ARTESYN AGQ500-48S28-6L

500 Watts Quarter Brick Converter

PRODUCT DESCRIPTION

Advanced Energy's Artesyn AGQ500-48S28-6L is a single output DC-DC converter with standard quarter-brick outline and pin configuration. It delivers up to 18A output current with 28V output voltage. Above 93.4% ultra-high efficiency and excellent thermal performance makes it an ideal choice to supply power to a power amplifier in telecom and data-com. The aluminum baseplate structure makes it possible for the module to work under -40 ^{O}C ~ 85 ^{O}C without air cooling and baseplate operating temperature up to 100 ^{O}C.

TECHNICAL REFERENCE NOTE

Total Power:

500 Watts

Input Voltage:

36-75 Vdc

# of Outputs:

Single

RoHS

SPECIAL FEATURES

- Delivers up to 18A output current
- Ultra-high efficiency 93.4% typ. at full load
- Wide input range: 36V ~ 75V
- Excellent thermal performance
- No minimum load requirement
- Basic isolation
- High power density
- Low output noise
- RoHS 3.0 (2011/65/EU)
- Remote control function
- Remote output sense
- Trim function: 14V ~ 33V
- Input under-voltage lockout
- Output over-current protection
- Output short circuit protection
- Output over-voltage protection
- Over-temperature protection
- Industry standard quarter-brick

SAFETY

- UL/CSA/IEC/EN62368 (60950-1)
- CE
- UL/TUV
- CE
- EN55032 Class B

Model Numbers

Standard	Output Voltage	Structure	Remote ON/OFF logic	ROHS
AGQ500-48S28-6L	28Vdc	Baseplate	Negative	RoHS 3.0 (2011/65/EU)
AGQ500-48S28P-6L	28Vdc	Baseplate	Positive	RoHS 3.0 (2011/65/EU)

Order Information

AGQ500	-	48	S	28	P	-	6	L
①		②	③	④	⑤		⑥	⑦

①	Model series	AGQ: series name, 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	28: 28V output
⑤	Remote ON/OFF logic	Default: negative logic; P: positive
⑥	Pin length	6: 3.8mm
⑦	RoHS status	L: RoHS 3.0 (2011/65/EU)

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 models	$V_{IN,DC}$	-	-	80	Vdc
Non-operating (100ms)	All models		-	-	100	Vdc
Ambient Operating Temperature	All models	T_A	-40	-	+85	^{O}C
Voltage at remote ON/OFF pin	All models		-0.3	-	15	Vdc
Storage Temperature	All models	T_{STG}	-55	-	+125	^{O}C
Isolation Voltage[1]						
Input to Output[2]	All models		1500	-	-	Vdc
Output to Metal[3]	All models		1500	-	-	Vdc
Input to Metal	All models		1000	-	-	Vdc
Voltage at Remote ON/OFF control (negative logic)						
Off-state voltage	All models		2.4	-	15	Vdc
On-state voltage	All models		-0.3	-	0.8	Vdc
Voltage at Remote ON/OFF control (positive logic)						
Off-state voltage	All models		-0.3	-	0.8	Vdc
On-state voltage	All models		2.4	-	15	Vdc
MTBF						
Telcordia SR-332-2006 80% load, 300LFM, 40^{O}C			-	1.5	-	10^6 hrs

Note 1 - Condition: 1mA for 60S, slew rate of 1500V/10S.
Note 2 - Basic insulation, pollution degree 2.
Note 3 - Functional insulation, pollution degree 2.

