MINIATURE FM TRANSMITTER

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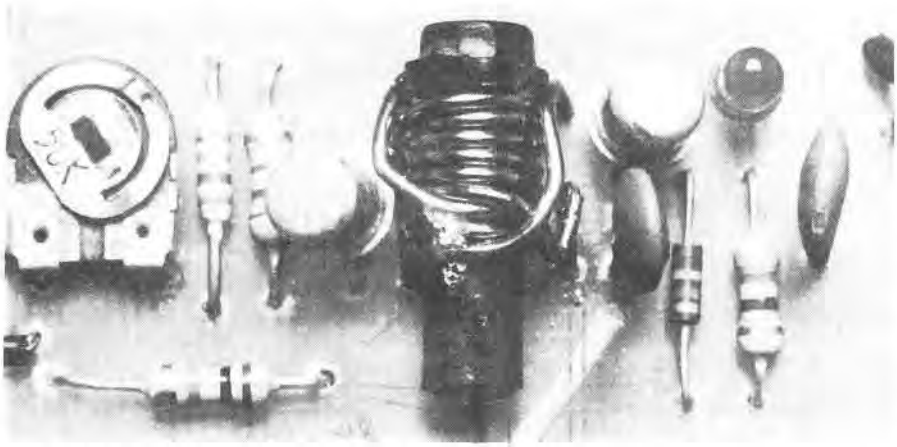
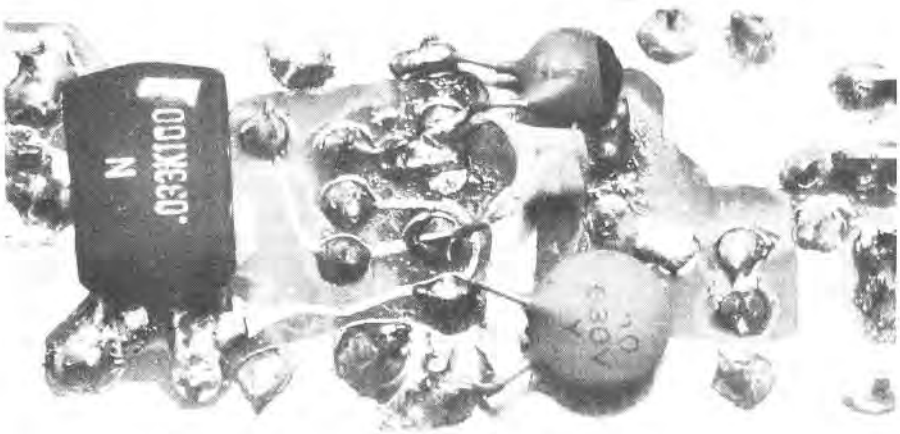
ETI continues its quest for smallness almost to vanishing point. The biggest part of this ultra tiny device is the battery. A fun project for Christmas.



Both sides of the board. Note the capacitors soldered to the bottom.



WE HAVE PUBLISHED several extremely compact projects recently. These have included the transmitter section of the optical car alarm switch (September '85) and the ETI-741 radio mic (January '85). For one reason or another both these projects were extremely complex and building them required considerable experience and a good deal of patience.

