

## AVO250-48S28B

**250 Watts**

**Eighth-brick Converter**

**Total Power:** 250 Watts  
**Input Voltage:** 36 to 75 Vdc  
**# of Outputs:** Single

### Special Features

- Delivering up to 9A output current
- Ultra-high efficiency 93% typ. at full load
- Wide input range: 36V ~ 75V
- Excellent thermal performance
- No minimum load requirement
- Basic isolation
- High power density
- Low output noise
- Reflow soldering-able
- RoHS 6 compliant
- Remote control function
- Remote output sense
- Trim function: 64% ~ 116%
- Input under voltage lockout
- Output over current protection
- Output short circuit protection
- Output over voltage protection
- Over temperature protection
- Industry standard eighth-brick pin-out outline
- Baseplate

### Safety

IEC/EN/UL/CSA 60950  
CE Mark  
UL/TUV  
EN55022 Class A



### Product Descriptions

The AVO250-48S28B is a single output DC/DC converter with standard eighth-brick form factor and pin configuration. It delivers up to 9A output current with 28V output.

Ultra-high 93% efficiency and excellent thermal performance makes it an ideal choice for using in telecommunication and datacom applications and can operate under an ambient temperature range of -40 °C ~ +85 °C, with full power available when the baseplate of the unit is kept below 100 °C.

### Applications

This family of units has been specifically designed to support the rigors of the supply of power to RF Power Amplifiers in small-cell, low power applications in Telecommunication applications.

The small form-factor, baseplate construction are exceptionally well suited for such applications where small space and contact-cooling are essential attributes required of the DCDC converter. Add this to the wide output trim range of 18V to 32V means that this unit is extremely versatile in the applications that it can address.

Typically, this unit is used along side a member of the AVD (1/16<sup>th</sup> brick) family of DCDC converters to provide the lower voltage required to supply power to digital circuitry present in such RF Power-Amplifier applications.

## Model Numbers

Standard	Output Voltage	Structure	Remote ON/OFF logic	RoHS Status
AVO250-48S28PB-6L	28Vdc	Baseplate	Positive	R6
AVO250-48S28B-6L	28Vdc	Baseplate	Negative	R6

## Ordering information

AVO250	-	48	S	28	P	B	-	6	L
①		②	③	④	⑤	⑥		⑦	⑧

①	Model series	AVO: series name , 250:output power 250W
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 logic; P: positive logic
⑥	Baseplate	B: with baseplate; default: open frame
⑦	Pin length	S: SMT; 6: 3.8mm ± 0.25mm
⑧	RoHS status	Y: Rohs, R5; L: RoHS, R6

## 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	All	$V_{IN,DC}$	-	-	80	Vdc
Operating -Continuous	All		-	-	100	Vdc
Non-operating -100mS						
Maximum Output Power	All	$P_{O,max}$	-	-	250	W
Ambient Operating Temperature	All	$T_A$	-40	-	+85	°C
Isolation Voltage <sup>1</sup>	All		1500	-	-	Vdc
Input to outputs			1000	-	-	Vdc
Input to metal			500	-	-	Vdc
Output to metal						
Operating baseplate temperature <sup>2</sup>	All		-40		+100	°C
Storage Temperature	All	$T_{STG}$	-55	-	+125	°C
Voltage at remote ON/OFF pin	All		-0.3	-	5	Vdc
Humidity (non-condensing)	All		-	-	95	%
Operating			-	-	95	%
Non-operating						

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

Note 2 - See thermal derating of output power in Table 6.

## 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	$I_O = I_{O,max}$	$V_{IN,ON}$	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 ( $I_O = I_{O,max}$ )	$V_{IN,DC} = 36V_{DC}$	$I_{IN,max}$	-	-	8	A
Recommended Input Fuse	Fast blow external fuse recommended		-	-	15	A
Recommended External Input Capacitance	Low ESR capacitor recommended	$C_{IN}$	220	-	-	uF
Input Reflected Ripple Current	Through 12uH inductor		-	11	-	mA
Operating Efficiency	$T_A = 25^\circ C$ $I_O = 100\% I_{O,max}$ $I_O = 50\% I_{O,max}$ $I_O = 20\% I_{O,max}$	$\eta$	92 92 88	93 93 91	- - -	%

Note 1 -  $T_a = 25^\circ C$ , airflow rate = 400 LFM,  $V_{in} = 48Vdc$ , nominal  $V_{out}$  unless otherwise noted.

