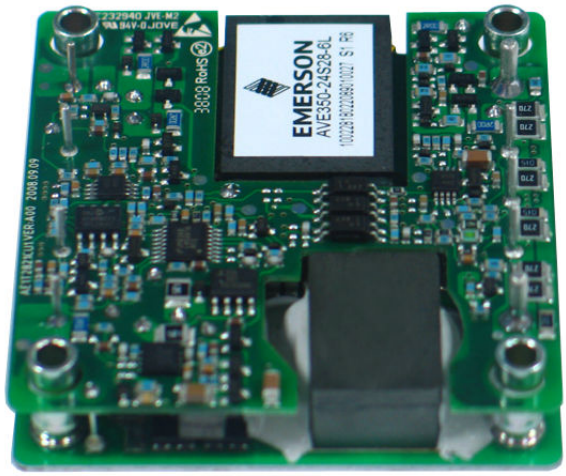
24Vdc Input, 28Vdc@12.5A Output Half-brick DC-DC Converter AVE350-24S28

Description

The AVE350-24S28 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 94% ultra-high efficiency and excellent thermal performance makes it an ideal choice to supply power to a power amplifier in telecom and datacom. Thanks to the aluminium baseplate it can work under -40°C ~ +85°C without air cooling.



Operational Features

- Delivering up to 12.5A output current
- Ultra-high efficiency 94% typ. at half load
- Wide input range: 18V ~ 36V
- Excellent thermal performance
- No minimum load requirement
- RoHS 6 compliant

Control Features

- Remote control function (negative or positive logic optional)
- Remote output sense
- Trim function: 50% ~ 118%

Protection Features

- Input under voltage lockout
- Output over current protection
- Output over voltage protection
- Over temperature protection

Mechanical Features

- Industry standard half-brick pin-out outline
- With baseplate
- Pin length option: 3.8mm

Safety & EMC

- Meets safety standards UL 60950-1, CSA-C22.2 NO. 60950-1, IEC/EN 60950-1 and GB4943
- Approved by UL and TUV
- Meets 2006/95/EEC and 93/68/EEC directives which facilitates CE marking in user's end product
- Meets conducted emission's requirements of EN55022 Class A with external filter

Electrical Characteristics

Full operating ambient temperature range is -40°C to +85°C.
Specifications are subject to change without notice.

Parameter		Min.	Typ.	Max.	Unit	Notes & Conditions
Absolute max. ratings						
Input voltage	Non-operating			50	V	100ms
	Operating			40	V	Continuous
Operating temperature		-40		85	°C	
Storage temperature		-55		125	°C	
Voltage at remote ON/OFF pin		-0.3		15	V	
Input characteristics						
Operating input voltage range		18	24	36	V	
Input under-voltage lockout	Turn-on voltage threshold	16	17	18	V	
	Turn-off voltage threshold	15	16	17	V	
	Lockout voltage hysteresis	0.5			V	
Max. input current				22	A	18V_{in}, output 350W
No-load input current				0.25	A	
Standby Input current				0.02	A	Remote OFF
Input reflected ripple current			50	300	mA_{rms}	Through 12μH inductor; Figure 15 24Vin, output:28V/12.5A
Recommended input fuse				30	A	Fast blow external fuse recommended; Figure 10
Input filter component values (C\L)			28/0.56		μF\μH	Internal values
Recommended external input capacitance			470		μF	Low ESR capacitor recommended; Figure 10
Output characteristics						
Output voltage set point (standard option)		27.72	28	28.28	V	24V_{in}, half load
Output voltage line regulation			0.05	0.5	%	
			14	140	mV	
Output voltage load regulation			0.1	0.5	%	
			28	140	mV	

