TECHNICAL REFERENCE NOTE

# ARTESYN AVD75B-48S12 Series

## 75 Watts Sixteenth-brick Converter


## PRODUCT DESCRIPTION

Advanced Energy's Artesyn AVD75B-48S12 is a single output DC/DC converter with standard sixteenth-brick outline and pin configuration. It delivers up to 6.25A output current with 12V output voltage. Above 93% ultra-high efficiency and excellent thermal performance make it an ideal choice to supply power in telecom and datacom.

### AT A GLANCE

**Total Power**

75 Watts

**Input Voltage**

36 to 75 Vdc

**# of Outputs**

Single

RoHS

## SPECIAL FEATURES

- Delivering up to 6.25A output current
- Ultra-high efficiency 93% typ. at full load
- Wide input range: 36V to75V
- Excellent thermal performance
- No minimum load requirement
- Basic isolation
- High power density
- Low output noise
- RoHS 3.0
- Startup Pre-bias
- Remote control function
- Remote output sense
- Trim function: 80% ~ 110%
- Input under voltage lockout
- Output over current protection
- Output short protection
- Output over voltage protection
- Over temperature protection
- Industry standard sixteenth-brick pin-out outline
- SMT or through-hole option

## SAFETY

- UL UL/CSA 60950-1
- TUV EN 62368-1
- CE EN 62368-1

## TYPICAL APPLICATIONS

- Telecom
- Datacom

# MODEL NUMBERS

| Standard | Output Voltage | Output Current | Structure | Remote ON/OFF logic | ROHS |
|---|---|---|---|---|---|
| AVD75B-48S12B-6L | 12Vdc | 6.25A | Baseplate | Negative | RoHS 3.0 |
| AVD75B-48S12-6L | 12Vdc | 6.25A | Open-frame | Negative | RoHS 3.0 |
| AVD75B-48S12TL | 12Vdc | 6.25A | Open-frame | Negative | RoHS 3.0 |
| AVD75B-48S12B-4L | 12Vdc | 6.25A | Baseplate | Negative | RoHS 3.0 |

## Order Information

| AVD75B | - | 48 | S | 12 | P | B | - | 6 | L |
|---|---|---|---|---|---|---|---|---|---|
| ① | | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | ⑧ | ⑨ |

| | | |
|---|---|---|
| ① | Model series | AVD: high efficiency sixteenth brick series, 75: output power 75W |
| ② | Input voltage | 48: 36V to 75V input range, rated input voltage 48V |
| ③ | Output number | S: single output |
| ④ | Rated output voltage | 12: 12V output |
| ⑤ | Remote ON/OFF logic | Default: negative logic; P: positive logic |
| ⑥ | Baseplate | B: with baseplate; default: open frame |
| ⑦ | - | Need "-" for through-hole unit, to separate the data of voltage and pin length, omit for SMT unit |
| ⑧ | Pin length | T: SMT; 6: 3.8mm ± 0.25mm pin length; 4: 4.8mm± 0.25mm |
| ⑨ | RoHS status | L: RoHS 3.0 |

### Options

None

# ELECTRICAL SPECIFICATIONS

## Absolute Maximum Ratings

Stress in excess of those listed in the "Absolute Maximum Ratings" may cause permanent damage to the power supply. These are stress ratings only and functional operation of the unit is not implied at these or any other conditions above those given in the operational sections of this TRN. Exposure to any absolute maximum rated condition for extended periods may adversely affect the power supply's reliability.

**Table 1. Absolute Maximum Ratings**

| Parameter | Model | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Input Voltage | | | | | | |
| Operating -Continuous | All | $V_{IN,DC}$ | - | - | 80 | Vdc |
| Non-operating -100mS | All | | - | - | 100 | Vdc |
| Maximum Output Power | All | $P_{O,max}$ | - | - | 75 | W |
| Isolation Voltage[1] | | | | | | |
| Input to output | All | | - | - | 2250 | Vdc |
| Ambient Operating Temperature | All | $T_A$ | -40 | - | +85 | $^{O}$C |
| Storage Temperature | All | $T_{STG}$ | -55 | - | +125 | $^{O}$C |
| Voltage at remote ON/OFF pin | All | | -0.3 | - | +12 | Vdc |
| Humidity (non-condensing) | | | | | | |
| Operating | All | | - | - | 95 | % |
| Non-operating | All | | - | - | 95 | % |

Note 1 - 1mA for 60s, slew rate of 1500V/10s

# ELECTRICAL SPECIFICATIONS

## Input Specifications

**Table 2. Input Specifications**

| Parameter | Conditions[1] | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Operating Input Voltage, DC | All | $V_{IN,DC}$ | 36 | 48 | 75 | Vdc |
| Turn-on Voltage Threshold | $I_O = I_{O,max}$ | $V_{IN,ON}$ | 31 | - | 36 | Vdc |
| Turn-off Voltage Threshold | $I_O = I_{O,max}$ | $V_{IN,OFF}$ | 30 | - | 35 | Vdc |
| Lockout Voltage Hysteresis | $I_O = I_{O,max}$ | | 1 | - | 3 | V |
| Maximum Input Current ($I_O = I_{O,max}$) | $V_{IN,DC}$ = 36Vdc | $I_{IN,max}$ | - | - | 3 | A |
| Recommended Input Fuse | Fast blow external fuse recommended | | - | - | 5 | A |
| Recommended External Input Capacitance | Low ESR capacitor recommended | $C_{IN}$ | 100 | - | - | uF |
| Input Reflected Ripple Current | Through 12uH inductor | $I_{IN,typ}$ | - | 25 | - | mA |
| Operating Efficiency | $T_A$ = 25 °C<br>$I_O = I_{O,max}$<br>$I_O$ = 50%$I_{O,max}$ | η | -<br>- | 93.3<br>91 | -<br>- | %<br>% |

Note 1 - Ta = 25 °C, airflow rate = 400 LFM, Vin = 48Vdc, nominal Vout unless otherwise noted.

