

AGF600-24S28

600 Watts

Full-Brick Converter

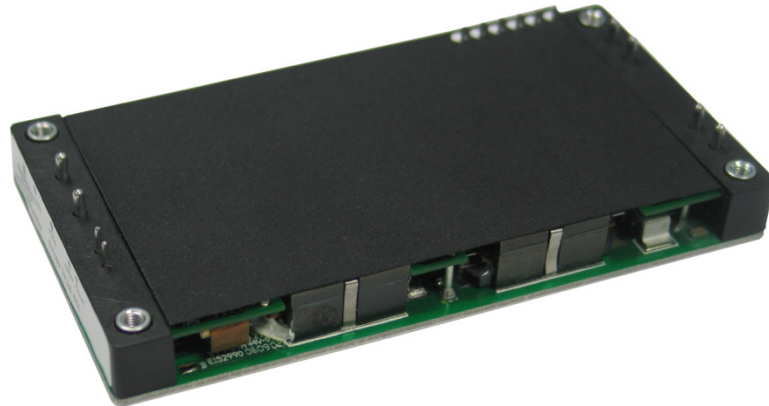
Total Power: 600 Watts
Input Voltage: 18 to 36 Vdc
of Outputs: Single

Special Features

- Delivering up to 21.5A output current
- Ultra-high efficiency 93.5% typ. at full load
- Wide input range: 18V ~ 36V
- Excellent thermal performance
- No minimum load requirement
- Fixed frequency operation
- RoHS 6 compliant
- Remote control function
- Remote output sense
- Trim function: -50% ~ +18%
- Input under voltage lockout
- Output over current protection
- Output over voltage protection
- Over temperature protection
- Industry standard full-brick pin-out outline
- With aluminum baseplate
- Pin length optional

Safety

IEC/EN/UL 60950-1 and GB4943
CE Mark
EN55022 Class A



Product Descriptions

The AGF600-24S28-6L is a single output DC-DC converter with standard full-brick form factor and pin configuration. It delivers up to 21.5A output current with 28V output voltage. Ultra-high 93.5% efficiency and excellent thermal performance make it an ideal choice to supply power to power amplifier in telecom RF application and can operate over an ambient temperature range of -40 °C ~ +85 °C without air cooling.

Applications

Telecom RF application

Model Numbers

Standard	Input Voltage	Output Voltage	Characteristic	RoHS Status
AGF600-24S28-6L	18-36Vdc	28Vdc	Without Thread	R6
AGF600-24S28-6LA	18-36Vdc	28Vdc	Customized Type	R6
AGF600-24S28-6LM	18-36Vdc	28Vdc	Thread Hole	R6

Ordering information

AGF600	-	24	S	28	-	6	L	*
①		②	③	④		⑤	⑥	⑦

①	Model series	AGF: high efficiency full brick series, 600: output power 600W
②	Input voltage	24: 18V ~ 36V input range, rated input voltage 24V
③	Output number	S: single output
④	Rated output voltage	28: 28V output
⑤	Pin length	-6: 3.8mm
⑥	RoHS status	Y: RoHS, R5; L: RoHS, R6
⑦	Characteristic	Default: Without Thread, M:Thread Hole / A: Customized Type

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	$V_{IN,DC}$	-	-	36	Vdc
	Non-operating -100mS		-	-	50	Vdc
Maximum Output Power	All	$P_{O,max}$	-	-	600	W
Isolation Voltage ¹	All		-	-	1500	Vdc
			-	-	1500	Vdc
			-	-	500	Vdc
Ambient Operating Temperature	All	T_A	-40	-	+85	°C
Storage Temperature	All	T_{STG}	-55	-	+125	°C
Current for remote ON/OFF pin	All		-	-	5	mA
Humidity (non-condensing)	Operating	All	-	-	95	%
	Non-operating	All	-	-	95	%

Note 1 - 1mA for 5s.

Input Specifications

Table 2. Input Specifications:

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, DC	All	$V_{IN,DC}$	18	24	36	Vdc
Turn-on Voltage Threshold	$I_O = I_{O,max}$	$V_{IN,ON}$	15	-	18	Vdc
Turn-off Voltage Threshold	$I_O = I_{O,max}$	$V_{IN,OFF}$	14	-	17	Vdc
Lockout Voltage Hysteresis	$I_O = I_{O,max}$		1	-	3	V
Maximum Input Current ($I_O = I_{O,max}$)	$V_{IN,DC} = 18V_{DC}$	$I_{IN,max}$	-	-	40	A
No-load Input Current ($I_O = I_{O,max}$)	$V_{IN,DC} = 24V_{DC}$	$I_{IN,no\ load}$	-	0.5	0.7	A
Standby Input Current	Remote OFF		-	0.05	0.1	A
Inrush Current Transient Rating			-	0.5	1	A ² s
Input reflected ripple current	Through 12 μ H inductor		-	-	320	mA
Recommended Input Fuse	Fast blow external fuse recommended		-	60	-	A
Recommended External Input Capacitance	Low ESR capacitor recommended	C_{IN}	-	1000	-	μ F
Input filter component values (C)	Internal values		-	4.7*13	-	μ F
Input filter component values (L)	Internal values			0.35		μ H
Operating Efficiency	$T_A = 25\ ^\circ C$ $I_O = I_{O,max}$ $I_O = 50\% I_{O,max}$	η	-	92.0	-	%
			-	93.5	-	%

