Don't let frozen food go to waste!

Build this simple freezer alarm

Inexpensive and easy to build, this freezer alarm will help prevent your valuable frozen goods from being ruined in the event of a freezer failure. A buzzer warns you the moment the freezer's temperature becomes higher than normal — while you still have time to save the goods.

By COLIN DAWSON

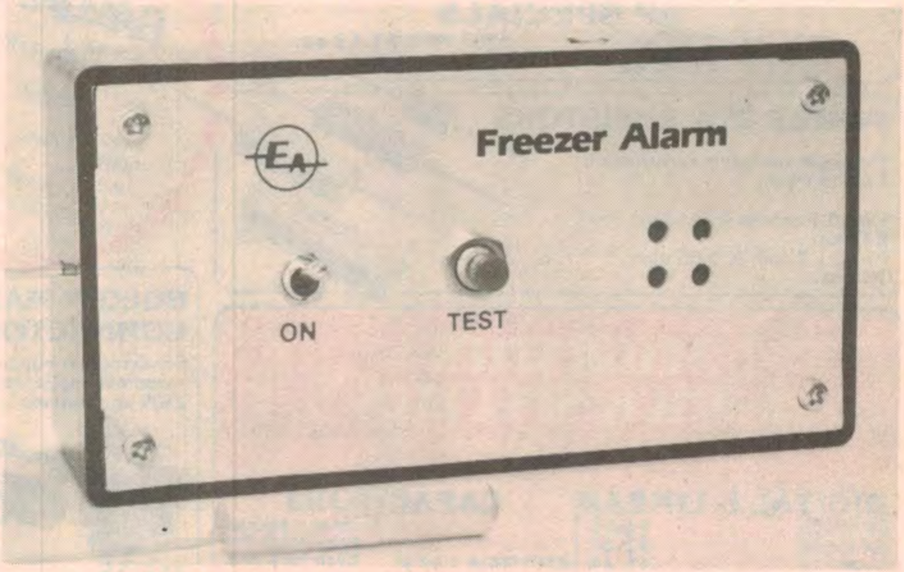
By allowing maximum advantage to be taken of "specials" and bulk purchasing, freezers are now a popular method of cushioning the spiralling cost of small goods. However, any cost advantage gained in this way can be immediately lost in the event of a freezer failure. Tens or even hundreds of dollars worth of small goods can be ruined as a result of a blown fuse or carelessly leaving the freezer door ajar.

This simple circuit is designed to guard against that possibility. It can be built for an outlay of around $20, uses readily available components, and is battery operated so that it will still work in the event of mains failure. Battery life, in normal circumstances, is around six months.

Of course, it's not only in domestic situations that our Freezer Alarm could save frozen foodstuffs. Owners of small corner stores usually have hundreds of dollars worth of stock stored in freezers, so any device that will effectively indicate a freezer failure has to be a worthwhile business investment. It could save both your ice cream and your customers!

Most of the circuit is housed in a plastic utility zippy box which can simply sit on or near the freezer to be monitored. A small probe mounts inside the freezer and is connected to the rest of the circuit by two wires. A test switch, situated on the front panel, checks the battery condition and verifies correct circuit operation.

Long battery life has been achieved by operating the circuit on a 1:10 duty cycle. In other words, the circuit is active for one second and then passive for 10 seconds. Current drain is 50μA in the passive state and 400μA during the active monitoring state, resulting in an average current drain of around 80μA.



The complete Freezer Alarm is housed in a small plastic box, and the panel we have prepared gives it a professional appearance. The sensing probe, which is normally in the freezer, is shown in front of the box.

