

Under Section 7 of the '67 Act (manufacture, sale, possession, not importing) the penalty is a max. fine of £2000, when such 'Restriction Orders' are in force (see above).

Under Section 5a of the 49 Act (as amended by schedule s75 of the 84 Act) you can get a max £2,000 or 6 months prison or both for 'sending false or misleading messages by means of wireless telegraphy, which are likely to affect any safety of life service or endanger the safety of any person or of any vessel, aircraft or vehicle.

Under Section 13 of the 49 Act (as amended by schedule 3 of the 84 Act) its an offence if you're 'Using any apparatus for the purpose of interfering with wireless telegraphy'. (Deliberate interference or 'jamming'. The penalties are the same as for section 5a above.

POWERS OF ENFORCEMENT

To bring proceedings under the Wireless Telegraphy Act requires the consent of the Sec. of State. In practice this means that the DTI decides whether to press charges. So it was usually (and usually still is) a 'summons offence'. If you were taken to the copshop unwillingly it was either on a pretext charge (like suspicion of stealing electricity) or unlawfully. But the 84 Act (s76) (which applies to offences under s1.1, s5a, and s13 of the 49 Act) gave a constable power to arrest without a warrant a person who has committed, or whom the constable with reasonable cause suspects to have committed, an offence to which this section applies, if the name and address are unknown to and cannot be ascertained by the constable, or the constable has reasonable grounds for doubting whether the person has given their real name and address, or whether the person will be at that address for a sufficiently long period for it to be possible to serve them with a summons.

This hampers wily pirates from slipping off with a false name and address (but if such an address is easily verifiable it should still be possible. Ed) and in practice gives the filth power to arrest on suspicion.

UNDER ARREST

Once you're nicked its like any other arrest. You should try and take notes, get the number of the cop who nicked you, ask to see a solicitor immediately under the new 'Duty Solicitor' scheme, refuse to answer any questions, refuse to be photographed or fingerprinted (though they don't need a magistrate's warrant now to force this), only sign for your own possessions and not for the TX gear they may add on the list, etc.

In practice since its the DTI and not the cops who bring prosecutions under the Wireless Telegraphy Acts you won't be charged then and there. What they will do is interview you separately and then let the DTI (radio Investigation Service) interview you. You don't have to say anything to them either, especially don't talk to that old charmer Eric Gotts who will try and trick info and admissions out of you.

They're supposed to let you go as soon as they've decided not to charge you (you get that by a summons). But they can hold you up to 3 days. Keep banging on the door and asking for your phone call. The only delay should be while they check out your address, though of course they'll be checking if you're wanted for anything else. There should be no question of bail if you haven't been charged.

SEARCHES, CONFISCATIONS, FORFEITURES....

Section 19 of the 49 Act provides for the issue of search warrants. They last for a month and authorise anyone named by the Sec. of State to search a premises or vehicle and exam-

ine or test any apparatus they find. This didn't allow them to seize anything till the case came to court, but this loophole was never realised till 83, when there followed an upsurge of pirates till the 84 Act brought in new powers.

The search powers were extended by the 84 Act and brought in wholesale confiscation powers. (By s79 of the 84 Act which applies to offences under s1.1, s5a and s13 of the 49 Act and s7 of the 67 Act).. Subsection 79.2 provides for the inclusion in such search warrants of the authority to seize and detain, for the purpose of relevant proceedings, any apparatus OR OTHER THING found in the course of the search, which appears to have been used in connection with or to be evidence of the commission of any of these offences.

This new power allowed the current practice of tracing and raiding studios and confiscating everything, and was reaffirmed by the Horizon Radio case of 1985, when a studio valued at £20,000 was confiscated (down to chairs and carpet) and, though the case was denied and the TX gear was never found, the DJ's were found guilty and fined in addition to the confiscation.

When faced with a Search warrant don't open the door, examine it through a window or letter box. Check the date, (if its valid) who it allows to search, if it allows for body search, if it allows for seizure of evidence, any names etc. Then ask them for I.D. to check if they are those authorised. After that its an offence to obstruct them. If you have an escape route, use it!

Under s80 of the 84 Act they can order forfeiture of any gear restricted under s7 of the 67 Act whether anyone is charged or not. If you're convicted they must order forfeiture.

Proceedings must be brought within six months. After that you can forget it.

Apparatus of the station does NOT include the studio unless programmes are done live.

CLAIMING BACK YOUR GEAR

If you haven't been charged after six months, or if you've won your case (sometimes happens!) you can in theory claim back anything seized. You write to the Radio Regulatory Dept of the DTI or your local Radio Interference Division, or better get a good solicitor to write, giving a clear description of the gear and saying you're the owner and can prove it. Such proof could be receipts for items like batteries, cassette players or an identifying mark on the gear. Don't admit to anything else but ownership, any other evidence that you've committed an offence and you could still be prosecuted. (Ask your solicitor first if there is an 'Order in force under Section 7 of the 67 Act prohibiting 'custody or control' of TX gear).

GOING TO COURT

Usually its by Summons, (unless under s5a or s13 it'll be in the magistrates court) if you get one get yourself a solicitor who knows something about it and Legal Aid if at all possible. Even if you're caught red handed you can deny everything and sometimes get away with it. If you're bending the truth a little don't tell your solicitor as they won't go along with it. If you think you have any chance at all plead Not Guilty, often solicitors will tell you to plead guilty just to save themselves the bother. But remember that the Magistrates Court is basically controlled by the police and most magistrates are right wing Tories (the old ones are often more liberal than the young Thatcher lovers). The police and the DTI witnesses will lie through their teeth if necessary to nail you. For instance the head of the DTI's RIS squad, Eric Gotts once told a magistrate he recognised an Our Radio member putting up an aerial on top of a 22 story tower block at night, from ground level, the evidence was accepted.

Be polite and courteous and smile at the bastards if you want to get off, and get your station to organise a bust fund and benefit to pay your fine. You can appeal against the decision, and you go to the Crown Court with a barrister, check with your solicitor if its worth it, you may have to pay high costs if you lose.

Radio Electronics (FM)

A General Introduction

CONTENTS

Foreward.
 Introduction.
 FM.
 Choosing a Frequency.
 Tape or Live.
 Mono or Stereo.
 Pre-emphasis.
 Compressors and Limiters.
 The oscillator: VFO's Crystals PLL's.
 Buffers.
 Amplifiers: Bandwidth/ Gain and Max output power/
 Input and output impedance/ VSWR /
 The Dummy Load/
 Harmonics: Wavemeters.
 Bandpass Filter / Connectors./ Feeders.
 Aerials: Polarisation / Siting.

FOREWARD

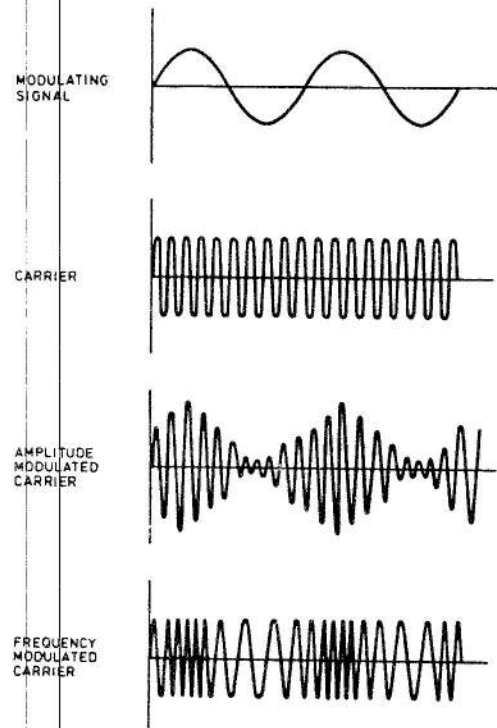
The following is by no means an introduction to electronics, there are many such books that cover the subject, but intends to explore some of the ideas and concept involved in radio broadcasting that are relevant to the pirate radio operator on VHF FM. In particular we will go a step by step tour of a typical VHF FM transmitter system starting with the output from the tape recorder or mixer, and finishing with a brief discussion of aerials. At each stage we will discuss the pros and cons of various alternatives and additional background info, eg. the use of test equipment will be introduced

Radio Frequency signals have AMPLITUDE and FREQUENCY. The frequency is how fast the signal is oscillating from one extreme to the other and back again. Frequency is measured in cycles per second (cp/s), which these days are known as HERTZ (Hz), 1000Hz = 1kHz, 1,000,000Hz = 1MHz The amplitude is to what extent the signal is oscillating. LEVEL or STRENGTH can be thought of as meaning the same as amplitude. Amplitude can be measured in Volts (v). There is more than one way of measuring amplitude.

INTRODUCTION

What we are trying to is get information from one place to lots of others. I'm using information here in a wider sense, meaning speech, music etc., rather than phone numbers of local hairdressers or whatever. Now I'm going to assume we're going to use radio broadcasting to achieve this, which immediately rules out things like standing on top of tall buildings and shouting really loud. We'll also assume we've got this info in the form of an audio frequency signal, ie. what comes out of a tape recorder or an audio mixer. You can't transmit audio frequency signals very easily so what we can do is impart the info in the audio frequency signal onto a higher frequency carrier signal. Two ways of doing this are AMPLITUDE MODULATION and FREQUENCY MODULATION (AM and FM).

In AM the amplitude of the carrier is determined at every instant by the amplitude of the audio signal, the carrier frequency remains constant. In FM the frequency of the carrier is determined at every instant by the amplitude of the audio signal, and the carrier amplitude remains constant.



Frequencies between 30 MHz and 300 MHz are known as Very High Frequencies or VHF. This corresponds to wavelengths between 10m and 1m. To convert between wavelength and frequency use the formula

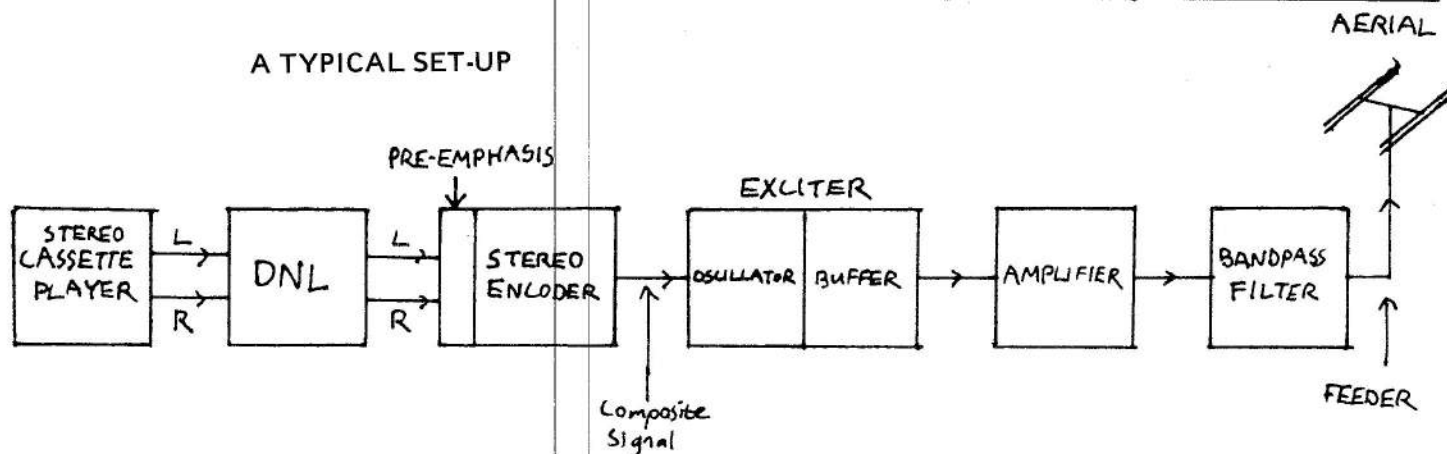
$$\text{wavelength (in metres)} = \frac{300}{\text{frequency (in MHz)}}$$

FM

There are two sorts of FM, known as Narrow Band FM (NBFM) and Wideband FM. They differ by the maximum allowable frequency shift of the carrier when the transmitter is fully modulated. This frequency shift is known as the DEVIATION. Legal CB radios use NBFM with a maximum deviation of 3 kHz. Wideband FM is used by the BBC and IBA for radio broadcasting and for studio to transmitter links. The standard maximum deviation for FM radio broadcasting in this country is 75kHz. There is no simple way to set the deviation of a transmitter without a Deviation Meter which is an expensive piece of test gear. Probably the best way to do this is to vary the level of the audio signal going into the transmitter (TX) and listen on a receiver, until your signal sounds about the same loudness as the other (legal) broadcast stations. If you use too high a deviation you'll use a bigger than necessary chunk of the radio spectrum and be more likely to cause interference to others, which will make you even more unpopular with the DTI.

The police use NBFM as well, which is why if you listen to them on an ordinary FM receiver, which is wideband, you can hear more than one channel at a time.

A TYPICAL SET-UP



CHOOSING A FREQUENCY

If Your first action could be to reach for you receiver and tune through looking for a blank space, think again, for a kick-off the UK FM broadcast band is 88 to 97.6 MHz and 102.1 to 108 MHz. 97.6 to 102.1 MHz is used by the police, so is best left alone. What stations you can receive is determined by where you are, as well as by the nature and positioning of your aerial. If you look to our old friend the Maplin catalogue we find on P24 of the current issue a list of the frequencies and locations of all FM broadcast stations. What it doesn't say, of course, is the frequency of existing pirates. TX Magazine gives a good rundown of these (see CONTACTS). Armed with this info you should make a list of all frequencies in use in, say, a 30 mile radius. If you write to the BBC or IBA's Engineering Info Offices they'll send you service maps of where their TX's are meant to be able to be heard. Then its just a question of finding a big enough gap between stations, with the proviso that your station shouldn't be nearer than 200kHz (0.2 MHz) to the frequency of any existing station. This is no problem as the band is half empty. Also don't choose a frequency which is 10.7 MHz away from any other station as for complex reasons (which involve the use of 10.7 MHz as intermediate frequency in FM receivers) reception will be hard for people listening to you and/or the other station.

Now lets take a little stroll through the whole system.

TAPE OR LIVE

What are we going to feed into our TX? The obvious two possibilities are

- A tape or cassette player.
- Live, either directly from the mixer or via some kind of link from studio to TX site (highly recommended).

TAPE. This is the safest approach in that you can put a tape on and then retire to a safe distance. Links are now being traced and studios busted, and some of the biggest pirates (eg LWR) are going back to taped broadcasts. If the DTI trace your transmission and turn up all they can do is confiscate your tape plater, TX and aerial, ie no arrests (unless they catch you changing the tape!). Its also the most inflexible alternative as tapes will have to be prepared in advance. Time checks, if you're into that, will be difficult and live phone ins are right out.

Give a little thought to your choice of tape recorder, as it will probably be the weakest link in terms of sound quality. In an old clapped out one the heads will be worn flat. Maybe you can use a 'Walkman' type of player, which are small, can be battery powered and have ok quality and are cheap. An amateur radio rally I was at recently were selling off very slightly damaged ones for £2 each. To reduce 'noise' or 'tape hiss'

on such recorders, if you're doing programmes with quiet passages, you can use a circuit known as a Dynamic Noise Limiter (DNL), which is placed on the output and cuts off the 'noise' just in quiet pauses. DNLs are sometimes used in the soundtracks of old films. You can find a DNL circuit in part of the 'Audio Embellisher' project in the Jan 84 issue of 'Elector' magazine.

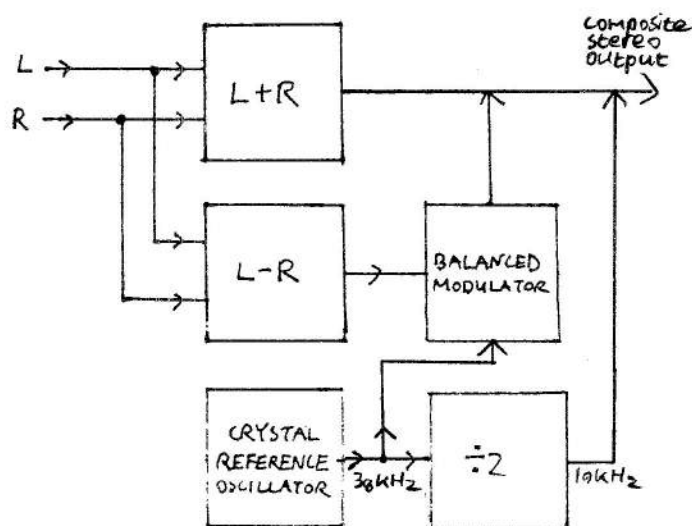
If you want to go upmarket you could use a proper ¼" reel to reel tape recorder, though few pirates do. The latest and greatest is to use 'Stack machines' which will change the tapes for you. Whatever you use get one that can be battery powered as you may not always have access to mains power.

MONO OR STEREO

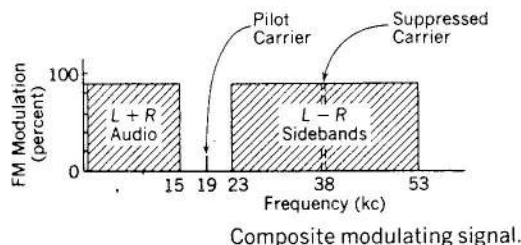
The advantages of mono are that the TX is kept as simple and cheap as possible, and you don't need as much power as on stereo to get the same result. The disadvantages are you don't sound as professional, quite small pirates are now using Stereo Encoders, and maybe people might dial past when the red stereo light on their receivers doesn't flash. With stereo the listener can get quality the same as legal stations. Weigh against this the extra cost, extra circuitry and more output power needed for the same signal.

What you need is a Stereo Encoder, which combines the left and right stereo signals into a single composite stereo signal which is then fed into your TX.

BLOCK DIAGRAM OF STEREO ENCODER



For those interested a brief technical description follows. The left (L) and Right (R) signals are fed into a summing and differential amp to get a L+R and L-R signal respectively. The L-R signal is mixed in a balanced modulator with a 38kHz sub carrier to produce an amplitude modulated double sideband-suppressed carrier signal. The 38kHz signal is derived from the same source as the 19kHz pilot tone. The composite output is formed by mixing the L+R signal, the sidebands containing the info of the L-R signal, and a bit of 19kHz pilot tone. The pilot tone switches on the Stereo Decoder in peoples' receivers.



Back in the receiver, once the Stereo Decoder has extracted the L+R and L-R signal the original left and right signals are easily got by

$$\begin{aligned} (L+R) + (L-R) &= 2L \\ (L+R) - (L-R) &= 2R \end{aligned}$$

The reason L+R and L-R signals are encoded rather than L and R is so that a mono receiver can just demodulate the L+R bit and ignore the rest of the signal. If L and R were encoded a mono receiver would only be able to hear the left channel. The 19kHz pilot tone is usually got from a crystal oscillator, to be quite accurate and stable. A crystal resonating on 4.8640 MHz is convenient as 4864 divided by 2 eight times is 19 kHz. This can easily be done by digital logic chips. But its highly unlikely you'll be able to buy a 4.8640 crystal off the shelf, so you'll have to have one made to order.

We had hoped to include a design for a Stereo Encoder in this book, but we haven't got it yet. See CONTACTS for where you can buy the design or a ready made system.

It doesn't matter if you didn't understand all of the above but one thing is important. The standard FM broadcast audio bandwidth extends only to 15kHz and Stereo Encoders are designed to assume this figure. If you put signals into them with frequencies above that the L+R signal and the lower side band of the L-R signal could spread into each other and you will get a right bloody mess. With a tape recorder you can't really get over 15kHz, but if you're live its quite possible. In that case you need a LOW PASS FILTER on each input to a stereo encoder. Maplin have a high quality design on page 243 of their current catalogue (summer 86). The pot could be replaced with a 500k resistor to wire the circuit permanently for max roll off. If you're using a link between studio and TX and you want stereo you'll have to know the bandwidth of the link. If its 53kHz (= 38+15) or more you can use it after the encoder. Otherwise you'll need two links and have to encode at the TX end.

PRE- EMPHASIS

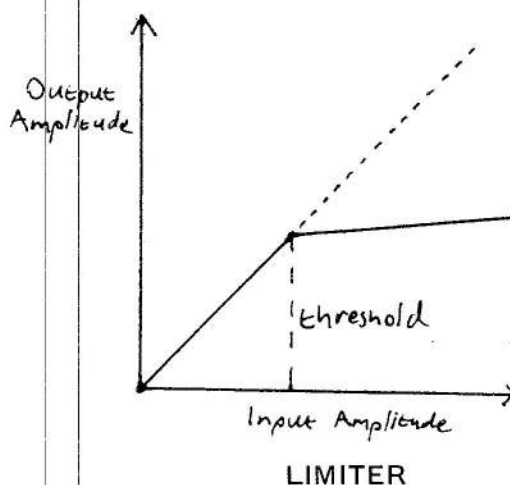
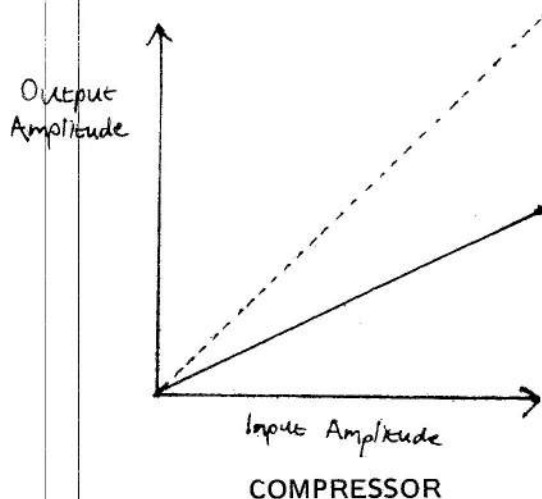
In a typical audio signal the high frequency sounds have less energy than the low ones and so produce less deviation of the carrier. This in turn makes them susceptible to 'noise' when received. To avoid this high frequencies are boosted before being transmitted by PRE-EMPHASIS. In the receiver the frequencies are cut by the same amount by DE-EMPHASIS. So the overall frequency response of TX to receiver stays flat, but the level of background noise is reduced a lot.

Pre and De-emphasis networks are characterised by their TIME CONSTANT. In the USA the standard is 75 μS, but in

UK its 50 μS so anything designed or bought from there needs slight modification. In a mono TX the pre-emphasis network can be built into the front end of the exciter. For a stereo TX such a network must NOT be in the exciter or it'll play hell with the composite stereo signal from the encoder. Instead you need 2 networks, one for each channel, on the inputs of the stereo encoder, They're actually often built into the studio encoder.

COMPRESSORS AND LIMITERS

Compressors and Limiters operate on the same principles, but their effects and the reasons for using them are completely different.



A compressor compresses, it reduces the DYNAMIC RANGE of its input signal. This means as the input amplitude varies over a certain range, the output amplitude varies over only a fraction of that range. The graph shows a 2:1 compression characteristic. In this case with every change in the input amplitude the output changes only half as much. The dotted line shows a 1:1 non compressed characteristic.

But a Limiter passes its signal unaffected till the input amplitude reaches its THRESHOLD. At this point the limiter prevents the output increasing much by compressing its input much more strongly than in compressors eg 10:1.

Some American music stations and some pirates compress their programmes to make it seem 'louder' and more 'upfront' than other stations, This occurs cos the compressor keeps the average level of the signal high, even in quiet parts of the prog. The flip side of this is listeners can soon get 'listener fatigue' as constant compression can become boring and irritating to the ear, as if the music were rammed into it!

Compression has other uses, you might compress your programme as you transfer it to tape to stop quieter bits fading into background tape hiss when played. The process of recording and replaying does this to some extent anyway. Don't compress the output of a tape recorder as it'll make tape noise worse. Guitar effect units, labelled compressors, are unlikely to be much use. Compressors intended for use in home studio recording are worth experimenting with. A stereo compressor with a 2:1 characteristic can be simply constructed around a NE570 or NE571 IC.

Limiters are used to stop a signal's amplitude going over a certain level. Eg when cutting a master disc in record manufacture, large PA systems at gigs to stop loudspeakers blowing every time someone burps in a mike and, surprise surprise, in broadcasting. In FM particularly, as the signal level increases so also does the bandwidth of the transmitted signal, risking interfering with other stations. With tape input to your TX the output is inherently limited by the recording process, no limiter needed. With live input to the TX its different. Though you might set the levels right to start, along comes a loud record or voice and you could be interfering with the next station. Use a limiter.

Any limiter based on 2 back to back diodes is little more than a guitar fuzz box and will sound like one. A suitable high quality limiter was described in the May 83 issue of 'Electronics Today' International Magazine.

THE OSCILLATOR

At the heart of everything is the OSCILLATOR that generates the VHF signal. The Frequency of this is modulated by applying an audio signal to it. The most common way of doing this is by using one or two VARICAP diodes. When a varicap diode is operated with a reverse bias the capacitance of the diode varies with that bias. The diode(s) is/are connected to a frequency determining part of the oscillator. The audio signal is connected across the diode to achieve frequency modulation. Also by varying the DC reverse bias the oscillator can be fine tuned. The higher the voltage, the lower the capacitance, the higher the frequency.

The VHF signal can either be generated directly, or the oscillator can oscillate on a lower frequency eg a third or half that desired and then followed by a TRIPLER or DOUBLER stage. There are three main types of oscillator:

- a) Variable Frequency Oscillator (VFO).
- b) Crystal Oscillator.
- c) Phase locked Loop Oscillator (PLL).

VFO's

These are simple oscillators which can be built round a single transistor. This can be:

- Bipolar Junction Transistor (BJT).
- Field Effect Transistor (FET).

The problem with oscillators based on BJT.s is that the frequency is too dependent on the temperature of the transistor. ie a few degrees temperature change will result in a significant change in transmitting frequency. For this reason oscillators based on BJT's are UNSUITABLE for serious use as a TX. FET's don't suffer from this problem so badly, so they can be used, but you should still bear it in mind.