## Output Specifications

Table 3. Output Specifications:

Parameter		Condition <sup>1</sup>	Symbol	Min	Typ	Max	Unit
Factory Set Voltage		$V_{IN,DC} = 48V_{DC}$ $I_O = I_{O,max}$	$V_O$	27.72	28	28.28	Vdc
Total Regulation		Inclusive of line, load temperature change, warm-up drift	$V_O$	27.2	28	28.8	Vdc
Output Voltage Line Regulation		All	$\%V_O$	-	-	0.5	%
			$V_O$	-	-	140	mV
Output Voltage Load Regulation		All	$\%V_O$	-	-	0.5	%
			$V_O$	-	-	140	mV
Output Voltage Temperature Regulation		All	$\%V_O$	-	-	0.02	%/°C
Output Voltage Trim Range		All	$V_O$	18	-	32.5	V
Output Ripple, pk-pk		Measure with a 1uF ceramic capacitor in parallel with a 10uF tantalum capacitor, 0 to 20MHz bandwidth	$V_O$	-	40	-	mV <sub>PK-PK</sub>
Output Current		All	$I_O$	0	-	9	A
Output DC current-limit inception <sup>2</sup>			$I_O$	9.9	-	18	A
$V_O$ Load Capacitance <sup>3</sup>		All	$C_O$	680	1000	4400	uF
$V_O$ Dynamic Response  Peak Deviation Settling Time		25% ~ 50% ~ 25% load change slew rate = 0.1A/us	$\pm V_O$ $T_s$	- -	75 0	- -	mV uSec
		50% ~ 75% ~ 50% load change slew rate = 0.1A/us	$\pm V_O$ $T_s$	- -	80 0	- -	mV uSec
Turn-on transient	Rise time	$I_O = I_{max}$	$T_{rise}$	-	60	100	mS
	Turn-on delay time	$I_O = I_{max}$	$T_{turn-on}$	-	60	100	mS
	Output voltage overshoot	$I_O = 0$	$\%V_O$	-	-	5	%

Note 1 -  $T_a = 25^\circ C$ , airflow rate = 400 LFM,  $V_{in} = 48V_{dc}$ , nominal  $V_{out}$  unless otherwise noted.

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		Condition <sup>1</sup>	Symbol	Min	Typ	Max	Unit
Switching frequency		All	$f_{SW}$	-	150	-	KHz
Remote ON/OFF control (Negative logic)	Off-state voltage	All		3.5	-	5	V
	On-state voltage	All		-0.3	-	1.2	V
Remote ON/OFF control (Positive logic)	On-state voltage	All		3.5	-	5	V
	Off-state voltage	All		-0.3	-	1.2	V
Output over-voltage protection <sup>4</sup>		All	$\%V_O$	120	-	135	%
Output over-temperature protection <sup>5</sup>		All	T	100	110	130	°C
Over-temperature hysteresis		All	T	5	-	-	°C
MTBF		Telcordia SR-332-2006; 80% load, 300LFM, 40 °C T <sub>A</sub>		-	1.5	-	10 <sup>6</sup> h

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

Note 5 - Auto recovery.

## AVO250-48S28B Performance Curves

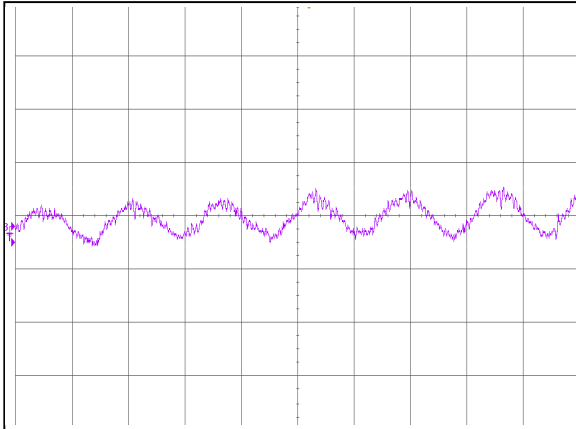


Figure 1: AVO250-48S28B Input Reflected Ripple Current Waveform  
Ch 3: I<sub>in</sub> (2 $\mu$ S/div, 10mA/div)

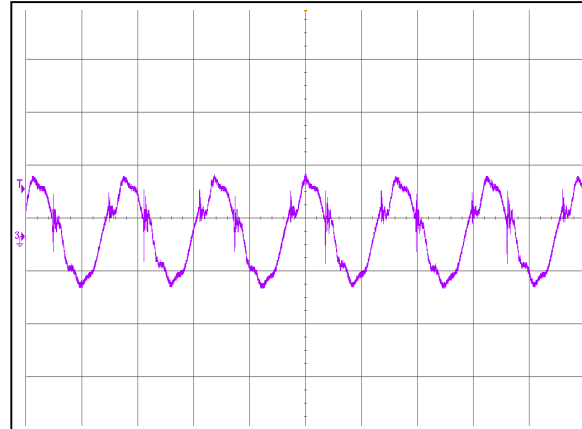


Figure 2: AVO250-48S28B Ripple and Noise Measurement  
Ch 3: V<sub>o</sub> (2 $\mu$ S/div, 20mV/div)

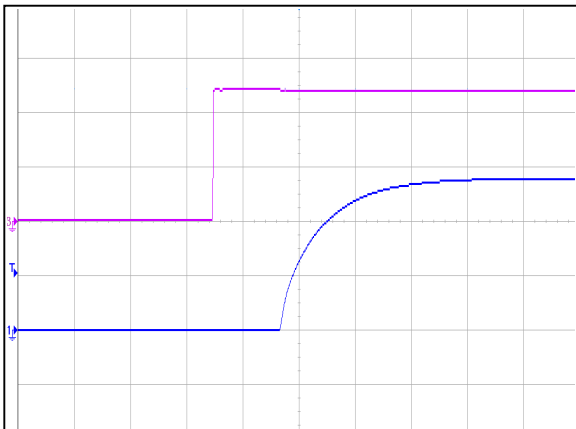


Figure 3: AVO250-48S28B Turn On Characteristic (50ms/div)  
Ch 1: V<sub>in</sub> (20V/div) Ch 3: V<sub>o</sub> (10V/div)