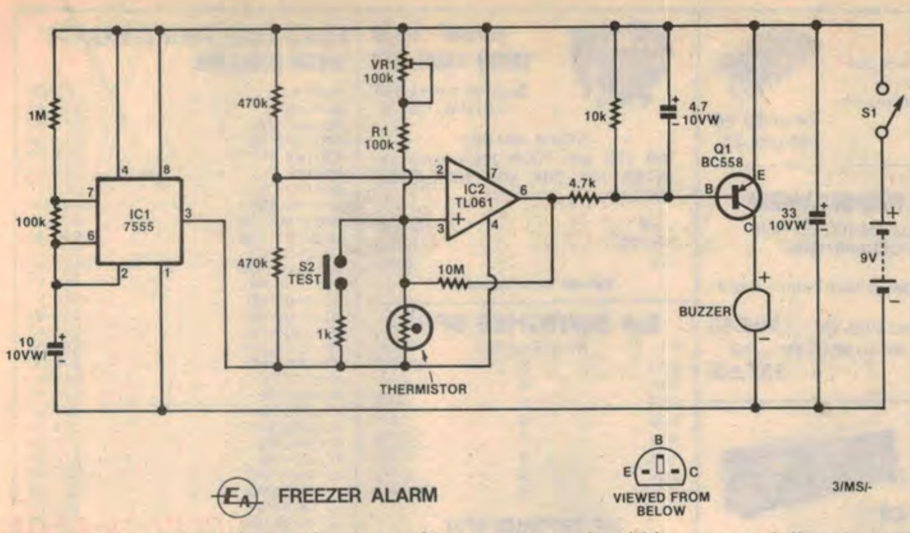
This increases to around 5mA (peak) when the alarm is triggered, due to the current drawn by the buzzer.

The one second on, 10 seconds off duty cycle is a compromise between reduced power consumption and the effectiveness of the alarm. When triggered, the buzzer will sound for one second every 10 seconds. This should prove satisfactory for most situations, although some readers may decide to increase the off period to reduce power consumption even further. The one second on period, however, can probably be regarded as a minimum.

Circuit diagram

The circuit diagram is straightforward and consists of a 7555 timer (IC1), a comparator (IC2), and a transistor driving a buzzer. IC1 is a CMOS version of the familiar 555 timer IC, and is wired here as an astable multivibrator to provide the 1:10 duty cycle. This 1:10 duty cycle is set by the 1MΩ and 100kΩ timing resistors and the 10μF electrolytic capacitor.

Here's how the 7555 works: Initially, the 10μF capacitor is charged to ⅓ supply voltage (ie ⅓Vcc) and the pin 3 output of IC1 is high. The 10μF capacitor now charges via the 1MΩ and 100kΩ timing resistors and, when it reaches ⅔Vcc 10 seconds later, the output at pin 3 goes low. The 10μF capacitor then discharges via the 100kΩ resistor and pin 7 and, when its voltage falls to ⅓Vcc after about one second, the pin 3 output goes high again and the timing cycle is repeated.



The circuit is a relatively simple one and it's operation should be easy to follow from the text. The basic sensing mechanism is associated with IC2, IC1 being used to give the 1:10 duty cycle and extended battery life.

As can be seen, the common rail for the comparator circuit (IC2) is connected to pin 3 of the 7555, rather than direct to the negative supply rail. This means that the comparator circuit is activated only when pin 3 of the 7555 goes low for one second at the end of each 10 second timing interval.

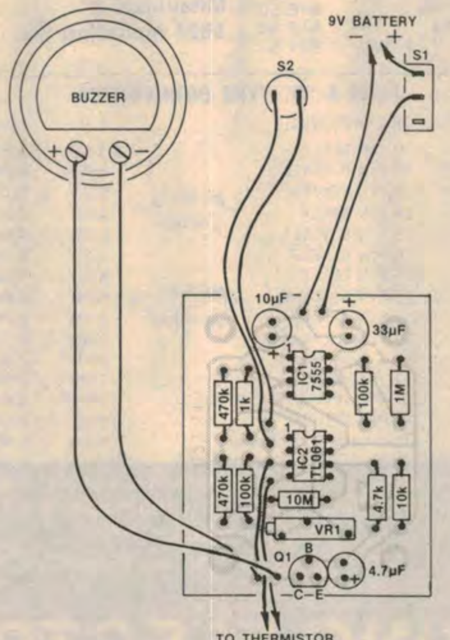
Hence we have the 1:10 duty cycle referred to above. When the output of the 7555 is high, the comparator circuit is off and the only current drawn from the battery will be that drawn by the 7555 itself. That is why we have used a 7555 in place of the familiar 555 – because it is a CMOS device, it's current consumption is far lower.

