SmartFan® *Adaptive Cooling and Ventilation*

SmartFan Benefits

Which of SmartFan's many benefits is most important depends on the particular application. In nearly all applications noise reduction, energy savings, temperature regulation, increased safety and fan service life are important. In HVAC applications, SmartFan adds comfort and convenience. When used in electronic equipment, SmartFan also increases reliability, makes fan choice less critical and permits reduced package size.

Noise Reduction

Whether at home or in the workplace excessive noise is distracting and tiring. It annoys. In some cases it interferes with normal face-to-face or telephone communication. Or, it may interfere with a worker's efficiency.

Noise is an important factor in the perceived quality of a product. All else being equal, a quieter product will always be chosen over the one that emits more noise. Though noise regulations exist in the United States, they are a more important force in Europe where many U.S. manufactured products are sold.

The equation below shows the 5th power relation between noise level and fan speed.

$$L = 50 \log R$$

Where L is the reduction in A-weighted noise level in dB(A), and R is fan speed as a fraction of full speed. Solving this equation for R = 1/2 (idle speed of 50%) shows the dramatic 15 dB(A) noise reduction possible with SmartFan.

Energy Savings

Reduced air mover speed means lower electrical power consumption. Power savings range from 50 to 75% at idle speed, depending on the fan type (AC or DC) and SmartFan controller model. The benefits of reduced power include not only cost savings but in battery operated equipment, extended battery life.

EPA's Energy Star Guidelines require that computer equipment be automatically switched to a reduced power mode when its full capability is not in use. SmartFan automatically senses a temperature change due to power reduction and reduces fan power and speed while holding temperature constant.

Temperature Control

Fans and blowers are inherently air flow controlling devices. But the goal in cooling applications is temperature control. SmartFan converts a fan or blower into a temperature regulator. Whether in an HVAC or equipment cooling application, SmartFan provides just the airflow needed to hold a predetermined temperature, no more and no less.

Close regulation of air or component surface temperature is important in many equipment cooling applications. Speed and air flow variations due to power line voltage and frequency (50 or 60 Hz) changes may result in unacceptable temperature changes. With SmartFan these variations, and the temperature changes caused by them, no longer exist.

Safety

By providing a warning of air mover failure an audible, visual or electrical alarm can avert disaster. An electrical alarm can even be used to shut down equipment or switch it to an idle mode. SmartFan alarms used in combination with a speed controller or separately, monitor temperature, fan speed or fan current.

Increased Fan Life

Bearing failure caused by heat and wear is the most common reason for fan and blower failure. By running air movers at reduced speed much of the time, SmartFan significantly increases bearing and fan life.

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Comfort and Convenience

In ventilating and air-conditioning applications, SmartFan enhances comfort by automatically adjusting air flow as needed. The annoyance of a blower that switches on and off, moving first too much air and then too little, is avoided.

Reliability

By regulating temperature, SmartFan improves equipment reliability. In systems with multiple air movers, should one fail, SmartFan simply increases the speed of the others to maintain air flow and temperature. In medical laser equipment, regulating temperature can greatly increase the service life of the laser tube.

MTBF studies on SmartFan controllers show values in the range of 10^6 hours, depending on model and operating temperature. According to manufacturers' data the service life of most air movers is less than 10^5 hours. SmartFan itself is inherently more reliable than the air movers it powers.

Fan Choice Less Critical

In fixed-speed designs and in speed controlled systems that compensate for room temperature changes (open loop), a change in fan model can create a problem. Fan models that seem identical often have different speeds and air flows. Substituting one model for another can result in a substantial change in air flow and noise level. The product becomes hotter or noisier. The closed loop temperature regulating SmartFan principle eliminates model-to-model and unit-to-unit variations.

Air Flow Is Independent of Power Line Frequency and Voltage Variations

A SmartFan controller makes speed and flow identical for 50 and 60 Hz power lines. It is well known that air movers run at lower speeds at 50 Hz than at 60 Hz. The speed drop depends on the fan design, but it is often about 15%. Making allowance for a 50 Hz line means that at 60 Hz, the fan or blower will run faster, moving more air and emitting more noise.

SmartFan is designed to eliminate this problem. In the control region, the fan must run at the same speed to maintain Control Temperature, whether connected to a 50 or 60 Hz power line. In the idle region too, SmartFan takes into account the power line frequency making idle speeds nearly identical.

In the idle region, an AC SmartFan controller serves as voltage regulator. A large change in line voltage results in only a small change in voltage applied to the fan with a correspondingly small change in idle speed.

