AC/DC Power Supply (Open-frame) Application Guide 2021

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1. Introduction

Before using the power supply, please pay special attention to the following warnings and precautions. Improper installation and operation may cause electric shock, damage to the power supply or fire, and other dangerous situations. Please carefully read and confirm the relevant warnings and precautions.

1.1 Warnings

(1) Please carefully handle the power supply to avoid damage to the product due to impact or fall.

(2) Do not touch the internal components of the power supply to prevent the product from being damaged by static electricity, component stress, etc.

(3) Do not bend the pins of the product to avoid the breakage of the internal PCB leading to the electrical disconnection and the abnormal working status of the product.

(4) Do not approach or touch the module when the module power supply is working to avoid electric shock due to the contact with the high voltage part.

1.2 Precautions

(1) Before powering on the product, please confirm that the input, output, and signal pins of the product, as well as required peripheral devices, have been correctly connected following the Design Reference and Dimensional Drawings in the Product Technical Manual.

(2) The AC-DC power supply module is a primary power supply. Please use it according to the corresponding safety specifications.

(3) It is required to connect a fuse to the L wire (the live wire) at the input end to meet the safety specifications. The selection of fuse can refer to the corresponding Technical Manual.

(4) The input and output ends of the AC-DC power supply module may lead to high voltage damage. Ensure that the end-user cannot touch both ends. Also, the equipment

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manufacturers must ensure that the input and output of the module are not easily short-circuited by the operator or the left metal components.

(5) The relevant applied circuits and parameters are for reference only. Please verify the parameters and circuits before completing the applied circuit design.

(6) If the module power supply (or the equipment using AC-DC power supply module) has been stored or idled for more than half a year, it is recommended to let it age without load for 1 hour every six months to ensure the service life and application reliability of the product.

(7) Conventional AC-DC products are not suitable for long-term work at high temperatures. If necessary, it is recommended to replace the product every or two years. The power supply module should not be placed near large heating devices, such as CPU, motor, etc.

(8) The module power supply may make a slight noise in no-load or light-load working status, which is normal.

(9) The module power supply is a component. Please install and use it under the guidance of professional designers.

(10) The withstanding voltage test is an ultimate destructive test, and no multiple tests are allowed.

(11) Changes to this Guide cannot be guaranteed to notify customers in time. In actual use, please pay attention to the latest instructions. For other issues, please refer to Analysis of Common Failures of AC-DC Module Power Supply.

2. Selection Guide of Power Supply Module

Firstly, determine the specifications of the required power supply. Then, screen the power supply module according to the corresponding indicators, and confirm whether to use standard modules or to customize. Figure 2-1 is the basic selection block diagram of our AC-DC power supply (open-frame type) products.

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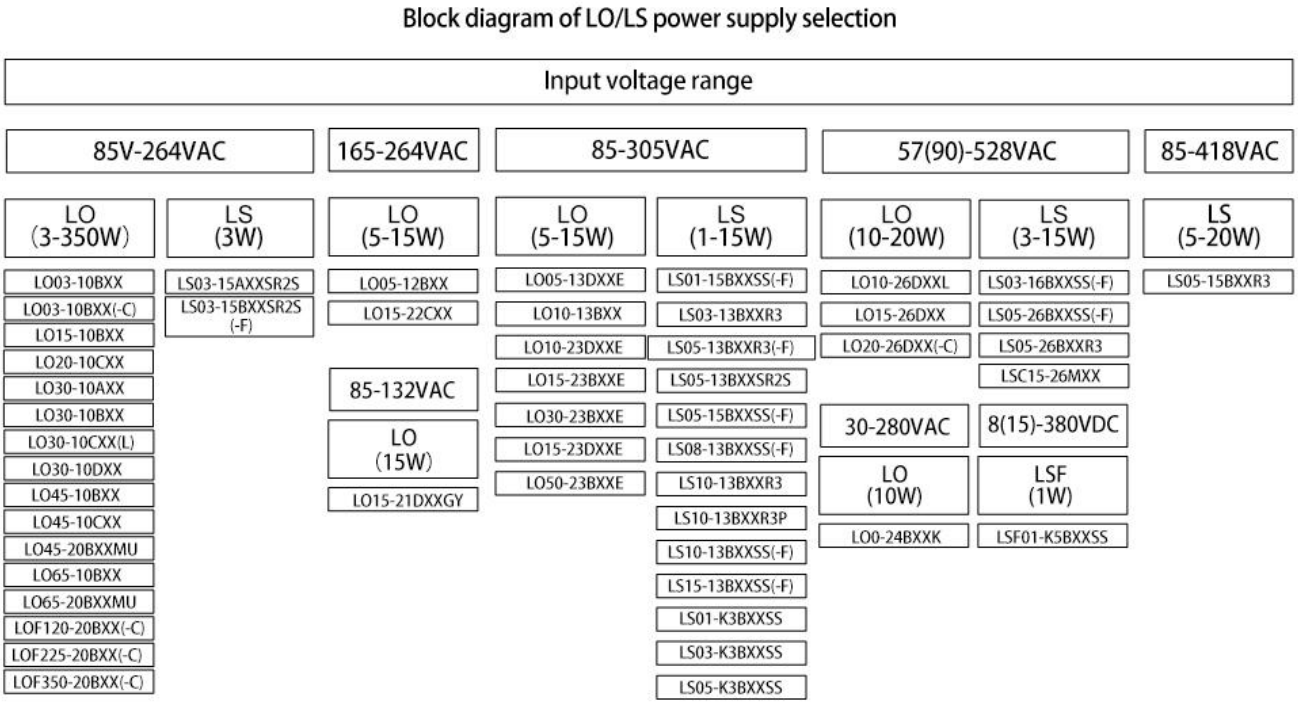

