PAH300・350S24 SERIES

Instruction Manual

■Before using this product

Be sure to take note of precautions and warnings indicated in this manual when using this product. Improper usage may lead to electric shock or fire. Be sure to read this instruction manual thoroughly before using this product.

■Precautions

● Avoid touching the baseplate and the case of this product because they get hot.

● There are high voltage and high temperature components within this product. Refrain from disassembling this product or touching its internal components as this may lead to electric shock or burn.

● To avoid unexpected accident from placing hands or face near the unit during operation.

● Verify that connection to input, output and signal terminals are correct as indicated in this instruction manual.

● For acquisition of various Safety Standards and safety improvement, be sure to use an external fuse.

● This product is designed for installation on electronic equipment.

● For input terminals of 24 V input models, apply a voltage from a primary source with reinforced or double insulation.

● Output voltage of this product is considered to have hazardous energy level (voltage of 2V and above with power of 240W and above) and must not have physical contact with operator. Protection must be provided on this module when installed on equipment to prevent physical contact with service technician himself or accidentally dropped tools during repair. Before repair, be sure to turn off the input source and confirm that input and output voltage have drop down to a safe level.

● Application circuit or component values described in this instruction manual are for reference only. When designing circuit, be sure to verify actual circuit operation before determining final application circuit or component values.

● Contents of this instruction manual are subject to change without notice. When using this product, please refer to latest data sheet to satisfy this product specification.

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APPD	CHK	DWG
Tomioka 19. Dec. 03	Kawagoe 19. Dec. '03	Y Hayama 19. Dec. 03

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PAH300·350S24-SERIES

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PAH300·350S24-SERIES

■ Block Diagram

Switching Frequency (fixed) : 330kHz (typ.)

■ Sequence Time Chart
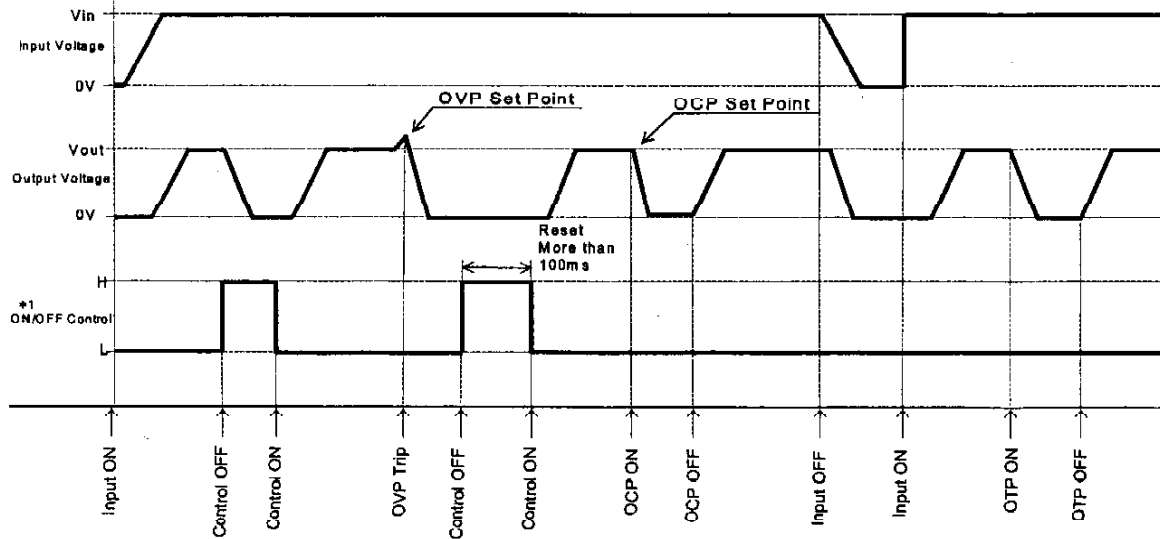
*1 level : 4 ≦ H ≦ 35(V) or Open
0 ≦ L ≦ 0.8(V) or Short

