = \sqrt{I_L(\mathrm{rms})^2 + (I_H(\mathrm{rms}) \cdot \mathrm{fc})^2}$$

fc: Frequency correction coefficient (Refer to the electrolytic capacitor catalog.)

For stable DC input, the ripple current by high frequency charging/discharging current is assumed for input electrolytic capacitor.

Input current: IDC (ms)

$I_{DC}(rms)$

DC

C102

① VIN(+)

M101

③ VIN(−)
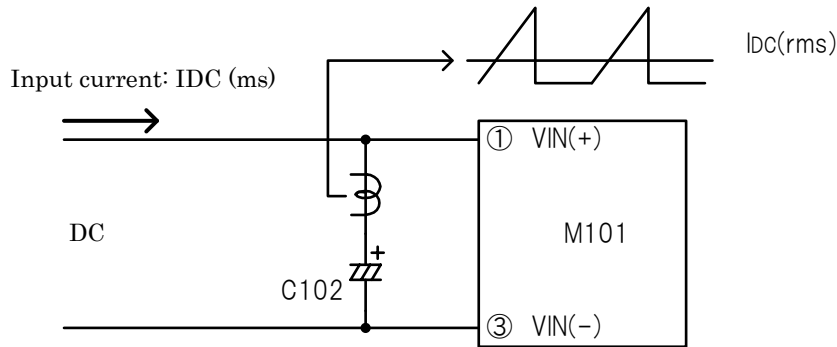
The ripple current of an electrolytic capacitor is a triangle wave high frequencycurrent with the input current (DC current) made the average value. Ripple current is calculated as follows:

Discharging current (Idis)

$I_{DC}(AVE)$

O

Charging current (Ich)
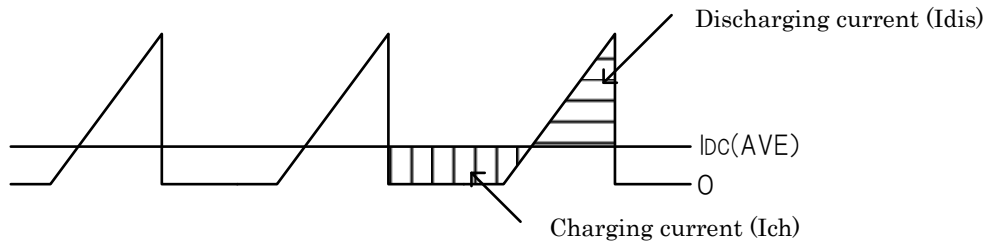
$$\text{Iripple} = \sqrt{\text{Idis}^2 + \text{Ich}^2}$$

1.10 Output smoothing electrolytic capacitor(C201)

The output smoothing electrolytic capacitor has a large effect on the characteristics and life of the product. Select the electrolytic capacitor by paying attention to the following:

①Install the capacitor very close to the module (M101) and use a wide pattern to connect M101.

Vo ⑬
⑫

M101

⑪
⑩

GND ⑨

C201

Triangle wave high frequency current flows.
Make the wiring wide and short.
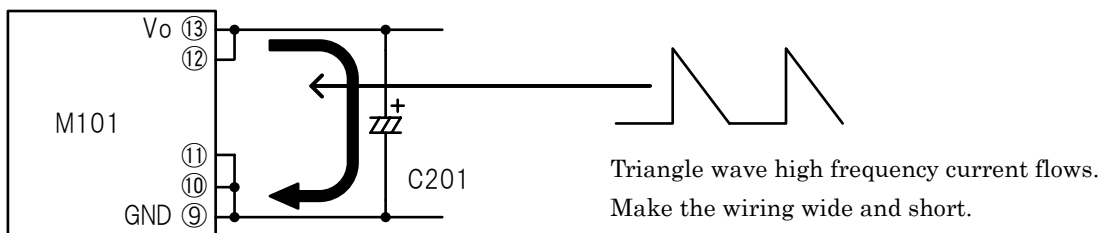
②Use an electrolytic capacitor with good frequency characteristics and low impedance.
Output ripple and noise and rise time may be affected depending on the ESR and ESL and wiring impedance of the capacitor.