Output Specifications

Table 3. Output Specifications:

Parameter	Condition	Symbol	Min	Typ	Max	Unit	
Factory Set Voltage	$V_{IN,DC} = 24V_{DC}$ $I_O = I_{O,max}$	V_O	27.72	28	28.28	Vdc	
Total Regulation	Inclusive of line, load temperature change, warm-up drift	V_O	27.20	28	28.80	Vdc	
Output Voltage Line Regulation	All	$\%V_O$	-	0.1	0.2	%	
		V_O		28	56	mV	
Output Voltage Load Regulation	All	$\%V_O$	-	0.2	0.5	%	
		V_O	-	56	140	mV	
Output Voltage Temperature Regulation	All	$\%V_O$	-	-	0.02	$\%/^{\circ}C$	
Output Voltage Trim Range	All	V_O	14	-	33	V	
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	-	21.5	A	
Output DC current-limit inception ¹		I_O	23.65	-	30.1	A	
V_O Load Capacitance ²	All	C_O	470	1000	10000	μF	
V_O Dynamic Response	Peak Deviation Settling Time	25% ~ 50% ~ 25% load change slew rate = 0.1A/us	$\pm V_O$	-	-	840	mV
		50% ~ 75% ~ 50% load change slew rate = 0.1A/us	T_s	-	-	500	μSec
Turn-on transient	Rise time	$I_O = I_{max}$	T_{rise}	20	-	200	mS
	Turn-on delay time	$I_O = I_{max}$	$T_{turn-on}$	0	-	200	mS
	Output voltage overshoot	$I_O = 0$	$\%V_O$	-	-	5	%

Note 1 - Hiccup: auto-restart when over-current condition is removed.

Note 2 - High frequency and low ESR is recommended.

Output Specifications

Table 3. Output Specifications, con't:

Parameter	Condition	Symbol	Min	Typ	Max	Unit
Switching frequency	All	f_{sw}	230	260	290	KHz
Remote ON/OFF Control	All		1.5	-	5	mA
Output over-voltage protection ³	All	$\%V_O$	125	-	143	%
Output over-temperature protection ⁴	All	T	105	115	130	°C
Over-temperature hysteresis	All	T	5	-	-	°C
Output voltage remote sense range	All	V_o	-	-	1	V
MTBF	Telcordia SR-332-2006; 80% load, 300LFM, 40 °C Ta		-	1.5	-	10 ⁶ h

Note 3 - Latch: reset by power on or remote on.

Note 4 - Auto recovery.

AGF600-24S28-6L Performance Curves

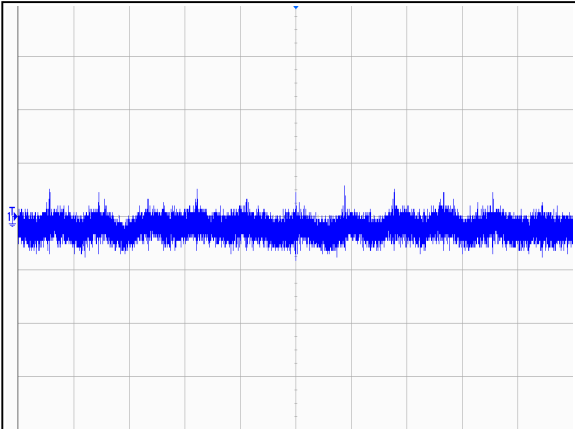


Figure 1: AGF600-24S28-6L Input Reflected Ripple Current Waveform
Ch 1: Iin (5 μ S/div, 20mA/div)

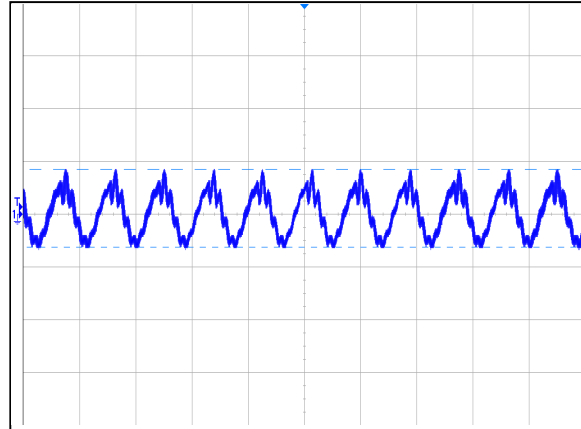


Figure 2: AGF600-24S28-6L Ripple and Noise Measurement
Ch 1: Vo (5 μ s/div, 100mV/div)

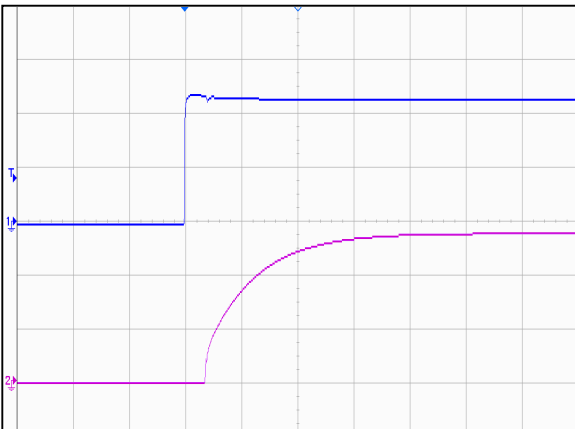


Figure 3: AGF600-24S28-6L Output Voltage Startup by power on (20ms/div)
Ch 1: Vin (10V/div) Ch 2: Vo (10V/div)

