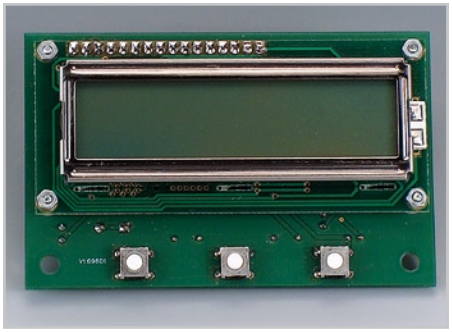
Universal Thermostat



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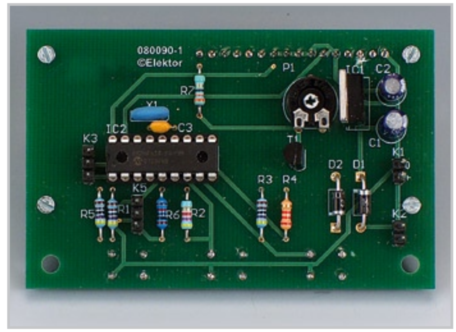
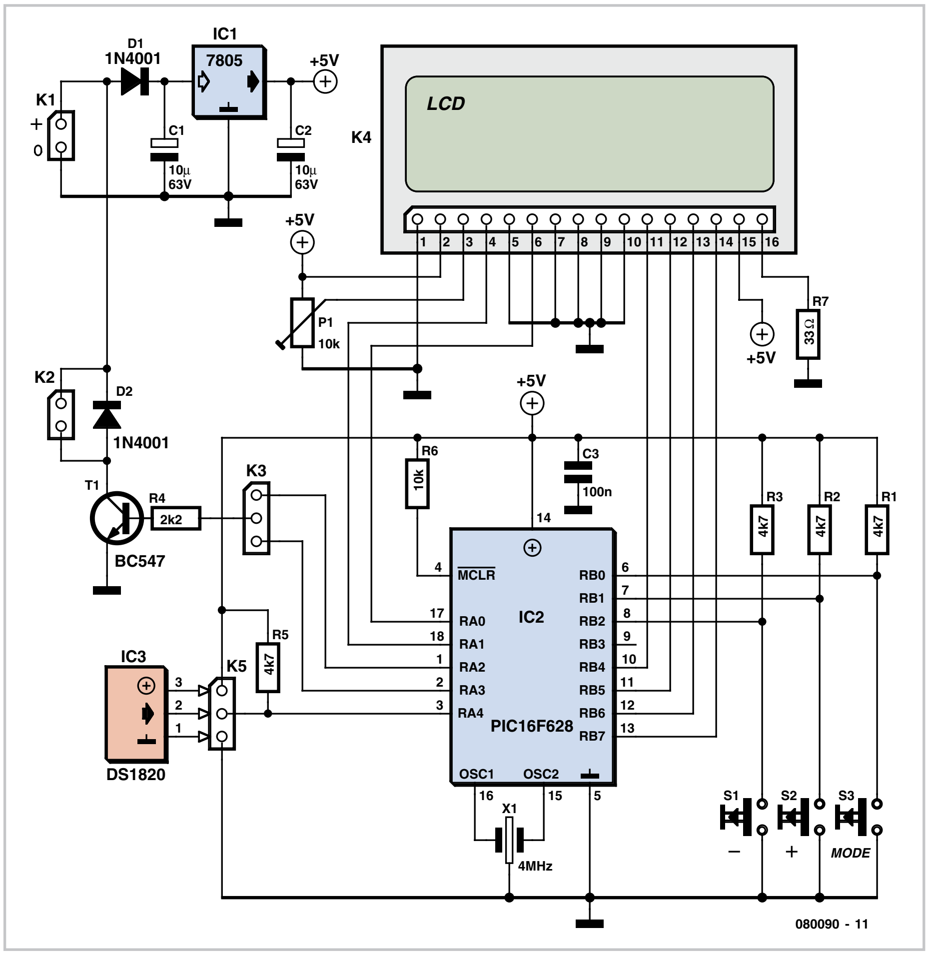
This circuit came about because of the dissatisfaction regarding the operation of the thermostat in a refrigerator. When using the built-in thermostat, it turned out that it was necessary to reduce the temperature setting in the summer in order to keep everything cold, compared to the setting in winter. This is probably as a result of a temperature sensor that is mounted too close to the cooling element, which means that phenomena such as thermal leaks and the average temperature in the fridge are not sufficiently accounted for in the control loop.

