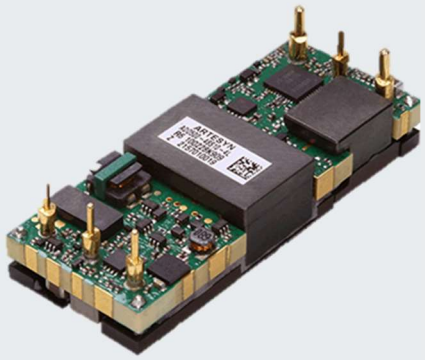
TECHNICAL REFERENCE NOTE

ARTESYN ADO500-48S10-4L SERIES

500 Watts 1/8 Brick Converter



PRODUCT DESCRIPTION

Advanced Energy's Artesyn ADO500-48S10-4L is a single output digital control, fully regulated control topology DC/DC converter with standard eighth-brick outline and pin configuration. It delivers up to 50A output current with 10.1V output voltage. Above 96.5% ultra-high efficiency and excellent thermal performance makes it an ideal choice to supply power in telecom and datacom. It can work under -20^{O}C ~ +85^{O}C with air cooling.

AT A GLANCE

Total Power

500 Watts

Input Voltage

45 to 56 Vdc

# of Outputs

Single

RoHS

SPECIAL FEATURES

- Delivers up to 56A output current
- Ultra-high efficiency 95.2% typ. at 70% load
- Parallel with droop current sharing
- Startup Pre-bias
- Wide input range: 45V to 56V
- Fully regulated output voltage
- Excellent thermal performance
- Power Good (PG) feature
- No minimum load requirement
- RoHS 3.0
- Remote control function (negative logic option)
- Input under voltage lockout
- Input over voltage lockout
- Output over current protection
- Output over voltage protection
- Over temperature protection

SAFETY

- TUV EN62368
- UL/TUV EN60950
- UL94,V-0
- CE and UKCA Mark

TYPICAL APPLICATIONS

- Datacom
- Telecom

MODEL NUMBERS

Standard	Output Voltage	Structure	Pin Type	RoHS Status	PMBus™
ADO500-48S10-4L	11.82Vdc	Open-frame	Through hole	RoHS 3.0	No

Order Information

ADO500	-	48	S	12	B	-	6	L
①		②	③	④	⑤		⑥	⑦

①	Model series	ADO: high efficiency digital control eighth brick series, 500: output power 500W
②	Input voltage	48: 45V ~ 56V input range, rated input voltage 48V
③	Output number	S: single output
④	Rated output voltage	10: 10V output
⑤	Baseplate status	B: with baseplate; default: open frame
⑥	Pin length	-4: 4.8mm
⑦	RoHS status	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	$V_{IN,DC}$	-	-	56	Vdc
Non-operating -100mS	All		-	-	80	Vdc
Maximum Output Power	All	$P_{O,max}$	-	-	500	W
Isolation Voltage[1]						
Input to output	All		-	-	800	Vdc
Ambient Operating Temperature	All	T_A	-20	-	+85	°C
Short-Term Operating Temperature 96 hours/year	All		-20	-	+90	°C
Storage Temperature	All	T_{STG}	-40	-	+125	°C
Voltage at remote ON/OFF pin	All		-	-	20	Vdc
Humidity (non-condensing)						
Operating	All		-	-	90	%
Non-operating	All		-	-	90	%

Note 1 - 1mA for 60s, slew rate of 1500V/10s. Functional insulation, pollution degree 2, input-metal part

ELECTRICAL SPECIFICATIONS

Input Specifications

Table 2. Input Specifications

Parameter	Condition[1]	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, DC	All	$V_{IN,DC}$	45	50	56	Vdc
Turn-on Voltage Threshold		$V_{IN,ON}$	41	-	45	Vdc
Turn-off Voltage Threshold		$V_{IN,OFF}$	40	-	42.5	Vdc
Input Under-voltage Lockout Hysteresis			1.5	-	3	Vdc
Input Over Voltage Protection			60	-	64	Vdc
Input Over Voltage Protection recovery voltage			57	-	63	Vdc
Input Over-voltage Lockout Hysteresis			1	-	3	Vdc
Maximum Input Current ($I_O = I_{O,max}$)	$V_{IN,DC}$ = 45Vdc	$I_{IN,max}$	-	-	13.5	A
No Load Input Current		I_{IN,no_load}	-	0.11	-	A
Standby Input current	Remote OFF	$I_{IN,Standby}$	-	0.04	0.2	A
Inrush current transient rating[2]		I_{IN}	-	-	50	%
Recommended Input Fuse	Fast blow external fuse recommended		-	-	25	A
Input filter component values (C\L)	Internal values		-	9.4\0.2	-	µF\µH
Recommended External Input Capacitance	Low ESR capacitor recommended	C_{IN}	220	-	500	uF
Input Reflected Ripple Current	Through 12uH inductor		-	70	-	mA

Note 1 - T_A = 25 ^{O}C, Vin = 48Vdc, nominal Vout unless otherwise noted.