The FET will heat itself up slightly, and other bits of the TX, like the power amps, will be fair old chucking heat out, and are usually built into the same case as the oscillator. The frequency will drift most when the TX is 1st switched on as all the components will be at the same temperature as the air outside the TX's case, this is known as the AMBIENT TEMP-

ERATURE. After the TX is turned on the heat from the amps will warm the air in the case directly or indirectly. As the FET warms the frequency will drift a bit. When heat loss equals heat gain you get THERMAL EQUILIBRIUM and it wont drift more. Keep your TX out of drafts to avoid messing this up. If you have a frequency counter plug in to a dummy load and see how long it takes for the frequency displayed to settle down, maybe about 15 minutes. If you have time you can arrive at the TX site early and run your TX for the warm up time with no input into a dummy load. This avoids listeners who tune in immediately having to retune as you r frequency drifts.

CRYSTAL OSCILLATORS

This is also a simple oscillator but incorporates a crystal into the frequency determining network. There are various types of crystal (fundamental, 3rd overtone, 5th overtone etc) and various ways of using them (series mode, parallel mode) but their basic properties are the same. They're resonant on one frequency which is determined by the crystal's characteristics when made. This is their problem, whereas VFO's are not very stable crystal oscillators are too bloody stable and its a job to get enough deviation. You'll probably lose the higher frequencies of your programme and stereo is right out. Also chances are you'll have to get a crystal made to order for your desired frequency so if you want to change it you'll need a new one. There are places which make crystals to order.

PHASE LOCKED LOOP (PLL) OSCILLATORS

The way its done properly is with the Phase Locked Loop oscillator. Tis combines the ease of tuning and wide deviation of a VFO with the frequency stability of a crystal oscillator. It works thus: A crystal oscillator is used to provide a reference frequency. This is digitally divided by logic chips to a relatively low frequency, say 25kHz. A VFO provides the output, which is also digitally divided to give another relatively low frequency. These two low frequencies are presented to a PHASE COMPARATOR which basically decides which frequency is higher by comparing the phases of the two signals. The phase comparator generates an ERROR VOLTAGE which is connected back to the input of the VFO through a LOW PASS FILTER (LPF). This is the loop bit.

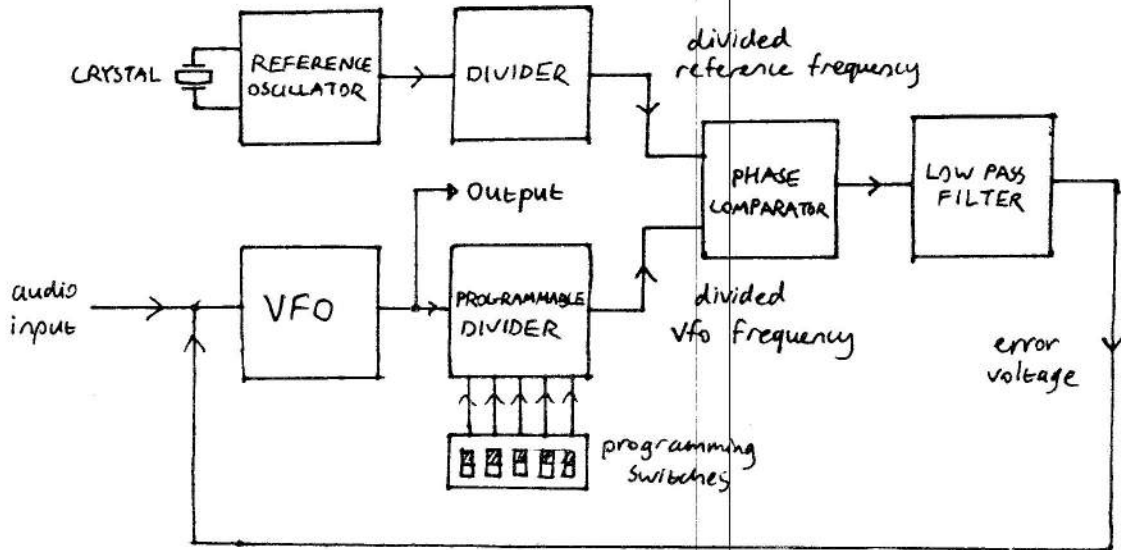
If the VFO is running too fast the phase comparator decreases the error voltage so as to slow it down till the phases at its input are the same. If its running too slow the error voltage is increased to speed it till the phases are the same. All this happens instantaneously of course so the output frequency remains constant.

In this way the temperature stability of the VFO isn't important and it can be built round a BJT, as its output frequency is phase locked to the crystal oscillator, and the frequency of this is very good. Clever eh?

Two more things to explain. How do you change the output frequency? By making the VFO's divider programmable. Say its set to divide by the number N. The phase comparator is a simple minded sort of soul, concerned only with equalising the phases at its inputs, it doesn't know whats really coming out of the VFO, which is N times the divided reference signal. Because this signal is so low compared to the VFO frequency N can be made to have hundreds of different values, giving hundreds of different output frequencies from the VFO. So changing the frequencies is just a matter of clicking some little switches. (Beats me...typissed).

Hang on a sec, the VFO is being frequency modulated by the audio input, so its frequency at any given instant depends on the voltage of the audio output. We don't want THIS

PHASE LOCKED LOOP OSCILLATOR BLOCK DIAGRAM



variation of the VFO's frequency to be ironed out by the PLL system so we 'iron out' the error voltage from the phase comparator, so it just contains the underlying trend rather than what's happening at any split second. This is the purpose of the low pass filter.

This system can be simplified by leaving out the dividers. If this is done you end up with an output frequency determined solely by the crystal. You've still got the wide deviation capability of course, which distinguishes this system from one based on a simple crystal oscillator. This sort of fixed frequency oscillator is used for things like wireless mikes and could be used for studio to TX links. Programmable PLL oscillators are used in all manner of professional communications equipment, including broadcast TX's.

We don't include a PLL oscillator design in this book. It's a bit complex to start with and the IC's are expensive. . See CONTACTS for where to get the design. or ready made.

BUFFERS

Any oscillator, regardless of its type, is followed by a buffer. This is usually one or two transistors operating in what is known as class A mode. Its function is to protect the oscillator from what is going on further along the circuit, especially from changes in its 'load' as the following stage is tuned. The combination of oscillator and buffer together is called the EXCITER and is a small but fully fledged TX. Small in respect to its output power. Typical values are in the region of 100 - 500 mW (1000mW = 1W).

AMPLIFIERS

To increase the power output of our fledgling TX we need to add an amplifier. Obviously we are talking about Radio Frequency (RF) amps, not audio amps. RF amps have certain important characteristics: a) Bandwidth b) Gain and maximum power output c) Input and output impedance.

BANDWIDTH This is the range of frequencies the amp will amplify properly. The Bandwidth is ultimately limited by the characteristics of the active devices in the amp (ie the transistors or valves) but more specifically by its type, LINEAR or a TUNED amplifier.

A linear amp will amplify quite a large range of frequencies and they have a good bandwidth, commonly 1.8 - 30 MHz which covers all of the amateur shortwave broadcast bands.. no good for a VHF pirate, but could be useful for a MW pirate. They operate in class A or B mode and have the advantage that they don't need adjusting when the frequency is changed. Their disadvantage are they're more complex and

dearer than tuned amps and are much harder to design, requiring extensive knowledge of the transistors round which the amp is constructed. Linear amps for VHF are uncommon.

Tuned amps only amplify a narrow band of frequencies, they have a small bandwidth, centred on one frequency which is determined by the TUNED CIRCUITS in the input and output networks of the amp. Tuned circuit have a RESONANT frequency. This can be adjusted by variable capacitors known as trimmers, to the desired frequency. The amp will produce max output when the tuned circuits resonant frequency is the same as the input frequency from the exciter. Tuned amps often operate in the class C mode, which is more efficient than A or B. This means more of the power being drawn from the battery or whatever turns into watts up the aerial rather than heat in the amp. They are relatively simple circuits, and are easier to design. The bandwidth is a trade-off with gain, the wider the bandwidth the less the gain. The disadvantages of a tuned amp is, of course, you have to tune it to the frequency you're using and if you change the frequency you'll you'll have to retune to maintain the gain of the amp.

GAIN AND MAXIMUM OUTPUT POWER

The POWER GAIN (as opposed to a voltage or current gain which is different) of an amp is defined as a ratio:

$$\text{power gain} = \frac{\text{output power}}{\text{input power}}$$

and is a measure of the amps ability to make its input 'bigger'. Power gains are often expressed in DECIBELS (dB) which are defined:

$$\text{power gain (dB)} = 10 \log_{10} \frac{\text{output power}}{\text{input power}}$$

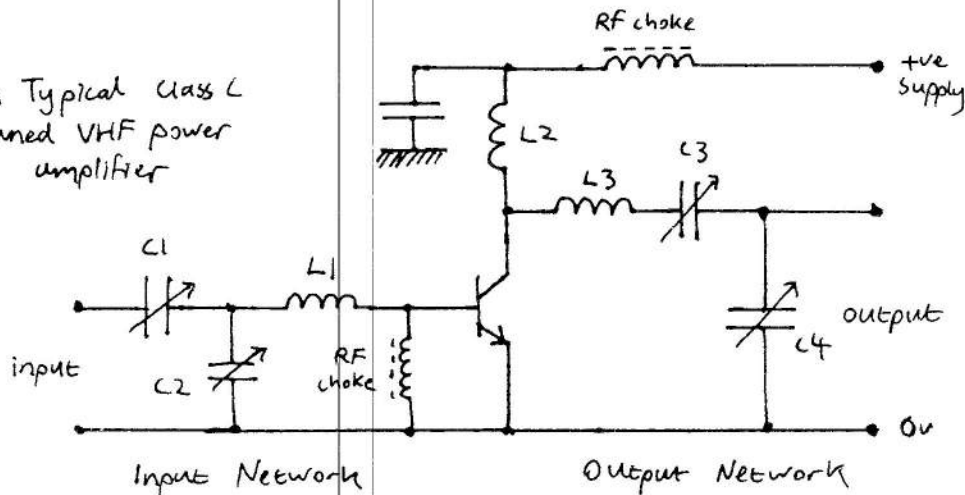
Amps also have a max output power. When this is reached increasing the input power wont result in more output power and may damage the amp.

In the case of single stage (ie one transistor) class C tuned amps the gain and max output power of the amp is basically the gain and max output power of the transistor. Knowing these we can calculate the power necessary to produce the max output power. EG lets consider the popular MRF237 transistor. According to the makers data sheet this has a max output power of 4w and a gain of 12dB. First we've to convert the gain in dB to ordinary gain :

$$\text{gain} = 10^{\frac{\text{gain (dB)}}{10}}$$

$$\text{for example gain} = 10^{\frac{12}{10}} = 10^{1.2} \approx 15.85$$

A Typical Class C
tuned VHF power
amplifier



$$\text{Input power} = \frac{\text{Output power}}{\text{gain}} = \frac{4}{15.85} = 0.25\text{w} = 250\text{mW}$$

So for 4w output power we need 250mW input power. Most excitors can manage this, hence the popularity of the MRF237 in the 1st amp after the exciter. The joker in the pack is that all these figures are for a frequency of 175MHz, that on which the transistor was designed. You can't predict what happens at 100MHz and have to experiment.

The MRF238 has 30w output power and a gain of 9dB, so it needs 3.8w input power. This can be had from the MRF237. That's how the makers (Motorola Corpse.) planned it.

INPUT AND OUTPUT IMPEDENCE

Impedence is the alternating current (AC) version of resistance. The standard impedence outputs of excitors and outputs and inputs of amps is 50Ω . The impedence of the input and the output networks of an amp is altered by the tuned circuits which you recall also tune the circuit in a tuned amp. The INPUT IMPEDENCE is important as it effects the LOAD the amp has on the stage before it. Max power is transferred between stages when the impedence of the output and input are equal. If the impedences aren't equal a MISMATCH is said to occur and in this case some energy is reflected back from the input of a stage into the output of the preceding one, where its wasted as heat.

THE VSWR METER

Some of you may know that we can use a VSWR meter (also known as Voltage standing wave ratio meter, SWR meter or a Reflectometer) to detect mismatch between TX and the aerial, but the VSWR meter is just as much at home doing this between amp stages. VSWR is the ratio of the forward (or incident) and reflected power. Except for dear ones they work the same. The switch is set to Forward or the SET button is pressed. The knob is then adjusted to make the meter read full scale. The switch is then set to Reverse or the button is pre-released. It now indicates the VSWR. A VSWR of 1:1 is perfect (no reflected power) and so unlikely. One of 00:1 shows all the power is reflected back into the amp, you'll get this with a VSWR connected to the amp output with nothing on the VSWR output (unless its got a built in dummy load). You'll also get it if there's a short circuit in the VSWR meter. In either case switch off IMMEDIATELY or you'll blow your power transistor.

The point of all this is to get the max power output from the amp into the aerial, instead of a hot TX and a bad signal.

To tune such an amp you need a LOAD connected to the output (or it'll blow up). We could use an aerial but this introduces an extra unknown quantity..the characteristics of the aerial. As well as the fact that we'd be broadcasting. What we need is a DUMMY LOAD.

THE DUMMY LOAD

This is basically a resistor, made so it presents a load to the amp's output independent of frequency (unlike the aerial). The 3 things about a dummy load we're interested in are:

- It should be suitable for the frequency we're interested in, about 100MHz.
- It should be rated to take the power we're trying to make.
- It should have a resistance of 50Ω . To match the output network of the amp.

When buying ask for one for the 2 meter band, amateur radio, centred on 145MHz. Most test gear for this band (dummy loads, VSWR meters, power meters, wavemeters, RF volt meters, frequency counters etc) will work on the frequencies we're interested in.

The amp should first be tuned with reduced input power and supply voltage. Adjust the input network trimmers C1 & C2 for the best input match (lowest reading on a VSWR meter connected to the input side) and adjust the output trimmers for max output power. Be sure the extra power is in the frequency you want and not in the HARMONICS. Check with a wave meter (more of this coming up). Another VSWR meter can be used for a relative indication of the output power, or the RF PROBE, described on page will give an absolute indication. The pairs of trimmers are very interdependent, adjust one and you'll have to adjust the other, and so on.

This done, if all OK, increase the input power by increasing the voltage supply to the previous stage, and the voltage supply slightly and repeat the tuning. Do all this a few times till you reach the required levels. Listen in on a nearby (but not too near) receiver. The signal should be in just one place on the dial with no funny noises or modulations going on. Check with a wave-meter. Altering the trimmers and varying the input power and supply voltage should result in smooth variations of the supply current and output power with no steps or jumps. The exception is, as the input power is reduced at some point the amp will switch off, a characteristics of Class C amps.

To vary the supply voltage you need a Variable Stabilised Power Supply Unit. If you can't get hold of one you could

build one. They're not expensive and are well handy, and give you some experience, if needed, of electronic construction.

HARMONICS

Harmonics are multiples of the transmitting frequency. For a frequency of 100mHz, the 1st harmonic, known as the FUNDAMENTAL is 100mHz, The second is 200mHz, the 3rd is 300mHz etc. They're produced as side effects in various parts of the circuit and will interfere with other users of these frequencies if let escape from the TX. Known as RADIO FREQUENCY INTERFERENCE (RFI). Tuned class C amps don't amplify harmonics, as they're out of the range of the amp's abilities. But the use of Class C means that harmonics are generated by the amp along with the desired frequency. The strongest ones (apart from the fundamental) from such amps are usually the 3rd, then the 5th etc. The amplitude of harmonics is minimised if the output networks are tuned properly, but they're still there. Oscillators and Buffers can also make harmonics if not set up right.

WAVEMETERS

To detect harmonics we need an ABSORPTION WAVEMETER usually called just a wavemeter. Or we can use a GRID DIP OSCILLATOR (GDO) or a gate dip oscillator, both of which are known as DIP METERS. Most dipmeters have a switch which turns them into wavemeters. A wavemeter has a tuning knob, calibrated in frequency, a meter showing signal strength, and some kind of short aerial. You hold the aerial near a coil in the bit of the circuit you're interested in, and tune the wavemeter. It shows how much signal is present on the frequencies shown on the scale. So you can see what frequencies are being generated in that part of the circuit. Ideally you'll just find the fundamental, unless the circuit is a frequency tripler or something.

If you buy a wavemeter be sure it covers the right range, from below 100mHz to get the fundamental to above 300mHz to get the 3rd harmonic.

Even with all tuned right you're still going to have some harmonics generated by the last stage. A sensible pirate won't let these reach the aerial, e.g. if you're using a frequency of 102.35mHz the third harmonic is 307.05mHz which happens to be that used by USAF Upper Heyford's Control Tower. You might think this funny but you won't stay on the air for long. To stop harmonics reaching the aerial we need a BANDPASS FILTER.

Each amp bumps up the power some more, cos the transistor in each one can only supply so much gain. So if you're the proud owner of a 5 watt and you're offered a 1000w amp it's useless as you'd need probably 100w input to drive it so you'd need amps in between.

To tune a series of amps on your TX you must break in, physically if needed, to tune each one at a time. Do this by unsoldering components and soldering in short bits of co-ax with plugs to connect to dummy load and VSWR meter.

BANDPASS FILTER

This filter only allows through a narrow band of frequencies, ie it has a narrow bandwidth, a good one would be less than 1MHz. It needs standard 50 ohm input and output impedance and be able to take the power you're using and be tuned to the frequency you want let through. Other frequencies are reduced drastically, by an amount known as INSERTION LOSS

reduced drastically. It reduces also the desired frequency slightly, by an amount known as INSERTION LOSS. To keep this loss low bandpass filters for high output powers are usually pretty chunky numbers.

Pirate gear doesn't have this filter built into the final stages so if you need one you have to add it on. It needs a well

screened case to stop harmonics leaking out. In fact your whole TX should be well screened for the same reason. Say for eg you used a shoebox and had your oscillator on a third of a frequency of 92.25mHz..you could be interfering with pagers of a local hospital as they use 31.75mHz. Proper screening and a bandpass filter will eliminate such possibilities.

CONNECTORS

As you may have guessed you can't use any connectors on VHF as they have to match the amp and feeder. Use BNC or the UHF series (PL259 plug and SO239 socket). UHF is best for higher powers as you can get a wider cable into the plug. N type is also good but dearer

FEEDERS

So you've got your nice clean harmonic free signal coming out of your bandpass filter..we're on the home run. All that's left is to get the signal up the aerial feeder to the aerial and we're away. BUT the aerial cable needs to MATCH the TX's output stage at one end and the aerial at the other. This cable like the TX's output, the connectors and the aerial has an impedance and to match this should be 50Ω. It also needs LOW LOSS or your watts will escape as heat. Not the same as a bad VSWR where you lose energy in the TX, a good VSWR does not mean the cable's okay. Decent cables for short runs are UR76 and RG56U. For longer runs or higher powers use UR67. (UR67 and UR76 are available from Cirkit).

AERIALS

At last, the aerial! You can run a pirate knowing little of TX's, but if you know nothing of aerials you'll have few listeners. So you must read a book on it. I recommend 'The Two Metre Antenna Handbook' by FC Judd G2BCX. It's a paperback by Newnes technical books at £5.95. You may get it in the library. Lots in it isn't useful but he goes into things like propagation, matching, VSWR in better detail. All the dimensions he gives are for the 2m amateur band, centred on 145mHz. To convert to other frequencies all dimensions (including diameter of aerial element, etc) should be divided by your frequency in mHz and then multiplied by 145. eg 978mm for 2m becomes $978 \times \frac{145}{145} = 1377\text{mm}$ for 103mHz.

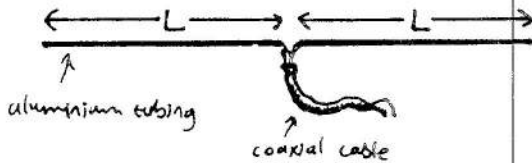
103

POLARISATION

One thing to decide is what polarisation to use. The main ones are HORIZONTAL and VERTICAL. To simplify you can say a horizontally placed aerial produces horizontally polarised radio waves and a vertically placed one vertically polarised radio waves. To receive a horizontally polarised signal you need a horizontally polarised aerial, and for a vertical one a vertically polarised aerial. Most receivers on FM have horizontally polarised aerials, but all car aerials are vertically polarised. So what polarisation you go for depends on the audience you expect. Eg on Sunday afternoon you'd expect people at home so use horizontal, while in rush hour you might favour vertical. You can build an aerial which splits the power between both, as used in legal stations, known as MIXED polarisation. But the effect of radio waves bouncing off buildings etc tends to twist the polarisation of your signal from horizontal to vertical and vice versa, so your signal could still be picked up by the wrong aerial.

Your transmitting site will affect your choice of aerial (see also Ch 2, How To Get Away With It). In the middle of the area you want to cover you'll need an OMNIDIRECTIONAL aerial which transmits equally all ways, while outside your coverage area you can beam the signal in, with a DIRECTIONAL aerial.

The simplest possible aerial for VHF is known as the HALF WAVE DIPOLE and looks like this:

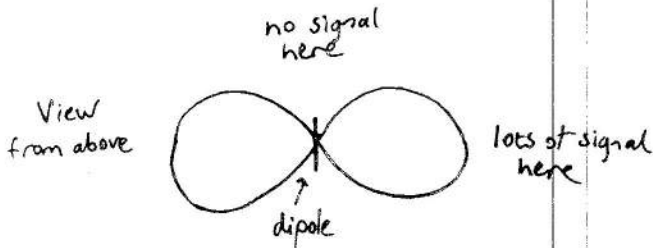


The elements can be bits of thin aluminium or copper tube. The lengths of each dipole, L, you get from your frequency

$$\text{by: } L = \frac{71}{f \text{ (in MHz)}} \text{ metres}$$

The impedance is about 72Ω which is close enough to 50Ω to be fed from 50Ω cable without too much power loss.

A half wave dipole used vertically is omnidirectional, but when used horizontally it has a fig of eight coverage like this:



which isn't v. useful. Also a dipole needs a balanced feed. You need a BALUN (Balance to UNbalance) transformer. These can be easily made out of bits of co-ax cable. If you don't do this power will be radiated from the feeder. An aerial with an impedance greatly different from 50Ω needs an IMPEDANCE TRANSFORMER Also made out of bits of co-ax, see aerial book for details.

Before going on air get a low VSWR by adjusting the position of the aerial and any adjustable pieces. Aim for 2:1 or less. Use low power into the aerial when tuning it up and adjusting, if using 100's of watts and a bit came off in your hand the VSWR could be so bad as to blow the final transistor. For the same reason check the continuity of the aerial with an ohmmeter before plugging in, to be sure it's what it's meant to be, either a short circuit or an open one, depending on the type. A dipole should be an open circuit.

SITING

Siting is very important. Height is the main factor, even more than watts! Since VHF radio waves go almost in straight lines. 100w in your front room will only reach your neighbours, while 5w up high and unblocked will go 5 miles or more. The waves do bend a bit so you'll cover more than you can see but it's hard to say how much. GO for it!

To join the Radio Support Group and get up dates and development aid write to RSG. c/o Box 010, 37 Stokes Croft, Bristol. Avon BS13PY. It costs £5 to join. Make cheques payable to D.R. Communications.

Appendix A. THE FREQUENCY COUNTER

If you can get hold of one setting up an exciter is so much easier, you can see what frequency you're on and if it's drifting. You don't need a physical connection to the circuit to use it as this can upset things. Either connect a single bit of wire to the input or use a BNC lead ending in a pair of crocodile clips clipped together to form a little loop. Frequency Counters are normally sensitive enough to get a reading when

the wire or loop is placed near a coil. You might get lots of other readings as you move it about. Look for a stable one near the frequency you expect (use receiver or a wavemeter if you're not sure) It's a bit of an art but you'll soon get the hang. For our purposes a frequency must have:

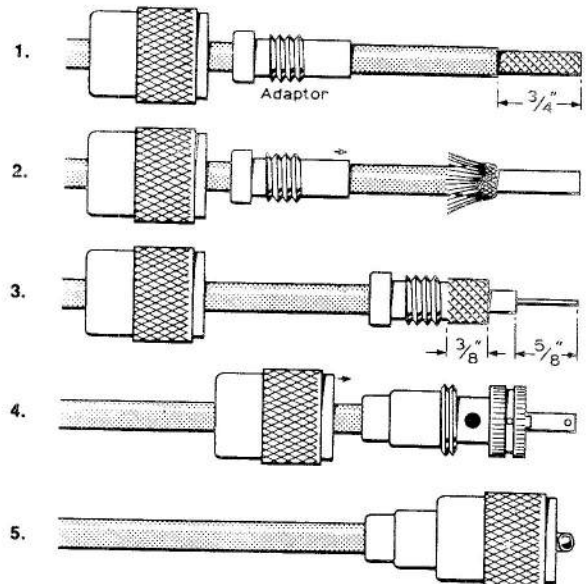
- The bandwidth, up to at least 150MHz.
- The Resolution i.e. number of digits on display. Four isn't good enough, six is OK, 8 is preferable.

The Thandor PFM200A is around £75 plus vat from Cirkit.

APPENDIX B UHF PLUG ASSEMBLY

UHF type (clamped screen)

- Cut end of cable even. Remove vinyl jacket $\frac{1}{4}$ in. Slide coupling ring and adaptor on cable.
- Fan braid slightly and fold back as shown.
- Position adaptor to dimension shown. Press braid down over body of adaptor and trim to $\frac{1}{8}$ in. Bare $\frac{1}{8}$ in of conductor. Tin exposed centre conductor.
- Screw plug sub-assembly on adaptor. Solder braid to shell through solder holes. Use enough heat to create bond of braid to shell. Solder conductor to contact.
- For final assembly, screw coupling ring on plug sub-assembly.

