Fixed Input Voltage DC/DC Converters Application Guide 2021

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1. Selection Guide

1.1. Selecting Power Supply

The first step is to confirm specifications of the power supply and then determine to choose a standard power supply module or a customized one according to requested parameters.

Step 1, select the input voltage range

If input voltage range is ±10% for 3.3V, 5V, 9V, 12V, 15V and 24V, unregulated output DC/DC converters A, B, E, F, G and H series are recommended. If it's ±5%, regulated output DC/DC converters IB, IE and IF series are recommended, which are switching power supply, linear regulator or zener diode with regulated output.

Step 2, select the output voltage and power

It's suggested to use the converter in 30% - 80% of nominal full load power at ambient temperature. In high temperature or low temperature environment, derating requirement should be taken into account. Choosing the right output power is one of the key factors for the success of the design. Too large or too small current will lead to lower reliability and excessive cost. Common output voltages are 3.3V, 5V, 9V, 12V, 15V, 24V, ±5V, ±12V, ±15V.

Step 3, select the output load

Output load determines output voltage. For applications such as RS485 and CAN communication bus IC where have a poor requirement for power accuracy, unregulated output DC/DC converters A, B, E, F, G and H series are recommended. For applications such as sensor, high-precision Op-amp (operational amplifier) and A/D and D/A chips where is sensitive to power accuracy and ripple & noise, regulated output DC/DC converters IB, IE and IF series are recommended.

Step 4, select the isolation

The isolation feature makes the input and output of the module to be two separate power supplies (non-common ground). In industrial bus system, Isolation helps rise the loop's resistance in harsh environments (lighting, arc interference) and isolates noise in analog circuit and digital circuit in hybrid circuit and converts voltages in multiple voltage power system. For products with dual outputs, it is necessary to confirm whether the two outputs need to be isolated. If isolation is required, dual isolation dual output products need to be

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selected. Available isolation are 1000VDC, 1500VDC, 2000VDC, 3000VDC, 3500VDC, 4200VDC, and 6000VDC.

Step 5, select the package

Three common packages are DIP, SIP, SMD and DFN. They are determined by the system space, system process and on-site application environment, e.g. if used in automotive systems, DIP or SMD package products should be selected, which have better anti-vibration performance.

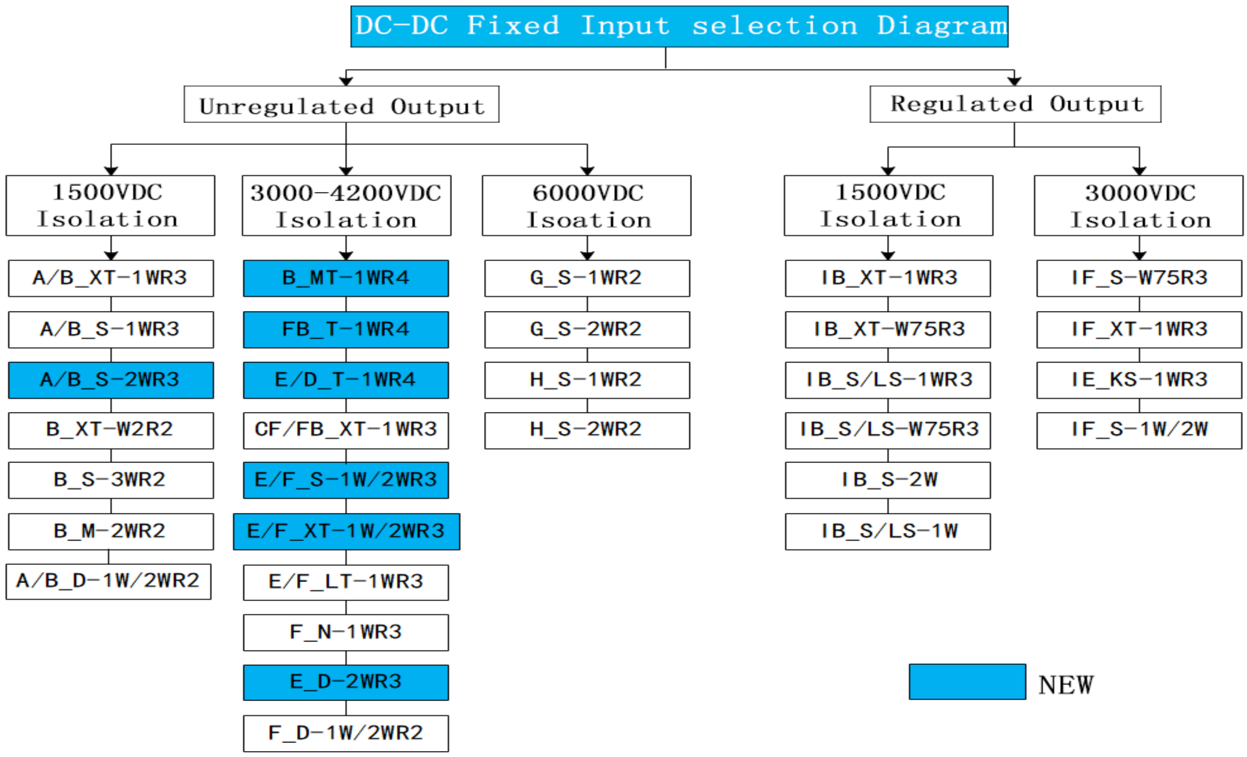

Table 1-1 Selection guide of MORNSUN fixed input DC/DC Converters

1.2. Designing Power Distribution System

Products' features and circuit's requirements should be taken into consideration when engineers design a power distribution system. And they have to optimize the system several times, by which acquires accurate operating parameters and environmental parameters of practical circuits to precisely choose suitable converters.

Step 1, ambient factors

Ambient factors include ambient temperature, transmission distance and so on.

Ambient temperature can affect converters and external components. Considering that the converters are used in high temperature, low temperature or high and low temperature cycle

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(such as: engine room and cabin), corresponding parameters may change. Engineers should clearly know these changes and design correct circuit in this application. It should be noted here that the ambient temperature of power module refers to the internal temperature of device rather than ambient temperature. The former is usually higher than the latter in that the device contains many heat generating components.

