

OPTICAL CAR ALARM SWITCH

Don't be fooled! This is not a torch at all but an optical car alarm switch. It consists of a transmitter (explained in Part 1) and receiver (Part 2) to deactivate car alarms and thus avoid delay mechanisms that can be exploited by the unwanted intruder. The project requires a little mechanical dexterity, but don't be too alarmed — we managed it!

S. K. Hui Part 1

THIEVES AND BURGLARS are getting really professional nowadays. A quick check of police or NRMA statistics will show that many of the stolen cars are equipped with alarm systems. The ordinary car alarm no longer gives you much protection at all! Scrapping the old one and installing a new sophisticated system is the best solution, but it's really expensive — you might be looking at \$300 or more.

Many classy cars, like the Renault Feugo or new BMW have built-in alarm systems. These have one common feature — remote turn off of the alarm, unlike most of the “do it yourself” alarm systems, which work on an entry delay. Such delays are usually adjustable up to tens of seconds. Unfortunately, a skilled burglar can disable your alarm within a few seconds.

There is one inexpensive way to update your alarm system. The ETI-343 Optical Car Alarm Switch. It is intended to be used with the most stupid car alarm system and turns it into something like the BMW's.

The idea is fairly simple. You turn the entry delay in your existing alarm to minimum time. Any unauthorized person trying to open the door or the boot will trigger the siren instantly. A little pocket size transmitter is used to turn off the alarm through the window before you get in. You can program your own transmitter code, which has $n \times 32 \times 1024$ different combinations. It is possible to have n number of different rates to clock out the code. Theoretically, n is an infinite number, but in this article, n is chosen to be

three, ie, three different sets of resistors and capacitors are given in Table 1 for different rates of transmission. A different set of components will give you a different bit rate of transmission. Two transmitters with the same code but different bit rates will not interfere with each other. It is possible for you to invent a new transmission rate (bit rate) which is not listed. The only trouble is that you have to go through the calculation of the component values, and you need enormous patience to tune the receiver oscillator to the correct value. This will be discussed in the next issue.

This project can be used in other applications. Turning off your car alarm is one typical application. I am sure many of you can figure out other innovative ways of using it.