Electrical Specifications

Input Specifications

Table 2. Input Specifications

Parameter		Conditions[1]	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, DC		All	$V_{IN,DC}$	36	48	75	Vdc
Input Under Voltage Lockout	Turn-on voltage Threshold	$I_O=I_{O,max}$	$V_{IN,ON}$	33	-	36	Vdc
	Turn-off voltage Threshold	$I_O=I_{O,max}$	$V_{IN,OFF}$	31	-	35	Vdc
	Lockout voltage Hysteresis	$I_O=I_{O,max}$		1	-	3	Vdc
Maximum Input Current		$V_{IN,DC}=V_{IN,min}$ $I_O=I_{O,max}$	$I_{IN,max}$	-	-	15.5	A
Input Reflected Ripple Current[2] (peak-peak)		Through 12µH inductor		-	18	-	mA
Efficiency		$V_{IN,DC}$=48Vdc $I_O=I_{O,max}$ I_O=50%$I_{O,max}$	η	92.4 93.5	- -	93.4 94.5	% %
Input Fuse[3]		External fast blow fuse is recommended		-	-	30	A
Recommended External Input Capacitance[4]		Low ESR capacitor recommended	C_{IN}	470	-	-	µF

Note 1 - TA=25°C, airflow rate = 400LFM, $V_{IN,DC}$=48Vdc, nominal output voltage unless otherwise noted
Note 2 - See figure 19 for more details.
Note 3 - See figure 14 for more details.
Note 4 - See figure 14 for more details.

Electrical Specifications

Output Specifications

Table 3. Output Specifications

Parameter		Conditions[1]	Symbol	Min	Typ	Max	Unit
Output Voltage Set-Point		$V_{IN,DC}=V_{IN,nom}$ $I_O=50\%I_{O,max}$ T_A =25 °C	V_O	27.72	28	28.28	Vdc
Output Voltage Line Regulation		$V_{IN,DC}=V_{IN,min}$ to $V_{IN,max}$	$\pm V_O$	- -	- -	0.5 140	% mV
Output Voltage Load Regulation		$I_O=I_{O,min}$ to $I_{O,max}$	$\pm V_O$	- -	- -	0.5 140	% mV
Output Voltage Temperature Regulation		All	$\%V_O$	-	-	0.02	%/°C
Operating Output Current Range		All	I_O	0	-	18	A
Operating Output Voltage Range		All	V_O	27.2	28	28.8	Vdc
Output Over Current Protection[2]		All	$I_{O,max}$	19	-	27	A
Output Ripple, pk-pk[3]		0 to 20MHz bandwidth	V_O	-	180	-	mVpp
Output Capacitance[4]		All	C_O	660	1000	4400	µF
Dynamic Response	Peak Deviation[5] Settling Time[6]	25%~50%~25%$I_{O,max}$ slew rate=0.1A/µs	$\pm V_O$ T_s	- -	300 140	- -	mV µS
		50%~75%~50%$I_{O,max}$ slew rate=0.1A/µs	$\pm V_O$ T_s	- -	330 150	- -	mV µS
Turn-on Transient	Rise Time	$V_{IN,DC}$=48Vdc, $I_O=I_{O,max}$	T_{rise}	-	250	-	mS
	Turn-on Delay Time	$I_O=50\%I_{O,max}$	$T_{turn-on}$	-	70	-	mS
	Turn-on Overshoot	I_O=0		-	-	5	%Vdc
Switching Frequency		All	f_{SW}	-	280	-	KHz
Output Voltage Trim Range		All		14	-	33	Vdc
Output Over Voltage Protection[7]		All		35.5	-	40	Vdc
Over Temperature Protection[8]		All	T	105	115	125	°C
Over Temperature Hysteresis		All	T	5	-	-	°C

Note 1 - TA=25°C, airflow rate=400LFM, VIN,DC=48Vdc, nominal output voltage unless otherwise noted.
Note 2 - Hiccup: auto-restart when over current condition is removed.
Note 3 - See figure 2 for more details, test condition: see figure 19.
Note 4 - High frequency and low ESR is recommended.
Note 5 - See figure 4 for more details; test condition: see figure 14.
Note 6 - Recovery to within 1%VO,nom.
Note 7 - Latch.
Note 8 - Auto recovery; over temperature protect test point: see figure 11.