The SmartFan Controller Principle

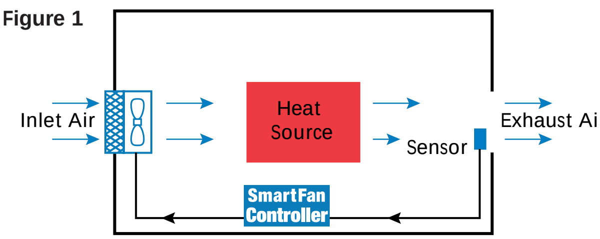
Operating a fan or blower at full speed continuously or possibly cycling it on and off is a sub optimal solution in most cooling and ventilating applications. Ideally, the fan or blower should be controlled to operate at whatever speed is necessary to satisfy the need of the moment, no more and no less.

The SmartFan Control Principle is graphically illustrated in an interactive demo on our WEB Site at

http://www.controlres.com/demo.htm

You choose system temperature rise, noise level and power consumption of a cooling system. The demo shows how SmartFan affects these parameters as inlet air temperatures vary.

Figure 1



As shown in **Figure 1**, SmartFan senses temperature down stream from an enclosed heat source, usually at an exhaust port and holds it nearly constant. Temperature is continually monitored by a sensor connected to the electronic controller. The controller powers the air movers, automatically adjusting their speed over a predetermined range.

The heat source may be electronic circuit boards, a heat exchanger, furnace or sun load on an enclosure. In some applications, the controller also automatically switches air movers on and off. Fans can be mounted at an air inlet, exhaust port or location between.

Controller Application in Electronic Equipment

SmartFan is used in computer workstations, file servers, telecommunications, test and medical equipment to reduce noise, regulate temperature and extend air mover service life.

Figure 2

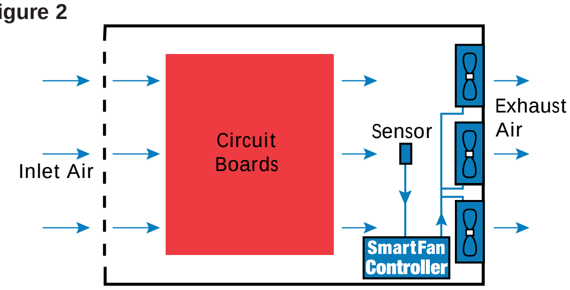


Figure 2 shows a three fan installation with both sensor and controller board located in the exhaust air stream. Alternatively, the sensor can be placed at any down stream location or mounted on a component or heat sink to control surface temperature directly. Controllers are available for DC or AC fans with power ratings ranging from 12 watts to over 1000 watts. In some applications, several logically OR'd air and/or surface sensors are used. Then, the sensor requiring the greatest air flow automatically controls the fans.

Figure 3

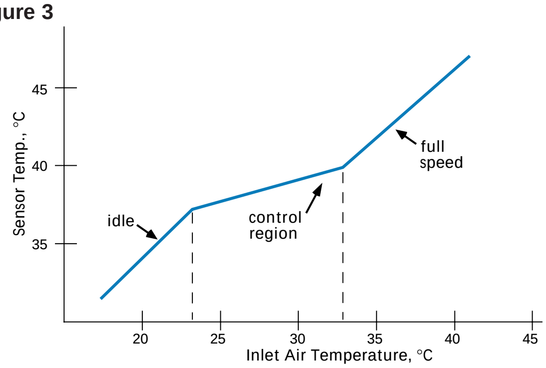


Figure 3 shows the relationship between inlet and exhaust temperatures for a system with a 7°C temperature rise (at full speed) using a 40°C control temperature. SmartFan also responds to changes in equipment power dissipation, flow resistance, atmospheric pressure and altitude, always maintaining near constant temperature. Temperature is held within about 3°C by varying fan speed from maximum at the Control Temperature down to about one-half speed at 3°C below the Control Temperature.

