MODEL NUMBERS

Standard	Output Voltage	Structure	Remote ON/OFF logic	RoHS Status
AVE350B-48S28-6	28Vdc	Baseplate	Negative	RoHS 3.0
AVE350B-48S28P-6L	28Vdc	Baseplate	Positive	RoHS 3.0

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
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 pin length
⑦	RoHS status	L: RoHS 3.0
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	All	$V_{IN,DC}$	-	-	80	Vdc
Non-operating -100mS	All		-	-	100	Vdc
Maximum Output Power	All	$P_{O,max}$	-	-	350	W
Isolation Voltage[1]						
Input to outputs	All		-	-	1500	Vdc
Input to baseplate			-	-	1500	Vdc
Outputs to baseplate			-	-	500	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	-	15	Vdc
Humidity (non-condensing)						
Operating	All		-	-	95	%
Non-operating			-	-	95	

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

ELECTRICAL SPECIFICATIONS

Input Specifications

Table 2. Input Specifications

Parameter	Condition[1]	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, DC	All	$V_{IN,DC}$	36	48	75	Vdc
Turn-on Voltage Threshold	$I_O = I_{O,max}$	$V_{IN,ON}$	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			7\0.68		µF\µH
Recommended External Input Capacitance	Low ESR capacitor recommended	C_{IN}	-	220	-	uF
Input Reflected Ripple Current	Through 12uH inductor		-	35	-	mA
Operating Efficiency	T_A=25 °C $I_O = I_{O,max}$ $I_O = 50\% I_{O,max}$	η	- -	93.5 93.2	- -	% %

Note 1 - Ta = 25 °C, airflow rate = 400 LFM, Vin = 48Vdc, nominal Vout unless otherwise noted. All electrical specification is guaranteed above 35V input voltage after module turn on.

ELECTRICAL SPECIFICATIONS

Output Specifications

Table 3. Output Specifications

Parameter		Condition	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	%/^{O}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	%Vo	60	-	118	%
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[2]			I_O	13.125	-	17.5	A
V_O Load Capacitance[3]		High frequency and low ESR are recommended	C_O	680	750	4000	uF
V_O Dynamic Response	Peak Deviation Settling Time	50% ~75%~50% slew rate = 0.1A/us	±V_O T_s	- -	210 -	840 500	mV uSec
Turn-on transient	Rise time	I_O = $I_{O,max}$	T_{rise}		16	100	mS
	Turn-on delay time	I_O = $I_{O,max}$	$T_{turn-on}$	-	17	50	mS
	Output voltage overshoot	I_O = 0	%V_O	-	0	-	%
Switching frequency		All	f_{SW}	-	285	-	KHz
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[4]		All	%V_O	115	-	140	%
Output over-temperature protection[5]		All	T	105	115	125	^{O}C
Over-temperature hysteresis		All	T	5	-	-	^{O}C
MTBF		Normal input/output Bellcore, TR332 method 1, case 3		-	2	-	10^6 h

Note 1 - Ta = 25 ^{O}C, airflow rate = 400 LFM, Vin = 48Vdc, nominal Vout 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.

Note 4 - Latch. Remain latched after OVP shutdown until power on or remote ON.

Note 5 - Auto recovery.

PERFORMANCE CURVES

AVE350B-48S28 Performance Curves

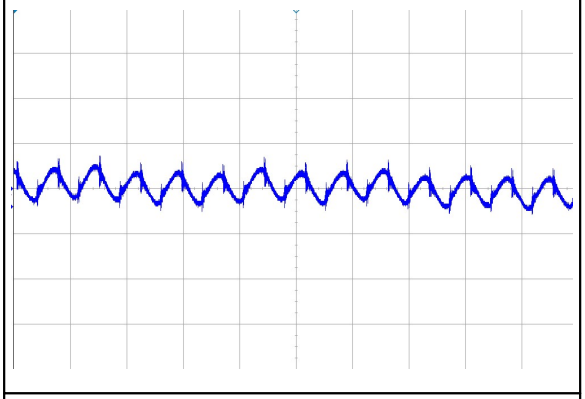


Figure 1: AVE350B-48S28 Input Reflected Ripple Current Waveform

Ch 1: Iin (5uS/div, 50mA/div)

