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# 1.2KW DCDC Converter Module
# Model NO. ATF1K2-540S28PM-G

## 1. Product Overview

ATF1K2-540S28PM-G series is a 1200W standard full-brick single output module, input 400~750Vdc, rated output voltage 28Vdc, output current 43A, efficiency up to 93%. Operating temperature range: -55 ℃ ~ 100℃ (case temperature), designed by: SJ20668-1998 "General Specification for Microcircuit Modules"

## 2. Electrical Characteristics

- Output voltage adjustment range: 50% ~ 110%
- 28Vout typical, Full load 1200W
- Built-in ORing fault protective circuit
- No minimum load limit
- Low output ripple& noise
- Wide input range: 400Vdc ~750Vdc
- Excellent thermal performance
- With parallel operation function

## 3. Control characteristics

- Positive logic at Control terminals
- Output remote sensing
- Power status IO Good indication
- Output current monitoring
- With PMbus communication interface
- Standalone auxiliary power 5V@100mA

## 4. Protection function

- Input under voltage protection
- Output overcurrent protection
- Output short circuit protection
- Output overvoltage protection
- Over temperature protection

## 5. Dimensions

- Standard full brick form factor (Figure 13)



Version: V0
File No.: SPEC-DC-O-046-0

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## 6. Electrical Characteristics

Unless otherwise specified, -55℃≤Tc≤100℃, Vin=540V±1V, Vo=28V, input capacitor 50uF electrolytic capacitor + 1uF metal film capacitor, output capacitor 10uF tantalum capacitor + 1uF ceramic capacitor

| Description | | Minimum | Typical | Maximum | Unit | Remark |
|---|---|---|---|---|---|---|
| Absolute Maximum | | | | | | |
| Input voltage | Non-working state | | | 800 | V | Less than 100ms |
| | Working status | | | 750 | V | Continuous Input |
| Operating temperature | | -55 | | 100 | ℃ | Substrate |
| Storage temperature | | -55 | | 125 | ℃ | |
| Primary control signal voltage | | -0.3 | | 18 | V | |
| Input characteristics | | | | | | |
| Operating voltage range | | 400 | 540 | 750 | V | |
| Input under voltage | Under voltage recovery point | 380 | 390 | 395 | V | |
| | Under voltage trigger point | 370 | 380 | 385 | V | |
| | Hysteresis | - | 10 | - | V | |
| Maximum input current | | | | 4 | A | 400V input, rated output, full load, Ta = 25℃ |
| No-load input consume current | | | 60 | | mA | Ta =25℃,Io=0A |
| Standby mode input current | | | 10 | 20 | mA | Ta =25℃ , sleep mode |
| Input fuse | | | | 10 | A | |
| Output Characteristics | | | | | | |
| Output voltage set point | | 27.72 | 28.00 | 28.28 | V | Full load, Ta = 25℃ |
| Line Regulation | | | | ±0.2 | % | |
| Load Regulation | | | | ±0.5 | % | |
| Temperature Regulation | | | | ±0.02 | % | |
| Output voltage range | | 27.16 | | 28.84 | V | Full temperature, full voltage, full load range |
| Switching frequency | | | 450 | | KHz | Output ripple frequency |
| Rated output current | | 0 | | 43 | A | |

| Description | Min. | Typical | Max. | Unit | Remark |
|---|---|---|---|---|---|

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| | | | | | | |
|---|---|---|---|---|---|---|
| Output ripple and noise | Peak-Peak | | 280 | | mV | Test conditions: 10uF Tantalum capacitor + 1uF (ceramic) BW=20MHz, Ta=25℃ |
| | RMS value | | 50 | | mV | |
| Output overcurrent point | | 47.3 | | 56 | A | Hiccup protection, automatically recover refer to Figure 3 |
| Output Capacitor | | 0 | | 20000 | μF | Recommended high frequency, low ESR capacitor ; constant resistance load |
| Dynamic characteristics | | | | | | |
| Dynamic Response | 50% ~ 75% ~ 50% Io max, (0.1A/μs) | | 3 | | % Vo | Ta=25°C |
| | Recovery time | | 200 | | μs | Recover to 1% of rated output voltage |
| Power-on transient | Rise time | | 150 | | ms | Full load, Vout 10%~90% |
| | Turn on delay time | | 350 | | ms | Turn on to 10% of Vout |
| | Output overshoot | 0 | 1 | 5 | %$V_o$ | |
| Efficiency | | | | | | |
| 100% load | | 92.0 | 93.0 | | % | Tc=40°C |
| 50% load | | 91.5 | 92.0 | | % | Tc=40°C |
| Insulation properties | | | | | | |
| Input to Output | | 3000 | | | Vdc | Withstand voltage (test conditions 1mA/60s, swing rate 1500V/10s), Ta=25℃ |
| Input to substrate | | 2250 | | | Vdc | |
| Output to substrate | | 750 | | | Vdc | |
| Input to Output | | 100 | | | MΩ | Insulation resistance (test condition: 500Vdc), Ta=25℃ |
| Input to substrate | | 100 | | | MΩ | |
| Output to substrate | | 100 | | | MΩ | |
| Other Features | | | | | | |
| Remote switch control | Turn-on voltage | 3.5 | - | 5 | V | |
| | Turn-on current | 1 | | 5 | mA | |
| | Turn off voltage | -0.3 | | 0.5 | V | |
| | Pin floating | Module does not power on | | | | |
| Output voltage adjustment range | | 60 | | 110 | %V | See the “Regulating Output Voltage” section |