Parameter		Min.	Typ.	Max.	Unit	Notes & Conditions
Output voltage temperature regulation			0.005	0.02	%/°C	
Total output voltage range		27.16	28	28.84	V	Over sample, line, load, temperature & life
Output voltage ripple and noise			100	300	mVpp	Figure 2 20MHz bandwidth; Figure 15
Operating output current range		0		12.5	A	Module can work in 30V/13.3A stably
Output DC current-limit inception		13.5		17.5	A	Foldback: see Figure 9
Output capacitance		470	680	4000	μF	High frequency and low ESR is recommended
Dynamic characteristics						
Dynamic response	50% ~ 75% ~ 50% $I_{o,max}$, 0.1A/μs		480		mV	Figure 4 Test condition: 25°C, nominal input voltage, see Figure 10
	Settling time		160		μs	Recovery to within 1% $V_{o,nom}$
Turn-on transient	Rise time		60	100	ms	Full load, Figure 5
	Turn-on delay time		20	40	ms	
	Output voltage overshoot		0	1	%V_o	
Efficiency						
100% load			92.7		%	Figure 1
50% load			94		%	Figure 1

Electrical Characteristics (Continued)

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Isolation characteristics					
Isolation voltage (conditions: 1mA for 60s, slew rate of 1500V/10s)	1500			V	Basic insulation, pollution degree 2, input to output
	1500			V	Basic insulation, pollution degree 2, input to baseplate
	500			V	Basic insulation, pollution degree 2, output to baseplate
Feature characteristics					
Switching frequency	200	220	240	kHz	

Parameter		Min.	Typ.	Max.	Unit	Notes & Conditions
Remote ON/OFF control (positive logic)	Off-state voltage	-0.3		0.8	V	See Figure 11
	On-state voltage	2.4		15	V	
Remote ON/OFF control (negative logic)	Off-state voltage	2.4		15	V	See Figure 11
	On-State Voltage	-0.3		0.8	V	
Output voltage trim range		14		33	V	See *Trim Characteristics* of *Application Note*
Output voltage remote sense range				0.5	V	
Output over-voltage protection		125	135	150	$\%V_{o,nom}$	Latch: remain latched after OVP shutdown untill power on or remote ON
Over-temperature shutdown		105	110		°C	Auto recovery; Test point: see Figure 18
Over-temperature hysteresis		5			°C	
Reliability characteristics						
Calculated MTBF (telcordia)			1.0		10^6h	Board@25°C, normal input/output Bellcore, TR332 method 1, case 3

Qualification Testing

Parameter	Unit (pcs)	Test condition
Halt test	4 ~ 5	$T_{a,min}$-10°C to $T_{a,max}$+10°C, 5°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/axis
Mechanical shock	3	30g, 6ms, 3axes, 6directions, 3time/direction
Thermal shock	3	-40°C to 100°C, unit temperature 20cycles
Thermal cycling	3	-40°C to 85°C, temperature change rate: 1°C/min, cycles: 2cycles
Humidity	3	40°C, 95%RH, 48h
Solder ability	15	IPC J-STD-002C-2007

Characteristic Curves

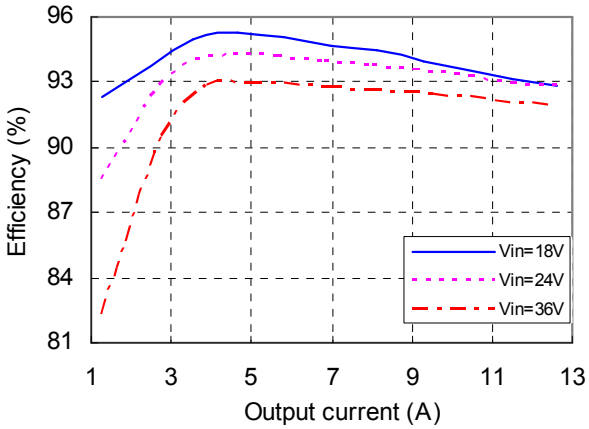


Figure 1 Efficiency vs. output current, T_a=25°C, T_c<40°C ,V_o=28V

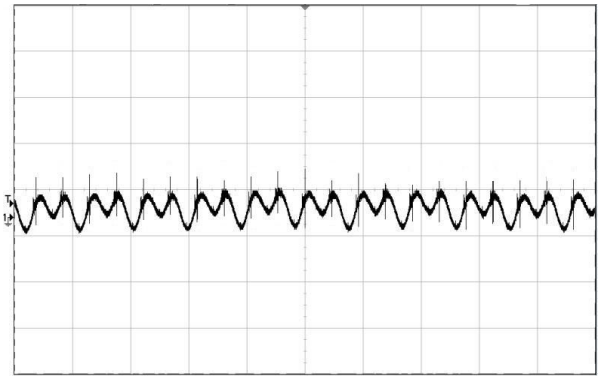


Figure 2 Output ripple & noise (10μs/div, 100mV/div), see Figure 15 for test configuration