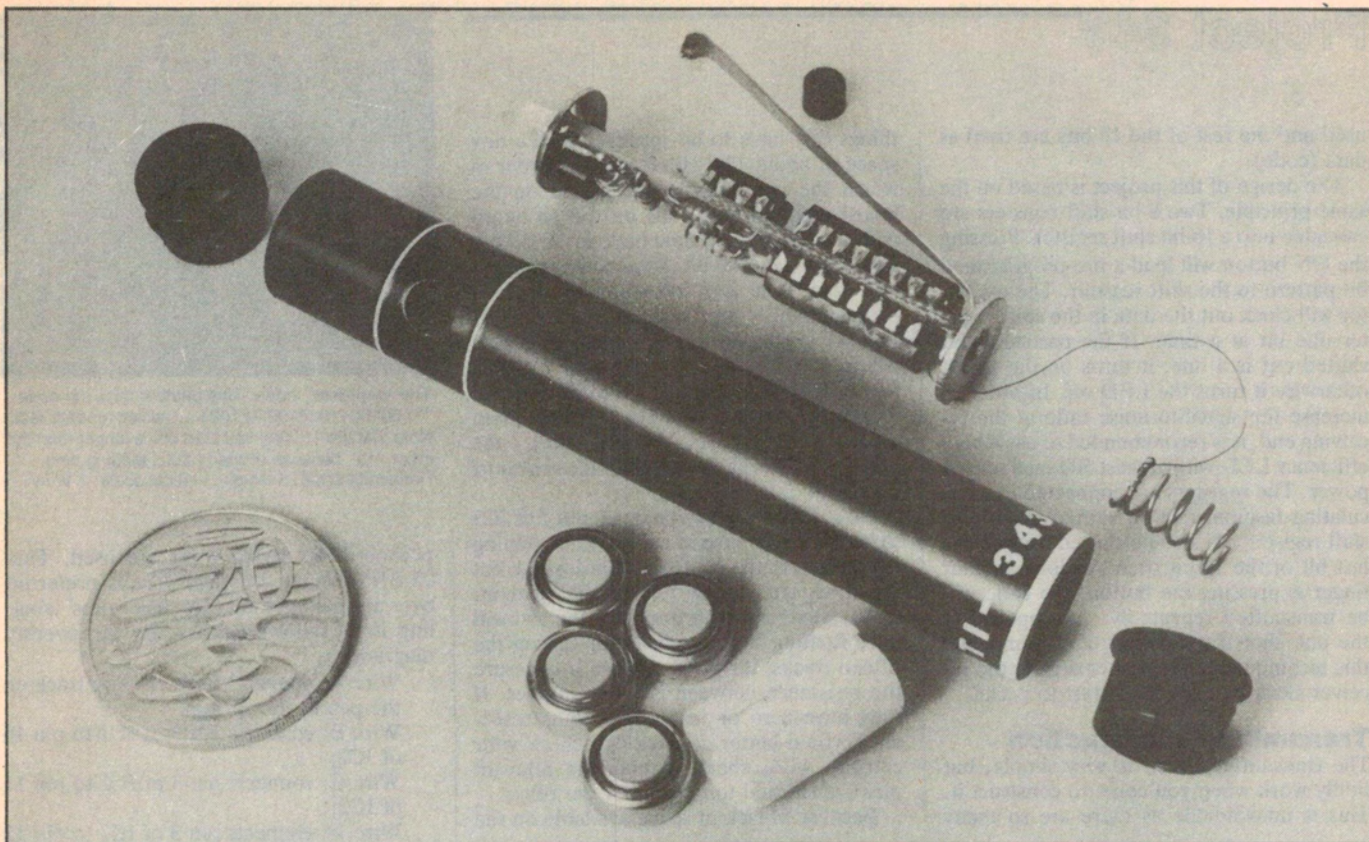
Principle of transmitter circuit

The whole system works on the principle of asynchronous communication. It is a bit like the 6850 ACIA (asynchronous communication interfacing adaptor). Those who are not familiar with this device will find the following useful.

Suppose an 8-bit code, eg, 10011110 is transmitted. If the code is clocked out by the rising edge of the transmitter clock, the waveform of the data will look like that in Figure 1a. This same waveform is sampled at the receiver end with a sampler circuit. According to the Nyquist sampling theorem, the rate of the sampling has to be at least twice as fast as the maximum data rate

in the transmitter. The sampling circuit is controlled by an oscillator. Usually there is a drift in the oscillator due to environmental factors such as temperature. The drift in the sampling rate can be minimized by having the oscillator oscillating many times faster than the actual sampling rate. The frequency of the oscillator is then divided down to give the correct sampling rate. Since nothing is perfect in this world, drift in the sampling rate can never be gotten rid of completely.

The ideal sampling point is in the middle of the mark (logic 1) or in the middle of a space (logic 0). This is shown in Figure 1b. The first bit transmitted is called the start bit and is used to synchronize the receiver oscillator. This allows the start bit to be sampled right in the middle. Since the transmitter clock is not transmitted to the receiver, the subsequent samples are controlled by the receiver oscillator which is not synchronized to the transmitter clock. The receiver oscillator is almost certainly drifting in the oscillator relative to the received signal. The effect is, as shown in Figure 1b, that the sampling points are drifting away from the middle of the bits. Eventually, wrong samples will be taken. In practice there is a limit to the maximum length of the word one can transmit without re-synchronizing the oscillator with the next start bit. In standard formats, the word normally contains a start bit, seven or eight bits of data, a parity bit and one or two stop bits. In our particular case, only one start bit is



All these parts fit into this compact transmitter making it an extremely 'handy' device.

HOW IT WORKS — ETI-343

The transmitter circuit is very simple. Pin 1 of IC3 is always connected to logic high. This is the start bit. The batteries are connected to the circuit when the button is pressed. Pin 9

of IC2 and IC3 will go high immediately because of the capacitor C2. The logic pattern at pin 1 of IC2 and pin 15, 14, 13, 4, 5, 6, 7 of IC2 and IC3 is loaded parallel into the shift registers (IC2, IC3). The voltage of pin 9 of IC2 and IC3 gradually dies away according to a