Electrical Specifications

AGQ500-48S28-6L Performance Curves

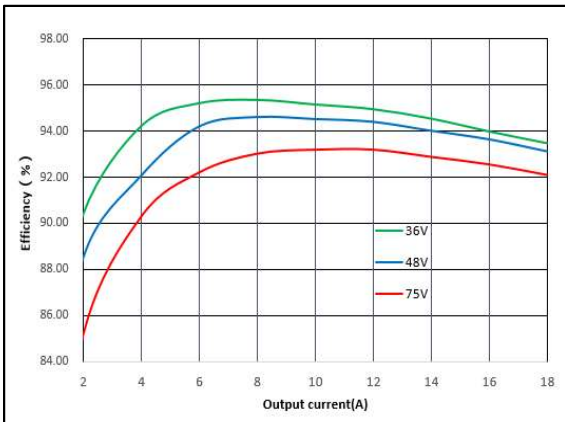


Figure 1: AGQ500-48S28-6L Efficiency Versus Output Current Curve
Vin = 36 to 75Vdc Vo=28V Load: Io = 2 to 18A

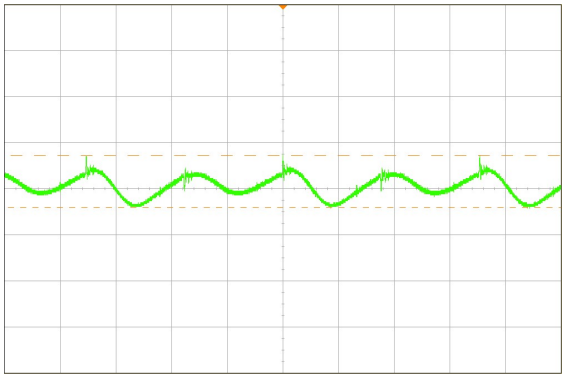


Figure 2: AGQ500-48S28-6L Ripple and Noise Measurement 2us/div, 100mV/div

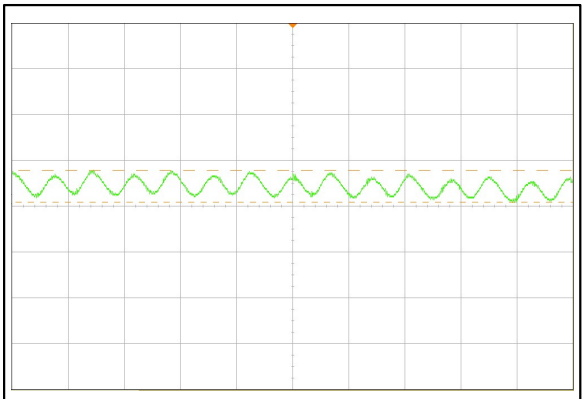


Figure 3: AGQ500-48S28-6L Input reflected ripple current 5uS/div, 20mA/div

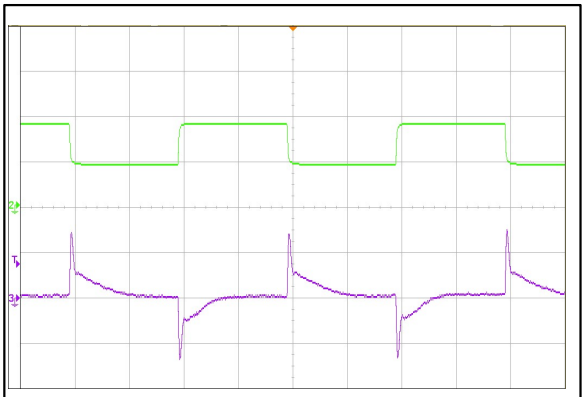


Figure 4: AGQ500-48S28-6L Transient Response(0.1A/uS slew rate, 2mS/div) Load: Io = 25% to 50% to 25% load change
Ch2: Io-green (5A/div), Ch3:Vo-purple (200mV/div)

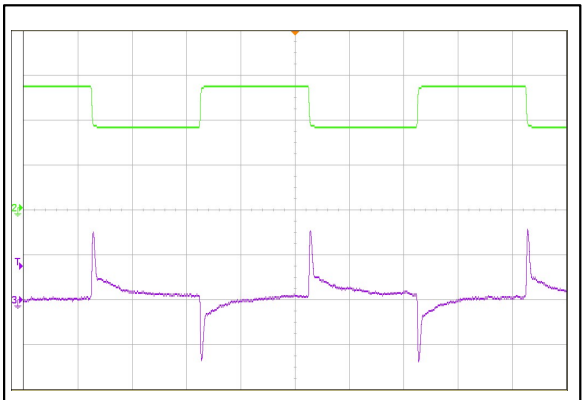


Figure 5: AGQ500-48S28-6L Transient Response(0.1A/uS slew rate, 2mS/div) Load: Io = 50% to 75% to 50% load change
Ch2: Io-green (5A/div), Ch3:Vo-purple (200mV/div)

