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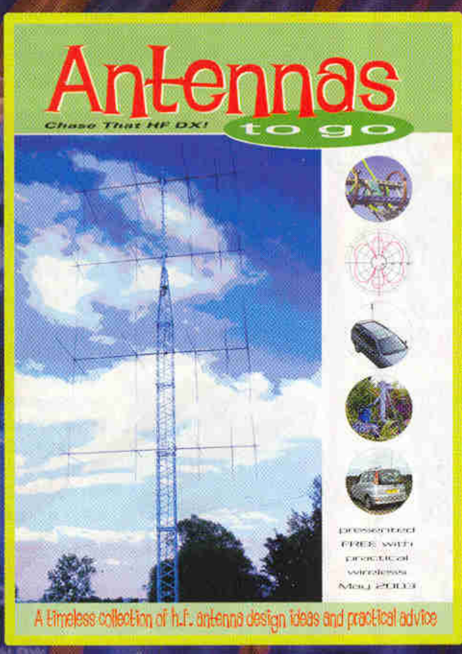

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Cover Subject
There's so much going on in this issue... that we were at a slight loss as to what to show on the cover this month! So we've shown a selection of the delights you'll find inside. And of course this month you'll have plenty to keep you busy as there's an extra 32 pages in the free *Antennas To Go - Chase That HF DX* magazine for you to read. The team hope you enjoy it and welcome your comments.

Remember Amateur Radio is a hobby for us all to enjoy - no matter what your level of expertise so, keep on spreading the word and encouraging newcomers to join in and have a go!

Design: **Steve Hunt**

Free with this issue!

May features

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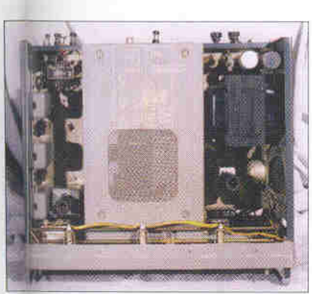
May regulars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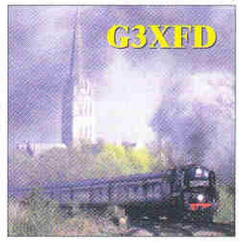

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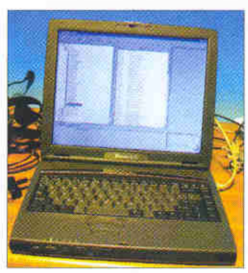
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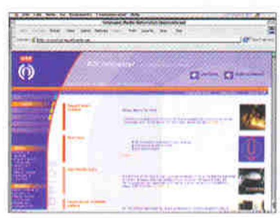
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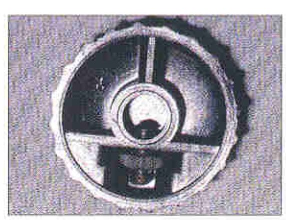
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Looking At...

The Birth of a Radio Wave

Gordon King G4VFV takes us back to the birth of radio signals as he looks at the radio wave.

After launching into the transmission side of Amateur Radio in the last four instalments of Looking At... by looking at simple transmitting circuits and network configurations for coupling the generated radio frequency (r.f.) energy into the ether to yield radio waves, it's now time to start looking at the specific stages of more realistic transmitters and transceivers in more detail. The best place to start, of course, it at the beginning where the r.f. is created and where the radio wave is actually born.

What's A Radio Wave?

So, what is a radio wave? Well, a radio wave is part of the great natural electromagnetic (EM) wave family which has residence not only around this planet of ours but also right into the depths of space. Waves in the so-called radio spectrum differ from their kin, light, heat, X-ray, cosmic, waves etc., only in terms of their wavelength and therefore frequency. All these EM waves travel through space at exactly the same speed, which is mighty close to 300 metres per microsecond!

The constant speed makes it so easy to find the length of a wave in metres (m) simply by dividing 300 by its frequency in megahertz or, conversely, to find the frequency of a wave in megahertz (MHz) by dividing 300 by its wavelength in metres. Let's look at a couple of examples:

The wavelength of a 21MHz wave works out to a shade over 14,28m (300/21=14.28), and the frequency of a 150kHz (0.15MHz) wave works out to 2000m (300/0.15=2000). This simple bit of arithmetic is applicable to all and every EM wave.

Electromagnetic radio waves are created by a rapid change in electric current passing through an antenna that's 'coupled', so to speak, into space (which, from the radio wave point of view, was once called the 'æther' - still a lovely word, but rarely used in this sense any more, which is a pity). Such coupling starts initially with the production of out of phase electric (E) and magnetic (H) fields.

However, at a relatively short distance after leaving the antenna, the E and H fields become phase coincident, and when this happens a fully-fledged EM radio wave is born. As the waves spread out from the antenna their amplitude progressively reduces, rather like the waves, which spread out on still water when disturbed by a stone.

Spreading causes the amplitude of the fields to diminish reciprocally with distance, which simply means that each time the distance is doubled, the strengths of the fields is halved. Field strength is usually a measure of the amplitude of the E field in terms of volts per metre (V/m).

A representation of a space-bound section or ray of an EM wave is given in **Fig. 1**, where it will be seen that the amplitudes of the E and H fields are at right-angles to each other and to the direction of wave travel.

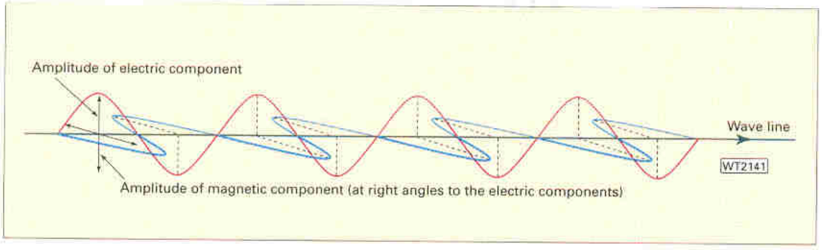


Fig. 1: Representation of the electric and magnetic components of a radio wave travelling through space. Wave polarisation is in the direction of the amplitude of the electric component.

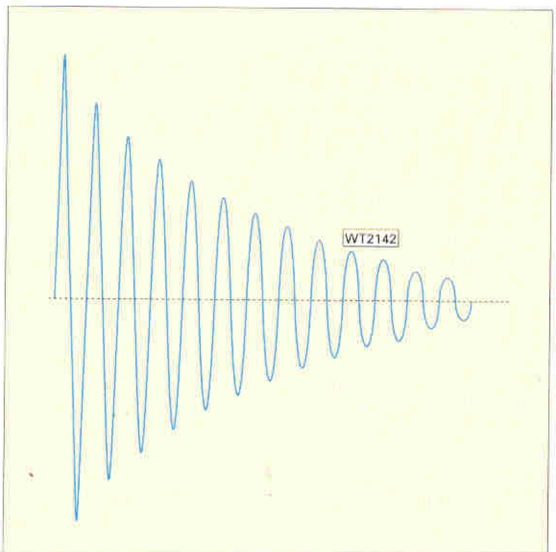


Fig 2. Oscillogram illustrating a burst of damped oscillation.

Wave Polarisation

Polarisation of a wave is in the direction of the amplitude of the electric field, which implies that the diagram represents a horizontally polarised wave. Excluding the effects of reflection, refraction and diffraction, EM waves travel outwards from source in straight lines at the remarkable speed of 300m per microsecond, just noted - the greatest speed so far proven in our universe.

The first designer-EM-wave was created by an electric spark or arc. This formed the heart of early transmitters - e.g. the spark or arc transmitter.

Before then, when our planet was very young, prior to the advent of man, naturally occurring EM waves would have caused a radio receiver to crackle or crash. Every flash of lightning or naturally occurring electrical disturbance gives rise to its own train of EM waves. Witness how we are bugged by QRN when endeavouring to DX when static is about!

Static QRN

Static QRM is caused by steep-sided pulses of electrical energy consisting of a wide spectrum of frequencies from zero upwards, diminishing in amplitude with increasing frequency that when picked up by the receiver have the effect of 'triggering' the tuned circuit into a chain of damped oscillation **(Fig. 2)**. The oscillatory chain is amplitude modulated at a frequency related to the pulse time. Interference sidebands are thus generated, and resolved by the detector in the usual way, the audio manifestation being the characteristic staccato crackles and crashes from headphones or loudspeaker!

So, you now have an elementary impression of what a fully fledged radio wave might look like if it could be seen, how it can be generated naturally and how it travels through space (the ether?). In the previous four Looking At .. columns I have looked at two simple transmitters and various ways in which the radio-frequency (r.f.) energy can be directed into an antenna.

As this series continues I will be investigating the aspects of transmission in greater detail, while also considering how best to focus on to the bands of frequencies that we are able, legally, to exploit without spilling into forbidden (to Radio Amateurs) parts of the radio spectrum and how to keep our signals clean and frequency stable, along with other interesting transmission-related subjects.

Variable Frequency

To round off let's take another look at the embryo of the radio wave, before its launch into the ether - the circuit which is responsible for the actual generation of the r.f. energy in the first place. A classic circuit of this kind, known as a variable frequency oscillator (v.f.o.), is shown in **Fig. 3**, where the active device is a junction-gate n-channel field effect transistor (f.e.t.).

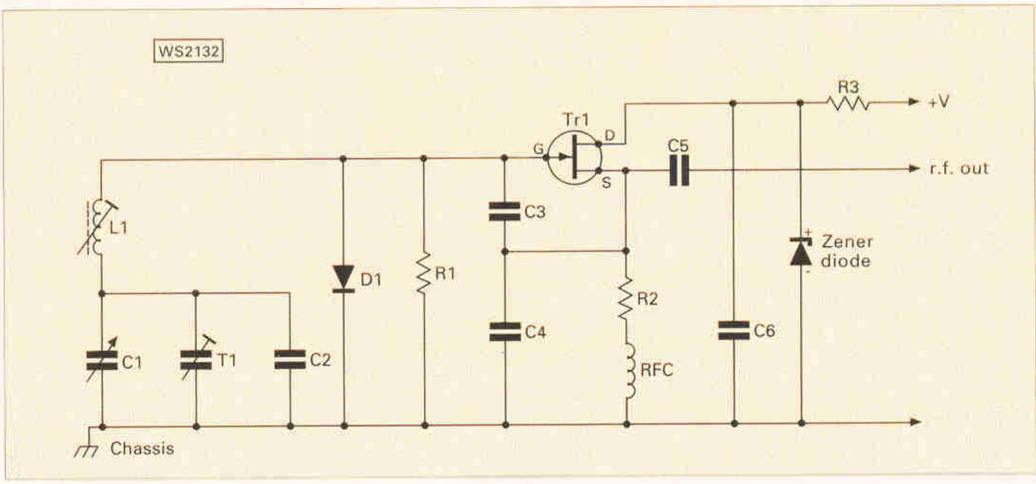
The oscillatory circuit consists of inductor L1 tuned by the parallel combination of the tuning capacitor proper VC1, the trimmer capacitor T1 and the fixed capacitor C1, whose values are chosen in conjunction with the inductance of L1 to suit the required amateur band. Trimming of the tuning range is also possible by adjusting the dust-iron core in L1, which alters the inductance value.

Positive feedback, and hence oscillation at the tuned frequency, results from the source (s) back coupling to the gate (g) of the f.e.t. The radio-frequency choke (r.f.c.) retains a high r.f. impedance, while the feedback ratio is a function of C2/C3 values. Drain (d) voltage is stabilised by the zener diode in conjunction with R3 and the decoupling capacitor C4.

The circuit, known as a series-tuned Colpitts oscillator, is renowned for stable operation when care is taken over the choice of components related to the sensitive frequency determining functions. The gate-clamping diode D1 is a specific aid in this respect, as also is the zener diode whose job is to stabilise the supply voltage. Output r.f. is taken from the source through C5, the value of which should be as small as possible consistent with the drive demands of subsequent stages. To help enthusiasts wishing to experiment with this kind of oscillator, I have included components values relevant to the 3.5MHz Amateur band.

Once again I have reached the end of this month's instalment. Enjoy your radio, and I'll be back the month after next.

PW



● Fig. 3: Circuit diagram of an f.e.t. variable frequency oscillator - the generator of the r.f. signal. Suggested experimental component values for the 3.5MHz Amateur band are: Tr1 2N3819 or more recent equivalent; L1 circa 22 microhenry; C1 air-spaced 25pF; T1 50pF; C2 75pF; C3 and C4 1nF; C5 47nF; C6 33pF (but see text); D1 1N914 or similar; R1 100k; R2 270; R3 circa 150 (but to relate to the zener diode and supply voltage and current); zener diode; circa 9.1V with 12V to 5V supply; r.f.c. 2.4 millihenry.

Radio Basics

Now that Radio Basics readers are armed (hopefully!) with a dip meter, Rob Mannion G3XFD continues describing the preparation stages of the latest project...the Basic-4 receiver.

Although this column is by far the most difficult for me to prepare for readers...it's also the most rewarding! It's only difficult because - due to space limitations - I have to limit the amount of information provided each month, together with the fact that the column is read by a wide range of readers... from outright beginners 'upwards' so to speak. And obviously, readers will understand I have to try to develop a balance so that beginners are assisted and the more experienced don't feel left out.

The feedback (see letters pages) - is most helpful and we're doing our best to respond. And while responding to your letters (I apologise we can only publish a selection of your letters) I suggest - that those of you who don't have a dip meter yet...to look in this month's information panel where there may be some good news for you!

Now it's time to get stuck in...and try some experiments. Please try them out for yourself...because they'll be very helpful - providing knowledge and experience.

Local Oscillator

Whenever superhet receiver designs are mentioned the term 'local oscillator' is always close by. This is because the local oscillator (l.o.) performs a vital task in the superhet by operating in conjunction with the 'mixer' circuitry to provide the required 'difference' or intermediate frequency (i.f.).

However, there's always the danger in over-simplifying explanations regarding the mixer-oscillator of a receiver. So I must point out that although often described separately as 'The Mixer' and 'The Oscillator' these particular stages are in fact often combined. When this is the case they're referred to as 'Mixer Oscillators'.

Additionally, not all simple receivers have radio frequency (r.f.) amplifying stages before the mixer/oscillator. Instead, they'll often just have the incoming r.f. fed straight into the mixer/oscillator unit. So, don't get yourself confused trying to find three separate stages...it might all be happening in the one stage!

The circuit, **Fig. 1**, shows a very simple crystal oscillator which I used in the 3.5MHz to medium converter project in the November 1998 issue of *PW*. It uses the MPF102 field effect transistor (f.e.t.) which I've chosen as the 'standard' active device for the simple RB projects.

The crystal used in the oscillator is a very cheap 4.43MHz colour sub-carrier crystal as used in PAL equipped television receivers. These are available from many sources and only cost around £1.50. The MPF102s are available from sources such as Sycom (see ad this issue), Bowood Electronics, etc.

A variable frequency oscillator could have been used for the project - but I had reasons for not adopting this approach! A variable frequency oscillator (v.f.o.) has to be set-up correctly to work on the frequency required and you need knowledge, experience and some form of indicator to prove that it is on the right frequency. (It's not unknown for a 3.5MHz v.f.o. to be effectively operating on 7MHz...the first harmonic of 3.5MHz - and I say this because I've been caught out myself in the past).

Instead, by using a crystal oscillator you can be assured that (a) the oscillator **should work** first time and (b) it should also be within a 'cat's whisker' of the frequency it's meant to be on (more of this later). However, the disadvantage is that the crystal oscillator in the form shown in Fig. 1, can also cause problems by producing many harmonics (multiples of the original crystal frequency). Despite this though, in this application the little crystal oscillator featured here is perfectly adequate and it can now form part of the learning and preparation process for the full Basic-4 receiver.

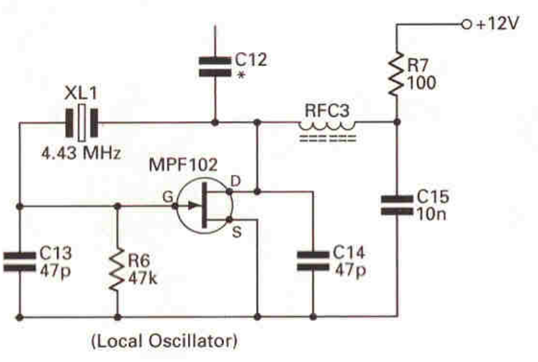


Fig. 1: The local oscillator is the 'heart' of any receiver based on a superhet. For efficient operation of the receiver it is essential that the oscillator operates correctly, and on the right frequency to produce the intermediate frequency (i.f.) required. Variable oscillators can be difficult for inexperienced constructors, and for this reason G3XFD has opted for the fixed frequency crystal oscillator (see text).

Full Circuit

If you now look at the full circuit, **Fig. 2,** you'll see that the local oscillator circuit in Fig. 1 forms the lower part of the illustration. Note that the oscillator's 12V power supply feed goes off to the common 12V d.c. positive supply rail which is also used by the rest of the converter. Note also that the negative '0V' rail (wire) is n now connected to the '0V' rail on the rest of the circuitry.

When the power is provided the l.o.'s MPF102 will start generating the 4.43MHz signal (the local oscillations) and this is then fed (The term 'injected' is commonly used) via capacitor C12 to the Gate (G) of the MPF102 which is situated directly above. This of course is the mixer transistor.

In the example shown, the incoming (amplified by the MPF102 f.e.t. tuned r.f. (t.r.f.) stage is tuned (by the inductor L1) to the 3.5MHz Amateur Band. It then - 'mixes' with the l.o. signal (Which is at 4.43MHz). This mixing process results in a number of 'difference' frequencies being generated* and we will then 'select' (or 'tune') the one we require. In this case the required frequency will be the difference between 4.43 and 3.8MHz (top of the 80 metre band), and 4.43 and 3.5MHz (bottom of the 80 metre band).

****Other signals appear, but we'll ignore the others at present.***

If you now do a simple bit of arithmetic you'll see that at the top end of the 80 metre band the difference between

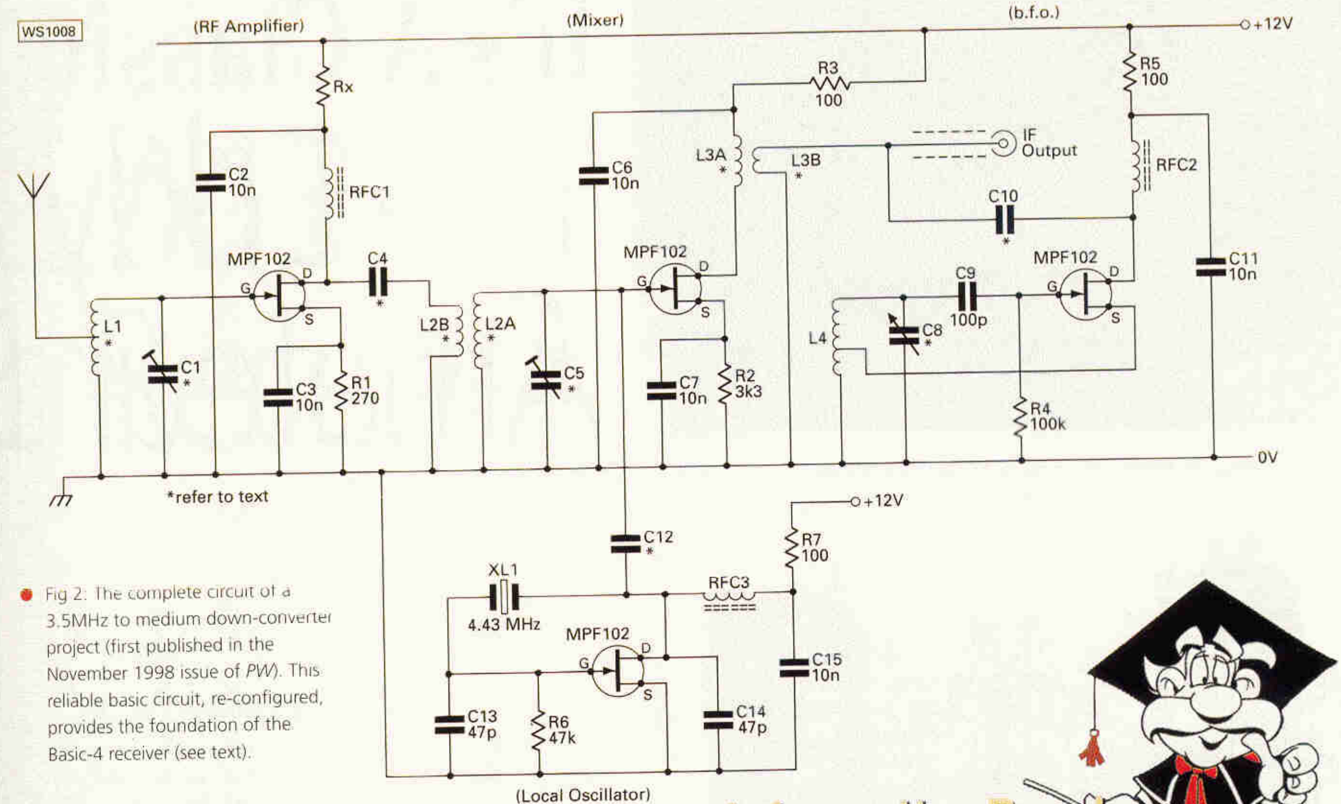


Fig 2: The complete circuit of a 3.5MHz to medium down-converter project (first published in the November 1998 issue of *PW*). This reliable basic circuit, re-configured, provides the foundation of the Basic-4 receiver (see text).

4.43MHz is 630kHz. At the bottom end of 80 metres the difference between 4.43 and 3.5MHz is 930kHz. In other words - the i.f. tuning range for the band covered by this converter is from 630 to 930kHz...ideal for tuning in on a medium wave radio (a car radio with a screened antenna input connection for the converter output was used in the original project).

However, as the 4.43MHz l.o. frequency is **ABOVE** the frequency of the incoming 80 metre band signals...**the i.f. tuning is reversed**. In other words 3.5MHz will appear at 930kHz, and 3.8MHz will appear at 630kHz. In practice this is not a disadvantage - a little odd at first perhaps...but not a real disadvantage.

Incidentally, with one of the odd little coincidences that happen in life...you can actually read about a famous receiver that uses the 'reverse tuning' technique in *PW* this month! You'll find it in the It's A Classic article which features the truly collectable Eddystone EA12 double conversion crystal controlled front-end receiver. So, if the famous Eddystone company can use crystal controlled front-end receivers...we can too!

Experiment & Build

Explanation over, I would like you to now build the l.o. from the circuit provided. If you don't have a 4.43MHz crystal (immediately) to hand - you can use another (surplus crystal between 4 and 12MHz abound in junk boxes, rallies stalls, etc.). Get the oscillator working, and then listen for it on a receiver.

Next, using your dip meter, wind and set-up an inductor to cover the band you want (let's stay with 3.5MHz for the moment eh?). Then build sections A and B in Fig. 2. (r.f. and mixer, not the b.f.o.). Wind and set-up L1 for 3.5MHz, and L3a for the middle of the medium wave band...using the dip meter to get the best results and, importantly, on the correct frequencies. Finally, you can apply the power to each stage, check for short circuits and if all is well...apply the antenna and feed the i.f output to a medium wave (preferably a car radio). Tune between 930 and 630kHz for the amateur band. We'll talk about the necessary b.f.o. section later!

