DC/DC (Wide Input Voltage) Module Power Supply Application Guide

Table of Contents

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China

www.amchard-power.com

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China
www.amchard-power.com

1. Power Module Selection Guide

1.1 Determining Power Specifications

First, determine the power specifications and filter according to the required indicators to decide whether to use a standard power module or a custom power supply.

Step 1: Select the Input Voltage of the Power Module
Input voltage ranges:5V (4.5-9V), 12V (9-18V), 24V (18-36V), 48V (36-75V) with a 2:1 input voltage range: Choose BT, GT series.24V (9-36V), 48V (18-75V), with a 4:1 input voltage range: Choose AT series.For applications with significant output voltage variations, such as 24V industrial bus power, 48V communication bus power, 220V transformer rectifier output, and various battery types (lead-acid, lithium, dry cells, etc.), or long-distance transmission, choose wide input voltage modules from the AT, or AB series. For output power above 3W, to improve overall efficiency, it is recommended to use GT or AT series modules. For special industries like automotive electronics, where the voltage range is wider, choose modules with even wider input voltage ranges, such as AB series.

Step 2: Select the Output Voltage of the Power Module
Common output voltage specifications include 3.3V, 5V, 9V, 12V, 15V, 24V, 28V, 48V, ±5V, ±9V, ±12V, and ±15V.

Step 3: Select the Power Rating of the Power Module
Once the load is determined, the output current is essentially fixed. The load current size is key to determining the power rating and directly affects the module's reliability and cost. Power modules are best used at 30%-80% of their rated power under normal temperature conditions. For high or low-temperature environments, derating must be considered. Choosing the appropriate output current is crucial for successful design, as too high or too low current can lead to reduced reliability and increased costs.

In high-temperature conditions, power modules should be derated. It is recommended to use the module at 70% of its rated power. For high-

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China
www.amchard-power.com

temperature applications or poor heat dissipation conditions, prioritize modules with larger volumes or larger packages. For long-term operation above 70°C, consult our technical service personnel to select a module suitable for high-temperature environments.

Additionally, altitude affects product heat dissipation and safety. At high altitudes, air density decreases, reducing the air's ability to absorb heat and arc energy, and increasing the diffusion concentration of arc ions, which can lead to arcing. Therefore, safety standards must meet high-altitude requirements. When using modules at high altitudes, consult our technical service personnel to ensure the product is suitable for such environments.

Step 4: Select the Isolation Characteristics of the Power Module

Isolation ensures that the input and output of the module are completely independent (not sharing a common ground). In industrial bus systems, isolation provides safety in harsh environments (lightning strikes, arc interference) and eliminates ground loops. In mixed circuits, it isolates noise between sensitive analog and digital circuits. In multi-voltage power systems, it enables voltage conversion. For dual or multi-output products, determine whether the outputs need to be isolated. If isolation is required, choose products with isolated outputs.

Step 5: Select the package size of the power module.

The power module needs to reserve enough space to consider the impact of its heat dissipation radiation on signal acquisition interference and the impact of the module's electromagnetic interference on the performance of other circuit components. Therefore, it is necessary to balance volume, cost, and also consider the reliability of the module.

In short, try to use standard module specifications to meet the requirements of low cost, mature technology, small development resistance, and save development time. For high isolation, ultra-wide voltage range input, high-temperature environment, EMC, UL certification, and other special requirements, it is best to consult our technical service personnel.

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China

www.amchard-power.com

1.2 System Power Distribution Design

The design of system power distribution often requires multiple optimizations based on the characteristics of the product and the requirements of the circuit. Accurate measurement of the actual circuit's operating parameters and environmental change range helps us more accurately select the appropriate module power supply.

Step 1: External factors.

The ambient temperature will have a certain impact on the power module and its external components. The power module may be used in high temperature, low temperature, or high and low temperature cycling environments (such as cabins, ships, etc.). We should understand the changes in the corresponding parameters of the power module under changing environmental conditions to ensure that it meets the requirements in the actual environment. It should be noted that the operating ambient temperature of the power module does not refer to the current temperature, but the space temperature inside the equipment and the shell; due to the presence of many heating devices, the temperature inside the shell is usually higher than the current temperature.

Table 1-1 Industry Operating Ambient Temperature Distribution

Industry Classification	**Ambient Temperature**
Commercial Products	0~70℃
Industrial Products	-40~85℃
Vehicle Equipment	-40~105℃
Field Operation Equipment	-55~85℃
Military Field	-55~125℃

Especially at high temperatures, the module is greatly derated, and sufficient margin should be considered in the design. It is advisable to choose electrolytic capacitors with good high and low temperature characteristics. At high temperatures, the anode foil electrostatic capacity of the capacitor decreases and the internal pressure increases, leading to failure. Please refer to the specification of the capacitor used for correct use.

In environments with arc, electrostatic discharge, unstable AC grid, start switch,

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China

www.amchard-power.com

relay, lightning strike and other interferences, the input voltage and current may far exceed the module's tolerance range, causing permanent damage to the module and paralysis of the load circuit. At this time, appropriate protection circuits should be added to ensure the safe operation of the power supply.

The transmission distance also has an impact on the system power supply. Generally, the following points should be noted when selecting:

(1) For indoor short lines, small temperature differences, and small interference, non-isolated or low-power modules are generally used;

(2) For outdoor long-distance transmission, in addition to considering lightning protection and isolation protection, the transmission loss should be accurately calculated, and a wide voltage input and sufficient power isolated power module should be selected.

(3) If the transmission distance is too long and the loss is large, the power supply of the module must provide sufficient power to ensure the normal operation of the module. Considering the starting current of the module, it is generally recommended that the power supply provide a current of 1.4~1.6 times the starting current of the module.

(4) It is recommended to connect a capacitor in parallel with the input pin of the module to improve the starting performance of the product.

Step 2: Working environment.

All power conversion products will have a certain loss converted into their own heat energy, causing themselves to heat up and affect the surrounding environment to heat up, causing data interference (thermal sensor devices) and device performance degradation, and even causing short circuits and fires. When laying out, there must be sufficient air flow space, or increase the heat dissipation area to reduce the temperature rise and ensure safety.

Since the switching power supply is realized by switching technology, its own switching oscillation circuit and internal magnetic components will generate electromagnetic interference and pollution to the surrounding devices in the form of conduction and radiation. Electromagnetic interference (EMI) refers to the pollution caused to the environment by the electromagnetic energy transmitted through electromagnetic radiation and signal lines and power lines. Electromagnetic interference cannot be completely eliminated, but some methods can be taken to reduce it to a safe level to achieve electromagnetic compatibility.

Step 3: Module layout.

Unreasonable grounding and power layout often cause system instability, high noise and other adverse phenomena.

In many applications, digital and analog circuits share the same power supply. In such designs, it is very important to separate or completely isolate the power supply and ground loops of the analog and digital circuits to avoid the interference of digital DC level changes and logic transient processes on sensitive analog circuits.

In high-speed dynamic analog and digital circuits, when the load is powered through long lines, the distributed resistance and inductance of the power distribution lines become obvious and are easily caused by the rapid change of the load current to cause noise spikes. This requires decoupling of the load and elimination of the series impedance on the line and the resonance caused by the distributed parameters.

2.Power Module Testing

After selecting the appropriate power supply, it is still very important to apply the electrical performance in the actual unit circuit. The product must be strictly tested before use. The following briefly introduces the general test methods of the module power supply.