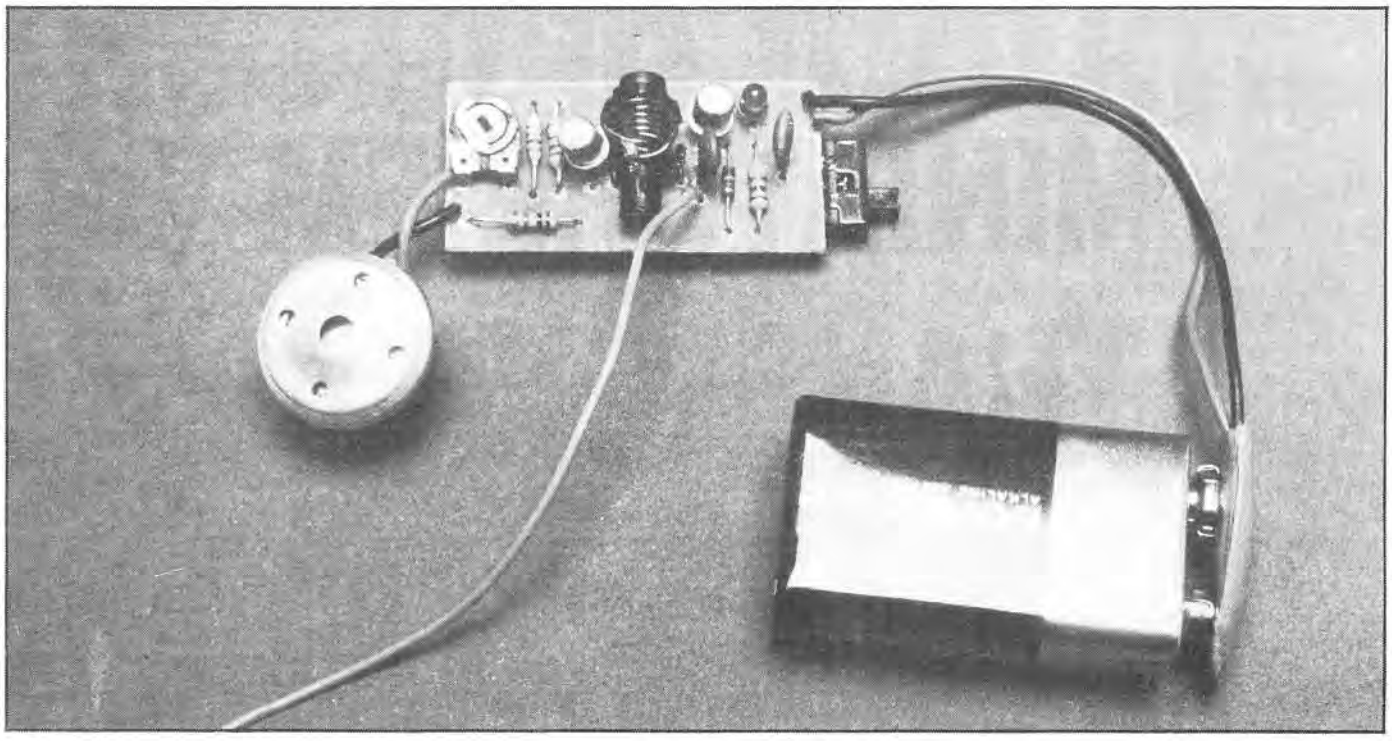
Here we publish something that's ultra small and easy to build. It's a minimum component radio transmitter operating at the bottom of the VHF radio band, somewhere around 88-90 MHz. We make no great claims for its fidelity, (strictly lo-fi) but it is perfectly adequate for transmitting speech over distances of 15 to 20 metres indoors, and further distances outside.

The design emphasises simplicity to the exclusion of almost every other consideration. The audio frequency from the microphone modulates a tuned circuit formed by the coil and some capacitors to derive an FM signal in the text book manner. Output from this is buffered and amplified by a single transistor amplifier and then fed to an aerial.

Construction

Construction is quite straightforward. First check the circuit board. Notice that it is rather small, so check that the etchant hasn't eaten right through the tracks anywhere, and also that no bridges remain where they shouldn't. It's a good idea to clean the board with some abrasive cleaner and plenty of water at this stage — that way you get to look at it closely.

