High Voltage Output Power Supply Application Guide 2022

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I. High-voltage Output Power Supply Selection Guide

There are two types of high-voltage output power supply, including isolated and non-isolated power supplies. The following process can be referred to select the proper power supply.

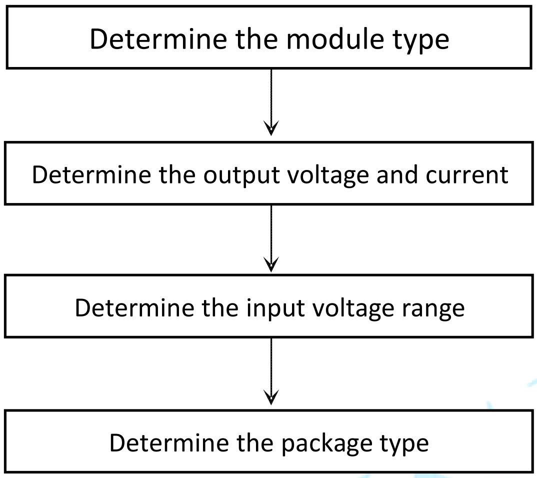

Figure 1-1 Product Selection Process

Steps for selecting the non-isolated high-voltage output power supply: (Figure 1-1)

Step 1: Determine the output voltage and current

It is prior to considering the output voltage and current when selecting a module. For a non-isolated high-voltage output power supply, the output voltage can be 200V, 400V, 600V, 1000V, 1250V, 1500V, 2000V, 3000V, 5000V, -200V, -600V, -1250V, -1500V, -2000V,-3000V, etc. It should be confirmed that if the output voltage is adjustable and if the current and voltage are constant.

The name suffix of this product series is expressed by the output current value, such as 0.5, 2, etc. The current output current values include 0.3mA, 0.4mA, 0.5mA, 0.6mA, 1mA, 2mA, 5mA, 10mA, 20mA, 30mA, etc.

The output current can be determined after choosing the load. The load current is critical to determine the power, and also has a direct effect on the reliability and cost of the module. The ideal power for the application of the power supply is between 30% - 80%. A proper output current value is one of the key factors for a successful design. A too large or too low current value may affect reliability and cause higher costs.

Please contact our FAE for more information if the converter is required to be used in an environment temperature above the technical specifications for a long time.

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Step 2: Determine the input voltage range

The non-isolated high-voltage output power supply is designed as a constant voltage circuit structure. It is required to keep the input voltage within a stable range. The common input voltage includes 3.7V/5V/12V/15V/24V, and the corresponding ranges are 3.2-4.2V, 4.75-5.25V, 10.8-13.2V, 13.5-16.5V, 21.6-26.4V, respectively. The last letter of the product model number represents the input voltage: B represents 5V input voltage, C is 12V, D is 15V, and F is 24V.

Step 3: Determine the package type of power supply

The primary package type for the non-isolated high-voltage output power supply is plug-in package. H and V series are two main product series. The pin in the H series is close to the middle part, while that in the V series is at the two ends.

Steps for selecting an isolated high-voltage output power supply.

Step 1: Determine the output voltage

Currently, there are only two types of isolated high-voltage output power supply, with the output voltages of 5V, 200V, and 5V, 500V, respectively.

Step 2: Determine the power

The power of the isolated high-voltage output power supply currently includes 3W and 4W.

Step 3: Determine the input voltage.

The input voltage of the isolated high-voltage power supply is 24V only.

Below is the high-voltage power supply module list.

