2 METRE F.M. RECEIVER

DUNCAN BOYD

Listen-in to the world of amateur radio with this double conversion superhet design. Can be used in the car or from a mains supply.

NOT all that long ago, a few decades perhaps, the average electronics hobbyist would have most likely been involved in designing and building radio receivers and associated equipment like amplifiers etc. This tendency was most likely influenced by the technology of the day. While today there are still many amateurs who build radio equipment, the general emphasis of our subject seems to have shifted to other areas, computers being a prime example.

This is no bad thing although some may argue differently and it does tend to hide the grass roots of technology which we would find difficult to live without in these days of electronic mail and mobile phones. This article describes a double-conversion superhet receiver for the 2 Metre f.m. band which may provide an inexpensive introduction to the subject of amateur radio.

On the v.h.f. band of radio frequencies there are a great many users each with their own portion of the band specially allocated. Operators include Radio Amateurs, Aircraft and public services like the Police and Fire Brigade. The most common mode of operation is f.m.

AMATEUR BAND

A portion of the band which is specifically set aside for radio amateurs is the 2 Metre band from 144MHz to 146MHz. This band allows local radio amateurs to keep in touch about "the latest project" and "events" etc.

Communication can be either direct or via repeater stations which are located around the country. These repeater stations are mainly intended for amateurs operating from cars or portable equipment whose range would be limited otherwise.

The 2M F.M. Receiver described here is tuned by means of a varicap diode and a Squelch control and Automatic Frequency Control (a.f.c.) are included. The project can be powered from a d.c. rail of between 11V and 16V, this allows portable operation or operation from a car, alternatively the project will accept the mains supply. The receiver is relatively inexpensive and so it could be left permanently installed in a car where most people would be reluctant to leave expensive commercial equipment.

SUPERHET

As with many receiver topologies the superhet was developed in the early 1920s by Major Edwin Armstrong of the US army. The superhet design provides a very cost effective and versatile solution to the radio receiver problem and the majority of receivers that are now available use this topology in some form or other.

Armstrong realised the difficulty of trying to reliably tune many receiver stages. He came up with the idea of putting the majority of the filtering and amplification at one fixed frequency, somewhere between the input frequency and the frequency of the demodulated signal, an Intermediate Frequency, (i.f.). He then converted the desired input frequency down to this i.f. before demodulation etc. Since the majority of the filtering and amplification is done at one fixed frequency the characteristics of the "i.f. stage" could be defined much more easily and accurately.

A block diagram of the superhet is shown in Fig. 1. The mixer is the key to the superhet design. The mixer is in effect a frequency changer, it does this by multiplying the incoming signal with a signal from an oscillator within the receiver (local oscillator).

A well known identity of Trigonometry that can be found in any maths text is $\text{Cos}A \times \text{Cos}B = 1/2\text{Cos}(A-B) + 1/2\text{Cos}(A+B)$. We can see from this that if we multiply two signals (A and B) we will obtain two further signals, one which is the sum $(A+B)$ and one which is the difference $(A-B)$ of the two signals. In receiver designs we can arrange for one of these signals to be at our i.f. frequency.

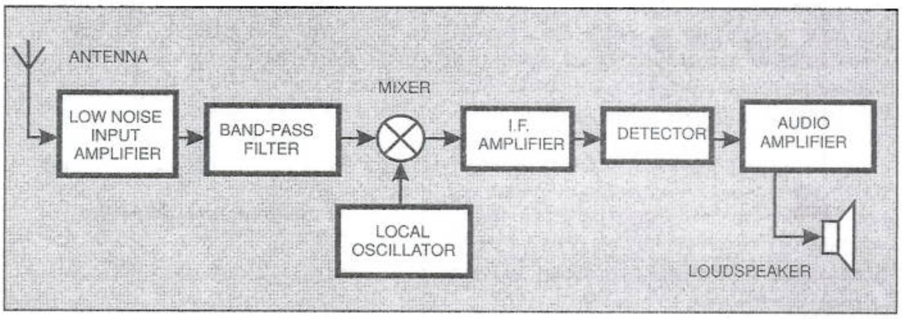


Fig. 1. Block diagram for a basic superhet.

A mixer can consist of any non-linear device, a diode or transistor could be used. Dual-gate MOSFETS are also quite common, the input signal is fed into one gate and the local oscillator is fed into the other gate. The load for the transistor may consist of a tuned circuit at the i.f. frequency, this provides some of the i.f. filtering.

This type of mixer is a single-ended system since there are single signal and oscillator ports. These mixers are relatively inefficient and as well as allowing the sum and difference signals to pass, the local oscillator (LO) and input signal will also pass through at quite high levels. There will also be a number of components at harmonics of signals A and B, these signals may mix to produce undesirable outputs at the i.f. frequency. Single or double balanced mixers where push-pull stages are employed are usually used to reduce the number of frequency components that are present as well as providing higher efficiency and better signal/noise performance.

FILTERS

Filters for use in i.f. sections are commonly available commercially. Over the years specific i.f. frequencies have been accepted for use in radio receiver circuitry, in general for v.h.f., 10·7MHz is used as the i.f., although sometimes 21·4MHz is used. In a.m. broadcast receivers i.f.s in the region of 455kHz to 470kHz are commonly used, these are chosen because they are in between the Medium wave and the Long wave bands in the radio spectrum.

Traditionally i.f. amplifiers would use an i.f. transformer with the primary and secondary of the transformer tuned to be resonant at the i.f. frequency. In practice, they might be de-tuned in opposite directions in order to give the required bandwidth whilst allowing steep roll off at each side, thus reducing the risk of adjacent channel interference. Many stages may be required to give a suitably steep roll off.

Ceramic and crystal filters are now offering a suitable alternative to the i.f. transformer. These filters are extremely small for the given performance and they don't need setting up or aligning and therefore they are simpler to use, the downside is that they are slightly more expensive.

If we wanted to tune a receiver to 145MHz and our i.f. is to be 10·7MHz then the local oscillator frequency could be $145 + 10{\cdot}7 = 155{\cdot}7$MHz or $145 - 10{\cdot}7 = 134{\cdot}3$MHz. Now let's say that we choose 134·3MHz then we have $145 - 134{\cdot}3 = 10{\cdot}7$MHz which is fine, but unfortunately $123{\cdot}6 - 134{\cdot}3 = -10{\cdot}7$MHz (we can think of negative frequencies reflecting through 0Hz to give positive frequencies). This means that signals at 145MHz and also 123·6MHz will be mixed down to 10·7MHz.

The unwanted signal at 123·6 MHz is termed the "Image" and is the main drawback of the superhet topology. Note that the Image is twice the i.f. away from the desired signal. In the block diagram of Fig. 1 the Bandpass Filter after the Input Amplifier is present to attenuate any signal at the Image Frequency as much as possible.

