Features

- Industry standard full-brick package and footprint
  4.6"×2.4"×0.5"
- High power density – 90W/in3
- High efficiency – 90% typical
- 2:1 input voltage range
- Low output noise and ripple
- Remote sense
- Over-temperature protection
- Output over/current voltage protection
- I.O.G. signal open collector output
- Output voltage adjustment +10% / -40%
- Baseplate operating temperature range -40℃ to 100℃
- UL60950-1/ EN60950-1 Certified
- RoHS (2002/95/EC) complaint

Options:

- Sprayed conformal coating
- RoHS

Numbering Convention

FDR - L 500 28 S C - C G5
① ② ③ ④ ⑤⑥ ⑦ ⑧

No	Features	Descriptions
①	Product Series	Full-brick Al-Baseplate Series
②	Remote on/off Logic	L – Negative Logic
		H or Default – Positive Logic
③	Typical Output Power	500 – Output Power 500Watts
④	Typical Output Voltage	28 – Output Voltage 28V
⑤	Number of Outputs	S – Single Output
⑥	Typical Input Voltage	C – Input Voltage 48V
⑦	Sprayed Conformal coating	C – Sprayed Conformal coating
		Default: no Sprayed Conformal coating
⑧	RoHS feature	G5 – RoHS5
		G – lead-free products, RoHS6

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1. Description

The power modules are DC-DC converters in an industry full-brick packaging and footprint, open-frame design, provide up to 28V_{DC} output voltage and 18A output current. The power modules feature a wide input voltage range, high efficiency, excellent thermal performance and high isolation voltage, and are is well suited for telecom ,communication, industrial applications and test equipments, etc.

2. Technical Specifications (Unless otherwise indicated, all specifications are typical at nominal input voltage, full load at 25℃, with an external sink, a 100uF/100V electrolytic capacitor at input, a 560uF/50V electrolytic capacitor and a 10μF ceramic capacitor at output . The temperature character of electrolytic capacitors shall be 105°C.)

Parameter		Test Condition	Min	Typ	Max	Unit
2.1 Absolute Maximum Ratings						
Input Voltage (Vi)		at no operating, continuous	0	—	80	Vdc
		transient (100ms)	—	—	100	Vdc
Max Output Power (Pomax)		allowable operating conditions	—	—	504	W
2.2 Input Specifications						
Typical Input Voltage(Vinom)		—	—	48	—	Vdc
Input Voltage Range		—	36	—	76	Vdc
Input Under-voltage protection		Ionom	31	—	34	Vdc
Input Under-voltage Recovery Point		Ionom	33	—	36	Vdc
Maximum Input current (Iimax)		Vimin, Vonom,Ionom	—	—	15.9	A.
No-load Input Current (Iio)		Vinom, Io=0A	—	140	200	mA
Static Input Current (Iiof)		Vinom, remote output shutdown	—	—	40	mA
No-load Loss		Vinom, Io=0A	—	6.7	9.6	W
Inrush Transient current		Io=Ionom	—	—	0.1	A^2S
Input Ripple Current		Vinom, Ionom	—	100	160	mA
Input Filtering Capacitance		Vinom～Vinmax	—	100	—	μF
Remote	On	1mA ≤ I(on/off) ≤ 5mA (between +ON/OFF and -ON/OFF)				
	Off	Open Circuit (between +ON/OFF and -ON/OFF)				
2.3 Output Specifications						
Output voltage set-point (Vonom)		Vinom, Ionom	27.72	28	28.28	Vdc
Typical Output Current (Ionom)		—	—	18	—	A.
Output Current Range (Io)		Po≤504W	0	—	18	A.
Line Regulation (Vov)		Vimin-Vimax, Ionom	—	—	±0.2	%Vo
Load Regulation (Vol)		0-100%Ionom, Vinom	—	—	±0.5	%Vo
Voltage Regulation Accuracy		0-100%Io,V_{INMIN}～V_{INMAX}	—	—	±1	%Vo

