TECHNICAL REFERENCE NOTE

ARTESYN AVO100-48S28 SERIES

100 Watts 1/8 Brick Converter

PRODUCT DESCRIPTION

Advanced Energy's Artesyn AVO100-48S28 series is a single output DC/DC converter with standard eighth-brick form factor and pin configuration. It delivers up to 3.75A output current with 28V output. Ultra-high 92% efficiency and excellent thermal performance makes it an ideal choice to supply power in datacom and telecommunication applications. It can operate over an ambient temperature range of -40°C to +85°C.

AT A GLANCE

Total Power

100 Watts

Input Voltage

36 to 75 Vdc

# of Outputs

Single

RoHS

SPECIAL FEATURES

- Delivering up to 3.57A output
- Ultra-high efficiency 92% typ. at full load
- Wide input range: 36 to 75Vdc
- Excellent thermal performance
- No minimum load requirement
- Basic isolation
- High power density
- Low output noise
- RoHS 3.0 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

SAFETY

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

TYPICAL APPLICATIONS

- Datacom
- Telecom

MODEL NUMBERS

Standard	Output Voltage	Structure	Remote ON/OFF logic	RoHS Status
AVO100-48S28-6L	28Vdc	Open-frame	Negative	RoHS 3.0
AVO100-48S28P-6L	28Vdc	Open-frame	Positive	RoHS 3.0
AVO100-48S28B-6L	28Vdc	Baseplate	Negative	RoHS 3.0
AVO100-48S28PB-6L	28Vdc	Baseplate	Positive	RoHS 3.0

Order Information

AVO100	-	48	S	28	P	B	-	6	L
①		②	③	④	⑤	⑥	⑦	⑧	⑨

①	Model series	AVO: high efficiency sixteenth brick series, 200: output power 200W
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	-	Need "-" for through-hole unit, to separate the data of voltage and pin length, omit for SMT unit
⑧	Pin length	S: SMT; 6: 3.8mm ± 0.25mm
⑨	RoHS status	Y: Rohs, R5; 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	$P_{O,max}$	-	-	100	W
Isolation Voltage[1]						
Input to outputs	All		1500	-	-	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		-0.7	-	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	Condition[1]	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, DC	All	$V_{IN,DC}$	36	48	75	Vdc
Turn-on Voltage Threshold	$I_O = I_{O,max}$	$V_{IN,ON}$	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 ($I_O = I_{O,max}$)	$V_{IN,DC} = 36V_{DC}$	$I_{IN,max}$	-	-	4	A
Recommended Input Fuse	Fast blow external fuse recommended		-	-	8	A
Recommended External Input Capacitance	Low ESR capacitor recommended	C_{IN}	100	-	-	uF
Input Reflected Ripple Current	Through 12uH inductor		-	25	-	mA
Operating Efficiency	T_A=25 °C $I_O = I_{O,max}$ $I_O = 50\%I_{O,max}$ $I_O = 20\%I_{O,max}$	η	91 89 82	92 90 84	- - -	%

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

ELECTRICAL SPECIFICATIONS

Output Specifications

Table 3. Output Specifications

Parameter		Condition[1]	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	%
		All	V_O	-	-	140	mV
Output Voltage Load Regulation		All	$\%V_O$	-	-	0.5	%
		All	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	-	30	-	mV_{PK-PK}
Output Current		All	I_O	0	-	3.57	A
Output DC current-limit inception[2]			I_O	3.75	-	6.43	A
V_O Load Capacitance[3]		All	C_O	470	1000	3300	uF
V_O Dynamic Response	Peak Deviation	25% ~ 50% ~ 25% Io,max load change slew rate = 0.1A/us	$\pm V_O$	-	130	-	mV
	Settling Time		T_s	-	0	-	uSec
	Peak Deviation	50% ~ 75% ~ 50% Io,max load change slew rate = 0.1A/us	$\pm V_O$	-	95	-	mV
	Settling Time		T_s	-	0	-	uSec
Turn-on transient	Rise time	I_O = I_{max}	T_{rise}	-	100	200	mS
	Turn-on delay time	I_O = I_{max}	$T_{turn-on}$	-	20	50	mS
	Output voltage overshoot	I_O = 0	$\%V_O$	-	-	5	%

Note 1 - Ta = 25 °C, airflow rate = 400 LFM, Vin = 48Vdc, nominal Vout unless otherwise indicated.
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		Condition[1]	Symbol	Min	Typ	Max	Unit
Switching frequency		All	f_{SW}	-	280	-	KHz
Remote ON/OFF control (positive logic)	Off-state voltage	All		-0.7		1.2	V
	On-state voltage	All		3.5	-	12	V
Remote ON/OFF control (Negative logic)	Off-state voltage	All		3.5	-	12	V
	On-state voltage	All		-0.7	-	1.2	V
Output over-voltage protection[4]		All	$\%V_O$	120	-	145	%
Output over-temperature protection[5]		All	T	100	110	130	^{O}C
Over-temperature hysteresis		All	T	5	-	-	^{O}C
MTBF		Telcordia SR-332-2006; 80% load, 300LFM, 40 ^{O}C T_A		-	1.5	-	10^6 h

Note 4 - Hiccup: auto-restart when over-voltage condition is removed.
Note 5 - Auto recovery.

ELECTRICAL SPECIFICATIONS

AVO100-48S28-6L Performance Curves

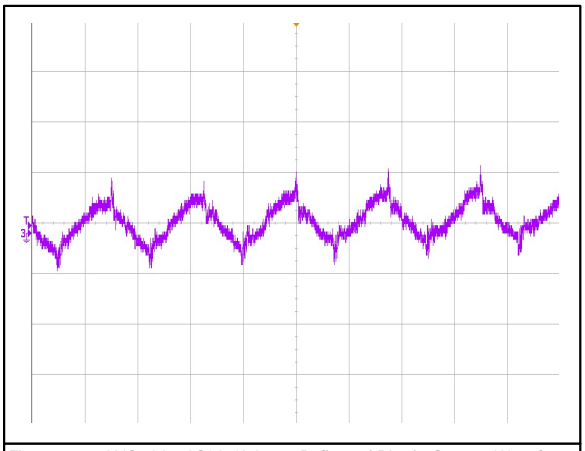


Figure 1: AVO100-48S28-6L Input Reflected Ripple Current Waveform

Ch 3: Iin (2uS/div, 10mA/div)

