NO.18, SIN-SIN RD., AN-PING INDUSTRIAL DIST., TAINAN 702 TAIWAN TEL : 886-6-2923150 FAX : 886-6-2923149

Application Notes - AC/DC Power Module

► Measurements

The pin of AC line (L), ac neutral (N) should be retained from the AC power outlet to the power supply input terminal without accidental interchange. The following condition applied in Figure 1.

- The input voltage is nominal AC input voltage.
- The load is set to the rated output load (Full Load).
- The ambient temperature is 25°C.

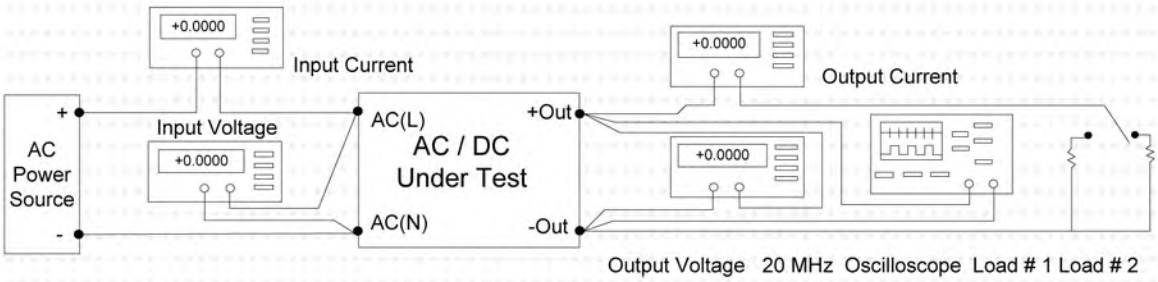

Figure 1

► Output Voltage Accuracy

Make and record the following measurements:

1. Output voltage at nominal input voltage (V_{ON}).	$\text{Output Voltage Accuracy} = \frac{V_{ON} - V_O}{V_O} \times 100\%$
2. Output voltage accuracy is derived by the formula.	V_O is output voltage specified in the data sheet.

Example: V_O =5.0V V_{ON} =4.9V

$$\text{Output Voltage Accuracy} = \frac{4.9V - 5.0V}{5.0V} \times 100\% = -2\%$$

► Line Regulation

Make and record the following measurements:

1. Output voltage at nominal input voltage (V_{ON}).	$\text{Line Regulation} = \frac{V_D - V_{ON}}{V_{ON}} \times 100\%$
2. Output voltage at maximum input voltage (V_{OH}).	
3. Output voltage at minimum input voltage (V_{OL}).	V_D is maximum output voltage deviation measured.
4. Line regulation is derived by the formula.	

Example: V_{ON} = 11.98V V_D = 12V

$$\text{Line Regulation} = \frac{12V - 11.98V}{11.98V} \times 100\% = 0.17\%$$

► Load Regulation

Make and record the following measurements:

1. Output voltage at full load (V_{OF}). 2. Output voltage at minimum load specified in the data sheet (V_{OM}). 3. Load regulation is derived by the formula.	$\text{Load Regulation} = \frac{V_{OM} - V_{OF}}{V_{OF}} \times 100\%$

Example: V_{OF}=4.95V V_{OM}=5.0V

$$\text{Load Regulation} = \frac{5.0V - 4.95V}{4.95V} \times 100\% = 1\%$$

► Cross Regulation

1. Dual Positives / Triple Output : Measured output Io = 20% to 100% of rated load. Other outputs are set at 50% of rated load. 2. Output voltage at full load (V_{OF}). 3. Output voltage at 20% load specified in the data sheet (V_{OM}). 4. Load regulation is derived by the formula.	$\text{Cross Regulation} = \frac{V_{OM} - V_{OF}}{V_{OF}} \times 100\%$

For example: V_{OM} = 5.033V_{DC} V_{OF} = 5.021V_{DC}

$$\text{Cross Regulation} = \frac{V_{OM} - V_{OF}}{V_{OF}} \times 100\% = \frac{5.033V - 5.021V}{5.021V} \times 100\% = 0.239\%$$

► Efficiency

Make and record the following measurements:

1. Output voltage at nominal input voltage (V_{ON}). Nominal input voltage (V_{IN}). 2. Input current at nominal input voltage (I_{IN}). Output current (I_{ON}). 3. Power Factor (PF). 4. Efficiency is derived by the formula.	Formula 1: $\text{Efficiency} = \frac{V_{ON} \times I_{ON}}{V_{IN} \times I_{IN} \times PF} \times 100\%$ Formula 2: $\text{Efficiency} = \frac{\text{Power (output)}}{\text{Power (input)}} \times 100\%$