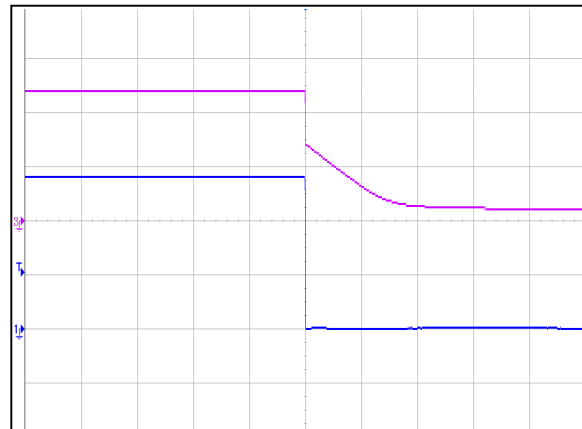


Figure 4: AVO250-48S28B Turn Off Characteristic (1S/div)  
Ch 1: V<sub>in</sub> (20V/div) Ch 3: V<sub>o</sub> (10V/div)

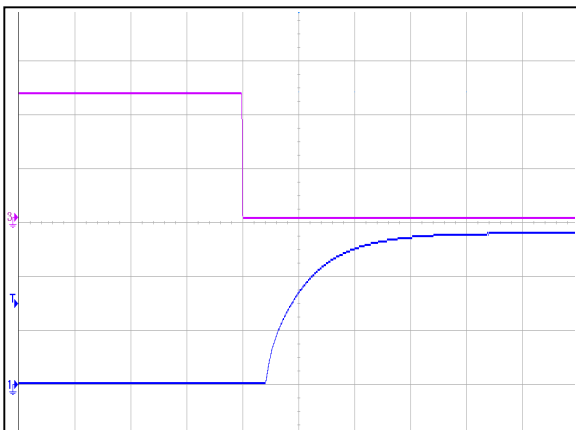


Figure 5: AVO250-48S28B Remote ON Waveform (5mS/div)  
Ch 1: V<sub>o</sub> (10V/div) Ch 3: Remote ON (2V/div)

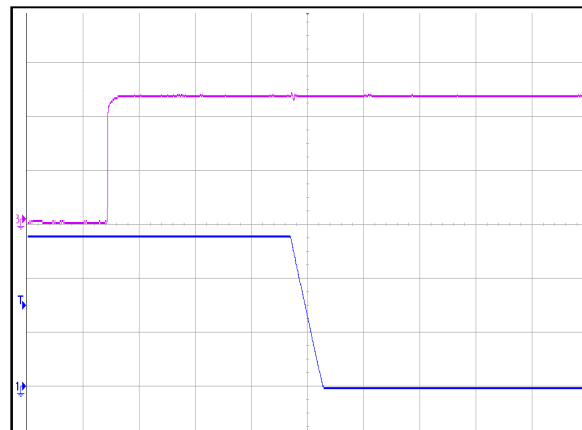


Figure 6: AVO250-48S28B Remote OFF Waveform (50mS/div)  
Ch 1: V<sub>o</sub> (10V/div) Ch 3: Remote OFF (2V/div)



## AVO250-48S28B Performance Curves

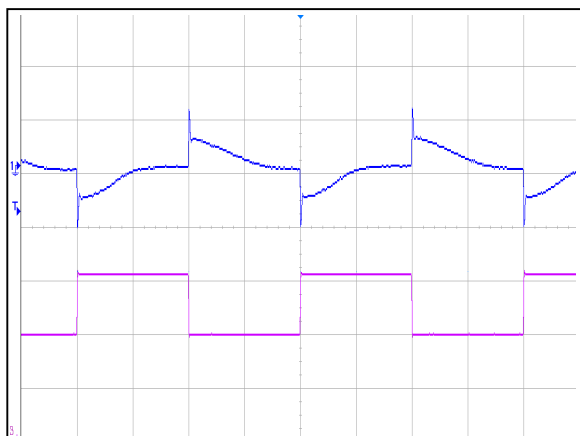


Figure 7: AVO250-48S28B Transient Response (2mS/div)  
25%-50%~25% load change, 0.1A/uS slew rate,  
Ch 1: Vo (50mV/div) Ch 3: Io (2A/div)

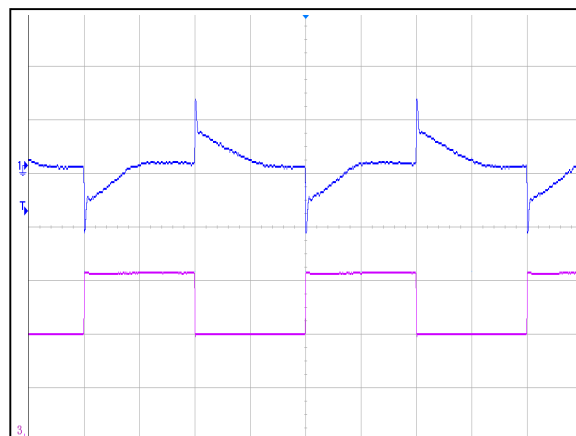


Figure 8: AVO250-48S28B Transient Response (2mS/div)  
50%-75%~50% load change, 0.1A/uS slew rate,  
Ch 1: Vo (50mV/div) Ch 3: Io (2A/div)