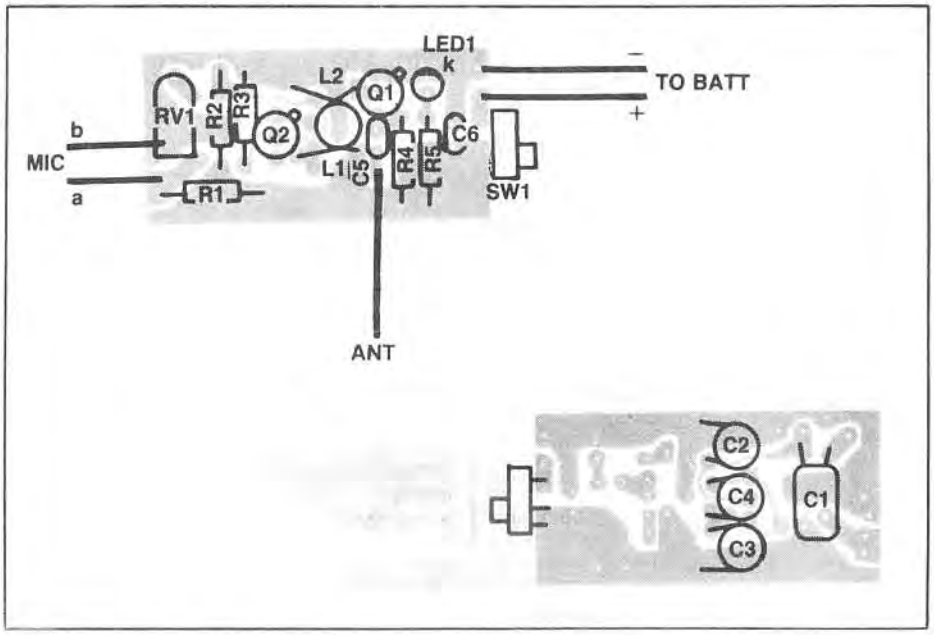
If the board hasn't already been drilled, do it now. Note that some of the components are soldered on to the back, so some of the pads don't have holes in the middle of them. Don't drill these out.



Now begin to solder the components on to the board. Begin with the resistors, then solder the two microphone leads into place. Then place the variable resistor. Do it in this order because one of the mic leads goes under the resistor, and it's rather tricky trying to get the wire into place if the resistors are already there. When you've done this, solder the two capacitors that fit on the component side into place, then the two transistors and the LED. Check the orientation of these components.

Now turn the board over and place the switch and four capacitors on the back. The easiest way of doing the capacitors is to first bend the legs at right angles about one mm from the component body. Cut the leg about one mm from the corner. Now drop some solder on to the pads, rest the capacitor on top of the fillet and apply some heat to the leg. This will heat the solder below and the component will sink into it. Apart from anything else, this method means you never need more than two hands for the operation. (Have you ever noticed how often in electronics you need one hand to hold the board, one hand for the component, one for the solder and one for the iron? If God had meant us to be electronic technicians we would all look like a multi armed Buddhist statue.) When you've finished this, fold over the 33n greencap, but leave the others standing upright for the time being.

Now comes the fun part — winding the coil. First wind on two turns around the former, cut the ends off and tin them. This forms L2. Next do the same for L1 making eight turns, and solder the four ends on to the board. Finally, solder the battery leads and the aerial in place, and go back over your work, searching for misplaced components, solder bridges or splatter.



PARTS LIST — ETI-751

Resistors ..... all ¼ W, 5%
- R1 ..... 10k
- R2 ..... 82k
- R3 ..... 2k2
- R4 ..... 560R
- R5 ..... 470R
- RV1 ..... 50k