Industries	**Working temperature**
Commercial	0-70℃
Industrial	-40-85℃
Vehicle on-board equipment	-40-105℃
Field exploration instrument	-55-85℃
Military	-55-125℃

Table 1-2 Working temperature of different Industries

It also should be noted that the module derates significantly at high temperature. In this case, the chosen converter should allow significant deration and connect an electrolytic capacitor with excellent high and low temperature performance. Please refer to datasheet when selecting the capacitor.

In an environment where there is interference such as arc, electrostatic discharge, unstable AC power grid, starter switch, relay, lightning strike, etc., the input voltage and current may far exceed the tolerance of the module, resulting in permanent damage to the module and paralysis of the load circuit. At this time, it is necessary to add a protection circuit to ensure the safe operation of the power supply.

Transmission distance is another factor affecting converters and external components. General suggestions are:

a) Non-isolation or low power converters are the first choice for indoors for its short distance, little temperature drop and weak interference.

b) Wide input and isolated, high-efficiency converters are the best choices for long-distance transmission. In addition to lightning protection, accurate transmission loss should be calculated.

c) It is recommended that start-up current of converter supplied by the power supply is 1.3 -

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1.6 times to ensure normal operation of the converter, resulting from long-distance transmission and large loss.

d) It is recommended to connect a capacitor at the input terminal of the converter to improve start-up performance itself.

Step 2, working circumstance.

A common sense is that all converters lose certain power and change it into their own heat energy, which will make surrounding environment warmer. Further, it causes data interference (heat-sensitive components) and performance degradation of devices and even causes short-circuit to fire. Thus, larger ventilation or heat dissipation space to reduce temperature rise is essential to ensure safety.

As DC/DC converters adopt switching technology, their own switching oscillator circuit and internal magnetic components will produce electromagnetic interference and pollution to surrounding ones by conduction and radiation. EMI cannot be completely eliminated, but can be reduced to a safe level by certain measures for electromagnetic compatibility.

Step 3, layout.

Unreasonable grounding and layout easily tend to cause unstable system, high noise and other undesirable phenomena.

In many applications, analog circuit and digital circuit share the same power supply, in which it is very important to separately use them or completely isolate the power supply from ground loop. It aims to avoiding the interference from digital DC voltage drop variation and logic suppressor process to analog circuit system.

In high-speed/dynamic analog circuit or digital circuit, the distributed resistance and equivalent inductance become noticeable and easily cause noise interference due to the rapid changes of load current when the load is far away from distribution. In this case, load decoupling and eliminating series impedance of the wire and resonances caused by distribution parameters are recommended.

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2. DC/DC Converter Testing Suggestions

Product's performance in practical application is also vital except a right power supply. Therefore, it needs to be tested and verified before use. Common test methods are available as follow:

2.1.Testing the Circuit Itself

Kelvin test method is a standard one as shown in diagram 2-1. Test conditions: ambient temperature Ta=25°C, humidity <75%.

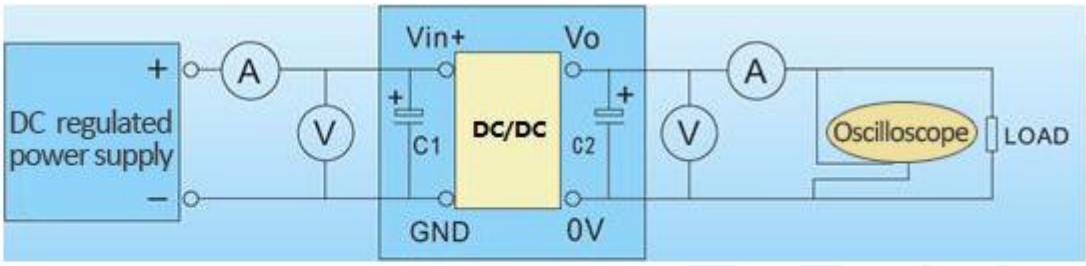

Diagram 2-1 Kelvin test method

Test instrument: DC adjustable regulated power supply (wide enough input voltage range), ammeter A (accuracy: 0.001A), voltmeter V (accuracy: 0.001V), load resistance (rated load: $\frac{Vo^2}{P}$, light load: $10\% \times \frac{Vo^2}{P}$)

Notes:

a) Wire connection: the less wire loss, the better it is. A multi-strand copper wire with 1mm diameter is the best choice to avoid excessive voltage drop. When the load current is large, it should shorten distances between output pins and the load, and increase cross-sectional area of the connecting wire to reduce the excessive voltage drop.

b) When testing ripple and noise, it is suggested to test output by using contact measuring method with a single pole to avoid measurement errors generated by input and output common ground and external interference. (See "ripple and noise")

c) Make sure the power supply current limit point of the front stage is set reasonably when testing, between 10% and 100% of the load. To ensure accurate voltage and ripple, the output capacitive load must not be greater than the value specified in the technical manual

2.2. Testing Converter's Performance

Performance testing begins with correct connections of power modules, by which to confirm

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whether parameters meet requirements or not.

a) Output voltage accuracy

Set input voltage at nominal value, and tested output voltage will be Vnom.

V_{outnom}: nominal output voltage at nominal input voltage and rated load	Output voltage accuracy $= \frac{Vout - Voutnom}{Voutnom} \times 100\%$
V_{out}: tested output voltage at nominal input voltage	

e.g. (B1212LS-1WR3): V_{outnom}=12V, rated load=144Ω, V_{out}=12.039V,

Output voltage accuracy $= \frac{12.039 - 12.000}{12.000} \times 100\% = 0.325\%$.

b) Line regulation

i): Fixed input, isolated unregulated series (series prefixed with A, B, E, F, G, and H):