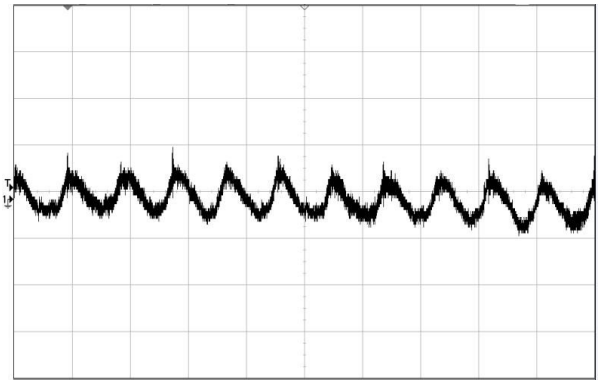


Figure 3 Input reflected ripple current (5μs/div , 10mA/div), see Figure 15 for test configuration

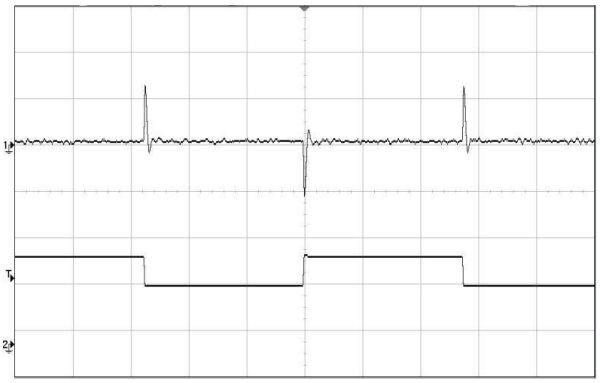


Figure 4 Dynamic response for 25% load step (50% ~ 75% ~ 50%) and 0.1A/μs slew rate, (2ms/div), see Figure 10 for test configuration; CH1-output voltage (200mV/div); CH2-output current (10A/div)

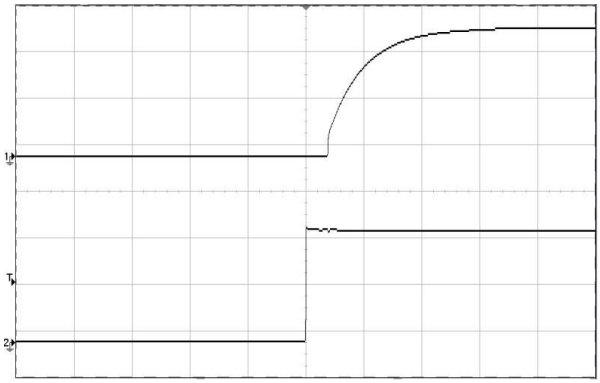


Figure 5 Output voltage startup by power on, (50ms/div), see Figure 10 for test configuration; CH1-output voltage (10V/div); CH2-intput voltage (10V/div)

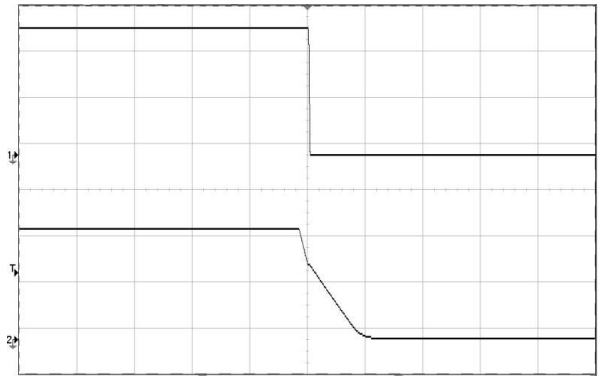


Figure 6 Output voltage shut down by power off, (50ms/div), see Figure 10 for test configuration; CH1-output voltage (10V/div); CH2-input voltage (10V/div)