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Parameter		Test Condition	Min	Typ	Max	Unit
Output Voltage Trim (Voadj)		Io≤Ionom, Po≤504W	-40	—	+10	%Vo
Output Over-voltage Protection	Protection Mode	——	lockout, turn-on recovery			—
	Protection Range	Po<Pomax	32.2		42	Vdc
Output Over-current protection	Protection Mode	——	Constant current, Automatic recovery			—
	Protection Range	Vinmin~Vinmax, Tc(baseplate temp.) = -40~100°C Vinom	105		150	%Iono m
Output Short-circuit protection	Protection Mode	——	Hiccup, Automatic recovery			—
Dynamic Load Response	Peak Deviation	25%-50%-25%Ionom 50%-50%-25%Ionom ΔIo/Δt=0.1A/μS,Vinom	—	—	1400	mV
	Settling Time		—	—	200	μs
	Peak Deviation	0%-100%-0%Ionom ΔIo/Δt=0.1A/μS,Vinom	—	—	14	V
	Settling Time		—	—	800	μs
Output Ripple and Noise	RMS(20MHz)	Vinom, Ionom, externally add a 560μF electrolytic capacitor and a 10μF ceramic capacitor to output, and add a 100μF/100V electrolytic capacitor to input	—	—	80	mV
	Peak-to-Peak(20MHz)		—	—	260	
	Peak-to-Peak(100MHz)		—	—	280	
External Output Capacitance (Co)		Vinmin~Vimax, 0~100%Io	560	—	10000	μF
Turn-on/off Peak Deviation		Vinom, Ionom	—	—	±5	%Vo
Turn-on Delay Time		90%Vinnom-- 10%Vonom	20	—	200	mS
Turn-on Rise Time		10%Vonom---90%Vonom	—	20	40	mS
AUX Terminal (Aux. Supply power)		Aux. Supply Current ≤20mA	7.6	8	8.4	Vdc
PC Terminal (Parallel operation)		See 4.11	Possible			
I.O.G Signal		See 4.9	Possible(Open collector output)			
Remote Sense voltage Sampling		See 4.7	Possible			
2.4 Safety Specifications						
Isolation voltage	Input to output	Leak Current ≤ 1mA, 1min	1500	—	—	Vdc
	Input to Case	Leak Current ≤ 1mA, 1min	1050	—	—	Vdc
	Output to Case	Leak Current ≤ 1mA, 1min	500	—	—	Vdc
Isolation Resistance (R_{ISO})		500V_{DC}	50	—	—	MΩ
Safety Certificate		UL, TUV-SUD				
2.5 Reliability						

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Parameter		Test Condition	Min	Typ	Max	Unit
Vibration Test(sine)		Frequency: 10~55Hz Amplitude: 0.35mm Acceleration: 50m/s^2 Cycle: X,Y,Z 30min each axis	After being tested, no damage to the converter and its components, the appearance, output voltage and output ripple and noise (p-p) meet the data sheet requirements.			
Impact Test (half-sine)		Peak Acceleration: 300m/s^2 Duration: 6ms 6 times for three perpendicular directions	After being tested, no damage to the converter and its components, the appearance, output voltage and output ripple and noise (p-p) meet the data sheet requirements.			
MTBF		≥2×10^{6}h Bellcore TR-332（Ta=25°C） ≥1×10^{6}h Bellcore TR-332（Ta=55°C）				
2.6 Environmental Specifications						
Relative Humidity		（40±2）℃, No dew	—	—	90	%RH
Cooling		——	Conduction Cooling (forced-air cooling or heatsink)			
Over-temperature protection	Protection Mode	—	Hiccup, Auto-recovery			
	Temperature Range	Baseplate Temp., see the diagram for test points	100℃~125℃			
	Recovery Hysteresis Range	Baseplate Temp., see the diagram for test points	5	10	15	℃
Operating Baseplate Temperature			-40	—	+100	℃
Storage Temperature (Tst)			-40	—	+100	℃
2.7 General Specifications						
Switching Frequency		——	—	250	—	kHz
Temperature Coefficient (Tcoeff)		——	—	—	±0.02	%/℃
Efficiency (η)		Vinom,Ionom	89	90	—	%
Weight			—	150	—	g
RoHS		According to 2002/95/EC directive				
Anti-sulfuration feature		Sprayed conformal coating				