If you don't feel confident enough to do as I've suggested...build the l.o. by itself and get that working. You can do that without a dip meter! Next time we'll move on to look at the regenerative 'active' detector stages and other tuning requirements. *PW*

Information Panel

Up-date information on buying a dip meter: I'm pleased to say that there's good news for prospective purchasers of dip meters! Following my mentioning the MFJ-201 dip meter which **Waters & Stanton PLC** import from the USA - as the MFJ agents in the UK - the company have informed me that they've managed a significant price reduction. So, with that good news I can tell you that a brand new MFJ-201 dip meter will now cost **£99.95** (Reduced from £129.95). Incidentally, for anyone familiar with the once commonly-available (but seemingly now not on sale in the UK) Altai dip-meter....the MFJ-201 meter has exactly the same styling, and technical details. It also looks very similar! Both the old Altai and the MFJ-201 dippers also include a built-in audio oscillator and modulator unit. **This is of great help when tuning up simple receivers which do not have beat frequency oscillators (such as crystal sets)**. I mention this because I know that many RB readers thoroughly enjoy experimenting with such receivers. So, a 'dipper' with a built in modulator should prove very helpful! I'm also hoping that there will be a kit dip meter available again soon. Watch this space for further news on this topic!

Headphone adapter project: During recent club/rally visits, a number of RB readers have reminded me that I've promised to present the high-to-low impedance project which will enable the efficient use of modern 8Ω impedance headphones with simple receivers (particularly crystal sets). I had intended to base this on discrete components and transformers but following a lengthy search a reliable supply of the latter has not been found. I now plan to present it in an i.c. (transformerless) version soon. **I'm sorry to keep you waiting**.

It's A Classic The Eddystone Amateur Ba

It's A Classic! The Eddystone EA12 receiver. The small control above the S-meter is the calibrator On-Off push button. The knurled spindle on the right hand opposite side, is the cursor adjustment for calibration purposes (see text).
Photographic facilities courtesy of Ken O'Brien.

Ben Nock G4BXD, takes a look at the Eddystone EA12 Amateur Bands only receiver...a receiver which many of us viewed as the 'ultimate' in the 1960s. Now very much collectable... what does Ben think of the design?

The recent demise of the once famous Eddystone name (latterly part of the Marconi Group and specialising in Broadcasting equipment) is certainly a sad event for radio communications. In their time Eddystone produced some memorable receivers for all aspects of radio, marine, commercial and of course amateur operating.

One of the few receivers **specifically designed** by Eddystone for the Amateur Radio operator was the EA12. This set, produced between 1964 and 1969 costing £178 at the time, covered what at that time were the Amateur Bands, i.e. the 1.8 to 28MHz (160, 80, 40, 20, 15 and 10 metre bands) before the advent of the WARC bands. The receiver used the high performance double conversion principle, was given a tuning scale large enough to read from across the room and a styling that was very eye-catching and still looks very smart today.

Many refinements were incorporated into the EA12 receiver, including filters for both radio and audio frequencies. It was also provided with a built-in calibrator, tuneable notch filter, separate detectors for a.m. and c.w./s.s.b., a large S-meter and fitted loudspeakers to name just a few.

Crystal Controlled

In total 13 valves and five silicon diodes are used in the EA12's double conversion superhet, which employs a crystal controlled front end. This converts the incoming antenna signal to a 60kHz wide intermediate frequency (i.f.), and a second tuneable mixer then converts this to a fixed tuned 100kHz second i.f. stage.

The front-end of the receiver comprises three valves, V1, 2 and 3, as a crystal controlled unit with an output of 1.1 to 1.7MHz. To provide better cross modulation reduction and signal blocking on strong stations a cascade type radio frequency (r.f.) amplifier circuit is used.

Bandpass coupling of tuned circuits between the antenna and r.f. amplifier ensure excellent front end selectivity. Next, a third section, coupled to the first two, connects the amplifier to the first mixer. The input circuitry includes a high-pass filter, providing better than -90dB attenuation below 1.7MHz.

The r.f. amplifier stage has both manual and automatic (when selected) gain control applied to it. There's a facility to mute the r.f. stage, and also on the last (100kHz) i.f. stage during transmissions, the mute level being adjustable to allow the monitoring of any outgoing transmissions.

The crystal oscillator operates on the fundamental crystal frequency on all but the 21 and 28MHz bands. On these bands its output is doubled in frequency. The oscillator frequency is on the high side of the signal frequency on all bands, which produces 'reverse tuning' on the main dial.

Stabilised Supply

A stabilised 150V supply is provided for the oscillator and buffer/doubler circuit. The first mixer stage uses the heptode section of V2, combining the amplified antenna signal and the crystal oscillator output, the other half of V2 acts as a buffer to the oscillator on all bands except 21 and 28MHz, where, as previously mentioned, it has to work as frequency doubler.

Band-pass coupled tuned circuits feed the signal to the second mixer stage and tune the range 1.1 to 1.7MHz utilising two sections of a three-gang capacitor unit. The second mixer, the heptode section of V4, is fed from its triode section, which acts as a buffer to V5, the tuneable oscillator. This light coupling allows automatic gain control (a.g.c.) to be applied to the 2nd mixer without pulling the second oscillator frequency.

The third section of the main variable capacitor unit forms the tuning circuit for the 2nd oscillator, V5. This oscillator operates on the low side of the i.f. range.

Unusually, the h.t. feed to the 2nd oscillator is from the unregulated supply. The idea behind this is that any variation in a.c. line voltage would cause the h.t. to vary but the tendency towards drift would be compensated by the opposite reaction due to the heater voltage change. If the stabilised h.t. was used then the change in heater voltage would not be compensated for.

ne EA12 nds Receiver

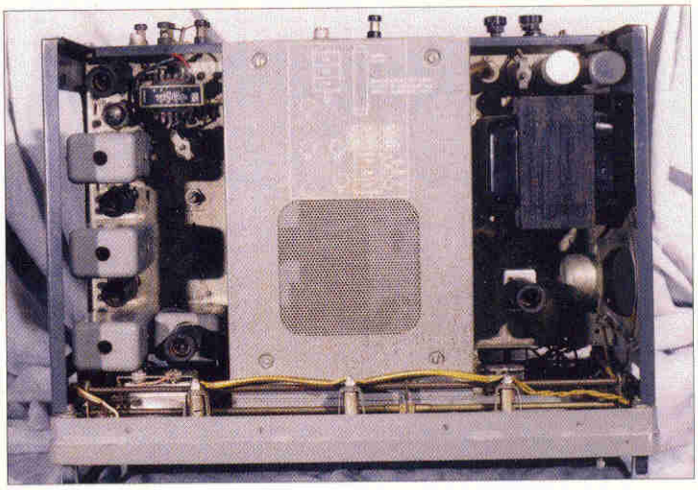


Fig. 1: Inside (above chassis) view of the EA12. The receiver can clearly seem to be substantially built (see text). Photograph G4BXD.

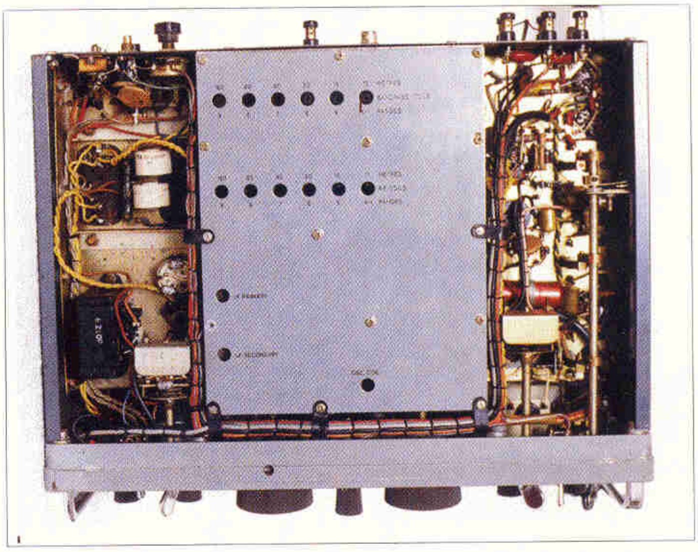


Fig. 2: Under chassis view of the EA12 receiver. Note coil and range details, necessary for calibration purposes (see text). Photograph G4BXD.

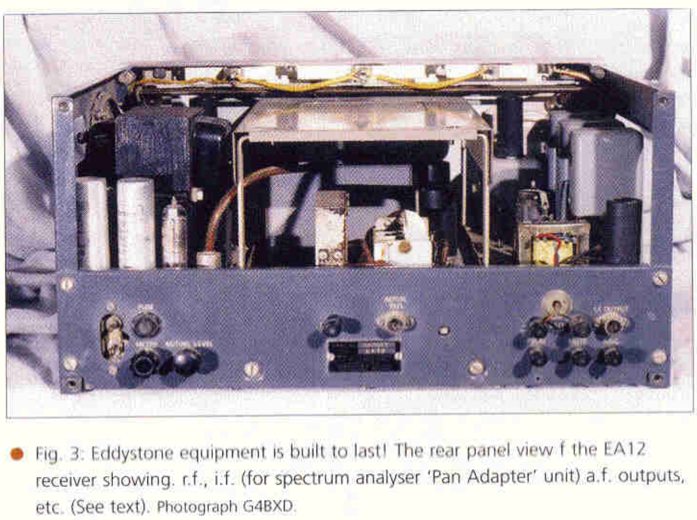


Fig. 3: Eddystone equipment is built to last! The rear panel view f the EA12 receiver showing. r.f., i.f. (for spectrum analyser 'Pan Adapter' unit) a.f. outputs, etc. (See text). Photograph G4BXD.

Valves 6 and 7 are employed as i.f. amplifiers with both stages being a.g.c. controlled with the addition of manual control of the first stage. This section of the receiver also includes the crystal filter unit and the notch filter.

Notch Filter

The tuneable notch filter can impart up to 40dB of very sharp rejection to the pass-band. The design uses the (much favoured by Eddystone) variable/adjustable secondary windings on the three i.f. transformers, which allow continuously variable selectivity.

A front mounted control gives three positive 'click' stops at 6, 3 and 1.3kHz bandwidth and if the same control is advanced further the crystal is introduced into the signal path, reducing the amazing bandwidth to 50Hz, all quoted to the -6dB points.

The 2nd amplifier stage also drives the S-meter but this is disconnected when the **AGC Off** position of the relevant switch is selected.

Muting voltages are obtained from the first stage and fed to a control on the rear panel of the set. External muting, from a transmitter relay for example, can also be applied.

A double diode in V8 is used as the a.m. detector and a.g.c. rectifier. Noise limiting in the a.m. mode is achieved with a silicon diode. Two speed a.g.c. response times are available, when the **AGC Off** condition is selected.

Valve 10 functions as product detector and beat frequency oscillator (b.f.o.). Switched fixed capacitors are used to select between upper and lower sideband and a pre-set offset, these capacitors are in series with the main b.f.o. tuning capacitor. The result is that on c.w. the b.f.o. can be varied by ±3.5kHz, whilst on s.s.b., only ±100Hz adjustment is available.

Detection Audio & Power

The product detector's audio output is taken through a diode noise clipper that can be switched out of circuit. The threshold of clipping can be manually set while a low-pass filter follows the clipper or detector output, giving a response of 500Hz at -10dB and 5kHz at -30dB.

A bandwidth of 300Hz at -6dB can be obtained when the c.w. filter is switched into circuit. Indeed as I've already mentioned, with the selectivity control settings of between 1.3kHz and just 50Hz are available to the listener.

Audio amplification is provided by half of V9 and then by V11, the output valve. An internal low impedance speaker is fitted to the set, but connections are also available for external speakers. Inserting high impedance headphones via the provided standard jack socket disconnects the internal speaker.

The power supply is fairly standard and uses a full wave rectifier circuit giving the main 250V h.t. rail. An OA2 regulator valve is used to provide a stabilised 150V rail. The low-tension side powers the valve heaters and also the plentiful and well thought-out dial illumination.

A 100 kHz crystal oscillator circuit is provided by V13. When required it's switched on by depressing a button at the

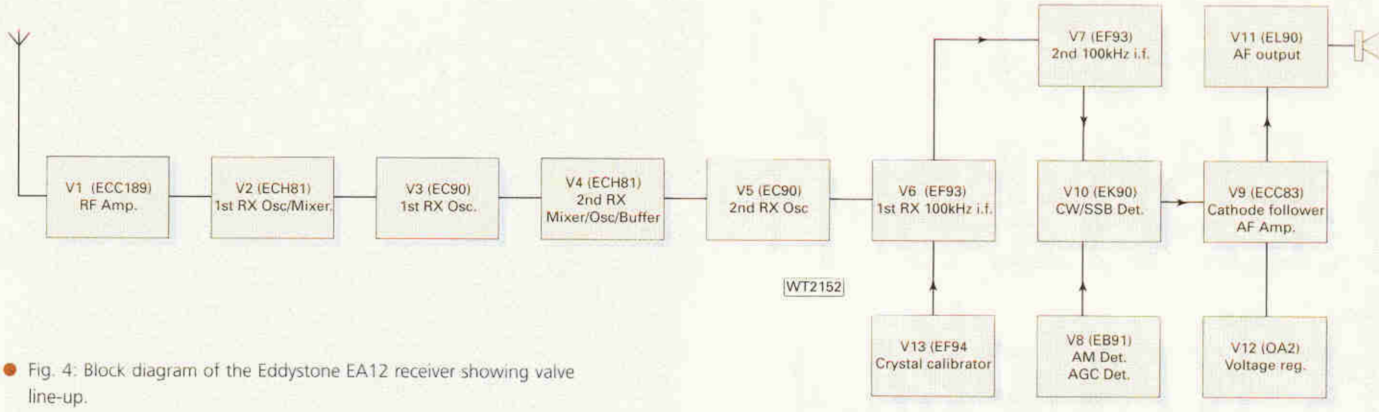


Fig. 4: Block diagram of the Eddystone EA12 receiver showing valve line-up.

top left of the receiver front panel, which grounds the cathode of the valve and starts the oscillator. Cleverly it also reduces the gain of the r.f. amplifier...making the calibration pips easier to find.

In practice, as the second i.f. is the same frequency as the calibrator fundamental, a beat note is heard even when the receivers is operating in the a.m. mode. Finally, the main tuning cursor can be physically moved to achieve accurate calibration settings.

Super Smooth Tuning

The large well illuminated tuning scale, the super smooth slow motion tuning and various variable pass-bands make the EA12 one of the nicest and easiest receivers to operate on the air. The main tuning has a 140:1 reduction gearing and with the large flywheel and a scale of over 254mm (10 inches) there's a 12kHz frequency shift per revolution of the tuning control which, with no backlash, makes for high resetting accuracy.

The EA12 was available in table top and rack mounted versions. An additional plate could be fitted under the front of the table version to raise its operating position making some of the controls easier to use.

The large knob style controls on the receiver all give a positive feel, are easy to operate and finish off the general appearance very effectively. Matching chrome levers are used on the a.g.c., selectivity and mode controls.

The internal layout of the receiver is very clean, r.f. sections in the centre, i.f. and the audio stages down one side, and the p.s.u. and b.f.o. down the other. However, the p.s.u. filter choke seems to be precariously close to the **Mode** switch! Incidentally, very detailed information on coil location and alignment points is carried on the base plate of the set.

Impressive Performance

Even when I've only used the EA12 on a short length of antenna, just five metres or so, the receiver has provided an impressive performance. Interference can be filtered out, and weak stations copied easily using the variable selectivity.

Very weak c.w. signals can be resolved using the adjustable selectivity and the various filters. On the my station's main outside antenna (35m of wire) the selectivity levels and filters really came into play. Incidentally, Eddystone also produced a panoramic display unit, the EP20, that could be used with the set to provide a visual display of the received signals.

The EA12 is heavy! It weighs nearly 23kg (50lbs or so in old money), but its relatively small 'footprint' - the space it occupies on the table - compared to an AR88 or RA 17 for instance, does mean that it could fit into a small shack.

In its day the EA12 must have been a quantum leap on other sets around at the time. For Radio Amateurs used to operating outdated war surplus it really must have been a futuristic set. Finally, my thanks to **Graeme Wormald G3GGL** for letting me photograph the inside of his EA12 which is in a better condition than that in my own collection. *PW*

Manufacturer's Specifications

Frequency range:	1.8-2.5, 3.4-4.0, 6.9-7.5, 13.9-14.5, 20.9-21.5, 27.9-30MHz (in four bands)
Intermediate freq:	1st i.f. 1.1-1.7MHz, 2nd i.f. 100kHz
Stability:	<100Hz drift per hour after 20 min. warm up <100Hz per hour drift for ±10% line voltage variation
Reception modes:	a.m., c.w., l.s.b., u.s.b.
Sensitivity:	2μV for 10dB SN/N for s.s.b., 0.5V for c.w.
Selectivity:	Variable 6kHz to 1.3kHz, 50 Hz with crystal filter (all -6dB)
Image rejection:	50dB or better
Dial accuracy:	Within 0.5% on all bands, 1kHz when using built-in calibrator
Power requirements:	105-125V or 210-250V a.c. 50/60Hz at 85VA
Rear panel connections:	h.f. antenna (75Ω unbalanced), i.f. o/p, 250Ω, Speaker 8Ω, headphones (2kΩ impedance), S-meter zero, mains input socket
Dimensions:	425 x 222 x 346mm
Weight:	approx.23kg (49lbs)

Valve compliment: V1: ECC189 (r.f. Amp). **V2**: ECH81 (1st receiver mixer/osc buffer). **V3**: EC90 (1st receiver osc). **V4**: ECH81 (2nd receiver mixer/osc buffer). **V5**: EC90 (2nd receiver osc). **V6**: EF93 (1st 100kHz IF). **V7**: EF93 (2nd 100kHz i.f.). **V8**: EB91 (a.m. det/a.g.c. det. **V9**: ECC83 (cathode follower and a.f. amp. **V10**: EK90 (c.w., s.s.b., detector). **V11**: EL90 (a.f. output). **V12**: OA2 (voltage regulator).**V13**: EF94 (crystal calibrator).

Diodes: D1 - DD006 : a.m. noise limiter. **D2/3 DD006**: c.w./s.s.b. noise clipper. **D4/5 DD058**: h.t. rectifier.

The *PW* Midge Catcher

David Banks M0EJB describes the *PW* Midge Catcher...an inexpensive multi-band mobile antenna. If you're keen on working h.f. mobile...it may be just the project for you!

I live on the western edge of the Lake District in North West England. My home is almost surrounded by hills, but with many high roads leading to sites with good horizons, mobile operation in the high h.f. bands is an attractive idea.

However, few multi-band mobile antennas are available, none, apparently, made in Europe. The American-made centre loaded 'Bugcatcher' is very highly regarded but expensive. Fortunately, this type of antenna was very popular for many years in the United Kingdom and information is available which will help the home constructor to build a similar type.

So, determined to have a go myself...I've built one using simple methods, materials from my local builders merchant and the scrap box. My costs were under £20, which compares favourably with the £125 - £300 for commercial versions. This article describes the production of my Mark One Midge Catcher* its set-up and use.

Note: The author decided on this name because of those rather prevalent nuisance (the polite term!) insects which are found both beside English Lakes and Scottish Lochs!).* ***Editor.*

Principal Dimensions

The principal dimensions and electrical layout of the prototype are shown in **Fig. 1**. The arrangement shows a continuous lower section, although the original was made demountable.

The coil, wound on a plastic water pipe former has a calculated inductance of 118μH. The upper section, shown in two pieces was so made, such that the retracted whip need not be lowered into the bottom metal section for tuning.

A telescopic upper section would also avoid this. Because the antenna is so freely adjustable for centre-inductance and length, none of the dimensions appear critical and it's inexpensive to try your own variations.

Much Heavier

The total length of the antenna, fully extended, is 2.8m, similar to many monoband whips, but much heavier! The lower stub can be of aluminium or copper and about 18mm diameter, the coil former and joint plugs are of white plastic water pipe, **Fig. 2**, whilst the upper stub is again of aluminium or copper, 9-12mm diameter.

The whip, from another discarded antenna, is 1.2m long and 2.5 mm in diameter. **Warning:** The water pipe **must be suitable** for use at the intended frequencies. A small piece may be tested in a microwave oven, where it should be heated dry in the presence of a cup of water, which should be boiled for two to three minutes. The chosen pipe should remain cool; if it isn't...try another type or make.

The coil is made from single strand copper wire of 1.7mm diameter stripped from three core high current mains lead – 13A is suitable. If the full length coil is made, about 7.2m of wire is required, taken from 2.5m of three core cable. **Be generous**...as you'll need an extra length to grip during winding.

Joints may be soldered. If purchased retail (as mine was), this is the only significant expense in building the antenna! The final material requirement is for the spacer plugs.

On the prototype the spacer plugs were made from various diameters of white pipe. They were then filled with polyester resin and filler as used in boat building in glass reinforced plastic (g.r.p.). This material appears to be widely used in commercial antennas.

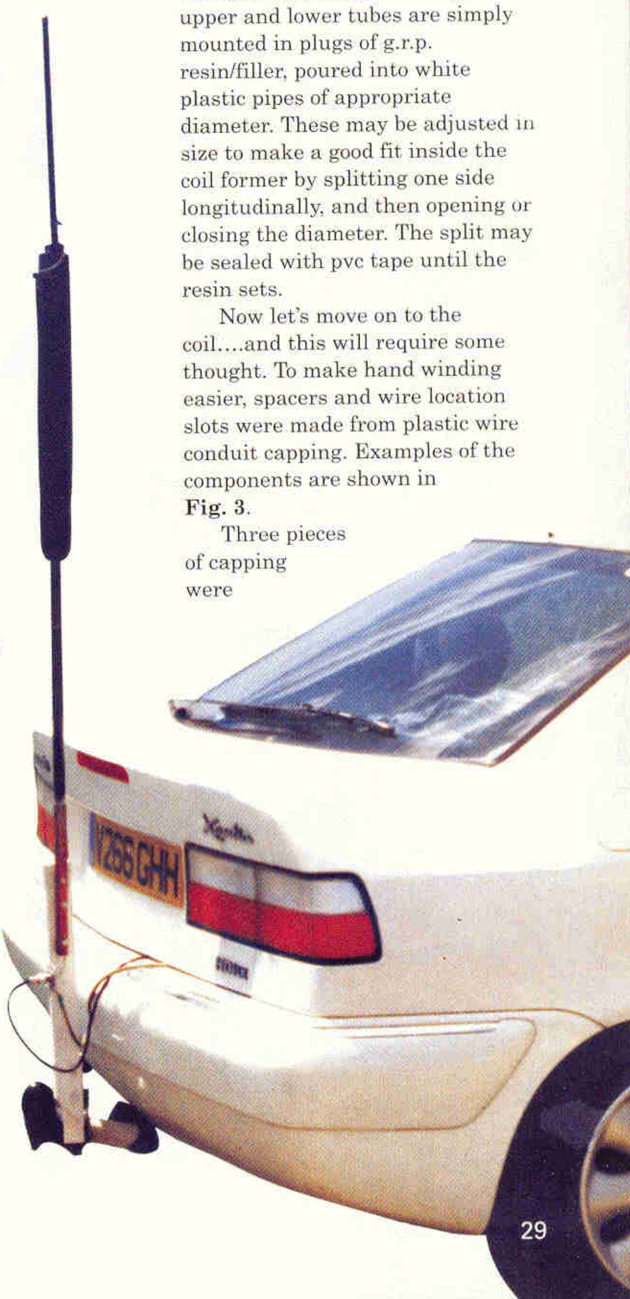
As an alternative, Tufnol (a phenolic resin & fibre material) or even wood may be used. But the ability to pour a liquid resin into a cylinder makes the plug making the easy.

Construction & Assembly

Let's now look at the construction and assembly stages. Firstly, The upper and lower tubes are simply mounted in plugs of g.r.p. resin/filler, poured into white plastic pipes of appropriate diameter. These may be adjusted in size to make a good fit inside the coil former by splitting one side longitudinally, and then opening or closing the diameter. The split may be sealed with pvc tape until the resin sets.