2.1 Power Module Test Circuit and Method

The power module adopts the standard Kelvin test method, as shown in Figure 2-1. Test conditions: room temperature Ta=25°C, humidity<75%.

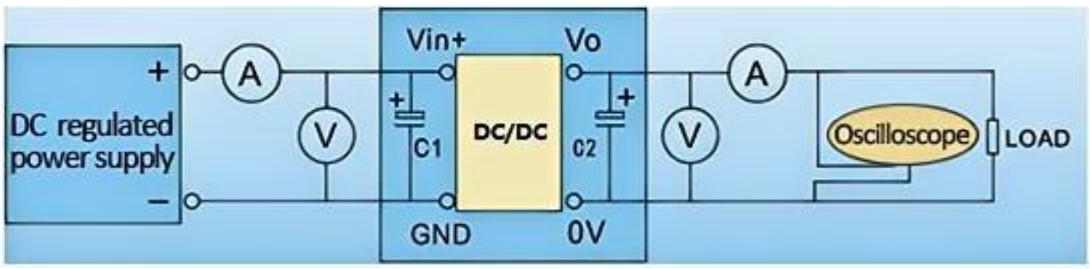


Figure 2-1

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China

www.amchard-power.com

Note:
(1) Connection: The smaller the line loss, the better. The best is a multi-strand copper wire with a diameter of 1mm to avoid excessive voltage drop. When the load current is large, the distance between the output pin and each load should be shortened, and the cross-sectional area of the connecting wire should be increased to reduce excessive voltage drop.
(2) It is recommended to use the single-channel probe direct measurement method to measure the output during measurement to avoid input and output common ground and external interference causing measurement errors. (See "Ripple and Noise" for details)

(3) During the test, ensure that the current limit point of the front-end power supply is set reasonably. At the same time, to ensure accurate voltage and ripple, the output capacitive load should not be greater than the value specified in the technical manual.

(4) For specific technical parameters, please refer to the corresponding technical manual of the product.

2.2 Basic Performance Testing of Power Modules

After connecting the power module, the performance can be tested and judged to confirm whether the performance parameters meet the standards.

2.2.1 Output Voltage Accuracy

Under the nominal input voltage and full load output conditions, the output set voltage is Voutnom
Output voltage accuracy = [Vout-Voutnom]/Voutnom * 100%

Test the output voltage Vout under the nominal input voltage

For example, the module BTB1212S-1WR2, the output set voltage is Voutnom = 12V, the rated load is 144Ω; the measured output voltage Vout = 12.039V, the output voltage accuracy = [12.039 - 12.000]/12.000 * 100% = 0.325%

2.2.2 Line Voltage Regulation

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China
www.amchard-power.com

Wide voltage input regulated output series:

Under the nominal voltage input and rated load, the measured output voltage is recorded as Voutnom
Under the upper limit of the input voltage and rated load, the measured output voltage is recorded as Vouth
Under the lower limit of the input voltage and rated load, the measured output voltage is recorded as Voutl
Vindex takes the maximum deviation of Vouth and Voutl from Voutm to calculate

Line regulation = [Vindex - Voutnom]/Voutnom * 100%

For example, the module BTB2405S-3WR2, the rated load is 600mA, Vouth = 5.01V, Voutm = 5.00V, Voutnom = 5.01V, line voltage regulation = [5.00 - 5.01]/5.01 * 100% = -0.2%

2.2.3 Load Regulation

Wide voltage input regulated output series:

Under the nominal voltage input and 10% load, the measured output voltage is recorded as Vb1
Under the nominal voltage input and 100% load, the measured output voltage is recorded as Vb2
Under the nominal voltage input and 50% load, the output voltage nominal value is recorded as Vb0
Vb takes the maximum deviation of Vb1 and Vb2 from Vb0

Load regulation = (Vb - Vb0)/Vb0 * 100%

2.2.4 Cross Regulation

For dual or multi-output modules, the voltage is generally sampled from the main output to form a closed-loop control loop. The change of the main load current has little effect on its output voltage. The auxiliary voltage is obtained through transformer coupling. The change of the main and auxiliary load current will cause a large change in the auxiliary output voltage. Therefore, for dual and multi-output modules, the load of each output must be balanced (the load balance is preferably no more than 5%), otherwise, the output voltage and load regulation will exceed the accuracy range.

The output voltage of the main load with 50% load is recorded as V1(50%), the output voltage of the other load with 50% load is recorded as V2(50%)

The output voltage of the main load with 100% load and the other load with 10% load is recorded as V2(10%)

The output voltage of the main load with 10% load and the other load with 100% load is recorded as V2(100%)

V2(50%), V2(10%), V2(100%) are the same output voltage value, V2' takes the maximum deviation of V2(10%) and V2'(100%) from V2(50%)

Cross regulation = [V2' - V2(50%)]/V2(50%) * 100%

2.2.5 Efficiency

Under the nominal input voltage Vin and full load Iout, the measured output voltage is recorded as Vout, the input current is recorded as Im

Efficiency η = (Iout * Vout)/(Im * Vin) * 100%

For example, the module BTB1212S-1WR2, Vin = 12V, the measured output voltage under full load is Vout = 11.951V, the output current Iout = 83.6mA, the input current Im = 100.7mA, η = [0.0836 * 11.951]/[0.1007 * 12.000] * 100% = 82.68%

2.2.6 Ripple and Noise

Ripple and noise are periodic and random AC components superimposed on the DC output, which also affect the output accuracy. Generally, ripple and noise are measured in peak-to-peak value (mVp).

Step 1: Set the oscilloscope bandwidth to 20MHz to effectively prevent high-frequency noise;

Step 2: Use the parallel line test method, twisted pair or proximity test method.

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China

www.amchard-power.com

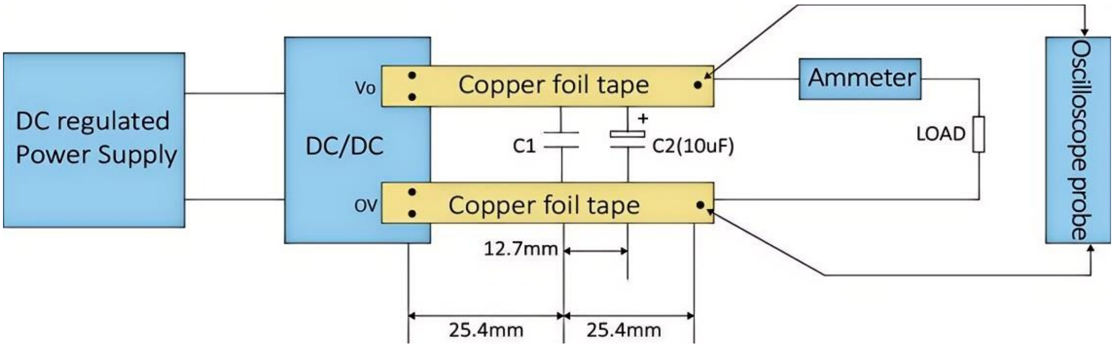


Figure 2-5

Note:

(1) C1: High-frequency ceramic capacitor, generally 1uF;

(2) C2: For wide voltage input series (such as GT, BT, AT series), C2 is 10uF (electrolytic capacitor), and the withstand voltage is more than twice the module output voltage;

(3) The distance between the two parallel copper strips is 2.5mm, and the sum of the voltage drops of the two parallel copper strips should be less than 2% of the output voltage value.

