# AC-DC Converter Application Guidelines

## 1. Foreword

The following guidelines should be carefully read prior to converter use. Improper use may result in the risk of electric shock, damaging the converter, or fire.

### 1.1 Risk of Injury

**A.** To avoid the risk of burns, do not touch the heat sink or the converter's case.

**B.** Do not touch the input terminals or open the case and touch internal components, which cold result in electric shock or burns.

**C.** When the converter is in operation, keep hands and face at a distance to avoid potential injury during improper operation.

### 1.2 Installation Advice

**A.** Please make sure the input terminals and signal terminals are properly connected in accordance with the stated datasheet requirements.

**B.** To ensure safe operation and meet safety standard requirements, install a slow blow fuse at input of the converter.

**C.** Installation and use of AC-DC converters should be handled by a qualified professional.

**D.** AC-DC converters are used in the primary transmission stage of a design and thus, should be installed in compliance with certain safety standards.

**E.** Please ensure that the input and output of the converter are incorporated into the design out of the reach of the end user. The end product manufacturer should also ensure that the converter is protected from being shorted by any service engineer or any metal filings.

**F.** The application circuits and parameters shown are for reference only. All parameters and circuits are to be verified before completing the circuit design.

**G.** To keep long life & good reliability, it requires 2 hours burn-in process every half year if our converter isn't used or just kept in stock for more than half a year.

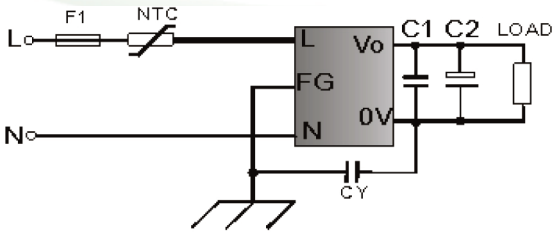
**H.** It's no problem if there is some slight noise inside of the converter when operated with little or no load.

**I.** We can't keep every customer well informed about this change, therefore please pay attention to our latest information, for other questions, please contact our technical service.

## 2. General AC-DC Converter Applications

### 2.1 Basic Application Circuit

**Figure 1.**
1. General AC-DC converter applications circuit




In Figure 1. F1 refers to the input fuse. Proper fuse selection should be a safety agency approved, slow blow fuse. Selection of the proper fuse rating is necessary to ensure power converter and system protection (potential failure if the rating is too high) and prevent false fuse blowing (which could happen if the rating is too low).

**Below is the formula to calculate the proper rating:**

**I** = 3 x Vo1 x Io1 / η / Vin (min.)

**Vo1** = output voltage

**Io1** = output current

η = the converter's efficiency

**Vin** (min) = the minimum input voltage

**Futher circuit notations:**

- **NTC** = is a thermistor.
- **CY and CX** = are safety capacitors.
- **C1** = is a high frequency ceramic capacitor or polyester capacitor, 0.1µF/50V.
- **C2** = is output filtering high frequency aluminum electrolytic capacitor. Select a 220µF rating if the output current is greater than 5A, or a 100µF rating if the output current is less than 5A. The insulation voltage should be derated to less than 80% of rated value.

For dual or triple output converters, the circuit of input side remains the same and the outputs should be considered independently in component selection (see Figure 3). The application circuit shown in Figure 1. is typical application circuit, whereby all GAPTEC products will meet EMI Class B, and Class 3 lightening strike and surge testing (see datasheets for more details). To comply with more stringent EMC testing, additional filtering should be incorporated.

**See Figure 2. for a suggested filtering circuit:**

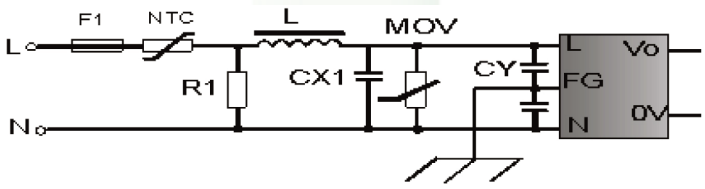



**Figure 2.**
Input filter circuit

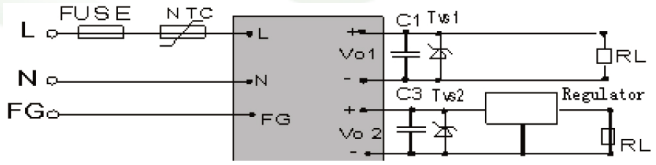



**Figure 3.**
Typical application circuit

For multi-output converters, the main output is typically a fully regulated output. If the end application requires critical regulation on the auxiliary output(s), a linear regulator or other regular should be added after the converter.

Please note: Some converters have built in linear regulators; please contact our technical support for more information.

## 3. AC-DC Converter Safety Related Design Notes

### 3.1 Marking Requirements

Wherever there are fuses, protective grounds, or switches, clear symbols should be indicated according safety standards. Touchable dangerous high voltage and energy sources should be marked with “Caution!” indications.