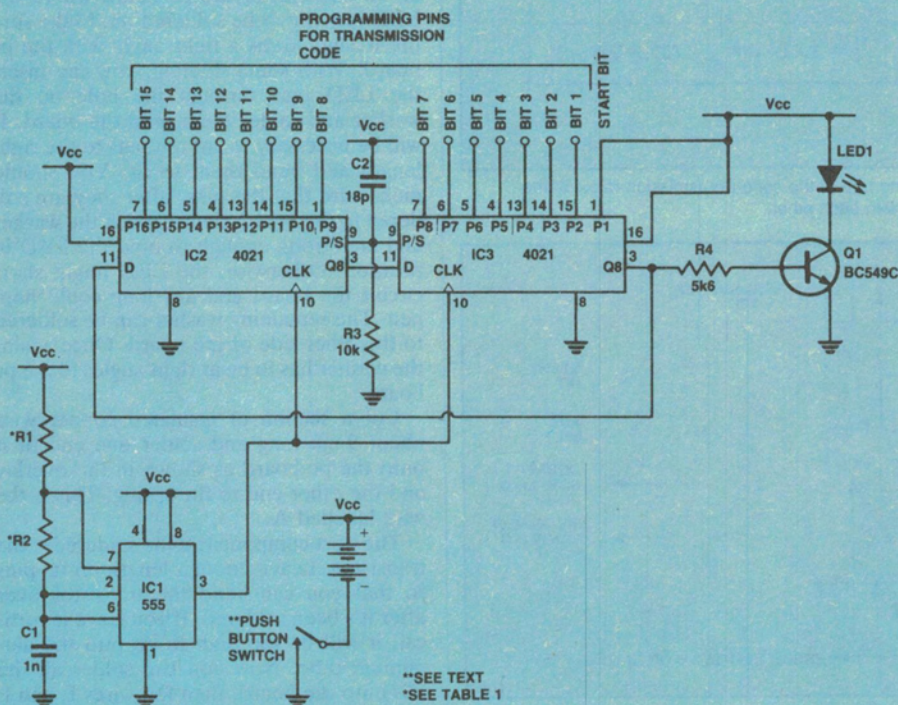
time constant formed by C2 and R3. As soon as this voltage goes low, control of the 4021s shifts to the serial mode. The clock input, pin 10, is driven by an 555 set up as an oscillator. The bit in pin 1 of IC3 gets shifted out first, the bit in pin 15 of IC3 is shifted out second, and so on. Any bit shifted out at pin 3 of IC3 also 'circulates' back to pin 11 of IC2. Repeated transmission of the same code is possible under this scheme. Components R1, R2 and C1 determine the clocking rate of the data from the following equations:

$$F_{ck} = \frac{1.443}{(R1 + R2 + R2) \times C1 \text{ Hz}}$$

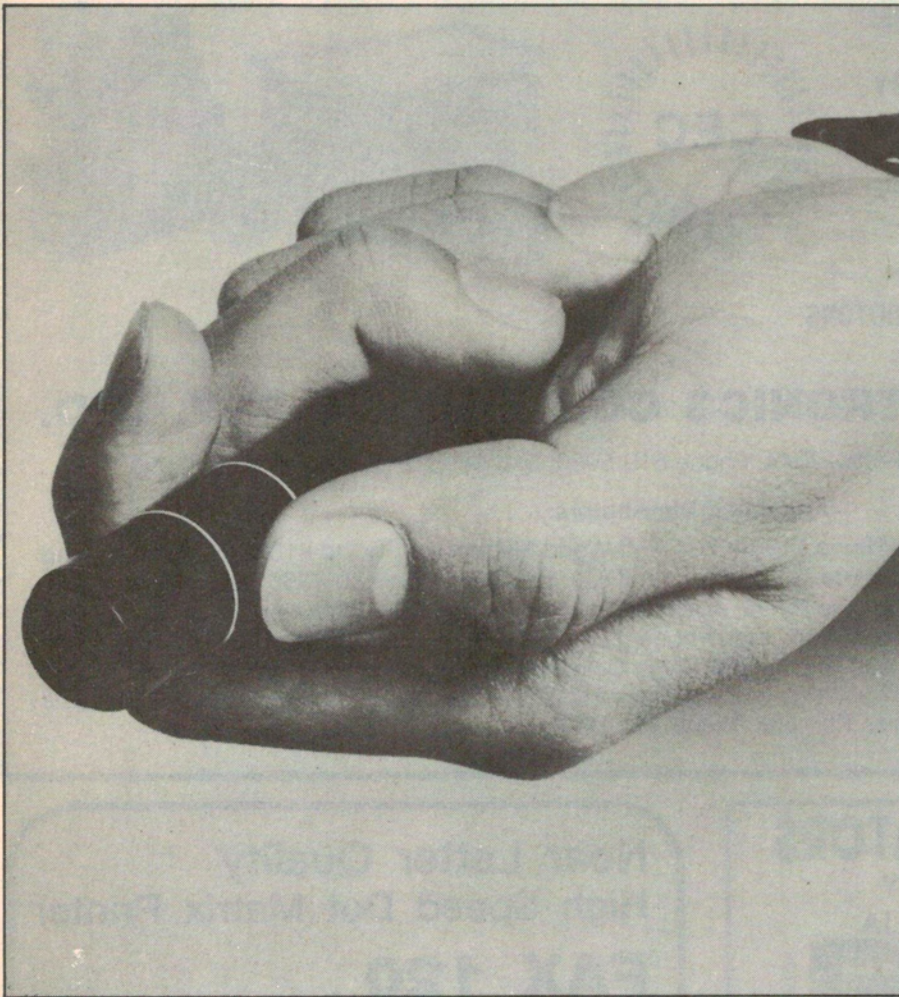
$$\text{Duty cycle of clock} = \frac{R2 + R1}{(R1 + R2 + R2)}$$

