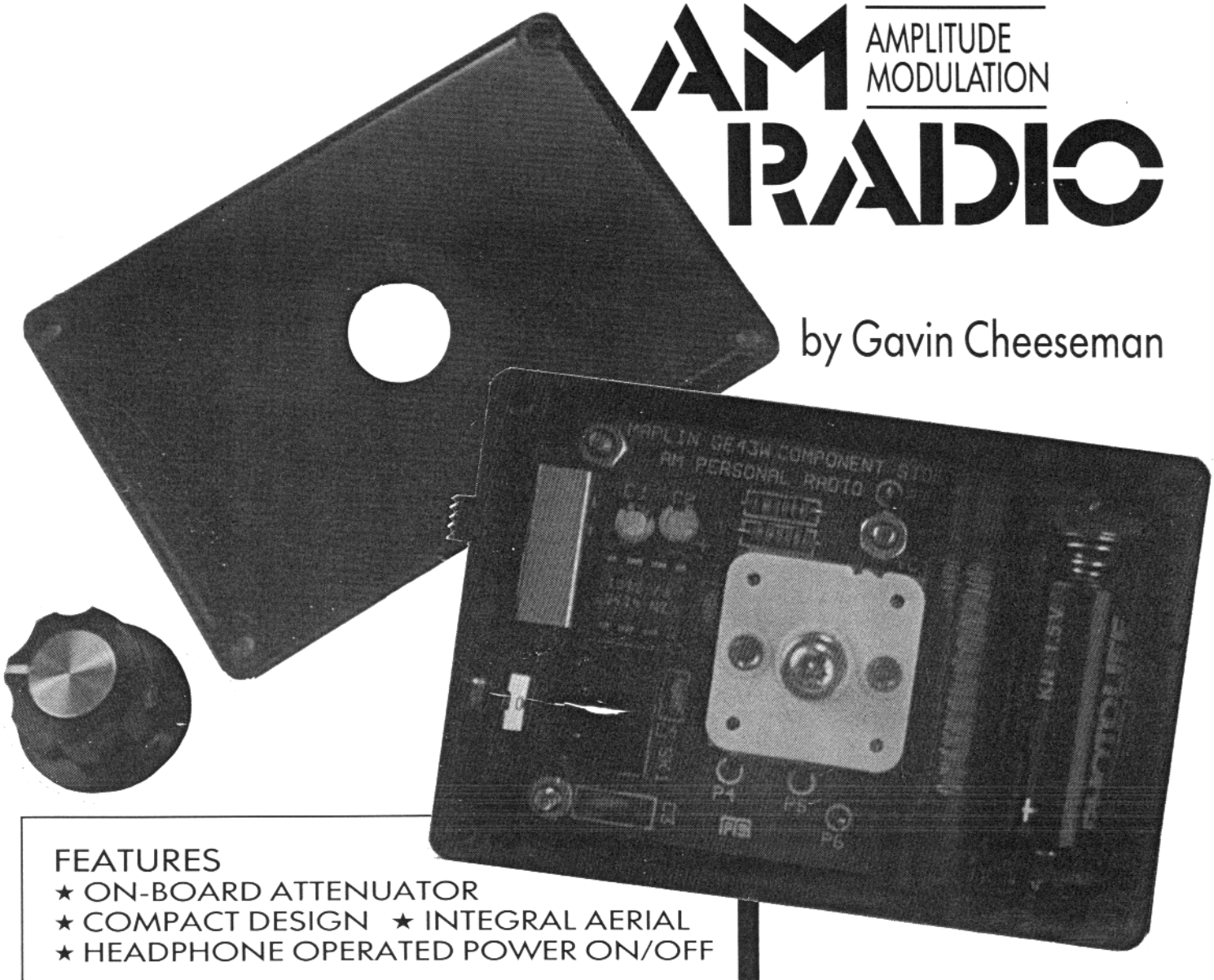
BEGINNERS' AM RADIO

AMPLITUDE MODULATION

by Gavin Cheeseman



FEATURES
★ ON-BOARD ATTENUATOR
★ COMPACT DESIGN ★ INTEGRAL AERIAL
★ HEADPHONE OPERATED POWER ON/OFF

Introduction

The increased use of the Medium Wave broadcast band by local radio stations has brought about a renewed interest in simple AM (Amplitude Modulation) receivers for the home constructor. Much of the interest comes from beginners, many of whom have very little experience (if any) in the construction of electronic circuits. With this in mind, the Beginners' AM Radio is a simple design requiring a minimum of alignment but which is however, capable of providing reasonable reception of the stronger stations. A key feature of the design is its small size and portability and to achieve this, the circuit uses a minimum of components and operates from a comparatively small 'N' size battery. Generally, the volume of the stations received is comparatively low due to the relatively simple design of the circuit and for this reason a rotary volume control is not used. A switchable attenuator is provided to prevent overloading and to reduce the volume of the demodulated signal should an exceptionally strong station be encountered. In the majority of cases it will not be necessary to use the attenuator; however, it was considered that