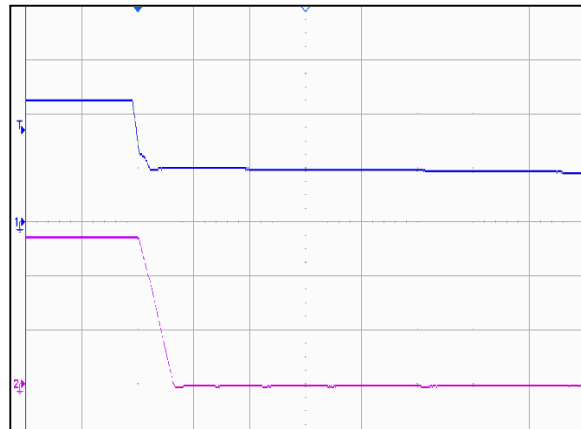


Figure 4: AGF600-24S28-6L Turn Off by power off (2mS/div)
Ch 1: Vin (10V/div) Ch 2: Vo (10V/div)

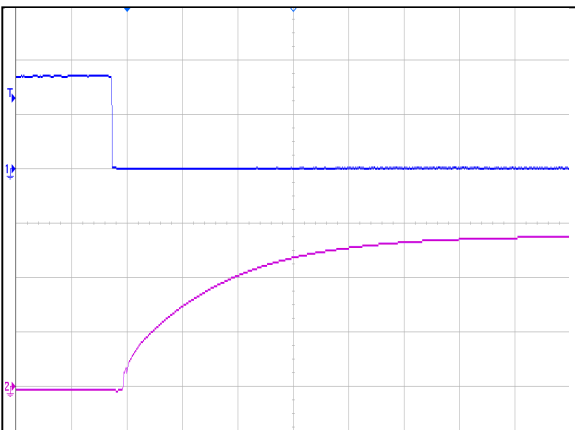


Figure 5: AGF600-24S28-6L Remote ON Waveform (10mS/div)
Ch 1: Remote ON (2V/div) Ch 2: Vo (10V/div)

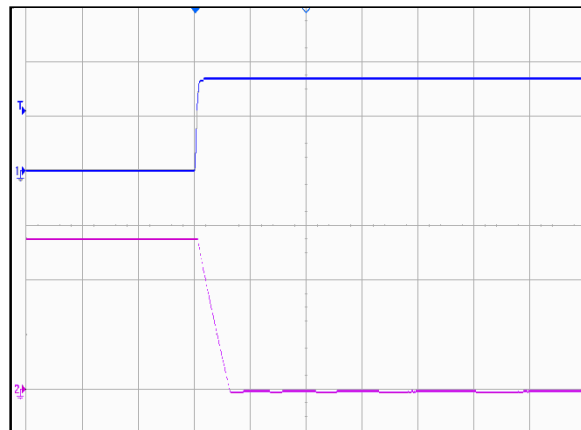


Figure 6: AGF600-24S28-6L Remote OFF Waveform (2mS/div)
Ch 1: Remote ON (2V/div) Ch 2: Vo (10V/div)

AGF600-24S28-6L Performance Curves

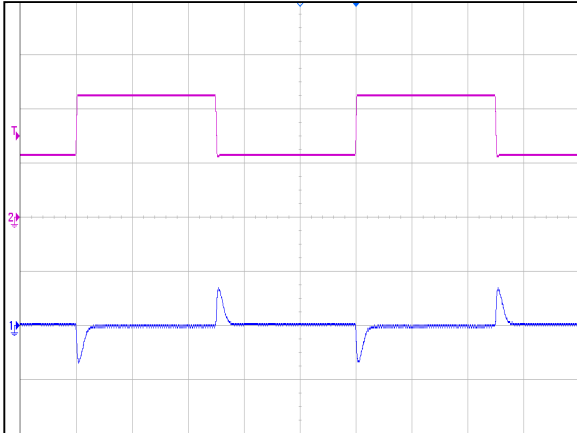


Figure 7: AGF600-24S28-6L Transient Response (1mS/div)
25%-50%-25% load change, 0.1A/uS slew rate
Ch 1: Vo (500mV/div) Ch 2: Io (5A/div)

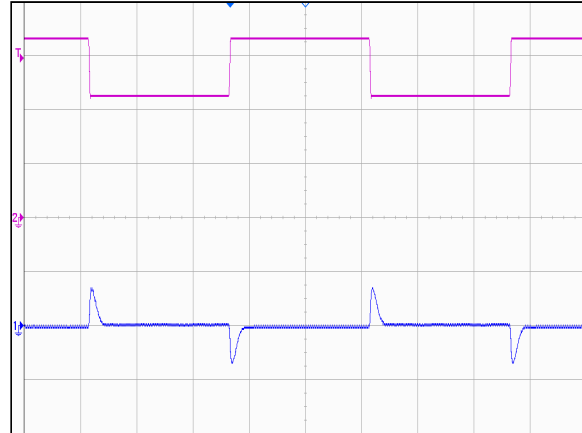


Figure 8: AGF600-24S28-6L Transient Response (1mS/div)
50%-75%-50% load change, 0.1A/uS slew rate
Ch 1: Vo (500mV/div) Ch 2: Io (5A/div)

