APPLICATION NOTE

TSM101 USED IN A THERMOSTAT

by R. LIOU

This technical note shows how to use the TSM101 integrated circuit to realize a simple Thermostat controlling a fan in cooling applications.

An example of realization is given with the corresponding calculations.

TSM101 PRESENTATION

The TSM101 integrated circuit incorporates a high stability series band gap voltage reference (1.24V 2% precision or 1% with the A version), two ORed operational amplifiers and a current source (1.4mA) as shown on Figure 1.

APPLICATION CONTEXT and PRINCIPLE OF OPERATION

A temperature controlled fan is a common application in all electronic systems confined in a reduced and enclosed volume. As an example, the TSM101 can be used in such applications for Mother Boards cooling, or in SMPS (Switch Mode Power Supplies).

This Thermostat is to be used in association with a temperature sensor (ex LM335). One Operational amplifier of the TSM101 compares the voltage given by the temperature sensor to an internal precision voltage reference, and as soon as the temperature is higher than the preset limit, the output of the operational amplifier is set active (active low) and can switch a fan motor ON.

Figure 2 shows how TSM101 is to be used in this application. Resistor bridge R1/R2 sets the temperature limit. C1 stabilizes the output voltage of the Temperature sensor. R3 ensures the hysteresis of the system.

An improvement is shown on figure 3 where the current source is used to supply the Temperature sensor (with 1.4mA cathode current). This requires that pin 2 and pin 5 be connected to the system ground. This saves the polarization resistor of the temperature sensor.

Figure 1 : TSM101 Schematic Diagram

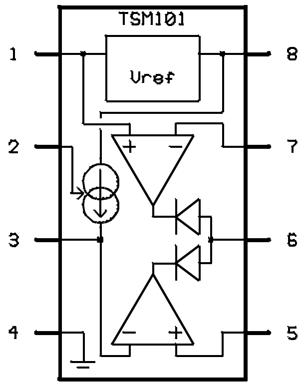


Figure 2 : Basic Thermostat Function

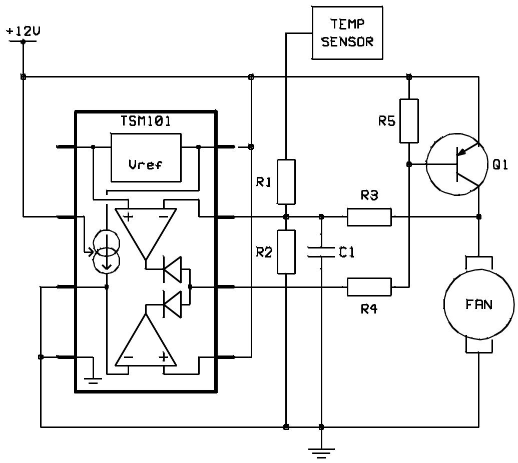
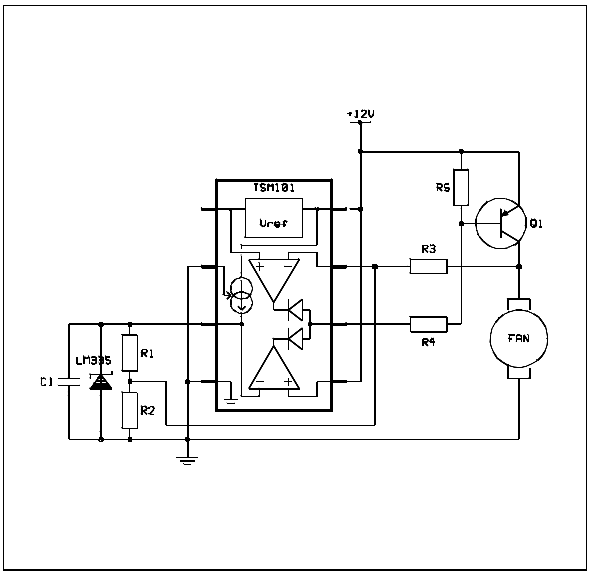


Figure 3 : The Internal Current Source Can Supply the Temperature Sensor



An other improvement can be achieved for Switch Mode Power Supplies (SMPS) where it is useful to start the cooling device as soon as the temperature is too high OR when the overall current is above a preset limit (the cooling device can therefore anticipate on the temperature elevation). This is shown on figure 4 where the drop voltage across the sense resistor R8 is compared to a set limit given by the resistor bridge R6/R7. In this configuration, the fan motor is started either by an overtemperature, or by an overcurrent.

CALCULATION OF THE ELEMENTS

The following calculations apply to an Overcurrent and Overtemperature Fan Controller (figure 4).

Temperature Control :

The temperature upper limit is determined by the resistor bridge R1/R2.

- Vref = Vsensor (T°) x R2 / (R1 + R2)

If the sensor is an LM335, then the voltage function of the temperature is a direct translation of the temperature in Kelvin degrees following :

- V (T°) = T° (°K) / 100.

As an example, at 25°C, the output voltage of the LM335 is (273 + 25) / 100=2.98V.

