KJ-8231 905050

Project 12:

FM Radio Microphone

Want to be able to hear when the baby wakes up and starts to cry — without having to run an intercom cable between rooms? Here's a low power radio microphone that's ideal for this kind of job. It's easy to build and get going, and puts out a signal that can be received on virtually any standard FM radio.

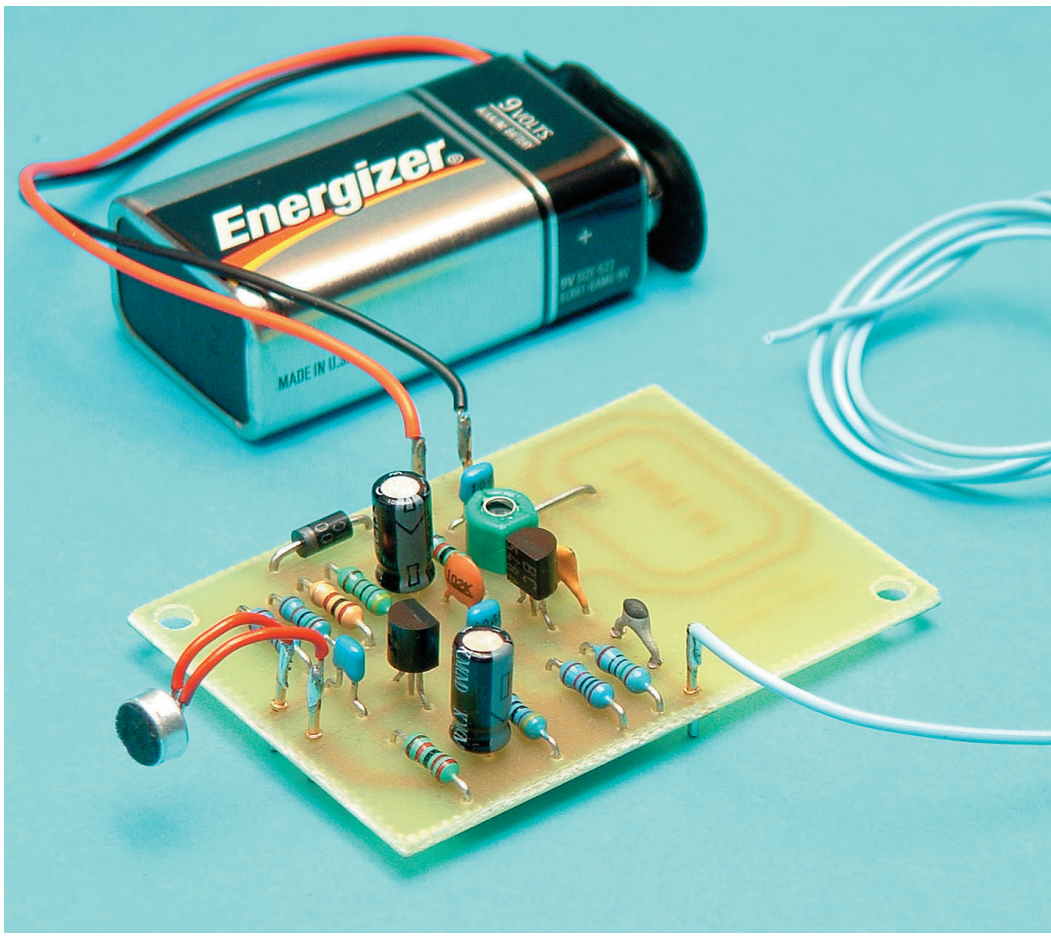
What does it do?

An FM radio mic is basically a very simple low power FM transmitter — like a 'bonsai' version of an FM radio station. It has an oscillator which produces a VHF (very high frequency) radio signal, with a frequency in the 88 - 108MHz band used for FM broadcasting.

There's also a microphone to pick up the sound you want to transmit, of course, and a small audio amplifier to boost the microphone's output. The output of the amplifier is then used to vary or **modulate** the frequency of the oscillator, so it produces an FM (frequency modulated) signal which can be received on a normal FM radio.

In this FM radio mic the output power from the oscillator is kept very low, so that it doesn't cause interference with your neighbours' reception of the normal FM stations. However by feeding the oscillator's output into a short length of wire used as a transmitting antenna, the signal can be received by any FM radio within about 10 metres of the radio mike itself.

This makes the radio mic very suitable for use as a baby minder. All you have to do is put it in the nursery near the baby's bassinet or cot, and then tune in its signal with an FM radio wherever you are in another room. This allows you to listen for any crying, without having to keep walking into the nursery — and also without having to go to a lot of trouble running a cable between the rooms.