③If the capacitance is too large, the overcurrent protection function may operate and the rise may be faulty at startup. A recommended value is shown in the following table.
Please ask us, when the capacity more than the following table is required.

Model	Recommendation capacitance	
	CR mode	CC mode
BPM0309SJ	TBD	TBD
BPM0580SJ	TBD	TBD
BPM1234SJ	TBD	TBD
BPM1527SJ	TBD	TBD
BPM2417SJ	TBD	TBD

④Since abnormal oscillation may occur by large phase delay if a capacitor with a very small ESR such as a tantalum capacitor or multilayer ceramic capacitor is used, use an electrolytic capacitor.

⑤The following rated voltage is recommended:
　·BPM0390SJ ： Rated voltage 10V or more
　·BPM0580SJ ： Rated voltage 10V or more
　·BPM1234SJ ： Rated voltage 25V or more
　·BPM1527SJ ： Rated voltage 25V or more
　·BPM2417SJ ： Rated voltage 35V or more

⑥Calculate the guaranteed life of the electrolytic capacitor and check that there is no problem.
Since the life calculation expression is different depending on the capacitor manufacturer and type, requesting life calculation by the manufacturer of the capacitor used is recommended.
Life can be calculated by using the temperature and ripple current of the electrolytic capacitor, the same as the input smoothing electrolytic capacitor.

1) Electrolytic capacitor temperature
The temperature at which the temperature on the body of the electrolytic capacitor is maximum is measured and is made a life calculation parameter.

2) Ripple current
A high frequency ripple current by charging/discharging current flows in the input electrolytic capacitor.
The ripple current is calculated by splitting it into the top (charging current) and bottom(discharging current) of output current (Io).


Charging current (Ich)

Io(AVE)

0

Discharging current (Idis)
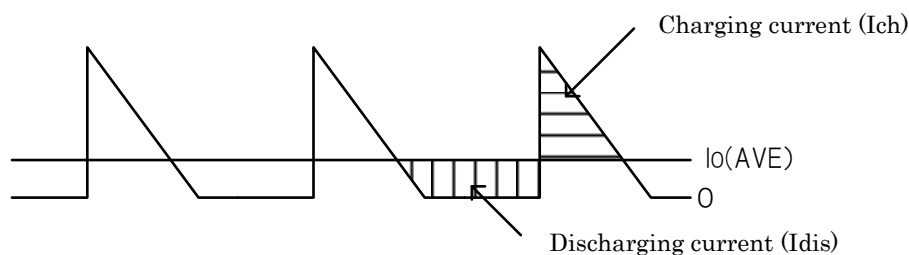
$$Iripple = \sqrt{Idis^2 + Ich^2}$$

⑦When planning to split the ripple current by using multiple electrolytic capacitors,be sure that ripple current measurement does not cause an unbalance.
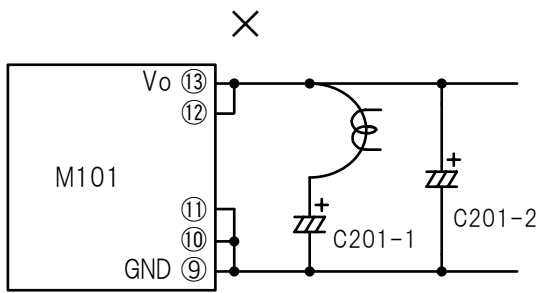
When current measurement leads, etc. are installed Only to the capacitor to be measured, the impedance is unbalanced and accurate measurement is not possible.
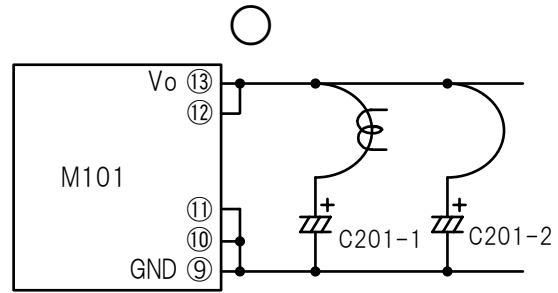
When the capacitor whose current is not to be measured has the same impedance as the capacitor to be measured, accurate measurement is possible.

