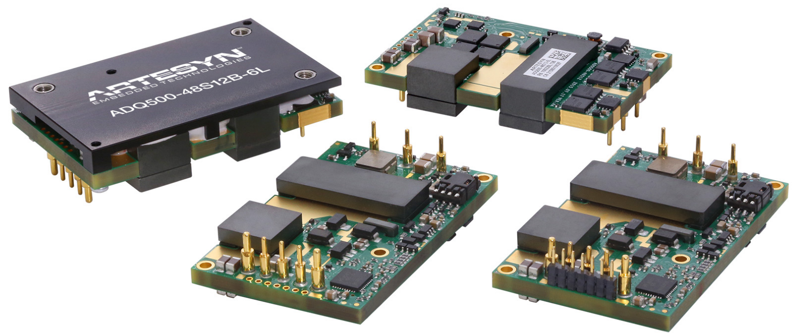
ADQ500-48S12

500 Watts
Quarter Brick Converter

Total Power: 500 Watts
Input Voltage: 36 to 75 Vdc
# of Outputs: Single
Main output: 12V dc



Special Features
- Delivering up to 42A output
- Ultra-high efficiency 95.5% typ. at half load
- Wide input range: 36V ~ 75V
- Startup Pre-bias: 0%Vout ~ 95%Vout
- Excellent thermal performance
- No minimum load requirement
- RoHS 6 compliant
- Remote control function (negative or positive logic optional)
- Remote output sense
- Trim
- PMBus Rev.1.2 Compliance
- Input under voltage lockout
- Output over current protection
- Output over voltage protection
- Over temperature protection
- Industry standard quarter brick pin-out outline
- Pin length option: 3.8mm

Safety
IEC/EN/UL/CSA 62368
CE Mark
UL/TUV
UL94,V-0

Product Descriptions
The ADQ500-48S12 is a single output DC/DC converter with standard quarter brick form factor and pin configuration. It delivers up to 42A output current with 12V output. Ultra-high 95.5% efficiency and excellent thermal performance makes it an ideal choice for use in computing and telecommunication applications and can operate over an ambient temperature range of -40 ^{O}C ~ +85 ^{O}C.

Applications
Telecom/ Datacom

ARTESYN™ EMBEDDED TECHNOLOGIES

Model Numbers

Standard	Output Voltage	Structure	Remote ON/OFF logic	RoHS Status	PMBus
ADQ500-48S12-6L	12Vdc	Open-frame	Negative	R6	N
ADQ500-48S12B-6L	12Vdc	Baseplate	Negative	R6	N
ADQ500-48S12-6LI	12Vdc	Open-frame	Negative	R6	Y
ADQ500-48S12B-6LI	12Vdc	Baseplate	Negative	R6	Y
ADQ500-48S12B-6LK	12Vdc	Baseplate	Negative	R6	N
ADQ500-48S12B-6LA	12Vdc	Baseplate	Negative	R6	N
ADQ500-48S12PB-6L	12Vdc	Baseplate	Positive	R6	N
ADQ500-48S12PB-6LI	12Vdc	Baseplate	Positive	R6	Y

Ordering information

ADQ500	-	48	S	12	P	B	-	6	L	I	K
1		2	3	4	5	6		7	8	9	10

1	Model series	ADQ: high efficiency quarter brick series, 500: output power 500W
2	Input voltage	48: 36V ~ 75V input range, rated input voltage 48V
3	Output number	S: single output
4	Rated output voltage	12: 12V output
5	Remote ON/OFF logic	Default: negative logic; P: positive logic
6	Baseplate	B: with baseplate; default: open frame
7	Pin length	Omit for 5.8mm±0.25mm 4: 4.8mm±0.25mm 6: 3.80mm±0.25mm 8: 2.80mm±0.25mm
8	RoHS status	Y: RoHS, R5; L: RoHS, R6
9	PMBus	Omit: No PMBus I: Support PMBus
10	Customer Code	

Options

Positive enable optional

Pin length optional

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 Non-operating -100mS	All	$V_{IN,DC}$	- -	- -	80 100	Vdc Vdc
Maximum Output Power	All	$P_{O,max}$	-	-	500	W
Ambient Operating Temperature	All	T_A	-40	-	+85	^{O}C
Storage Temperature	All	T_{STG}	-55	-	+125	^{O}C
Voltage at remote ON/OFF pin	All		-0.3	-	18	Vdc
Humidity (non-condensing) Operating Non-operating	All All		- -	- -	95 95	% %

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	$I_O = I_{O,max}$	$V_{IN,ON}$	-	35	-	Vdc
Turn-off Voltage Threshold	$I_O = I_{O,max}$	$V_{IN,OFF}$	-	33	-	Vdc
Lockout Voltage Hysteresis	$I_O = I_{O,max}$		-	2	-	Vdc
Maximum Input Current ($I_O = I_{O,max}$)	$V_{IN,DC}$ = 36Vdc $I_O = I_{O,max}$	$I_{IN,max}$	-	-	15	A
No-load input current	48Vin		-	0.10	-	A
Standby Input current	Remote OFF		-	0.01	0.1	A
Recommended Input Fuse	Fast blow external fuse recommended		-	-	30	A
Input filter component values (C\L)	Internal values		-	9.4\0.33	-	µF\µH
Recommended External Input Capacitance	Low ESR capacitor recommended	C_{IN}	220	-	-	µF
Input Reflected Ripple Current	Through 12uH inductor		-	70	-	mA
Operating Efficiency[2]	T_A=25 ^{O}C $I_O = I_{O,max}$ $I_O = 50\% I_{O,max}$	η	- -	94.5 95.5	- -	% %

Note 1 - Ta = 25 ^{O}C, airflow rate = 400 LFM, Vin = 48Vdc, nominal Vout unless otherwise noted.
Note 2 - Refer to figure 9 and figure18

Output Specifications

Table 3. Output Specifications:

Parameter		Notes & Condition[1]	Symbol	Min	Typ	Max	Unit
Factory Set Voltage		$I_O=I_{O,max}$	V_O	11.88	12	12.12	Vdc
Output Voltage Line Regulation		All	V_O	-	20	60	mV
Output Voltage Load Regulation		All	V_O	-	20	60	mV
Output Voltage Temperature Regulation		All	V_O	-	0.002	0.02	%/^{O}C
Output Voltage Trim Range		All	V_O	-20		10	%
Output Ripple, pk-pk		Measure with a 1uF ceramic capacitor in parallel with a 10uF tantalum capacitor, 0 to 20MHz bandwidth	V_O	-	200	-	mV_{PK-PK}
Output Current		All	I_O	0	-	42	A
Output DC current-limit inception[2]		All	I_O	46.5	-	59	A
V_O Load Capacitance[3]		All	C_O	470		10000	µF
V_O Dynamic Response Peak Deviation Settling Time		50% ~ 75% ~ 50% $I_{O,max}$, 0.1A/µs	$\pm V_O$ Ts	- -	200 200	- -	mV uS
		50% ~ 75% ~ 50% $I_{O,max}$, 1A/µs	$\pm V_O$ Ts	- -	200 200	- -	mV µS
Turn-on transient	Rise time	$I_O=I_{O,max}$	T_{rise}	-	15	100	mS
	Turn-on delay time	$I_O=I_{O,max}$	$T_{turn-on}$	-	50	100	mS
	Output voltage overshoot	$I_O = 0$	$\%V_O$	-	0	-	%
Isolation Voltage Input to outputs		1mA for 60s Slew rate of 500V/1s		1500	-	-	Vdc
Switching frequency[3]		All	f_{SW}	-	175	-	KHz
Remote ON/OFF control (positive logic)	Off-state voltage	All		-0.3	-	1.2	Vdc
	On-state voltage	All		3.5	-	18	Vdc

Note 1 - Ta = 25 ^{O}C, airflow rate = 400 LFM, Vin = 48Vdc, nominal Vout unless otherwise noted.
Note 2 - Hiccup: auto-restart when over-current condition is removed.
Note 3 - For ADQ500-48S12B-6LA, typical switch frequency is 140kHz.