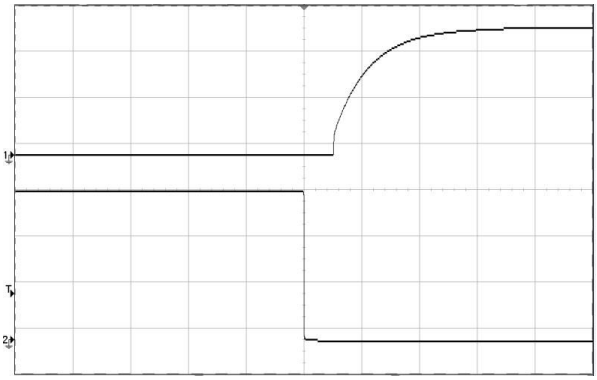


Figure 7 Output voltage startup by remote ON, (50ms/div), see Figure 10 for test configuration; CH1-output voltage (10V/div); CH2-remote ON (2V/div)

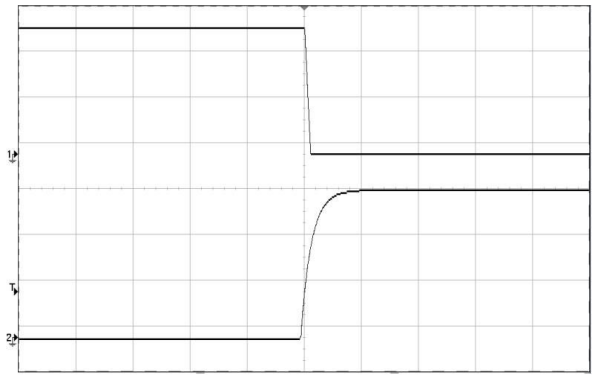


Figure 8 Output voltage shutdown by remote OFF, (10ms/div), see Figure 10 for test configuration; CH1-output voltage (10V/div); CH2-remote OFF voltage (2V/div)

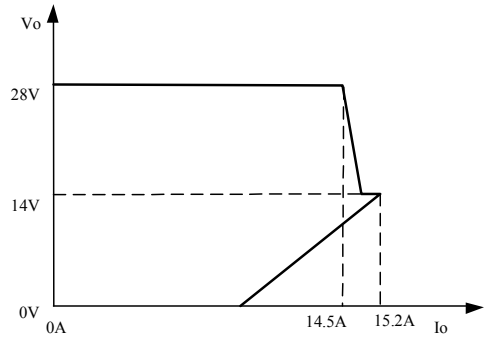


Figure 9 Over-current protection characteristics

Application Note

Typical Application

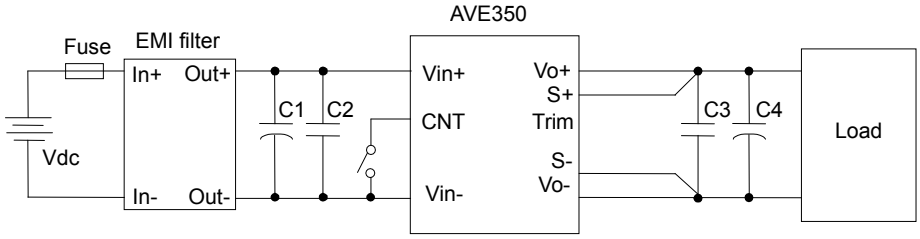


Figure 10 Typical application

C1: 470μF/100V electrolytic capacitor, P/N: UPW2A471MHD (Nichicon) or equivalent caps
C2, C3: 1μF/100V X7R ceramic capacitor, P/N: C3225X7R2A105KT0L0U (TDK) or equivalent caps
C4: 680μF/63V electrolytic capacitor, P/N: UPW1J681MHD(Nichicon) or equivalent caps
Note: If ambient temperature is below -5°C, additional 680μF electrolytic capacitor (Low ESR） is needed for output.
Fuse: External fast blow fuse with a rating of 30A. The recommended fuse model is 314030 from LITTLEFUSE.

Remote ON/OFF

Either positive or negative remote ON/OFF logic is available in AVE350-24S28. The logic is CMOS and TTL compatible.
The following figure is the detailed internal circuit and reference in AVE350-24S28.