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| | | | | | |
|---|---|---|---|---|---|
| Output voltage remote sensing range | | | 0.5 | V | See the application note on “Output Voltage Remote Sensing”. |
| Fault detection and isolation | Built in ORing and anti-reverse polarity circuit | | | | |
| Current sharing deviation | | 5 | 10 | % | 8 Parallel |
| Number of parallel connections | | | 8 | set | Can be paralleled directly |
| Output overvoltage protection | 32 | | 39 | V | Hiccup: Automatically recovers when overvoltage condition is removed |
| Over temperature shutdown | 105 | | 125 | ℃ | Substrate temperature |
| Over temperature hysteresis | 5 | | | ℃ | |
| Weight | | 245 | | g | |

## 7. Application Notes

- Typical Applications

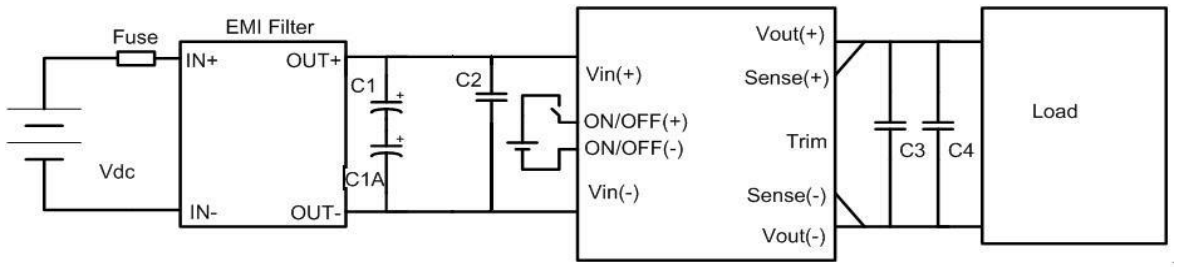


Figure 1 Typical application wiring diagram

C1, C1A: 100μF/450V electrolytic capacitor; Model: 450QXW100MEFC16X35 (Rubycon) or similar capacitors;

C2: 3μF/800V film capacitor, Model: C3D2K305KB00382 (Xiamen Farad) or similar capacitors;

C3: 10μF/75 tantalum electrolytic capacitor, Model: T521X106M075ATE050 (KEMET) or similar;

C4: 4x 220μF/50V solid aluminum electrolytic capacitors, Model: UPL1H221M1012 (UNICON) or similar capacitors;

Fuse: Fast-blow fuse with rated current of 10A.

Note: When using the module's own auxiliary power Vaux as an enable signal, Vaux is connected to ON/OFF+, Vaux _GND is connected to ON/OFF- (for non-communication version, Vout(-) is connected to ON/OFF-). Please note the clearance distance should be more than 4mm between the input power wires or traces of PCB layout.

- Output current limiting and power limiting protection instructions

When the output load is greater than 1.1*Io_nom, the output voltage begins to drop, and the

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constant current point is about 1.1*Io_nom. If the load current continues to increase, the output voltage continues to drop. When it drops to 0.4Vo_nom, the module output under voltage protection shuts down.

The power module output is set between 28V to achieve constant power output.