Output Specifications

Table 3. Output Specifications, con't:

Parameter		Notes & Condition	Symbol	Min	Typ	Max	Unit
Remote ON/OFF control (Negative logic)	Off-state voltage	All		3.5	-	18	Vdc
	On-state voltage	All		-0.3	-	1.2	Vdc
Output over-voltage protection[4]		All	V_O	13.8	-	16	Vdc
Pre-bias		All		0	-	95	%
Output over-temperature protection[5] With baseplate Without baseplate		All All		- -	110 120	- -	^oC ^oC
Over-temperature hysteresis		All		10	-	-	^oC
+ Sense		All	Vo	-	-	+0.5	Vdc
- Sense		All	Vo	-	-	-0.5	Vdc
MTBF		Telcordia SR-332-2006; 80% load, 300LFM, 40 ^oC T_A		-	1.5	-	10^6 h

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

PMBusTM signal interface characteristics

Table 4. PMbus signal interface characteristics:

Parameter	Condition1	Symbol	Min	Typ	Max	Unit
Input High Voltage (CLK,DATA)			2.1	-	3.6	V
Input Low Voltage (CLK,DATA)			0	-	0.4	V
Input High Level Current (CLK,DATA)			-10	-	10	uA
Output Low Voltage (CLK,DATA)	IO=2mA		-	-	0.4	V
Output high level open drain Leakage (CLK,DATA)	VO = 3.3V		-	5	-	uA
PMBUS operation frequency				100		KHz

ADQ500-48S12-6L Performance Curves

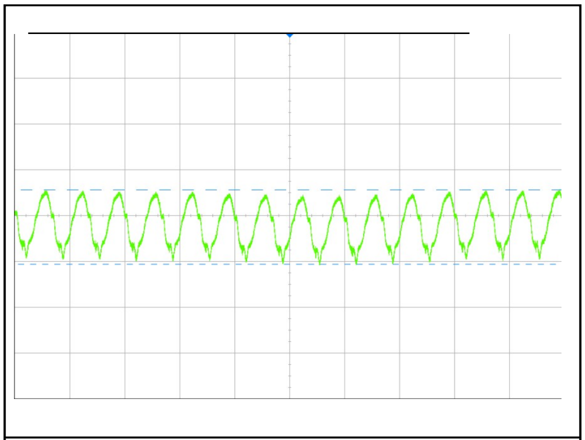


Figure 1: ADQ500-48S12-6L Input Reflected Ripple Current Waveform
Vin = 48Vdc Load: Io = 42A
Ch 1: Iin (5uS/div, 50mA/div)

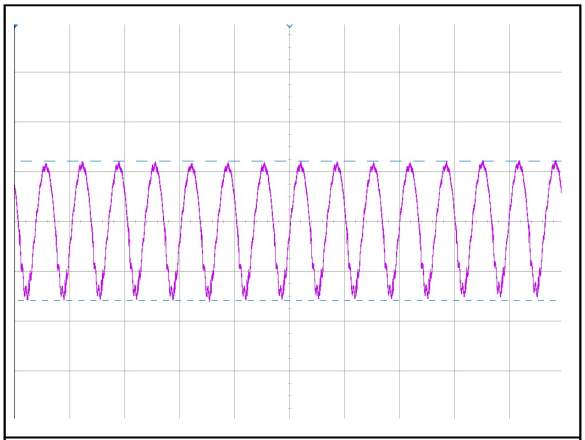


Figure 2: ADQ500-48S12-6L Ripple and Noise Measurement
Vin = 48Vdc Load: Io = 42A
Ch 1: Vo (5us/div 20mA/div)

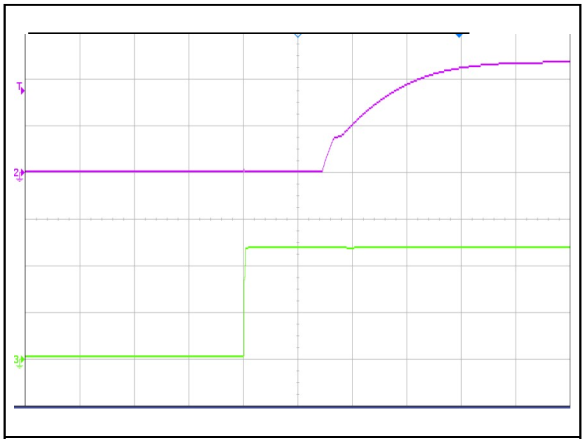


Figure 3: ADQ500-48S12-6L Output Voltage Startup Characteristic
Vin = 48Vdc Load: Io = 42A (20mS/div)
Ch 2: Vo (5V/div) Ch 3: Vin (20V/div)

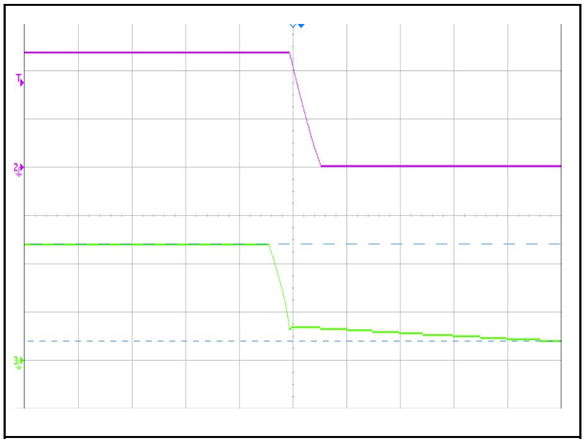


Figure 4: ADQ500-48S12-6L Turn Off Characteristic (2mS/div)
Vin = 48Vdc Load: Io = 42A
Ch 2: Vo (5V/div) Ch 3: Vin (20V/div)

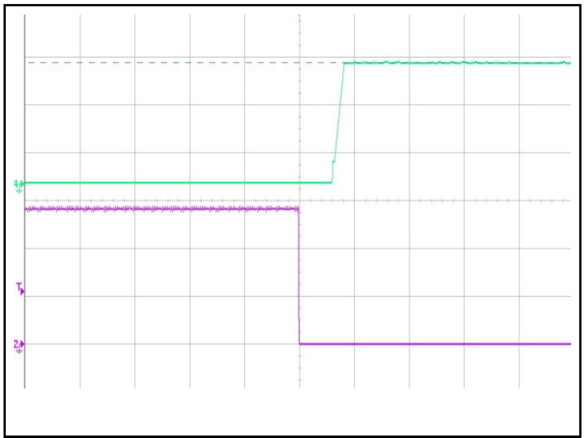


Figure 5: ADQ500-48S12-6L Remote ON Waveform (50mS/div)
Vin = 48Vdc Load: Io =42A
Ch 2: Vo (5V/div) Ch 4: Remote ON (2V/div)

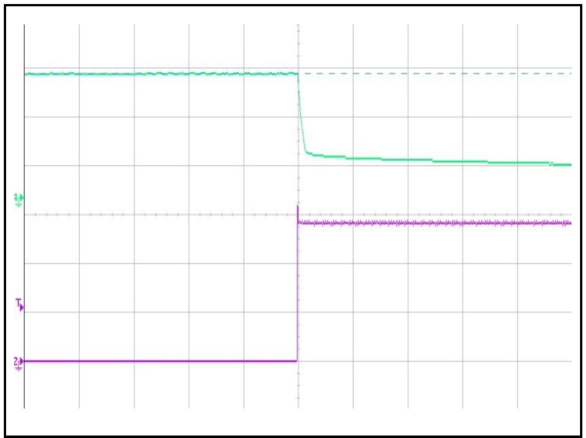


Figure 6: ADQ500-48S12-6L Remote OFF Waveform (20mS/div)
Vin = 48Vdc Load: Io = 42A
Ch 2: Vo (5V/div) CH4: Remote OFF (2V/div)

ADQ500-48S12-6L Performance Curves

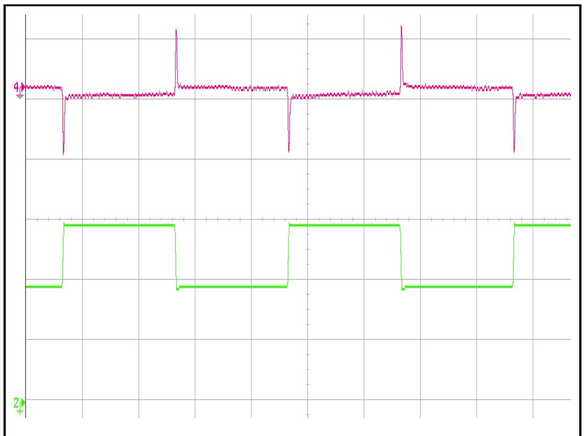


Figure 7: ADQ500-48S12-6L Transient Response (2mS/div)
50%~75%~50% load change, 0.1A/uS slew rate, Vin = 48Vdc
Ch 2: Io (10A/div) Ch 4: Vo (200mV/div)

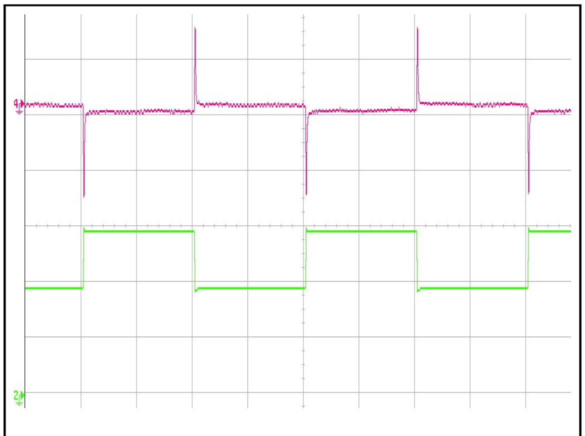


Figure 8: ADQ500-48S12-6L Transient Response (2mS/div)
50%~75%~50% load change, 1A/uS slew rate, Vin = 48Vdc
Ch 2: Io (10A/div) Ch 4: Vo (200mV/div)