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■Terminal Explanation

```
          ┌──────────────────────────┐
          │  ◎                    ◎   │
   −Vin   │ o    ┌──────────┐     O   │ −V
   CASE   │ o    │          │     o   │ −S
          │      │  NAME  PLATE │    o   │ TRM
   CNT    │ o    │          │     o   │ +S
   +Vin   │ o    └──────────┘     O   │ +V
          │  ◎                    ◎   │
          └──────────────────────────┘
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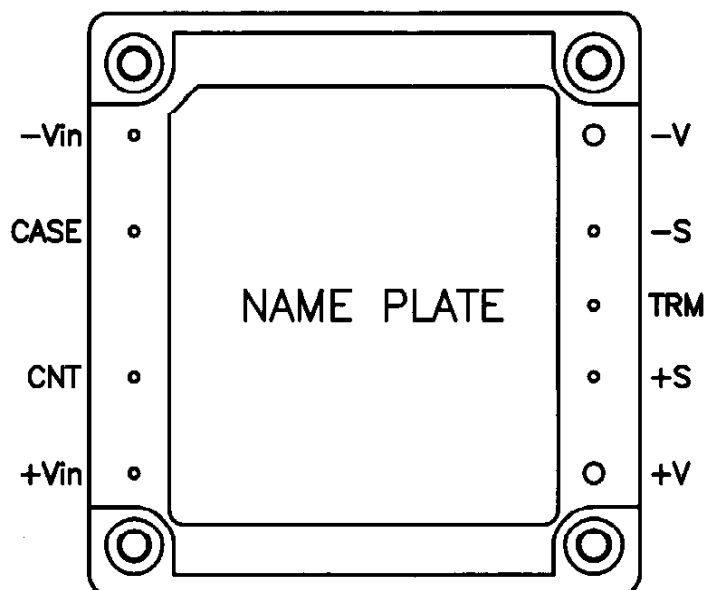
[Input Side Terminals]
−Vin   : −Input Terminal
CASE : Baseplate Terminal
CNT   : ON/OFF Control Terminal
+Vin   : +Input Terminal

[Output Side Terminals]
−V   : −Output Terminal
−S   : −Remote Sensing Terminal
TRM : Output Voltage Trimming Terminal
+S   : +Remote Sensing Terminal
+V   : +Output Terminal

Baseplate can be connected to FG (frame ground) M3 threaded holes. (standard model)
Connect +Vin, −Vin, +V, −V with consideration of contacting resistance.

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■Explanations on Specifications

1. Input Voltage Range

Input voltage range for PAH300 · 350S24 Series is indicated below.

Input Voltage Range : 18~36VDC

Basically, ripple voltage (Vrpl) which results from rectification and filtering of commercial AC line is included within the input voltage as shown in fig. 1-1. Ripple voltage must be limited within the voltage described below.

Allowable input ripple voltage : 2Vp-p

When this value is exceeded, the output ripple voltage becomes large.

Note that sudden input voltage change may cause variation of output voltage transitionally.

Also, input voltage waveform peak value must not exceed above input voltage range.
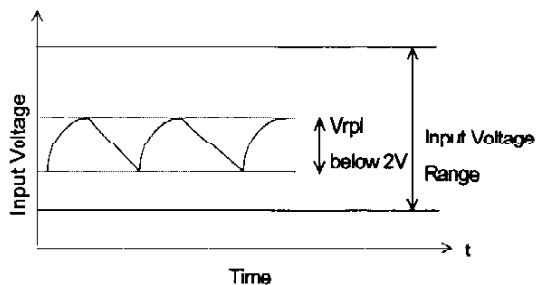
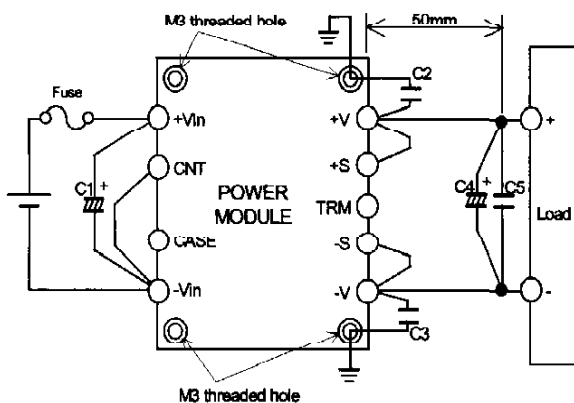

Fig.1-1 Input Ripple Voltage

● **Basic Connection**

Fig.1-2 Basic Connection

Input Fuse

This power module has no built-in fuse. Use external fuse to acquire various Safety Standards and to improve safety. Also, use fast-blow type for every module.

Furthermore, fuse must be connected to the +Vin side if −Vin side is used as ground, or fuse must be connected to −Vin side if +Vin side is used as a ground.

Input Fuse recommended current rating:
PAH300S24 : 30A
PAH350S24 : 40A

C1:

To prevent the effect of input line inductance to the power module, connect electrolytic capacitor or ceramic capacitor between +Vin and −Vin terminals.

Furthermore, use electrolytic capacitor with small ESR value. Especially take note that during line turn off at low ambient temperature, power module output will not normally shut down due to unstable C1 voltage.

Also, ripple current flows across this capacitor. Therefore, verify maximum allowable ripple current this capacitor when selecting component. Verify actual ripple current value by actual measurement.

Recommended capacitor value : 220 μ F × 2pcs and
above (Parallel connect)
(Voltage Rating 50V and above)

Notes

1. Use low impedance electrolytic capacitor with excellent temperature characteristics.
   (Nippon Chemi-con LXY Series or equivalent)

2. When input line inductance becomes excessively high due to insertion of choke coil, operation of the power module could become unstable. For this case, increase C1 value more than the value indicated above.

3. When ambient temperature becomes lower than −20℃, connect 4 more and above capacitors indicated above in parallel to reduce ESR.

C2, C3 : 0.022 μ F

To reduce spike noise voltage at the output, connect film capacitors or ceramic capacitors between +V and the nearest M3 threaded hole and between −V and the nearest M3 threaded hole.

