C B Projects

R. A. PENFOLD

CB PROJECTS

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by
R.A. PENFOLD

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PREFACE

CB simply stands for Citizens Band, and is a radio band set aside for private two-way radio communications. It differs from amateur radio in that the necessary licence can be obtained simply by paying the appropriate fee, and no examination passes are necessary. However, there are far stricter limitations on such things as output power, modes of transmission, and the type of aerial that can be used for CB communications. These restrictions are imposed primarily to reduce the risk of CB operators (who mostly have little or no knowledge of the technical side of radio communications) from causing interference to other radio services. CB is really only intended for communications over distances of no more than a few miles and is not intended for those who wish to make worldwide radio contacts.

The first official citizens band was the 27 MHz AM band which was permitted by the FCC in the USA in 1958. This 40 channel band has been adopted by other countries since then, albeit with some modifications in many instances. CB radio was not legalised in the UK until 1981 and is considerably different to the original (USA) citizens band.

Firstly there are two bands, one at about 27MHz and the other at about 934 MHz. The 27 MHz band is different to the American system in that although they both have 40 channels, the two bands cover different frequency spans and only partially overlap. Another important difference is that the British 27 MHz band uses FM (Frequency Modulation) rather than AM (Amplitude Modulation) like the American band. The range obtained is not much affected by changing from one mode to the other, and there is no real disadvantage in the use of FM. The advantage of FM, and undoubtedly the reason for its adoption for the British Citizens Band is that FM transmitters are somewhat less likely to cause interference to other services than AM types, although FM transmitters are, of course, still quite capable of causing such interference.

While it seems to be the 27 MHz citizens band that is of most interest to the majority of potential users of CB radio, the possibilities of the 934 MHz band should not be ignored.

This band is capable of providing communication over a range that is not all that far below the range attainable on the 27 MHz band, and the higher frequency enables very compact aerials to be used effectively. This would seem to make the 934 MHz band a better proposition for small hand-held rigs.

Of course, you do not need to have any technical know-how to use a CB rig, but for the electronics hobbyist (or anyone capable of using a soldering iron and a few other simple tools) it is possible to derive more pleasure from this hobby by constructing some items of equipment yourself. Probably few people would wish to build their own rig as this would be a rather complex business, there would be the problem of getting approval for the finished equipment, and it would probably cost more than the very reasonably priced commercially produced rigs anyway! However, there are a number of accessories that can be home-constructed quite inexpensively, making them competitive with commercially produced equipment in instances where a commercial alternative exists. In certain cases comparable commercial products do not exist and there is no alternative to home-constructed equipment, except to go without the particular item of equipment concerned!

This book provides a number of useful and interesting designs for CB accessories including such things as a speech processor, interference filters and a simple CB radio receiver. All the designs are suitable for constructors of limited experience because stripboard layouts and wiring diagrams are provided, together with notes on construction. Where appropriate, setting up procedures are described in detail and it is not necessary to have any test equipment in order to get finished projects to function properly.

R. A. Penfold

CONTENTS

WARNING NOTES

U.K. READERS

Please note that all references in this book to licencing regulations and specifications are based on information that was available or proposed at the time of writing. However as Citizens Band radio is in its infancy in this country these regulations may well be subject to change as the system develops and various snags and pitfalls become apparent during practical use.

Therefore it is strongly recommended that the reader always checks the official current regulations as issued by the appropriate authorities.

To operate outside current legislation is illegal.

OVERSEAS READERS

Most of the projects in this book should apply to any country that has 27MHz Citizens Band radio. The CB receiver will only apply to those countries that allow FM or multimode operation on the 27MHz band.

However certain countries do not permit the use of add-on units such as the Cordless Microphone or the Speech Processor.

It is strongly recommended that the reader always checks the local CB regulations of a particular country.

SPEECH PROCESSOR

While speech may be easily understood under normal conditions, poor reception conditions can produce noise that tends to mask a voice signal, possibly making it unintelligible. Under these circumstances there are ways of improving intelligibility by processing the signal from the microphone before it is fed into the transmitter.

One simple way of improving intelligibility is to ensure that the transmitter is always fully modulated, since an inadequate audio input at the transmitter will obviously give a weak audio signal from receivers that pick-up the signal. A weak audio signal would inevitably give reduced signal to noise ratio. Full modulation can be ensured by using an automatic level control, either as an add-on unit, or one built into the transmitter.

From the communications point of view, an unfortunate characteristic of speech is that it has a high peak level in comparison to the average level. It is the peak level that is of importance when setting the audio input level to a transmitter, and not the average level. This means that in order to prevent signal peaks from overmodulating the transmitter a low average level of modulation has to be accepted unless the signal is processed to increase the average level in relation to the peak level.

One simple method of achieving this is to feed the audio signal into a clipping circuit of some kind. A clipper merely prevents the signal voltage from exceeding some predetermined level, but has no effect on signals below this level. Thus a signal waveform as shown in Figure 1(a) would emerge from a clipping circuit looking something like the waveform of Figure 1(b). It is self evident that by clipping off the signal peaks the average signal level has been greatly increased in relation to the peak signal level.

One problem with a simple "hard" clipping circuit is that it seriously distorts the signal being processed. For example, a sinewave input signal such as that shown in Figure 2(a) would emerge from a clipping circuit having a waveform like that of Figure 2(b), even if only a modest amount of clipping was to be

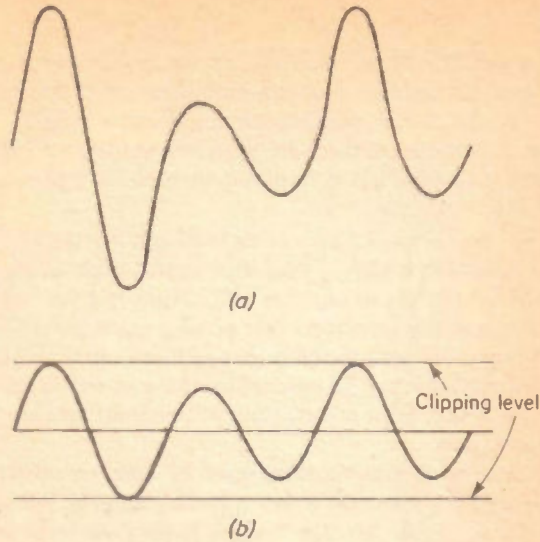


Fig. 1 A signal waveform of the type shown in (a) has a high peak to average level ratio. The clipped version of the signal (b) has a much higher average level in comparison to the peak level.

employed. The two signals look significantly different, and would sound very different as well. The sinewave input contains just one frequency, but the clipped output would additionally contain many strong harmonics (or multiples of the fundamental input frequency in other words). A signal that has been hard clipped tends to sound rather "rough", and intelligibility is quite likely to be reduced rather than improved by this type of clipping.

Better results can be obtained using "soft" clipping. With this method the output signal level does rise somewhat as the input signal is increased above the clipping level, although only a very limited amount. A greater increase in the output level when the clipping level is exceeded would give a further reduction in the distortion products generated by the unit,

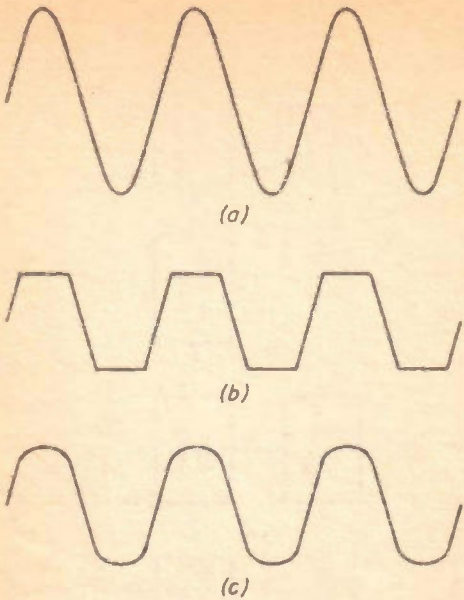


Fig. 2 A sinewave input (a) is severely distorted when hard clipped (b). Soft clipping (c) produces far less distortion.

but it would also give a reduction in the effectiveness of the unit. Figure 2(c) shows the output waveform that is obtained if a sinewave is subjected to "soft" clipping, and this is obviously somewhat closer to the original than the "hard" clipped waveform of Figure 2(b). The "soft" clipped signal has a stronger fundamental content and reduced harmonic content, and therefore gives a much "cleaner" sounding output signal.

Block Diagram

Figure 3 shows a block diagram representation of the Speech Processor unit featured here. This is basically a soft limiter, but one or two refinements have been included to further

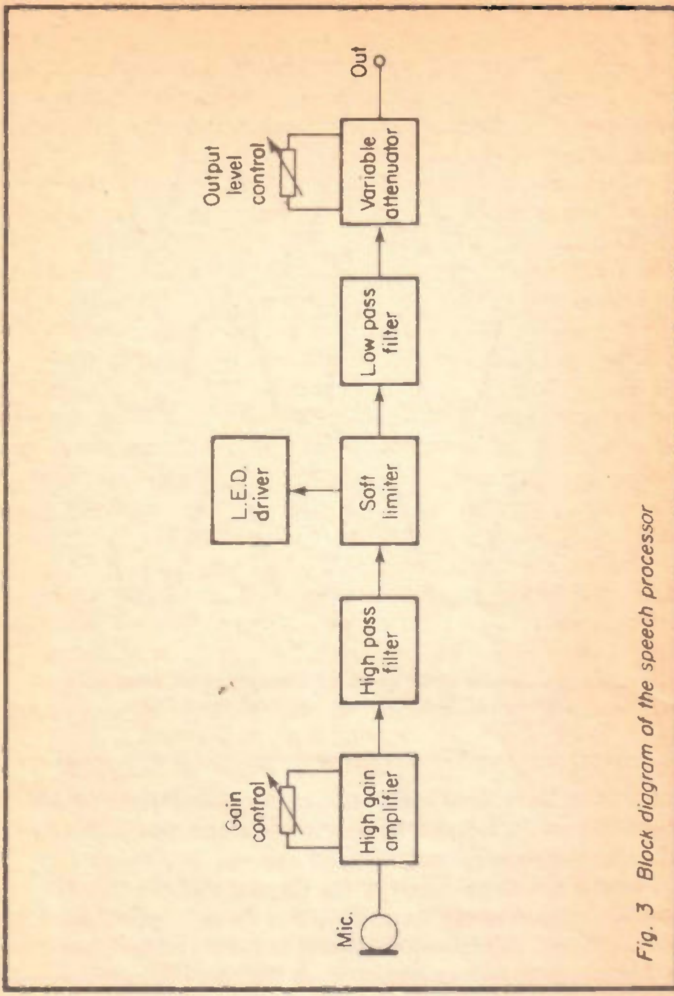


Fig. 3 Block diagram of the speech processor

increase performance. The unit is intended for use with a 50k (or thereabouts) dynamic microphone, and the output from this is first taken to a high gain amplifier. The amplifier is necessary merely because it is difficult to produce a clipping circuit that operates at the very low signal voltages produced by a microphone. A gain control is included in this part of the circuit, and this enables the severity of the clipping to be controlled. This is an essential feature since too little clipping would make the unit very ineffective, and excessive clipping would result in the output signal being so seriously distorted that the unit would be unusable.

The soft limiter is preceded by a high pass filter and followed by a low pass filter. The reason for including the low pass filter at the output is that the clipping action generates harmonics of the fundamental input frequencies, and this tends to boost the output of the unit at higher frequencies. The low pass filter removes or significantly attenuates many of these harmonics, and thus prevents an excessive treble output and effectively reduces distortion as well. The purpose of the high pass filtering at the input of the soft clipper is two-fold. One reason is simply that low frequencies do not significantly aid the intelligibility of speech, and can in fact hinder it. Their removal can therefore aid the effectiveness of the unit, and is certainly not detrimental to the performance of the processor.

The second reason for using the high pass filtering is that low input frequencies produce harmonic output frequencies from the clipping circuit that are at middle and high audio frequencies. While the low pass filtering can reduce the high frequency harmonics, those at middle audio frequencies will not be affected. Filtering of the middle audio frequencies is not practical since this would seriously impair the intelligibility of the output signal. A much better method is to reduce the low frequency input content so that a minimal harmonic content at middle frequencies can be generated by the clipping circuit.

The LED indicator is operated when the circuit is driven into clipping, and this is very helpful when setting the gain control for a suitable degree of clipping. The attenuator at the output is merely needed to reduce the fairly high output level back down to a similar level of the microphone input signal.

Units of this type can give an effective increase in the signal of 10dB (about three times), and can therefore be a very worthwhile addition when conditions are such that the other station is having difficulty in copying your signal. Under good or even moderate conditions, when your signal is being readily copied anyway, there is obviously no advantage in using a unit of this type (although there is no point in removing it, except perhaps to save battery drain). Although the circuit is quite simple and inexpensive when compared to some units of this type, it nevertheless seems to be very effective.

The Circuit

Figure 4 shows the complete circuit diagram of the Speech Processor.

The input stage uses Tr1 as a low noise common emitter amplifier having emitter resistor R3 to introduce negative feedback which boosts the input impedance of the unit to a suitable figure to match a high impedance dynamic microphone. The gain of the input stage is insufficient to bring the microphone signal to a high enough level to drive the clipping circuit, and so a second stage of amplification is used. The second stage uses Tr2 as a high gain common emitter amplifier.

Variable attenuator VR1 is connected between the two stages of amplification, and this is the control which is used to set the required clipping level. Due to the high gain of the circuit an input of as little as 1mV RMS can drive the unit to the threshold of clipping, and this level of sensitivity should be adequate for use with any normal high impedance dynamic microphone.

The low pass filtering is incorporated in the input amplifier circuitry, and is obtained merely by using rather low value coupling capacitors in the circuit (C2, C4, C5 and C7). These provide a fairly rapid roll off of frequencies below about 200 Hertz.

A straight forward diode clipping circuit is used, with D1 and D2 acting as low voltage (about 0.5 volt) zener diodes when forward biased by the output signal of Tr2. Thus D1 clips the signal at plus 0.5 volts, and D2 limits the signal at minus 0.5 volts. Silicon diodes and rectifiers have a well defined forward threshold voltage, and therefore give hard limiting unless some additional circuitry is used. In this case just one resistor (R6) is used to give the required soft limiting. When D1 or D2 is biased into conduction a current will flow through R6, producing a voltage across this component that is pro-

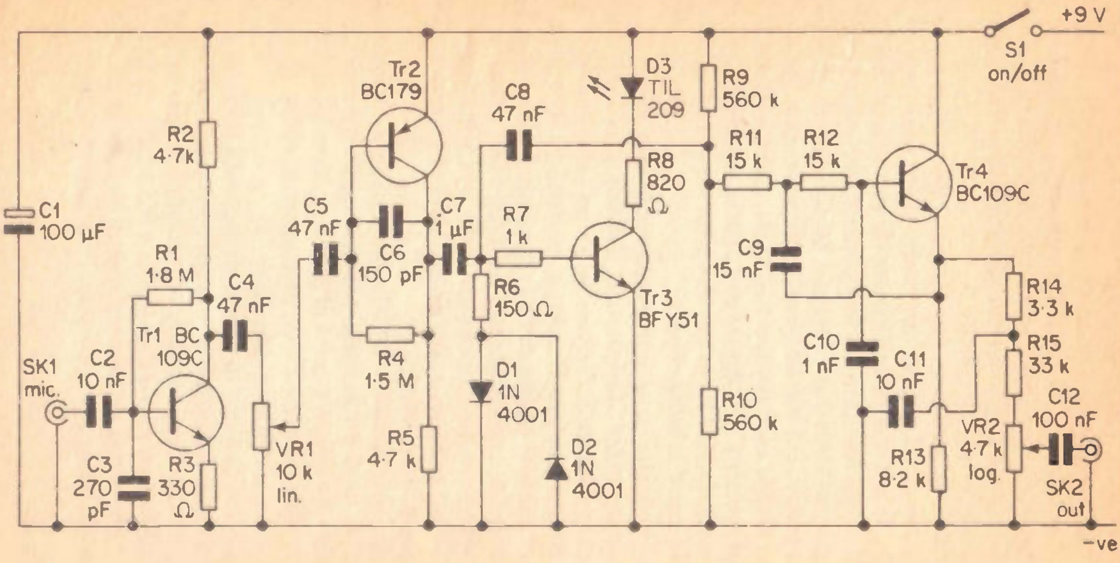


Fig. 4 The circuit diagram of the speech processor

portional to the current flowing through it. Thus the voltage at the junction of C7 and R6 can rise above the 0.5 volt clipping level, but due to the fairly low value of R6 it can only rise slightly above this level (bearing in mind the limited drive current and voltage available from the amplifier). This gives a very good soft clipping effect.

When the circuit is driven into clipping, the voltage present at the junction of C7 and R6 on positive signal peaks will be sufficient to bias Tr3 into conduction by way of base feed resistor R7. This results in D3 being pulsed with current and lighting up to indicate that clipping is being achieved. If the clipping is severe, Tr3 will be biased into conduction for a substantial part of each positive half cycle, giving a relatively high average current through D3 and causing it to light relatively brightly. D3 therefore also gives some idea of how severely the signal is being clipped.

