Phone Minder

by COLIN DAWSON

– versatile bell extender and pager

Dubbed the Phone Minder, this handy gadget functions as both a bell extender and paging unit, or can perform either function separately. It should be of particular value to those who suffer hearing problems.

Many people suffer from partial deafness which prevents them from hearing the telephone ringing unless they happen to be very close to it. These people are usually quite able to maintain a normal conversation once they do answer the phone – it's just that, for various reasons, they are often unable to hear the bell, especially if the telephone is in another room.

The solution to this problem is a bell repeater – an alert device that detects a ringing telephone and generates a different frequency to the bell. This frequency can then be amplified and used to drive a loudspeaker. Our Phone Minder is capable of driving a loudspeaker to quite a high volume and includes provision to adjust the new "bell" frequency to accommodate individual hearing problems.

The big advantage of this scheme is that it allows the loudspeaker to be located remotely from the phone, say in another room or in the garage. Indeed, Phone Minder is intended for just such a role. It's easy to install and, most importantly, requires no direct connections to the telephone itself.

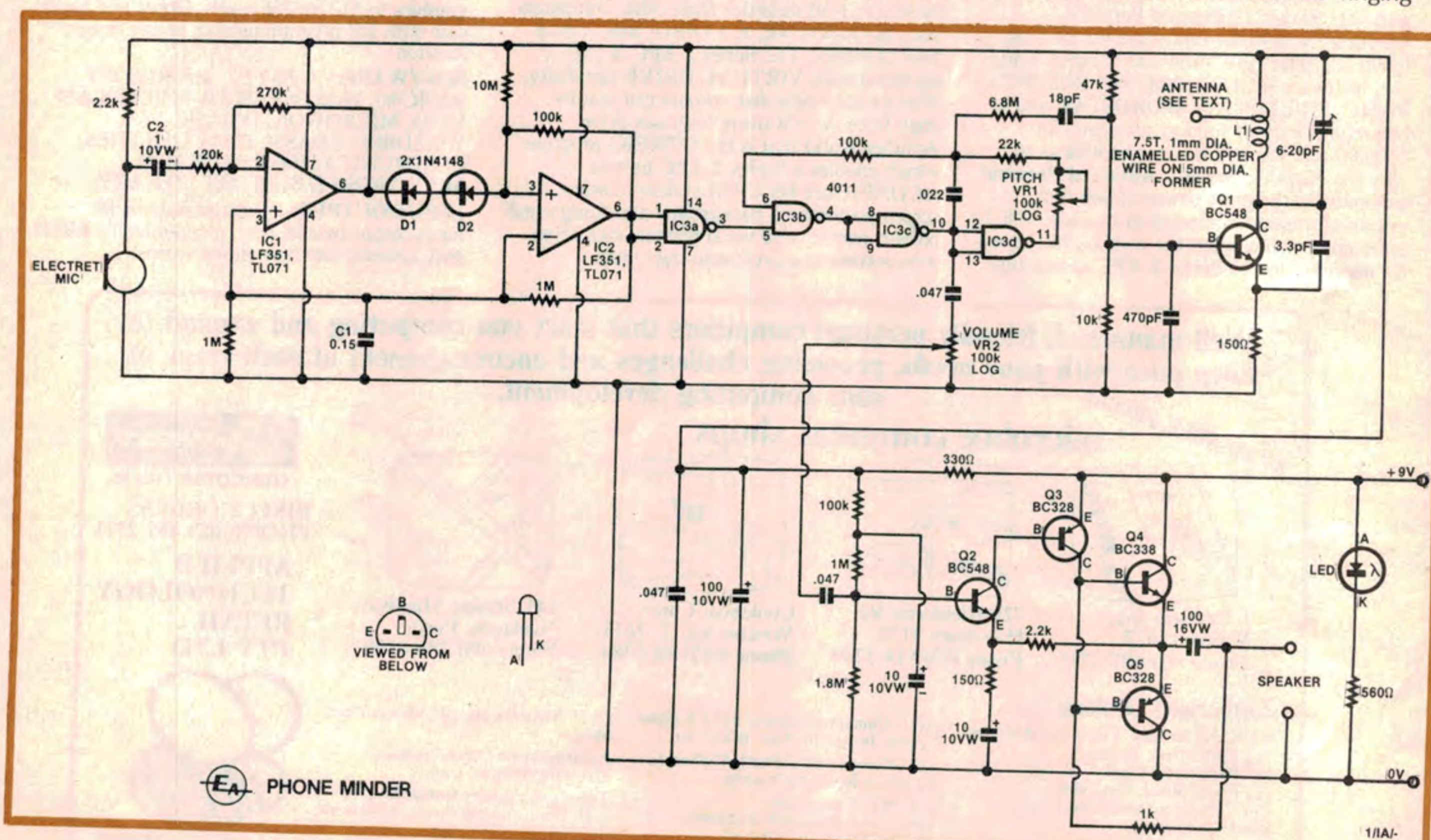
But what if you're out in the back yard? A simple bell extender is really restricted to use indoors, unless you fit very long speaker leads or add a high power amplifier. Clearly, effective coverage outside the house would be impractical in many situations, the more so when one considers the neighbours.