Figure 2-1 Block diagram of LO/LS power supply selection

Note: Due to the company's continuous development and technological breakthroughs and innovations, the launch of new products will inevitably lead to an update of the selection diagram.

Step 1: Determine the input source type.

Confirm whether the input source of the module is AC or DC. In general, AC/DC module is used for AC input, and DC/DC module is used for DC input. (Our AC-DC power supply module can also work under DC input voltage conditions).

Step 2: Determine the standard reference voltage according to the input voltage range. (Refer to Figure 2-1 for the input voltage range.)

Step 3: Select the power and package type of the product according to the size of the load. Our LS/LO products are all bare boards, and the LOF series products have an enclosed version (with suffix -C).

Step 4: Select appropriate output voltage according to the type of load. The output voltage of our products is generally 3.3V, 5V, 9V, 12V, 15V, 18V, 24V, 48V, 54V, ±5V, ±12V, and ±15V.

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Step 5: Select the isolation property of the module.

The isolation property of the module enables the input and the output of the module as two completely separate (non-common ground) power supplies. In the industrial bus system, the isolation characteristic of the module in the face of harsh environments (lightning strikes and arc interference) plays a role in eliminating ground loops. In hybrid circuits, the isolation characteristic is applied to isolate the noise from sensitive analog and digital circuits. In a multi-voltage power supply system, it helps the conversion of the voltage. The isolation voltages of our LO/LS series products are generally 3000VAC and 4000VAC.

Our LS01-K3B05SS, LS03-K3B12SS, and LS05-K3BxxSS products can be applied for AC-DC low-power non-isolated design.

The LSF01-K5BxxSS product is especially for the single live wire application design.

It is recommended to use the module power supply meeting with the standard specifications to ensure the product's high performance-cost ratio and reliability and the advantages of fast sample delivery. For special performance requirements such as higher isolation, ultra-wide input voltage range, high-temperature environment, EMC certification, etc., it is recommended to consult our technical service personnel.

3. Applications of the AC-DC Power Supply Module

3.1 Circuit Connection for Basic Test

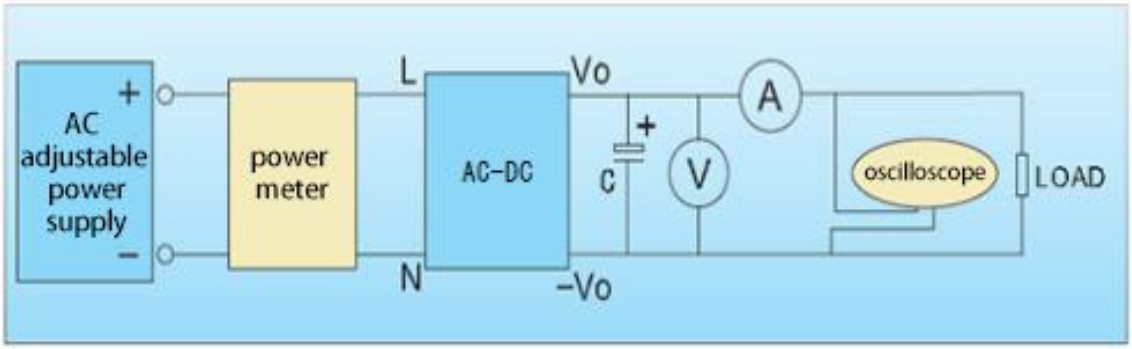

Figure 3-1 Circuit connection for Basic Test

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3.2 Typical Application Circuit of Products