### 3.2 Input Cable Requirements:

Input cables of L, N and E should be brown, blue and yellow/green cables, respectively. Ensure that the ground cable (yellow & green cable) of Type I devices (those that rely on basic insulation and protection ground to avoid electric shock) are securely connected to the ground, and the earth resistance is lower than 0.1Ω

### 3.3 Clearance and Creepage

For Type I devices, ensure:

- L and N are in front of the fuse.
- The clearance distance between the input and the metal case is above 2mm and creepage is above 2.5mm.

For Type II devices (those that rely on strengthened insulation or double insulation to avoid electric shock) ensure:

- L and N are in front of the fuse
- The clearance distance between the input and the metal case is above 2mm and creepage is above 2.5mm.
- The clearance between the input and the metal case or SELV is above 4mm, and creepage of that is above 5mm.

### 3.4 Input energy

If the input capacitor is large, a discharge resistor may be added to ensure that, after disconnect, the voltage held between Input L, N, and the protective ground will be discharged to 37% of its maximum value or below. In Figure 2, R1 is the discharge resistor.

## 4. Heat Dissipation in AC-DC Converter Module Applications

Trends toward higher density in AC-DC module designs make heat dissipation an important concern. The effect of heat on the electrolytic capacitor is of particular concern, as the life of such capacitors can be drastically reduced when operated in a constant high temperature environment, leading to a higher potential for failure. Proper handling of heat will increase the life of the converter and surrounding components, thus lowering risk of failures. Some suggestions for handling dissipated heat are summarized, below:

### (1) Ambient Air Cooling

For miniature and high power density converters, free air cooling is recommended, mainly due to cost and space concerns.

- Heat dissipates to the ambient air through the converter case or exposed surfaces. Heat may also dissipate to ambient air if there is a gap between the converter and the PCB.
- Heat dissipates from the converter case and exposed surfaces to PCB by radiation.
- Heat conducts through terminals (pins) to PCB.

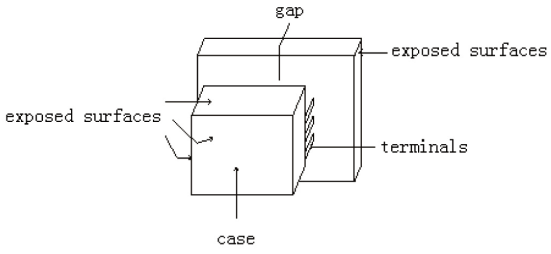



**Figure 4.**
Converter assembled on PCB

**In such as before mentioned applications, please pay particular attention to:**

### A. Air Flow

Because the heat dissipation is mainly through convection and radiation, the converter needs an environment with good air flow. It may be helpful to design heat dissipation venting holes throughout the end product, near the converter's location. For best convection cooling, ensure that air flow is not blocked by large components.

### B. Layout of Heat Generating Components

In most applications, the AC-DC converter is usually not the only heat generating component. It is recommended to keep a good distance between each heat generating component to minimize heat dissipating clusters.

### C. PCB Design

The PCB, which the power converter is assembled on, is not only a base to mount the converter, but also acts as a heat sink for it, therefore heat dissipation should be considered in PCB layout. We recommend to extend the area of the main copper loop and decrease the component density on the PCB to improve the ambient environment.

### (2) Heat Sinks

When free air convection is insufficient, we recommend the use of a heat sink for further cooling. As the converters are filled with heat conductive silicon or epoxy, the heat distribution in converters is even and it radiates from the converter to the air. The efficiency of this convection is dependent on the size of the surface area of the converter. The use of heat sinks is a practical method to add surface area and improve the convection. There are many kinds of heat sinks available in the market. GAPTEC recommends considering the following factors in selecting a heat sink:

- The heat sink should be made of a good heat conducting material, such as aluminum and copper.
- The larger the surface area, the better the radiation. Therefore, heat sinks usually have a ridged surface or special coatings to make a larger surface area.
- Use the longest and thickest possible heat sink for best convection.

Heat sinks are best attached to the converter's surface, where the difference in temperature between the surface and the ambient is largest. The use of heat conductive material between the heat sink and the converter's surface to make a better contact and to improve heat conductance is suggested. To avoid case distortion, please do not affix the heat sink too firmly to the converter case.

### (3) Forced Air Cooling

In some systems, where a heat sink does not effectively reduce the ambient temperature, a fan is used to improve the heat radiation. Fans can lower the surface temperature of the converter, but large fans also occupy extra space in the system. It is important to select a suitable fan size, where the speed of the fan will determine how effective it is. The faster the speed, the better the effect on reducing radiated heat. As high speed will also cause increased noise, there is a need to balance the choice between how effective the fan should be against how much audible noise it generates.