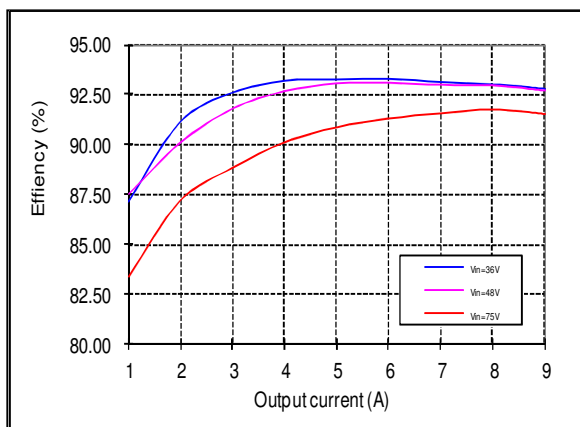


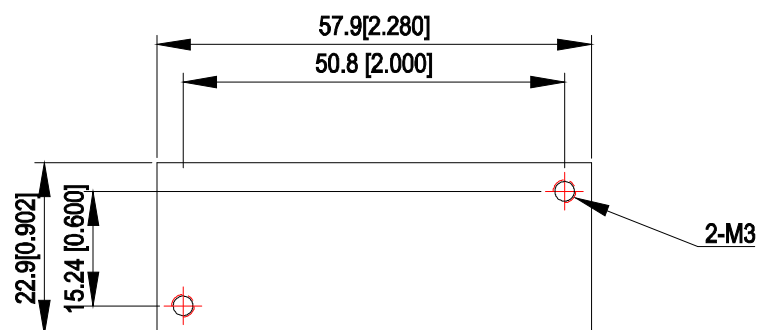
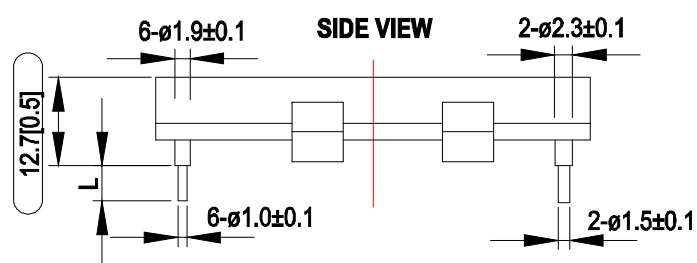
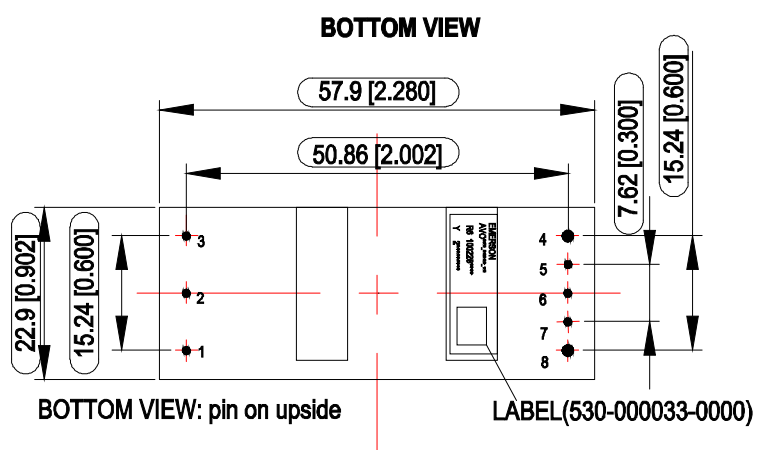
Figure 9: AVO250-48S28B Efficiency Curves @ 25 degC, 400LFM, 28Vo

Loading: Io = 10% increment to 9A



## Mechanical Specifications

### Mechanical Outlines



UNIT: mm[inch] BOTTOM VIEW: pin on upside

TOLERANCE: X.Xmm $\pm$ 0.5mm[X.X in. $\pm$ 0.02in.]

X.XXmm $\pm$ 0.25mm[X.XX in. $\pm$ 0.01in.]

Notes: Dimensions within the box are critical dimensions.