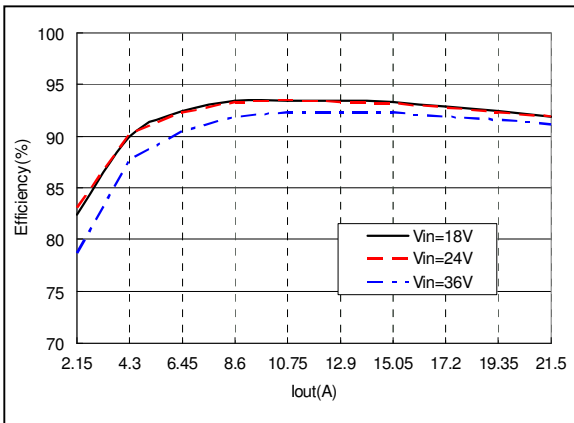


Figure 9: AGF600-24S28-6L Efficiency Curves @ 25 degC
Loading: Io = 10% increment to 21.5A

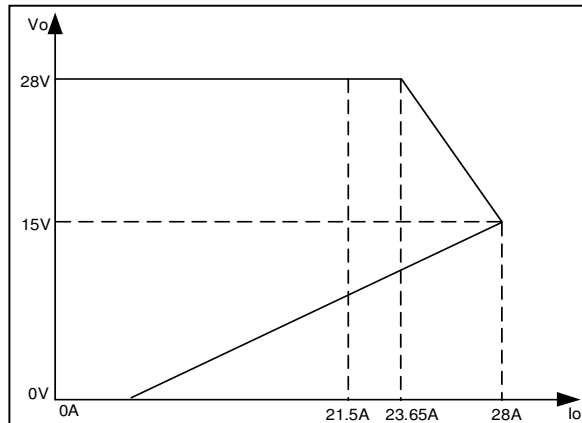
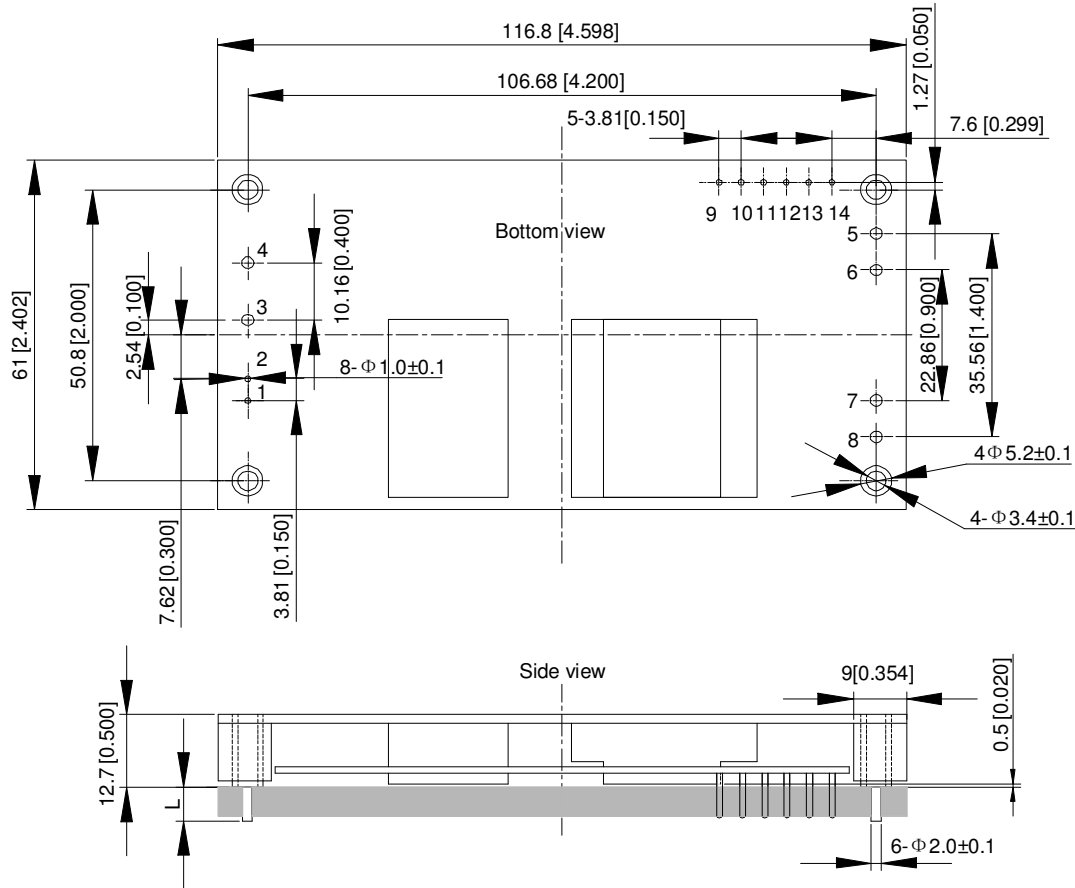


Figure 10: AGF600-24S28-6L Over Current protection characteristic

Mechanical Specifications

Mechanical Outlines



Unit: mm[inch] Bottom view: pin on upside
Tolerance: X.Xmm \pm 0.5mm[X.X in. \pm 0.02in.]
X.XXmm \pm 0.25mm[X.XX in. \pm 0.01in.]

