Micropower crystal oven

Commercial crystal ovens are notoriously power hungry, being designed to work way above room temperature. Operating at a user-defined temperature just above the maximum anticipated ambient, Rae Perälä's oven can be run from a battery.

The circuit presented here can be used as a battery operated thermostat oven. It consists of two *7555* timer circuits, but it could incorporate a dual timer circuit *7556*. Both the *7555* and *7556* are c-mos types, which guarantees a very low power consumption.

Figure 1 shows the complete circuit. Timer IC_1 acts as an oscillator, and IC_2 as a heating control circuit. **Figure 2** shows the IC output voltages. Output voltage of IC_1 lies mostly at the positive battery voltage V_B, giving only short 23µs zero voltage pulses, represented by T_2, in the intervals of 3.5ms, shown as T_1.

Output pulses of IC_1 trigger IC_2, which is connected as a monostable multivibrator. Its produces a positive-going 2.5ms pulse, represented by T_3, every time its trigger input in pin 2 goes below the one third of the battery voltage.

Timer IC_2 output controls an n-type enhancement mos transistor, used for driving current pulses to the heating resistor.

The triggering voltage of IC_2 is formed from the output pulses of IC_1 by a voltage divider. One part of the potential divider is a potentiometer used to adjust the temperature. The other is a 100kΩ negative temperature coefficient thermistor mounted inside the oven.

The advantage of using a voltage divider is that changes in the battery voltage have no influence on the circuit operation. The circuit is adjusted so, that the resistance value of P is exactly one half of the resistance value of the thermistor at the temperature required in the oven.

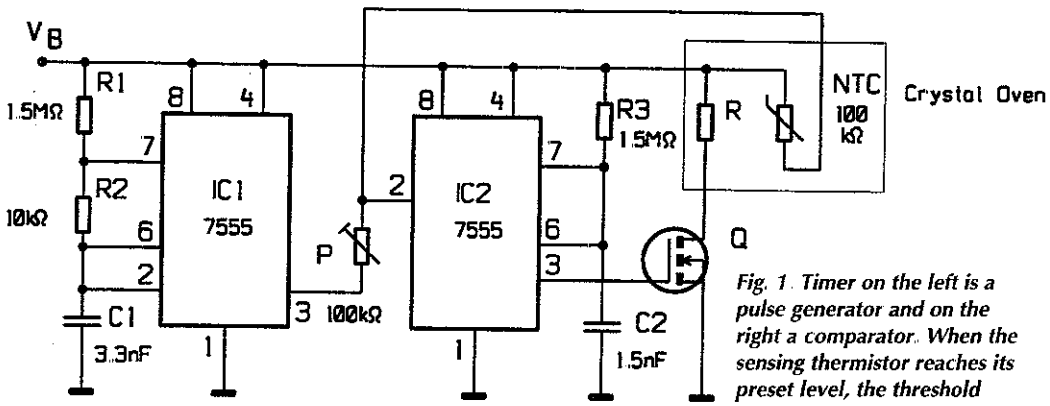

Fig. 1. Timer on the left is a pulse generator and on the right a comparator. When the sensing thermistor reaches its preset level, the threshold becomes too high to let the comparator trigger and heater resistor R receives no heating pulses.

How it works

While the oven temperature is below the preset value, the trigger input voltage of IC_2 at pin 2 goes below the triggering limit $V_B/3$ during every zero pulse from IC_1. This means that IC_2 is triggered, producing heating current pulses to the oven.

When the oven temperature reaches the value attained, the thermistor's resistance value decreases. This prevents the trigger pulses for IC_2 from going below one third of the battery voltage. Now, the heater no longer turns on.

From Fig. 2, you can see that the positive output pulses from IC_2 begin exactly at the rising edge of triggering pulses from IC_1. In this illustration, the first two triggering pulses trigger IC_2, as would be the case if the oven temperature were too low. During the third pulse the oven temperature level is assumed to have increased so. Triggering does not take place and the heater remains off.

The oven temperature should be adjusted a little higher than the maximum expected ambient temperature, via potentiometer P. An unnecessary high oven temperature increases the heating power demand.

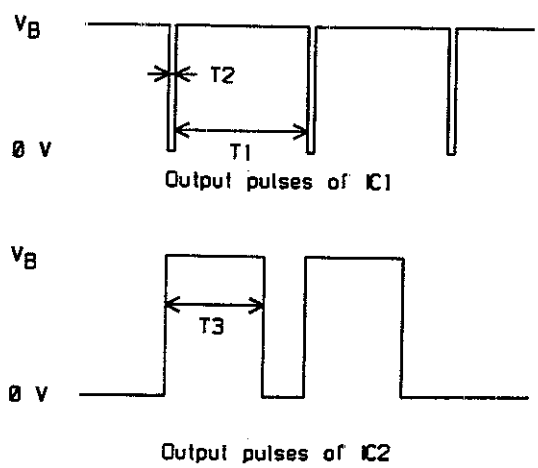

Fig. 2. Timing of the oven circuit, showing two trigger pulses causing heating and a final pulse that is not passed through to the output since the heater is up to temperature.

The circuit is a micro power one. While the heater is off battery current of 170µA will be sufficient for the whole circuit. A small crystal oven can be heated by a current of few milliamps. The heating resistor and the type of the mos transistor can be selected according to the amount of heat needed. Heater current can be minimised by making sure that the oven is well insulated.

The circuit operates with battery voltages between 8 V to 15 V. Theoretically, the circuit is not sensitive to battery voltage because operation depends on the resistance ratio of the thermistor and potentiometer P. In practice, I have found that the oven temperature alters a little when the battery voltage changes. This problem can be avoided by regulating the voltage connected to the ICs using a micropower regulator. Voltage supplying the heating resistor needs no regulation, so adding such a regulator does not have a significant affect on consumption. ■