2.2.7 Dynamic Load

When the load changes suddenly, all power supplies have a corresponding response time. During the transient response, the output voltage of the power supply will have a momentary overshoot and then return to the normal output state. The dynamic response is measured by the magnitude of the overshoot and the length of the response time, which is an important indicator of the power supply performance.

The specific measurement method is to use an electronic load to simulate the sudden change of the load current. Usually, the load is set to 25%-50%-25% and 50%-75%-50% of the rated output current, and the current jump rise and fall slope is selected: 0.08-0.1A/us, the oscilloscope is set to AC coupling, 20Mhz bandwidth. Use the oscilloscope to measure the maximum deviation of the output voltage and the response time. The dynamic load test waveform is shown in Figure 2-6.

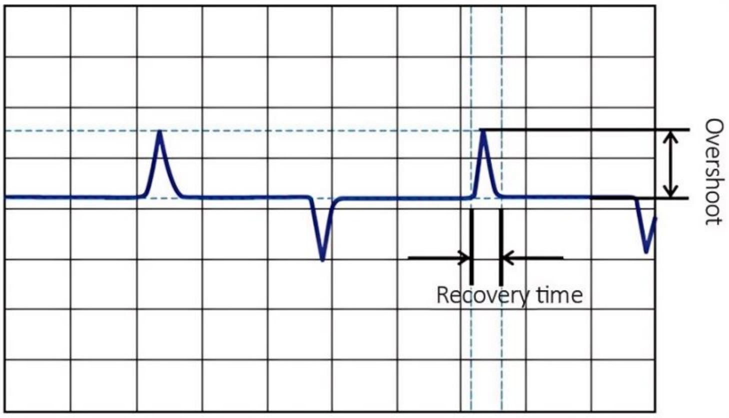


Figure 2-6 Waveform of dynamic load Test

2.2.8 Start-up Time

The start-up time is the response delay time from the input turn-on to the output reaching the target voltage value relative to the input, also known as the delay time. It is generally measured under the rated full load. The external filter (including input and output capacitors) will greatly delay the start-up time. The actual design should be weighed against the ripple noise requirements. For specific products and application questions, please consult technical personnel.

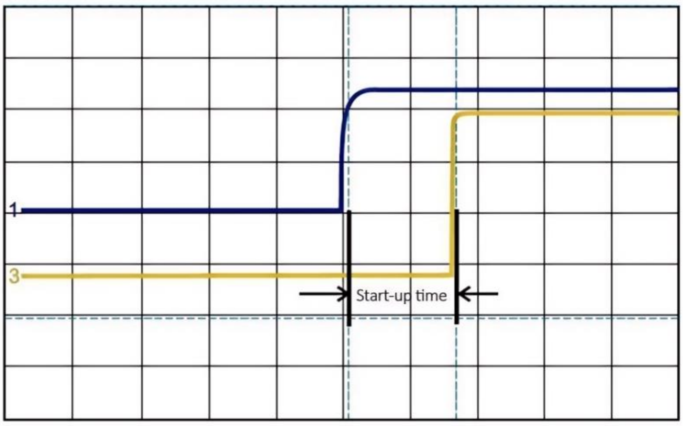


Figure 2-7 shows the start-up time test waveform.

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China
www.amchard-power.com

2.2.9 Isolation and Insulation Characteristics

Withstand voltage test method: According to the withstand voltage test standard, slowly increase the withstand voltage value from 0, adjust the withstand voltage value to the set maximum withstand voltage and maintain the maximum withstand voltage value for one minute.

Insulation strength: Apply isolation voltage (DC or AC peak) between input and output for 1 minute.

Insulation resistance: Apply 500VDC between input and output, and the insulation resistance between input and output should be greater than 1GΩ.

The isolation voltage in the product technical manual is only valid for a one-minute quick test. If a longer withstand voltage time or long-term high withstand voltage operation is required, the rated working voltage must refer to the relevant standards. According to the IEC950 standard, the conversion relationship between the isolation test voltage and the rated working voltage can be shown in the following curve Figure 2-9 (vertical coordinate: isolation test voltage; horizontal coordinate: rated working voltage). The typical breakdown voltage level of the IEC950 standard is shown in Table 2-1.

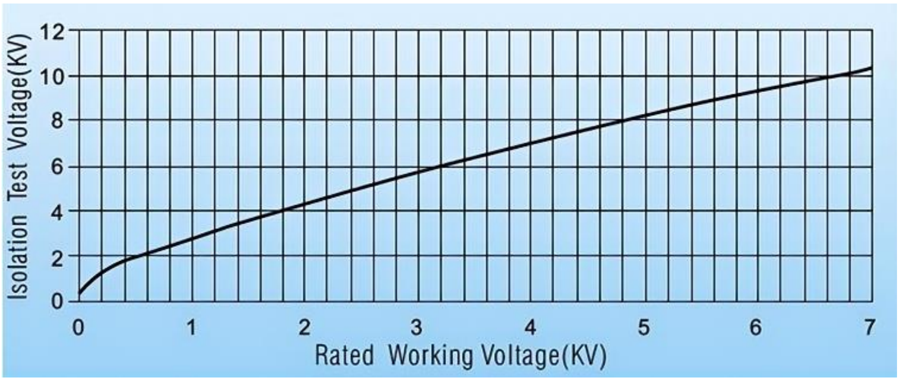


Figure 2-9

2.2.10 Power Module Case Temperature Rise Test

The case temperature rise can be tested with a thermal imager or thermocouple. Since the emissivity affects the measurement results of the infrared thermal imager, it may cause certain deviations in the measurement results. Generally, it is recommended to use a thermocouple for testing.

If the ambient temperature Ta = 25°C, the actual case temperature of the power module measured by the thermocouple is Tc = 50°C, then the temperature rise of the module is ΔT = Tc - Ta = 50 - 25 = 25°C. Where Tc represents the case temperature, Ta represents the ambient temperature, and ΔT represents the temperature rise.

Note: Due to the different power, case material, internal design, etc., the case temperature of different modules will vary greatly. Under the same environmental conditions, the metal case has better heat dissipation than the plastic case, and the junction temperature of internal components is lower, and the reliability is better. For a closed environment, because there is no natural ventilation, it is recommended to keep the power module and temperature-sensitive components as far away as possible or isolate them into two spaces.

2.2.11 Input Reflected Ripple Current Test

The input reflected ripple current mainly refers to the AC component of the ripple current that is not completely filtered by the module's filter and reflected to the DC power input. The input reflected ripple current measurement requires the front end to be connected with inductance and capacitance components to match the source impedance, as shown in Figure 2-10.