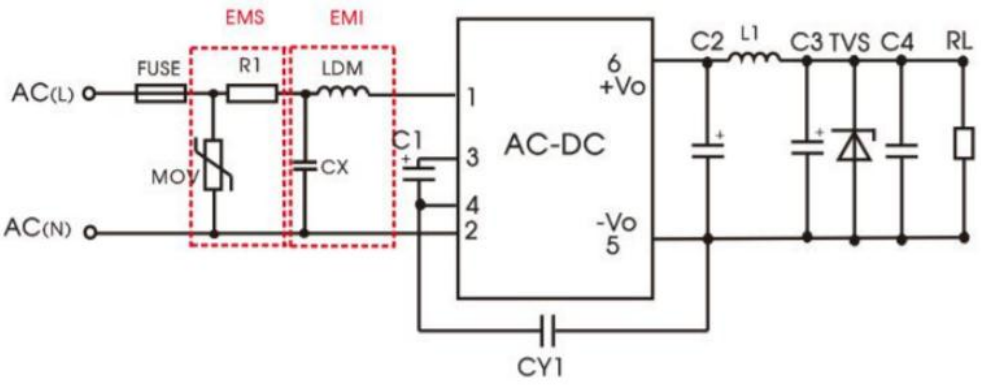

Figure 3-2 Typical application circuit of conventional LS series products (LO series products usually do not require peripheral circuits)

(1) FUSE is an input-side fuse, and the slow blow fuse with safety certification should be selected. The recommended value is: for EMS level- Ⅲ (differential mode 1KV, common-mode 2KV), select 1A/300V; for EMS level- Ⅳ (differential Mode 2KV, common-mode 4KV), select 2A/300V (the rated voltage can be increased or decreased depending on the input voltage range). For the specific selection, please refer to the recommended values in the Technical Manual.

Note: The too large rated current value of the fuse would weaken the performance of the fuse. Also, the too low value would easily cause false fusing due to the charging of the input capacitor during the startup.

(2) MOV is a voltage-sensitive resistor, which protects the surge voltage at the input end of the product. It is recommended to refer to the corresponding parameters in Technical Manual for the selection of varistor specifications.

(3) R1 is the plug-in resistor (required) used to suppress the impulse current as the product starts up. This resistor must be a wire-wound resistor. Metal and carbon film resistors are not applicable due to their poor resistance to impulse current. (For specific resistance values, please refer to the Product Technical Manual).

(4) C1 is the electrolytic capacitor for the input energy storage (required). For selecting the capacitance value, please refer to the recommended specification value in the Technical

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Manual. The reduction of the capacitor withstanding voltage is greater than 80%.

(5) C4 is a ceramic capacitor, which can remove high-frequency noise. Refer to the Technical Manual for the capacitance value.

(6) The TVS tube is recommended to protect the subsequent circuit when the module works abnormally.

(7) C2 and C3 are filter capacitors for output energy storage (required) to reduce output ripple noise. The high frequency and low resistance capacitors are recommended.

(8) LDM is the input differential mode inductor used to improve the EMI of the product and the interference signal under low frequency.

(9) CX capacitor is an X safety capacitor, mainly used to improve the EMI of products and absorb part of the surge signal from the power grid.

(10) Y capacitor is used to improve the EMI and output noise and be added between the primary and secondary power supply.

4. FAQs

4.1 Input and Output Grounding

Input grounding: The input end of the AC-DC module power supply generally has three pins, i.e., live wire L, neutral wire N, and protective ground PE. PE is usually connected to the ground wire of the equipment enclosure or the power grid.

Output grounding: Some customers directly connect the output ground to the protective ground in practical applications, as shown in the left figure below. This connection may cause abnormal output or damage to the product due to the interference from lightning surges, pulse groups, etc. Thus, it is not recommended to connect the output ground to the protective ground directly. Instead, they can be connected through a Y capacitor (1000pF/400V is recommended), as shown in Figure 5-1.