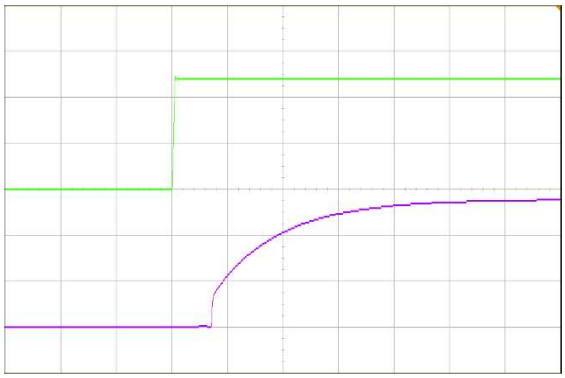


Figure 6: AGQ500-48S28-6L Start up Characteristic by power on(100mS/div)
Ch2: VIN-green (20V/div), Ch3: Vo-purple (10V/div)

Electrical Specifications

AGQ500-48S28-6L Performance Curves

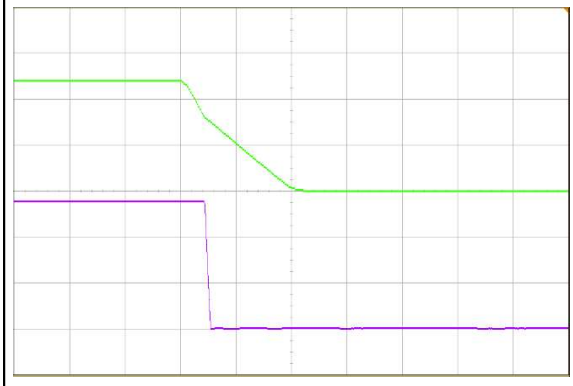


Figure 7: AGQ500-48S28-6L Shut down Characteristic by power off(50mS/div)
Ch2: VIN-green (20V/div), Ch3: Vo-purple (10V/div)

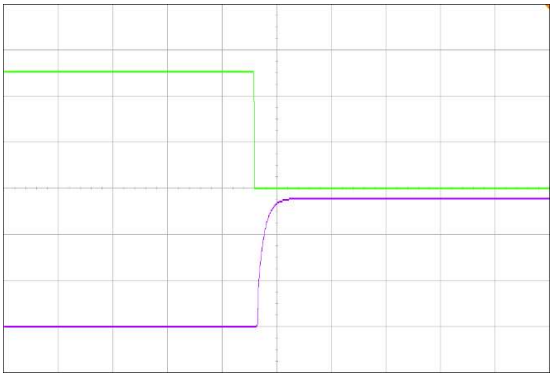


Figure 8: AGQ500-48S28-6L Remote ON Waveform(1S/div)
Ch2: Remote ON-green (2V/div), Ch3: Vo-purple (10V/div)