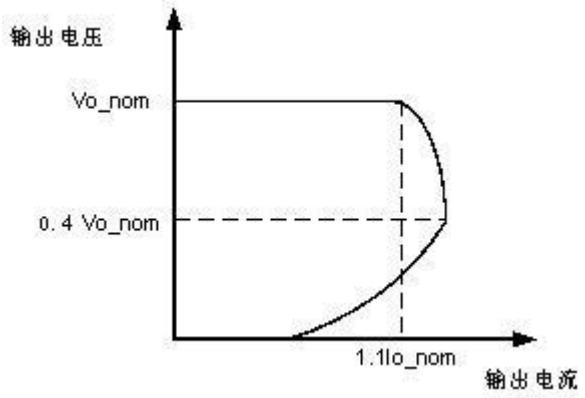


Figure 2 Output current limiting protection

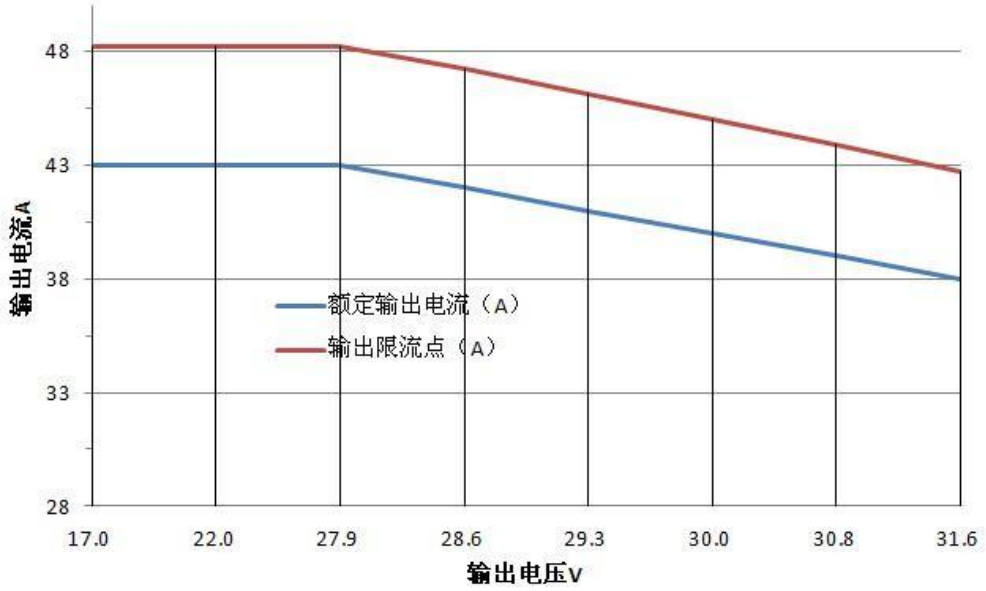


Figure 3 Output current limiting curve

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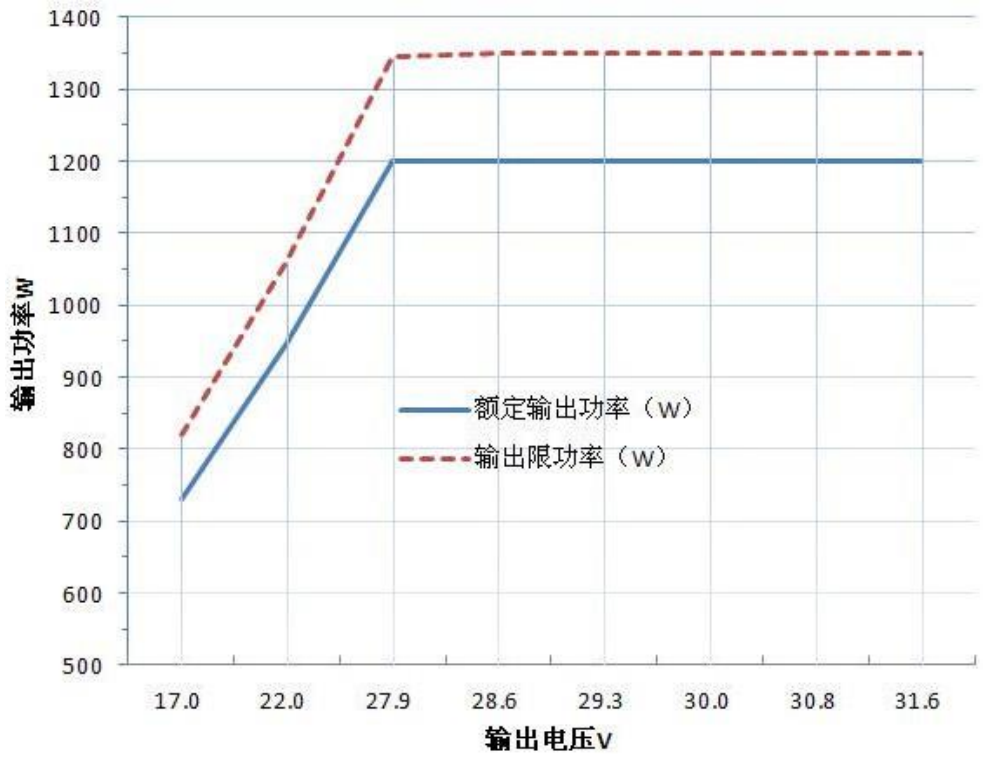


Figure 4 Output power limit curve

- Remote switch

  Please do not exceed the voltage range in the table between ON/OFF+/- to ensure correct operation. The external remote switch circuit is recommended to be the circuit shown in Figure 5. The external remote switch circuit needs to provide at least 1mA of driving current to ensure normal ON/OFF operation. When the control switch is suspended, the power supply is in a disabled state and has no output.

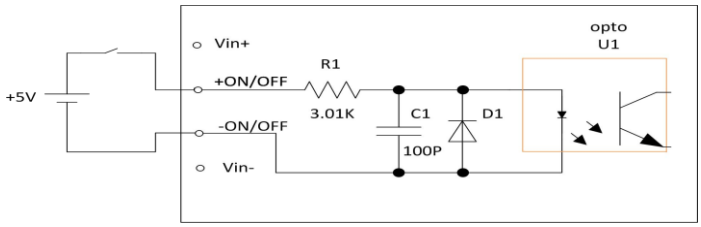


Figure 5 External remote switch circuit

- Output voltage regulation characteristics

  The power module supports two output voltage adjustment methods: external resistance method and voltage method. When the modules are used in parallel for voltage adjustment, no matter which adjustment method is used, please note that the Trim pins of the power modules cannot be directly connected.

  1) Resistance method:

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Connecting a resistor Rdown between the Trim pin and the Vout(-) pin will reduce the output voltage, as shown in Figure 6;

Connecting a resistor Rup between the Trim pin and the Vout(+) pin will increase the output voltage. You need to connect a 10KΩ fixed resistor in parallel with the Trim pin to Vout(-), as shown in Figure 7.