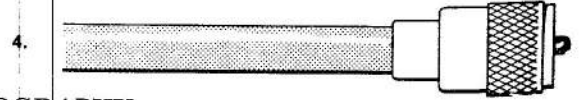
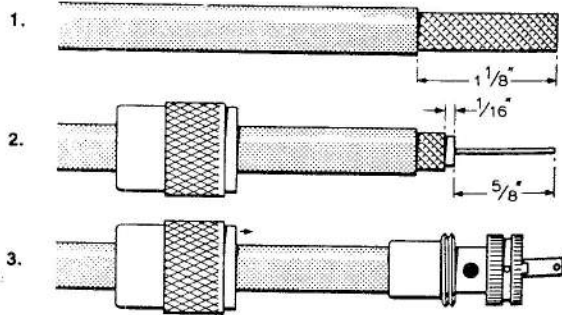


UHF type (clamped screen)

UHF type (soldered screen)

- Cut end of cable even. Remove vinyl jacket $\frac{1}{4}$ in.
- Bare $\frac{1}{8}$ in of centre conductor. Trim braided shield. Slide coupling ring on cable. Tin exposed centre conductor and braid.
- Screw the plug sub-assembly on cable. Solder assembly to braid through solder holes. Use enough heat to create bond to braid to shell. Solder centre conductor to contact.
- For final assembly, screw coupling ring on plug sub-assembly.

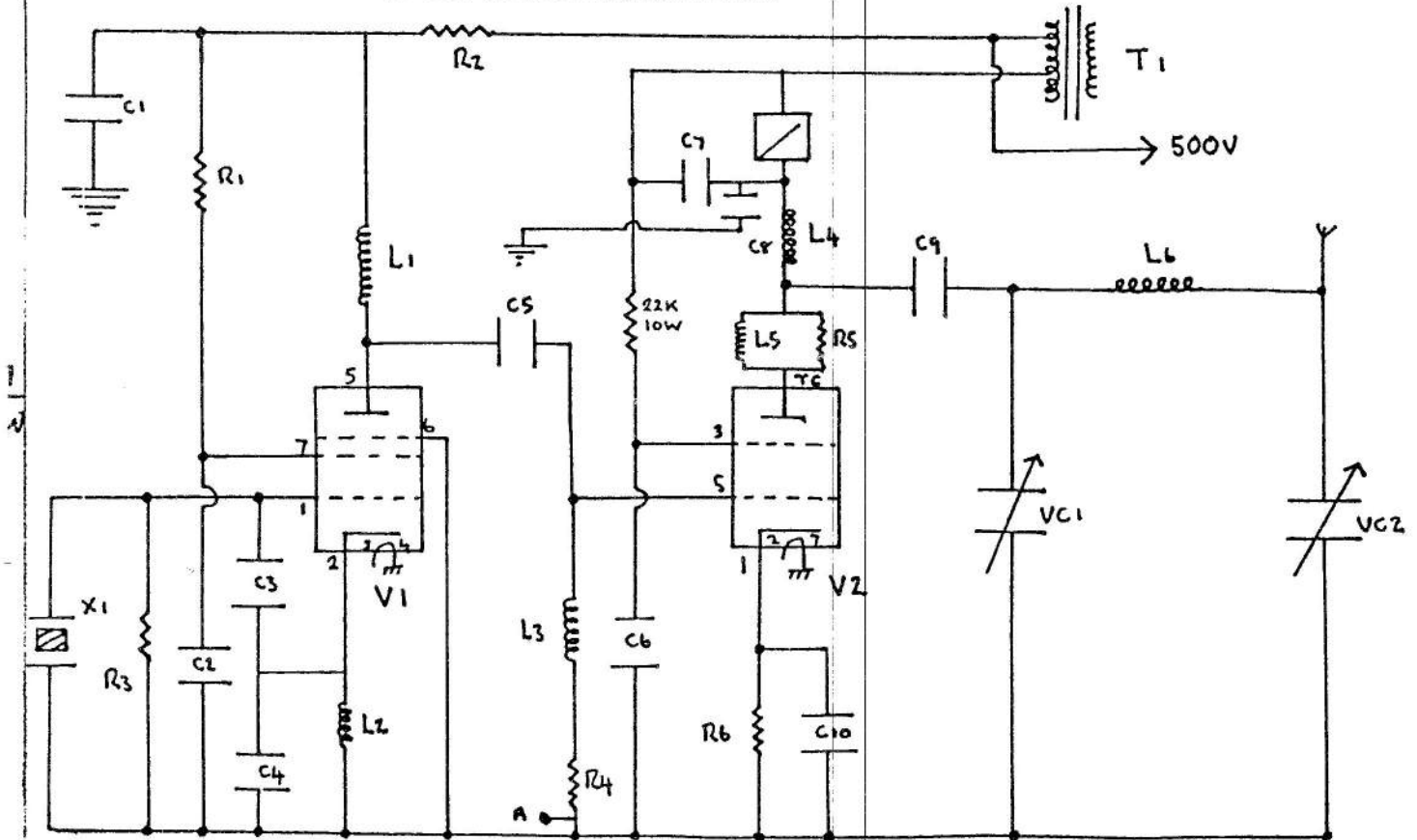
UHF type (soldered screen)



BIBLIOGRAPHY

How to Draw and Make your own PCB by R.A.Penfold Babani Books. £1.95 from Maplin.
 Two Meter Antenna Handbook by F.L.Judd G2BCX Newnes Technical Books £5.95.
 VHF UHF Manual edited by G.R.Jessop G6JB RSGB
 This book is a mish mash of info aimed at Radio Amateurs. Some is relevant, most isnt. The chapter on aerials is worth a look. About a tenner.

60WATT MEDIUM WAVE TRANSMITTER



60 Watt medium wave transmitter

RESISTORS - all 1/2 watt unless stated

- R 1 4.7K 2W
- R 2 27K 3W
- R 3 22K
- R 4 22K
- R 5 33
- R 6 220 3W
- R 7 (between C7 & C6) 47K 3W

COILS

- L 1 2.5 mH RF Choke
- L 2 2.5 mH RF Choke
- L 3 2.5 mH RF Choke
- L 4 2.5 mH RF Choke 200 mA
- L 5 6 turns 22 swg en. cu. wire round resistor
- L 6 70 turns 22 swg en. cu. wire round 1 3/4" former.
Tapped at 5 40 turns
and then every 5 turns.

MISCELLANEOUS

- M 1 150 mA meter
- X 1 medium wave crystal (1MHz - 1.5 MHz)
- T 1 modulation transformer (Woden UM 1 or similar)
- A Metering point. Disconnect R4 from earth. 6146 grid current should be set to 3.4 mA by changing the value of EF 91 screen grid resistor if necessary.)

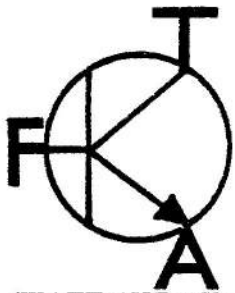
CAPACITORS

- C 1 0.005 mfd 500v
- C 2 0.005 mfd 500v
- C 3 30 pf 50v
- C 4 200 pf 50v
- C 5 100 pf 500v
- C 6 0.005 mfd 500v
- C 7 0.01 mfd 1Kv
- C 8 0.005 mfd 1Kv
- C 9 0.005 mfd 1Kv MICA
- C 10 0.005 mfd 50v
- VC 1 500 pf (wide spa
- VC 2 1000 pf

VALVES

- V 1 EF 91 or 6AM6
- V 2 6146 or QV06-20

ERROR There should be a link between the cathode of V1 and the junction of C 3 & C 4.



FREE THE AIRWAVES TRANSMITTER PLANS

1/2 WATT DRIVER STAGE (DIAGRAM 1)

4WATT VHF M Transmitter, parts and instructions

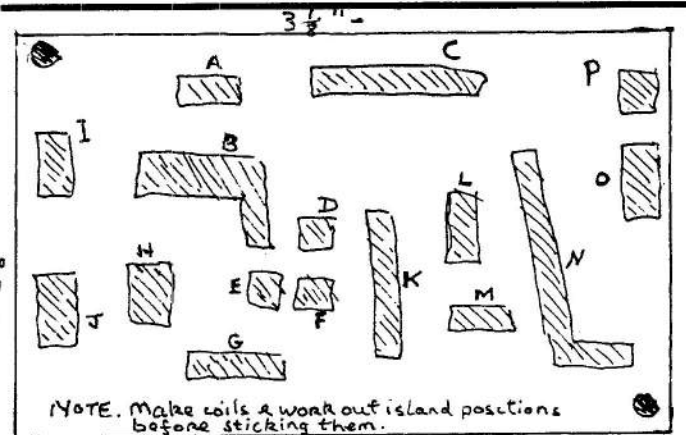
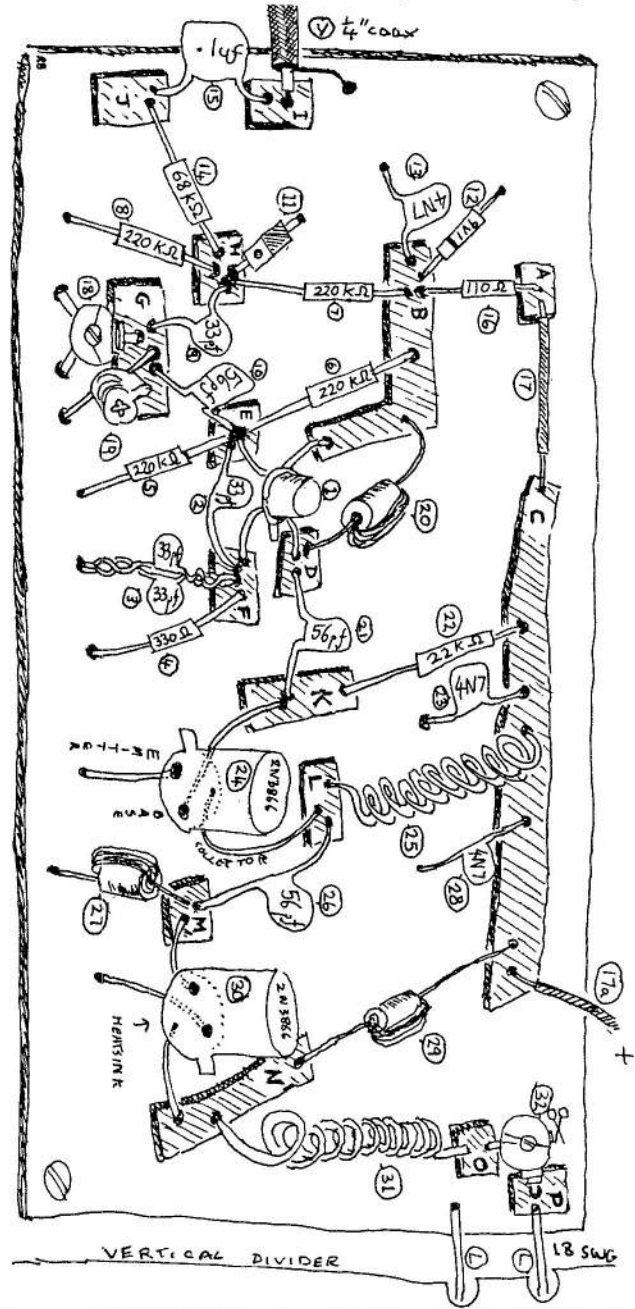
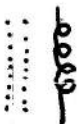
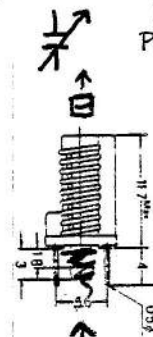
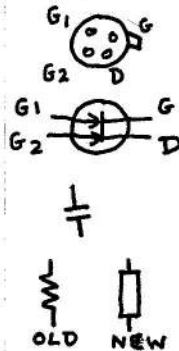
* Get some *double-sided copper clad PCB*, enough to make boards in Diag. II and IV, and a piece 1 1/2" x 3". Cut PCB with *stanley knife* - score, bend, snap. Cut islands with *junior hacksaw*. Clean with *emery cloth*. Drill holes 1/8" bit. Mark islands with felt tip A to X (see Diags. II and IV). Mark board. Glue islands with *Lochite superglue* - one drop will do. Clean islands of any glue. Apply liberal amount of *solder* to islands with a decent *iron*, 25watt Weller is a good buy, small style.

DIAGRAM I. ASSEMBLY ORDER

1. **3SK51 or 40673 dual-gate mosfet transistor**
Cut two legs off to about 2/10", opposite sticking-out bit. Apply solder. Try not to handle transistor, but use legs to position. Stick these legs to islands B and E. Cut other legs, press down and solder to islands D and F.
2. **33pf capacitor**
Same principle, cut one leg, apply solder, use other leg to position.
3. Wind 2 x 33pf capacitors legs together. Solder to islands F and the negative rail, which is the board.
4. **330 Ω resistor, 1/4 watt (orange/orange/brown)**
Keep close to 3, island F to board.
- 5/6/7/8. **4 x 220K Ω 1/4 watt (red/red/yellow)**
9. **33pf**
10. **56pf**
11. **BB105B or BB205B varicap diode**
Spot nearest island.
12. **9V1 zener diode**
Line nearest island.
13. **4N7 capacitor (or 4700pf, or .0047uf)**
14. **68K Ω (blue/grey/orange)**
15. **.1UF capacitor (or 100N, or 100,000 pf)**
16. **110 Ω (brown/brown/brown)**
17. **Single piece of insulated 3-amp wire**. 17a. Same
18. **2-22 pf foil trimmer/variable capacitor (plastic)**
Odd leg is positive and goes to island G
19. **MC108 Toko VHF mounted coil inductor 5.5 turns, 0.64 μ.H**
This is the most tricky component in the circuit, due to difficulty in raising ferrite core. Sharpen a piece of plastic with Stanley Knife to act as trimmer. Be patient. Order a number of different coils near this one, so that you can experiment, as it is this component and the variable capacitor above that combine to create the frequency for transmission.

MC 108 TOKO: Another way of getting into the ferrite core is to heat up a needle in a flame, pierce underneath, and then push up.

20. **RF choke, fixed inductor**
This isn't ready-made, but you have to build it yourself. Get a dozen **FX 1115 ferrite beads** and some **28-gauge, enamelled SWG copper-wire**. Wind wire through middle 6 times. Remove enamel from the ends, best way to do this is to burn off then use emery cloth.

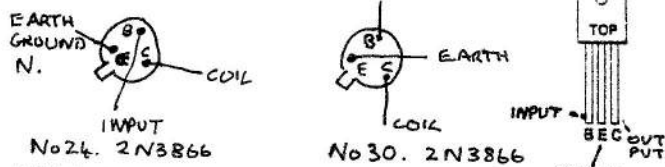


Actual Size 2-1/8" x 3-1/8" with islands for 1/2 WATT DRIVER STAGE (Fig 2).

- 21. 56pf
- 22. 22KΩ
- 23. 4N7

24. 2N3866 transistor
 Before bending legs into right position relative to islands, we must *heatsink* transistor. Small heatsink will do. Plus we need *silicon grease* in a syringe. Put grease around sides of transistor can, prise open heatsink with screwdriver, slide tranny in, take out screwdriver. Bend legs and cut. Solder. Make sure with crossover that no legs touch.

VIEW FROM BELOW



**This transistor can be replaced by 2N4427 if used with 2SC 1971 in place of the MRF237.. 2N4427 has the same pin position.

25. 18-gauge enamelled SWG copperwire
 Wind wire 9 times around pencil, shape legs, scrape off enamel and solder.

- 26. 56pf.
- 27. RF Choke. Fixed inductor. Same as no. 20.
- 28. 4N7
- 29. RF choke, as above

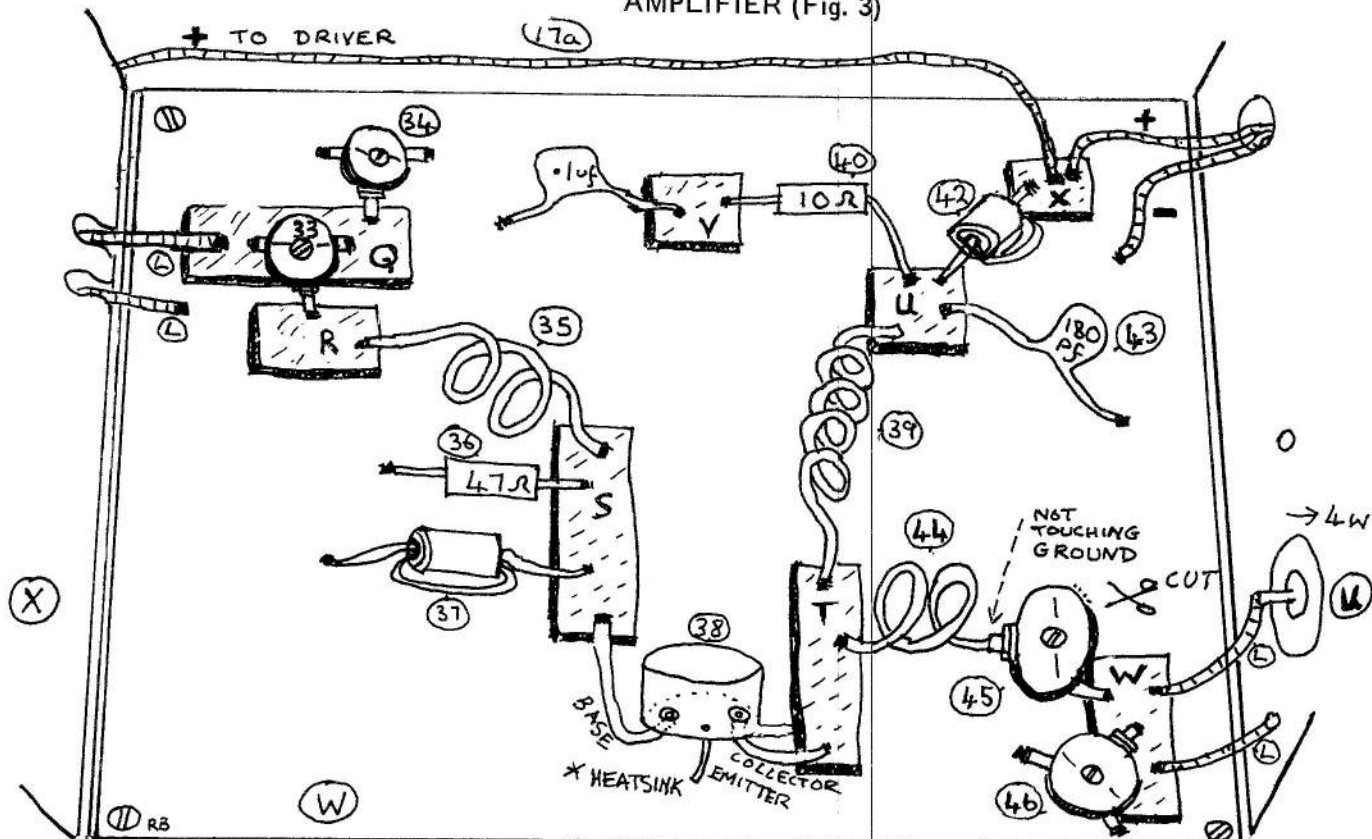
- 30. 2N3866 The larger the heatsink, the better. See No. 24.
- 31. SWG 18 gauge enamel copperwire 10 turns this time.
- 32. 2-22 pf variable
 Positive leg to P. Cut off leg facing leg on 0.

** The first board can now be tested once we have added piece of UF67 Coax, or any heavy-duty 7mm CB Coax. (See diag. V). We must fix Coax to a UFH male plug (see diag. VII). Plus we need *stereo 1/4" jackplug socket* plus 250KΩ *log pot* and some insulated 3-amp wire. To properly test and develop we need:

- a) a *power supply* — a CB 13.8v 3-amp unit, or a 12v car/motorbike battery.
- b) a power/SWR meter—capable of up to 150mHz, plus dummy load=25W
- c) A frequency counter. This is the most expensive item. A Thandor PFM200A is the best value
 We could do without a frequency counter, but if anything is slightly out, ie off the VHF band, than a radio receiver is no good to find a fault.
- d) A cassette-player with a 5-pin Din plug.
- e) A radio receiver

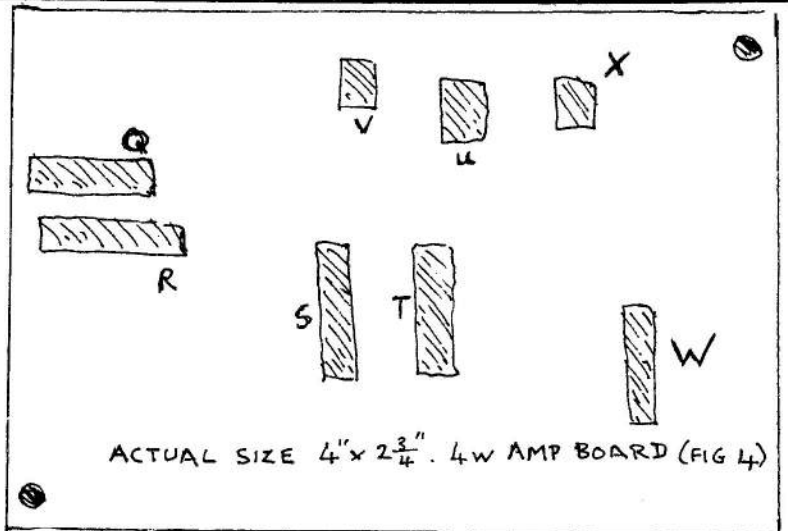
Fit to power supply, fit to power meter. Turn on frequency counter. Set counter to 0.2 gate, put probe into left-hand socket (probe can be just a piece of single core insulated wire). Turn on power. Adjust parts no. 18 and no. 19. See the reading change. Choose a free frequency. To adjust power, turn part no. 32 (to adjust variable capacitors, use a plastic trimmer).
 If all's going well, plug in cassette (5-pin Din plug to 1/4" jack Tandys). Put in your favourite tape, turn on radio, and if everything's okay you should hear your tape on the radio. If something is wrong, check and double-check. If you can't work it out, send board back to us via Free The Airwaves and we will see what's wrong. If everything's okay then you can go to the next stage.

SCHEMATIC DIAGRAM FOR 4WATT AMPLIFIER (Fig. 3)



(41) = 7 mm UHF plug socket (Output to SWR meter/aerial or 25w amp) (34) = 18 SWG
 (X) = soldered dividing wall. (W) = board and islands, double sided copper clad PCB superglued.
 See also Fig. 6.

- 33. 3-90 pf variable capacitor (foil trimmer).
- 34. As above
- 35. 2 and a half turns of 18 guage tin coated SWG using a 1/4" drill as former.
- 36. 47Ω resistor.
- 37. RF choke, same components but only 3 turns.
- 38. MRF237 transistor Large heatsink.



- 40. 10 Ω resistor.
- 41. .1uf.
- 42. RF choke - 3 turns.
- 43. N18 (or 180pf)
- 44. 2 turns 18 TC SWG Solder directly to positive leg of part no. 45, which is a 3-90pf trimmer. Cut off leg facing away from island W.
- 45. 3-90pf trimmer
- 46. 3-90pf trimmer

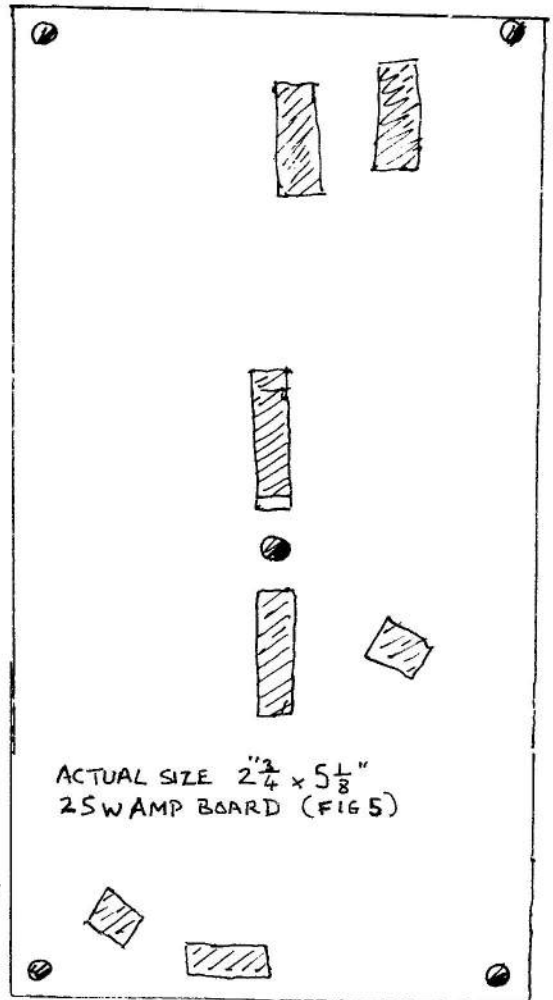
We are now ready to fit into a box (see diag. VI). Get 8" x 3" x 1 1/2" aluminium box. Drill holes. To put in divider, solder along dotted line in diag. 111 and solder along side of divider. Don't solder together yet. Solder TCSWG18 wire between earth and islands P and Q. With the second wire make sure there is no contact with earth. Now solder divider, also making sure no contact with P and Q connection. Last points to solder, using same wire: from island W to centre of UHF female plug, and from earth to outer. Solder 4N7 capacitor from the stereo plug to earth. see dia. 6 and 8 for positions).

If all's well on testing, using same procedure as with first board - you should get nearly 5 watts with the 13.8v supply. To trim up power, go through each variable capacitor starting from island P until you get the maximum reading from each capacitor.