The start bit normally turns LED1 on longer than other bits. This is because during the parallel loading of the registers, the start bit is active at pin 3 of IC3 already. The start bit stays active for one period of the clock plus the loading time. Therefore, the loading time constant of the register is made small compared to the clock period. That is, C2 and R3 are small.

As I said before, three different transmission rates are given in Table 1 with their component values already calculated. If any reader wants to use a transmission rate not listed in the table, the above formulas can be used. Whatever rate you choose, make sure it is not faster than the fastest given in the table, otherwise, the loading time of the registers becomes comparable with the clocking period. This might upset the sampling mechanism in the receiver.



optical alarm switch



multaneously with your construction work:

1) After cutting your 15 tracks to program your code use a meter to make sure the positive and negative rails are no longer short circuiting. Then put one probe of your meter to the ground or Vcc rail and the other to one of the programming pins. Check whether that pad does connect to the ground ('0') or Vcc ('1') as programmed. Then repeat the same checking for the rest of the programmed pads. Make sure that you have the code correct.

2) As mentioned before, every time an insulated copper wire is soldered, make sure it connects the two points as required. This can be confirmed by checking the resistance between the two points joined by the wire.

3) Be careful not to let the pins of the LED touch the washer. And make sure the polarity of the LED is correct when you solder it on.

4) Give a little pull on the washers after you solder them. They should be as firm as a mountain.

5) There are several tracks right on the

edge of the pc board. When inserting the pc board into the aluminium tube, those tracks should not be touching the inner wall of the tube. If they do, a strip of sticky tape on both edges of the pc board will insulate the tracks from the tube.

6) You need four mercury batteries piled up in order to give you enough voltage. They are the same kind of battery you use in a calculator. The body of the battery is usually the positive terminal and it *must* be insulated from the tube. You can roll the four batteries together with a piece of paper, like rolling a cigarette. Stop the paper from coming loose with a bit of sticky tape. Whenever you change the batteries, don't forget to put the batteries inside the paper tube before you put the whole lot back in.

7) Think before you put the batteries in. Wrong polarity will destroy your circuit instantly! The spring is supposed to make contact with the *positive* terminal and the washer at the end of the pc board is to the *negative* terminal of the battery.

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used and the rest of the 15 bits are used as data (code).

The design of this project is based on the same principle. Two 8-bit shift registers are cascaded into a 16-bit shift register. Pressing the ON button will load a pre-programmed bit pattern to the shift register. The oscillator will clock out the data in the shift register one bit at a time. If the particular bit shifted out is a one, it turns on the LED, otherwise it turns the LED off. In order to increase the signal-to-noise ratio at the receiving end, it is recommended to use a high efficiency LED with at least 500 mcd output power. The registers are connected in a circulating fashion: any bit shifted out of the shift register will also be shifted back to the last bit of the 16-bit train. So long as your finger is pressing the button, the code will be transmitted repeatedly. As opposed to the one shot transmission, I've found that this technique allows greater drift in the receiver clock before errors start to occur.

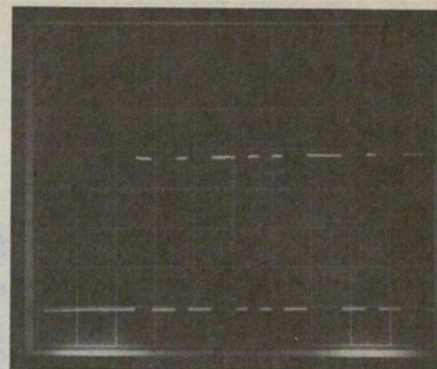
Transmitter construction

The transmitter circuit is very simple, but fiddly work when you come to construct it. This is unavoidable as there are so many

things that have to be squeezed into a tiny space of about 12.2 cubic cm. The order in which the components are placed on the board is important. Pads on the pc board with a small middle hole have to be drilled with a 0.8 mm drill bit. Solid pads should be left alone. The first job you have to do is program your own transmitter code by cutting the tracks on the pc board. The pads where pins 15, 14, 13, 4, 5, 6 and 7 of IC2 and IC3, and pin 1 of IC2 are to be soldered to have ground and Vcc connected to them through thin tracks. Initially then, the positive and negative supply rails are short circuited.