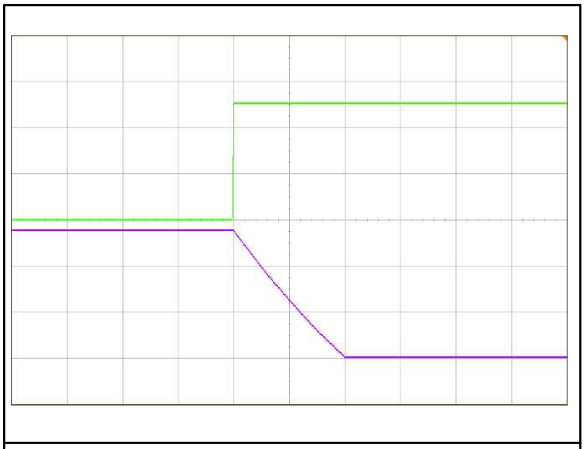
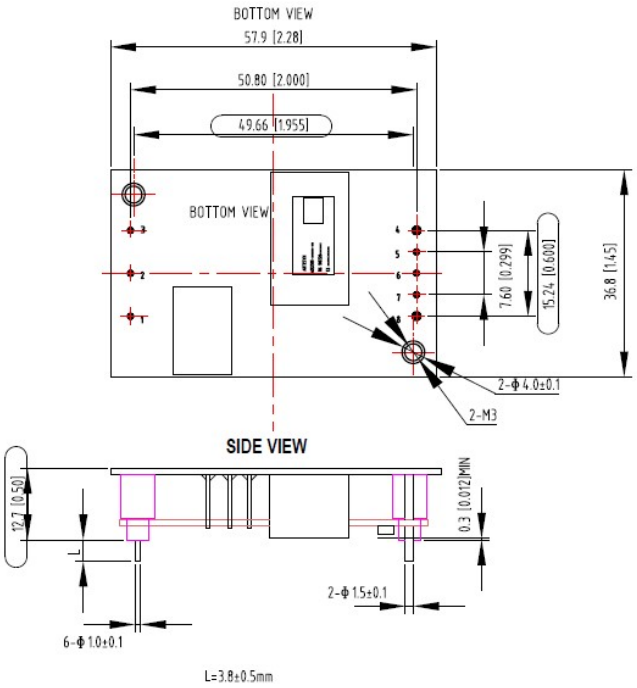


Figure 9: AGQ500-48S28-6L Remote OFF Waveform(1S/div)
Ch2: Remote ON-green (2V/div), Ch3: Vo-purple (10V/div)

Mechanical Specifications

Mechanical Outlines – Baseplate Module



Note:
1. All dimensions is mm (inches)
2. Tolerance: X.X±0.5mm (X.XX±0.02in.)
X.XX±0.25mm (X.XXX±0.01in.)
3.Dimensions within the box are critical dimensions

Mechanical Specifications

Pin length option

Device code suffix	L
-4	4.6mm±0.5mm
-6	3.8mm±0.5mm
-8	2.8mm±0.5mm
None	5.8mm±0.5mm

Pin Designations

Pin No	Name
1	Vin+
2	Remote ON/OFF
3	Vin-
4	Vo-
5	S-
6	Trim
7	S+
8	Vo+

Environmental Specifications

EMC Immunity:

AGQ500-48S28-6L power supply is designed to meet the following Electromagnetic Compatibility (EMC) immunity specifications.

Table 4. Environmental Specifications

Document	Description	Criteria
EN55032 Class B Limits	Conducted and Radiated EMI Limits, DC input port	/
IEC/EN 61000-4-2, Level 3	Electromagnetic Compatibility (EMC) - Testing and measurement techniques: Electrostatic Discharge (ESD) immunity test	B
IEC/EN 61000-4-4, Level3	Electromagnetic Compatibility (EMC) - Testing and measurement techniques: Electrical Fast Transient (EFT). DC input port	B
IEC/EN 61000-4-5	Electromagnetic Compatibility (EMC) - Testing and measurement techniques: Immunity to Surges (Surges) - 600V common mode and 600V differential mode for DC input port	B
IEC/EN 61000-4-6, Level 2	Electromagnetic Compatibility (EMC) - Testing and measurement techniques: Continuous Conducted Interference. DC input port	A
EN61000-4-29	Electromagnetic Compatibility (EMC) - Testing and measurement techniques: Voltage Dips and Short Interruptions and Voltage Variations (Dips). 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.