For example: V_{ON} = 5.005V_{DC}, I_{ON} = 2A
V_{IN} = 115V_{AC}, I_{IN} = 0.2022A, PF = 0.569
Power (output) = $V_{ON} \times I_{ON}$ = 5.005 × 2 =10.01W
Power(input) =13.3W

$$\text{Formula 1: Efficiency} = \frac{V_{ON} \times I_{ON}}{V_{IN} \times I_{IN} \times PF} \times 100\% = \frac{5.005V_{DC} \times 2A}{115V_{AC} \times 0.2022A \times 0.569} \times 100\% = 75.65\%$$

$$\text{Formula 2: Efficiency} = \frac{\text{Power (output)}}{\text{Power (intput)}} \times 100\% = \frac{10.01W}{13.3W} \times 100\% = 75.26\%$$

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▶ Output Ripple & Noise

This is an AC measurement at the output of a power module at rated load and +25°C ambient temperature.
The measurement is made in either millivolts RMS or millivolts peak-to-peak. Figure 2 shows the typical voltage waveform. In the case of AC/DC Power Modules, the output ripple voltage is a series of small pulses with high frequency content, and for this reason It is almost always specified as peak-to-peak rather than RMS value.

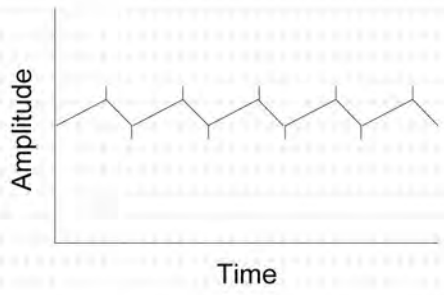

Figure 2

Because of the high frequency content of this ripple, special measurement techniques must be employed so that correct measurements are obtained. First, a 20MHz bandwidth oscilloscope is normally used for the measurement so that all significant harmonics of the ripple spikes are included. The actual ripple voltage measurement must be carefully made in order not to induce error voltages in the test equipment. Therefore, the conventional ground clip on an oscilloscope probe (See Figure 3) should never be used in this type of measurement. This clip, when placed in a field of radiated high frequency energy, acts as an antenna or inductive pickup loop, creating an extraneous voltage that is not part of the output noise of the converter.

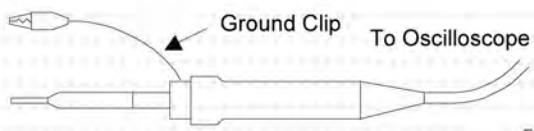

Figure 3

This noise pickup is eliminated as shown in Figure 4 by using a scope probe with an external ground band or ring and pressing this band directly against the output common terminal of the power converter while the tip contacts the voltage output terminal. This makes the shortest possible connection across the output terminal.

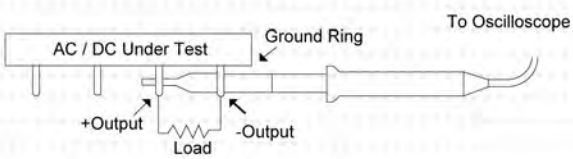

Figure 4

Another method of measuring the output voltage ripple & noise that is specified for many switching power supplies is shown in Figure 5.
A 30cm twisted pair of no. 20 AWG copper wire is connected to a 10uF capacitor of proper polarity and voltage rating.

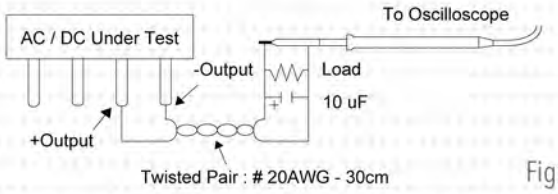

Figure 5

The oscilloscope probe ground led should connect right to the ground ring of the probe and be as short as possible.
The oscilloscope bandwidth should be at 20MHz and connected to AC ground.

▶ NOTE

1. Specifications typical at Ta=+25°C, resistive load, 115VAC, 60Hz input voltage, rated output current unless otherwise noted.
2. Ripple & Noise measurement bandwidth is 0-20MHz.
3. These power modules require a minimum output loading to maintain specified regulation.
4. Operation under no-load conditions will not damage these devices; however they may not meet all listed specifications.
5. All AC/DC modules should be externally fused at the front end for protection.
6. Other input and output voltage may be available, please contact factory.
7. Specifications subject to change without notice.