INPUT AMPLIFIER

In systems at v.h.f. and above, problems with noise and signal loss in cables and receiver circuitry becomes a problem. To combat this, the first stage in high frequency receivers is usually a high quality (low noise) amplifier. This amplifies the signal adding as little noise as possible prior to the signal, being de-graded in other stages of the receiver.

In some cases an amplifier may be placed directly after the antenna to overcome the losses in the coaxial cable connecting the antenna to the receiver. This is the reason that satellite receiver systems have an amplifier located at the antenna dish. In fact, since these systems are used at extremely high frequencies there is also a mixer located at the antenna, this converts the signal to a lower frequency and allows lower cost cabling to be used between the antenna and the set top box.

LOCAL OSCILLATOR

In a receiver the Local Oscillator can take many forms and there are many texts that will provide suitable circuitry, whether the oscillator is to have a fixed frequency or a variable frequency. The important considerations in radio receiver oscillators are that they should be stable in frequency and have low noise and spurious signal content in their output.

One of the troubles when using v.h.f. oscillators is that they tend to drift in frequency slightly with temperature and there are circuits available to combat this, although this usually adds to the complexity and cost. One method is to start with a low frequency oscillator and then multiply the frequency up by tapping off and filtering the harmonics of a non-linear amplifier.

Other methods involve feedback to keep the oscillator's output frequency stable.

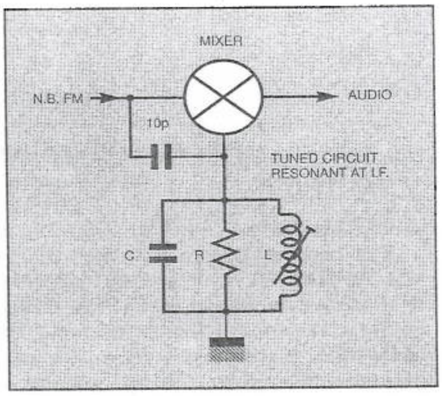


Fig. 2. Demodulator circuit.

DEMODULATION

There are many methods of demodulating a Frequency Modulated (f.m.) signal, one common circuit, which is often missed in the text books, is the Quadrature demodulator. This type of demodulation is far from perfect and is not particularly linear, however it is simple and is used in many communication systems where the quality of the demodulated signal is not the highest priority. Fig. 2 shows the arrangement; here we have a mixer where the two input signals are at the same frequency.

This means that only the difference component is at zero frequency or d.c. The level of the d.c. voltage is proportional to the phase difference between the two signals. When the phase difference is 90 degrees the signals are in "Quadrature" and the d.c. voltage will be zero.

In the circuit of Fig 2 the combination of the 10pF capacitor and the *LCR* parallel tuned circuit give us a 90 degree phase difference between the ports of the mixer when the tuned circuit is resonant. As the frequency deviates from the centre the phase difference will vary from 90 degrees and therefore we have a voltage at the output of the mixer which varies in sympathy with the modulation.

CONVERSION

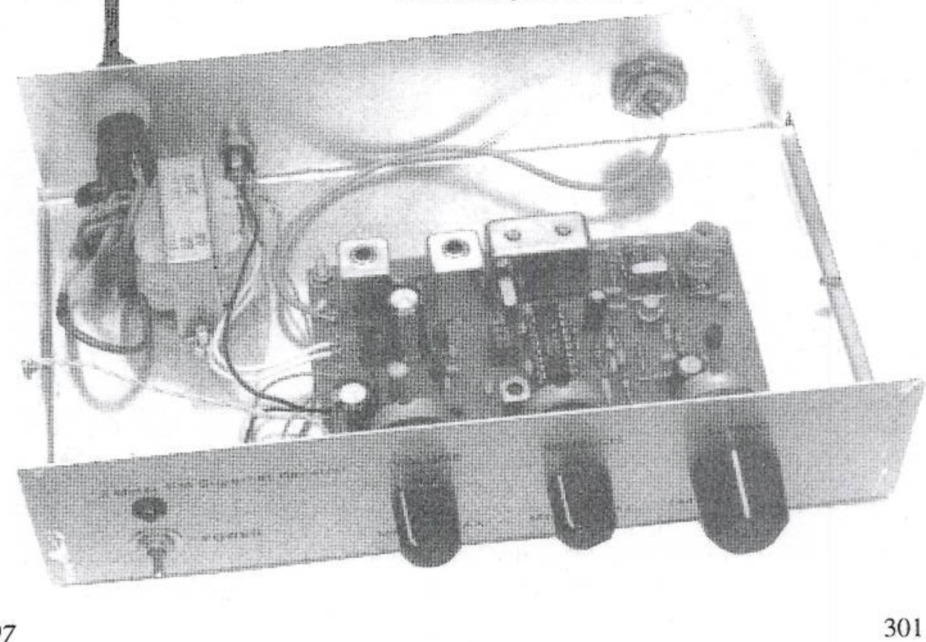
The circuit we have just described is that of a single conversion superhet. This means that there is only one mixer or frequency changer stage. This system is often preferred but if the i.f. frequency is low, i.e. 455kHz, then it becomes difficult to filter out the image frequency which will only be 910kHz away from the chosen frequency.

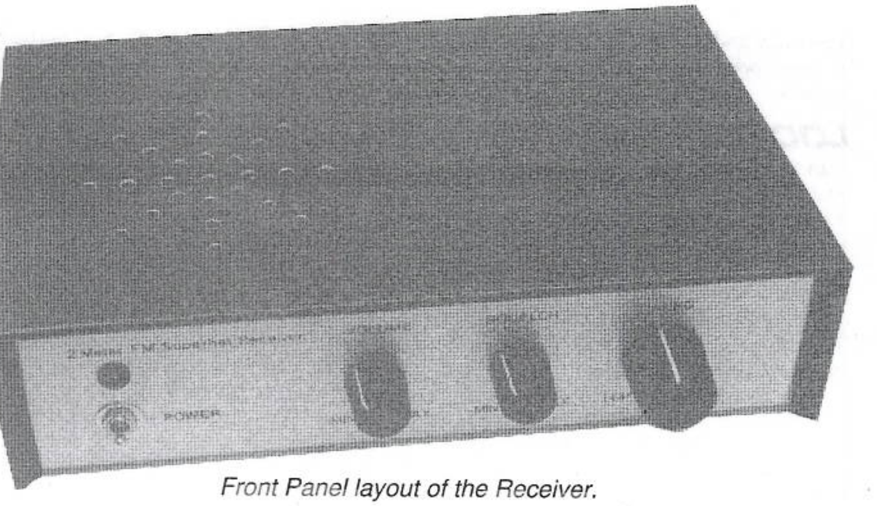
Double or triple conversion designs reduce this problem. In these designs the signal is mixed down in stages before being demodulated. In a three-stage design the i.f.s might be at 21·4MHz, 10·7MHz and 455kHz. This means that the image will now be 42·8MHz away from the desired signal and this is much easier to filter.

