

## AVE350B-48S28

**350 Watts**

**Half-brick Converter**

**Total Power:** 350 Watts  
**Input Voltage:** 36 to 75Vdc  
**# of Outputs:** Single



### Special Features

- Delivering up to 12.5A output
- Ultra-high efficiency 93.5% typ. at half load and 93.2% type at half load
- Wide input range: 36V ~ 75V
- Excellent thermal performance
- No minimum load requirement
- RoHS 6 compliant
- Remote output sense
- Trim function: 60% ~ 118%
- Input under voltage lockout
- Output over current protection
- Output over voltage protection
- Over temperature protection
- Industry standard half-brick pin-out outline
- With baseplate
- Remote control logic optional
- Pin length optional

### Safety

UL 60950-1  
CSA-C22.2  
IEC/EN 60950-1  
GB4943  
TUV  
CE Mark

### Product Descriptions

The AVE350B-48S28 is a single output DC/DC converter with standard half-brick outline and pin configuration. It delivers up to 12.5A output current with 28V output voltage. Above 93.5% ultra-high efficiency and excellent thermal performance makes it an ideal choice to supply power to a power amplifier used in telecom and datacom applications. With the aluminium baseplate it can work under -40 °C ~ +85 °C without air cooling.

### Applications

Telecom/ Datacom

## Model Numbers

Standard	Output Voltage	Structure	Remote ON/OFF logic	RoHS Status
AVE350B-48S28-6	28Vdc	Baseplate	Negative	R6
AVE350B-48S28P-6	28Vdc	Baseplate	Positive	R6

## Ordering information

AVE350B	-	48	S	28	P	-	6	L	/M
①		②	③	④	⑤		⑥	⑦	⑧

①	Model series	AVE: high efficiency half brick series, 350: output power 350W, B: version
②	Input voltage	48: 36V ~ 75V input range, rated input voltage 48V
③	Output number	S: single output
④	Rated output voltage	28: 28V output
⑤	Remote ON/OFF logic	Default: negative; P: positive logic
⑥	Pin length	6: 3.8mm
⑦	RoHS status	L: RoHS, R6
⑧	Mounting hole	Default: through hole; M: screw thread

## 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 Non-operating -100mS	All	$V_{IN,DC}$	-	-	80	Vdc
	All		-	-	100	Vdc
Maximum Output Power	All	$P_{O,max}$	-	-	350	W
Isolation Voltage <sup>1</sup> Input to output Input to baseplate Output to baseplate	Open frame module		-	-	1500	Vdc
	Baseplate module		-	-	1500	Vdc
	Baseplate module		-	-	500	Vdc
Ambient Operating Temperature	All	$T_A$	-40	-	+85	°C
Storage Temperature	All	$T_{STG}$	-55	-	+125	°C
Voltage at remote ON/OFF pin	All		-0.3	-	15	Vdc
Humidity (non-condensing) Operating Non-operating	All		-	-	95	%
			-	-	95	

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

## Input Specifications

Table 2. Input Specifications:

Parameter	Conditions <sup>1</sup>	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, DC	All	$V_{IN,DC}$	36	48	75	Vdc
Turn-on Voltage Threshold	$I_O = I_{O,max}$	$V_{IN,ON}$	33	35	36	Vdc
Turn-off Voltage Threshold	$I_O = I_{O,max}$	$V_{IN,OFF}$	31	33	35	Vdc
Lockout Voltage Hysteresis	$I_O = I_{O,max}$		1	2	3	V
Maximum Input Current ( $I_O = I_{O,max}$ )	$V_{IN,DC} = 36V_{DC}$	$I_{IN,max}$	-	10.5	11.5	A
No-load input current		$I_{IN,no-load}$	-	0.035	-	A
Standby Input current	Remote OFF	$I_{IN,standby}$	-	0.001	-	A
Recommended Input Fuse	Fast blow external fuse recommended		-	-	15	A
Input filter component values (C\L)	Internal values			70.68		$\mu F \backslash \mu H$
Recommended External Input Capacitance	Low ESR capacitor recommended	$C_{IN}$	-	220	-	$\mu F$
Input Reflected Ripple Current	Through 12 $\mu H$ inductor		-	35	-	mA
Operating Efficiency	$T_A = 25^\circ C$ $I_O = I_{O,max}$ $I_O = 50\% I_{O,max}$	$\eta$	- -	93.5 93.2	- -	% %

Note 1 -  $T_A = 25^\circ C$ , airflow rate = 400 LFM,  $V_{in} = 48V_{dc}$ , nominal  $V_{out}$  unless otherwise noted. All electrical specification is guaranteed above 35V input voltage after module turn on.