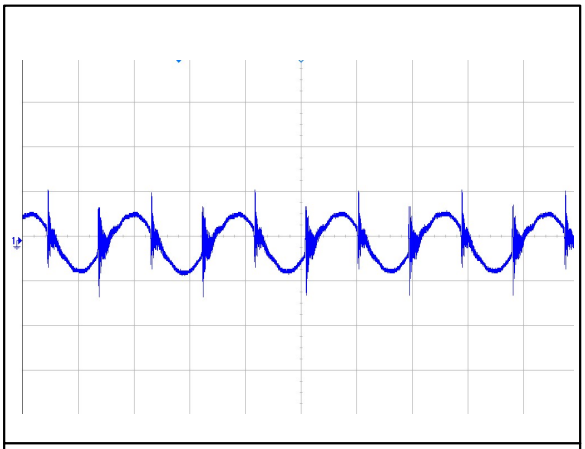


Figure 2: AVE350B-48S28 Ripple and Noise Measurement

Ch 1: Vo (2uS/div, 50mV/div)

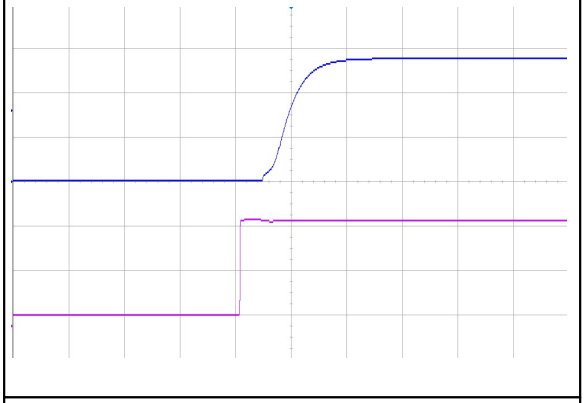


Figure 3: AVE350B-48S28 Output Voltage Startup Characteristic (20mS/div)

Ch 1: Vin (10V/div) Ch 2: Vo (20V/div)

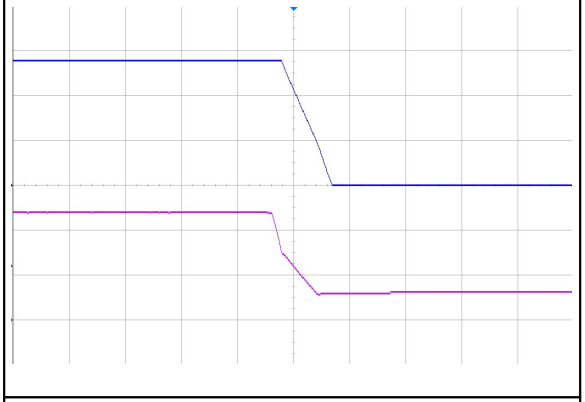


Figure 4: AVE350B-48S28 Turn Off Characteristic (5mS/div)

Ch 1: Vin (10V/div) Ch 2: Vo (20V/div)

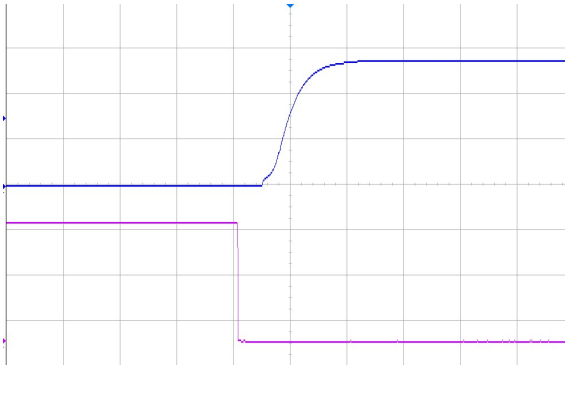


Figure 5: AVE350B-48S28 Remote ON Waveform (20mS/div)

Ch 1: Remote ON (10V/div) Ch 2: Vo (2V/div)