Now let's move on to the coil....and this will require some thought. To make hand winding easier, spacers and wire location slots were made from plastic wire conduit capping. Examples of the components are shown in **Fig. 3**.

Three pieces of capping were



● The completed *PW* Midge Catcher h.f. mobile antenna, posed on M0EJB's car.

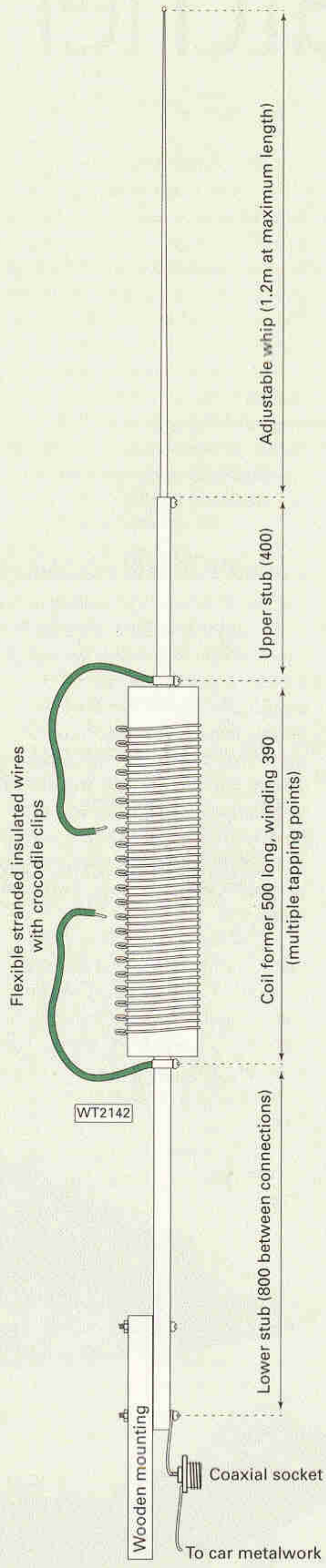


Fig. 1: Details on physical lengths, dimensions and lay-out of the mobile antenna. (See text).

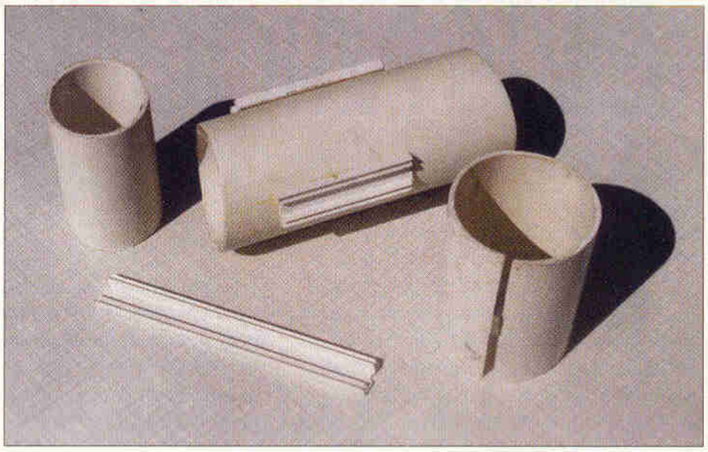


Fig. 2: The starting point - pvc tubing for the loading coil body. The author explains a simple, but essential, test to check that the piping chosen is suitable for radio frequency work (see text).

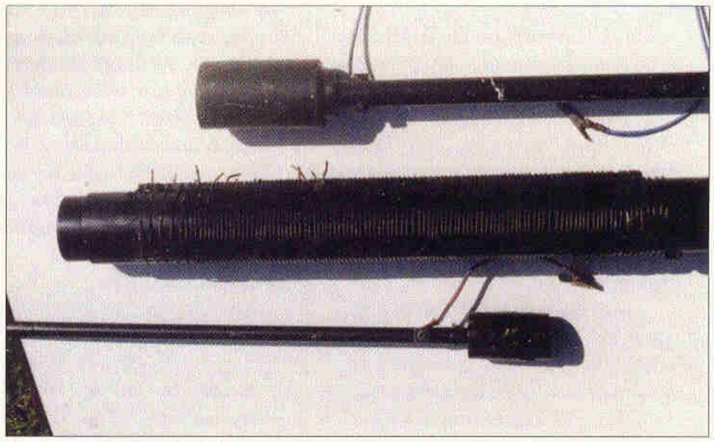


Fig. 3: The principle components of the antenna, the lower section (top), loading coil (with multiple tapping points) and part of the whip section (below).

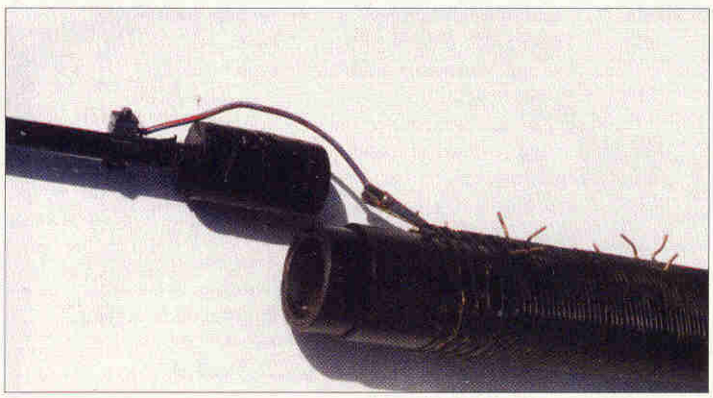


Fig. 4: Author's photograph of the top section whip with its associated plug connection. Note that epoxy resin adhesive must not be used to fix the plug into place and that the last four turns of the loading coil are wide-spaced (see text).

taped, side-by-side, to a piece of wood and slotted, ensuring that wire spacing was maintained close to 3.2 turns/cm or 8 turns/inch. The strips were glued to the former longitudinally at 120° intervals with Evo-Stik floor tile adhesive.

Winding The Coil

Winding the coil was accomplished by stretching one length of stripped wire, holding one end very firmly in a vice. I then walked the former towards the vice whilst rotating, slotting the wire into the slots, taping at intervals to retain position. (The helix was wound anti-clockwise).

As one length of stripped wire is too short for the full coil, where required I soldered the necessary lengths into place. **Note that whilst the wire pitch is nominally as noted above**...the last four turns at the top are 6-8mm spaced to assist fine tuning.

On my prototype a total of 112 turns were wound to cover 3.5 to 28MHz. (Tapping positions will be described later).

The coil ends are then secured by self-tapping screws, see **Fig. 4**. **Note: no epoxy resin adhesive, e.g. Araldite should be used**. Incidentally, Self-tapping screws can also be used to stop the plugs sliding too far into the coil former.

Finally, the upper end of the upper rigid tube must be adapted to clamp the whip. The simplest way is to split the pipe and use a small clamp, e.g. a hose clip.

Alternatively, the pipe wall **may accept** a self-tapping screw with the end filed flat. I used a small, thicker walled brass pipe fitting tapped M4, and this provided an

Fig. 5: Full end-on view of M0EJB's car with the Midge Catcher in place and operational. Note the flying leads for selecting tapping points. See text for mounting and attachment suggestions.

effective clamp with a good electrical contact.

Mounting The Antenna

The lower end of the antenna may be mounted in a variety of ways. I fitted mine to an accessory plate on my car's caravan towing bracket (Heading photograph and **Fig. 5**).

I simply bolted the lower stub to a piece of plastic covered wood and connected the bottom fixing bolt to the centre feed from the coaxial cable to the transmitter. The earth is taken to the car body by 6mm diameter flexible wire.

Braid from discarded large diameter coaxial cable is often used for this job and can be very successful. The quality of the earth connections is important. **Make sure they're clean and paint free!**

Setting Up

It's now time to start the setting up the antenna ready for use on the air. And here...as many readers will remember...the tapping of a close wound centre loading coil is a well known problem...to such an extent that special clips are sold to assist in the use of small crocodile clips without fouling adjacent turns.

I initially tested my completed antenna for feed point impedance and s.w.r. using an Autek RF1 analyser to measure these values at each frequency. (This is not easy, as at this stage, the user will not know where to fix taps, and clips must be used).

However, when the first approximations are made, small **L** shaped stand-off taps may be soldered to the coil for clip connections. The top four or five wide spaced coils require one or more L clips each.

Next, using an analyser or your s.w.r. meter, find the approximate setting on the coil body and finely adjust at the top take-off point. On first tests I found, as expected, impedance of the order of 18-25Ω on 3.5 and 7MHz, but even so, at all frequencies from 3.5 to 28MHz, the s.w.r. was less than 2:1.

As I have a mobile antenna matching unit (An MFJ 845, as often illustrated by the Editor as he uses one for mobile/portable work), I use this for final adjustment for transmission. This has allowed me to record s.w.r.s below 1.3:1 on all bands.

As a guide, **Table 1** shows some of my final tap positions. However, you'll be very fortunate to duplicate these with a home built system!

Band (MHz)	Top lead (Tapped)	Bottom lead turns:- (Tapped)	Whip (extension)
3.5	2 turns down	9 turns from the base	Full
7	2 turns down	34 turns from the top	Full
14	1 turn down	10 turns from the top	Full
18.068	Top turn	5 turns from the top	Full
21	-	*Direct to top (coil by-passed)	Full
24.89	-	*Direct to top (coil by-passed)	70%
28	-	*Direct to top (coil by-passed)	50%

Table 1: Tap and whip positions for matching on seven h.f. bands. Note: In the direct mode, the two crocodile clips are connected together, eliminating the coil.

Ready To Go!

So, you're now ready to go. It's not necessary to set all frequencies before using the antenna, as this can be done in stages. In use, I carry mine dismantled and use it only when stationary.With suitable bracing the antenna could be carried erect. But at full length the whip moves some distance...so please bear this in mind!

As with many home projects, this antenna evolved during construction and several possibilities for improvement exist. When, as is likely, a MkII is built, the modifications shown below will probably be adopted:- (i). The lowest frequency covered will be 40m, making a shorter, wider spaced coil for easier adjustment. (ii). The mounting plugs will be made integral with the coil former, to tidy these areas, and simplify the joints. (iii).

Either a telescopic whip, or two fixed length sections for low and high frequencies will be used to avoid any possibility of a lowered whip sliding into the lower stub. So, there it is...the *PW* Midge Catcher! I hope that your project gives you as much pleasure and interest as mine has - I've certainly learned a great deal. *PW*

Further Reading

1) **Waters P. G3OJV** *Waters & Stanton Catalogue 2001* pp 126-7
2) **Irwin, W.K. W1KI** The High Sierra HS 1500 Mobile Antenna. ARRL, *QST* Nov.1999 pp 72-73
3) **King, F.W. KM4IE** A $20 mobile antenna. ARRL, *QST* April 2000 pp *33-35.*
4) *Moxon L. HF antennas for all locations* RSGB 2nd Ed. 1993 Chapter 16.
5) *Dodd, P. Backyard Antennas RSGB 2000 pp 35-38.*
6) High Sierra Antennas http://www.hsantennas.com/info
7) http://www.texasbugcatcher.com/
8) http://www.visradio.com
9) http://www.eham.net/reviews/detail/412

Licensed & Ready To

In the second of his articles aimed at advising the many keen new h.f. operators, Rob Mannion G3XFD takes a look at the all important antenna and essential accessories.

Following last month's article you'll now know there are a lot of useful transceivers available to you, so this month...I'm planning to concentrate on looking at the important antenna aspects. Without an effective antenna you could have the best rig money could buy but still not be heard!

However, before I delve into antennas, etc., it's necessary to comment on the subject of M3 operators using 'non-CE certificated' equipment. I'm doing this because following last month's article several readers contacted me on the subject, and I also heard it being discussed on 3.5MHz, where the participants in the QSO seemed to be thoroughly confused following my recommendation of older equipment...particularly the Trio/Kenwood TS-120V QRP transceiver.

The general consensus of opinion (of those people who contacted me) and those heard on the air was, that M3 Licensees **would not be complying with their Licence** – and consequently the law - by operating equipment not carrying the CE mark. Obviously, my personal recommendations had caused some concerns because I had seemingly encouraged M3s to (possibly) risk breaking the law.

However, I'm pleased to report that, following further discussions with the Radiocommunications Agency's (RA) Amateur Radio Section, there is no doubt in their opinion that M3 Licensees **would not be breaking the law in any way whatsoever providing the Amateur Radio equipment in question complied with the regulations which were in force when the equipment was manufactured. The CE regulations are not retrospective and transceivers such as the TS-120V** were, and are or course, still very much legal to operate on the Amateur Radio bands, under the conditions of your Licence.

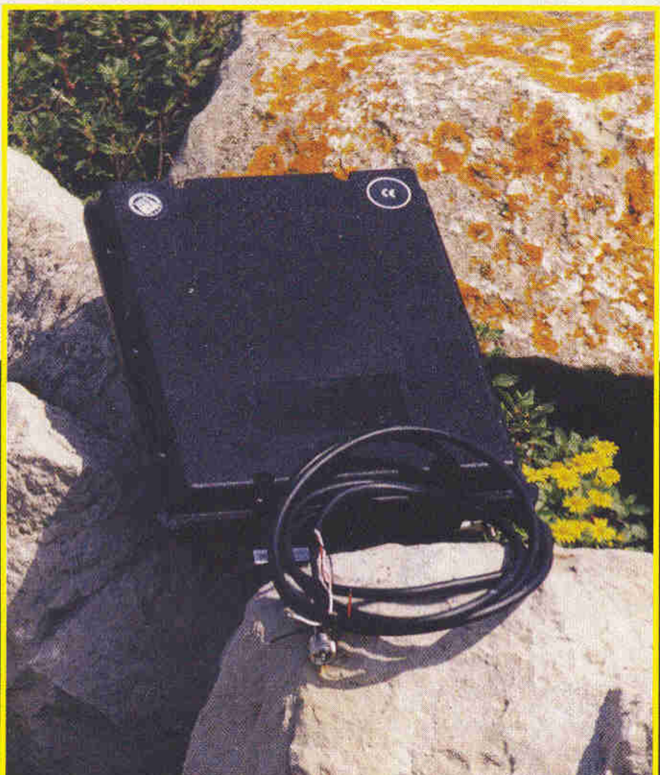
Despite what I've just written, I can re-assure readers that before preparing the article and presenting it in *PW*, I was already confident that when M3s do operate non-CE approved equipment the above information was correct. But if you do come across any equipment (especially any which has been converted to work on the Amateur Bands from other allocations)...that you seek advice.

In closing on this matter, the RA spokesman assured me that none of the new regulations were intended to discourage or cause problems to the M3 Licensee. Personally speaking...that shows me just what a close and supportive regulatory body we have in the UK!

Antennas & Accessories

So, it's time to start looking at those all important antennas and the essential accessories. But I must warn you...**here I'm adopting a truly simplistic approach** - if you want a technical treatise I strongly recommend you buy a copy of *The ARRL Antenna Book*...which should be in your library anyway! And finally - before I get stuck into the main article - as I've been preparing it for you it's become glaringly obvious that there's so much information to pass on - what was intended to be a single article has rapidly turned into a mini series. So, with out further ado...let's get on with it.

My first advice to you is - if you're completely new to h.f. - that you try some of the ideas I'm suggesting in this article, get some experience and then go on to enjoy some of the more complicated projects which are



Just starting out on h.f.? If so...in this article aimed at you Rob Mannion G3XFD thinks that the SGC-230 automatic antenna tuner - amongst other equipment...will be ideal. It's rugged, waterproof, very reliable and will get you on the air quickly!

A standard, two meter antenna tuner/standing wave ratio indicating unit capable of taking a long wire antenna is a necessity says Rob G3XFD (see text).

Go!

Antennas

offered in the special free *Antennas To Go* magazine that comes with this issue of *PW*. The suggested combination is ideal in my opinion and should keep you busy for a few years! (I've been playing around with antennas for approaching 50 years and have not yet finished learning. In fact, the more I enjoy the subject, the more I realise just how little I know!

Much has been said about what you can buy and erect for h.f. operations but when it comes down to it one of the simplest approaches is the good old 'long wire' (l.w.a.) antenna. **Often misnamed, this antenna is strictly only a long wire when it's longer than necessary for the frequency band in use**. So, let's now take a look at this amazingly versatile antenna.

Popular Wire

Listening on the bands, and from the notes I've made in my log book over the years, it's interesting to read how popular the l.w.a. is in the UK. However, it seems to be not so popular in the rest of Europe and the evidence indicates it's a particular favourite in that little group of Islands that begin just off the French coast (Britain and Ireland!).

Yes, indeed, from what I've learned in my travels Britain and Ireland share much more of an interest than just a joint international golfing team...we also enjoy using the l.w.a.! Nothing strange in that...it's an effective, very simple, and straightforward antenna.

There are many advantages for the operator using a l.w.a. - **but there are also disadvantages**. The first is that unless proper investigations are carried out (beyond the scope of this article) you'll never know just what the individual antenna is doing. In other words...where the main radiation lobes are, its most effective direction, etc.

So, you should be aware that the l.w.a. is a 'suck it and see type of antenna. **You'll get results**, and they can be superb...but each antenna (due to its location and the local situation) will be different. Some operators will be able to work the world with a l.w.a., and other will find it difficult to work the USA, etc.

The other thing to remember about long wires is that you need a good earth (ground system) and the best antenna tuning unit (a.t.u.) you can afford to buy or make. I think the best types are those fitted with two meters so that it's possible to adjust the tuning on the unit while closely watching the forward power (**the energy you want to be radiated**) and the reflected power - that energy which has not been radiated which is being returned down the wire.

The lower the reflected power the better - both because it means you'll be radiating more effectively and that unwanted excessive heat build-up (from the reflected power) cannot rise to a level where damage to the power amplifier (p.a.) transistors. Less reflected power also reduces the risk of your transmissions causing interference (more on that later).

Literally any of the commercial manual antenna tuning units which comes with a connection marked **Wire/Single Wire/Long Wire** terminal on the rear will be suitable. The a.t.u. is simply connected directly into your transceiver via the coaxial input, and a low pass filter* (l.p.f) and the l.w.a. is then connected on to the connection mentioned.

I strongly advise any beginner, or less experienced operator to only purchase an a.t.u./s.w.r. unit which comes with **two individual moving coil meters**, so that both the **Forward Power** and the **Reflected Power** can be watched at the same time. In this way it will be possible to carefully monitor that the reflected power does not inadvertently increase during adjustment. If it does...you can stop immediately and start re-adjusting.

My advice is that you should buy an a.t.u./s.w.r. meter unit which will measure to below 10W output. Yes, I know M3s operate at low power anyway...but if you adopt the habit of tuning up using the lowest power as possible...you'll be less likely to damage the power amplifier (p.a.) stages of your rig if something did go wrong.

Additionally, if you did accidentally tune up on a frequency which is in use (**you will listen first won't you?** ...it really does pay to do so, even if conditions can change quickly, leading to those mostly accidental 'I was here first' confrontations!) you'll stand much less chance of causing inference to another QSO already in progress.

**** More about this important requirement later.***

Antenna Tuning Luxury?

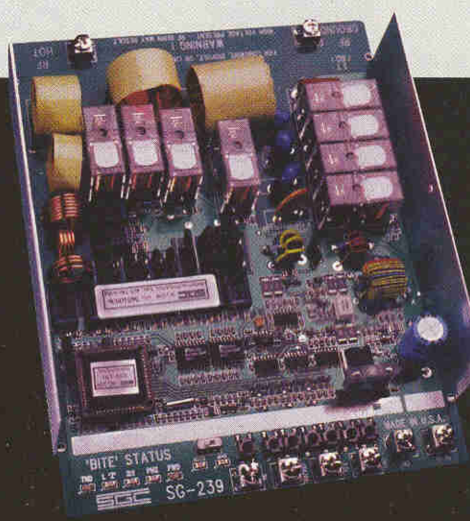
Many Radio Amateurs, particularly those just entering the hobby are often restricted to a tight budget so they may consider buying specialist antenna tuning systems a luxury. But they're not a luxury really...instead they can help provide you with an instant, easy-to-use solution and provide an enormous amount of enjoyment, with many other advantages. And in this category I'm thinking particularly about the various automatic antenna tuning units (a.a.t.us) which are available.

I feel bound to recommend an a.a.t.u. to readers, especially to the less experienced. This is because by using an a.a.t.u. - much of the guesswork is taken away – leaving you to enjoy working the bands. Eventually, you'll have the confidence to begin experimenting with antennas, adding even more to your pleasure...and knowledge.

Another reason for being so keen on a.a.t.u.s ...is that I use the extremely successful SGC-230 system at home myself. I also use it in my portable work*. It has the tremendous advantage that it starts tuning up as soon as it sees r.f. appearing at the input. It does it extremely rapidly, and it 'remembers' your favourite frequencies.

I shall be mentioning this approach again next time, as I

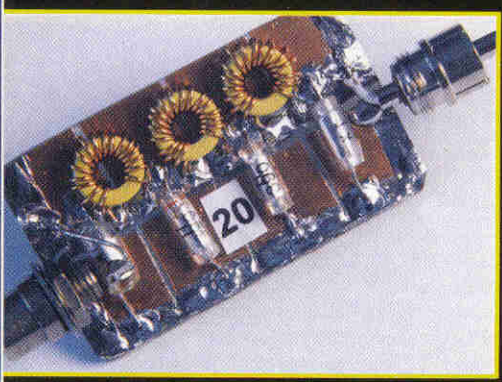
In use the SGC automatic antenna tuners (a.a.t.u.s) only require r.f. drive and a 13.8V power supply).



There are a variety of a.a.t.us. available for Amateur Radio use. This version, the SG-239 can be mounted inside a building or a vehicle.

consider it to be ideal for the beginner on h.f.

Fortunately for any one intending to follow my suggestions, **Waters & Stanton PLC** – who are the Agents for the American SGC Company – have announced significant price reductions on the selection of auto tuners they sell. I mention this because as they are imported from the USA – the a.a.t.u.s still aren't cheap...but on the other hand you do get an extremely versatile unit for your money. So, all in all....perhaps they aren't that expensive are they?



A low-pass filter.

The SGC-230 I use I has seen some terrible weather over the winter, and has operated faultlessly. Mounted on the side of my garage, I feed it with double screened coaxial cable and a lightweight cable with a 13.8V d.c. power feed. An l.p.f. is fitted at the transceiver end of the coaxial cable.

The system either operates a long wire for me (when working portable) or the 10m long fibreglass fishing pole These necessary earth is provided by a copper spike, driven into the sandy soil below the garage.

**Note: more about this topic next month.*

Antenna Length?

When using the l.w.a. system – a good length to start off with – if you have the space - is one approximately 41 metres long (the good old 132 footer for us greybeards). Placed as high as you can get it – it will work well indeed, even if it isn't straight and has to be 'dog-legged' to fit in your available space..

Warning note: Please ensure you keep your l.w.a. away from overhead telephone, wires, downleads, etc., to avoid possible interference. Bear in mind also that the long wire can be a difficult antenna to use whenever there's the slightest possibility of television interference (TVI) or radio interference (If you notice antennas in your area carry mast-head amplifiers...be prepared for possible problems!).

The TVI can develop because the l.w.a.'s single wire in effect acts as **feeder and radiator** and depending on the band you're working on, and the individual circumstances of your antenna and its location – you could end up with a very high field strength very near the house, or near overhead power/or telephones lines.

When it comes to reducing the possibility of interference...**it's always good practice to use a low-pass filter***.