the inclusion of this facility would be beneficial to some users. In order to capitalise on the available space, the on/off switch forms an integral part of the headphone socket; the receiver being powered up when the headphones are connected and powered down when they are removed.

Circuit Description

The Beginners' AM Radio employs the Tuned Radio Frequency (TRF) principle of radio reception in which the tuning is carried out in the RF amplifier stage only and the receiver is based around the ZN415E AM radio IC. Supplied in an 8-pin DIL package, the ZN415E comprises an RF amplifier, demodulator, audio amplifier and AGC (Automatic Gain Control) circuit. Referring to Figure 1, it can be seen that IC1 requires very few external components to function.

Aerial coil L1 effectively serves two purposes, acting as the receiving aerial and also forming a tuned input circuit in combination with variable capacitor VC1. Capacitor C3 acts as a very simple low pass filter, removing the remaining radio frequency (RF) signal from the recovered audio. Conversely, C1 and C2 act as interstage coupling capacitors allowing audio frequencies to pass but removing the very low frequency components of the signal and blocking DC. Slide-switch S1 operates the attenuator: when S1 is open,

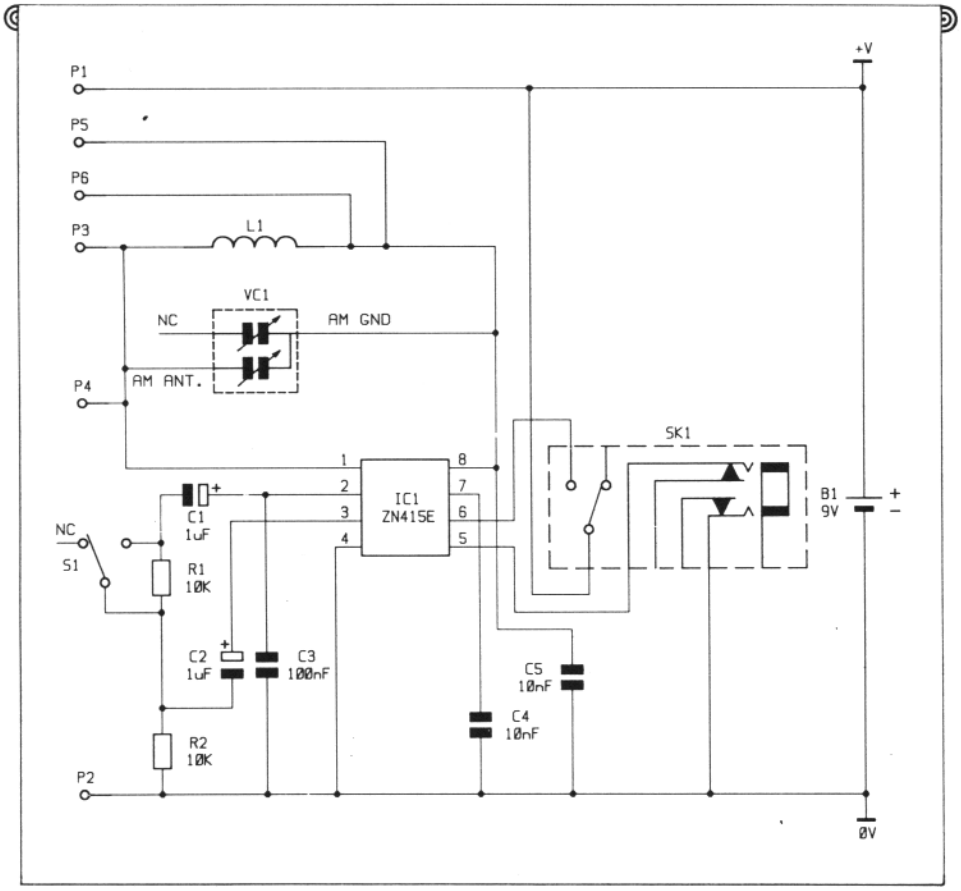


Figure 1. Circuit diagram.