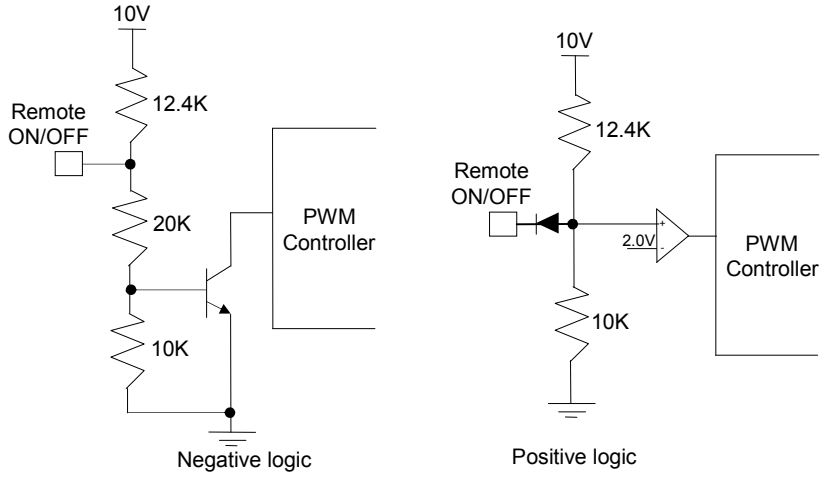


Figure 11 Remote ON/OFF internal diagram

Trim Characteristics

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

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

$$R_{adj_up} = (\frac{V_O(100\% + \Delta\%)}{1.225 \times \Delta\%} - \frac{100\% + 2 \times \Delta\%}{\Delta\%})k\Omega$$

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

V_{norm} : Nominal output voltage.

For example, to get 33V output, the trimming resistor is

$$R_{adj_up} = (\frac{33}{1.225 \times (33-28)/28} - \frac{100\% + 2 \times (33-28)/28}{(33-28)/28}) = 143.26k\Omega$$

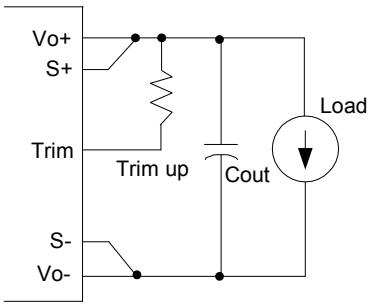


Figure 12 Trim up

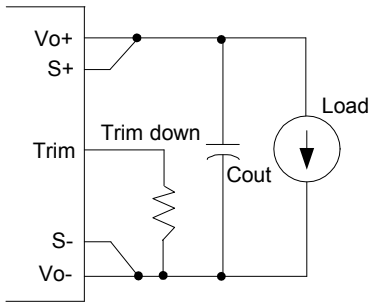


Figure 13 Trim down

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

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

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 figure14.

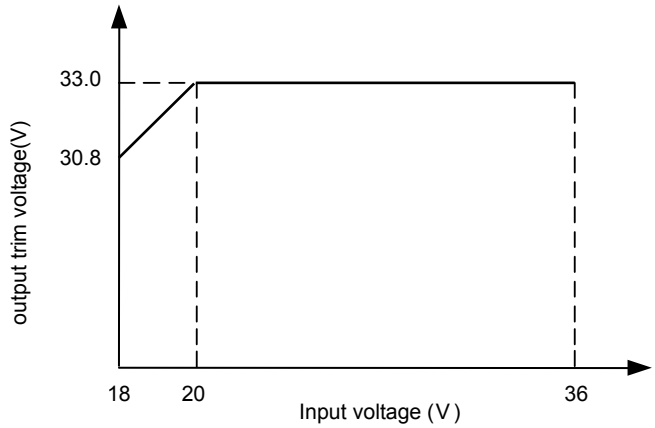


Figure 14 Output trim voltage vs. input voltage

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 10.
If the sense compensate function is not necessary, connect S+ to V_o+ and S- to V_o- directly.