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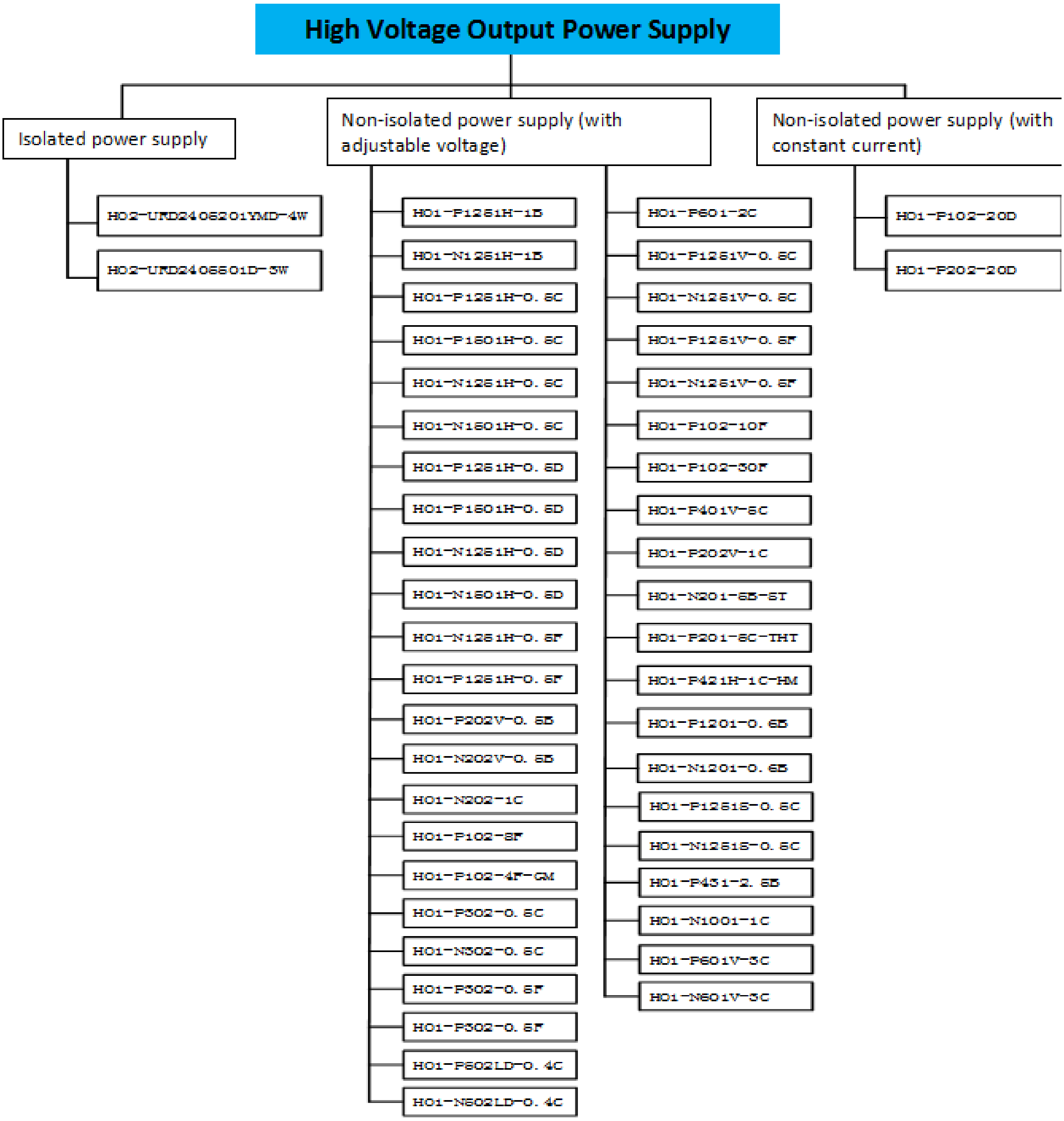

Figure 1-2 Product List

Note: HO1-P102-20D and HO1-P202-20D are high-voltage output power supplies with constant output current used to charge the high-voltage capacitor.

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II. Power Supply Test

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 follows:

A. Testing the Circuit Itself

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

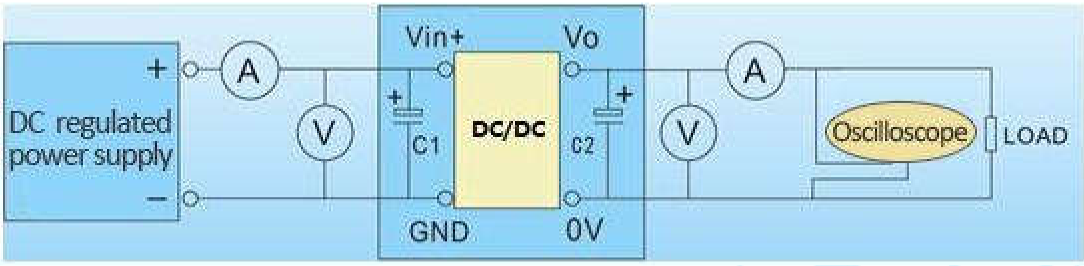

Figure 2-1 Kelvin Test

Test instruments: DC adjustable regulated power supply (wide enough input voltage range), ampere ammeter A (accuracy: 0.001A), voltmeter V (accuracy: 0.001V), electric load, and oscilloscope.

Note:

(1) 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.

(2) 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")

(3) 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.

(4) For more details please refer to datasheet.