# ELECTRICAL SPECIFICATIONS

## Output Specifications

**Table 3. Output Specifications**

| Parameter | | Conditions[1] | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| Factory Set Voltage | | $V_{IN,DC}$ = 48Vdc<br>$I_O$ = 50%$I_{O,max}$ | $V_O$ | 11.88 | 12 | 12.12 | Vdc |
| Output Voltage Line Regulation | | All | ±%$V_O$ | - | 0.06 | - | % |
| | | | ±$V_O$ | - | 7.5 | - | mV |
| Output Voltage Load Regulation | | All | ±%$V_O$ | - | 0.06 | - | % |
| | | | ±$V_O$ | - | 7.5 | - | mV |
| Output Voltage Temperature Regulation | | All | %$V_O$ | - | - | 0.02 | %/°C |
| Output Voltage Trim Range | | All | $V_O$ | 9.6 | - | 13.2 | V |
| Output Ripple, pk-pk | | Measure with a 1uF ceramic capacitor in parallel with a 10uF tantalum capacitor, 0 to 20MHz bandwidth | $V_O$ | - | 64 | - | $mV_{PK-PK}$ |
| Output Current | | All | $I_O$ | 0 | - | 6.25 | A |
| Output DC current-limit inception[2] | | All | $I_O$ | 8 | - | 12 | A |
| $V_O$ Load Capacitance[3] | | All | $C_O$ | 220 | - | 3300 | uF |
| $V_O$ Dynamic Response | Peak Deviation<br>Settling Time | 25%~50%~25%<br>or<br>50%~75%~50%<br>25% load change<br>slew rate = 0.1A/us | ±$V_O$<br>$T_s$ | -<br>- | 60<br>50 | -<br>- | mV<br>uSec |
| | | 25%~50%~25%<br>or<br>50%~75%~50%<br>25% load change<br>slew rate = 1A/us | ±$V_O$<br>$T_s$ | -<br>- | 70<br>100 | -<br>- | mV<br>uSec |
| Turn-on Transient | Rise time | $I_O$ = $I_{O,max}$ | $T_{rise}$ | - | 20 | - | mS |
| | Turn-on delay time | $I_O$ = $I_{O,max}$ | $T_{turn-on}$ | - | 10 | - | mS |
| | Output voltage overshoot | $I_O$ = 0 | %$V_O$ | - | - | 5 | % |
| Switching Frequency | | All | $f_{SW}$ | - | 350 | - | KHz |
| Remote ON/OFF control (Positive logic) | Off-state voltage | All | | -0.3 | - | 1.2 | V |
| | On-state voltage | All | | 3.5 | - | 5 | V |
| Remote ON/OFF control (Negative logic) | Off-state voltage | All | | 3.5 | - | 5 | V |
| | On-state voltage | All | | -0.3 | - | 1.2 | V |

Note 1 - Ta = 25 °C, airflow rate = 400 LFM, Vin = 48Vdc, nominal Vout unless otherwise noted.
Note 2 - Hiccup: auto-restart when over-current condition is removed.
Note 3 - High frequency and low ESR is recommended.

# ELECTRICAL SPECIFICATIONS

## Output Specifications

**Table 3. Output Specifications Con't**

| Parameter | Conditions | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Output over-voltage protection[4] | Static | $V_O$ | 14 | - | 16.8 | V |
| | Dynamic | $V_O$ | 14 | - | 17.0 | V |
| Output over-temperature protection[5] | All | T | - | 120 | - | $^{O}$C |
| Over-temperature hysteresis | All | T | - | 10 | - | $^{O}$C |
| MTBF[6] | Telcordia SR-332-2006; 80% load, 300LFM, 40 $^{O}$C $T_A$ | | 2.0 | - | - | $10^6$ h |

Note 4 - Hiccup: auto-restart when over-voltage condition is removed.
Note 5 - Auto recovery. over-temperature protect(OTP) test point: see Figure 10 and Figure 11.
Note 6 - 300LFM, 40$^{O}$C, 48Vdc input voltage, 80%$I_{O,max}$

# ELECTRICAL SPECIFICATIONS

## AVD75B-48S12 Performance Curves

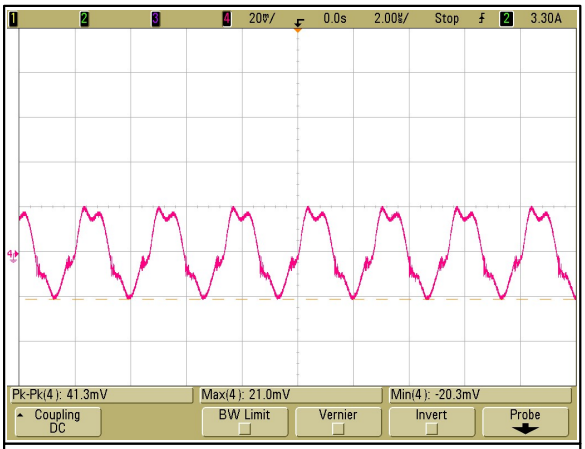



Figure 1: AVD50B-48S12 Output Ripple Waveform
2uS/div
Ch 4: $V_O$ (20mV/div)

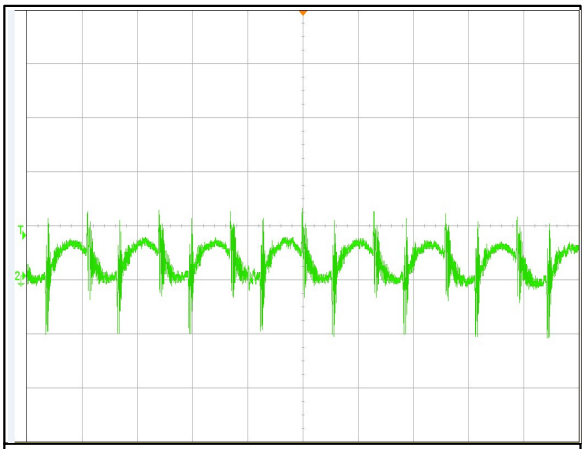


Figure 2: AVD50B-48S12 Input Reflected Ripple Current
2uS/div
Ch 2: $I_{IN}$ (10mA/div)

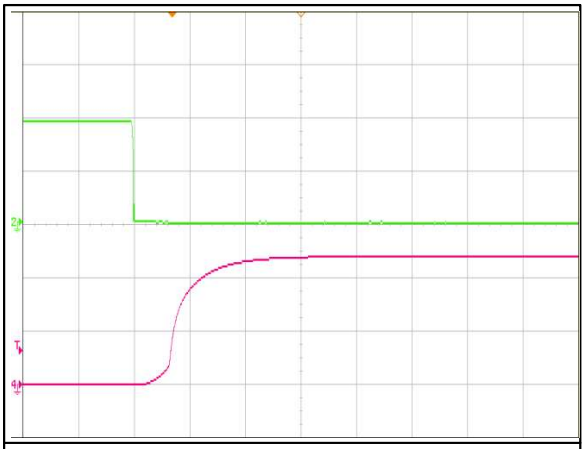


Figure 3: AVD75B-48S12 Output Voltage Start Up By Remote On
$V_{IN}$ = 48Vdc, $I_O$ = $I_{O,max}$ , 20mS/div
Ch 2: Remote On (2V/div) Ch 4: $V_O$ (5V/div)

Figure 3: AVD75B-48S12 Output Voltage Shut Down By Remote Off
$V_{IN}$ = 48Vdc, $I_O$ = $I_{O,max}$ , 10mS/div
Ch 2: Remote Off (2V/div) Ch 4: $V_O$ (5V/div)

