Ultra-wide High Input Voltage PV Power Supply Application Guide 2017

I. Foreword

Please carefully read and confirm following warnings and precautions before using the module power supply, in case electric shock, damaging the module, fire and other dangerous situations due to improper installation operation.

A. Warnings

a) Handle with Care. To impact or drop will cause damage to the module;

b) Do not open the module's case or touch internal devices, to avoid static, device stress and other vulnerable circumstances;

c) Be not close to the module or touch the radiator and case when it's working, to avoid harms to human body in case of the module's abnormal operation.

B. Precautions

a) Make sure that the product's input/output pins and necessary peripheral devices are connected correctly as datasheet before powering the product.

b) Connect a fuse at the input terminal in order to meet the safety requirements. Fuse selection please refer to datasheet.

c) Ensure that end-users cannot touch the input terminal of PV power converter because of the high voltage danger. Manufacturers must ensure that the module's input/output will not cause short circuit due to engineers' mistakes.

d) Relevant application circuit and parameters are for reference only. They must be verified before the application circuit design is completed.

e) Please note that guide's subject to alterations without notice. In practical application, please refer to the latest instructions.

II. Selection Guide

The first step is to confirm specifications of the power supply and then determine to choose a standard power converter or a customized one according to requested parameters. Available GAPTEC PV series:

https://gaptec-electronic.com/produkte_html/DC-DC-Wandler_PV.php

1. Confirm input voltage range.

As shown in Diagram 2-1, GAPTEC PV series offer inputs of 100-1000VDC, 100-1200VDC, 200-1200VDC, 200-1400VDC, 200-1500VDC and 150-1500VDC. Please select the right product as the practical application.

2. Confirm power and package according to load.

GAPTEC now offers powers of 5-45W and packages of horizontal and non-horizontal. Non-horizontal package is named with original product's name plus a suffix. For 5-15W, products suffixed with /CM are chassis mounting, with /DR are DIN-Rail mounting. For 40W, products suffixed with /CM are chassis mounting, with /DR DIN-Rail mounting. Such as: 15DCP_xxS4/CM or 15DCP_xxS4/DR. For more details please refer to the datasheets.

3. Confirm output voltage according to type of the load.

Outputs of 5V, 9V, 12V, 15V and 24V are available.

4. Confirm isolation.

Isolation makes input and output of the converter completely separate from each other (separate ground connection). It helps rise the loop's resistance in industrial bus system, isolates noise in analog circuit and digital circuit in hybrid circuit and converts voltages in multiple voltage power system, achieving safely isolation in harsh environments (lightning, arc interference). GAPTEC PV series offer isolation of 4000VAC. For special applications, please refer to datasheet.

It's recommended to use standard power converter, to ensure that the product is more cost-effective, reliable and shorter sample delivery time. For higher isolation, wide input voltage range, high temperature environment, EMC and other requirements, please consult GAPTEC FAEs.

III. Peripheral Circuit Descriptions

PV power converter is mainly used in high-voltage application where the environment is relatively harsh, including photovoltaic power generation, high-voltage frequency conversion, SVG, etc.
It's suggested to connect a protection circuit in practical application as shown in diagram 3-1, whose both CE and RE meets CISPR22/EN55022 CLASS A, pulse group immunity IEC/EN61000-4-4 ±4KV and surge immunity IEC/EN61000-4-5 ± 2KV. Diagram 3-2 shows recommended circuit-layout and details please refer to datasheet. Please note the safety requirements of wiring.
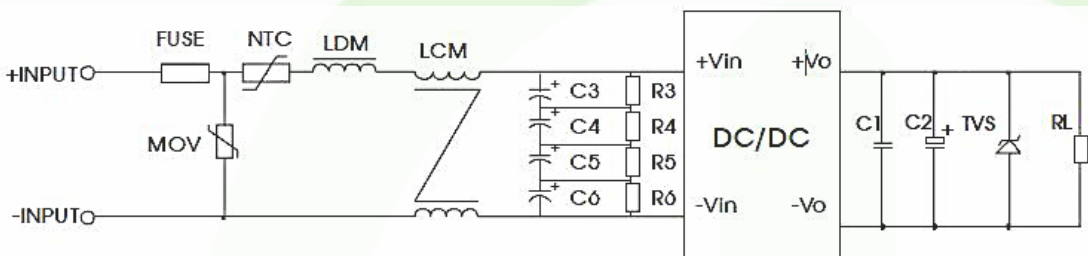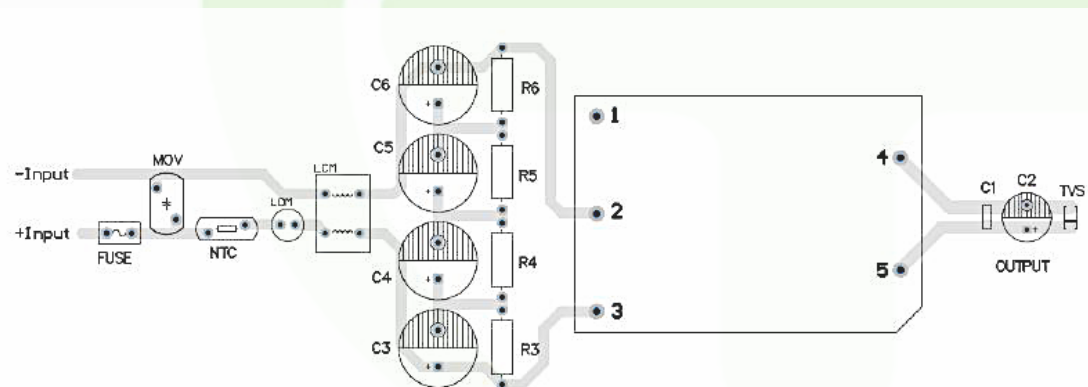
Diagram 3-1 EMC Solution-recommended Circuit