The adjustment resistor accuracy is not less than 1%, and the power consumption is not less than 1/10W. The voltage increase formula is as follows:

$$Rup = \frac{49 * Vo + 145}{1.1 * Vo - 20}\ k\Omega$$

(Formula 1)

Where Vo is the voltage you want to adjust.

For example, if you want to adjust the voltage to Vo=30V, you can get Rup=124.23KΩ by calculating it through formula 1. You need to connect a 124.23KΩ resistor (a potentiometer or multiple resistors in parallel to get a suitable resistance) between the Trim pin and the Vout(+) pin, and connect a 10KΩ resistor in parallel to the Vout(-) pin with the Trim pin.

The voltage reduction formula is as follows:

$$Rdown = \frac{57 * Vo - 940}{28 - Vo}\ k\Omega$$

(Formula 2)

If you want to adjust the voltage to Vo=21V, you can get Rdown=36.7K by calculating through formula 2. You need to connect a 36.7Ω resistor between the Trim pin and the Vout(-) pin, and no other resistors are needed.

When multiple power supplies are connected in parallel and the voltage is adjusted through Trim, the Trim resistor needs to be connected in parallel to the Trim pin of each module, and the Trim pins of the power modules are not connected to each other.

For example, for 8 parallel down applications, 8 Rdown resistors with the same resistance value are required, connected to their respective Trim pins and output ground. For 8 parallel up applications, 8 Rup resistors with the same resistance value are required, connected to their respective Trim pins and Vout(+), and matched with the Trim pins to connect 10KΩ resistors in parallel to their respective Vout(-). The connection between the Trim resistor and the output positive or negative should be connected to the positive or negative output pin of each power module at a single point to avoid introducing power loop current.

2) Voltage method:

Connect a voltage source TIRM_ADJ between the Trim pin and Vout(-). The size of the

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voltage source will determine the size of the output voltage. The maximum voltage source connected cannot exceed 5V, otherwise there is a risk of damaging the power module.

The voltage method voltage regulation formula is as follows: Vo=V_TRIM*6.283+16.54;

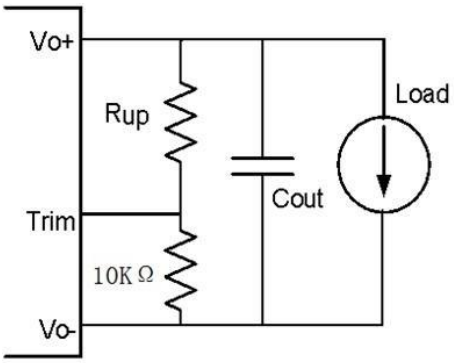
Wherein, V_TRIM is the Trim pin voltage, and Vo is the voltage to be adjusted;

When a single module is regulating the voltage, the voltage source TIRM_ADJ can be directly filtered and connected to the Trim pin of the module, as shown in Figure 8.

When multiple modules are connected in parallel for voltage regulation, the Trim pins of each module cannot be directly connected. The application is shown in Figure 9. An external operational amplifier is required for filtering and isolation before sending it to the respective Trim pins of the power module. The parameters in the figure are for reference only, and the appropriate parameters should be determined according to the actual application.

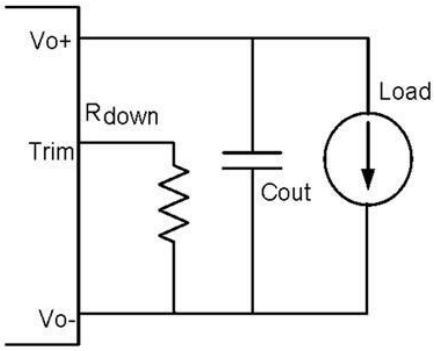
Note1: When the output voltage is increased, the output current should be reduced accordingly in order not to exceed the maximum output power;

Note2: When the output voltage is reduced, the maximum output current of the module cannot exceed the rated maximum current.




电阻法上调

Figure 6 Output voltage adjustment (resistance method) Figure




电阻法下调

7 Output voltage adjustment (resistance method)

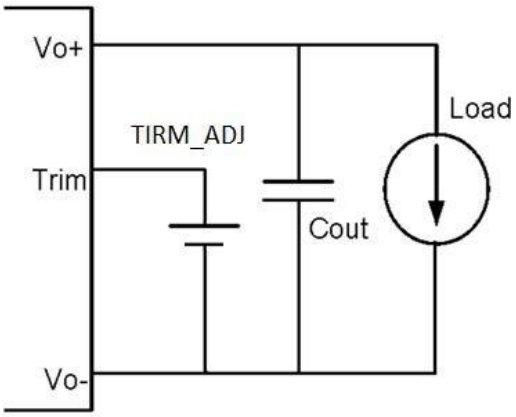



Figure 8 Output voltage up/down adjustment (voltage method)