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

EMC Test Conditions:

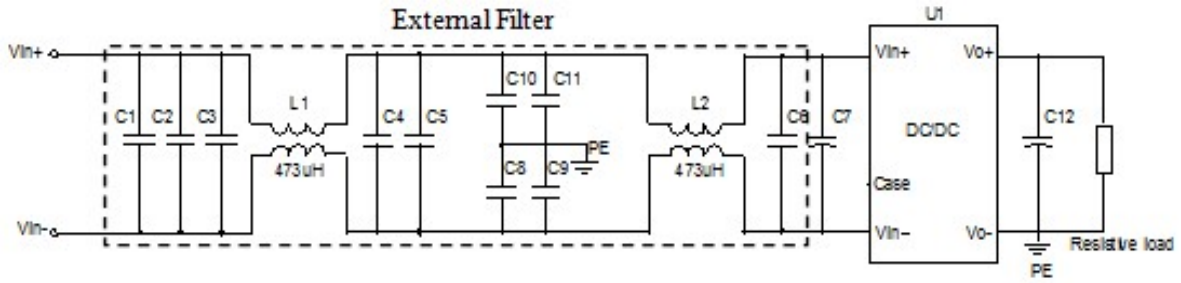


Figure 10 EMC test configuration

U1: Module to test, AGQ500-48S28-6L.

C1 ~ C5: 2.2uF/100V X7R ceramic capacitor, P/N: GRM31CR72A225KA73(muRata) or equivalent caps.

C6:0.1uF/100V X7R ceramic capacitor, P/N: 12101C104JAT2A (AVX) or equivalent caps.

C8 ~ C11: 0.47uF/630V ceramic capacitor, P/N: C5750X7T2J474K250KC (TDK) or equivalent caps.

C7: 470μF/100V electrolytic capacitor, P/N: UPM2A471MHD (Nichicon) or equivalent caps.

C12:2* 470μF/100V electrolytic capacitor, P/N: UPM2A471MHD (Nichicon) or equivalent caps or equivalent PE: Connect to Vo-, Case: Not connected

Environmental Specifications

Safety Certifications

The AGQ500-48S28-6L 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 AGQ500-48S28-6L series module

Standard	Agency	Description
UL/CSA 62368		US and Canada Requirements
EN62368		European Requirements
IEC62368		International Requirements
CE		CE Marking

Environmental Specifications

Thermal Considerations – Baseplate module (AGQ500-48S28-6L)

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 heatsink. The converter can deliver full output power at 85°C ambient temperature provided the baseplate temperature is kept below the max values in the table 6. Figure 13 shows the derating output current vs. baseplate temperature. The baseplate temperature test points locations are shown in figure 12.

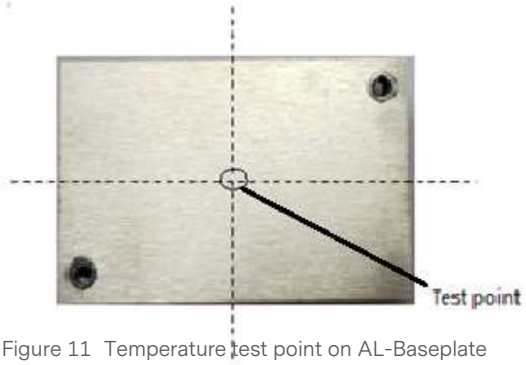


Figure 11 Temperature test point on AL-Baseplate

Figure 12 Temperature test points

Table 6. Temperature Limit of the test points	
Test Point	Temperature limit
Test point	100 °C
Test point-1	108 °C

For a typical application, Figure 12 shows the derating of output current vs. ambient air temperature at different air velocity.

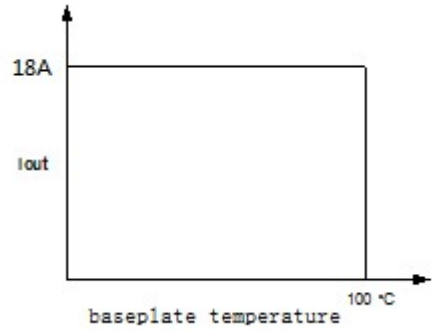


Figure 13 Output power derating, 48V_{in}

Environmental Specifications

Table 7. Qualification Certifications		
Parameter	Unit(pcs)	Test Condition
Halt test	4~5	Ta, min -20 ^{O}C to Ta,max+35 ^{O}C, 5 ^{O}C step, $V_{IN,DC}=V_{IN,min}$ to $V_{IN,max}$, $I_O=I_{O,min}$ to $I_{O,max}$
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, 3 axes, 6 directions, 3 time/direction
Thermal Shock	3	-55 ^{O}C to 125 ^{O}C, temperature 20 cycles
Thermal Cycling	3	-40 ^{O}C to 85 ^{O}C, temperature change rate: 1^{O}C/min, cycles: 2cycles
Humidity	3	40 ^{O}C, 95%RH, 48hrs
Solder ability	15	IPC J-STD-002C-2007

Environmental Specifications

Typical Application

This is the typical application of the AGQ500-48S28-6L power supply, more details refer to Figure 10.