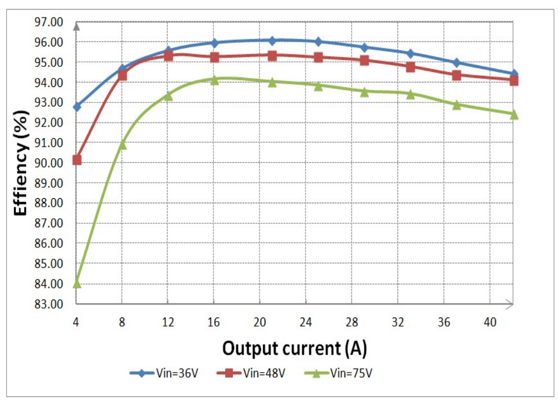


Figure 9: ADQ500-48S12-6L Efficiency Curves @ 25 degC

Loading: Io = 10% increment to 42A

ADQ500-48S12B-6L Performance Curves

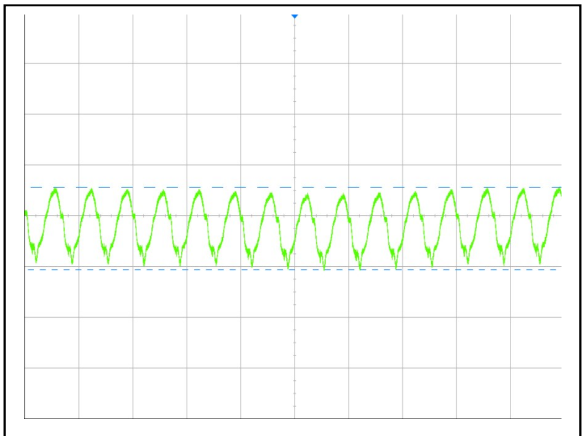


Figure 10: ADQ500-48S12B-6L Input Reflected Ripple Current Waveform
Vin = 48Vdc Load: Io = 42A
Ch 1: Iin (5uS/div, 50mA/div)

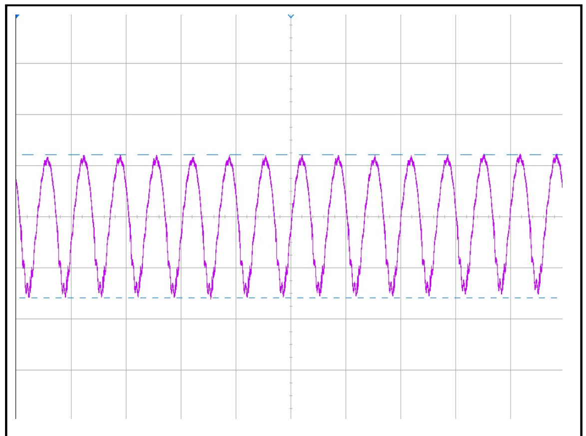


Figure 11: ADQ500-48S12B-6L Ripple and Noise Measurement
Vin = 48Vdc Load: Io = 42A
Ch 1: Vo (5us/div, 20mV/div)

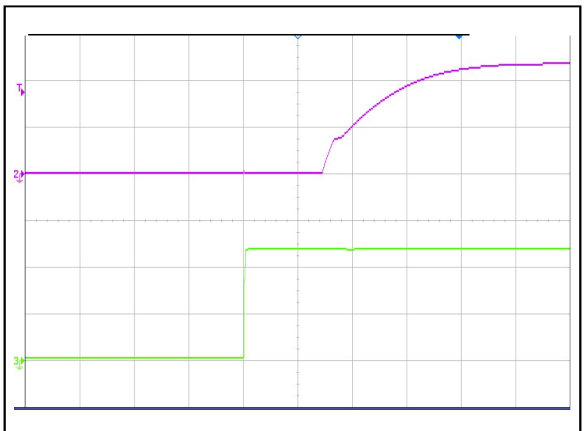


Figure 12: ADQ500-48S12B-6L Output Voltage Startup Characteristic
Vin = 48Vdc Load: Io = 42A (20mS/div)
Ch 2: Vo (5V/div) Ch 3: Vin (20V/div)

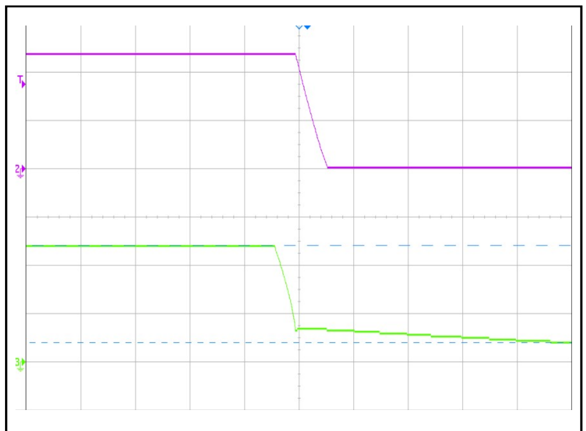


Figure 13: ADQ500-48S12B-6L Turn Off Characteristic (2mS/div)
Vin = 48Vdc Load: Io = 42A
Ch 2: Vo (5V/div) Ch 3: Vin (20V/div)

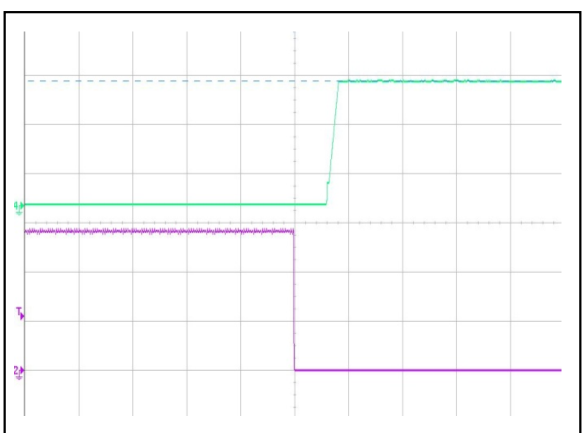


Figure 14: ADQ500-48S12B-6L Remote ON Waveform (10mS/div)
Vin = 48Vdc Load: Io =42A
Ch 2: Vo (5V/div) Ch 4: Remote ON (2V/div)

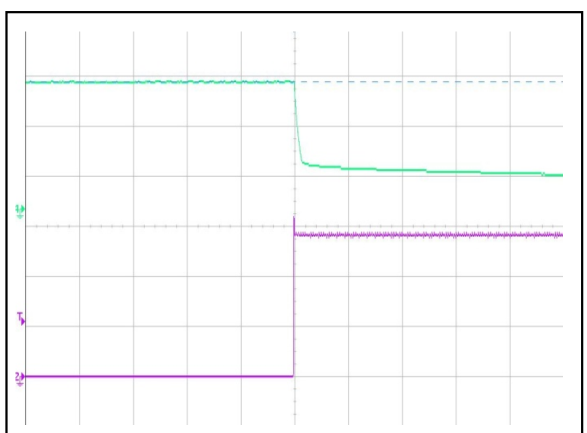


Figure 15: ADQ500-48S12B-6L Remote OFF Waveform (20mS/div)
Vin = 48Vdc Load: Io = 42A
Ch 2: Vo (5V/div) CH4: Remote OFF (2V/div)

ADQ500-48S12B-6L Performance Curves

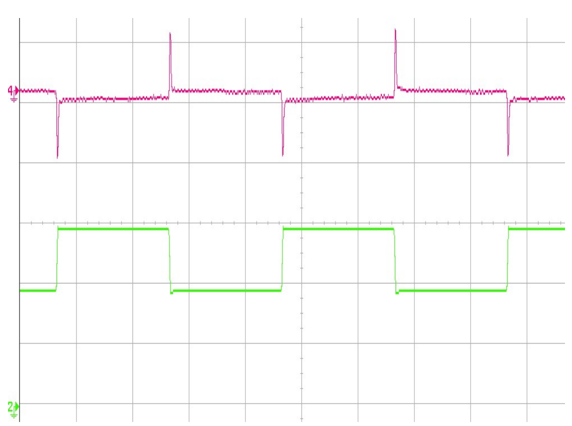


Figure 16: ADQ500-48S12B-6L Transient Response (2mS/div)
50%~75%~50% load change, 0.1A/uS slew rate, Vin = 48Vdc
Ch 2: Io (10A/div) Ch 4: Vo (200mV/div)

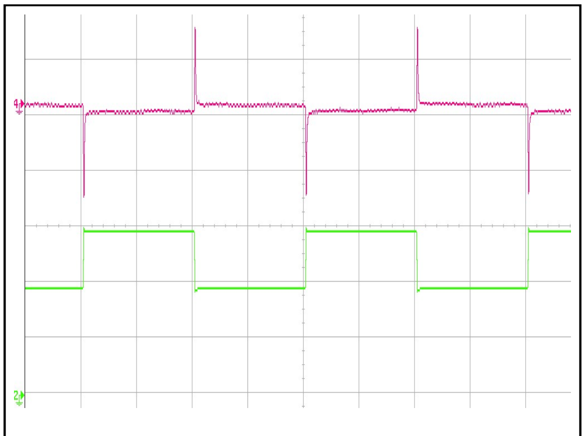


Figure 17: ADQ500-48S12B-6L Transient Response (2mS/div)
50%~75%~50% load change, 1A/uS slew rate, Vin = 48Vdc
Ch 2: Io (10A/div) Ch 4: Vo (200mV/div)