Also, take note that output spike noise voltage could vary according to PCB (printed circuit board) wiring design

However, for cases where baseplate is connected to +V or −V, use the nearest M3 threaded hole. (M3 threaded holes is internally connected to baseplate inside the Power Module.) For this type of connection, C2 and C3 can be omitted.

C4 :

For stable operation, connect an electrolytic capacitor between +V and −V at 50mm distance from the output terminals.

Take note that output ripple and output shutdown could be affected by electrolytic capacitor, equivalent impedance and inductance characteristics of wiring.

Take note that output ripple voltage could vary according to PCB wiring design.

For cases of abrupt changes in load current or input voltage, increasing capacitance value of the external capacitors could reduce the voltage fluctuation.

Vout	C4
12V	25V 470 μ F
28V	50V 220 μ F

Table1-1   C4:Recommended Values of External Output Capacitor

Notes
1. Use low impedance electrolytic capacitor with excellent temperature characteristics.
   (Nippon Chemi-con LXY Series or equivalent)

2. Use three capacitors indicated above in parallel when ambient temperature becomes lower than −20℃ to reduce ESR.

3. Take note of the allowable ripple current of the capacitor to be used. Especially, when load adding capacitors for abrupt current changes, be sure to verify that ripple current does not exceed allowable ripple current before use.

C5 : 0.1 μ F

To reduce spike noise voltage at the output, connect a ceramic capacitor between +V and −V within 50mm distance from the output terminals.

Also, take note that output spike noise voltage could vary according to PCB wiring design.

C6 :

When switches or connectors are used between input source and PAH300·350S24 Series input terminals, impulse surge voltage is generated due to input throw-in by switch on/off or due to inserting/ removing of power module from the active line. For this case, connect an additional electrolytic capacitor C6 as
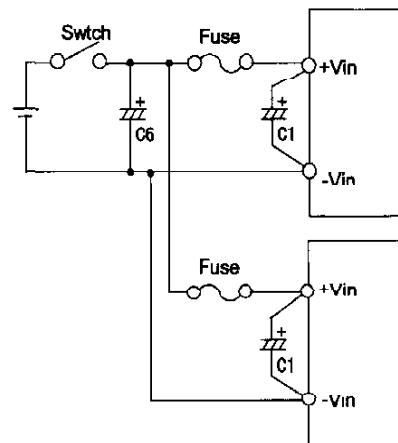
shown in fig.1-3 and fig. 1-4.

Recommended Capacitance Value : 220 μ F and above
(Voltage Rating 50V and above)

Also, in-rush current flows at line throw-in. Therefore, be sure to verify capability of switch or fuse to withstand I^2t at line throw-in.
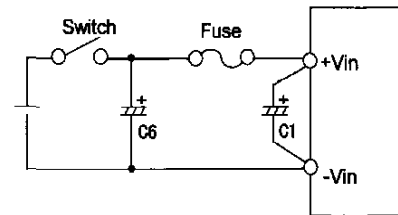

Fig.1-3 Input Filter with Input Switch

Fig.1-4 Input Filter when Plural Power Modules

Reverse input connection

Reverse input polarity would cause module damage. For cases where reverse connections are possible, connect a protective diode and fuse. Use protective diode with higher voltage rating than the input voltage, and with higher surge current rating than the fuse.
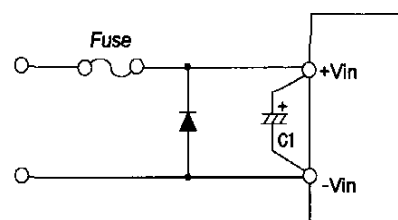
Fig.1-5 Protection for Reversed Connection of Input

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● **Recommended input filter as EMI countermeasure**
(conforms to VCCI Class 1, FCC class A)

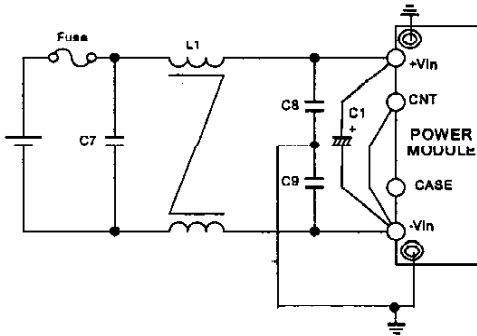**(1) Recommended input filter
as EMI countermeasure**

**Fig.1-6 Recommended input filter
as EMI countermeasure**

Recommended Values:
C1 : 680 μ F (Electrolytic Capacitor)
   3 pcs in parallel
C7 : 10 μ F (Ceramic Capacitor)
C8,C9 : 0.47 μ F (Film Capacitor)
L1 : 1mH (Common-mode choke coil)

Notes
1. For the power module output, connect output capacitors described in the basic circuit connection.

2. C1 (Electrolytic Capacitor) value can be reduced if impedance of input line is lower and operation of power module is stable.