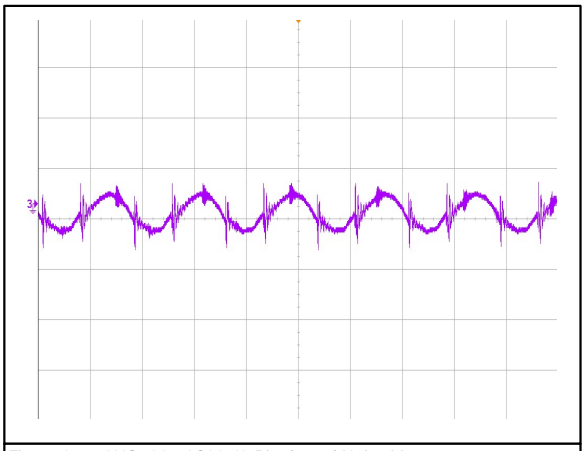


Figure 2: AVO100-48S28-6L Ripple and Noise Measurement

Ch 3: Vo (2us/div, 20mV/div)

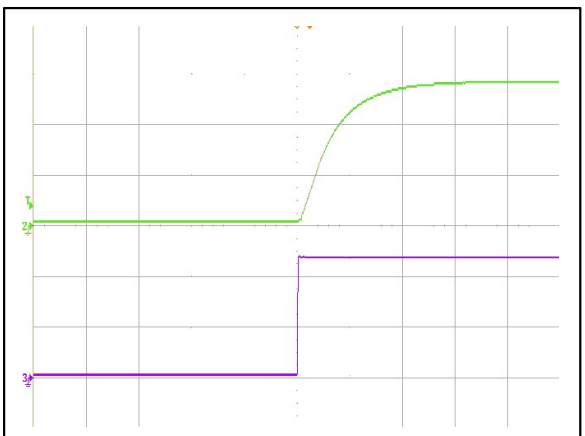


Figure 3: AVO100-48S28-6L Turn on Characteristic (100mS/div)

Ch 2: Vo (10V/div) Ch 3: Vin (20V/div)

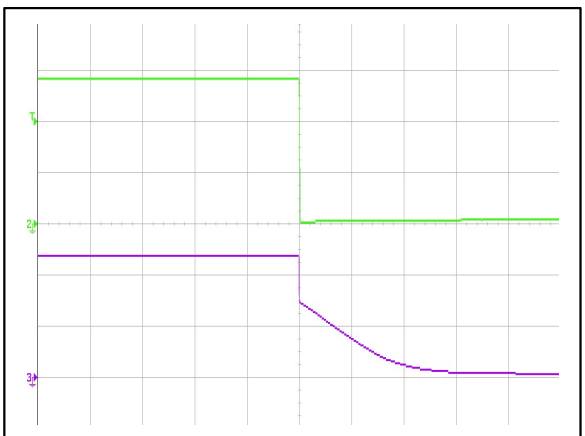


Figure 4: AVO100-48S28-6L Turn Off Characteristic (200mS/div)

Ch 2: Vo (10V/div) Ch 3: Vin (20V/div)

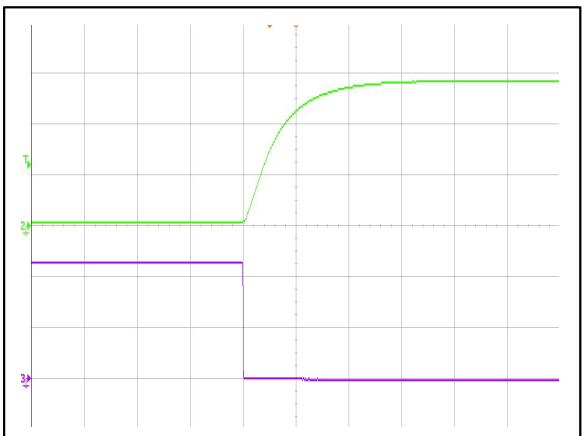


Figure 5: AVO100-48S28-6L Remote ON Waveform (100mS/div)

Ch 2: Vo (10V/div) Ch 3: Remote ON (2V/div)

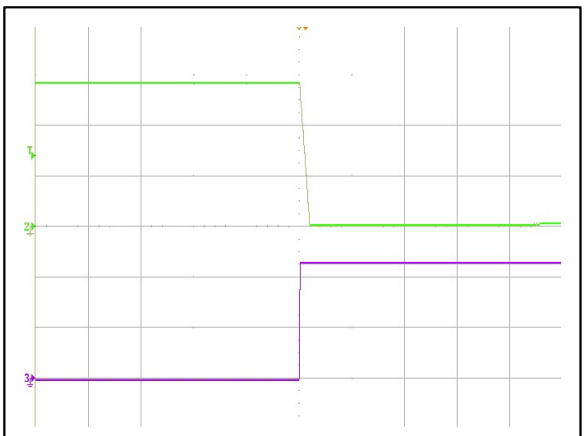


Figure 6: AVO100-48S28-6L Remote OFF Waveform (20mS/div)

Ch 2: Vo (10V/div) CH 3: Remote OFF (2V/div)

ELECTRICAL SPECIFICATIONS

AVO100-48S28-6L Performance Curves

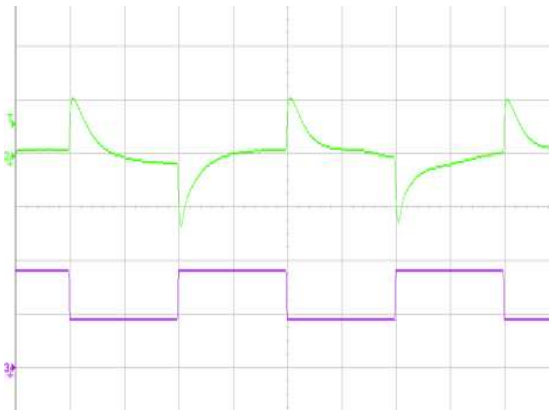


Figure 7: AVO100-48S28-6L Transient Response (2mS/div)
25%~50%~25% load change, 0.1A/uS slew rate,
Ch 2: Vo (100mV/div) Ch 3: Io (1A/div)