Now, if you want to program pin 7 of IC3 to be a '1', you have to cut the track joining the ground to the pad. If a '0' is desired, cut the track connecting Vcc to that pad instead. Never cut both tracks, or the pad will have floating state input. After cutting the fifteen tracks, it's good practice to measure the resistance between ground and Vcc. If they have zero or just a few ohms resistance, you'd better go back and check your cutting. Also, check that all the relevant pins are shorted to one rail or the other.

Because of lack of space available on the



The 'captured' code. This photo shows the code "1" 0010011010100 — 1001 ... which repeats itself. Note that the "1" (the first start bit) is longer than the other "1s" because of the parallel loading time. Horizontal scale: 5 ms/div; vertical scale: 1 V/div.

pc board, six flying wires are used. Thin 32 BNS insulated copper wire is preferred over normal hook up wire. The wires' labelling is as follows (please see the overlay diagram):

Wire A: connects from the Vcc track on the pcb to the spring;

Wire B: connects pin 3 of IC1 to pin 10 of IC2;

Wire C: connects pin 3 of IC2 to pin 11 of IC3;

Wire D: connects pin 3 of IC3 to pin 11 of IC2;

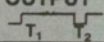
Wire E: connects pin 16 of IC2 to the anode of LED1;

Wire F: connects pin 3 of IC3 to resistor R4 as shown in the overlay.

It is important to solder wires B, C, D before any components. Then solder the resistors and the capacitors onto the pc board. Next, solder one of the Vcc brass washers on to one end of the pc board where the LED is going to be soldered on. Make sure the washer forms a right angle with the pc board. With some fiddling, you can insert the LED pins through the hole on the washer and solder them onto the board. It will be necessary to cut the pins to the right length and bend them to fit. You should make sure that the pins, after they are soldered to the board, do not touch the washer and are strong enough to hold the LED in position. Otherwise, the LED might short circuit the board and anything could happen. The remaining washer can be soldered to the other side of the board. Once again, the washer has to be at right angles to the pc board.

Cut a section of insulated copper wire about 9 cm long and solder one end of it onto the pc board as shown in the overlay and the other end to the spring. This is the wire labelled A.

The next component to be soldered is the transistor. Leave enough length on its pins so that you can bend the transistor over after it's been soldered. If you leave it vertical, it will be too high to go into the aluminium tube. Now you can solder all the ICs onto the board, then the wires E and F must be soldered directly onto the assigned pins of the ICs (see the overlay). The other

R1	R2	C1	555 TIMER OUTPUT 	PERIOD OF CLOCK $T = T_1 + T_2$	TRANSMISSION RATE $F_{CK} = 1/T$
33k	270k	1nF	$T_1 = 0.21 \text{ ms}$ $T_2 = 0.187 \text{ ms}$	$T = 0.397 \text{ ms}$	2519 BITS/S
82k	470k	1nF	$T_1 = 0.3825 \text{ ms}$ $T_2 = 0.3257 \text{ ms}$	$T = 0.7082 \text{ ms}$	1412 BITS/S
680k	680k	1nF	$T_1 = 0.9425 \text{ ms}$ $T_2 = 0.47124 \text{ ms}$	$T = 1.414 \text{ ms}$	707.3 BITS/S

$$T_1 = 0.693 (R1 + R2) C1$$

$$T_2 = 0.693 (R2) C1$$

Table 1. Listed component values determine the clocking rate of the code (transmission rate). Same codes with different transmission rates do not interfere with each other.