3. VCCI Class 1, FCC Class A limits can be satisfied with the above recommended filter at Densei-Lambda measuring conditions. However, there are cases where above limits might not be satisfied due to input and output wiring method, as well as, peripheral circuits. When selecting input filter, be sure to verify actual EMI characteristics (CE and RE) before finalizing the filter. Refer to PAH300·350S24-* Evaluation Data for details.

2. Output Voltage Adjustment Range

Output voltage could be adjusted within the range described below by external resister or variable resistor.
However, take note that OVP might trigger when output voltage adjustment exceeds the ranges indicated below.

Output Voltage Adjustment Range
12V : -40%~+10% of nominal output Voltage
28V : -40%~+18% of nominal output Voltage

When increasing the output voltage, reduce the output current accordingly so as not to exceed the maximum output power.
Take note that input voltage range is limited as shown in fig.2-1 when output voltage is increased.
Remote sensing is possible even when output voltage is varied. For details on remote sensing function, please refer to "9.Remote Sensing".
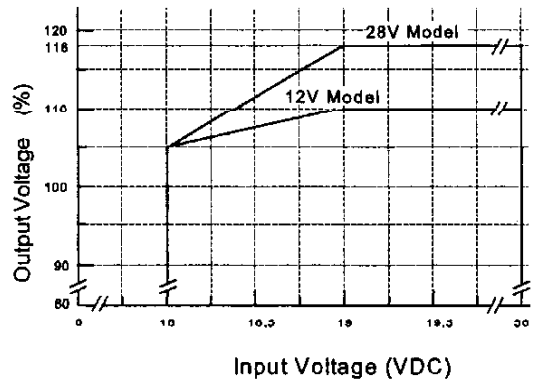

Fig.2-1 Limit of Input Voltage

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● **Output Voltage Adjustment by external resistor or by variable resistor**

(1) In case of adjusting output voltage lower

  (1-1) Available maximum output current = rated output current

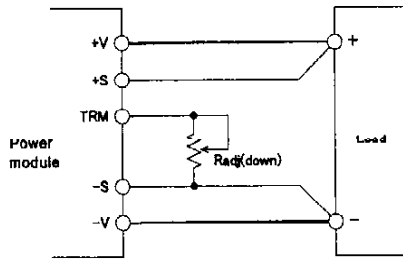 (1-2) Connect an external resistor Radj(down) between the TRM terminal and −S terminal.

Fig.2-2 Connection for output voltage trim down

(1-3) Equation of external resistor and output voltage.

$$Radj(down) = \left(\frac{100\%}{\Delta\%} - 2 \right)[k\Omega]$$

Radj(down) : Value of external resistor

Δ(%)   : Output voltage change rate against nominal output voltage

Below graph is relation Δ(%) and value of external resistor.

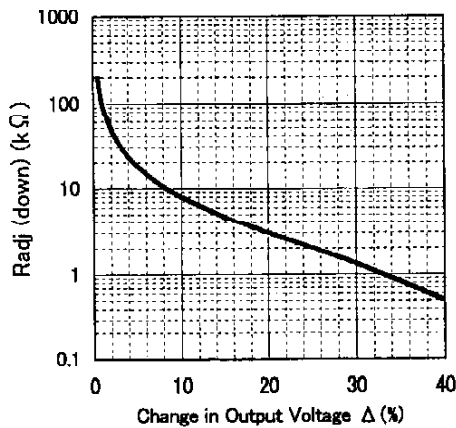**Fig.2-3 Δ(%) vs. Radj(down) (1)**

(2) In case of adjusting output voltage higher

  (2-1) Allowable maximum output current = maximum output power ÷ output voltage (reduce maximum output current in specification.)

  (2-2) Connect an external resistor Radj(up) between TRM terminal and +S terminal.
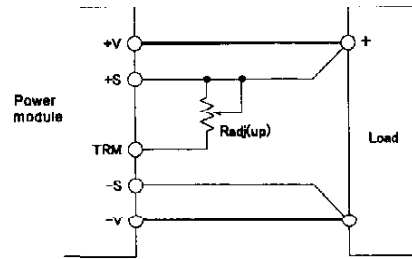
Fig.2-4 Connection for output voltage trim up

(2-3) Equation of external resistor and output voltage

$$Radj(up) = \left(\frac{Vo(100\% + \Delta\%)}{1.225 \times \Delta\%} - \frac{100\% + 2 \times \Delta\%}{\Delta\%} \right)[k\Omega]$$

Vo   : nominal output value of module

Radj(up) : external adjustment resistor

Δ (%)   : Output voltage change rate against nominal output voltage

Below graph is relation Δ(%) and value of external resistor.

Fig.2-5 Δ% vs.Radj(up) (2)

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3. Maximum Ripple and Noise
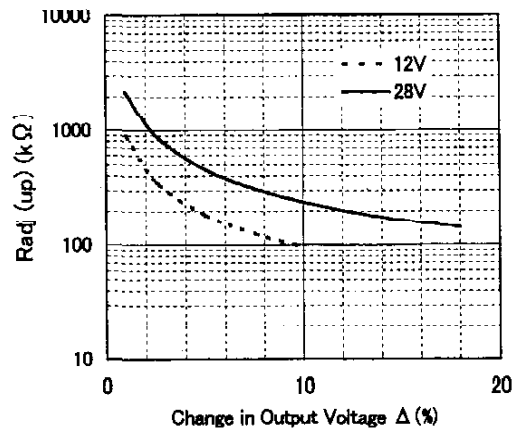
Measured value according to the specified methods based on JEITA-9141 (Clause 7.12 and clause 7.13) which is described in the following.

Connect according to fig.3-1 and measure. Connect capacitors (C2, C3: film capacitor or ceramic capacitor 0.022 μ F) between output terminals and the nearest M3 threaded hole. Connect capacitors (C4: refer to table 1-1 for electrolytic capacitor values, C5: ceramic capacitor 0.1 μ F) at 50mm distance from the output terminals. Measure at ceramic capacitor (C5) terminals as shown in fig. 3-1 using coaxial cable with JEITA attachment. Use oscilloscope with 100MHz frequency bandwidth or equivalent.

Take note that output ripple voltage and output spike noise may vary depending on PCB wiring design.

Generally, output ripple voltage and output spike noise can be reduced by increasing capacitance value of external capacitor.
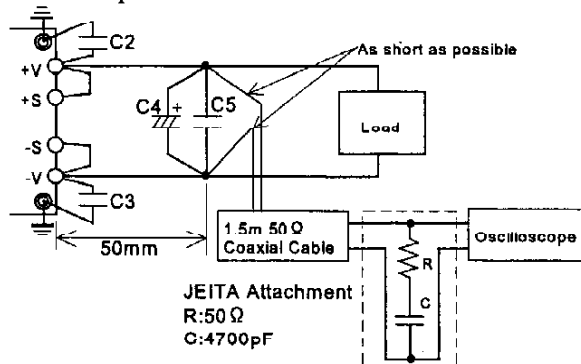

Fig.3-1 Measurement of Maximum Output Ripple & Noise

4. Maximum Line Regulation