B. Testing Converter's Performance

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Performance testing begins with correct connections of power modules, by which to confirm whether parameters meet requirements or not.

a) Output voltage accuracy

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

e.g. (HO1-P1501H-0.5C): $V_{outnom} = 1500V$, rated load = 0.5mA, $V_{out} = 1503V$,

Output voltage accuracy $= \frac{1503 - 1500}{1500} \times 100\% = 0.2\%$

b) Linear Voltage Regulating Rate

V_{outnom}: output voltage at nominal input voltage and rated load	linear voltage regulating rate $= \frac{V_{mdev} - V_{outn}}{V_{outnom}} \times 100\%$
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. (HO1-P1501H-0.5C): rated load=0.5mA, $V_{outh} = 1501V$, $V_{outnl} = 1500V$, $V_{outnom} = 1501V$

Line regulation $= \frac{1500 - 1501}{1501} \times 100\% = -0.067\%$

c) Load regulating

V_{b1}: output voltage at nominal input voltage and 10% load	load regulating $= \frac{V_b - V_{b0}}{V_{b0}} \times 100\%$
V_{b2}: output voltage at nominal input voltage and	

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100% load	
V_{b0} : output voltage at nominal input voltage and 50% load	
V_b : V_{b1} or V_{b2} which is deviated from V_{b0} more	

e.g. (HO1-P1501H-0.5C): With 100% load, $V_{b2}=1501V$. With 10% load, $V_{bl}=1502V$. With 50% load, $V_{b0}=1502V$.

load regulating $= \frac{1501-1502}{1502} \times 100\% = -0.067\%$

d) Efficiency

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

e.g. (HO1-P1501H-0.5C): $V_{in}=12V$, $V_{out}=1501V$, $I_{in}=95mA$, $I_{out}=0.5mA$

$$\eta = \frac{0.5 \times 1501}{95 \times 12} \times 100\% = 65.83\%$$

e) Ripple 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 (mVP-P).

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

Second: Adopt the recommended circuit test method, as shown in Figure 2-2.

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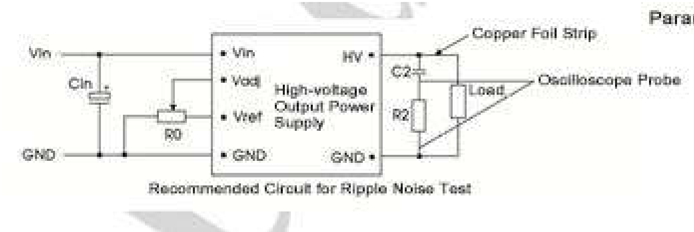

Parameter Instruction

Cin	100µF/25V Aluminum Electrolytic Capacitor
R0	Adjustable Resistance ≥ 10KΩ
R2	1KΩ/2W Resistance
C2	472K/250VAC Y2 Capacitance

Figure 2-2 Test Method for Ripple Noise

Note:

(1) C2: 472K/250VAC Y2 Capacitance

(2) R2：1KΩ/2W Resistance

(3) 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.

Actual tested ripple and noise will vary depending on different circuit and external components. Figure 2-3 shows the actual tested ripple and noise waveform.

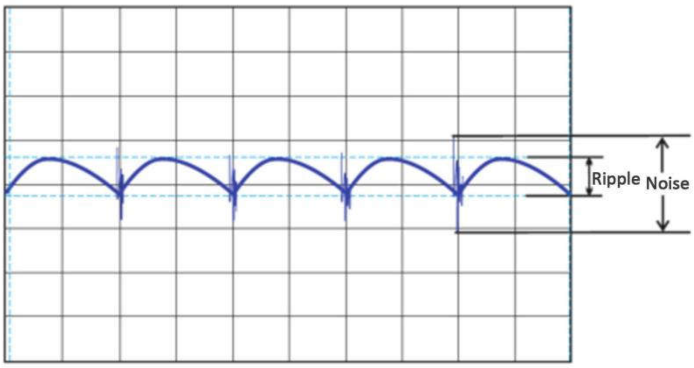

Figure 2-3 Waveform of Ripple & Noise Test

f) Start-up Time

The startup time is the response delay time of the output reaching the target voltage value relative to the input after the input starts. Generally, the startup time could be measured under the rated full load. As the external filter (including input and output capacitance) would greatly delay the startup time, the actual design should consider it with the ripple noise requirements. Figure 2-6 displays the startup time test waveform.

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Start-up time refers to corresponding delay time during which input voltage exists 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. Figure 2-4 shows the actual tested start-up time waveform.