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▶ Absolute Maximum Ratings

Exceeding the specified absolute maximum ratings may severely damage the module. These ratings are intended as guidelines for absolute worst case operating conditions and are not to be interpreted asrecommended operating condition.

▶ Fusing Considerations

Usually, please consult the suggestion of the guide of up-market selected works of input fuse to the products DATASHEET while using the slow-blow type fuse. Whether a fast or slow-blow fuse is required depends upon the application. Generally, a slow blow fuse will provide adequate protection and the module's internal circuitry will handle any short period transient faults. A fast blow fuse is recommended for redundant systems to prevent a failed unit from shorting the input bus.

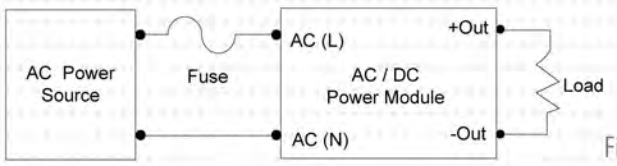


Figure 1

▶ Maximum operating temperature

The maximum operating temperature for a power module is determined by the internal temperature rise of its components. In an AC-DC Power Module, a small proportion of the input power is not converted to output power, but is dissipated as heat inside the module. The amount of power dissipated depends on the efficiency of the module, defined as the ratio of useful output power to supplied input power.

At an ambient temperature of 70°C the internal temperature of some components may be over 100°C.

The internal temperature of any component must never exceed its maximum operating temperature, and for this reason many AC/DC Power Module specify derated outputs at higher operating temperatures. In other cases the power module is specifically designed with special components and thermal techniques to allow operation at full load to 71°C with no derating.

Whether or not the unit is derated at higher temperatures, it is a good idea to provide additional cooling above 50°C ambient temperature. Is not just to keep a power module operating with in its specified operating area, but to increased reliability. However, for normal operation the module should not be run at the maximum allowable temperature since the Mean Time between Failures (MTBF) will reduce sharply as temperature increases.

▶ Power Line Transients

Power line transients can cause damage to the AC/DC Power Module. If voltage transients in a given application can exceed the maximum rated input voltage of the AC/DC Power Module, it may be necessary to provide external protection devices. Figure 2 shows transient protection methods commonly used.

An AC/DC Power Module input is protected by a fuse and TVS (or power zener diode). The TVS effectively absorbs and dissipates transient voltages above its breakdown Voltage.

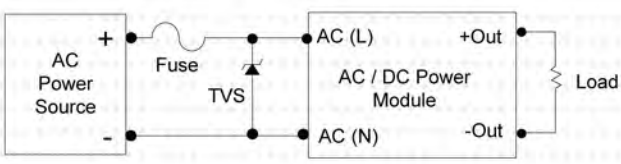


Figure 2

► Series Connection

One frequent application of the series connection is in using a dual output power module as a higher voltage single output module as shown in Figure 3.

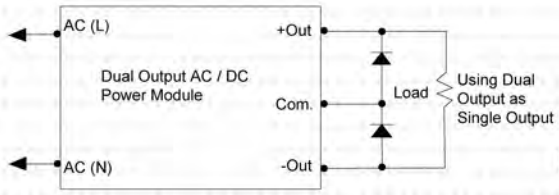


Figure 3

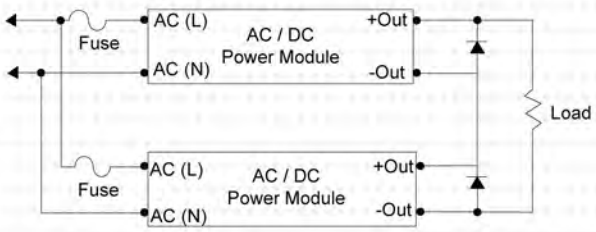
The outputs are already series connected by means of the common output terminal, so it is only necessary to float the common and connect the load directly across positive and negative output terminals as shown. In this manner 24, 30, or 36V outputs can be realized from ±12, ±15, or ±18 dual output power modules respectively.

In general, AC/DC Power Module can be operated with outputs connected in series. Note there will be an addition of ripple voltage at the outputs since the power module in general will not have synchronous ripple voltages.