Maximum value of output voltage change when input voltage is gradually varied (steady state) within specified input voltage range.

5. Maximum Load Regulation

Maximum value of output voltage change when output current is gradually varied (steady state) within specified output current range.

When using at dynamic load mode, audible noise could be heard from the power module and output voltage fluctuation might increase. A thorough pre-evaluation must be performed before using this power module.

6. Over Current Protection (OCP)

This power module has built-in OCP function.
Output will recover when short circuit or overload

conditions are released. OCP setting value is fixed and therefore, cannot be externally adjusted.

Also, take note that power module might be damaged continuing output short circuit or over load conditions depending on thermal conditions.

7. Over Voltage Protection (OVP)

This power module has built-in OVP function.
OVP set point is relative to the rated output voltage value. OVP setting value is fixed and therefore, can not be externally adjusted.

When OVP is triggered, output can be recovered by turning input line off and then turning it on again after lowering the input voltage below the voltage value indicated below, or by manual reset of the CNT terminal. Reset time for CNT terminal is 100ms or longer.

OVP release input voltage value : 3VDC and below

When verifying OVP function by applying external voltage at the output terminals, applied voltage value should not exceed specified OVP maximum value. Refer to specification table for OVP maximum value. Avoid applying external voltage that exceeds OVP maximum value because this will cause power module damage.

8. Over Temperature Protection (OTP)

This power module has built-in OTP function.
This function operates and shuts down the output when ambient temperature or internal temperature of power module abnormally rises. OTP operates at 105℃ to 130℃ baseplate temperature. OTP can be released when baseplate temperature drops down approximately to within 80℃ to 95℃. However, take note that OTP will operate again unless the cause of abnormal heat of the power module is eliminated.

9. Remote Sensing (+S, -S terminal)

Remote sensing terminal is provided to compensate for voltage drop across the wirings from the power module output terminal to the load input terminal.

When remote sensing function is not used (local sensing), short +S terminal to +V terminal and, -S terminal to -V terminal.

Take note that voltage compensation range for line drop (voltage drop due to wiring) is determined such that output voltage at the output terminals is within output voltage range and that voltage between -V and -S terminals is within 2V or less. Even for remote

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sensing case, use power module such that output power is within specified maximumoutput power.
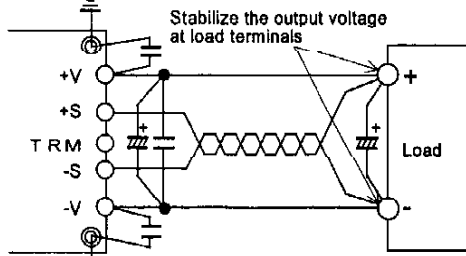Furthermore, reduce noise effect by using shield wire, twist pair, or parallel pattern.
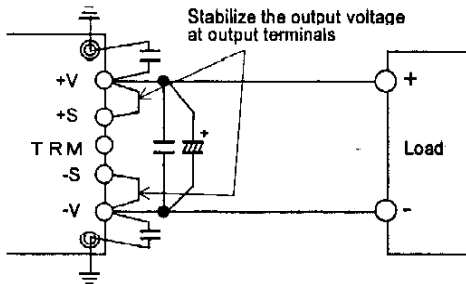

Fig.9-1 Remote Sensing is in Use

Fig.9-2 Remote Sensing is Not in Use

10. ON/OFF Control (CNT terminal)

Without turning the input supply on and off, the output can be enabled and disabled using this function. This function also can be used for output sequence of plural power modules.

There are two kinds of logic control, Negative logic control and Positive logic control, depend on the option selected.

ON/OFF control circuit is on the primary side (the input side). For secondary control, isolation can be achieved through the use of an opto-coupler or relay.

	Logic	CNT Terminal Level to -Vin Terminal	Output status