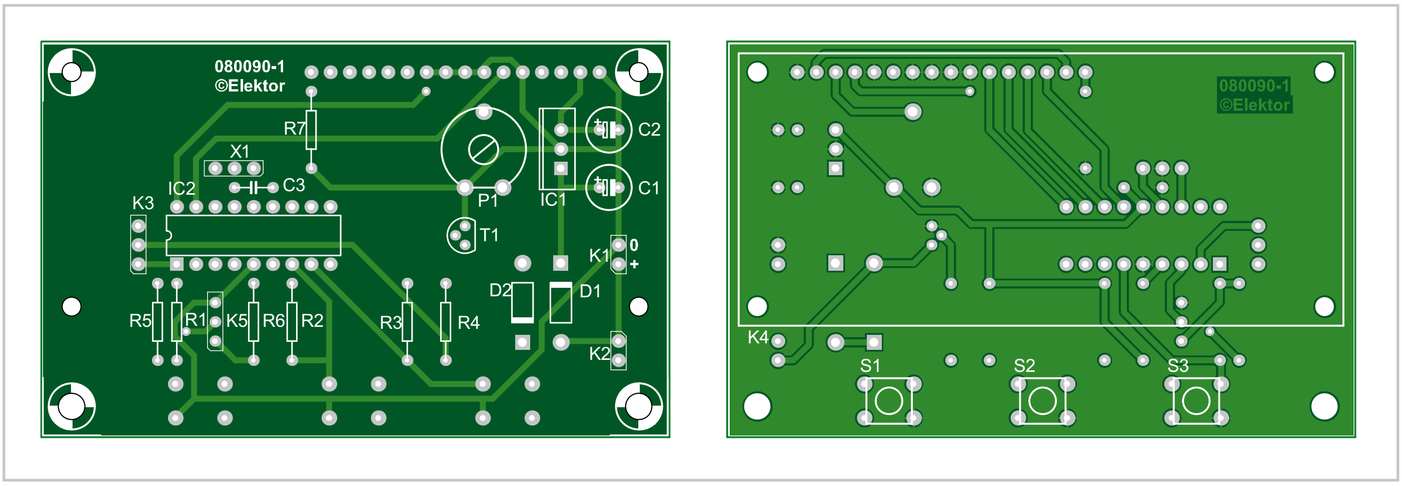
While designing the circuit for this electronic thermostat a decision was made to increase the control range so that it would also be suitable for other applications. Potential applications are the temperature control of a (living) room, heating of a flower box and obviously the etching tank!

The control range is adjustable from -25 °C to +75 °C in steps of 0.25 °C. The hysteresis is also adjustable. Hysteresis is the temperature error at which the system will turn on or off. A very small hysteresis results in a very stable temperature but has as disadvantage that the heating or cooling system turns on and off at a high rate, which generally leads to extra wear and tear in the compressor (cooling) or pump (heating). The hysteresis can be adjusted from 0.1 °C (very stable temperature) to 10 °C (practically no control at all...) in steps of 0.1 °C. The settings can be changed with 3 push buttons and the information is displayed on a 2×16 character LCD. The settings are stored in the EEPROM inside the PIC. During normal operation the LCD is used to display the actual temperature.

The main component in this circuit consists of a PIC 16F628. In addition to the aforementioned 2×16 character LC display, the







temperature sensor, type DS1820, also serves an important role in the circuit (connected to K5). Fortunately the DS1820 is already factory calibrated, so this saves us from a difficult task. A classic 7805-regulator and a common transistor pretty much complete the circuit. The clock source for the PIC is supplied by a 4 MHz ceramic resonator with built-in capacitors (Conrad Electronics order number 726406/726507).