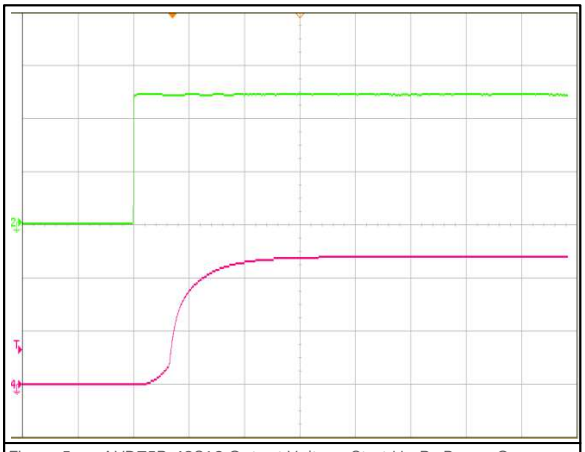


Figure 5: AVD75B-48S12 Output Voltage Start Up By Power On
$V_{IN}$ = 48Vdc, $I_O$ = $I_{O,max}$, 20mS/div
Ch 2: $V_{IN}$ (20V/div) Ch 4: $V_O$ (5V/div)

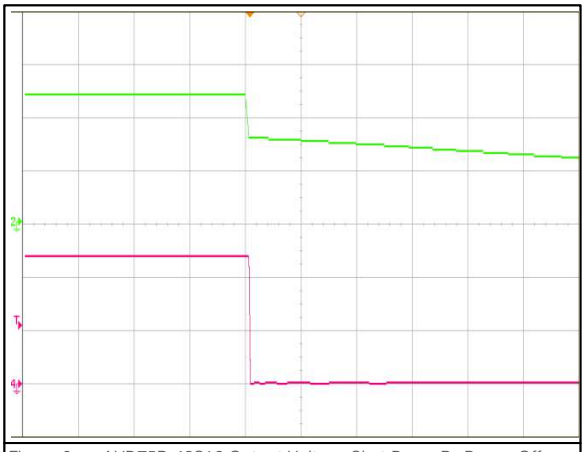


Figure 6: AVD75B-48S12 Output Voltage Shut Down By Power Off
$V_{IN}$ = 48Vdc, $I_O$ = $I_{O,max}$, 20mS/div
Ch 2: $V_{IN}$ (20V/div) Ch 4: $V_O$ (5V/div)

# ELECTRICAL SPECIFICATIONS

## AVD75B-48S12 Performance Curves

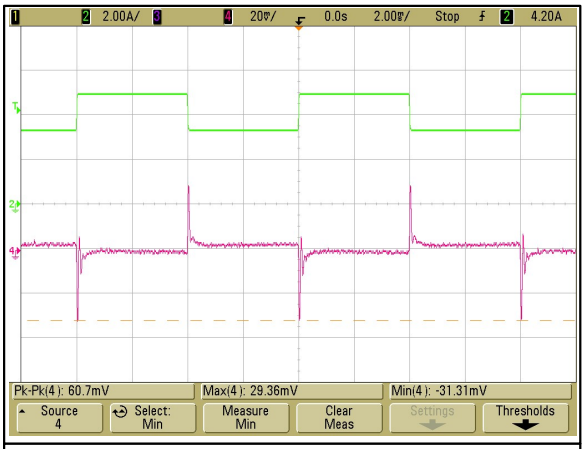



Figure 7: AVD75B-48S12 Transient Response (2mS/div)
0.1A/us slew rate
Ch 4: Vo (20mV/div) Ch 2: Io (2A/div)

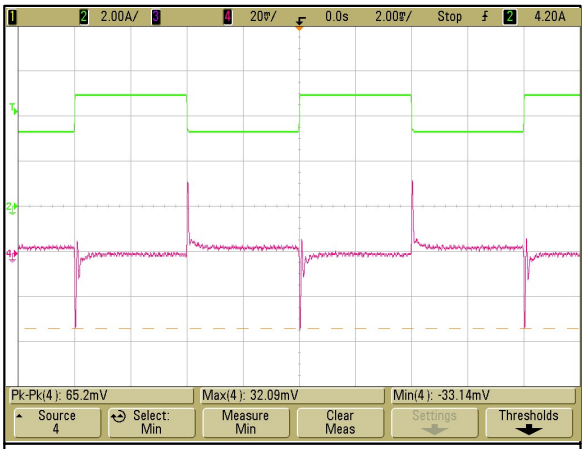



Figure 8: AVD75B-48S12 Transient Response (2mS/div)
1A/us slew rate
Ch 4: Vo (20mV/div) Ch 2: Io (2A/div)

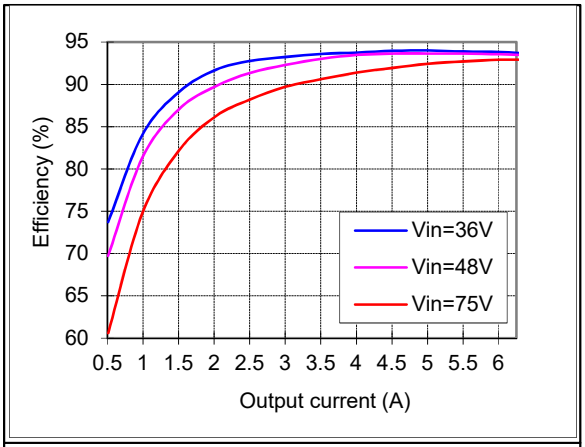



Figure 9: AVD75B-48S12 Efficiency Curves @ 25 °C, 400LFM

Loading: Io = 10% increment to 6.25A

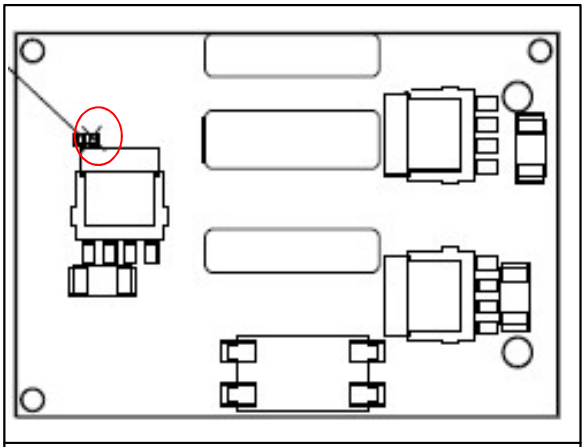


Figure 10: AVD75B-48S12 OTP test point (Open-frame module)

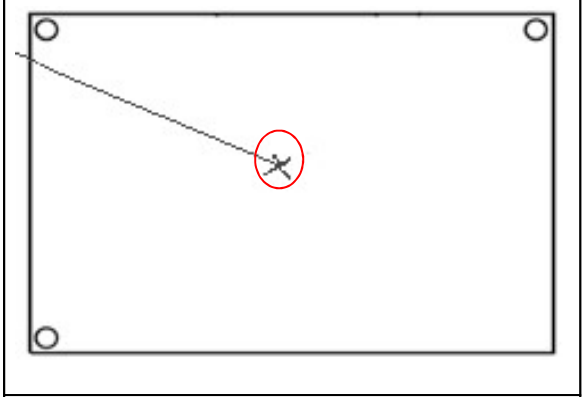


Figure 11: AVD75B-48S12B OTP test point (Module with baseplate)