Inductance and capacitance recommended values: Lin(4.7μH), Cin(220μF, ESR < 1.0Ω at 100 KHz)

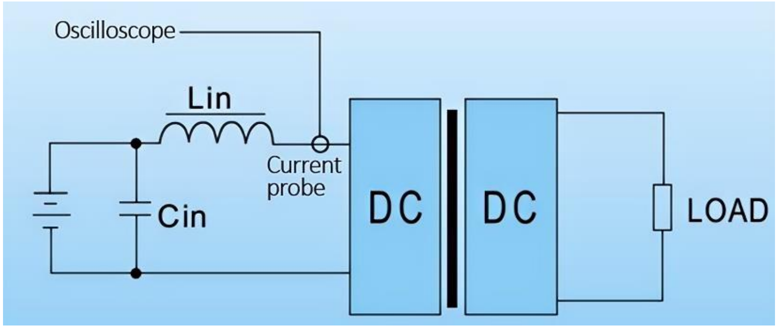


Figure 2-10 Input Reflection Ripple Current Test

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China

www.amchard-power.com

3.Power Module Applications

3.1 Series Connection

DC output isolation modules allow multiple modules to be connected in series by connecting the "positive output" of one module to the "negative output" of another module, which can obtain some unconventional or higher voltage values. As shown below:

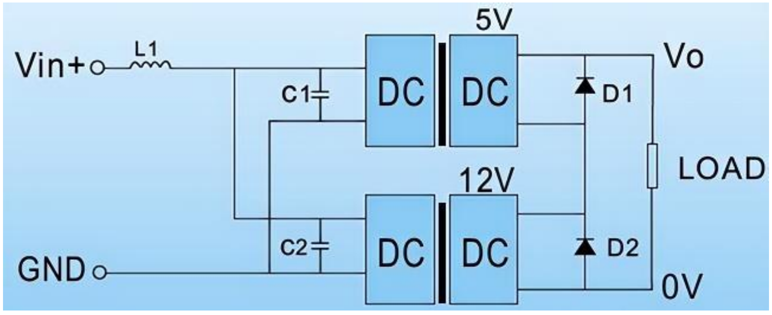


Figure 3-1 Method 1 of DC/DC Converters connected in series

The first module is 5V output, the second module is 12V output, and the series connection gets 17V unconventional voltage. The total output current, that is, the load power consumption, cannot exceed the nominal value of the module with the smallest output rated current. Generally, the output ripple voltage of the two modules will not be synchronized, and the series operation will have additional ripple, and the output noise will also increase. More filtering measures should be taken in the application.

In the figure, a reverse-biased diode is connected in parallel to the output of each module (generally, a Schottky diode with a low voltage drop of about 0.3V is used, and a voltage drop that is too large will damage the product) to prevent reverse voltage from being applied to another module. An LC filter circuit is added to the input of the module to prevent mutual interference between the modules. The inductance is generally between 2.2-6.8uH, and the capacitance is generally between 1.0-4.7uF. The parameters are determined according to the actual circuit application.

Higher output voltage can also be obtained through dual output products, for

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China

www.amchard-power.com

example, the following figure outputs 10V.

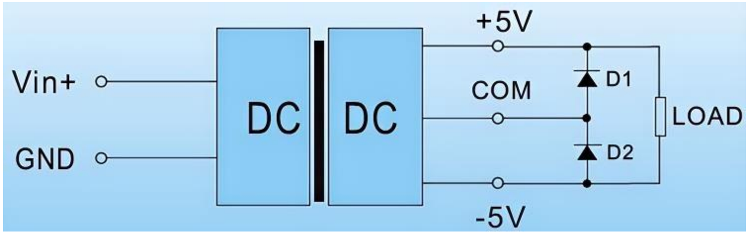


Figure 3-2 Method 2 of DC/DC Converters connected in series

3.2 Parallel Connection

To improve system reliability, redundant design methods are used to connect multiple identical modules in parallel to reduce failure rates. It should be noted that the method of directly connecting the outputs of two modules in parallel is not recommended because the output voltages of the two modules cannot be exactly the same, and the module with the higher output voltage may provide all the load current. Secondly, even if the output voltages of the two power supplies are adjusted to be exactly the same, due to their different output impedances and their changes with time and temperature, the load currents of the two power supplies will be unbalanced, which may cause one of the power modules to be damaged due to overload. The following briefly introduces several redundant design methods:

(1) For high voltage, low current output modules

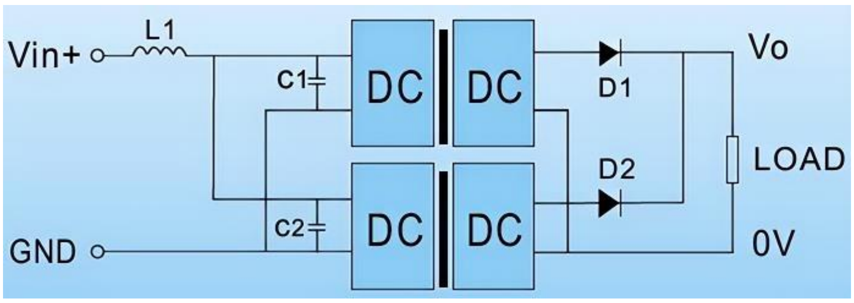


Figure 3-3 Method 1 of DC/DC Converters connected in parallel

Figure 3-3 recommends using a low voltage drop Schottky diode to avoid the diode's voltage drop affecting the operation of the back-end system, and pay attention to selecting a diode with a withstand voltage higher than the output voltage. This method will generate additional ripple noise, and external capacitors or filter circuits are needed to reduce the ripple.

(2) For low voltage, high current output modules

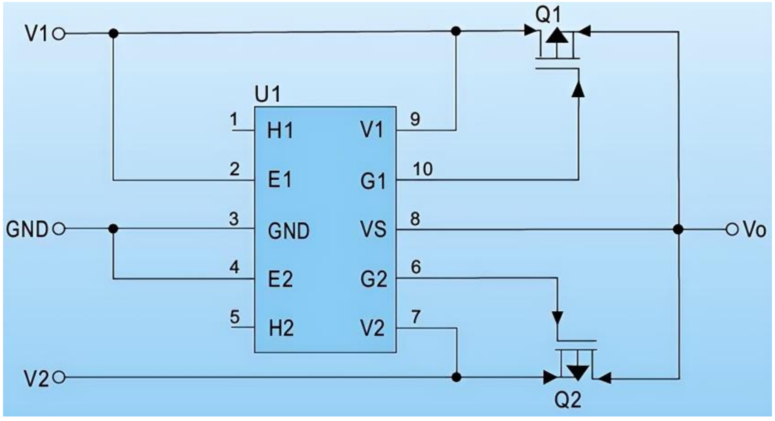


Figure 3-4 Method 2 of DC/DC Converters connected in parallel

The diode redundant design has high power consumption and is not practical in low voltage and high current applications. In such applications, high-power MOS tubes and chips are generally used to replace the diode solution, which facilitates the design of redundant power supply. The MOS tube in the circuit reduces the conduction voltage drop on the one hand, and on the other hand, when the input current is large, it reduces the loss of the device, making the product work more efficiently.

(3) For single output modules connected in parallel to obtain positive and negative dual outputs

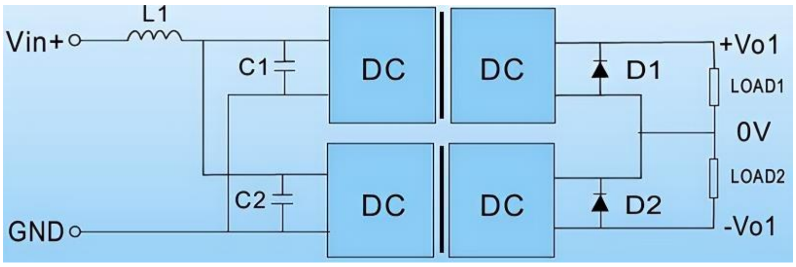


Figure 3-5 Method 3 of DC/DC Converters connected in parallel

If the actual application requires a large difference between the positive and negative outputs (for example, the main load is heavy and the auxiliary load is light), the dual output module is prone to load imbalance, resulting in voltage accuracy exceeding the standard and affecting the application. It is not recommended to use. It is recommended to select two modules according to the actual load requirements and use them according to the above connection method.