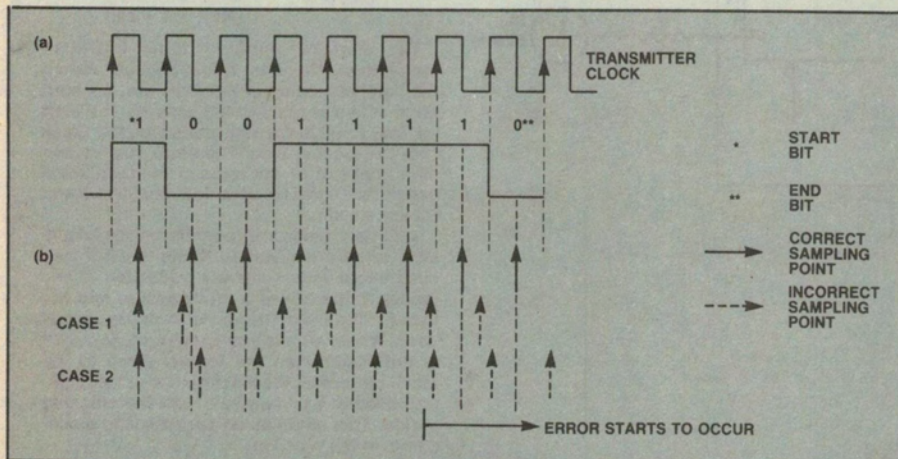
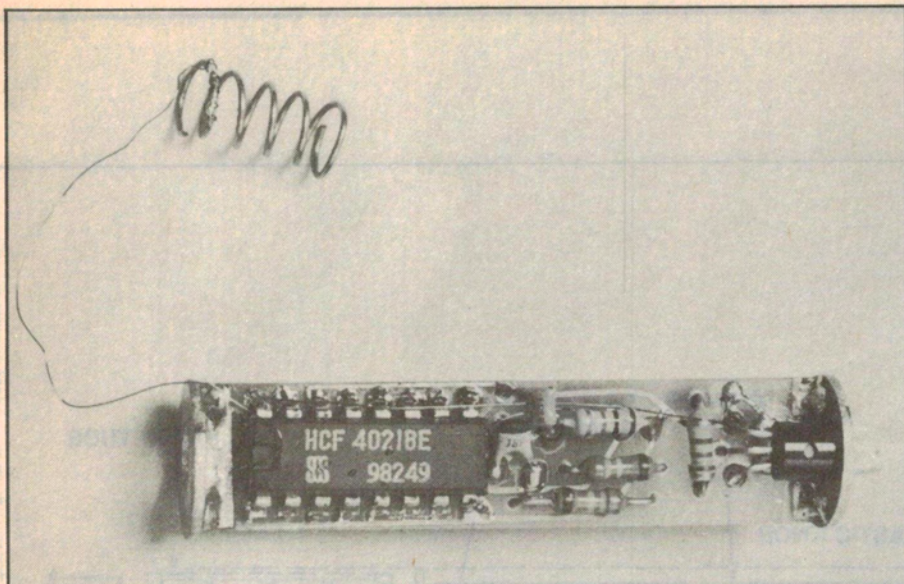
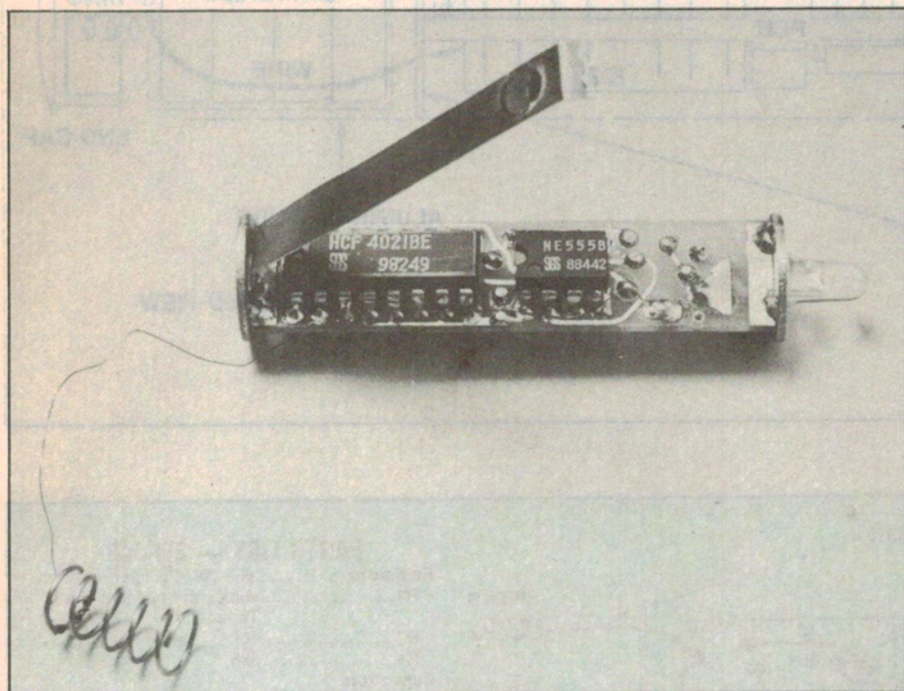


Figure 1. A drifting receiver clock affects the sampling instant. The sampling points drift away which results in error when the same data bit is sampled twice or missed.



