Comparative analysis of power supply single speed air mover and an entire electronics enclosure system fan

Typical densely packaged electronic systems and power supplies utilize a fan for forced-air cooling. Power supply cooling technology often follows computer electronic thermal solutions such as the following:

- Thermal vias
- MOSFET surface mount packaging
- Power transfer by bonding exposed leads to a thermal plan on printed circuit boards
- Metalized substrates
- Isolation materials
- Laminar bus bars
- Direct bond copper
- Isolated metal substrates
- Glass on epoxy
- Thick film on ceramic
- Copper on ceramic

Computer systems process information, whereas power supply systems process power. With both systems, electrical energy goes in and physical heat comes out.

The need for forced-air cooling should be determined at an early stage in system electronics enclosure design. It is important that the Systems Designer have electrical, mechanical, magnetic, thermal, acoustic and chemical knowledge to design good airflow to heat-generating components. It is also important to allow adequate space and power for the physical cooling solution. The first stage in designing a forced-air cooling system is to estimate the required airflow. The primary variable depends on the heat generated within the enclosure and the maximum temperature rise permitted. AC input power is a good initial estimate of the power dissipated within the enclosure. In estimating the power dissipated within a system, the power dissipation figure used should be a worst-case estimate for a fully loaded system.

Airflow calculations using heat dissipation and temperature rise for system impedance characteristics.

The required airflow is obtained either by calculation or from a standard graph. The equation for calculating the required airflow through an electronics enclosure is as follows:

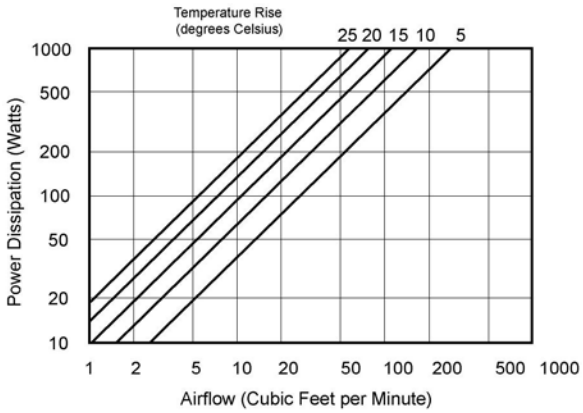
$$Q = 1.76\ W / T_C$$

Where:
Q = Airflow required in CFM
W = Heat dissipated in watts
Tc = Temperature rise above inlet temp ° C

For example, how much CFM air-cooling does a system need that dissipates or consumes 300 Watts, allowing only a 10 degree C rise? The above equation results in 52.8 CFM.

This equation can be graphed on the following logarithmic chart (Figure 1) with the vertical axis representing the heat to be removed and the horizontal axis representing the airflow; both axes are logarithmic. The sloping lines define the temperature rise in degrees C. Use the graph by locating the sloping line that represents the permitted temperature rise. Then, locate the point on this line that corresponds to the heat to be removed. The horizontal position of this point shows the airflow required.

FIGURE 1

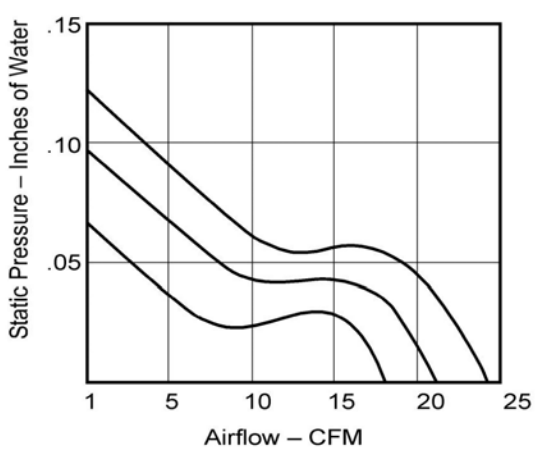


Power Dissipation vs. Airflow for Various Temperature Increases

System Impedance

Because obstructions in the airflow path cause static pressure within the enclosure, determining the actual airflow needed by a fan mounted in an enclosure is much more difficult than calculating the airflow required. Figure 2 shows the nonlinear relationship between airflow and static pressure for a typical fan. Obstructions should be minimized to achieve maximum airflow. Air guiding devices, in the form of baffles, may be necessary to direct the airflow over the components that need cooling.

FIGURE 2

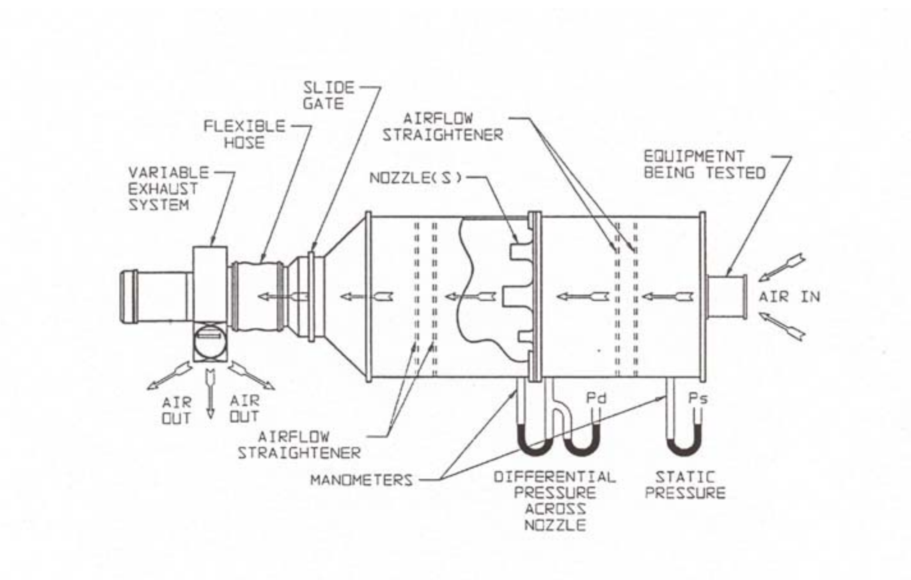


Typical Relationship between Airflow and Static Pressure for an Axial Cooling Fan