Perhaps the ideal solution would be for every household to be equipped with a pocket pager, but most of us can't justify the expense. Instead, we decided to add a low power FM transmitter to the circuit – one that can be used in conjunction with any domestic FM receiver. This provides sufficient range to cover most back yards and, if you already have a portable FM radio, will cost you a lot less than a commercial paging device.

So the circuit which evolved for this project is both an amplifier and a transmitter. It will prove handy for anyone with a telephone, but particularly so for those with hearing difficulties.

Design features

In use, the Phone Minder sits next to the telephone. An electret microphone is taped directly to the back of the telephone where it can pick up the sound of the bell, and this enables the circuit to detect the "ringing" tone. The circuit then responds to the sound of the bell by emitting a 400ms tone burst, the format of which resembles the ringing



format of the bell itself.

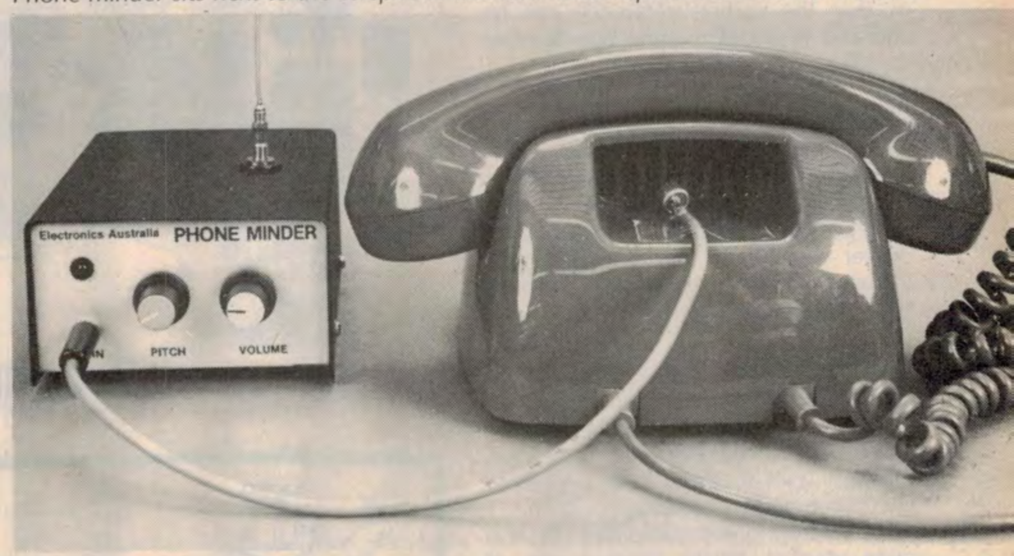
To explain further, the ring circuit of an ordinary telephone generates a repeating pattern of two short rings followed by a pause. The tone bursts produced by the Phone Minder duplicate this pattern. By adjusting the front-panel pitch control, the user can adjust the tone burst frequency to suit his requirements.

The amplifier incorporated into this circuit is capable of delivering about one watt into an 8Ω speaker which results in quite a high sound level, particularly where a reasonably efficient speaker is used. As most situations will not call for maximum power from the amplifier, a volume control is also included on the front panel.

The transmitter normally only transmits a carrier frequency, which means that an FM receiver tuned to the correct frequency will have no output – ie, it will be mute (apart from a small amount of hum). Whenever the phone rings, the same modulated tone that is fed to the amplifier is also fed to the transmitter. Anyone listening to the tuned receiver will thus hear the ring tone.