The low pass filter is an active type which uses Tr4 in the standard second order configuration, and this gives a roll off of about 12dB per octave at frequencies above approximately 3.5kHz. Further low pass filtering is provided by R14 and C11 which form a simple passive filter at the output of the unit, and these increase the attenuation rate to about 18dB per octave. R15 and VR2 form the output attenuator, and VR2 enables the output level to be set at the desired level. C12 provides DC blocking at the output.

The only other control is S1 which is a straight forward on/off switch. A small 9 volt battery such as a PP3 is a suitable power source for the unit and will give very many hours of operation at only about 2.5 mA, plus an average of a few milliamps more which is consumed by D3.

Since the unit is likely to be in a strong radio frequency field (for obvious reasons) it is necessary to incorporate RF filtering to reduce the possibility of instability, either just in the processor, or even in the system as a whole, due to stray feedback. The necessary filtering is given by C3 and C6, plus the low pass filtering at the output of the unit of course.

Construction

It is recommended that a metal case should be used to house the unit as this will provide screening against RF and AF signals which might otherwise be picked up in the wiring, and could cause either instability or a reduced signal to noise ratio. Diecast aluminium boxes have excellent screening properties and are ideal for ths application, but any case of all metal construction should be satisfactory.

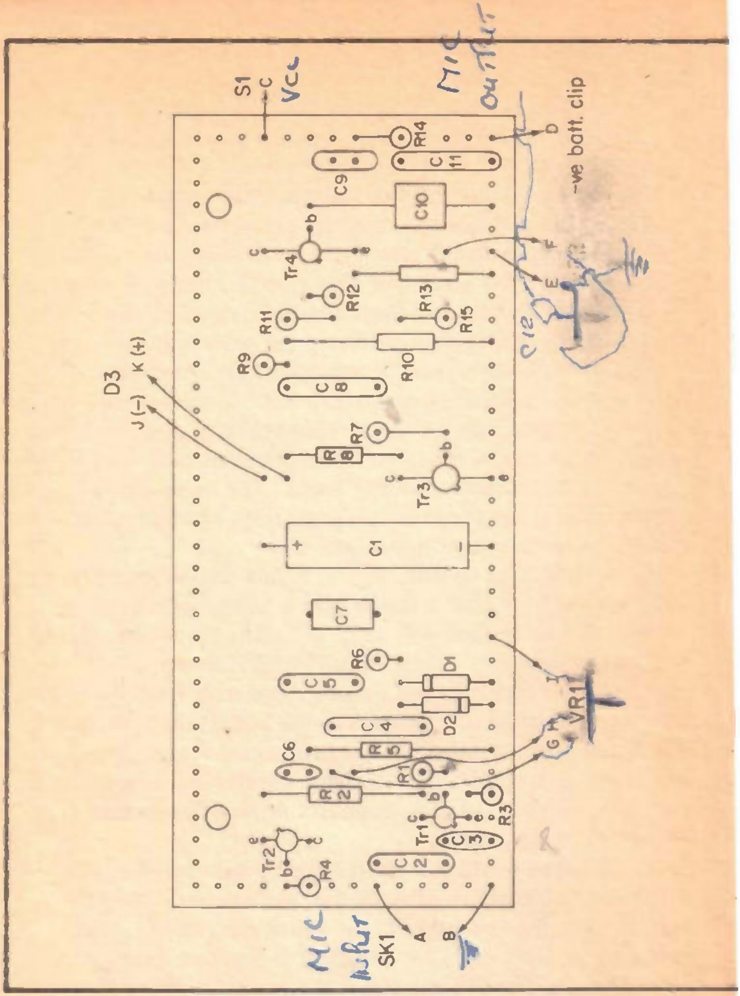
The three controls and two sockets are fitted on one of the long side panels of the case, and this then effectively becomes the front panel, with the removable panel being used as the lid of the case. On the prototype SK1 and SK2 are both minature (3.5mm) jack sockets, but these can be changed to some other type of audio connector if preferred for some reason.

Except for C12 the small components are fitted onto a 0.1in matrix stripboard panel which has 14 copper strips by 34 holes. Figure 5 shows the component layqut of this board plus the positions of the two 3.3mm diameter mounting holes and the 10 breaks in the copper strips. The mounting holes and the cuts in the copper strips must both be made prior to soldering the components into position.

There should be no difficulty in fitting the components into place and soldering them to the board, but be careful to connect the electrolytic capacitor (C1) and the semiconductor devices the right way round. Also, be careful not to accidentally bridge adjacent copper strips with small blobs of excess solder, especially at areas of the board where there are numerous connection points and bridges are very easily produced. It is a good idea to check the finished board for such short circuits using a continuity tester of some kind if a suitable tester is to hand.

The finished board is mounted on the base panel of the case using either M3 or 6BA fixings, and spacers should be used to keep the underside of the board clear of the metal casing so that the strips are not shorted together through the case. However, before the board can be finally fitted into place it must be wired up to the battery clip, D3, S1, etc. Figure 6, together with Figure 5, details all the point-to-point style wiring. As can be seen from Figure 6, C12 is mounted direct between VR2 and SK2.

If 3.5mm jack sockets are used for SK1 and SK2 the metal will be earthed to the negative supply rail of the circuit via these. If different sockets are used it may be necessary to



eartn the case via a soldertag bolted to the case at any convenient point.

Adjustment and Use

The microphone plugs into SK1, and a screened lead is used to take the processed signal from SK2 to the microphone input of

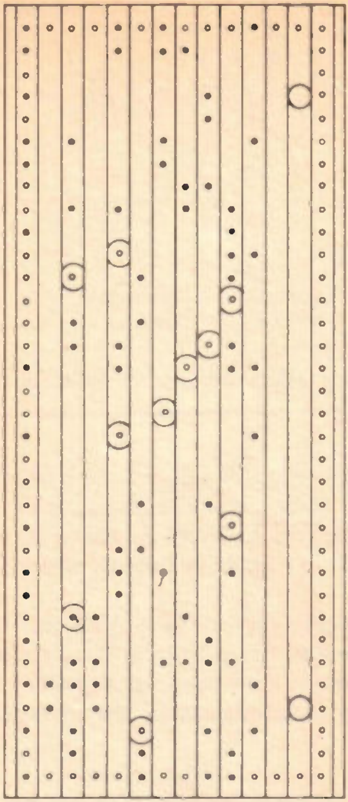


Fig. 5 Constructional details of the speech processor

the transmitter. VR2 is simply adjusted to give an output signal level that roughly matches the output of the microphone in use, so that the transmitter functions in the same manner with or without the processor in use.

VR1 must be adjusted quite carefully if the unit is to be of maximum benefit. With this control well backed off D3 will

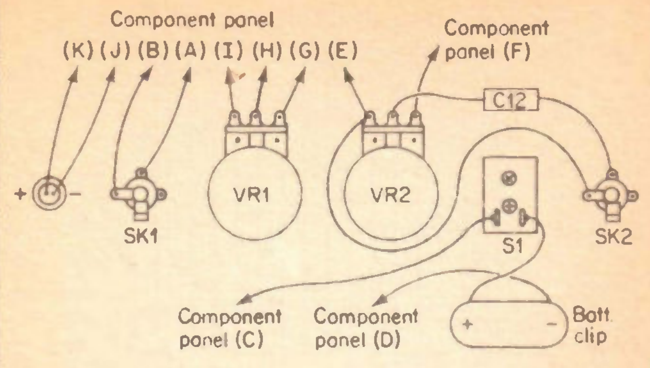


Fig. 6 The point to point wiring of the speech processor

probably fail to light up, or will only flash briefly and dimly on signal peaks. Under these circumstances the processor will have little or no effect, and VR1 should be advanced slightly so that D3 lights up reasonably brightly when talking into the microphone.

Avoid the temptation to advance VR1 any further than this, since this would almost certainly result in a very high level of distortion on the output signal, making the signal very difficult to copy and giving exactly the opposite effect to the desired one!

Components for Speech Processor (Figure 4)

Resistors, all 1/3 watt 5%

R1	1.8M	R2	4.7k
R3	330 ohms	R4	1.5M
R5	4.7k	R6	150 ohms
R7	1k	R8	820 ohms
R9	560k	R10	560k
R11	15k	R12	15k
R13	8.2k	R14	3.3k
R15	33k		
VR1	10k lin carbon	VR2	4.7k log carbon

Capacitors

C1	100μF 10V electrolytic		
C2	10nF polyester (C280)		
C3	270pF ceramic plate		
C4	47nF polyester (C280)		
C5	47nF polyester (C280)		
C6	150pF ceramic plate		
C7	1μF polycarbonate (PCM)		
C8	47nF polyester (C280)		
C9	15nF polyester (C280)		
C10	1nF polystyrene		
C11	10nF polyester (C280)		
C12	100 nF polyester (C280)		
Semiconductors			
Tr1	BC109C	Tr2	BC179
Tr3	BFY51	Tr4	BC109C
D1	1N4001	D2	1N4001
D3	TIL209		
Switch			
S1	SPST toggle type		

Miscellaneous

Diecast aluminium box or similar metal case
0.1in matrix stripboard
Two 3.5mm jack sockets (SK1 and SK2)
Panel holder for D3
Two control knobs
PP3 size battery and connector to suit
Wire, solder, etc.

AERIAL BOOSTER

Although modern communications equipment mostly operates efficiently on the higher frequency bands (which includes the 27MHz FM Citizens Band), performance at these frequencies is not all one would desire in many cases, and there is room for improvement. Receiver performance in particular tends to fall off somewhat at higher frequencies, and good sensitivity plus image rejection are more difficult to achieve at 27MHz than at (say) 2.7MHz. A more complete explanation of the term "image rejection" will be given in a later section of this book, but for those who are unfamiliar with this term it should perhaps be explained that most radio receivers are based on the heterodyne principle, and one drawback of this system is that it produces spurious responses. Usually the most severe of these is the "image response" (sometimes just called the "image"), and this is often less than 1MHz away from the main reception frequency of the set (although this depends on the design of the particular set concerned, and can be much further away). With the image response so close to the main one it is difficult to remove or even greatly attenuate it at frequencies as high as 27MHz or so, and this can result in signals picked up on the image response causing serious interference to the wanted signal. The set is effectively tuned to two frequencies at once!

One way of obtaining improved image rejection is to add a tuned amplifier between the aerial and the receiver, because this will boost signals at the proper reception frequency, but will little affect or even attenuate signals at the image frequency. A further obvious benefit of such an amplifier is that it improves the sensitivity of the receiving set up.

The level of improvement obtained by adding a tuned aerial amplifier, or "preselector" as it is often termed, obviously depends to a large extent on the performance of the receiver with which it is used. With a set having poor image rejection and low sensitivity there is likely to be a substantial improvement, whereas with a set having a very high level of performance in both respects there is little room for improvement, and a preselector can be of only limited effect.

This simple design has preset tuning, although it could be easily modified to have a tuning control if desired. However, the 27MHz FM Citizens Band is only some 390 kHz wide, and the bandwidth of the amplifier is just about sufficient to give very good results over the entire band if it is peaked at the centre of the band. Thus there is little to be gained by using a tuning control; it would simply make the unit less convenient to use.

Power is obtained from an internal PP3 size battery, and this has a reasonably long operating life as the current consumption of the unit is only about 8mA. However, if the amplifier is going to be used a great deal it would be advisable to use a larger battery such as a PP7 or PP9 as this would give reduced running costs.

The Circuit

The circuit is based on two transistors; one JFET type and one bipolar device, as can be seen by refering to the circuit diagram of the unit which appears in Figure 7.

The main winding of T1 plus TC1 form the input tuned circuit, and TC1 is adjusted to bring the tuned circuit to resonance at the centre of the 27MHz FM Citizens Band. If a tuning control is desired, this can be accomplished by simply adding a 10pf air spaced variable capacitor in parallel with TC1. The aerial signal is coupled into the tuned circuit by way of a low impedance coupling winding on T1.

The signal in the tuned circuit is coupled direct into the gate of Tr1, and the main winding of T1 is used to bias Tr1's gate to the negative supply rail. It is not necessary to use a coupling winding to couple the signal in the tuned circuit to the input of Tr1 since Tr1 has a very high input impedance, and this matches the high output impedance of the tuned circuit. The coupling winding which connects between pins 5 and 7 of T1 is therefore unused in this application.

Tr1 is a straight forward JFET common source amplifier which has R1 as its source bias resistor and C1 as the source bypass capacitor. L1 is the load for Tr1, and this component can be any RF choke having a value of around 1 to 10mH.

C2 couples the output of Tr1 to the input of a second stage of amplification, and this utilises Tr2 as a straight forward

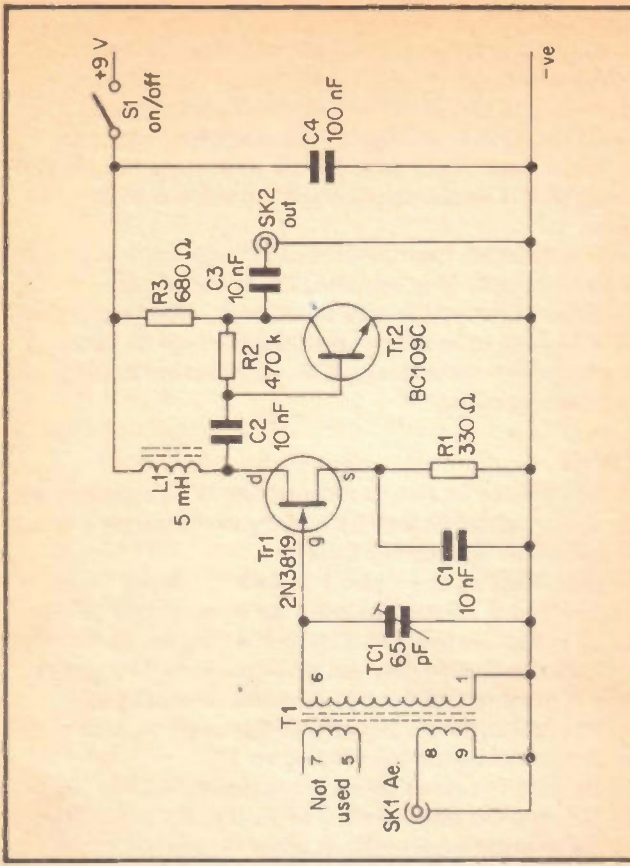


Fig. 7 The circuit diagram of the aerial booster

broadband common emitter amplifier. C3 couples the output of Tr2 to the output socket (SK2) and provides DC blocking at the output. S1 is the on/off switch, and C4 is a supply decoupling capacitor.

Construction

A diecast aluminium box makes an ideal housing for this project, but any small metal box that is capable of accommodating all the components should be suitable. Probably the most convenient layout is to have S1 mounted on the front panel with SK1 SK2 at opposite ends of the rear panel. T1 can also be mounted on the rear panel of the case, and T1 will be supplied with a plastic mounting nut that screws onto the plastic thread at one end of the former. The mounting nut should only be tightened by hand as it is otherwise quite likely that it will be over-tightened and the plastic thread will be damaged.

The other components, except for the battery and TC1, are fitted onto a 0.1in matrix stripboard which as 16 holes by 16 copper strips. Figure 8 gives details of this board. There are no breaks in the copper strips, and it is therefore only necessary to drill the two mounting holes before fitting and soldering the components into place.

The remaining wiring of the unit is then completed before finally bolting the component panel in position at any convenient place on the base panel of the case. TC1 is mounted on T1, and TC1 can be any trimmer having a maximum value of around 65 to 100pf. With most types it will be necessary to use an extension lead on one of its tags in order to fit it across the appropriate pins of T1. Although it is possible to solder direct to the pins of T1, this is not recommended since the polystyrene coil former tends to melt when the bit of the soldering iron is applied to a pin. This makes soldering difficult and could result in serious damage to T1. The nine pin base of T1 will fit a B9A valveholder, and it is advisable to fit one of these onto T1 and then make the connections to the holder.

Make sure that the leads to SK1 are not transposed, and the same also applies to the leads which connect to SK2. The non-earthy leads connect to the central tag or terminal of the sockets, while the earth leads connect to the chassis. It may be necessary to fit soldertags onto one mounting bolt of SK1 and SK2 in order to provide suitable chassis connection points. Try to keep all the connecting wires short and direct.