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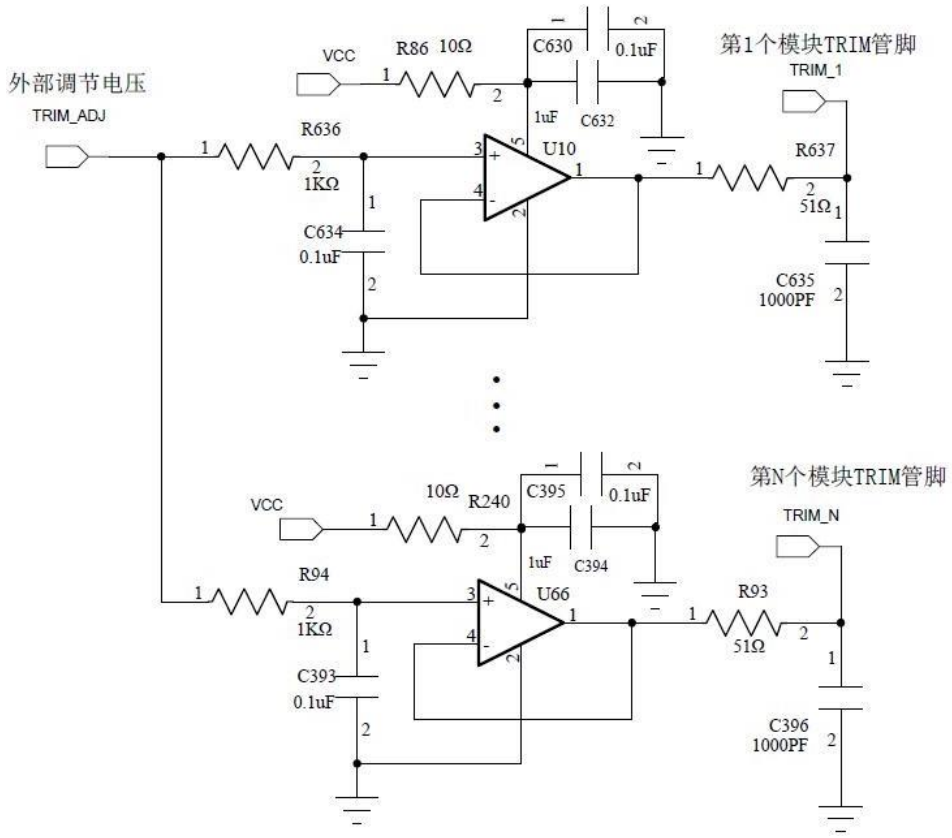


Figure 9 Output voltage up/down adjustment (voltage method parallel connection)

- Output ripple noise test configuration

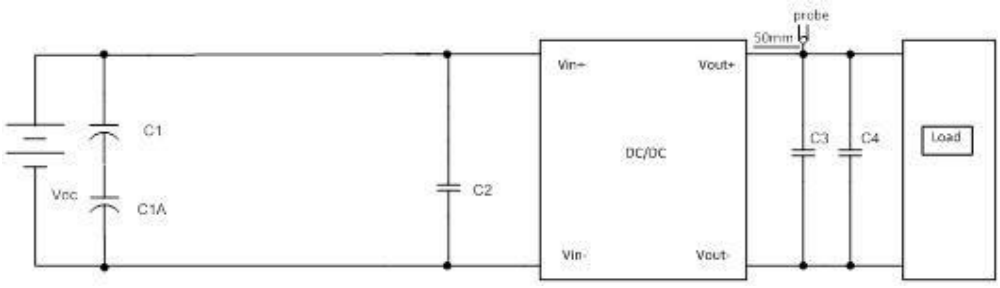


Figure 10 Output ripple and noise test configuration

Vdc: DC power supply

C1 ~ C4: See Figure 1

Note: It is recommended to use a coaxial cable and test an output capacitor of 10uF tantalum + 1uF ceramic capacitor at a distance of about 50mm from the module output port, or use the ground loop test method.

- Reference Location

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Vin(-): input side power reference ground;
ON/OFF(-): enable reference ground, insulated from both input and output sides, withstand voltage of 3000Vdc; Vout(-): output side power reference ground;
Vaux_GND: reference ground of output side auxiliary power supply in communication version, insulated from main power output Vout(-) function. In non-communication version, Vaux uses Vout(-) as reference ground.

- Auxiliary power supply
  The power module provides an external 5V auxiliary power supply with a maximum operating current of 100mA. For the communication version, the reference ground is Vaux_Gnd, which is isolated from the main power output function. It can be used as a power supply for ON/OFF switch control, or to power other circuits in the system. For the non-communication version, Vaux uses Vout(-) as the reference ground.

- Output status indication
  The power output status is reported to the system through the IOG signal. A high level indicates that the power supply is working properly, and a low level indicates a power failure. The signal reference ground is the Vout(-) pin.

- Output current reporting
  The power supply output current is converted to voltage analog quantity internally and reported through the Imonintor pin, with the reference ground being the Vout(-) pin. Calculation formula: Imonintor voltage = Iout*0.08, where Iout is the actual output current of the power supply.
  For example: output current 40A, the reported voltage of Io_monitor is 3.2V.

- Output voltage remote sensing
  The module with output voltage remote compensation function can compensate for the voltage drop caused by the line by shorting Sense+/- and the +/- of the load, thereby keeping the voltage at the load end constant.
  This module can support output voltage remote compensation, with a maximum compensation voltage of 0.5V. However, since the Sense+/- pins are connected to the feedback sampling circuit, unreasonable wiring will introduce interference, resulting in output oscillation and other phenomena.
  The wiring of Sense+/- must ensure a low impedance loop, and it is recommended to use twisted pair connection to enhance anti-interference ability. For applications where the output line voltage drop is acceptable, it is recommended to short the root of the module output pin and Sense+/- respectively to avoid affecting the normal operation of the power module.
- Parallel Application
  This module can support up to 8 parallel applications. The parallel circuit diagram is shown in the

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figure below. The Ishare and StartSync pins of all modules are connected together. The Sense+ and Sense- leads of each module are shown in the figure, and they are directly short-circuited at their respective output pins.