The only other limitation on series connection is that the total output voltage should not exceed the working breakdown voltage of any one of the power module this may be substantially less than the dielectric test voltage.

A common practice in the series connection of power converters is to connect reverse biases diodes across the output of each series connected power supply as shown in Figure 4.

Diodes placed on the outputs of the module ensure that on start-up the module are protected against reverse polarity. This can occur when the modules do not begin delivering power to the load simultaneously.



Series Connection With Reverse Voltage Protection Diode

Figure 4

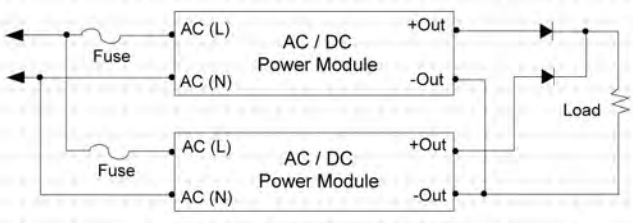
► Parallel Connection

The parallel connection of AC-DC Power Module outputs is a much more difficult problem than series connection. In fact, as a general rule it should not be done unless the power modules are specifically designed for parallel operation or the manufacturer says it can be done.

The problem with parallel operation it that it is nearly impossible to get equal load sharing between two power modules. First of all, two output voltages from fixed-output AC/DC Power Module will not be exactly equal. The Module with the larger output voltage will tend to provide the entire load current. Even if the outputs can be adjusted so that they are precisely equal, a difference in output impedance and also drift with time and temperature will cause the loads to become unbalanced.

► Redundancy

A good reason for parallel operation of power module is in providing power redundancy. In Figure 5, two power modules have their outputs connected in parallel throughtwo diodes. For 100% redundancy each power module must be capable of supplying the total load. In this case, it does not matter whether the load current is shared equally, however it is desirable for each output to provide at least part of the load current. A diode should be fitted to the output of each of the paralleled units in order to isolate the module from the output bus in the event of a failure.



Redundant Parallel Connection With Diode

Figure 5

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► No Load Operation

The problem with no load operation of AC/DC Power Module is the output voltage will exceed specified tolerance, maybe +20% or more. In fact, output voltage is undefined when loading below 10% of maximum output current. Keep minimum loading on the output to ensure the output voltage remains within a specified tolerance.

► Safety Instructions

1. Before installation read these instructions carefully and completely. This installation instruction cannot claim for every possible example of installation, operation or maintenance. Further information's are obtainable from your local distributor office or from the product data sheet which can be downloaded from the internet at http://www.minmax.com.tw
2. The power supplies are constructed in accordance with the safety requirements of IEC/EN60950-1 and UL60950-1. They fulfil the requirements of the Low Voltage Directive (LVD) and carry the CE-mark. They are UL and cUL Approved in accordance to UL60950-1 (recognized).
3. Before an installation, maintenance or modification work ensure that the main switch is switched off and prevented from being switched on again. In case of non-observance touching at any alive components or improper dealing with this power supply can result in death, severe personal injury or substantial property damage. The successful and safe operation is dependent of proper storage, handling, installation and operation.
4. Compliance with the relevant national regulations (in the USA, Europe and the other countries) must be observed and ensured. Before operation is started the following conditions must be ensured:

- Connection to mains supply in compliance with national regulations (VDE100 and EN50178).
- By use of stranded wires, all strands must be fastened in the terminal blocks.
- Power supply and mains cables must be sufficiently fused.
- All output wires must be rated for the power supply output current and muse be connected with the correct polarity.
- Sufficient cooling must be ensured.
- Keep away from fire and water.
- Never work on the power supply if power is supplied! Risk of electric arcs and electrical shock which can cause death, severe personal injury of substantial property damage.
- Warning : Hazardous voltages and components storing a very substantial amount of energy are present in this power supply during normal operation conditions. However, these are inaccessible. Improper handling may result in an electric shock or serious burns!

Δ Do not open the power supply until at least 5 minutes after if has been disconnected from the mains on all poles.

► Installation Instructions

- This power supply is designed for professional indoor systems. In operation the power supply must not be accessible; it may be installed and put into service by qualified personnel only.
- The correct mounting position for optimal cooling performance must be observed. Observe power derating. (See data sheet)
- Recycling : The unit contains elements which are suitable for recycling, and components which need special disposal.

You are there fore requested to make sure that the power supply will be recycled by the end of its service life.