Adjustment and Use

The aerial is connected to SK1 and a coaxial lead takes the output from SK2 to the aerial input of the receiver. With the receiver tuned to a station on a channel near the middle of the 27MHz FM Citizens Band, TC1 is adjusted to peak the

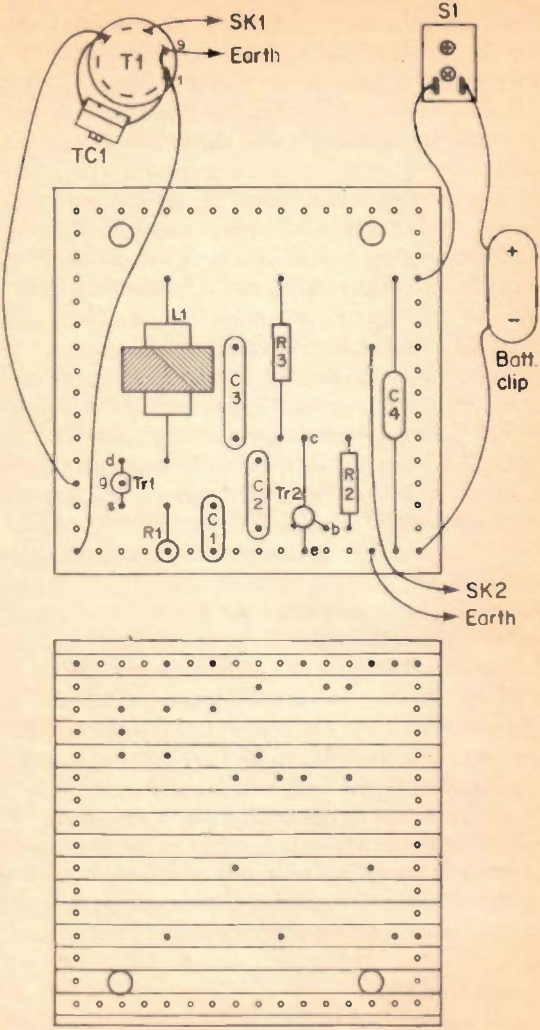


Fig. 8 Constructional details of the aerial booster

signal. It is possible that it will also be necessary to unscrew the core of T1 slightly in order to peak the unit.

If the amplifier is used with a transceiver it cannot simply be fitted into the aerial lead since it would block the signal during transmission and could even be damaged. Either it must be built into the rig so that it is bypassed by the transmit/receive circuitry of the rig, or it must be built as an external unit having built-in bypass switching which must be switched to the bypass mode prior to switching the rig to "transmit". The second method is a little inconvenient, and the first method is better, but it should only be attempted by someone with the appropriate technical knowledge to tackle the job.

Components for Aerial Booster (Figure 7)

Resistors, all 1/3 watt 5%

R1	330 ohms	R2	470k
R3	680 ohms		

Capacitors

C1	10nF polyester (C280)
C2	10nF polyester (C280)
C3	10nF polyester (C280)
C4	100nF polyester (C280)
TC1	5.5 to 65pF trimmer (see text)

Semiconductors

Tr1	2N3819	Tr2	BC109C

Inductors

T1	Denco blue aerial coil for transistor usage, range 5T
L1	5mH RF choke

Switch

S1	SPST toggle type

Miscellaneous

Diecast box or similar metal case
0.1in matrix stripboard panel
B9A valveholder (coil holder for T1)
PP3 size battery and connector to suit
Two coaxial sockets (SK1 and SK2)
Wire, solder, etc.

For static operation of a CB rig it is obviously of little handicap to have a microphone which connects to the rig in the usual way. However, for mobile operation it is more convenient and less cumbersome to have a microphone which couples its signal to the transmitter in a way which does not require any connecting cable. One way of achieving this, and probably the most simple way, is to use an infra-red link. This consists of a small infra-red transmitter unit fitted onto the microphone and a matching receiver unit fitted at the microphone socket of the rig. The transmitter sends a pulsed signal which is frequency modulated by the signal from the microphone, and is directed towards a sensor at the receiver. The signals from the sensor are processed to recover the original modulating signal, which is then fed to the rig.

Frequency Modulation

The frequency modulation employed in this system is the same as the frequency modulation used in CB rigs incidentally, although the actual frequencies involved in this cordless microphone system are far lower than those used on either the 27 MHz or 934 MHz Citizens Bands. The basic principle is exactly the same in each case though.

If there is no audio input to the transmitter, the output pulses occur at constant intervals, or at a constant frequency in other words. If the audio signal is positive in polarity, the frequency of the pulses is increased. The stronger the audio signal voltage, the greater the increase in frequency. Similarly, a negative going audio input voltage produces a change in frequency, but a decrease rather than an increase, with the level of change again being proportional to the amplitude of the modulating signal.

The receiver provides the opposite effect, and gives an output voltage that is dependent upon the frequency of the input signal. Thus the unmodulated input signal gives a fixed output voltage as it is at a fixed frequency. When the input pulse signal is modulated, the increases in frequency produce an increase in output voltage from the receiver, and decreases in frequency produce a reduction in output voltage. This varying output voltage from the receiver is, of course, the same as the original modulating voltage (i.e. the microphone signal) at the transmitter.

A system of this type could in fact use ordinary (visible) light, rather than infra-red which is at wavelengths that are just too long to be perceived by the human eye. However, infra-red systems seem to be less affected by ambient light than systems using visible light. This is probably due to the fact that most infra-red semiconductor devices (including those used in this system) have built-in infra-red filters that exclude light at frequencies outside the infra-red range. Ordinary light sensitive devices have no filtering, and respond to a wide spectrum of frequencies, making them vulnerable to interference from virtually any ambient light.

Transmitter Circuit

The complete circuit diagram of the transmitter is given in Figure 9, and this is quite simple and straight forward.

The basic "carrier" signal is generated by IC1 which is a CMOS 555 timer IC (the ICM7555) used in the standard astable mode. The ICM7555 is used in preference to the standard 555 device as this gives a reduction in current consumption of about 8mA, and this helps to give long battery life.

This type of oscillator operates by having timing capacitor C5 first charge to 2/3V+ by way of R4 and R5, and then discharge to 1/3V+ via R5 and an internal transistor of the IC. This process continues indefinitely with the output terminal of the device (pin 3) going high while C5 is charging, and low while it is discharging. The high output period is therefore governed by the values of R4, R5 and C5, while the low output period is governed by the values of R5 and C5 (the impedance of the internal transistor of IC1 being too low to be of any significance). The charge resistance of C5 (R4 plus R5) is obviously much larger than the discharge resistance (R5 alone), and the output is therefore in the high state for a much longer time than it is in the low state. The mark space ratio of the output is around ten to one in fact.

Tr2 is an emitter follower buffer stage which is used at the

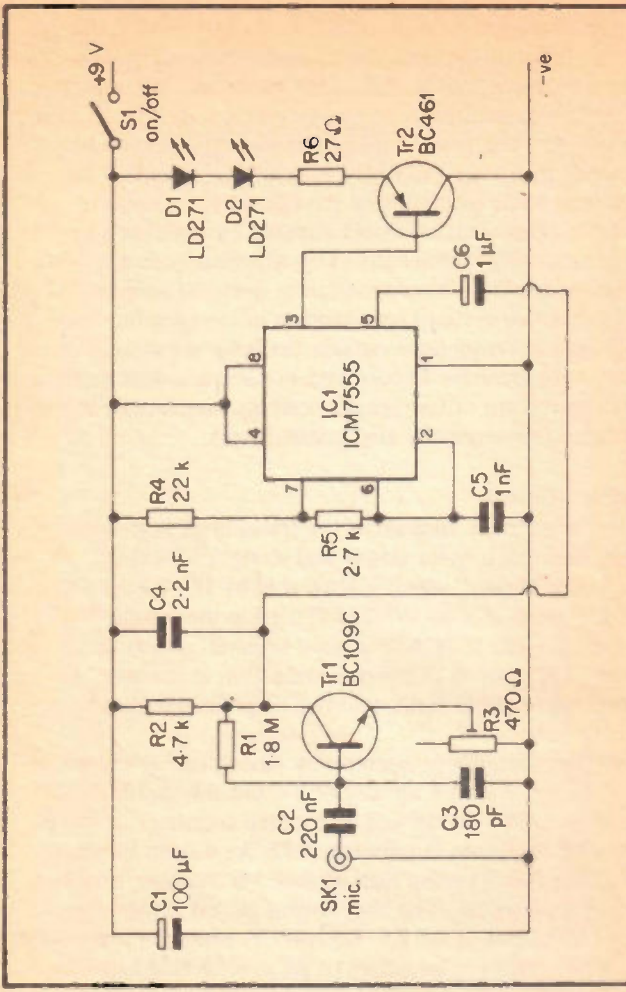


Fig. 9 The circuit diagram of the cordless microphone transmitter

output of IC1, and this drives two infra-red LEDs (D1 and D2) which are connected in series. R6 is a current limiting resistor which sets the LED current at a suitable level (about 100mA). The LEDs are only switched on while IC1's output is low, and they are thus pulsed on only very briefly, and are switched off for by far the majority of the time. The point of using these brief pulses of fairly high current is that it gives a strong output signal from the two LEDs, but keeps the average current consumption of the circuit down to a reasonable level of only about 10mA.

The oscillator can be frequency modulated by applying the audio modulating signal to pin 5 of IC1. This pin connects to an internal potential divider circuit of IC1, and it is this divider that sets the 2/3V+ threshold level at which IC1 triggers to the discharge mode, and discharges C5. If a positive going signal is applied to pin 5, this obviously raises the threshold level and it takes C5 longer to charge to this level. The greater the increase in the threshold level, the longer it takes C5 to charge to this level. This reduces the operating frequency of the astable, with the reduction in frequency being proportional to the control voltage.

Negative going modulation signals reduce the 2/3V+ threshold level, and it then takes C5 less time to charge to the trigger level. This gives an increase in output frequency, and the increase is proportional to the amplitude of the modulation signal. This gives the desired frequency modulation.

Note that although positive signals give a decrease in frequency, and negative ones give an increase in frequency (not negative signals giving a decrease and positive signals giving an increase, as was stated in the initial explanation of FM), this does not effect the operation of the system. It merely results in the signal being inverted; the final audio signal does not sound any different as a result of this.

The signal from a high impedance dynamic microphone is not sufficient to fully modulate the transmitter, and Tr1 has therefore been used in a simple common emitter amplifier which is used to boost the microphone signal to a more suitable level. It is important that the transmitter is fully modulated since the background noise level does not vary with changes in modulation level. This means that only a low level of modulation will result in the wanted signal being little more than the noise level, and poor results will be obtained. Using a high level of modulation keeps the wanted signal well above the noise level and gives good results.

R3 controls the gain of the input stage; minimum value here corresponding to maximum gain. This is adjusted to give just enough gain to fully modulate the transmitter. Do not be tempted to use any more gain than is absolutely necessary as this would result in overmodulation and a consequent high level of distortion from the unit.

C3 and C4 are RF filter capacitors which prevent problems due to stray feedback. C6 couples the output signal of Tr1 to the appropriate pin of IC1.

Construction

Figure 10 shows the 0.1in matrix stripboard layout for the transmitter, and this is based on a board having 14 copper strips by 23 holes. Construction of the board is perfectly straight forward and the normal construction techniques are used. Although IC1 is a CMOS device, the handling precautions that are normally taken with CMOS devices to avoid damage due to high static voltages are unnecessary here. This is due to the fully effective internal protection circuitry of the ICM7555 device.

Mechanical construction of the unit must obviously be varied to suit the particular conditions under which the system is used. However, it should be borne in mind that the two LEDs have built-in lenses which make them directional, with maximum output occuring at 180 degrees to the leadout wires. There is a substantial output somewhat off-axis, and by aiming the LEDs in slightly different directions the directivity can be further reduced. The range of the system is not very great, being just a few feet, but this is obviously quite adequate in this application. It is possible to increase the range somewhat by reducing the value of R6 slightly, but this will be at the cost of increased current consumption. It may well be found that perfectly adequate results can be obtained using a higher value for R6, and this would have the advantage of giving increased battery life. If the unit is to be used a great deal it would probably be best to use a NiCad PP3 battery as the power source, but otherwise an ordinary PP3 size battery should be a reasonably economic power source.

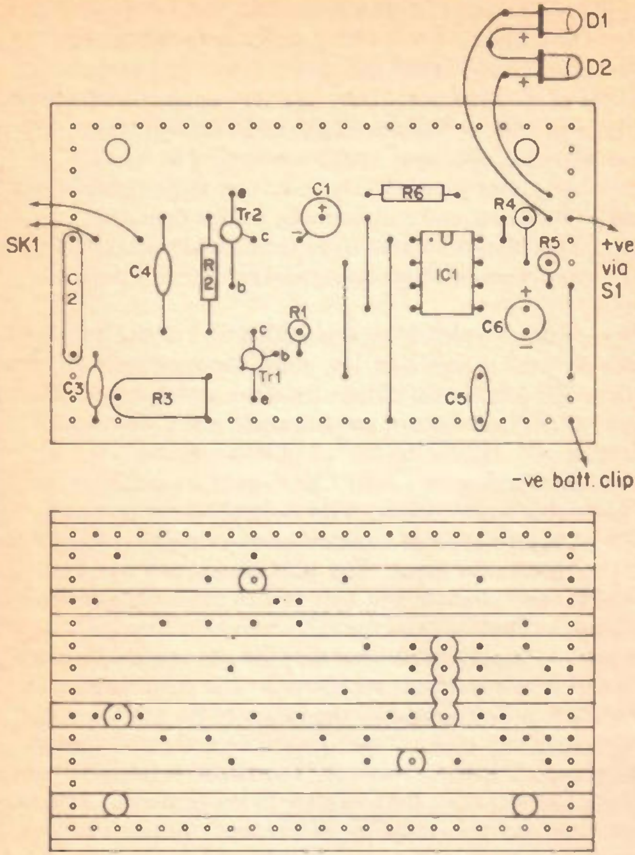


Fig. 10 Constructional details of the cordless microphone transmitter

Receiver Circuit

The circuit diagram of the receiver is shown in Figure 11. D1 is the infra-red detector diode, and this has R1 as its load resistor. The leakage current of D1, which is reverse biased, depends upon the infra-red light level to which it is subjected. The pulses of infra-red from the transmitter cause small increases in the leakage level, and this results in small voltage pulses being generated in sympathy at the junction of R1 and D1. These voltage pulses are not likely to be very large under normal operating conditions, and will normally be less than one millivolt. They therefore need to be substantially amplified in order to bring them to a high enough level to drive a detector circuit.

The necessary amplification is provided by Tr1 and Tr2, both of which are used as high gain, low noise, common emitter amplifiers. C2 couples the output from the sensor circuitry to the input of the first stage of amplification, and C3 provides RF filtering. C4 couples the two amplifiers together.

The demodulator uses a 4001 CMOS quad 2 input NOR gate as a monostable multivibrator. This is simply a circuit which provides an output pulse of fixed duration each time a trigger signal is applied to the input. The 4001 is used in a well known monostable configuration, and only two of the four gates are actually used. The inputs of the other two gates are connected to the negative supply rail so that they are not operated by stray signals, and the two outputs are ignored. The pulse length of the monstable is determined by the values of R6 and C5, and is very approximately 0.68 CR seconds (or only about 6.8 micro seconds using the specified values). The circuit is triggered by taking pin 1 of IC1 from the low state to the high one. As this terminal is taken to the collector of Tr2, and this point in the circuit will be switching between virtually the two supply voltages in the presence of a suitable input signal, the monostable produces one output pulse for each pulse received from the transmitter.

Under quiescent conditions (i.e. without the carrier wave being modulated) the monostable will be triggered at a rate that gives an average output potential of around 2 volts. If the input frequency increases, the number of output pulses also increases, and this gives a higher average voltage at the output of the

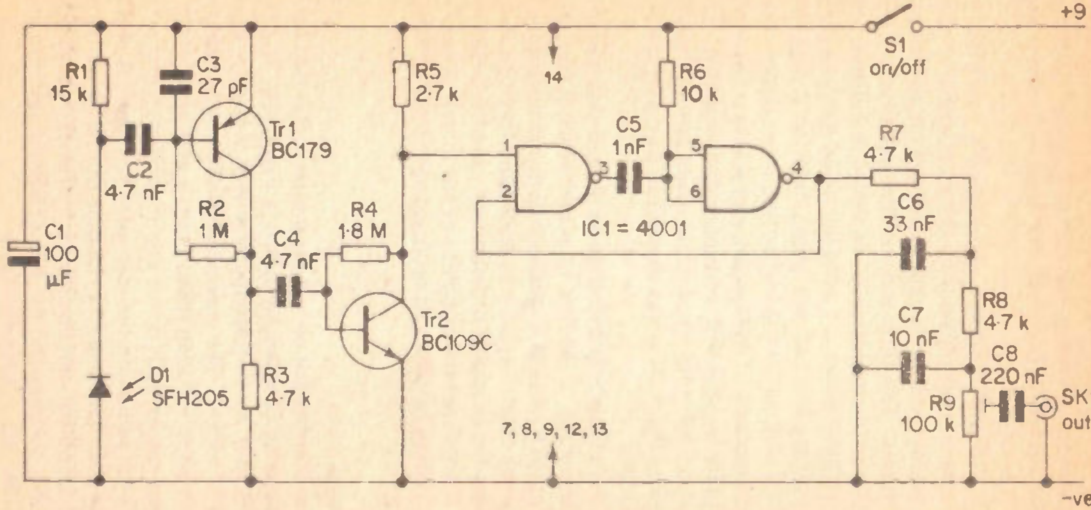


Fig. 11 The circuit diagram of the cordless microphone receiver

monostable. A reduction in the input frequency gives fewer output pulses and hence reduced average output voltage from the monostable. This gives the required demodulation, and despite the simplicity of the system it gives excellent audio quality.