If multiple module power supplies share the bus voltage input, in order to prevent the product from forming a reflected ripple to the input in the customer's system, which may cause the power supply to work abnormally, it is recommended to add an LC filter circuit to the input of each power module.

3.3 Input Reverse Polarity Protection

The input reverse polarity protection circuit is shown in the figure below. It should be noted that when a negative voltage power supply (such as communication -48VDC) is connected, the "0V" of the input voltage is connected to the "Vin+" of the module input, and the "-48V" is connected to the "GND" of the input to ensure the forward potential difference of the input. The voltage drop of diode D1 in Figure 3-6 should be as small as possible to avoid too much loss on the line, and the reverse withstand voltage should be greater than the maximum input voltage and leave a margin.

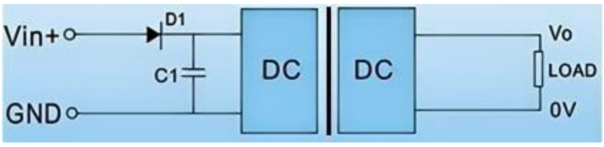


Figure 3-6 Input reverse polarity protection circuit

3.4 Input Undervoltage Protection

When the module shares the power supply with other circuits, a large drop in the input voltage caused by external short circuit or overload will cause the module output to be unstable and cause misoperation. At this time, an undervoltage protection circuit can be used to turn off the circuit when the input is lower than a certain set voltage value to ensure the normal operation of the module, as shown in the figure:

R1 and R2 are set to the undervoltage shutdown threshold, where the PNP transistor Q1 can be replaced by a P-channel MOS, for example, for a 9-18V input module, the undervoltage protection can be set between 8-9V. Note: The above circuit will form a voltage drop of about 0.7V. For low voltage input modules, it is necessary to pay attention to whether there will be other effects.

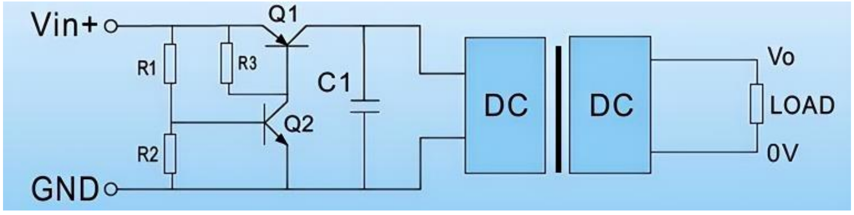


Figure 3-7 Input under-voltage protection circuit

3.5 Input Overcurrent and Overvoltage Protection

Power modules are often damaged or even burned due to instantaneous high-energy surges caused by switching actions, arcs, lightning induction, short circuits causing overcurrent, or overvoltage caused by unstable grid bus. The protection circuit is as follows:

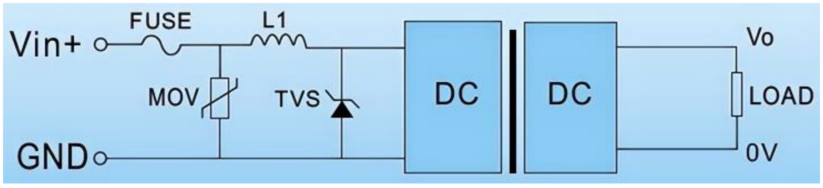


Figure 3-8 Instant over voltage and over current protection circuit

Note: Ensure that the fuse can withstand the instantaneous impact of the surge current when power is on. For specific parameters, please refer to the corresponding technical manual.

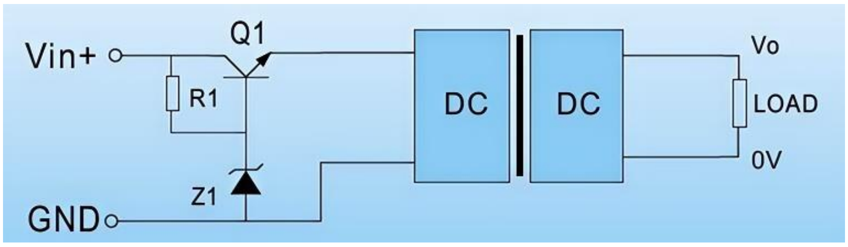


Figure 3-9 Continuous over voltage protection circuit

Note: The input overvoltage protection parameter design should not exceed the maximum input voltage marked in the module technical manual. For example, for a 9-36V input voltage, the set overvoltage protection voltage should not

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China
www.amchard-power.com

exceed the maximum value of 40V marked in the module technical manual.

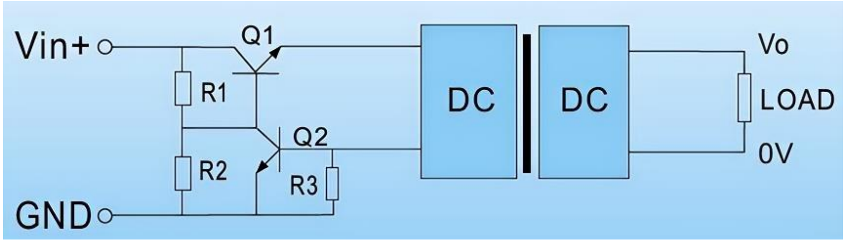


Figure 3-10 Continuous over current protection circuit

The overcurrent protection is realized by detecting the input current. Select the appropriate current limit I_{limit} (the current value set for overcurrent protection in the circuit), and the grounding resistor R3 is determined by the limit current I_{limit} and the conduction voltage drop VBE of the transistor Q2. The specific calculation formula is:

$$R3 = \frac{0.7V}{I_{limit}}$$

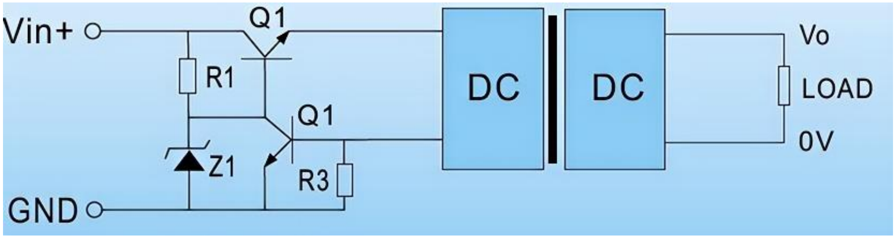


Figure 3-11 Continuous over voltage and over current protection circuit

Note that the power consumption of the resistor R3 must be considered.

3.6 Input and Output Filter Circuits

In circuits sensitive to ripple and noise, additional filtering measures can be added to the input and output of the module to reduce ripple and noise.