Pin length option

Device code suffix	L
-4	4.8mm \pm 0.5mm
-6	3.8mm \pm 0.5mm
-8	2.8mm \pm 0.5mm
None	5.8mm \pm 0.5mm

Pin Designations

Pin NO.	Name	Function
1	+On/Off	Remote control
2	-On/Off	Remote control return
3	V_{in+}	Positive input voltage
4	V_{in-}	Negative input voltage
5, 6	V_{o-}	Negative output voltage
7, 8	V_{o+}	Positive output voltage
9	AUX	Auxiliary voltage
10	IOG	Inverter operation good
11	NC	Not connected
12	Trim	Trim terminal
13	+S	Positive remote sense
14	-S	Negative remote sense

Safety Certifications

The AGF600-24S28-6L 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 4. Safety Certifications for AGF600-24S28-6L power supply system:

Document	File #	Description
UL 60950-1		Safety of information Technology Equipment
IEC/EN 60950-1		European Requirements
GB4943		China Requirements
CE		CE Marking

Operating Temperature

The AGF600-24S28-6L power supply will start and operate within stated specifications at an ambient temperature from -40 °C to 85 °C under all load conditions. The storage temperature is -55 °C to 125 °C.

Thermal Considerations

The converter can operate in a enclosed environment without forced air convection. Cooling of the converter is achieved mainly by conduction from the baseplate to a heat sink. The converter can deliver full output power at 85 °C ambient temperature provided the baseplate temperature is kept the max values 100 °C.

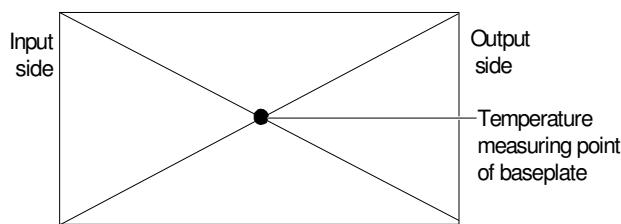


Figure 11 Temperature test point on base plate

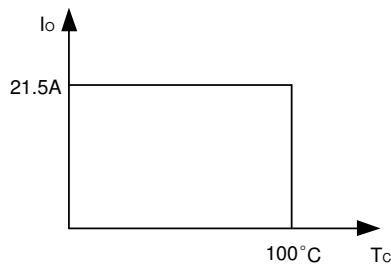


Figure 12 Output power derating curve, T_c: temperature test point on baseplate.

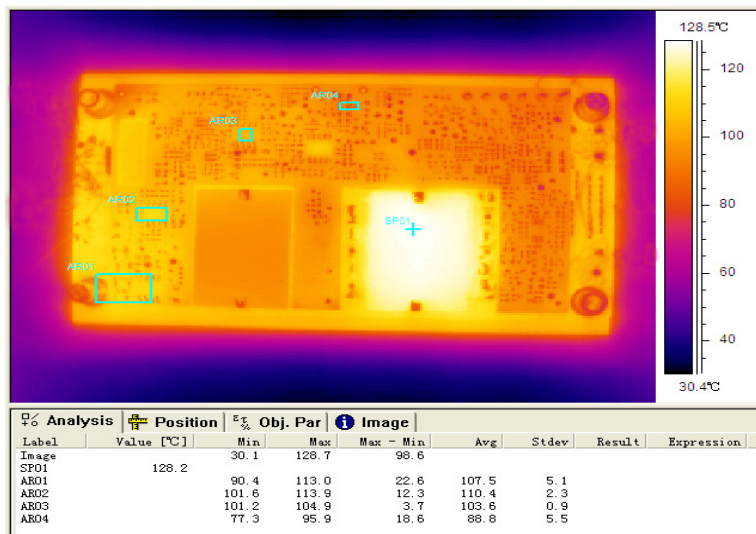


Figure 13 Thermal image, 24V_{in}, 28V_o, full load, room temperature

Qualification Testing

Table 5: Qualification Testing:

Parameter	Unit (pcs)	Test condition
Halt test	4-5	Ta,min-10 °C to Ta,max+10 °C, 5 °C step, Vin = min to max, 0 ~ 105% load
Vibration	3	Frequency range: 5Hz ~ 20Hz, 20Hz ~ 200Hz, A.S.D: 1.0m2/s3, -3db/oct, axes of vibration: X/Y/Z; Time: 30min/axis
Mechanical Shock	3	30g, 6ms, 3axes, 6directions, 3time/direction
Thermal Shock	3	-40 °C to 100 °C, unit temperature 20cycles
Thermal Cycling	3	-40 °C to 85 °C, temperature change rate: 1 °C/min, cycles: 2cycles
Humidity	3	40 °C, 95%RH, 48hours
Solder Ability	15	IPC J-STD-002C-2007

Application Notes

Typical Application

Below is the typical application of the AGF600-24S28-6L power supply.