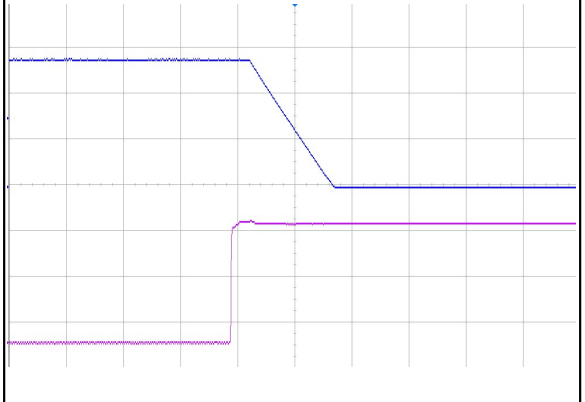


Figure 6: AVE350B-48S28 Remote OFF Waveform (1mS/div)

Ch 1: Remote OFF (10V/div) CH3: Vo (2V/div)

PERFORMANCE CURVES

AVE350B-48S28 Performance Curves

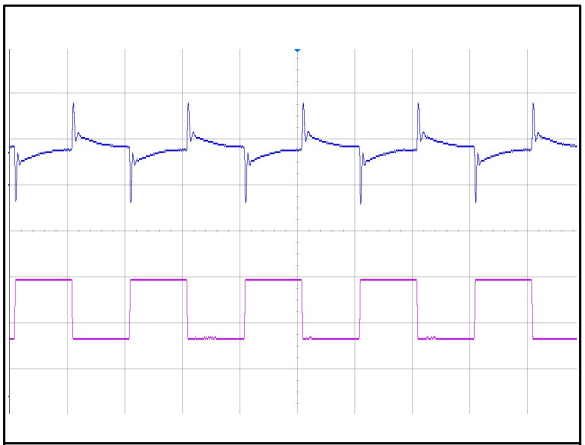


Figure 7: AVE350B-48S28 Transient Response (5mS/div)
25%~50%~25% load change, 0.1A/uS slew rate,
Ch 1: Vo (200mV/div) Ch 2: Io (2.5A/div)