There are two switching outputs from the PIC, one for cooling applications and another one when heating is called for. When cooling, the refrigeration system obviously has to be turned on when the temperature is too high, while when heating, the appropriate action needs to be taken when the temperature threatens to become too low. A jumper in this circuit makes the selection between cooling (jumper 2-3 on K3) and heating (jumper 1-2 on K3) possible.

When the circuit is turned on, the display shows 'TEMPERATURE' with underneath that the actual temperature in degrees Celsius. If the sensor is not connected then an error message will be displayed. By holding down the 'Mode' button until an asterisk appears, the text 'SET TEMPERATURE' appears and you can set the desired temperature in steps with the + and - buttons. By pressing the Mode-button again it is possible to set the desired hysteresis with the + and – buttons.

A hysteresis of 1 °C means that with a temperature setpoint of 20 °C and when heating, the output becomes active when the temperature drops below 19 °C (20–1), while everything turns off when the temperature reaches 21 °C (20+1).

To connect the circuit to external equipment a relay control (via K2) was chosen because of safety considerations. The transistor can easily handle currents up to 100 mA and a free-wheeling diode suppresses the back-emf from the relay coil. The power supply voltage can be selected based on the rated coil voltage of the relay that is used, 12 V, for example.

Keep in mind that when using this circuit to replace the thermostat in a fridge, the compressor motor which is to be controlled is directly connected to the mains and **a safe implementation of the complete circuit is therefore absolutely essential.**

If this circuit is used to heat, for example, a flower box, it can be useful to replace the switching transistor with a HEXFET. A prototype circuit with an IRFP3710, supplied a 12-V heating element with 1.5 A without any trouble at all, while the losses where so small that no heatsink was required. The 5-V output voltage from the PIC was in this case sufficient to turn the FET on properly.

The program in the 16F628 fills only about half of the available program memory space. Because there was no compelling need to program the whole thing in a particularly 'compact' way, the PicBasic Pro compiler was used for generating the hex file for the PIC.

Both the source file (1820THER.BAS) as well as the hex file to be programmed into the 16F628 (1820THER.HEX) are available free from the Elektor website as file number 080090-11.zip.

The source code is liberally commented, so that making changes (changing the temperature range, for example) is quite straightforward.

The temperature is initially set to 20 °C and the hysteresis to 2 °C.

For the sensor it is best if you use a 'plain' DS1820 and fit it with a length of 3-way ribbon cable. When using it with a refrigerator this has the advantage that the sensor cable can be easily routed to the outside because the rubber seal on the fridge door still closes sufficiently well to seal around the cable. Once the ribbon cable is connected to the DS1820, you can cover the sensor entirely with a thin layer of two-part epoxy glue and (before the glue has set) shrink a small length of heatshrink tubing around it. This gives a good, waterproof seal.

Alternatively you can buy a ready-made waterproof DS1820 sensor (for example Conrad Electronics # 184037/184052). These have, however, a type of telephone cable that is somewhat thicker than the ribbon cable.

(080090-I)

COMPONENTS LIST

Resistors
R1,R2,R3,R5 = 4kΩ7
R4 = 2kΩ2
R6 = 10kΩ
R7 = 33Ω
P1 = 10kΩ preset

Capacitor
C1,C2 = 10µF 63V
C3 = 100nF

Semiconductors
D1,D2 = 1N4001
T1 = BC547
IC1 = 7805
IC2 = PIC16F628-04/P (programmed, with software # 080090-11)

Miscellaneous
X1 = 4MHz ceramic resonator
S1...S3 = miniature push button
K1,K2 = 2-way pinheader
K3,K5 = 3-way pinheader
K4 = 16-way pinheader
DS1820 and 3-way ribbon cable
LCD with 2x16 characters
PCB #080090-1 from www.thepcbshop.com

Downloads

The source- and hex-code for this project, 080090-11.zip, as well as the layout for the PCB (080090-1.zip) are available as a free download from the Elektor website.