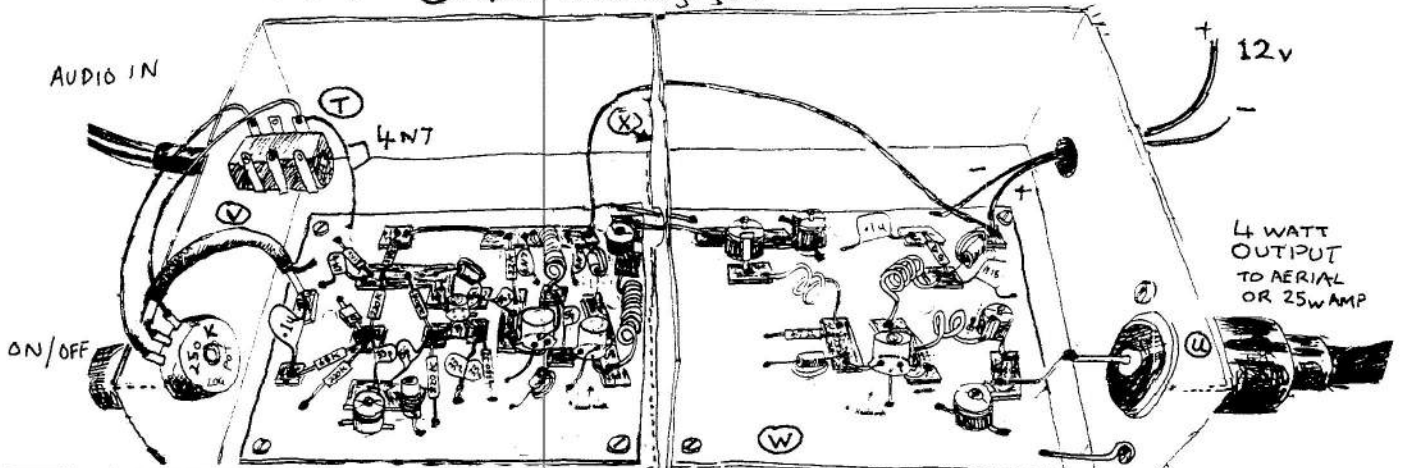
Now you must make an aerial. Get 10 metres of UR67 Coax. 4 metres of 1/2" aluminium tubing (either go to a specialist metal supplier, or get an old H or X 407 VHF TV aerial). Cut to the frequency required (see diag. V11 for calculation). Plus we need some 1/2" electrical conduit and about 3 feet of 2" by 1" wood.

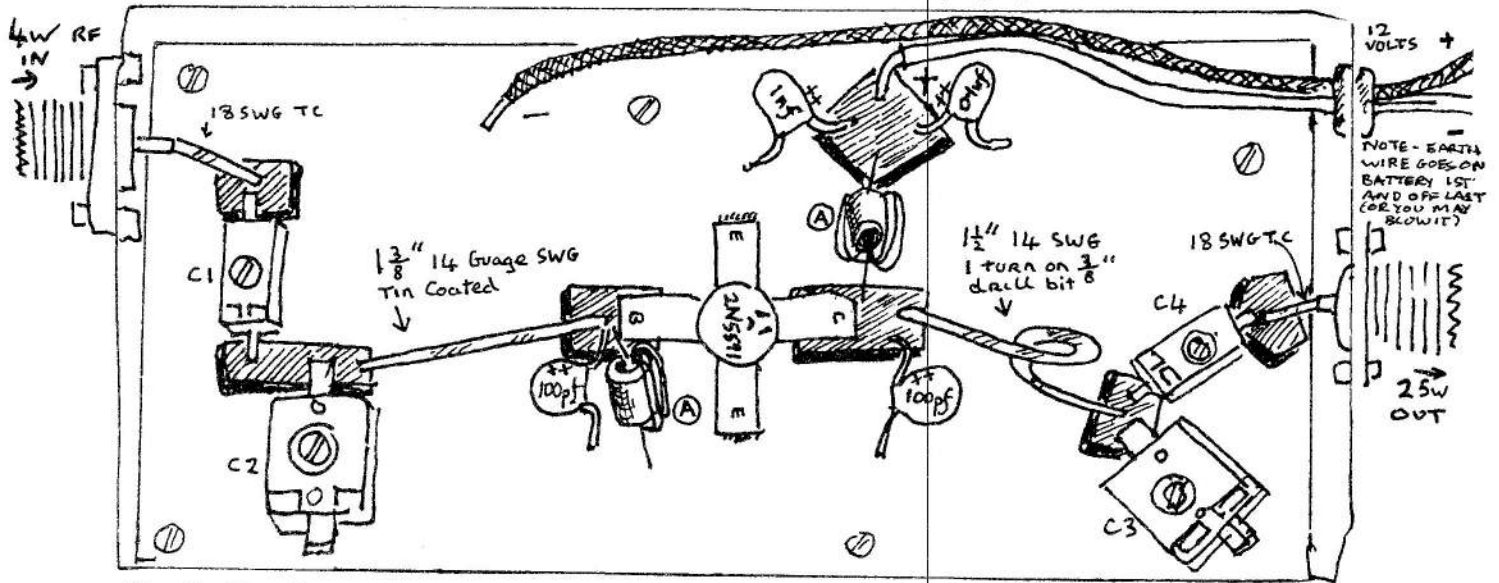
To tune aerial to its maximum efficiency, we want a setting nearest to 1 on the SWR scale. Experiment first with dummy load. Remember, maximum watts and a rubbish SWR reading won't help you get a better signal.

To test press SWR button, press SET button, slide scale till the meter reads SET, then press TEST button- if its properly tuned, the needle will drop to 1. Now try with aerial- don't worry about power reading- with a setting of 2.5 SWR, this will get you over a mile with a 12v battery. Try aerial in different positions and locations. The best results will only come with experience and experimentation.



BOX & WIRING (Fig. 6)
 ⊕ = 1/4" jack plug socket.
 ⊙ = 1/4" co-ax. (see fig 3.)



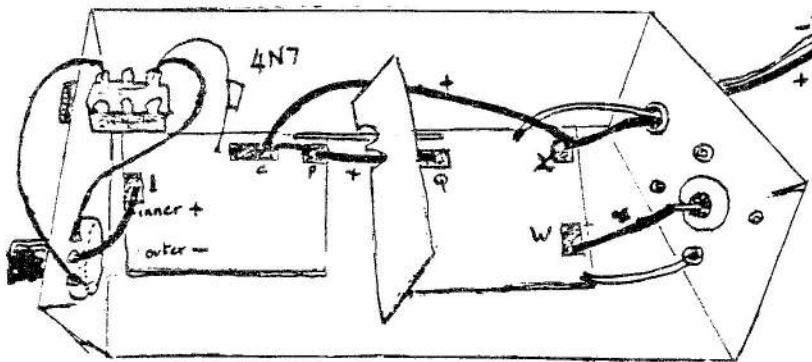


- C1 5-80 pF C2 ARCO 464 25-280 pF
 C4 5-80 pF C3 " " " "
 (A) FERRITE BEAD - 3 TURNS SWG 28 RF CHOKE

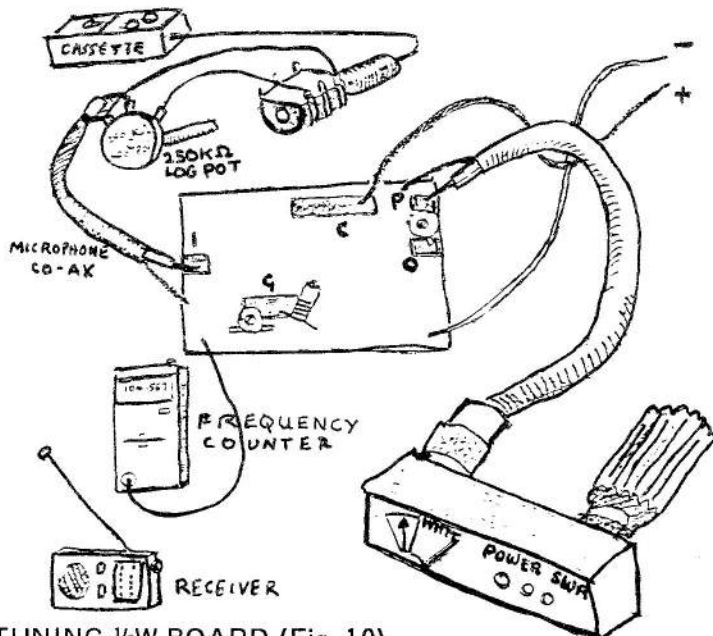
NOTES.

- 1.) AS WE GO TO PRESS WE FIND THAT THE ARCO CAPACITORS (C3 AND C2) ARE NO LONGER EASILY AVAILABLE. WE CAN GET ROUND THIS BUT DON'T HAVE TIME TO TEST THE NEW DESIGN. ANYONE WITH A SOURCE OR STOCK OF ABOVE PLEASE CONTACT 'FREE THE AIRWAVES'!
- 2.) LAST ONE WE BUILT WE USED SILVER INSTEAD OF TIN COATED WIRE WITH BETTER RESULTS.
- 3.) 25W IS THE MAX OUTPUT. SHOULD BE OK WITH 80W AMP (P.61)

HEAT SINK (UNDER 2N 5591)



WIRING (Fig. 8)



TUNING 1/2W BOARD (Fig. 10)

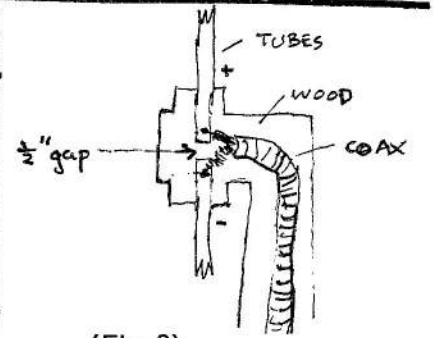
Anyone who has any better ideas, why not let us know so we can make them available. Or, if you have any queries, or want to get parts, or even ready built, please write.

Free The Airwaves

Approximately 480 one - mile - radius local VHFMM communication stations are possible in London. In the most dense areas we are talking about 50,000 people, eg. the Elephant and Castle district. For less dense areas, where, say, only 12,000 people live in a 5 - mile radius, we are trying to develop a 10 watt transmitter. Again, if anyone knows any useful information, don't sit on it, give it to Free The Airwaves.

THE LATEST 'RADIO CRIMES' IS OUT NOW! FOR NEXT 3 COPIES SEND MINIMUM DONATION. £2 (For organisations £10) for next 3 ISSUES. to : FREE THE AIRWAVES. BCM BOX 1502, LON. WC1N3XX.

Aerial design
 Keep inner wire as short as you can and as covered as you can
 Face dipole with inner wire upward.



(Fig. 9)

LENGTH OF TUBING = $\frac{300}{f} \pm 4$

5 Watt Transmitter. Complete Building Instructions.

GENERAL DESCRIPTION

The following describes a small VHF FM transmitter with an output power of 5 watts, adequate to cover a 3 or 4 mile radius reception area from a suitable high transmitting site. The microphone or cassette recorder can be connected directly to this transmitter. To test and tune it you will need a multimeter, a dipmeter and preferably a RF power meter.

With just a modicum of effort this 'peoples transmitter' achieves acceptable frequency stability, low feedback from output to input, and a stable power output. In-built pre-emphasis means that the audio quality is good.

5 Watt Transmitter : CIRCUIT DESCRIPTION

T1 is configured as a microphone pre-amp with enough sensitivity for low impedance microphones. T2 and T3 are configured to provide standard pre-emphasis. D4 provides protection against the supply being connected the wrong way round. The field effect transistor (FET) T4, (BF245) is configured as an oscillator (and is a very good feature for stopping the frequency from wandering). Two varicap diodes D3 and D3' (BB105) or a double varicap diode (BB204) allow the frequency of the oscillator to be modulated. T5 is configured as a buffer. T6 and T7 are cascaded to form a high performance amplifier, with high stability. The transformer L2 ; L3 enhances the performance of this amplifier. C25 and R9 protect T7 from overload. T8 is the power amplifier.

If the transmitter is tuned up at a frequency of about 98 Mhz (see later) the desired frequency can be set with C16 without the power output falling below 4 watts, i.e. it should not be necessary to re-tune.

When drilling the printed circuit board (PCB) use 3mm diameter for mounting holes, 1mm diameter for trimmers and coils, and 0.8mm diameter for the rest. Mark the mounting holes on the bottom of the case.

Radio Support Group

We reprint here complete details of a more sophisticated 5W TX which has been translated and developed by our Radio Support Group in Bristol. The approximate cost of parts (excluding PCB board and case) is a mere £16, once you've got hold of the tools and testing gear.

To join Radio Support Group and get updates and development aid write to:

Radio Support Group, c/o Drowned Rat

Communications.

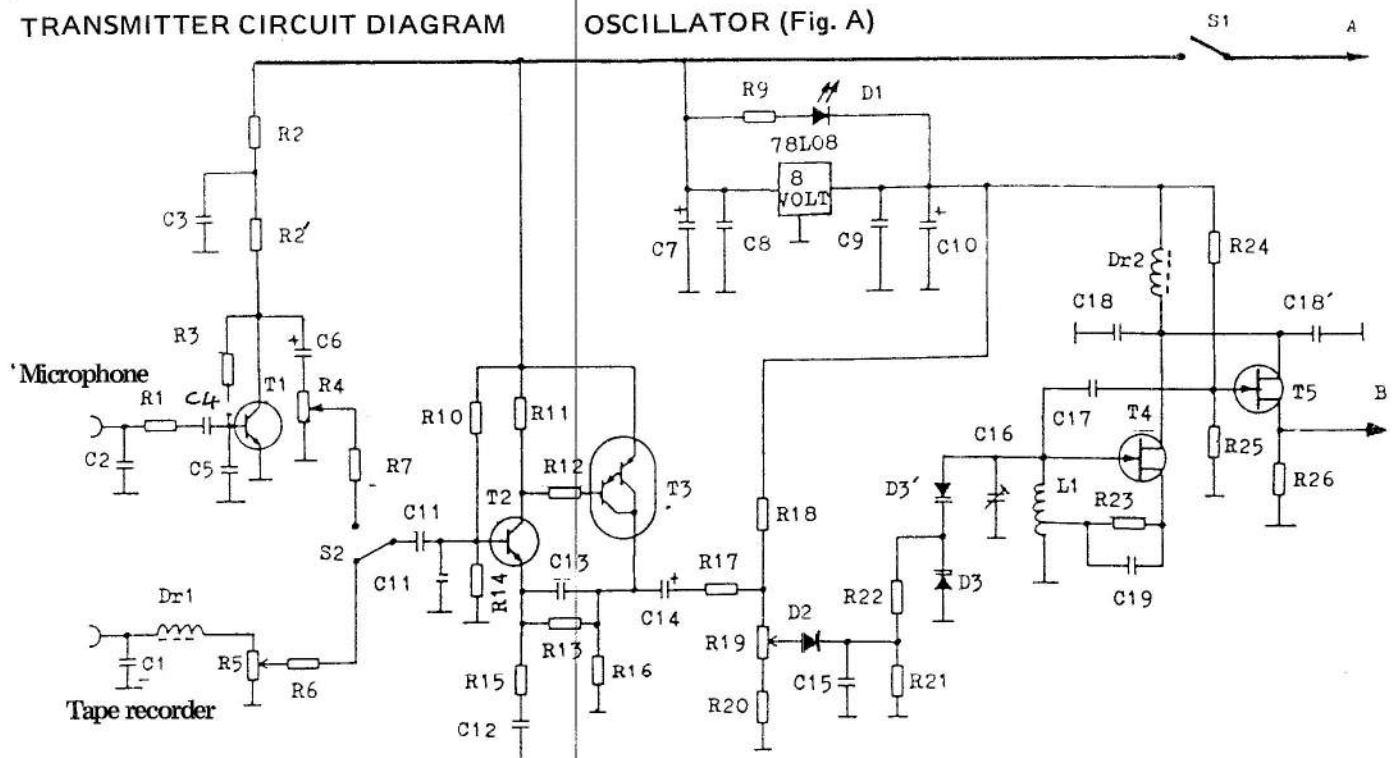
Box 010,
27 Stokes Croft,
Bristol,
Avon BS1 3PY.

Begin by constructing the low frequency section, and the oscillator and the buffer, i.e. all the parts in Figure A of the circuit diagram. First mount the resistors, then the diodes. The symbol for a diode in the circuit diagram is an arrow with a bar in front of it. The bar corresponding to the broad ring of the diode and the varicap, and the middle lead on the BB204.

Next mount the capacitors and trimmers. Be careful when bending the leads of the ceramic capacitors near the body of the capacitor, as it can crack. Ensure the electrolytic and tantalum capacitors are mounted the right way round. Finally mount the semiconductors and the coil L1. The coil should touch the PCB with all its turns (windings) and should be inserted with no tension on the turns. After testing stick it to the PCB with UHU (glue). This will improve frequency stability and help prevent microphony. The coils are best wound on drill bits of the correct diameter. R23 and C19 are soldered 1½ turns from the cold end of the coil (thats the end connected to earth). Use solder sparingly to avoid damaging the coil. Mount the semiconductors the right way round. The pinouts are shown from below.

TRANSMITTER CIRCUIT DIAGRAM

OSCILLATOR (Fig. A)



This is the underside of the board viewed from below (Components on other side).

Ⓐ lines up with Ⓐ on Fig F. Make your PCB board from this.



Ⓐ OSCILLATOR PCB DESIGN Actual Size Fig. B

Now check whether the right component is in the right place. Inspect the track side of the board for short circuits and breaks. Check for short circuits across the power supply connections with an ohm-meter. Apply 12 volts via an am-meter, preferably from a stabilised power supply with current limiting. Otherwise put a 1 amp fast-blow fuse in the positive supply lead. If it blows there is either a short circuit, or D4 is the wrong way round, or the power supply is the wrong way round. Check D4 each time the fuse blows. There should be a current of 20 to 25 milli-amperes (mA) (without the LED connected). Tune a receiver to the desired frequency and adjust R19 and C16 until the receiver goes quiet. This means the oscillator is OK. With C16 in its middle position the oscillator frequency will probably be between 100 and 104 mhz.

Now connect an audio signal to an input. Switch S2 has to have been connected to do this. adjust the two pre-set resistors, R24 for the microphone input and R5 for the tape recorder input, so that the signal can be heard in the receiver as loud as possible without distortion. It can be a bit louder than all the other broadcasting transmitters. If you can hear your signal on several frequencies as you tune the receiver, use the transmitter without an aerial or take it into another room. If you can still hear it in several places then something is wrong.

If you have a dip-meter (or absorption wavemeter) its much easier to check whether the oscillator only oscillates on one frequency. If it does oscillate on more than one frequency, re-solder R23 /C19 onto the coil L1 a turn from the cold end. The best point of contact is when the oscillator only oscillates properly on any one frequency in the FM band. In 90% of all cases the point of contact is 1½ turns. Exceptionally high gain FET's are responsible for the exceptions.

If the oscillator doesn't work at all, and the voltage supply is correct, either D3, D3', T4, or T5 are the wrong way round, or there is a short circuit. Bear in mind that the oscillator is THE MOST CRITICAL PART of the whole circuit.

Mountains of solder and dry joints (to be avoided anyway) are most harmful here. All parts, especially L1, have to be completely stable and must not move on impact. The bodies of T4 and T5 should be no more than 2 to 3mm above the PCB.

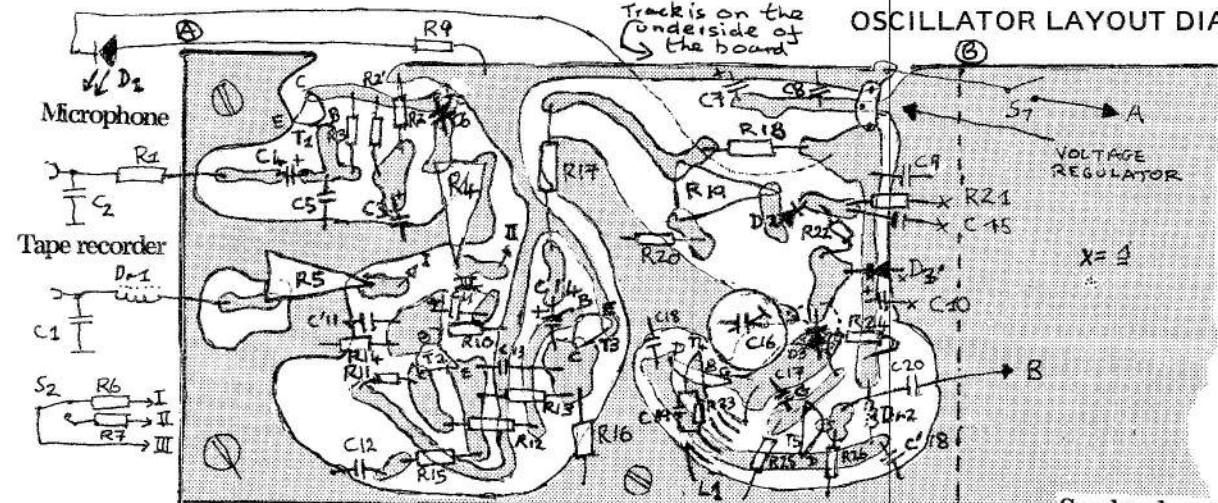
Rotating R19 anticlockwise increases the transmitter frequency as does unmeshing C16. The frequency should be adjustable between 80 - 150 Mhz. (If you want a higher frequency see later '2M Modification').

The final adjustment of the oscillator and tuning the amplifiers can only be done after finally building the transmitter into its case and putting the top on. If you want to alter the frequency often rotate R19 fully anticlockwise and set the highest wanted frequency with C16. The frequency can now be altered using R19. You could possibly replace C16 with a ceramic capacitor (colour black or red!). If you want to use a frequency under 80 Mhz add one turn to L1. If you use a BB204 for D3 you can tune across the whole FM band with R19. The circuit is designed so that the modulation index remains constant as you change the frequency.

Now the VHF amplification stages (Figure D of the circuit diagram). Begin by mounting the resistors and capacitors. The ferrite bead Dr6 is threaded onto one of the R27's leads. All connections which go to earth (X in the circuit diagram) solder onto the top and bottom of the PCB. In all other cases solder only on top. Construct the transformer L2:L3 (see Fig K). Use 0.2 diameter enamelled copper wire for L3. Wind round a ferrite bead 3 times and tighten carefully. Don't cut the wire too close to the bead. Tin the ends. If you can solder through the enamel, no problem. Otherwise hold the ends of the wire in a lighter flame and carefully scrape off the remainder of the enamel with fine sandpaper. Then tin with solder. Put bits of sellotape on the ends so as not to confuse them with L2. Same thing now with L2, only its 6 windings this time, three right and three left of L3, spread equally over the bead. Now mount L2:L3, keeping the wire ends short, and fix it in place with glue.

Next mount the trimmers. All the legs that are going to be soldered on top of the PCB should be tinned with solder beforehand, as should their respective contact points on the PCB. Bend these legs outward at right angles so that the trimmer will lie flat against the PCB. Use a little soldering iron (15-20w) and be very careful, the material the trimmers are made of can't take much heat at all. It must NOT be touched with the tip of the iron. Check after soldering that you can turn the trimmers easily.

OSCILLATOR LAYOUT DIAGRAM (Fig. C)



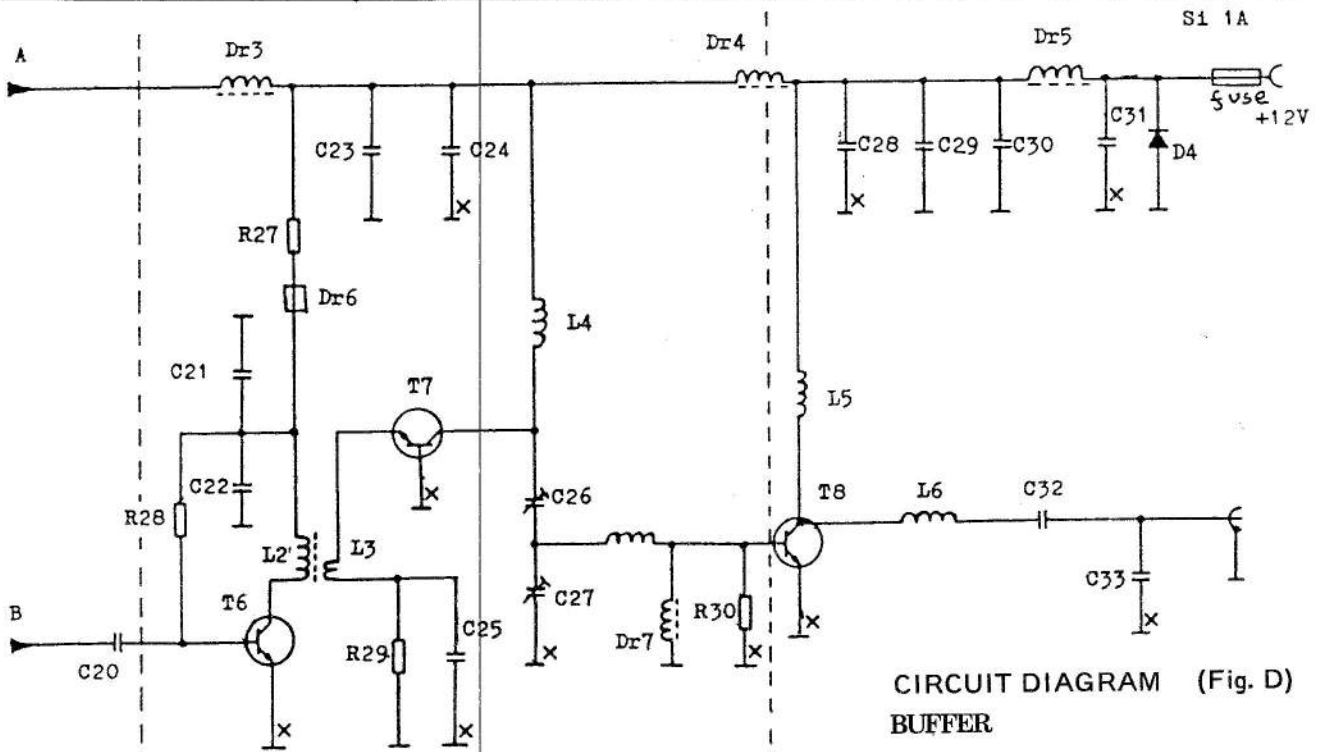
X = soldered on both sides

This is the left hand side of top side (component side) of the board viewed from above

Ⓐ Ⓑ Ⓒ line up with Figs A, E and F. A bit of a mind twister!

on layouts... X = Soldered Top and Underside

See back page for blow-up of design.



