Thursday, January 29, 2009
What Size Fan Do I Need?

There are many AC-DC power supplies and DC-DC converters with output power ratings that can vary dependant upon the type of air cooling provided. "Convection air cooling" usually refers to situations where a power supply or converter is cooled by the prevailing ambient air temperature, adjacent to the power device, without forced-air-flow from fans or blowers. If the power device has two output power ratings, the "convection cooled" (still-air) power rating is lower than the "forced-air convection cooled" rating.
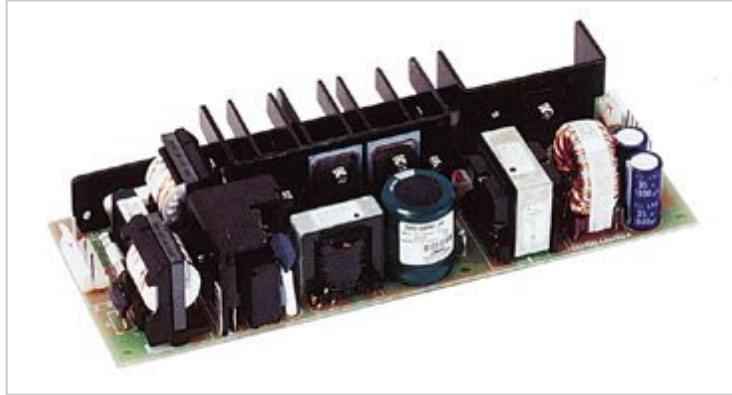
The power supply pictured above is an open frame switchmode supply with two output power ratings. For "convection cooled" applications, this supply can provide up to 151W of output power. However, with "forced-air-cooling" it can provide up to 201W of output power. The datasheet for this power supply indicates that for "forced-air-cooled" applications, 1.5 m/s (Meters per Second) must be provided by the user. 1.5 m/s equals 295 LFM (Linear Feet per Minute). Refer to conversion factors shown below.

Most fans are rated in CFM or Cubic Feet per Minute of air "Volume" flow. So, what size fan do you need to provide 295 LFM of air "Velocity" flow for the above application?

Most times the power supply is cooled by directing the air flow along its longest dimension; for example, from the input connector end to the output connector end. However, always read the power supply's instruction manual to determine the manufacturer's recommended axis for the cooling air-flow. The usual method for determining the required fan size is to first determine the height and width for the opening or port through which the air will flow around and through the power supply. In this instance the power supply is 3.15" wide and 1.46" high (and 8.2" long). We can consider the supply's width times its height as the minimum area of the inlet port for forced air cooling of the supply. Then, we need to convert these dimensions from inches to feet by dividing by 12". 3.15" = 0.26' and 1.46" = 0.12'. So, the minimum "Area" of the port through which the air must flow to cool the power supply is 0.26' x 0.12' = 0.0312 square feet. The formula for determining the CFM (volume) rating of the fan when the required LFM (velocity) is known is as follows:

CFM = LFM x Area (in square feet)

Therefore, in this example:

CFM = 295 LFM x 0.0312 ft^2 = 9.2 CFM (min. fan rating)

Fans are rated in CFM based upon the expected free-flow of the air coming from them, without obstructions, which cause back-pressure. Of course, real world applications always include some obstructions. To ensure the least amount of back-pressure, it is best to have the exit ports in the enclosure about 1.5 times the area of the minimum entry port. In most applications there are other heat loads and components that can obstruct the path or free flow of the cooling air. It is therefore wise to select a fan with a higher rating than is calculated. Perhaps a 10 CFM or larger fan should be used in this application.

Tip: The use of a larger fan running at a slower speed can deliver the same airflow as a smaller fan running at a higher speed, but the larger fan will be much quieter.

Since most fans have round air outlets and square mounting patterns, the air-flow from the fan may require ducting within the end-product's enclosure to direct the cooling air to the high power devices including the power supply.

The same process would be used to determine the correct fan rating for AC-DC power modules or DC-DC converters, with or without heatsinks that require forced-air-cooling. When heatsinks are used (see photo below), always direct the air flow in the same direction as the slots between the fins of the heatsink.

In all situations, the system must be tested with the selected fan and all other devices in-place to confirm that the power supply or converter and the load it drives do not exceed their maximum operating temperature, under worst case conditions (maximum ambient inlet air temperature, 100% power load, etc.). If problems are observed, a higher CFM rated fan or dual fans may be required.

In the metric world, fans are sometimes rated in "m^3/hr" (Cubic Meters per Hour) and the air velocity is rated in "m/s" (Meters per Second). The following Metric to English conversion factors may be useful.

$1 \ m^3$/hr = 36 ft^3/hr ÷ 60 min. = 0.60 CFM (cubic feet per minute)
1 m/s = 3.28 ft/sec x 60 sec = 196.85 LFM (linear feet per minute)

Some fans and power supplies have dimensions in mm (millimeters).
Just remember that 1 inch = 25.4 mm, and 1 mm = 0.04"

There are a number of very good online calculators to assist you in determining the fan size and ratings required for various forced-air-cooling applications. Here are a few of those websites:

http://www.airperformancetech.com/conversion-tools.htm
http://www.aavidthermalloy.com/technical/airflow.shtml
http://www.calculatoredge.com/optical%20engg/air%20flow.htm

Posted by Power Guy