Even though the current drain of the circuit is quite low – around 9mA plus the LED current in the quiescent state – batteries are not really a practical power source. They would have to be replaced nearly every day, or several times a week if we dispensed with the LED. Given this limitation, a plugpack power supply is far more viable.

Phone Minder sits next to the telephone and uses a microphone to monitor the bell.



We found that, with the plugpack power supply, the project must be housed in a metal case, otherwise an unacceptable level of hum will modulate the transmitter. If the transmitter part of the circuit is not used, the project could probably be built into a cheaper plastic box.

Superficially, the amplifier section of this circuit would appear quite simple to implement – just an oscillator gated on by the sound of the telephone bell. However, this basic format suffers a major limitation. The loudspeaker must be located a long way from the telephone, otherwise a feedback loop will develop with the microphone picking up the sound of the loudspeaker and thereby triggering the tone generator into further operation.

There are two alternatives available to solve this problem: the microphone preamplifier circuit could be made

Phone Minder

selective so that it can detect only the telephone bell, or the tone generator can be made to operate for a predetermined period during which time the microphone preamplifier is disabled. The first of these approaches is the most difficult, as the tone generator would have to operate at a different frequency to the bell. Given that a telephone bell generates a range of frequencies, the tone generator would only be able to operate over a very restricted frequency range.

Obviously, the project loses much of its appeal if the tone generator is restricted in frequency. The whole point of its existence is to provide a tone which can be adjusted over a wide range. For this reason, we have chosen the second option of disabling the microphone for brief periods.

We have also designed the tone generator so that it is modulated at about 20Hz, which gives it that unmistakable "telephone sound", irrespective of the tone frequency.

The transmitter is very low power only, enough to give a reliable range of about 50 metres from a typical suburban dwelling. Buildings incorporating large metal structures will severely reduce the range. A trimmer capacitor is provided so that the carrier frequency can be adjusted to avoid existing broadcasting stations.

How it works

The circuit can be broken down into four distinct sections: a microphone preamplifier, detector and mute circuit; a tone generator; an FM transmitter; and a power amplifier. This simplifies the circuit description, as we can consider each section separately.

Cudlipp reborn

Actually the circuit is based on "Cudlipp", an electronic cricket which was featured in our February, 1982 issue. This just goes to show how a frivolous circuit can have a useful application.

The microphone preamplifier circuit is quite unusual, having three modes of operation which could be termed "listen", "oscillate" and "mute". Let's consider the listen mode first.

Normally, the output of IC2 (pin 6) is latched high which means that it is close to the supply voltage. This is fed back via a 1MΩ resistor to the non-inverting input (pin 3) of IC1. This pin is also connected to ground by another 1MΩ resistor so that the two resistors form a voltage divider and hold pin 3 of IC1 at half supply.

IC1 functions as an inverting amplifier with a gain of about two. Note that its inverting input is connected to its pin 6 output via a 270kΩ resistor. This feedback arrangement ensures that, in the absence of an input signal, pin 2 will be held to the same level as pin 3 – ie, pins 2, 3 and 6 will all be at half-supply.

Refer now to IC2. Its inverting input is held at half-supply by the same divider biasing pin 3 of IC1, while the non-inverting input (pin 3) is tied about 1.4V above half-supply by diodes D1 and D2 and the 10MΩ and 100kΩ resistors. Thus, IC2 is a comparator which is latched high (as already mentioned) in the listening mode.

When the microphone "hears" the telephone bell, the resulting signal is amplified by IC1 and rectified by diodes D1 and D2. This tends to pull the non-inverting input of IC2 low and, if the signal is large enough, causes IC2 to change state from high to low.