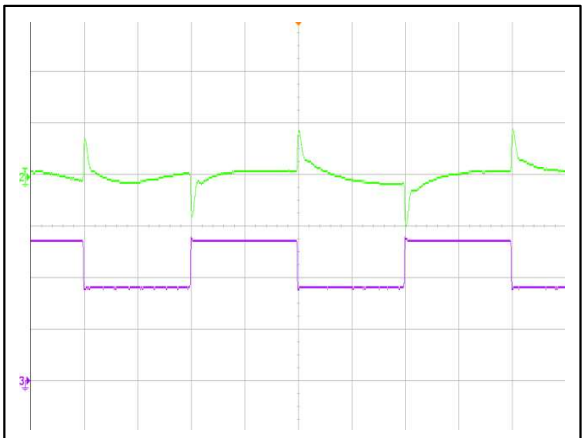


Figure 8: AVO100-48S28-6L Transient Response (2mS/div)
50%~75%~50% load change, 0.1A/uS slew rate,
Ch 2: Vo (100mV/div) Ch 3: Io (1A/div)

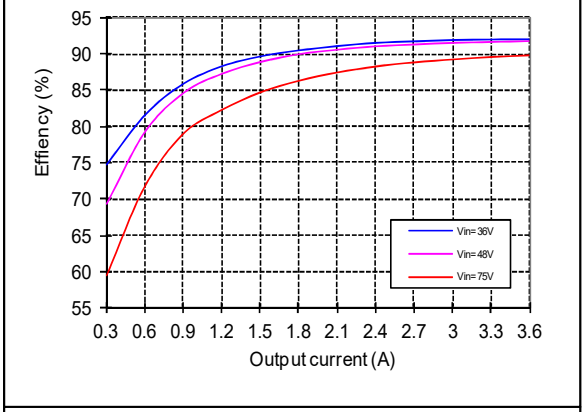


Figure 9: AVO100-48S28-6L Efficiency Curves
@ 25 degC, 400LFM, Vo = 28V
Loading: Io = 10% increment to 3.6A

ELECTRICAL SPECIFICATIONS

AVO100-48S28B-6L Performance Curves

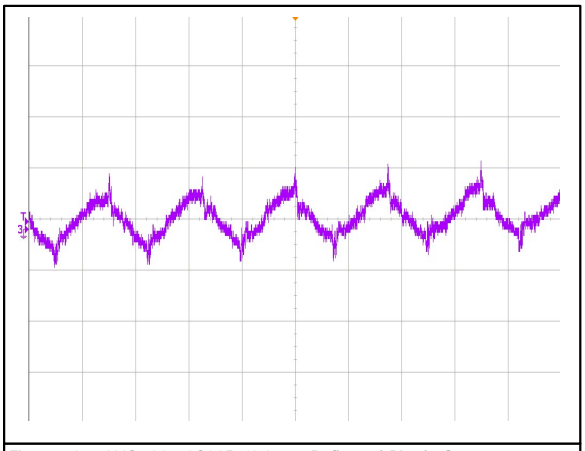


Figure 10: AVO100-48S28B-6L Input Reflected Ripple Current Waveform
Ch 3: Iin (2uS/div, 10mA/div)

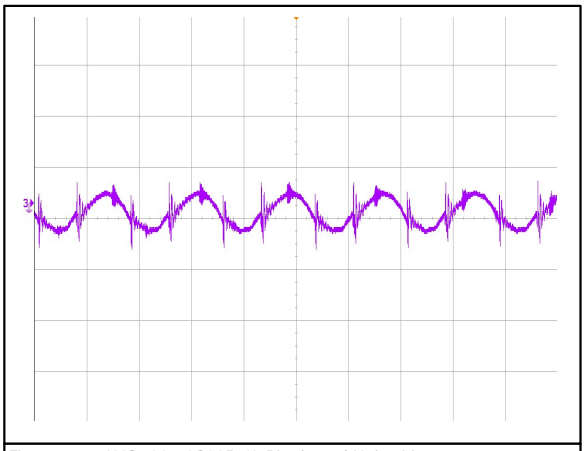


Figure 11: AVO100-48S28B-6L Ripple and Noise Measurement
Ch 3: Vo (2us/div, 20mV/div)

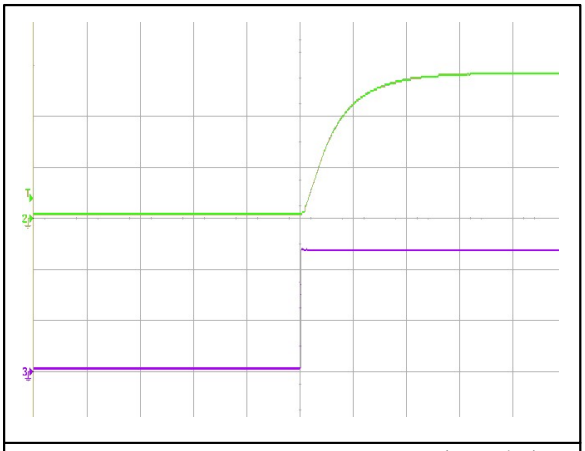


Figure 12: AVO100-48S28B-6L Turn on Characteristic (100mS/div)
Ch 2: Vo (10V/div) Ch 3: Vin (20V/div)

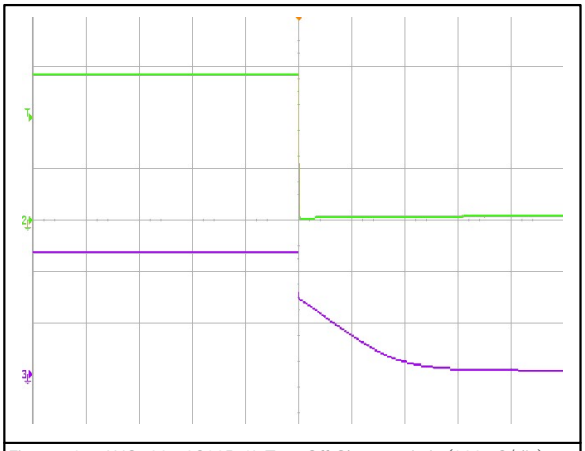


Figure 13: AVO100-48S28B-6L Turn Off Characteristic (200mS/div)
Ch 2: Vo (2V/div) Ch 3: Vin (20V/div)