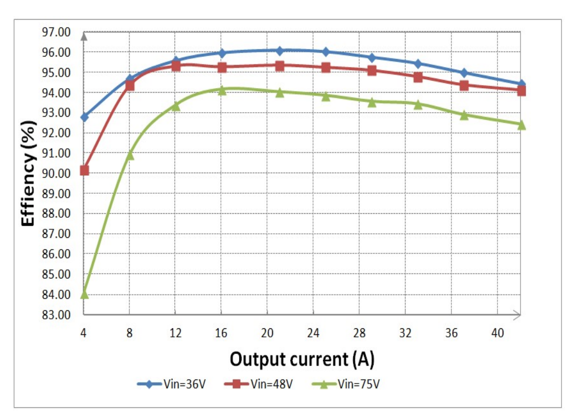


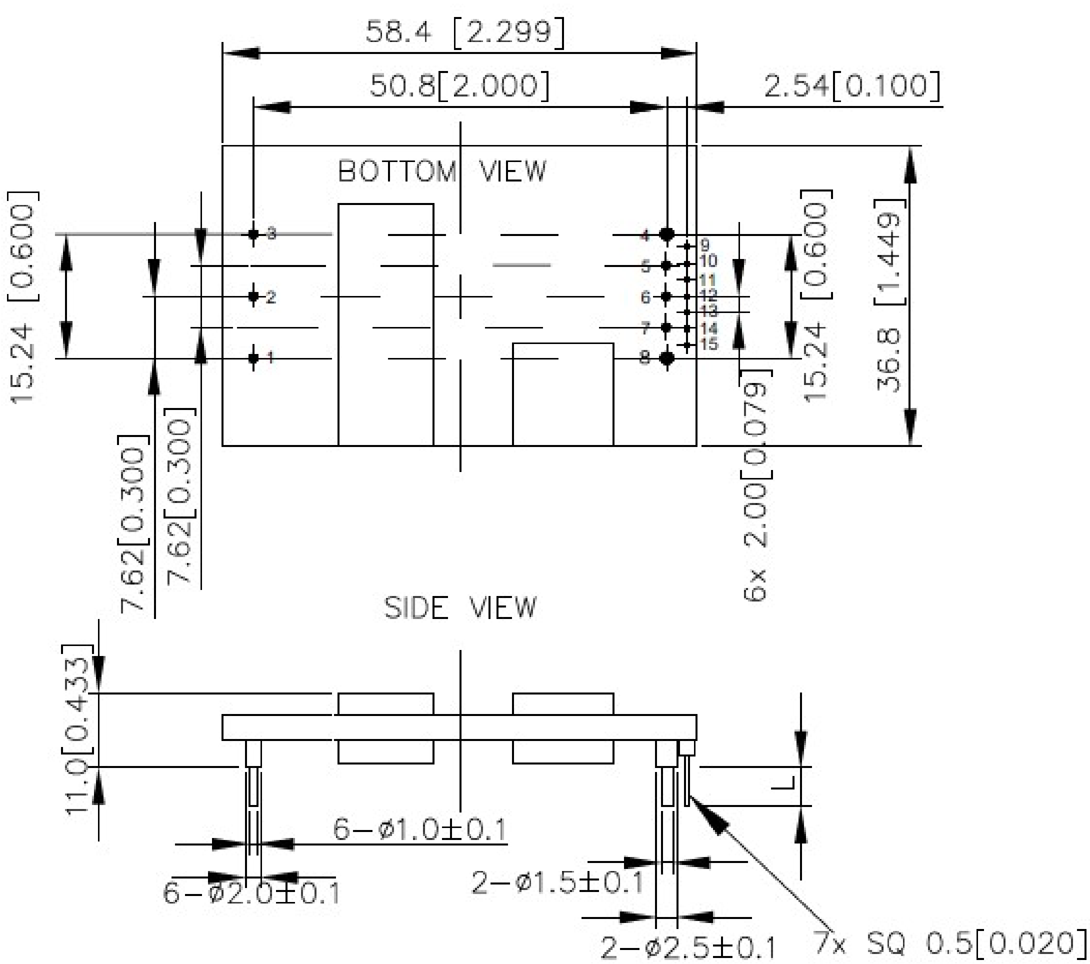
Figure 18: ADQ500-48S12B-6L Efficiency Curves @ 25 degC

Loading: Io = 10% increment to 42A

Mechanical Specifications

Mechanical Outlines – Open-frame Module

ADQ500-48S12-6L



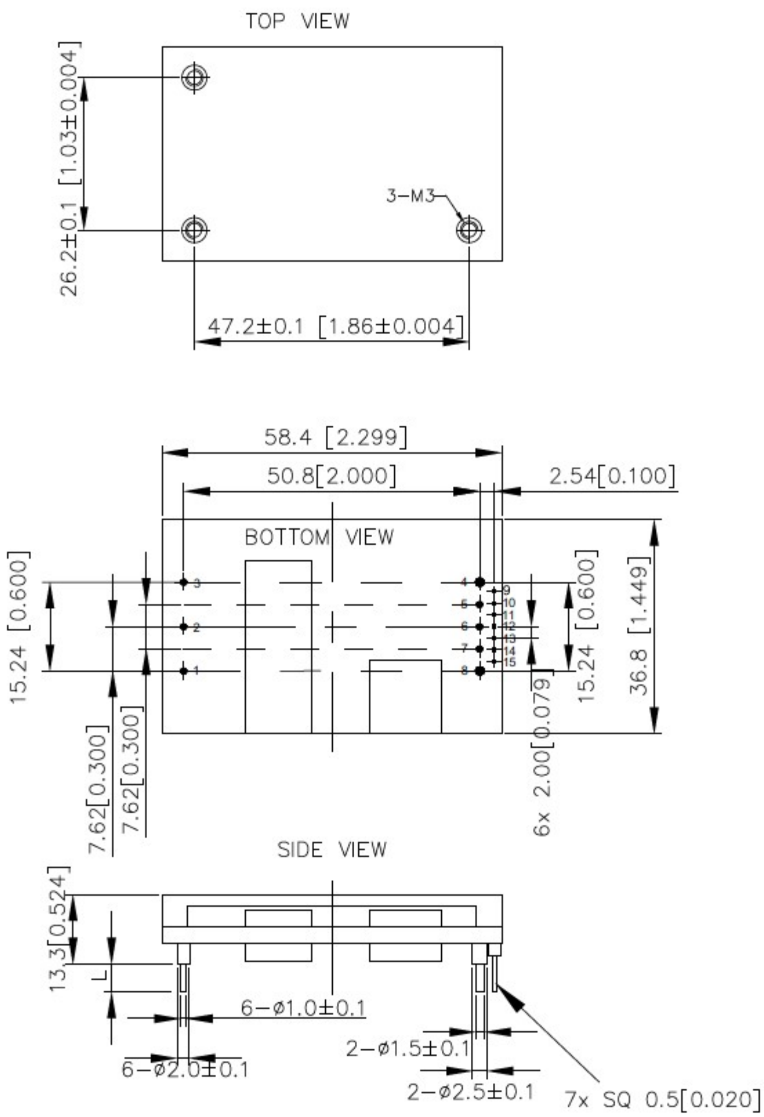
UNIT: mm[inch]

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

X.XX mm±0.25 mm[X.XXX in. ±0.01 in.]

Mechanical Outlines – Baseplate Module

ADQ500-48S12B-6L



UNIT: mm[inch]

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

X.XX mm±0.25 mm[X.XXX in. ±0.01 in.]

Pin length option

Table 5. 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	V_{in}+	Positive input voltage
2	Remote ON/OFF	Remote control
3	V_{in}-	Negative input voltage
4	V_o-	Negative output voltage
5	-Sense	Remote sense negative
6	trim	Voltage adjustment
7	+Sense	Remote sense positive
8	V_o+	Positive output voltage
9	C2	Digital
10	Sig_Gnd	
11	Data	
12	SMBAlert	
13	Clock	
14	Addr1	
15	Addr0	

Environmental Specifications

EMC Immunity

ADQ500-48S12 power supply is designed to meet the following EMC immunity specifications:

Table 6. Environmental Specifications:

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

Criterion A: Normal performance during and after test.
Criterion B: For EFT and surges, low-voltage protection or reset is not allowed. Temporary output voltage fluctuation ceases after disturbances ceases, and from which the EUT recovers its normal performance automatically. For Dips and ESD, output voltage fluctuation or reset is allowed during the test, but recovers to its normal performance automatically after the disturbance ceases.

Recommend EMC Filter Configuration

See Figure 30

Safety Certifications

The ADQ500-48S12 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 7. Safety Certifications for ADQ500-48S12- series power supply system

Document	File #	Description
UL/CSA 62368	E132002-A384-UL	US and Canada Requirements
EN62368		European Requirements
IEC62368		International Requirements
CE	C8031	CE Marking
TUV	B 15 07 13890 02251	Germany Requirements
UL94,V-0		flammability rating

Operating Temperature

The ADQ500 series power supplies will start and operate within stated specifications at an ambient temperature from -40 ^{O}C to 85 ^{O}C under all load conditions. The storage temperature is -55 ^{O}C to 125 ^{O}C.