You'll have seen my previous references to the l.p.f. and those we use in Amateur Radio normally severely attenuate signals above 30MHz, in an effort to reduce harmonic interference to the broadcast services etc., which operate between 40 and (approximately) 900MHz.

***Note:** *These filters are available from Amateur Radio dealers...and you may even get a discount if you buy an a.t.u. and l.p.f. at the same time. It's worth asking anyway!*

High Field Strength

Despite the inclusion of the l.p.f. between your transceiver and the a.t.u., you should be aware that when confronted by a very high field strength (perhaps from your transceiver) nearby radios/TVs and hi-fi units can suffer from interference. This can happen because the majority of domestic radio/TV equipment is mounted within unscreened plastic casings nowadays. As a result it's possible for such equipment to be susceptible to picking up transmissions either from the antenna input (TVs and radios, via coaxial cable inputs or via wire or ferrite rod antennas) or from speaker leads/microphone leads/cassette recording inputs, etc., and via telephone wires.

Incidentally, in my experience telephones are some of the worst effected items of equipment by otherwise perfectly legitimate radio transmissions. Not surprising when you remember they're connected – mostly – to long overhead 'antennas' (those dratted wires which festoon our streets!

Fortunately, the low power available to the M3 means that it will be less likely for your transmissions to cause any bother. But be on the look out, especially on your own family's broadcasting receiving equipment.

Earthing System

A good 'radio earth' is essential for Amateur Radio, and especially when you're using a l.w.a. But you should really avoid using the house mains wiring earthing system. Don't rely on water piping either - even if you do find some exposed metal piping to connect the earth wiring to - there could be a section of plastic pipe between your system and 'true earth' and you could end up radiating a signal from the 'earth' into house wiring, etc.

Warning: Never, on any account use any central heating or gas piping, both of which can be extremely dangerous. (Don't forget, there are many items on a central heating system at mains potential...not just the circulating pump. The gas pipe dangers speak for themselves don't they?

It's best to buy a really good, long, copper earth spike and drive it into dampened soil in your garden, patio, or wherever you can. But please be careful and avoid gas, or electricity pipes to your home. Common sense will indicate the route the pipework takes going into a house (usually the straightest line possible to the front or back door, and into the house).

Personally speaking, I feel perfectly safe when my earth is connected directly to my rig, especially when the mains power input is fully isolated on the primary side of the transformer. Again, my personal choice is always to go for a power supply which is fully isolated from the mains....and this means using a transformered unit. In effect of course, the transceiver is then operating from a low voltage supply which is 'induced' (you could regard it as being 'generated') by the mains 240V a.c. supply input.

There will usually be a safety earth linkage on the chassis, from the mains earth. This will be via the **yellow/green striped** wire you'll see soldered or attached to a bolted lug. This then, through the three core cable to the 13A plug, connects your whole system to the mains earthing for safety purposes. So, if a fault on the mains transformer primary develops and a short circuit occurs, the protecting fuse will rupture ('Blow') removing the mains supply.

Transformer secondary problems (the low voltage side) don't normally cause instant failures. Instead...the transformers tend to overheat...and the cooking smell is un-mistakable! Eventually the transformer overheats so badly that the inner winding insulation burns through and there would be short circuiting of windings- and the mains fuse will rupture. **So please ensure you always have the correct, specified fuse in the 13A plug (or on the unit itself)**.

Finally, for radio frequency purposes, it is - in my opinion, completely safe to directly connect the transceiver and a.t.u. directly to your 'radio earth'. It helps reduce mains borne noise from household equipment and will greatly assist your outgoing transmissions because the ground surrounding your antenna then literally becomes a reflective radio 'mirror'. So, get busy **and set up a good earth system now!**

Next month I'm planning to describe some simple antenna systems using wires and whips - together with how you can set about enjoying the hobby using a little bit of carpentry and your car roof. Don't forget...even if you live in a tiny one-bedroomed flat...you can enjoy our hobby outdoors too!

PW

Mobile Origins

Nowadays, many people take mobile working for granted. However, John Worthington GW3COI remembers a time when mobile working was not permitted!

I suppose many newly licensed Radio Amateurs take mobile working for granted, as these days not only are there many hand-held rigs available, but nearly all equipment can be readily and easily mounted in a car and special antennas are also freely available. However, during the decade from 1947 **mobile working was not permitted**, although a few operators were experimenting with specially home-brewed gear that could be used, and I was among them.

To comply with regulations, I would stop the car in a suitable spot and then operate. You wouldn't expect me to break the regulations, would you?

Fascinating Problems

Mobile operation brought with it its own fascinating problems. By far the biggest as far as I was concerned was the fact that in spite of the many hours spent working with a.t.u.s. and different sized whips and wires, I was unable to work anyone further away than about a couple of miles and at the extreme of this range, signals were weak indeed.

The other main problem was interference from the car engine and electrics, but gradually as my expertise increased and co-operation plus conversation with other /M experimenters soon brought forth remedies and tips. One of the best of these was to choose your car from a very short list, i.e. certain models which were known to be relatively interference free!

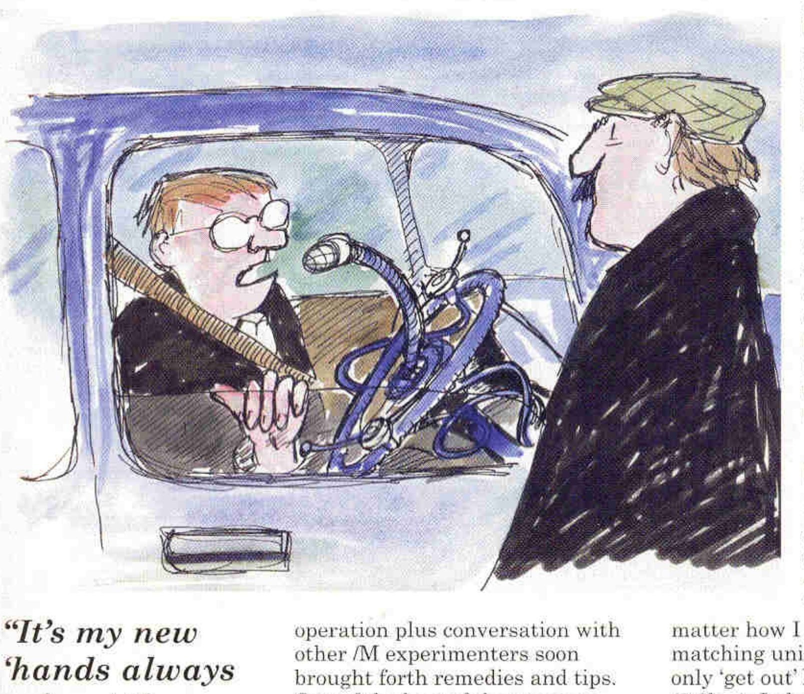
The equipment used, of course were from, the years of bountiful 'ex government' surplus sales, and there were several Army transmitter/receiver combinations which gave excellent account of themselves as portable gear. Naturally, would-be /M folk, like yours truly, soon acquired one and it was a luxury to have transmitter, receiver, power pack and even a.t.u. all in one box, whereas before I'd always used separate units, which were mostly home-made.

Made Official

However, the poor results I was getting, even though I was using a huge 14 foot (4.2m) whip antenna, puzzled me. So, I renewed my trials of different a.t.u.s. with vigour in an effort to discover what I was doing wrong.

Then suddenly, or so it seemed, mobile working was made official and there was a small upspurge of new people coming into the hobby who really knew something about radio. In a short time, these 'geniuses' were making contacts at a range of 20 miles (32km) on 'Top Band' and from eyewitness accounts this was achieved by having a loading coil somewhere on the whip. Apparently, it could be at the bottom, middle or top and had to be the right inductance for the band you worked.

Yes, I know all you technical 'boffins' reading this are probably falling about with these revelations! But such was the 'modus operarandi' among the radio illiterates like myself at the time (and we were the pioneers)!



"It's my new 'hands always on' mobile radio system...."

Coil Wound

I soon wound a coil and mounted it at the bottom of the whip. It looked 'right', but no matter how I juggled with a matching unit etc, I could still only 'get out' less than two miles (3.2km). I also tried mounting the coil at the top and I changed the winding.

In fact, I went through a whole range of trials without any success, then word came that the secret had been revealed. A certain 'G' whose call I have since forgotten, was giving lectures to certain clubs to spread the 'gospel' of constructing a whip that was resonant $\lambda/4$ wave against the mass of the car.

At last I appreciated what a grid dip meter was for! So I built one using the little Eddystone plug-in coils and was soon achieving contacts of ten miles (16km) on Top Band! The thrill of this has to be appreciated when you consider the for years I had been barking up the wrong whip!

Lots of Actviity

It soon became obvious that 1.8MHz (160m) was where most of the /M activity happened and where many of the designs of antenna appeared. The dictum that coils should be physically long, three times width was followed most of the time but there were some wonderfully bizarre productions where even guy wires were needed to protect the pedestrian and travelling public alike. It was still tbelieved that large antennas resulted in greater signals and 12ft (3.6km) whips soon became common.

Gradually, all the experimental work produced the type of loaded whip, which you can now easily buy. This was because it was eventually agreed that although the theory about coil proportions was substanially correct, you could have a more aesthetic looking antenna and lose little S-meter movement!

Mobile Progress

I haven't mentioned the progress of mobile v.h.f. working as that merely became a question of transferring existing commercial frequency designs. However, v.h.f. mobile was not popular and even in the heavily populated Midlands, a mobile to fixed QSO was quite rare and a mobile-to-mobile could literally only occur by arrangement.

It took the arrival of the, then new B licence to really establish mobiles on v.h.f. when numbers became large enough and of course, news of USA repeater experience plus native commercial repeater use led to native Amateur models. And now, of course, it's really 'old hat'!

PW

A Spectrum Analyser In

A spectrum analyser is an extremely useful piece of test equipment. If you don't have one, why not read on, as Andrew Holme describes his home-built version.

I decided to try my hand at building a spectrum analyser after seeing a design by **Roger Blackwell G4PMK**, in *The Radio Communication Handbook.* I had to adapt Roger's design though, because I couldn't get the Motorola MC 3356 i.c. used in his design. This article is an account of what I came up with, how it performed and how it might be improved.

A block diagram of the analyser is shown in in **Fig. 1**. You'll see that it's, in effect, a dual conversion superhet with a video output rather than audio. The unit takes input signals in the range 0-50MHz, mixing them with the output from the first oscillator, a voltage controlled oscillator (v.c.o.). So, up-converting the band to a first intermediate frequency (i.f.) of 170MHz.

Although I've not shown it in any of the diagrams, **a low-pass filter is required at the input, otherwise there would be many more spurious signals, due to unwanted inputs**. There have been several low-pass filter designs in *PW* that would be suitable.

Before filtering, the mixed signals from the first mixer are broadband amplified (20dB) before passing through the helical filter (centred on 170MHz). The first i.f. was chosen to suit a helical filter I had in stock. There's no real reason why another frequency (such as 145MHz) couldn't be used instead. The helical filter's bandwidth of 2MHz, serves only to reduce or remove spurious responses.

Spurious Output

Without the helical filter, there will be many spurious output signals at 26.45, 31.8, 38.833, 45.967 and 63.6MHz. These spurii are due to harmonics created from the first mixer, that fall exactly 10.7MHz above or below harmonics of the second local oscillator.

The narrower first i.f. band of signals, is then mixed again, this time with the output of a crystal oscillator (159.3MHz) to create the second i.f. This time a narrow band crystal filter with a centre frequency of 10.7MHz is used, and it's this crystal filter that determines the actual resolution bandwidth.

So, let us turn now to the main controlling sweep generator, the circuit of which, is shown in **Fig. 2**. This circuit consists of a '555' timer (IC1) that controls the sweep rate. Variable resistor Ra sets the speed, while an integration function circuit around IC2 generates the ramp voltages. Integrator capacitor Ca is a polyester layer type.

Other controls are: Rb, which sets the sweep width and Rd (coarse) and Rc (fine) variables, set the display centre frequency as coarse and fine 'tune'. I could have used a 10-turn pot to set the centre frequency, but frequency changes are faster to achieve with separate controls.

The sweep output on IC4 pin 6 is directly connected to the v.c.o. control input. The oscilloscope is triggered using the flyback pulses on IC1 pin 3. Most spectrum analyser circuits usually have the oscilloscope's X-input driven by a ramp voltage. But my 'scope doesn't have an X-input!

Sharp And Steady

Smoothing at the input to IC5 (pin 3) is essential for a sharp, steady display when zooming in. Ca, c and d are 270nF metallised polyester film capacitors. I put three capacitors in parallel as I had no bigger value non-polarised types to hand. Electrolytics are suitable for power supply decoupling, though a ceramic disc decouples pin 5 of IC1.

The 741 type i.c. is adequate in this application except for its limited output swing. A rail-to-rail output would be better. The 12V rail itself is also a limitation, as some varicap diodes need up to 30V. The POS-300 v.c.o. mentioned elsewhere requires only a 1-16V swing for the control voltage.

The front-end schematic is shown in **Fig. 3** And is as outlined above. The inductor, RFC, in the supply feed of the IC6, is made of two turns of 0.45mm (26 s.w.g.) enamelled copper wire on a ferrite bead. The helical filter, a Toko 272MT-1007A, was purchased from Barend Hendricksen.

For this application, the i.f. and r.f. ports of the SBL-1 mixer are reversed. The analyser input (0-50MHz) is fed to pins 3/4 because these pins are directly coupled to the internal diode ring mixer, enabling very low input frequencies to be up-converted to the first i.f. stage. The transformer-coupled ports, of the SLB-1, don't work down to low frequencies.

Optimum Balance

For optimum balance, the SBL-1 requires a 50Ω broadband resistive termination on all ports. The 4dB attenuator at the output port was an attempt to provide this. A 2.5dB pad was used on the v.c.o. input. The SBL-1 requires +7dBm (1.4V peak to peak) drive from the local oscillator (l.o.). The output of my v.c.o. amplifier is +9.5dBm. The POS-300 output level is +10dBm so a 3dB pad would be required if that were used.

The MMIC, IC6 provides 20dB of gain to compensate for the SBL-1's insertion loss. The signal

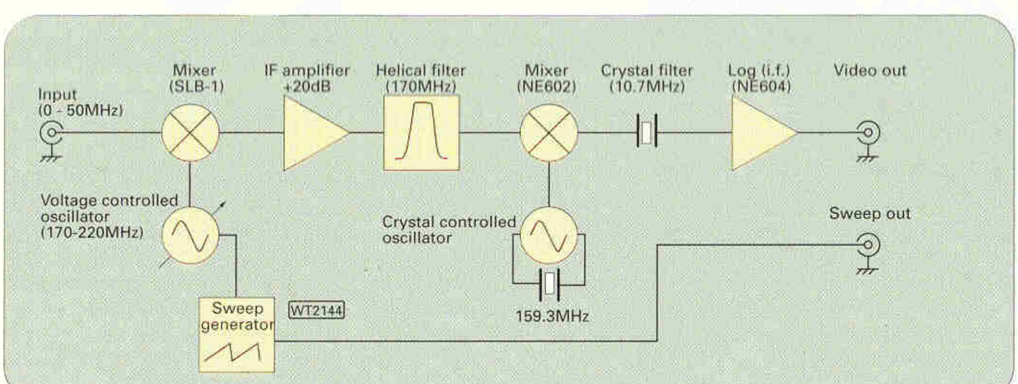


Fig 1. The block diagram of Andrew's design.

n Your Shack!

suffers 6dB loss in the mixer, 4dB more in the attenuator and a further 9dB through the filter. So, I placed the gain before the filter to improve overall sensitivity.

Conveniently, the MMIC is powered through the filter. The R-BIAS resistor, sets the current at 45mA. Unfortunately, the MMIC doesn't see a broadband match. A better solution might be to place a further small attenuator after the i.c. or to use a diplexer.

Now to the second i.f. stage, shown in **Fig. 4,** which shows the second mixer, crystal filter and logarithmic amplifier, that make up the second i.f. stage. The NE600 series of i.c.s were originally developed for analogue cellular 'phones.

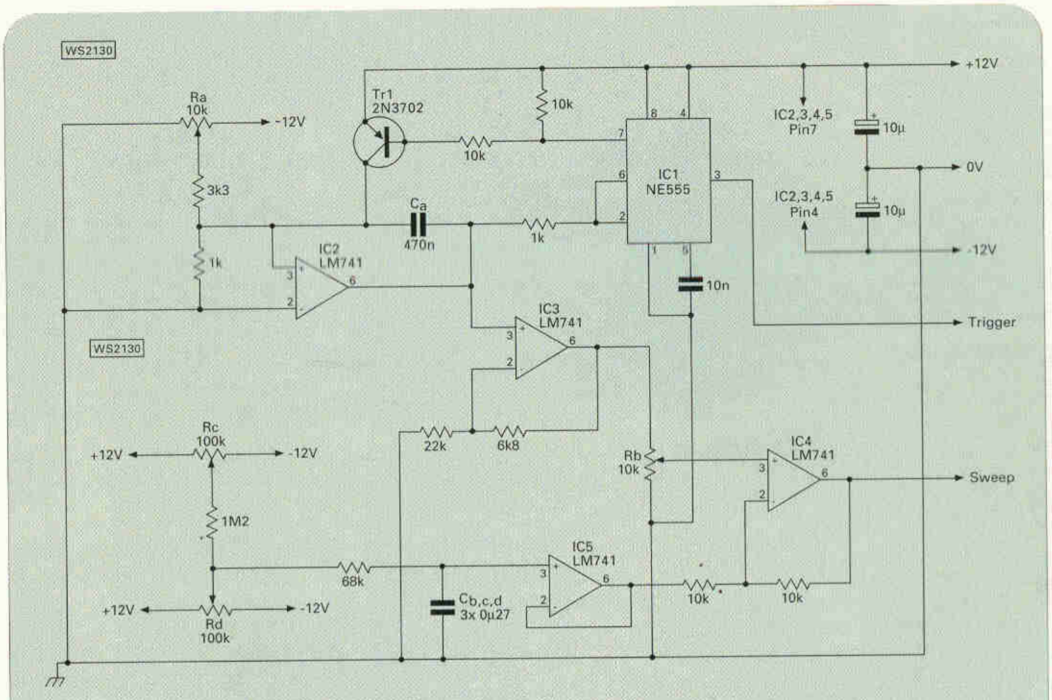


Fig. 2: The basic timing and control circuit.

Now Obsolete

Although still popular with amateur constructors, regrettably, both i.c.s are now obsolete‡. The NE602 contains an r.f. amplifier, oscillator transistor and balanced mixer, while the NE604 is the complete electronics of an i.f. amplifier and f.m. demodulator. ***(‡ Equivalents to the NE602, labelled SA602AN and SA612AN are now available from RS Components. Search* http://ww.rswww.com *for SA602AN or SA612AN.* Editor)**

The inductor in the 170MHz tuned circuit, L2, is a Toko S18 series 0.040µH coil with ferrite slug. The filter coil, L3, consists of five turns of 0.45mm (26s.w.g.) enamelled copper wire on a ferrite bead, The 10.7MHz tuned circuit, T1, is a Toko KACSK3894A coil.

I adjusted the input matching circuit by connecting a terminated oscilloscope to the input whilst injecting a signal into L2 using an inductively coupled oscillator. The optimum oscillator drive level into pin 6 is 200mV peak-to-peak (-10dBm in R1).

The termination impedance (1.5kΩ) of the 10M15A crystal filter is compatible with the single-ended output impedance of the NE602. Though the matching of the crystal filter to the NE604 via T1, and the purpose of resistors R2 and R3 require explanation.

The NE604 i.c. has over 100dB of gain. To ensure stability, the manufacturer's data sheet recommends the use of external shunt resistors. The 1.6kΩ input resistance at pin 1 is shunted by R2. The filter 'sees' 1.66kΩ across half the primary of T1, which has a turns ratio of 7+7 to 4. The 82pF capacitor is integral to the Toko coil.

No attempt is made to match the 1kΩ output impedance of the first i.f. amplifier at pin 14 to the 330Ω termination impedance of the ceramic filter, however, the input impedance of the limiter at pin 12 in parallel with R3 correctly terminates the filter output.

Aids Stability

Resistor R3 also aids stability. A 12dB insertion loss is required between pins 12 and 14 for maximum received signal strength indication (r.s.s.i.) linearity. This was not achieved and so the unit is not completely linear.

Good power supply decoupling is essential with so much gain so, monolithic

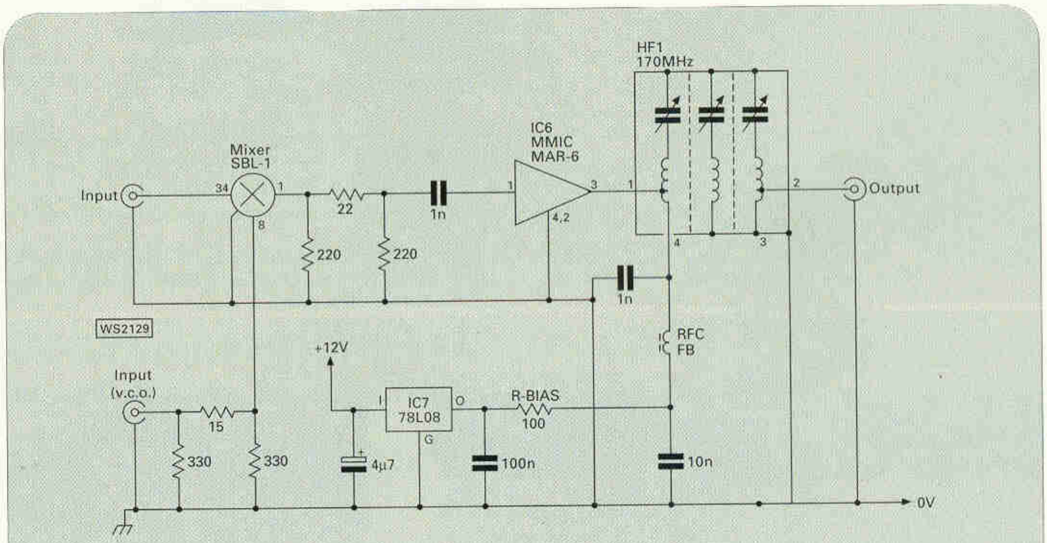
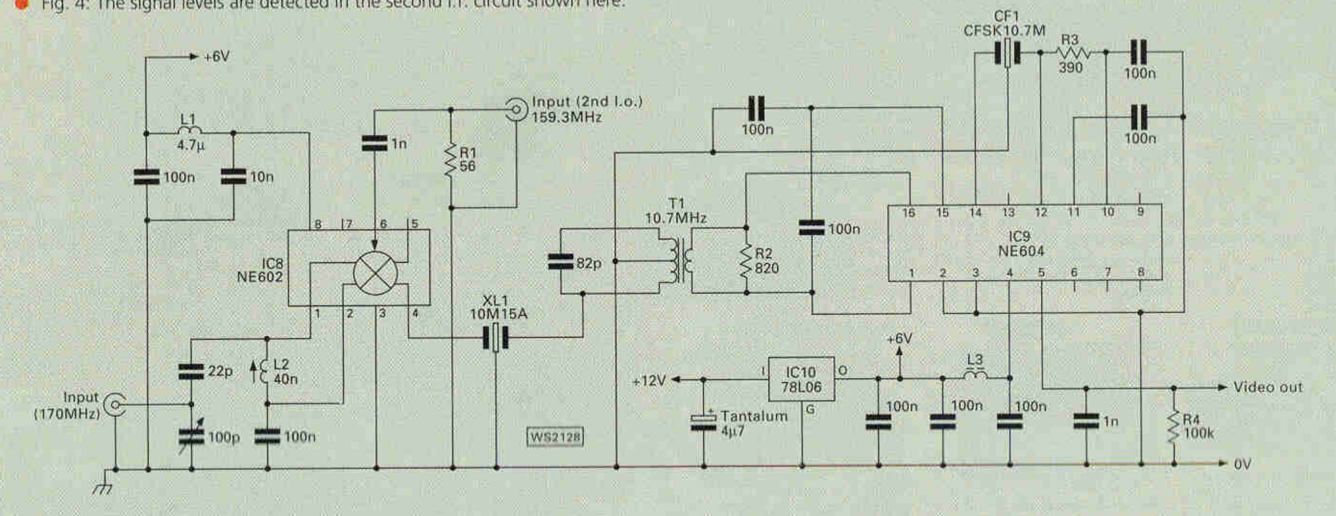
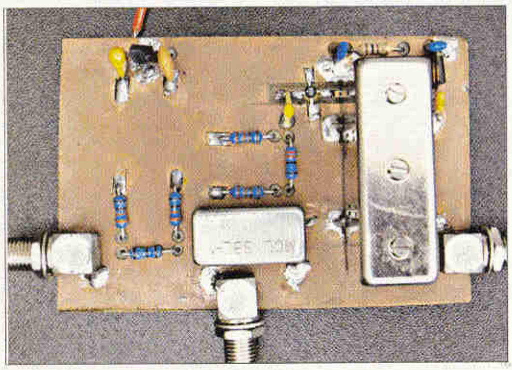


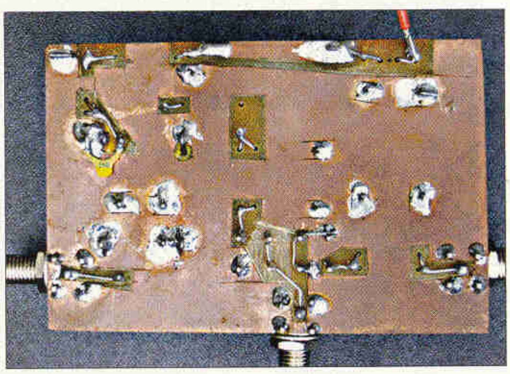
Fig. 3: After a low-pass filter the input signals pass into the first mixer.