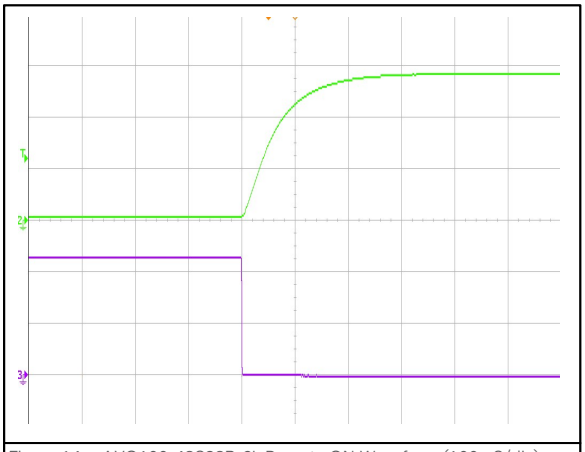


Figure 14: AVO100-48S28B-6L Remote ON Waveform (100mS/div)
Ch 2: Vo (10V/div) Ch 3: Remote ON (2V/div)

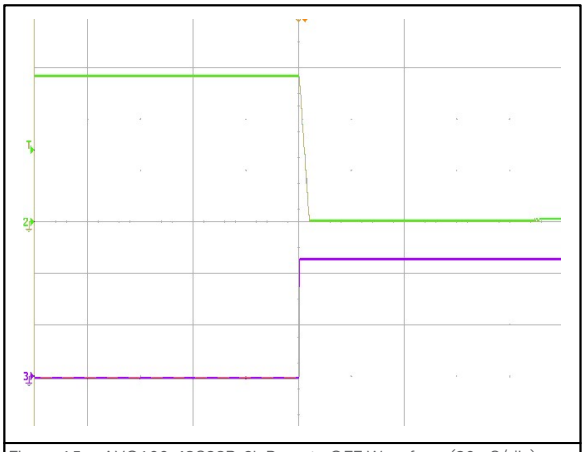


Figure 15: AVO100-48S28B-6L Remote OFF Waveform (20mS/div)
Ch 2: Vo (10V/div) CH3: Remote OFF (2V/div)

ELECTRICAL SPECIFICATIONS

AVO100-48S28B-6L Performance Curves

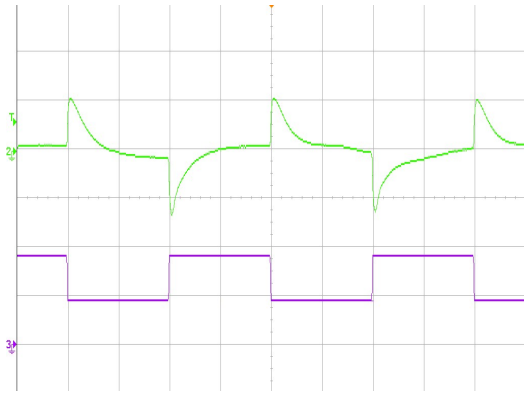


Figure 16: AVO100-48S28B-6L Transient Response (2mS/div)
25%~50%~25% load change, 0.1A/uS slew rate,
Ch 2: Vo (100mV/div) Ch 3: Io (1A/div)

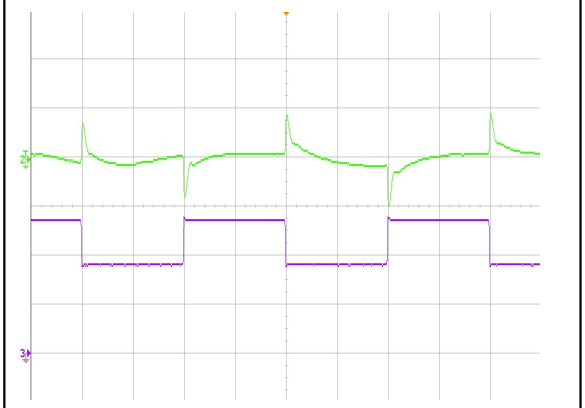


Figure 17: AVO100-48S28B-6L Transient Response (2mS/div)
50%~75%~50% load change, 0.1A/uS slew rate,
Ch 2: Vo (100mV/div) Ch 3: Io (1A/div)

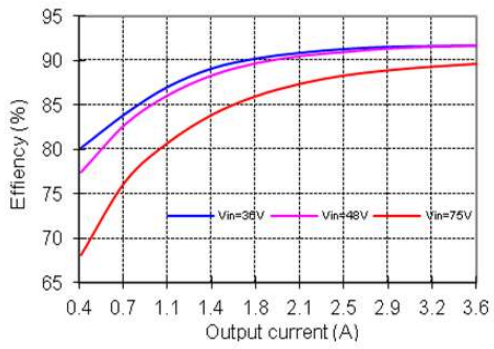
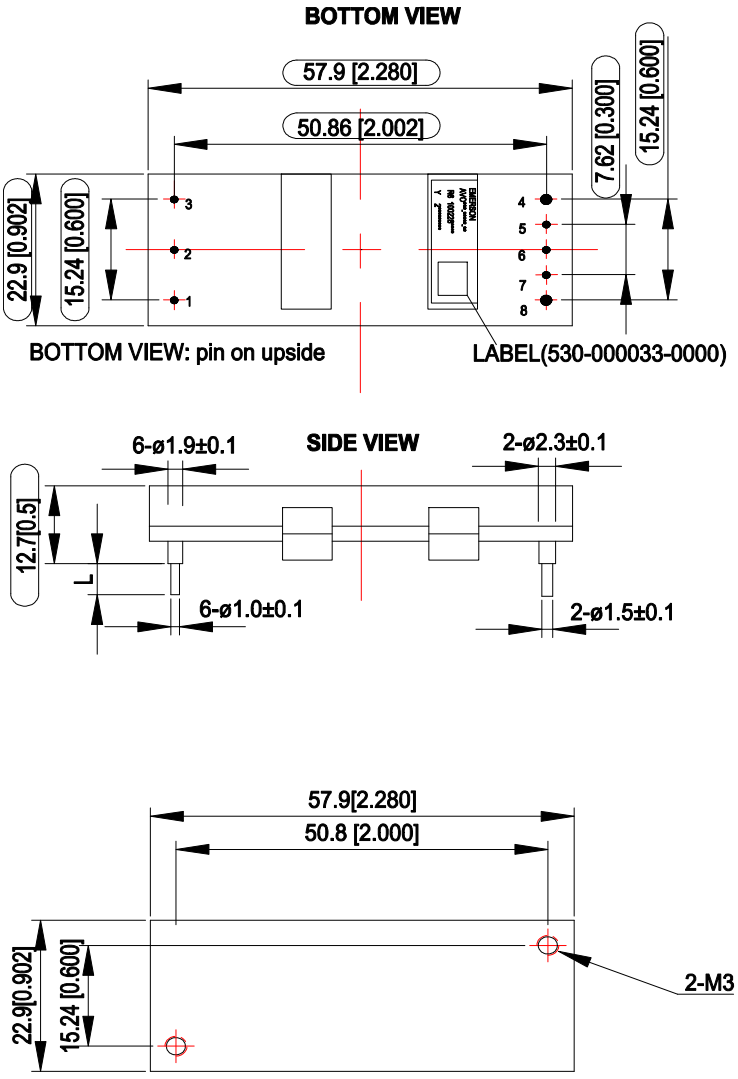