Diagram 3-2 Recommended Circuit Layout

Note: Safety and width recommendations for wiring: width ≥3mm, distance of wires ≥6mm, distance from the ground ≥6m.

IV. Basic Electrical Performance Testing Suggestions

A. Output Voltage Accuracy:

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

B. Line Regulation:

V_{outn} : output voltage at nominal input voltage and rated load	
V_{outh} : output voltage at rated load when input voltage at its upper limit	Line regulation $$= \frac{V_{outn} - V_{mdev}}{V_{outn}} \times 100\%$$
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	

C. Load Regulation:

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

D. Efficiency η:

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

E. Ripple & Noise:

Ripple and noise are 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, test with parallel cable measuring method, twisted-pair cable measuring method or contact measuring method as shown in diagram 4-1.
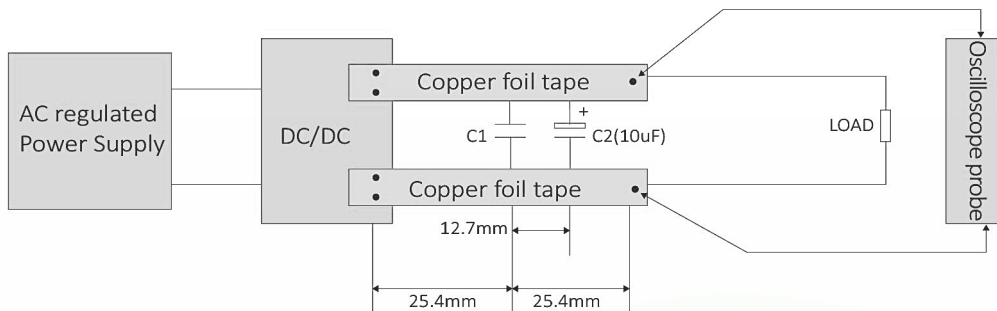
Diagram 4-1 Parallel cable measuring method

Notes:

a) C1 = 1uF (high-frequency ceramic capacitor).

b) C2 = an electrolytic capacitor with 10uF capacitance. The withstand voltage should derate 80% or more, consistent with datasheet.

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.
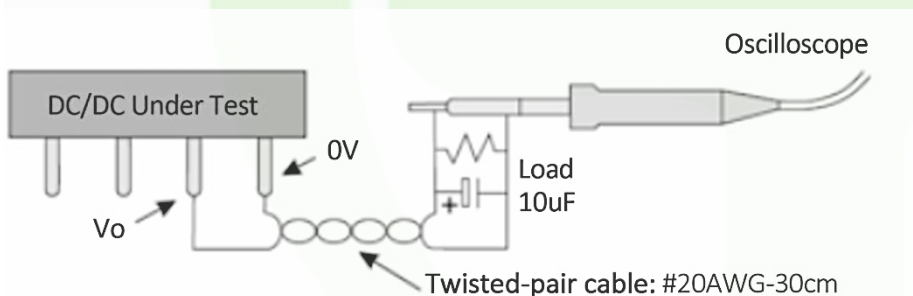