Next mount the transistors. First T6 and T7. The transistors should be mounted close to the PCB (2-3mm). This is especially important for the emitter of T7 (base to earth). Ensure that nothing metallic touches T7's case as this is connected internally to its collector. Now mount the MRF237. Slightly countersink the base and collector holes on the underside of the board with a 3mm drill. This is to prevent a short circuit between the transistor's base and collector leads with the earth plane. Mount the transistor underneath the board onto the earthplane, having first put some heatsink compound on the bottom of the transistor (ie between the transistor and the board). Push the transistor against the PCB and solder base and collector on top. You can either cut off the emitter lead beforehand (this is connected internally to the case) or put it through its hole, and bend it so it can be soldered to the screen to the left of T8 (to be put on later). Using a high powered soldering iron (at least 50w) solder the case of the transistor to the earth plane. This has to be done as fast as possible. Rather hot and fast than slow and cold!

Now wind and mount the remaining coils. It doesn't matter in which sense you wind them (clock or anticlock-wise) except that they should stand at right angles to each other (at each stage) and be as far as possible from the sides of the case. This is especially important for L4 and L6. L6 should be approx. 5mm above the PCB.

The printed circuit board should be attached to the bottom of the case in such a way that the MRF237 is gently pressed against the bottom of the case. This is done with bolts

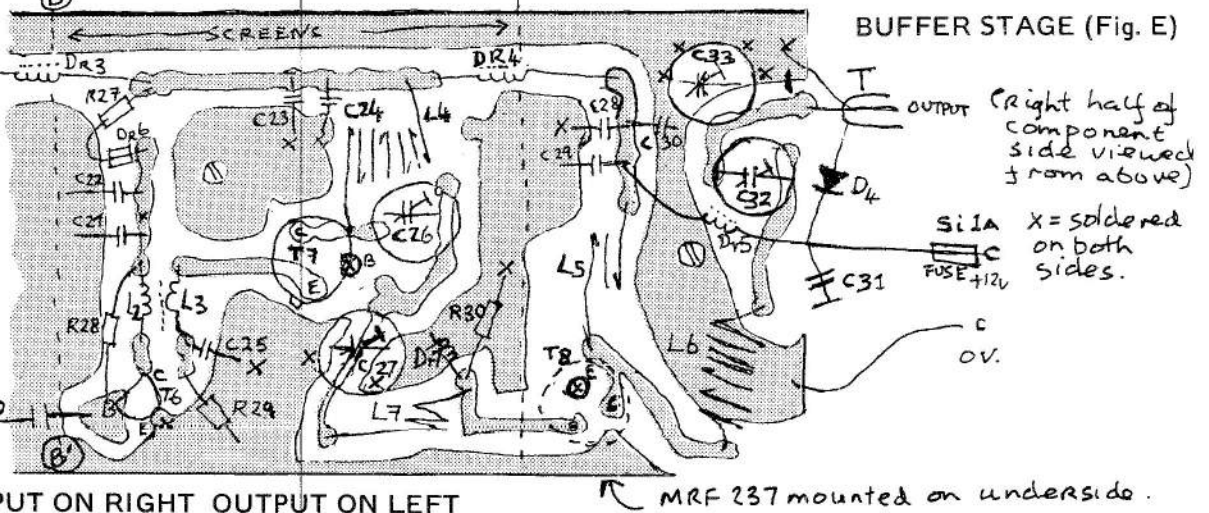
washers, spacers and nuts. Don't forget to put some heatsink compound between the transistor and the case.

The screens to the left of T6 and T8 are made from bits of single or double sided PCB. They should be measured to fit neatly with the sides and top of the case. Where a PCB track goes from one chamber to the next the screen will have to be filed at the bottom to prevent shorting. Watch the trimmers when soldering!

The circuit is complete now, only Dr3, Dr4, Dr5 are missing. Connect 12v to the input of the 8v regulator and to the top of R27. There should be a current of 30-50 mA. The collector of T6 should be at 10-11v. If it is 0v, L2 is an open circuit. If the voltage is too low, R28 has to be increased, and if too high (rarely) decrease R28. Now mount Dr3. Put trimmer C27 into middle position. Turn C26 so it is 1/4 meshed. Connect the 12v supply again, the current should be 80-120 mA. Write down the current and then adjust C26 and C27. The current consumption will change and T7 will get hotter than T6 (but should still be cool enough to touch). If the current consumption is still 50 mA as before there is a mistake somewhere. There should be a 12v on the case of T7. If there are no short circuits and no tantalum capacitors connected the wrong way round (Do check each stage meticulously before connecting the supply) the only possibility is a broken trimmer. If you have a dip meter or absorption wavemeter hold it near L4 and tune through..ie check there is no spurious output on other frequencies. Switch off again.

Finally mount Dr4 and Dr5 and clip a heatsink onto the

In the Fig C half of board the track is on underside. But on the buffer half the track is on top and below is solid copper. All components on this side. In Fig C they connect through drilled holes. Geddit? (B) and (B') line up with Fig. C.



MRF 237. Solder a piece of co-ax cable to the output. Connect the cable by soldering a suitable plug onto the end to a dummy load via a Voltage Standing Wave Radio meter (VSWR meter) with power indication. Alternatively use the circuit in Fig.2 as the dummy load and a VSWR meter without power indication.

NEVER use the transmitter without a load! Short circuits can destroy the MRF237!

Check with an ohm meter that your dummy load has a resistance of 50 ohm. Now adjust your power supply to a maximum current of 800mA (if you can, that is). Adjust the trimmers C26... $\frac{1}{4}$ C27... $\frac{1}{2}$ C32... $\frac{1}{4}$ C33... $\frac{1}{4}$ (ie. C26 $\frac{1}{4}$ meshed, C27 $\frac{1}{2}$ meshed etc.)

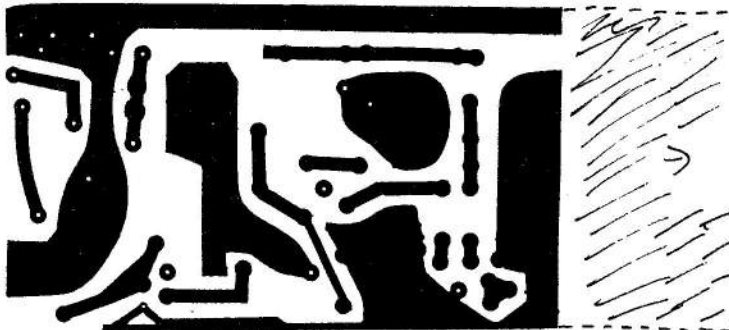


FIG. F PCB DESIGN FOR BUFFER STAGE OF OSCILLATOR. (The actual pattern you get on top side of board is mirror of this) Viewed from below. (Figs B & F on same board!) ACTUAL SIZE

After switching on watch simultaneously power output and input current. Tune for max output power. Use a brass or aluminium tuning tool with an insulated handle. Tune C26, then C27 (doesn't have much effect) then C32, lastly C33. For the 1st 2 trimmers increasing power output results in an increase in input current. Not so with the final stage, if you mistune that current consumption can get too high.

Some power supplies go mad with high frequencies..try and get one which is high frequency stabilised. Very careful people start tuning with low power supply voltages, but the stage supplied by the voltage regulator needs 12v to make sure the V regulator is working properly. You should repeat the tuning several times to get the feel of it. Maximum output power is 6 watts with a 12v supply and a MRF237, which corresponds to an input current of 750 mA to the whole circuit, of which 640mA goes to the MRF237. Under these conditions the transistor dissipates 8w (as heat) which it can handle if it has good heatsinking. If you have a trial run outside the case, the earth plane will just about keep the transistor cool. The MRF237 can cope with 700mA for some time, but bear in mind that the voltage of a lead/acid battery can be up to 13.5 volts..ie its better to lower the output power by 0.5w, which isn't noticeable, than to risk low reliability by the transistor running too hot and blowing.

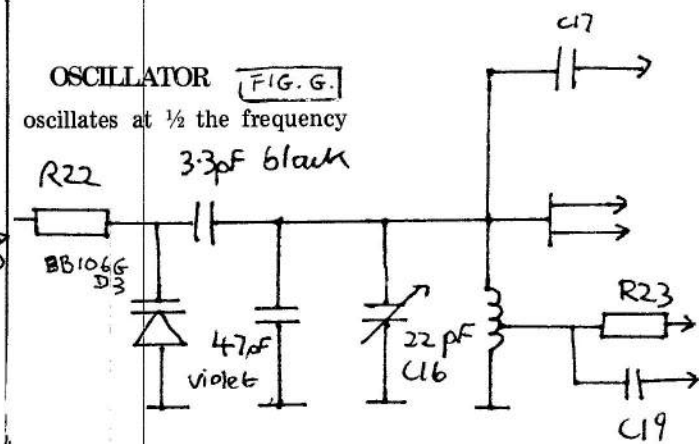
Using the formula $I = w/v$ (w over v), you can calculate the maximum allowable input current for a particular supply voltage V , and $W = 8$ watts. The power can be easily reduced by adjusting C27. You should only do this after everything is built into the case as the sides of the case affect the coils and lower the circuit's amplification. In any case there is enough spare gain in the circuit to tune it uncritically and still supply the MRF237 with enough input drive. With a dipmeter switched to absorption wavemeter mode check all stages are working on only the oscillator frequency. If the amplifier stages have sufficient gain the tuning should be completely uncritical and the oscillator should have good stability, even when used outside the case. This is in spite of the broadband circuit design. If C26 is completely enmeshed at maximum output power then pull the turns of L4 apart slightly.

Now mounting the board onto the case. Drill holes above the trimmers in the top of the case so the final tuning of the trimmers and R19 can be done with the top in place. Drill holes also for the switches, sockets and LED. Power supply and output sockets should be on one of the shorter sides. In the high frequency part of the board put thin copper foil

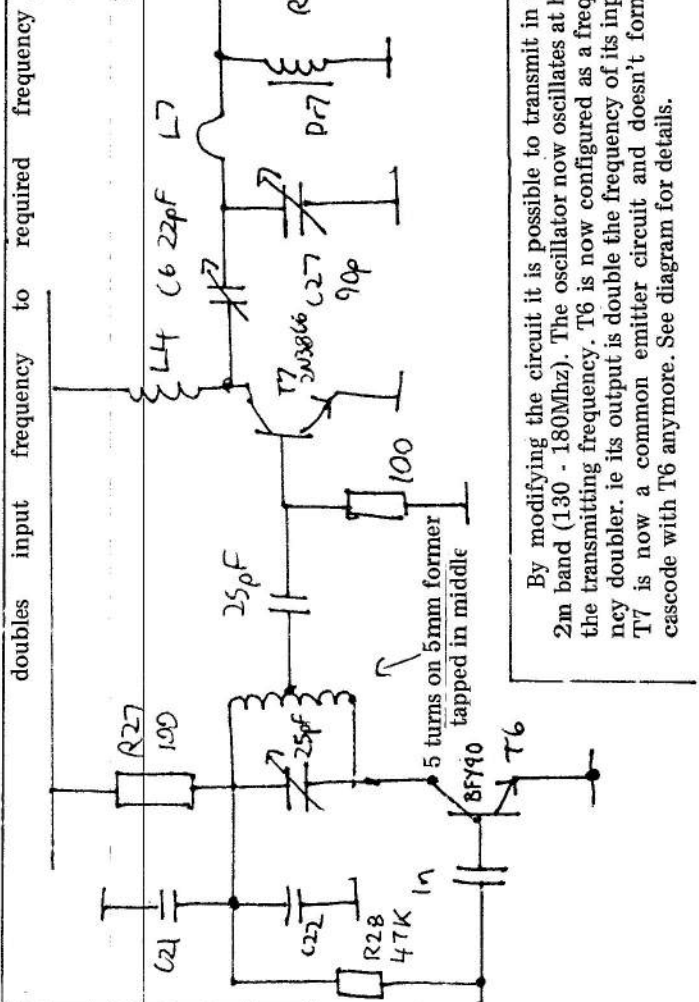
round the edge of the PCB, as far as the earth plane extends to, and round the edges of the screening walls. Solder on both sides of the PCB and the screening walls. Now using spacers, etc, mount the PCB. Don't forget heatsink compound for the MRF237. Mount the sockets and switch with all the components which are to be mounted on them (see diagram). Connect the output socket to C33 with the shortest possible length of wire. The earth connection can be soldered to a tag, which is bolted to one of the socket's mounting holes.

Now the final tuning. This is the same as the trial run. You should not use a dummy load with a SWR worse than 1 : 1.4. In practice the output power can be estimated from the power consumption of the transmitter, if you assume the efficiency is 60-70% approx.

2m MODIFICATION.

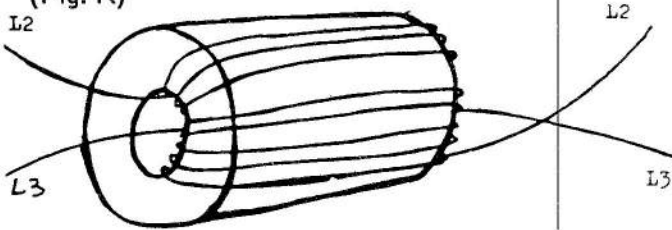


DOUBLER (Fig. H),






By modifying the circuit it is possible to transmit in the 2m band (130 - 180Mhz). The oscillator now oscillates at half the transmitting frequency. T6 is now configured as a frequency doubler. ie its output is double the frequency of its input. T7 is now a common emitter circuit and doesn't form a cascode with T6 anymore. See diagram for details.






Transformer L2:L3 wound on FX1115 ferrite bead.
(Fig. K)



C28 Inf ceramic
C29 100nf ceramic
C30 16nf 16v tantalum
C31 Inf ceramic
C32, C33 As C27



D1 LED
D2 1N4148
D3, D3' either BB105G (two) or one BB204G  
D4 1N4001

T1 BC549, BC239, BC109 (pref C type) 

T2 as for T1
T3 BC516
T4 BF256B or BF245B (not C type!) 
T5 BF256B or BF245B (C type possible) 
T6 BF254 or BFY90 
T7 2N3866 or 2N4427 
T8 MRF 237 

DR1 Wide band choke mounted directly
on tape recorder socket
DR2 3 turns of 0.2mm (34SWG)
enamelled copper wire on FX 1115 ferrite bead
DR3 wide band choke
DR4 wide band choke
DR5 wide band choke
DR6 FX1115 ferrite bead on lead of R27
DR7 wide band choke

L1 4½ turns of 1mm (18SWG) silver coated copper wire on
6mm former, tapped at 1½ turns from cold end
L2 6 turns of 0.3mm (34SWG) on FX1115 ferrite bead
L3 2 turns of (same as above) " "
L4 7 turns of 1mm (18SWG) silver coated copper wire on
8mm former
L5 3 turns of 1mm (18SWG) silver coated copper wire on a
6mm former
L6 6 turns 1mm (18SWG) silver coated copper wire on a
6mm former
L7 as L5

78L08 8v voltage regulator  viewed from below
S1, S2 switches 
Printed Circuit Board (PCB)
S0239 UHF socket with earthing tag
copper foil
braided wire
power supply connectors
input connectors
1A fast blow fuse and holder

COMPONENT LIST FOR 5 WATT TRANSMITTER.

R1 220
R2 470
R2' 4.7k
R3 1m
R4 100k min. trimmer, horizontal
R5 100k " " "
R6 47k
R7 47k
R8 not required
R9 220
R10 470k
R11 47k
R12 1k
R13 4.7k
R14 470k
R15 100
R16 2.2k
R17 2.2k
R18 2.7k
R19 100k min. trimmer, horizontal
R20 47k
R21 100k
R22 100k
R23 220
R24 150k
R25 100k
R26 180
R27 100
R28 27k
R29 2.2
R30 52 or 47

C1 Inf ceramic
C2 Inf ceramic
C3 47 μf 16v elect. PCB mounting
C4 10 μf 16v elect.
C5 1 nf ceramic
C6 10 μf 16v elect.
C7 15 μf 16v elect.
C8 Inf ceramic
C9 1 nf ceramic
C10 16 μf 16v tantalum
C11 47 pf ceramic
C12 10 nf polystyrene foil
C13 680pf polystyrene foil
C14 16 μf 16v tantalum
C15 680pf ceramic

C16 2-22pf min. foil trimmer 7.5mm,

green. (eg. Cirkit 06-22001)
C17 6.8pf ceramic
C18 plus C18', C19, and C20 1 nf ceram.
C21 100 nf ceramic
C22 Inf ceramic
C23 100nf ceramic
C24, C25 Inf ceramic
C26 2-27pf min. foil trimmer 7.5mm, red
(eg. Cirkit 06-36001)
C27 5.5-80pf min. foil trimmer 10mm, red
(eg. Cirkit 06-80001)

FOOTNOTES

Here is some info for people who aren't too knowledgeable about high frequency circuitry, and who probably have had even less experience on a practical level.

1. COMPONENTS SHOULD HAVE SHORT LEADS.

Every additional unnecessary length of wire in VHF circuits increases the chances of undesirable oscillations (properly called parasitic oscillations). To guard against this solder components as close to the Pcb as you can, to get an unambiguous output on just ONE frequency!

2. WE WON'T GET ANYWHERE WITHOUT EARTH.

The case must be earthed, ie be at zero volts potential relative to the negative side of the supply. Use a tag bolted to

the output sockets' mounting holes. Solder a thick bit of braided wire between the tag and the neg. supply input socket. This will earth the case, but the circuit board still needs earthing. There might be an earth contact from the MRF237 to the heatsink to the case but its better to provide an additional safe earth connection. Another piece of thick braided wire will work. Solder one end to the earth plane and connect the other to the case near the power supply connections.

If you use metal connectors for the microphone and tape recorder input sockets they will be earthed through the case. If you use plastic ones you'll have to solder a wire between the earth tag on the connector and the earth plane on the board. Better still regardless of choice of connector is to use a piece of screened audio co-ax.

3. EARTHLY DELIGHTS.

Its important to use a double sided PCB for the High Frequency stages, so that any part of the circuit can be easily earthed.

4. HEAT HAS TO GET OUT.

If, for eg, the threaded bolt of a high power transistor has broken off, its no use trying to solder it back on. A soldered joint doesn't transfer heat at all well, so either the transis-

tor overheats and is destroyed, or the heat melts the joint and then it overheats and is destroyed.

Similarly any heatsink has to be all one piece of metal. Even a setup like "threaded bolt- heatsink compound- heatsink -case-heatsink compound- another heatsink" does not transfer enough heat to the outside air. (But here we're talking about mega power situations you wont face with your 5 watter).

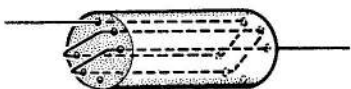
5. CAN YOU PUT ANY ONE IN ANY POSITION?

No. We'll have to wait till after the revolution for that. If you want to use different transistors than those mentioned you'll have to check the pin outs to see which is base, collector, etc. There are nearly as many pin outs as there are transistors. Check in a catalogue or data book that replacements are compatible.

6. MATCHMAKING

If you want to use a telescopic aerial check the matching before each use. You'll get much better results with a proper aerial. You might get a better match without using the full extension. How far you can pull such an aerial out depends (among other things) on the transmitting frequency..Matching can only properly be done with a VSWR meter, thats why its a basic piece of test gear.. See later under AERIALS.

Detail Of A Wideband Choke. **FIG. I**



TO MAKE A WIDE BAND CHOKE:

Get a FX1898 ferrite bead or Cirkit stock no. 55-25111. Wind 2½ turns of 24 SWG tinned or enamelled copper wire through 5 of the 6 holes as shown on the diagram.

WHERE TO GET THE PARTS:

Cricklewood Electronics, for instance, stock everything except the ferrite beads and the wire. Their MRF237 is rather expensive (£7.05).

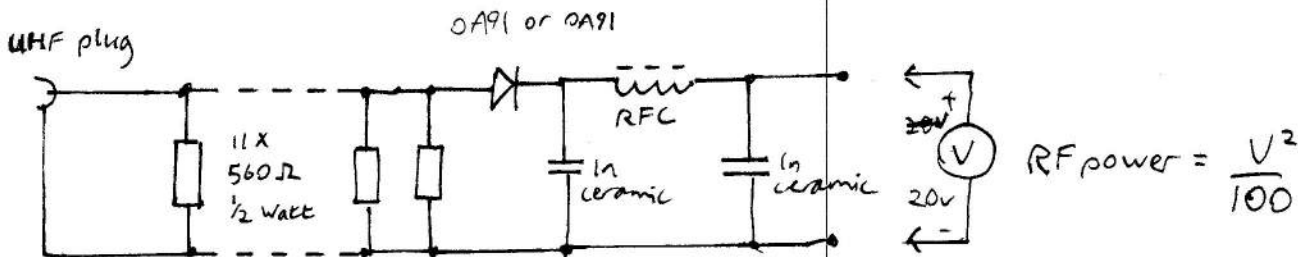
Maplin has most of the bits except some semiconductors, FX1898 and the silver coated wire.

Cirkit stocks most of the bits including the FX1115 ferrite beads (comes in packs of 10), the other ferrite bead, and the silver coated copper wire. They don't stock all the semiconductors but their MRF237 is cheaper (£4.46).

Cricklewood Electronics Ltd, 40 Cricklewood Broadway, Lon NW23ET. Tel. 01-450-0995 or 01-452-0161. Free catalogue on request.

Maplin and Cirkit catalogues from your local W.H.Smut.

(5WATT TRANSMITTER) DUMMY LOAD WITH POWER MEASURING CIRCUIT (Fig. J)



RFC is five turns (34SWG) on FX1115 ferrite bead.

If you buy a dummy load (loads less hassle, a 30w one will set you back £9) you can build the rest of the circuit (ie the diode, capacitors and choke) into the body of a UHF plug.

Get a UHF T-piece connector and you can connect the transmitter output into the dummy load and power measuring circuit at the same time

MAKING YOUR PCB BOARD

You can make your PCB board photographically by using the blacked in Fig. B & F.

A paperback book which describes the whole and several alternative processes in intimate detail is 'How to Design and Make Your Own PCB's' by R.A. Penfold. Published in the Babani Series of electronic books. It's available from the Maplin Catalogue, Page 48, (costs £1.95), and there's a good chance your local library will have it.

COST

5 WATT TRANSMITTER. . . approx. £16, excluding PCB and case.

15 to 80 WATT AMPLIFIER. . . approx. £70, excluding PCB and case and heatsink.

80 Watt Amplifier

This Amp should be quite suitable to attach onto the 25W (max.)—design on p54. We haven't built one ourselves yet.

General Description.

The following describes a 80w VHF FM amplifier. Input and output impedances are 50 ohm. Output power is 80w with a 12.5v supply and 15w input power. Its possible to increase the input power to 25w but this does not increase output power significantly. You shouldn't use more than 25w of input power without using an input attenuator.

The power supply has to be much more serious affair than for a 25w design. The power amp can draw up to 14A DC. Adding this to the current drawn by a 25 watt transmitter and we're talking 16A. You'll have to work with a car battery or similar lead/acid battery rated at least 20Ah. If you have a RF stabilised mains power supply with a 20A output capability you could apply 13.5 volts to the amplifier and achieve an output power of 110w. We suggest you only try this if you have proper heatsinking and guaranteed low SWR. (The manufacturers data sheet says dont exceed 100w output power (on the transistor). The bandwidth of this amp is 5Mhz for a 20% decrease. You can only use this bandwidth if you use a low pass filter on the output, otherwise the simple built in bandstop filter L6/C10 (tuned to the 2nd harmonic) will restrict the usable bandwidth to 2 Mhz.

Our prototype used a relay to provide reverse polarity protection. Three LED's indicate ready, reverse polarity, and high temperature. On reaching 90degrees C the amplifier is disconnected from the supply. The transmitter feeding this amplifier should also be connected via this relay, as the power transistor doesn't take kindly to having input power applied to it when it doesn't have a supply voltage.

The amplifier power supply should be connected using crocodile clips or big plugs...something like a DIN plug could not handle the current. The supply cables should be of 3-5 square mm cross section and no longer than 100cm.