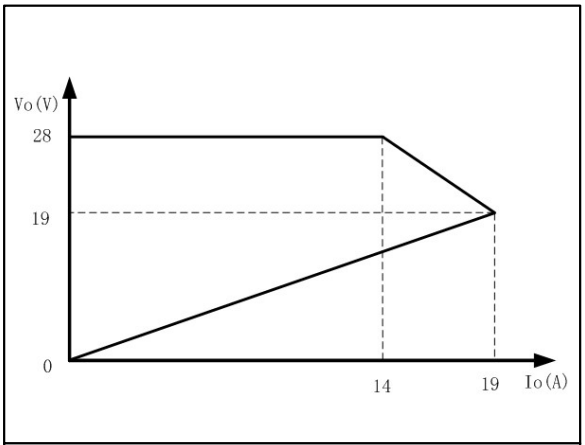


Figure 8: AVE350B-48S28 Over-current Protection Characteristics

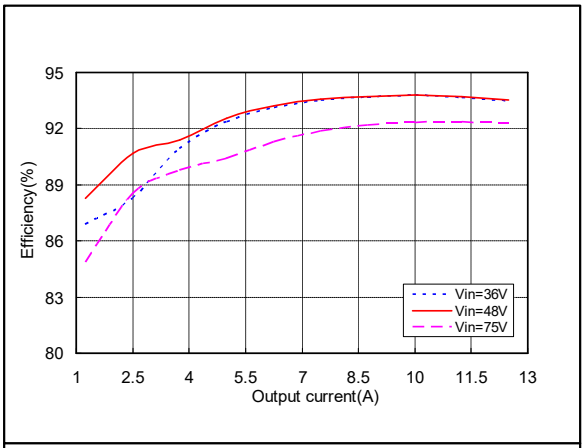
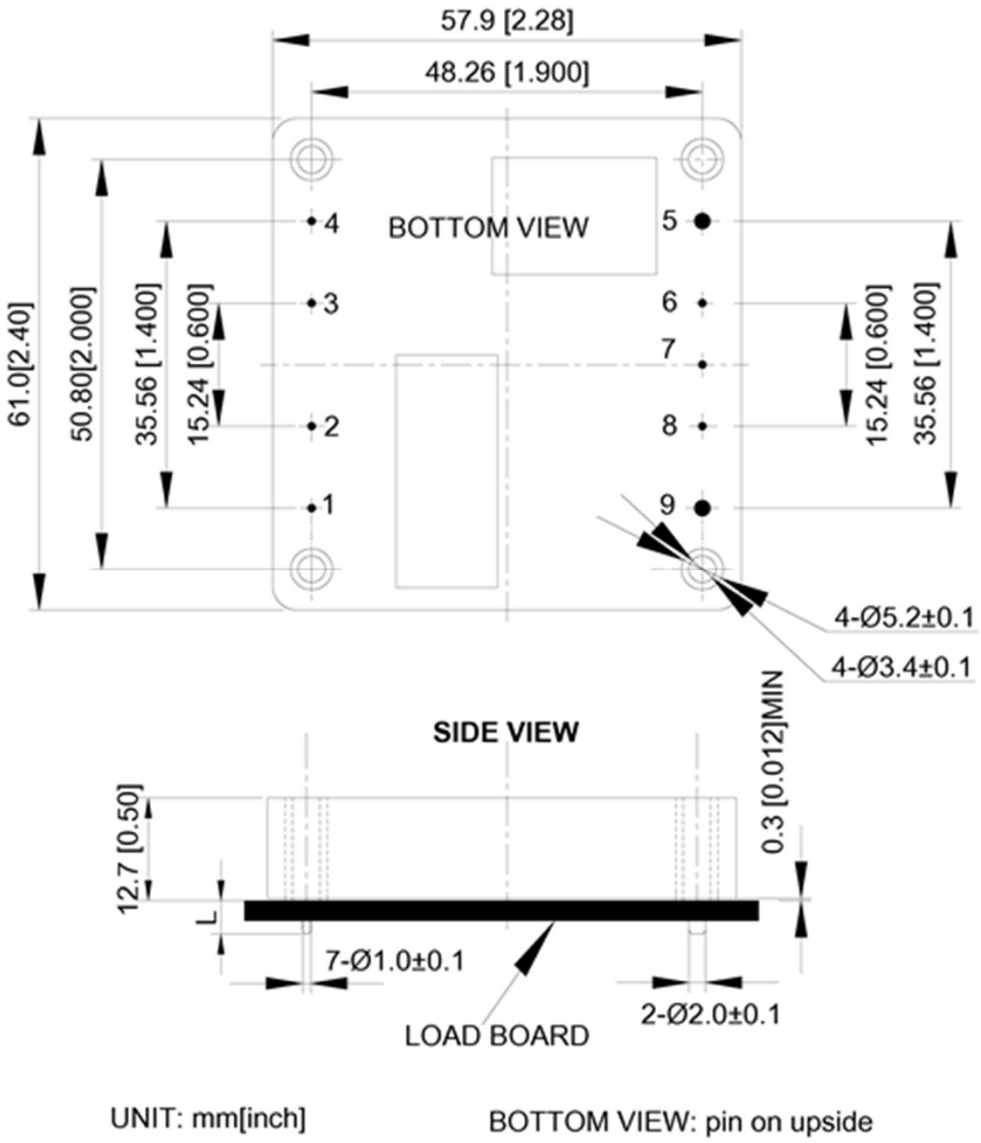


Figure 9: AVE350B-48S28 Efficiency Curves Vo=28Vdc

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

MECHNICAL SPECIFICATIONS

Mechanical Outlines



UNIT: mm[inch]

TOLERANCE: X.X mm±0.5 mm[X.XX in. ±0.02 in.]

X.XX mm±0.25 mm[X.XXX in. ±0.01 in.]