# MECHANICAL SPECIFICATIONS

## Mechanical Outlines – Surface Mounted Module

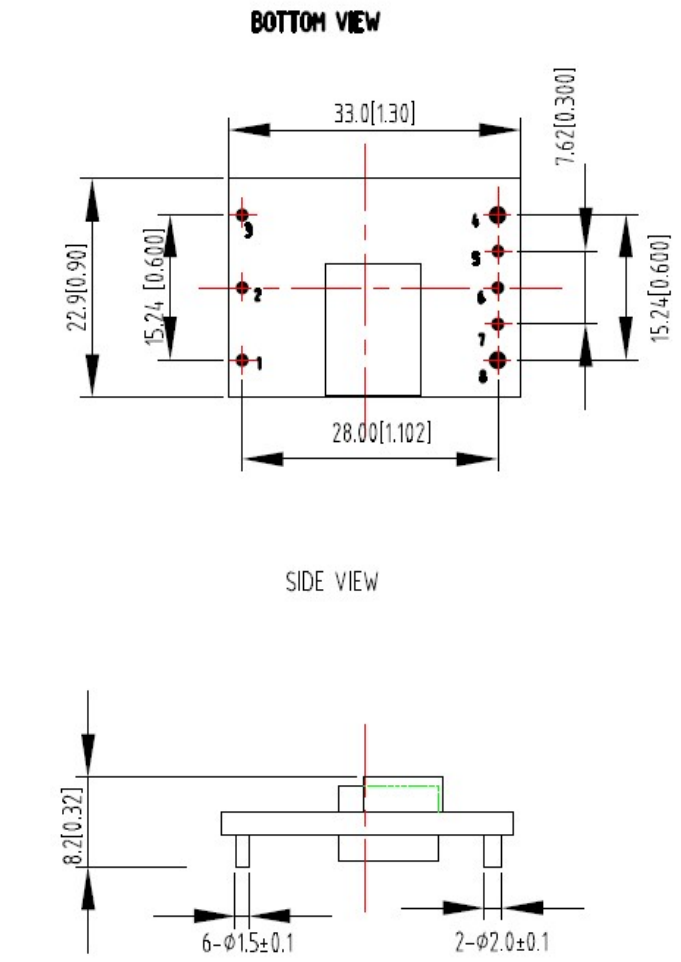



Figure 12 Mechanical Outlines for Surface Mounted Module

# MECHANICAL SPECIFICATIONS

## Mechanical Outlines – Open Frame Module

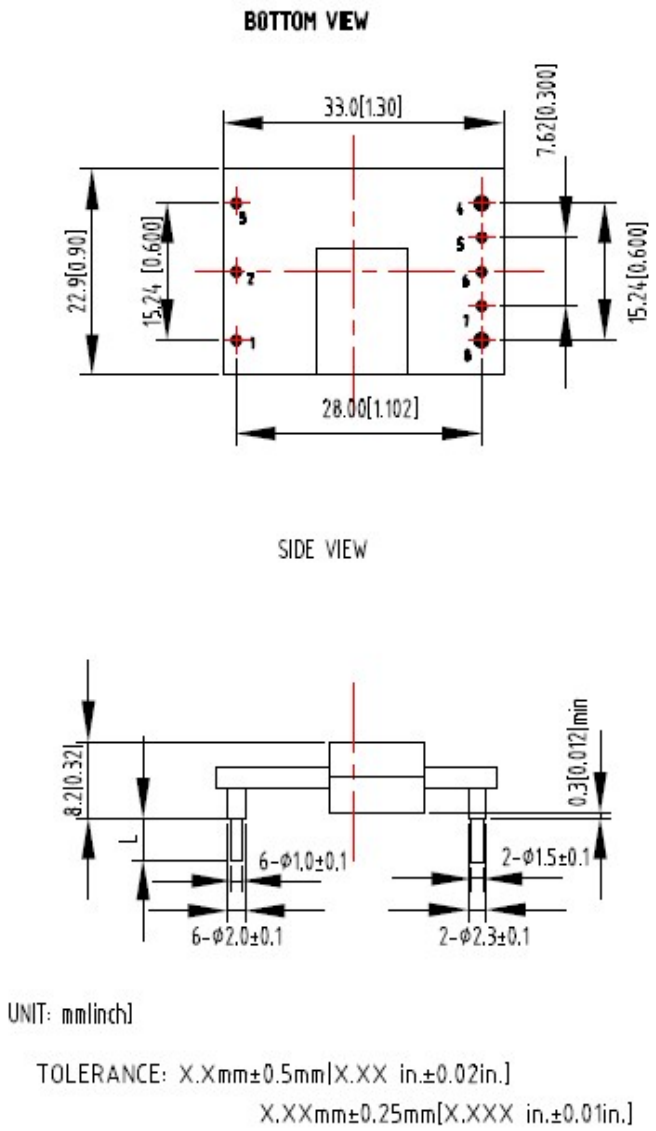



Figure 13 Mechanical Outlines for Open Frame Module

# MECHANICAL SPECIFICATIONS

## Mechanical Outlines – Baseplate Module

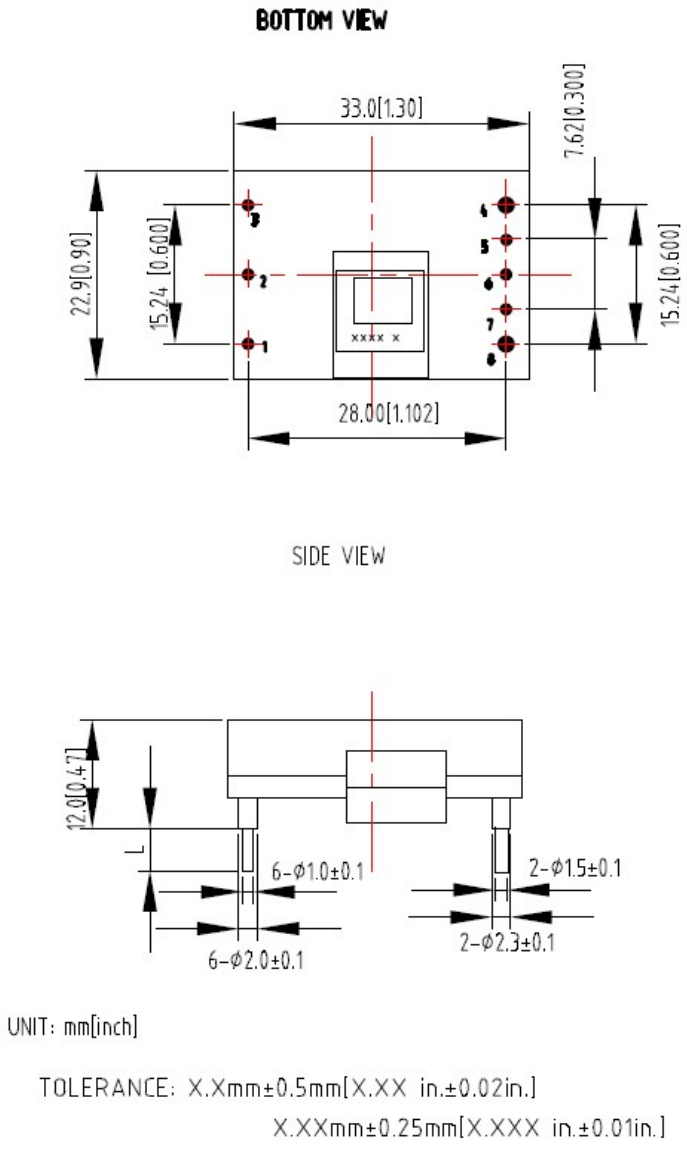



Figure 14 Mechanical Outlines for Baseplate Module

Note: Depth penetration into base plate, of M3 screws used at baseplate mounting holes, not to exceed maximum of 3.0mm