## Pin length option

Device code suffix	L
-4	4.8mm $\pm$ 0.25 mm
-6	3.8mm $\pm$ 0.25 mm
-8	2.8mm $\pm$ 0.25 mm
None	5.8mm $\pm$ 0.25 mm

## Pin Designations

Pin No.	Name	Function
1	$V_{in+}$	Positive input terminal
2	Remote ON/OFF	ON/OFF control terminal
3	$V_{in-}$	Negative input terminal
4	$V_{o-}$	Negative output terminal
5	S-	Negative remote sense
6	Trim	Output voltage trim
7	S+	Positive remote sense
8	$V_{o+}$	Positive output terminal

## Environmental Specifications

### **EMC Immunity**

AVO200-48S05-6L power supply is designed to meet the following EMC immunity specifications:

Table 4. Environmental Specifications:

Document	Criteria	Description
EN55022, Class A Limits	A	Conducted and Radiated EMI Limits
IEC/EN 61000-4-2, Level 3	B	Electromagnetic Compatibility (EMC) - Testing and measurement techniques - Electrostatic discharge immunity test. Enclosure Port
IEC/EN 61000-4-6, Level 2	A	Electromagnetic Compatibility (EMC) - Testing and measurement techniques, Continuous Conducted Interference. DC input port
IEC/EN 61000-4-4, Level3	B	Electromagnetic Compatibility (EMC) - Testing and measurement techniques, Electrical Fast Transient. DC input port.
IEC/EN 61000-4-5	B	Electromagnetic Compatibility (EMC) - Testing and measurement techniques, Immunity to surges - 600V common mode and 600V differential mode for DC ports
EN61000-4-29	B	Electromagnetic Compatibility (EMC) - Testing and measurement techniques, Voltage Dips and short interruptions and voltage variations. DC input port.

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 the 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 Specification

### EMC Test Conditions

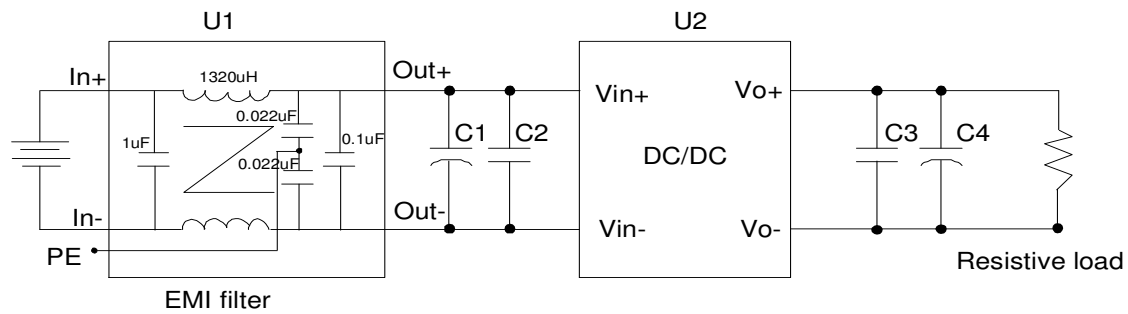


Figure 10 EMC test configuration

U1: Input EMC filter

U2: Module to test, AVO250-48S28B

C1 ~ C4: See Figure 19

### **Safety Certifications**

The AVO250-48S28B 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 AVO200-48S28-6L power supply system:

Document	File #	Description
UL/CSA 60950		US and Canada Requirements
EN60950		European Requirements
IEC60950		International Requirements
CE		CE Marking

## Operating Temperature

The AVO250-48S28B power supply 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 can both operate in two different modes.

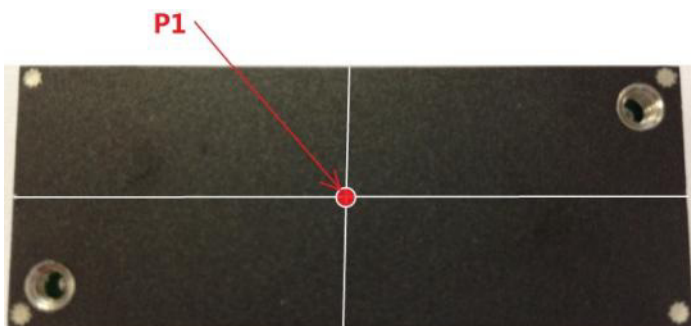
Mode 1: The converter can operate in an enclosed environment without forced air convection. Cooling of the converter is achieved mainly by conduction from the baseplate to a heat sink. The converter can deliver full output power at 85 °C ambient temperature provided the baseplate temperature is kept the max values 100 °C. P1 in Figure 11 is the baseplate test point. Test data listed in Table 6.

Table 6. Thermal derating at different input voltage:

Vin	Output Current (max)
36V	4.8A
48V	4.3A
60V	3.8A
75V	3.1A

Mode 2: 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 11. The temperature at this point should not exceed the maximum values in the table 7.

Test point on baseplate



Test point on PCB

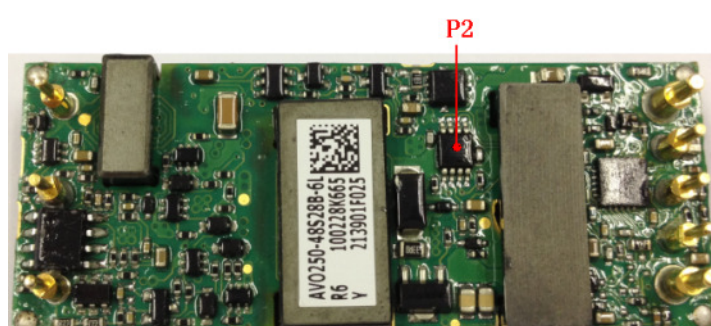


Figure 11 Temperature test points

Table 7. Temperature limit of the test points:

Test point	Temperature limit
P1	113 °C
P2	118 °C

The converter can operate with a smaller heatsink and sufficient airflow. Figure 13 shows the derating output current vs. ambient air temperature at different air velocity with a specified heatsink. Figure 14 shows the thermal image taken by a RF camera at a rated I/O condition.