MECHNICAL SPECIFICATIONS

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	Vin+	Positive input voltage
2	CNT	Remote ON/OFF control
3	Case	Case
4	Vin-	Negative input voltage
5	Vo-	Negative output voltage
6	S-	Negative remote sense
7	Trim	Output voltage trim
8	S+	Positive remote sense
9	Vo+	Positive output voltage

ENVIRONMENTAL SPECIFICATIONS

EMC Immunity

AVE350B-48S28 Series power supply is designed to meet the following EMC immunity specifications:		
Parameter	**Condition[1]**	**Criteria**
EN55032, 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 Filter Configuration

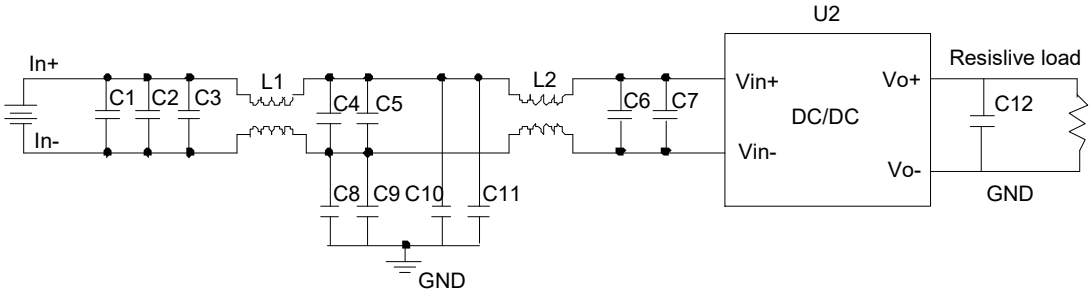


Figure 10 EMC filter configuration

U2: Module to test, AVE350B-48S28

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^{O}C max

ENVIRONMENTAL SPECIFICATIONS

Safety Certifications

The AVE350B-48S28 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

Standard	File #	Description
UL60950,CSA-C22.2	E132002-A104-UL - X13	US and Canada Requirements
EN62368-1	B 013890 3252 Rev. 00	European Requirements
EN60950	B 16 01 13890 02601	International Requirements
CE	1735	CE Marking

ENVIRONMENTAL SPECIFICATIONS

Operating Temperature

The AVE350B-48S28 series power supplies 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.

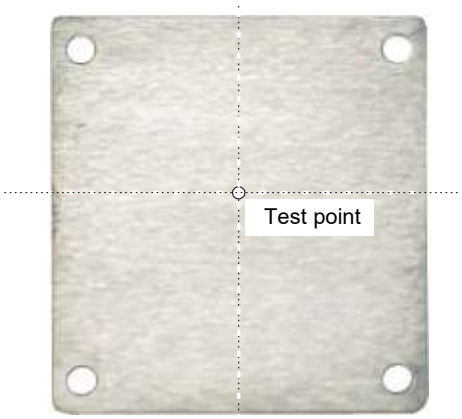


Figure 11 Temperature test points

Test Point	Temperature limit
Test point on baseplate	105^{O}C

ENVIRONMENTAL SPECIFICATIONS

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.