Radio microphones have many other uses too, of course. For example secret service 'spooks' use them for listening to people they suspect may be planning terrorism, and private investigators use them for eavesdropping on people suspected of cheating on their partners, or stealing from their employers, etc.

The parts you'll need for this project:

- 1 PC board, code SHRTC212, 59 x 41mm
- 1 Mini electret mic insert
- 1 9V battery, 216 type
- 1 Battery clip lead to suit
- 5 PCB terminal pins, 1mm dia.
- 1 750mm length of insulated hookup wire
- 1 50mm length of 2-core lead
- 1 Small pack of resin-cored solder

Semiconductors

- 1 PN100 NPN transistor (Q1)
- 1 BC548 NPN transistor (Q2)
- 1 1N4004 diode (D1)

Capacitors

- 2 10µF 16V RB electrolytic
- 3 100nF multilayer monolithic
- 1 1nF disc ceramic
- 1 6.8pF NPO ceramic
- 1 3.9pF NPO ceramic
- 1 6.2-30pF trimcap (VC1, green)

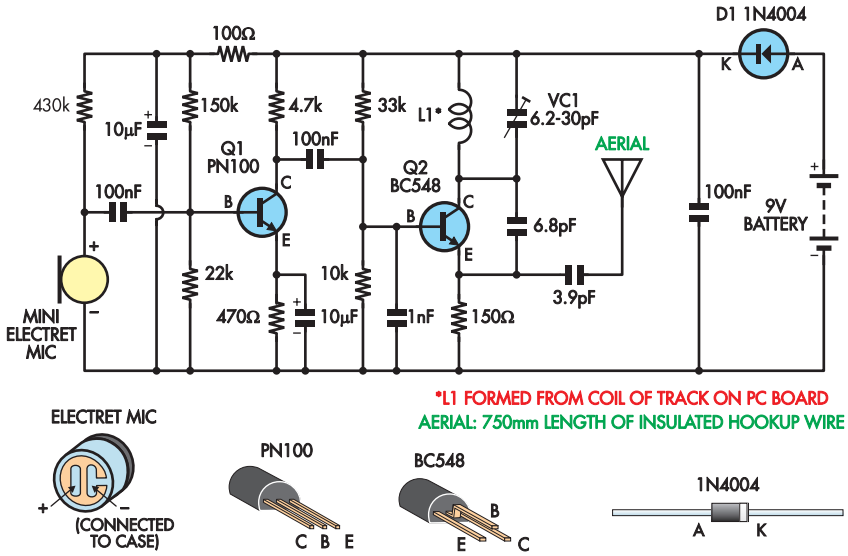
Resistors (0.25W 1%)