Figure 4

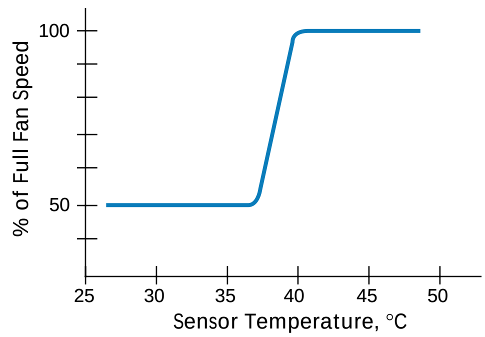


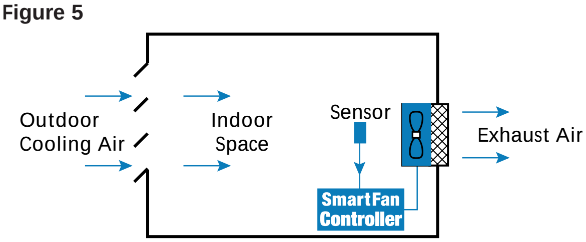
Figure 4 shows this relationship for a 40°C Control Temperature. Permitting air temperature to change somewhat when fan speed and air velocity are varied helps regulate semiconductor junction temperatures for greater reliability.

An option available on most SmartFan models is a temperature alarm triggered at 10°C above Control Temperature. Alarms that sense fan speed or the electrical current delivered to the fan are available separately or in combination with speed controllers.

Controller Application in HVAC Equipment

SmartFan is used in HVAC applications to reduce noise, save energy and increase comfort and convenience. Under normal thermal load conditions, fan noise is substantially reduced and energy use is cut in half. The thermal shock, discomfort and inconvenience from fans switching on and off is avoided. A typical ventilating application is shown in **Figure 5.** Outdoor cooling air is drawn indoors only at the rate necessary to maintain near constant temperature inside. The fan is automatically switched on to run at a low speed at a preset temperature. Above this temperature, speed is proportionally controlled to regulate temperature. When the indoor space is sufficiently cooled, the fan switches off.

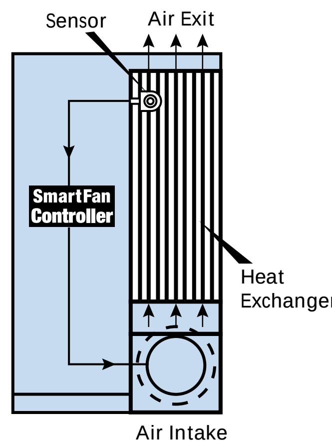
Figure 5



Controlling the speed of a whole house fan, power attic ventilator or stove fan can reduce noise, save energy and by automatically regulating temperature, increase comfort and convenience.

Most SmartFan controllers are supplied for use directly with a temperature sensor as described above. However, in more complex HVAC applications SmartFan AC-V (pg. 22) and AC-VX (pg. 24) can accept a voltage or current loop control signal and proportionally control fan speed as well as turn the fan on and off.

Figure 6



In the heat exchanger application shown in **Figure 6**, surface or fluid temperature is sensed. The SmartFan controller then forces the fan to run at the speed necessary for constant fluid temperature. Noise is reduced and energy saved. In HVAC applications, an alarm based on sensor temperature, air mover speed or electrical current delivered to the air mover can be provided.

SmartFan Alarms

Should a fan or blower in a cooling or ventilating application fail to operate properly, the results can be disastrous. In computer and telecommunication equipment, failure of an air mover may cause operational failure or even permanent damage. In ventilating applications, contaminants may build to dangerous levels, equipment may fail or livestock may perish.

There are at least four effective methods of detecting air mover failure.

Measuring air or surface temperature is fundamental. In combination with speed control it adds little cost because the sensor used to control speed can also provide a signal to the alarm circuitry. Alarms based on sensing critical surface temperatures are very effective. One disadvantage when air temperature is sensed is a possible delay after air mover failure, before the alarm is triggered. A temperature alarm will of course, also respond to failures other than the air mover. For example, operation of equipment at excessive ambient temperature or a clogged air filter could also trigger the alarm.

Air mover speed is sensed using pulses generated by a Hall Effect device installed in the fan. Below a predetermined speed, an alarm is triggered. This method is very reliable, however it requires a special fan with a Hall Effect output. Because the Hall Effect device is part of any brushless DC fan, the output adds little to cost. This feature may add significant cost to an AC fan and may not be available on some.

The electrical current delivered to the air mover is a good indicator of performance. It is easily monitored for AC as well as DC fans and requires no special fan features. It is inexpensive and because most failures will result in abnormal current, quite reliable. Both high and low current limits can be set but usually, only a low limit is necessary.

The speed of a DC air mover can also be determined by sensing the electrical current pulses delivered to the fan. Though this method is somewhat more costly than that based on Hall Effect pulses, no special fan feature is required.

Alarms are available as an **electrical signal** to drive logic, as a **visual signal** (e.g. using an LED) or as an **audible signal** (e.g. using a piezo alarm). Any or all of these alarm signals can be provided to satisfy a particular application.