HOW IT WORKS

The 2M F.M. Receiver is a double conversion design and the system block diagram can be seen in Fig. 3. The front-end of the receiver consists of a dual-gate f.e.t. tuned r.f. amplifier. This is a low-noise amplifier which provides around 15dB of r.f. gain, although this will be dependant on the actual supply voltage.

General layout of compenents in the metal case.





Front Panel layout of the Receiver.

Following the amplifier is a 2MHz bandwidth Bandpass Filter which is centred at 145MHz. This filter will considerably reduce the level of any signal at the image frequency as well as any other out of band signals.

The output of the bandpass filter supplies the signal to the input of the first mixer. The mixer and local oscillator are contained within IC1 (Fig. 4), the local oscillator can be tuned from 133·3MHz to 135·3MHz by means of a varicap diode and inductor coil. The output of the mixer will be at 10·7MHz and we have a 15kHz bandwidth crystal filter and some amplification at this frequency.

The output of the i.f. amplifier stage is fed into the second mixer, this and the 10·245MHz crystal oscillator are contained within IC2. A frequency of 10·245MHz was chosen because 10·7 – 10·245MHz will give us a second i.f. frequency of 455kHz.

A ceramic filter is employed here, the output of which is amplified and passed through some limiter stages which are also within IC2. The output of the limiter stages drive the demodulator which consists of IC2 and a Quadrature coil tuned to 455kHz.

The output of the demodulator is fed into an audio amplifier IC3 which drives the loudspeaker. IC2 provides a squelch signal which shorts the input of the amplifier to ground (0V) when there is no signal present, this removes the annoying hiss between channels.

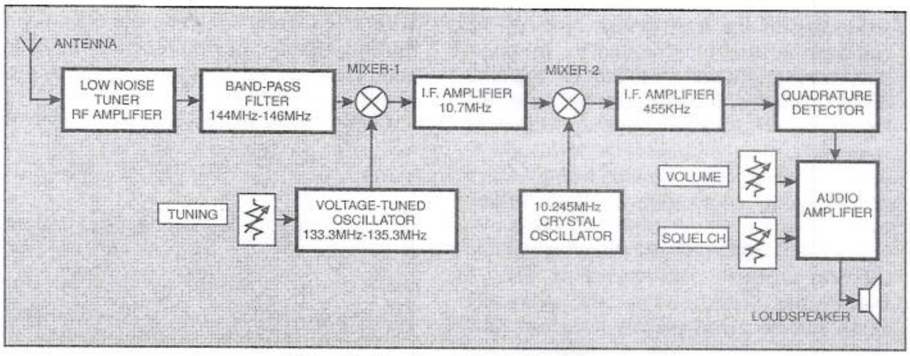


Fig. 3. System block diagram.

CIRCUIT DESCRIPTION

The main receiver circuit diagram for the 2M F.M. Receiver can be seen in Fig. 4. Received broadcast signals are picked up by the antenna and enter the circuit via socket SK1. Capacitors C1 and C2 match the 50 ohm impedance of the antenna to the dual-gate MOSFET input amplifier TR1. Coil L1 is present to tune the amplifier to have a bandpass characteristic centred around 145MHz.

The output of this tuned circuit (C1, C2 and L1) is fed into one gate of TR1, a low-noise high frequency amplifier, the other input gate is biased at around 4V by resistors R2 and R3, this gives the best combination of high gain and low noise. The output of TR1 is again tuned to a centre frequency of 145MHz, this is done by components L2, C5 and C6. Capacitors C5 and C6 match the output of TR1 to the 50 ohm input impedance of the 145MHz bandpass filter X1. Resistor R4 is present to reduce the possibility of the amplifier oscillating.

The components that make up the input amplifier are contained within a small area on the printed circuit board (p.c.b.) and this gives rise to the situation where energy from coil L2 could be coupled into coil L1, for this reason L1 and L2 are enclosed within metal screening cans; this also helps stop the amplifier oscillating. Resistor R1 and capacitor C4 provide some filtering of the supply line.

The frequency response of the input amplifier can be seen in Fig. 5a, the bandpass characteristic can be clearly seen but it is desirable to have a much greater attenuation at the image frequency of 123·6MHz. For this reason a pre-tuned Helical filter, X1, is inserted after the amplifier, this is centred around 145MHz with a bandwidth of 2MHz. The frequency response of the amplifier and filter together can be seen in Fig. 5b, this shows a much higher attenuation out of band and we can see that any component at the image frequency will be reduced considerably.

MIXER/OSCILLATOR

Signals from the filter X1 are coupled to the first mixer, within IC1, by capacitor C7. The mixer and oscillator are internal to IC1, an NE602 dual balanced mixed/oscillator. However, the oscillator requires the use of an external tuned circuit.

Most of the components to the right of IC1 on the circuit diagram (Fig. 4) are concerned with the oscillator. Resistors R8, R9 and potentiometer VR1 form a variable potential divider, this acts as the tuning control. The output of the divider is filtered by capacitor C14 and applied to VD1 via resistor R7. VD7 is a varicap diode, whose capacitance varies with the reverse voltage across it, this variation in capacitance is used to vary the resonant frequency of the tuned circuit.

Other components fundamental to the tuned circuit are capacitors C12, C13 and ferrite inductor coil L3, the ferrite coil being used to vary the centre frequency of the tuned circuit. With the components shown, the resonant frequency of the tuned circuit can be varied around 134·3MHz.

The MC3359 IC2 provides us with a.f.c. (Automatic Frequency Control), this helps compensate for local oscillator drift due to temperature etc. The output of the a.g.c. is filtered by R12 and capacitor C16 before being applied, via R11, to the base of transistor TR2. TR2 modifies the tuning voltage which is applied to the varicap diode

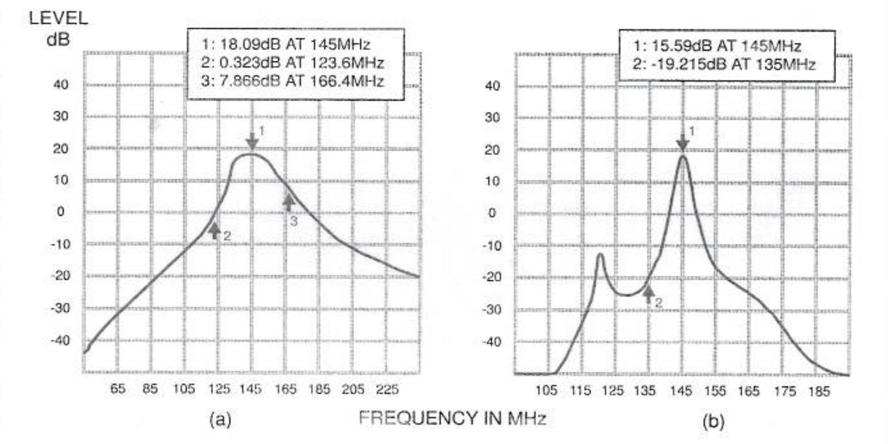


Fig. 5 (a) Input amplifier response and (b) amplifier/filter response.