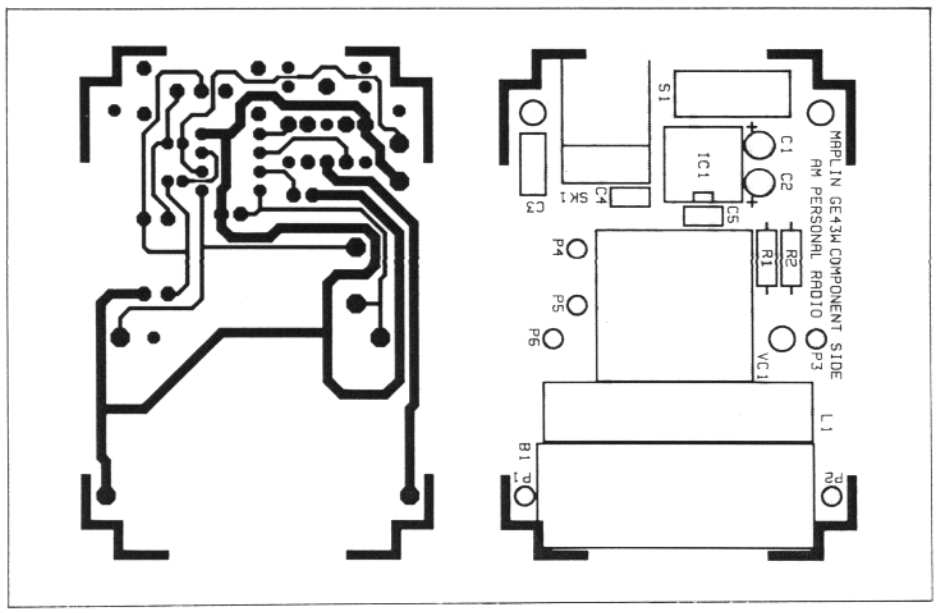


Figure 2. PCB track and legend.

resistors R1 and R2 act as a potential divider, reducing the signal level; however, if S1 is closed R1 is bypassed and the signal is allowed to pass unhindered. Capacitors C4 and C5 are decoupling components. The final audio output (after amplification) is fed to jack socket SK1 which also provides power supply switching via an internal SPDT switch. It should be noted that for optimum performance the outer (screen) connection of the socket remains open circuit; this presents the output with a higher impedance load as the headphones are then effectively connected in series.

Construction

The Beginners' AM Radio uses a high quality, fibreglass PCB with a printed legend for high reliability and ease of construction. Begin by fitting the resistors. The IC socket should be fitted such that the notch at one end of the socket corresponds with that on the PCB legend (shown in Figure 2). Do not insert the IC at this stage. Jack socket SK1 should then be installed keeping the base of the component flush with the PCB as much as possible. Similar considerations apply when installing the slide switch (S1). When fitting electrolytic capacitors C1 and C2, make sure that the correct polarity is observed; the negative lead, indicated by a minus (−) sign on the side of the capacitor, must be inserted away from the positive (+) symbol on the PCB legend.

Next fit the PCB pins. After insertion, use a hot soldering iron to press the pins into place. If sufficient heat is used, it should not be necessary to use any great amount of force. Once in place, the pins may then be soldered. The battery holder tags are soldered directly onto the appropriate PCB pins; the negative end of the holder can be identified by the internal spring clip terminal. Solder the holder's positive tag to P1 and the negative tag to P2.

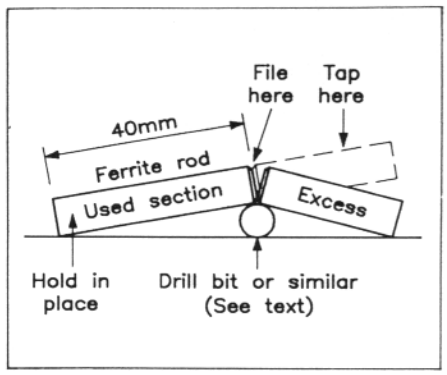


Figure 3. Cutting the ferrite rod.