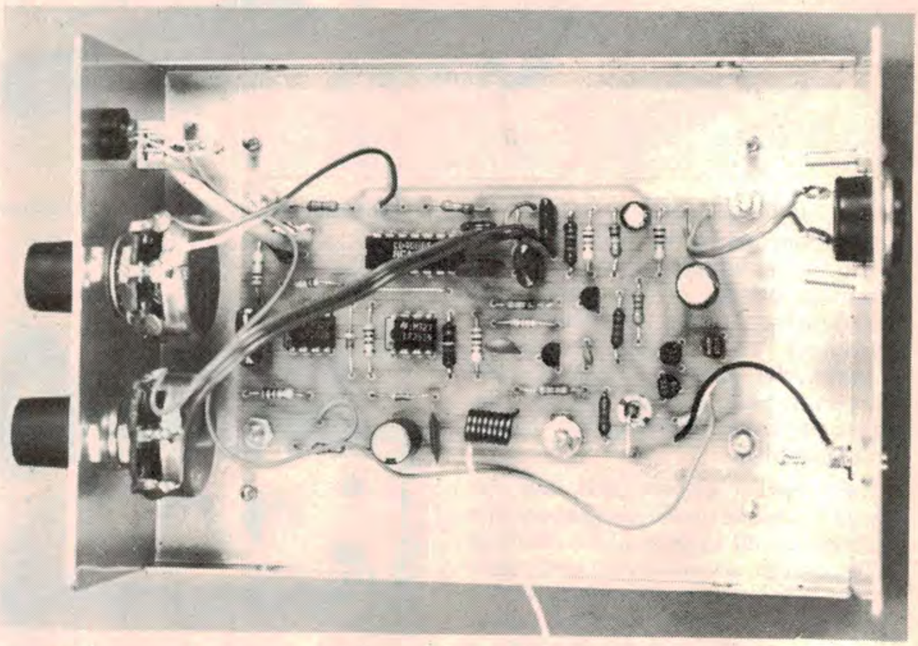
We estimate that the current cost of parts for this project is approximately

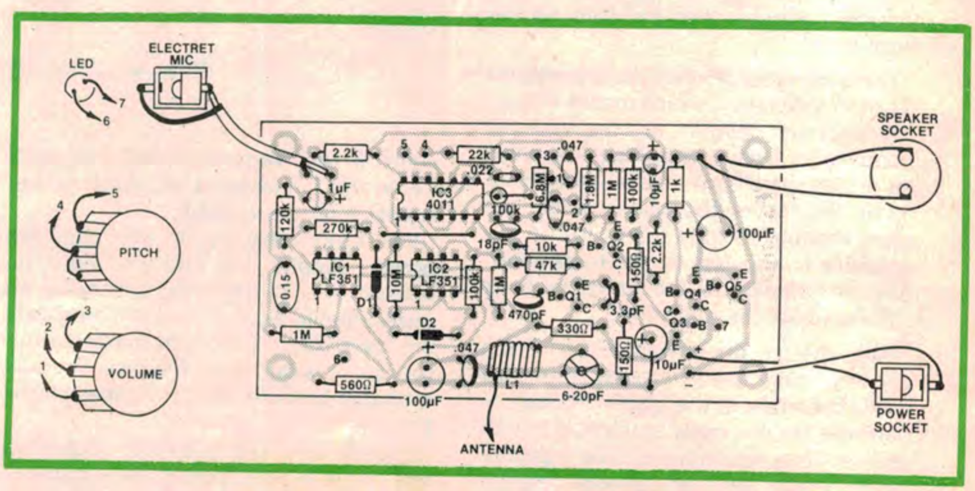
$25

This includes sales tax but not the cost of a plugpack supply, FM tuner, or loudspeaker.

IC2 now enters the oscillate mode whereby it produces a brief series of signal pulses from its output. When the output of IC1 goes low, the output of IC2 immediately swings from close to the supply voltage to about 2V. This means that the mid-point of the 1MΩ voltage divider network will now drop from half-supply to about 1V, although this drop is momentarily delayed by C1.

The charge on C1 very quickly falls to a level where IC1 is effectively inhibited, ie the non-inverting input (pin 3) is taken lower than any of the negative signal "peaks" which appear on the inverting input. Hence its output is latched low.





After about 20ms, the voltage on C1 also falls below the voltage on pin 3 of IC2 (about 2V). This causes the output of IC2 to change state from low to high which enables C1 to begin charging up again. But since pin 3 is tied low by the output of IC1, IC2 again changes state as soon as pin 2 goes slightly above pin 3.

Thus IC2 oscillates at about 20Hz while ever the output of IC1 is low.

The output of IC1 remains low until C2 discharges sufficiently (via the 120kΩ and 270kΩ resistors) to let pin 2 drop below pin 3. When this happens, IC1's output goes high, which effectively stops pin 3 of IC2 from being forced low. This means that, as soon as IC2 again changes state from low to high, the oscillatory mode is halted and normal bias is restored to the circuit.