Note:
1. Low-temperature Test at -40℃: Vinom, Ionom, externally add a 2800μF electrolytic capacitor and a 10μF ceramic capacitor to output, and add a 330μF/100V electrolytic capacitor to input.
2. High-temperature Test: additional heatsink, with force-air cooling, Efficiency-η>88%

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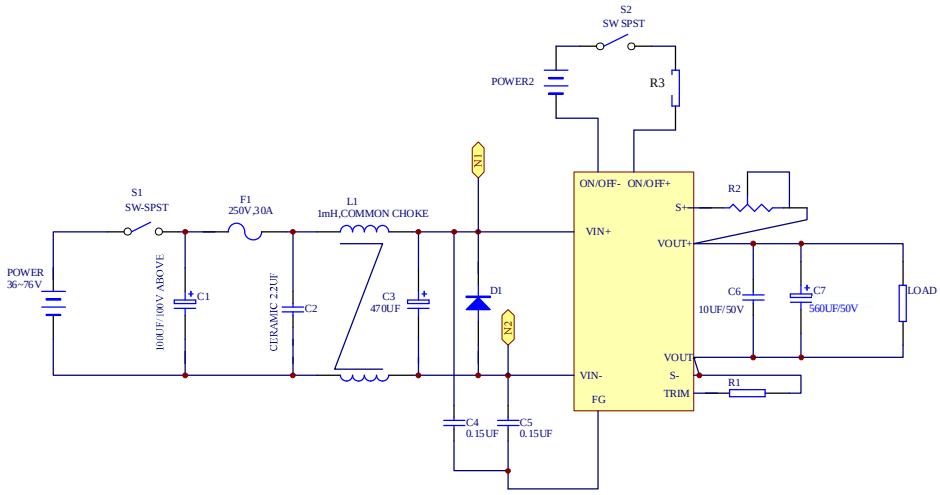
3. Basic Application Circuit and Considerations

3.1 Typical Application



3.2 When no external power supply for remote, short connect –ON/OFF to –Vin directly, and connect +ON/OFF to +Vin using an external resistor R3(30kΩ).

3.3 When no EMC requirement, L1, C3, C4 and C5 are optional.

3.4 With no demand for output trim, +S and –S shall respectively be connected to +Vout and –Vout directly. For testing, respectively connect +S and –S to +Vout and –Vout, or the module is at over-voltage status.

3.4.1 For output trim-up, with no resistor R1, adjust rheostat R2 to trim output up (V_O~+10%V_O).

Note: output power ≤ 504W, R2≤3kΩ

3.4.2 For output trim-down, with no rheostat R2, short connect +S to +V_O, adjust resistor R1 to trim output down (-40%V_O~V_O)

Note: output current ≤ 18A(Maximum), R1≥9.1kΩ

3.5 When running at -20℃, double the capacitance of C1, and triple the capacitance of C7; when running at -40℃, quadruple the capacitance of C1, and sextuple the capacitance of C7. Use several capacitors in parallel to reduce ESR.

3.6 For high-temperature application, keep air channels clear, and provide cooling as per the derating curve.

3.7 C6 shall be high-frequency ceramic capacitor.

4. Instruction for Use/Test (heatsink or forced cooling required)

4.1 An input voltage exceeding the max. input voltage may cause permanent damage to the module. An max. input ripple exceeding 4V may make the output ripple exceed the data sheet. Sudden changes of input voltage will cause output voltage inrush. The module is not internally fused, and an external 30A/250V fuse is required. The leads of C3, C6 and C7 shall be as short as possible. D1 is used to protect the module from inverse input voltage, and it shall endure a isolation voltage more than 100V.