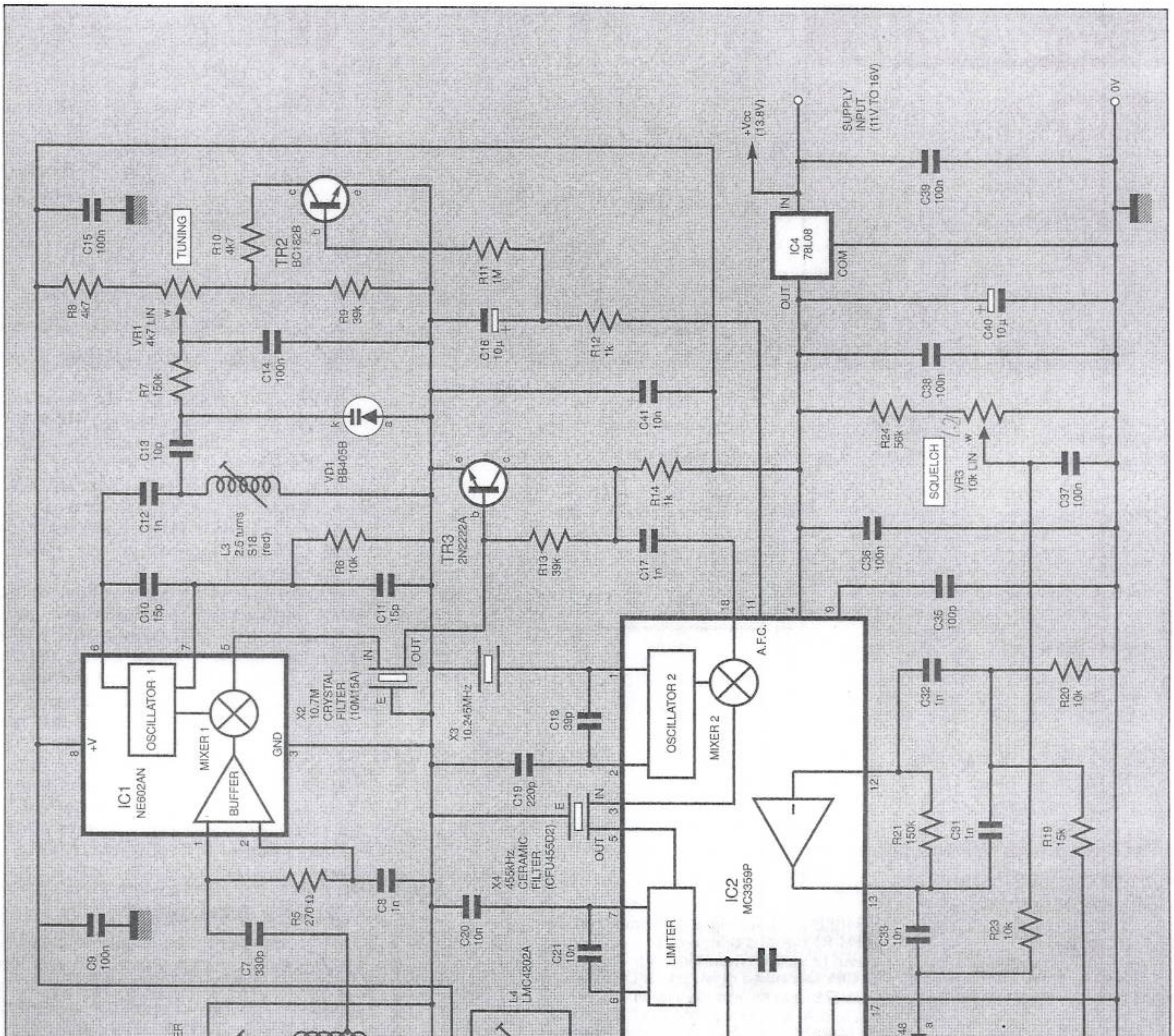


Fig. 4. Complete circuit diagram, except mains supply, for the 2M F.M. Receiver.

COMPONENTS

Resistors

R1	220Ω
R2, R22	100k (2 off)
R3	82k
R4	47Ω
R5	270Ω
R6, R16, R20, R23	10k (4 off)
R7, R21	150k (2 off)
R8, R10	4k7 (2 off)
R9, R13	39k (2 off)
R11	1M
R12, R14, R25	1k (3 off)
R15	22k
R17	3Ω9
R18	5k6
R19	15k
R24	56k

All 0·25W 5% metal film

See SHOP TALK Page

Potentiometers

VR1	4k7 rotary carbon, linear
VR2	10k rotary carbon, log.
VR3	10k rotary carbon, linear

All p.c.b. mounting types

Capacitors

C1	6p8		
C2	27p	C10, C11	15p (2 off)
C3, C20, C21, C23, C33, C41	10n (6 off)	C13	10p
C4, C8, C12, C17, C31, C32	1n (6 off)	C16, C40	10µ radial elect. 16V (2 off)
C5	8p2	C19	220p
C6, C18	39p (2 off)	C25, C34	1µ radial elect. 16V (2 off)
C7	330p	C28	3n3
C9, C14, C15, C22, C24, C26, C27, C30, C36 to C39, C43, C44	100n (14 off)	C29	100µ radial elect. 16V
		C35	100p
		C42	470µ radial elect. 25V

All capacitors are monolithic ceramic with 2·5mm lead spacing, except where stated.

Semiconductors

VD1	BB405B u.h.f. tuning a.f.c. varicap diode
D1 to D4	1N4148 signal diode (4 off)
D5	green l.e.d. with mounting clip
TR1	BF981 low-noise dual-gate MOSFET
TR2	BC182B *npn* silicon transistor
TR3	2N2222A *npn* gen. purpose r.f. transistor
IC1	NE602AN dual balanced mixer/oscillator
IC2	MC3359P mixer/oscillator/demodalator (ULN3859)
IC3	LM386N power amp.
IC4	78L08 +8V 100mA voltage regulator
IC5	78L15 +15V 100mA voltage regulator
REC1	DB005 50V 1A 4-pin d.i.l. bridge rectifier

Inductors

L1, L2	Toko 3·5 turns v.h.f. ferrite core coil, with screening can, type S18 Orange (2 off)
L3	Toko 2·5 turns v.h.f. ferrite core coil, type S18 Red
L4	Toko 7mm 455kHz ferrite core coil, type LMC4202A 7E Black

Miscellaneous

X1	145MHz bandpass filter (271MT1008)
X2	10·7MHz crystal filter (10M15A)
X3	10·245MHz crystal
X4	455kHz ceramic filter (CFU455D2)
LS1	8Ω 0·5W 76mm dia. loudspeaker
SK1	BNC chassis mounting socket
SK2	2·5mm power socket
S1	s.p.s.t. toggle switch
S2	d.p.d.t. toggle switch (mains rated – not on model)
FS1	250mA 20mm mains fuse, with panel fuseholder
T1	230V mains transformer, with 15V 250mA secondary

Printed circuit board available from the *EPE PCB Service*, code 144; metal case, size 203mm × 127mm × 51mm; 8-pin d.i.l. socket (2 off); 18-pin d.i.l. socket; plastic knob (3 off); strain relief grommet; solder tag; p.c.b. mounting spacer (4 off) and fixing nuts and bolts; multistrand connecting wire; length of single-core screened cable; mains lead; solder etc.