CIRCUIT

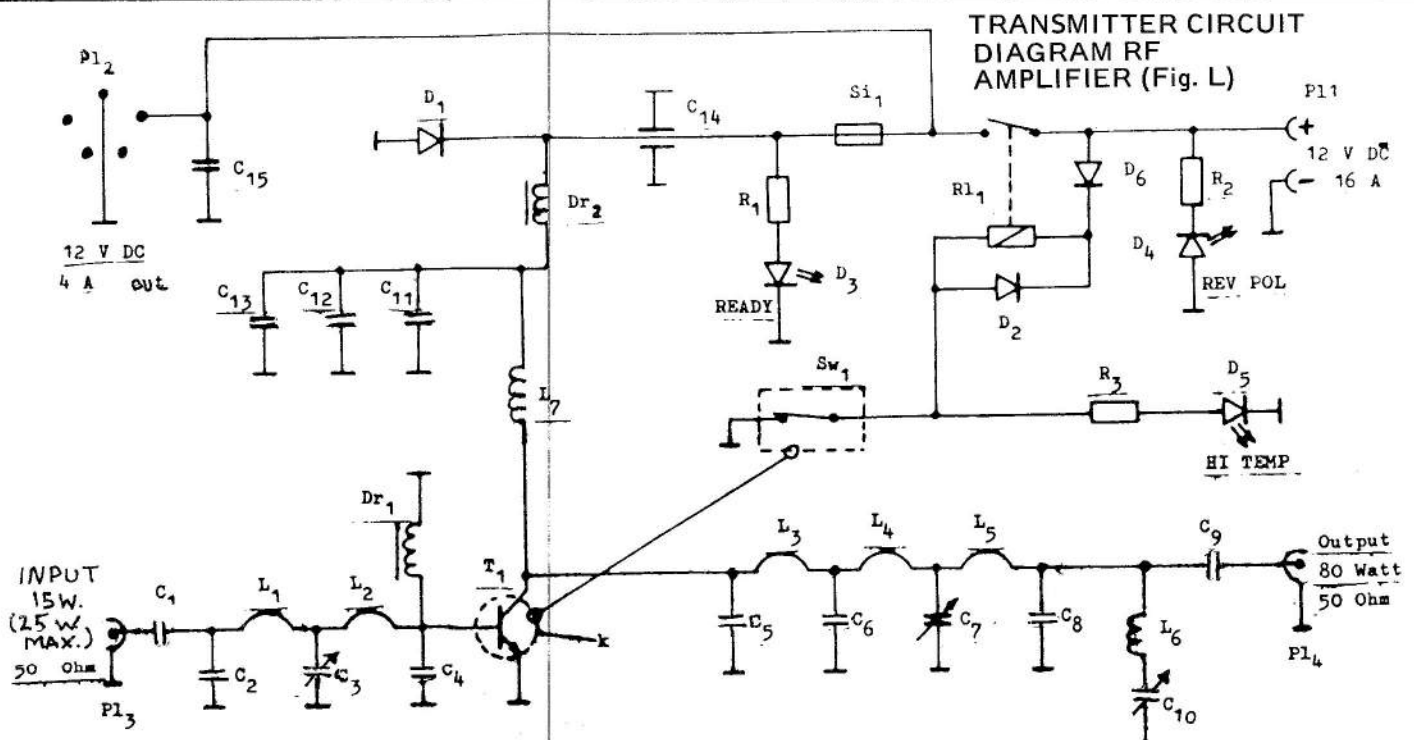
The heart of the circuit is the RF power transistor MRF 245. This is a controlled Q transistor with internal base and collector matching. This transistor is designed for the 145-175 Mhz VHF band and exhibits broad band characteristics within this range. The circuit is tuned as the development of a linear amplifier, and would require extensive knowledge of the transistor and extensive calculations. The transistor's characteris-

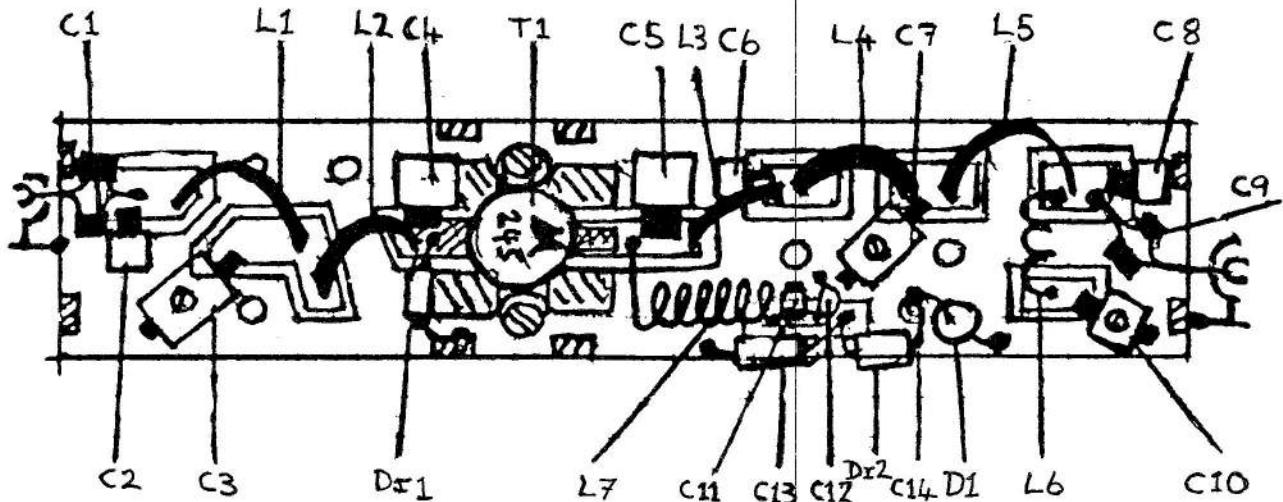
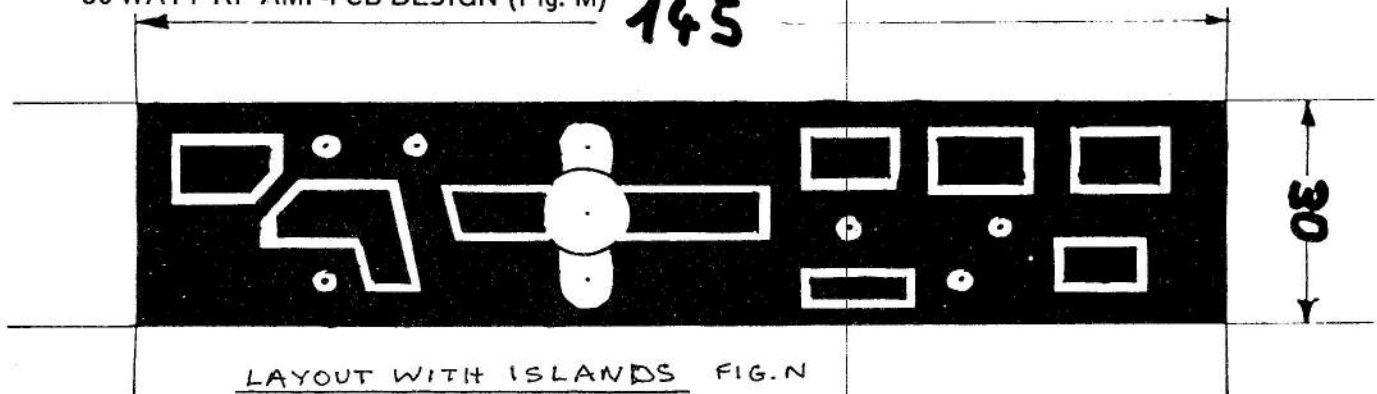
tics in the frequency band we are interested in are not published by the maker and we you'd need loads of expensive test gear to find them for yourself. Therefore this circuit was developed mainly by experiment. If you had all the test gear you could probably achieve a better bandwidth and greater harmonic suppression.

At the base and collector of the MRF245 are the relatively high value capacitors C4 and C5. These are part of the low pass impedance matching networks for input and output. Enormous currents flow through these capacitors so they have to be specially chosen eg Unelco mica capacitors or Erie high Q chip capacitors with low pass C3G dielectric. Because of the small size of the chip capacitors they've a tendency to overheat. Avoid this by using a combination in parallel to add up to the correct value, which is 440-550 nf. The only variable component of the input network is the trimmer C3. This allows the input network to be tuned across a wide range of frequencies. The input network has a narrower bandwidth than the output network.

The transistor MRF245 operates in class C mode, and so has no base bias, Dr1 ensures this condition is met. The power supply voltage is applied to the collector via L7. The output impedance transformation back to 50 ohm is performed by three pi networks with low pass characteristics. This network is tuned with C7. L6 and C7 form a bandstop filter which is tuned to the 2nd harmonic. It works by providing a low impedance path to earth for frequencies in that region, thereby reducing the power output of the 2nd harmonic. If you can't get a dipped mica capacitor for C9 use two or three readily available ones in parallel. The purpose of this capacitor is to isolate the DC supply from the aerial output, it doesn't do any matching. Using ceramic capacitors in parallel is necessary cos it keeps the parasitic inductance small. Similarly for C1 use a dipped mica or 2 or 3 ceramic capacitors in parallel.

The power supply decoupling is very important. The capacitors C11, C12 and C13 have different orders of magnitude as they're only efficient at preventing parasitic oscillations in a particular frequency range. Together they'll do it over a wide range. The supply is further decoupled by choke Dr2 and feedthrough capacitor C14. The amp is protected from reverse power supply polarity by a relay. The relay's contacts only close, allowing the supply voltage to the





amplifier, if the supply is connected the right way round. If the relay fails by, eg, the contacts welding together, which can happen with 16A, D1 will short the supply voltage and the fuse will blow. Reverse polarity on plug PL1 is indicated by the green LED D4. 'Ready' is indicated by red LED D3. The amplifier is protected by a thermal switch. If the heatsink exceeds 90 degrees c the supply to the relay coil is interrupted which disconnects the power to the amp. This is shown by yellow LED D5. The amp is reconnected when the heatsink cools below 70 C. Plug PL2 supplies the exciter (12v max 5 A) which should also be protected from overheating or reverse polarity.

CONSTRUCTION

Use double sided glass fibre PCB. The suggested layout is only one of many possibilities. If you change the layout do NOT alter the size or shape of the islands on the PCB to which any of the inductors L1 to L5 or the transistor are soldered. This is to ensure the inductors have the same bending radius and therefore inductance as they have on our prototype. The suggested circuit plan was designed to use miniature mica compression trimmers. Anything else will probably be too big to fit on our design. If you enlarge the PCB by 10mm on both sides you'll have more room for alternative set-ups.

You should have all parts on hand and then redesign the PCB layout accordingly, bearing in mind what you're going to do about heatsinking and putting the whole thing in a case. You might need to drill another hole in the PCB to accommodate the temperature switch. Decide how you'll mount and position the feedthrough capacitor, bearing in mind that its fragile and shouldn't be subjected to any mechanical stresses.

We recommend you introduce a second PCB, completely screened from the High Frequency PCB, on which is mounted the reverse polarity protection relay, the LED's and the DC output socket PL2.

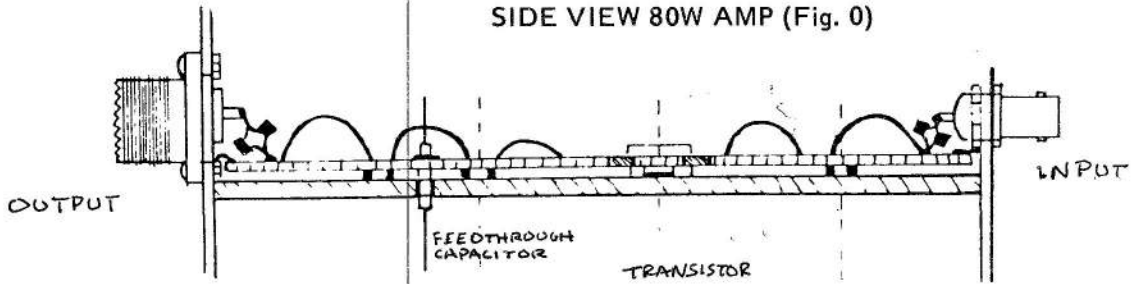
The high frequency input and output sockets should be mounted on the case directly over the PCB so they're perpendicular to the PCB. Or the sockets can be over the ends of the PCB, parallel to the board, in which case the length of the PCB dictates the length of the case and heatsink in this dimension.

The sockets must have a durable and flawless connection to the earth plane on the PCB. The best thing is to connect a thick wire from the PCB earth plane to the case next to the sockets. Either solder directly to the case material, or preferably use tags bolted through the sockets, mounting holes. Most BNC sockets have their own tags which you can use.

Drill the holes in the PCB. Apart from the holes for the transistor the PCB should be bolted to the heatsink at least twice on the base and collector side of the PCB. Use 6BA/M3 or larger bolts. Solder brass or copper strips along the long edges of the PCB to connect the top and bottom earth planes together, do the same by soldering strips through the hole where the emitter flanges of the transistor are to be soldered. This is so the emitter will be connected to both the top and bottom earth planes next to the body of the transistor. If your PCB is much wider than our design we recommend you introduce such 'through contacts' two times each near the emitter. There should also be a through contact near the feedthrough capacitor. To do this drill a small hole in the PCB, insert a thick wire, and solder on both sides. The earth plane should have a good connection both to the high frequency sockets and the negative supply connection.

After these plumbing jobs mount the transistor from above. Solder the whole length of the emitter flanges. These are the ones on the outside. The collector is the smaller of the two inner flanges. Then mount capacitors C4 and C5. Cut L1 to L5 out of copper or brass sheet and mount these as shown on the diagram together with C1 to C9. When soldering the capacitors make the joint as large as possible to keep stray inductance low and achieve better heat conduction. The loose ends of C1 and C9 will be soldered directly to the central contacts of the BNC or UHF sockets later on. When soldering the trimmers ensure to solder the contact which is connected to the rotating part to earth, otherwise you'll have big problems trying to tune the circuit with metallic instruments. Before you solder in L7 you should mount C11, C12 and C13 then Dr2 and Dr1. Leaving Dr1 out would be disastrous (positive base voltage = high collector current = new transistor). The feedthrough capacitor C14 can be fitted now, or left till later, depending on which construction you've chosen.

SIDE VIEW 80W AMP (Fig. 0)



After finishing work on the PCB it can be bolted to the heatsink. Put a thin coat of heatsink compound on the bottom of the mounting flange of the transistor. Bolt this flange to the heatsink with 6BA or M3 bolts. The PCB is then bolted to the heatsink in 4 places, using shakeproof washers above and below the PCB at such a height so as not to flex the PCB or put

any stress on the transistors leadouts. If this is done right the PCB will end up about 2mm above the heatsink. Obviously you'll have drilled holes in the heatsink corresponding to those in the PCB and the transistor mounting flanges. The use of shakeproof washers ensures good contact on both sides and stops loosening by vibration. Provisionally attach a fuse and the input and output sockets and you can start tuning.

TUNING

Tuning the amplifier is relatively simple, but you have to have the right test gear. You'll need a 100w power meter and a correspondingly rated 50 ohm dummy load. Most shortwave dummy loads can be used up to 100Mhz, eg. the well known oil cooled tin models. At 80w they can be used without the oil for several minutes. If you use a dummy load in conjunction with a feed through power metre (or calibrated SWR meter) this must be able to cope with 100w at 100Mhz as well. The best solution is to get a complete dummy load power meter. For brief standing wave and relative power measurements you can use the normal little SWR meter, but its recommended that you reduce their sensitivitiy by adding a resistor of about 10 K ohms in series with each gang of the twin potentiometer. This prevents the meter indicating FSD with the sensitivity set just above zero. Also the matching of the pentiometer gangs is not guaranteed at the extremes of its travel, which could result in a wrong SWR reading. If you use the SWR meter for more than brief periods, at a power over 40w, the diodes will get warm and your readings will be inaccurate. So switch on transmitter and amp just to take a reading and then switch off.

To tune the 2nd harmonic filter you'll need a dipmeter or an absorbtion wavemeter (or a spectrum analyser if you've a

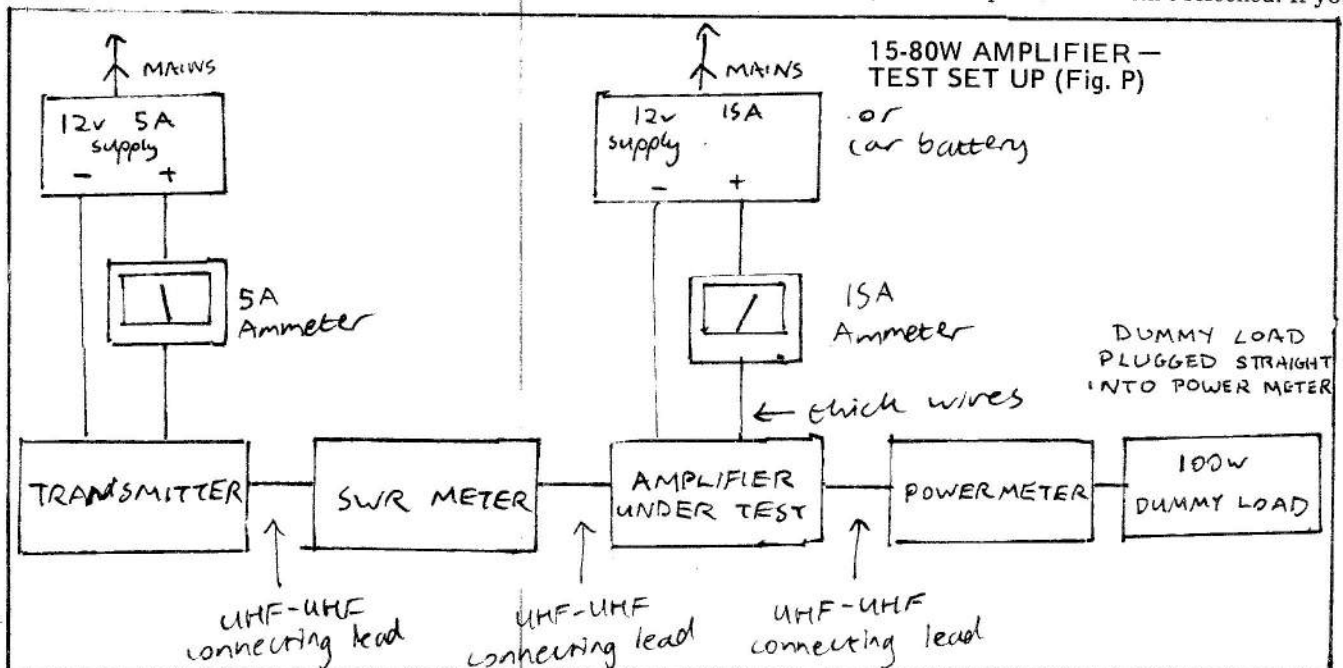
few grand to spare). You'll need two ammeters, a 5A for the TX (transmitter) power supply and a 15A for the amp power supply, assuming they're not part of any mains supply units you may be using. Useful, but not necessary, are two volt meters, one of each supply.

To sum up, to tune the amp you need: A transmitter, ideally 15-20w output power, tuned to the desired frequency. A 12v 5A mains power supply to run the TX. A 5A amp supply, assuming they're not part of any mains supply units you may be using. Useful, but not necessary, are two volt meters, one of each supply. A lead to connect the Tx to a SWR meter. A lead to connect the SWR meter to the amp. being tested. A 12v 15A mains power supply or 12v car battery. A 15A ammeter. A lead to connect the amplifier into the power meter. A power meter. . . A lead to connect the power meter into the dummy load. The dummy load. The dip meter (see diagram)

Tuning is as follows. Switch on the amplifier. It should draw practically no current, Now switch on the 15w TX which obviously has to work properly. Read the 5A ammeter and the SWR meter. The SWR value will probably be bad and the amp still drawing hardly any current.. and the power meter showing a low reading. Carefully adjust C3. Suddenly the current shown on the 15A ammeter will rise sharply, and the power meter will follow more or less. Adjust C3 so the current is about 7A, Now adjust C7 for maximum power output, for this C10 should be completely unmeshed (min. capacitance) .Adjust C3 and C7 alternately to trim the amplifier for max power output. Depending on the supply voltage and the thickness of the supply leads you should be able to get 80- 110 watts. The little SWR meter between the TX and the amp. should show a good SWR reading (less than 1 : 2) The amplifier current consumption should be between 10 and 14A. The transmitter's consumption should be about the same as if it was driving a dummy load (check it if you can't remember).

If you run into problems and things aren't clean switch itt all off. Think. This stuff is power electronics..ie it can get real hot and start smouldering.

After this rough tuning tune the amp's harmonic filter. Set up the dipmeter so it covers 100-250Mhz. It has to be near the dummy load in a position that isn't screened. If you



can't find such a position you could for example unscrew the top off the dummy load, but beware, you're now transmitting!

Approaching with the dipmeter you'll detect a definite indication at the desired frequency, even at some distance. Now set the dipmeter to double the frequency and approach the dummy load again. Tune the dipmeter..you shouldn't get any other readings but the one on double the transmitting frequency. If you get a reading that increases steadily as you tune up the scale of the dipmeter this is an aperiodical coupling to the dummy load.. the readings are meaningless.

If you get close enough to the dummy load to get aperiodic coupling but still no indication of the first harmonic, the amp should be OK as far as that harmonic is concerned, but there is usually a fairly strong indication at double the frequency after rough tuning.

Keep the dipmeter in position tuned to the 2nd harmonic and using an insulated screwdriver with a short blade adjust C10. Suddenly the indication on the dipmeter will disappear completely, but the output power will fall as well. Adjust C7 to improve the power output again, and then adjust C10 to obliterate the 2nd harmonic again. This will give you optimum tuning for a bandwidth of about 1Mhz.

If you want a wider bandwidth you'll have to tune up differently. When performing the rough tuning (C10 completely unmeshed as before) turn C7 further than to achieve max power so that the power output and current consumption decrease again. (output power will be 65-80w). Now tune the TX to the lowest frequency of the desired frequency range and minimise the 2nd harmonic using a dipmeter and C10 as described above. Check the power output across your desired frequency range.

The wider the bandwidth you want the more output power you'll have to sacrifice. Tuning for a bandwidth of more than 4Mhz involves a lot of high precision work. C3 could be used to keep the output power constant across a wide bandwidth but this can result in the in SWR readings of 1:3 between the TX and the amp at the extremes of the band. In this situation the TX has to be cooled well.

PARTS

The biggest problem in building a VHF amp for this output power is getting the necessary parts. Often CB and amateur radio specialist shops won't have all of them. Most are to be had by mail order from various sources.

The MRF 245 and MRF247 are also stocked by Raedek Electronics at £33 each. Phone for current prices (See CONTACTS below). The fixed capacitors C2, C4, C5, C6 and C8 are special due to their high quality and extremely low inductance leads. Use either dipped mica or high quality ceramic chip capacitors with C3J dielectric. The dipped mica capacitors are made by UNELCO. Also check out the SEMCO range of capacitors in the Cirkit catalogue. There are two different sizes, the principle of construction is the same. Several layers of metal foil are insulated from each other by layers of very thin mica. Every second layer of foil is led to the outside of the tag of the capacitor, the other foil layers connect to the metal clip holding the system together. This side should be soldered to earth and the tag soldered to the PCB islands. The ceramic chip capacitors (ERIE high Q ones with C3G dielectric) are symmetrical. At each end of the almost square chip (about 4X4mm) is a solderable metal strip. Which one of these is earth doesn't matter. Cirkit stock a small range of chip ceramics. They call them Leadless Ceramic.

If you can't get the right value you should think of using smaller values in parallel. Unelco capacitors can be soldered on top of each other if you haven't space. This shouldn't cost too much if you don't build too many amps. For C4 and C5 definitely use the larger dipped mica. If you can only get ceramic chip use two in parallel cos of their tendency to heat up. For the trimmers C3 and C7 you can't use anything but mica compression trimmers. These work by compressing metal foils insulated from each other with mica. By tightening the bolt you compress and increase the capacitance. For C10 you should use a miniature air spaced trimmer cos of its low capacity.

To make the strip inductors get some copper or brass

sheet metal of about 0.1mm thickness. This can be had hopefully from craft shops. The silver coated copper wire is available from Cirkit. You could use insulated copper wire for L7.

The heatsink largely determines the looks and construction of the amp. There are special heatsinks the above described PCB can be sunk into. If you can't find one best use a standard heatsink of enough cooling capacity, ie. thermal resistance less than 0.5 degrees C/W. The shape of the heatsink will determine the problems when designing the heatsink protection, feedthrough capacitor, case, etc.

For better bandwidth use MRF247 instead of MRF 245.

Naturally you wouldn't even consider using an amp of this power into some crummy piece of TV co-ax cable, Get some Uniradio 67 from Cirkit.

PARTS LIST FOR THE 80 WATT AMPLIFIER

- T1 MRF245 or MRF247 (Raedek)
- D1 IN5402
- D2, D6 IN4002
- D3 Red LED
- D4 Green LED
- D5 Yellow LED
- SC1 16A fuse and fuse holder
- PL1 Din socket 5 pin 240 degree, or what you fancy
- PL2 two 4mm sockets, one red, one black
- PL3 BNC socket or UHF S0239 socket with earth tag
- PL4 S0239 UHF socket with earth tag
- SW1 90 degree C thermal switch (not thermal fuse)
- R1, R2, R3, 1k. ohm
- RL1 Relay 12v 150ohm, 16A contacts
- C1 500pf dipped mica capacitor or two nf ceramic in parallel
- C2 10 or 15pf Unelco or Semco or Erie high Q C3G dielectric
- C3 10 to 80pf or 15 to 115pf or 30 to 120pf mica compression trimmer
- C4 500pf (440 to 510) Unelco or Semco or two Erie 220pf in parallel
- C5 as C4
- C6 100pf Unelco, Semco or Erie
- C7 as C3
- C8 22pf Unelco or Semco or two 10pf Erie in parallel
- C9 as C1
- C10 5 to 15pf Air trimmer
- C11 3.3nf ceramic, preferably chip ceramic
- C12 100nf ceramic
- C13 10µf 35v tantalum
- C14 4.7nf feedthrough capacitor, boltable
- C15 3.3nf ceramic
- L1 3 X 35 X 0.1mm brass or copper strip
- L2 3 X 25 X 0.1mm " " "
- L3 3 X 15 X 0.1mm " " "
- L4 3 X 25 X 0.1mm " " "
- L5 3 X 35 X 0.1mm " " "
- L6 3½ turns 1mm (18SWG) silver coated copper wire on 6mm former
- L7 6 turns 2mm (14SWG) silver coated copper wire on 7mm former
- Dr1, Dr2 wideband ferrite choke (see parts list of 5w transmitter for details of these)

Copper or brass sheet

Heatsink, thermal resistance less than 0.5 degrees C / W

CIRKIT, Park Lane, Broxbourne, Herts, EN10 7NQ. Tel. (0992) 444111.