● Fig. 4: The signal levels are detected in the second i.f. circuit shown here.

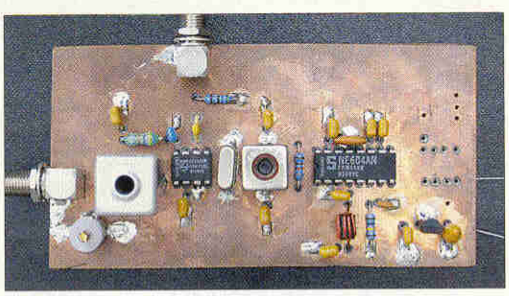




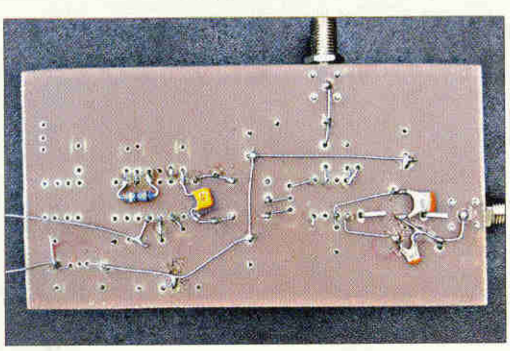
● Fig. 5: Looking down on the components of the first mixer p.c.b.



● Fig. 6. The first mixer board from below.



● Fig. 7. The second i.f. board follows the general layout of its circuit diagram.



● Fig. 8. The second i.f. and detector board from below.

ceramic decoupling capacitors were used throughout. An r.s.s.i. output greater than 250mV without an input signal is an indication of unwanted oscillation.

I was pleased to note that on my prototype, the quiescent r.s.s.i. was well below 200mV. Fortunately, a quadrature coil is not required in this application, as the audio output is not used. This probably helps to reduce feedback.

My original voltage controlled oscillator (v.c.o.) is a varicap-controlled f.e.t. oscillator, followed by an emitter-follower stage, made up from discrete components. An amplifier stage, to raise the output sufficient for the SLB-1 mixer, consists of a pair of cascaded MSA-0404 MMICs.

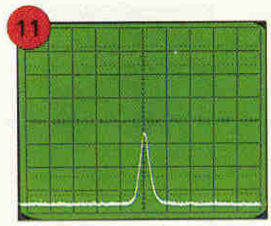
Other than that description, I'm not going to describe the first oscillator in any more detail, because I recommend using a commercial v.c.o. such as the Mini-Circuits POS-300 instead. This module can be mounted adjacent to the first mixer. Its compactness, frequency span and linearity are unbeatable.!

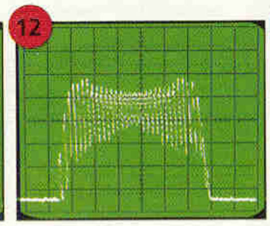
Similarly, I won't describe the second local oscillator either, except to say it was a separate Butler circuit using a custom made fifth-overtone 159.3MHz crystal. Though for my next version, I'll probably use the NE602/612's internal oscillator which, according to a Philips application note, operates reliably with crystals 'cut' as high as the seventh overtone.

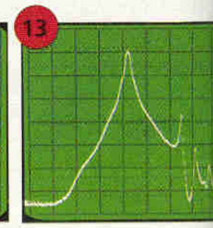
The internal mixer of the NE602 isn't though, the best in the world at 170MHz! It's noisy and, the input match is tricky from a 50Ω input. But the circuit's saving grace is that it's a simple design to implement.

Construction

Throughout the construction, it's a good idea to use ground plane techniques for all r.f. circuitry. And my design was no different. The front-end **Figs. 5**







● Fig 11: An un-modulated -85dBm carrier at 50kHz per division.

● Fig. 12: An f.m. signal with a deviation of 50kHz modulated by a 1kHz sine wave.

● Fig. 13: The analyser shows the response of its 2-pole 10M15A filter at approximately 50kHz per division.

● Fig. 14: The narrower, steeper sided passband of the 8-pole 10F15D at 20kHz per division.

● Fig. 15: A comb of 'pip' markers produced by a 1MHz square-wave crystal oscillator.

● Fig. 16: Signals down to 1μV e.m.f (-113dBm) are visible above the noise 'lawn' (4MHz per division).

and **6**, was built on double-sided copper clad printed circuit board, though single sided board was used for the other r.f modules.

The front-end circuit itself was built on double-sided copper clad board. The MAR-6 amplifier was surface mounted by burring out a shallow recess with a sanding bit. Underneath, unwanted copper was removed by peeling it up whilst simultaneously applying heat.

I also used SMA connectors and miniature coaxial cable to route signals between the separate boards. The second i.f. board is shown in **Figs. 7** and **8**, which like the first mixer follows the circuit diagram in layout. The i.f. strip was built on single sided copper clad board with the copper acting as a ground plane. A few components, including R3, are mounted underneath the board.

I built a second i.f. strip to try out the 10F15D 8-pole filter. To match this filter's 3kΩ-termination impedance, a 1.5kΩ resistor was inserted in series with the filter input, and the value of R2 was increased to 2.7kΩ.

The sweep generator **Figs. 9** and **10** was built on 0.1in perforated board using Molex connectors for external connections. The circuitry around IC1 and IC2 is 'borrowed' from Roger Blackwell's design.

Drilling Templates

I made drilling templates, marked out on 0.1in graph paper first. I could have created them on a computer, but often 'one-offs' are quicker by hand. I just pushed the legs of the helical filter through the paper to mark its pinout.

The boards were drilled with a small craft drill. The residual copper from around the holes, was cleared using a Vero cutting tool. Heat breaks in the copper foil were scored with a scalpel to make soldering to the top easier.

The prototype was constructed as six modules:

1 Sweep generator
2 Voltage controlled oscillator (v.c.o.)
3 An amplifier for the v.c.o.
4 Front-end (first mixer, i.f. amplifier and filter)
5 Second local oscillator
6 Second mixer and logarithmic i.f. amplifier / detector

You may wonder why I created so many modules. Well, my answer to that, is that the design was experimental. I didn't know how much gain would be needed to raise the output of the first oscillator to the required level until I'd built and tested it.

I also didn't want to put too much of the circuitry on one board in case something went wrong! This way, each module could be tested separately. As it was experimental, I also built two versions of the second i.f. to try different crystal filters.

Fun To Play

The spectrum analyser is fun to play with! Activity in the h.f. spectrum can be seen using a short antenna. I've also connected the analyser to the panoramic output of a Racal RA1217 Receiver. It's sometimes possible to simultaneously see and hear individual c.w. signals.

Without an antenna, I can see the base and handset carriers of my cordless telephone at 31 and 40MHz and I can also see my neighbour's wireless baby alarm at 49MHz!

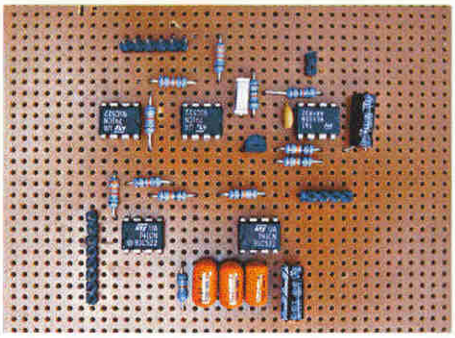


Fig. 9: A perf-board layout for the control and sweep oscillator.

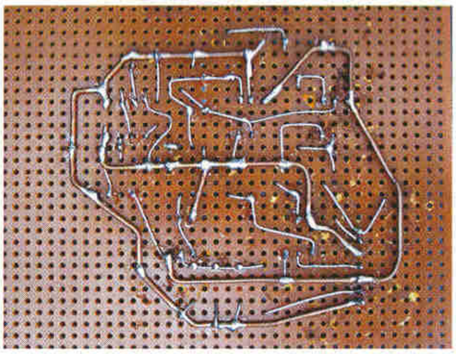


Fig. 10: Interconnections on the control oscillator board.

An un-modulated -85dBm carrier is shown in **Fig. 11**, at 50kHz per division using the 2-pole filter. The display is very stable. The screen of **Fig. 12** shows an f.m. signal with a deviation of 50kHz modulated by a 1kHz sine wave. Varying the deviation, modulating frequency and sweep rate produces interesting effects!

The analyser can curve trace its own crystal filter, as **Fig. 13** shows the response of the 2-pole 10M15A at approximately 50kHz per division. The second peak is 34dB below the top.

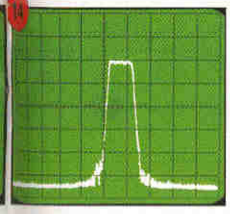
The well defined curve of **Fig. 14** is the narrower, steeper sided pass-band of the 8-pole 10F15D at 20kHz per division. Passband ripple is visible. The character of these filters is not ideal for a spectrum analyser! They were designed for f.m. communications.

A comb of 'pip' markers produced by a 1MHz square-wave crystal oscillator is shown in **Fig. 15**. The span was 0.5 to 13.5MHz. Note the level of the first few even harmonics relative to the other peaks. A perfect square wave is composed of only odd harmonics.

The trace of **Fig. 16** shows a -10dBm signal at 4MHz per division. Signals down to 1μV e.m.f (-113dBm) are visible above the noise lawn. The r.s.s.i. is fairly logarithmic up to -30dBm where it limits, giving a dynamic range of about 80dB. Inputs above -20dBm increase the noise level across the band - except near the carrier. I suspect the MAR-6 output only sees a 50Ω load in this quiet zone.

Although both, the NE602 and the NE604 i.c.s have been discontinued, samples can still be obtained. I found Barend Hendricksen in Holland a useful source for r.f. components.

I can also recommend another source at **Sycom** where **Robin G3NFV** will often look specifically for many components for *PW* and similar projects. The SMA plugs and sockets, along with other 'professional' parts, can often be picked up cheaply at rallies and 'junk sales'. *PW*



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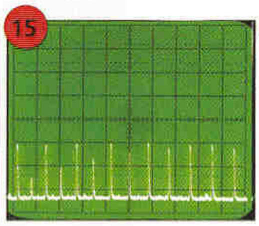

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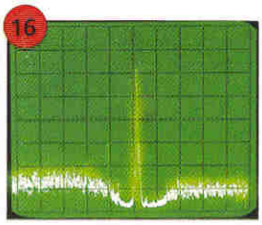


16

References

Barend Hendricksen
http://www.xs4all.nl/~barendh

Sycom: Tel: 01372 372587

Philips application note AN1983 *Crystal oscillators and frequency multipliers using the NE602 and NE612* (available in PDF format; search the Internet for AN1983)

Wes Hayward W7ZOI, and Terry White K7TAU, A Spectrum Analyzer for the Radio Amateur *QST*, August and September of 1998

Roger Blackwell, Simple Spectrum Analyser *Radio Communication Handbook*, 6th Edition, RSGB.

There are many interesting articles about spectrum analysers on the Internet. Some to try are:

http://www.nitehawk.com/rasmit/sa50.html

http://www.qsl.net/n9zia/wireless/pdf/9808035.pdf

http://www.qsl.net/n9zia/wireless/pdf/9809037.pdf

http://www.bright.net/~kanga/w7zoi/SAphotos.html

http://www06.u-page.so-net.ne.jp/ga2/semba/speana/e_speana.htm

Billy Williamson GM8MMA lives in the Shetland Islands near where the former USSR's giant aircraft often probed UK airspace. He's now found a fascinating Russian book crediting most radio inventions as being Soviet!

Radio? Russian!

I recently acquired a book entitled *In the World of Radio Waves* published in Moscow in 1951. I doubt if it was ever translated from the Russian...but it makes very interesting reading today, giving a Soviet view of radio history.

Although published by the State Publishers of Children's Literature, the book is written at about popular science level and seems rather advanced for children in my opinion, and it may perhaps be aimed at teenagers.

One of the most bizarre aspects of Soviet propaganda was its insistence that virtually everything was invented in Russia or the Soviet Union. So, no surprise to find this improbable idea well represented here!

No foreigners are credited with actually having invented anything; although **Hughes**, **Hertz**, **Branly** and **Lodge** are said to have studied radio waves. Marconi fares even less well...he's dismissed as having simply copied the work of the Russian pioneer **Alexandre Popov**! (**Fig. 1**).

Claims Exaggerated

Even if the book is not telling direct lies, it's obvious that many of the claims are exaggerated. For instance Popov is credited with being the chief inventor not only of radio but also of radar, even though he died as long ago as 1906!

The basis for the claim that Popov invented radar is that he carried out some laboratory experiments, which showed that radio waves could be reflected from metal sheets. There are a number of similar cases given where Russians are credited with complex inventions when it's clear they did no more than carry out a few basic experiments.

For the benefit of historians who may wish to investigate I've given a list of these supposed inventions. Apart from this, the book is, for it's time relatively free from political rhetoric.

Most of the propaganda is confined to a single chapter: *The Voice of Soviet Radio*. The chapter's contents can be summed up in two quotes: *"Capitalists use (radio) to deceive the workers of their country, to spread slander against the Soviet Union and democratic countries and to kindle a new war. Soviet Radio is the voice of truth and freedom, the voice of a great nation leading the struggle for peace"*. So now you know!

Fig. 1: Alexandre Popov 1859-1906. Beware of imitators...although a great innovator and scientist...Popov is credited with 'inventing' Radar in the interesting Soviet-era book discovered by GM8MAA (see text).

Radio & Electronics

The book's *Radio & Electronics* title is somewhat misleading since it describes not just radio...but all aspects of electronics. An early story concerns one **Dr. Bogoslovski** who in 1882 set up two microphones on the stage of the Bolshoi Theatre.

The Doctor ran cables back to his house and connected them to telephone receivers. By this means 12 people, **Fig. 2**, were able to listen to a performance of Verdi's *Rigoletto*.

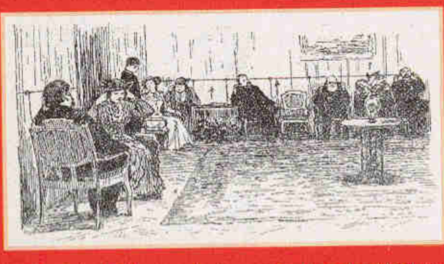


Fig. 2: In 1882 an early pioneer, Dr. Bogoslovski set up two microphones on the stage of the Bolshoi Theatre. By this means 12 people, were able to listen to a performance of Verdi's opera Rigoletto at his home. (See text).

Nowadays you would hardly think that this 'Dial an Opera' system could have had more than novelty value. **However, it proved extremely popular**! In fact, so much so that the good Doctor eventually had to abandon it as it was taking up more time than he could afford!

However, it may be that opera-by-telephone experiment influenced the development of radio entertainment in the USSR. This may be the case because, in 1925 an amplifier was installed in Union House in Moscow with cables connecting it to loudspeakers, **Fig. 3**, fitted in workers' clubs throughout the city. It was then extended with cables being run to theatres, concert halls, sports stadiums, etc., so that Union House became a sort of distribution centre for broadcasting live performances from various sources of entertainment.

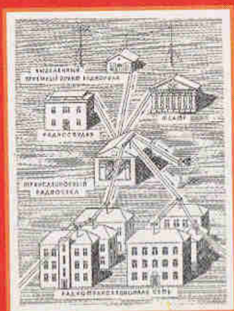


Fig. 3: The opera-by-telephone experiment may have influenced the development of radio entertainment in the USSR because in 1925 an amplifier was installed in Union House in Moscow with cables connecting it to loudspeakers, fitted in workers' clubs throughout the city. Note that the receiving station was located away from the city to limit interference (see text).

Similar Systems

Similar systems were set up in other Soviet cities. When radio broadcasting began radio receivers were added, often located outside the town to reduce local interference, and again 'piped 'to the distribution centre.

Loudspeakers were now also being located in private houses and blocks of flats. The distribution station could then either rebroadcast the national services, or transmit local programmes.

At the start of the Second World War in the USSR, there were more than 11,000 distribution centres supplying about 60,000,000 loudspeakers. There were also more than 1,000,000 conventional radio receivers.

The system proved very useful during the war, when it was the practice to switch off the national transmitters during the hours of darkness to prevent enemy aircraft using them as navigational aids. The wired system meant that important announcements could still be made and morale raising local broadcasts transmitted. Interestingly, the system was still in use when the book was written. With the Soviet obsession for statistics the book informs the reader that in Moscow there were more than 3000km of cable and about 1000,000 loudspeakers.

Pulse Position Modulation

While most of the inventions described are familiar to me, mention must be made of one which isn't. At the risk of incurring the scorn of more knowledgeable readers I have to confess to never having heard of the system in question.

The book's chapter *One Radio Station Carries Several Transmissions* describes a modulation system, which seems

Invented It!

remarkably advanced for its time. This is particularly remarkable when it's remembered that it was all done using valve technology.

Basically, the system as described, used a pulsed transmission system employing Pulse Position Modulation. In the gaps between the pulses, other pulses corresponding to another programme are inserted. In this way several music programmes or several tens of telephone conversations can be transmitted simultaneously. The system seems to have been confined to ultra short wave (now v.h.f.) which suggests that quite a wide bandwidth was needed.

Television Broadcast

The first TV broadcast took place from Moscow on the 2 May 1931 on a wavelength of 56.6m. Radio Amateurs in Moscow and Leningrad received pictures on home built machines. Although the book doesn't mention whose invention this was, it seems very similar to Baird's mechanical system, using a rotating Nipkov scanning disc to give 30 lines at a resolution of 40 elements per line.

The received picture was about the size of a matchbox. Later, regular broadcasts were started, the frequency being changed to a much lower on, a 'very long' wavelength...the other details are vague I'm afraid. Pictures were received as far away as Novosibirsk, at a distance of about 2000km.

Then, in 1938 an all-electronic system was introduced in Moscow and Leningrad, although standards unfortunately are not specified. By 1951 a 625 line system was operating in Moscow, giving (it's claimed) the clearest TV pictures in the world.

Curiously, the distribution station philosophy also afflicted the start of TV. In 1940 one such station was installed at the top of a block of flats on Petrovski Boulevard in Moscow. Since extension cathode ray tubes c.r.t.s) were hardly feasible, it was necessary to use TV sets..."Of very simple construction" in all the flats.

Presumably the simple sets were similar to present day monitors. However, as they would have to contain the timebases and high voltage power supplies,(the circuitry which was most likely to fail) it really seems more trouble than it was worth!

Colour Television

At the time the book was written, experiments in colour TV were taking place. Two systems were being tested with one being credited to **I. A. Adamian** using rotating colour filters (the sequential system).

The other system, devised by **Y. S. Volkov** used a c.r.t. with colour phosphors to produce images in red, green and blue...the three primary colours being optically combined. (The idea is illustrated in **Fig. 4.**).

There were obvious disadvantages to both the Russian systems and it seems neither was accepted. Eventually the USSR and its satellite states adopted the French SECAM system.

Hazardous Predictions

Occasionally throughout the book, the author indulges in the hazardous business of prediction with the usual mixed success. He seems unaware of the invention of the transistor in the USA, and speaks instead of valves of the future which will be no larger than a pea.

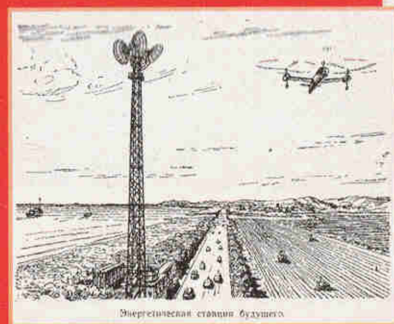


Fig. 5: The book also describes the possibility of transmitting significant amounts of power using concentrated microwave beams. The accompanying illustration shows ships, cars, aircraft and tractors under power from a microwave transmitter! (See text).

Although writing less than a decade before the USSR's spectacular space successes...the author makes no mention of space communication. On the other hand he correctly predicts that congestion on the m.f. bands will cause most future communication developments to take place in the v.h.f. and u.h.f. bands.

The author also successfully foresaw teleconferencing! However, in the final chapters he really lets his imagination go and wrote - in the chapter *Transport of the Future* that "*G. I. Babat has invented a new system of road transport. Comrade Babat proposes a network of wires to be run under the surfaces of main roads and fed with high frequency current. The vehicle, which he calls the Vechmobile, has a coil mounted underneath to draw power from this network by induction*". The Vechmobile was also to have to been provided with auxiliary batteries so that it could also be used on side roads not provided with a power network.

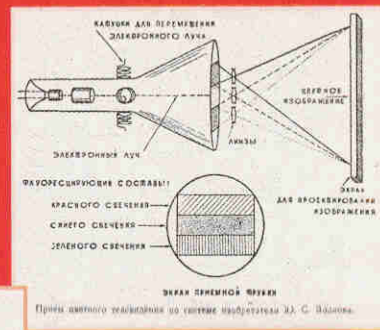


Fig. 4: The proposed Volkov colour television system (see text)

In another chapter entitled Transmission *of Electricity without Wires* the author described the possibility of transmitting significant amounts of power using concentrated microwave beams. The accompanying illustration, **Fig. 5**, however, is pure fantasy. Ships, cars, aircraft and (this being the USSR) ....tractors, all optimistically carry small dish antennas.

It would certainly help to keep your fish supper warm on the way home. But...I wonder what the anti-mobile telephone mast lobby would make of this idea! The book is a fascinating look back into the past and I'm pleased I can read Russian, as I would have missed it otherwise!