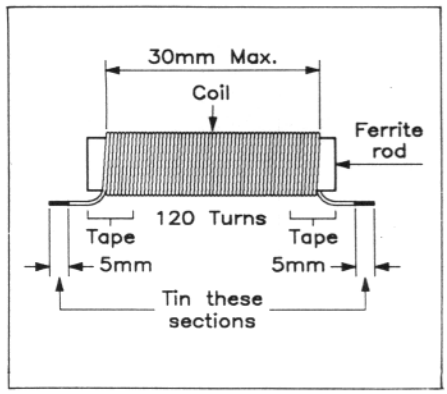
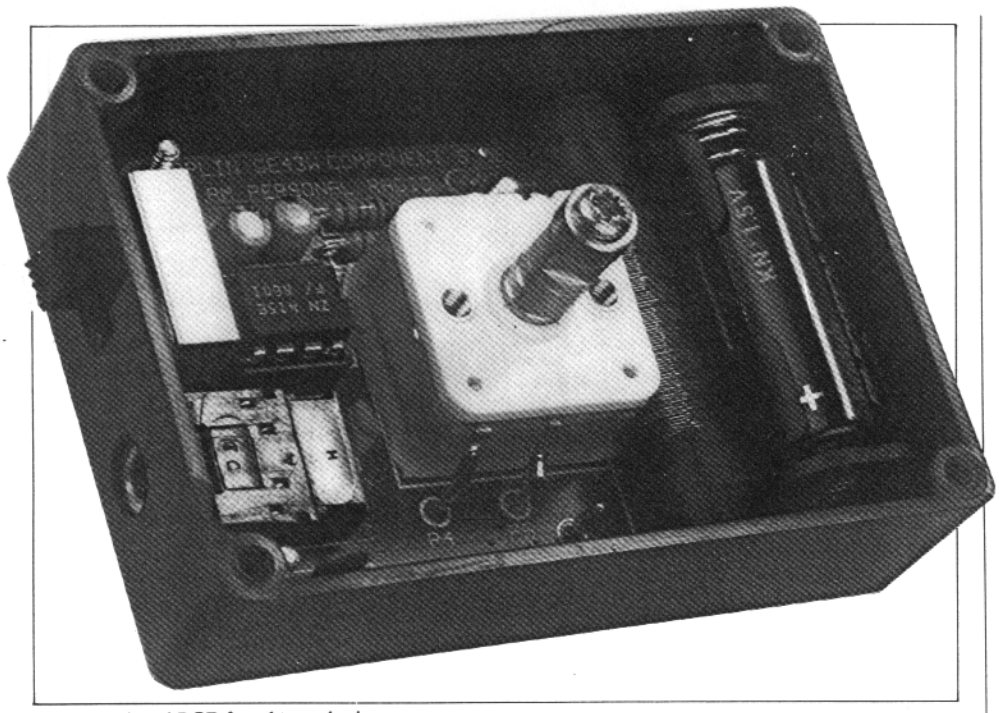


Figure 4. Constructing L1.

By far the most involved part of constructing the module is winding the aerial coil L1. Although this is not actually difficult some care is required to make sure that the correct length of ferrite is cut and that the coil is wound neatly. Enough excess wire is included in the kit to allow several attempts at winding the coil should this be necessary but if the instructions are followed precisely you should encounter few problems.

To construct L1, it is first necessary to cut the ferrite rod supplied to a suitable size to fit onto the PCB. The easiest method of cutting ferrite is to file a ring around the rod at the point where it is required to break and then while holding it firmly the unwanted part of the rod should be tapped lightly until it fractures. A small metal rod such as a screwdriver or drill bit can be used to aid the breaking of the ferrite rod and this technique is illustrated in Figure 3. During the process, it is recommended that for safety, the rod is covered with a piece of cloth as sharp splinters of ferrite can be produced at the breaking point.

The coil is wound from 120 turns of 34swg enamelled copper wire as shown in Figure 4. There are several methods of fixing the wire in place, but the quickest and easiest is by adhesive tape. Electrical insulating tape is best but ordinary, clear household adhesive tape will suffice. The wire should be secured with the tape at



The completed PCB fitted into the box.

one end of the ferrite rod and close wound in a neat fashion. When the coil is finished, the last few turns should be held in place using a second piece of adhesive tape. Alternatively the ends of the coil may be glued to the ferrite rod; this method probably provides a more permanent solution but it will be necessary to hold the coil in place whilst the glue is drying.