$V_{in+10\%}$: nominal input voltage and add 10% as its upper limit	$\Delta Vout = \frac{Vout+10\% - Vout-10\%}{Voutnom} \times 100\%$
$V_{in-10\%}$: nominal input voltage and minus 10% as its lower limit	
$V_{out+10\%}$: output voltage at full load when input voltage at its upper limit	$\Delta Vin = \frac{Vin+10\% - Vin-10\%}{Vinnom} \times 100\%$
$V_{out-10\%}$: output voltage at full load when input voltage at its lower limit	
V_{innom}: nominal input voltage	$Lineregulation = \left\| \frac{\Delta Vout}{\Delta Vin} \right\|$
V_{outnom}: nominal output voltage	

e.g. (B0505LS-1WR3): rated load=25Ω, $V_{in+10\%}$=5.5V, $V_{in-10\%}$=4.5V V_{innom}=5V, V_{outnom}=5V, $V_{out+10\%}$=5.32V, $V_{out-10\%}$=4.2V

$$\Delta V_{out} = \frac{5.32V - 4.2V}{5V} \times 100\% = 22.4\%, \quad \Delta V_{in} = \frac{5.5V - 4.5V}{5V} \times 100\% = 20\%$$

Line regulation$=\left|\frac{\Delta V_{out}}{\Delta V_{in}}\right|$=1.12

ii): Fixed input, isolated regulated series (series prefixed with IB, IE, IF):

V_{outnom}: output voltage at nominal input voltage and	

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rated load	Line regulation $= \frac{Vmdev - Voutnom}{Voutnom} \times 100\%$
V_{outh}: output voltage at rated load when input voltage at its upper limit	
V_{outl}: output voltage at rated load when input voltage at its lower limit	
V_{mdev}: V_{outh} or V_{outl} which is deviated from V_{outn} more	

e.g. (IB2405S-3WR2): rated load=600mA， V_{outh}=5.01V, V_{outl}=5.00V, V_{outnom}=5.01V,

Line regulation= $\frac{5.00-5.01}{5.01}$ x100%=-0.2%

c) Load regulation

i): Fixed input, isolated unregulated series (series prefixed with A, B, E, F, G, H):

V_{outnl}: output voltage at nominal input voltage and 10% load	Loadregulation $= \frac{V_{outnl} - V_{outfl}}{V_{outfl}} \times 100\%$
V_{outfl}: output voltage at nominal input voltage and full load	

e.g. (B0505S-1WR3): rated load=25Ω， Voutnl=5.29V, Voutfl=4.77V,

Load regulation= $\frac{5.29V - 4.77V}{4.77V} \times 100\% = 10.9\%$

ii): Fixed input, isolated regulated series (Series prefixed with IB, IE, IF):

V_{b1}: output voltage at nominal input voltage and 10% load	Load regulation $= \frac{V_b - V_{b2}}{V_{b2}} \times 100\%$
V_{b2}: output voltage at nominal input voltage and full load	
V_{b0}: output voltage at nominal input voltage and 50% load	
V_b: V_{b0} or V_{b1} which is deviated from V_{b2} more	

d) Efficiency

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V_{in} : nominal input voltage I_{out} : output current at full load V_{out} : output voltage at nominal input voltage and full load I_{in} : input current	Efficiency $\eta = \frac{I_{out} \times V_{out}}{I_{in} \times V_{in}} \times 100\%$

e.g. (B1212LS-1WR3): V_{in}=12V, V_{out}=11.951V, I_{out}=83.6mA, I_{in}=100.7mA,

$$\eta = \frac{0.0836 \times 11.951}{0.1007 \times 12.000} \times 100\% = 82.68\%$$

e) Ripple and noise

Ripple and noise is the periodic and random AC variation superimposed on DC output, which affects output accuracy and usually is calculated with peak-to-peak (mV_{P-P}).

First, set oscilloscope bandwidth 20MHz to effectively prevent high-frequency noise.

Second, test with parallel cable measuring method, twisted-pair cable measuring method or contact measuring method.

Below testing is with parallel cable measuring method.

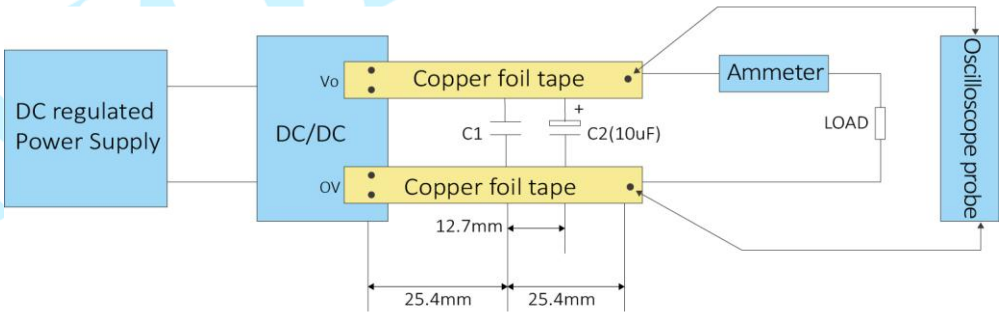

Diagram 2-2 Parallel cable measuring method

Notes:

a) C1: a ceramic capacitor with 1uF capacitance.

b) C2: a capacitor suitable for fixed input products (series prefixed with A, B, E, F, G, H, IB, IE, IF), please refer to datasheet. Normally 10uF is recommended.

c) Distance between two paralleled copper foils is 2.5 mm and, of which the sum of voltage drops should be less than 2% of nominal output voltage.

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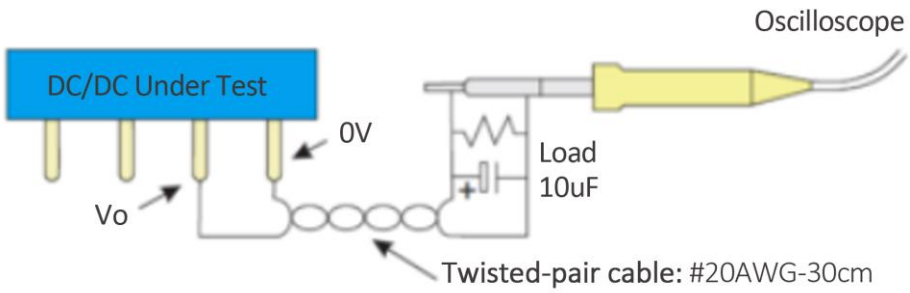

Diagram 2-3 Twisted-pair cable measuring method

Another testing is with twisted-pair cable measuring method as shown above in diagram 2-3. Connect tested power supply Vo and 0V with a twisted-pair cable which is composed of 30cm long and #20AWG, and then connect a dummy load between them. Next, connect a 10μF electrolytic capacitor at the end of the twisted-pair cable, which connects the Vo at one terminal and connects the ground at the other.