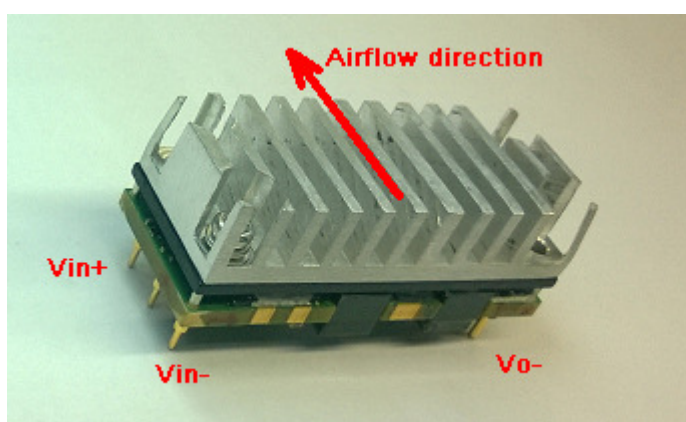


Figure 12-1 Typical test condition, heatsink size (L\*W\*H): 57.9mm\*22.86\*12.7mm

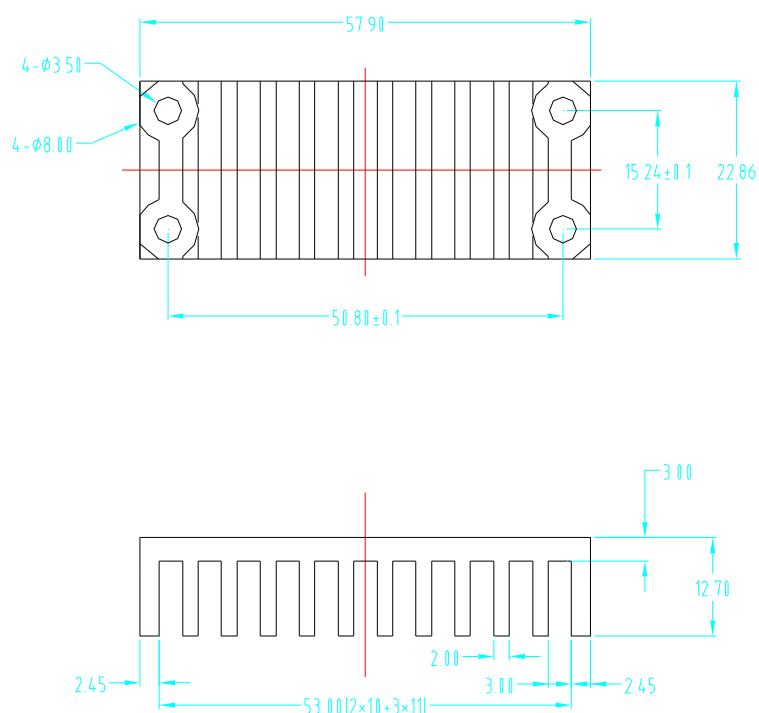


Figure 12-2 Heatsink mechanical diagram



For a typical application, Figure 13 shows the derating of output current vs. ambient air temperature at different air velocity.

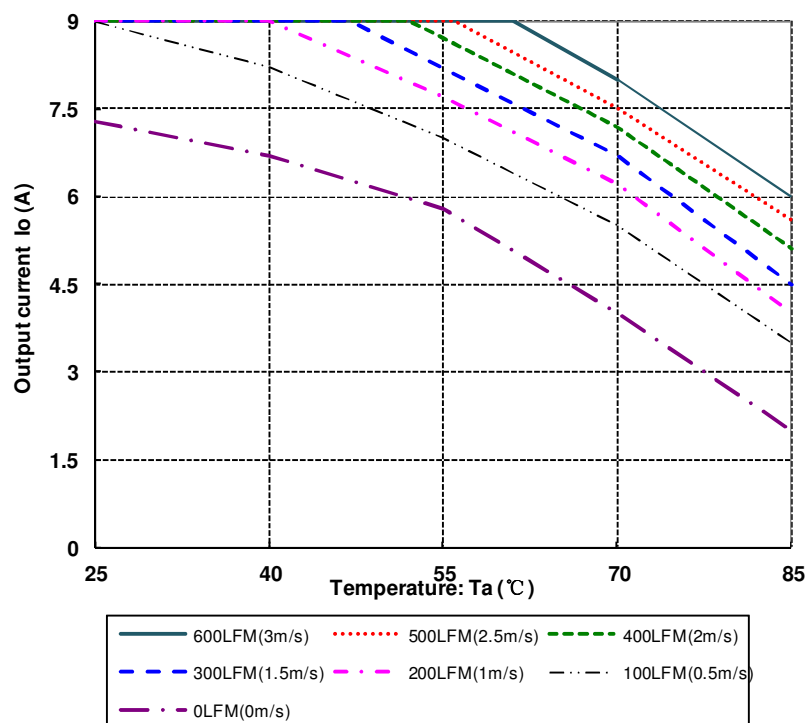


Figure 13 Output power derating,  $48V_{in}$ , air flowing across the converter from pin 3 to pin 1