Note 2 - Inrush Current is defined as the peak current drawn by the unit when unit is enabled after Vin is present. I_{IN} is defined as the steady-state operating current when unit is operating under the same conditions.

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= 50% $I_{O,max}$	V_O	10.21	10.26	10.31	Vdc
Total Regulation		Over sample, line, load, temperature & life	V_O	9.6	10.26	11.2	Vdc
Output Voltage Line Regulation		All		-	±25	±70	mV
Output Voltage Load Regulation		All		-	±380	±500	mV
Output Voltage Temperature Regulation		All		-	0.002	0.02	%/^{O}C
Output Ripple, pk-pk		20MHz bandwidth	V_O	-	-	150	mV_{PK-PK}
Output Current		All	I_O	0	-	50	A
Output DC current-limit inception[2]		All		55	-	72	A
V_O Load Capacitance[3]		All	C_O	470	-	3470	uF
V_O Dynamic Response	Peak Deviation Settling Time	25%~50%~25% & 50%~75%~50% slew rate = 1A/us	±V_O T_s	- -	330 500	- -	mV uSec
Factory Set Voltage		$V_{IN,DC}$ = 48V_{DC} I_O= 50% $I_{O,max}$	V_O	10.21	10.26	10.31	Vdc
Turn-on transient	Rise time	I_O = I_{max}	T_{rise}	-	-	15	mS
	Turn-on delay	By AC		-	-	30	mS
	Turn-on delay	By Enable		-	4	-	mS
	Turn-On overshoot			-	-	350	mV
	Turn-Off Undershoot			-	-	350	mV
Switching Frequency		All	f_{SW}	-	185	-	KHz
Remote ON/OFF control (Negative (default); Positive available)	Off-state voltage	All		2.4	-	20	V
	On-state voltage	All		-0.3	-	0.8	V
	Current On (out of pin)	All		-	-	200	uA
	Current Off (out of pin)	All		-	-	10	uA

Note 1 - T_A = 25 ^{O}C, Vin = 48Vdc, nominal Vout unless otherwise noted.
Note 2 - Hiccup: auto-restart when over-current condition is removed
Note 3 - 22uF*5 PCS Cap + Oscon or POSCAP

ELECTRICAL SPECIFICATIONS

Output Specifications Con't

Table 3. Output Specifications, con't:

Parameter		Condition	Symbol	Min	Typ	Max	Unit
Output over-voltage protection[4]		All	V_O	11.8	-	15.0	V
Output over-temperature protection[5]		All	T	100	125	130	^{O}C
Power Good Voltage[6]	High state voltage	Referenced to Vout(-)		2.4	-	5.5	V
	Low state voltage			0	-	0.8	V
Power Good leakage current	High level			0	-	10	uA
	Low level			0	-	5	mA
Power Good Signal De-assert Response Time[7]				0	-	1.0	mS
Parallel unit		All				2	Units
Current share		I_O= (0%-160%) $I_{O,max}$		-	-	10	%
Pre-bias		Vo means full load output voltage at 48V I_O = 0A	Vo	0	-	100	%
MTBF		Airflow = 300LFM T_A =40^{O}C V_{IN}= $V_{IN,nom}$ I_O = 80%$I_{O,max}$ Telcordia,SR332 Method 1 Case3		-	2	-	10^6 h

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

Note 5 - Auto recovery. See Figure 11 test point.

Note 6 - Non-latching open-collector output, normally low.

Note 7 - Power-Good Signal De-assert Response Time is defined as the duration between the fault occurring and the Power-Good Signal de-asserting.

ELECTRICAL SPECIFICATIONS

ADO500-48S10-4L-6L Performance Curves

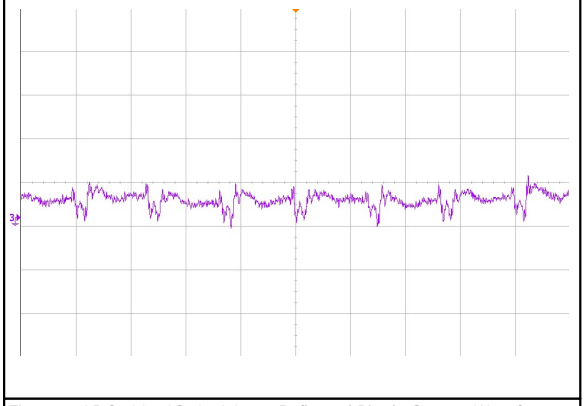


Figure 1: ADO500-48S10-4L Input Reflected Ripple Current Waveform

Ch 3: Iin (2uS/div, 50mA/div)