# MECHANICAL SPECIFICATIONS

## Pin length option

| Device code suffix | L |
|---|---|
| -4 | 4.8mm±0.25mm |
| -6 | 3.8mm±0.25mm |
| -8 | 2.8mm±0.25mm |
| None | 5.8mm±0.25mm |

## Pin Designations

| Pin No | Name | Function |
|---|---|---|
| 1 | Vin+ | Positive input terminal |
| 2 | Remote On/Off | Remote control terminal |
| 3 | Vin- | Negative input terminal |
| 4 | Vo- | Negative output terminal |
| 5 | S- | Negative remote sense terminal |
| 6 | Trim | Output voltage trim terminal |
| 7 | S+ | Positive remote sense terminal |
| 8 | Vo+ | Positive output terminal |

# ENVIRONMENTAL SPECIFICATIONS

## Electromagnetic compatibility Characteristics

AVD75B-48S12 power supply is designed to meet the following EMC immunity specifications:

**Table 4. Environmental Specifications**

| Document | Description | Criteria |
|---|---|---|
| EN55032, Class A Limits | Conducted and Radiated EMI Limits, DC input port | / |
| IEC/EN 61000-4-2, Level 3 | Electromagnetic Compatibility (EMC) - Testing and measurement techniques - Electrostatic discharge immunity test. Enclosure Port | B |
| IEC/EN 61000-4-6, Level 2 | Electromagnetic Compatibility (EMC) - Testing and measurement techniques, Continuous Conducted Interference. DC input port | A |
| IEC/EN 61000-4-4, Level 3 | Electromagnetic Compatibility (EMC) - Testing and measurement techniques, Electrical Fast Transient. DC input port. | B |
| IEC/EN 61000-4-5 | Electromagnetic Compatibility (EMC) - Testing and measurement techniques, Immunity to surges - 600V common mode and 600V differential mode for DC ports | B |
| EN61000-4-29 | Electromagnetic Compatibility (EMC) - Testing and measurement techniques, Voltage Dips and short interruptions and voltage variations. DC input port | B |

Criterion A: Normal performance during and after test.
Criterion B: For EFT and surges, low-voltage protection or reset is not allowed. Temporary output voltage fluctuation ceases after disturbances ceases, and from which the EUT recovers its normal performance automatically. For Dips and ESD, output voltage fluctuation or reset is allowed during the test, but recovers to its normal performance automatically after the disturbance ceases.

# ENVIRONMENTAL SPECIFICATIONS

## Safety Certifications

The AVD75B-48S12 power supply is intended for inclusion in other equipment and the installer must ensure that it is in compliance with all the requirements of the end application. This product is only for inclusion by professional installers within other equipment and must not be operated as a stand alone product.

**Table 5. Safety Certifications for AVD75B-48S12 power supply system**

| Standard | Agency | Description |
|---|---|---|
| UL 60950-1, 2nd Edition, 2014-10-14; CAN/CSA C22.2 No. 60950-1-07, 2nd Edition, 2014-10 | UL+CUL | US and Canada Requirements |
| EN 62368-1:2014/A11:2017 | TUV-SUD | European Requirements |
| EN 62368-1:2014+A11:2017 | CE | CE Marking |

# ENVIRONMENTAL SPECIFICATIONS

## Operating Temperature

The AVD75B-48S12 series power supply will start and operate within stated specifications at an ambient temperature from -40 $^{O}$C to 85 $^{O}$C under all load conditions. The storage temperature is -55 $^{O}$C to 125 $^{O}$C.

## Thermal Considerations

The converter is designed to operate in different thermal environments and sufficient cooling must be provided. Proper cooling of the DC/DC converter can be verified by measuring the temperature at the test point as shown in the Figure 15. The temperature at this point should not exceed the max values in the table 6.

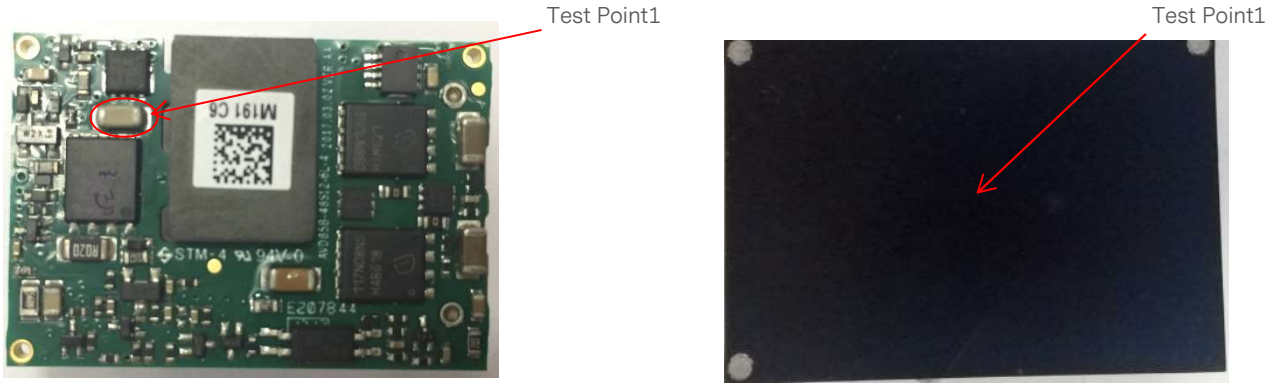



Figure 15 Temperature test point

| Table 6. Temperature limit of the test point | |
|---|---|
| Test Point | Temperature limit |
| Test point 1(C3) | 135$^{O}$C |
| Test point 2 (Baseplate) | 120$^{O}$C |

# ENVIRONMENTAL SPECIFICATIONS

## Thermal Considerations – Con't

For a typical application, below are the derating curves show the derating of output current vs. ambient air temperature at different air velocity. The airflow direction is from Vin- to Vin+.