R7, C6, R8 and C7 form a two stage low pass filter which integrates the output pulses from the monostable so that the required average voltage is obtained at the output, and not a series of pulses. This filter reduces the upper audio bandwidth of the receiver to considerably less than the full audio range, but as explained earlier, for effective voice communication an upper frequency limit of only about 3kHz or so is perfectly acceptable. Rolling off the higher frequencies improves the signal to noise ratio of the system, and makes it easy to ensure that the pulse signal is very considerably attenuated. This is important, as the pulse signal could easily produce spurious outputs from the rig if it was allowed to leak into the transmitter section.

R9 is the variable output attenuator, and this is used to reduce the output of the unit to a level which is comparable to that produced by a high impedance dynamic microphone. The unattenuated output signal is considerably too high in amplitude. C8 provides DC blocking at the output, and S1 is the on/off switch. The current consumption of the circuit is only about 5mA, and it can be operated economically from a PP3 size 9 volt battery.

Construction

The unit is constructed on a 0.1in matrix stripboard having 15 copper strips by 26 holes, as shown in Figure 12. IC1 is a CMOS device, but as it is a very inexpensive type it hardly justifies the use of an IC socket. The normal CMOS handling precautions should of course be taken when dealing with this device though.

The unit can be built into a small metal case, and a ¼in jack plug can be mounted on the case using the rear cover of the plug as a fixing nut. The barrel of the plug should be on the exterior of the case, and the unit can plug into the rig instead of the microphone, the plug and the microphone socket providing the unit with the only fixing necessary.

D1 must be positioned behind a window in the case, and this

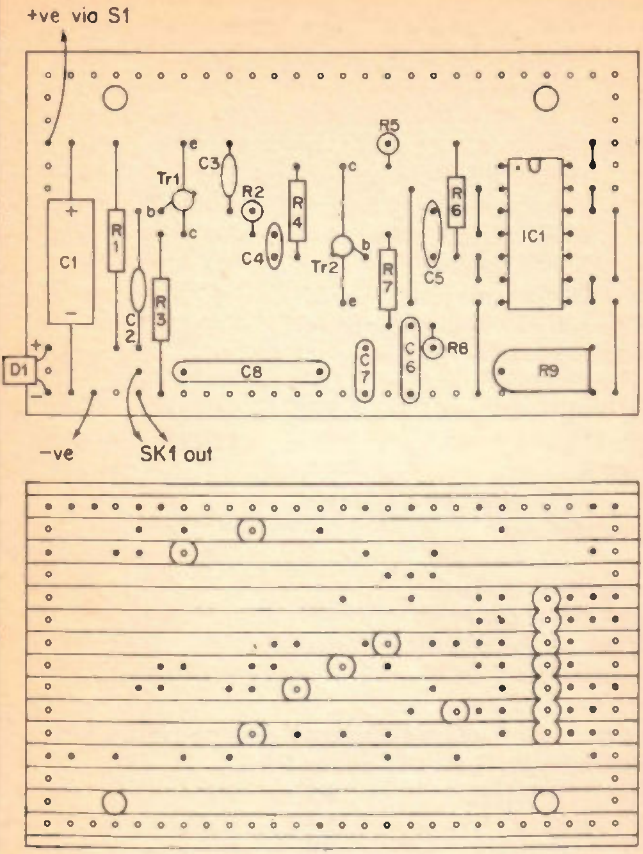


Fig. 12 Constructional details of the cordless microphone receiver

window must obviously face in the direction of the transmitter. The sensitive surface of D1 must face towards the window, and the curved surface of D1 is the sensitive one.

Components for Cordless Microphone Transmitter (Figure 9)

Resistors, all 1/3 watt 5% except R3

R1	1.8M	R2	4.7k
R3	470 ohms 0.1 watt horizontal preset	R4	22k
R5	2.7k	R6	27 ohms

Capacitors

C1	100μF 10V electrolytic
C2	220nF polyester (C280)
C3	180pF ceramic plate
C4	2.2nF ceramic plate
C5	1nF ceramic plate
C6	1μF 25V electrolytic (pcm)

Semiconductors

IC1	ICM7555		
Tr1	BC109C	Tr2	BC461
D1	LD271	D2	LD271

Switch

S1 SPST miniature toggle type

Miscellaneous

Case
0.1in matrix stripboard
¼in jack socket (SK1)
9 volt battery and connector to suit
Wire, solder, etc.

Components for Cordless Microphone Receiver (Figure 11)

Resistors, all 1/3 watt 5% except R9

R1	15k	R2	1M
R3	4.7k	R4	1.8M
R5	2.7k	R6	10k
R7	4.7k	R8	4.7k
R9	100k 0.1 watt horizontal preset		

Capacitors

C1	100μF 10V electrolytic
C2	4.7nF ceramic plate
C3	27pF ceramic plate
C4	4.7nF ceramic plate
C5	1nF ceramic plate

C6	33nF polyester (C280)		
C7	10nF polyester (C280)		
C8	220nF polyester (C280)		
Semiconductors			
IC1	4001		
Tr1	BC179	Tr2	BC109C
D1	SFH205		
Switch			
S1	SPST miniature toggle type		
Miscellaneous			

Case
0.1in matrix stripboard
¼ in jack plug (SK1)
9 volt battery and connector to suit
Wire, solder, etc.

HIGH PASS AERIAL FILTER

There are a number of ways in which a 27MHz CB transmitter can interfere with domestic TV reception and other radio services. It is not necessarily due to a fault in the rig that interference occurs, since TV sets and most other types of radio receiving device have spurious responses. If one of these responses should coincide with a CB channel, then there is obviously a likelyhood of a CB rig causing interference if it is operated in fairly close proximity to the receiver concerned. In such cases it is the receiving equipment that is at fault, and the operator of the CB equipment is not really under any legal or moral obligation to rectify matters.

Unfortunately, in many cases where interference is being caused by transmitting equipment it is due to spurious outputs from the transmitter, rather than spurious responses of the receiver with it suffering from the interference. The fact that such interference is being caused does not necessarily mean that the transmitting equipment is either faulty or not adjusted correctly. All transmitting equipment produces spurious outputs, but these should be at a far lower level than the main output. However, if a transmitter is being operated in very close proximity to sensitive receiving equipment, it obviously only requires an extremely weak spurious output to cause interference to become evident on the receiving equipment.

The most common form of spurious output from a transmitter is harmonics. These are simply multiples of the fundamental transmitting frequency, and a transmitter operating at (say) 27MHz would produce harmonics at 54MHz, 81MHz, 108MHz and so on. This is one respect in which the 930MHz citizens band is better than the 27MHz one, since multiples of 930MHz band frequencies are far too high in frequency to cause interference to most radio services. Those radio services that do exist on these higher frequencies are not of a type that is likely to be affected by harmonic interference from CB rigs.

It is often possible to reduce or even eliminate interference caused by CB equipment by using an aerial filter. If the problem is due to spurious responses of the receiver, the filter must be fitted in the aerial lead of the receiver so that it effectively reduces the spurious responses of the receiver. Obviously a filter will be needed for each set that is effected.

If the problem is due to harmonics from the transmitter, only one filter is required, and this is fitted in the aerial lead of the transmitter so that it attenuates the offending harmonics.

The Circuit

If a 27MHz CB rig causes interference with a UHF TV receiver due to spurious responses of the TV set, it is a high pass filter that is used to reduce the interference. As its name implies, this type of filter passes high frequency signals (above about 400MHz in this case) but attenuates signals at lower frequencies (including those in the 27MHz citizens band).

Due to the substantial differences in the frequencies associated with the 27MHz citizens band and the UHF TV band it is quite easy to provide a high level of attenuation at 27MHz CB frequencies while giving minimal losses at UHF TV frequencies. A simple passive filter is all that is required, and Figure 13 shows the circuit diagram of a practical design. This gives losses of well over 40dB (in other words a considerably more than one hundred fold decrease in the amplitude of the output signal) at 27MHz.

The circuit is quite conventional, and relies upon the fact that the impedance of an inductor rises with increases in the applied frequency while the impedance of a capacitor decreases with rises in the applied frequency. Thus at the UHF TV

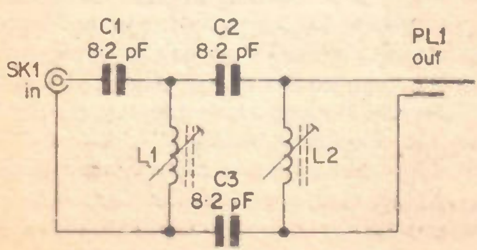


Fig. 13 The circuit of the high pass aerial filter

frequencies C1, C2 and C3 provide an easy path for signals through the filter. L1 and L2 exhibit quite high impedances at these frequencies, and therefore fail to have any real effect on signals at these frequencies.

At lower frequencies of around 27MHz C1, C2 and C3 have much higher impedances, and this tends to quite significantly hinder the passage of signals through the unit. L1 and L2 have much lower impedances at these frequencies than on the UHF TV band, and they therefore tend to shunt substantial amounts of signal to earth, producing further signal losses. Thus the circuit provides the required high pass action using just a few inexpensive components.

Construction

The circuit is built on a piece of 0.1in matrix plain perforated board (i.e. the type that does not have copper strips). The board measures 11 x 16 holes, and uses the component layout shown in Figure 14. The components are connected together in the appropriate manner by simply soldering the leadout wires together on the underside of the board. This wiring is also shown in Figure 14. It should be found that the component leadout wires are sufficient to permit the completion of all this wiring, but about 22 swg tinned copper link wires can be used if this is not the case.

The unit can be housed in virtually any small plastic case, and the only requirement is that the case should be large enough to take the input socket and the component panel. A soldertag is fitted under one of the mounting nuts of SK1 in order to provide a chassis connection point for this socket. The board connects to SK1 via two short leads. The output of the filter connects to the TV set via a short length of coaxial cable which is terminated in a coaxial plug. The other end of the cable is threaded through a hole drilled in the case and then connected to the component board.

The two ready made coils have adjustable ferrite cores, but the settings of these is of very little importance in this application, and there is no need to adjust the cores.

Of course, with filters of this type it is possible to obtain greater rejection of the unwanted frequencies by adding two or more filters in series. However, the small insertion loss at pass

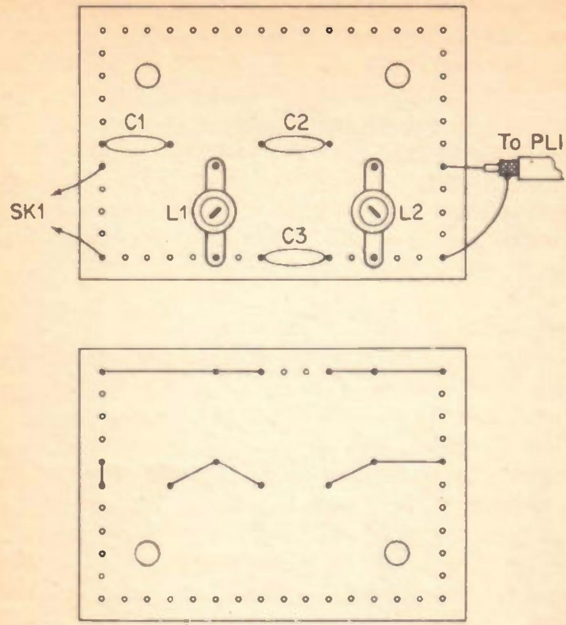


Fig. 14 Constructional details of the high pass aerial filter

frequencies will increase with each additional filter that is added, and this could become a problem if the aerial signal is fairly weak to start with. Also, one filter should provide sufficient attenuation at 27MHz to eliminate any interference caused as a result of the fundamental signal. If the filter is ineffective it is almost certain that the interference is being caused in some other way.

Components for High Pass Aerial Filter (Figure 13)

Capacitors

C1	8.2pf ceramic plate
C2	8.2pf ceramic plate

C3 8.2pf ceramic plate

Inductors

L1 4½ turn S18 coil with ferrite core (Ambit)

L2 4½ turn S18 coil with ferrite core

Miscellaneous

Plastic case

Plain 0.1in matrix perforated board

Coaxial socket (SK1)

Coaxial plug (PL1)

Coaxial cable

Wire, solder, etc.

HARMONIC FILTER

This is a conventional low pass filter which is connected in the aerial lead of the CB rig, and attenuates harmonics on the output of the transmitter. It can also be used if problems with VHF, TV or radio broadcast stations breaking through at the receiver section of the rig are causing problems, but it is primarily intended for use where harmonics from the transmitter are causing interference.

The Circuit

The circuit of the unit is quite straight forward, as can be seen from the circuit diagram of Figure 15. As was the case with the high pass filter described earlier, a simple passive filter is all that is required.

In principle this circuit operates in very much the same way as the high pass filter circuit of Figure 13, but the inductive and capacitive elements have been swopped over (and the two filters use slightly different configurations).

At relatively low frequencies (below about 35MHz) the three inductors (L1 to L3) provide only very small losses as they have a very low combined impedance. The two capacitors (C1 and C2) exhibit very high impedances, and therefore have no significant effect on the circuit. The input signal is therefore able to pass straight through the filter with no significant attenuation provided it is within this frequency range, and

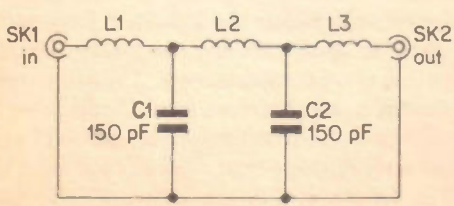


Fig. 15 The circuit diagram of the harmonic filter

this would obviously include the fundamental output of a 27MHz CB rig.

At higher frequencies the impedance provided by L1 to L3 steadily increases, giving significant and increasing losses through the filter. The impedance of C1 and C2 reduces as the signal frequency is increased, and this results in some of the input signal being leaked away to earth at frequencies above the passband. This increases the roll off rate of the filter considerably and therefore gives much greater attenuation of the unwanted harmonics. The filter provides in the region of 40dB of attenuation over the FM broadcast band (Band II), and around 60dB over the UHF TV band (i.e. a reduction in amplitude of about one thousand times over the UHF TV band).

Construction

The three coils are home-constructed from 16 swg tinned copper wire, or 16 swg enamelled copper wire can be used if the insulation is removed at the appropriate points to permit soldered connections to be made to the coils. All three coils are the same, and they consist of six turns of wire wound round a temporary coil former of about 10mm in diameter (the shank of a 10mm diameter twist drill is suitable). The turns are spaced roughly one wires thickness apart. They are left with leadout wires about 10mm long, and these are tinned with solder.

A major problem with filters of this type is the leakage of UHF signals around the filter, giving a very significant loss of performance. The standard method of minimising this problem, and the method used here, is to house the filter in a metal box with internal screens to isolate the inductors from each other. In this case there are three coils and two screens are therefore needed to give the three compartments. Unfortunately, ready made boxes having internal screens are difficult to obtain, and it will be necessary to construct your own case and screens, or fit screens into a ready made box. The screens must be made a very good fit in the case if they are to be fully effective. A small hole is drilled at the centre of each screen, and a small PVC grommet is fitted into each hole. The coaxial sockets are mounted at opposite ends of the case.

Figure 16 shows how the components are wired together. The holes in the screens permit the leads from the coils to pass through from one compartment to the next, and the grommets insulate the leadout wires from the screens. The earth connections are carried through the case incidentally. Keep the leadout wires of C1 and C2 as short as possible, or the performance of the unit may suffer significantly at UHF.

It may be found that the performance of the unit can be improved somewhat over the VHF band II by making C1 and C2 slightly higher in value, or by adding an extra turn or two onto each coil. However, there is little room for improvement here, and it is quite likely that any reduction in harmonics over the VHF band II will be accompanied by a reduction in the fundamental signal of the rig. This will be partially due to losses through the filter at the fundamental frequency, and partially due to the filter preventing an efficient transfer of the signal into the aerial. You should therefore keep a check on the performance of the system if the modifications to the filter are tried.

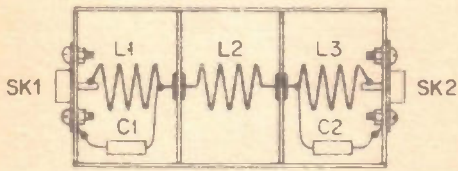


Fig. 16 Constructional details of the harmonic filter

Components for Harmonic Filter (Figure 15)

Capacitors

C1	150pF silver mica	C2	150pF silver mica

Inductors

See text

Miscellaneous

SK1	Coaxial socket	SK2	Coaxial socket

Metal case with two screens

16swg enamelled or tinned copper wire for coils
Two PVC grommets
Soldertags, solder, etc.

A field strength meter simply gives a relative indication of the strength of the signal radiated from the aerial of the transmitter. This is useful when making adjustments to a rig, when comparing the effectiveness of different types of aerial, when making adjustments to an aerial, or when mapping out the directional properties of an aerial.