## Output Specifications

Table 3. Output Specifications:

Parameter	Conditions <sup>1</sup>	Symbol	Min	Typ	Max	Unit	
Factory Set Voltage	$V_{IN,DC} = 48V_{DC}$ $I_O = 50\%I_{O,max}$	$V_O$	27.72	28	28.28	Vdc	
Output Voltage Line Regulation	All	$\%V_O$	-	0.05	1	%	
Output Voltage Load Regulation	All	$\%V_O$	-	0.1	1	%	
Output Voltage Temperature Regulation	All	$\%V_O$	-	0.01	0.02	$\%/^{\circ}C$	
Total output voltage range (Over sample, line, load, temperature & life)	All	$V_O$	27.16	28	28.84	V	
Output Voltage Trim Range	All	$\%V_O$	60	-	116	%	
Output voltage remote sense range	All		-	-	0.5	V	
Output Ripple, pk-pk	20MHz bandwidth	$V_O$	-	120	200	$mV_{PK-PK}$	
Output Current		$I_O$	0	-	12.5	A	
Output DC current-limit inception <sup>1</sup>		$I_O$	13.125	-	17.5	A	
$V_O$ Load Capacitance <sup>2</sup>	High frequency and low ESR are recommended	$C_O$	680	750	4000	$\mu F$	
$V_O$ Dynamic Response	Peak Deviation	50% ~75%~50%	$\pm V_O$	-	210	840	mV
	Settling Time	slew rate = 0.1A/us	$T_s$	-	-	500	$\mu Sec$
Turn-on transient	Rise time	$I_O = I_{max}$	$T_{rise}$		16	100	mS
	Turn-on delay time	$I_O = I_{max}$	$T_{turn-on}$	-	17	50	mS
	Output voltage overshoot	$I_O = 0$	$\%V_O$	-	0	-	%
Switching frequency	All	$f_{SW}$	-	285	-	KHz	

Note 1 -  $T_a = 25^{\circ}C$ , airflow rate = 400 LFM,  $V_{in} = 48V_{dc}$ , nominal  $V_{out}$  unless otherwise noted. All electrical specification is guaranteed above 35V input voltage after module turn on.

Note 2 - Hiccup: auto-restart when over-current condition is removed.

Note 3 - High frequency and low ESR is recommended.

## Output Specifications

Table 3. Output Specifications, con't:

Parameter		Conditions <sup>1</sup>	Symbol	Min	Typ	Max	Unit
Remote ON/OFF control (positive logic)	Off-state voltage	All		-0.3	-	0.8	V
	On-state voltage	All		2.4	-	15	V
Remote ON/OFF control (negative logic)	Off-state voltage	All		2.4	-	15	V
	On-state voltage	All		-0.3	-	0.8	V
Output over-voltage protection <sup>3</sup>		All	$\%V_O$	115	-	140	%
Output over-temperature protection <sup>4</sup>		All	T	105	115	125	°C
Over-temperature hysteresis		All	T	5	-	-	°C
MTBF		Normal input/output Bellcore, TR332 method 1, case 3		-	2	-	10 <sup>6</sup> h

Note 4 - Hiccup: auto-restart when over-voltage condition is removed.

Note 5 - Auto recovery.

**AVE350B-48S28 Performance Curves**

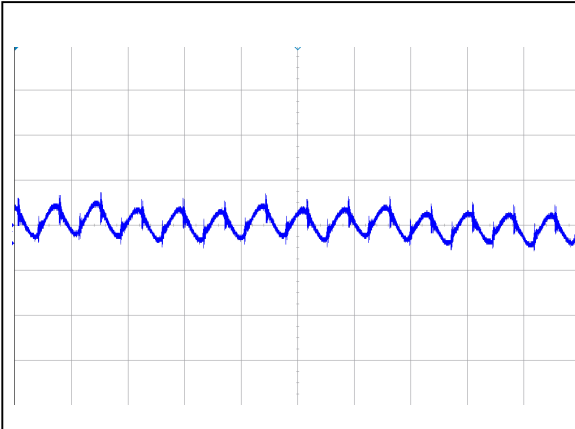


Figure 1: AVE350B-48S28 Input Reflected Ripple Current Waveform (5uS/div, 50mA/div)

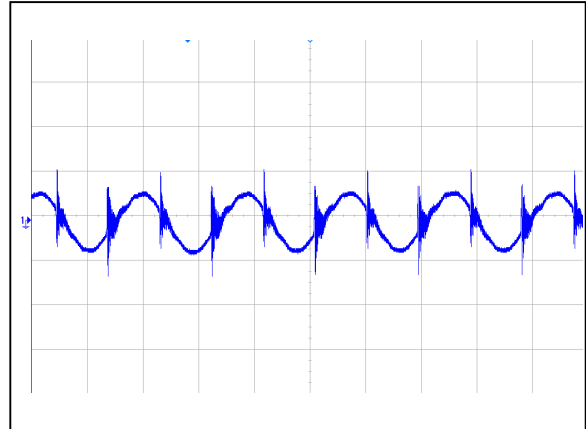


Figure 2: AVE350B-48S28 Ripple and Noise Measurement (2uS/div, 50mV/div)