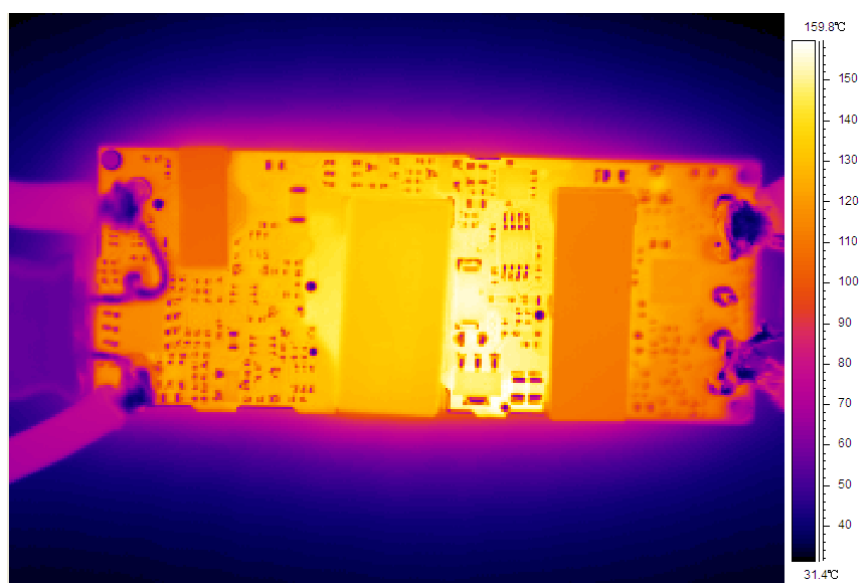


Figure 14 Infrared thermal image,  $48V_{in}$ @full load, 200LFM, 25°C

## Qualification Testing

Table 8. Qualification Testing:

Parameter	Unit (pcs)	Test condition
Halt test	4-5	Ta,min-10 °C to Ta,max+10 °C , 5 °C step, Vin = min to max, 0 ~ 105% load
Vibration	3	Frequency range: 5Hz ~ 20Hz, 20Hz ~ 200Hz, A.S.D: 1.0m2/s3, -3db/oct, axes of vibration: X/Y/Z. Time: 30min/axes
Mechanical Shock	3	30g, 6ms, 3axes, 6directions, 3time/direction
Thermal Shock	3	-40 °C to +100 °C , unit temperature 20 cycles
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

## Application Notes

### Typical Application

Below is the typical application of the AVO250-48S28B power supply.

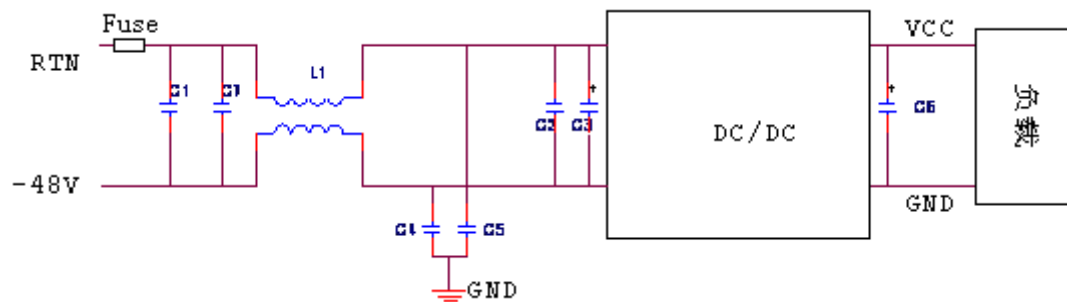


Figure 15 Typical application

C1 C7: SMD ceramic-100V-1000nF-X7R-1210.

C2: SMD ceramic-100V-100nF- $\pm 10\%$ -X7R-1206.

C3: 220 $\mu$ F/100V electrolytic capacitor; P/N: UPM1A221MED or equivalent caps.

C6: 680 $\mu$ F/50V electrolytic capacitor; P/N: UPM1A221MED+ UPM1A471MHD or equivalent caps.

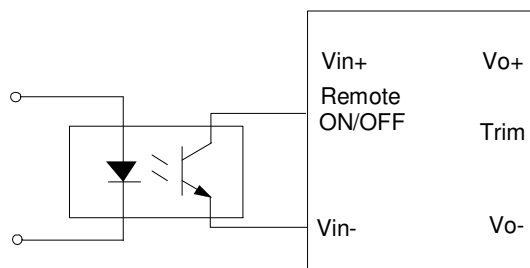
C4 C5: SMD ceramic-0.1U/1000V/X7R- 2220.

L1: 809 $\mu$ H- $\pm 25\%$ -9.7A-R5K-28\*26\*12.7mm.