- 1 150k
- 1 22k
- 1 4.7k
- 1 150Ω
- 1 33k
- 1 10k
- 1 470Ω
- 1 100Ω
- 1 430k

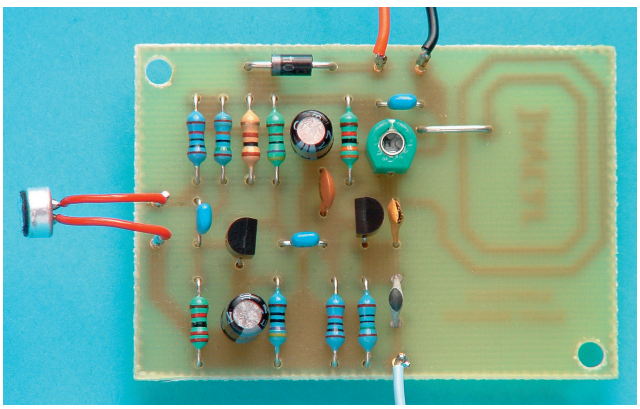
Putting it together

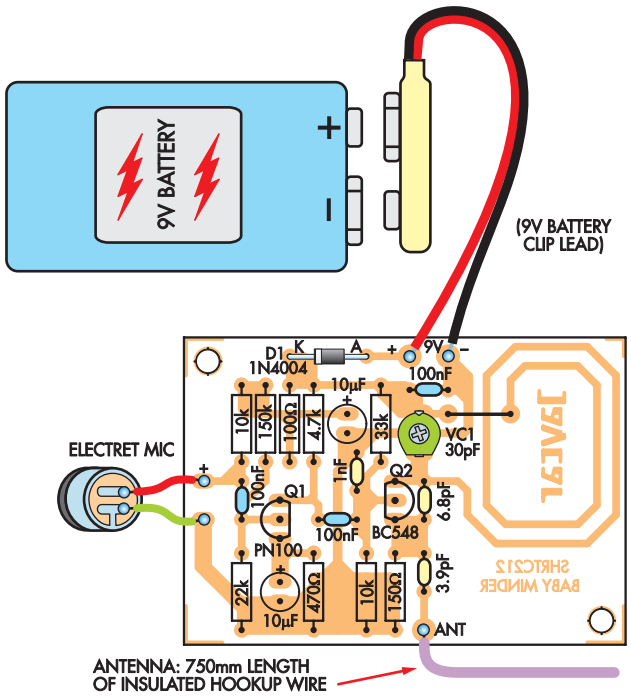
Except for the 9V battery that provides its power, and the wire used for its antenna, all of the parts used in the FM Radio Mic are mounted directly on a small PC board. The board is coded

Here's the circuit diagram (right) for the FM Radio Mic. It uses only two transistors – one to amplify the audio signals from the electret mic (Q1), and the other to oscillate at a frequency in the VHF FM band (Q2).



To help you in assembling your own FM Radio Mic, here's the wiring diagram (right) and a closeup photo of the finished board assembly showing it very close to actual size. Use them both as a guide and you shouldn't go wrong, because there isn't even a coil to wind!





SHRTC212 and although its tracks provide the oscillator's resonating coil as well as making the circuit connections, it still measures only 59 x 41mm.

Before starting to assemble the project, it's a good idea to open up the kit and lay out the parts so you can check that you have everything. At the same time you should inspect the PC board to make sure all of the holes have been drilled, there are no hairline cracks in any of the tracks and no accidental 'bridges' left between pads.

If everything is present and correct, the first assembly step is fitting the wire link. This goes up near the top of the board and just to the right of its centre, as you can see from the wiring diagram. It can be made from a 15mm length of either tinned copper wire or an offcut from a resistor lead, because there's no need for it to be insulated.

Next you can fit the five PCB terminal pins. Two of these go at top centre of the board, for the battery cliplead connections, while another pair go at the left-hand end of the board for the microphone insert connections. The remaining pin goes at bottom centre of the board, for the antenna wire connection.

With the link and pins fitted, the next components to fit are the fixed resistors. There are nine of these in this project, and they all mount in the usual horizontal manner. Only two of them have the same value though, (10k), so if you identify these and fit them into the board first this will help avoid mistakes. In any case use the wiring diagram to make sure you fit each of the resistors in their correct places. If you also fit all of the resistors so their colour code bands read in the same direction (like 'south' to 'north'), this will also make it easier if you ever need to troubleshoot the project down the track.

Next fit the unpolarised capacitors. There are six of these and they're all quite small, so be very careful when you're identifying them — and also when you're dressing their leads so they're spaced to fit into the board holes. Notice that the three 100nF capacitors are all of the multilayer monolithic ceramic type, which have a shiny body and are usually blue in colour. The other three low value capacitors are of the equally small ceramic disc type, with a matt-finish body and

Tech Talk: How does it work?

The heart of the FM Radio Mic is transistor Q2, which is connected as a VHF oscillator. It oscillates because of the 6.8pF capacitor providing feedback between the transistor's collector and emitter, and its frequency of oscillation is set by the tuned circuit formed by trimcap VC1 and inductor L1.

In this case inductor L1 isn't the usual coil of wire, but a small spiral of copper track on the PC board itself. We've done this so that you don't have the hassle of winding a coil — just fit the short wire link which connects one end of the 'printed' coil. We've also made L1 just the right size so that the oscillator's frequency can be set to anywhere in the 88-108MHz FM broadcasting band, simply by adjusting VC1.

As you can see we pick off a small amount of the oscillator's RF energy from the emitter of Q2, and feed it to the antenna wire via a 3.9pF coupling capacitor.

The weak audio signals from the electret microphone insert are first fed to the base of transistor Q1, which is connected as a common emitter audio amplifier. The stronger audio signals which appear at the collector of Q1 are then fed to the base of the oscillator transistor Q2, via the 100nF coupling capacitor.

Although the base of Q2 is bypassed to the negative line via the 1nF capacitor, and therefore has no RF signal on it, the bypass capacitor has quite a high impedance for audio frequencies. So the audio signals from Q1 are able to vary the base bias on Q2, and this varies the transistor's internal capacitance. As a result its oscillating frequency is varied a small amount as well, producing the frequency modulation we want.

usually either grey or light beige in colour.