The unit described here has good sensitivity so that it can be used easily with low powered rigs. It is also self contained so that it is easily portable.

The Circuit

Figure 17 shows the complete circuit diagram of the Field Strength Meter.

A telescopic aerial is used, and signals received by this are coupled to the main winding of T1 via a small coupling winding. The main winding of T1 forms the aerial tuned circuit in conjunction with C1 and VC1. The latter is the tuning control, and actually gives coverage of significantly more than the 27MHz citizens band. This excess of coverage ensures that adjustment of T1 is not critical, and the unit will probably cover the entire 27MHz citizens band regardless of the setting of T1's core.

The output of T1 is direct coupled to the input of Tr1 which is used as a common source RF amplifier. Due to the very high input impedance of Tr1 the coupling winding of T1 is not needed in this circuit, and the direct coupling of the tuned circuit to the input of T1 is quite acceptable. The main winding of T1 acts as the gate bias resistance for Tr1, and this stage is quite conventional in other respects.

C2 couples the output of Tr1 to a simple rectifier and smoothing circuit which produces a positive DC bias across R3 that is roughly proportional to the strength of the received signal. This signal will only be very weak if the unit is used with a low power rig or is some distance from the aerial, and additional amplification is needed in order to drive a moving coil meter.

This extra amplification is provided by IC1 which is an

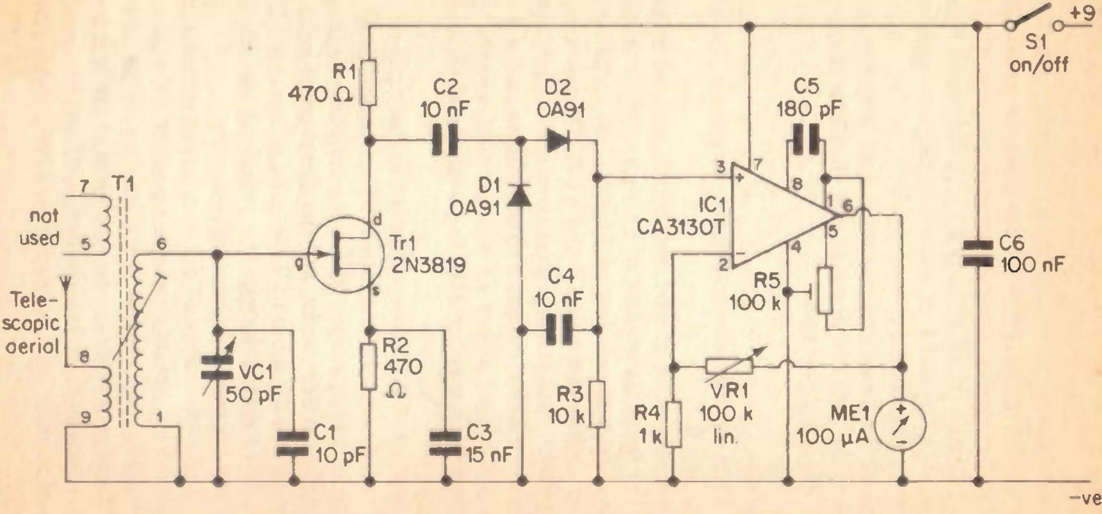


Fig. 17 The circuit diagram of the field strength meter

operational amplifier used in the non-inverting mode. The input signal is coupled direct to the non-inverting input, and a controlled amount of negative feedback is applied from the output to the inverting input by VR1 and R4. VR1 is the sensitivity control and this can be backed off if the unit is overloaded by a strong signal. Maximum resistance in VR1 corresponds to maximum sensitivity.

C5 is the compensation capacitor for IC1, and this prevents IC1 from becoming unstable. R5 is an offset null control, and this is used to compensate for deficiencies in IC1 which cause the output voltage to drift positive of the negative supply rail. By adjusting R5 it is possible to trim the output voltage down to the negative supply rail potential under quiescent conditions. This gives a reading of zero on ME1 which is driven direct from the output of IC1.

When an input signal is received a positive input bias is applied to the non-inverting input of IC1, and this gives an output voltage of up to about one hundred times the input level, depending on the setting of VR1. It is this substantial amount of DC amplification that gives the unit its high degree of sensitivity.

S1 is the on/off switch and C6 is a supply decoupling capacitor. The current consumption of the unit is only about 5mA, and a small (PP3)-size battery will provide many hours of operation.

Construction

The three controls and the meter are mounted on the front panel of the unit, and it is recommended that a metal case should be used for this project. If the meter is a standard 60 x 45mm plastic front type it will require a main mounting hole which is 38mm (1½in) in diameter. This can be cut using a coping saw, fretsaw, of miniature round file. It must be cut quite accurately or it will be found that either the meter cannot be fitted into place, or the cutout will encroach into the part of the panel where the four smaller mounting holes must be made. One way of achieving accurate results is to make the cutout slightly small and then carefully file it out to the right size using a large half round file. The four smaller holes are 3.3mm in diameter and their positions can be located by fitting the meter into the main cutout and using the meter as a sort of template.

T1 is mounted on the rear panel of the case and this has a threaded portion at one end of the former which enables it to be easily fixed to the case. T1 is supplied complete with a plastic fixing nut, but this should only be tightened by hand in order to ensure that it is not overtightened and the plastic threads consequently damaged.

While it is possible to solder direct to the pins of T1, this must be done quite speedily as the heat from the soldering iron will rapidly start to melt the plastic coil former. It is better to fit a B9A valveholder onto the pins of the coil and then make the connections to the valveholder.

Most of the other components are fitted onto a 0.1in matrix stripboard. Figure 18 gives details of this panel and the other wiring of the instrument. As can be seen from this, C1 is mounted on VC1 and is not fitted on the component panel.

Normal techniques are used to complete the component panel and point-to-point style wiring, but note that IC1 is a CMOS device and the normal MOS handling precautions must be taken in order to avoid static charges damaging the device. Leave IC1 in its protective packaging (which will probably be conductive foam around its leadout wires) until it is to be connected into circuit, and make it the last component to be soldered in place. Handle the device as little as possible and use a soldering iron with an earthed bit when connecting it (or disconnect the soldering iron from the mains when connecting it). There are only two breaks in the copper strips incidentally, so be careful not to omit these. The wiring to T1 and VC1 carries high frequency signals, and it is advisable to keep these leads as short as possible.

The method of mounting the telescopic aerial must be chosen to suit the particular type employed in the unit. Ideally the aerial should be a type which is about 1 metre or more in length, but a shorter type will work, albeit with reduced sensitivity.

Once the unit has been finished and checked for wiring errors, set R5 at a roughly midway setting and switch the unit on. If there is a positive deflection of the meter, adjust R5 just sufficiently to reduce the meter reading to zero. If there is

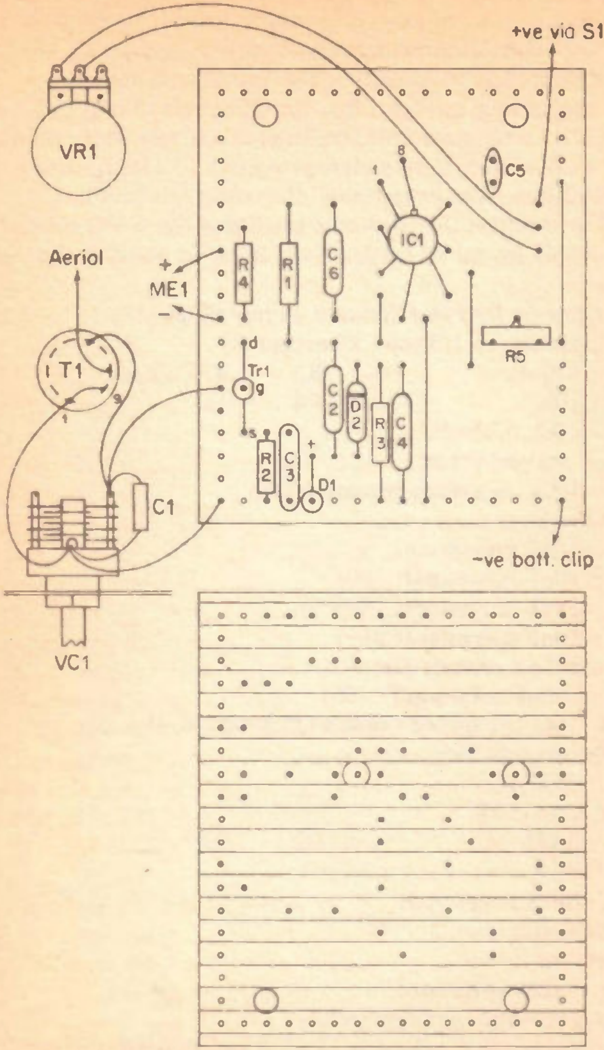


Fig. 18 Constructional details of the field strength meter

no deflection of the meter, adjust R5 to obtain a deflection and then back it off just far enough to reduce the meter reading to zero. This adjustment can be done most accurately if VR1 is set for maximum sensitivity (set fully clockwise).

In use it may be found that the unit tends to overload even with VR1 well backed off, although this is only likely to occur if the unit is used in very close proximity to a fairly strong transmission. The easiest way of avoiding this problem is simply to retract the telescopic aerial slightly, or the monitor can simply be moved further away from the aerial of the rig.

Components for Field Strength Meter (Figure 17)

Resistors, all 1/3 watt 5% except R5

R1	470 ohms	R2	470 ohms
R3	10k	R4	1k
R5	100k 0.1 watt vertical preset		
VR1	100k lin carbon potentiometer		

Capacitors

C1	10pF polystyrene
C2	10nF polyester (C280)
C3	15nF polyester (C280)
C4	10nF polyester (C280)
C5	180pF ceramic plate
C6	100nF polyester (C280)
VC1	50pF air spaced variable (Jackson C804)

Semiconductors

Tr1	2N3819		
IC1	CA3130T		
D1	0A91	D2	0A91

Switch

S1 SPST toggle type

Miscellaneous

Metal case
0.1in matrix stripboard
100μA moving coil meter (ME1)
Denco Blue aerial coil range 5T (T1) and B9A valveholder
Control knobs
Wire, solder, etc.

12 volt portable and mobile CB rigs are extremely popular and very reasonably priced. The usefulness of a rig of this type can be considerably enhanced by the addition of a mains power supply so that it can be used easily and economically for fixed station use when required. A suitable power supply can be built quite inexpensively and needs only a minimum of circuitry.

A suitable design is shown in the circuit diagram of Figure 19. This gives a maximum output current of 1 amp, and this is more than adequate for British CB specification equipment (bearing in mind the restrictions on output power imposed by this specification on both the 27MHz and 930MHz bands). The output is well stabilised and smoothed, and there should be no problems wlth mains hum during reception or transmission. The unit incorporates output current limiting and is therefore not damaged by accidental short term short circuits or other forms of output overloading.

The Circuit

It is essential for the supply to provide isolation from the mains supply for safety reasons, and mains transformer T1 is therefore used to provide this isolation and to step down the high voltage mains supply to a suitable level. S1 is the on/off switch and LP1 is the on/off indicator. Note that the latter must be a type which has an internal series resistor for use on the standard 240 volt mains supply, and can only be a simple neon bulb if a suitable external series resistor is used.

The twin secondary windings of T1 feed a straight forward push-pull rectifier and smoothing circuit which consists of D1, D2 and C1. These produce an output which has a reasonably low ripple content even at high load currents, but in order to be sure of obtaining no significant mains hum from the rig it is necessary to use further smoothing. It is also necessary to stabilise the output voltage at a suitable level since the potential across C1 varies considerably between zero and full load.

The additional smoothing and regulation is provided by IC1 which is a 12 volt monolithic voltage regulator. Although a 12

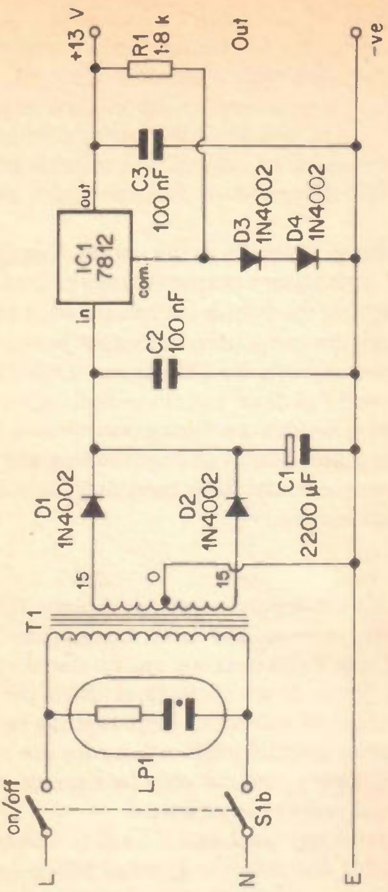


Fig. 19 The circuit diagram of the 12 volt power supply

volt car battery has a nominal potential of 12 volts, the actual output voltage of a battery of this type varies quite significantly, and is usually somewhat higher than the nominal figure. The output voltage of this supply has therefore been set at a little over 13 volts by the additional of D3 and D4 between the common terminal of IC1 and the negative supply rail. D3 and

D4 each act as a sort of low voltage zener diode having an avalanche voltage of approximately 0.6 volts, and these are biased by the current flowing in the common circuit of IC1. This raises the potentials at the common and output terminals of IC1 by about 1.2 volts (2 x 0.6 volts) giving an output potential of around 13.2 volts. Of course, if a straight forward 12 volt output is preferred for some reason it is merely necessary to replace D3 and D4 with shorting links, but better results are likely to be obtained using the circuit with the two diodes included.

C2 and C3 are included to avoid IC1 becoming unstable, and C3 also improves the transient response of the unit. R1 gives a small improvement in the regulation efficiency of the unit by giving a more consistent current through D3 and D4, and therefore producing a more stable voltage across these diodes.

Although the unit may not appear to have any form of output short circuit protection, it does in fact have this feature as it is incorporated in the internal circuitry of IC1.

Construction

The supply is built into any metal instrument case that can comfortably accommodate all the components. S1 and LP1 are mounted on the front panel while T1 is mounted at any convenient spot on the base panel. Fit a soldertag on one of the fixings for T1 to provide a chassis connection. An entrance hole for the mains lead should be drilled in the rear panel of the case, and it is advisable to fit this hole with a rubber grommet for the protection of the mains cable. A second hole can be drilled in the rear panel to provide an exit point for the output leads, and again it is recommended that this should be fitted with a grommet. If preferred, the output of the unit can be taken to suitable terminals or sockets fitted on the front or rear panel of the unit. Whether leads, terminals, or sockets are used, use different colours for each one so that the polarity of the output can be readily identified, and there is little danger of the output being connected to the rig with the wrong polarity.

A 0.1in matrix Veroboard having 21 copper strips by 20 holes is used to accommodate all the other components, and

Figure 20 provides details of this board and the wiring of the supply. There are no breaks in the copper strips on the underside of the board incidentally.

Normal constructional techniques are employed when producing the circuit board and wiring up the unit, and there should be no difficulties here. For reasons of safety make quite sure that the mains earth lead is reliably connected to the

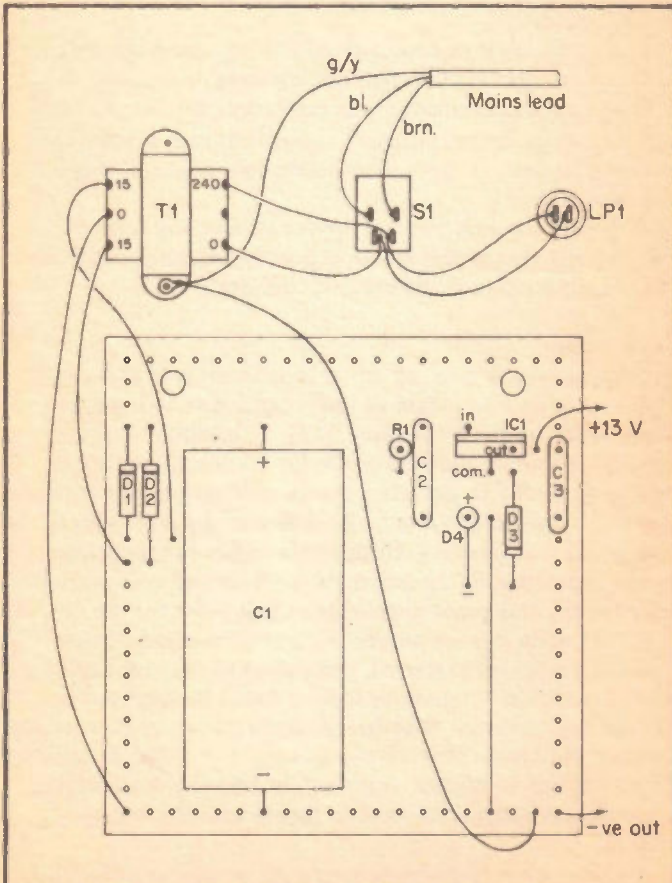


Fig. 20 Constructional details of the 12 volt power supply

soldertag fitted on T1, and that the lead from here to the negative supply rail of the component panel is not omitted.