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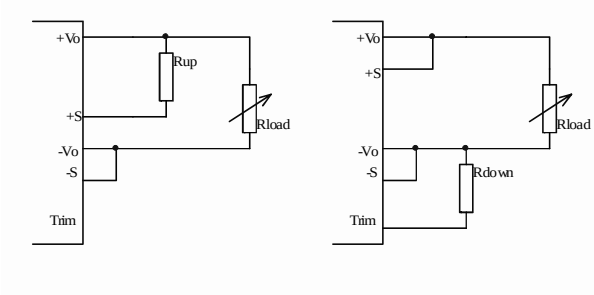
4.2 Output Voltage Trim

4.2.1 External Resistor Mode



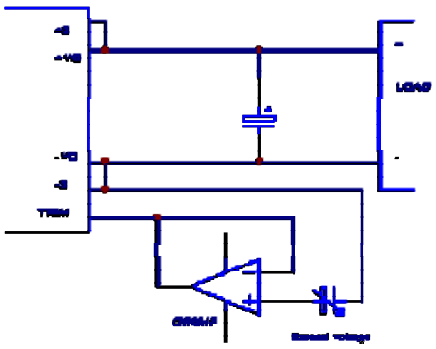
Trim up/down with external resistor

Trim-up: Rup=Vo（1+Δ%）－28 （kΩ） 0≤ Δ ≤10

Trim-down: Rdown=5.92（1/Δ%－1）（kΩ） 0< Δ ≤40

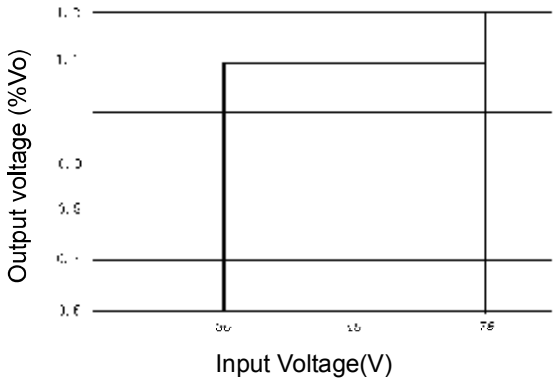
Δ(%): Ratio of output voltage changes to nominal output voltage

4.2.2 External Power Supply Mode: adjust the input voltage of amplifier to trim up/down the output voltage



Trim up/down with external power supply

4.2.3 Output Voltage Trim



4.2.4 Note: The over-voltage protection will function when trim-up voltage is higher than over-voltage threshold.

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4.3 Max Ripple and Noise: test the ripple and noise as the following figure shows. The output leads shall be twisted-pair, of which the length is no more than 50mm.

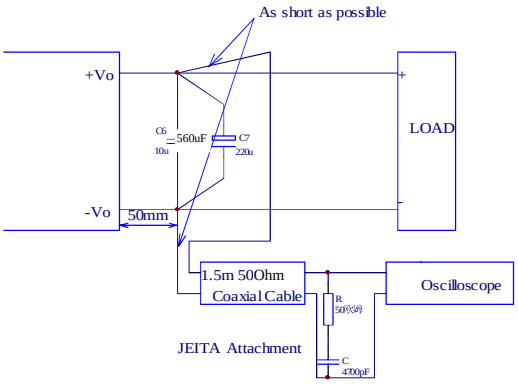

Figure for testing output ripple and noise

4.4 Over-current Protection

Operating at over-current conditions for long time may cause damage to the module; if the output is in short-circuit, the module is in hiccup mode, and the output current varies from a few mA to hundreds of mA.

4.5 Over-voltage Protection

When the module is at over-voltage conditions, the module is deadlocked; after eliminating the over-voltage conditions, the module needs to be reset to recover the output voltage.

Test Method: disconnect +S and +Vout (low load), series an additional 50k rheostat between +S and +Vout, adjust the rheostat to trim the output voltage up (32.2V to 42V), the module will turn off the output voltage until being reset.

4.6 Over-temperature Protection

When the baseplate temperature is at 100℃ to 125℃, the over-temperature protection functions, and the output is turn off; when the baseplate temperature is 5℃ to 15℃ less than the protection point, the module is auto recovered.