Now you can fit the small trimcap VC1, which goes just above the centre of the board. Make sure you fit it with its flat side facing downwards, towards the 6.8pF fixed capacitor.

Next fit the two small 10µF electrolytic caps, which both fit with their negative 'stripe side' leads towards the bottom of the board. Although the board doesn't provide any extra holes for these electros, this shouldn't be a problem because just about all 10µF electros of the PC board mounting type come with their leads already spaced 2.5mm apart — and that's just the hole spacing we've provided for them on the board.

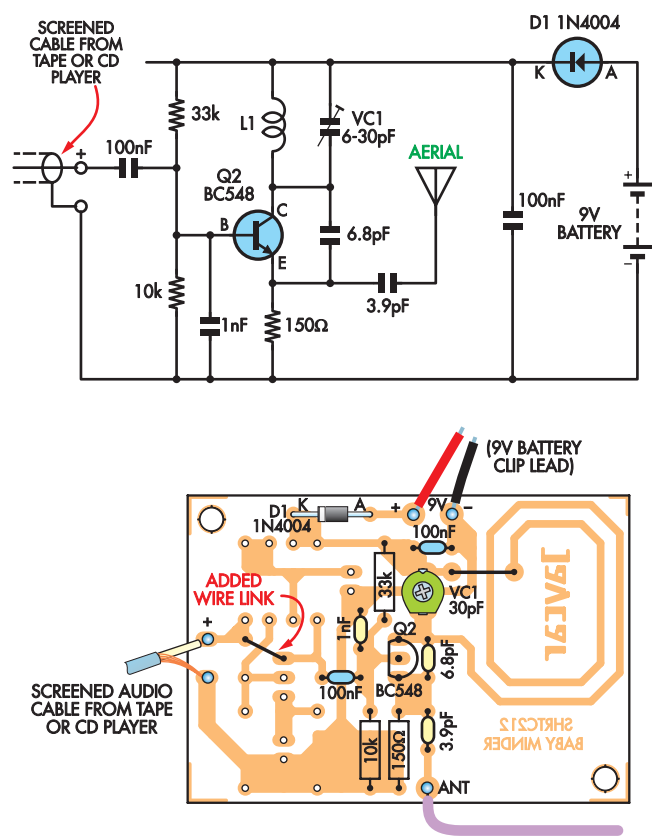
The next component to fit is D1, the 1N4004 diode. This mounts up at the top of the board, just to the left of the terminal pins for the battery cliplead. Make sure you follow the wiring diagram and fit it with its cathode band end towards the left.

Next fit the two transistors Q1 and Q2. Make sure you fit the PN100 transistor in the Q1 position, and the BC548 in the Q2 position. Notice that the two are fitted so their flat sides are facing each other.

The final component to fit is the mini electret mic insert, which as you can see connects to the terminal pins on the left-hand end of the board. But don't try to solder its rear connection pads directly to the terminal pins, because this would require too much heating and risk damaging the mic's internal circuitry. We recommend that you prepare two short lengths of insulated hookup wire, say about 30mm long. Bare about 4mm at each end, and carefully tin them with your soldering iron. Then carefully solder one end of each wire to the pads on the rear of the mic, doing this as quickly as you can to avoid trouble. Then you can hold the mic insert while you solder the other end of each wire to the PCB terminal pins. Just make sure that you solder the wire that connects to the mic's 'connected to the case' pad to the terminal pin marked '-', because the mic insert is polarised. It won't work the other way around.

Your FM Radio Mic should now be just about complete. All that remains is to solder one end of the antenna wire to the 'ANT' pin at the bottom of the board, and also solder the battery cliplead wires to the 9V pins at the top of the board. Make sure you get the polarity of the cliplead wires right, though: the red wire goes to the '+' pin on the left, nearer diode D1.

There's just one last job to do before you can try out the FM Radio Mic, and you can probably guess what it is. That's right: check the board carefully to make sure you're fitted all of the components in their right position, and the right way around in the case of the polarised parts. It's also a good idea to give the underside of the board a quick inspection too, in case you've forgotten to make one of the solder joints — or left a dry joint or solder bridge shorting between pads.



Here's how to modify the FM Radio Mic so it can be used to feed audio from your tape or CD player into a hifi system via its FM tuner.

Trying it out

If everything checks OK, it's time to grab a 9V battery and a small jeweller's screwdriver or mini alignment tool for adjusting trimcap VC1. Then take these and the FM Radio Mic to a spot within a couple of metres of an FM radio — or bring the radio near your workbench, if that's easier.