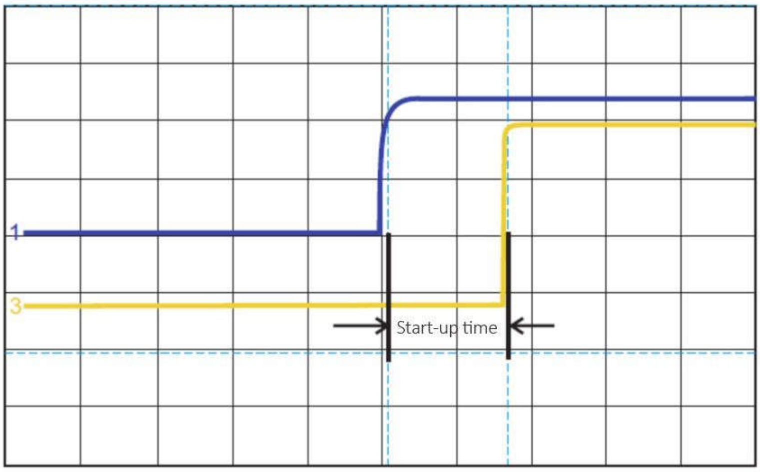

Figure 2-4 Startup Time Test Waveform

g) 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 Ta is 25 ℃, and the measured temperature of power supply Tc is 50℃. Then the temperature rise △T is 35℃ (△T =Tc- Ta= 50℃-25℃=25℃).

Note: Temperature of power supply varies due to different power, material of case and internal design, etc. In a closed environment, to keep power supply away from components that are sensitive to temperature or isolate them for no natural ventilation.

III. Applications of High-voltage Output Power Supply

A. Typical Application

The typical application for the non-isolated high-voltage output power supply series (with adjustable

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output voltage) is shown in Figure 3-1.

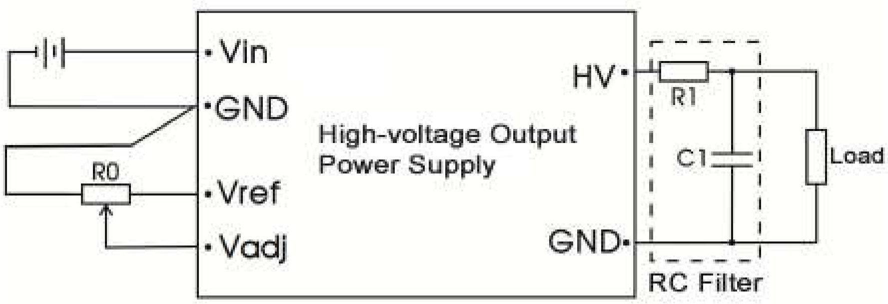

Figure 3-1 Typical Application of the Module with Adjustable Output Voltage

The recommended capacitor C1 for the module output is 4.7nF/2000V, R1 is 2KΩ, and R0 is the adjustable resistance, ≥10KΩ.

The typical application of the non-isolated high-voltage output power supply series with constant output current is shown in Figure 3-2: A high-voltage capacitor is added to the module output.

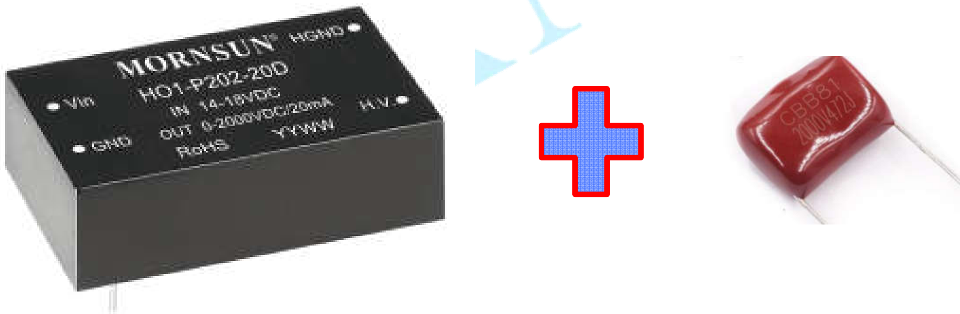

Figure 3-2 Typical Application of the Module with Constant Output Current

B. Reverse Input Polarity Protection

In the application, if the polarity of the input end is uncertain, it is recommended to add reverse input polarity protection. Usually, the simplest way is using a series diode. At present, the HO1-P/NxxxxH-0.5B/C/D/F series products are internally integrated anti-reverse protection, other types of high-voltage power supplies do not have this function:

This type of application needs to pay attention to the selection of the input diode, such as its power, voltage drop, etc., to ensure that the input voltage of the module would not exceed the standard

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range due to the voltage drop of the diode.