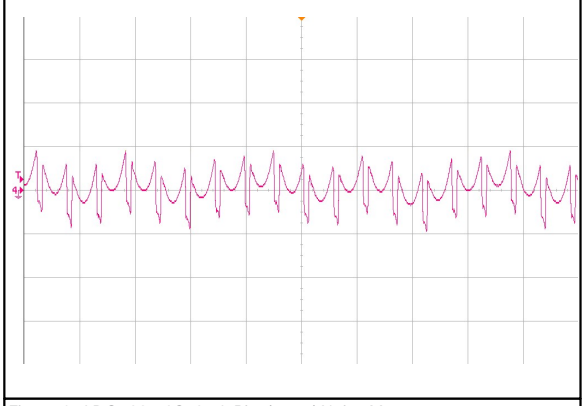


Figure 2: ADO500-48S10-4L Ripple and Noise Measurement

Ch 4: Vo (5uS/div, 50mV/div)

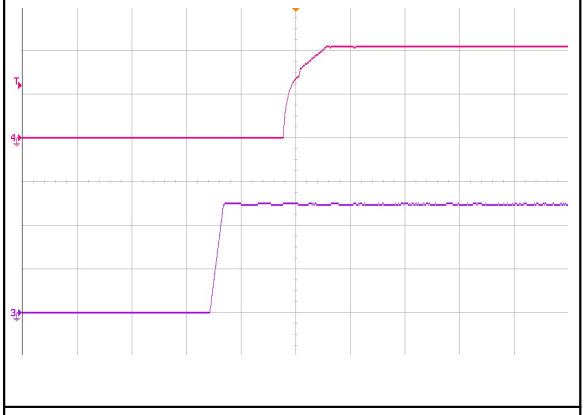


Figure 3: ADO500-48S10-4L Output Voltage Startup Characteristic (20mS/div)

Ch 4: Vo (5V/div) Ch 3: Vin (20V/div)

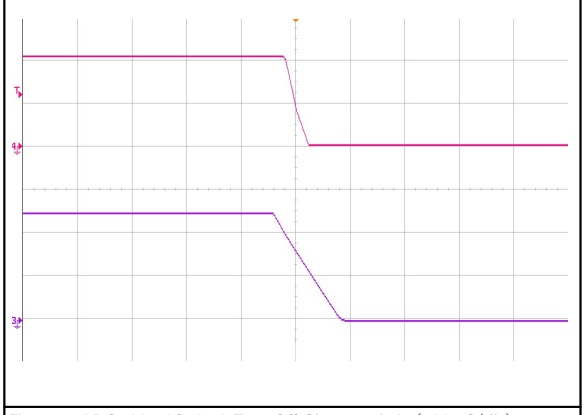


Figure 4: ADO500-48S10-4L Turn Off Characteristic (100mS/div)

Ch 4: Vo (5V/div) Ch 3: Vin (20V/div)

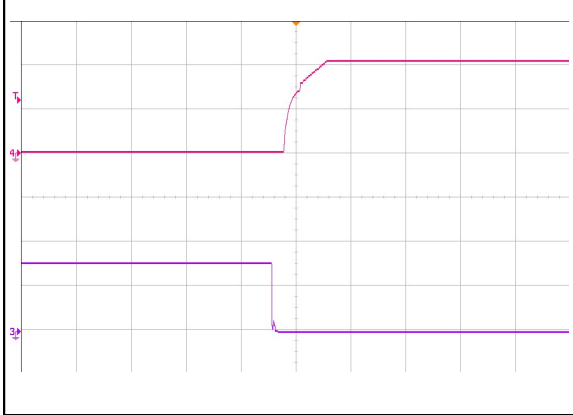


Figure 5: ADO500-48S10-4L Remote ON Waveform (20mS/div)

Ch 4: Vo (5V/div) Ch 3: Remote ON (2V/div)

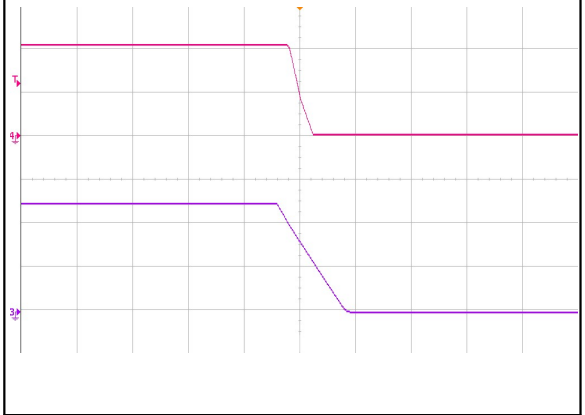


Figure 6: ADO500-48S10-4L Remote OFF Waveform (200mS/div)