4.7 Remote Sense (+S, -S terminals)

When using remote sense, use twisted-pair to connect +S and –S respectively to + LOAD and –LOAD; when not using remote sense, connect +S and –S respectively to +Vo and –Vo. The twisted-pair shall be as short as possible.

4.8 Remote on/off (+ON/OFF and -ON/OFF terminals): two modes;

Note:

a. if the leads of +ON/OFF and -ON/OFF are a bit longer, add a 0.1uF capacitor between +ON/OFF and -ON/OFF.

b. A current-limit resistor can be also connected to -ON/OFF.

c. 1mA ≤ I(ON/OFF) ≤ 5mA

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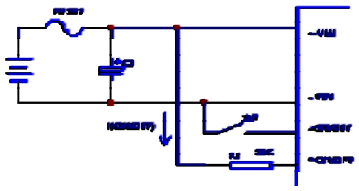
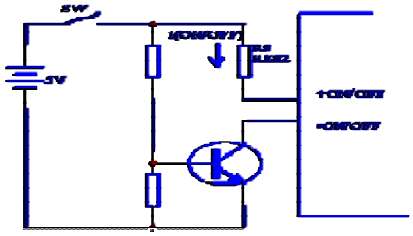
4.8.1 Connect ON/OFF terminals to input terminals: put a 30kΩ resistor R1 between +ON/OFF and +Vin.



Remote on/off mode I: Connect ON/OFF terminals to input terminals

4.8.2 Connect ON/OFF terminals to external power supply



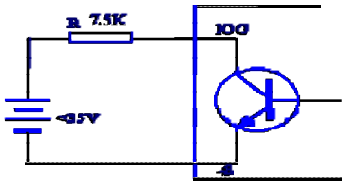
Remote on/off mode II: Connect ON/OFF terminals to external power supply

4.9 I.O.G. Signal (INVERTER OPERATION GOOD)

Monitor the I.O.G. signals to learn about whether the module operates normally. The I.O.G. signal is at low resistance state when the module operates normally (not including the deadlock status caused by over-voltage protection), or at high resistance state when the module stops or operates abnormally (not including over-current, dynamic response, short-circuit protection).

When the module operates normally, the internal transistor V304 is on, and I.O.G. is at low level; when the short-circuit protection functions, the output and V304 are in hiccup mode, and I.O.G. alternates between high level and low level; when over-voltage protection functions, V304 is off, and I.O.G. is at high level; when over-current protection functions, V304 is on and I.O.G. is at low level.

Condition of Use: I.O.G. has open-collector output, the external voltage shall be less than 35V, and the sinking current is 5mA.



IGM Signal Test (the internal transistor is V304)

4.10 For isolation voltage test, short +Vin to –Vin, short +ON/OFF to -ON/OFF, short +Vout to-Vout, and short signal terminals, like I.O.G., Trim, +S and –S.

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4.11 Parallel Application

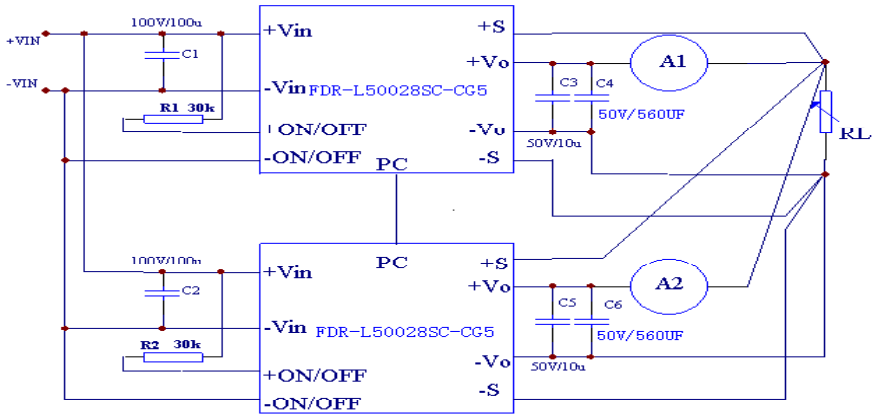
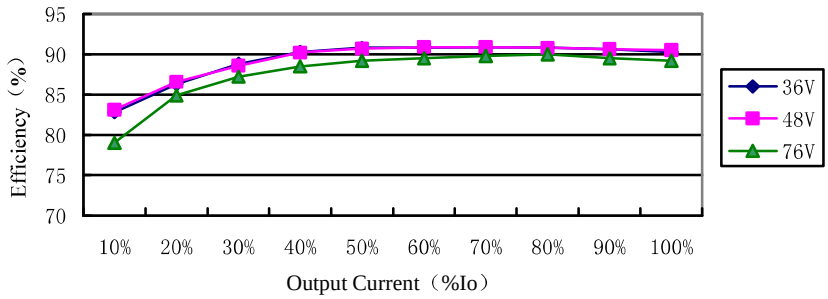