Thermal Considerations – Open-frame module

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

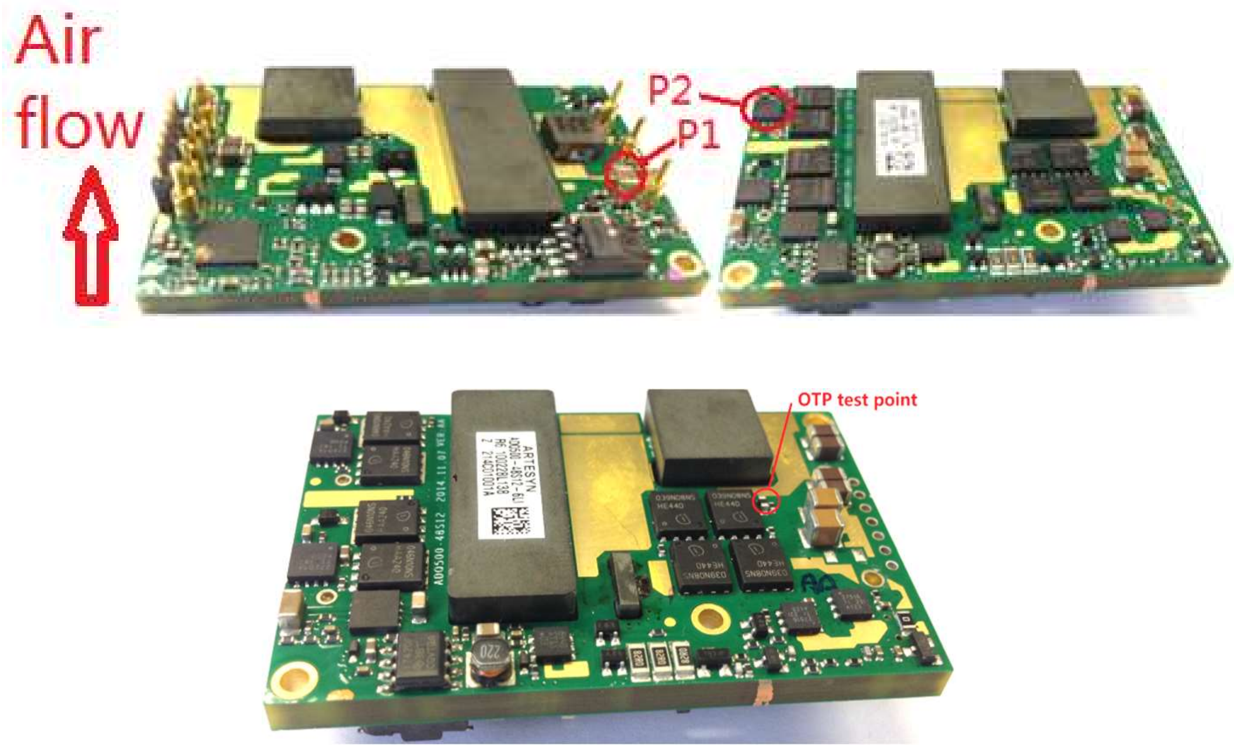


Figure 19 Temperature test point

Table 8. Temperature limit of the test point

Test Point	Temperature Limit
P1	115 ^{O}C
P2	120 ^{O}C

For a typical application, figure 20 shows the derating of output current vs. ambient air temperature at different air velocity@48V input. Figure 21 shows the thermal image taken by a RF camera at a rated I/O condition.

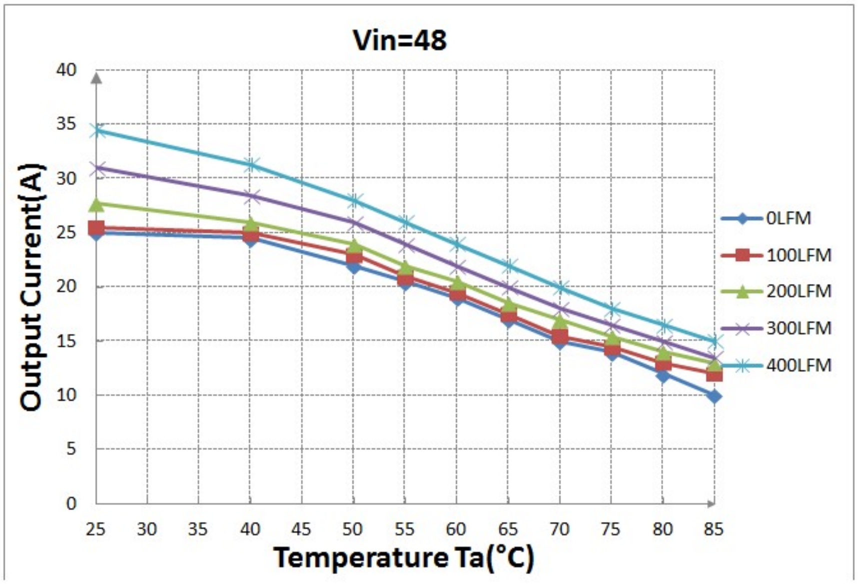


Figure 20 Output power derating, $48V_{IN}$, air flowing across the converter from V_{IN} -to V_{IN}+

Figure 21 Thermal image, $48V_{IN}$, $12V_O$ full load, room temperature

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 figure 22. The temperature at this point should not exceed the max values in the table 8.

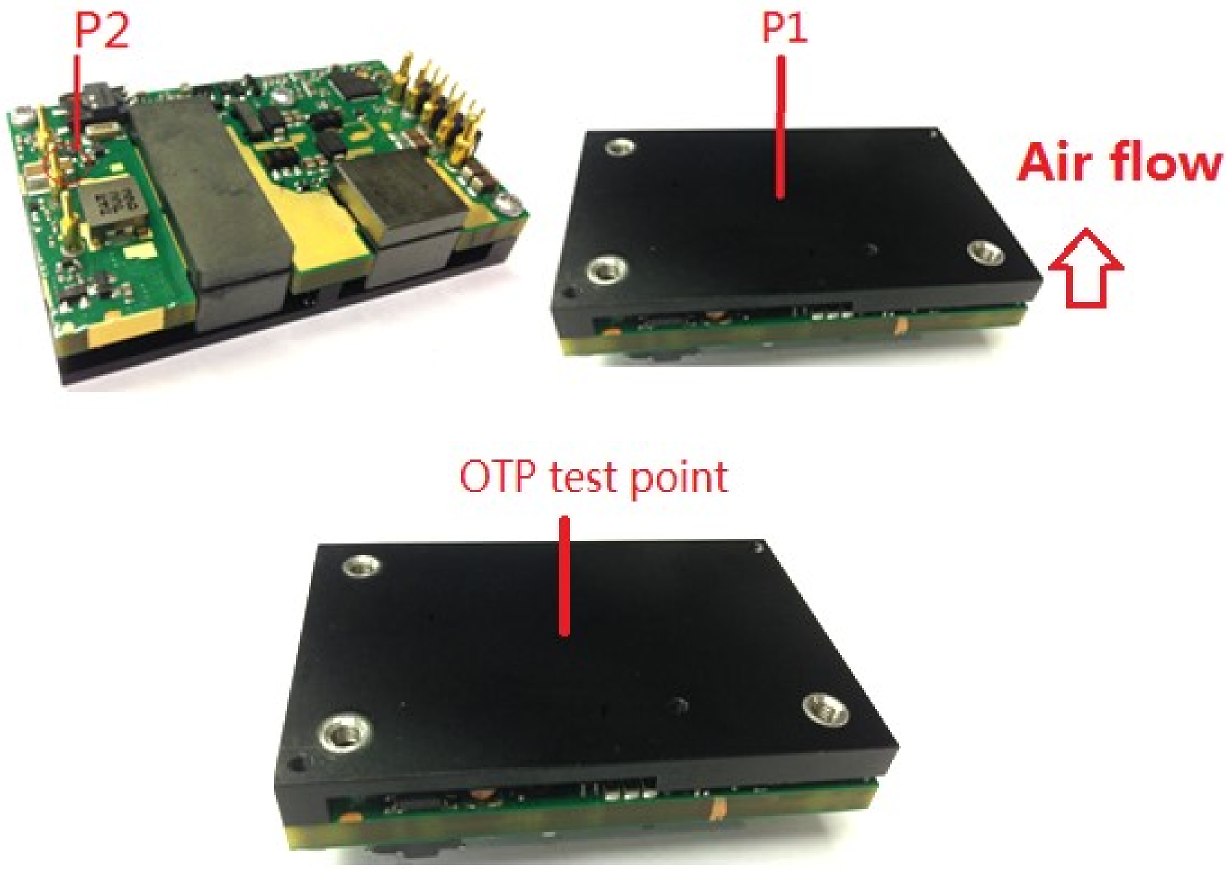


Figure 22 Temperature test points

Table 9. Temperature limit of the test point

Test Point	Temperature Limit
P1	110 ^{O}C
P2	115 ^{O}C

The typical test condition is shown in Figure 23.
For a typical application, figure 24 shows the derating of output current vs. ambient air temperature at different air velocity @48V input.