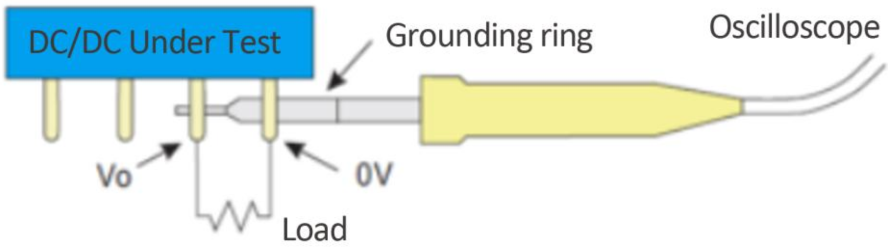

Diagram 2-4 Contact measuring method with oscilloscope

Contact measuring method, as shown in diagram 2-4, is usually adopted for oscilloscope to shield interference. Because the oscilloscope's ground clip could absorb various high-frequency noise, affecting test results. Whatever single output or double outputs or more, the test method is similar. Connect an oscilloscope probe to each output terminal. Then actual tested ripple and noise will vary depending on different circuit and external components. Diagram 2-5 shows the actual tested ripple and noise waveform.

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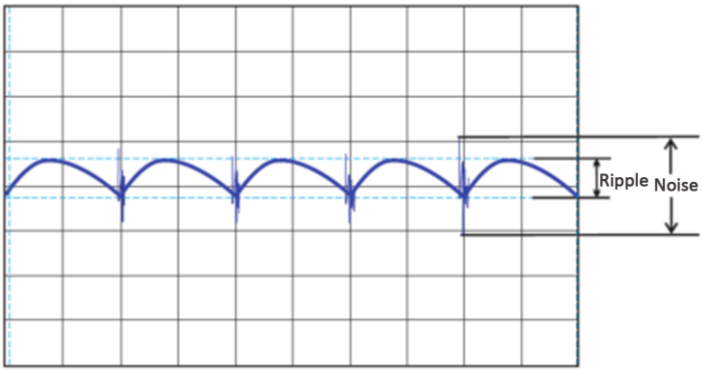

Diagram 2-5 Waveform of Ripple & Noise Test

f) Start-up time

Start-up time refers to corresponding delay time during which input voltage turns on and output voltage reaches to a targeted value. It is found that external filters (including input and output capacitors) can significantly delay the start-up time when tested at rated full load, so in practical design, taking start-up time and ripple and noise into consideration together is recommended. Fixed input DC/DC Converter adopts open-loop design, thus they have fast start-up time. For more details please refer to datasheet or contact our sales department. Diagram 2-6 shows the actual tested start-up time waveform.

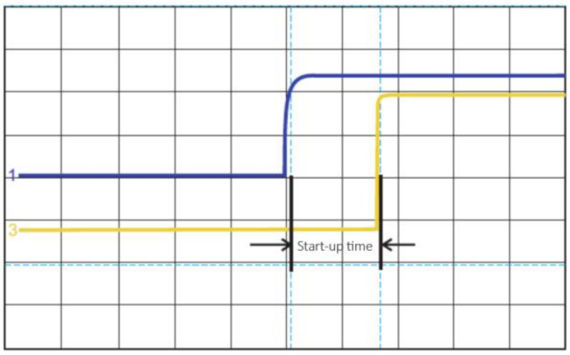

Diagram 2-6 Waveform of Start-up Time Test

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g) Isolation and insulation

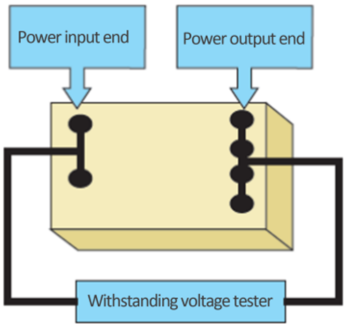

Diagram 2-7 Method of Withstand Test

Withstand test: Following withstand test standards, withstand value shall be set from 0 slowly upward and remain 1 minute at the maximum rated isolation.

Insulation test: measure it for 1 minute by applying isolation voltage between the input and output.

Insulation resistance: the value should be above 1GOhm when applying 500VDC between input and output.

Isolation voltage shown in datasheet is only valid for a one-minute quick test. Therefore, rated working voltage must refer to relevant standard if it's required longer operation at high withstand voltage. And the switching relationship between the isolation voltage and the rated working voltage, according to the IEC950 standard, is shown as Diagram 2-8. Standard typical breakdown voltage of IEC950 is shown in Table 2-1.

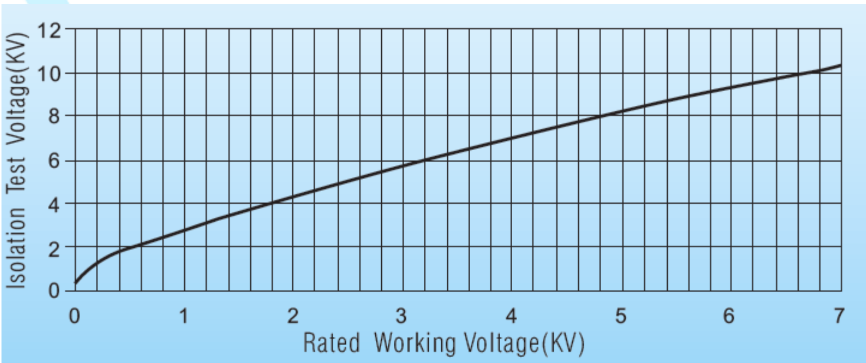

Diagram 2-8 Relationship between Isolation Test Voltage and Rated Working Voltage

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Isolation Test Voltage (Vrms)	Rated Working Voltage (Vrms)
1000	130
1500	230
3000	1100
6000	3050

Table 2-1 Typical Breakdown Voltage Ratings According to IEC950

h) Temperature rise test

Temperature rise test is usually with the help of thermal imager or thermocouple. The former can be affected and lead to a certain deviation in measurement results due to the emissivity. Therefore, the latter, test with thermocouple, is recommended.

For example, given that the ambient temperature T_a is 25°C, and the measured temperature of power supply T_c is 60°C. Then the temperature rise △T is 35°C (△T is 35=T_c- T_a= 60°C-25°C =35°C.)