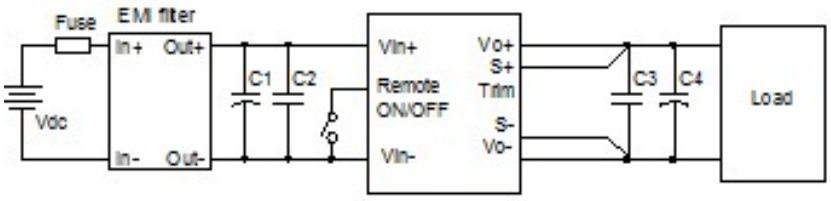


Figure 14 Typical application

C1: 470uF/100V electrolytic capacitor, P/N: UPW2A471MHD(Nichicon) or equivalent

C2: 0.1uF/100V X7R ceramic capacitor, P/N: 12101C104JAT2A (AVX) or equivalent caps

C3: 1μF/100V X7R ceramic capacitor, P/N: C3225X7R2A105KT0L0U (TDK) or equivalent

C4: 2*470μF/100V electrolytic capacitor, P/N: UPM2A471MHD (Nichicon) or equivalent caps

Fuse: 30A fast blow fuse. P/N: 314030P (LITTLEFUSE).

Double minimum input/output capacitance is necessary for normal operation and performance in case of Ta<0^{O}C.

Environmental Specifications

Remote ON/OFF

Either positive or negative remote ON/OFF logic is available in AGQ500-48S28-6L. The logic is CMOS and TTL compatible. The following figure is the detailed internal circuit and reference in AGQ500-48S28-6L.

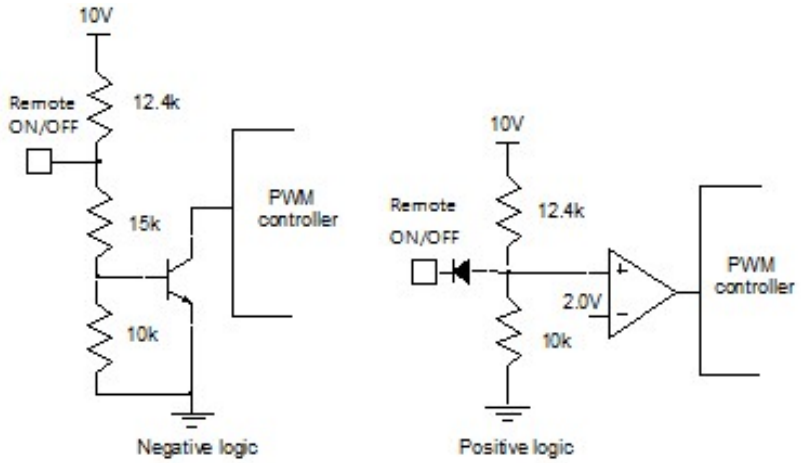


Figure 15 Remote ON/OFF internal diagram

Environmental Specifications

Trim Characteristics

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

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

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

Δ : Output rate against normal output voltage.

$$\Delta=\left|\frac{100\times(v_0-v_{norm})}{v_{norm}}\right|$$

V_{norm} : Normal output voltage

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

$$\Delta=\frac{100\times(v_0-v_{norm})}{v_{norm}}=\frac{100\times(33-2\ )}{50}=17.86$$

$$R_{adj\_up}=\frac{28\times(100\%+17.86\%)}{1.225\times17.86\%)}-\frac{100\%+2\times17.86\%)}{17.86\%}=143.24\,k\Omega$$

For 1% adjustment resistor, the trimmed output voltage is guaranteed within ±2%. The output voltage can also be trimmed by potential applied at the Trim pin.