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China
www.amchard-power.com

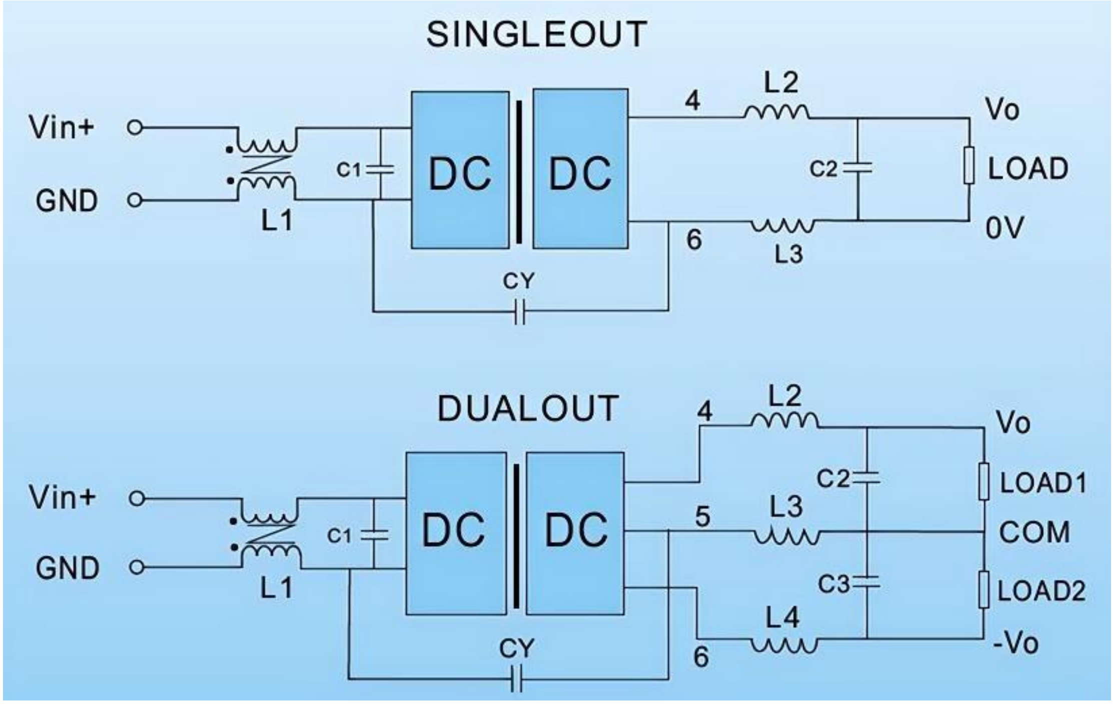


Figure 3-12 Recommended circuit reducing ripple &noise

The external capacitor at the input can absorb the voltage spikes at the input, store energy, and maintain a stable voltage. The external capacitor at the output can greatly reduce the output ripple, but too large a capacitance or too low an ESR can easily cause startup problems; for very low ripple requirements, an "LC" filter network can be used or a low ripple output power module can be selected.

C1: Reduce input ripple, use electrolytic capacitors, and refer to technical data for capacitance values;
L2/L3/L4, C2/C3: Form an LC filter network to reduce output ripple. Use low internal resistance aluminum electrolytic capacitors or ceramic capacitors for the capacitors. The value can be selected according to the actual ripple size and should not exceed the maximum capacitive load;
L1, CY: L1 is a common mode inductor to suppress common mode interference, and Y1 is a Y capacitor of 100-1000pF.

Note:
For the components of the filter circuit, the following formula is generally used for calculation, and the frequency is generally selected as one-tenth of the module switching frequency.

$$fc = \frac{1}{2\pi\sqrt{LC}}$$

The calculated filter may vary due to application design and load conditions, so the final parameters must be adjusted according to the actual application situation.

When selecting the value of the output filter capacitor, special attention should be paid not to exceed the maximum capacitive load specified in the technical manual.

3.7 EMC

3.7.1 Electromagnetic Interference (EMI)

Electromagnetic interference refers to the pollution caused to the environment by electromagnetic energy transmitted through space and through signal lines and power lines. Electromagnetic interference cannot be completely eliminated, but it can be reduced to a safe level.

Effective ways to suppress electromagnetic interference generally include:

(1) Shielding electromagnetic interference radiation, selecting products with metal shielding packages, or adding shielding covers to reduce radiation;

(2) Reasonable grounding;

(3) Filtering power lines and signal lines to reduce the conduction of electromagnetic interference, such as using appropriate filters or filter networks to reduce the conduction of electromagnetic interference.

(4) Separating the power module power supply from the small signal circuit layout can effectively avoid the interference of the power module on the small signal circuit.

3.7.2 Electromagnetic Compatibility (EMC)

Electromagnetic compatibility refers to the ability of electronic equipment and power supplies to work reliably under certain electromagnetic interference environments, and also the ability of electronic equipment and power supplies to limit their own electromagnetic interference and avoid interfering with other electronic equipment around them.

Improving electromagnetic compatibility can be approached from the following three aspects:

(1) Reducing the radiation of electromagnetic interference sources;

(2) Shielding the propagation path of electromagnetic interference;

(3) Improving the anti-electromagnetic interference ability of electronic equipment and power supplies.

According to the mode of propagation, electromagnetic interference is divided into the following two types:

The first type, conducted interference

Conducted interference is the noise generated by the system entering the DC input line or signal line, with a frequency range of 150KHz-30MHz.

Conducted interference can be either common mode or differential mode. The LC network is the main method used to suppress conducted interference.

The second type, radiated interference

Radiated interference is directly propagated in the form of electromagnetic waves, acting as a transmitting antenna, with a frequency coverage range of 30MHz-1GHz. Radiated interference can be suppressed by metal shielding.

3.7.3 EMC Recommended Circuit

Since the DC/DC module is a secondary power supply, in order to pass the EMC test of the entire equipment, a protection circuit is generally connected externally at the DC/DC port or signal port. An inductor is added between the TVS tube and the varistor to balance, so that most of the interference energy is released through the varistor, which combines the advantages of the lower potential voltage of the TVS and the larger current capacity of the varistor, providing good protection for the subsequent circuit. The calculation of the inductor parameters can refer to the following formula, where Ipp/2 mainly considers a 50% derating for the TVS tube. Reference formula:

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China

www.amchard-power.com

$$L = \frac{(Uc1 - Uc2) \times (20-8)}{lpp/2}$$

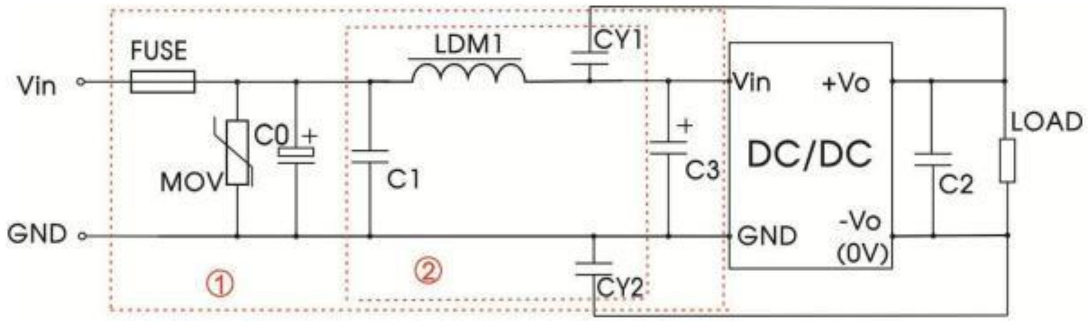


Figure 3-13 EMC Solution-recommended Circuit

Part ① is the peripheral recommended circuit diagram for the EMS test part; Part ② is for EMI filtering and can be selected according to requirements. For specific peripheral recommended circuit parameters, please refer to the corresponding product technical manual.

3.7.4 DC-DC Product Conducted Disturbance Simulation Test Abnormal

DC-DC conducted disturbance (CE) can simulate the requirements of Class A level, but when tested in terminal applications, the power supply alone cannot meet the requirements, and the base frequency or low frequency exceeds the standard. At this time, the following issues should be noted:

(1) Different certification bodies, affected by different environments and different test instruments, may have differences of 3-6dB, which is within the normal range of standard requirements.