Figure for parallel application

Note: the output voltage of each module shall within the output voltage set-point range, and the output power shall not exceed 95% of total rated power.

5 Characteristic Curves (Ta=25℃)

5.1 Efficiency Curve



Load	20%Io	50%Io	80%Io
Efficiency（%）（Vin=48V）	86.4	90.7	90.8

Efficiency Curve

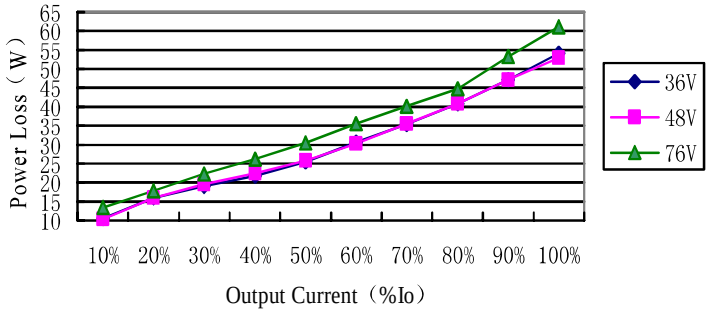


Figure 10. Power Loss vs Output Current

5.2 Dynamic Response

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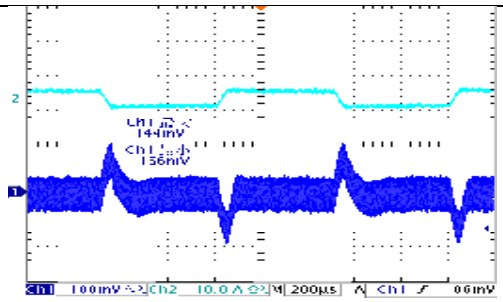
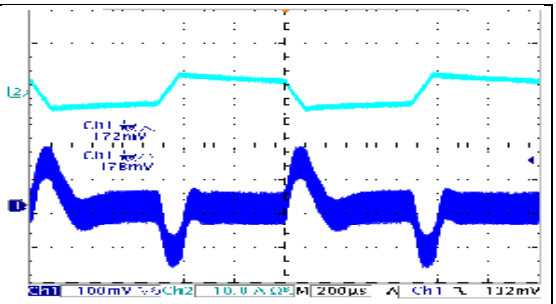
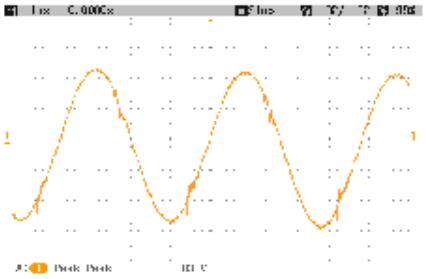
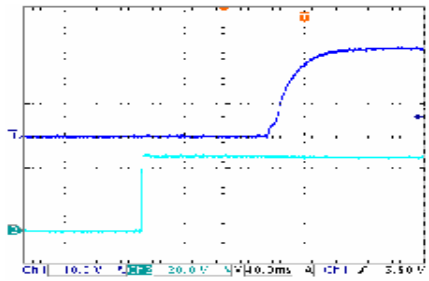
Test Condition: Vin=48V, add an 100μF electrolytic capacitor to input, add an 10μF tantalum capacitor and 560μF electrolytic capacitor to output