Test condition: power supply is in nominal voltage input and at rated power.

Note: Temperature of power supply varies due to different power, material of case and internal design, etc. Under the same condition, a metal case has better heat dissipation, lower temperature of internal component and higher reliability than a plastic one. It's recommended, in a closed environment, to keep power supply away from components that are sensitive to temperature or isolate them for no natural ventilation.

i) Input Reflection Ripple Current Test

As shown in Diagram 2-9, The oscilloscope needs to be connected to the current probe, and recommended values: Lin (4.7 uH), Cin (220 uF, ESR <1.0Ω at 100 KHz).

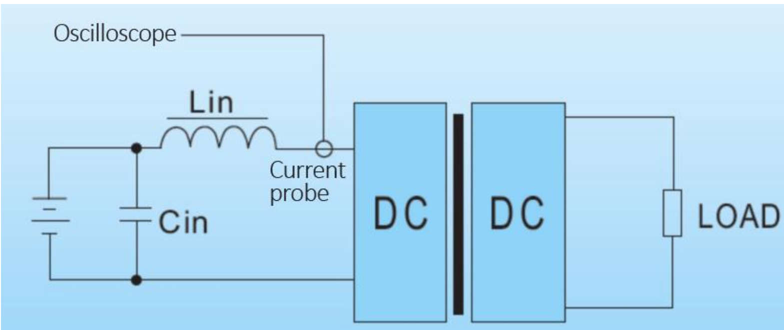

Diagram 2-9 Input Reflection Ripple Current Test

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3. Applications of DC/DC Converters

3.1. DC/DC Converters Connected in Series

DC output isolation module allows multiple modules in series. "Positive output" of one DC/DC Converter connects with "negative output" of the other DC/DC Converter one by one, as shown in Diagram 3-1, which results in certain unconventional or higher voltage values.

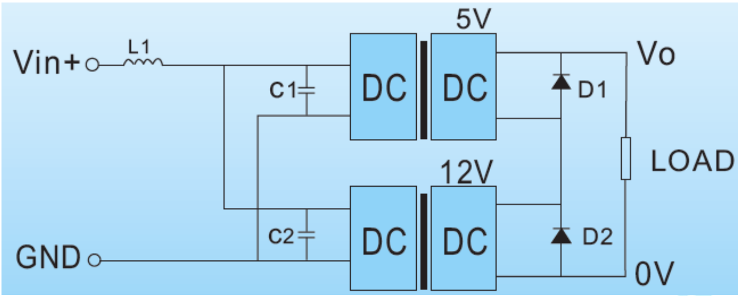

Diagram 3-1 Method 1 of DC/DC Converters connected in series

The first converter outputs 5V, and the second does 12V. An unconventional voltage of 17V will be generated if they were in series. The total output current is that the load power consumption cannot exceed the minimum output rated current of the converters. Under normal circumstances, the two modules output ripple voltage will not be synchronized. Modules in series will add additional ripple and larger output noise. It's recommended to connect external filters in practical applications.

In the diagram, the output of each converter is connected a reverse bias diode in parallel (generally use Schottky diode with 0.3V low voltage drop, reason: excessive voltage drop may damage the product), so as not add reverse voltage to the other converter. Connect a LC filter circuit at the input is to prevent the interference between the converters. In this case, the inductance is generally between 2.2-6.8uH and the capacitance generally between 1.0-4.7uF. However, their values all depend on the actual circuit. Another method to get a higher output voltage is with the help of dual output products, as the following diagram, and the output is 10V.

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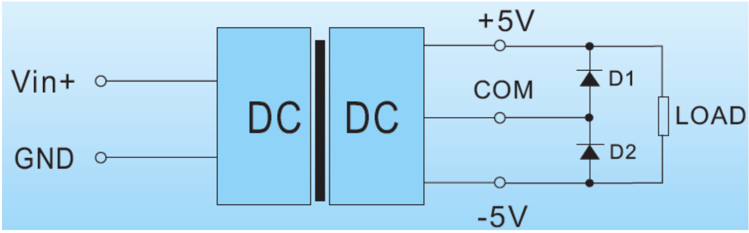

Diagram 3-2 Method 2 of DC/DC Converters connected in series

3.2. DC/DC Converters Connected in Parallel

Power supplies used in parallel may for two purposes, one is that redundant design to improve the reliability of the system and reduce the possibility of system failure, and the other one is that used in parallel to increase power. But such a method to increase power is not recommended, because the output voltage of the two modules can't be exactly equal, the power supply module with a high output voltage may provide the full load current, resulting in module overload and damage.

Here are some brief introduction to redundant design:

a) For high voltage but low current DC/DC Converters:

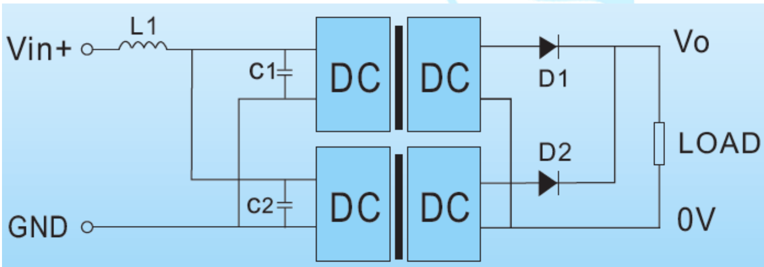

Diagram 3-3 Method 1 of DC/DC Converters connected in parallel

Diagram 3-3 recommends the use of low voltage drop Schottky diodes to avoid the voltage drop affecting the back-end system. And please note that, the diode voltage should be higher than the output voltage. This design will produce additional ripple and noise. Therefore, external capacitors or filter circuit is needed to reduce the ripple.