The input and output power lines of the modules are short-circuited separately, and the power line impedance of each module is kept as similar as possible. No other devices are allowed between the output pins of the module and the short-circuit point, otherwise it will affect the current sharing effect. If devices such as common-mode inductors are used at the output, it is recommended to place them after the short-circuit point.

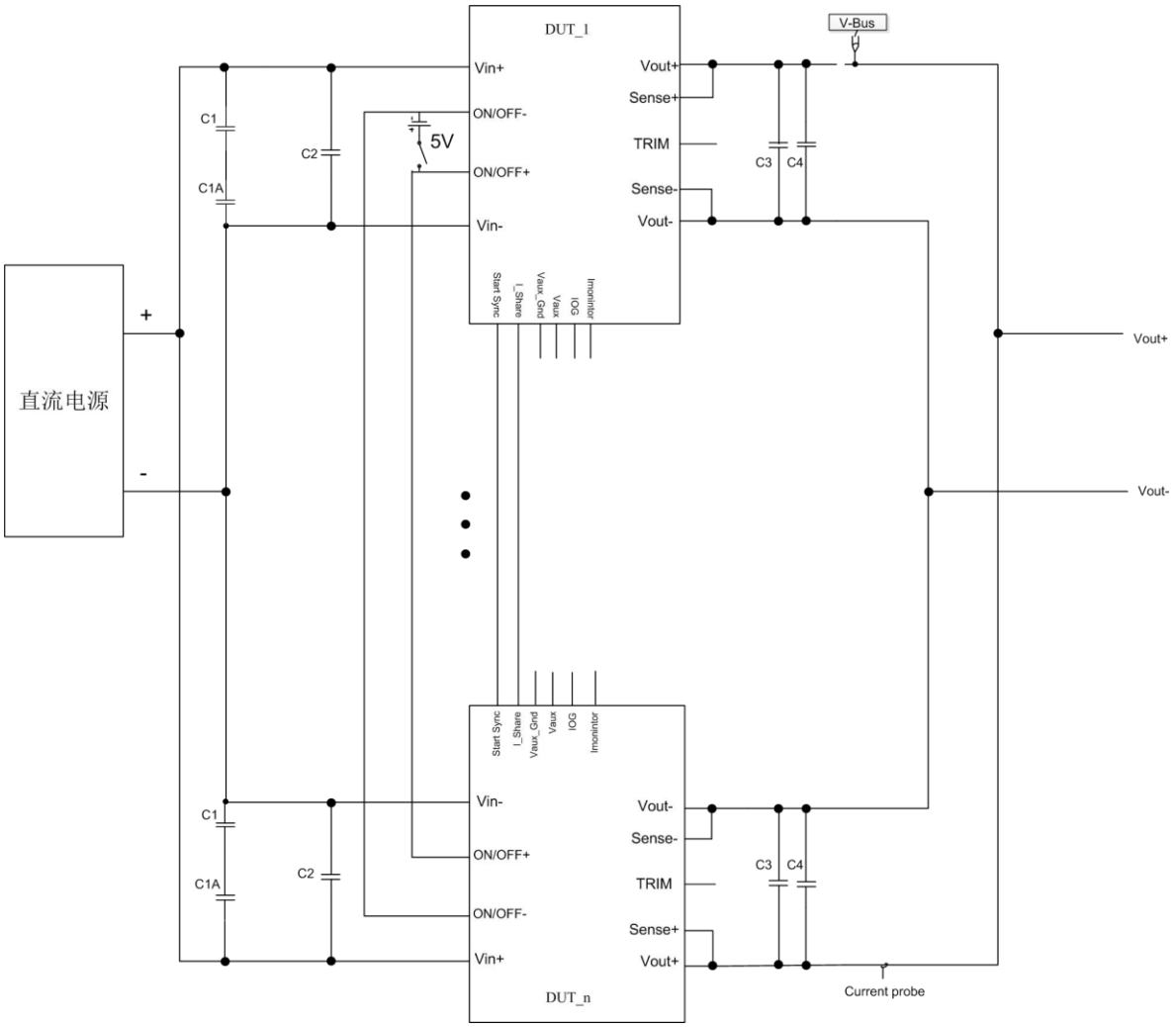


Figure 11 Schematic diagram of parallel connection of modules

- Thermal Derating Curve

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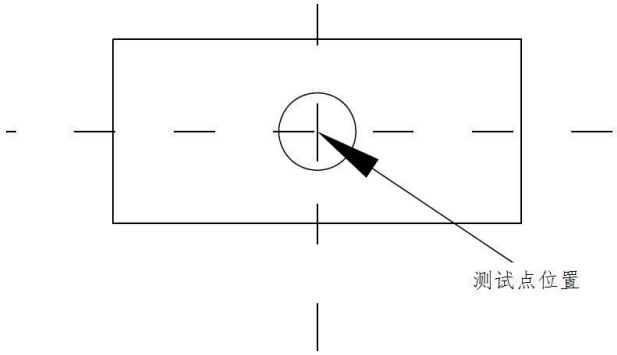
The module dissipates heat through a heat sink connected to the base plate. The relationship between the output current and the base plate temperature is shown below (it is recommended to drill holes on the heat sink and stick temperature measurement points for testing to ensure that the power base plate is close to the external heat sink). Under rated input conditions:



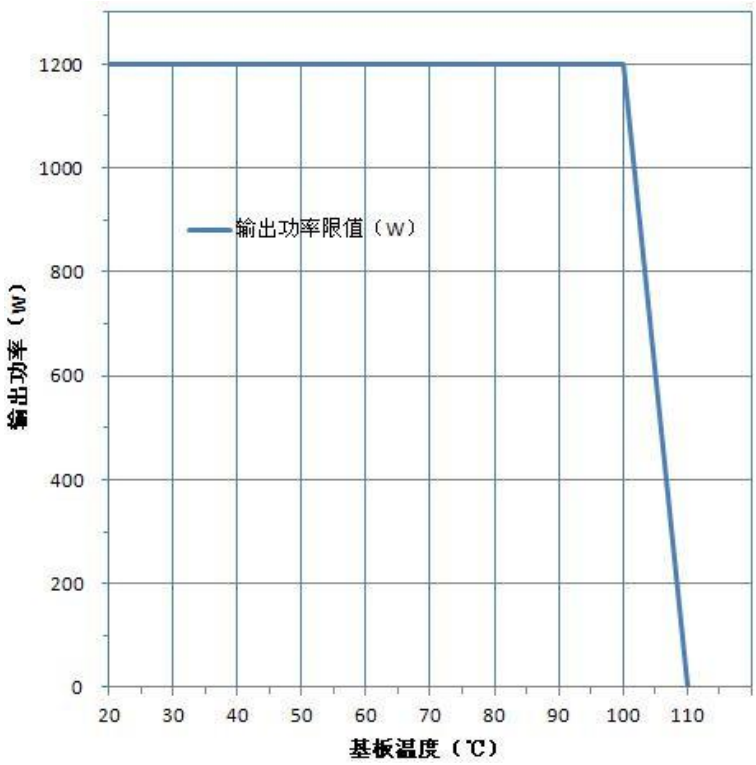




Figure 12 Thermal Derating Curve (Rated 540V Input, Rated Output)