Diagram 4-2 Twisted-pair cable measuring method

Another is with twisted-pair cable measuring method as shown above in diagram 4-2. Connect tested power supply Vo and 0V with a twisted-pair cable which is composed of 30cm length and #20AWG, and then connect a dummy load between them. Next, connect a $10\mu F$ electrolytic capacitor at the end of the twisted-pair cable, which connects the end of oscilloscope's probe at one terminal and connects the ground at the other.
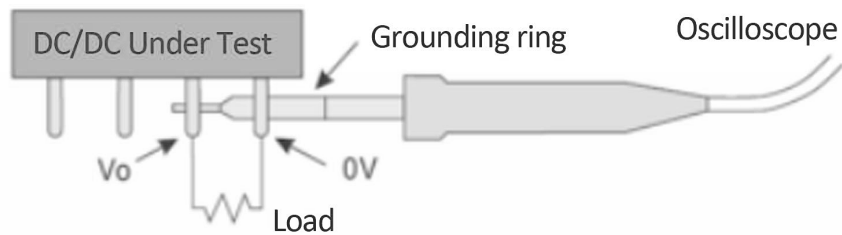
Diagram 4-3 Contact measuring method

Contact measuring method, as shown in diagram 4-3, is usually adopted for oscilloscope to shield interference. Because the oscilloscope's ground clip could absorb various high-frequency noise, affecting test results. The actual tested ripple and noise varies depending on different circuit and external components. Diagram 4-4 shows the actual tested ripple and noise waveform.
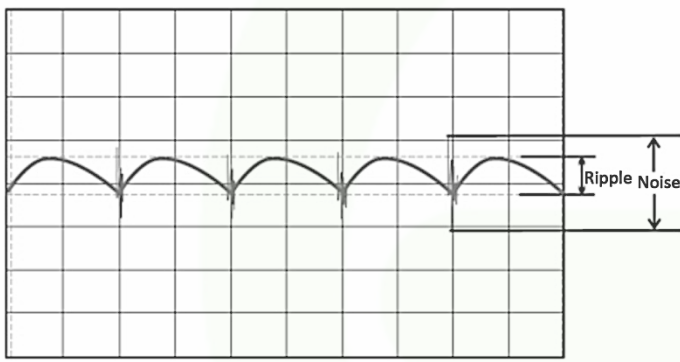

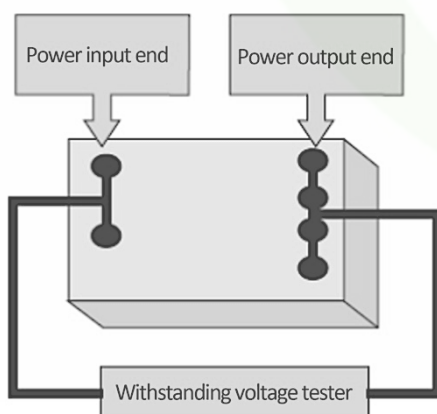Diagram 4-4 Waveform of Ripple & Noise Test

F. Isolation and Insulation:

Diagram 4-5 Method of Withstand Test

Withstand test:

According to withstand test standards, withstand value shall be set from 0 slowly upward and remain 1 minute at the set value. Diagram 4-5 shows the connection of wires.

Insulation test:

Short circuit input and output pins, then apply isolation voltage between them and test it for 1 minute.

V. FAQs

A. How to select a fuse used at the input terminal?

There's a high-voltage maximum to 1500V at the input terminal of PV power supply. As a result, it's strict to the fuse. To meet the safety requirements, the fuse should withstand the high voltage and be selected according to practical application (environment, product model), in addition to the power. Fuse parameters corresponding to the PV power converter please refer to datasheet.

B. Input under-voltage protection?

PV power supply is widely used in the photovoltaic power generation system, whose solar array panels' output voltage is related to sunshine intensity. If the intensity is strong, then the output voltage is high. On the contrary, output voltage is low. Therefore, the output voltage of solar array panels to the PV power supply is unstable and can affect the stability of PV power supply's output voltage when supply voltage is extremely low. GAPTEC PV series are designed with input under-voltage protection at the input terminal which can protect system stability from low input voltage. When the input voltage is lower than the value of under-voltage protection, the product will directly shutdown and ensure the safety of system. GAPTEC PV series offering input voltages of 200-1200VDC, 200-1400VDC and 200-1500VDC are all designed with input under-voltage protection.