RAEDEK Electronics, 102 Priory Road, Scribes Lane, Hall Green, Birmingham B28 0TB. Tel. 021 474 6000

Also useful are Cirkit and Maplin catalogues, from your local W.H.Smith.

FM Aerials: Construction Plans.

These plans include details for the construction of antennas suitable for the FM broadcast band. Their is nothing magical about their design, just basic rules governing the construction of antenna systems. They can therefore be modified to work at other frequencies as well. They work equally well for the transmission of AM, FM, PM, PCM, and CW.

BASIC RULES:

- (1) An antenna and its transmission line should have the same value of impedance.
- (2) A half-wave dipole antenna has a nominal feed impedance of 75 ohms.
- (3) Two similar antennas connected in parallel have 1/2 of the normal impedance.
- (4) Generally, the effective power increases directly to the number of antennas used.
- (5) An effective power gain in one direction results in a power loss somewhere else.
- (6) There is always a loss of power in a transmission line.
- (7) The smaller the size of a transmission line, the greater its loss.
- (8) A 1/4 wavelength of transmission line can act as an impedance transformer.
- (9) A 1/2 wavelength of transmission line exhibits the same impedance at both ends.
- (10) A 1/4 wavelength of transmission line can act as an RF decoupler.
- (11) A 1/4 wavelength of transmission line delays a signal by 90 degrees (1/4 cycle).
- (12) Radio waves travel at the speed of light through space (and air).
- (13) Radio waves travel slower over wires and through cables.
- (14) A super low VSWR is not needed, a VSWR of 1.5 or even 2 to 1 is acceptable.
- (15) A 100 foot piece of RG-8 coax allows only 63% of the power to reach the antenna.
- (16) A 100 foot piece of RG-59 coax allows only 50% of the power to reach the antenna.
- (17) Radio waves travel at .66 light speed through cables with "poly" insulation.
- (18) Radio waves travel at .82 light speed through cables with "foam" insulation.
- (19) Radio waves travel at .95 light speed over large wires (pipe, etc) (uninsulated).
- (20) Radio waves travel at light speed over very thin wires (uninsulated)

The above are simple rules that do contain exceptions. But for our purposes they will do just fine.

ANTENNAS DISCUSSED

Simple Stacked Vertical Dipoles	(Vertical Polarization)
Inverted Vee Antenna	(Horizontal Polarization - some Vertical)
Half-Wave Phased Colinear	(Vertical Polarization)
Stackable Vertical Dipoles	(Vertical Polarization)
Stackable Horizontal Dipoles	(Horizontal Polarization)
Circular Polarization	

CALCULATIONS:

	Answers for 100 MHz
(1) Wavelength in inches = $11811 / f_{MHz}$	$11811/100 = 118.11$ inches
(2) 1/4 Wavelength (poly) coax = $.66 \times .25 \times$	$.66 \times .25 \times 118.11 = 19.49$ "
(3) 1/4 Wavelength (foam)coax = $.82 \times .25 \times$	$.82 \times .25 \times 118.11 = 24.21$ "
(4) 1/4 Wavelength (large wire)= $.95 \times .25 \times$	$.95 \times .25 \times 118.11 = 28.05$ "
(5) 1/4 Wavelength (thin wire) = $1.0 \times .25 \times$	$1.0 \times .25 \times 118.11 = 29.52$ "

- (6) 1/2 Wavelength (poly) coax = $.66 \times .50 \times$ $.66 \times .50 \times 118.11 = 38.98$ " |
- (7) 1/2 Wavelength (foam)coax = $.82 \times .50 \times$ $.82 \times .50 \times 118.11 = 48.43$ " |
- (8) 1/2 Wavelength (large wire)= $.95 \times .50 \times$ $.95 \times .50 \times 118.11 = 56.10$ " |
- (9) 1/2 Wavelength (thin wire) = $1.0 \times .50 \times$ $1.0 \times .50 \times 118.11 = 59.06$ " |
- (10) .8 Wavelength (space or air)=
 $.80 \times 118.11 = 94.49$ " |
- (11) 3/4 Wavelength (thin wire)
 $.75 \times 118.11 = 88.58$ " |
- (12) 5/4 Wavelength (thin wire)
 $1.25 \times 118.11 = 147.64$ " |

Above answers "rounded-off" to the nearest 1/8" for 100 MHz

- (1) 118 1/8 "
- (2) 19 1/2 "
- (3) 24 1/4 "
- (4) 28 "
- (5) 29 1/2 "
- (6) 39 "
- (7) 48 3/8 "
- (8) 56 1/8 "
- (9) 59 "
- (10) 94 1/2 "
- (11) 88 5/8 "
- (12) 147 5/8 "

The above calculations have been made for 100 MHz as a "center" frequency for the FM band. For precise results you may wish to do your own calculations for your particular frequency of operation. Simply divide 11811 by your frequency in MHz to obtain your wavelength in inches. Use that figure with the other equations to obtain the necessary dimensions.

SIMPLE STACKED VERTICAL DIPOLES (Fig. 1)

This is a very simple yet effective antenna. It is constructed from lengths of RG-8 coaxial cable. The uppermost radiator is just a small wire of 1/8th inch or less in diameter. It may be soldered to the center conductor of the coax, or you may simply use the inner conductor of the coax itself. You can hold it up straight by attaching a wood splint along its length and securing that splint to the coax below.

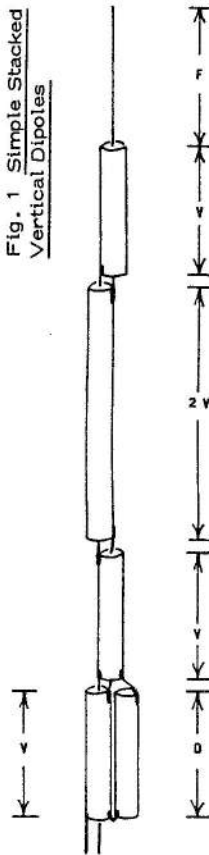


Fig. 1 Simple Stacked Vertical Dipoles

The center conductor of one coax is soldered to the outer conductor of the next coax, and so on down to the bottom. The bottom section of the coax is a piece of coax with the center conductor cut off completely. It is used as a 1/4 wavelength

"decoupler". This allows the antenna to be fed with an unbalanced transmission line (coax). Without this decoupler the feed coax would also radiate signal and upset the coverage pattern of the system.

When completed the whole thing can be slipped into a section of 3/4" PVC pipe. The top end is covered with a PVC cap glued in place. The bottom end cap has a 5/8" hole drilled through it. An SO-239 connector is fastened into the hole. The antenna is then fed with a 50 ohm coax such as RG-8. The feed impedance is closer to 36 ohms than 50 ohms so the VSWR will be about 1.4 to 1.

If the antenna is free standing or mounted on a wood support the coverage pattern will be omnidirectional (see Fig. C, pattern #1). If the antenna is mounted 1/4 wavelength out from a metal support (such as a tv mast) it will be "shadowed" on the mast side but will show some "gain" toward its front side (see Fig. C, pattern # 4).

The antenna itself exhibits a 3 dB gain (2 X power) because of the two dipoles and would have a coverage distance (in respect to a single dipole) similar to Fig. D, pattern # 2. If it is mounted 1/4 wavelength out from a metal mast it could give up to a 6 dB gain (4 X power) as seen in Fig. D, pattern # 4. The increased distance however is at the expense of lost coverage area in the "shadow" of the mast (Fig. C, pattern # 4).

The top dipole consists of two 1/4 wave sections (F) and (V). The top dipole is fed from the bottom dipole by a 1/2 wave transmission line (2V). The bottom dipole consists of sections (V) and (V).

Dimensions (Using RG-8 (poly) coax, design frequency of 100 MHz)

- F 1/4 wave (thin wire) 29 1/2"
- V 1/4 wave (poly coax) 19 1/2"
- 2V 1/2 wave (poly coax) 39 "
- D 1/4 wave (large wire) 28 "

INVERTED VEE ANTENNA (Fig. 2)

Although simple in construction this antenna can get out quite well. Part of its appeal is that it doesn't look like any more than a regular TV mast. You can even have your tv antenna on top without spoiling its operation.

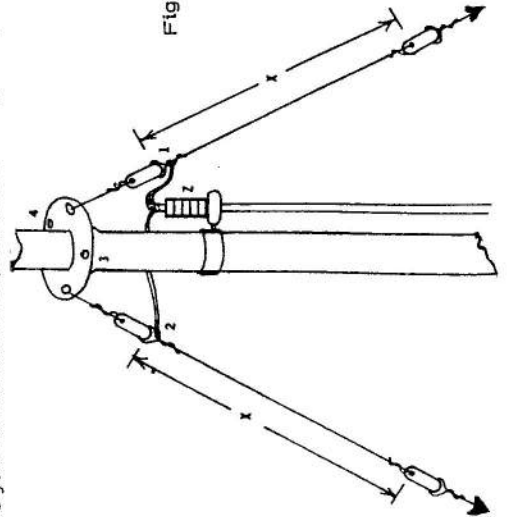


Fig. 2 Inverted Vee Antenna

In its simplest form the antenna is unidirectional with a pattern similar to Fig. C, pattern # 4 (even though this antenna is horizontally polarized). The wider spread between the guy wires selected determines how much horizontal and how much vertical polarization will be imparted to the signal. If the guy wires are almost straight up and down the signal will be mostly vertical. A wide spread between wires makes the signal more horizontally polarized. This simple form is where two guy wires on the same side of the mast are selected. Maximum power is radiated in that direction.

If you have a four-wire guy system and select opposing guy wires you will have a bi-directional coverage similar to Fig. A, pattern # 2. Much the same as any horizontal dipole.

If you connect the 1/4 wave phase delay harness (Fig. 3) to the other two opposing guy wires (four-wire guy system) you'll make it omnidirectional. This is because you'll be feeding the second set of guy wires (second dipole) 90 degrees out-of-phase with the first. The result is the radiated signal "spins" around the two dipoles thereby "pointing" in all directions. It completes one trip "around" during each cycle of your frequency. At 100 MHz this is 100,000,000 times each second!

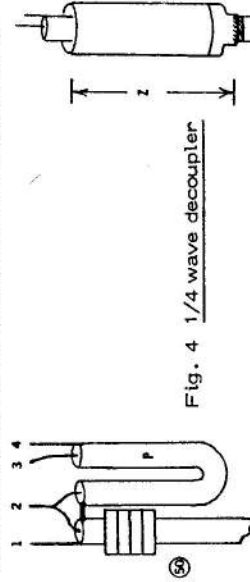


Fig. 4 1/4 wave decoupler

Fig. 3 Phase delay harness

This is a balanced antenna. If it is to be fed with unbalanced line (coax) it needs a decoupler. Four or five large ferrite beads may be slipped over the coax, close to the end, to act as the decoupler. If you prefer a decoupler can be made from a piece of 1" copper pipe. A 1" to 1/2" reducer is soldered to one end. The whole thing is slipped over the coax. A bit of coax insulation is removed and the small end-of-the-reducer is soldered to the coax shield. The other end of the pipe is left open (see Fig. 4).

When the phasing delay harness is used you'll have two antennas connected in parallel. When fed with a 50 ohm cable (RG-8) you'll have a VSWR of 1.4 to 1. A lower VSWR can be had if the 1/4 wavelength of coax leaving the antenna is a 50 ohm impedance (RG-8) acting as an impedance matching transformer. The rest of the coax all the way back to the transmitter would have to be 75 ohm coax.

Dimensions, design frequency of 100 MHz	Effective power gains		
	Uni-	Bi-	Omn-
X 1/4 wave (thin wire)	2	1	1/2
3/4 wave (thin wire)	4	2	1
5/4 wave (thin wire)	8	4	2
1/4 wave (poly coax)	19 1/2"	(use 75 ohm coax such as RG-59)	
Z 1/4 wave (pipe)	28"	(Fig. 4 decoupler)	

HALF-WAVE PHASED COLINEAR (Fig. 5)

This is a fairly rugged antenna. It is constructed from 1/2" copper water pipe and 1/2" copper pipe fittings. It mounts to mast with a single "U" bolt. It may be polished and then sprayed with a clear lacquer for a real professional appearance.

It consists of two 1/2 wave elements, one above the other, which are fed from a 1/4 wave "shorted stub". The "stub" is the "U" shaped section whose dimensions

the antenna is mounted on a metal mast it will exhibit additional gain (up to a gain of 4) but will be unidirectional as in Fig. C, pattern # 4.

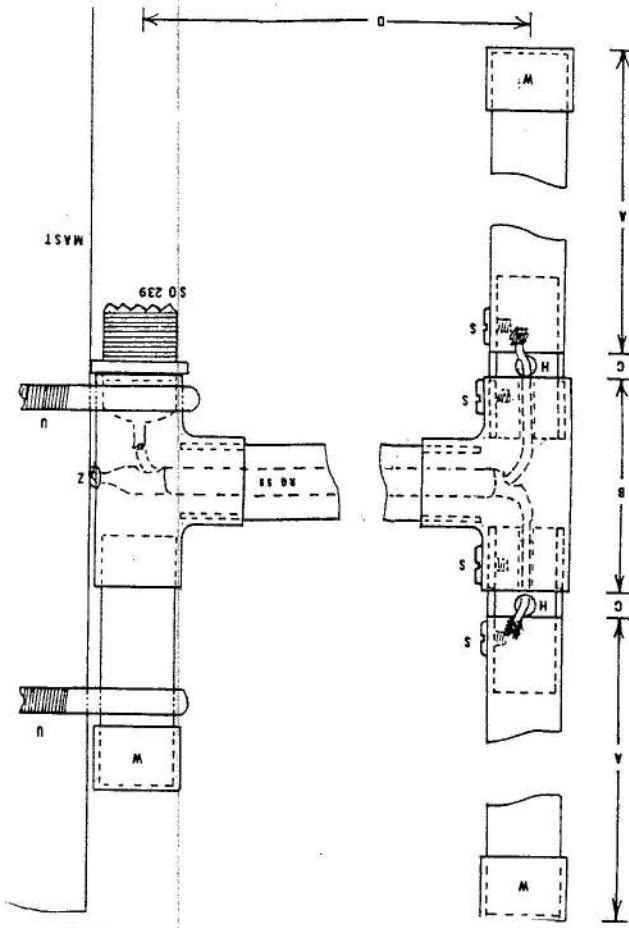
Dimensions, design frequency of 100 MHz

P	1/2 wave (pipe)	56	1/8"
N	1/4 wave (pipe) X .63	17	5/8"
G	1/4 wave (pipe) X .34	9	3/4"
K	1/4 wave (pipe) X .11	3	"
2P	1/2 wave (poly) coax	39"	(RG-8)

L = any length of 50 ohm coax such as RG-8

A STACKABLE VERTICAL DIPOLE (Fig. 7)

This is a rugged vertical dipole which, when stacked with others, gives a power gain of a little greater than the number of dipoles used. A stack of 2 (also known as 2 bays) has a gain of about 2.1. A 4 bay antenna may have a gain of up to 4.5! Figs. E through I show various stacking arrangements. These stacking arrangements are discussed later on.



The dipole is constructed from 1/2" copper pipe, two 1/2" "T" fittings and three end caps. The area marked "H" show pieces of 1/2" diameter plastic such as lucite or polystyrene. These plastic pieces are the last pieces to be installed.

Out all the pipe sections to the appropriate length. Slip on the fittings and check your dimensions. Do not install the coax, plastic, or SO-239 yet! Solder all the fittings and end caps into place. Keep it all straight by holding it against a flat surface. Drill a 3/16" hole at point "Z".

Out a piece of RG-59 coax to a length longer than dimension D. Remove some of the outer insulation as shown in the drawing. Spread apart the braided shield a bit and carefully pull out the center conductor (still insulated). Prepare the cable as shown in the drawing. Solder the center conductor of one end of the coax to the solder pin of the SO-239. Twist the braided shield at that end so it can be pushed through hole Z from the inside. Do it, while shoving the SO-239 into the

Fig. 5 Half-Wave Phased Colinear

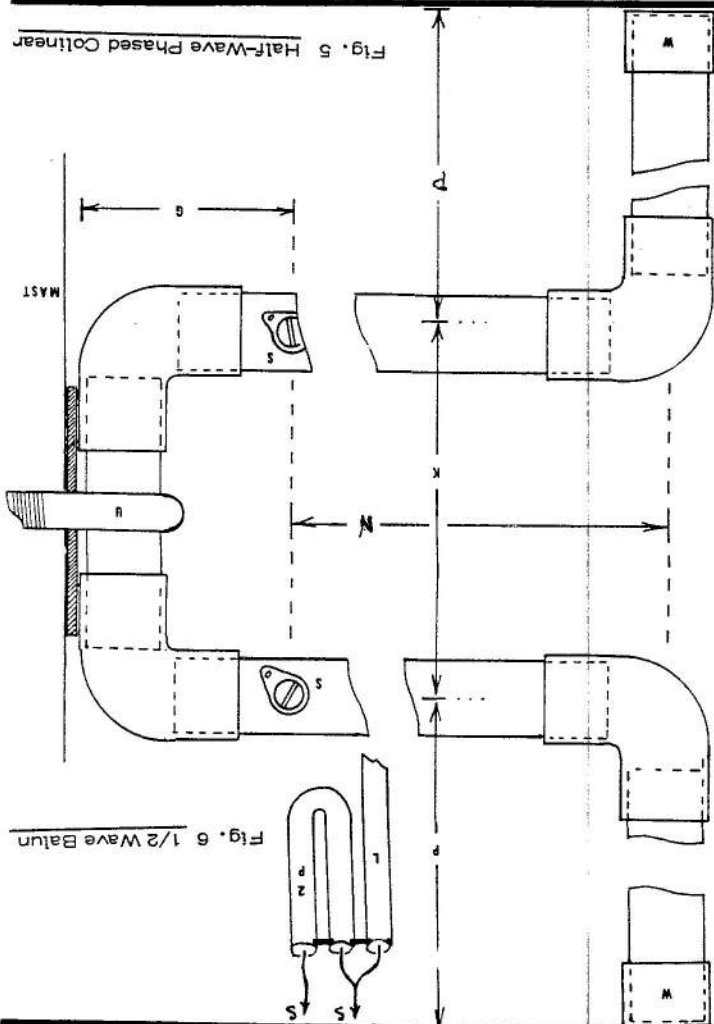


Fig. 6 1/2 Wave Balun

$N + G = 1/4$ of a wavelength. Since this is a balanced antenna which will be fed by an unbalanced line (coax) it will need a "balun". A balun is a device that adapts a BALANCED line to an UNBALANCED load. Both antenna elements must be fed in the proper phase relationship so a 1/2 wave balun is used. This is shown in Fig. 6.

The balun is made from 50 ohm coax (RG-8) with the shields of all ends connected together. The shields will not connect to the antenna however. Only the center conductors, marked with an "S" will connect to the antenna screws, also marked "S".

Begin by cutting all your copper pipe to the appropriate lengths. Fit the sections of pipe into the 90 degree elbows. Slip on the end caps (W) (to keep water out when it rains). Lay the whole thing down on a flat surface and check your overall dimensions. Adjust the pipe lengths if required so your dimensions are exactly as shown below. Now solder each joint (fitting). After it has cooled, drill two holes for the screws (S). The hole should be threaded for a 6-32 screw. A self-threading screw may be used (not a sheet metal screw). Use a solder lug under the screw for connection of the balun.

If the antenna is mounted on a metal mast a piece of hard rubber should be used as an insulator. Only the exact center of the 1/4 wave stub may be connected to a metal object. If a wooden support is used this is not a concern. You can even use two "U" bolts if you want.

The antenna gives a power gain of at least 2 when mounted on a wooden support. The coverage pattern is similar to Fig. C, pattern 1 (omnidirectional). The distance and angle of the radiation is similar to Fig. D, pattern # 2. If the antenna is turned so it is horizontally polarized it will have a bi-directional (horizontal) coverage as shown by Fig. A, pattern # 2. A metal or wood mast may be used.

open end of the "T" fitting. Solder the shield to the outside of the "T" fitting. Now solder the SO-239 into place. If the SO-239 has been plated it may be necessary to file off some of plating before it will solder well. CAREFULLY - not too hot!

Two holes have to be drilled now in the plastic pieces. Use a 3/16" drill bit. One hole starts at the end of the piece and ends half-way through. The second hole starts at the side of the piece and goes half way through to meet the first hole. You may drill this second hole at an angle toward the first hole to make pulling wires through it a lot easier.

The inside of the "T" fitting is made for the outside diameter of the 1/2" pipe. The plastic piece will fit too loose if installed directly. So...cut filler bushings out of 1/2" pipe (about 1/2" long) and slip into the open ends of the "T" fitting.

Bring the center conductor of the coax out the bottom end of the "T" fitting and feed it through one of your plastic pieces. Bring the coax braid (twisted) out of the other end and pull it through a plastic piece. Slip the plastic pieces into the "T" fitting. Drill a tap size hole (6-32 self-tapping screw) through the "T" fitting, the filler bushing, and part way into the plastic (Caution- not too far!). Install the screw to secure the plastic piece in place. Now do the same for the coax braid end of the fitting.

Now slide on the dipole sections of pipe. Secure to the plastic with a 6-32 self-tapping screw. Solder the coax leads as shown in the drawing. An alternate method of connecting the coax leads is shown in Fig. 9.

Fig. 8 Omnidirectional Horizontal Dipole (Top View)

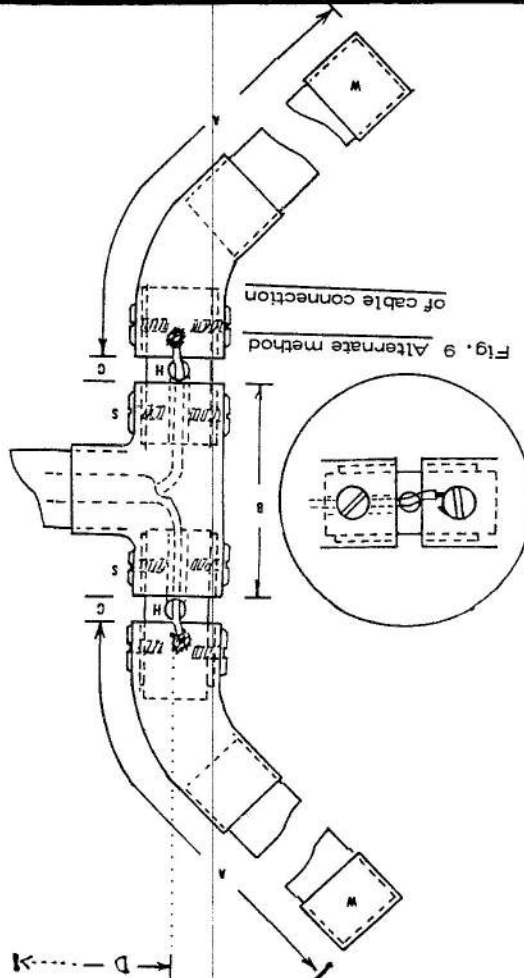


Fig. 9 Alternate method of cable connection

Finishing touches include polishing the copper pipe and coating it with clear lacquer. Close up any holes with silicone sealant to keep out moisture. Check with an ohmmeter for shorts between dipole elements and shorts between the elements and the supporting boom. Check also for continuity between the center pin of the SO-239 and the lower dipole element.

Mount on the mast so the SO-239 is facing down. A little grease on the threads when you screw on the plug later will help to keep moisture out.

When stacking these units the dipole connected to the coax braid MUST BE

POINTING UP to maintain the proper phase relationship between units. The length of the little mounting stub (top "U" bolt) is not critical, 2" to 4", it's just for a mounting spot for the "U" bolt anyway.

Dimensions, design frequency of 100 MHz

A	1/4 wave (pipe)	28"	C	large enough for wire	3/16"
B	Standard "T" fitting	2"	D	1/4 wave (pipe)	28"

AN OMNIDIRECTIONAL, STACKABLE, HORIZONTAL DIPOLE (Fig. 8)

The previous vertical dipole can be modified to make a horizontally polarized antenna. By simply rotating the dipole elements (and the "T" fitting) at the end of support boom 90 degrees you have a horizontal antenna. The coverage pattern would be bi-directional however, similar to Fig. A, pattern # 2.

By bending the dipole elements forward slightly we can further modify the antenna so it will present a nearly omni-directional coverage. The coverage would then look like Fig. A, Pattern # 1.

Of course bending copper pipe is a bit of a chore so we'll use 45 degree 1/2" copper fittings instead. With the exception of the above modifications and the addition of two 45 degree fittings, the construction is the same as the vertical dipole. Just use those instructions for its assembly.

When completed the dipole arms should be horizontal, the mounting end of the support boom vertical, and the SO-239 pointing down. When stacking these units be sure that right dipole element is the one with the coax braid connected to it. This is necessary to maintain proper phasing. If proper phasing is not maintained one antenna will tend to cancel out the radiation from one of the other units - result is terrible coverage or no coverage at all!

Dimensions, design frequency of 100 MHz
All same as stackable vertical dipole.