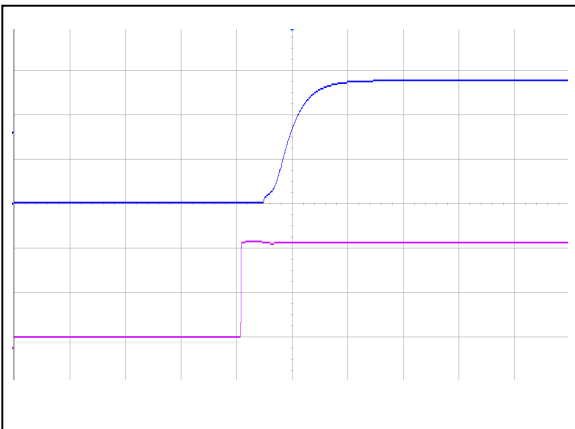


Figure 3: AVE350B-48S28 Output Voltage Startup Characteristic (20mS/div)

Ch 1: Vo (10V/div)

Ch 3: Vo (20V/div)

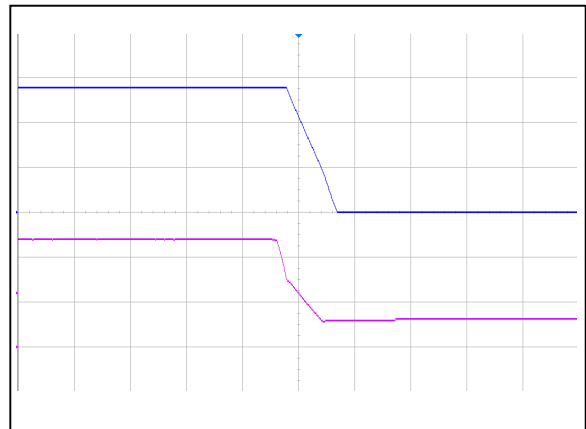


Figure 4: AVE350B-48S28 Turn Off Characteristic (2mS/div)

Ch 1: Vo (10V/div)

Ch 3: Vo (20V/div)

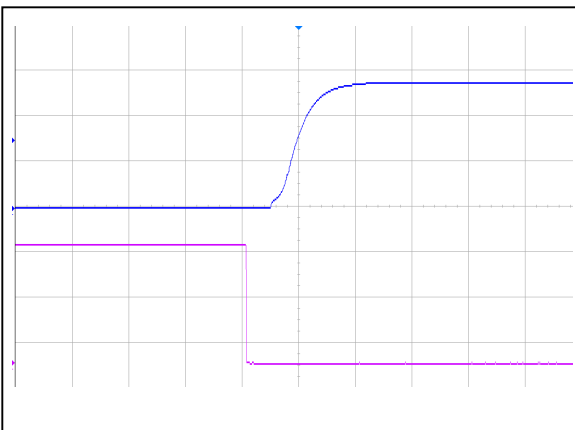


Figure 5: AVE350B-48S28 Remote ON Waveform (20mS/div)

Ch 1: Vo (10V/div)

Ch 2: Remote ON (2V/div)

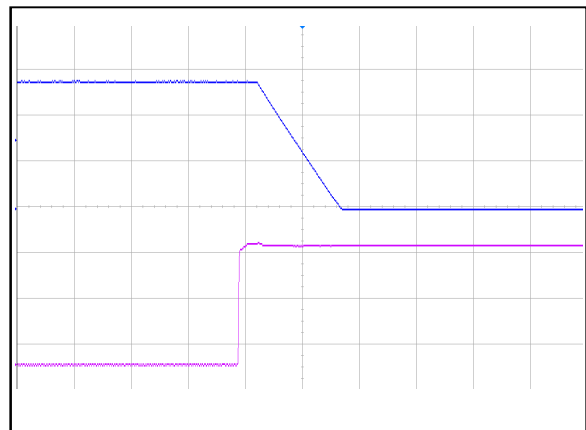


Figure 6: AVE350B-48S28 Remote OFF Waveform (1mS/div)

Ch 1: Vo (10V/div)

CH 2: Remote OFF (2V/div)

## AVE350B-48S28 Performance Curves

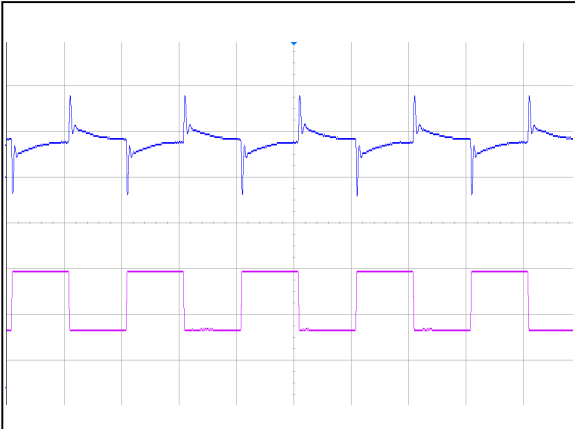


Figure 7: AVE350B-48S28 Transient Response (5mS/div)  
 25%-50%-25% load change, 0.1A/uS slew rate  
 Ch 1: Vo (200mV/div) Ch 2: Io (2.5A/div)