A long, rectangular shaped AC-DC converter should use a horizontal fan, and channeled heat sinks should use vertical fans, in order to encourage air flow through the channels.

## 5. Input Under Voltage Impact

### 5.1 Block Diagram of AC-DC Converter

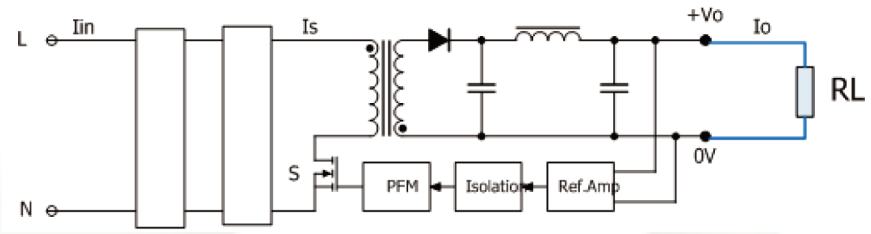
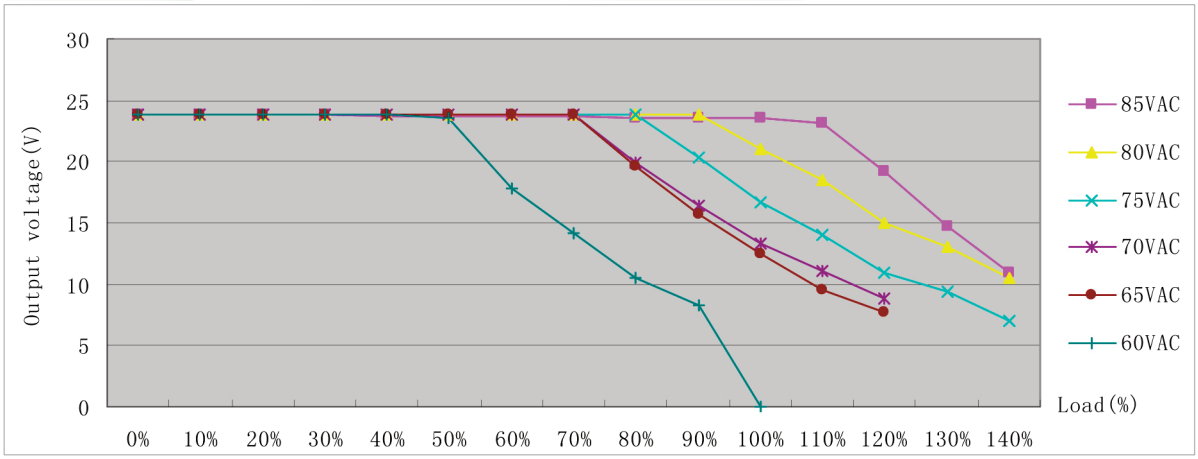



**Figure 5.**
Rectifier filtering

### 5.2 Impact to Converter Reliability

The input voltage range of GAPTEC's AC-DC converters is 85~264VAC or 120~370VDC. When the converter is operated within the rated input voltage range, the output current can be used up to the maximum rated specification. The total output power is Io x Vo. If the converter is operated with an input voltage that is under the rated voltage, offering the same output power of Io x Vo, causes the current (Is) at the transistor (S) to be increased. Long term operation under this condition will damage the transistor (S).

### 5.3 Input Voltage vs Load Capability (3ACA_3R series)




| Load | 0% | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 110% | 120% | 130% | 140% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 85VAC | 23.85 | 23.82 | 23.79 | 23.77 | 23.74 | 23.71 | 23.68 | 23.65 | 23.61 | 23.58 | 23.57 | 23.19 | 19.2 | 14.7 | 11 |
| 80VAC | 23.83 | 23.82 | 23.82 | 23.83 | 23.82 | 23.82 | 23.81 | 23.81 | 23.81 | 23.8 | 21 | 18.5 | 15 | 13 | 10.5 |
| 75VAC | 23.83 | 23.83 | 23.83 | 23.83 | 23.82 | 23.82 | 23.82 | 23.81 | 23.77 | 20.29 | 16.65 | 14.02 | 10.98 | 9.39 | 7.04 |
| 70VAC | 23.83 | 23.83 | 23.83 | 23.83 | 23.82 | 23.82 | 23.81 | 23.79 | 19.96 | 16.44 | 13.32 | 11.14 | 8.79 | | |
| 65VAC | 23.83 | 23.83 | 23.83 | 23.83 | 23.82 | 23.82 | 23.82 | 23.8 | 19.6 | 15.67 | 12.46 | 9.57 | 7.65 | | |
| 60VAC | 23.83 | 23.83 | 23.83 | 23.83 | 23.82 | 23.51 | 17.86 | 14.13 | 10.52 | 8.28 | 0 | | | | |

APPLICATION NOTES