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- Structure diagram

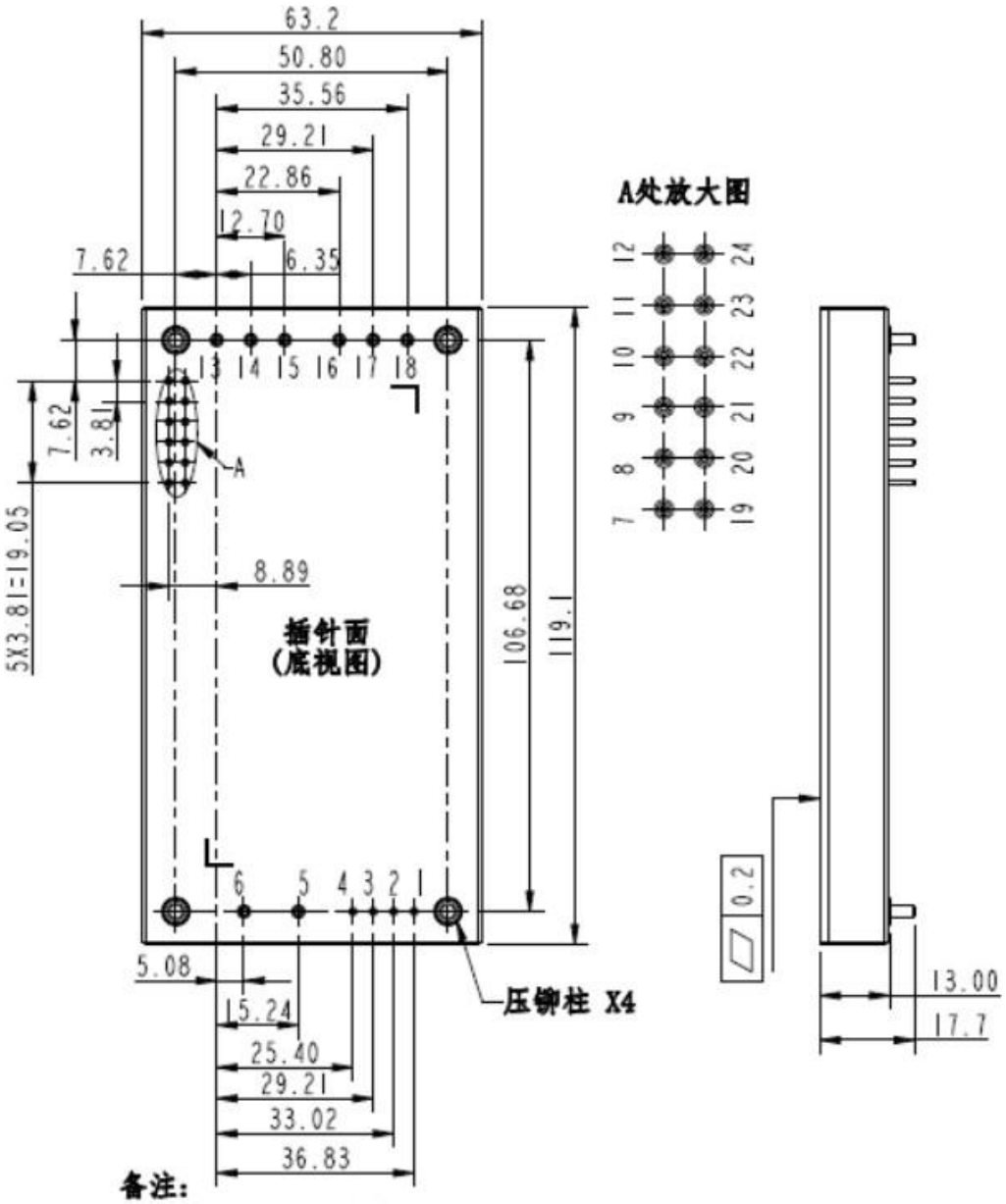


Figure 13 Mechanical Dimensions (Bottom View, Pins Upward)

- Pin Definition

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| Pin | Symbol | Function | Pin | Symbol | Function |
|---|---|---|---|---|---|
| 1 | NC | Floating | 13 | Vout(-) | Output negative terminal |
| 2 | NC | Floating | 14 | Vout(-) | Output negative terminal |
| 3 | ON/OFF（+） | Primary side control positive | 15 | Vout(-) | Output negative terminal |
| 4 | ON/OFF（-） | Primary side control negative | 16 | Vout(+) | Output positive terminal |
| 5 | Vin(+) | Input positive | 17 | Vout(+) | Output positive terminal |
| 6 | Vin(-) | Input negative | 18 | Vout(+) | Output positive terminal |
| 7 | Vaux | Auxiliary power supply | 19* | Vaux _Gnd | Auxiliary power supply reference ground |
| 8 | StartSync | Start-up synchronization | 20* | Imonintor | Output current reporting |
| 9 | Ishare | Current sharing pin | 21* | PMBUS_Addr 0 | PMBUS address setting pin |
| 10 | TRIM | Output voltage adjustment | 22* | PMBUS_Clock | PMBUS clock |
| 11 | SENSE(+) | Remote compensation positive | 23* | PMBUS_Data | PMBUS data |
| 12 | SENSE(-) | Remote compensation negative | 24* | IOG | Output status indication |

*Note: Applicable to the version with I2C communication. In the version without communication, Pin19~24 are not plugged in, and Vaux is referenced to Vout(-).

- Screening Validation

| Item | Description | Test method | Condition and requirements | Sampling |
|---|---|---|---|---|
| 1 | Internal visual inspection | GJB 548B method 2017 | - | 100% |
| 2 | High temperature storage | GJB 150.3A | Ta＝125℃,48h | 100% |
| 3 | Temperature cycling | GJB 548B method 1010 | Ta=-55$^{0}_{-10}$ ℃～125$^{+15}_{0}$℃,10 次, t1=15min±1min,t2≤1min | 100% |
| 4 | Aging | GJB 360B method 108 | Tc＝100℃,96h | 100% |
| 5 | Three-temperature electrical test | — | Comply with technical specifications | 100% |
| 6 | External visual inspection | GJB 548B method 2009 | - | 100% |

- Assembly Instructions

The module substrate needs to be close to the system heat dissipation surface for heat dissipation.

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Due to the flatness of the contact surface, thermal grease or thermal pads must be used to enhance the heat conduction effect, otherwise the module will cause premature over-temperature protection.

Note: When assembling the module, be sure to fix the screws first, and then weld the pins to prevent the pins from being subjected to mechanical stress, otherwise it will cause permanent damage.

- Welding Instructions

Suitable for wave or manual soldering, not reflow soldering. When using wave soldering, the temperature on the pin is up to 260℃, and the maximum duration is 7 seconds. When manual soldering, the soldering iron temperature should be maintained at 300℃~350℃, and the time applied to the pin is less than 10 seconds. Long-term soldering iron contact will cause internal damage to the module.

- Naming convention

| LW | F | 1K2 | - | 540 | S | 28 | P | M | - | G | - | N | T | - | - |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | | 4 | 5 | 6 | 7 | 8 | | 9 | | 10 | 11 | | 12 |

| | | |
|---|---|---|
| 1 | Product series | LW |
| 2 | Product size category | F: Full Brick |
| 3 | Output power | 1K2: 1200W |
| 4 | Rated input voltage | 540: 540V input |
| 5 | Number of output channels | S: Single output |
| 6 | Rated output voltage | 28: 28V output |
| 7 | Parallel function | Default: No parallel function<br>P: With parallel current sharing function |
| 8 | Screening level | M: Military |
| 9 | Device level | Default: Imported devices<br>G: Domestic devices |
| 10 | Control characteristics | Default: Positive logic<br>N: Negative logic |
| 11 | Installation method | Default: Through hole<br>T: Thread hole, M3 threaded hole |
| 12 | Communication method | Default: No communication function |