The length of the oscillatory mode is set by the time constant formed by C2 and the associated feedback resistors around IC1. In practice, IC2 produces a 400ms signal burst each time the telephone rings – ie, two 400ms bursts will be produced during each cycle, corresponding to the two short rings produced by the telephone.

At the end of the oscillatory phase, the circuit enters an 800ms mute cycle while the voltages around IC1 restabilise to half supply. During this time, the circuit cannot be retriggered. This feature allows us to make the tone burst equivalent in length to the telephone ring while ensuring that we only get two tone bursts per cycle.

By comparison, the rest of the circuit is (thankfully) quite straightforward. The output of IC2 is inverted by IC3a which, in turn, enables a CMOS oscillator formed by gates IC3b, 3c and 3d. This "tone generator" operates at a frequency of between about 260Hz and 1250Hz, depending upon the setting of VR1.

When the output of IC2 is low (and thus the output of IC3a is high) the CMOS tone generator will be enabled (ie, will oscillate). As we have seen, the output signal from IC2 oscillates at 20Hz in 400ms bursts. The output from the tone generator thus consists of 400ms tone bursts modulated at 20Hz.

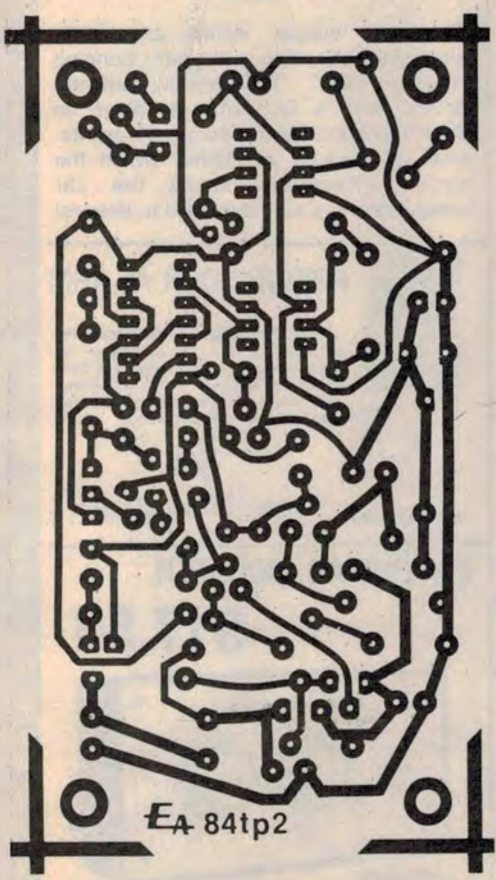
The output of IC3c (pin 10) is fed into the volume control (VR2) via a .047μF capacitor. From there, it passes via another .047μF capacitor to the base of transistor Q2.

Q2, Q3, Q4, and Q5 form a simple direct-coupled audio amplifier. The base of Q2 is biased to around 5V by the 1MΩ and 1.8MΩ resistors, while the 100kΩ resistor and associated 10μF capacitor decouple the bias network from the supply line. Q2's collector is direct-coupled to the base of Q3 and this in turn drives Q4 and Q5 which form a complementary output stage.

AC voltage gain of the amplifier is set to around 15 by the ratio of the 2.2kΩ and 150Ω resistors in the feedback network while the 10μF capacitor in series with the 150Ω resistor curtails the frequency response below 100Hz.

Note that, unlike the audio amplifier used in the Headphone Amplifier featured elsewhere in this issue, this circuit does not include provision to adjust the output stage quiescent current. This is because, in this application, we are not worried about crossover distortion.

The FM transmitter stage is actually very simple, consisting of a single NPN transistor (Q1) driving an LC tank circuit. It can be set to any frequency within the FM broadcast band by means of a 6-20pF trimmer capacitor, while drive for the antenna is taken from a tap on inductor



PARTS LIST

1 metal case, 100 x 150 x 60mm (W x D x H)
1 Scotchcal label, 100 x 53mm
1 PCB, code 84tp2, 105 x 56mm
1 electret microphone insert
2 3.5mm mono jack sockets and plugs
1 2-pin panel socket and plug
1 4mm banana socket and plug
1 30cm-length of 1mm enamelled copper wire
1 1-metre length of shielded audio cable

SEMICONDUCTORS
2 TL071 or LF351 FET-input op amps
1 4011 CMOS quad NAND gate
2 BC548 NPN transistors
2 BC328 PNP transistors
1 BC338 NPN transistor
2 1N4148 diodes
1 red LED and matching bezel