Before switching on the finished unit it is a good idea to thoroughly check all the wiring a few times, and to check for accidental short circuits between adjacent copper strips of the component panel due to splashes of excess solder. If possible, check that the output voltage of the unit is approximately correct before connecting it to a rig.

Components for 12 Volt Power Supply (Figure 19)

Resistor, 1/3 watt 5%

R1 1.8k

Capacitors

C1 2200μF 25V electrolytic
C2 100nF polyester (C280)
C3 100nF polyester (C280)

Semiconductors

IC1 μA7812 (12 volt 1 amp positive regulator)
D1 to D4 1N4002 (4 off)

Switch

S1 DPST toggle type

Transformer

T1 Standard mains primary, 15 – 0 – 15 volt 2 amp secondary

Miscellaneous

Metal instrument case
0.1in matrix stripboard
Panel neon with integral resistor for 240 volt mains use (LP1)
Finned heatsink for IC1
Mains lead, fused plug (3A), wire, solder, etc.

CB RECEIVER

If you merely want to monitor the 27MHz FM citizens band and do not wish to transmit, the expense of a full CB rig is not really justified. On the other hand, there are not that many receivers that are capable of operation over the British 27MHz citizens band. There are a number of receivers which cover this band in part, a few that cover it in full (including expensive communications receivers), but few cover the whole band and are capable of narrow band FM (nbfm) reception, which is the only mode of operation permitted on the British 27MHz citizens band. Converters for use with an ordinary AM radio are of little use either since an ordinary medium wave broadcast receiver will only give crude nbfm reception.

The fairly simple and inexpensive receiver described here is intended as a CB monitor receiver, and is not designed to be used as part of a CB transceiver. It is tunable over the full British 27MHz citizens band, with continuous tuning rather than switched channels. It has good sensitivity and will give good results using a telescopic aerial, or a piece of aerial wire about 3 metres or so long can be used with slightly improved performance as a result. The unit has a proper nbfm demodulator and gives a low distortion audio output. It has an internal loudspeaker and 9 volt battery supply. It can be powered from the mains using an optional mains power supply unit.

Block Diagram

The circuit is of the superheterodyne type, as are all normal commercial radio receivers (both broadcast and communications types). At first a superheterodyne (or superhet as sets of this type are more commonly termed) may seem to be a little over complicated, but sets of this type do in fact enable a high level of performance to be attained without the cost and complexity of the circuit becoming exorbitant. The obvious arrangement for a radio receiver is to have a filter and amplifier at the input to select the desired transmission and amplify this signal, followed by a demodulator and audio amplifier to recover and amplify the original audio signal before feeding it to the loudspeaker.

There are a number of drawbacks with this system, one of which is simply that at fairly high frequencies (which includes the 27MHz citizens band) it is difficult to produce a tunable filter that will pick out the desired transmission and block other signals on nearby channels. It is also relatively difficult to obtain high sensitivity at fairly high frequencies. The superhet system overcomes both these problems so that good selectivity and sensitivity can both be attained. The way in which this is achieved is to have a receiver which operates at a fairly low and fixed frequency. With the operating frequency both fixed and comparitively low there is no problem in obtaining high gain and the narrow bandwidth needed to give good sensitivity and selectivity respectively. The circuitry at the input of the receiver picks out the desired transmission and alters its frequency so that it can be processed by the main receiver circuitry. The heterodyne principle is used to produce this change in frequency, and it is from this that the term "superheterodyne" or "superhet" is derived.

Figure 21 shows in block diagram form the arrangement used in this receiver. A preset filter at the input allows signals at frequencies within the limits of the 27MHz FM citizens band to pass through to the subsequent stage with little attenuation, but it provides increasing attenuation outside this band. The next stage in the unit is a mixer, and this has its second input fed with the output of a variable frequency oscillator (VFO). The VFO is tunable over a range which is 455kHz higher than the input frequency range. This produces a difference frequency at the output (i.e. the input frequency minus the VFO frequency) of 455kHz, due to the heterodyne action within the mixer.

This output frequency of 455kHz is known as the intermediate frequency or "IF" for short, and 455kHz is a standard intermediate frequency. At this frequency it is possible to readily obtain high gain, and there are a number of inexpensive IF filters and transformers that enable reasonable selectivity to be attained. Two stages of IF amplification are provided, the second stage being based on an integrated circuit which also provides demodulation. The selectivity is provided by two IF transformers and one ceramic filter. The AF amplifier uses a second integrated circuit and provides plenty of drive for a medium or high impedance loudspeaker.

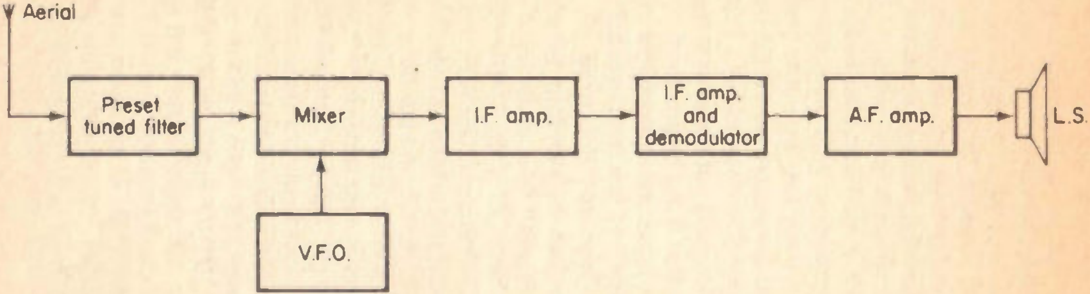


Fig. 21 Block diagram of the C.B receiver

IF and AF Circuits

Figure 22 shows the IF, Demodulator and Audio circuitry of the receiver. IFT1 provides the initial IF selectivity of the unit. There are output signals from the mixer other than the required IF signal, and it is therefore advisable to use filtering right at the input of the IF stages in order to remove the unwanted signals before they have an opportunity to cause any problems.

C1 couples the output of IFT1 to the base of Tr1. The latter is used as a conventional common emitter stage having a resistive load. This is quite acceptable at the frequencies involved here and this stage has reasonably good voltage gain. CF1 is a three terminal 455kHz ceramic filter type CFM2 (or similar) and this provides a frequency selective coupling from the output of Tr1 to the input of IC1.

IC1 is a TBA120S device, and this incorporates a limiting IF amplifier together with a quadrature type FM demodulator. It also has an audio buffer stage and DC volume control at its output. R3 is used to bias the input of the device and C2 plus C3 are decoupling components.

The quadrature detector is a very convenient type which requires just a single untapped tuned circuit. In this circuit the tuned winding of IFT2 is this tuned circuit, and the tapping and secondary winding of IFT2 are not used. C4 and C5 are also part of the quadrature detector circuit. Although the TBA120S is primarily intended for use as a wideband FM amplifier and detector operating at an IF of several megahertz, it works well as a narrow band FM demodulator at a relatively low IF. The reduced IF automatically reduces the bandwidth of the detector and increases its sensitivity so that good results with nbfm signals are obtained. R4 is used to damp the tuned circuit slightly as the bandwidth of the unit might otherwise be slightly too narrow.

VR1 is the only discrete component in the DC volume control circuit, and this gives maximum volume at maximum resistance, and minimum volume at minimum resistance.

As there are only two tuned circuits in the IF amplifier and demodulator circuitry alignment of this part of the receiver is quite straight forward and it is not essential to have any test gear in order to carry out this alignment.

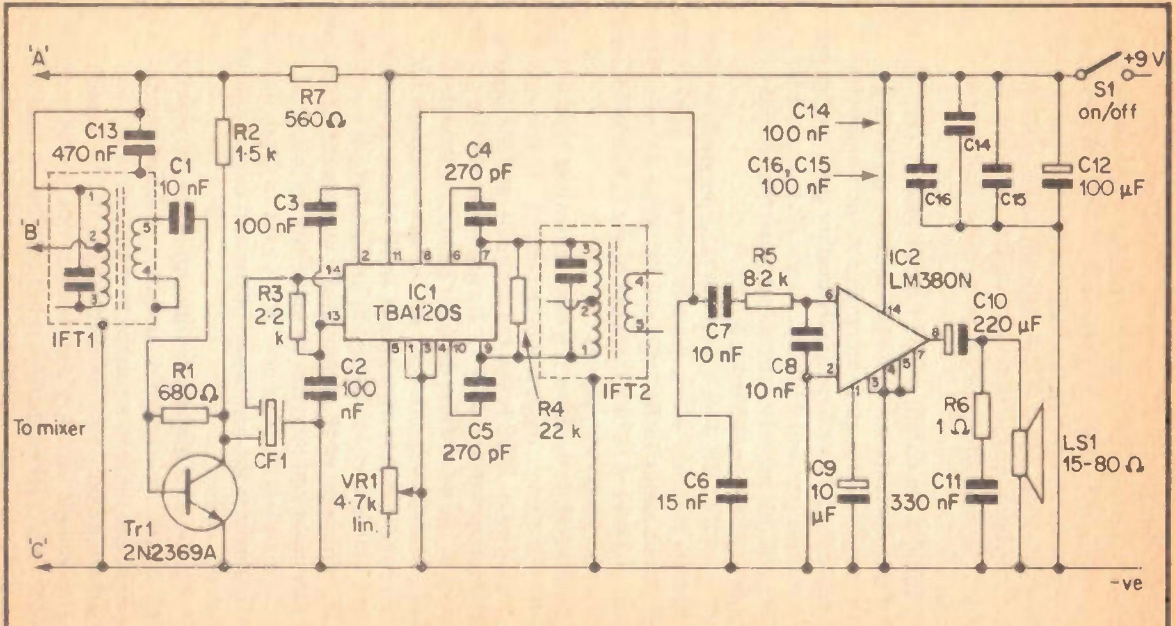


Fig. 22 The circuit diagram of the I.F. demodulator, and audio stages of the CB receiver

RF filtering is provided at the output of the demodulator circuitry by C6, R5 and C8 (C7 merely gives DC blocking). This filtering actually reduces the upper audio response of the circuit quite considerably as well, but this does not significantly effect the intelligibility of the output since these higher frequencies are not needed in order to give a comprehensible output. This rolling off of the upper audio response has the beneficial effect of giving a greatly improved signal to noise ratio. It also gives a high degree of attenuation at the 455kHz intermediate frequency so that there is little risk of any residual IF signal leaking into the audio output stage (which would almost certainly cause instability if it were allowed to occur).

The AF amplifier uses the well known LM380N device which gives low distortion, is quite inexpensive, and requires few discrete components. The audio signal is applied to the inverting input of the device, and the non-inverting input (pin 2) is connected to the earth line in order to avoid stray pick-up at this input (which could otherwise cause a reduced signal to noise ratio or instability). C9 decouples the supply to the preamplifier stage of IC2 and this helps to avoid instability due to feedback through the supply lines. C12 to C16 are all supply decoupling components. C10 is the output coupling capacitor and R6 plus C11 form a Zobel network which aids the stability of IC2. The output power of the circuit is around 100 to 200mW into a high impedance loudspeaker, and this gives adequate volume for normal use. However, a 15 or 16 ohm impedance speaker can be used if a higher output power and volume are required. Using a 15 or 16 ohm speaker gives an output power of up to about 400mW RMS.

Mixer and Oscillator

The circuit diagram of the mixer and oscillator stages of the receiver is shown in Figure 23. This is a quite conventional arrangement using a dual gate MOSFET (Tr2) as the mixer and a JFET device (Tr3) as the oscillator.

The main winding of T1 and C17 form the aerial tuned circuit which readily couples signals within the desired band through to Tr2, but attenuates other signals. T1 has an adjustable core which is used to peak the response of the

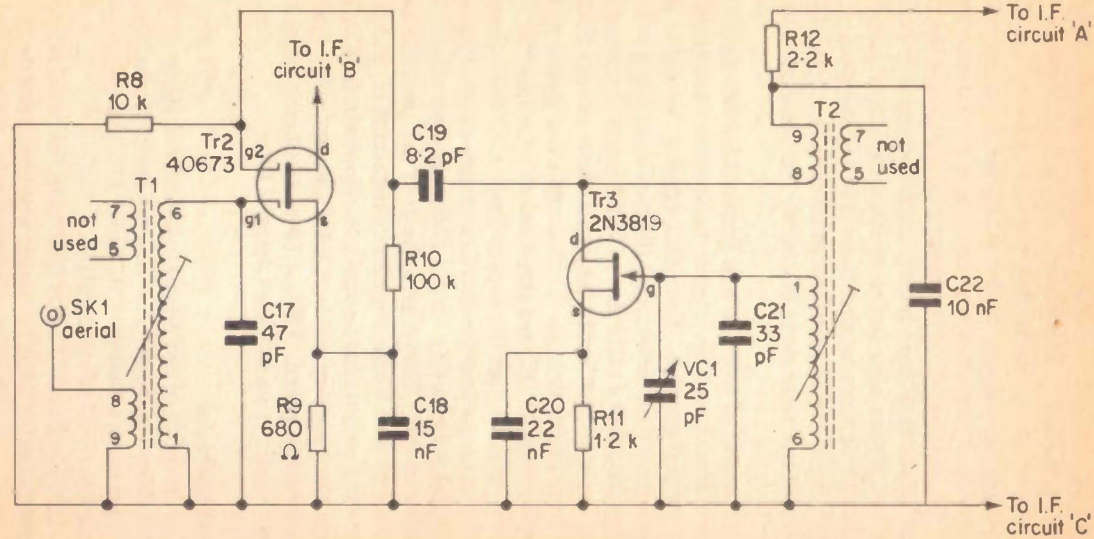


Fig. 23 The circuit diagram of the mixer and oscillator sections of the CB receiver

circuit at the centre of the 27MHz FM citizens band. A small coupling winding on T1 is used to introduce the aerial signal into the tuned circuit. There is a low impedance output coupling winding on T1, but this is only required if the transformer feeds into a bipolar stage. A MOSFET such as Tr2 has a very high input impedance and can be fed direct with the signal across the tuned circuit. The g1 terminal of Tr2 is biased to the negative supply through the main winding of T1.

R9 is the source bias resistor for Tr2 and C18 is the bypass capacitor for this component. Tr2's gate bias is provided from the source terminal via the potential divider formed by R8 and R10. This gives a small positive potential at the g2 terminal, and this is modulated by the oscillator signal which is coupled to the g2 terminal via C19. Varying the g2 potential varies the gain of Tr2 from its g1 terminal to the drain terminal, and it is the variations in gain caused by the oscillator signal that give the required heterodyne mixing action. The primary winding of IFT1 in the IF circuitry forms the drain load for Tr2.

The oscillator is a simple type using feedback via a tuned transformer (T2) to provide oscillation at the required frequency. The tuned circuit is formed by the main winding of T2, C21 and VC1; the latter being the tuning control for the oscillator (and the receiver as a whole, of course). The main winding of T2 biases the gate of Tr3.

A small winding on T2 acts as the drain load for Tr3 and couples its output into the tuned winding. There is a third winding on T2, but it is not required in the circuit and is left unconnected. Note that the coil specified for the T2 position is not really intended for use as an oscillator coil, and is in fact identical to the component used in the T1 position. Results were found to be very poor using the correct oscillator coil in the T2 position (the Denco Red coil range 5T) with breakthrough from short wave broadcast stations. This was caused by the oscillator running at half the required frequency, with the second harmonic of this signal being used as the oscillator signal. The simple input filtering of this circuit coupled with the fact that the fundamental oscillator signal was far stronger than the second harmonic led to the problems with breakthrough. Using an aerial coil in the T2 position gives a fundamental oscillator signal of the right frequency, and completely eliminates the breakthrough problem.

Construction

The circuitry can be readily accommodated in a case having dimensions of around 180 x 150 x 75mm or larger. A metal case should be used so that the IF circuitry is screened and there is no breakthrough of signals at the intermediate frequency. A metal case also helps to minimise radiation of the oscillator signal.

VC1 is mounted on the left hand side of the front panel with VR1 near the centre and LS1 on the right hand side of the panel. LS1 must be fitted behind a speaker grille, and this can simply consist of a neat matrix of small holes. Very few miniature speakers have mounting holes, and it will probably be necessary to glue LS1 in place using a good quality adhesive such as an epoxy type. Only apply a small amount of adhesive to the front rim of the speaker so that no adhesive is smeared onto the diaphragm.

SK1 is mounted on the rear panel of the case, but this can be omitted if the unit is to have a telescopic aerial and will never be used with an external antenna. If a telescopic aerial is fitted to the unit this is either wired to SK1 or connected in place of SK1 if the latter is omitted. The method of mounting the aerial must be varied to suit the particular type used, but make sure it is properly insulated from the case or the signals picked up by the aerial will be lost straight to earth.

T1 and T2 are mounted in B9A valveholders which are in turn mounted on the base panel of the case, on the left hand side of the unit, on a L shaped aluminium bracket. A soldertag is fitted onto one of the M3 or 6BA mounting bolts of each coilholder. The coil assembly is mounted with the coilholder pins facing and fairly close to VC1, but leave sufficient working space so that it is possible to fit components onto the tags of the coilholders.