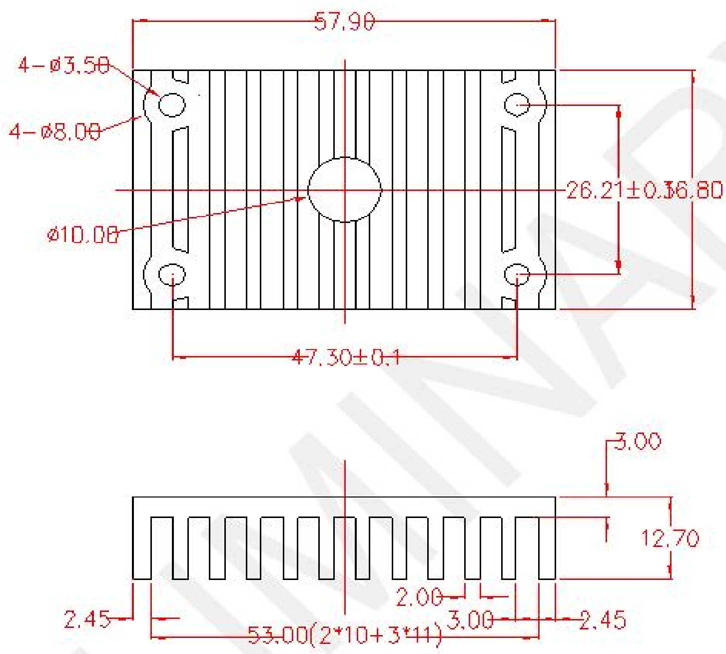


Figure 23 Typical test condition, heatsink

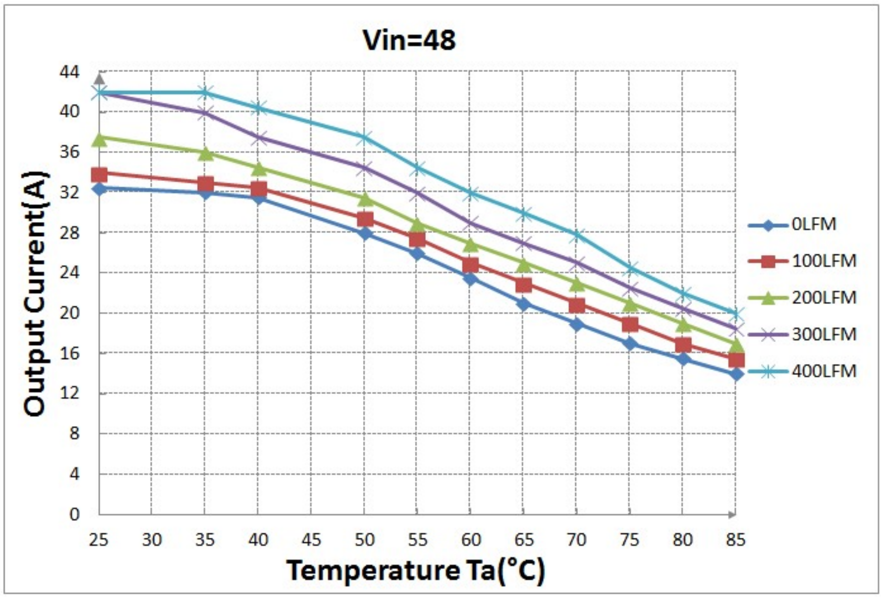


Figure 24 Output power derating, $48V_{IN}$, air flowing across the converter from V_{IN} - to V_{IN} +

Qualification Testing

Table 10. Qualification testing

Parameter	Unit (pcs)	Test condition
Halt test	4 ~ 5	Ta,min-10^{O}C to Ta,max+30^{O}C, 5^{O}C step, Vin = 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/axes
Mechanical shock	3	30g, 6ms, 3axes, 6directions, 3times/direction
Thermal shock	3	-55^{O}C to 125^{O}C, unit temperature 20cycles
Thermal cycling	3	-40^{O}C to 85^{O}C, temperature change rate: 1° C/min, cycles: 2cycles
Humidity	3	40^{O}C, 95%RH, 48h
Solder ability	15	IPC J-STD-002C-2007

Application Notes

Typical Application

Below is the typical application of the ADQ500-48S12 series power supply.

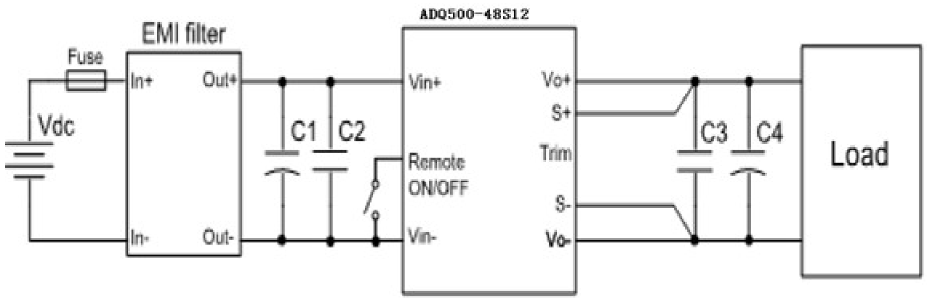


Figure 25 Typical application

C1: 220μF/100V electrolytic capacitor, P/N: UPM2A221MPD (Nichicon) or equivalent caps
C2, C3: 1μF/100V X7R ceramic capacitor, P/N: C3225X7R2A105KT0L0U (TDK) or equivalent caps
C4: 470μF/25V electrolytic capacitor, P/N: UPM1E471MED (Nichicon) or equivalent caps

Note: If ambient temperature is below -5^{O}C, double output capacitor (Low ESR, ESR≤100mΩ) is needed for output.

Fuse: External fast blow fuse with a rating of 30A/250Vac. The recommended fuse model is **0314030 MRP** from Karwin Tech limited..

EMI filter: Refer to figure 30

Remote ON/OFF

Either positive or negative remote ON/OFF logic is available in ADQ500-48S12. The logic is CMOS and TTL compatible. Below is the detailed internal circuit and reference in ADQ500-48S12.

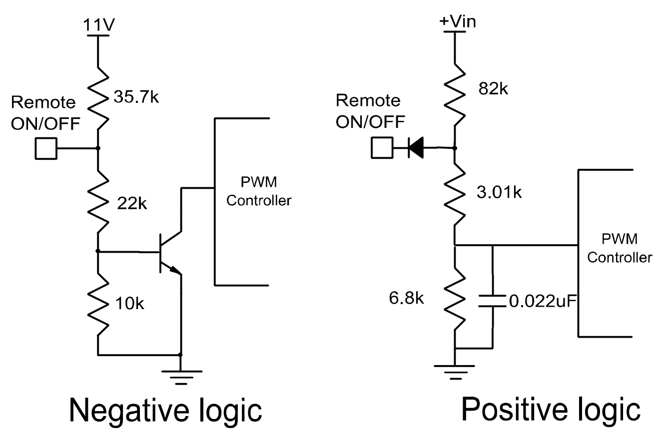


Figure 26 Remote ON/OFF internal diagram

Remote sense

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

Trim Characteristics

To increase or decrease the output voltage set point, connect an external resistor between the TRIM pin and either the Vo+ or Vo-. The TRIM pin should be left open if this feature is not used. Below Trim equation is only adapt to the module without droop current sharing option code; For the module with droop current sharing option code, please contact Artesyn's technical support team. Connecting an external resistor between Trim pin and Vo- pin will decrease the output voltage. While connection it between Trim and Vo+ will increase the output voltage. The following equations determine the external resistance to obtain the trimmed output voltage.

$$R_{adj-down} = \frac{511}{\Delta} - 10.22(K\Omega)$$

$$R_{adj-up} = \frac{5.11 \times V_{nom} \times (100 + \Delta)}{1.225 \times \Delta} - \frac{511}{\Delta} - 10.22(K\Omega)$$

Δ :Output e rate against nominal output voltage.

$$\Delta = \frac{100 \times (V_{nom} - V_0)}{V_{nom}}$$

V_{norm} :Nominal output voltage.
For example, to get 13.2V output, the trimming resistor is

$$\Delta = \frac{100 \times (V_{nom} - V_0)}{V_{nom}} = \frac{100 \times (13.2 - 12)}{12} = 10$$

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

$$R_{adj-up} = \frac{5.11 \times 12 \times (100 + 10)}{1.225 \times 10} - \frac{511}{10} - 10.22 = 489.3(K\Omega)$$

$$V_O = (V_{trim} + 1.225) \times 1.347$$

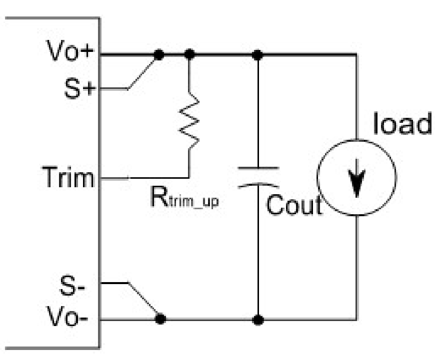


Figure 27 Trim up

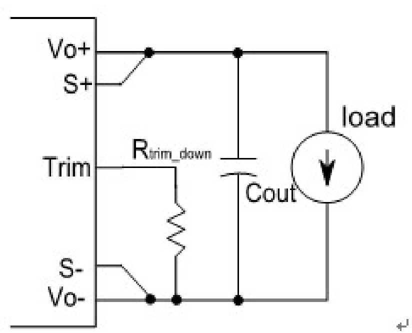


Figure 28 Trim down

Where is the potential applied at the Trim pin, and Vo is the desired output voltage. When trimming up, the output current should be decreased accordingly so as not to exceed the maximum output power.