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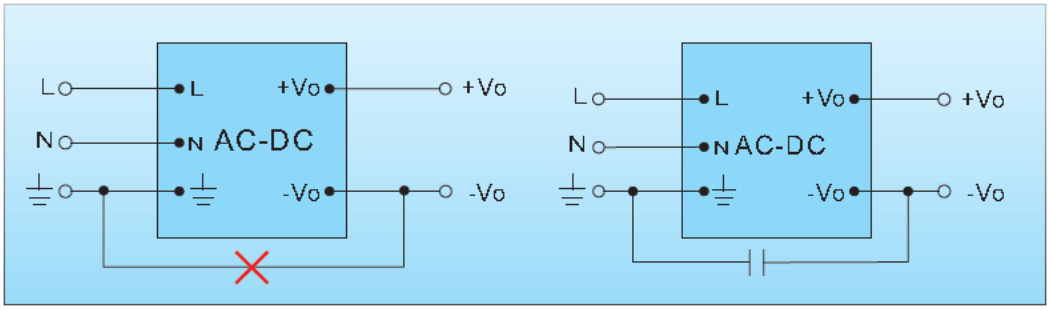

Figure 5-1 Connection of the output ground and the protective ground

4.2 Surge Current

There are two types of surge currents: (1) the peak current at the moment of product startup (usually called the product startup impulse current); (2) the current formed by the vast surge voltage induced during working.

The primary solution to suppress the peak current at the start of the product is to add a protective device thermistor or wire-wound resistor at the input end to reduce the surge current; the surge current generated by the high voltage is mainly protected by the voltage-sensitive resistor and releases energy through the voltage-sensitive resistor.

4.3 Leakage Current

There are two understandings for leakage current. One is the leakage current between the input end and the protective ground during the regular operation of the product (i.e., contact leakage current); the other is the leakage current between the isolation bands during the withstanding voltage test of the product. (i.e., withstanding voltage leakage current).

4.4 AC and DC Input

The input end of the AC-DC power supply generally adopts full-bridge rectification to meet both AC and DC voltage power supply modes.

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4.5 Relationship between the Type I and Type II Equipment and Protective Ground FG

There are clear definitions for Type I and Type II equipment in EN62368:

Type I equipment adopts basic insulation and a connection device. As the basic insulation fails, the conductive parts would carry dangerous voltage. The connection device is used to connect the conductive parts with dangerous voltage to the protective grounding conductor in the wiring of the building. Type I equipment has a protective ground FG pin. Our LH (E) series products can be seen as an example.

Type II equipment adopts anti-electroshock protection relying on basic insulation and additional safety protection measures (such as adopting equipment with double insulation or reinforced insulation). This type of equipment neither relies on protective grounding nor protective measures based on installation conditions. Type II equipment does not have a protective ground FG pin. Our LS/LD series products can be seen as an example.

4.6 Voltage Transient at Input End

The voltage transient of the input power line is destructive to the product. If the power transient at the input end is greater than the high limit of the product input, a protection circuit must be added to the input end.

4.7 No-load Use of Output

The no-load use of products with multiple outputs would cause the output voltage to exceed the specification, reaching 20% or more. In practical applications, the minimum load is recommended to be 10% of the total load.

4.8 Working Temperature

When the product works in a high-temperature environment, the temperature of its internal components is much higher than that of the environment. The reliable operation of conventional products allows the highest ambient working temperature of 70℃ or 85℃. Generally, as the ambient temperature reaches 55℃, the power should be reduced to cool

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the product. The product working at low temperatures also requires power reduction due to the low-temperature characteristics of internal electrolytic capacitors and other components. At the same time, the output ripple noise value would be larger than that at normal temperature. Please refer to the Technical Manual corresponding to the product model for the specific content of the derating curve.

4.9 The Silkscreen Printing Voltage Label of the Product Enclosure

The silkscreen printing of the product is labeled as 100VAC-277VAC, and why is the Technical Manual labeled as 85VAC-305VAC?

It is mainly in consideration of the safety certification. Generally, when testing products, certification agencies would test their performance by fluctuations of ±10% or even ±15% according to the input voltage range on the product silk screen label. Therefore, the industry's silkscreen label of the product with an input range of 85VAC-305VAC product will generally be marked with the input voltage range of 100VAC-277VAC; that of the product with an input range of 85VAC-264VAC will generally be marked with the input voltage range of 100VAC-240VAC.