Approx Cost Guidance Only **£55**

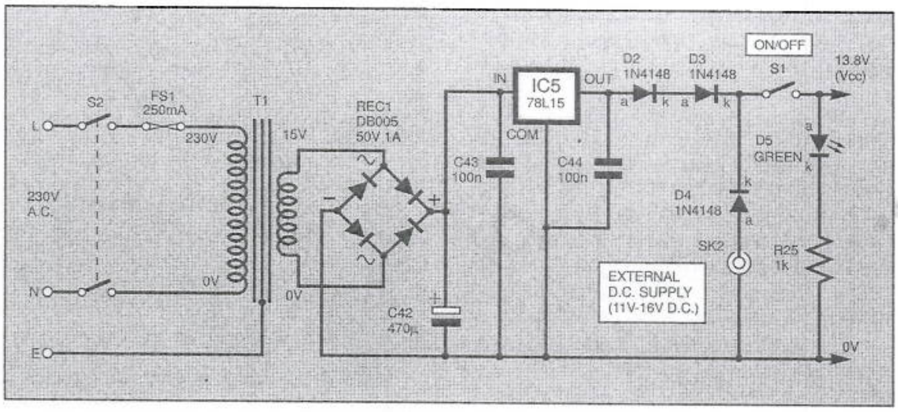


Fig. 6. Mains power supply, with external d.c. socket, for the Receiver.

VD1. The voltage is modified in such a fashion as to track the input signal.

CRYSTAL CONTROL

The output from the first mixer stage (IC1 pin 5) is fed into X2, a 10·7MHz crystal i.f. filter, the output of which is applied to the base (b) of TR3, a common emitter amplifier biased by resistors R13 and R14. The output of this i.f. amplifier is applied, via capacitor C17, to the second mixer stage which is contained within IC2 (pin 18), an MC3359 mixer/oscillator/demodulator i.c.

The oscillator in IC2 is controlled using an external crystal X3, the frequency of this crystal is 10·245MHz. Capacitors C18 and C19 are also part of the external oscillator circuit.

Our first i.f. of 10·7MHz and our second local oscillator of 10·245MHz give us a second i.f. at 10·7 – 10·245 = 455kHz. X4 is a ceramic i.f. filter centred around 455kHz and the output is i.f. amplified and limited within the IC2. The limiting removes the effect of any amplitude variations that may be present on the signal, this is one of the main advantages of F.M.

The output of the limiter circuit is then Quadrature demodulated with the aid of the external tuned circuit consisting of coil L4 and resistor R15. Capacitor C22 is a supply decoupler.

DE-EMPHASIS

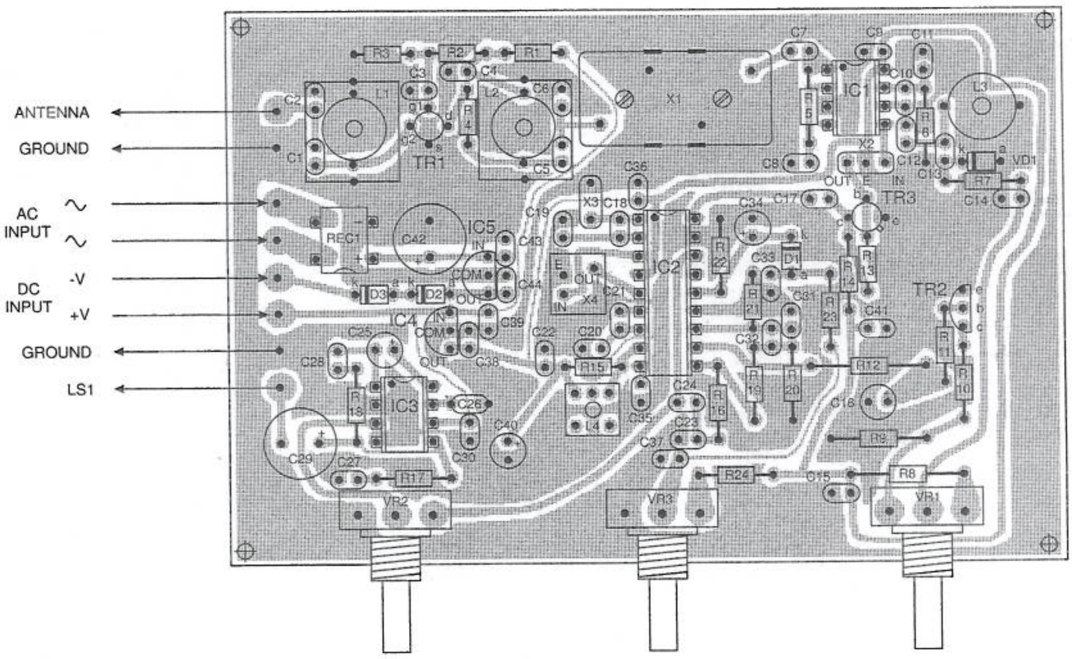
The output of the demodulator, at pin 10 IC2, goes two routes. First of all it is low pass filtered by R16 and C23 before being applied to the audio amplifier stage IC3, via capacitor C24. This low pass filtering is called "de-emphasis". The high frequencies are amplified or "emphasised" at the transmitter and the de-emphasis in the receiver compensates for this with the intended benefit of reducing the high frequency noise in the received signal.

Potentiometer VR2 provides a volume control for the audio amplifier IC3, which is based around the LM386 device. Capacitor C27 and resistor R17 provide a load for the amplifier at higher frequencies where the impedance of the loudspeaker is high. Capacitor C25 defines the gain of the amplifier and R18 and C28 reduce the noise produced by the amplifier at the higher gains. Capacitor C30 is a supply decoupler.

SQUELCH CIRCUIT

The second route the signal takes is to the Squelch circuit. The signal from the demodulator, at pin 10 IC2, goes via resistor R19 to a bandpass filter/amplifier based around the op.amp within IC2 and external components R20, R21, C31 and C32. This filter is roughly centred around 12kHz.