The mixer and oscillator circuitry is wired up point-to-point style, as shown in the wiring diagram of Figure 24. Note that a number of the earth connections (such as the one to VC1) are carried through the metal case and the coil mounting bracket. The wiring is all reasonably simple and straight forward, but try to keep all leads as short as possible in the interests of obtaining

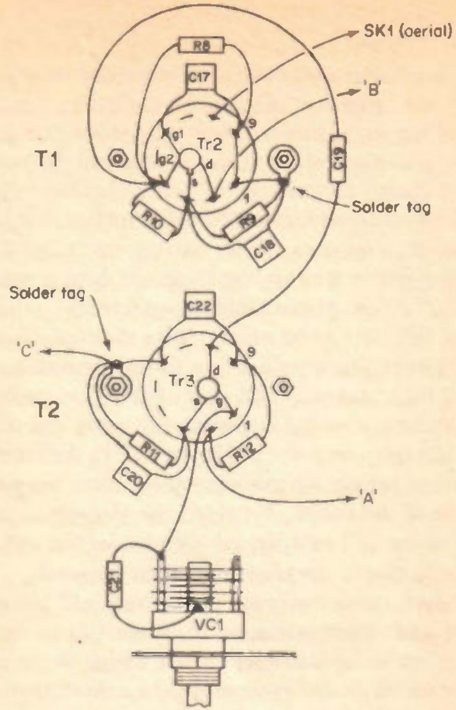


Fig. 24 The point to point wiring of the mixer and oscillator

good efficiency and stability. Tr2 is a MOSFET device, but it has internal protection diodes which make special anti-static handling precautions unnecessary, and it will probably not be supplied with a shorting clip on its leads (although a few devices do have this clip, and if fitted it must be removed prior to switching on the finished receiver). With this method of construction it is advisable to trim the leadout wires to length and generously tin them with solder before trying to solder them in place. It is also advisable to tin all the tags with solder prior to soldering the components into circuit. It should then be found that good strong soldered joints can be produced with no difficulty.

Component Panel

Most of the other components are wired up on a plain 0.1 in matrix board. Figure 25 shows the component layout for this board and the underside wiring is illustrated in Figure 26. While completing a board of this type is not quite as easy as building a circuit on the type of board that has copper strips, few difficulties should arise provided the board is constructed in a methodical manner. After cutting the board down to size and making the two mounting holes, fit double sided Veropins in the board at the places where connections to the pins of IFT1 and IFT2 are to be made. Note that only four pins of IFT1 are used (plus a connection to the screening can via one mounting lug), and only two pins of IFT2 are connected (again plus a connection to the screening can using one of the mounting lugs as a connection point). The two IFTs are then mounted on the board simply by soldering them onto the pins on the upper side of the board. Provided the Veropins and the pins and lugs of the IFTs are tinned with solder beforehand, this should be perfectly simple and straight forward.

The other components are then fitted into place, one at a time, and soldered together on the underside of the board in the appropriate fashion, keeping the wiring as close to the underside of the board as possible. In a number of cases it will be found that the leadout wires of the components are not long enough to complete all the wiring, and bridging leads made from about 22swg tinned copper wire can be used to fill any gaps in the wiring.

Note that C14 to C16 are fitted on the underside of the board once the other wiring has been completed, and these should be fitted between the exact positions shown in Figure 26 if they are to be fully effective. If they are omitted or wired between the positive and negative supply rails at the wrong points it is quite likely that instability will occur at higher gain settings of VR1.

Wire the completed board to the rest of the receiver before finally fitting it in place on the right hand side of the case. Keep all this point-to-point wiring as short as reasonably possible. Use spacers over the mounting bolts for the panel to keep the wiring on the underside of the component board well clear of the metal case.

Resistor R6 and Capacitor C11 are mounted and wired across the loudspeaker. As the current consumption of the receiver is typically about 20mA, and rises somewhat at high volume levels, it is advisable to use a PP6 or larger size battery to power the unit. However, make sure you use a case of adequate dimensions if you intend to use a larger battery such as a PP9 size.

Adjustment

Assuming suitable test gear to aid the alignment of the receiver is not available, IFT1 and IFT2 can simply be adjusted to peak the noise output of the receiver. CF1 is pretuned, and does not need any adjustment (there is, in fact, no way of tuning a ceramic filter). If the set is functioning properly it should be found that quite a high noise level is obtained when IFT1 and IFT2 have been peaked, and this high quiescent noise level is quite normal with FM receivers.

T2 is given the correct setting by trial and error. This is a matter of adjusting the core of T2 and varying the setting of VC1 in search of 27MHz FM citizens band transmissions. It is then a matter of finding a setting for the core of T2 that brings received CB transmissions to around the centre of the tuning range of VC1. As VC1 gives coverage of slightly more than the full 27MHz FM citizens band the unit should then cover the whole band even if the core of T2 is not set absolutely perfectly.

The core of T1 is adjusted to give optimum sensitivity with the set tuned to a station at roughly the centre of the tuning range. This adjustment can be made most easily on a fairly weak station which will be accompanied by a fair amount of noise. T1 is then adjusted for minimum noise (not maximum volume, since the limiting action of the IF amplifier in IC1 plus the way in which an FM detector works gives very little change in volume even if the input signal is varied in strength by a considerable amount). It is likely that changes in the setting of T1's core will slightly effect the tuning of the receiver, and it will be necessary to compensate for this by adjusting VC1 slightly.

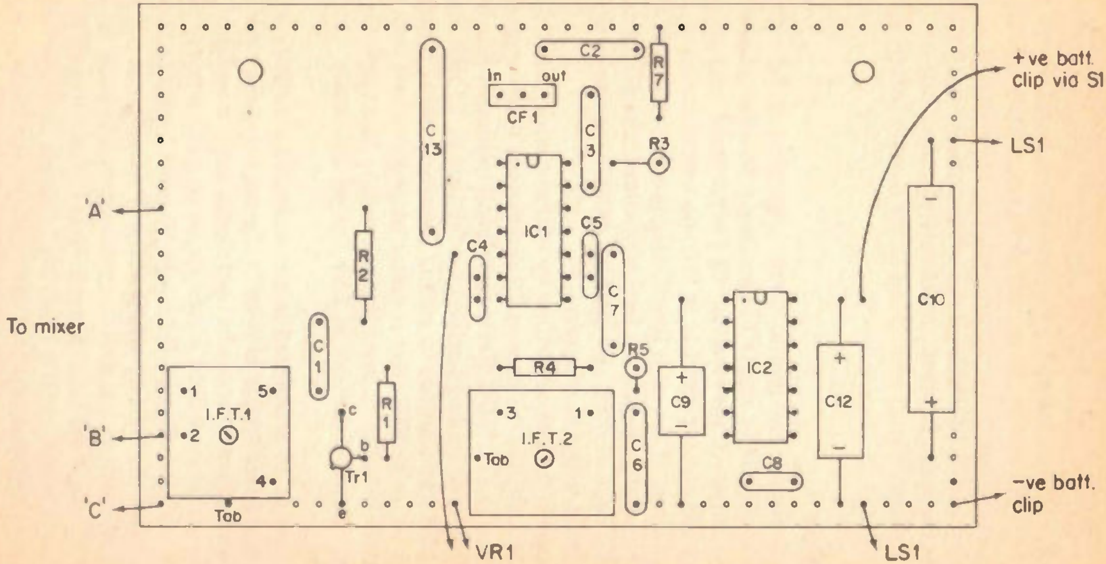


Fig. 25 Constructional details of the I.F./A.F. panel

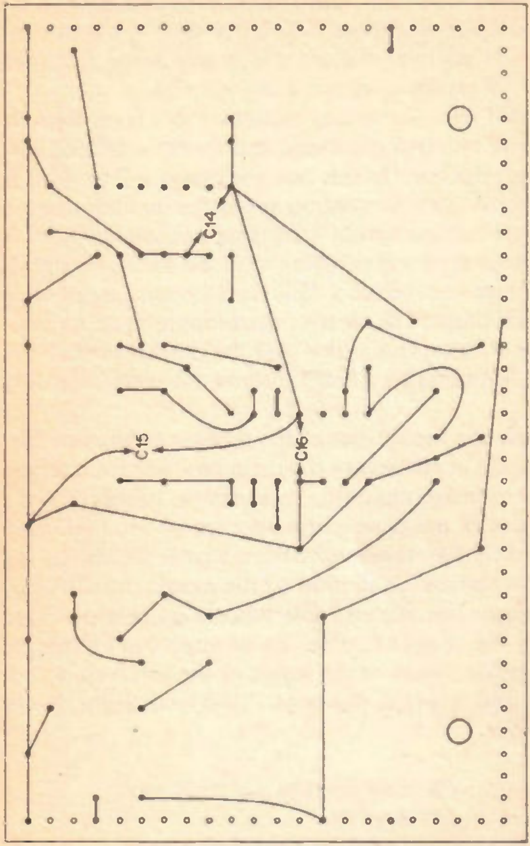


Fig. 26 The underside wiring of the A.F./I.F. panel

If the set is used with an external aerial, this can simply consist of about 3 metres or so of aerial wire strung around the room. If a proper outdoor aerial is available this can be used and will give somewhat better results, although it is quite likely that a fairly simple aerial will enable a good many transmissions to be received. Of course, the 27MHz FM citizens band is only suitable for communications over fairly short distances, and the number of stations received will largely depend on the number of CB stations operating in your area.

As pointed out in an earlier section of this book, superhet receivers have spurious responses, and the most serious of these is the image response. In this case the image will be 455kHz (i.e. the intermediate frequency) above the oscillator frequency. This happens because signals 455kHz either side of the oscillator frequency will combine with the oscillator signal in the mixer stage to produce a 455kHz difference signal which is fed to the IF stage. The receiver therefore receives on two frequencies at once, and in this case the spurious image response is 910kHz (2 x 455kHz) above the main reception frequency.

Of course, the input filter of the receiver attenuates the image response in relation to the main one, but it far from eliminates the image response. In a receiver of this type a limited degree of image rejection may not be too important as it is quite likely that there will be few signals within the range of the image response, and most of the signals that do occur at these frequencies will probably be only quite weak. However, if necessary the image rejection can be improved by using an additional tuned circuit at the input, or the aerial amplifier design featured earlier in this book could be added at the input of the receiver.

Components for CB Receiver (Figures 22 & 23)

Resistors, all 1/3 watt 5%

R1	680k	R2	1.5k
R3	2.2k	R4	22k
R5	8.2k	R6	1 ohm
R7	560 ohms	R8	10k
R9	680 ohms	R10	100k
R11	1.2k	R12	2.2k

VR1	4.7k lin carbon with switch (S1)

Capacitors

C1	10nF ceramic plate
C2	100nF polyester (C280)
C3	100nF polyester (C280)
C4	270pF ceramic plate
C5	270pF ceramic plate
C6	15nF ceramic plate
C7	10nF ceramic plate
C8	10nF ceramic plate
C9	10μF 25V electrolytic
C10	220μF 10V electrolytic
C11	330nF polyester (C280)
C12	100μF 10V electrolytic
C13	470nF polyester (C280)
C14	100nF polyester (C280)
C15	100nF polyester (C280)
C16	100nF polyester (C280)
C17	47pF polystyrene or mica
C18	15nF ceramic plate
C19	8.2pF polystyrene, ceramic, or mica
C20	22nF ceramic plate
C21	33pF polystyrene or mica
C22	10nF ceramic plate
VC1	25pF air spaced (Jackson C804)

Semiconductors

Tr1	2N2369A	Tr2	40673
Tr3	2N3819		
IC1	TBA120S or SN76660N		
IC2	LM380N		

Inductors

T1	Denco blue aerial coil for transistor usage, range 5T
T2	Denco blue aerial coil for transistor usage, range 5T
IFT1	Denco IFT13/470kHz
IFT2	Denco IFT14/470kHz
CF1	455kHz ceramic filter type CFM2 (Ambit) or similar

Miscellaneous

Metal case

Plain 0.1in matrix board

Miniature high or medium impedance loudspeaker

9 volt battery and connector to suit
Aerial socket and (or) telescopic aerial
Two B9A valveholders (used as coilholders)
Control knobs
Veropins, wire, solder, soldertags, etc.

If the CB receiver described in the previous section of this book is required only for use at home and will not be used as a portable receiver, a mains power supply is preferable to battery operation as it gives far lower running costs in the medium and long term. It is an easy matter to build a mains power supply into the unit provided a case of adequate dimensions is used for the receiver (a case measuring around 220 x 150 x 75mm should give more than adequate space for all the components including the mains power supply).

This mains power supply circuit is quite simple and inexpensive, but it gives good regulation and has a very well smoothed output that ensures an insignificant level of mains hum is present on the output of the receiver.

The Circuit

Figure 27 shows the complete circuit diagram of the power supply unit.

S1 is the on/off switch, and it is advisable to use a separate component here rather than a switch ganged with the volume control of the receiver. T1 is the isolation and step-down transformer, and this has the output of its centre tapped secondary winding full wave rectified by D1 and D2 which form a straight forward push-pull rectifier circuit. The pulsating DC output of D1 and D2 is smoothed by C1.

As the loading of the supply is likely to vary quite considerably in use, the output voltage of the supply will also vary substantially unless a voltage regulation circuit is used. Apart from eliminating these substantial fluctuations in voltage, a regulator also provides electronic smoothing of the supply so that a very low ripple content is evident at the output.

The regulation in this circuit is provided by IC1 which is a small (100mA maximum) 5 volt monolithic voltage regulator. A 5 volt type is used merely because a 9 volt type is not readily available. Of course, it is necessary to use the device in a configuration that provides the necessary increase in output potential so that the required 9 volts (nominal) is obtained. This increase in output is produced in a manner which is

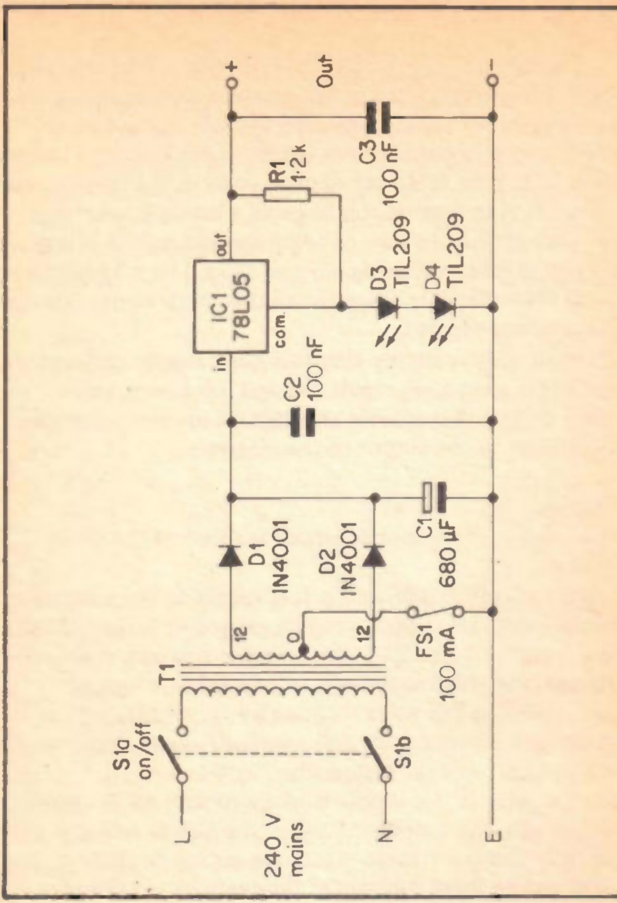


Fig. 27 The circuit diagram of the power supply for the CB receiver

basically the same as that employed in the 12 volt power supply which was described earlier in this publication. However, a much larger boost in output voltage is required in this case, and two LEDs connected in series are used in the common terminal of the regulator rather than two ordinary silicon diodes or rectifiers. LEDs have a forward threshold voltage of about 1.8 to 2 volts instead of the 0.5 to 0.65 volts of ordinary silicon diodes. This gives a boost in output voltage of about

3.6 to 4 volts, giving an actual output potential of around 8.6 to 9 volts. The output voltage of a 9 volt battery actually varies from about 9.5 volts when new down to about 7.5 volts when nearing exhaustion, and so an output voltage of around 8.6 to 9 volts is perfectly acceptable. D3 is used as the on/off indicator as well as acting as part of the voltage booster circuit. R1 is included to increase the bias current through D3 and D4 so that D3 has adequate brightness to act as the on/off indicator. C2 and C3 are supply decoupling components that aid the stability of IC1 and improve the transient response of the supply.

Although the 78L05 device has built-in current limiting circuitry, as its output voltage is boosted by such a large amount in this circuit the current limiting becomes ineffective. However, as the supply is intended to be an integral part of a radio receiver it is unlikely that a short circuit or other overload will occur at the output, and as FS1 provides protection against short circuits and overloads anyway, this is unimportant.