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b) For low voltage but high current DC/DC Converters:

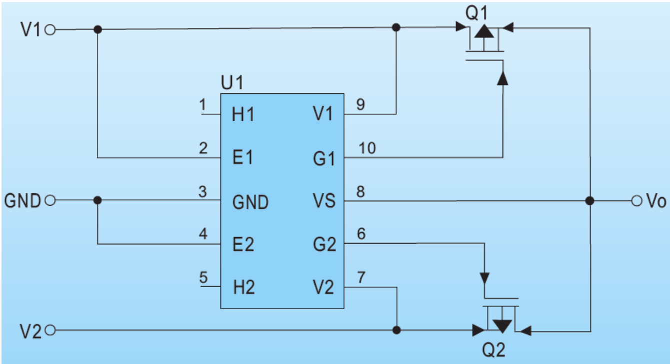

Diagram 3-4 Method 2 of DC/DC Converters connected in parallel

Redundant design of diode will lead to larger power consumption and is not so practical in low-voltage high-current applications. Therefore, it generally uses a high-power MOSFET and its driver to replace the diode. The MOSFET in the circuit, on one hand, is to reduce the conduction voltage drop. On the other hand, when the input current is large, it reduces the power loss of the device and makes products work more effectively.

c) For applications where single output DC/DC Converters in parallel to get positive and negative output:

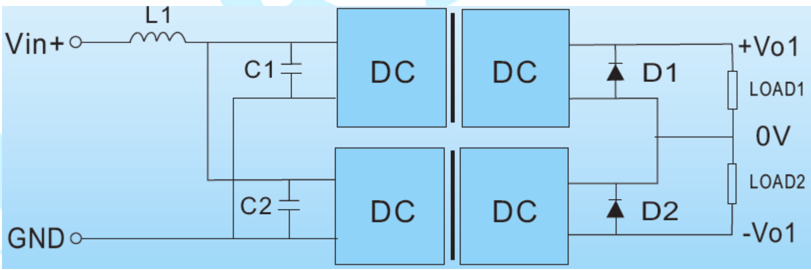

Diagram 3-5 Method 3 of DC/DC Converters connected in parallel

If the difference of required positive and negative outputs in actual application are big (e.g.: the main circuit should be with heavy load, and the auxiliary circuit with light load), the converter with balanced dual outputs is prone to unbalanced load and resulting in insufficient voltage accuracy. In this case, using one converter with balanced dual outputs is not recommended. It is recommended to select two converters according to the requirement of actual load and connect them as above diagram.

When there are several converters sharing a bus voltage input, it is recommended to connect an LC filter circuit at the input terminal of each converter. Because it may form a reflection of

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the ripple to the input terminal in the customer's system and cause the power supply's abnormal operation.

3.3. Input Reverse Polarity Protection

The circuit is shown as below. It is worth noting that the inputs "Vin +" and "- 48V" should be respectively connected to "0V" and "GND" to ensure the positive potential difference at input terminal when connecting a negative voltage supply (e.g.: communication field: -48VDC). The voltage drop of the diode D1 in Diagram 3-6 should be as small as possible to avoid too much wire loss, and the reverse withstand voltage should be greater enough than its input voltage and have margin.

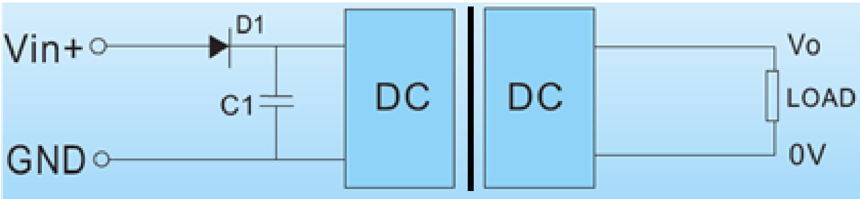

Diagram 3-6 Input reverse polarity protection circuit

3.4. Input Under-voltage Protection

When a converter shares a same power supply with other circuits, a large drop of input voltage caused by external short circuit or overload will cause the converter's output instability and malfunction. In this case, it is recommended to design an under-voltage protection circuit which would turn off at a set voltage value, ensuring the normal operation of the converter, as shown in Diagram 3-7:

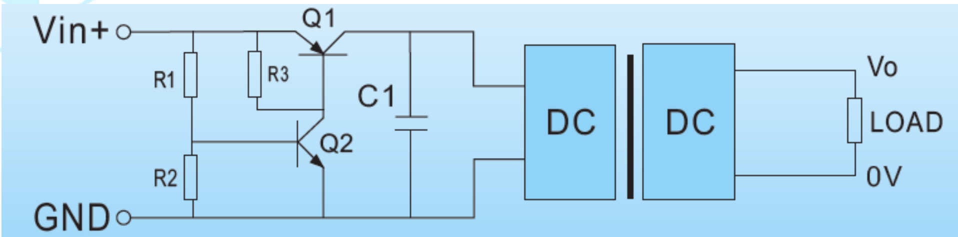

Diagram 3-7 Input under-voltage protection circuit

Resistances R1 and R2 are set as low voltage threshold. Transistor Q1 in PNP can use P-channel MOS. For example, an input of 5V can set voltage threshold at 4-4.5V.

Note: The above circuit will produce a voltage drop about 0.7V. It should be considered whether there will be other effects for low-voltage input converter.

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3.5. Input Over-current and Over-voltage Protection

Internal components of the module may damage or lead to module failure because of switching action, arc or surges caused by lightning strikes; over-current caused by short-circuit and over-voltage caused by unstable electric grid. The over -current and over-voltage protection circuit is as follows:

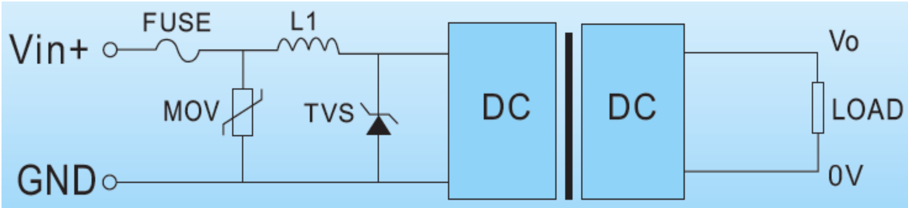

Diagram 3-8 instant over-current and over-voltage protection circuit

Note1: Ensure that the fuse can withstand the instantaneous surge current when switch-on. More information please refer to datasheet.