Let us assume that an acceptable upper temperature limit is 50°C, therefore :

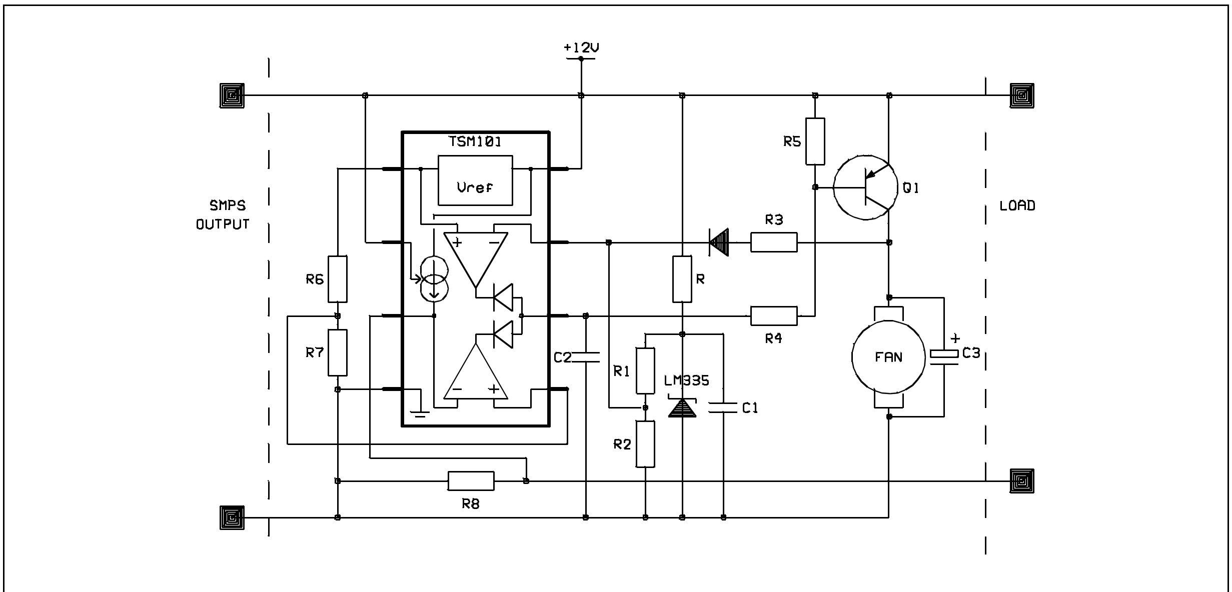
- 1.24 = 3.23 x R2 / (R1+ R2) with R1+ R2 = 30kΩ as a good compromise precision/consumption.
- R2 = 12kΩ, R1 = 18kΩ starts the fan at 50°C.
- C1 = 0.1µF stabilizes the LM335 output.
- R = 10kΩ supplies the LM335.

Current Control :

The current limit is determined by the resistor bridge R6/R7 and the sense resistor R8.

In many applications where it is necessary to reduce temperature with air flow, a common current scale is in between 1 and 10 amps.

Figure 4 : An Overcurrent and Overtemperature Fan Control



Let us assume that TSM101 is used as a thermostat for an application which has a maximum consumption of 10A and requires air flow starting at a current consumption of 2A.

The voltage drop through the sense resistor R8 is given by :

- Vdrop = Vref x R7 / (R6 + R7)

At 10A, a tolerable voltage drop can be chosen as 50mV, therefore, the voltage drop corresponding to 2A is 10mV.

- 0.01 = 1.24 x R7 / (R6 + R7) where R6 + R7 ~ 1.2kΩ to ensure proper charge for the voltage reference.
- R7 = 10Ω, R6 = 1.2kΩ

The sense resistor R8 determines the upper current limit following :

- Vdrop = R8 x Imax
- R8 = 5mΩ

Motor Control :

The power transistor Q1 is controlled via its base resistor R4. To limit the base current to 10mA, R4 should be chosen in the range of 1kΩ. The pull up resistor R5 can be chosen in the range of 10kΩ.

- R4 = 1kΩ, R5 = 10kΩ

The hysteresis on the temperature is determined by R3 : when Q1 is ON, the negative input voltage of the operational amplifier is pulled up ; when it is OFF, the negative input is pulled down. To make a unidirectional hysteresis, a diode is inserted in series with R3 in order to achieve hysteresis when the fan is ON. R3 must be greater than R2 // R1 not to offset the measurement of the temperature sensor.

- R2 // R1 = R1 x R2 / (R1 + R2) = 7.2kΩ = Req

Let us assume that the precision of the temperature control is in the range of +/- 1°C, and that we expect a 5°C hysteresis.

On the input (pin 7) of TSM101, 1°C corresponds to 10mV x R2 / (R1 + R2) = 4mV, therefore, 5°C will correspond to Vhyst = 20mV.

The resistor R3 should have an influence of 20mV on pin 7, following the equation :

- Vcc x Req / (R3 + Req) = Vhyst
- R3 = 4.3MΩ

The capacitors C2 and C3 stabilize respectively the command of the power transistor and filter the noise due to the motor.