Figure 18: AVO100-48S28-6L Efficiency Curves
@ 25 degC, 400LFM, Vo = 28V
Loading: Io = 10% increment to 3.6A

MECHANICAL SPECIFICATIONS

Mechanical Outlines - Baseplate Module (unit: mm)

AVO100-48S28B-6L



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.]

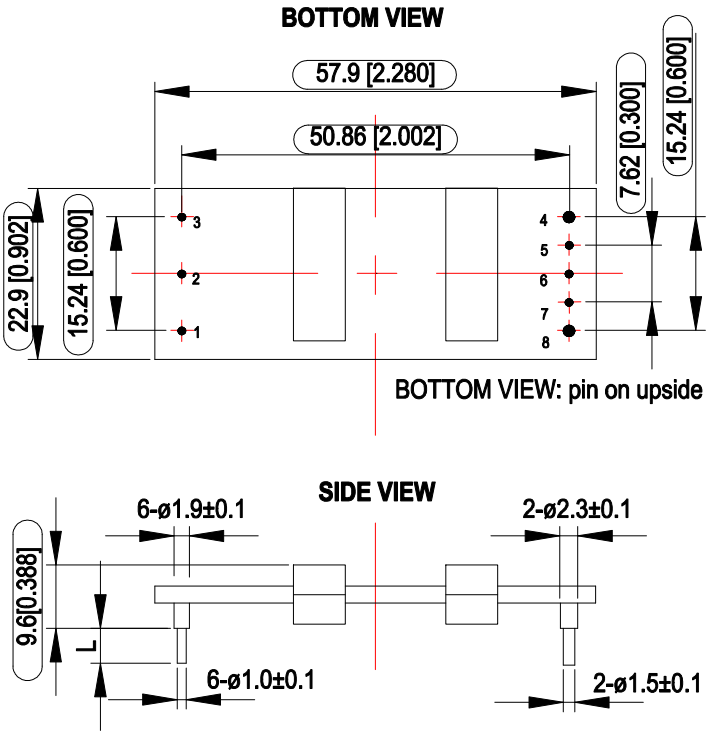
Notes: Dimensions whitin the box are critical dimensions.

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

MECHANICAL SPECIFICATIONS

Mechanical Outlines - Open Frame Module (unit: mm)

AVO100-48S28-6L



UNIT: mm[inch] L=3.8±0.25mm

TOLERANCE: X.Xmm±0.5mm[X.X in.±0.02in.]
X.XXmm±0.25mm[X.XX in.±0.01in.]

Notes: Dimensions whitin the box are critical dimensions.

MECHANICAL SPECIFICATIONS

Pin Length Option

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

Pin Designations

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

ENVIRONMENTAL SPECIFICATIONS

EMC Immunity

AVO100-48S28 series power supply is designed to meet the following EMC immunity specifications:

Table 4. Environmental Specifications

Document	Description	Criteria
EN55022, Class A Limits	Conducted Emission	A
IEC/EN 61000-4-2, Level 3	Immunity to Electrostatic Discharge	B
IEC/EN 61000-4-6, Level 2	Immunity to Continuous Conducted Interference	A
IEC/EN 61000-4-4, Level3	Immunity to Electrical Fast Transient	B
IEC/EN 61000-4-5	Immunity to Surges	B
EN61000-4-29	Immunity to Voltage Dips and Short Interruptions and Voltage Variations	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 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 SPECIFICATIONS

Safety Certifications

The AVO100-48S28 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 AVO100-48S28 series module

Document	Agency	Description
UL/CSA 60950	UL+CUL	US and Canada Requirements
EN60950	TUV	European Requirements
IEC60950	IEC	International Requirements
CE	CE	CE Marking
UKCA	UKCA	UK Requirements

ENVIRONMENTAL SPECIFICATIONS

EMC Test Conditions

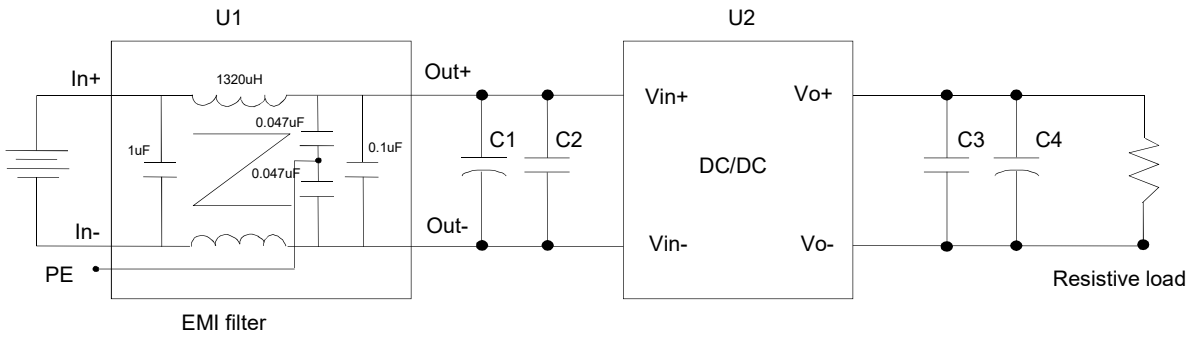


Figure 19: EMC test configuration

U1: Input EMC filter

U2: Module to test, AVO100-48S28-6L / AVO100-48S28B-6L

C1 ~ C4: See Figure 15

ENVIRONMENTAL SPECIFICATIONS

Operating Temperature

The AVO100-48S28 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 Consideration

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 20. The temperature at this point should not exceed the max values in the table 6.