1.11 LCπ type filter(L201,C202)

Output ripple voltage reduction is possible to a certain degree by using a low impedance electrolytic capacitor at C201. However, the addition of a one-stage LCπ type filter is effective in lowering the output ripple voltage more.

①Since a ripple current equivalent to C201 may flow depending on the impedance of L201, check the ripple current,temperature rise, and life of C202 also.

②Triangle wave high frequency current also flows in L201. Check that L201 is not saturated at the peak current.
In addition, consider the DC resistance of L201 and check that there is no problem with temperature rise.
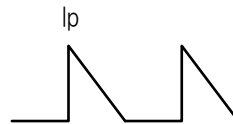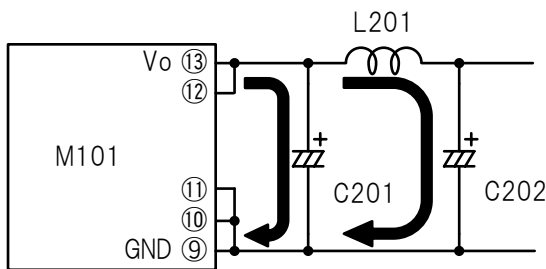
High frequency current also flows in L201 and C202.
Check that L201 is not saturated even at Ip.

2. Protection function

2.1 Overcurrent protection function

An overcurrent protection function is provided as protection when an output short circuit or overload occurs. The operation mode is automatic reset operation.

Overload detected

Output Voltage

Automatic reset operation
Intermittent operation in low power region

Output current
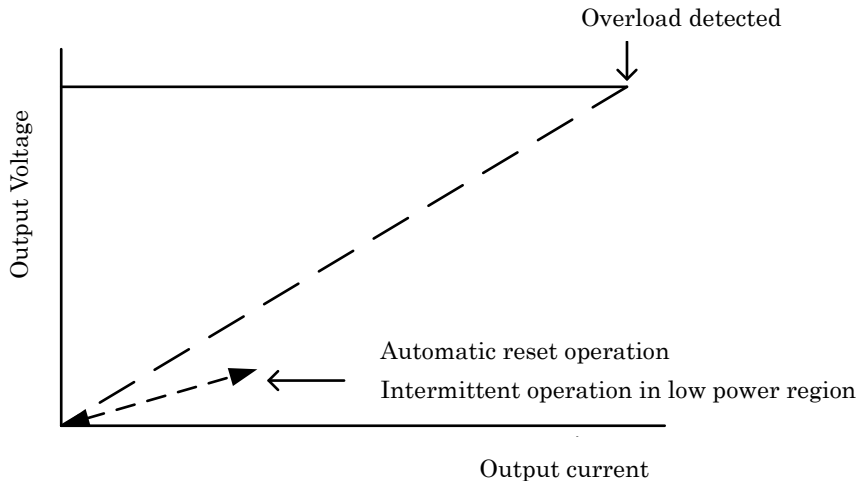
·Automatic reset operation
  In the output short circuit and overload states, intermittent operation is performed in the low power region.
  Operation is automatically reset to normal operation when the short circuit or overload is removed.

2.2 Overvoltage protection function

An overvoltage protection function is provided to prevent damage by impression of an overvoltage onto the load. The operation mode is latch operation.
When the overvoltage protection circuit operated, it is reset by turning off the input and then turning on the input again.
Reset time changes with input electrolytic capacity, input voltage, etc.