Comparator IC2 consists of a TL061 Fet-input op amp which is used to compare the sensor voltage (from the probe) with a reference voltage. In this circuit, the non-inverting input is used as the sense input, and the inverting input biased to ½Vcc by two 470kΩ resistors. Since both resistors have the same temperature coefficient, the output from this voltage divider will be virtually independent of ambient temperature.

A second voltage divider consisting of the 100kΩ trimpot (VR1), a 100kΩ resistor and a negative temperature coefficient (NTC) resistor biases the sense input (pin 3) of IC2. As the temperature rises, the resistance of the thermistor decreases, and thus the voltage on the sense input also decreases – ie the voltage across the thermistor is inversely proportional to temperature. By comparing the two voltages on the inputs to the comparator, it is possible to determine when the temperature of the probe exceeds a certain value, as preset by trimpot VR1.

Normally, the voltage on pin 3 is higher than the reference voltage on pin 2, so the output of IC2 is high and PNP transistor Q1 is held off. However, when the critical temperature is exceeded, the voltage on pin 3 drops below that on pin 2 and the output of the comparator swings low. Transistor Q1 now turns on and drives a piezo-electric buzzer connected between the collector and the negative supply rail.

Positive feedback for comparator IC2 is via a 10MΩ resistor connected between pins 6 and 3. This gives the comparator a degree of hysteresis and is necessary to ensure reliable triggering at the critical temperature. Note that the output of IC2 goes high whenever the pin 3 output of the 7555 is high, so Q1 is held off during the 10s passive period. The only time pin 6 of IC2 can go low is during the 1s active period, and then only if an over-temperature condition is detected.



Above is the component layout on the printed board while at right is the board pattern shown actual size.

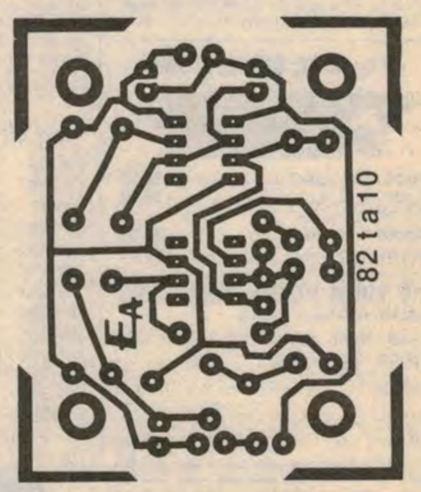
The 4.7kΩ resistor on the output of IC2 limits the transistor base current to a safe value while a 10kΩ pull-up resistor further ensures that the transistor is normally biased off. However, because the output IC2 does not swing fully to the supply rails, a click is produced by the buzzer each time the TL061 is activated by the 7555 unless further precautions are taken. The 4.7μF capacitor between the base of Q1 and the positive supply rail filters out these clicks, so that the buzzer remains silent until triggered.

Multi-turn trimpot VR1 allows the voltage on pin 3 of the comparator to be adjusted independently of temperature effects, so that the freezer alarm can be set to trigger at the required temperature. In addition, pushbutton switch S2 has been included to provide a battery check and test function. This switch and a series 1kΩ resistor are wired across the thermistor and, when S2 is depressed, a temperature high is simulated.

Power for the circuit is derived from a small 9V battery (Everready type 216, or similar). A 33μF 10VW electrolytic capacitor is added to give a low supply output impedance.

Construction

The first area of construction to be dealt with is the actual freezer probe. For this, you will require a 40mm length of plastic tubing with an inside diameter of approximately 5mm. This is used to house the thermistor; we found the body of a cheap ball point pen ideal for the purpose.



We estimate that the current cost of components for this project is approximately

$21

This includes sales tax but does not include the 9V battery.

The length of 40mm is by no means critical, but there is probably no point in making it any smaller. Solder two wires to the thermistor leads and slide the assembly into the tube. The length of the wires will depend on how far the alarm is to be located from the freezer. We used about 1.5m and this should prove sufficient in most cases.