C. May AC power cause start-up failure?

PV power supply's input is powered by DC power. If it's powered by AC power, it should add a rectifier at the input terminal to convert into DC power and to power the PV power supply. The easiest way is to add a rectifier bridge and capacitor at the input terminal together.

Because it may cause start-up failure even though the input is 200VAC, if only added the rectifier bridge without the capacitor or with the capacitor offering small capacity.

D. How to clean and maintain products?

PV power supply installed in customers' system may need cleaning. GAPTEC PV series has two kinds of case, metal case and plastic case. It's recommended to simply wipe and clean with alcohol and not soak them in that a corrosive cleaning fluid will produce a chemical reaction and cause poor appearance.

E. Operating temperature?

The temperature of product's internal components is much higher than the ambient temperature in the high temperature environment. In order to ensure the product works reliable, the highest ambient temperature of common products' is 50° and will derate when it reaches 50°. For more details please refer to datasheet. Following diagram 5-1 shows typical working environment temperature derating curve of PV series with 100-1000VDC input.
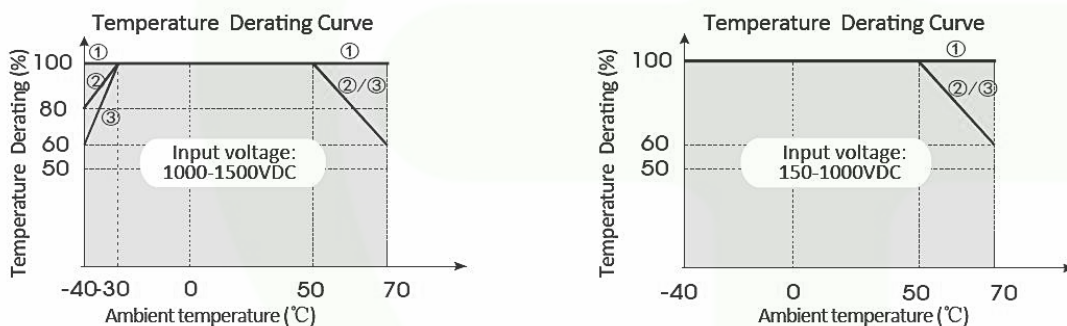

Diagram 5-1 Temperature derating curve

F. Radiated Susceptibility (RS)?

Strong radiation will affect PV power supply's internal circuits such as control circuit, loop regulation circuit and so on. RS test standard is IEC/EN61000-4-3 10V/m, which is used to test whether the converter work normally. GAPTEC PV series totally meet the standard. However, when faced with stronger RS such as strong radiation equipment walkie-talkie, the power supply should

be far away from them for the equipment's RS, stronger several times or more than that tested in a laboratory, will seriously affect the power supply's performance.

G. EMC Peripheral Recommended Circuit?

PV power supply is mainly used in high-voltage applications where the environment is relatively harsh, including photovoltaic power generation, high voltage inverter, SVG, etc. In practical application, it's suggested to connect a protection circuit, especially for applications of solar array board placed in the outside or even the Gobi Desert, so as to reduce the strong interference, ensure the stability of the system and protect the product from damaging. For more details please refer to datasheet.

VI. Thermal design for Applications

A. Natural Air Cooling

For power supply (mainly on-board power supply) in high power density and compact size, natural air cooling is usually adopted for volume, cost and other concerns. Common cooling methods of on-board power supply are the following ones:

a) Natural air convection: dissipate the heat from the power supply and exposed surface to the air through the natural convection. If there is a space between the supply and the PCB, the heat will be dissipated to its surroundings.

b) Radiation: dissipate the heat from exposed surface of the supply to its surroundings or from the bottom of the supply to the PCB via radiation.

c) Conduction: dissipate the heat through the supply's pins to the PCB via conduction.

B. Forced Air Cooling

In many applications, it's not so helpful even if it's installed a heat-sink. In this case, heat dissipation is more difficult and recommended to add a fan as the main cooling method.

General guiding principles for the fan's installation are, for rectangular power supply, blowing direction of the fan should be horizontal and blowing direction of channels within the fan should be vertical, in order to form a "chimney effect" conducive to heat. In addition,

a thermal grease or other thermal filler material may be applied between the fan and the converter's case (or metal substrate) to tighten them to reduce thermal resistance. However, an attention is that over-tightening will cause the deformation of the converter's case (or metal substrate).