TEMPERATURE COMPENSATION FOR LCD MODULES

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Liquid crystal display (LCD) modules have grown in popularity over the past few years because they are easy to use and provide an attractive display. Unfortunately, they have a troublesome drawback: poor temperature compensation.This article shows a way of improving that.

LCD modules come in a variety of sizes: from one line of 16 characters to four lines of 20 characters. They contain all the necessary drive circuits, so that interfacing them with microprocessors is very simple—see Fig. 1.

Unfortunately, the poor temperature compensation of these devices makes it necessary, in order to ensure optimum contrast of the display, to vary the input signal from about 400 mV to 800 mV over the temperature range 0–50 °C. This signal variation may, of course, be obtained manually with the aid of a simple potentiometer, but a much neater way is automatic temperature compensation.

When I started on this problem, I first of all tried the circuit shown in Fig.2. This uses a darlington configuration to boost the temperature coefficient of the base emitter voltage and to reduce the required base bias current.

As the base-emitter voltage decreases with rising temperatures, the current in in R_1 drops. This reduces the voltage across R_2, which in turn increases the voltage across R_e and consequently the emitter current. Most of the emitter current flows in the collector circuit and thus as the emitter current increases, the voltage across R_c increases. It follows that the voltage across R_c is directly proportional to the temperature.

Assuming that the current in R_1 and R_2 is small compared with the current in R_e, we can show that the gain of the circuit is related to V_e:

$$i_1 = V_{be} / R_2 = V_b / R_2$$

and

$$i_2 = V_c / R_2 = V_e / R_e.$$

In both cases it is assumed that there is no base current.

$$dV_{be} / R_1 = di_1 \text{ or } dV_{be} = di_1 \times R_1,$$

in which dV_{be} is the change in base-emitter voltage with temperature.

Now,

$$dV_b = dV_{be} \times R_2 / R_1.$$

Since V_{be} is large compared with dV_{be}, it may be assumed that it is constant, so that $dV_b = dV_e$.

$$dV_e / R_e = di_e \qquad (i_e = i_c)$$

$$dV_{be} \times R_2 / R_e \times R_1 = di_c$$

Fig. 1. Graphical representation of a 4-digit LCD module.

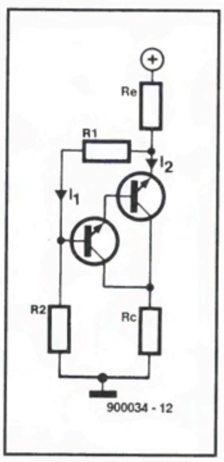

Fig. 2.

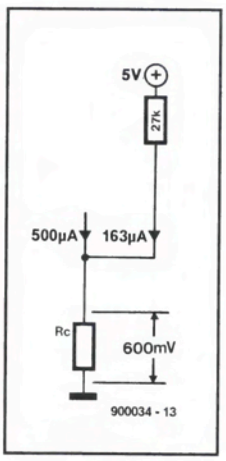

Fig. 3.

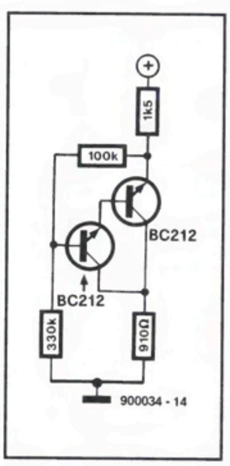

Fig. 4.

$$dV_c = dV_{be} \times R_2 \times R_c / R_1 \times R_e$$

$$dV_c / dV_{be} = A = R_2 \times R_c / R_1 \times R_e,$$

where A is the gain;

$$R_2 = V_b / i_1;\ R_1 = V_{be} / i_1;\ R_c = V_c / i_2$$

and $R_e = V_e / i_2$

Substituting, we obtain:

$$A = V_b \times V_c / V_e \times V_{be}$$

Since $V_b = V_{cc} - V_e - V_{be}$, this can be reduced to:

$$V_e = (V_{cc} - V_{be}) \times V_c / (V_{be} \times A + V_c)$$

With this equation we can estimate the required V_e and thus the resistor values required.

To calculate the emitter voltage we need to know the gain required and this is:

$$A = T_{e(R)} / T_{e(T)},$$

where $T_{e(R)}$ is the required temperature coefficient and $T_{e(T)}$ is the temperature coefficient of the transistor.

$T_{e(T)}$ of the darlington configuration is about 3.2 mV / °C owing to the small collector current (this causes a relatively large internal emitter resistance, which reduces the effective temperature coefficient of the base-emitter junction).

When using the circuit with an LCD module, you must take account of the 27 kΩ internal pull-up resistor—see Fig. 3.

With the Hitachi module , we require 600 mV at 25 °C. In Fig. 2 we see that with a current of 500 µA through the transistor and one of 163 µA through the internal resistor, the value of R_c will be

600 mV / 663 μA = 905 Ω. A practical value here is 910 Ω.

The 27 kΩ pull-up resistor means that the V_{cc} used in the equation is reduced by

$$910 / (27{,}000 + 910) \times V_{cc} = 163 \text{ mV}.$$

This makes V_{cc} = 4.84 V.

The V_{be} of the darlington pair is about 1 V with 500 μA flowing in the collector circuit, so that

$$V_{be} = (4.84 - 1) \times 0.6 / (1 \times 2.5 + 0.6) = 0.743 \text{ mV}$$

Let i_1 = 10 μA, so that i_e = 510 μA at 25 °C. Then:

$$R_e = 0.743 \text{ mV} / 510 \text{ μA} = 1.46 \text{ kΩ};$$

$$R_1 = 1 \text{ V} / 10 \text{ μA} = 100 \text{ kΩ};$$

$$R_2 = (5 \text{ V} - 1.743 \text{ V}) / 10 \text{ μA} = 325.7 \text{ kΩ}.$$

The final circuit is shown in Fig. 4: the output from the prototype was linear over the temperature range of 0–50 °C. At 0 °C, V_c = 425 mV and at 50 °C, V_c = 850 mV. ■