Ch 4: Vo (5V/div) Ch 3: Remote ON (2V/div)

ELECTRICAL SPECIFICATIONS

ADO500-48S10-4L Performance Curves

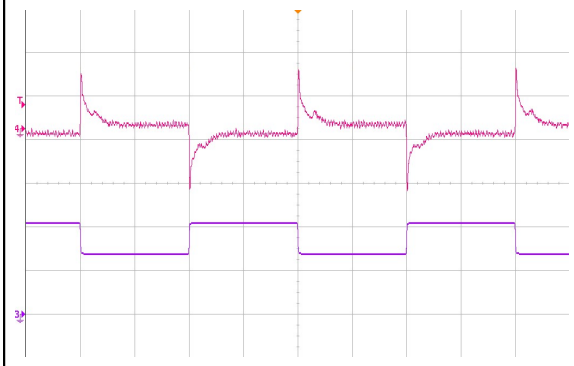


Figure 7: ADO500-48S10-4L Transient Response (500uS/div)
50%~75%~50% load change, 0.1A/uS slew rate
Ch 4: Vo (200mV/div) Ch 3: Io (20A/div)

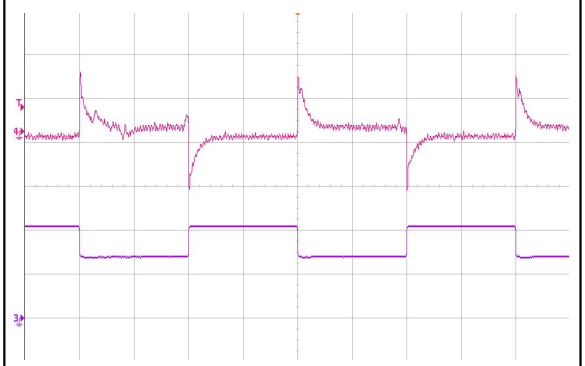


Figure 8: ADO500-48S10-4L Transient Response (500uS/div)
50%~75%~50% load change, 1A/uS slew rate
Ch 4: Vo (200mV/div) Ch 3: Io (20A/div)

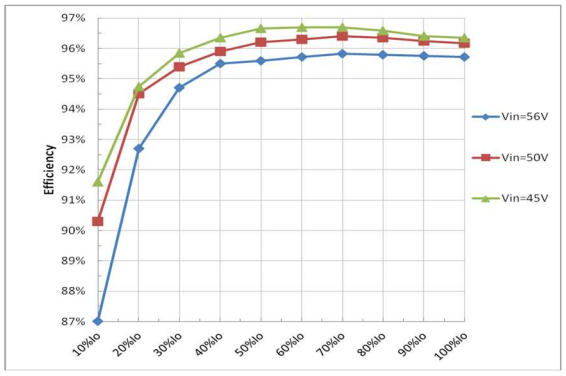


Figure 9: ADO500-48S10-4L Efficiency vs. output current, Ta=25oC, Vo=11.9V
Loading: Io = 10% increment to 26A

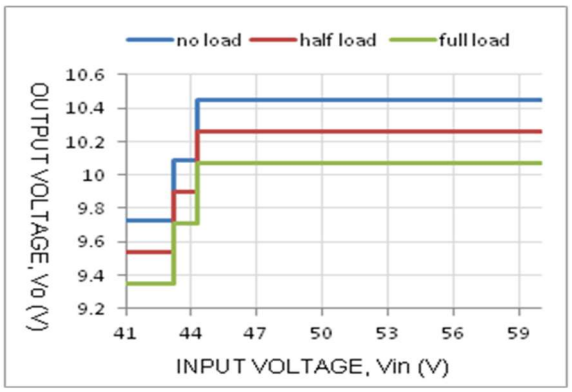


Figure 10: ADO500-48S10-4L Typical output voltage regulation vs. input voltage at room temperature

Figure 11: ADO500-48S10-4L OTP Test Point

ELECTRICAL SPECIFICATIONS

Protection Function Specifications

Input Fusing

An external fuse is recommended. To meet international safety requirements, a 250V rated fuse should be used. Recommended rating is 25A for the converter.

Note: The fuse is fast blow type.

Over Voltage Protection (OVP)

The output over-voltage protection consists of circuitry that monitors the voltage on the output terminals. If the voltage on the output terminals exceeds the over voltage protection threshold, then the converter will work on hiccup mode. When the over-voltage condition is removed, the converter will automatically restart.