C. Input and Output Filter Circuit

In circuits sensitive to ripple and noise, filters can be added to the input and output ends of the module to reduce ripple and noise. The recommended circuit is shown in Figure 3-3:

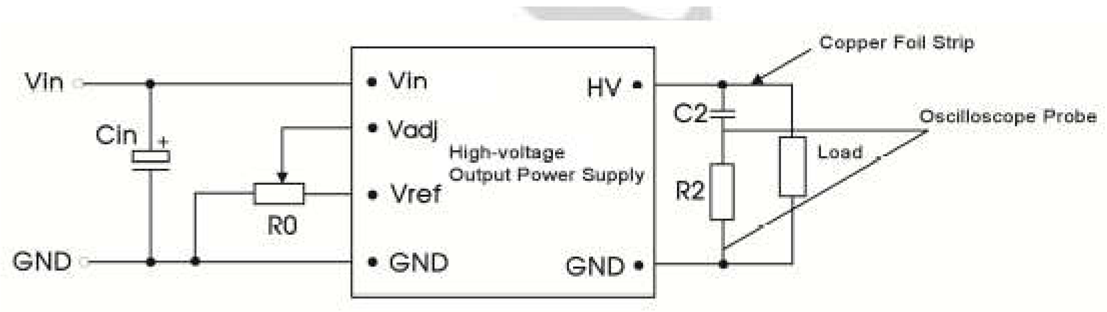

Figure 3-3 Recommended Circuit to Reduce Ripple Noise

Please refer to datasheet when selecting Cin and R2/C2.

D. 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 as follows:

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

(2) Reasonable grounding;

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

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

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supply to limit their own electromagnetic interference and avoid interference to other electronic equipment.

Improving EMC is available from the following three aspects:

(1) To reduce the radiation of source of EMC interference;

(2) To shield EMC interference transmission;

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

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

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

(2) 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 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. The protection circuit of the power supply part is shown in Figure 3-4.

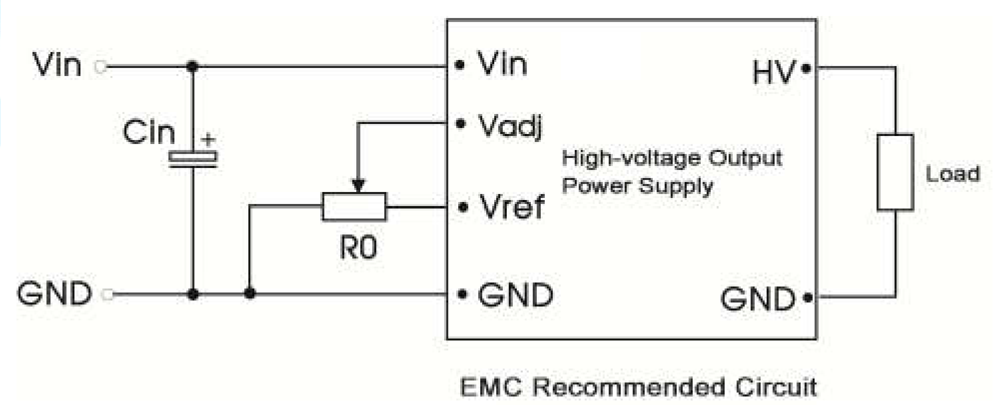

Figure 3-4 EMC Solution-recommended Circuit

For more details please refer to datasheet.

E. Capacitive Load

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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 datasheet.

F. Pin-out

(1) TRIM

The HO1-P/NxxxxH-0.5B/C/D/F product series also support output voltage adjustment. The connection of the external resistance is shown in Figure 3-5.