PW

RUSSIAN INVENTIONS

Photocell	A. G. Stoletov (1888)
Magnetron	N. F. Alexeyev & D. Y. Malyarov 1937
LORAN	E. M. Rubchinski
Decca Navigator	L. I. Mandalshtam & N. D. Papalevski (1930)
Electronic camera tube	S. I. Katayev (1938)
Aircraft auto pilot	K. E. Tsiolkovski
Film sound system	A. F. Shorin, P. G. Tager & V. D. Okhotnikov (1926)
Electronic organ	A. A. Volodin

Valve&Vintage

It's Ben Nock G4BXD on duty in the vintage 'shop' this month and he's already been out and about visiting rallies! Some of the treasures he's found now appear in the column...and in his photographs!

A warm welcome to you as I man the Valve & Vintage 'shop' once more! We are well into the year now and already several rallies have gone by....and I say "thank you" to all those who've said "hello" at the various venues.

A big thanks go to Ann and the gang at the **Harwell Rally Group** for the show in February, another great event. And also to the lads at the Swansea rally in February.

Surprise...surprise...a few new items have found their way into the stores here! What a surprise?... I hear you say...so let's press on and have a look at what's turned up.

Aircraft Radios

First off this time I've got some aircraft radios to show you: the Receiver Type 78 and the Transmitter Type 53, **Fig. 1**, which are part of the ARI.5205 station. These are two aircraft sets, for high frequency (h.f.) use , covering 2.4 to 13MHz in two bands.

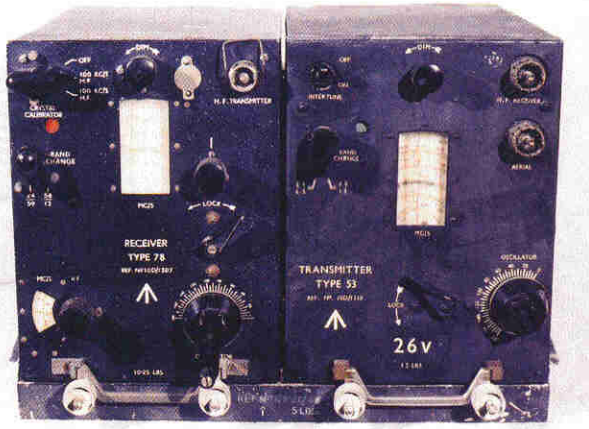


Fig. 1: The Receiver 78 and Transmitter 53 in a mounting cradle.

The receiver is in fact just a front-end, and there's an additional box which contains the intermediate frequency (i.f.) stages and the audio amplifier. The transmitter runs three 807 valves, one as the master oscillator and two in parallel as the power output stage, giving 33W on c.w. and 8W on radiotelephony.

The receiver front-end is a five valve tuner with a 560kHz i.f. output. A calibrator gives 100kHz pips and there's also a radio frequency (r.f.) preselector control. In original service use there would be two receiver tuners and two transmitters. the 53 and 78 were the h.f. units, with the low frequency (l.f.) 76 and 51 sets tuning 150 to 505kHz. (**Fig. 2**, shows an internal view).

The receiver is a standard superhet design, comprising of an r.f. amplifier, mixer, local oscillator and the circuit is straightforward to trace. The transmitter on the other hand is a little different in that I think the oscillator tunes just the one range and its output is doubled on the higher range.

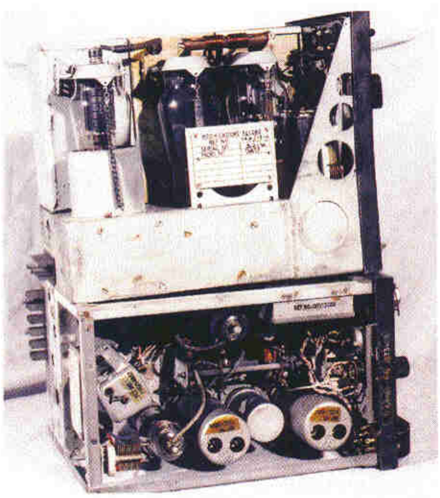


Fig. 2: Inside the 78 (bottom) and 53 sets, note the three 807 valves in the transmitter.

I don't have a circuit of the transmitter though, so if anyone can help out there I'd be most obliged. As usual I will gratefully acknowledge any help from our loyal readers.

Aircraft To Army

It's from Aircraft to Army use now as I look at the UK/PRC-352 equipment. This comprises of the PRC-351 manpack with the additional UK/AM-352 high power amplifier. The photograph, **Fig. 3**, shows the transceiver with the power amplifier mounted in the UK/VRQ-301 vehicle interface unit.

The PRC-351 is an 1,841 channel 25kHz spaced v.h.f. set operating between 30 and 76MHz. It delivers 4W of narrow band frequency modulated (n.b.f.m.) or 20W with the additional amplifier.

The previously mentioned vehicle interface unit allows the radio and amplifier to be powered from the vehicle battery. It also provides interconnections to the main radio harness when used in an FFR (Fitted For Radio) military vehicle.

The specification for the radio states a 5kHz deviation n.b.f.m. signal and a sensitivity of 1µV for 10db S/N. Power is from a 24V supply, either the 3.3Ah clip on battery or the vehicle supply. The 351 on its own draws 100mA on receive and 850mA on transmit, with the added amplifier that increases to 2.85A on transmit.

Canadian Manpack Set

Another Army set now, but this time it's one from across the water in Canada. The CPRC-26, **Fig. 4**, is an earlier v.h.f. manpack set, crystal controlled and self contained unit for infantry use.

The CPRC-26 resembles the British Wireless Set No 88 in its shape, size and operation. It also uses the same battery type valves, its power amplifier (p.a.) stage is a 3B4 type giving in the order of 300mW of output.

In use the radio offers six channels between 47 and 55.4MHz and employs frequency modulation. However, there are six separate versions of this set labelled A to F which have slightly different frequencies (though in service use, channel 1 was a common frequency to all variants).

The manual states the set is designed for short range communication, 1.6km (1 mile) being normal range, and that the equipment is both shock and immersion-proof, also withstanding being dropped by parachute. A special loop antenna can be fitted which would enable the operator to home in to another set.

On an interesting note, the manual states there is an extension cable that can be used between set and battery so that in cold weather operations the batteries can be carried inside the operators clothing. Real central heating...for the batteries only!

Construction of the Canadian set is modular, see **Fig. 5**, and each unit can simply be replaced to speed up repair in forward positions. The top plate covering the units identifies each module again aiding repair.

The radio runs off a dry battery supplying 90, 45, 3 and 1.5V with an expected life of 20 hours in service use. In addition to the normal 1.5m (4ft) whip antenna, a trailing wire counterpoise could be used to increase range. This could also be used as the antenna itself, allowing less conspicuous operation but reducing the set's range.

The Versatile Valve

Valves are versatile and just to prove that they're not only used in receivers or transmitters...a nice little stabilised power supply, Fig. 6., arrived for my collection the other day. In fact it was 'donated' to me as it didn't work, it was going to the tip but I took it as the case looked worth re-using. The fault quoted was that as the h.t. came up to full strength...the fuses popped.

Opening up the unit revealed three rectifiers and two 5B/240M valves. Measurement showed that two of the rectifiers, R18 types, were unserviceable. These were replaced with modern silicon diodes and the unit retried.

Fig. 4: The CPRC-26 in canvas case with handset and whip antenna (See text).

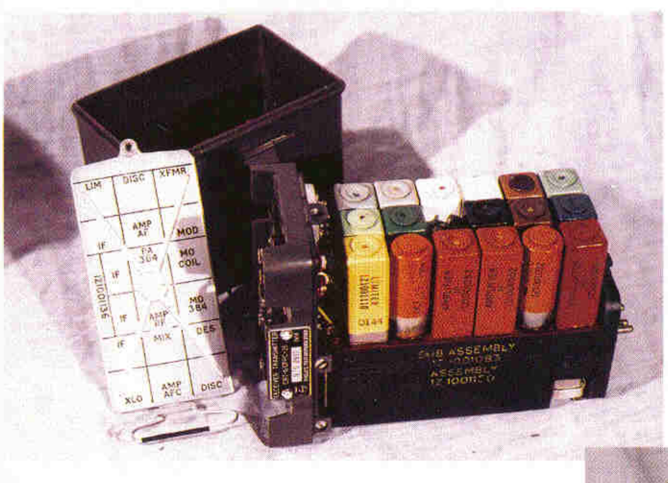


Fig. 5: The internal modular construction inside the CPRC-26 radio.

This time all was well, the 5B/240M's being operated as series regulators. I noticed though, that even with the voltage control at zero as the unit warmed up from switch-on that the output volts rose then fell back. This was soon traced to the fact that there was still a valve rectifier in the negative control voltage feed.

I found that as the heaters of the 5B/240s warmed they were passing voltage until the negative rectifier also warmed up and gave the required clamping volts. Replacing the negative valve rectifier with a modern diode cured this effect.

The front meter is a strange device in that it has two sets of connections, one for current and one for voltage. On investigation further I found that the current part didn't work, so using the working voltage section, with some rewiring later, this was eventually used to measure both the current and voltage.

So, I now have a regulated 0-500V high tension power supply ideal for testing these valved sets. If anyone else has anything they are thinking of throwing out...please do let me know!

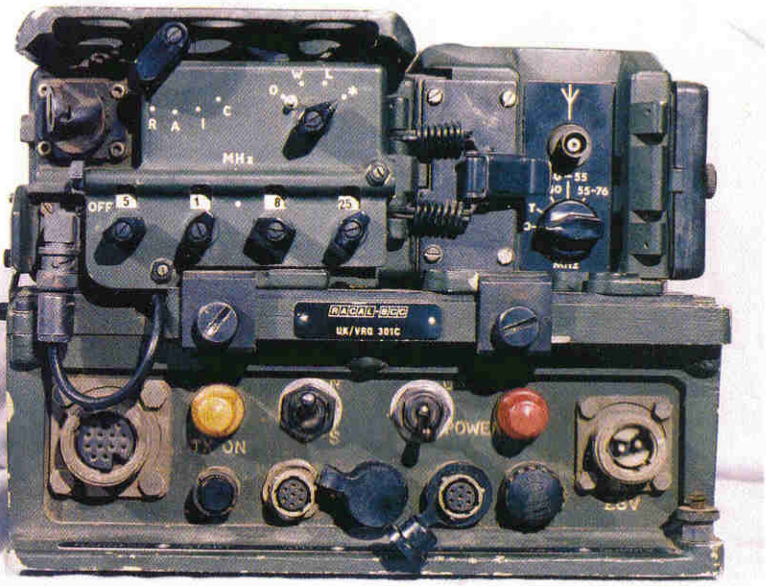


Fig. 3: The PRC-351 transceiver with amplifier (right) and vehicle interface below (see text).

And Finally

Finally this time...two readers have sent requests for help. Firstly **Blair VE6AGH**, would like to hear from anyone with operational experience of using the SSR-5 receiver transmitter equipment. Please contact him QTHR or via E-mail at **ve6agh@rac.ca** Also, **Bill GI4OYM**, would like to obtain a circuit and info on the Racal Field Kaynard equipment, contact him at QTHR or via **wire@breathemail.net**

Well that's all for now and I'm looking forward to seeing you at possibly the London, Great Barr and Drayton Manor rallies. As always you can write to me at: **62 Cobden Street, Kidderminster, Worcestershire DY11 6RP**, or via e-mail at **G4BXD@qsl.net** and why not have a look at my web pages at **www.qsl.net/g4bxd**

Cheerio for now.

PW

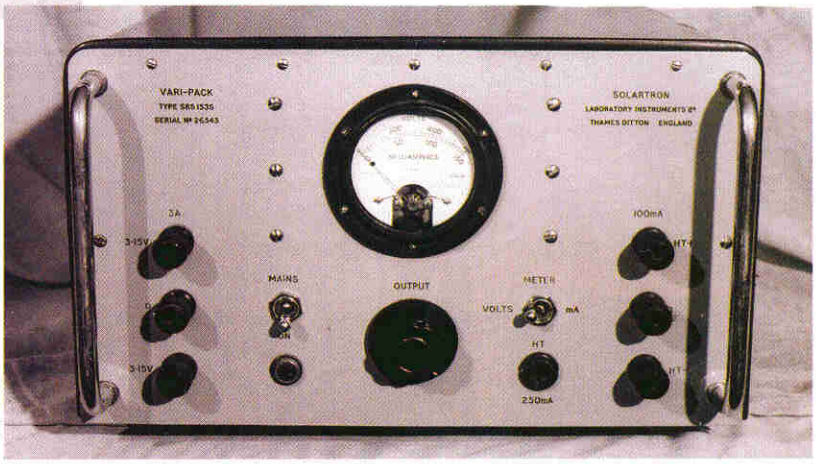


Fig. 6: The valve regulated high tension power supply, now fully working. Before being nutured back to good health it was heading for the rubbish skip (see text).

AVOID THAT ZAP!

Build The Simply Static Meter

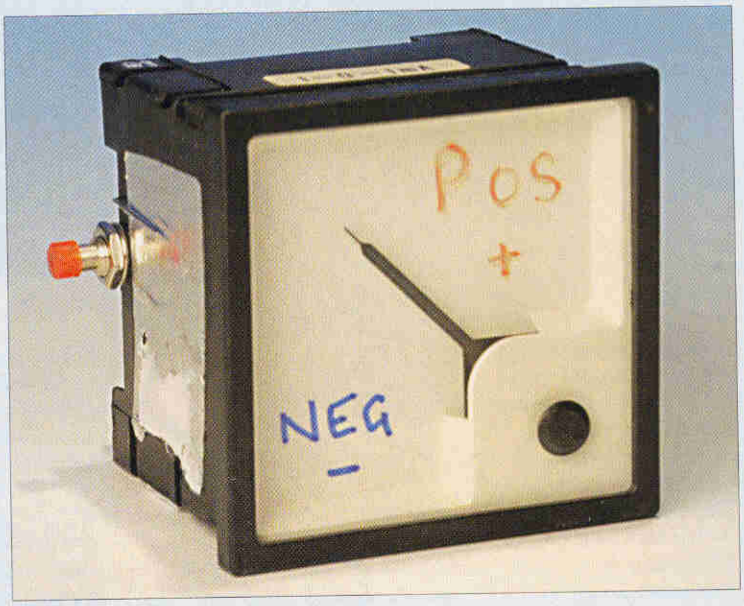
Bill Jarvis GM8APX, was surprised at the high static levels around his own home and shack. The resulting project should help anyone who has been caught out by static - from a simple finger-tip zap to a destroyed semiconductor.

We're all bothered by static charges aren't we? Ranging from the static 'belt' we get when passing office furniture such as filing cabinets, right round to inflicting instant death to sensitive semiconductors...there's a static charge waiting for its chance! So, my project will be ideal for people who are worried about high static charges when handling semiconductors, etc.

If you're interested in detecting a static charge...it's easy to make an electroscope. This can be made from an empty bean tin, an empty yoghurt pot, a pin, and a dab of Blu-Tak, and a piece of foil chocolate wrapper. However, the resulting simple instrument does not indicate the sign and magnitude of the charge unless you give it a known charge first - which can be inconvenient!

So, you then have to consider making a dedicated, but simple instrument which will do what's needed and then of course you'll have to look at the inevitable money input! However, a 1-0-1mA moving coil meter (centre zero), **Fig. 1**, has been available for under £10 from Greenweld. This, together with an ICL7611 op-amp with input impedance of 10^12Ω turns it into a bi-directional electroscope which tells you the sign of the charge on yourself, and provides you a good idea of its magnitude.

You could also calibrate the pull-out dial scale in volts (or, more appropriately, kilovolts - if you have modern synthetic clothes, shoes or carpets) although the circuit I suggest cuts off before the meter can reach full scale deflection (f.s.d.). So it becomes impossible to overload it, and easier to estimate static charges by the distance needed to give half-scale deflection (i.e., half way from centre zero to either end).



The Simply Static project is both fascinating and really simple to build! If you have ever experienced the effects of a static discharge this instrument will open a new world to you. But be warned...don't stroke the cat while it's switched on!

Fig. 1: The Simply Static project is based on a 1-0-1mA moving coil meter (centre zero), which has been available for under £10 from Greenweld. This, together with an ICL7611 op-amp with input impedance of 10^12Ω turns it into a bi-directional electroscope which tells you the sign of the charge on yourself, and provides you a good idea of its magnitude (see text).

Meter Sizes

The required 0-1-0 mA meter is available in two sizes, **Fig. 2**, but it is easy to construct the op-amp circuit in the back of the meter, even in the smaller size one. Both sizes have easy-to-remove-and-replace card dials, on which you could write anything which suits your needs.

The meters were intended for mounting in a square panel hole, the larger of the two versions measures 91 x 91mm and the smaller being 67 x 67mm. However, they don't need mounting in this application, and can stand alone on the side of your choice, with the PP3 battery and circuit safely inside the recessed back panel.

I made both of my prototypes with push-on-release-off buttons, as there's no need to leave the battery draining away. To operate the instrument all that's needed is just push on the button when you want to know whether there's any static near you - and it's sign confirm...you'll be able to do so...and soon get used to what combination of clothes, shoes, and carpets lead to what sign of static!

Metal Strip

One version (Fig. 2) has a metal strip along the bottom, as a vague sort of 'earth' (but remember your work-top could possibly show a different earth potential to your body, if the floor is a good insulator).

The other version, **Fig. 3**, has two 4mm terminals on top, and the push switch on the left-hand side. The layout is highly non-critical!

You will also need two 10MΩ (or any very high) metal film resistors, to avoid frightening the (albeit well protected) i.c. inputs; and two of about 8.1kΩ, so that the meter cannot go off scale with a 9V supply. You could also of course use a 6V supply, and lower voltage halving resistances...but that would mean more drain when the on-button is pressed.

The Circuit

The circuit is shown in **Fig. 5**, and for my version I used an i.c. holder and 8-pin i.c. pads from the Copper Island Construction kits (from **Duncan Walters G4DFV**, **see note*** below), which I fixed into place - using Cyanocrylate adhesive - between the meter terminals. But you could mount the i.c. many other ways but you do get the adhesive with the kit! The battery clip is also glued to the inside back of the meter movement; but I'm just lazy.

When it comes to calibrating the instrument it would be easy to calibrate the instrument in volts, by connecting in parallel with a conventional digital voltmeter. However, for evaluating the field (in volts per metre) you would also need a ruler....and as most rulers nowadays are made of plastic, just picking it up would cause chaos!

****Note:** For further information on the Copper Islands Kits please see G4DFV's advert in the Classified Ads section this issue, or the review in page 49 January 2002. **Editor**).*

Coulomb Meter

To make a coulomb-meter, you could parallel the inputs with a small capacitor. For a pico-ammeter, all you need to is bridge the terminals with a piece of dry paper.

The i.c. I've used in the project has provision for setting an accurate zero **but I found no need for this**. If the needle moves one way, you've "gotta plus charge" ...and if it moves the other way..... (guess what?).

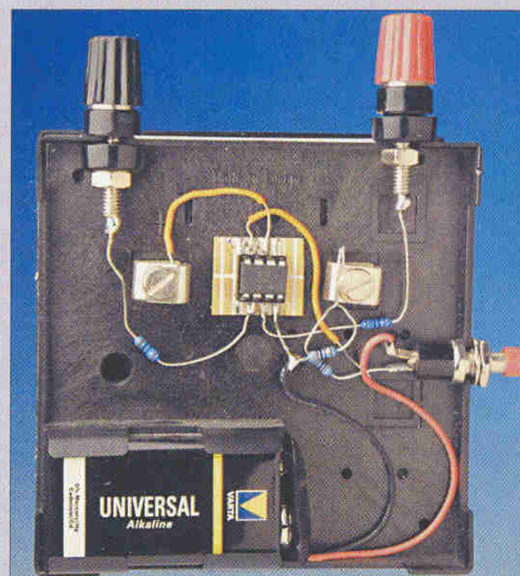
When it's all set up and working you'll find it's amusing to hold the meter whilst going round the house stroking different objects (But be careful when stroking the cat!). And you never know...the Simple Static meter might even make the basis of a party game!

To test the quality of insulators, just bridge the positive (+) and negative (-) terminals with a strip of the insulating material, and see how long the meter takes to return to centre zero. A really good insulator gives an indication which makes the meter move so slowly back to zero...it's like watching paint dry.

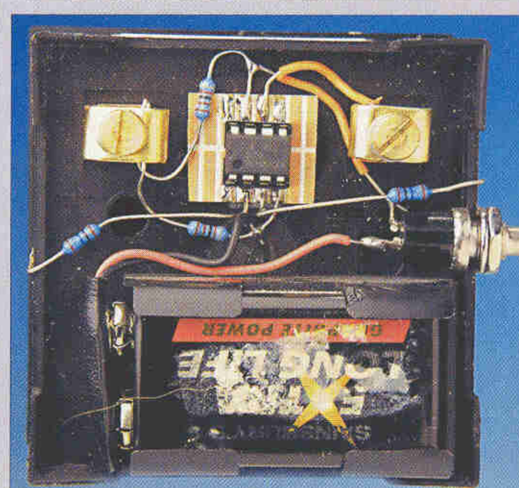
The 4mm terminals in my larger prototype have the added convenience of also taking 2 or 1mm plugs when the threaded insulator is loosened, and of accepting a wide range of wire gauges. Altogether it's a very useful little unit...and it should help you to avoid being zapped and also save those precious field effect transistor from the dreaded mini-thunderbolts!

PW

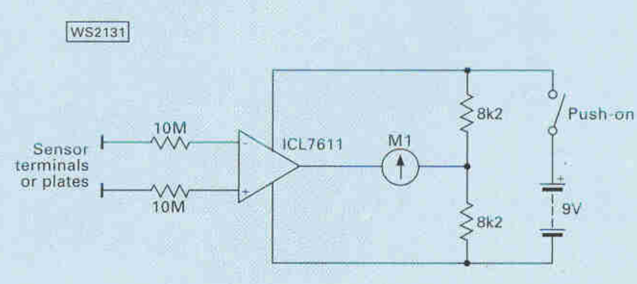
● Fig. 2: The required 0-1-0mA meter is available in two sizes. However, the author explains it is easy to construct the required op amplifier circuit in the back of the meter, even in the smaller size meter unit. Both sizes have easy-to-remove-and-replace card dials (see text).



● Fig. 3: The author built his second prototype into the smaller meter case, and employed two terminals for holding (for example) insulating materials to be tested. He also says that you must be prepared to like "Watching paint dry" when testing materials! (see text).



● Fig. 4: The Simply Static project shown built into the larger meter's housing. Not that the op amp is mounted on a Copper Islands Circuit Outfit (CICO) i.c. holder. (See text for details).



● Fig. 5: Circuit of the Simply Static project. It really could not be simpler! The project uses an op amp and very few components (see text).

Contact Address

Greenweld Ltd.,
Unit 14, Horndon Business Centre, West Horndon, Brentwood, Essex CM13 3XD.
No telephone numbers are mentioned in their adverts - other than a FAX number: **(01277) 812419** for orders. Alternatively they can be contacted by e-mail at **bargains@greenweld.co.uk**

Please note: Readers are asked to bear in mind that the meter used by GM8APX would be of surplus origin. However, if they aren't available from this source, the centre zero 1-0-1ma meter is quite common - although other suppliers may have different sizes, styles and shapes of meter. Whatever happens though...do build a Simply Static meter for yourself...they're fascinating to use! **Editor**.

Antenna Workshop

The versatile SPC Antenna Tuner for the h.f. Bands, is described by John Heys G3BDQ this month.

With it's acronym name derived from **S**eries, **P**arallel **C**apacity the SPC matching circuit is a modification of the 'T' matcher and is attributed to the late **Doug de Maw W1FB**. The circuit offers many advantages over other designs and internal matching units. When correctly adjusted, an SPC a.t.u. will efficiently match the 50Ω transmitter output impedance to impedances from under 25Ω to over 1kΩ.