When there is no received signal present on the output of the demodulator there will only be high frequency noise or hiss, which is very annoying. The 12kHz filter/amplifier combination will amplify



this noise. The output of the filter/amplifier at IC2 pin 13 is coupled to a peak reader circuit by capacitor C33. It is also added to the d.c. voltage generated by the potential divider R24 and VR3. The peak reader circuit consists of diode D1 which rectifies the noise plus d.c. whilst C34 will hold the peak voltage for a short time determined by the time constant of C34/R22.

When the voltage across C34 reaches about 0·7V, this switches on a transistor within IC2 (between pin 16 and pin 14). This transistor takes the input signal of the audio amplifier to ground (0V) and so the hiss isn't amplified and applied to the loudspeaker LS1. When there is a legitimate signal present at the output of the demodulator the voltage across C33 will be less than the 0·7V and so the signal will be amplified and applied to the speaker as normal.

The level of noise that will activate the squelch circuit is varied by means of potentiometer VR3.

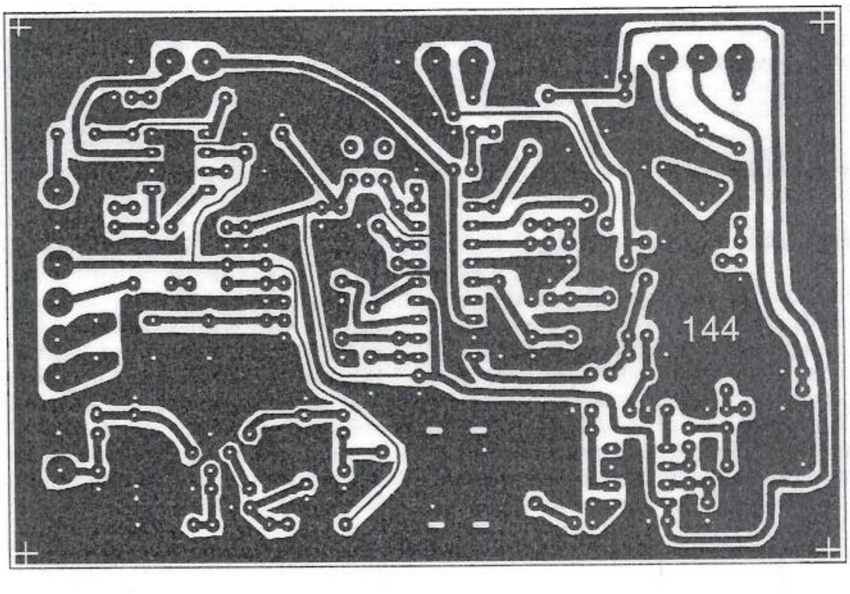


Fig. 7. Receiver printed circuit board component layout and full size copper foil master pattern.

POWER SUPPLIES

There are two power lines used within the Receiver. The 13·8V or the battery voltage (Fig. 6) is used to power the front end amplifier and the audio amplifier sections.

The other stages of the receiver are powered from an 8V regulated supply which is derived from the higher voltage rail. IC4 is an LM78L08 100mA regulator device which is decoupled by capacitors C38, C39 and C40.

The front-end r.f. amplifier and audio output amplifier power supply circuit diagram can be seen in Fig. 6. The 15V secondary winding from the mains transformer T1 is full-wave rectified by REC1 and smoothed by electrolytic capacitor C42. The unregulated voltage is then regulated to 15V by IC5, which is a 100mA voltage regulator. Capacitors C43 and C44 provide decoupling and remove any possibility of IC1 oscillating.

The regulated 15V supply now passes through diodes D2 and D3, this drops the voltage down to around 13·8V, the diodes also isolate the battery supply from the output of the regulator. The External D.C. supply enters the circuit at SK2 and passes through diode D4 to supply switch S1. This means that if a battery and the mains are supplied at the same time then the 13·8V will not appear across the battery. Light emitting diode D5 and resistor R25 provide an indication that the Receiver is powered up.

CONSTRUCTION

The 2M F.M. Receiver is constructed on one single-sided printed circuit board (p.c.b.). The component side layout and full size track pattern can be seen in Fig. 7. This board is available from the *EPE PCB Service*, code 144.

Assembly of the components can be carried out in any order you feel content with, ideally starting with the lowest profile components. The three p.c.b. mounting rotary potentiometers should be left until last since they are quite bulky compared with the rest of the components.

It was chosen to mount these directly on the p.c.b. to simplify construction of the receiver. If, however, you prefer to mount them on the front panel of the chosen enclosure for the receiver this is fine and wires should be taken to the appropriate positions on the board.

If the project is to be battery powered only, the components in Fig. 6 can be omitted. The use of i.c. sockets is strongly recommended.

Take care over the polarities and orientation of the electrolytic capacitors and semiconductors. Following assembly, thoroughly check that the soldered joints

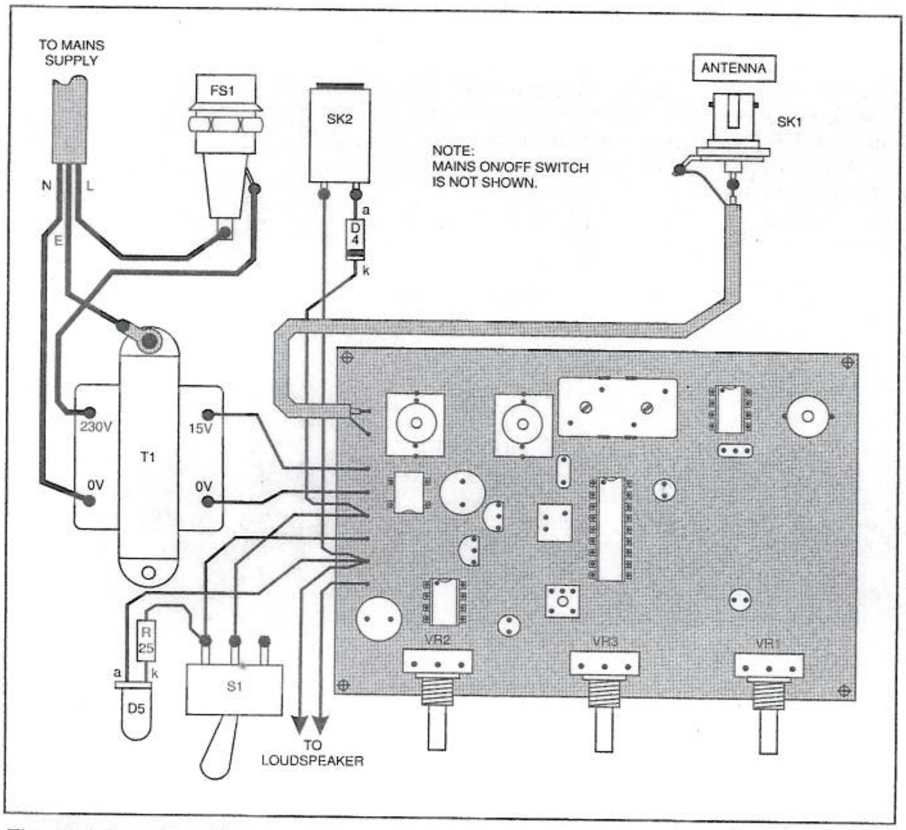


Fig. 8. Interwiring from p.c.b. to off-board components. The double-pole mains on/off switch (S2), shown in the power supply circuit diagram, was not used in the prototype model. This is inserted directly into the Live and Neutral leads of the mains cable before the transformer and fuseholder.

are satisfactorily made and that the components are indeed correctly oriented.