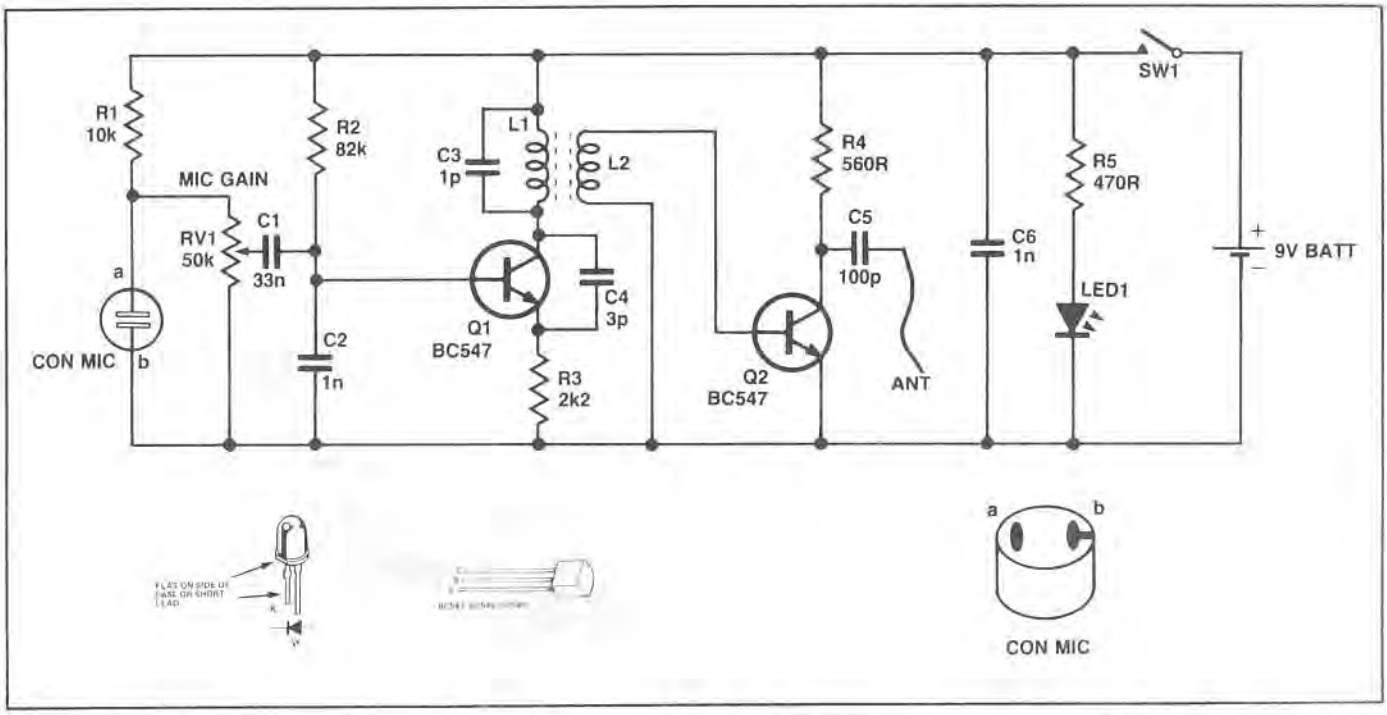
Capacitors
- C1 ..... 33n greencap
- C2, 6 ..... 1n ceramic
- C3 ..... 1p ceramic
- C4 ..... 3p ceramic
- C5 ..... 100p ceramic

Semiconductors
- Q1, 2 ..... BC547, '549 or equivalent
- LED1 ..... 3 mm round LED

Miscellaneous

1 x 5 mm coil former, DSE Cat L-1010, together with a ferrite core like DSE Cat L-1302 and some enamelled 0.8 mm winding wire like DSE Cat W-3120; one ultra miniature SPDT slide switch (DSE Cat S-1015). The microphone should be an electret type — we used the DSE C-1160. A battery type 216 snap connector and 1300 mm of thin hook up wire to serve as the antenna.

Price estimate: $8.50



Setting up

At this stage, you need some other bits and pieces. An FM receiver is essential, a function generator and CRO desirable. Firstly, connect the battery, operate the switch and check that the LED comes on. If it doesn't, switch off straight away. Either the battery is a dud, the LED is in the wrong way around or you have the battery leads swopped over.