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

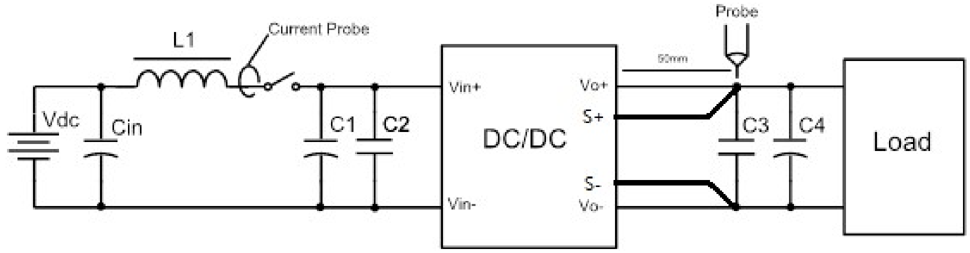


Figure 29 Input ripple & inrush current, ripple & noise test configuration

Vdc: DC power supply
L1: 12μH
Cin: 220μF/100V typical
C1 ~ C4: See Figure 25
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 test conditions

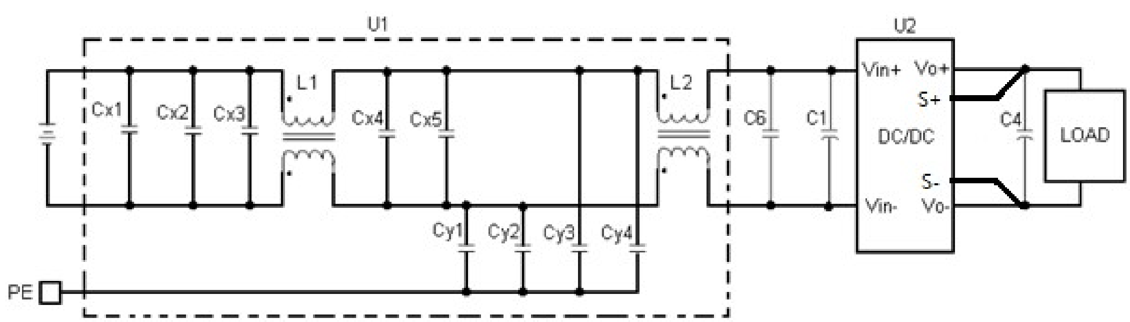


Figure 30 EMC test configuration

U1: Input EMC filter
U2: Module to test, ADQ500-48S12
C_{X1}, $C_{X2,}$ $C_{X4:}$ 1000nF/100V/X7R capacitor
$C_{X3,}C_{X5}$: 2200nF/100V/X7S capacitor
C_{y1}, C_{y2}, C_{y3}, C_{y4}: 1.0μF/630V/X7T, Y capacitor
L1, L2: 473μH, common mode inductor
C6: 100nF/100V/X7R capacitor
C1: 220μF/100V electrolytic capacitor
C4: 470μF/25V electrolytic capacitor

PMBus Communication

The module has a digital PMBus interface to allow the module to be monitored, controlled and configured by the system. The module supports 4 PMBus signal lines, Data, Clock, SMBALERT (optional), Control (C2 pin, optional), and 2 Address line Addr0 and Addr1. More detail PMBus information can be found in the PMB Power Management Protocol Specification, Part I and part II, revision 1.2; which is shown in http://pmbus.org . Both 100kHz and 400kHz bus speeds are supported by the module. Connection for the PMBus interface should be following the High Power DC specifications given in section 3.1.3 in the SMBus specification V2.0 or the Low Power DC specifications in section 3.1.2. The complete SMBus specification is shown in http://smbus.org.

The module supports the Packet Error Checking (PEC) protocol. It can check the PEC byte provided by the PMBus master, and include a PEC byte in all message responses to the master.

SMBALERT protocol is also supported by the module. SMBALERT line is also a wired-AND signal; by which the module can alert the PMBUS master via pulling the SMBALERT pin to an active low. There are two ways that the master and the module response to the alert of SMBALERT line.

One way is for the module used in a system that does not support Alert Response Address (ARA). The module is to retain its resistor programmed address, when it is in an ALERT active condition. The master will communicate with the slave module using the programmed address, and using the various READ_STATUS commands to find who cause for the SMBALERT. The CLEAR_FAULTS command will clear the SMBALERT.

The other way is for the module used in a system that does support Alert Response Address (ARA). In this case, the master simultaneously accesses all SMBALERT devices through the ARA. Only the device which pulled SMBALERT low will acknowledge the ARA. The master is expected to perform the modified received byte operation to get the address of the alert slave, and retire the SMBALERT active signal. And then, the alter slave will return to its resistor programmed address, allowing normal master-slave communications to proceed.

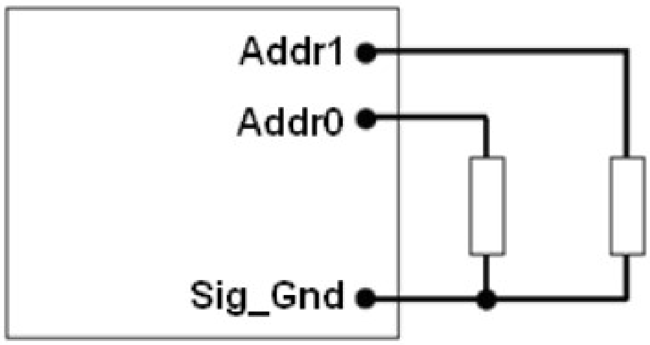
If more than one slave pulls SMBALERT line low, the lowest address slave will win communication rights via standard arbitration during the slave address transfer. After acknowledging the ARA, the lowest address slave must disengage its SMBALERT pull down. If the master still sees SMBALERT line low, it knows to send another ARA and ask again “Now, who is holding the alert down”. The second slave is now locked-up and can’t responsive. But the solution is easy; the master should now initiate a “dummy command”, for example read command on the bus and read any parameter from any slave. After this, the second slave (the one that lost arbitration in the first run) will be released. Now, if master sends the second ARA, the second slave will provide its address to the Master.

The module contains a data flash used to store configuration settings, which will not be programmed into the device data flash automatically. The STORE_DEFAULT_ALL command must be used to commit the current settings are transfer from RAM to data flash as device defaults.

PMBus Addressing

The Module has flexible PMBUS addressing capability. When connect different resistor from Addr0 and Addr1 pin to GND pin, 64 possible addresses can be acquired. The address is in the form of octal digits; Each pin offer one octal digit, and then combine together to form the decimal address as shown in below.

Address = 8 * ADDR1 + ADDR0



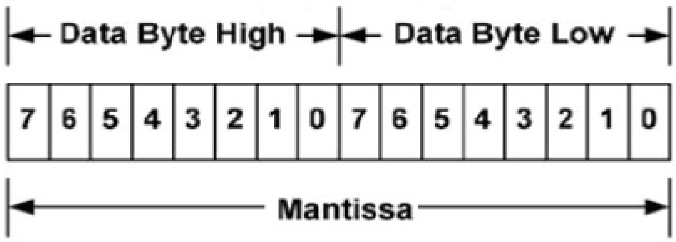
Corresponded to each octal digit, the requested resistor values are shown in below, and +/-5% resistors accuracy can be accepted. If there is any resistance exceeding the requested range, address 127 will be return. 0-12 and 40, 44, 45, and 55 in decimal address can't be used, since they are reserved according to the SMBus specifications, and which will also return address 127.

Addr	Level	R2	R1
0	0.25	24.9K	24.9K
1	0.50	49.9K	49.9K
2	0.75	75K	75K
3	1.00	100K	100K
4	1.25	124K	124K
5	1.50	150K	150K
6	1.75	174K	174K
7	2.00	200K	200K

PMBus Data Format

The module receives and report date in LINEAR format. The Exponent of the data words is fixed at a reasonable value for the command; altering the exponent is not supported. DIRECT format is not supported by the module.

For commands that set or report any voltage thresholds related to the output voltage, the module supports the linear data format consisting of a two byte value with a 16-bit, unsigned mantissa, and a fixed exponent of -12. The format of the two data bytes is shown below:



The equation can be written as:

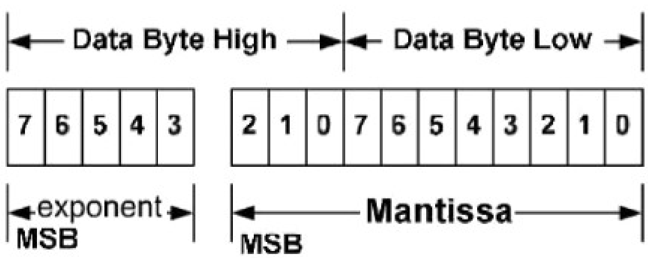
Vout = Mantissa x

For example, considering set Vout to 12V by VOUT_COMMAND, the read/write data can be calculated refer to below process:

1. Mantissa = $Vout/2^{-9} = 12/2^{-9} = 6144$;

2. Converter the calculated Mantissa to hexadecimal 0x1800.

For commands that set or report all other thresholds, including input voltages, output current, temperature, time and frequency, the supported linear data format is a two byte value with: an 11 bit, two's complement mantissa , and a 5 bit, two's complement exponent (scaling factor).The format of the two data bytes is shown as in below.



The equation can be written as:

Value = Mantissa x

For example, considering set the turn on threshold of input under voltage lockout to 33V by VIN_ON command; the read/write data can be calculated refer to below process:

1. Get the exponent of Vin, 0; whose binary is 00000

2. Mantissa =Vin/=33/=33;

3. Converter the calculated Mantissa to hexadecimal 21, then converter to binary 00000100001;

4. Combine the exponent and the mantissa, 00000 and 0000000000100001;

5. Converter binary 0000000000100001 to hexadecimal 0021.

The detail exponent and resolution of main parameter is to be decided later.

Supported PMBus Command

The main PMBus commands described in the PMBus 1.2 specification are supported by the module. Partial PMBus commands are fully supported; Partial PMBus commands have difference with the definition in PMBus 1.2 specification. The details about all the supported PMBus commands are to be decided later.