There's now a growing trend to incorporate an internal a.t.u. into many new transceivers. Should the operator of one of these transceivers wish to use an end-fed single wire antenna though, the inboard matcher will be unable to cope with the wide ranging impedances presented by the antenna on different bands.

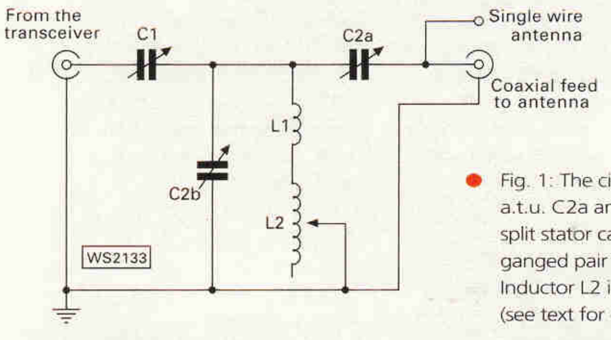


Fig. 1: The circuit of the SPC a.t.u. C2a and b may be a split stator capacitor, or a ganged pair of capacitors. Inductor L2 is a rotary unit (see text for details).

Fig. 2: Front view of the a.t.u. which has a Perspex panel. The turns counter for the rotary inductor allows for quick band changing.

High Impedances

Most internal matching units cannot deal with the high impedances that are often presented by long wire, Windom or other wire antennas. When you employ a linear amplifier, the internal matcher becomes redundant and an external a.t.u. able to handle the higher transmit power becomes essential.

Internal a.t.u.s are really designed to work with antenna systems that present, at the transmitter, impedances not too far removed from a nominal 50Ω. Quite often a multi-band beam antenna, incorporating traps for multi-band operation will show a low s.w.r. only over small sections of each band.

On one of the wider bands, such as 21 or 28MHz, an internal a.t.u. can 'tune out' any small mismatches created by the antenna's limited bandwidth. So, the transceiver will always be presented with a 50Ω load and full output power is maintained. But these internal matching units are engineered to cope with quite a low range of impedances

Due mainly to space limitations, inbuilt matchers tend to use quite small toroidal inductors and fixed capacitors. Though these components take up little space, they generally result in a power through-loss of ten per cent.

Air spaced variable capacitors and cylindrical inductors when used in a matching circuit, as shown in **Fig. 1**, will allow the construction of an a.t.u. which has virtually no loss of power and which can be designed to safely handle transmitter powers ranging from QRP levels up to our legal limits and beyond.

There will always has some capacitance across the inductances L1 and L2, which helps to reduce unwanted h.f. harmonics. This feature although, is perhaps not quite so important, as modern transceivers tend to have very little unwanted harmonic output.

Ganged together

The variable capacitors C2a and C2b (Fig. 1) are ganged together and may be either a split stator item or a pair of capacitors, one of which must have both front and rear spindles to allow coupling. The maximum capacitance of each capacitor should be at least 150pF.

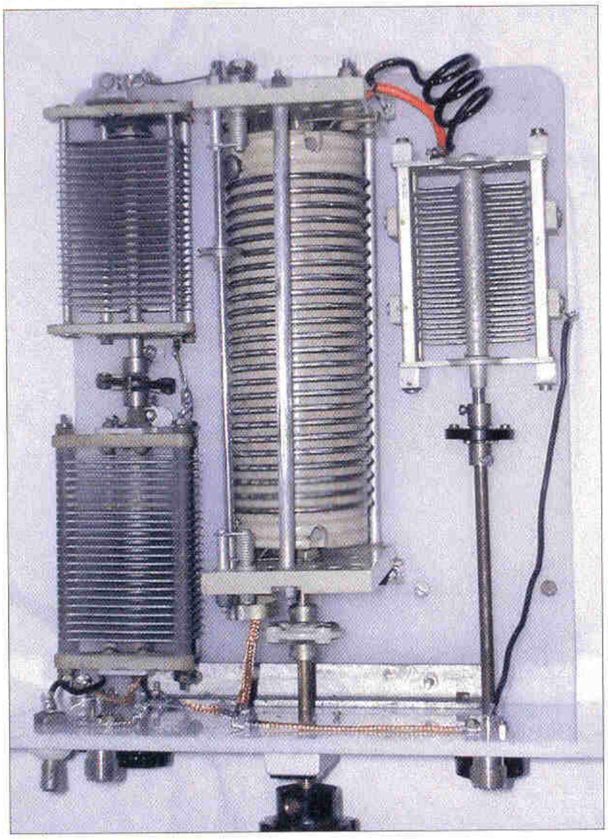
The values for C2a and b, are not critical and higher value capacitances may be employed. My SPC matcher uses 356pF capacitors for C2a and C2b. Values for capacitor C1 can have a maximum capacitance anywhere between 175 and 360pF.

The vane spacing of the variable capacitors used determines the power handling capability of the a.t.u. and wide spaced variable capacitors are now becoming scarce and expensive. Fortunately, they can still turn up at Rallies and Club 'Junk' sales.

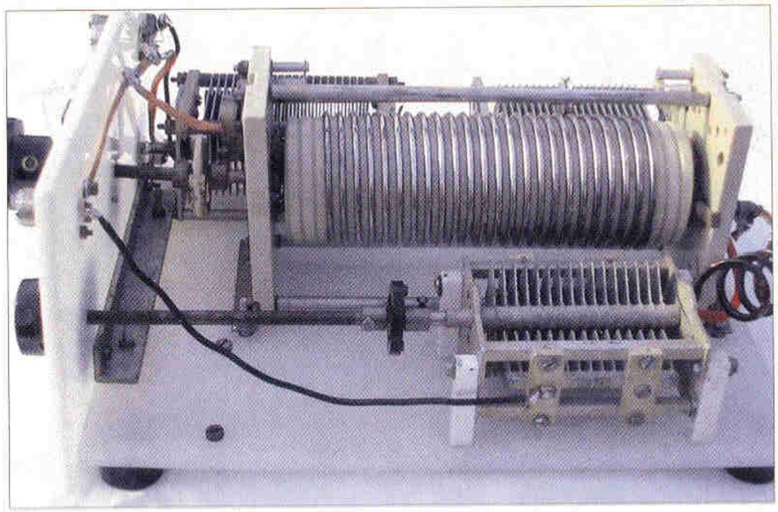
I find that variable capacitors from old aircraft transmitters are ideal buys, and many capacitors used in my a.t.u. designs were from this source. Often they have spent many years in the junk box before being used.

However, capacitor 'flashover' **is not just a product of close vane spacing**. Flashover can also arise when the a.t.u. inductance is set incorrectly. To allow fine setting of the inductance value, the inductance L2 should preferably be a rotary unit, often known as a 'Roller coaster' or 'Mangle'. If you're unsure what one of those is, ask grandma!

A multi-tapped coil may be used, but it can often be difficult to find the correct tap point for each band. You would also need a high quality ceramic rotary multi-way switch, to be able to handle high transmitter power. These rotary inductors are becoming scarce too, but they sometimes turn up at club sales, or surplus flea markets.



● Fig. 3: Top view of the SPC antenna matcher. The layout is arranged to allow short wiring, minimise stray inductance and unwanted capacitance.



● Fig. 4: Side view of the a.t.u. with C1 in the foreground. This capacitor came from a wartime aircraft transmitter. Inductor L1 is wound with enamelled heavy gauge wire.

Not Grounded

Please note, that in Fig. 1 the earthy end of the L2 is not grounded. Although you may see some published SPC circuits where this point of the the coil is grounded, I've found that when this is linked, there's always a possibility that unwanted resonances can occur at some settings.

Unwanted resonances in the coil will cause power loss and coil heating. If the matcher is to be used on all the h.f. bands, L2 must have a maximum inductance of at least 20µH. As the inductor used in my prototype version has a maximum inductance of only 11µH, it cannot tune the 1.8 and 3.5MHz bands.

Conversely on the 28MHz band, L2 is at a minimal value, and would only use less than one turn. So, its efficiency would be low. To obviate this, a small fixed coil L1 is used in series with the variable inductor L2. This small inductor has an inductance of about 1µH and should be made with heavy gauge (three or four millimetre - 8/10s.w.g.) copper wire.

Old starter motors have some really thick wire. But wherever you get it from, form it into three turns with an internal diameter of 25mm stretched over a 38mm length.

Real Hardware

Translating the circuit diagram (Fig. 1) of the SPC a.t.u. into real hardware can invite certain problems. The connections to C1 and C2a are all above earth potential and the inductor L2 will only have its designed high *Q* (efficiency) when positioned at least its diameter, or more, from any earthed or metallic surface.

A metal base and panel would invite insulation and spacing problems so, I made mine from plastic materials. The base, a slab of Polypropylene material, measures 305×40mm. Fortunately, the new cutting boards for kitchen use are made from this and are available quite cheaply.

My local discount store had large 480×320mm boards for a little over £3. This plastic can be sawn and drilled easily and is fine for self-tapping screws. It has a smooth waxy feel and superb insulating properties.

The front panel is a piece of white Perspex bought as an 'off-cut' from the scrapbox of my local glass works. It is held securely to the baseboard by a short length of stout non-ferrous (aluminium) angle shape. The photograph of **Fig. 2** illustrates the panel layout.

It may look rather unusual, but the antennas enter my shack from the left so the antenna connectors are positioned to the left, whilst the input SO-239 coaxial socket is on the right. Normally, coaxial connectors are located at the back of an a.t.u., but my table top and shelf arrangements would make this awkward.

Top View

The top view of the completed unit, **Fig. 3**, shows C2a and b on the left of the baseboard, with C1 is on the right hand side towards the back. The connections to the fixed vanes of C2a and C2b go to L1 as do the moving vanes of C1.

If a split stator variable capacitor unit is used for C2, then the combined moving vanes will connect to L1. Earth loops are avoided by having a length of copper braid run along the panel to which all earth connections are made.

The layout used makes for very short r.f. wiring, as you can see in **Fig. 4**, which gives a side view of the a.t.u. and two of its four 'feet' are just visible at the front and back edges of the baseboard. These feet raise the board away from any earthy surface.

Operation

In operation on 7MHz, the variable inductor (L2) only needs nine turns in circuit. This setting reduces to five turns on 10MHz, two turns on 14MHz, one and a half turns on 18MHz. On trying the 21MHz, just one turn was needed , dropping to just half a turn for the 24MHz band. As I mentioned before, on 28MHz just L1 is in use.

The initial setting up on each band can be done by using a low transmit power and a resistive dummy load. This can be in the range 100 to 600Ω to simulate an actually antenna connection.

The capacitor controls may be set to between a third and half maximum value, then the variable inductor, L2 is rotated until the lowest s.w.r. is found. All the capacitors then should be adjusted to bring down the s.w.r. to unity. Now you're ready to go with higher power. Do not adjust L2 with full transmit power applied.

I've found that the tuning is fairly sharp on 7MHz and ideally, reduction drives for the variable capacitors would be useful. A turns counter for L2 is obligatory, to make repeated settings easily, and I obtained a suitable one from **Mainline Surplus Sales**.

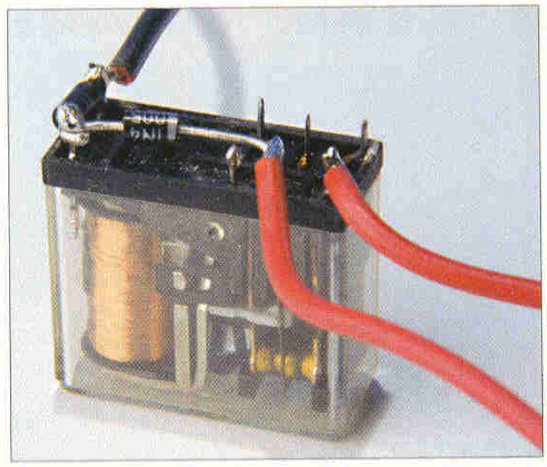
Works Well

This SPC design works well and shows almost no power loss. My unit can easily handle 1.2kW without capacitor flashover and 'loafs' along at the UK legal power levels. Using a rotary inductor with an inductance of 20µH or more will allow operational additionally on the 1.8 and 3.5MHz bands.

Finally, I am indebted to **Bill Staples G0AKY** for taking the pictures to illustrate this article.

PW

Carrying On The Practical Way



● This month's G3RJV project...protect your equipment by providing 'Idiot proof relaying safety' against wrong polarity power supply connections!

"Getting it the right way round" is the theme of this month's practical ideas column by the Rev. George Dobbs. And by using 'Idiot diodes' he's playing very safe....by ensuring that his radio equipment isn't damaged by incorrectly connected power supplies.

"Experience is the name everyone gives to their mistakes"

Oscar Wilde (1854 - 1900),

from *Lady Windermere's Fan*.

On the shelf above my main workbench, I have a nice home-brew 7MHz transceiver. It's a reliable small transceiver I once enjoyed using for occasional portable work but it lies there unused nowadays...because of two classical mistakes.

The first mistake was that I lent it to a fellow Radio Amateur and the second was that I forgot to install reverse polarity protection when I built it! No doubt, by now, you're ahead of me in the story. He borrowed it and connected the power supply the wrong way round causing its demise. So, now the rig is in the "I'll get around to repairing it one day" queue of the shelf that grows with the years.

I'm not one to apportion blame, but I guess that the bottom-line reason really lies with me. This is because it's a basic error to build any precious item of equipment without adding provision for reverse polarity protection.

A lot of active components in electronic circuits simply do not like being connected the wrong way round to a power supply and most of them die very quickly. The great pity of reverse polarity accidents is that they are so easy to avoid. Just a few extra parts will protect equipment from expensive, and very often difficult to change, components going up in smoke.

The Idiot Diode

Most radio constructors know about the 'idiot diode', the most basic method of polarity protection. This simply makes use of the property of a diode to pass current one only way.

A single 'idiot diode' protection circuit is shown in **Fig. 1**, where a diode is placed in series with the power supply line. **The diode must be capable of passing the maximum current the equipment is likely to draw**.

Silicon diodes in the 1N4000 series are commonly used for the circuit. It's a popular idea with constructors because a single diode is easy to add to any electronic circuit.

Like many simple solutions, the single diode has drawbacks. The most obvious is the loss of voltage across the diode as the device will have a forward voltage drop.

In the case of the 1N4001 the voltage drop will be in the order of 0.8V. This is quite a significant loss of power supply voltage.

A series diode also adds a non-linear impedance to the power supply. This is not a problem for many items of equipment but not good practice in radio frequency circuits. However, it's surprising how many stability problems can begin with a poor power supply.

Ultimate Idiot Circuit

The diagram, **Fig. 2**, shows the ultimate idiot diode circuit. Rather than a single diode, here a diode bridge is included. This could perhaps be called the 'moron diode' as it's foolproof.

When the equipment is connected via the bridge, the power supply can be connected either way round and it will offer the correct polarity to the equipment. Obviously the real problem here is the voltage loss through the diodes, and that will be at least 1.5V...which is usually unacceptable for most applications.

A diode can be added in parallel to the power supply as shown in **Fig. 3**. In this situation, the diode is reverse biased and only draws very little leakage current.

Should the supply be connected the wrong way round, the diode will act as a short circuit to ground. This should shut off a well-protected, or fused, power supply but the safest method is to add a series fuse, as shown in Fig. 3.

The fuse should be rated high enough to pass the maximum current drawn by the equipment **but not much higher**. It needs to blow if the polarity is reversed and the diode begins to draw a high current.

I've seen discussions in Amateur Radio literature about using a transient suppressor diode for the bridge application. It would directly replace the normal diode in Fig. 3.

Transient suppressor diodes are similar to regular zener diodes, but can suppress larger amounts of energy. They are designed to fail-safe, so if a surge damages them, it won't damage the rest of the network. A normal diode is likely to fail open-circuit, thus losing protection entirely, but the suppressers are designed to fail, ending up short-circuited.

In Junk Box?

Transient suppressor diodes are hardly the sort of thing many of us have lying around in our junk boxes but they are available from electronic suppliers, companies like Farnell. The type 1.5KE18A looks suitable for the application.

The 1.5KE18A is made by General Semiconductor and Fairchild and appears in the Farnell catalogue. The diode has low leakage for a reverse voltage up to about 15V, and then conducts heavily when the voltage exceeds 18V. So it can protect against surge voltages, as well as providing protection if the supply is reversed.

My favourite polarity protection circuit is shown in **Fig. 4**. There's a few more bits in it, **but it is foolproof**. If the supply is connected the wrong way round, the equipment receives no power whatsoever. Nowadays...if I'm building any significant equipment, this is what I add in the power supply line.

The requirements are small; two diodes and a 12V relay. The relay must have at least one set of change-over contacts and these contacts should be large enough to handle switching the total current of the equipment being protected. (Almost any 12-volt relay will do the job).

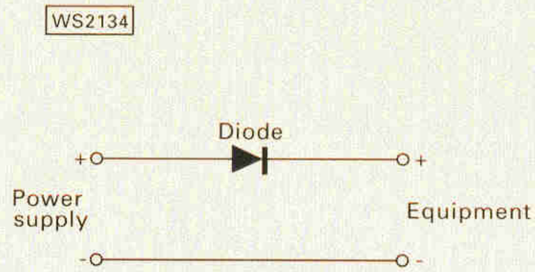
Simple Circuit

The circuit is simple: When the power is applied, the series diode ensures that the relay does not 'see' the voltage unless the polarity is correct. The diode - in parallel with the relay coil - helps to reduce voltage spikes caused by the magnetic field of the relay coil.

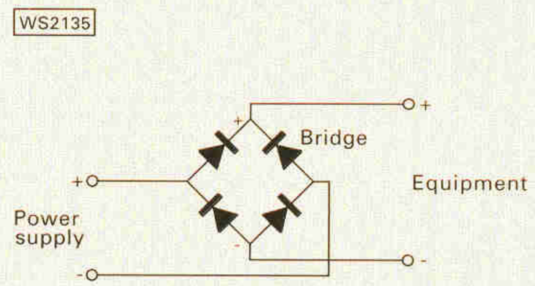
The power supply is connected to the equipment via the switching contacts on the relay. The normally open (NO) relay switch contacts are between the power supply and the equipment. These are the contacts that are open when the relay is switched off.

If the supply is connected the right way round, the 12V reaches the relay coil and the normally open contacts will close. This allows the full supply voltage to reach the equipment. No positive voltage at the top of the relay means no voltage reaching the equipment.... **and that is what I call safe!** *PW*

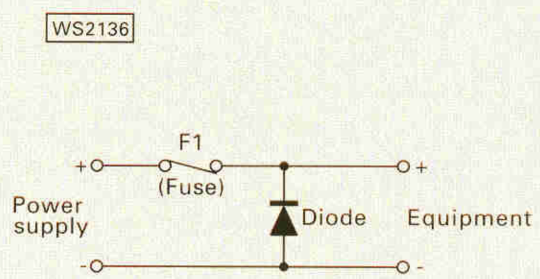
● Fig. 1: A single 'idiot diode' protection circuit is shown here, when a diode is placed in series with the power supply line. The diode must be capable of passing the maximum current the equipment is likely to draw (See text).

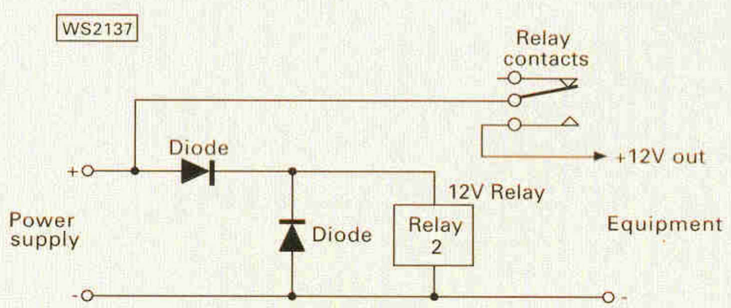


● Fig. 2: Diagram detailing the circuit which G3RJV considers to be the "ultimate idiot diode circuit". Rather than a single diode, a diode bridge is included (See text).



● Fig. 3: A diode can be added in parallel to the power supply as shown here. Here the diode is reverse biased and only draws very little leakage current. Should the supply be connected the wrong way round, the diode will act as a short circuit to ground (see text).

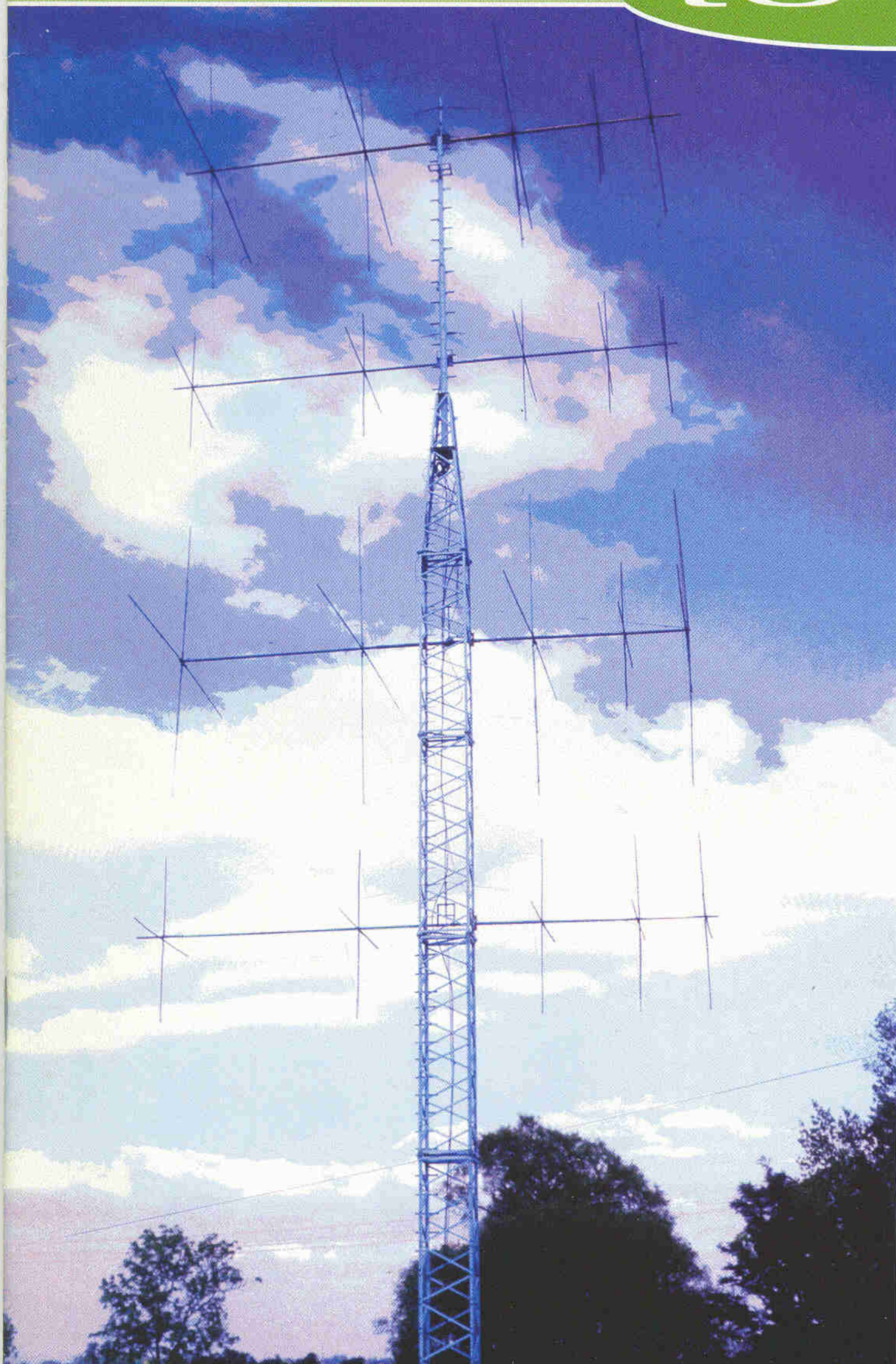


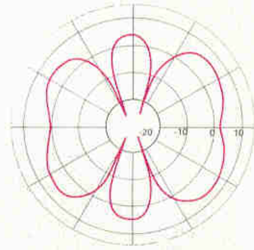


● Fig. 4: This polarity protection circuit is a favourite of G3RJV's. George says "There's a few more bits in it, but it is foolproof". If the supply is connected the wrong way round, the equipment receives no power whatsoever (see text).