Avoid impressing a voltage onto the output terminals from the outside by wrap around from overvoltage operation check and the load side at receiving inspection because it may cause damage.
Overvoltage operation check is a method that checks operation by changing the resistance value of Vref.
For more information, please contact us.

2.3 Overheating protection function

An overheating protection function is provided to prevent damage, smoke generation, etc. if the module temperature becomes abnormally high for some reason.
The operation mode is latch operation.
When the overheating protection function operated, it is reset by cutting off   the input and then turning on the input again.
Please insure the cause of the over-heat condition is removed prior to resetting the system.

3. Startup time adjustment

The startup time at which the output voltage rises to 90% of the specified output voltage after input power is first applied is set as follows:
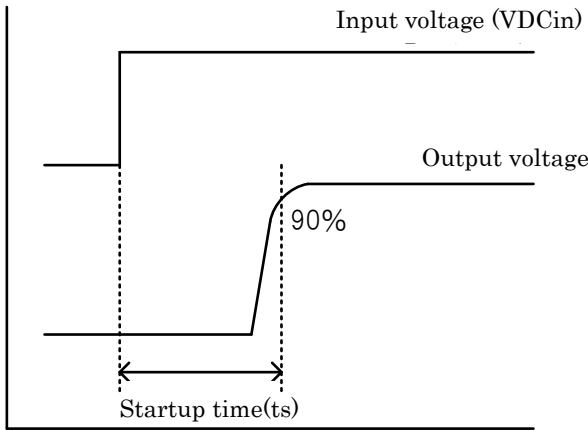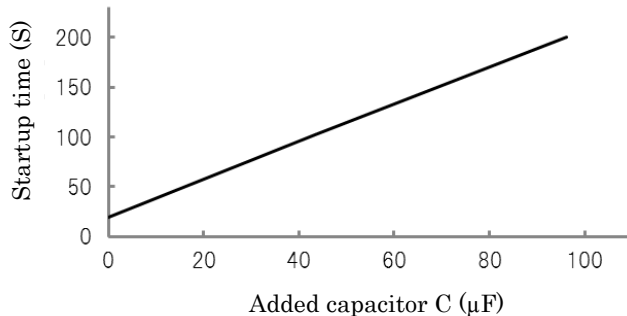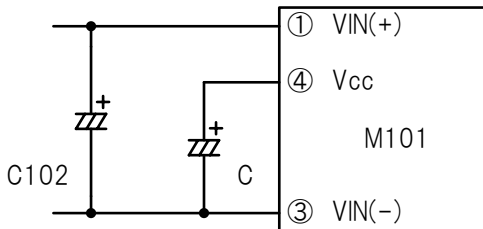

The startup time can be adjusted by connecting an external resistor and capacitoras follows:

Connect capacitor C to Vcc (pin 4) and VIN(-) (pin 3) of M101.
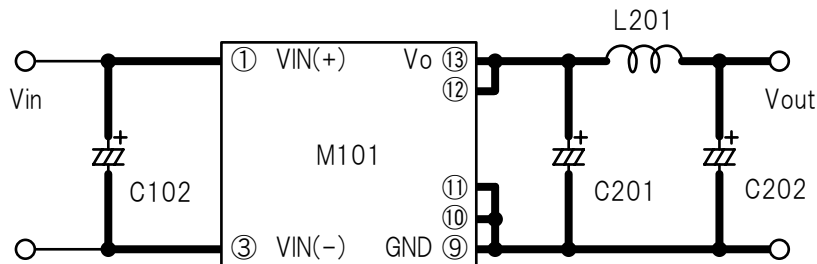
Use a capacitor C with a rated voltage of 35V or more.
When using an electrolytic capacitor, check the temperature rise and life.