The pc board showing side A components.



The pc board showing side B components.

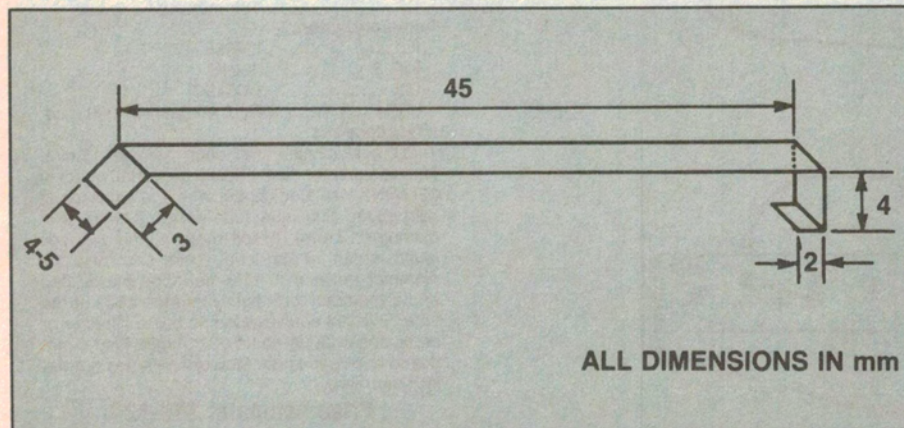


Figure 2. Bending diagram for the copper strip to make a pushbutton switch.

ends are soldered on to the pc board normally. Be careful during this operation. Quite often when you think the copper wires are soldered on, they are not. The insulating material melts and keeps the wire in position even though the copper is still unconnected to the track.

A meter should be used to check the resistance between the two points that are joined by the wire. Because the surface mounting technique is used here for the ICs, you have to cut their pins and solder them directly on the pads. Another point to look for: wire A has to reach the batteries from the pc board. Inevitably, it has to go past the rim of the brass washer, which is a tight fit in the tube. To avoid the wire being trapped in between the tube and the washer, a small slot can be filed in the rim of the washer using a needle file.

The last thing you have to do is make a pushbutton switch for the transmitter. Cut a strip of copper or brass (28G or 30G) about 60 x 4 mm. Bend it and solder it onto the board as shown in Figure 2. The other end of the copper strip is bent so that it is about to touch the tinned contact on the board. The copper strip is now acting like a cantilever and only a slight push near the end should cause the contact to make. Now put the transmitter circuit, including the batteries and the plastic ends into the aluminium tube. The tube is 94 mm in length and the inner diameter is 13 mm.

Next drill a hole for the pushbutton itself: this will be 5 mm in diameter, its centre sited 21 mm from the end of the tube. The plastic knob is inserted through the hole; it will land on the end of the copper cantilever (see Figure 3). When operated this effectively connects the batteries to the circuit and activates the transmission. To improve the quality of your 'home made' pushbutton switch, tin the tip of the copper strip with solder.

Now you are ready for a test. Push the button and see whether the LED lights up. If everything is OK, take out the knob, scratch the copper strip at the point where the knob is going to be glued on. Put a drop of glue onto the copper strip through the hole on the aluminium tube, press the plastic knob back on and allow time for the glue to dry. To make the transmitter more reliable against shock, a few drops of araldite can be put in the gap between the washers and the inner wall of the tube to fix the pc board.

Testing and setting up

Normal practice is to construct a circuit, first, set it up and then, if it is not working, troubleshoot it. Because of its compactness and the surface mounting technique used in this circuit, it will be very difficult to correct any mistake once the circuit is built. To make sure everything works the first time, the following points should be observed si-