Variable capacitor VC1 is held in position on the PCB using the self adhesive pads provided. Remove the protective backing from one side of each of the pads and position them such that they cover the area marked out for VC1 on the PCB and also part of the area marked for L1 as shown in Figure 5. Do not remove the remaining half of the backing until you are ready to fix VC1 into place. Position VC1 such that the terminals marked A and G line up with P4 and P5 respectively. The variable capacitor terminals can then be soldered to the PCB pins. The third terminal of VC1 (marked O) remains unconnected and should be trimmed to prevent it shorting against P6.

Press L1 into position so that the overlapping section of adhesive pad holds the coil in place. Solder the ends of L1 to P3 and P6. It is a good idea to tin the tip of the wire before soldering to ensure that the enamel is removed. The tinned section of wire should extend no more than 5mm from each end. The length of wire between the coil and the PCB pins should be kept as short as possible, no longer than 2cm. When all of the other components are in place, the IC can then be fitted, ensuring that the notch at one end of the IC corresponds with that of the socket. After completing construction of the receiver, it is a good idea to double check your work to make sure that there are no obvious errors. In particular, double check the soldering for any dry joints or solder short circuits. For further information on soldering and constructional techniques, refer to the Constructors' Guide included in the kit.

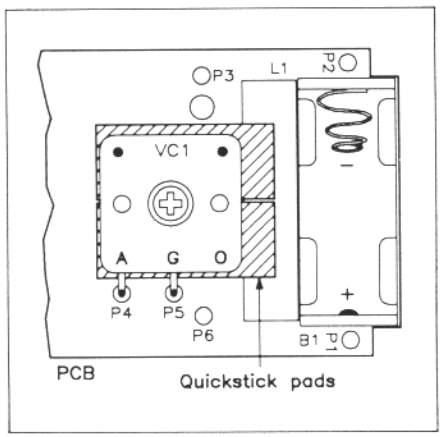


Figure 5. Positioning the adhesive pads.

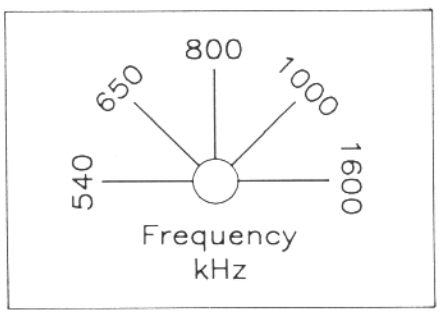


Figure 6. Tuning range.

Testing

The Beginners' AM Radio is designed to operate with medium impedance headphones such as the type commonly used for personal stereos (32Ω approx.). A suitable set of headphones is Maplin stock code YM42V. The overall performance obtained from the circuit is very much dependent on your location and strong local stations will usually provide the best quality reception. It should, however, be possible to receive some medium strength signals at reduced volume levels. The receiver is designed to operate from an alkaline N type battery such as Maplin stock code FM13P. Clip the battery into the holder, making sure that the correct polarity is observed; the positive end of the battery faces toward P1. Plug a suitable set of headphones into the headphone socket (SK1). With S1 in the open position, listen to the output from the headphones and adjust VC1 until a signal is received. If you have no test equipment, then the frequency range of the receiver can only be determined by listening to different stations of known frequency and noting the relevant settings of VC1.

Figure 6 shows the frequency range obtained from the prototype and the corresponding settings of VC1. Obtaining the correct frequency range is very much down to accurate coil winding. For those who possess an RF signal generator and wish set up the frequency range accurately, VC1 can be trimmed using the adjustment screws on the back of the capacitor; however, it should be noted that only fine tuning is possible using this method and accurate coil winding is still important. Any