Standard	Negative Logic	H Level (4V≤H≤35V) or Open	OFF
/T option		L Level (0V≤L≤0.8V) or Short	ON
/P option	Positive Logic	H Level (4V≤H≤35V) or Open	ON
/PT option		L Level (0V≤L≤0.8V) or Short	OFF

Notes
1. When ON/OFF control function is not used for the Standard and /T option, CNT terminal should be shorted to -Vin terminal.
2. When ON/OFF control function is not used for the /P option and /PT option, CNT terminal should be opened.
3. When using long wiring, for prevention of noise, attach a 0.1µF capacitor between CNT terminal and -Vin terminal.

4. At L level, maximum source current from CNT terminal to -Vin terminal is 0.5mA
5. The maximum CNT terminal voltage is 35V.

(1) Output ON/OFF control

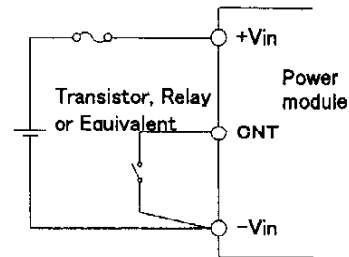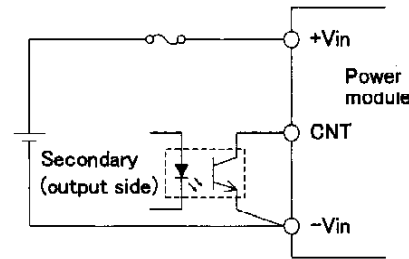**Fig.10-1 CNT Connection (1)**

(2) Secondary (output side) control

Fig.10-2 CNT Connection (2)

11. Parallel Operation

Parallel Operation can not be used.

12. Series Operation

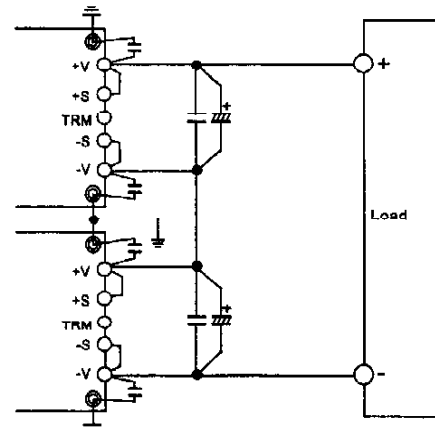Series operation is possible for PAH300·350S24 series. Connections shown fig. 12-1 and fig. 12-2 are possible.

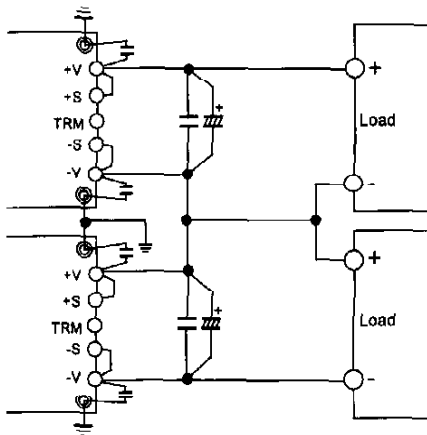**Fig.12-1 Series Operation due to High Output Voltage**

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Fig.12-2 Series Operation due to ±Output

13. Operating ambient Temperature

There is no restriction on mounting direction but there should be enough consideration for airflow so that heat does not accumulate around the power module vicinity. Determine external components configuration and mounting direction on PCB such that air could flow through the heatsink at forced cooling and conventional cooling.

By maintaining actual baseplate temperature below 100℃, operation is possible.

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

Note :

Maximum baseplate temperature is 100℃. For worst case operating condition, verify baseplate temperature at measurement point indicated in fig. 13-1.
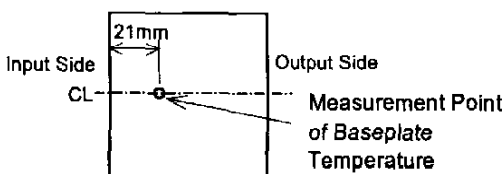

Fig.13-1 Measurement Point of Baseplate Temperature

For better improvement of power module reliability, derating of baseplate temperature when using is recommended.

14. Operating Ambient Humidity

Take note that moisture could lead to power module abnormal operation or damage.

15. Storage Ambient Temperature

Abrupt temperature change would cause moisture formation that leads to poor solderabilty of each terminal of the power module.

16. Storage Ambient Humidity

Take enough care when storing the power module because rust which causes poor solderability would form in each terminal when stored in high temperature, high humidity environment.

17. Cooling Method

Operating temperature range is specified by the baseplate temperature. Therefore, several methods of heat dissipation are possible.

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

18. Baseplate Temperature vs. Output Voltage Drift

Output voltage drift is defined as the rate of voltage change when baseplate temperature only is changed during operation.
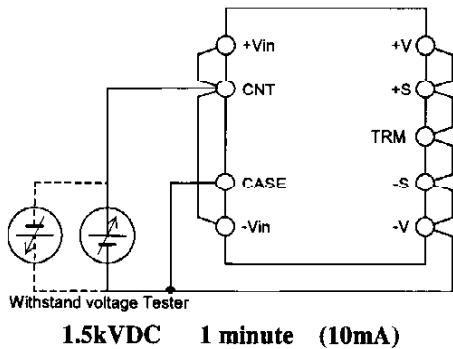
19. Withstand Voltage

This power module is designed to have a withstand voltage of 1.5kVDC between input and baseplate, 1.5kVDC between input and output and 500VDC between output and baseplate for 1 minute. When conducting withstand voltage test during incoming inspection, be sure to apply DC voltage. Also, set the current limit value of the withstand voltage testing equipment to 10mA.

Be sure to avoid conducting test with AC voltage because this would cause power module damage.