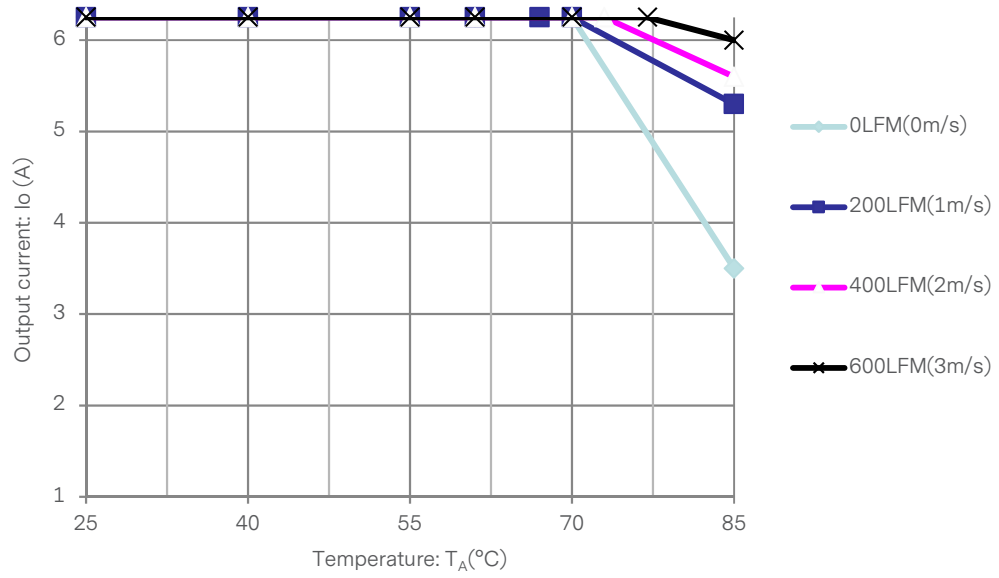



Figure 16 AVD75B-48S12-6L and AVD75B-48S12TL

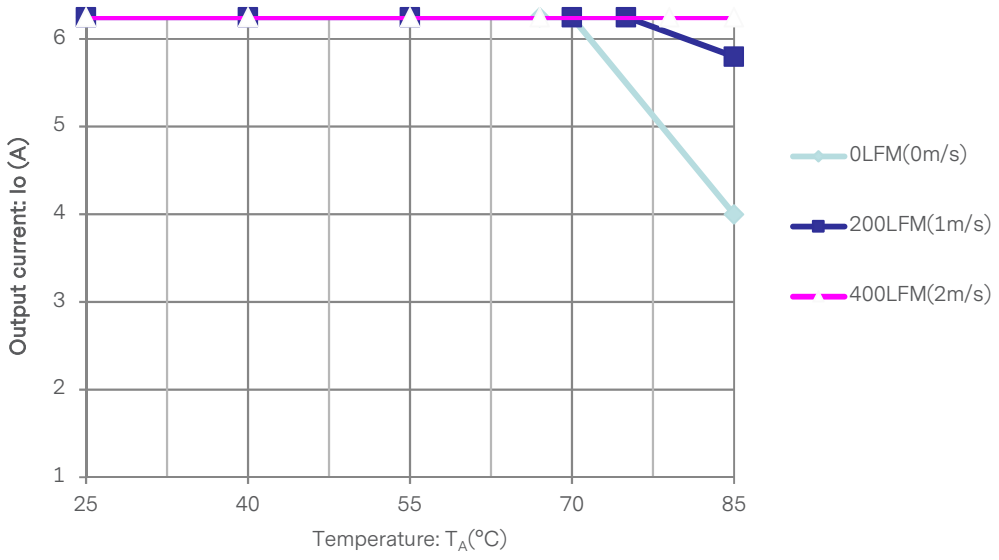



Figure 17 AVD75B-48S12B-6L

# ENVIRONMENTAL SPECIFICATIONS

## Qualification Testing

| Parameter | Unit (pcs) | Test condition |
|---|---|---|
| Halt test | 4-5 | $T_{a,min}$-20 °C to $T_{a,max}$+25 °C, 10 °C step, $V_{in}$ = min to max, 0 ~ 100% load |
| Vibration | 3 | Frequency range: 5Hz ~ 20Hz, 20Hz ~ 200Hz, A.S.D: 1.0$m^2/s^3$, -3db/oct, axes of vibration: X/Y/Z. Time: 30min/axes |
| Mechanical Shock | 3 | 30g, 6ms, 3axes, 6directions, 3time/direction |
| Thermal Shock | 3 | -55 °C to 125 °C, unit temperature 20 cycles |
| Thermal Cycling | 3 | -40 °C to 55 °C, temperature change rate: 1°C/min, cycles: 2cycles |
| Humidity | 3 | 40 °C, 95%RH, 48h |
| Solder Ability | 15 | IPC J-STD-002C-2007 |

# APPLICATION NOTES

## Typical Application

Below is the typical application of the AVD75B-48S12 series power supply.

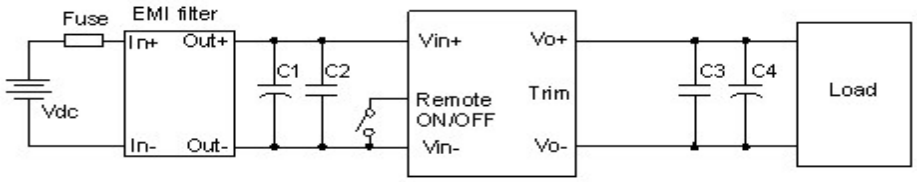



Figure 18 Typical application

C1: 220uF/100V electrolytic capacitor, P/N: UPM2A101MPD (Nichicon) or equivalent caps.

C2: 0.1uF/100V X7R ceramic capacitor, P/N: C3216X7R2A104KT0L0S (TDK) or equivalent caps.

C3: 1uF/100V X7R ceramic capacitor, P/N: C3216X7R2A105KT0L0U (TDK) or equivalent caps.

C4: 220uF oscon capacitor, P/N: CUXAE1C221M2BA (Sanyo).

Fuse: External fast blow fuse with a rating of 5A. The recommended fuse model is 0453005.MR from LITTLEFUSE.

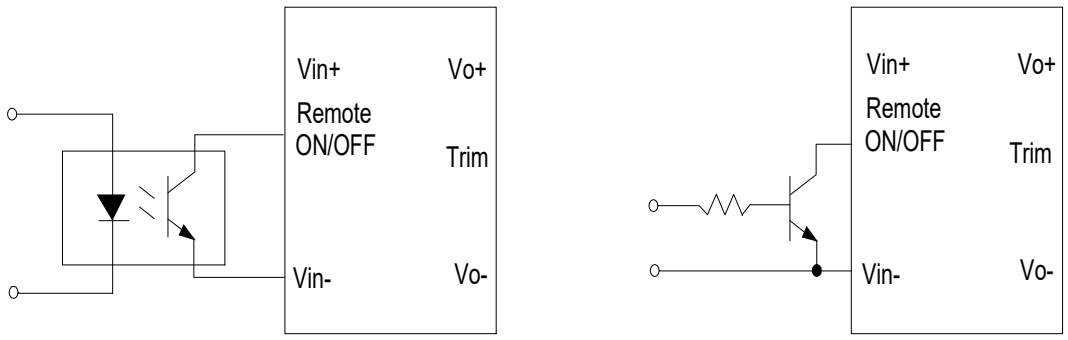
EMI filter: see Figure 23.