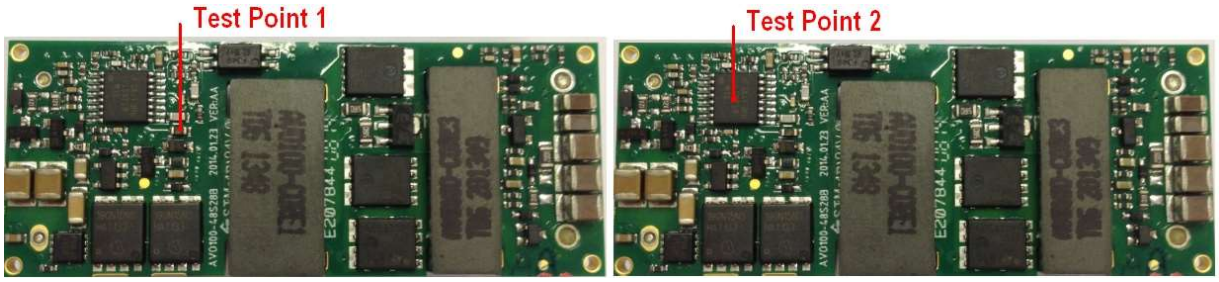


Figure 20: Temperature test point

Table 6. Temperature limit of the test point	
Test Point	**Temperature Limit**
Test point 1	127 ^{O}C
Test point 2	110 ^{O}C

For a typical application, figure 21 shows the derating of output current vs. ambient air temperature at different air velocity.

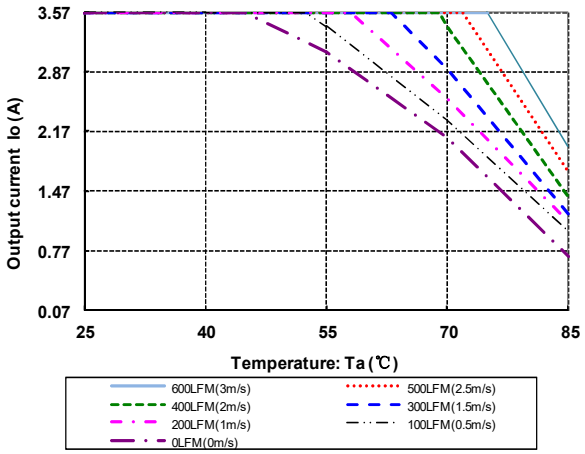


Figure 21: Output power derating, 48V_{in}, air flowing across the converter from pin 3 to pin 1

ENVIRONMENTAL SPECIFICATIONS

Thermal Considerations –Base plate module

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 ^{O}C ambient temperature provided the baseplate temperature is kept the max values 100 ^{O}C.

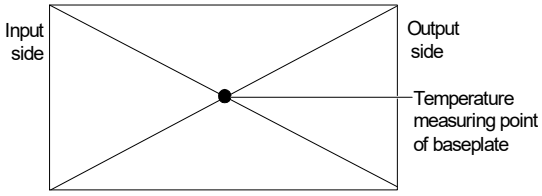


Figure 22: Temperature test point on base plate

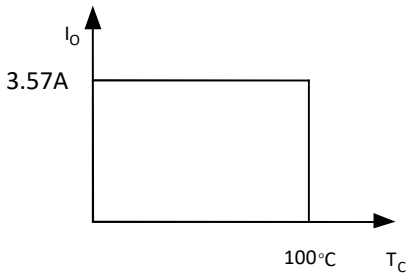
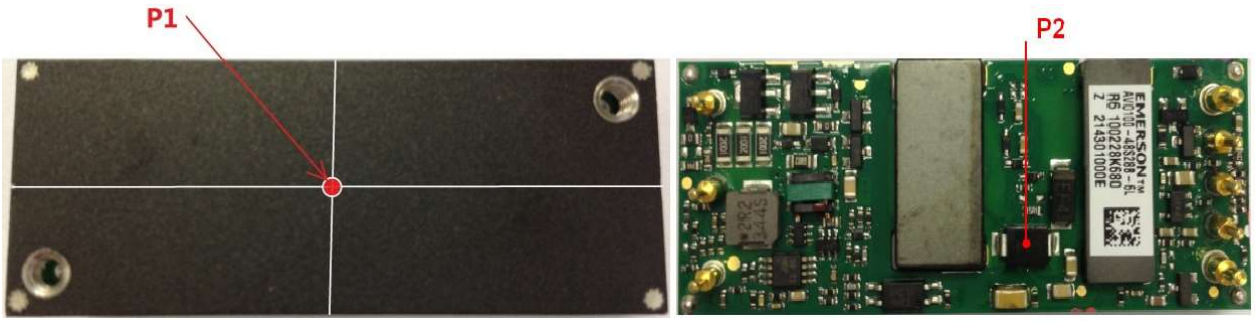


Figure 23 :Output power derating curve, Tc: temperature test point on baseplate, see Figure 22

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 24. The temperature at this point should not exceed the max values in the table 7.