Parameter	Min	Nom	Max	Unit
V_O Output Overvoltage	11.8	/	15.0	V

Over Current Protection (OCP)

When output current exceeds 110 to 144% of rated current, the converter will work on hiccup mode. When the over-current condition is removed, the converter will automatically restart.

Parameter	Min	Nom	Max	Unit
V_O Output Overcurrent	55	/	72	A

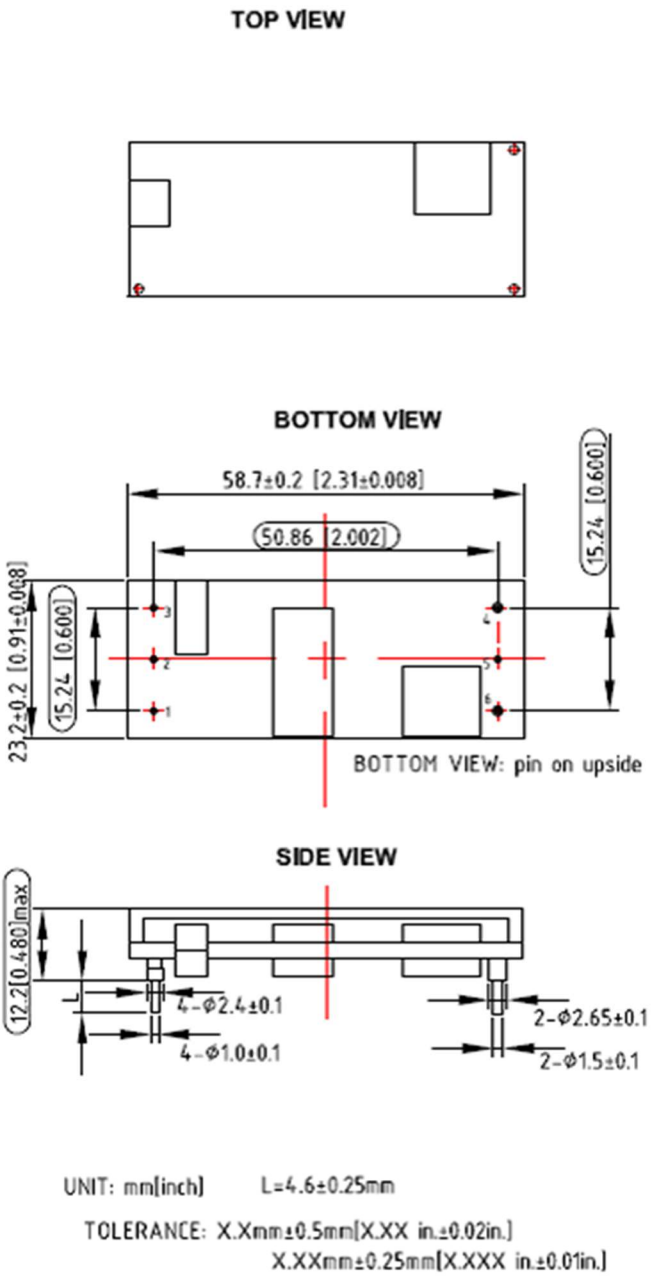
Over Temperature Protection (OTP)

The converter features an over-temperature protection circuit to safeguard against thermal damage. The converter will shutdown when the maximum device reference temperature is exceeded. When the over-temperature condition is removed, the converter will automatically restart.

Parameter	Min	Nom	Max	Unit
V_O Output Over Temperature	100	125	130	°C

MECHANICAL SPECIFICATIONS

Mechanical Outlines- Open Frame Module (unit: mm)



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	Remote control
3	Vin-	Negative input voltage
4	Vo-	Negative output voltage
5	PG	Power Good
6	Vo+	Positive output voltage

ENVIRONMENTAL SPECIFICATIONS

EMC Immunity

ADO500-48S10-4L series power supply is designed to meet the following EMC immunity specifications.

Table 4. Environmental Specifications

Document	Description	Criteria
EN55022 DC input port, Class B Limits	Conducted Emission	/
IEC/EN 61000-4-2 Enclosure Port, Level 3	Immunity to Electrostatic Discharge	B
IEC/EN 61000-4-6, DC input port, Level 2	Immunity to Continuous Conducted Interference	A
IEC/EN 61000-4-4 DC input port, Level3	Immunity to Electrical Fast Transient	B
IEC/EN 61000-4-5 DC input port	Immunity to Surges Line to Ground(earth): 600V Line to Line: 600V	B
EN61000-4-29 DC input port	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 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.