With the LED on, switch on the receiver and sweep through the FM band to see if you can find the 751's carrier. You should detect this as a sudden silencing of the FM noise. It helps if you can connect the function generator to the mic leads. Feed in a sine wave of about 1 kHz, and then you should hear tone from the receiver when you're tuned in.

More than likely you will find nothing on this first attempt. Tune the receiver to about 88 MHz, right at the bottom of the FM band, and screw the slug through the barrel. Still no luck? Carefully remove one side of L1 and take a turning off the coil, and then repeat the whole process. The frequency of the coil is quite sensitive to the number of turns and the position of the slug, so you may have to do this a number of times. We eventually got ours set up at about six turns.

It's a good idea to put on more turns than you need. That way you know that if it's not tuning properly you must remove coils. Also, if you need to increase the number of turns, you don't have to start right from the beginning again with a new piece of wire. Be careful to use the minimum amount of heat possible during all this resoldering, to avoid damaging the tracks.

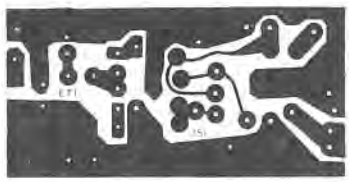
If you have trouble during this stage of the operation, a CRO is very helpful. If you probe the collector of Q1 you should see the oscillator waveform, which will tell you what is happening. If you don't have access to a CRO that will run about 90 MHz, a multimeter across the base emitter of Q1 will at least prove that part of the circuit, if it reads approximately 0.6 volts.

When you get it set up remove the function generator, solder in the mic and adjust the pot for maximum volume and minimum distortion. Fold over the remaining capacitors on the back of the board and glue the windings, slug and former together so nothing can move.

Using

The next problem is mounting the device. This is entirely up to your own ingenuity and imagination. A few points to notice. If you want to use it to monitor a particular position, you may not need the switch. In that case remove it and bridge across the switch pads with a bit of wire. The LED then serves very little purpose, so you may wish to consider removing it together with its associated resistor. As a bonus this will also reduce battery drain.

However you do it, make sure the mic is securely mounted. If you leave it to dangle off the leads it won't last long. If you intend mounting the device in a case things will take care of themselves. If not, consider using a short piece of one of the component legs instead of wire for the connection. That should lead to a sufficiently stiff mounting. ●



HOW IT WORKS — ETI-751

The principle of the circuit is obvious but the exact solutions for characteristics of the oscillator are hard to calculate. Making rough approximations on the way, we found that the inductor L1 would be somewhere around 500 nH. A working sample of the inductor was actually measured under the L-C-R bridge. We obtained a value which is fairly near to the calculated one.

The signals picked up by the condenser microphone are ac coupled to the transistor Q1. RV1 can be manually set to attenuate this coupling. Varying this pot will affect the sensitivity and the distortion of the circuit.

The ac signal from the microphone will vary the ac emitter current of transistor Q1. This changing current changes the effectiveness of the capacitor C4 as seen by the tuned circuit formed by L1, R3, C3 and C4. The apparent changing capacitance of C4 shifts the oscillation frequency of the tuned circuits.

Capacitor, C4, also plays an important feedback role keeping the oscillator oscillating. The free running frequency of the tuned circuit with no input microphone signal is around 88 MHz. This is the carrier frequency. The modulation of this frequency by the microphone signal generates the FM signal which can be picked up by a normal radio.

To stop the antenna from loading the tuned circuit directly, a secondary wiring is used to couple the signal to transistor Q2. This also introduces a bit more gain to the circuit. If the output resistance of Q1 is Ro and the input resistance of Q2 is Ri, the turns ratio N of the transformer formed by L1 and L2 is given as:

$$N = k \frac{Ro}{Ri}$$

where k is the coupling between the windings. Its value depends solely on the material of the slug. The LED and R5 form a circuit ON indicator when the battery is connected to the circuit.