Test point on base plate

Test point on PCB



ENVIRONMENTAL SPECIFICATIONS

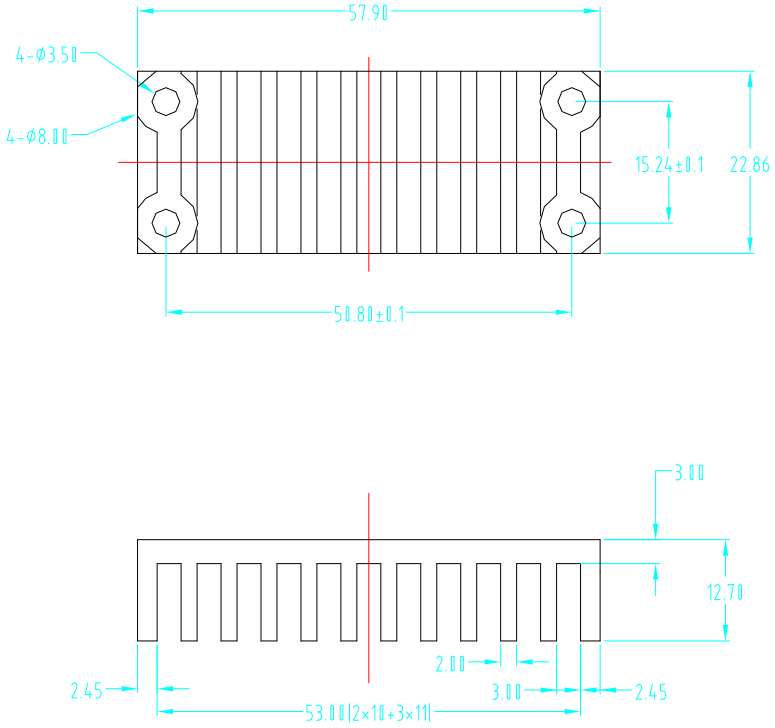


Figure 24: Temperature test point & heat sink mechanical diagram

Table 7. Temperature limit of the test point	
Test Point	**Temperature Limit**
Test point 1 (P1)	106 °C
Test point 2 (P1)	110 °C

ENVIRONMENTAL SPECIFICATIONS

For a typical application, figure 25 shows the derating of output current vs. ambient air temperature at different air velocity.

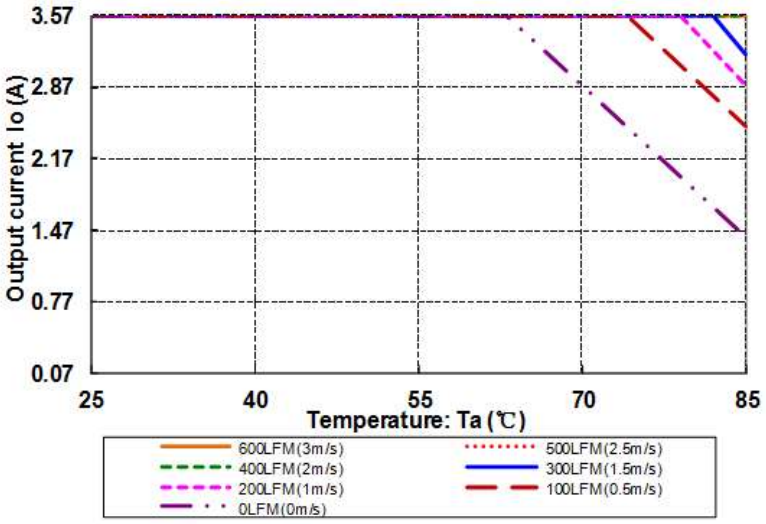


Figure 25: Output power derating, 48V_{in}, air flowing across the converter from pin 3 to pin 1

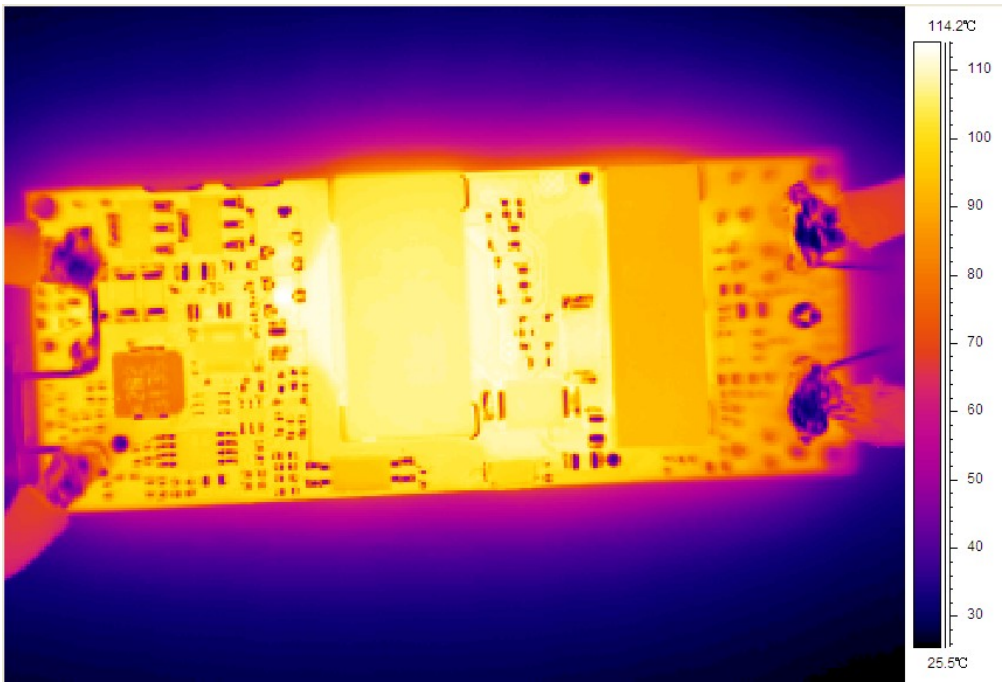


Figure 26: Thermal image, 36V_{in}, 28V_o, full load, room temperature, 200LFM

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: /s^3, -3db/oct, axes of vibration: X/Y/Z Time: 30 min/axes
Mechanical shock	3	30g, 6ms, 3 axes, 6 directions, 3 time/direction
Thermal shock	3	-40 ^{O}C to +100 ^{O}C, unit temperature 20 cycles
Thermal cycling	3	-40 ^{O}C to +85 ^{O}C, temperature change rate: 1^{O}C/min, cycles: 2 cycles
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 AVO100-48S28 series power supply.