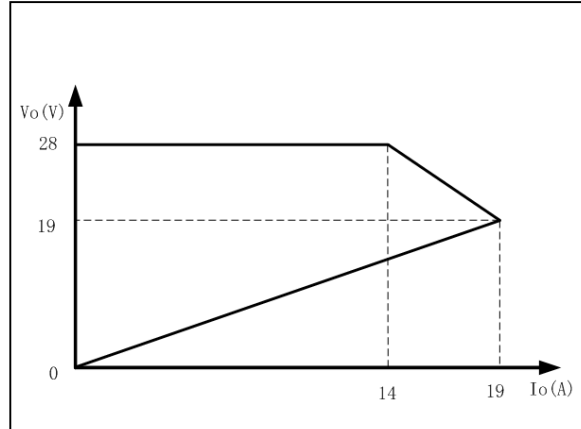


Figure 8: AVE350B-48S28 Over-current Protection Characteristics

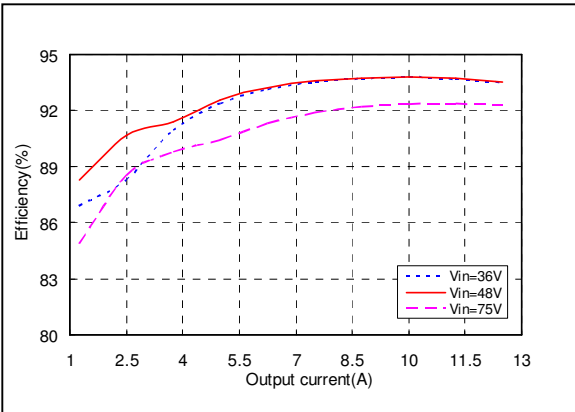


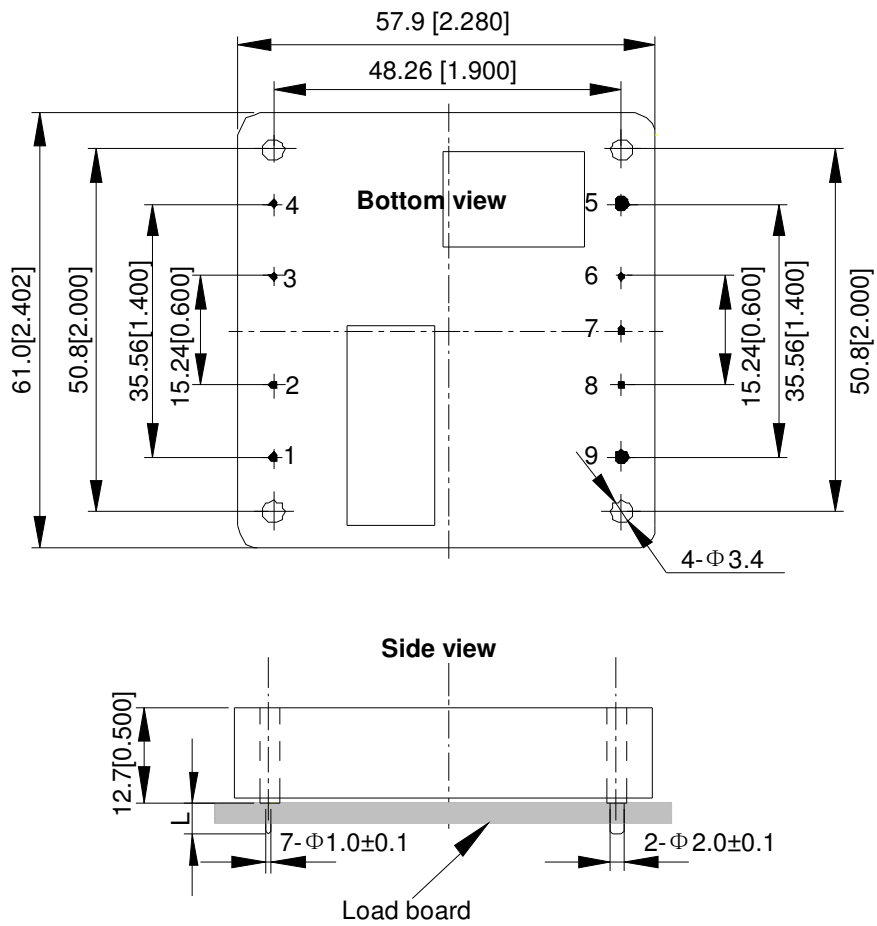
Figure 9: AVE350B-48S28 Efficiency Curves Vo=28V

Tc: temperature test point on baseplate, Ta=25 °C, Tc<40 °C



## Mechanical Specifications

### Mechanical Outlines



Unit: mm[inch]

Bottom view: pin on upside

Tolerance: X.Xmm±0.5mm[X.X in.±0.02in.]

X.XXmm±0.25mm[X.XX in.±0.01in.]

## Pin Length Option

Device code suffix	L
-4	4.8mm ±0.5 mm
-6	3.8mm ±0.5 mm
-8	2.8mm ±0.5 mm
None	5.8mm ±0.5 mm

## Pin Designations

Pin No	Name	Function
1	V <sub>in+</sub>	Positive input voltage
2	CNT	Remote ON/OFF control
3	Case	NC
4	V <sub>in-</sub>	Negative input voltage
5	V <sub>o-</sub>	Negative output voltage
6	S-	Negative sense
7	Trim	Output voltage trim
8	S+	Positive sense
9	V <sub>o+</sub>	Positive output voltage

## Environmental Specifications

### EMC Immunity

AVE350B-48S28 Series power supply is designed to meet the following EMC immunity specifications:

Document	Description	Criteria
EN55022, Class B Limits	Conducted and Radiated EMI Limits	/
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.