4. Pattern design precautions

4.1 Main current line
Since the input current, output current, and high frequency current flow in the bold line parts of the connection diagram (figure below), make the pattern wide and short.
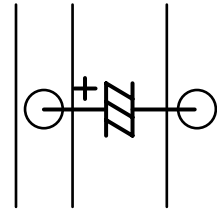
4.2 Input and output capacitors

Install the input smoothing capacitor (C102) and output capacitor (C201) close to M101.

If more than one output capacitor is to be used, all the capacitors must be of the same type and be placed in the same location so that they are not affected by circuit patterns.

When there is a PFC output capacitor and a separate inverter smoothing capacitor, these capacitors can be shared.   However, when the distance is long, the input smoothing capacitor only for M101 must be installed near M101. In addition, when the pattern from the output terminals and load of M101 is narrow and long, make the pattern wide thick and short because it had an effect on output accuracy.
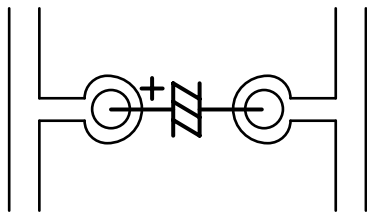

× 　Example of a bad pattern　　　　○ 　Example of a good pattern

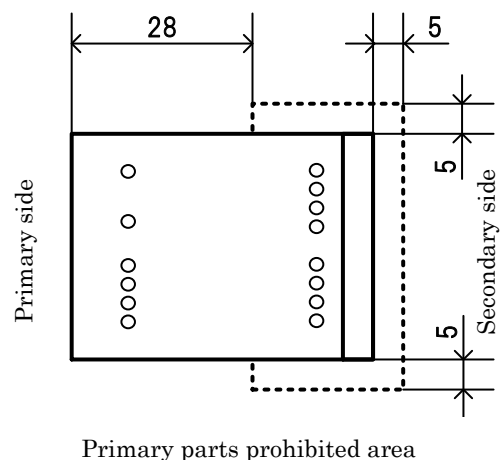## 4.3 Pattern prohibited area

When a double sided circuit board is used, do not provide a pattern directly below M101 of the parts side of the circuit board. If there is a pattern directly below M101 of the parts side, the insulation distance between the primary and secondary sides will not meet the specified value and safety cannot be ensured.
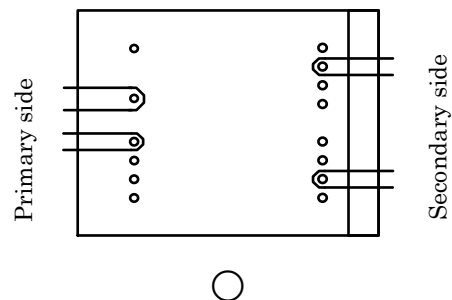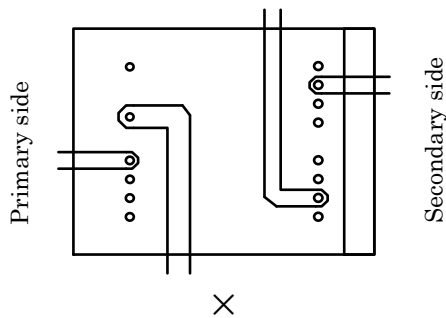
The installation prohibited area of primary parts and secondary parts is shown in the figure below.
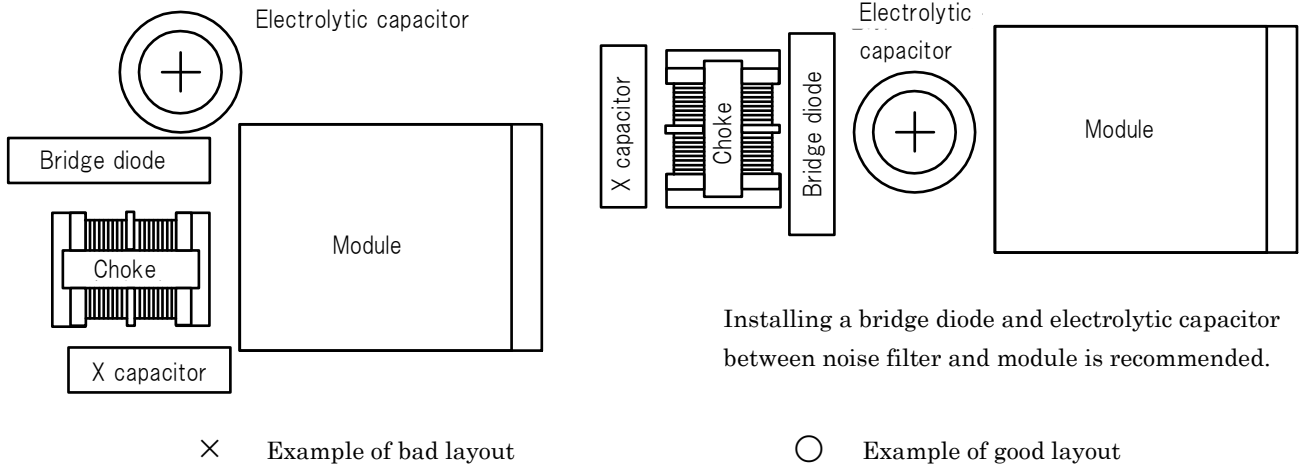Do not install parts inside the dotted lines.
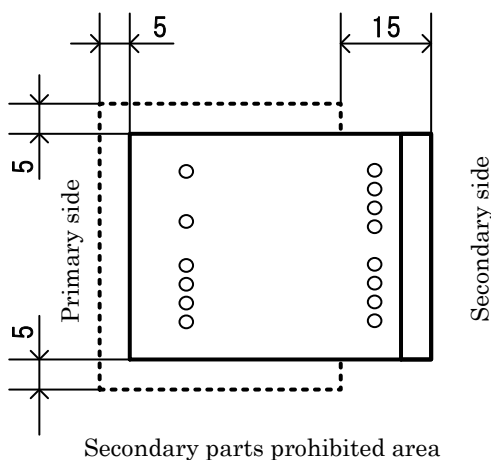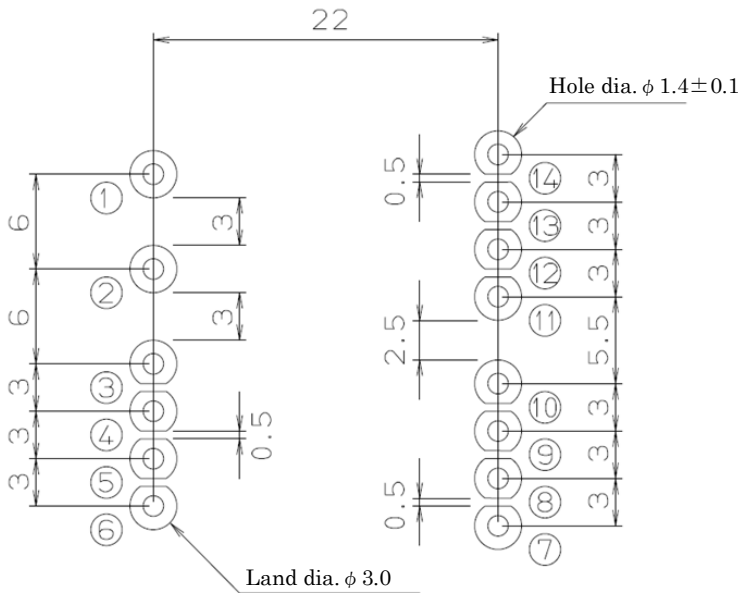

Secondary parts prohibited area　　　　Primary parts prohibited area

5. Noise filter layout precautions

When a noise filter (X capacitor, choke) is located near the module, the original noise reduction effect may not be produced and noise reduction may become difficult.
Make the distance between noise filter and module long.