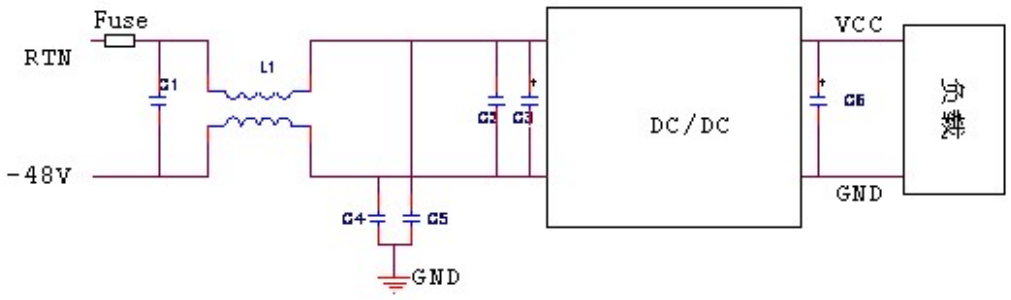


Figure 27: Typical application

C1: SMDceramic-100V-1000nF-X7R-1210

C2: SMDceramic-100V-100nF-±10%-X7R-1206

C3: 100μF/100V electrolytic capacitor; P/N: UPM1A221MED or equivalent caps

C6: 470μF/50V electrolytic capacitor; P/N: UPM1A221MED+ UPM1A471MHD or equivalent caps

C4 C5: SMD ceramic-47n/1000V/X7R- 1210

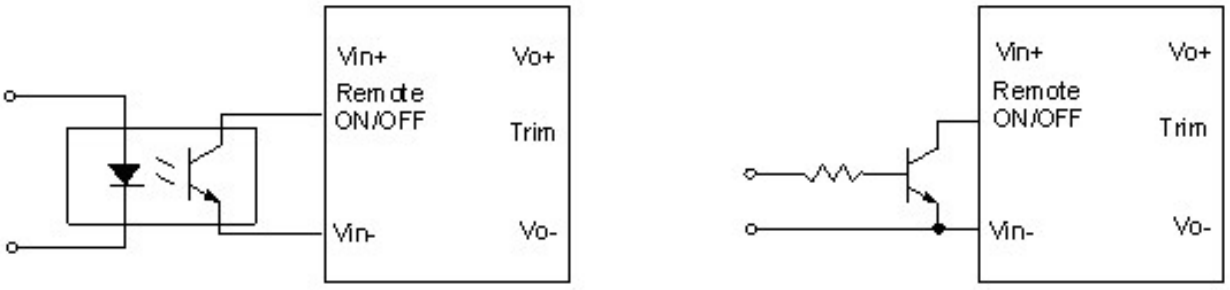
L1: 1320uH-±25%-4A-R5K-21*21*12.5mm

Fuse: External fast blow fuse with a rating of 8A. The recommended fuse model is 0314008.P from LITTLEFUSE.

APPLICATION NOTES

Remote ON/OFF

Negative remote ON/OFF logic is available in AVO100-48S28. 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 3 to ensure proper operation. The external Remote ON/OFF circuit is highly recommended as shown in figure 28.



Isolated remote ON/OFF circuit

Non-isolated remote ON/OFF circuit

Figure 28: 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.

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

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

△:Output e rate against nominal output voltage.

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

V_{nom}: Nominal output voltage.

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

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

$$R_{adj-up} = \frac{28(100 + 16.07)}{1.225 \times 16.07} - \frac{100\% + 2 \times 16.07\%}{16.07\%} = 156.87(K\Omega)$$

For 1% adjustment resistor, the trimmed output voltage is guaranteed within ±2%.
When trimming up, the output current should be decreased accordingly so as not to exceed the maximum output power.

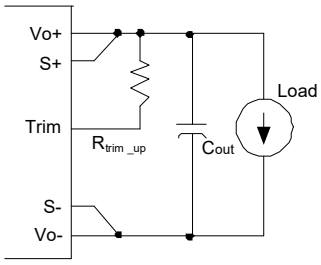


Figure 29: Trim up

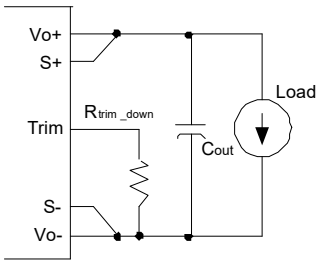
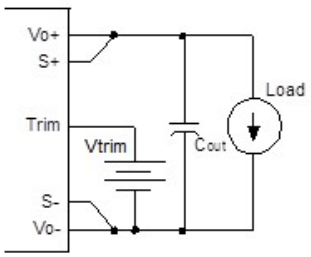


Figure 30: Trim down

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

Connecting an external voltage 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. external voltage trim as follows formula.

$$V_o = (V_{trim} + 1.225) \times 11.43$$



APPLICATION NOTES

Input Ripple & Output Ripple & Noise Test Configuration

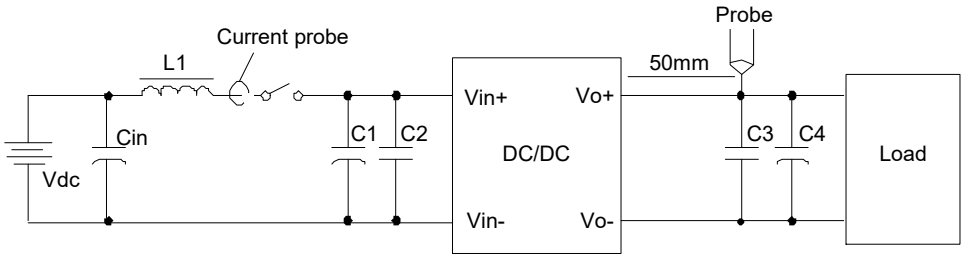


Figure 31: Input ripple & inrush current, output ripple & noise test configuration

Vdc: DC power supply

L1: 12uH

Cin: 220uF/100V typical

C1: 100μF/100V electrolytic capacitor, High frequency and low ESR

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

C4: 1000μF/50V electrolytic capacitor, High frequency and low ESR

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.

APPLICATION NOTES

Soldering

The product is intended for standard manual, wave soldering.

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

When manual soldering is used, 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 similative.

RECORD OF REVISION AND CHANGES

Issue	Date	Description	Originators
1.0	07.11.2014	First Issue	X. Sun
1.1	1.15.2018	Add the condition and template error	K. Wang
1.2	12.17.2019	Delete the reflow soldering	J. Zhang
1.3	03.17.2022	Update UKCA mark	E. 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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