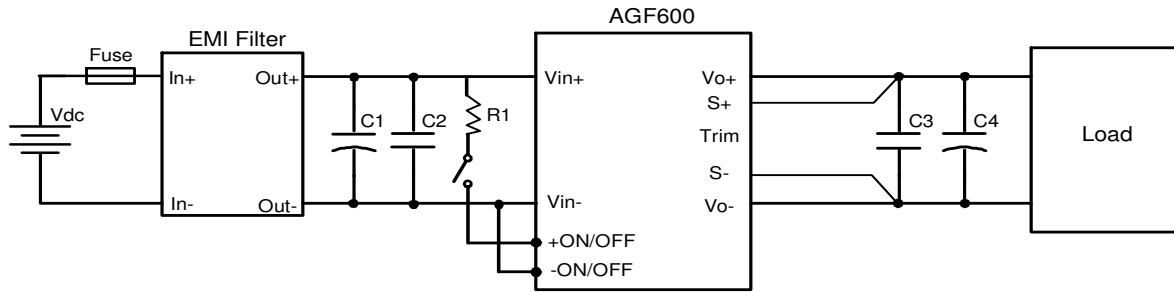


Figure 14 Typical application

R1: 10k Ω (1W) current limiting resistor

C1: 1000 μ F/50V electrolytic capacitor, P/N: UPW2A471MHD (Nichicon) or equivalent caps

C2, C3: 1 μ F/100V X7R ceramic capacitor, P/N: C3225X7R2A105KT0L0U(TDK) or equivalent caps

C4: 7X150 μ F electrolytic capacitor, P/N: UUD1H151MNL1GS (Nichicon) or equivalent caps

Note: If ambient temperature is below -5 $^{\circ}$ C, additional 1000 μ F electrolytic capacitor is needed for output.

Fuse: External fast blow fuse with a rating of 60A. The recommended fuse model is F60AH (100/250V).

Sense Characteristics

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 14.

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

Remote ON/OFF

A remote ON/OFF control circuit is provided which is isolated from the input side, as well as, the output side. (Isolation withstand voltage: 1.5KVdc)

Connection of remote ON/OFF terminal is shown in the Figure 14. Output voltage turns remote on when current is made to flow through remote ON/OFF terminal. Remote ON/OFF terminal can be controlled by opening or closing connections (with switch or relay).

Maximum source current for remote ON/OFF terminal is 5mA. Therefore, current limiting resistor value must be set such that this maximum source current value is not exceeded. Also, the allowable maximum reverse current flow is 5mA.

Controlling the remote ON/OFF terminal from the input side

Connect current limiting resistor R1 as shown in Figure 15.

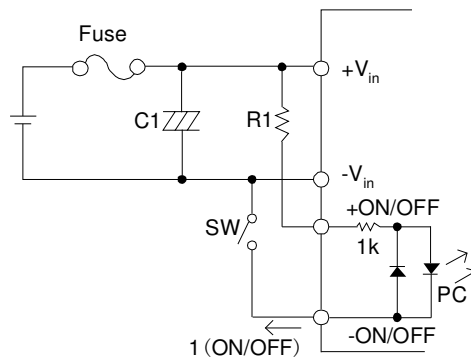


Figure 15 Connection of remote ON/OFF control (A)

R1: Recommended resistor value: 10kΩ (1W)

Controlling the remote ON/OFF terminal from the output side

Connect the current limiting resistor R1 as shown in Figure 16.

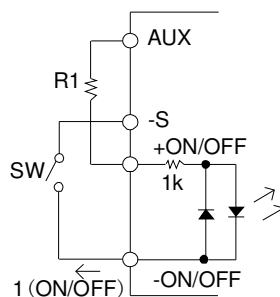


Figure 16 Connection of remote ON/OFF control (B)

R1: Recommended resistor Value: 2kΩ (1/2W)

Note:

- 1.A decoupling capacitor of about 0.1 μ F between the +remote ON/OFF terminal and –remote ON/OFF terminal is needed when input wiring is too long.
- 2.Current limiting resistor can also be connected to the –remote ON/OFF terminal side.

Remote ON/OFF level	Output status
Open (<100 μ A)	Remote OFF
1.5mA \leq I (ON/OFF) \leq 5mA	Remote ON

AUX

AUX is built in to operate the output side RC. If AUX is not used for RC, AUX can also be used for IOG signal output by opto-coupler. Output voltage value is within 7~10Vdc range, maximum output current is 20mA. Ground for the AUX terminal is -S terminal. AUX can be used for IOG signal output by opto-coupler.

*Note: Avoid short circuit of AUX terminal with other terminals as this would lead to power module damage.

IOG

IOG signal turns 'H' from 'L' within 1s when the output of the module is shut down. The specification of IOG is shown in the following table.

Item	IOG
Function	Normal operation 'L'
	Malfunction 'H'
Base pin	-Sense
Level voltage 'L'	0.5V max at 5mA
Level voltage 'H'	5V typ
Maximum sink current	5mA max
Maximum applicable voltage	35V max

There are two methods to use the IOG. The level from IOG can be used directly to monitor the operation of the module, as shown in Figure 17(A). An external power supply, which is no more than 35V, can also be used for IOG, and a current limiting resistor (R1) must be added to ensure the sink current less than 5mA, as shown in Figure 17(B).

