Single thermistor can serve as simple temperature regulator

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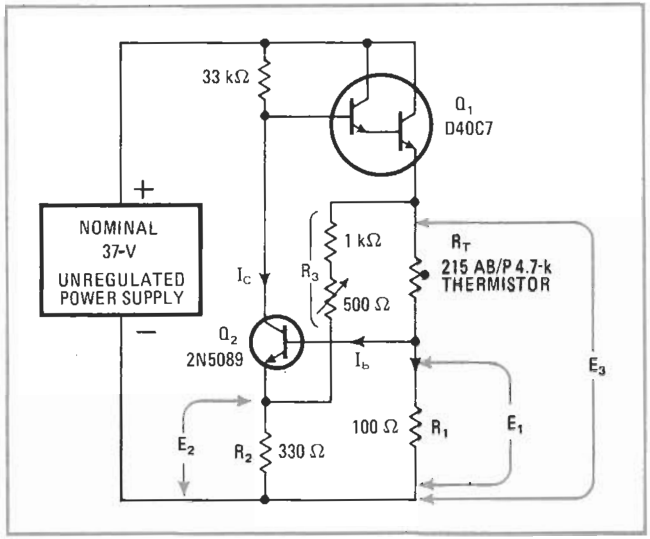
It is often desirable to stabilize the temperature of a small device such as the differential input transistor for a high-gain dc amplifier. The device temperature can be held constant by placing it in thermal contact with a thermistor that is made to maintain its own internal temperature at a constant value. The differential transistor is mounted on the stud of the thermistor in a thermally insulated enclosure.

General criteria for design are given below, and a practical design is shown for a 55°C control temperature; with proper insulation, the temperature can be held constant to within about 1° for ambient temperatures anywhere in the range from 20°C to 50°C. More precise designs are possible, but external thermal loading may then become of more significance than the thermistor-bead temperature changes. The stud-mounted thermistor used in this circuit is ideal for many applications.

An unregulated power supply is adequate because the circuit is primarily sensitive to the resistance of the thermistor. The power-supply voltage should be at least 50% higher than the expected voltage drop across the thermistor at the desired temperature.

The figure shows the regulator circuit. If the temperature drops below the equilibrium value, the thermistor's resistance increases; therefore, the voltage across R_1 decreases, reducing conduction through transistor Q_2. Q_1 then passes more current, which heats the thermistor and decreases its resistance.

The component values are derived by assuming the equilibrium-temperature value for thermistor resistance



Temperature regulator. Thermistor maintains temperature at a constant value corresponding to value of its resistance R_T, given by the design equation. Components shown hold a small device at 55°C (±1°C) over wide range of ambient temperatures; the device is mounted on thermistor stud in a thermally insulated enclosure.

R_T. For small I_c,

$$E_3 = KE_2$$

where the constant K is $(R_3+R_2)/R_2$. For a silicon device,

$$E_1 = E_2 + 0.6$$

Therefore,

$$E_3 = K(E_1 - 0.6)$$

For small I_b,

$$E_1 = I_T R_1$$

where I_T is the current that is needed to maintain temperature T.

Therefore,