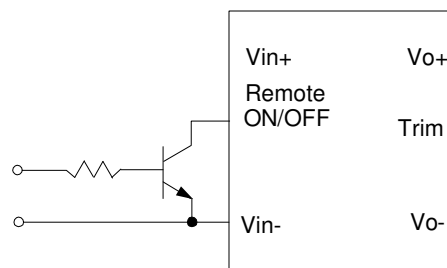
Fuse: External fast blow fuse with a rating of 15A. The recommended fuse model is 0314015.P from LITTLEFUSE.

## Remote ON/OFF

Either positive or negative remote ON/OFF logic is available in AVO250-48S28B. 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 1 to ensure proper operation. The external Remote ON/OFF circuit is highly recommended as shown in figure 16.



Isolated remote ON/OFF circuit



Non-isolated remote ON/OFF circuit

Figure 16 External Remote ON/OFF circuit

## 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.

$$\Delta = \left| \frac{100 \times (V_{nom} - V_o)}{V_{nom}} \right|$$

$V_{nom}$ : Nominal output voltage.

For example, to get 32.5V output, the trimming resistor is

$$\Delta = \frac{100 \times (V_{nom} - V_o)}{V_{nom}} = \frac{100 \times (32.5 - 28)}{28} = 16.07$$

$$R_{adj\_up} = \frac{32.5(100 + 16.07)}{1.225 \times 16.07} - \frac{100\% + 2 \times 16.07\%}{16.07\%} = 189.6(K\Omega)$$

For 1% adjustment resistor, the trimmed output voltage is guaranteed within  $\pm 2\%$ .

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

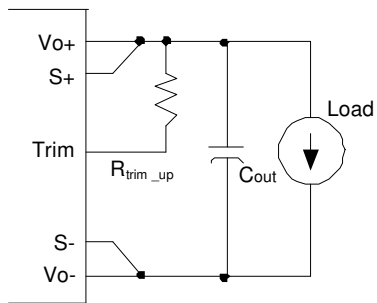


Figure 17 Trim up

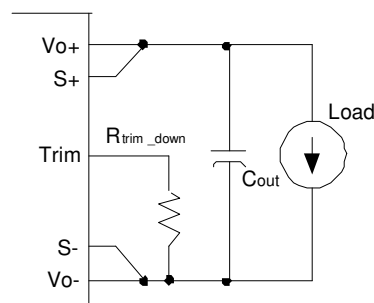


Figure 18 Trim down

For AVO250-48S28B, if the sense compensate function is not necessary, connect S+ to Vo+ and S- to Vo- directly.

## Input Ripple & Output Ripple & Noise Test Configuration

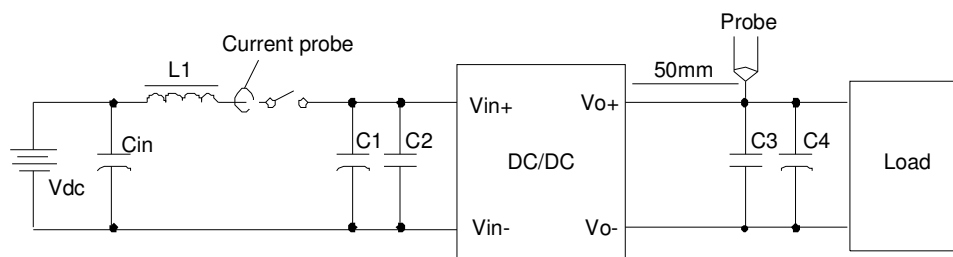


Figure 19 Input ripple & inrush current, output ripple & noise test configuration

$V_{dc}$ : DC power supply

$L1$ : 12 $\mu$ H

$C_{in}$ : 220 $\mu$ F/100V typical

$C1$ : 220 $\mu$ F/100V electrolytic capacitor, High frequency and low ESR

$C2$   $C3$ : SMDceramic-100V-1000nF-X7R-1210

$C4$ : 1000 $\mu$ F/50V electrolytic capacitor, High frequency and low ESR

Note: It is recommended to use a coaxial cable with series 50 $\Omega$  resistor and 0.68 $\mu$ F ceramic capacitor or a ground ring of probe to test output ripple & noise.

### **Soldering**

The product AVO250-48S28B and AVO250-48S28PB-6L are intended for standard manual, reflow or wave soldering.

When reflow soldering is used, the temperature on pins is specified to maximum 260 °C for maximum 10s.

When wave soldering is used, the temperature on pins is specified to maximum 260 °C for maximum 7s.

When manual soldering is used, 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 similitative.



## Hazardous Substances Announcement (RoHS of China)

Parts	Hazardous Substances					
	Pb	Hg	Cd	Cr <sup>6+</sup>	PBB	PBDE
AVO250-48S28B-6	x	x	x	x	x	x
AVO250-48S28PB-6L	x	x	x	x	x	x
<p>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</p> <p>√: 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</p> <p>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:</p> <ol style="list-style-type: none"> <li>1. Solders (including high-temperature solder in parts) contain plumbum.</li> <li>2. Glass of electric parts contains plumbum.</li> <li>3. Copper alloy of pins contains plumbum</li> </ol>						

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