Furthermore, avoid throw in or shut off of the testing equipment when applying or when shutting down the test voltage. Instead, gradually increase or decrease the applied voltage. Take note especially not to use the timer of the test equipment because when the timer switches the applied voltage off, impulse voltage which has several times the magnitude of the applied voltage is generated causing damage to the power module.

Connect the terminals as shown in the diagram below.

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1.5kVDC   1 minute   (10mA)

Fig.19-1 Withstand Voltage Test for Input-Output and Input-Baseplate

500VDC   1minute   (10mA)
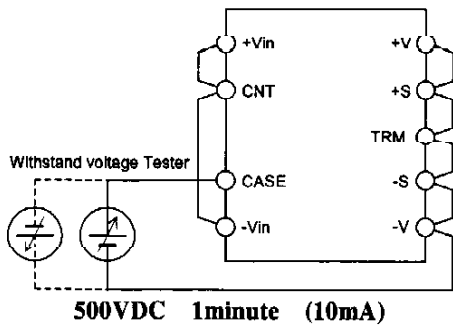
Fig.19-2 Withstand Voltage Test for Output-Baseplate

20. Isolation Resistance

Use DC isolation tester (MAX 500V) between output and baseplate. Isolation resistance value is 100MΩ and above at 500VDC applied voltage. Also take note that depending on the isolation tester used, some testers generate high voltage pulse. Discharge the power module after test using a resistor, etc.

Over 100MΩ at 500VDC
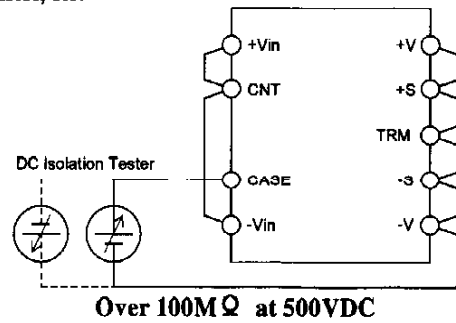
Fig.20-1 Isolation Test

21. Vibration

Vibration of power module is defined in case of mounting on printed circuit board.

22. Shock

Withstand shock value is defined to be the value at Densei-Lambda shipment and packaging conditions.

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■ Installation

1. Mounting Method

By the following instruction shown in Fig.1-1 and Fig.1-2, mount power module onto printed circuit board.
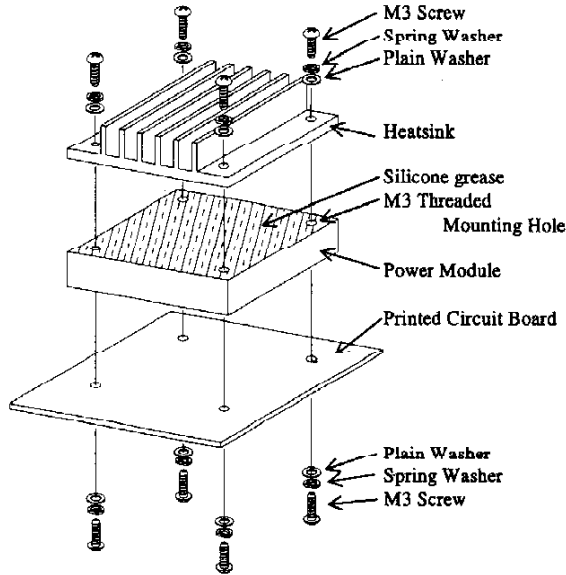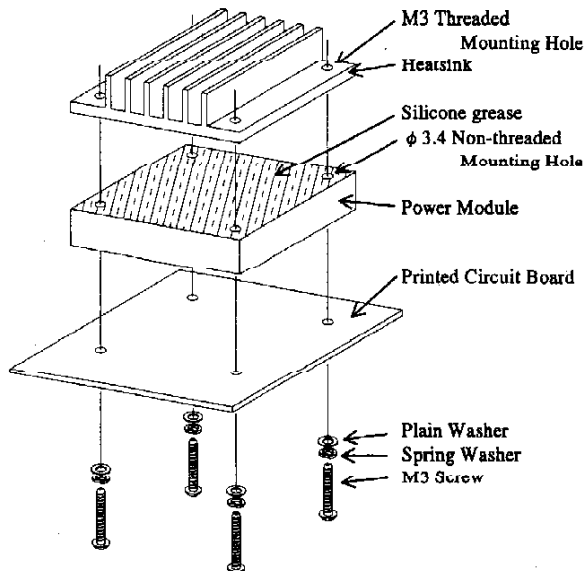

**Fig.1-1 Mounting method
for standard model and /P option model**

Labels: M3 Screw, Spring Washer, Plain Washer, Heatsink, Silicone grease, M3 Threaded Mounting Hole, Power Module, Printed Circuit Board, Plain Washer, Spring Washer, M3 Screw

**Fig.1-2 Mounting method
for /T option model and /PT option model**

Labels: M3 Threaded Mounting Hole, Heatsink, Silicone grease, φ3.4 Non-threaded Mounting Hole, Power Module, Printed Circuit Board, Plain Washer, Spring Washer, M3 Screw

(1) Method to Fix

(1-1) Standard model and /P option model
To fix a power module onto printed circuit board, use M3 screws and mount it to the M3 threaded holes (4 places) of the power module. Recommended torque is 0.54N·m.

(1-2) /T option model and /PT option model
To fix a power module onto printed circuit board, use M3 screws and mount it to the M3 threaded holes of the heatsink (4 places) through the φ3.4 non-threaded holes (4 places) of the power module. Recommended torque is 0.54N·m

(2) Mounting Holes

Mounting holes of the power module are connected to baseplate. Connect baseplate to FG (Frame Ground) by using this mounting holes.

(3) Mounting Holes on Printed Circuit Board

Refer to the following sizes when determining diameter of hole and land diameter of printed circuit board.

Input / Signal terminals (φ1.0 mm)
  Hole diameter   : φ1.5 mm
  Land diameter   : φ3.0 mm
Output terminals (φ2.0 mm)
  Hole diameter   : φ2.5 mm
  Land diameter   : φ4.5 mm
Mounting Holes (FG)
  Hole diameter   : φ3.5 mm
  Land diameter   : φ5.5 mm

For position of the holes, see outline drawing of the power module.

(4) Recommended Material of PCB

Recommended materials of the printed circuit board is double sided glass epoxy with through holes. (thickness t:1.6mm , copper 35 μ m).

(5) Input/ Output terminal pin

Connect +Vin, -Vin, +V, -V terminals such that contact resistance is minimal. Note that if contact resistance is high, efficiency will drop and power module will be damaged by abnormal heat.

(6) Input / Output Pattern Width