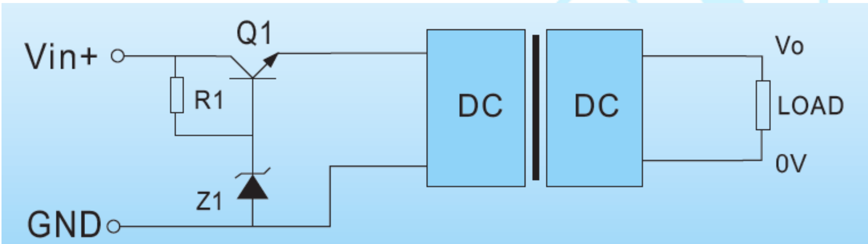

Diagram 3-9 Continuous over-voltage protection circuit

Note 2: The input value for over-voltage protection cannot exceed the maximum input voltage indicated in the datasheet.

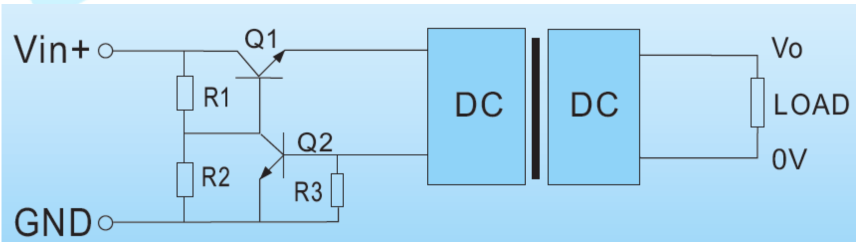

Diagram 3-10 Continuous over-current protection circuit

Set an appropriate limit current I_{limt} (set current value in the circuit for over-current protection) to achieve overcurrent protection by detecting the input current. Grounding resistance R3 should be determined together by I_{limt} and the conduction voltage drop of transistor Q2 VBE.

The formula is $R3 = \frac{0.7V}{I_{limt}}$. And it is necessary to consider of the power consumption of

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resistor R3.

Note 3: The above circuit will produce a voltage drop. It should be considered whether there will be other effects for low-voltage input converter.

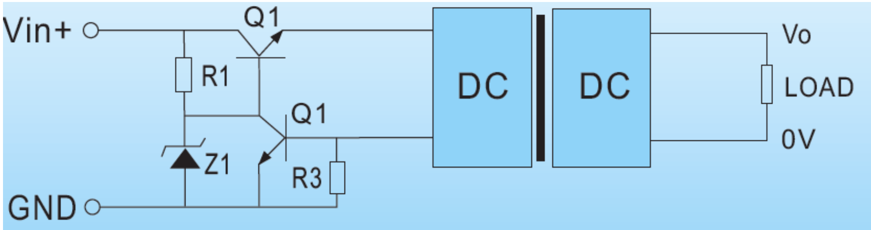

Diagram 3-61 Continuous over-voltage and over-current protection circuit

3.6. Input and Output Filtering Circuit

Filters are usually connected at the input and output terminals of the converters to reduce ripple and noise in applications where are sensitive.

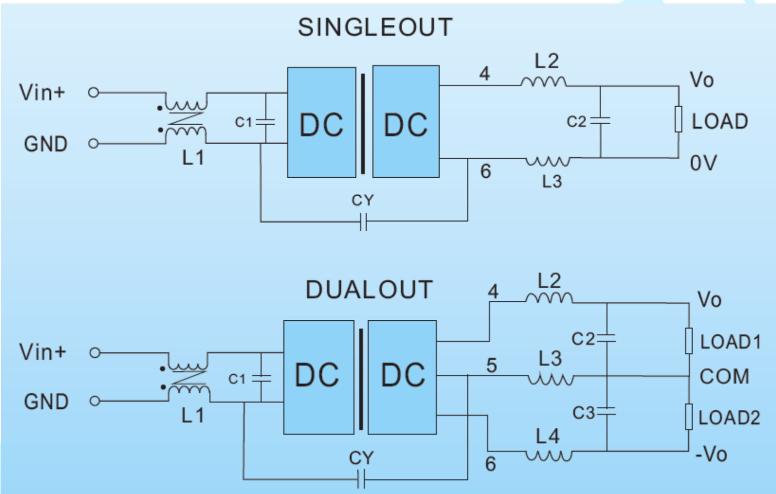

Diagram 3-72 Recommended circuit reducing ripple & noise

Adding a capacitor at the input terminal can absorb the voltage spikes, save the energy and keep the voltage stable. Adding a capacitor at the output terminal can greatly reduce the output ripple, but it's likely to cause the failure of start-up due to too large capacitance or too low ESR. For applications requiring extremely low ripple, using a "LC" filter network or using converters with low ripple is an alternative.

C1: electrolytic capacitors, to reduce input ripple. Its value please refer to datasheet;

L2/L3/L4, C2/C3: forming an LC filter network to reduce the output ripple. The capacitor is suggested to a ceramic capacitor or an electrolytic capacitor with low resistance, whose value is determined according to the actual ripple but cannot exceed the maximum capacitive load;

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L1, CY: L1 is a common mode inductor to suppress common mode interference. Y1 is a Y capacitor offering 100-1000pF.

Note:

1) For MORNSUN's fixed input, unregulated output converters, it's recommended to connect conventional ceramic capacitors, not tantalum capacitor. Because the latter's ESR is very small and appears dummy output short when start-up, resulting in the input current impacts and damages the converter. Usually, inrush current of a 10uF tantalum capacitor has reached the limit of internal components.

2) For the components of the filter circuit, they are generally calculated according to the following formula and the frequency should be one of tenth of the converter's switching frequency.

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

The calculated value of filter may vary due to different application designs and load conditions, so the value must be adjusted in conjunction with the practical application.

When setting the value of the filter capacitor, it cannot exceed the maximum capacitive load indicated in datasheet.

3.7. Electromagnetic Interference and Electromagnetic Compatibility

a) Electromagnetic Interference (EMI)

Electromagnetic interference (EMI) is a disruption that affects an electrical circuit because of either electromagnetic induction or electromagnetic radiation. It cannot be completely eliminated, but can be reduced to a safe level. Certain effective ways to suppress EMI are generally:

i) To shield EMI radiation: to select the products in metal shielded package or to add additional shield so as to reduce EMI radiation;

ii) Reasonable grounding;

iii) To select suitable filters or filter networks to reduce the transmission of EMI from the wire and the signal line;

iv) To separately layout the converters and the small signal circuit, in order to effectively avoid

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the interference of the former to the latter.

b) Electromagnetic Compatibility (EMC)

EMC is the ability of electronic equipment and power supply to work stably and reliably in a certain electromagnetic interference environment. It is also the ability of electronic equipment and power supply to limit their own electromagnetic interference and avoid interference with other electronic equipment.