The thermistor used in the prototype was obtained from Dick Smith Electronics (Catalogue No. R-1792). Its specifications include a resistance of 47kΩ at 25°C and a working range from −25°C to +125°C, which make it ideal for this application. While it should be possible to use other themistors with similar specifications, it may be necessary to change the value of the 100kΩ series resistor to obtain correct operation over the required temperature range.

thermistor also warrants some comment. It needs to be as small as possible so as to interfere with the door seal as little as possible, and also moderately flexible to withstand normal movement. We used two wires peeled off together from a length of rainbow cable, but this may be a trifle wasteful for the home constructor. Very light duty figure-8 cable is probably the next best choice, or you may use just enough rainbow cable to reach the outside of the freezer, and then join this neatly to a length of figure-8 cable.

The temperature probe will need to be a waterproof assembly, as any moisture will cause erroneous alarms. Also, the thermistor should be just protruding from one end of the tube to ensure good thermal contact (this will prove an advantage in the calibration procedure). To seal the tube, pot both ends of the

This picture gives a good idea of how the various sections fit together in the plastic box. Note that the battery should be mounted so that it does not foul the piezo-electric buzzer.

tube with an epoxy or silicone adhesive. This done, put the probe aside and turn to the printed circuit board (PCB).

The PCB is coded 82ta10 and measures 59 x 48mm. Before embarking on its assembly, note that the 7555 timer IC is not fitted until after the calibration procedure has been completed. Instead, a wire link must be temporarily fitted between the holes intended for pins 1 and 3. This allows IC2 to operate continuously and makes calibration much easier to carry out.

Begin assembly of the PCB by fitting the resistors, followed by the TL061 op amp, the transistor and the multi-turn trimpot. Finally, mount the three electrolytic capacitors. Note that the semiconductors and capacitors are all polarised, so make sure that you fit them the right way round.

For those situations where the freezer alarm will meet the critical eye of house guests, we have prepared a Scotchcal front panel to greatly enhance its appearance. If you intend to use the front panel, it should be affixed to the lid of the case and the following holes drilled: 4 x 4mm for the mounting screws; 6.5mm for the power switch; 7.5mm for the test switch; and several holes as applicable for the piezo-electric buzzer. Note that the buzzer is held in place with epoxy adhesive – the holes are simply to allow the sound to escape. In fact, the buzzer can be glued in place when all the holes are drilled.

Attention can now be turned to the plastic utility (zippy) box. All that is required is to drill a hole at one end of the box for the sensor wires and to install a battery clip. The size of the hole required for the sensor wires will depend on the wires you have used – we found 2.5mm large enough. The battery clip can be manufactured from a piece of scrap aluminium of approximately 10 x 35mm. Before mounting the battery clip, make sure that the battery will clear the piezo-electric transducer.

All that remains of construction for the moment is to complete the wiring. This includes wiring to the sensor probe, the piezo-electric buzzer, the power switch, the battery and the test switch. The PCB can now be clipped into the integral supports in the case or, if you prefer, installed using machine screws and nuts.

To test the unit, set the multi-turn trimpot fully clockwise (keep turning the adjusting screw until you hear the clicks) and temporarily short out the fixed 100kΩ (R1) resistor with a wire link. Now switch the freezer alarm on. The buzzer should immediately emit a continuous alarm tone and you should be able to cancel this by adjusting the trimpot anti-clockwise.

Correct circuit operation can now be verified by pushing the test button or by heating the sensor slightly. In both cases, the alarm should re-trigger. The circuit is now ready for calibration, but first switch the unit off and remove the shorting link across the 100kΩ resistor. (Note: The link is only necessary to allow the unit to be tested with the probe at room temperature.)

Calibration

Freezers normally operate in the temperature range −15°C to −18°C and the freezer alarm should be calibrated to trigger at about 5°C above this. Prior to calibration, the probe should be placed in the freezer for several hours or, preferably, overnight. The alarm should be switched off during this period.

Note that the probe should be placed somewhere near the bottom (or back) of the freezer so that it will be unaffected by temperature fluctuations due to the freezer door being opened.