Fig. A Horizontal Coverage (Top view) Fig. B Horizontal Coverage (Side view)

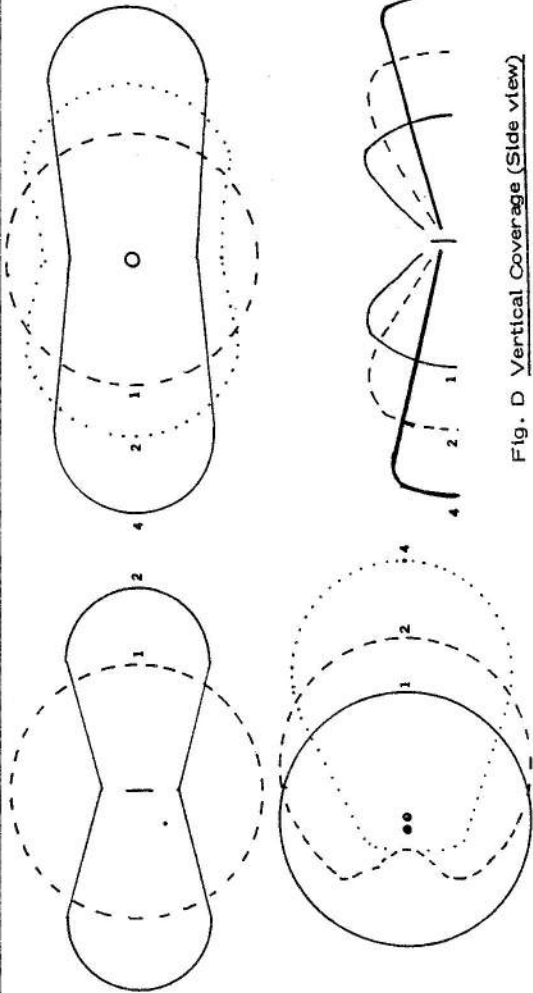


Fig. C Vertical Coverage (Top view)

Fig. D Vertical Coverage (Side view)

STACKING ANTENNAS FOR MORE GAIN Figs. E - J

When we speak of an antenna as having gain we are really talking about its EFFECTIVE RADIATED POWER or simply its ERP. The antenna can be made to concentrate the power fed to it by sending it out in one or more directions. This means however that some other direction will not receive as much power. Simply, more distance in one direction means less distance in another direction.

Stacking of vertical antennas tends to lower the radiation angle. Less power is radiated up toward the sky, being channeled outward instead. This of course increases the coverage area. Fig. D shows the relationship of stacking versus the effective distance. Pattern # 1 is for a single antenna. Pattern # 2 shows the results of 2 stacked verticals with an ERP of about 2 X. Pattern # 4 shows a 4-bay antenna.

The above is the case where the antennas are mounted on a wooden support. If a metal tower or mast is used it will reflect some of the power forward. This also results in additional ERP. This raises the overall ERP by a factor of about 2. This means that a 4-bay vertical on a metal mast could have an ERP of 2 times 4 for a total of 8 times the power! Of course coverage area is lost behind the tower as we see in Fig. C, pattern # 4.

Stacking of horizontal antennas compresses the radiation angle. Instead of the signal being sent off into space or toward the earth, it is "focused" outward. This can be seen in Fig. B. Pattern # 1 shows a single horizontal dipole. Pattern # 2 shows a flattening and pushing outward of the radiated energy. Pattern # 4 shows the results from a 4-bay antenna.

Although a metal tower will produce a shadow area behind omni-directional horizontals also, it is not nearly as pronounced as with verticals. In most cases it is not worth worrying about.

The most practical number of horizontal bays seems to be 4. More than that tends to concentrate the "beam" of radiation too much. It gets out further but can actually travel "over" nearby receiving antennas.

The amount of distance obtained related to effective increases in power is equal to the square root of the power increase. These relationships are shown below:

Power Increase	Distance	Power Increase	Distance
2	1.4 X	7	2.65 X
3	1.73 X	8	2.83 X
4	2.0 X	9	3.0 X
5	2.23 X	10	3.16 X
6	2.45 X		

This holds true for increases in transmitter power also. Doubling your transmitter power results in only a 1.4 X increase in distance.

Fig. E shows a single antenna. It may be a vertical or a horizontal unit although a vertical one is shown here. Its feed impedance is about 75 ohms. The horizontal antenna's feed impedance is slightly less due to the elements being angled forward. For lowest VSWR it should be fed with a 75 ohm coax. It may be fed with a 50 ohm coax however with only a 1.4 to 1 VSWR.

Fig. F shows two stacked antennas. They may both be vertical, or both horizontal, or may be one of each. If both antennas are the same polarization it would have an ERP of 2. If you have one of each then the ERP is 1 - but with both horizontal and vertical polarization. The total feed impedance at the coax T is now 1/2 of 75 ohms. This 37.5 ohm impedance can be fed with a 50 ohm coax with only a 1.33 to 1 VSWR. If you want to feed it with 75 ohm coax you must have a 1/4 wave impedance matching

...er. This is shown as the # 50 with a circle around it. This is piece of 50 ohm coax 1/4 wavelength long. This is either 19 1/2" or 24 1/4" long depending on whether you are using poly or foam coax. The cables from the antennas to the coax T (Y1) may be of any convenient length BUT...they must be the SAME length. If they are different lengths the phasing between antennas will not be correct! Highest gain is achieved when the spacing between antenna centers of antennas is about .8 X wavelength in air. This is 94 1/2 inches at 100 MHz. (E = 94 1/2")

Fig. G shows a 4-bay vertical system. Fig. H shows a 2-bay vertical with a 2-bay horizontal. You could just as easily have a 4-bay horizontal for Fig. G. In the case of Fig. H the vertical antennas can be fitted in between the horizontal units. This takes up a little less tower space. Note this is also done in the 4-bay vertical, 4-bay horizontal system of Fig. I. Dimension E is still 94 1/2" at 100 MHz.

The length of connecting cables Y2 may also be of any convenient length BUT both must be of the same length! Again in Figs. G and H you are paralleling two 75 ohm impedances (Y2 + Y2). This point may be fed with a 50 ohm coax (VSWR of 1.33 to 1).

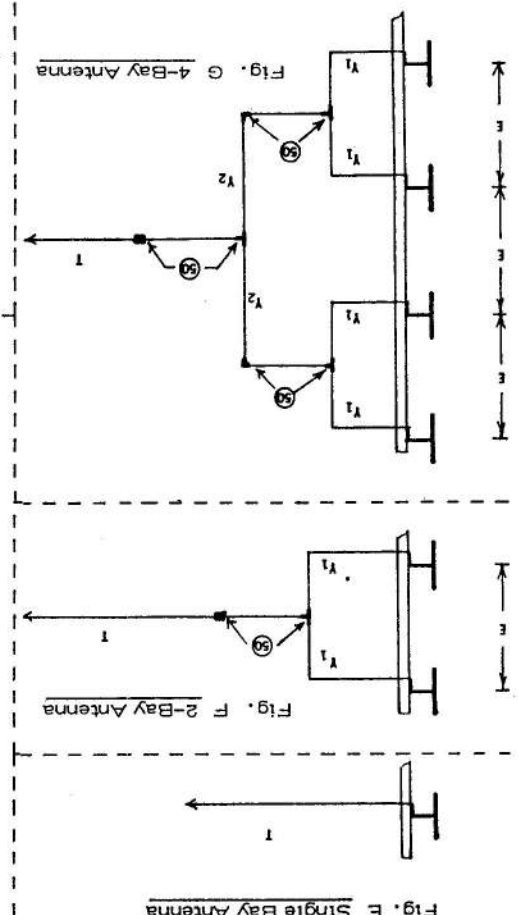
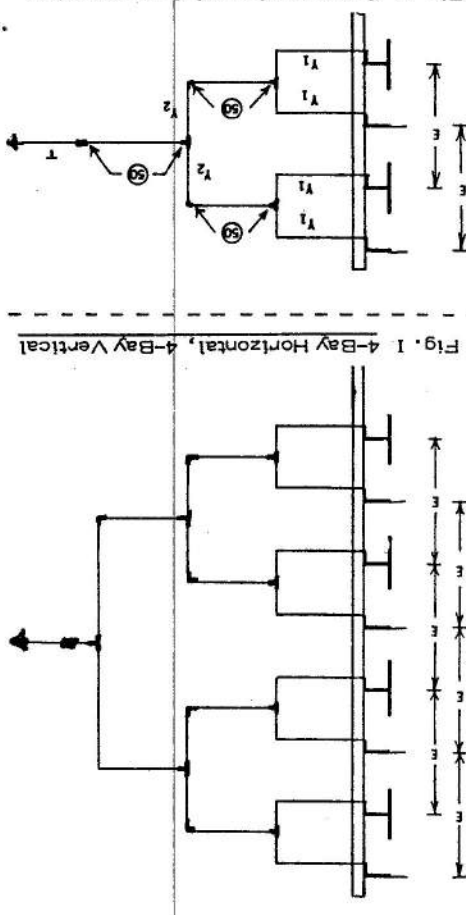


Fig. E Single Bay Antenna

Fig. G 4-Bay Antenna

Fig. H 2-Bay Horizontal, 2-Bay Vertical

Suppressor and Filter: Construction Plans.

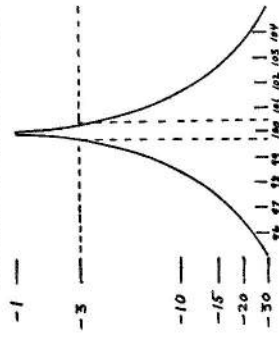
One of the biggest problems with any transmitter is the production of undesired frequencies. These may be produced by secondary resonant circuits within the oscillator stage or amplifier stages. These frequencies have no relationship to the desired frequency whatsoever and may appear anywhere on the band or out. Harmonic frequencies, multiples of the desired frequency, are produced by the non-linear characteristics of the amplifying devices themselves, either tubes or transistors. This means an FM transmitter operating at 100 MHz may produce harmonics at 200, 300, 400, 500... etc MHz. The most common non-linearity produced frequencies are the odd harmonics, 3rd, 5th, 7th, etc.

A filter which will reduce or eliminate all but the desired frequency must have a finite pass-band. In the FM band we have a channel width of 200 KHz. This means the filter's pass band must not be less than 200 KHz or signal quality will suffer. Unfortunately as band width is made narrower in a filter the insertion loss becomes greater. A compromise then is where an acceptable band width (pass band) joins an acceptable insertion loss (power loss). The RFI is tunable from 80 to 120 MHz.

General pass band and insertion loss characteristics of the PANAXIS RFI are:

Pass Band	Insertion Loss (dB)	Power Output(%)	Resultant Field (%)
2 MHz	.45	90	95
1 MHz	.70	85	92
.5 MHz	.97	80	90

As an example, with the RFI adjusted for a 1 MHz pass band, the insertion loss would be .7 dB, resulting in 85% of the power being transferred from input to output. This sounds bad until you consider that the field strength voltage decreases as the square root of the power decrease. In this example the range would be cut back to 92% of the range-obtainable-without-the-filter.



The graph at the left illustrates a 500 KHz bandwidth (-3dB point) and a 1 dB insertion loss. Output drops off rapidly for frequencies farthest away from the center frequency, in this 100 MHz is being used as the center. Up to 30 dB of attenuation at 5 MHz away from the center frequency is possible with proper adjustment. SWR is approximately 1.05 to 1 with a 50 ohm input/output. SWR will be about 1.5 to 1 with 75 ohm input/output, unless taps are adjusted for 75 ohm operation only.

The coils are a little tricky but if you take your time you should have only a little trouble. The two coils are wound in OPPOSITE DIRECTIONS. This is important because when they are installed you'll want the "tap" point to be correct. The tap is at one full turn from the bottom of each coil. The long leg at the bottom of each coil is part of the impedance of the tap and is required - do not shorten it by more than 1/2 inch!

Wind the coil on a 3/8" drill bit shank or other 3/8" diameter object. You'll want 8 full turns with extra wire left at each end. Take a short piece of the same wire size and push it in between a couple of the turns near the end of the coil. Rotate the wire while holding the spacer wire between the turns. In this way you'll space

If you want to feed it with 75 ohm coax you'll need another 1/4 wave transformer, just like that used in Fig. F. All 50's with a circle around denote 1/4 wave-50 ohm transformers.

By now you should be an old pro and can figure out the harness arrangement for Fig. 1. Just remember: all Y1's are the same length, all Y2's are the same length, and (for Fig. 1) all Y3's are the same length, and all junctions need an impedance matching transformer.

A bit of information you may find discouraging. 100 feet of RG-8 coax allows only 63% of the transmitter power to reach the antenna system. RG-59 is worse! It only allows 50% of the transmitter power to reach the antenna (100 feet). In other words, use RG-8 as much as you can, keep the transmission line short between the antenna and the transmitter. Of course the higher up your antenna the better it will get out, but this means longer transmission lines. You'll have to come up with a compromise between antenna height, transmission line length, and antenna gain.

CIRCULAR POLARIZATION

You may modify your antenna system to achieve circular polarization. If you stack a horizontal unit directly above a vertical unit, so the support booms are actually touching, and the horizontal unit straddles the vertical you are close!

Look at Fig. H for a moment. Picture the top horizontal unit resting right on top of the top vertical element. Their radiation centers would be almost at the same point. Now make the vertical's Y1 cable any length that's convenient, BUT, make the horizontal's Y1 cable 1/4 wavelength longer! Repeat the above for all vertical/horizontal pairs. All the other cables and transformers remain the same as before.

The extra 1/4 wavelength of cable going to the horizontal unit delays the signal by 90 degrees. The signal is first radiated by the vertical, then 90 degrees later by the horizontal, then the vertical, then the horizontal, and so on. The signal is now spun out in all directions at 100,000,000 times each second! While the other systems of stacked antennas gave both horizontal and vertical polarizations, this method gives all-other-polarizations-in-between!

The gain in any one polarization does not change however. When you mix the polarizations equally you have 1/2 power going horizontal and 1/2 power going vertical (or somewhere in between). This also holds true for the stacked verticals and horizontal without circular polarization.

Example: 1/2 power goes to 2-bay vertical with gain of 2...total gain = 1
1/2 power goes to 2-bay horizontal with gain of 2...total gain = 1

Therefore: a 4-bay antenna, with 2 horizontal and 2 vertical has a gain of only 1 but its a gain of one in each polarization.

Now, a final mind blower! Here is a typical example of what you will be fighting to get out a decent signal:

Transmitter power = 10 watts = TPO
100' of RG-8 = 63% efficiency = F
4-bay horizontal = gain of 4 (H) = G
4-bay vertical = gain of 4(V) = G

Therefore:
 $TPO \times F \times G = \text{actual ERP}$
 $10 \times .63 \times 4 = 25.2 \text{ watts}$

However:
only 1/2 of the power is going to each polarization, so...you have only 12.6 watts (H) and 12.6 watts

GOOD LUCK!

each of the turns a wire diameter apart. You could do it of course by simply pulling the turns apart but the spacing would not be uniform or look all that neat!

With a pair of long (or needle) nose pliers bend the wire ends of the coil at right angles to the coil turns. See Fig. 2 for more detail. The "top" end of the coil is the toughest. It must be bent so the end wire comes up and over the supports of the variable capacitor.

The second coil is made in the same manner except it is wound in the OPPOSITE DIRECTION. Again, bend the top end wire so it will center the coil between the bottom and top of the box when the end wire is resting on the variable capacitor's supports.

Solder the coils to their respective capacitor supports as shown. The wire ends at the "top" of the coils are placed very close together and cut off just before it can touch the opposite capacitor. These two wires, one from the "top" of each coil, are purposely placed close to each other. A very small capacity exists between them - this is your coupling capacitor between resonant circuits! The closer they are the greater your passband and the greater the power transfer. About 3 thicknesses of this paper fitting between these wires will give about a 2 MHz pass band. Farther apart will narrow the pass band and reduce power transfer.

Cut the bottom wire of each coil to the proper length to solder to the solder lugs. The solder lugs should not be attached to the box when you do this. The box will act as a heat sink making soldering difficult. After soldering attach the lugs to the box with the 4-40 screws. Install the shield at this time.

Now solder the center pin of each coax connector to tap position of the appropriate coil. This should be about 1 full turn. Put the lid on the box and put it to work!

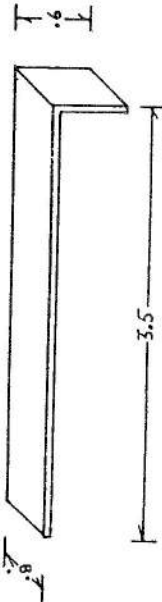


Fig. 3 Shield detail

PARTS LIST & SOURCES

Quantity	Description
1	Cast Aluminum box, 2.4" x 4.4" by 1.0"
2	Air variable capacitors, .4" x .4" square, 1/4" mount, 10 Pfd max
2	Coax connectors of your choice, Type F, BNC, CH-239, etc.
2	4-40 x 1/4" machine screws
2	4-40 nuts
2	solder lugs, #4 hole
1	Aluminum strip approx. 4.5" long, .8" wide, 1/16th" thick
2	Feet # 14 or # 12 bare copper wire (silver plated best if you can get it but not absolutely necessary.) (Try hardware stores)

MOUSER ELECTRONICS
 11433 Woodside Ave
 Santee, CA 92071
 (619) 449-2222

RADIO SHACK
 Check local phone listings

PANAXIS
 (Full kits)

ASSEMBLY INSTRUCTIONS

Begin by drilling the appropriate mounting holes. Dimensions are given in Fig. 2 at right.

The cast aluminum box is just 1" thick (deep). All holes are drilled midway on each side, in other words .5" up from the bottom of the box.

Install the variable capacitors and coax connectors. The coils (inductors) are installed almost last. Position the capacitors so the "open" part of the plates is toward the bottom of the box. This puts the bottom of the cap with its support brackets at the top so you can solder your coil to it.

Next wind your coils and bend your aluminum strip to make your shield.

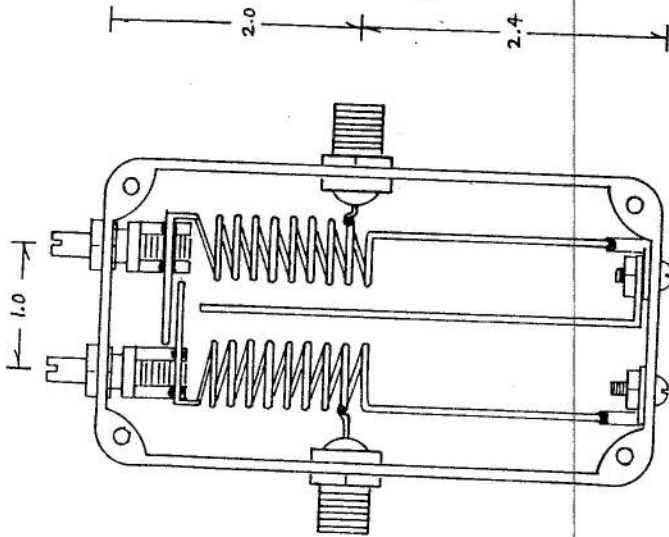


Fig. 2 Assembly Drawing

THEORY OF OPERATION

The filter consists of two parallel resonant circuits very loosely coupled by a small capacitor. Coupling between inductors by their magnetic fields is kept to a minimum by a shield. ETC.

OPERATION

Operation is very simple. Just connect the output of your transmitter to one of the coax connectors. Connect the other coax connector output to your antenna. The unit is symmetrical so either coax connector may be used as an input or an output.

Adjust each variable capacitor to be about the center of its range. Connect some means to monitor the filter's output. This can be an RF voltmeter, an SWR meter or power meter. The antenna should be connected or false tuning may result. You may also use a field strength meter to indicate when you have tuned the filter for maximum power output. As a last resort you can even use the tuning meter of your FM receiver. Tune it to your frequency.

Turn on your transmitter. Tune one filter variable until you get an output. Then tune the other variable capacitor to increase that output. Repeat this several times until both capacitors have been "peaked" for maximum output.

CONTACT

Radio Support Group

D.R.COMMUNICATIONS: c/o 37 Stokes Croft, Bristol

A technical aid, development and research group for radical pirates. Membership £5, for which you get a free copy of this book, and advice, updates and help building the designs in it. Money goes to buy better test gear and parts. Donations welcome.

Free The Airwaves

FREE THE AIRWAVES: BCM Box 1502. London WC1N3XX Produce RADIO CRIMES (same address and all good book shops, 30p + stamp). Campaigns for local neighbourhood pirates. A Clearing house for pirate info. Membership £2.00 for individuals £10 for organisations. Design simple transmitters and answer technical queries on them.

TRANSMITTERS BUILT TO ORDER: write to LEE, 71 Ave de Fontainebleau. B.P. 38, 77310 Pringy-Ponthierry, France. Tel (6) 438 1159. (cost: expensive. Send reply coupon).

RESEARCH COMMUNICATIONS: Unit 3, Dane John Works, Gordon Rd, Canterbury, Kent. Offering transmitters of 50 w for a mere (wait for it) £780 plus £30 post plus Vat. Who are they kidding!

PANAXIS PRODUCTIONS: p.o.Box 130, Paradise, CA 95969 USA. Sell TX's, and everything else by mail order. Good catalogue. But Paradise don't come cheap. Even to buy the design and building instructions for e.g. their Stereo Encoder (Model SG - P) will cost you 15 dollars. Don't go for their cheap exciter, its a dud toy. (In USA standard preemphasis is 75 us, here its 50 us, so a few values have to change in stereo generators etc.).

CRYSTALS MADE TO ORDER: from IQD Communications Devices, Nth St, Crewkerne TA187AR, or from Gollidge Electronics, Merriott, Somerset YA165NS. Tel. 0460 73718.

RADIO AMATEURS HANDBOOK: published by American Radio Relay League (ARRL) yearly. Goldmine. Costs 20 dollars but second hand books often available from Fair Radio Sales, PO Box 1105, Lima, Ohio 45802, USA.
OUR RADIO. c/o RATS, BM Hurricane, Lodon WC1N3XX.

RELAY MAGAZINE (may be dead after loss of grant, middle of the road) STOP PRESS. STILL GOING STRONG AT: BON MARCHÉ, BRIXTON RD, LON SW9.

TX. LONDON'S ALTERNATIVE RADIO MAGAZINE: contains excellent rundown of current pirates, commercial but will print news, boasts that dreadful sexist bigot, Chris England on the 'crew'. from BCM Box 225, Lon WC1N3XX. 90p.

ANORAKS UK: Distributors, do TX, Free Radio Waves and a weekly report called AUK (good). Also distribute all kinds of pirate paraphernalia (if thats how you spell it). Have a catalogue. From PO Box 539, Blackpool, Lancashire FY14RE.

THE FREE RADIO RENDEVU: (TFRR): Short wave pirates, inc. news and logs of stations on air. From Pengarth, Pennance Lane Lanner, Redruth, Cornwall TR165TW.

LONDON SQUATTERS PIRATES: 3 local stations starting April 87. Nth Sth and East london. Radio Interference (S.Lon) can be heard at present on 106mhz around 6pm Fri. All c/o BCM 1502, Lon WC13XX.

MEDIA MONITOR: Nice little mag. Covers short wave and FM and legal. Weekly. 50p + stamp. No 37 has good feature on worldwide jamming wars. (28pp A5). From Roger Tidy, 11 St Philip Hse, Lloyd Baker St, London WC1 9BA.

HACKNEY BROADCASTING AUTHORITY: Community pirate, started on Oct 4th Day of Action called by CRA, but were drowned out due to broadcasting too close to the powerful Kiss FM (maybe they could be heard in Hackney). Did progs on Battle of Cable St, housing, Latin American music and history etc. Have 2 paid workers and went for CR licence, supported by Hackney Council. Not heard since. 94 mHz. Address lost.

SPECTRUM RADIO: Open access group, developed from CCR which developed from Our Radio etc. At one time had 5 paid workers from a GLC grant. Went for CR licence. Never broadcast (not the rock station of same name). Interchange, 15 Wilkin Street, London NW5 3NG.

VOICE OF NICARAGUA: English broadcast Mon-Sat, 1.00 and 5.00pm on 6015kHz.

PEOPLES COMMUNITY RADIO LINE: have returned in Birmingham after 2 busts. 103.7mHz. c/o 151 Dudley Rd, Edgbaston, Birmingham B18 7QY.

JBC:BLACK MUSIC FOR BRENT. Best and most regular (mostly 7 day) of the good dozen black music stations, have recently started Irish and Asian programmes. Not busted much, maybe cos on low power and move TX regularly. Supported by Brent Council in CR licence bid. 104.75mHz 126a Roundwood Road, London MW10.

SINA RADIO: seems to be the last Asian pirate left. Broadcast with low power, 7 days to the Southall area, don't seem to be busted as much as others. Bilingual Hindi/English.

LONDON GREEK RADIO: has been busted at least 100 times, but survives by sheer persistence where other Greek pirates have vanished. Scored a legal precedent in Aug 86 when the landlord of their Tx site was busted and fined £1250! Commercial. 105mHz Po Box 225, London N19 45N.

FREE TEC: most efficient, reliable and helpful place to get ready made technical gear. Bandmaster FM 35w, £85. 5w complete £40 etc. Have no address, but Free Radio Waves will forward mail. Freetec, c/o Free Radio Waves, FLAGSONES, West Heath Lane, Sevenoaks, Kent TN13 1TA.

BROADCASTING: VHF rigs etc. forwarding address C/o BCM Box 225, London WC1N3XX.

ANFIELD COMMUNITY RADIO: c/o 111 Pinehurst Ave, Anfield, Liverpool, L4 7UG. 1413 kHz. MW.

RADIO LIBERTARIA: Spanish anarchist pirate. San Martin 5 1a, Valencia, Espana.

NUOVA ELECTRONICA: sell complete TX's and all kinds of gear and kits, including PLL exciters. Write in Italian (all instructions also come in Italian) to Via Cracovia 19, Bologna, Italy.

ELEKTRONIKA: sell transmitter kits etc. Guy in shop speaks English. Address: Papaverhoek 22. Amsterdam Noord, Holland Tel. Amsterdam 327514.

FREE RADIO WAVES: Pirate buffs. some good info, worth a read. from Flagstones, West Heath Lane, Sevenoaks, Kent. 90p (40pp a5).

CROWBAR, (A) SQUAT PAPER + BLACK FLAG, (B) NEWS FORTNIGHTLY: BM HURRICANE, LON. WC1N3XX.

WAVE
CLOSED