Improving EMC is available from the following three aspects:

i) To reduce the radiation of source of EMC interference;

ii) To shield the transmission of EMC interference;

iii) To improve anti-electromagnetic interference of the electronic equipment and power supply.

According to the way of transmission, EMC interference is divided into:

i) Conduction interference. It is the noise generated by the system into the DC input line or signal line. The frequency range is 150 KHz-30MHz. Conduction interference has common mode and differential mode. LC network is often used to suppress the conducted interference.

ii) Radiation interference. It directly spreads in electromagnetic waves, plays a role of launch antenna and its frequency range is 30MHz-1GHz. Radiation interference can be suppressed by metal shielding.

c) EMC Solution-recommended Circuit

As DC/DC converters are secondary power supplies, in order to pass EMS test, they usually connect external protection circuit at the DC/DC port or signal port, and add an inductance between TVS and varistor ((VDR)) to discharge most of the interference energy. It can combine the TVS's lower clamping voltage and the varistor's larger flow, protecting the back-circuit. Here's the formula to calculate the inductance’s value, where Ipp/2 mainly taking a 50% derating of the TVS into account: $L = \frac{(Uc1 - Uc2) \times (20 - 8)}{Ipp / 2}$

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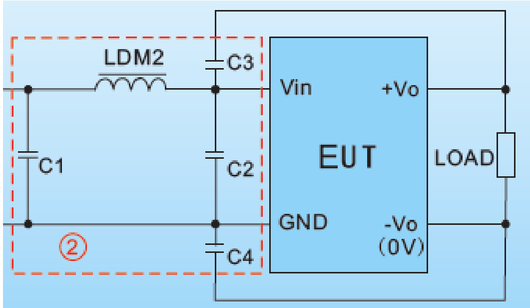

Diagram 3-83 EMC Solution-recommended Circuit

The circuit marked ② is used for EMI filtering and can be selected according to requirements. Generally, DC/DC converters do not require EMS protection, but EMI peripheral circuits. For more information please refer to datasheet. MORNUSN's fixed input converters are secondary power supplies, only need EMI protection, and EMS protection at the front-circuit.

3.8. Capacitive Load

Electrolytic capacitors can be added to the output of the power converter, but general switching power converter has a maximum capacitive load requirement as too large capacitance or low ESR (equivalent series resistance) may cause the module to work unstable or bad start-up. For more details, please refer to the datasheet.

4. FAQs

4.1. Do MORNSUN's DC/DC converters support hot-plug?

"Hot-plug", simply refers to directly unplug or plug converters in the system without power-off.

The converters is not allowed to hot-plug during operation in that it will produce several times or even more of large current and voltage spikes of the converters, affecting internal components and damaging the converters in worse circumstances. Therefore, the converters don't support hot-plug.

4.2. Can MORNSUN's DC/DC converters be used at no-load or light-load?

The converters can be used at no-load or light-load applications. However, under this condition, the conversion efficiency of the converters is relatively low and some indicators may not meet the requirements of datasheet. From the view of reliability, it's better to avoid these applications and the minimum output current of the converters should be no less than

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10% of rated one. It's suggested to use the converters at 30-80% load or to choose the converters with lower power.

4.3. Reasons cause start-up failures of MORNSUN's DC/DC converters?

Reason 1: In actual application, the capacitive load exceeds the maximum value indicated in datasheet. Larger output capacitor requires larger starting current, which will cause the start-up failure of the converters. To reduce the output capacitance at the output terminal or connect buffer circuit at it is a good choice to increase the capacity of the converters.

Reason 2: Limited to the maximum power provided by the current-sensitive power supply such as intrinsically safe power supply, the starting power cannot meet the requirements of the converters (the converters require a large starting power at start-up). It is recommended to select the products with small starting current or connect a small resistance or NTC at the input terminal of the converters to reduce the start current.

Reason 3: the inductive load (usually motor coil) does not produce induced electromotive force when starting up. Only the coil's resistor r works in the entire loop, will resistance be very small (usually mΩ ~ Ω level). According to $I = \frac{V}{r}$, the current will be larger to exceed the over-current protection value of the converters, triggering the protections of the converters and start-up failures. It is recommended to connect a small resistor in series at the output terminal for converters with low power, or select a power supply with larger power.

Reason 4: The actual load or working power of the system is greater than the converters rated power, and the output voltage of the fixed voltage converter will decrease as the load becomes larger, which will cause the system to work improperly or damage the power converter.

4.4.Is it available to connect a tantalum capacitor at input and output terminals of MORNSUN's DC/DC converters?

On one hand, tantalum capacitor is relatively easy to breakdown for its short circuit characteristics and poor anti-surge ability. Once there is a relatively large instantaneous current or a high surge voltage at start-up, the tantalum capacitor will be over-voltage to breakdown and cause short circuit. On the other hand, tantalum capacitor's withstand voltage will become low in high temperature environment. Therefore, in applications it's best

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not to connect any tantalum capacitor but ceramic capacitors or aluminum electrolytic capacitors at the input and output terminals of DC/DC converters.

4.5 Whether the isolation voltage indicator in the datasheet meets the isolation requirements of the system?

The isolation voltage indicator in the datasheet is only for a one-minute test. If the system itself has long-term isolation withstand voltage requirements, it is recommended to refer to the **clause 2.2 g) Isolation and insulation** (diagram 2-8 Relationship between Isolation Test Voltage and Rated Working Voltage) to select the appropriate isolation power supply products, Isolation test voltage is not equal to insulation level of the entire system.

4.6 The fixed voltage input converter generally has low power and low capacity of capacitive load. Can we use electronic load in CC mode to test the module performance?

Our new fixed voltage input DC converter R3 series can meet the use of electronic load in CC mode to test their basic performance, and R3 series products' capacitive load has been greatly improved, such as the B0505S-1WR3 capacitive load is up to 2400μF.

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