Pilot-lamp controller stabilizes crystal oven

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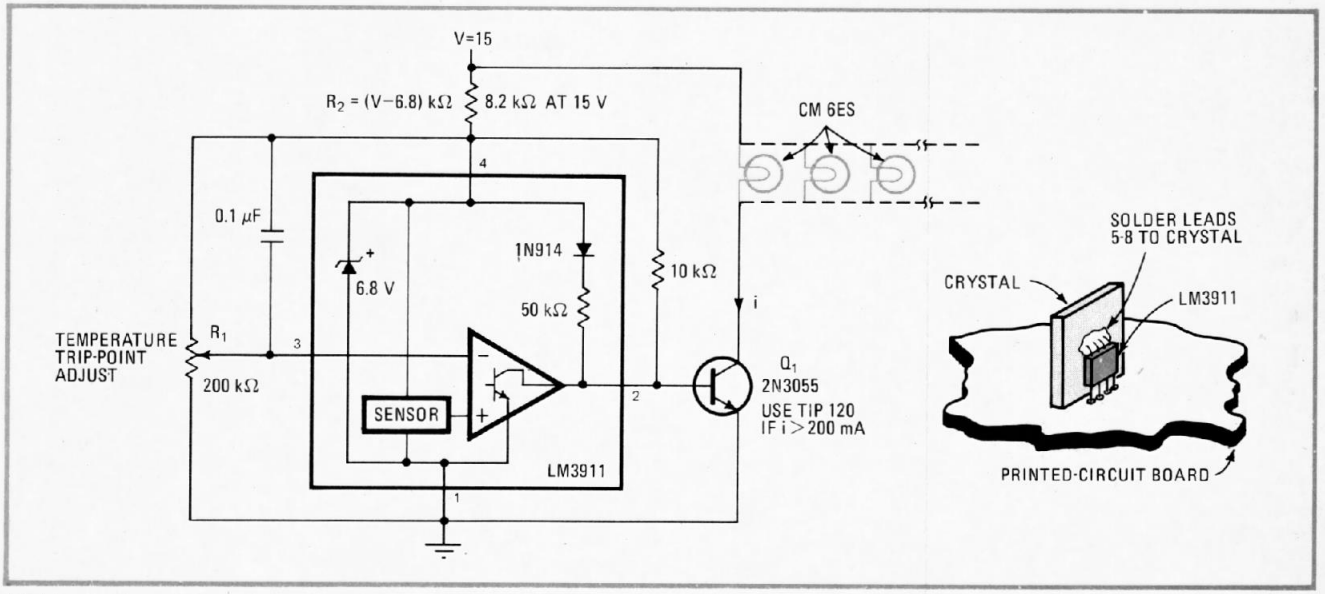
Crystal oscillators and phase-locked loops often need a temperature oven to retain maximum frequency stability, but the ones available are either expensive or use special components not readily at hand. The oven (left, below), however, uses low-cost parts such as standard pilot lamps for the heater elements and a one-chip control and sensing circuit that can maintain the temperature to within 0.5°C of the set value. The oven can be built for $7 or $8, the major cash outlay being for the oven's enclosure.

The LM3911 temperature controller is the heart of the circuit. It contains a temperature sensor, a stable voltage reference, and an operational amplifier. The sensor, which exhibits a temperature change of 10 millivolts per degree kelvin, is connected directly to the noninverting input of the op amp. Its output voltage is compared with the voltage set externally by the temperature trip-point potentiometer, R_1.

If the oven temperature increases above the trip point, the voltage from the op amp begins to fall. Consequently, the current emanating from transistor Q_1 decreases, and so does the pilot lights' filament current. Current continues to decrease until the oven temperature falls sufficiently to be detected by the sensor. At that time, the voltage at the noninverting port of the op amp falls, op-amp output voltage increases, and filament current increases. The process is continuous.

The LM3911 provides sufficient base-current drive for a transistor with modest gain, such as the 2N3055. This transistor will drive four Chicago Miniature 6ES lamps. If more lamps or lamps with a higher current are required for generating high oven temperatures, Q_1 should be replaced with a Darlington-pair npn power transistor, such as the TIP20.

When two lamps are used, the circuit can be set to an



Light adjustment. Crystal oven uses low-cost pilot lamps for heat source, $2 integrated-circuit temperature controller (left). Current through lamps, and thus temperature generated, is a function of the actual oven temperature and the temperature set by read: R_1. Temperature-critical elements of crystal oscillator should be placed close to LM3911 (right). Unused pins of LM3911 are soldered directly to crystal holder.

oven temperature between 22°C and 43°C, for a 1.5-by-2-by-3-inch enclosure and an outside temperature of 20°C or more. Stable operation is reached in less than 10 minutes from a cold start. For each additional lamp in the circuit, the oven temperature will increase a maximum of 10°C or so.

The most temperature-critical circuit elements should be placed close to the LM3911, near the center of the oven housing. If a crystal oscillator is housed, it should be in direct contact with the LM3911. The temperature controller is available in several package types. In all cases, pins 1 through 4 are used to make circuit connections. If the eight-pin, dual in-line package is the one employed, unused pins 5 through 8 should be soldered directly to the crystal holder, as shown in (b).

Almost any material may be used for the oven enclosure. However, the inside surface of the selected case should be covered with asbestos or some other insulating material. A 1/16-inch-thick layer of the insulating material, glued to the inside of the cover, will suffice.

The component values shown in the circuit assume a 15-v supply voltage, but other voltages can be used by changing the value of R_2 to equal $(V-6.8)$ kilohms. The pilot lamps should have an operating voltage slightly below the supply voltage used. □

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