Large current flows through input and output pattern. If pattern width is too narrow, heat on pattern will increase because of voltage drop of pattern. Relationship between allowable current and pattern width varies depending on materials of printed circuit board, thickness of conductor. It is definitely necessary to confirm on manufacturers of printed circuit board for designing pattern.

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2. Heatsink Installation Method

(1) Method to Fix

(1-1) Standard model and /P option model

To fix the heatsink onto power module, use M3 screws and mount it to the M3 threaded holes (4 places) at the baseplate side. Recommended torque is 0.54 N·m.

(1-2) /T option model and /PT option model

To fix the heatsink onto power module, use M3 screws those are the same screws for mounting power module onto printed circuit board.

Use silicone grease or thermal conductive sheet in between heatsink and baseplate to minimize the contact thermal resistance and to enhance the heat conductivity. Also use the no-warped heatsink and make sure good contact between baseplate and heatsink.

(2) Mounting Hole of Heatsink

Recommended mounting hole is as follows.

(2-1) Standard model and /P option model
ϕ 3.5 Non-threaded hole

(2-2) Standard model and /P option model
M3 Threaded hole

3. Regarding Vibration

The vibration specification of the module is determined assuming that only the power module is mounted on printed circuit board. To prevent excessive force to the module and the printed circuit board, fix the heatsink to the chassis as well as to the module when a large size of heastsink is used.

4. Recommended Soldering Method

Recommended soldering conditions are as follows.

(1) Soldering dip

Dip condition : 260°C within 10 seconds
Pre-heat condition : 110°C during 30~40 seconds

(2) Soldering iron

ϕ 1.0 mm : 350°C (60W) within 3 seconds
ϕ 2.0 mm : 350°C (150W) within 20 seconds

※Soldering time changes according to heat capacity of soldering iron, pattern on printed circuit board, etc. Please confirm actual performance.

5. Recommended Cleaning Condition

Recommended cleaning condition after soldering is as follows.

(1) Cleaning solvent

IPA (isopropyl alcohol)

(2) Cleaning Procedure

Use brush and dry the solvent completely.

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■Before concluding power module damage

Verify following items before concluding power module damage.

1) No output voltage
- Is specified input voltage applied?
- Are the ON/OFF control terminal (CNT), remote sensing terminal (+S, -S), output voltage trimming terminal (TRM) correctly connected?
- For cases where output voltage adjustment is used, is the resistor or variable resistor setting, connections correctly done?
- Are there no abnormalities in the output load used?
- Is the baseplate temperature within the specified temperature range?

2) Output voltage is high
- Are the remote sensing terminals (+S, -S) correctly connected?
- Is the measurement done at the sensing points?
- For cases where output voltage adjustment is used, is the resistor or volume setting, connections correctly done?

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?
- For cases where output voltage adjustment is used, is the resistor or variable resistor setting, connections correctly done?
- Are there no abnormalities in the output load used?

4) Load regulation and line regulation is large
- Is specified input voltage applied?
- Are the input terminals and the output terminals firmly connected?
- Is the measurement done at the sensing points?
- Is the input or output wire too thin?

5) Output ripple voltage is large
- Is the measuring method used the same or equivalent with the specified method in the Application Notes?
- Is the input ripple voltage value within the specified value?

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