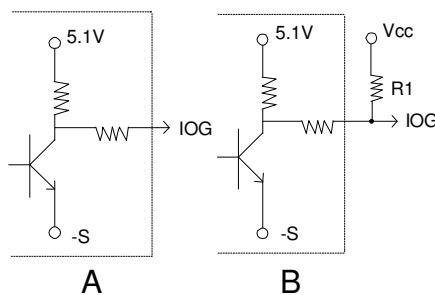


Figure 17 The application of IOG

Trim Characteristics

The output voltage of the converter can be trimmed using the trim pin provided. Connecting an external resistor between Trim pin and V_o^- pin will decrease the output voltage, while connecting it between $+S$ and V_o^+ will increase the output voltage. Trimming down more than 50% and trimming up more than 18% can cause the module to regulate improperly. If the trim pin is not needed, it should be left open.

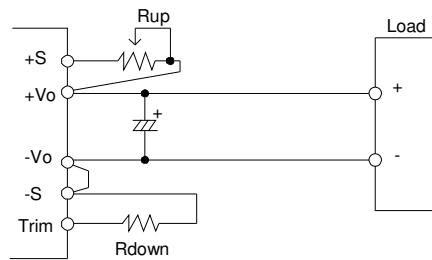


Figure 18 T_{rim} circuit

$$R_{up} = 28 \left(\frac{V_o - V_e}{V_e} \right) k\Omega$$

$$R_{down} = -5.97 \left(\frac{V_o}{V_o - V_e} \right) k\Omega$$

V_e is the rated output voltage and V_o is the goal voltage.

For example, to get 30V output, the resistor is:

$$R_{up} = 28 \left(\frac{30 - 28}{28} \right) k\Omega = 2k\Omega$$

For another example, to get 14V output, the resistor is:

$$R_{down} = -5.97 \left(\frac{14}{14 - 28} \right) k\Omega = 5.97k\Omega$$

The output voltage can also be trimmed by potential applied at the Trim pin. An external resistor is needed between Trim pin and V_{trim} .

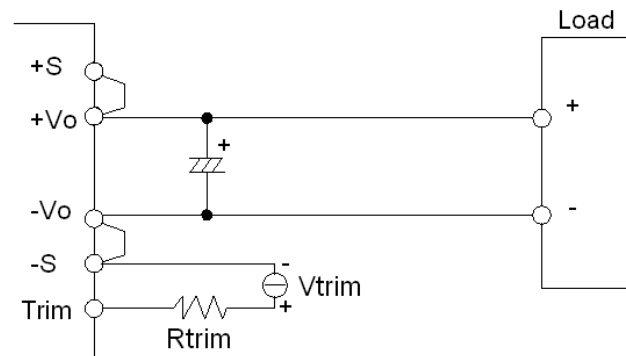


Figure 19 Trimmed by V_{trim} circuit

$$V_{trim} = 1 + k\Delta\%$$

$$k = (R_{trim} + 5.97) / 5.97$$

$$\Delta\% = (V_o - V_e) / V_e \times 100\%$$

Where V_{trim} is the potential applied at the Trim pin, and V_o is the desired output voltage, and V_e is 28V, $\Delta\%$ have a range of -50%~118%. The unit for R_{trim} is k Ω .

When $R_{trim}=5.97k$

$$V_{trim} = V_o / 14 - 1$$

The corresponding relationship between V_{trim} and V_o is shown in Figure 20.

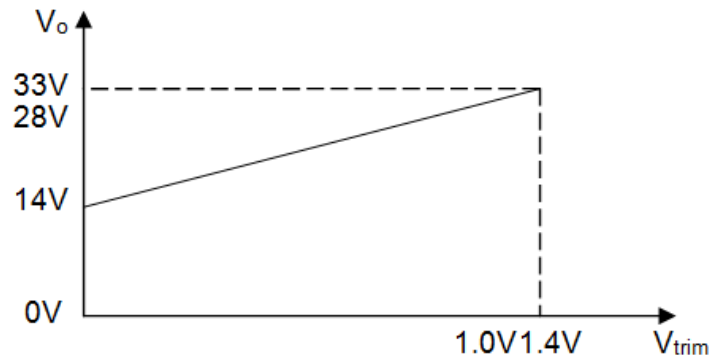


Figure 20 V_{trim} voltage vs. output voltage ($R_{trim}=5.97k$)

Considering the real resistor value, $R_{trim}=5.1k$ is recommend, the equation is shown as below.

$$V_{trim} = 0.067V_o - 0.854$$

The corresponding relationship between V_{trim} and V_o is shown in Figure 21.

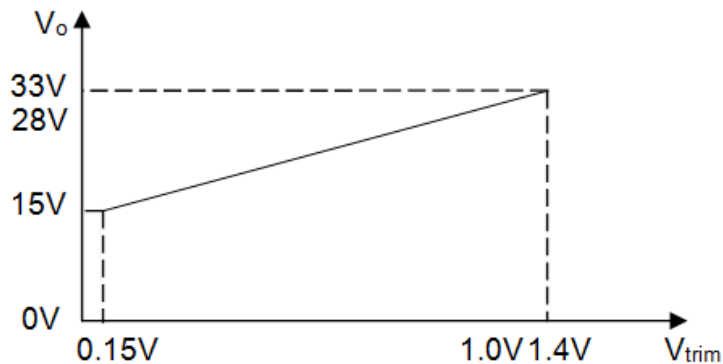


Figure 21 V_{trim} voltage vs. output voltage ($R_{trim}=5.1k$)

Note: Input voltage should be limited when output voltage increases, shown in the following figure 22.