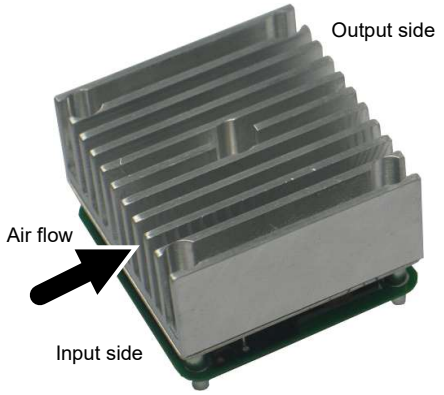


Figure 12 Typical application with a smaller heatsink and airflow

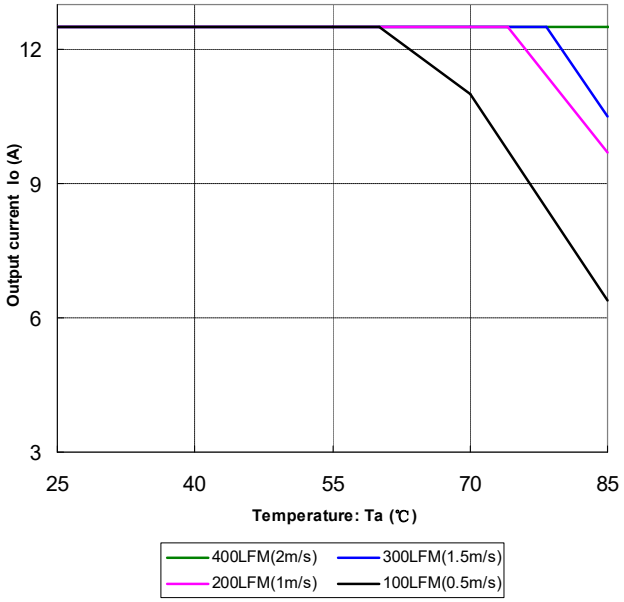


Figure 13 Output power derating, 48Vin

ENVIRONMENTAL SPECIFICATIONS

Qualification Testing

Parameter	Unit (pcs)	Test condition
Halt test	4-5	$T_{a,min}$-10 ^{O}C to $T_{a,max}$+10 ^{O}C, 5 ^{O}C step, V_{in} = min to max, 0 ~ 105% load
Vibration	3	Frequency range: 5Hz ~ 20Hz, 20Hz ~ 200Hz, A.S.D: 1.0m^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	-40 ^{O}C to 100 ^{O}C, unit temperature 20cycles
Thermal Cycling	3	-40 ^{O}C to 55 ^{O}C, temperature change rate: 1^{O}C/min, cycles: 2cycles
Humidity	3	40 ^{O}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.

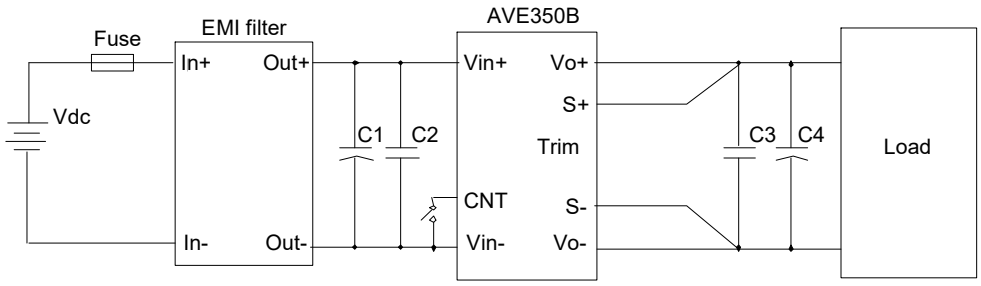


Figure 14 Typical application

C1: 220μF/100V electrolytic capacitor, P/N: UPM2A221MHD (Nichicon) or equivalent caps

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

C4: 750μF/50V electrolytic capacitor (150uF*5pcs), P/N: UUD1H151MNL1GS (Nichicon) or equivalent caps

Note: If ambient temperature is below -5 ^{O}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.

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APPLICATION NOTES

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.