Construction

By using a larger case for the receiver sufficient space for the power supply components is made on the right hand portion of the case. The front panel must be drilled to take S1 and the panel holder for D3 in addition to the other front panel mounted components of the main receiver circuitry. T1 is mounted on the base panel of the case towards the front and as far to the right as possible so that it is well separated from the other circuitry. A soldertag is fitted on one of the mounting bolts of T1 in order to provide a chassis connection point. The fuseholder for FS1 is mounted just to the left of T1. An entrance hole for the mains lead is drilled in the rear panel of the case adjacent to S1, and this hole should be fitted with a PVC grommet to protect the mains cable.

The remaining power supply components are assembled on a 0.1in matrix Veroboard which has 16 copper strips by 17 holes. This is illustrated in Figure 28 which also shows all the wiring of the supply. No breaks are required in the copper strips on the underside of the board incidentally.

Construction of the supply should not give any problems, but for reasons of safety it is essential to use a three core mains

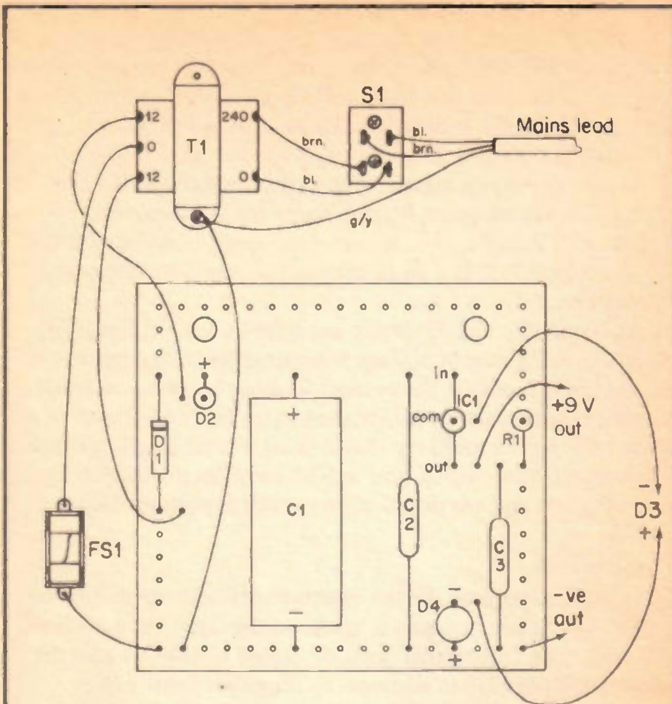


Fig. 28 Constructional details of the power supply for CB receiver

lead and connect the earth lead to the chassis of the receiver (via the soldertag fitted on T1). If possible, check that the output voltage of the completed supply is approximately correct before connecting it to the main receiver circuitry and testing it in practice.

Components for Receiver Power Supply (Figure 27)

Resistor, 1/3 watt 5%

R1 1.2k

Capacitors

C1 680μF 25V electrolytic

C2 100nF polyester (C280)

C3	100nF polyester (C280)		
	Semiconductors		
IC1	μA78L05 (5 volt 100mA positive regulator)		
D1	1N4001	D2	1N4001
D3	TIL209	D4	TIL209
	Transformer		
T1	Standard mains primary, 12 – 0 – 12 volt 100mA secondary		
	Switch		
S1	DPST toggle switch		
	Miscellaneous		

0.1in matrix stripboard
20mm chassis mounting fuseholder and 100mA fuse to suit
Panel holder for D3
Mains lead, mains plug, wire, solder, etc.

Hand-held rigs are very popular, but have one major drawback in that they mostly run from a number of ordinary dry cells (usually the HP7 type) and the fairly high current consumption of the transmitter gives only a quite short operating life per set of batteries. Since it is quite common for about eight batteries to be used to power rigs of this type, a set of replacement batteries can be quite costly. This can make hand-held rigs very expensive to run unless they are used only sparingly.

A more practical way of powering a hand-held rig is to use a set of NiCad rechargeable cells. These are relatively expensive to buy initially, but the cost of recharging them is too small to be of any consequence, and the NiCad cells would normally be expected to have an operating life equal to that of the rig. Thus the use of NiCad cells gives low running costs in the long term and does not effect the portability of the rig in any way.

Recharging about eight NiCad cells can be something of a problem as many commercial chargers and home constructor designs will not charge this many at once. This means either recharging the cells in two batches (which is rather slow) or using two chargers (which is rather expensive). The simple NiCad charger described here is capable of recharging up to ten cells at a time, and it can be built quite cheaply. It has a nominal charge current of 50mA which is ideal for AA size cells, and can be used to recharge C size cells if the charge time is suitably lengthened. The charge time with AA cells is about 14 to 16 hours.

The Circuit

Figure 29 gives the full circuit diagram of the NiCad charger.

T1 is the isolation and step-down transformer, and its output is given full wave rectification by the push-pull rectifier formed by D1 and D2. C1 smooths the output of the rectifier circuit. No on/off switch is fitted to the unit as it will presumably be unplugged from the mains when it is not being used, although an on/off switch could of course easily be added if desired.

NiCad cells have an extremely low internal resistance, and

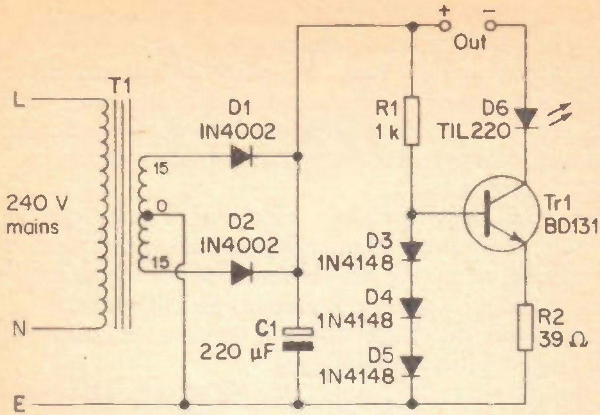


Fig. 29 The circuit diagram of the NiCad charger

therefore present virtually a short circuit to the charger circuit provided the latter gives an output potential which is higher than that of the cells. Coupled with the fact that NiCads must be charged at a current which is no more than a certain level (which is usually quite low), this makes it essential to incorporate a current limiting circuit of some kind in the charger to ensure that an excess charge current is not allowed to flow.

In this circuit a simple and conventional constant current generator circuit based on Tr1 is used to set the output current at the required level. R1 plus D3 to D5 are used to bias the base of Tr1 about 2.5 volts or so positive. This is somewhat higher than the voltage one would normally expect to find across a series of three forward biased silicon diodes, and this is due to the fairly high bias current flowing through this circuit. There is a voltage crop of about 0.6 volts or so across the base-emitter junction of Tr1 so that a little under 2 volts appears across emitter resistor R2. This gives a current of about 50mA through R2, and since the emitter and collector currents of a transistor are virtually the same, there will be a current flow of about 50mA at the output provided a circuit having a suitably low impedance is connected here. The NiCad batteries (provided no more than ten are used) provide a suitably low load impedance and are therefore charged with the appropriate current of 50mA. Not all NiCad manufacturers stipulate a maximum charge current equal to the figure quoted above, and there are minor variations from one manufacturer to another. However, a charge current of 50mA should be suitable for any AA cell.

D6 is a LED indicator which is included in series with the output for two reasons. One is simply to act as an indicator to show whether or not the NiCads have been connected properly and are charging. Secondly, it prevents the NiCads from discharging into the charger circuit if they are left connected to the charger when it is unplugged.

If the unit is used to charge C size NiCad cells it is advisable to reduce R2 to about 18 ohms in value. This increases the charge current to a little over 100mA and gives a full recharge time of around 24 hours (an excessively long recharge time of about 48 hours is obtained if this modification is not made). Ordinary AA NiCad cells should not be charged from the unit if R2 is reduced to 18 ohms, although the fast charge (AAF) type can be charged safely from the unit if this modification is made (the full recharge time then being only about 7 hours).

If the circuit is modified for increased output current D6 must be replaced with a shorting link as the current flow would be sufficient to damage this device. Alternatively, if the output indicator feature is still desired, three TIL220 LEDs wired in parallel should be satisfactory as the output indicator. The output current will be shared roughly evenly between each LED and no single LED should be fed with an excessive current. Note though, that the LEDs must be large types, they must all be of the same type, and they must all be the same colour (LEDs of different colours or types would have different forward threshold voltages and would draw far from equal currents).

Even if the standard (50mA) version of the circuit is used, D6 must still be a large (0.2in) LED as smaller types could be damaged by a current of 50mA.

Construction

The charger can be housed in all but the smallest of metal boxes or instrument cases. D6 is mounted on the front panel and an exit hole for the output lead is also made here. The rear panel of the case is drilled to make an entrance hole for the mains lead, and both this and the exit hole in the front panel should be fitted with a PVC grommet. The mains transformer is mounted on the base panel of the case on one side of the unit, leaving sufficient space for the component panel to fit on the base panel on the opposite side of the unit. A soldertag is fitted on one of the mounting bolts of T1. Note that for reasons of safety the unit should be housed in a case that has a screw-on lid, and not in a case having a lid or cover that can simply be unclipped (so that dangerous mains connectioı would be exposed).

Figure 30 gives details of the component panel and wiring of the unit. The 0.1in matrix Veroboard has 10 holes by 14 copper strips and there are no breaks needed in any of the strips. Construction of the unit is very straight forward and there should not really be any problems here. However, check the wiring very carefully before switching the unit on as an error could easily result in damage to certain components. It would also be a good idea to check for accidental short circuits between adjacent copper strips due to minute blobs of excess solder before trying the unit out. Again, expensive damage could be caused to the unit if such short circuits are not corrected prior to switch-on.

The cells to be charged must be connected in series (i.e. in a chain with the batteries connected positive to negative to positive to negative to positive etc.) and not in parallel (i.e. not all the positives connected together and all the negative terminals connected together). A convenient way of connecting the cells together correctly is to fit them in the plastic battery holders that are available for various sizes and numbers of cells. You may well wish to charge more cells than can be accommodated in a single holder, and it will then be necessary to use two holders connected in series. Holders for odd numbers of cells are not available, but it is possible to obtain a "dummy" cell which can be used to short circuit what would otherwise be an unoccupied section of a holder (or a shorting lead could be

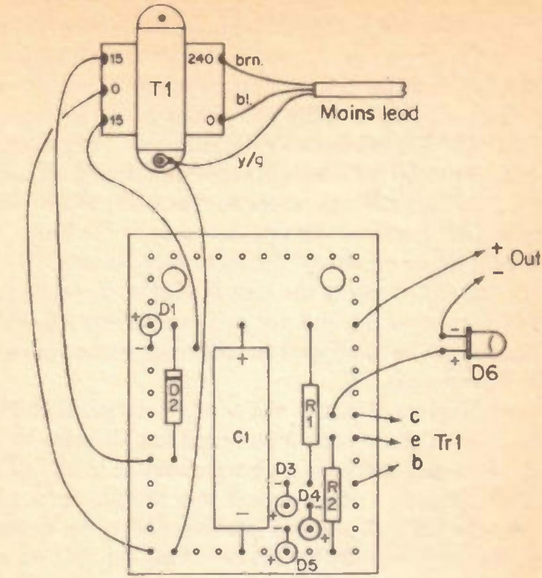


Fig. 30 Constructional details of the NiCad charger

added across the unused section of a holder). The connections to the holders are made via PP3 type battery connectors, and so there should be no problems here.

Components for NiCad Charger (Figure 29)

Resistors			
R1	1k ½ watt 5%	R2	39 ohms ½ watt 5%
Capacitor			
C1	220μF 25V electrolytic		
Semiconductors			
Tr1	BD131		
D1	1N4002	D2	1N4002
D3	1N4148	D4	1N4148
D5	1N4148	D6	TIL220

Transformer

T1 Standard mains primary, 15 – 0 – 15 volt 200mA secondary (or twin 15 volt 200mA windings connected in series)

Miscellaneous

Case

0.1in matrix stripboard panel

Output connector and battery holder(s)

Holder for D6, mains lead, mains plug, wire, solder, etc.

CB REGULATIONS

It is only legal to use citizens band rigs in the UK if the operator has the appropriate licence (which can be obtained by paying the appropriate fee, and no examinations have to be passed first). It is also necessary for the rig to be type approved, and equipment which has this approval has the appropriate mark stamped or engraved on the front panel. This mark consists of a circle with either CB 27/81 or CB 934/81 marked at the centre. Type approval ensures that the equipment complies to a very tight technical specification which minimises the risk of the equipment causing interference to other radio users. It is a condition of the licence that the equipment is maintained to this specification incidentally.

27MHz Band

There are 40 permitted channels in the 27MHz citizens band, and the frequencies of these are as follows:-

Channel	*Frequency*	*Channel*	*Frequency*
1	27.60125MHz	2	27.61125MHz
3	27.62125MHz	4	27.63125MHz
5	27.64125MHz	6	27.65125MHz
7	27.66125MHz	8	27.67125MHz
9	27.68125MHz	10	27.69125MHz
11	27.70125MHz	12	27.71125MHz
13	27.72125MHz	14	27.73125MHz
15	27.74125MHz	16	27.75125MHz
17	27.76125MHz	18	27.77125MHz
19	27.78125MHz	20	27.79125MHz
21	27.80125MHz	22	27.81125MHz
23	27.82125MHz	24	27.83125MHz
25	27.84125MHz	26	27.85125MHz
27	27.86125MHz	28	27.87125MHz
29	27.88125MHz	30	27.89125MHz
31	27.90125MHz	32	27.91125MHz
33	27.92125MHz	34	27.93125MHz
35	27.94125MHz	36	27.95125MHz
37	27.96125MHz	38	27.97125MHz
39	27.98125MHz	40	27.99125MHz

As will be apparent from the above table, 10kHz channel spacing is used on this band.

The maximum output power on this band is 4 watts, and with the antenna permitted under the licence conditions this gives a maximum effective radiated power of 2 watts. The permitted antenna is a single element rod or wire which can be no longer than 1.5 metres. If this is mounted at a height of more than 7 metres the transmitter power must be reduced by 10dB, and equipment manufacturers must either equip rigs with a built-in attenuator to give this reduction if required, or a suitable attenuator must be available as an optional extra. Angle modulation is the only form of modulation permitted on this band.

934MHz Band

There are just 20 permitted channels on the 934MHz citizens band, and the channel spacing is 50kHz. The frequencies of these channels are as follows:-

Channel	*Frequency*	*Channel*	*Frequency*
1	934.025MHz	2	934.075MHz
3	934.125MHz	4	934.175MHz
5	934.225MHz	6	934.275MHz
7	934.325MHz	8	934.375MHz
9	934.425MHz	10	934.475MHz
11	934.525MHz	12	934.575MHz
13	934.625MHz	14	934.675MHz
15	934.725MHz	16	934.775MHz
17	934.825MHz	18	934.875MHz
19	934.925MHz	20	934.975MHz

The maximum output power on this band is 8 watts provided an external antenna is used. The antenna can have a maximum of four elements and none of these must be more than 170mm in length. This gives a maximum effective radiated power of 25 watts. If the antenna is mounted at a height of 10 metres or more it is necessary to reduce the output power by 10dB, and like the 27MHz citizens band, equipment manufacturers must make provision for this reduction either in the form of a built-in attenuator or an add-on unit. Rigs having a built-in antenna have a maximum permitted effective radiated power of just 3 watts.

Like the 27MHz citizens band, the only permitted form of modulation is angle modulation, and equipment will only be type approved if no provision for other types of modulation is made.

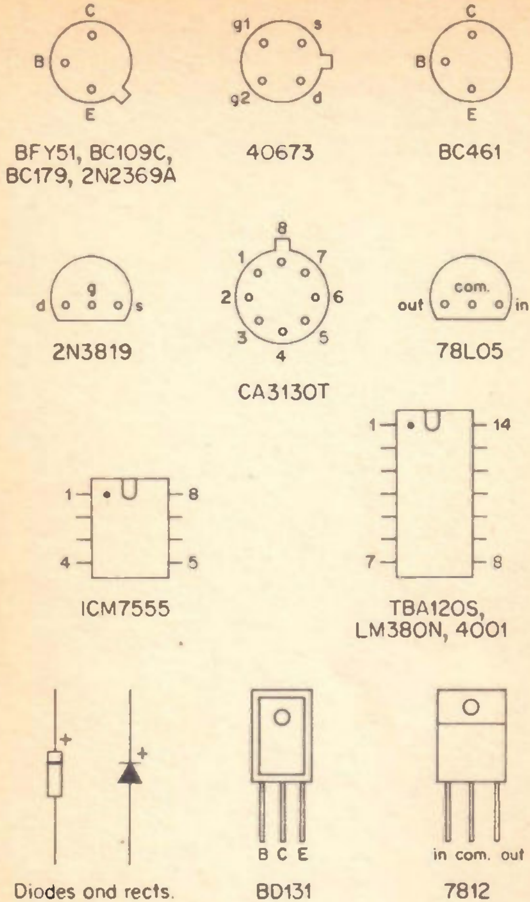


Fig. 31 Semiconductor leadouts and pinouts (transistor base views, IC top views)

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