4.10 Anti-interference from the Radiation

The intense radiation would affect the working of the internal circuits of the power supply, such as the control circuit and the loop adjustment circuit. The radiated immunity test standard of the switching power supply is IEC/EN61000-4-3 10V/m. Under this condition, the testing power supply can work stably. When interfered with intense radiation, such as walkie-talkies and other equipment with intense radiation, the switching power supply would generate high radiation. Also, the radiation intensity is several times or even dozens of times higher beyond the laboratory test conditions. Therefore, the switching power supply should be kept away from intense radiation equipment while it is used.

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4.11 Recommended Periphery Circuit of EMC

The front-end input of the AC/DC power supply is powered by high voltage power, and the power supply environment at the input end is relatively complicated. Therefore, it is necessary to add an EMC protection circuit at the input end. For LS products with small volumes, the protection circuit can be built according to customer needs, while the periphery circuit should be built following the Technical Manual. Otherwise, the product may be damaged in a complicated power supply environment.

4.12 Time Sequence of the Power Supply

When multiple systems or multiple functional circuits are started together, the control circuit must start first to ensure that the system can be initialized normally. Then all components can be normally charged. Therefore, when selecting a power supply for each system or functional circuit, if the system requires accurate time sequence control, the startup time of the power supply is critical. In the case of an abnormal power supply, the control circuit is required to be powered off at the end to ensure the normal shutdown of the entire system. Therefore, it is also essential to focus on the power-down retention time of the power supply module.

5. Application Safety Design of the LO/LS Open-frame Power Supply

5.1 Signs

The marking specifications and symbols at the fuse, protective ground, and switch must be clarified by the safety regulations. The dangerous voltage and energy that can be touched are required to be marked with danger warning signs.

5.2 Materials

The input L, N, FG connecting wires are brown, blue, and yellowish-green, respectively. All of them are equipment that relies on basic insulation and protective ground to prevent

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electric shock (Type I equipment). Ensure that the grounding wire (yellowish-green wire) is well connected to the earth, and the grounding resistance is less than 0.1Ω.

5.3 Creepage Distance and Electrical clearance

Ensure that the electrical clearance between L and N before the fuse is greater than 2mm, the creepage distance greater than 2.5mm, the electrical clearance between the input and the metal enclosure or SELV circuit greater than 5mm, and the creepage distance greater than 6.4mm (for applications in high altitude environments, please follow the relevant standard multiplication factor to increases the creepage distance and electrical clearance).

5.4 Capacitance at Input End

Suppose an X capacitor is connected to the input end of the product to improve its EMI performance. In that case, when the input capacitance is too large, a discharge resistor is required to be connected in parallel. The discharge time constant should be less than 2S (the discharge time constant is equal to the multiplication of the capacitance and the resistance). According to the latest safety standards, if the addition of a capacitor at the input cannot lead to the voltage falling below the safety voltage (i.e., 60V) within 2S, a discharge resistor must be added. For more specific information, please consult our safety engineers.

6. Thermal Design for Power Module Applications

6.1 Natural Air Cooling

Due to factors such as size and cost, most miniaturized, high-power-density power modules (mainly on-board power modules) use natural air cooling as the primary heat dissipation method. The following methods are generally used to dissipate heat for on-board power modules:

(1) Through the natural convection of air, the heat can be transferred from the power module enclosure and the exposed surface to the air. Even if there is a gap between the

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power module and the PCB, the heat would also be transferred to the surrounding environment through the channel;

(2) Through radiation, the heat can be radiated from the exposed enclosure of the module to the surface of surrounding objects or from the bottom of the module to the PCB board;

(3) The heat can also be transmitted to the PCB board through the module pins by conduction.

6.2 Mandatory radiator

In many application systems, even if the heat sink is installed, the working conditions of the power supply cannot be effectively improved. In such systems with difficulty in heat dissipation, adding a mandatory radiator (such as a fan) is necessary as the primary heat dissipation method.

The general guideline for fan installation is that for long power modules, the blowing direction of the fan should be horizontal, and the blowing direction of the fan in the channel should be vertical to form a "chimney effect" and thereby facilitate heat dissipation. Besides, a layer of thermal grease or other thermally conductive fillers can be applied between the fan and the module to make the fan and the module power supply enclosure (or power supply metal substrate) tightly combined to reduce thermal resistance. Note that the over-tightened combination would cause the power supply enclosure (or power supply metal substrate) to be deformed.

In high altitude with thin air and lower atmospheric pressure, as the heat dissipation of the system itself is relatively poor, mandatory heat dissipation or power reduction is required to reduce the rising temperature of the system.

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