48V input and full load output are default.

# APPLICATION NOTES

## Remote ON/OFF

Negative remote ON/OFF logic is available in AVD75B-48S12. The logic is CMOS and TTL compatible. The voltage between pin Remote ON/OFF and pin Vin- must not exceed the range listed in table “Feature characteristics” to ensure proper operation. The external Remote ON/OFF circuit is highly recommended as shown in figure 19.




Isolated remote ON/OFF circuit

Non-isolated remote ON/OFF circuit

Figure 19 External Remote ON/OFF circuit

# APPLICATION NOTES

## Trim Characteristics

Connecting an external resistor between Trim pin and Vo- pin will decrease the output voltage. While connecting it between Trim and Vo+ will increase the output voltage. The following equations determine the external resistance to obtain the trimmed output voltage.

$$R_{adj-down} = \frac{510}{\Delta} - 10.2(K\Omega)$$

$$R_{adj-up} = \frac{5.1 \times V_{nom} \times (100 + \Delta)}{1.225 \times \Delta} - \frac{510}{\Delta} - 10.2(K\Omega)$$

△:Output rate against nominal output voltage.

$$\Delta = \frac{100 \times (V_{nom} - V_0)}{V_{nom}}$$

$V_{nom}$: Nominal output voltage.

For example, to get 13.2V output, the trimming resistor is

$$\Delta = \frac{100 \times (V_o - V_{o,nom})}{V_{o,nom}} = \frac{100 \times (13.2 - 12)}{12} = 10$$

$$R_{adj-up} = \frac{5.1 \times 12 \times (100 + 10)}{1.225 \times 10} - \frac{510}{10} - 10.2 = 488.35(K\Omega)$$

When trimming up, the output current should be decreased accordingly so as not to exceed the maximum output power.

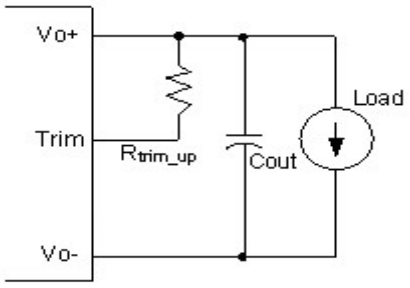



Figure 20 Trim up

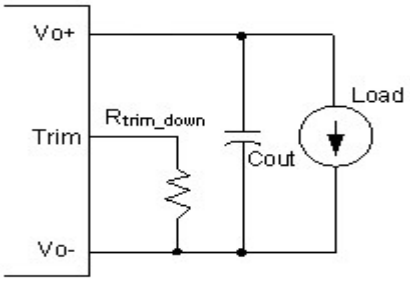



Figure 21 Trim down

If the sense compensate function is not necessary, connect S+ to Vo+ and S- to Vo- directly.

# APPLICATION NOTES

## Input Ripple & Inrush Current and Output Ripple & Noise Test Configuration

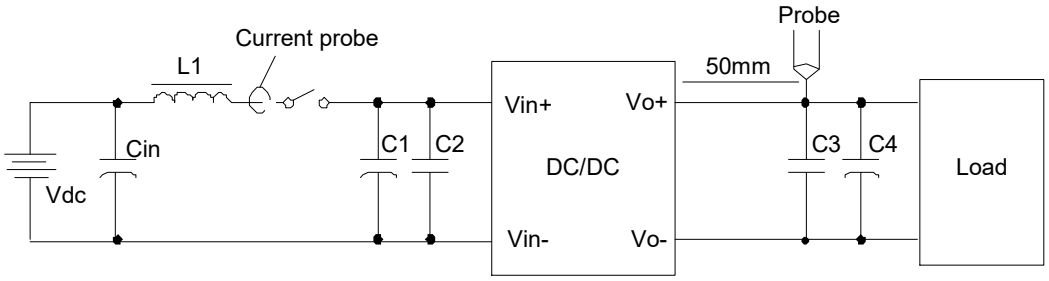



Figure 22 Input ripple & output ripple & noise test configuration

Vdc: DC power supply

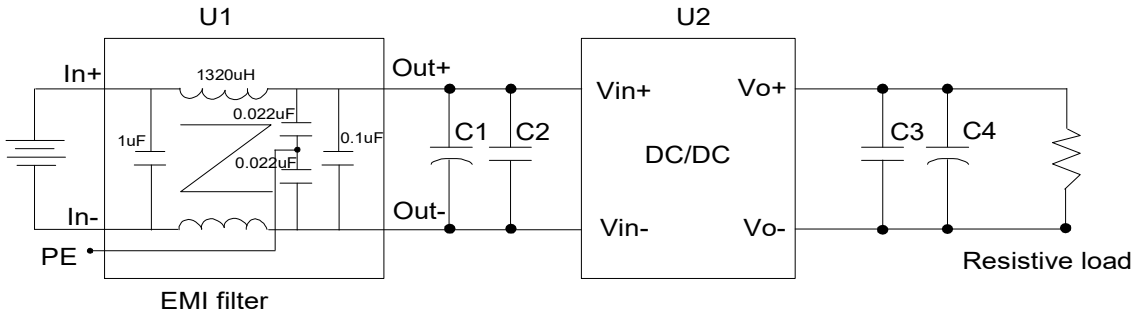
L1: 12uH

Cin: 220uF/100V typical

C1 ~ C4: See Figure 18

Note - Using a coaxial cable with series 50ohm resistor and 0.68uF ceramic capacitor or a ground ring of probe to test output ripple & noise is recommended.

## EMC Test configuration




U1: Input EMC filter
U2: Module to test, AVD75B-48S12
C1 ~ C4: See Figure 18

Figure 23 EMC Test configuration

# APPLICATION NOTES

## Package Information

### Package type

moisture sensitivity level 3, moisture barrier bags.

### Minimal package QTY

192 pcs.