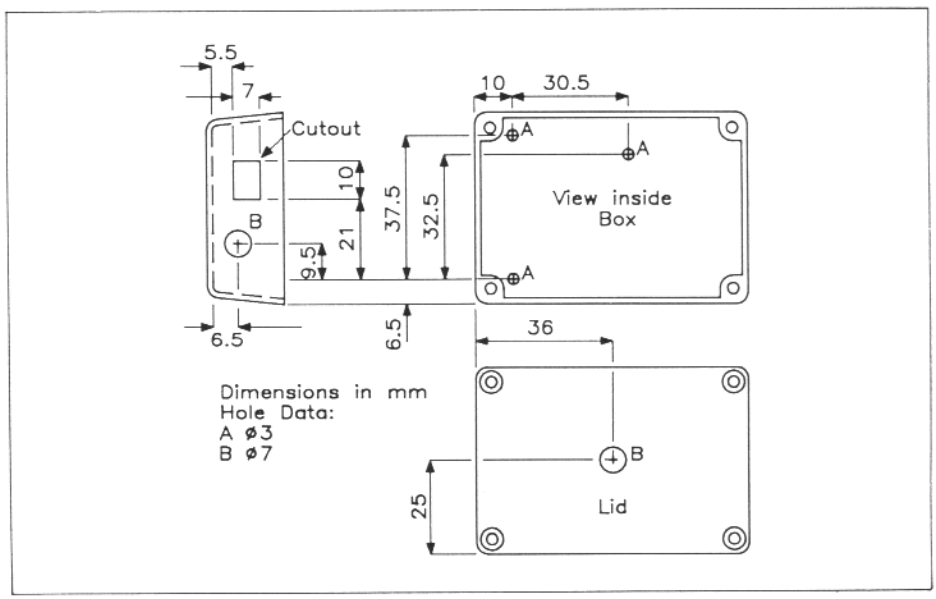


Figure 7. Drilling details.

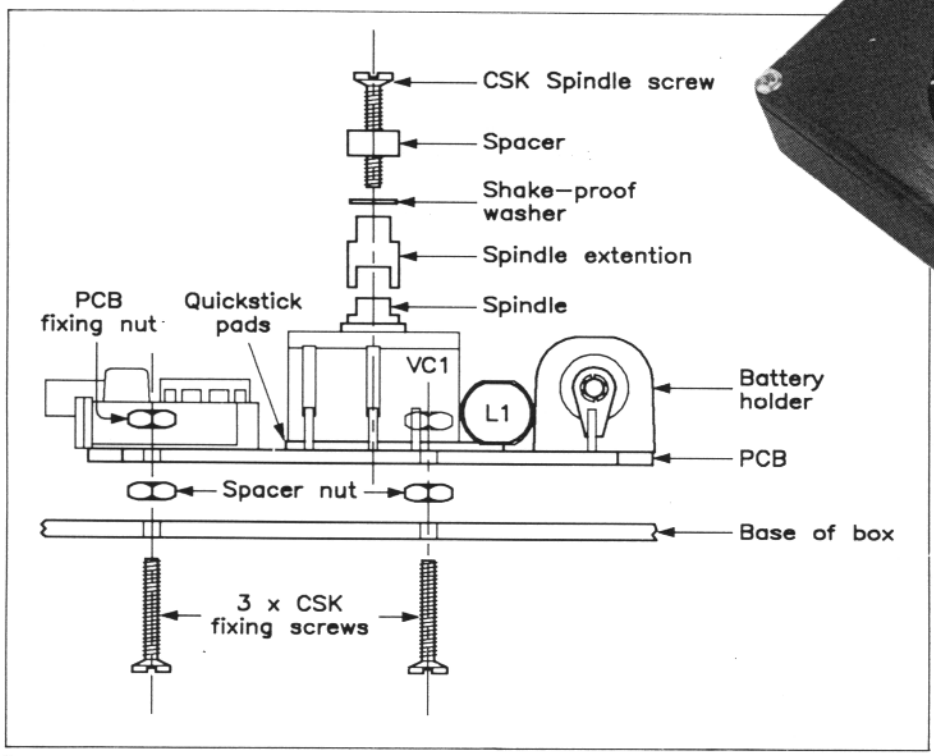
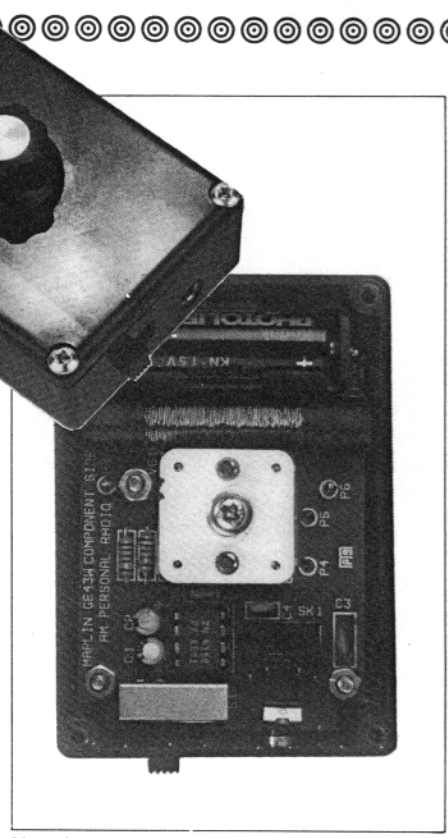


Figure 8. Final assembly.