Installing a bridge diode and electrolytic capacitor between noise filter and module is recommended.

×   Example of bad layout   ○   Example of good layout

6. Recommended hole diameter, land, and pin pitch

·Parts side view
·Numbers with a circle are pin numbers

To provide strength against vibration and dropping, provide lands at all pins and solder.

Unit : mm

7. Recommended soldering conditions (lead-free solder)

①Flow soldering: 255±3 ℃   5 seconds or less   preheat end 110℃±10℃
②Soldering iron: 350℃(MAX)   4 seconds or less

8. Output derating

When the ambient temperature exceeds +50℃, reduce the output power in accordance with the output derating chart below.
When the ambient temperature is affected by the heat generated by surrounding components, then the ambient temperature measurement point must be made in proximity to the heat generating components as shown below
When there are no heat generating parts nearby, make the temperature 20mm from the module and 20mm above the circuit board the ambient temperature.
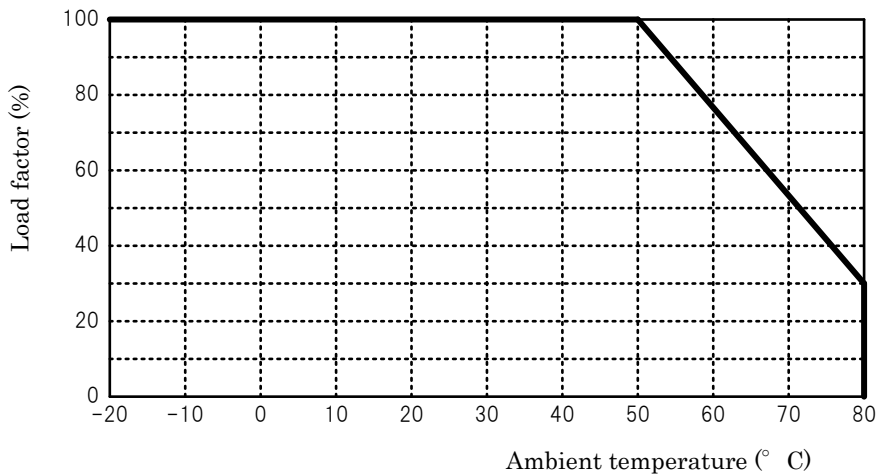
Ambient temperature measurement point when there are heat generating parts nearby
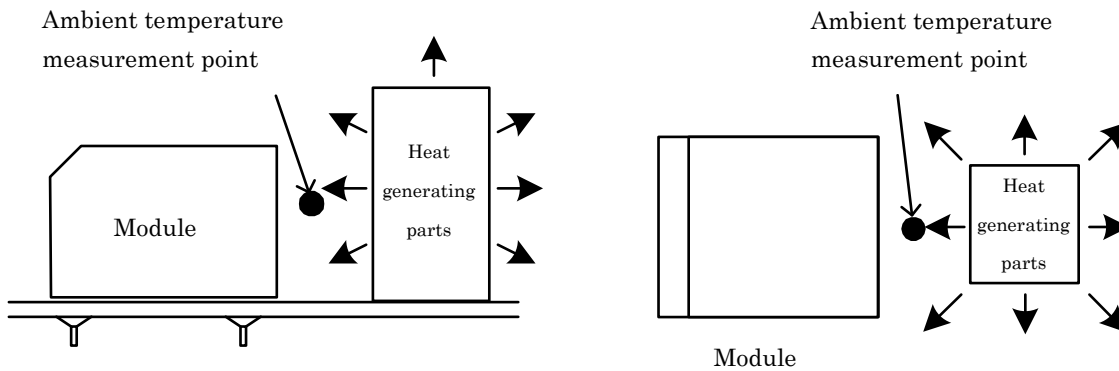
Ambient temperature measurement point when there is no effect of heating generating part
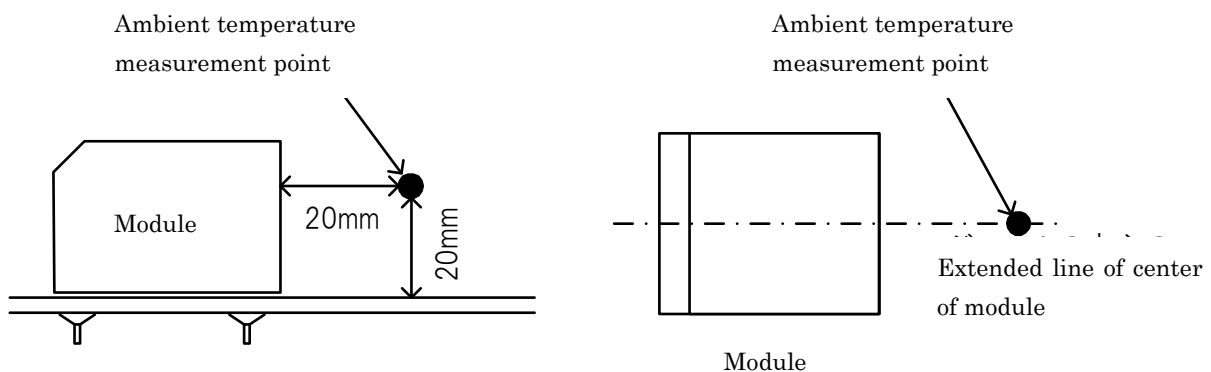
User Precautions