### Package disassembly

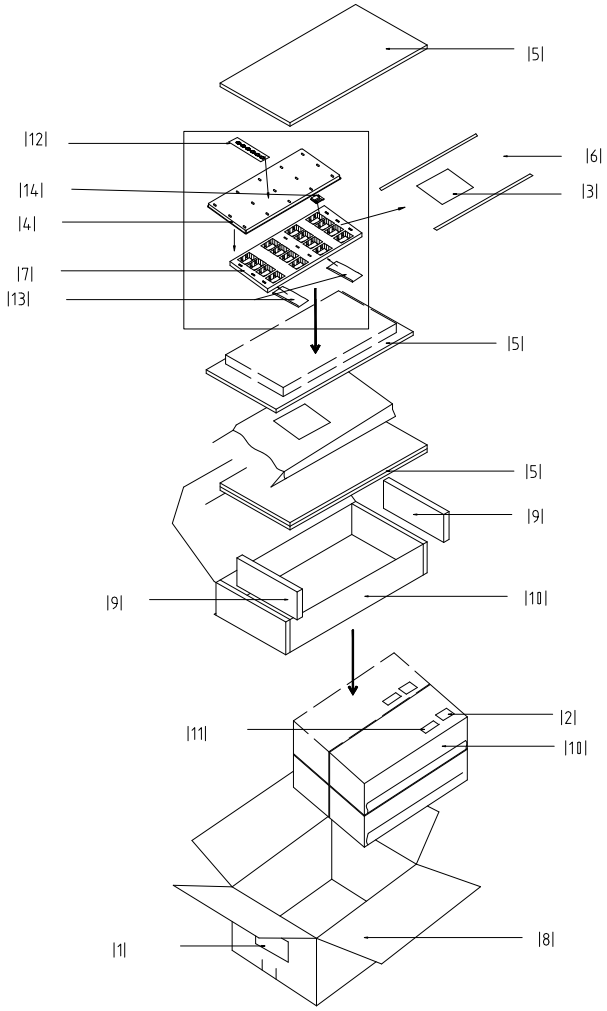


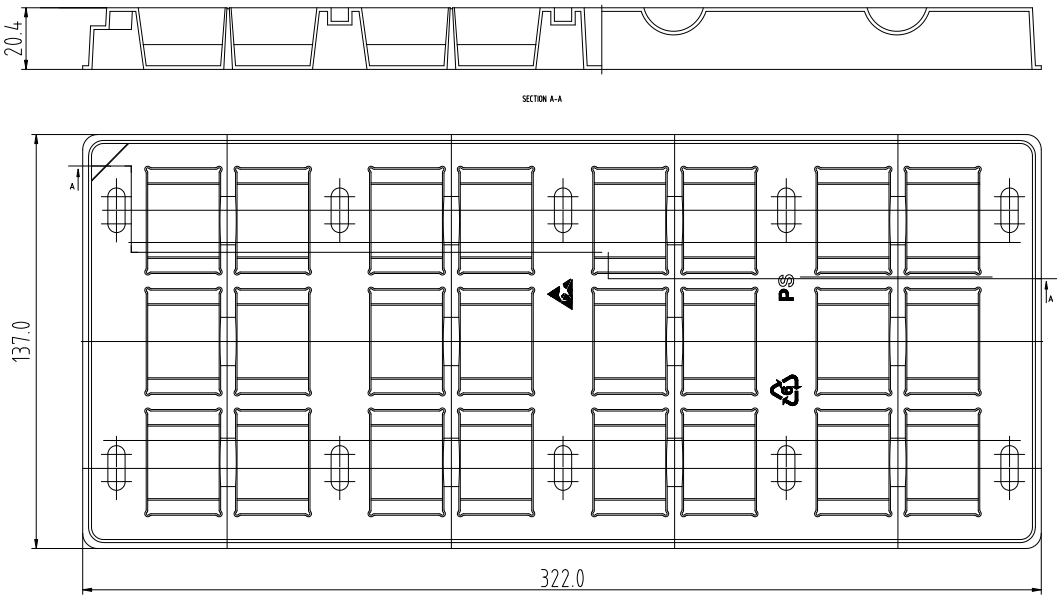

Figure 24 Package disassembly

# APPLICATION NOTES

## Package Information

| Table 7. Assemblies description | |
|---|---|
| No. | Description |
| 1 | Shipping label |
| 2 | Moisture proof identification label |
| 3 | Moistureproof caution label |
| 4 | Tray cover |
| 5 | Anti-static PE foam 1 |
| 6 | Moisture barrier bag |
| 7 | Tray |
| 8 | Shipping carton |
| 9 | Anti-static PE foam 2 |
| 10 | Inner box |
| 11 | Model barcode label |
| 12 | Humidity indicating card |
| 13 | Desiccant |
| 14 | Model |

### Package tray information



# SOLDERING INFORMATION

## Soldering

The product is intended for standard manual or wave soldering.

| | Product Requirement | Product Name |
|---|---|---|
| R6 | Wave soldering | AVD75B-48S12B-6L<br>AVD75B-48S12-6L |

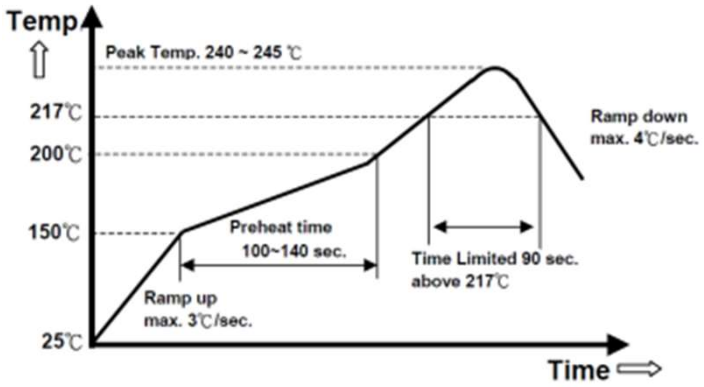
When wave soldering is used, the temperature on pins is specified to maximum 260 $^{O}$C for maximum 7s.

When soldering by hand, the iron temperature should be maintained at 300 $^{O}$C ~ 380 $^{O}$C and applied to the converter pins for less than 10s. Longer exposure can cause internal damage to the converter. Cleaning of solder joint can be performed with cleaning solvent IPA or simulative.

The below products are intended for standard reflow soldering.

| | Product Requirement | Product Name |
|---|---|---|
| R6 | Reflow soldering | AVD75B-48S12-6L<br>AVD75B-48S12TL |

When reflow soldering is used, please refer to following fig for recommended temperature profile parameters.



## Record of Revision and Changes

| Issue | Date | Description | Originators |
|---|---|---|---|
| 1.0 | 08.08.2017 | First Issue | L. Lee |
| 1.1 | 11.21.2017 | Update the isolation voltage | L. Lee |
| 1.2 | 07.10.2018 | Update the trim error | K. Wang |
| 1.3 | 12.09.2019 | Update the soldering information | L. Lee |
| 1.4 | 06.04.2020 | Update RoHS information | V. Guo |
| 1.5 | 06.17.2020 | Update 62368-1 cert | L.Lee |
| 1.6 | 06.10.2021 | Update AE template | J. Zhang |
| 1.7 | 11.19.2021 | Add the AVD75B-48S12B-4L | K. Wang |

## ABOUT ADVANCED ENERGY

Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

Our products enable customer innovation in complex applications for a wide range of industries including semiconductor equipment, industrial, manufacturing, telecommunications, data center computing, and medical. With deep applications know-how and responsive service and support across the globe, we build collaborative partnerships to meet rapid technological developments, propel growth for our customers, and innovate the future of power.

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