(2) If the DC-DC test only exceeds the base frequency, it is necessary to determine whether the product is tested under the conditions specified in our technical manual. When matching the DC-DC product with the artificial power network, due to the resonance of the input capacitor or inductor of the DC-DC with the inductor in the artificial power network, startup problems (input

voltage fluctuation or power supply current overcurrent) often occur, leading to test abnormalities. In this case, an electrolytic capacitor (recommended value 100uF) can be added to the power input to stabilize the power supply or increase the input voltage to stabilize the product.

3.8 Capacitive Load

For general switching power modules, there is a maximum capacitive load requirement. The output of the module power supply can be connected with an electrolytic capacitor, but too large a capacity and too low an ESR (Equivalent Series Resistance) may cause unstable operation or startup problems of the module. For the specific external capacitor value, please refer to the external capacitor table in the product technical data.

3.9 Functional Pin Usage

(1) Output Voltage Fine Adjustment Range

Users can fine-tune the output voltage within ±10% of the rated value by connecting an external resistor to the TRIM pin. The power of the power module should be limited within the maximum rated output power. If the output voltage is higher than its nominal value, the output current should be reduced to comply with the maximum output power limit. When the output voltage is lower than its nominal value, the output current should not exceed the rated current.

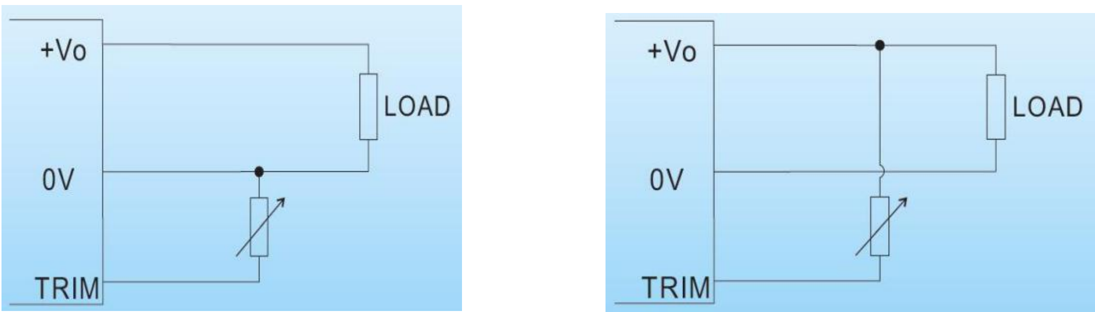


Figure 3-14 Output Voltage Fine Adjustment External Resistor Connection Method

The connection method of the external resistor is shown in the figure. If you want to increase the output voltage (left figure output up), you can add a resistor between the TRIM pin and the output ground; if you want to decrease

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China

www.amchard-power.com

the output voltage (right figure output down), you can add a resistor between the TRIM pin and the output Vo. If the fine-tuning function is not used, the TRIM pin can be left floating.

The adjustment through the Trim pin cannot obtain all the desired voltages. The adjustment has a certain range, generally around ±10% in the industry. If the required voltage exceeds the adjustable range, it may conflict with the output overvoltage protection function of the module, affecting the normal use of the module. In this case, other methods can only be used to obtain the required voltage.

(2) Remote Compensation Function (sense pin)

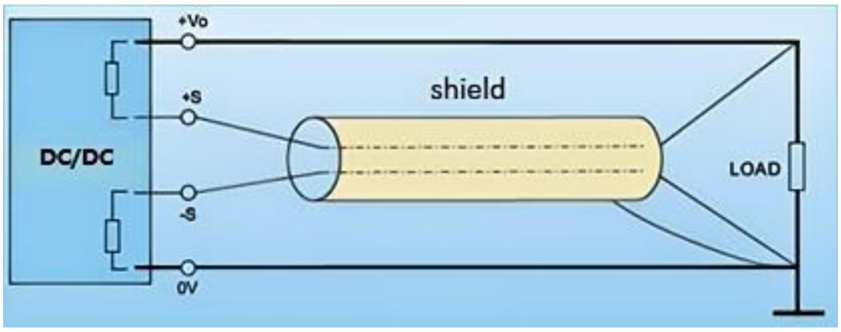


Figure 3-15 Remote Sensing Connection Method

When the module is powered over a long distance, in order to meet the voltage requirements of the normal operation of the load, the remote voltage compensation method is generally used to increase the input voltage of the load. The +SENSE and -SENSE remote voltage compensation pins of the module compensate the input voltage of the remote load. To meet the application requirements, the customer can use wires for remote connection. However, since the external connection of the wires will cause a lot of EMI interference, EMI treatment must be performed in actual applications, shielding the wires or using twisted pairs for connection, as shown in the figure.

(3) Switch Control

Switch control refers to the "ON" (allow) and "OFF" (prohibit) operations of the module output voltage. There are two standard ways of switch control for the module:

Positive logic: The CTRL control pin is connected to -Vin, the output is OFF; the CTRL control pin is open or connected to high level, the output is ON.

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China
www.amchard-power.com

Negative logic: The CTRL control pin is connected to -Vin, the output is ON; the CTRL control pin is open, the output is OFF.

Figure 3-16 Isolation Control Method

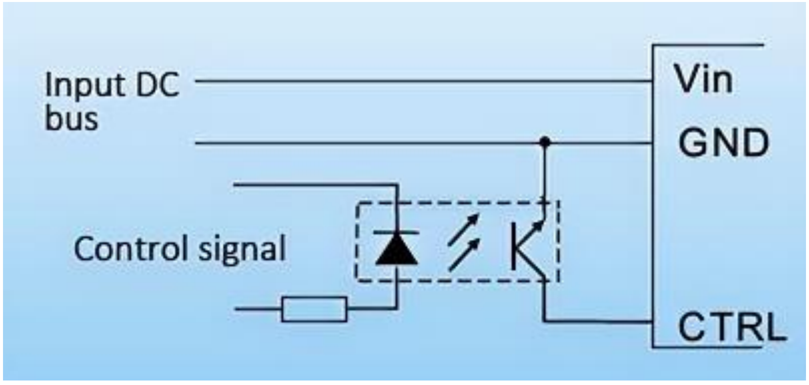
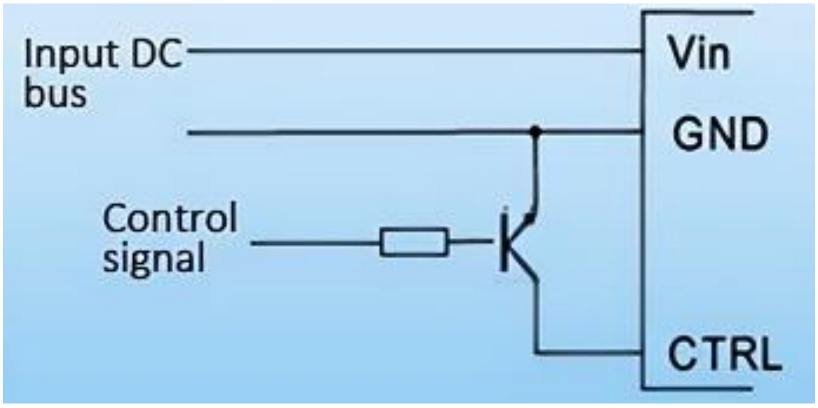


Figure 3-17 Common control method



In some special applications, isolation control is required. Figure 3-16 is a reference circuit for isolation control.