	
25%-50%-25% Dynamic Load	25%-75%-25% Dynamic Load

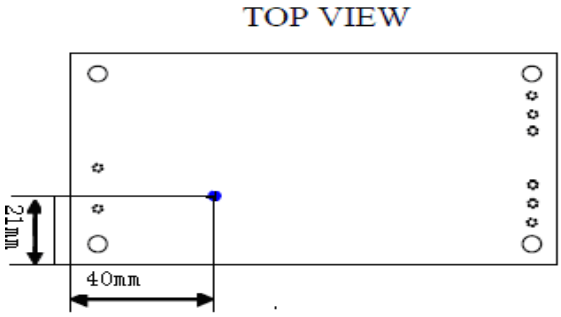
5.3 Output Ripple and Power-on Wave

Test Condition: Ta=25℃, Vin=48V, Io=18A, 20MHz, externally add a 560μF electrolytic capacitor and a 10μF tantalum capacitor to output, and add a 100μF/100V electrolytic capacitor to input

	
Output Ripple	Power-on Wave（Vin=48V, Io=18A, CR mode, CH1: output wave, CH2: input wave）

5.4 Temperature Derating Curve

The module can operate at a tougher temperature. However, a good thermal dissipation is necessary for normal operation. Monitor the temperatures of points as the following figure shows to judge whether the operation temperature exceeds the specified temperature limit.



Temperature Test Points (Top View of Al-PCB)

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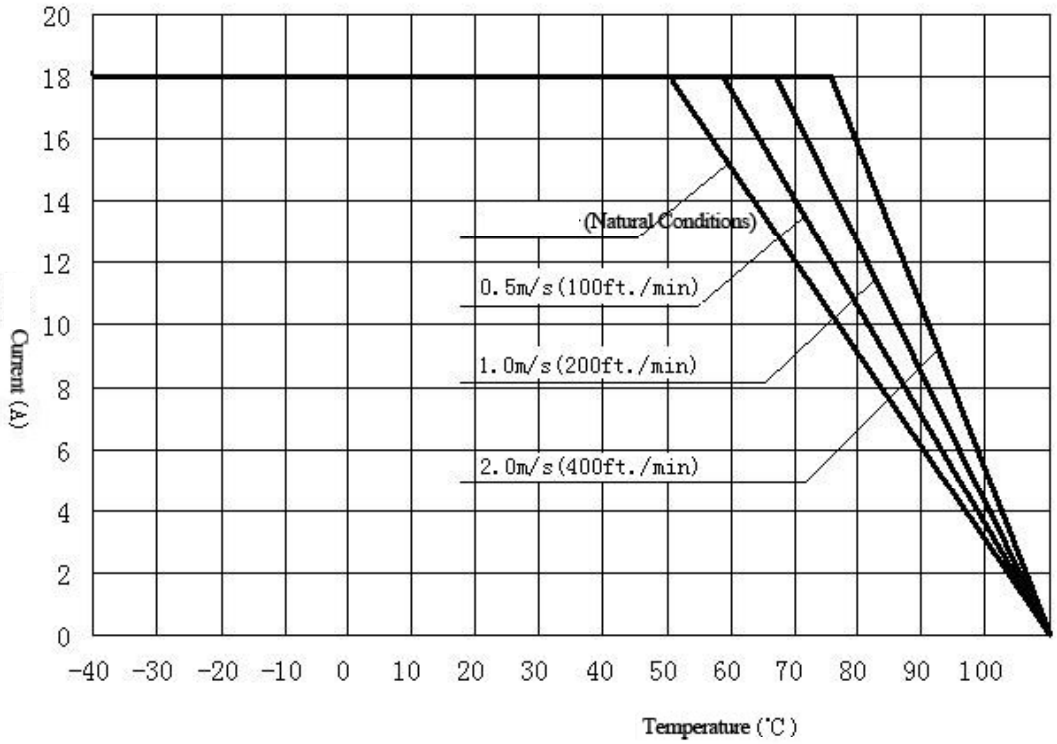
The following figure is the temperature-derating curve with heat sink (300mm×220mm×43mm)