Now turn on the FM radio, and tune it carefully until you find a spot on the dial where there are no FM stations which can be received in your area.

Next connect the 9V battery to the Radio Mic's cliplead, and then very slowly turn trimcap VC1 with the mini screwdriver or alignment tool. VC1 is the Radio Mic's tuning control, so before long you should match the Mic's

output signal frequency to the radio's tuning frequency. You'll probably hear a feedback 'howl' as this occurs, because the Radio Mic will be picking up the sound of its own signal from the radio's speaker.

To make sure you get the Radio Mic's tuning exactly 'spot on', you may have to turn down the radio's volume control — and/or move the radio further away. The best idea is to get someone else to listen to the radio in another room, and let you know when you set VC1 to give the loudest and clearest 'transmission' of your voice.

But what if you can't detect any signal on the FM radio, with any setting of the Radio Mic's trimcap? You guessed it again, that will probably be because your Radio Mic isn't working. And if it isn't working, that'll be almost certainly because you've made some kind of mistake in wiring it up. So disconnect the battery and start looking for the problem.

Perhaps you've connected the battery cliplead wires the wrong way around to the terminal pins, or else fitted diode D1 to the board around the wrong way. Or you may have swapped the PN100 and BC548 transistors, or connected one of the other polarised parts the wrong way around — one of the 10µF electros perhaps.

If you seem to be able to receive a 'silent signal' on the radio with one setting of VC1, but there's no sign of any sound picked up by the electret mic, this will probably be because you've accidentally reversed the connections to the mic insert.

Once you do track down your mistake and fix it, your FM Radio Mic should be complete and ready for use.

What to do next

With a few small modifications, you can adapt the FM Radio Mic so it can be used as a radio sound link — to feed audio signals from your personal tape or CD player into a hifi stereo system, via the FM radio tuner. In fact it's easy to modify it for this type of use, because the modification mainly involves removing all of the components used for the electret mic and the audio amplifier stage around Q1. Or not fitting them in the first place, if you prefer.

The components you don't need for this are the electret mic insert, the 150k, 22k, 4.7k, 470Ω and 100Ω resistors and also the 10k resistor at upper left on the board. In fact you can also leave out transistor Q1, both of the 10µF electros and the 100nF monolithic cap that normally fits to the left of Q1.

With these components removed all you need do is fit a wire link to the board as shown in the small diagram on the page opposite. Then a screened audio input cable can be connected to the pins usually used to connect the electret mic. This cable can be connected to the headphone or 'line' output of your tape or CD player, to bring in the signals to be transmitted.

It's quite easy, as you can see.

Meet the Pioneers of Electronics:

Michael Faraday

Born in London in 1791, Michael Faraday grew up in a very poor family and began work as an apprentice bookbinder. But he was fascinated by science, and went to lectures at the Royal Institution by the great Humphry Davy. Davy offered him a job as his assistant, and soon Faraday was experimenting with magnets, batteries and coils of wire.

Faraday was the first to discover the principles of **electromagnetic induction** – how a changing magnetic field through a coil of wire can induce a voltage into it. In other words, he discovered that magnetism could produce electricity just as electricity could produce magnetism. This discovery set the stage for the invention of both electrical generators and transformers. In fact he built the first crude electric motor and dynamo (generator), and also produced the first simple instrument to indicate electric charge: the **electroscope**.

Faraday was also the first to properly analyse electrolysis – what happens when an electric current passes through a conducting liquid. This provided the understanding needed for many future industries, like electroplating and electrolytic metal refining.

Georg Simon Ohm

Born in Erlangen, Germany in 1787, Georg Ohm was the son of a mechanical engineer who taught him a wide range of mechanical skills. But the family was quite poor, and he didn't have the opportunity to go to university for a full scientific education. Instead he found a job teaching in a local school, and experimented with electricity as a hobby. Using the skills learned from his father, he made most of his equipment himself – including batteries he made when he learned of the work of Volta, and a sensitive galvanometer he could use to measure very small currents.

When he learned that the 'flow' of heat energy from one point to another depended directly on the temperature difference between them and inversely on how unwilling the material between them was to conduct heat, Ohm guessed that similar factors probably controlled the flow of electric currents. He then carried out many experiments which showed in 1827 that this was indeed true: the flow of current through a conductor is directly proportional to the voltage difference across it, and inversely proportional to the resistance of the conductor itself. This turned out to be a fundamental law of electricity, named **Ohm's Law** in his honour.