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

Where V_{trim} is the potential applied at the Trim pin, and V_o is the desired output voltage.

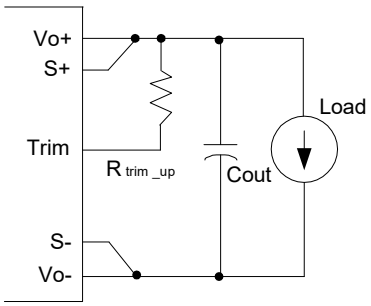


Figure 16 Trim up

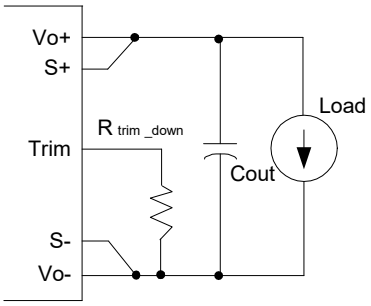


Figure 17 Trim down

For AGQ500-48S28-6L, if the sense compensate function is not necessary, connect S+ to Vo+ and S- to Vo- directly. When trimming up, the output current should be decreased accordingly so as not to exceed the maximum output power. When trimming up the output voltage, the minimum input voltage should be increased as shown in below figure 18.

Environmental Specifications

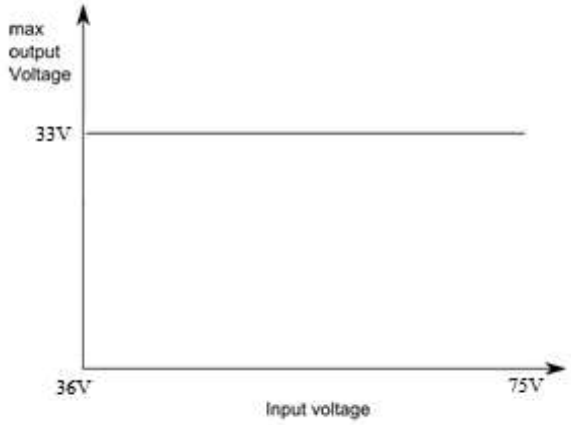


Figure 18 Trimming up the output voltage

Environmental Specifications

Input Ripple, Output Ripple & Noise Test Configuration

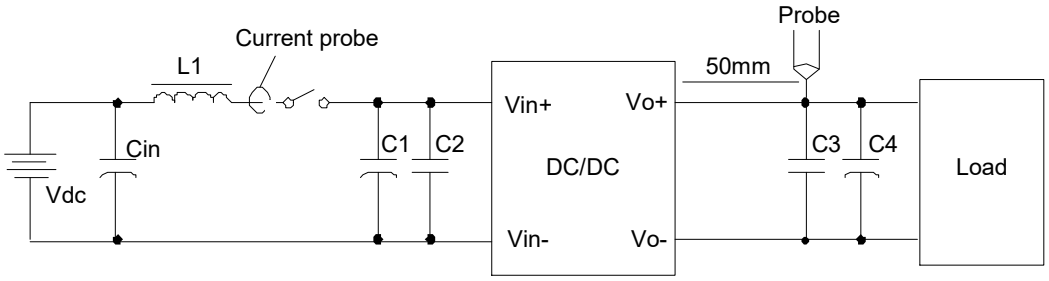


Figure 19 Input ripple, inrush current output ripple & noise test configuration

Vdc: DC power supply

L1: 12μH

Cin: 220μF/100V typical

C1: 470μF/100V electrolytic capacitor, High frequency and low ESR

C2:0.1uF/100V X7R ceramic capacitor, P/N: 12101C104JAT2A (AVX) or equivalent caps

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

C4: 2* 470μF/100V electrolytic capacitor, High frequency and low ESR

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

Environmental Specifications

Soldering

The AGQ500-48S28-6L 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 simulative.

Record of Revision and Changes

Issue	Date	Description	Originators
1.0	03.31.2020	First Issue	J. Ma

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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