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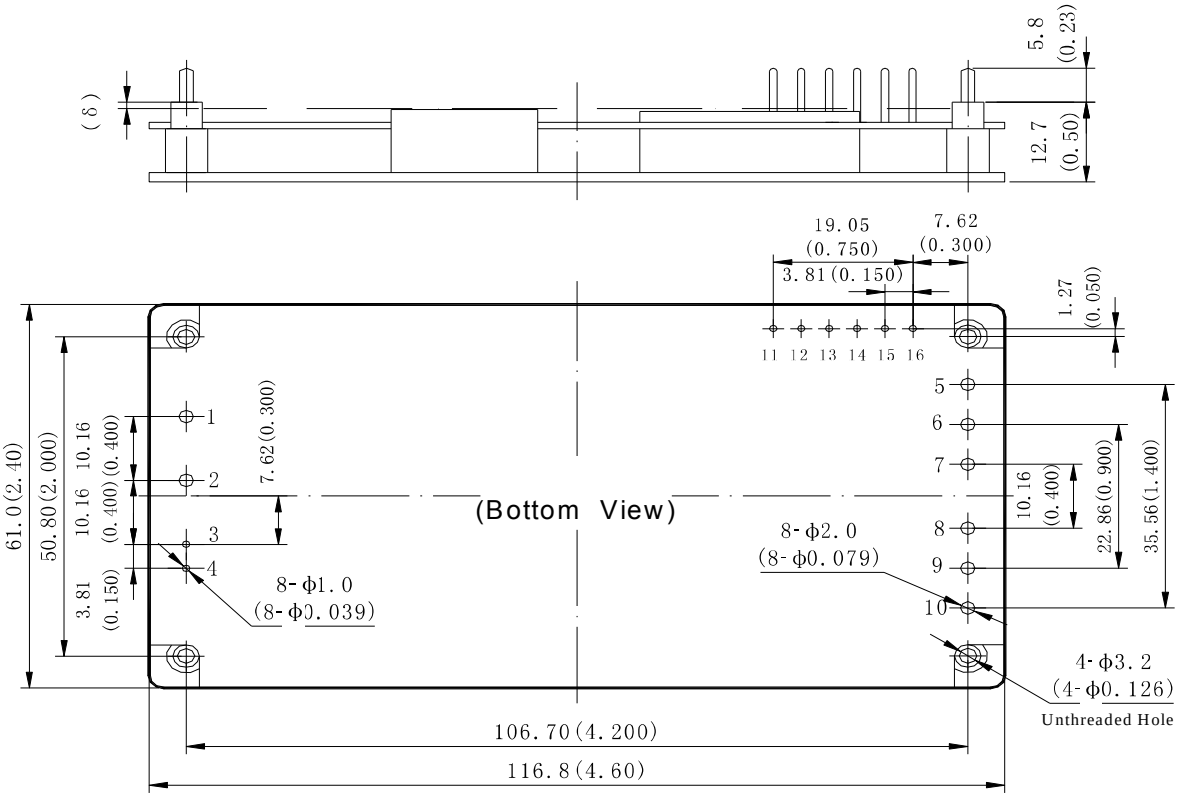
6. Dimensions and Pin definition



No.	1	2	3	4	5、6、7	8、9、10	11	12	13	14	15	16
Symbol	-Vin	+Vin	-ON/OFF	+ON/OFF	-Vout	+Vout	AUX	IOG	PC	TRIM	+S	-S
Definition	Negtive Input	Positive Input	Negtive Remote on/off	Positive Remote on/off	Negtive Output	Positive Output	Aux. Power Supply	Signal	Parallel Conn.	Trim up/down	Positive Remote Sense	Negtive Remote Sense

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