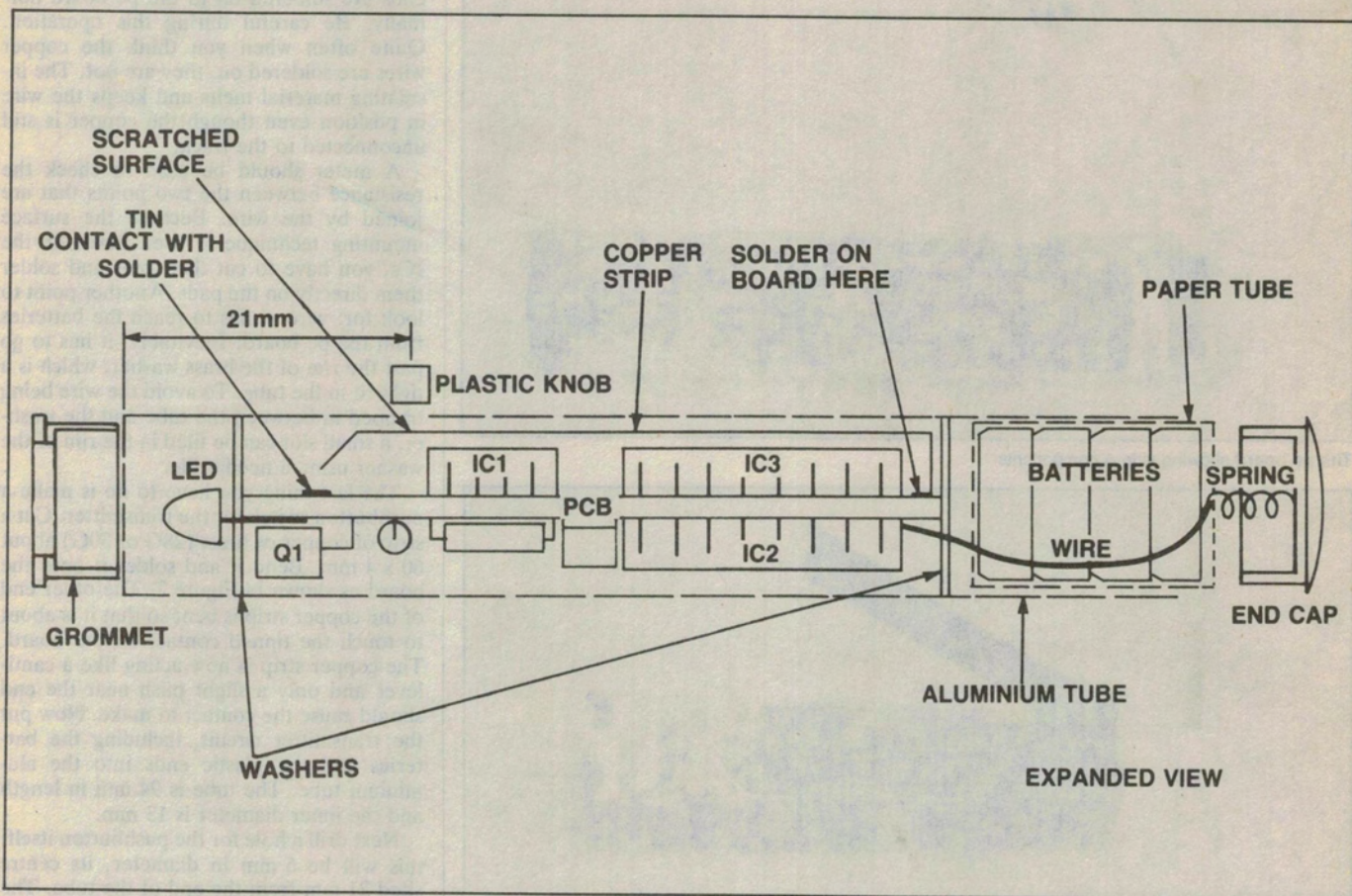


Figure 3. The assembly drawing for the transmitter.

PARTS LIST — ETI-343

Resistors.....all 1/4 W, 1% tolerance
R1, 2.....values are optional, see Table 1
R3.....10k
R4.....5k6

Capacitors
C1.....1n resin dipped monolithic ceramic
C2.....18p miniature ceramic

Semiconductors
IC1.....LM555
IC2, 3.....4021B
Q1.....BC549C
LED1.....Red, megabrite 1000 mcd

Miscellaneous
Two brass washers (max outer diameter 13 mm, min diameter for centre hole 5 mm). Half metre of 32G BNS insulated copper wire and a section of light gauge aluminium tube (length 94 mm inner diameter 13 mm). A soft metal spring with coil length about 10 mm long, 2 mm pitch and coil diameter between 5 to 8 mm. One plastic cap and a grommet to fit tightly into the ends of the tube. ETI-343 double-sided pc board. Copper or brass sheet (30G) about 60 x 4 mm. One 5 mm diameter plastic knob. Mercury batteries are not included here.

Price estimate: \$19-\$24