Criterion C: Temporary loss of output, the correction of which requires operator intervention.

Criterion D: Loss of output which is not recoverable, owing to damage to hardware.

## Environmental Specifications

### EMC Fliter Configuration

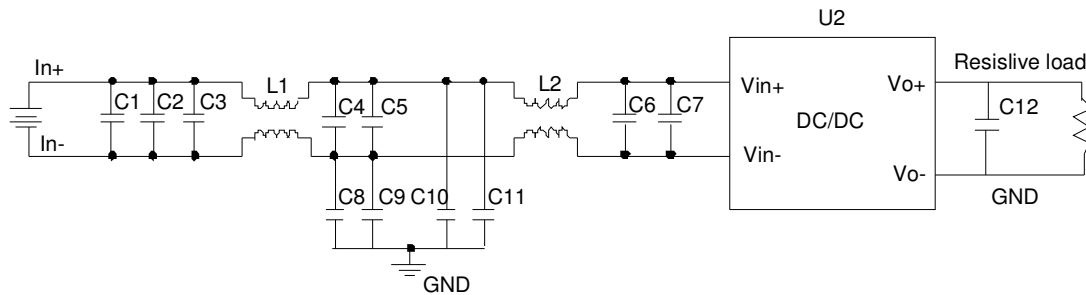


Figure 10 EMC test configuration

U2: Module to test, AVQ300-48S12

C1 ~ C5: SMD ceramic capacitor -100V-1000nF-X7R-1210

C6: SMD ceramic capacitor -100V-100nF-±10%-X7R-1206

C8 ~ C11: High-voltage CHIP ceramic capacitor. Capacitance: 0.1U/630V/X7R. Size: 2220. Capable of withstanding 1kV voltage

C7: Input electrolytic capacitor, according to the same type as C1 in Figure 14

C12: Output electrolytic capacitor, according to the same type as C4 in Figure 14

PE: Connected to output

L1, L2: Common mode inductor - single phase -473uH-±25%-14A magnetic ring 1\*25.4\*12.7mm - working temperature range includes module temperature rise. Temperature rise at rated current: 55° C max

## **Safety Certifications**

The AVQ300-48S12 Series 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 4. Safety Certifications for AVE350B-48S28 series power supply system

<b>Document</b>	<b>File #</b>	<b>Description</b>
UL60950,CSA-C22.2		US and Canada Requirements
EN60950-1		European Requirements
IEC60950		International Requirements
GB4943		Chinese Requirements
CE		CE Marking

**Operating Temperature**

The AVE350B-48S28 series power supplies will start and operate within stated specifications at an ambient temperature from -40 °C to 85 °C under all load conditions. The storage temperature is -55 °C to 125 °C.

**Thermal Considerations**

The converter is designed to operate in different thermal environments and sufficient cooling must be provided.

**Application without forced air convection**

Proper cooling of the DC/DC converter can be verified by measuring the temperature at the test points, shown in Figure 11. The temperature at these points should not exceed the max values in the Table 5.

The converter can operate in an enclosed environment without forced air convection. Cooling of the converter is achieved mainly by conduction from the baseplate to a heatsink. The converter can deliver full output power at 85 °C ambient temperature provided both temperature test points, shown in Figure 11, are kept below the max values in the Table 5.

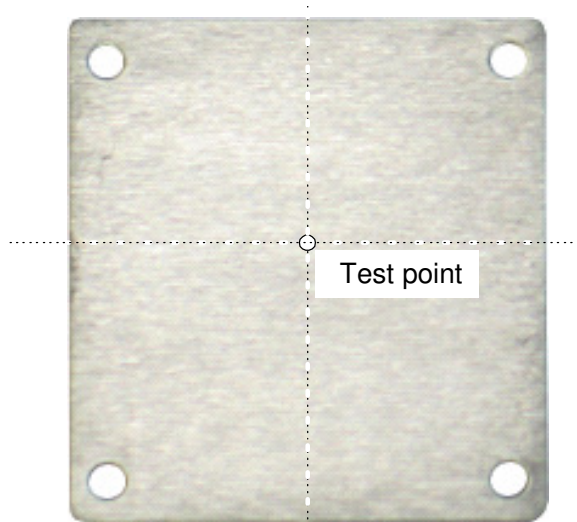


Figure 11 Temperature test point on baseplate

Test Point	Temperature limit
Test point on baseplate	105°C

Table 5 Temperature limit of the test points

## Application with forced air convection

The converter can also operate with a smaller heatsink and sufficient airflow. Proper cooling of the DC/DC converter can be verified by measuring the temperature at the test points, shown in Figure 12. The temperature at these points should not exceed the max values in the Table 5.

For a typical application, Figure 13 shows the derating output current vs. ambient air temperature at different air velocity with a specified heatsink (Size:L:61mm,W:58mm,H:25.4mm), shown in Figure 12.