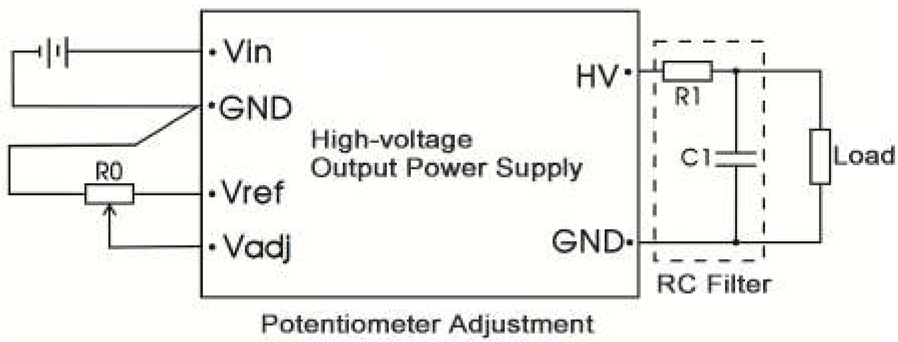

Figure 3-5 Adjustment of Output Voltage (Potentiometer Adjustment)

Besides the potentiometer, the output voltage can be adjusted directly by the control voltage pin. A 0-5V signal is corresponding to the output voltage of the 0-upper limit. The use of the pin can be seen in Figure 3-6.

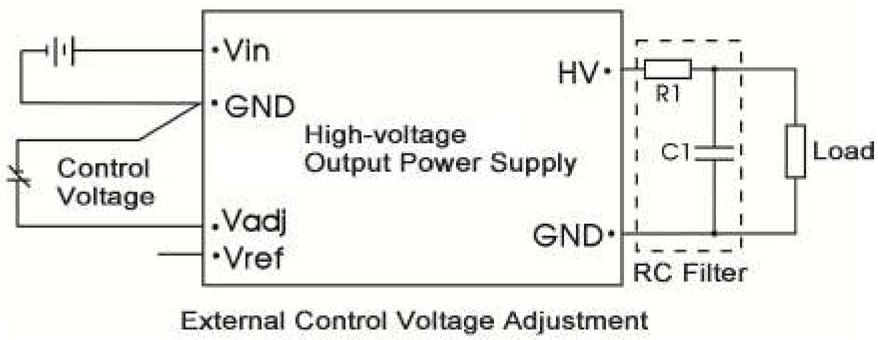

Figure 3-6 Adjustment of the Output Voltage (External Control Voltage Adjustment)

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The corresponding relationship of the control voltage to the output voltage is shown in Figure 3-7.

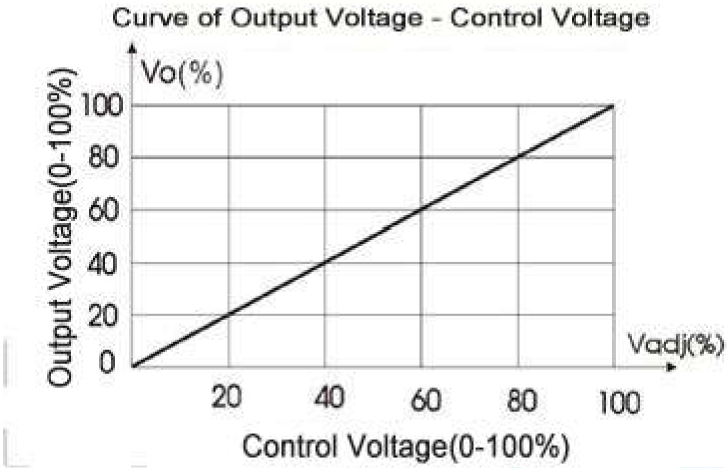

Figure 3-7 Curve of Output Voltage - Control Voltage

IV. FAQs

A. 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.

B. What Does the "Guaranteed Range" of Output Voltage Mean?

The output range of the output-adjustable high-voltage power supply is generally from 0 to the maximum value, but there is the "guaranteed range value" marked on the specification. Such as HO1-P1251H-0.5C, the output range is 0~+1250V, and the guaranteed range value is +200~1250V. Its guaranteed range value means that the output is in the range of +200~+1250V, the product's reference voltage Vref accuracy can meet the specification in the datasheet as the typical value is ±1%, the maximum value is ±2%. If the output voltage is in the range of 0~200V, the reference voltage accuracy may exceed the specification.

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C. The Output Voltage Accuracy of the Power Supply

There are two types of output voltage for the high-voltage output power supply, including constant voltage and constant current types. The output voltage of the constant current product is variable, and the output voltage of the constant voltage product is adjustable. The output voltage of both types can be adjusted directly by the resistance and control voltage to reach high accuracy.

D. The Reasons for the Power Supply Damage

The reasons for the module damage may include:

(1) The polarity of the input power supply is reversed (some models of products have anti-reverse connection protection).

(2) The input voltage exceeds the upper limit specified in the Technical Manual.

(3) Hot-swapping produces a large voltage peak, or there is an overshoot occurring in the input power supply.

(4) Overloading.

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