FINAL ASSEMBLY

The Receiver is best suited to a metal enclosure which will provide some screening. Holes should be drilled to suit the antenna connector SK1, the external power connector SK2, the shafts for the potentiometers, the power switch S1, fuseholder FS1 and the loudspeaker LS1 which can be either bolted or glued into position. Before mounting the loudspeaker drill a matrix of "sound exit" holes in the case, see photographs. In addition holes will be required in the base for the mains transformer and for the spacers on which the p.c.b. will be mounted.

Once all the holes have been drilled as required the front panel can be sprayed using car touch-up paint. Rub-down lettering can then be used to provide suitable legends on the front panel which can then be sprayed with clear protective lacquer.

Once the case is complete, the printed circuit board can be fitted in place and wired up as per Fig. 8.

TESTING

Before powering up the receiver, the resistance across the d.c. supply lines should be checked. This should be in excess of six kilohms (6k). If it differs greatly check the position and orientation of all components and ensure that there are no solder splashes on the board underside copper tracks.

With the receiver switched off, plug in the mains lead and check the voltage at the D.C. pin on the board, it should be around 13·8V. Disconnect the mains and apply a battery and again check for the correct voltage on the D.C. pin. If all is well then we can proceed with powering up the receiver.

With the Volume and Squelch controls turned to their minimum positions and the Tuning control set to mid travel, switch the receiver on and advance the volume control clockwise. If all is well there should be a hissing sound from the loudspeaker.

If this does not happen check all the voltage levels on the semiconductors and re-check their orientation. When these voltages are correct and the hissing sound is present the receiver can be tuned up.

ALIGNMENT

Adjust the ferrite "slugs" within L1, L2 and L3 so that they are flush with the tops of their formers. (The ferrite cores in these coils are very fragile and adjustments should only be made with nylon or brass trimming tools – *never use* a steel screwdriver). Adjust L4 for the maximum noise output. Adjusting the first local oscillator is best done with a frequency counter or spectrum analyser if these are available, successful adjustment can, however be achieved without these instruments with a little patience.

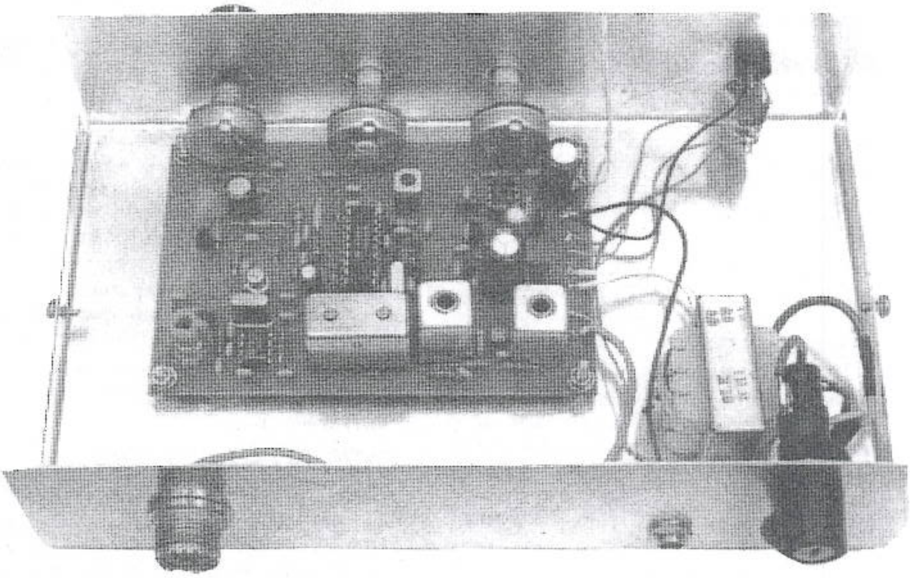
Turn the slug in L3 and L4 one quarter turn into the former, with the Tuning control set to mid position, this should correspond to around 134·3MHz (which will result in the receiver demodulating signals at 145MHz). Using a frequency counter or spectrum analyser to "sniff" the r.f. energy from L3 this can be confirmed and the slug can be adjusted to bring the oscillator to exactly 134·3MHz.

With this adjustment complete and with a suitable antenna connected turning the tuning control VR1 should reveal any stations that are operating on the band. If a repeater of known frequency is heard this can again be used to calibrate the local oscillator. Once a station has been successfully located the ferrite core of L4 can be adjusted for the best audio quality (this can be done more easily with one end of R12 disconnected).

FRONT-END

The next stage in the alignment is to adjust the response of the front-end input amplifier. With the receiver tuned into a fairly week station adjust the core of L2 for maximum signal strength. If an oscilloscope is available this can be done very easily by adjusting L2 for the maximum amplitude of the 455kHz sinusoid that should be seen on pin 5 of the IC2. Coil L1 can now be adjusted to give the minimum noise output on the signal.

If all is well with the Squelch circuit the receiver should go silent when the Squelch control VR3 is advanced beyond a certain



Layout of components inside the metal case. Note the loudspeaker is mounted on the underside of the case lid behind a series of "sound holes".

point. If this is not the case, check the voltage on the wiper (moving contact) of VR3 and also on pin 14 of the IC2. When in use the Squelch control should be advanced just beyond the point where the hiss disappears.

AERIALS

There are many commercial aerials available for the two meter band which will work well with the 2M F.M. Receiver but good results can be obtained without going to a great expense in this area. In its simplest mode the aerial need not consist of more than a piece of wire connected to the aerial socket. However, clearly the best performance will be obtained with some sort of resonant aerial located out doors.

One of the simplest aerials is, of course, the half-wave dipole and Fig. 9 shows a suitable arrangement for a dipole resonant on the two metre band. The elements can be made from stiff wire or thin bore copper pipe such as that used in car brake pipes.

Cut the elements to length then solder a large solder tag to one end. Cut a piece of perspex or suitable insulating material to an appropriate size (5cm × 10cm) and drill holes in the positions indicated for two wood screws and for two M4 bolts which will be used to mount the elements. Suitable coax cable can be connected using large solder tags connected to the same bolts.

The perspex insulator can be screwed to some sort of boom, a broom handle with a "flat" cut in one end is very good for this purpose. This boom can be used to mount the aerial as high as possible out of doors perhaps using a TV aerial clamp or similar.

