THERMISTOR-BASED TEMPERATURE CONTROLLER

For many electronics applications, the exact value of temperature is not as important as the ability to maintain that temperature. The following project shows how to use a thermistor to create a circuit that acts as a temperature-controlled switch. The circuit is then used to detect over-temperature conditions and to act as a simple on/off temperature controller. For a much more detailed discussion of this material, see “Thermistors in Homebrew Projects,” by Bill Sabin, WØIYH, which is also included on the *Handbook* CD-ROM.

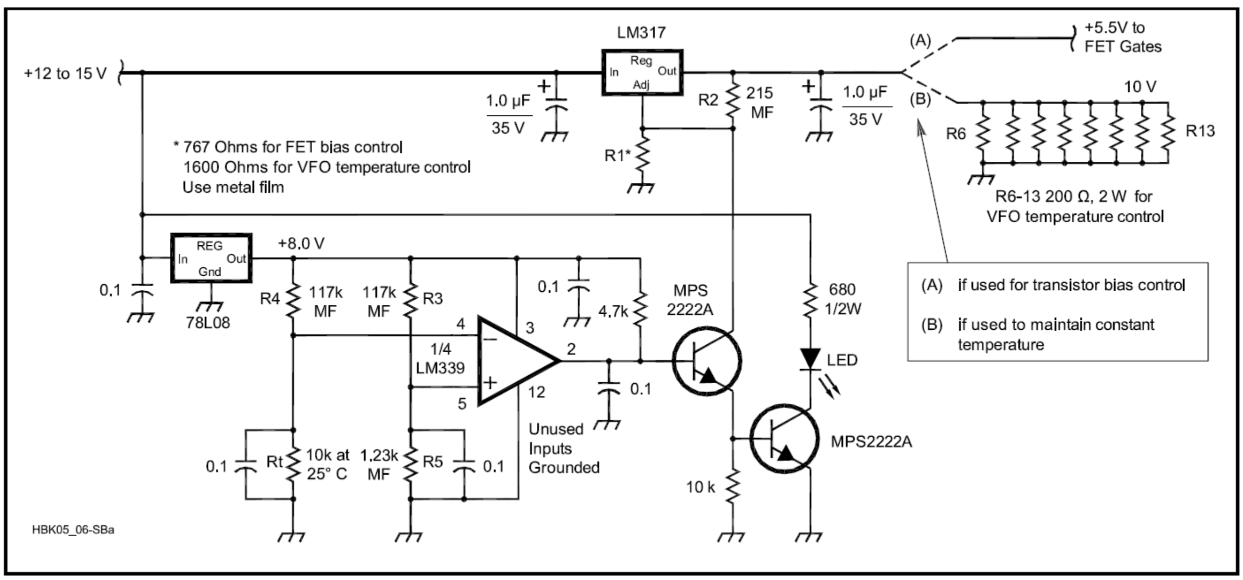

Figure 1 — Temperature controller for a power transistor (option A) or VFO (option B).

The circuit of **Figure 1** uses a thermistor (R1) to detect a case temperature of about 93 °C, with an on/off operating range of about 0.3 °C. A red LED warns of an over-temperature condition that requires attention. The LM339 comparator toggles when R_t = R5. Resistors R3, R4, R5 and the thermistor form a Wheatstone bridge. R3 and R4 are chosen to make the inputs to the LM339 about 0.5 V at the desired temperature. This greatly reduces self-heating of the thermistor, which could cause a substantial error in the circuit behavior. The RadioShack Precision Thermistor (RS part number 271-110) used in this circuit is rated at 10 kΩ ± 1% at 25 °C. It comes with a calibration chart from –50 °C to +110 °C that you can use to get an approximate resistance at any temperature in that range. For many temperature protection applications you don't have to know the exact temperature. You won't need an exact calibration, but you can verify that the thermistor is working properly by measuring its resistance at 20 °C (68 °F) and in boiling water (≅100 °C).

MOSFET POWER TRANSISTOR PROTECTOR

It is very desirable to compensate the temperature sensitivity of power transistors. In bipolar (BJT) transistors, thermal runaway occurs because the dc current gain increases as the transistors get hotter. In MOSFET transistors, thermal runaway is less likely to occur but with excessive drain dissipation or inadequate cooling, the junction temperature may increase until its maximum allowable value is exceeded. Suppose you want to protect a power amplifier that uses a pair of MRF150 MOSFETs.

You can place a thermistor on the heat sink close to the transistors so that the bias adjustment tracks the flange temperature. Another good idea is to attach a thermistor to the ceramic case of the FET with a small drop of epoxy. That way it will respond more quickly to a sudden temperature increase, possibly saving the transistor from destruction. Use the following procedure to get the desired temperature control:

The MRF150 MOSFET has a maximum allowed junction temperature of 200 °C. The thermal resistance θ_{JC} from junction to case is 0.6 °C per watt. The maximum expected dissipation of the FET in normal operation is 110 W. Select a case temperature of 93 °C. This makes the junction temperature 93 °C + (0.6 °C/W) × (110 W) =159 °C, which is a safe 41 °C below the maximum allowed temperature.

The FET has a rating of 300 W maximum dissipation at a case temperature of 25 °C, derated at 1.71 W per °C. At 93 °C case temperature, the maximum allowed dissipation is 300 W – 1.71 W/°C × (93 °C – 25 °C) = 184 W. The safety margin at that temperature is 184 – 110 = 74 W.

A very simple way to determine the correct value of R5 is to put the thermistor in 93 °C water (let it stabilize) and adjust R5 so that the circuit toggles. At 93°C, the measured value of the thermistor should be about 1230 Ω.

To use the circuit of Fig 1 to control the FET bias voltage, set R1 to be 767 Ω. This value, along with R2, adjusts the LM317 voltage regulator output to 5.5 V for the FET gate bias. When the thermistor heats to the set point, the LM339 comparator toggles on. This brings the FET gate voltage to a low level and completely turns off the FETs until the temperature drops about 0.3°C. Use metal film resistors throughout the circuit.

TEMPERATURE CONTROL FOR VFOS

The same circuit can be used to control the temperature of a VFO (variable frequency oscillator) with a few simple changes. Select R1 to be 1600 Ω (metal film) to adjust the LM317 for 10 V. Add resistors R6 through R13 as a heater element. Place the VFO in a thermally insulated enclosure. The eight 200-Ω, 2-W, metal-oxide resistors at the output of the LM317 supply about 4 W to maintain a temperature of about 33 °C inside the enclosure. The resistors are placed so that heat is distributed uniformly. Five are placed near the bottom and three near the top. The thermistor is mounted in the center of the box, close to the tuned circuit and in physical contact with the oscillator ground-plane surface, using a small drop of epoxy.

Use a massive and well-insulated enclosure to slow the rate of temperature change. In one project, over a 0.1 °C range, the frequency at 5.0 MHz varied up and down ±20 Hz or less, with a period of about five minutes. Superimposed is a very slow drift of average frequency that is due to settling down of components, including possibly the thermistor. These gradual changes became negligible after a few days of “burn-in.” One problem that is virtually eliminated by the constant temperature is a small but significant “retrace” effect of the cores and capacitors, and perhaps also the thermistor, where a substantial temperature transient of some kind may take from minutes to hours to recover the previous L and C values.