Input Ripple & Inrush Current And Output Ripple & Noise Test Configuration

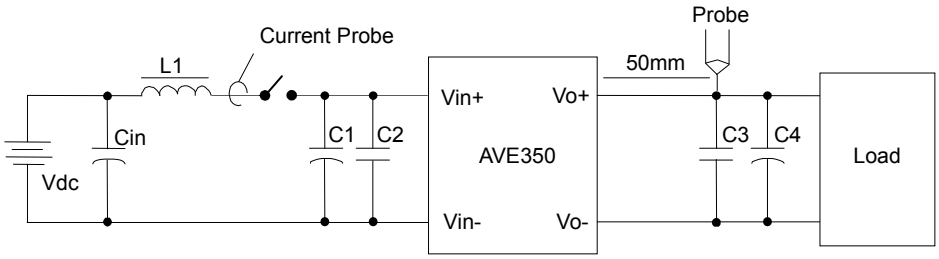


Figure 15 Input ripple & inrush current, ripple & noise test configuration

Vdc: DC power supply
L1: 12μH
Cin: 220μF/100V typical
C1 ~ C4: See Figure 10
Note: Using a coaxial cable with series 50Ω resistor and 0.68μF ceramic capacitor or a ground ring of probe to test output ripple & noise is recommended.

EMC Filter Configuration

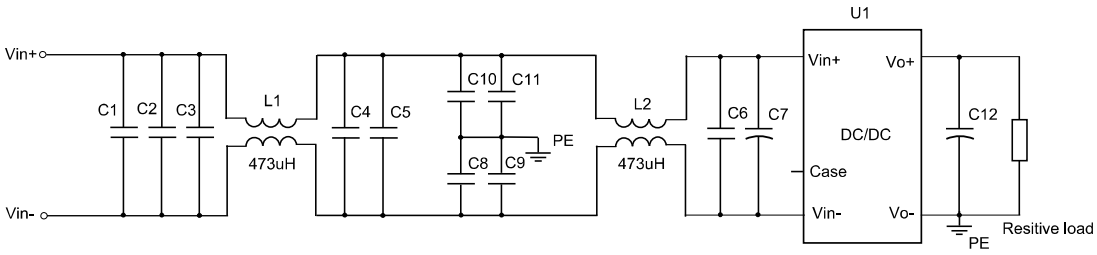
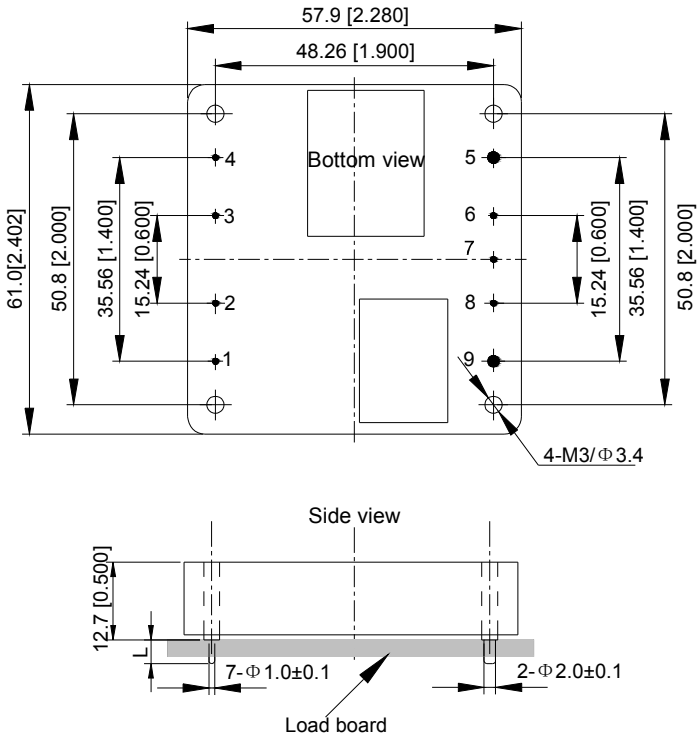


Figure 16 EMC test configuration

U1: Module to test, AVE350-24S28
C1 ~ C5: 1uF/100V X7R ceramic capacitor, P/N: C3225X7R2A105KT (TDK) or equivalent caps
C6:0.1uF/100V X7R ceramic capacitor, P/N: 12101C104JAT2A (AVX) or equivalent caps
C8 ~ C11: 0.22uF/630V X7R ceramic capacitor, P/N: 2220CC224KA11A (AVX) or equivalent caps
C7: 470μF/100V electrolytic capacitor, P/N: UPW2A471MHD (Nichicon) or equivalent caps
C12:680uF/63V electrolytic capacitor, P/N: UPW1J681MHD(Nichicon) or equivalent caps
PE: Connect to Vo-
Case：Not connected

Mechanical Diagram



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.]