●The content of this manual is subject to change without prior notice for the purpose of improvements, etc. Ensure that you are in possession of the most up-to-date information when using this product.

●The operation examples and circuit examples shown in this manual are for reference purposes only, and Tamura Corporation disclaims all responsibility for any violations of industrial property rights, intellectual property rights and any other rights owned by Tamura Corporation or third parties that these may entail.

●The circuit examples and part constants listed in these specifications are provided as reference for the verification of characteristics. The user is to perform design, verification, and judgment under his or her own responsibility, taking into account the various conditions.

●Tamura Corporation constantly strives to improve quality and reliability, but functional failures and failures are bound to occur with some probability in power products. To ensure that failures do not cause accidents resulting in injury or death, fire accidents, social damage, and so on, users are to thoroughly verify the safety of their designs in devices and/or systems.

●This product is intended for use in consumer electronics (electric home appliances, business equipment, information equipment, communication terminal equipment, measuring devices, and so on.) If considering use of this product in equipment or devices that require high reliability (medical devices, transportation equipment, traffic signal control equipment, fire and crime prevention equipment, aeronautics and space devices, nuclear power control, fuel control, in-vehicle equipment, safety devices, and so on), please consult a Tamura sales representative in advance. Do not use this product for such applications without written permission from Tamura Corporation.

●This product is intended for use in environments where consumer electronics are commonly used.
It is not designed for use in special environments such as listed below, and if such use is considered, the user is to perform thorough safety and reliability checks under his/her responsibility.
– Use in liquids such as water, oil, chemical solutions, or organic solvents, and use in locations where the product will be exposed to such liquids
– Use that involves exposure to direct sunlight, outdoor exposure, or dusty conditions
– Use in locations where corrosive gases such as salt air, C12, H2S, NH3, SO2, or NO2, are present
– Use in environments with strong static electricity or electromagnetic radiation
– Use that involves placing inflammable material next to the product
– Use of this product either sealed with a resin filling or coated with resin
– Use of water or a water soluble detergent for flux cleaning
– Use in locations where condensation is liable to occur

●This product is not designed to resist radiation.

●This product is not designed to be connected in series or parallel.
Do no operate this product in a series, parallel, or N+1 redundant configuration.

●The content of this manual may not be transferred or copied without prior written permission.