ENVIRONMENTAL SPECIFICATIONS

Safety Certifications

The ADO500-48S10-4L 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 ADO500-48S10-4L power supply system:

Standard	Agency	Description
UL/CSA 60950	UL+CUL	US and Canada Requirements
EN62368	TUV-SUD	European Requirements
UL94	CE	Materials meet V-0 flammability rating
CE		CE Marking
UKCA Mark		UK Requirements

ENVIRONMENTAL SPECIFICATIONS

Operating Temperature

The ADO500-48S10-4L series module will start and operate within stated specifications at an ambient temperature from -20 ^{O}C to 85 ^{O}C under all load conditions. The storage temperature is -40 ^{O}C to 125 ^{O}C.

Thermal Considerations - Base plate module

The converter is designed to operate in different thermal environments and sufficient cooling must be provided. Proper cooling can be verified by measuring the temperature at the test points as shown in the Figure 12. The temperature at these test points should not exceed the maximum values in Table 6.

For a typical application, forced airflow direction is from Vin to VO, Figure 13 shows the derating of output current vs. ambient air temperature at different air velocity.

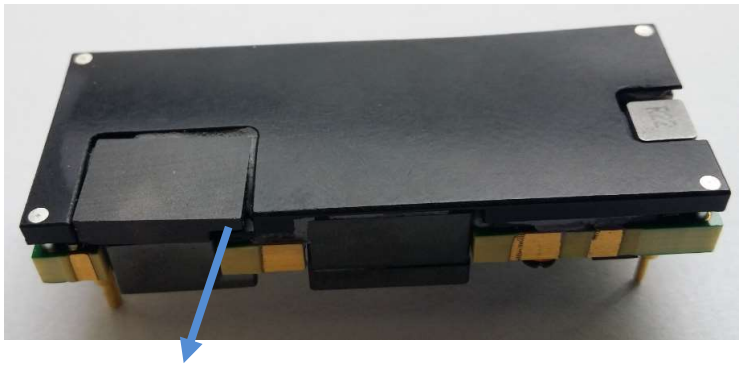


Figure 12 Temperature test point

Table 6 Temperature limit of the test point	
Test Point	**Temperature Limit (^{O}C)**
Test point 1	129

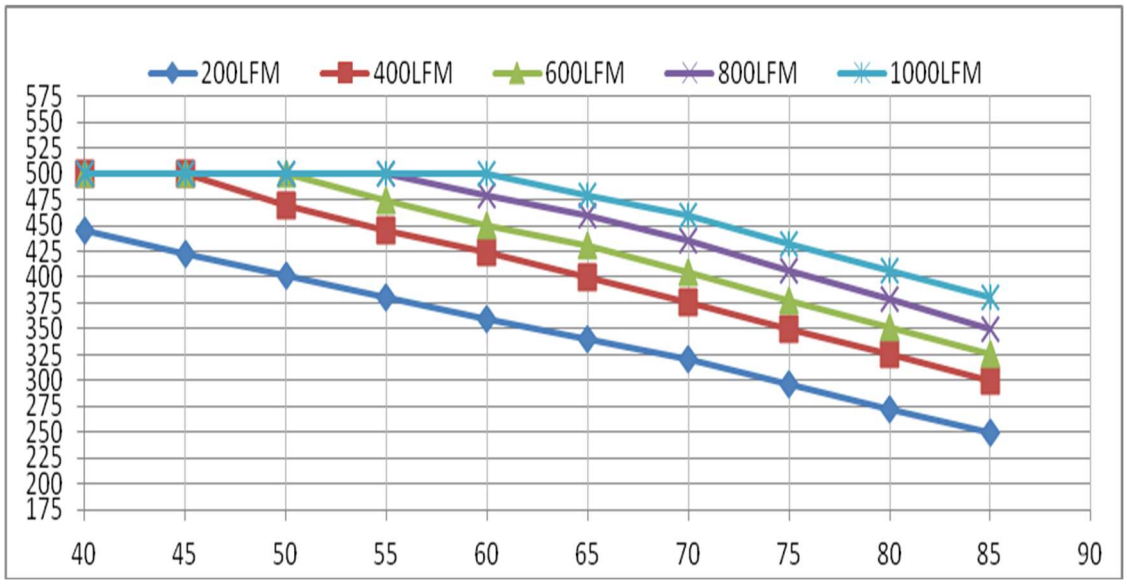


Figure 13 Derating curve

ENVIRONMENTAL SPECIFICATIONS

Parameter	Unit (pcs)	Test condition
Halt test	4-5	$T_{a,min}$-50 °C to $T_{a,max}$+10 °C, 5 °C step, V_{in} = min to max, 0 ~ 100% 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	-20 °C to 90 °C, temperature change rate: 1°C/min, cycles: 2cycles
Humidity	3	40 °C, 90%RH, 48h
Solder Ability	15	IPC J-STD-002C-2007

APPLICATION NOTES

Typical Application

Below is the typical application of the ADO500-48S10-4L series power supply.