Figure 17 Mechanical diagram

Pin length option

Device code suffix	L
-4	4.8mm±0.2mm
-6	3.8mm±0.2mm
-8	2.8mm±0.2mm
None	5.8mm±0.2mm

Pin Designations

Pin NO.	Name	Function
1	V_{in}+	Positive input voltage
2	CNT	Remote control
3	Case	Pin connected to baseplate
4	V_{in}-	Negative input voltage
5	V_o-	Negative output voltage
6	S-	Negative sense
7	Trim	Output voltage trim
8	S+	Positive sense
9	V_o+	Positive output voltage

Soldering

The product is intended for standard manual or wave soldering.
When wave soldering is used, the temperature on pins is specified to maximum 260°C for maximum 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.

Thermal Considerations

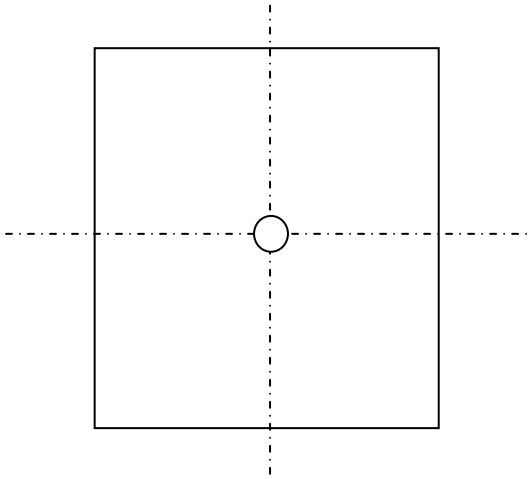


Figure 18 Temperature test point on baseplate

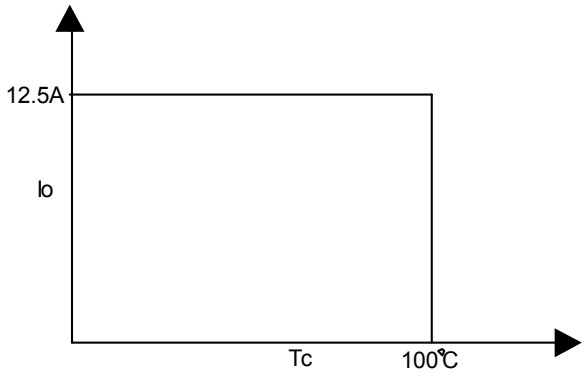


Figure 19 Output power derating, $24V_{in}$

T_c: temperature test point on baseplate, see Figure 18 for test configuration

Ordering Information

AVE350	-	24	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	24: 18V ~ 36V input range, rated input voltage 24V
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	Structure	Default: through hole; M: screw thread

Model number	Description
AVE350-24S28-6L	3.8mm pin length; negative on/off logic; without thread inside mounting hole; R6 compliant
AVE350-24S28P-6L	3.8mm pin length; positive on/off logic; without thread inside mounting hole; R6 compliant
AVE350-24S28-6L/M	3.8mm pin length; negative on/off logic; with thread inside mounting hole; R6 compliant
AVE350-24S28P-6L/M	3.8mm pin length; positive on/off logic; with thread inside mounting hole; R6 compliant
AVE350-24S28-6Y	3.8mm pin length; negative on/off logic; without thread inside mounting hole; R5 compliant

Hazardous Substances Announcement (RoHS Of China)

Parts	Hazardous substances					
	Pb	Hg	Cd	Cr^{6+}	PBB	PBDE
AVE350-24S28	○	○	○	○	○	○

○: 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

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

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Тел: +7 (812) 336 43 04 (многоканальный)
Email: org@lifeelectronics.ru

www.lifeelectronics.ru