AMCHARD module power supplies have two control methods: voltage control and current control.

GT and AT series: The module is turned on and off by providing a control voltage to the CTRL control pin. When the CTRL control pin voltage is lower than 1.2VDC or directly connected to the input ground, the module is in the off state; when the CTRL control pin is provided with 2.5-12V voltage (the CTRL control pin is at a high level relative to the input ground) by an external power supply or the module input voltage, the module is in the on state and works normally.

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China

www.amchard-power.com

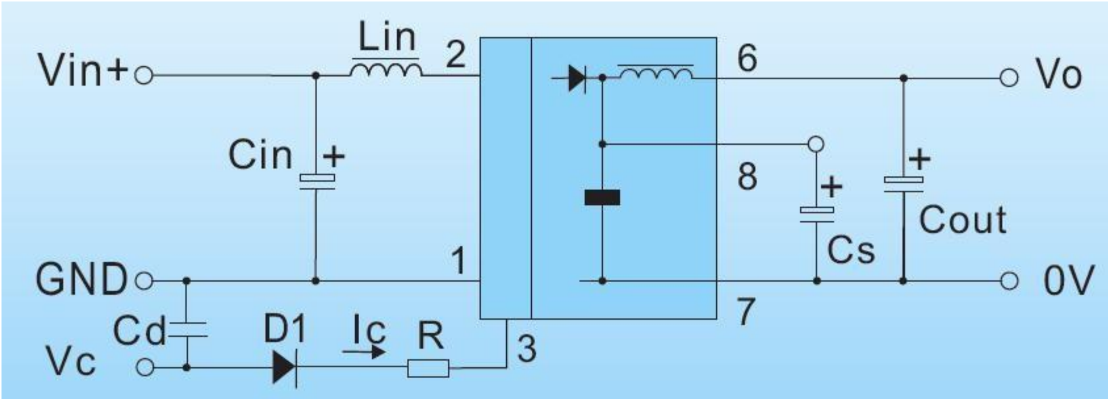


Figure 3-18 CTRL of WR and PW Series

WR and PW series: When the CTRL pin is floating or in a high impedance state, the module works normally. When the module needs to be turned off, the control voltage VC (that is, the CTRL control pin is at a high level relative to the input ground) is injected into the CTRL control pin through the resistor R, and the current flowing into the pin is preferably 5~10mA, to control the internal shutdown MOS of the module, thereby achieving the function of shutting down the module.

Special attention should be paid to the fact that the CTRL pin of this series cannot be shorted to the input ground or connected to a low level, otherwise it may cause a short circuit at the input (MOS tube) or even damage the module.

When customers use products with the CTRL control pin function, they can control the module's on and off by changing the voltage of the CTRL pin according to the actual usage requirements and the data manual provided by the power supply manufacturer, thereby controlling the system. If the customer does not need to use the control function of the module, the CTRL control pin can be left floating. If there are some interference sources in the actual circuit, it is recommended to protect the pin from interference (stay away from the interference source), otherwise it may cause the product module to malfunction or be damaged.

Room 1318, Building 1, Hengzhao Plaza, No. 3 Shuixi Fuye 1st Street, Huangpu District, Guangzhou City, Guangdong Province, China

www.amchard-power.com

4.Common Questions

4.1 Can the Module Support Hot Swapping?

"Hot swapping" simply means directly plugging or unplugging the power module in the system without turning off the power supply.

The module is not allowed to be hot-swapped during operation, because a large current and voltage spike will be generated at the moment of hot swapping, which may be several times or even dozens of times the input voltage and current of the module, causing a great impact on the internal devices of the module, and in severe cases, it may damage the module. Therefore, the module is not allowed to be hot-swapped during operation.

Note: When the product is hot-swapped, connecting an electrolytic capacitor in parallel at the input can provide some protection.

4.2 Can the Module Operate Under No Load or Light Load?

Under no load or light load conditions, the module can be used, but the conversion efficiency of the module is relatively low under these conditions. The product loop is unstable under no load, and oscillation may occur, and some indicators may not meet the technical manual requirements. From the perspective of reliability, it is best to avoid using the module under no load or light load. The minimum working current of the module output should not be less than 5% of the rated current

4.3 Possible Reasons for Module Startup Failure

Reason 1: In actual applications, the capacitive load exceeds the maximum capacitive load specified in the module technical manual. The output capacitor is too large, and a large starting current is required at the moment of startup, which will cause the module to fail to start. It is recommended to reduce the output capacitor or add a buffer circuit at the output to improve the module's ability to drive capacitive loads.

Reason 2: Limited by the maximum starting current of the intrinsic safety power supply, the maximum power provided by the intrinsic safety power supply does not meet the starting power requirement of the module (the module requires a large starting power at startup). It is recommended to choose a product with a small starting current or connect a small resistor or NTC in series at the input of the module to reduce the starting current of the module.

Reason 3: The inductive load (usually the motor coil) does not generate an induced electromotive force at the moment of startup, and only the internal resistance r of the coil works in the entire circuit. The internal resistance of the coil is very small (generally mΩ level ~ Ω level). According to I = V/R, the current generated at the moment of startup will be very large, exceeding the overcurrent protection point of the module, causing the module to enter the protection state and fail to start. For low-power modules, it is recommended to connect a small resistor in series at the output or choose a power module with a larger power.

4.4 High No-Load Power Consumption for Products Above 20W

For DC-DC products, 20W-30W output 3.3V, 5V products and products above 50W, the synchronous rectification scheme is adopted, so the no-load power consumption is relatively large. For specific data, please refer to the detailed specification.

4.5 Operating Temperature

When the product works in a high-temperature environment, the temperature of its internal components is much higher than the environment. To ensure the reliable operation of the product, the highest ambient operating temperature of conventional products is 85°C. When the ambient temperature reaches 55°C or 60°C, derating is required (specific derating curves need to refer to the detailed specifications); while working at low temperatures, the lowest ambient operating temperature of the product is -40°C, and no low-temperature derating is required.

4.6 Dual Output, Load Imbalance

The feedback loop of multi-output products only takes the main output voltage. Due to load imbalance, the voltage accuracy will be poor. In normal applications, it is necessary to ensure load balance according to the technical specifications. Generally, the load difference of each output is required to be within ±5%. In conventional applications, load balance can be achieved by connecting a dummy load externally.

4.7 Multi-Output, Power-Off Sequence Requirements

For multi-output products, the auxiliary output voltage is obtained through transformer coupling. The power-off sequence is related to the load size, but once the main output voltage drops to zero, the auxiliary output will have no voltage output.

4.8 Common Noise Suppression Measures

For DC-DC products, noise within 20MHz can be attenuated using LC filtering or π-type filtering. However, for noise at 100MHz or 200MHz, a combination of common mode inductors and capacitors is required for filtering.

4.9 Overtemperature Protection

For power modules above 50W, overtemperature protection is generally set. When selecting these products, customers should confirm this function in the technical manual and then carry out reasonable thermal design.

In actual applications or during aging, the product may have no output after working for a period of time. This is because the product has entered the overtemperature protection state. After the temperature drops, the product can be restarted and the output can be re-established. This is a normal phenomenon. Improving the heat dissipation of the product or derating can prevent the product from entering the overtemperature protection state.