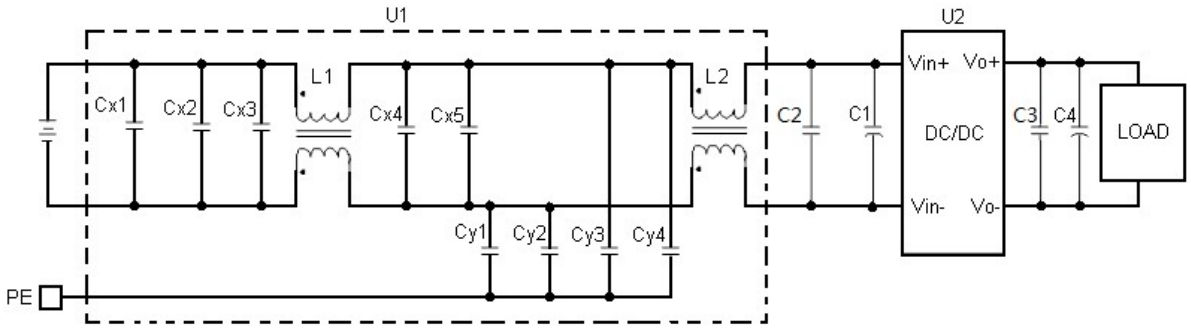


Figure 14 Typical application

C1: 220μF/100V electrolytic capacitor, P/N: UPM2A221MPD (Nichicon) or equivalent caps

C2: 1μF/100V/X7R capacitor

C3: 22uF/16V/X7S *5 PCS capacitor

C4: 1000μF/25V electrolytic capacitor, P/N: OScon or POSCAP

U1: Input EMC filter

U2: Module to test, ADO500-48S10-4L

CX1, CX2, CX3, CX4, CX5: 1μF/100V/X7R capacitor

Cy1, Cy2, Cy3, Cy4: 0.88μF/630V/X7R, Y capacitor

L1, L2: 473μH, common mode inductor

Fuse: External fast blow fuse with a rating of 25A/250Vac. The recommended fuse model is 0314025.P from Karwin Tech limited.

APPLICATION NOTES

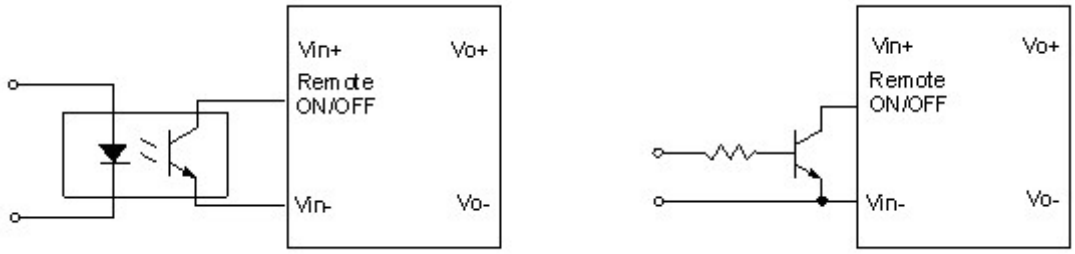
Remote ON/OFF

Negative remote ON/OFF logic is available in ADO500-48S10-4L. The logic is CMOS and TTL compatible.

Remote ON/OFF (ENABLE) can be controlled by an external switch between the on/off terminal and the Vin(-) terminal. The switch can be an open collector or open drain.

The voltage between pin Remote ON/OFF and pin Vin- must not exceed the range listed in table “Feature characteristics” to ensure proper operation. The external Remote ON/OFF circuit is highly recommended as shown in figure 15.

For the negative logic, if the remote ON/OFF (ENABLE) feature is not used, please maintain the ENABLE pin to Vin(-).



Isolated remote ON/OFF circuit

Non-isolated remote ON/OFF circuit

Figure 15 External Remote ON/OFF circuit

APPLICATION NOTES

Parallel and Droop Current Sharing

The modules are capable of operating in parallel, and realizing current sharing by droop current sharing method. There is about 400mV output voltage droop from 0A to full output Load, and there is no current sharing pin. By connecting the Vin pin and the Vo pin of the parallel module together, the current sharing can be realized automatically.

If system has no redundancy requirement, the module can be connected in parallel directly for higher power delivery without adding external oring-fet; whereas, If redundancy is required, the external oring-fet should be added.

For a normal parallel operation the following precautions must be observed:

1. The current sharing accuracy equation is:

X% = | Io – (Itotal / N) | / Irated, Where,

Io is the output current of per module;
Itotal is the total load current;
N is parallel module numbers;
Irated is the rated full load current of per module.