When the probe temperature has stabilised, switch the unit on and slowly turn the trimpot clockwise until the alarm just sounds. Finally, turn the trimpot 2½ to 3 turns anti-clockwise again. Your Freezer Alarm is now calibrated to trigger at approximately 5°C above the normal temperature of the freezer (one complete turn of the trimpot is equivalent to a temperature change of around 2°C.

We should point out here that freezers in domestic refrigerators usually operate at higher temperatures than stand-alone freezers, a typical figure being −5°C. In this case, the Freezer Alarm should be calibrated to trigger at around 0°C. You can do this by immersing the probe in an ice-water mixture and then suitably adjusting the trimpot so that the unit just triggers.

With calibration completed, remove the wire link from the printed circuit board and install the 7555. This is a CMOS device, so the usual precautions should be taken: earth the barrel of your soldering iron to the negative supply rail on the PCB (use a small clip lead), and solder the supply pins (1 and 8) first.

As a final check, switch the unit on and press the test switch. There should be 10 seconds of silence and then the alarm should sound for one second. If this is the case, your Freezer Alarm is ready for service but don't forget to check the battery condition at regular intervals.

PARTS LIST

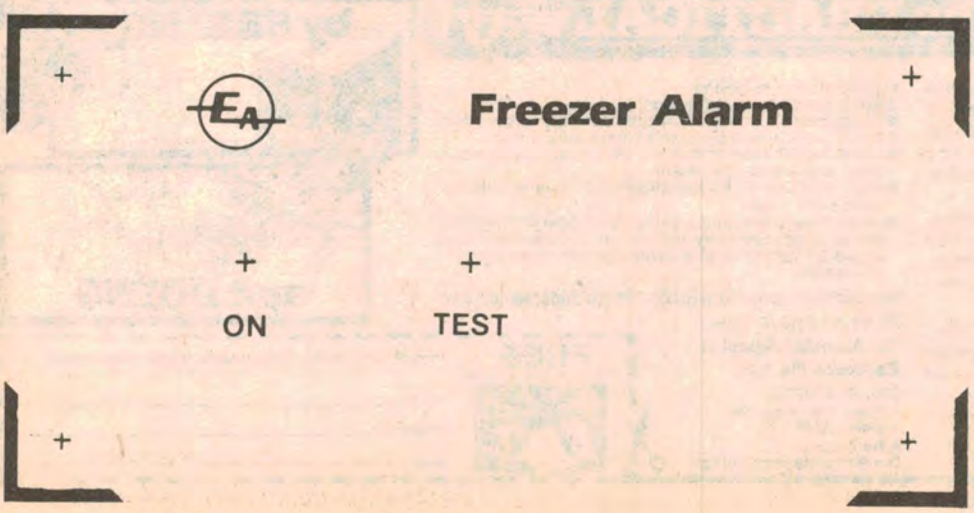
1 printed circuit board, code 82ta10, 59 x 48mm
1 plastic utility case, 40 x 68 x 130mm
1 Scotchcal front panel, 125 x 63mm
1 SPST miniature toggle switch
1 SPST momentary contact pushbutton switch
1 9V piezo-electric buzzer
1 9V battery and clip
1 ballpoint pen tube, or similar (see text)

SEMICONDUCTORS
1 7555 CMOS timer
1 TL061 Fet-input op amp
1 BC558 PNP transistor

CAPACITORS
1 33µF/10VW PC mounting electrolytic
1 10µF/10VW PC mounting electrolytic
1 4.7µF/10VW PC mounting electrolytic

RESISTORS (5%, ¼W)
1 x 10MΩ, 1 x 1MΩ, 2 x 470kΩ, 2 x 100kΩ, 1 x 10kΩ, 1 x 4.7kΩ, 1 x 1kΩ, 1 x 100kΩ multi-turn trimpot, 1 x 47kΩ NTC thermistor (see text)

MISCELLANEOUS
Hook-up wire, rainbow cable, machine screws and nuts, scrap aluminium for battery clamp, epoxy adhesive, solder, etc.



The front panel, shown actual size. These should be available from various component retailers when this article appears.