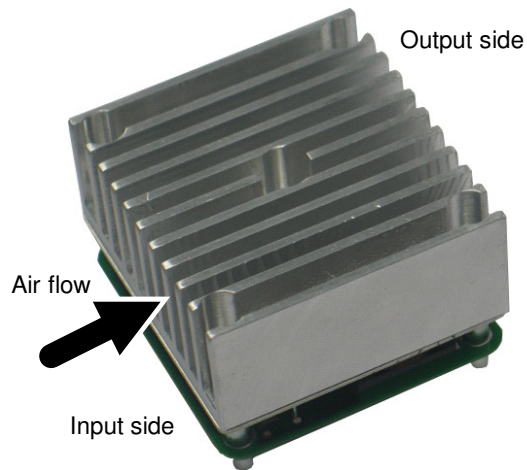


Figure 12 Typical application with a smaller heatsink and airflow

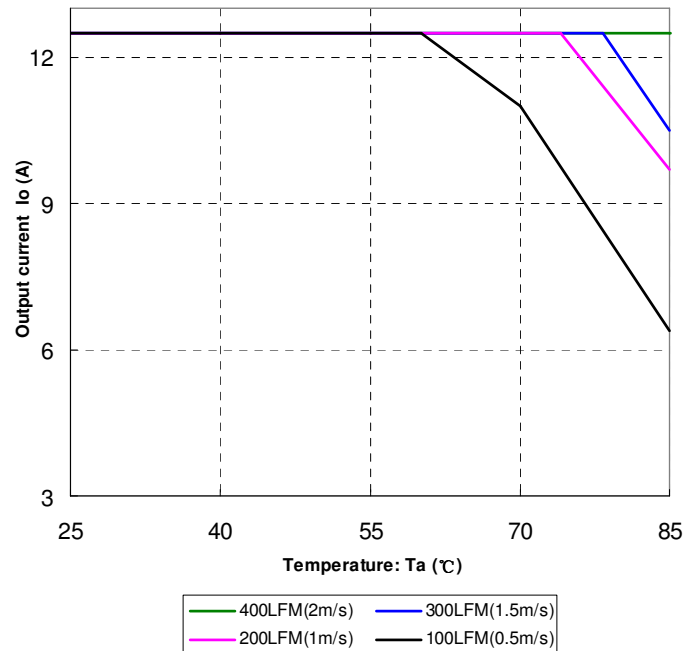


Figure 13 Output power derating, 48Vin

## Qualification Testing

Parameter	Unit (pcs)	Test condition
Halt test	4-5	$T_{a,min} - 10\text{ }^{\circ}\text{C}$ to $T_{a,max} + 10\text{ }^{\circ}\text{C}$ , $5\text{ }^{\circ}\text{C}$ step, $V_{in}$ = min to max, 0 ~ 105% load
Vibration	3	Frequency range: 5Hz ~ 20Hz, 20Hz ~ 200Hz, A.S.D: $1.0\text{m}^2/\text{s}^3$ , -3db/oct, axes of vibration: X/Y/Z. Time: 30min/axes
Mechanical Shock	3	30g, 6ms, 3axes, 6directions, 3time/direction
Thermal Shock	3	$-40\text{ }^{\circ}\text{C}$ to $100\text{ }^{\circ}\text{C}$ , unit temperature 20cycles
Thermal Cycling	3	$-40\text{ }^{\circ}\text{C}$ to $85\text{ }^{\circ}\text{C}$ , temperature change rate: $1\text{ }^{\circ}\text{C}/\text{min}$ , cycles: 2cycles
Humidity	3	$40\text{ }^{\circ}\text{C}$ , 95%RH, 48h
Solder Ability	15	IPC J-STD-002C-2007



## Application Notes

### Typical Application

Below is the typical application of the AVE350B-48S28 series power supply.

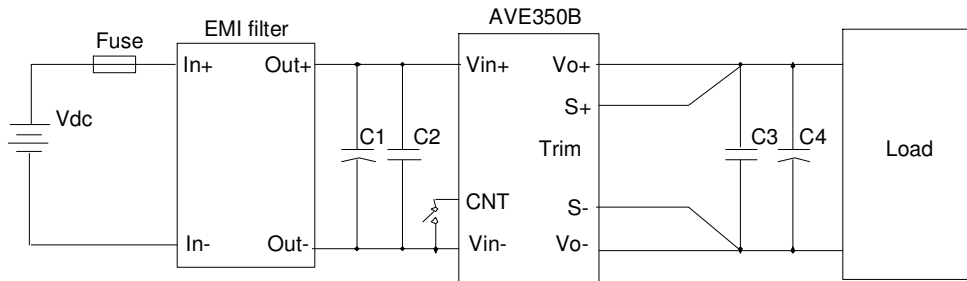


Figure 14 Typical application

C1: 220 $\mu$ F/100V electrolytic capacitor, P/N: UPM2A221MHD (Nichicon) or equivalent caps

C2, C3: 1 $\mu$ F/100V X7R ceramic capacitor, P/N: C3225X7R2A105KT0L0U (TDK) or equivalent caps

C4: 750 $\mu$ F/50V electrolytic capacitor (150 $\mu$ F\*5pcs), P/N: UUD1H151MNL1GS (Nichicon) or equivalent caps

Note: If ambient temperature is below -5  $^{\circ}$ C, double input & output capacitance is necessary for normal operation and performance.