View from above of assembled PCB and box.

alignment should be carried out before VC1 is fixed in position as the adhesive pads are not re-usable.

Housing the Receiver

A suitable box in which to house the finished module is Maplin stock code LL12N (not supplied in the kit). It is necessary to drill the box in order to mount the PCB and to allow access to the attenuator switch, headphone socket and tuning capacitor. Figure 7 shows the necessary drilling information. Attenuator switch, S1 requires a rectangular hole; the easiest way to cut this is probably to drill the box out as accurately as possible and use a file or a sharp knife to cut the hole to the correct shape.

Figure 8 shows the PCB mounting details together with the spindle and knob assembly for VC1. The PCB has 3 fixing holes and is mounted using M2·5 nuts and screws. Nuts are also used as spacers to separate the PCB from the base of the box. After the box is drilled, insert the three fixing screws through the appropriate holes and fit the spacer nuts. The nuts should not be fully tightened at this stage and no more than 5mm of each screw should protrude into the inside of the case. The PCB may then be placed in position and the three fixing nuts can be screwed into place using a pair of long nose or snipe nose pliers. The screws should then be tightened so that the heads are flush with the outside of the box and the nuts hold the PCB tightly in place. Before the tuning knob is fitted in position fix the box lid into place using the 4 self-tapping screws supplied.

The knob used is a type K7A (Stock code YX01B). Tuning capacitor VC1 should be set to the fully anti-clockwise position and the knob placed over the spindle. For alignment purposes, position the knob so that the pointer corresponds with the position of P5 on the PCB and tighten the knob fixing screw. Check that the knob does not foul the lid of the box by rotating it from fully anti-clockwise to fully clockwise. If the action is not smooth release the fixing screw and raise the knob. Tighten the fixing screw and repeat the above procedure until a smooth action is obtained.

Finally, the Table below shows the specification of the prototype receiver.

Power Supply	**Alkaline N type**
Operating Frequency	**540kHz – 1600kHz**
Suitable Headphone impedance	**32 Ohm nominal**
PCB Dimensions	**66mm x 45mm**

BEGINNERS' AM RADIO PARTS LIST

RESISTORS: All 0·6W 1% Metal Film

R1,2	10k	2	(M10K)

CAPACITORS

C1,2	1μF 63V Minelect	2	(YY31J)
C3	100nF Minidisc	1	(YR75S)
C4,5	10nF Ceramic	2	(WX77J)
VC1	Min. AM Tuner Capacitor	1	(FT78K)

SEMICONDUCTORS

IC1	ZN415E	1	(QY61R)

MISCELLANEOUS

S1	R/A SPST Slide Switch	1	(FV01B)
P1-6	Pins 2145	6 Pins	(FL24B)
SK1	PCB 3·5 Stereo SPCO Skt.	1	(JM22Y)
	N Battery Box	1	(JB84F)
	Ferrite Rod 810	1	(YG20W)
	EC Wire 34 swg	1 Roll	(BL42V)
	DIL Socket 8-Pin	1	(BL17T)
	PC Board	1	(GE43W)
	Constructors' Guide	1	(XH79L)
	Quickstick Pads	2 Pads	(HB22Y)
	Instruction Leaflet	1	(XK22Y)

OPTIONAL (not in kit)

Verobox 301	1	(LL12N)
Alkaline KN Battery	1	(FM13P)
Knob K7A	1	(YX01B)
Spacer 4BA x ¼ inch	1 Pkt	(FW31J)
Poziscrew M2·5 x 12mm	1 Pkt	(BF40T)
Isoshake M2·5	1 Pkt	(BF45Y)
Isonut M2·5	1 Pkt	(BF59P)

The above items, excluding Optional, are available as a kit:
Order As LP28F (Beginners' AM Radio)
The following item is also available separately:
Beginners' AM Radio PCB (GE43W)