Static Pressure for an Axial Cooling Fan

The experimental method of finding airflow through an enclosure is not very accurate and also very time-consuming. An airflow chamber is required, as shown in Figure 3, and caution must be taken to simulate real application use of the electronics enclosure being tested.

FIGURE 3



This article provides the following rules used to estimate airflow resistance:

- An empty enclosure usually reduces airflow by 5 to 20%.
- A densely packed enclosure reduces airflow by 60% or more.
- Most large tower computer electronic enclosures have a static pressure of between 0.05 and 0.15 in. H_20.

Assuming a dense package, the fan in the previous example should be capable of delivering 80cfm in free air, instead of 52.8 cfm. Most experienced designers are aware that fan manufacturers use the most optimistic statistical figures to represent their products.

Intake, Exhaust, and Baffles

System Designers have the option of mounting an air-cooling device to:

a) Exhaust warm air from the enclosure, or
b) Blow cool air into the enclosure.

Theoretically, the same volume of air is used to dissipate heat. Depending on the specific real world application, each arrangement has advantages and disadvantages.

Incoming air flows laminarly, which means air drawn into the enclosure, is flowing laminarly. Laminar flow allows for a uniformly distributed airflow in the enclosure. This is important in eliminating stagnant air and possible hot spots.

Air exhausted out of an enclosure is turbulent. Heat dissipation in a turbulent airflow could be double that of a laminar flow with the same volumetric flow rate. Thermal-Mechanical Engineers will agree that turbulent airflow is desirable in cooling solutions.

The turbulent airflow region near a fan exhaust is limited to a very short distance, depending on the size of the fan. This is why it is desirable to have a heat sink, or the components needing the most cooling, immediately at the fan output. Developing a well-defined airflow path through the entire enclosure is extremely important. Air vent area should be 50 percent larger than the fan opening. This is why most system exhaust fans are placed at the output of a computer or power supply enclosure.

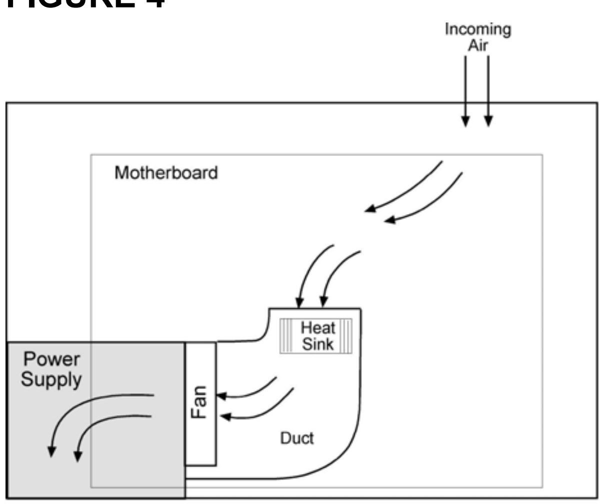
Recirculatuion is desirable for very large computer server systems. However, in most small electronic enclosures, air recirculation should be avoided. With small form factor fans, all of the airflow can be lost because of recirculation problems.

Baffles, shrouds, or ducting systems are often necessary to eliminate recirculation of the same air and direct air on to or away from hot spots. The airflow path as electricity will always take the path of least resistance. Physical subassemblies and components within the enclosure, such as large capacitors and circuit boards, could be smartly positioned to direct the airflow to places that require cooling. Natural convection cooling should take precedence in electronic enclosure designs. Therefore, a Systems Designer should place warm components above cool components, much the same way heavy components are placed on the bottom of rack systems.

Fans used to exhaust heat from an electronics enclosure reduce the pressure within the enclosure and dust is drawn in through all the vents and openings. Dust accumulation can produce many problems. Because exhaust fans tend to operate under hotter conditions exhaust fans can be half the life of an intake fan.

A chief recommendation of this article is to use a single systems fan that ventilates an entire electronics enclosure and the power supply is recommended as shown in Figure 4.

FIGURE 4



Top View of Computer Chassis

Notice that this system recommendation uses a baffle ducting system, which evacuates hot air from the electronics enclosure while pushing air through the power supply. This design economizes cooling solutions and requires that a single systems designer be responsible for both power supply and electronics system thermal solutions.

A variable speed fan is recommended to reduce noise and maximize power efficiency. Notice that most power supply fans simply run at a fixed speed. Applying additional airflow through the power supply will not adversely damage the power supply circuits. With a variable speed fan, the fan circuit automatically controls the speed. JMC has recently patented a software controlled SMBus/I2C OS or BIOS configurable Intellifan. The Intellifan is independent of analog circuitry and imprecise thermistors. As the temperature changes, the fan speed adjusts precisely. Optimum airflow is obtained at all times.

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