Fuse: External fast blow fuse with a rating of 15A. The recommended fuse model is 324015P from LITTELFUSE.

**Remote ON/OFF**

Either positive or negative remote ON/OFF logic is available in AVE350B-48S28. The logic is CMOS and TTL compatible. Some typical applications for CNT function refer to the following figure 15.

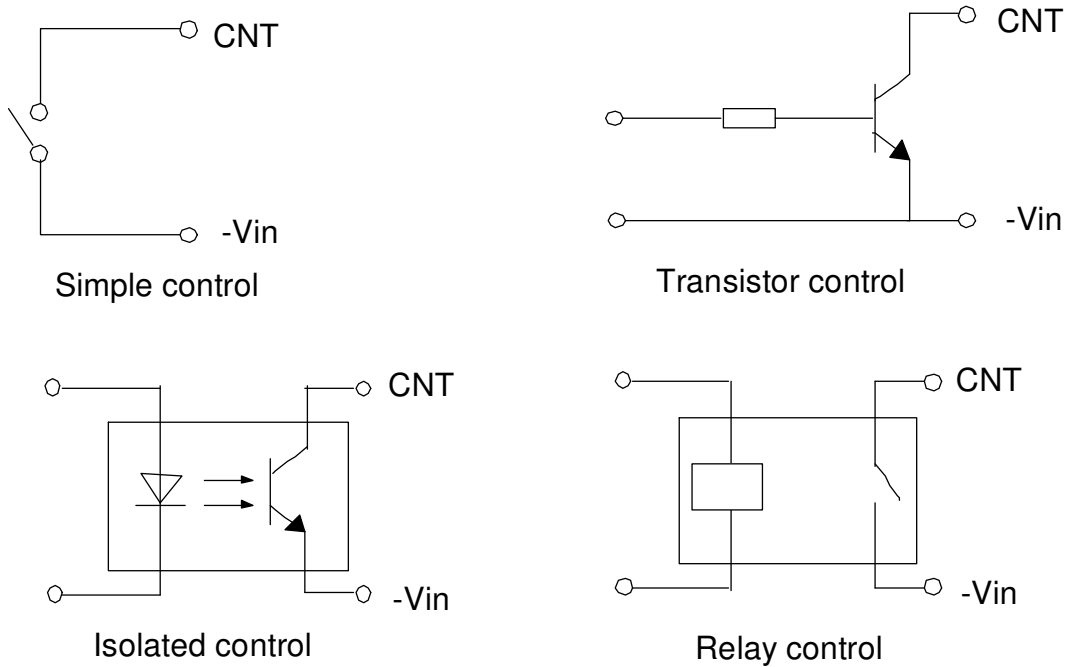


Figure 15 Remote ON/OFF internal diagram

## 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.

$$R_{adj\_down} = \left( \frac{100\%}{\Delta\%} - 2 \right) k\Omega$$

$$R_{adj\_up} = \left( \frac{V_o(100\% + \Delta\%)}{1.225 \times \Delta\%} - \frac{100\% + 2 \times \Delta\%}{\Delta\%} \right) k\Omega$$

$\Delta$ : Output error rate against nominal output voltage.

$V_{nom}$ : Nominal output voltage.

For example, to get 32.2V output, the trimming resistor is

$$R_{adj\_up} = \left( \frac{32.2}{1.225 \times (32.2 - 28) / 28} - \frac{100\% + 2 \times (32.2 - 28) / 28}{(32.2 - 28) / 28} \right) k\Omega = 166.57k\Omega$$

The output voltage can also be trimmed by potential applied at the Trim pin.

$$V_o = (11.43 \times V_{trim} + 14)V$$

Where  $V_{trim}$  is the potential applied at the Trim pin, and  $V_o$  is the desired output voltage.

When trimming up, the output current should be decreased accordingly so as not to exceed the maximum output power and the minimum input voltage should be increased as shown in Figure 16

