# Airflow Monitor

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Fans are usually monitored by measuring their operating currents. If the current lies within a certain range, it is assumed that the fan is spinning properly and providing a stream of cooling air. If it falls below a lower threshold or exceeds an upper threshold, something is wrong with the fan: it is either defective or blocked by some sort of object.

The cooling airflow generated by a fan can be directly monitored using the Analog Devices TMP12 sensor IC (www.analog.com). This IC contains a temperature sensor and a heater resistor, as well as two comparators and a reference-voltage source. **Figure 1** shows the complete circuit diagram of an airflow monitor. The voltage divider formed by R1, R2 and R3 defines the temperature thresholds and the hysteresis for the switching points (via the current $I_{REF}$ flowing through the resistor chain). The internal heater resistor can be powered directly from the supply voltage via pin 5 (Heater), but an external resistor (R5) can also be connected in series between the supply voltage and pin 5 to reduce the internal power dissipation of the IC. The circuit output is provided here by two LEDs driven by the open-collector outputs $\overline{\text{UNDER}}$ (pin 6) and $\overline{\text{OVER}}$ (pin 7).

The operating principle of the TMP12 IC is that it is warmed by the integrated heater resistor and cooled by the airs flow. If there is no airflow or the airflow is insufficient due to a defective fan or obstructed air inlet, the temperature increases until the amount of heat dissipated by the IC (by conduction to the circuit board or other means) balances the amount of heat generated inside the IC. **Figure 2** shows this in the form of two curves. The power dissipation of the internal 100-Ω heater resistor is plotted on the X axis. This can be as much as 250 mW if pin 5 is connected directly to +5 V. If the heater resistor is not dissipating any power, the sensor will be at approximately ambient temperature, which is here taken to be +50 °C. If the power dissipated by the heater resistor increases, the level to which the temperature of the IC will rise can be read from the two curves, which show the situation with and without cooling airflow. As indicated, the temperature thresholds $T_{SETHIGH}$ and $T_{SETLOW}$ are dimensioned such that with the amount of power converted into heat by the resistor (in this case, 250 mW), the temperature for the curve with cooling airflow lies between the two temperature thresholds. Here the threshold temperatures are +55 °C and +60 °C.

The voltage divider R1/R2/R3 determines not only the absolute positions of the temperature thresholds, but also the hysteresis of the switching points. The hysteresis is determined by the current $I_{REF}$ flowing through the resistor chain. The associated formulas are shown in **Figure 3.** Here ΔT is the hysteresis, which in this case is set to 2 °C and yields a value of 17 µA for $I_{REF}$. The node voltages for the voltage divider can now be determined from the threshold temperatures, which in this case yields $V_{SETHIGH}$ = 1.666 V for an upper threshold

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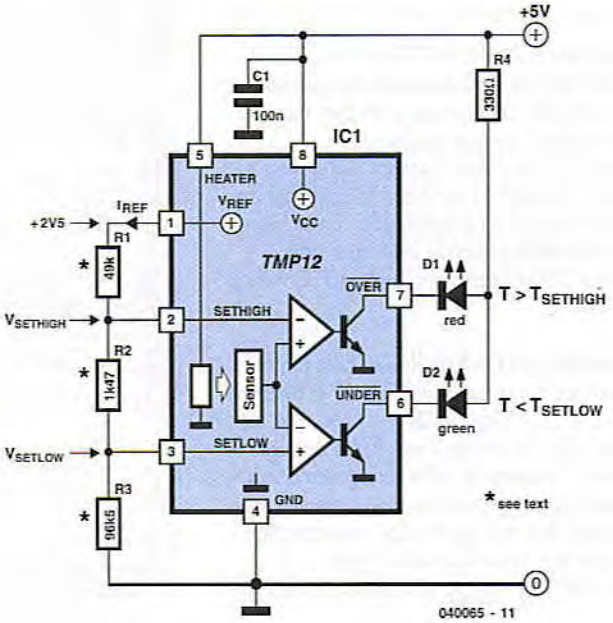


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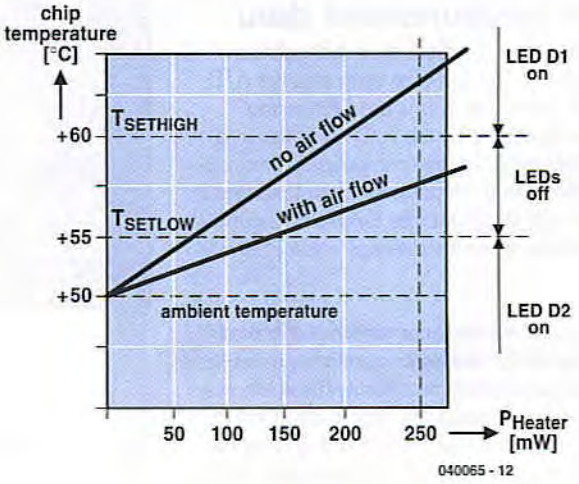


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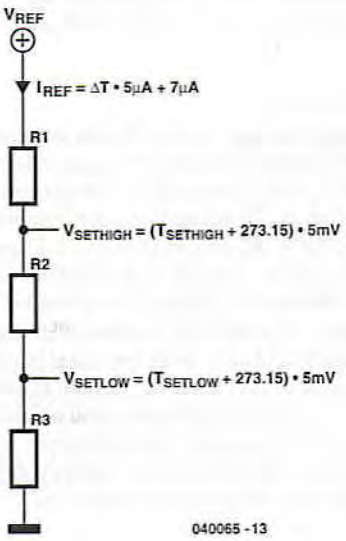

of +60 °C and $V_{SETLOW}$ = 1.641 V for a lower threshold of +55 °C As $V_{REF}$ = 2.5 V, the values of R1, R2 and R3 can now be readily calculated from the current and the voltage drops across the resistors. The values calculated in this manner are shown in the schematic diagram, without taking into account whether such values are actually available. As the temperature thresholds used here are relatively close together, the actual values of the resistors must be quite close to the calculated values. This can be achieved by connecting standard-value fixed resistors in series and/or parallel, or by using trimpots.

The TMP12 can be used to generate digital monitoring signals for a processor or switch on a supplementary fan (via a driver stage connected to the outputs). Another possible application is controlling an oven that is switched off by the TMP12 when it reaches its set-point temperature. Such an oven can be used to operate a crystal oscillator at an elevated temperature in order to make it insensitive to temperature variations (a crystal oven). According to its data sheet, the IC can be used at temperatures between –40 °C und +125 °C.

(040065-1)