2. To ensure a better current sharing accuracy, the design guidelines below should be followed:

a) The inputs of the converters must be connected to the same voltage source; and the PCB trace resistance from Input voltage source to Vin+ and Vin- of each converter should be equalized as closely as possible.

b) The PCB trace resistance from each converter's output to the load should be equalized as closely as possible.

c) For accurate current sharing accuracy test, the module should be soldered into the host PCB in order to avoid any unbalance of the contact resistance between the modules and the host board.

3. To ensure the parallel module can start up monotonically without trigging the OCP circuit, the design guidelines should be followed:

a) Before the parallel modules have finished their start up and PG signal is asserted, the total load current should be lower than the rated current of 1 module.

b) The ON/OFF pin of the converters should be connected together to keep the parallel modules starting up at the same time.

c) The under voltage lockout point will slightly vary from unit to unit. The dv/dt of the rising edge of the input source voltage must be greater than 1V/mS to ensure that the parallel modules start up at the same time.

4. If fault tolerance is desired in parallel applications, output ORing devices should be used to prevent a failure of either module from collapsing the load bus.

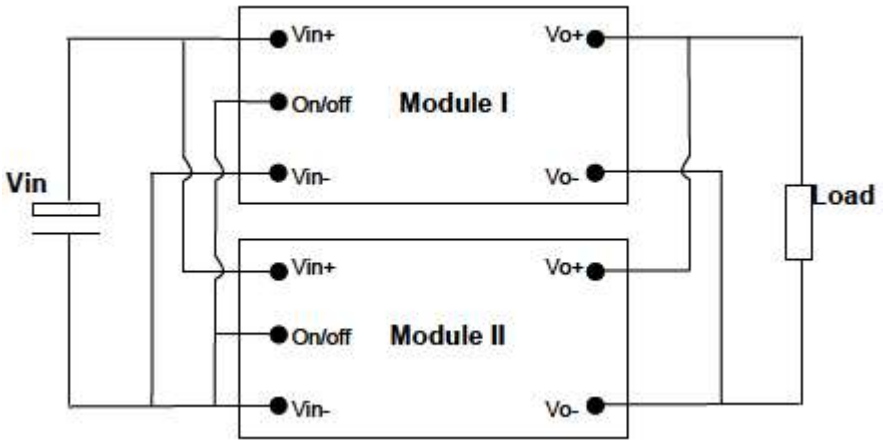


Figure 16 Parallel and droop current sharing configuration for no redundancy requirement system

APPLICATION NOTES

Power Good, PG

The module provides a Power Good (PG Pin) feature, to indicate that the output voltage is within the normal output voltage range of the power module. The PG signal will be changed to a logic -high state if any condition such as over temperature, over current, UVLO, OVP, startup with diode emulation mode or loss of regulation occurs that would result in the output voltage going below the normal voltage range value.

Before the parallel module's have finished their start up and PG signal asserts, the total load current should be lower than the rated current of 1 module.

If the user is not using the Power Good feature, the pin may be left as not connected.

APPLICATION NOTES

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

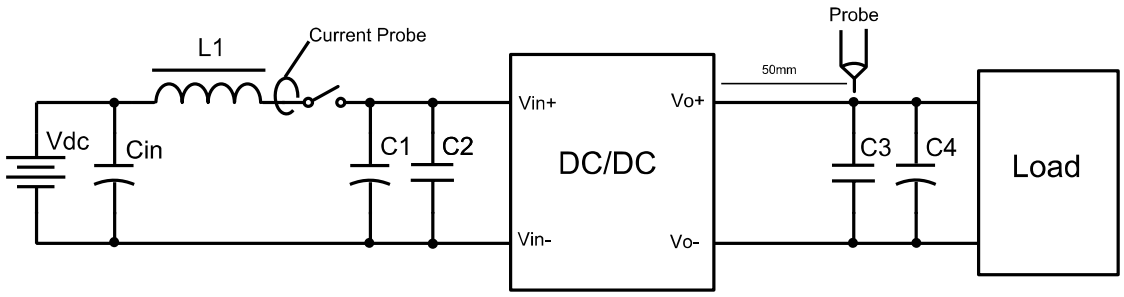


Figure 17 Input ripple & inrush current output ripple & noise test configuration

Vdc: DC power supply

L1: 12μH

Cin: 220μF/100V typical

C1 C4: See Figure 14

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.

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 ^{O}C for maximum 7s.

When soldering by hand, 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	01.29.2016	First Issue	E. Wang
1.1	04.13.2016	Change the photo at first page	K. Wang
1.2	02.24.2020	Update RoHS 3 status	C. Liu
1.3	05.20.2022	Add UKCA Mark	J.Zhang

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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