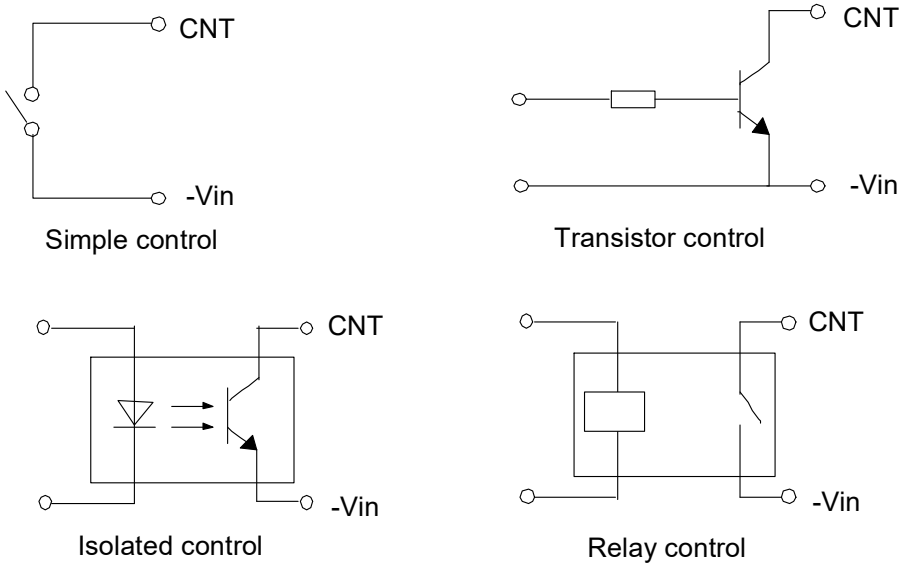

Figure 15 Remote ON/OFF internal diagram

APPLICATION NOTES

Trim Characteristics

Connecting an external resistor between Trim and Vo- 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.

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

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

Δ: Output rate against nominal output voltage.

V_{norm}: Nominal output voltage.

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

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

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 voltage applied at the trim pin and Vo-, 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 the following figure 16.

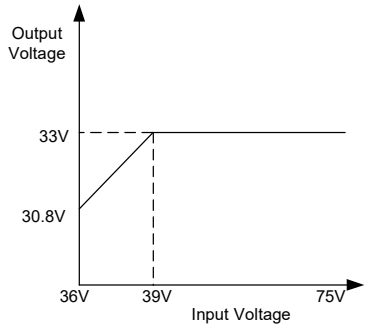

Figure 16 Max trim-up voltage vs. input voltage

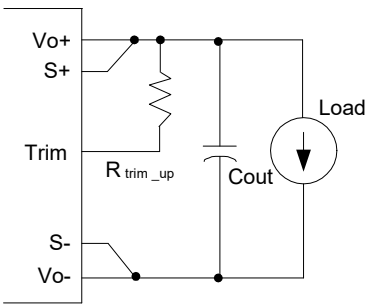

Figure 17 Trim up

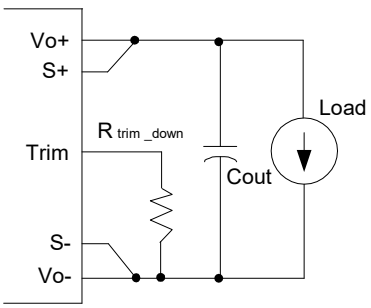

Figure 18 Trim down

APPLICATION NOTES

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 for details.

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

Inrush Current, Input and Output Ripple & Noise Test Configuration

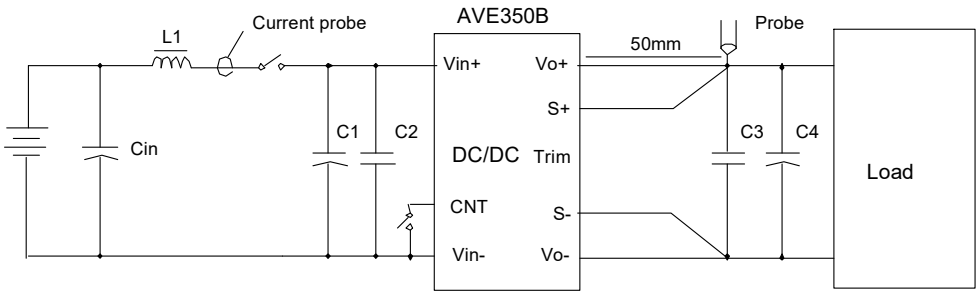

Figure 19 Input ripple & inrush current, output ripple & noise test configuration

Vdc: DC power supply

L1: 12uH inductor

Cin: 220uF/100V electrolytic capacitor

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.

SOLDERING INFORMATION

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 similative.

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
1.6	10.13.2017	Update the OVP mode	A. Zhang
1.7	02.26.2020	Update RoHS status	C.Liu
1.8	12.08.2020	Update Trim Range Typo	K. Wang
1.9	07.22.2021	Update AE template	V. Guo

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.

PRECISION | POWER | PERFORMANCE

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