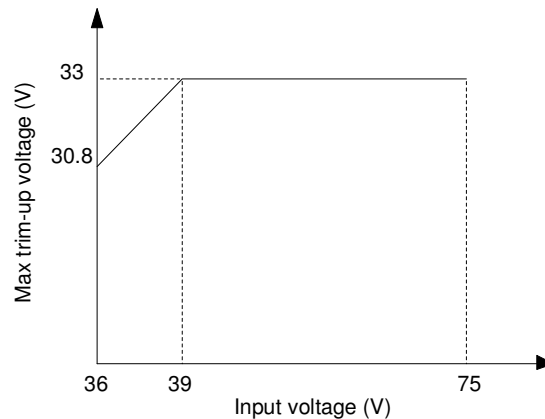


Figure 16 Max trim-up voltage vs. input voltage

**Trim Characteristics, Con't**

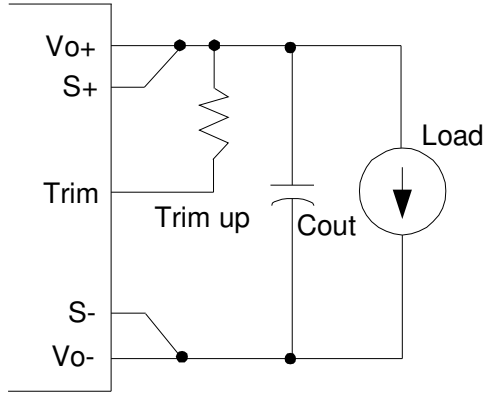


Figure 17 Trim up

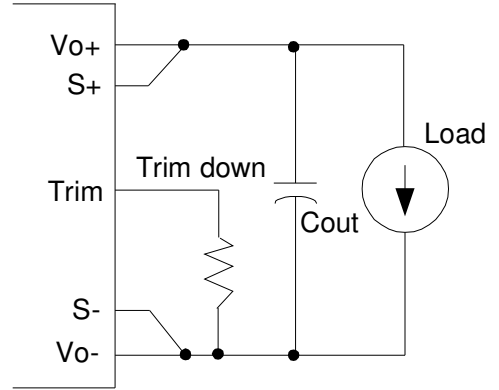


Figure 18 Trim down

### **Sense Characteristics**

If the load is far from the unit, connect S+ and S- to the terminal of the load respectively to compensate the voltage drop on the transmission line. See Figure 14.

If the sense compensate function is not necessary, connect S+ to  $V_{o+}$  and S- to  $V_{o-}$  directly.

**Input Ripple & Output Ripple & Noise Test Configuration**

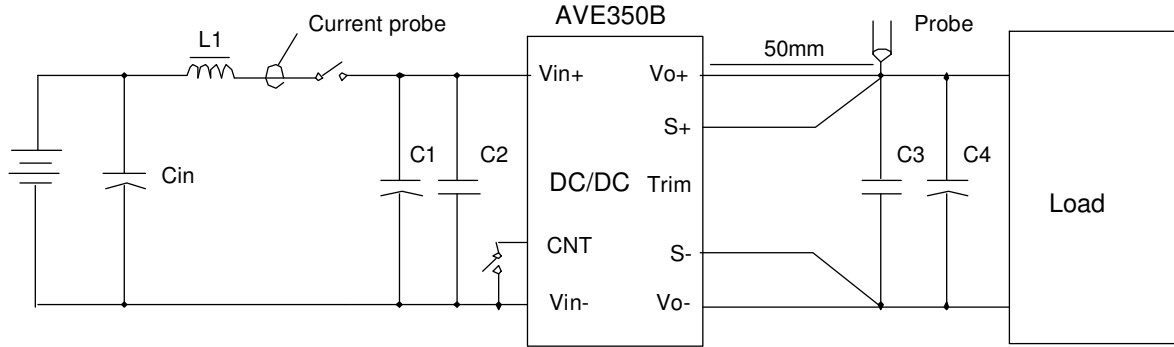


Figure 19 Input ripple & output ripple & noise test configuration

Vdc: DC power supply

L1: 12uH

Cin: 220uF/100V typical

C1 ~ C4: See Figure 14

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.

### **Sense Characteristics**

If the load is far from the unit, connect S+ and S- to the terminals of the load respectively to compensate the voltage drop on the transmission line. See figure 10.

If the sense compensation function is not necessary, connect S+ to  $V_o+$  and S- to  $V_o-$  directly.

### **Soldering**

The product is intended for standard manual or wave soldering.

When wave soldering is used, the temperature on pins is specified to maximum 255 °C for R5 compliant product and maximum 260 °C for R6 compliant product. And the duration must be less than 7s.

When soldering by hand, the iron temperature should be maintained at 300 °C ~ 380 °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.



**Hazardous Substances Announcement (RoHS of China R6)**

Parts	Hazardous Substances					
	Pb	Hg	Cd	Cr <sup>6+</sup>	PBB	PBDE
AVE350B-48S28	x	x	x	x	x	x

x: Means the content of the hazardous substances in all the average quality materials of the part is within the limits specified in SJ/T-11363-2006

√: Means the content of the hazardous substances in at least one of the average quality materials of the part is outside the limits specified in SJ/T11363-2006

Artesyn Embedded Technologies has been committed to the design and manufacturing of environment-friendly products. It will reduce and eventually eliminate the hazardous substances in the products through unremitting efforts in research. However, limited by the current technical level, the following parts still contain hazardous substances due to the lack of reliable substitute or mature solution:

1. Solders (including high-temperature solder in parts) contain plumbum.
2. Glass of electric parts contains plumbum.
3. Copper alloy of pins contains plumbum

## Record of Revision and Changes

Issue	Date	Description	Originators
1.0	07.02.2014	First Issue	G.Xue
1.1	10.15.2014	Add condition	G.Xue
1.2	09.15.2015	Change Pin3 from “pin connected to baseplate” to “NC”	G.Xue
1.3	03.21.2016	Add a sentence “electrical specification is guaranteed above 35V input voltage after module turn on” at input and output section.	K. Wang
1.4	11.01.2016	Update the Pin tolerance	K. Wang
1.5	11.17.2016	Update the C7and C12 note	K. Wang

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