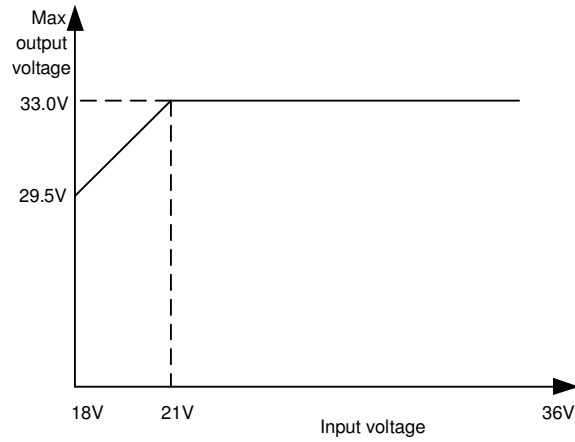


Figure 22 T_{rim-up} voltage vs. Input Voltage

Input Ripple & Output Ripple & Noise Test Configuration

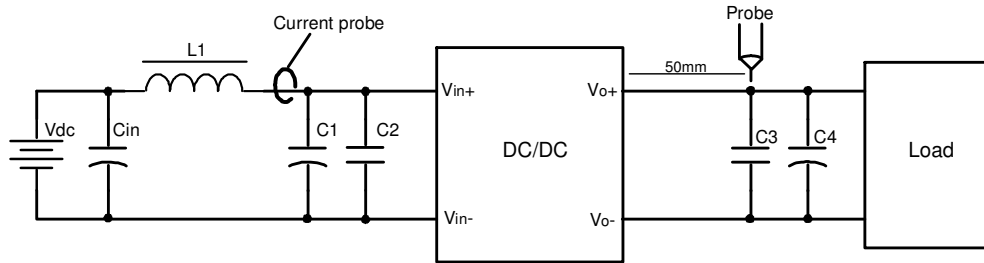


Figure 23 Input ripple & inrush current, ripple & noise test configuration

Vdc: DC power supply

L1: 12uH

Cin: 220uF/100V typical

C1 ~ C4: See Figure 14

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.

EMC Filter Configuration

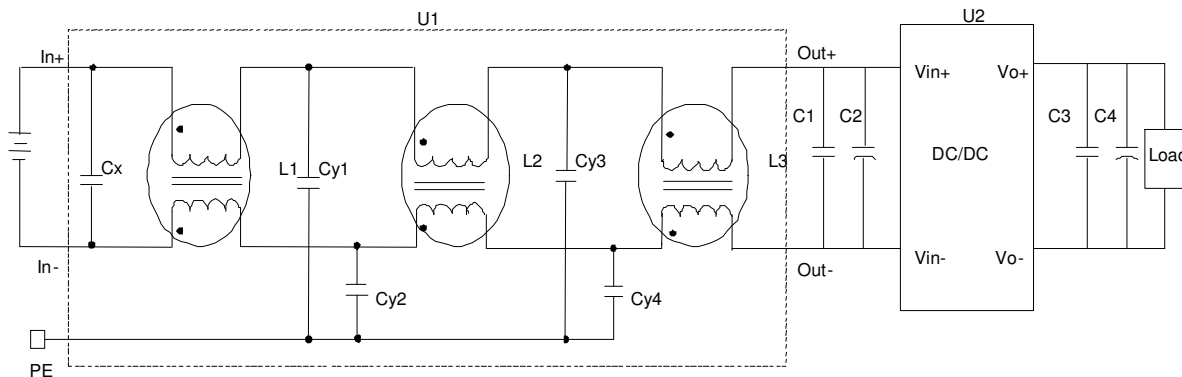


Figure 24 EMC test configuration

C_x: 5.7μF/100V capacitor

Cy1, Cy2, Cy3, Cy4: 4700pF, Y capacitor

L1, L2, L3: 100μH, common mode inductor

C1: 1000μF/50V electrolytic capacitor, P/N: UPW2A471MHD (Nichicon) or equivalent caps

C2, C3: 1μF/100V X7R ceramic capacitor, P/N: C3225X7R2A105KT0L0U(TDK) or equivalent caps

C4: 7X150μF electrolytic capacitor, P/N: UUD1H151MNL1GS (Nichicon) or equivalent caps

U1: 40A input EMC filter module (P/N: FM100-40)

U2: Module under test, AGF600-24S28-6L

Weight

The AGF600-24S28-6L weight is 156g.maximum.

Soldering

The product is intended for standard manual or wave soldering.

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

When soldering by hand, the iron temperature should be maintained at 300 °C ~ 380 °C and applied to the converter pins for less than 10s. Longer exposure can cause internal damage to the converter.

Cleaning of solder joint can be performed with cleaning solvent IPA or simulative.

Hazardous Substances Announcement (RoHS of China)

Parts	Hazardous Substances					
	Pb	Hg	Cd	Cr ⁶⁺	PBB	PBDE
AGF600-24S28-6L	○	○	○	○	○	○
AGF600-24S28-6LA	○	○	○	○	○	○
AGF600-24S28-6LM	○	○	○	○	○	○

○: 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
1.1	05.08.2015	First Issue	X. Sun
1.2	11.02.2016	Updated the Pin Length tolerance	K. Wang

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