If the receiver is to be used in a car, the standard car aerial can be used. If this is the telescopic type the sections should be adjusted to 49cm in length. This 49cm is half a wavelength at 145MHz it can be calculated by dividing 71·25 by the frequency in MHz, in our case 145.

IN USE

Although this is a simple design with the minimum of parts, the dual-gate MOSFET front end gives the Receiver a sensitivity which should be equal to, if not better than, some commercial equipment and with a suitable aerial connected good results can be obtained throughout the two metre band. The prototype has been in use for some time and has obtained good results in a variety of locations. It does tend to drift slightly when first switched on but after a few minutes it remains stable on the chosen station.

Although it was designed for the 2M Amateur Band the actual frequency of operation can be easily changed by altering the position of the ferrite core in coil L3. Indeed, a different value inductor could be loaded here to give a significantly different frequency coverage.

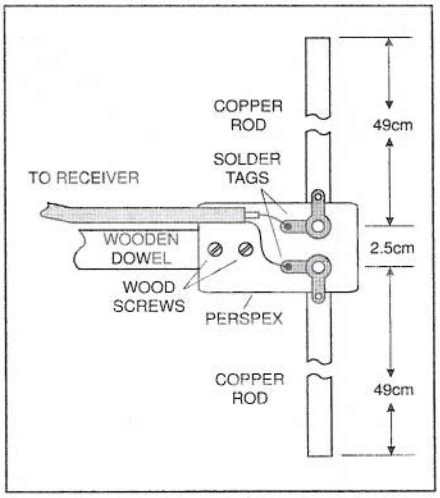


Fig. 9. Detail for a DIY version of a ½-wave dipole aerial.

The filters in this receiver are, of course, at 145MHz and will therefore attenuate signals outside this band. However, adjusting L3 can still allow coverage of local Taxi bands etc.

The 2MHz bandwidth of the receiver is controlled by resistors R8 and R9. These values can be changed to give a wider or narrower bandwidth. Reducing R9 to 390 ohms and removing R8 altogether will give around 6MHz of bandwidth. □

SHOP TALK
with David Barrington

2M F.M. Receiver

We had quite a nightmare when we came to sourcing components for the *2M F.M. Receiver* project. We found that the expected supplier of the MC3359P mixer/oscillator/demodulator chip had exhausted his supplies and was unable to track down further ongoing stocks, even for his own kits.

After several phone calls, even to the manufacturers, we eventually discovered that the **Macro Group** of Slough ***(Tel; 01628 504383)*** have stocks and readers should ring them for latest prices and availability. We understand that the ULN3859 is a similar device but no stockists have been found.

Some of the other components can be classed as "specials" and are carried by **Cirkit** ***(Tel. 01992 448899)***. These include: the BB405B varicap diode, code 12-01055; 4-in d.i.l. bridge rectifier DB005, code 12-01050; BF981 MOSFET, code 60-06981; 2N2222A transistor, code 58-02222; and the NE602AN dual mix/osc., code 61-00602.

They also specialise in Toko coils and can supply all the inductor coils and screening can. They should be ordered as follows: 3·5 turns v.h.f. ferrite S18 Orange, code 35-10303 (plus screening can 21-09105); 2·5 turns v.h.f. ferrite S18 Red, code 35-10203: and the 7mm 455kHz ferrite type LMC4202A 7E Black, code 35-42021.

For the filters and crystal quote: Bandpass 271MT1008, code 17-01008; Crystal filter 10M15A, code 20-10152; 10·24MHz crystal, code 45-10003; and ceramic filter CFU455D2, code 16-45582. The 15V 250mA mains transformer should be generally available.

The Receiver printed circuit board is available from the *EPE PCB Service,* code 144.

Alarm-Operated Car Window Winder

You must use heavy-duty automotive wire where specified when building the *Alarm-Operated Car Window Winder* project. Remember, you *MUST* disconnect the vehicle's battery *before* connecting the unit into the vehicle's electrics.

Also, in view of the high currents present, there is a risk of overheating and even fire if you do not double-check your wiring and make good connections prior to reconnecting the car battery.

Make sure you have provided a good "solid" earth (chassis) connection and that you have placed an in-line fuse in *each* Closer circuit "live" power line cable. Be extremely cautious, watching and smelling for telltale signs of heat etc when setting-up – Warning over.

All components required for the Trigger and Closer circuits should be readily available. However, for the Closer circuit you may experience a little difficulty in obtaining 0·015 ohm resistor rated at 4W. You should find one in the "wirewound" range stocked by advertisers, but you may have to select a 7W type as these seem more readily available.

You must use a relay which has contacts capable of handling currents of at least 16A. A typical example is the **Maplin** 12V d.c. 16A miniature relay, code YX99H. Other similar types may be offered, but check that the relay contact arrangement will suit the circuit board or you may have to "hardwire" it to the board.

The two small printed circuit boards are available from the *EPE PCB Service,* codes 150 (Trigger) and 151 (Closer) respectively. You will need a Closer p.c.b. for each window you wish to control.

PIC-A-Tuner

Only a couple of items for the *PIC-A-Tuner* project give rise to further comment and these concern the PIC microcontroller and display module.

If you intend to program your own PIC, make sure you ask for the 10MHz version of the PIC16C84. Also, we understand from the designer that a 3-key membrane keypad does not appear to be listed by anyone and a 4-key "pad" was used in the prototype, with one key not used. The one in the model came from **Electromail** ***(Tel. 01536 204555)***, code 130-381.

Turning to the l.c.d. display module, you may find that by shopping around you can purchase a 2-line 8-character module at a "bargain basement" price from one of our advertisers. Before buying, check it is a HD44100-compatible device.

For those who wish to purchase a ready-programmed PIC16C84, these can be obtained from **Magenta** ***(Tel. 01283 565435)*** for the sum of £15 inclusive. Alternatively, if you wish to do your own programming, the software is available on a 3·5in disk from the Editorial Offices – see the PCB page for details or, for Internet users, free from our FTP site: **ftp://ftp.epemag.wimborne.co.uk.**

The printed circuit board is available from the *EPE PCB Service,* code 149.

Quasi-Bell Door Alert

No problems should be encountered by constructors of the *Quasi-Bell Door Alert* project. All components appear to be "off-the-shelf" items. Most advertisers stock a miniature, about 76mm dia., 64 ohm loudspeaker. If you wish to use a "telephone" mic. insert you could try contacting **Bull Electrical** or **J&N Factors,** see their advertisement pages.

The printed circuit board is available from the *EPE PCB Service,* code 133.

PIC-Agoras

Fully-programmed PIC16C84 microcontrollers for PIC-Agoras are available from **Magenta** ***(Tel. 01283 565435)*** at £15 each inclusive of VAT, etc. You will need to program in your own wheel size, however, as discussed in the text.

If you have TASM-compatible PIC-programming facilities, you can, of course, program your own chip. The software is available either on disk from the *EPE* Offices or from our Web site (see page 363).