.ADQ500-48S12 Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
0x01	OPERATION	0x80	R/W	1	Bit field	Turn the module on or off by PMBUS command.
0x02	ON_OFF_CONFIG	0x1D (Neg Logic); 0x1F (Pos Logic);	R/W	1	Bit field	Configures the combination of primary on/off pin and PMBUS command.
0x03	CLEAR_FAULTS	/	Send	1	/	Clear any fault bits that have been set.
0x11	STORE_DEFAULT_ALL	/	Send	1	/	Stores operating parameters from RAM to data flash. This command is effective to the parameter of all command in the table.
0x12	RESTORE_DEFAULT_ALL	/	Send	1	/	Restores operating parameters from data flash to RAM. This command can't be issued when the power unit is running.
0x20	VOUT_MODE	0x17	Read	1	mode+ exp	To read Vo data format.
0x21	VOUT_COMMAND	12.0Vdc	R/W	2	Vout Linear	Set the output voltage. Range: 9.6~13.2Vdc Exponent: -9
0x33	FREQUENCY_SWITCH	175KHz	R/W	2	Linear	Set the switching frequency. Range: 150~180KHz Exponent: 0
0x35	VIN_ON	34Vdc	R/W	2	Linear	Set the turn on voltage threshold of Vin under voltage lockout. VIN_ON should be higher than VIN_OFF, and keep 2V hystersis. Range: 32~46Vdc Exponent: 0
0x36	VIN_OFF	32Vdc	R/W	2	Linear	Set the turn off voltage threshold of Vin under voltage lockout. VIN_ON should be higher than VIN_OFF, and keep 2V hystersis. Range: 31~46Vdc Exponent: 0
0x40	VOUT_OV_FAULT_LIMIT	15Vdc	R/W	2	Vout Linear	Set the output overvoltage fault threshold. Must be higher than the value of VOUT_COMMAND and VOUT_OV_WARN_LIMIT; Range:11-16Vdc Exponent:-9
0x41	VOUT_OV_FAULT_RESPONSE	0xB8	Read	1	Bit field	Instructs what action to take in response to an output overvoltage fault.
0x42	VOUT_OV_WARN_LIMIT	15Vdc	R/W	2	Vout Linear	Set a threshold causing an output voltage high warning. Must be less than VOUT_OV_FAULT_LIMIT value. Range:11~16Vdc Exponent:-9

ADQ500-48S12 Series Supported PMBus^{TM} Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
0x46	IOUT_OC_FAULT_LIMIT	50A	R/W	2	Linear	Set the output overcurrent fault threshold. Must be greater than IOUT_OC_WARN_LIMIT value Range:20~60A Exponent:0
0x47	IOUT_OC_FAULT_RESPONSE	0xF8	Read	1	Bit field	Instructs what action to take in response to an output overcurrent fault.
0x4A	IOUT_OC_WARN_LIMIT	46A	R/W	2	Linear	Set a threshold causing an output current high warning. Must be less than IOUT_OC_FAULT_LIMIT value. Range:10~45A Exponent:0
0x4F	OT_FAULT_LIMIT	120Deg.C	R/W	2	Linear	Set the over temperature fault threshold. Must be greater than OT_WARN_LIMIT value. Range:25~140Deg.C
0x55	VIN_OV_FAULT_LIMIT	110Vdc	R/W	2	Linear	Set the input overvoltage fault threshold. Range:48~110Vdc Exponent:0
0x5E	POWER_GOOD_ON	11Vdc	R/W	2	Vout Linear	Sets the output voltage at which the bit 3 of STATUS_WORD high byte should be asserted. Must be greater than POWER_GOOD_OFF value by 1.6V. Range:8.1 ~13.2Vdc Exponent:-9
0x5F	POWER_GOOD_OFF	9Vdc	R/W	2	Vout Linear	Sets the output voltage at which the bit 3 of STATUS_WORD high byte should be negated. Must be less than POWER_GOOD_ON value by 1.6V. Range:8.1 ~13.2Vdc Exponent:-9
0x79	STATUS_WORD	/	Read	2	Bit field	Returns the information with a summar of the module's fault/warning.
0x88	READ_VIN	/	Read	2	Linear	Returns the input voltage of the module.
0x8B	READ_VOUT	/	Read	2	Vout Linear	Returns the output voltage of the module.
0x8C	READ_IOUT T	/	Read	2	Linear	Returns the output current of the module.
0x8E	READ_TEMPERATURE_1	/	Read	2	Linear	Returns the module's hot spot temperature of the module.
0x98	PMBUS_REVISION	1.2	Read	1	Bit field	Reads the revision of the PMBus.
0xE0	MFR_ C2_Configure	0x00	R/W	1	Bit field	Configures the C2 pin (secondary on/off pin) function and logic;
0xE1	MFR_PGOOD _POLARITY	0x00	R/W	1	Bit field	Configure Power Good logic.
0xF7	MFR_C1_C2_ARA_CONFIG	0x00	R/W	1	Bit field	Configure C2 pin function.

OPERATION [0x01]

Bit number	Purpose	Bit Value	Meaning	Default Settings: 0x80
7:	Enable/Disable the module	1	Output is enabled	1
		0	Output is disabled	
6:	Reserved			0
5:4	Margins	00	No margin	00
		01	Margin low(Act on Fault)	
		10	Margin high(Act on Fault)	
3:0	Reserved			0000

VOUT_OV_FAULT_RESPONSE [0x41]

Bit number	Purpose	Bit Value	Meaning	Default Settings:0xB8
7: 6	Response settings	10	Unit shuts down and responds according to the retry settings	10
5:3	Retry setting	111	Unit continuously restarts while fault is present until commanded off	111
		000	Unit does not attempt to restart on fault	
2:0	Delay time setting	000	No delay supported	000

IOUT_OC_FAULT_RESPONSE [0x47]

Bit number	Purpose	Bit Value	Meaning	Default Setting:0xF8
7: 6	Response settings	11	Unit shuts down and responds according to the retry settings	11
5:3	Retry setting	111	Unit continuously restarts while fault is present until commanded off	111
		000	Unit does not attempt to restart on fault	
2:0	Delay time setting	000	No delay supported	000

STATUS_WORD [0x79]

High byte

Bit number	Purpose	Bit Value	Meaning
7	An output over voltage fault or warning	1	Occurred
		0	No Occurred
6	An output over current fault or warning	1	Occurred
		0	No Occurred
5	An input voltage fault, including over voltage and under-voltage	1	Occurred
		0	No Occurred
4	Reserved		
3	Power_Good	1	is negated
		0	ok
2:0	Reserved		

Low Byte

Bit number	Purpose	Bit Value	Meaning
7	Reserved		
6	OFF (The unit is not providing power to the output by OCP OVP OVIN)	1	Occurred
		0	No Occurred
5	An output over voltage fault	1	Occurred
		0	No Occurred
4	An output over current fault	1	Occurred
		0	No Occurred
3	An input under voltage fault	1	Occurred
		0	No Occurred
2	A temperature fault or warning	1	Occurred
		0	No Occurred
1	Reserved		
0	Reserved		

MFR_C1_C2_ARA_CONFIG [0xF7]

Bit number	Purpose	Bit Value	Meaning
7:5	Reserved	000	Reserved
4	Reserved	0	Reserved
3:0	PIN Configuration	0000	C2 pin: POWER_GOOD
		0010	C2 pin: ON/OFF (Secondary)

MFR_ C2_Configure [0xE0]

Bit number	Purpose	Bit Value	Meaning
7:2	Reserved	000000	Reserved
1	ON/OFF Configuration	0	Secondary side on/off pin state when mapped to C2 is ignored
		1	AND – Primary and Secondary side on/off
0	PIN Configuration	0	Negative Logic (Low Enable: Input < 0.8V wrt Vout(-)
		1	Positive Logic (High Enable: Input > 2.0V wrt Vout(-)

MFR_PGOOD_POLARITY [0xE1]

Bit number	Purpose	Bit Value	Meaning
7:1	Reserved	0000000	Reserved
0	Power Good Logic	0	Negative PGOOD logic
		1	Positive PGOOD logic

Weight

The ADQ500-48S12-6L(Open Frame) weight is 57.2g.maximum.(46.8g.minmum)
The ADQ500-48S12B-6L(Baseplate) weight is 80.3g.maximum.(65.7g.minmum)

Soldering

Wave 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.

Hazardous Substances Announcement (RoHS of China)

Parts	Hazardous Substances					
	Pb	Hg	Cd	Cr^{6+}	PBB	PBDE
ADQ500-48S12-6L	x	x	x	x	x	x
ADQ500-48S12B-6L	x	x	x	x	x	x
ADQ500-48S12-6LI	x	x	x	x	x	x
ADQ500-48S12B-6LI	x	x	x	x	x	x
ADQ500-48S12B-6LK	x	x	x	x	x	x
ADQ500-48S12B-6LA	x	x	x	x	x	x
ADQ500-48S12B-6LS	x	x	x	x	x	x
ADQ500-48S12PB-6L	x	x	x	x	x	x
ADQ500-48S12PB-6LI	x	x	x	x	x	x

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

√: 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

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:

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

Record of Revision and Changes

Issue	Date	Description	Originators
1.0	09.18.2015	First Issue	A. Li
1.1	01.25.2017	Update the new P/N ADH700-48S28-6LA for NSA.	K. Wang
1.2	03.31.2017	Update the model number the “ADH700-48S28-6LA” can not support PMBus	K. Wang
1.3	05.17.2019	Update product spec	K. Wang
1.4	06.21.2019	Update the ADQ500-48S12B-6LA switch frequency to 140kHz	K. Wang