CAPACITORS
2 100μF/16V PC electrolytic
1 10μF/16V PC electrolytic
1 10μF/16V axial lead electrolytic
1 1μF/16V electrolytic
1 0.15μF metallised polyester
3 .047μF metallised polyester or ceramic
1 .022μF metallised polyester or ceramic
1 470pF ceramic
1 18pF ceramic
1 3.3pF ceramic
1 6-20pF trimmer

RESISTORS (¼W, 5%)
1 x 10MΩ, 1 x 6.8MΩ, 1 x 1.8MΩ, 3 x 1MΩ, 1 x 270kΩ, 1 x 120kΩ, 3 x 100kΩ, 1 x 47kΩ, 1 x 22kΩ, 1 x 10kΩ, 2 x 2.2kΩ, 1 x 1kΩ, 1 x 560Ω, 1 x 330Ω, 2 x 150Ω, 2 x 100kΩ log potentiometers.

MISCELLANEOUS
Machine screws and nuts, rainbow cable, 9V plugpack supply, 8Ω loudspeaker, speaker cable etc.

Phone Minder

L1. Frequency modulation is achieved by applying an audio signal to the base of the transistor.

Only a small amount of drive is required to achieve adequate modulation depth. For this reason, the signal is coupled from the tone generator to Q1 via a series 6.8MΩ resistor and 18pF capacitor. The drive for the transmitter is taken from a point on the tone generator which has a sawtooth waveform. This provides a much cleaner and more pleasing sound from the receiver.

Construction

Most of the parts are mounted on a printed circuit board (PCB) coded 84tp2 and measuring 105 x 56mm. Mount the parts on the board according to the overlay diagram, beginning with the resistors and capacitors and then moving on to the semiconductors. Take care with component orientation and don't forget the wire link adjacent to IC3.

IC3 is a CMOS device, so be sure to observe the usual precautions. Earth the barrel of your soldering iron to the earth track on the PCB (use a small clip lead) and solder the supply pins (7 and 14) first.

Inductor L1 consists of 7½ turns of 1mm enamelled copper wire wound on a 5mm former. A drill bit makes a convenient former – wind on 7½ turns, then trim and clean the ends of enamel before mounting the coil on the PCB. The antenna is connected to the inductor one turn from the positive end (ie the end furthest from the trimmer capacitor). Scrape away the enamel from a small section so that you can solder the antenna lead to it.

A standard metal case measuring 100 x 150 x 60mm (W x D x H) is used to house the circuitry and this is fitted with a Scotchcal front-panel label to provide a neat finish. Spray the Scotchcal label with a hard-setting clear lacquer (eg, "Estapol") before fixing it in position. The label can then be used as a drilling template for the front panel.

Other holes to be drilled in the case include mounting holes for the PCB, the speaker socket and the 3.5mm power jack socket. In addition, a banana-type antenna socket is mounted on the lid of the case directly above inductor L1.

The various items of hardware may now be mounted in position and the wiring completed. Use shielded cable for connections between the microphone socket and the PCB (and for connections to the plug and the microphone itself). All other wiring can be run using rainbow cable or light-duty hookup wire.

Once the wiring has been completed, go back over your work and check carefully for errors. In particular, check the power supply polarity. If you get the supply reversed, you could damage an IC or a transistor.

Testing

Testing the circuit involves little more than trying it out. Connect up a loudspeaker and power supply, set the volume control to half way, and whistle directly into the microphone. This should be sufficient to trigger the circuit so that it produces a modulated tone. Check that you can alter the pitch of this tone with the pitch control.

Next, the transmitter can be tested. Tune your receiver to a blank space in the FM band, switch the muting control off and adjust the trimmer capacitor on the Phone Minder PCB until a signal is detected (ie, the white noise produced by the receiver is reduced). Triggering the Phone Minder should now produce a tone from the receiver's loudspeaker (as well as from the speaker plugged into the Phone Minder itself).

Where available, a plastic alignment tool should be used to adjust the trimmer capacitor to prevent detuning effects. A frequency of around 95MHz should prove satisfactory in most cases.

Finally, an external antenna is necessary to ensure adequate transmitter range. A 30cm length of wire plugged into the antenna socket and mounted vertically will be sufficient for most applications. If a rigid antenna is used, the end of the wire should be bent in a loop as a safety precaution.