Antennas to go

Chase That HF DX!





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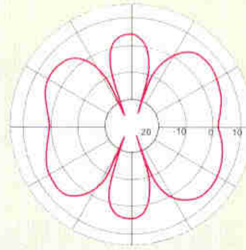
A timeless collection of h.f. antenna design ideas and practical advice

Antennas to go

Chase That HF DX!



Contents

Introduction

Welcome to our very special h.f. themed antenna mini-magazine! Everyone on *Practical Wireless* hopes that you'll enjoy the carefully selected ideas and projects...aimed specifically at all our keen antenna-building readers and those who'd like to try for the first time.

However, we quickly realised the term 'mini-magazine' wasn't a fair choice of name...because as the idea grew, it was obvious it could provide enough material to keep you building and experimenting for the rest of the year. It was then we realised it had become a remarkably handy selection of re-prints, ideal for reference.

Chosen Carefully

As you'll realise, some of the articles are recent, and some are from the *PW* archives. All however, have been chosen carefully with the *PW* reader in mind, particularly with the increased interest in h.f. I mention this because you'll soon see that there's a good selection of delta loop/loop and cubical quad type antennas included...and this is directly due to the interest shown in similar projects published in *PW* in the last year or so.

I make no apology for the fact we're trying to encourage readers - particularly those with limited experience of h.f. or antenna building - by emphasising that **you** try a quad loop or delta loop for yourselves through our selection of projects. The results can be astounding! I say this - because the combination of low power (let's say the M3 level of 10W) and a suitable loop antenna - can be so successful that it could provide you with world-wide DX. And all you'll need is some wire, bamboo canes, and a few other odds and ends. Nothing expensive - but they can provide priceless results.

Try them out for yourself...enjoy the experience, work that DX and learn more about antennas! Coming later this year...look out for the next free magazine... ***Antennas To Go...Chase That VHF DX!***

Rob Mannion G3XFD

Editor: Rob Mannion
Production: Donna Vincent
Art & Design: Steve Hunt

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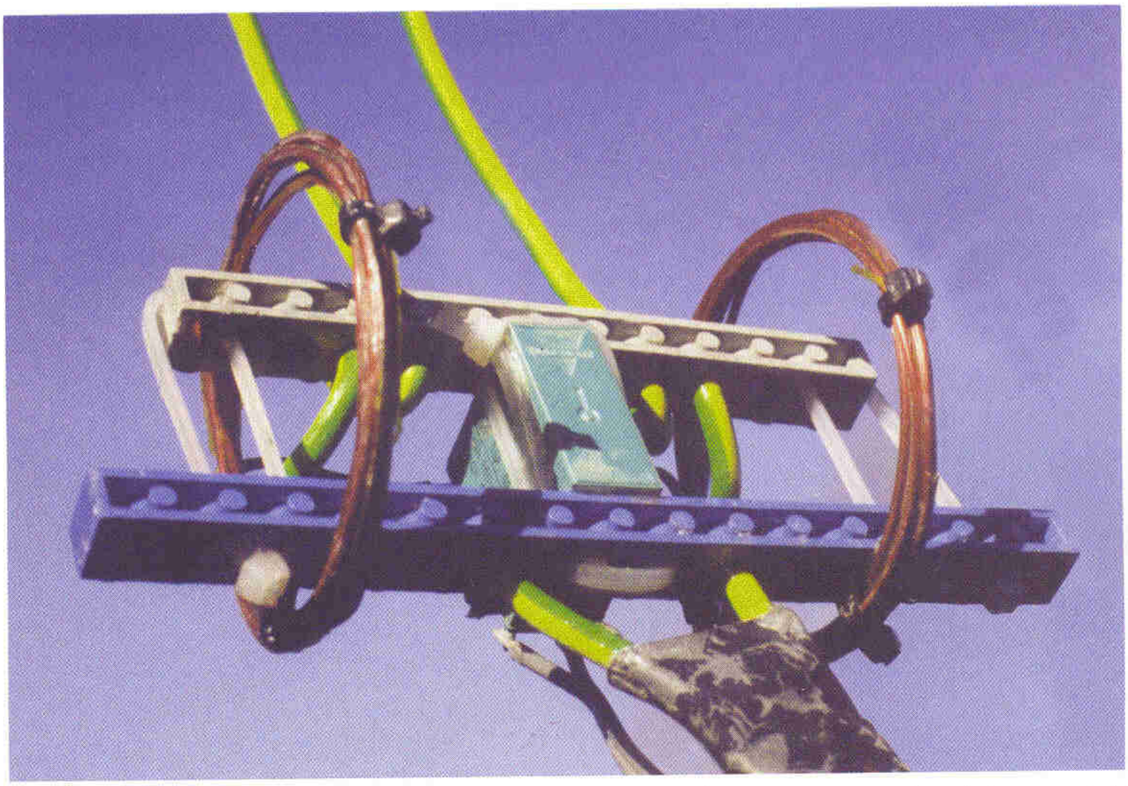
Cover Subject
The impressive antenna array is an entirely home-made project owned and constructed by **Chris (Krzysztof Sobon) SP7GIQ** who lives near the town of Lask in Central Poland and is probably the only Amateur antenna of its kind in the world. The supporting tower comes from a construction crane and the base is made from several tonnes of concrete. Initially two arrays of quad antennas (second from bottom and the uppermost one) for 14, 21 and 28MHz were installed and then more recently the two single band 28MHz quads were added.

Photograph: **Henryk Kotowski SM0JHF** Design: **Steve Hunt**

◆ AN ANTENNA THAT THINKS IT'S A DIPOLE BUT IS REALLY A 'V' BEAM!

A Practical 'V' Beam for 18MHz

Here's an antenna that thinks it's a dipole for 3.5MHz and above, but it's really a V beam for the 18MHz band. Read about the antenna that Edward Rule G3FEW used on returning to Amateur Radio.



The two additional coils allow the 18MHz V beam to work effectively on 3.75MHz (see text for details).

Returning to Amateur Radio after being away from it for 14 years, I found many changes had taken place during our separation. Not least the introduction of the WARC bands of 10, 18 and 24MHz. But let me explain how this antenna grew out of my new start.

My new start in Amateur Radio was on my old favourite of 3.5MHz and from there I was soon encouraged to try the new WARC band of 18MHz. My first antenna for this band was a simple vertical, one that allowed me to find out that this new, to me at least, band had much potential.

The 18MHz band, was I quickly found, a friendly band with something of the old Amateur spirit, with stations more interested in a chat, rather than a simple rubber stamp QSO. However, I decided that a better antenna was needed if I were to enjoy the band's full capabilities.

The first antenna was a full-wave length long simple wire antenna, voltage fed from a quarter-wave length matching stub. The results I had were very encouraging, but I felt that I could do better.

The design presented here is the culmination of my attempts to do better. And I think I have done better as, in my first year on 18MHz, I've managed to work over 120 countries, including some of them through pile-ups!

◆ Why A V?

I should first explain why I'm using a V beam. Look at the illustration of **Fig. 1** where I've shown the relative pattern of a full-wave wire antenna. As

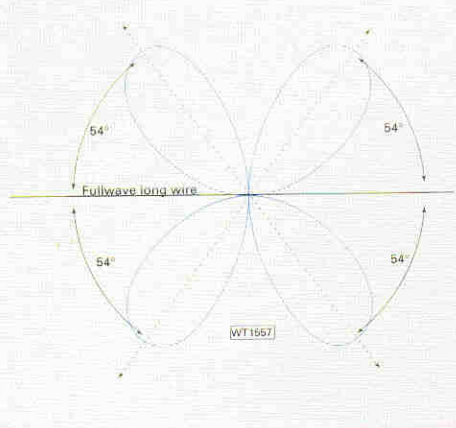


Fig. 1: A full-wavelength long wire give four signal lobes at 54° away from the run of the wire.

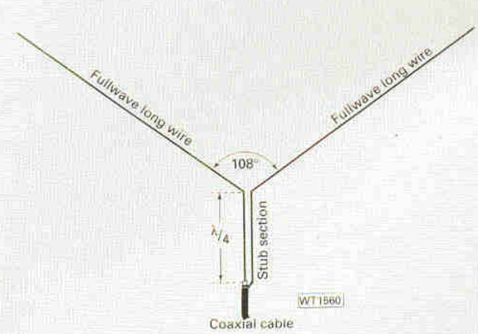


Fig. 2: This is the design, using two wire antennas, that G3FEW settled on.

is shown there are four major signal lobes with maxima at angles of 54° from the line of the wire.

I reasoned that, with correct phasing, if two full-wave wires were angled as shown in **Fig. 2**, then some of their lobes could add together and provide useful gain in two directions. The two directions would bisect the lines of the two full-wave antennas.

The angle of the major lobes decreases as the number of (full) wavelengths increase. This would allow the design of a narrow, high gain beam antenna to be built. In fact, such antennas are used for point-to-point communications, but are not really suitable for Amateur Radio use, due to the limited coverage resulting from the narrow angled beam.

For most Amateur Radio use, a single full-wave V beam antenna would give useful gain in two main directions with a beamwidth which is fairly broad. The remaining side lobes, giving coverage in other directions, but without the gain of the main directions.

So, the result is an antenna with good overall radiation, but with a gain of 1-2 S-points in two directions. The illustration **Fig. 3**, shows the addition of the two forward and reverse lobes, but that the side lobes will not cancel one another. They neither in nor out out phase with one another. So, some energy is directed to the sides as well.

Construction Considerations

Now to look at the construction considerations. My garden is around 17m wide in an east-west direction and around 27m long in a north-side one with the shack roughly in the middle at one side.

So, it may be considered ideal for this design as the main lobe directions are effectively east-west.

The main layout is shown in **Fig. 4**. The rear end of my shack (an extension of the garage) is on the eastern side and has just one support mast around 7m tall mounted on the end wall of the shack. This mast is the centre support for the system.

One wire end is supported with an insulated line tied to a tree in my neighbour's garden. The other, is held in place by a nylon rope passing over the roof of the bungalow. The average height of the antenna is only around 6m, but the results have been outstanding on s.s.b. with 100W of r.f. from the Kenwood TS-530S.

The antenna is simple to make, being just two wires, each some 16.05m long using, in my case, heavy gauge insulated earthing wire with a cross sectional area of 2.5 square millimetres. It's available from most d.i.y. outlets and is, I feel, ideal for antennas.

The length of the two legs is rather shorter than the theoretical 16.5m, but the antenna works well. Also, the wire's separation angle of 108° is not that

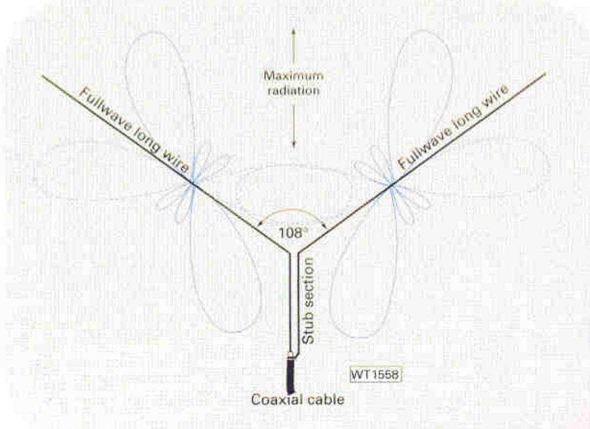


Fig. 3: Using two full-wavelength angled at 108° allows two pairs of the individual lobes to add, giving improved performance in two directions, and yet has some good all-round capabilities too!

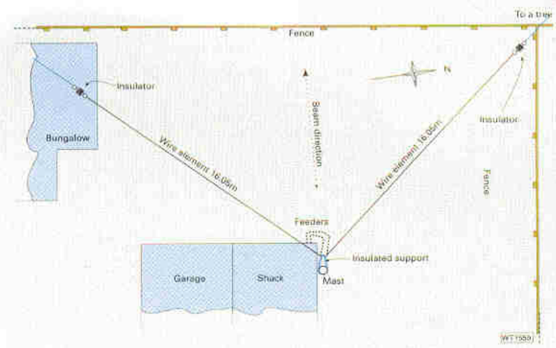


Fig 4: This is the layout at the QTH of G3FEW meaning the antenna fires roughly East-West, but also works to other points of the compass..

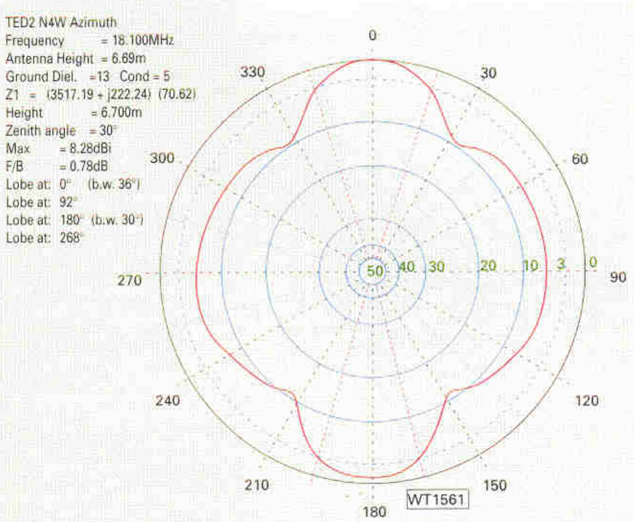


Fig. 5: Some 6dBd of gain in two directions in the horizontal plane, but only a slight loss against the dipole in other directions makes this a useful antenna to have.

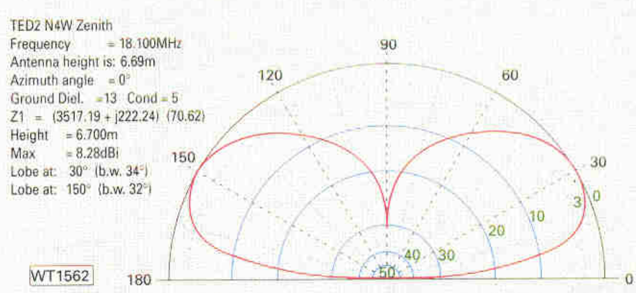


Fig. 6: The front and back lobes have launch angles slightly higher than would be considered ideal, but they're still a better than many antennas when near the ground.

Table 1

Band (MHz)	Match (s.w.r.)
3.75	1.5:1
7.05	Max:
10.15	Max:
14.250	Max:
18.125	1.1:1
21.250	Max:
24.938	2.1:1
28.500	Max:

Table 1: Measurements of s.w.r. taken without using an a.t.u. By using an a.t.u. it should be possible to use the antenna on some of these bands.

critical and in practice, there seems to be room for variation without dramatic changes of performance.

The wires are fed from at their close ends with a quarter-wave matching stub of 600Ω open wire twin feeder. The length of this matching stub should be 3.55m, which is connected in turn to a 10m length of 50Ω coaxial cable to connect to the transceiver in the shack. The redrawn plots of **Fig. 5** and **Fig. 6** show the computer analysis of the antenna set-up

Due to the layout of my garden, the main lobes are slightly south of East and North of West, giving a gain of about 6dB over as dipole. The side lobes giving good radiation in other directions, giving an additional overall coverage.

Almost Perfect

The standing wave ratio (s.w.r.) was almost perfect at the 18MHz band centre without any other form of matching. But if you experience problems, then adjustment of the lengths of the wire elements will alter the s.w.r. to bring the s.w.r. within the range you would like.

The arrangement described was in use for several months and proved to work well. However, with all the wire available I also wanted to use it on other bands, and my eventual choice was for dual 3.5 and 18MHz use. So, I set about modifying the system.

The length of the 18MHz full-wave wire, plus the 600Ω feeder added up to just rather short of a quarter-wave length on 3.5MHz. All that was needed was a small additional inductor in each leg (to keep the system balanced) to resonate the antenna on that band too!

Neither the fact that the angle of the elements is only 108°, nor the fact that the centre section of the 3.5MHz dipole is vertical open wire feeder has had any noticeable effect on my use of that band. I've had signals of S9 consistently from Europe and a reasonable amount of DX work.

Extra Wire

The extra wire switched into circuit to bring the antenna to resonance on 3.5MHz consists of two small coils at the coaxial feed-point. Each coil is made up of five turns of heavy insulated wire with a diameter of 50mm. The heading photograph on page 24 shows the coils and the simple band-change relay. The circuit that I use for change-over is shown in **Fig. 7**.

Some adjustment of the number of turns and their diameter may need to be made to bring the resonance point to the centre of your area of interest on the 3.5MHz band. The point of lowest s.w.r may be adjusted quite easily by altering these coils.

Make sure that the antenna is set-up correctly on 18MHz first, then make and temporarily fit the two coils in line, then check the s.w.r. on 3.5MHz. To adjust the point of lowest s.w.r. on 3.5MHz lower the centre point and adjust the spacing between turns or number of turns until the s.w.r is acceptable.

I've found that when the centre point is lowered only part way and a set of step-ladders used to gain access to the coils, there's little need to raise the antenna again to check the s.w.r. as this make only a slight difference.

I set my antenna to lowest s.w.r at 3.570MHz as my interests lay in the s.s.b. portion of that band, but it would be possible to set the lowest s.w.r. anywhere in the band.

You should be able to see from Fig. 7 that I've used two lengths of Lego material (it's stable and has good insulation properties) as the support for the coils. But whatever you use you should give the coils and changeover relay several good coats of varnish to weatherproof them before hauling the finally back up again.

Simple Arrangement

On this simple antenna arrangement, I've managed to work all bands except 1.8MHz with the aid of a good antenna matcher. Without a doubt, a better arrangement would be to use extra relays to bring in different coils for each band, but I've not tried this idea yet.

Although the dimensions given work well at my location, you may have to experiment with your version to obtain the best results. My layout gives a low s.w.r. over the whole of the 18MHz band and has been optimised for lowest s.w.r in the 'phone section of the 3.5MHz band.

You will probably need to use an a.t.u. for other bands, to reduce the s.w.r. to acceptable levels. The values shown in **Table 1** give the values, I found with my antenna. A better solution would be to use a balanced output a.t.u. and extend the open wire feeders down to the shack, dispensing with the coaxial cable feed all together.

Such a simple antenna, but very affective nonetheless!

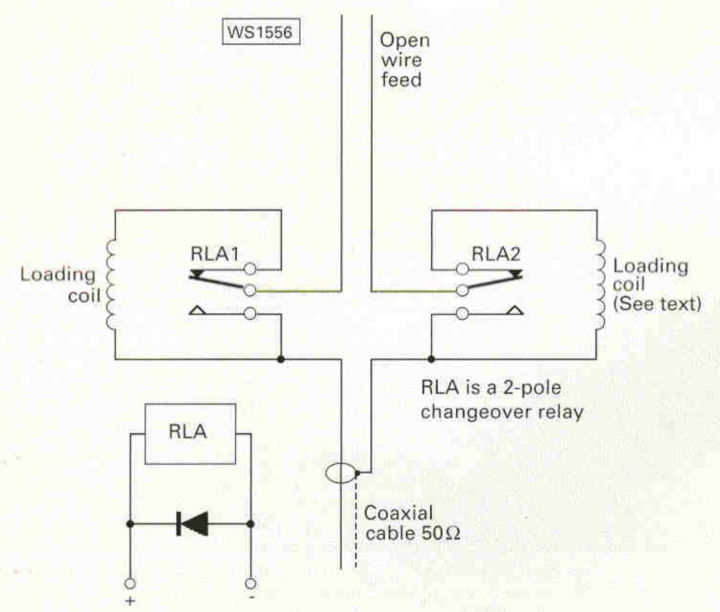


Fig. 7: A simple changeover relay adds the coils in series for use on the 3.5MHz band. The control voltage is taken on a separate wires that run alongside the coaxial cable.

◆ THE ROLE OF V.S.W.R. OR S.W.R. IS VERY IMPORTANT IN RADIO + COMM

Standing Wave Ratio - What About It?

The late Joe Carr K4IPV demystifies s.w.r. - he describes how it's measured and looks at its effect on the antenna and transmitter.

Standing wave ratio (s.w.r.) is a topic that is of intense interest to radio enthusiasts. Amateur Radio operators use antennas, most of which work best when the s.w.r. is 1:1, indicating that the antenna impedance is matched to the feedline impedance. There is a lot of heat and smoke about s.w.r. in radio circles. It's one of things that qualifies as an 'urban myth' in our hobby. Some of the heat and smoke on this matter is well justified. In other cases, the perceived problems are not real, and in still others the problems are little more than hogwash.

◆ Dispelling Myths

In order to dispel some of the myths, let's first take a look at s.w.r. theory, considering s.w.r. in an antenna system. Suppose a single cycle of a signal is launched down a transmission line (it is called the 'incident' or 'forward' wave). When the load (in this case an antenna) is matched to the transmission line, that's also matched to the transmitter, all of the incident wave is radiated into space. None is reflected back down the transmission line towards the source.

Now, let's consider what happens when the load is say, 200Ω (in a nominal 50Ω system). The incident wave isn't totally absorbed by the load (resistor or antenna). So, part of the wave will be reflected back towards the source. This is the reflected wave. Both incident and reflected waves are both examples of travelling waves. The reflected wave represents power that is lost, and can cause other problems too.

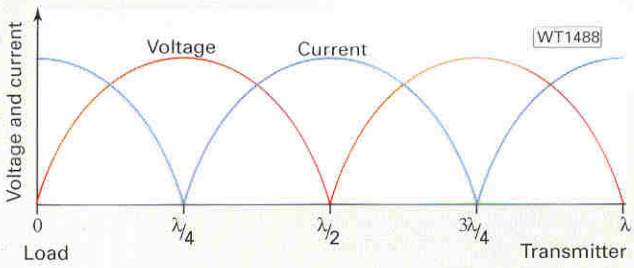


Fig. 1: The illustration represents a short circuit load (minimum voltage, maximum current). Note that at odd λ/4 points (from the load) represent open circuit conditions.

The situation I've just described represents a single-cycle pulse launched down a transmission line. In a real radio system, the oscillations of the incident wave are constant. Then the reflected waves will interfere with following incident waves. At any given point, the amplitude of the wave is the algebraic sum of the interfering incident and reflected signals. The resultant pattern caused by the interference of the incident and reflected waves is called a standing wave.

If you measure the voltage or current at all points along the transmission line from the load back to the source, then you will find a situation like one of those in **Fig. 1**. If the load, line and source are all matched, then you will find the voltage level on the line is 'flat' as in **Fig. 2**. This situation occurs when all of the incident signal is radiated.

If the load and feedline are not matched, then some variant between Fig. 1 and Fig. 2 will be found. Current and voltage levels rise to maxima, then fall to minima every half-wavelength along the line. Both waveforms are constantly displaced from each other by 90° along the line.

◆ Several Ways

The figure for s.w.r. can be calculated in several ways. For instance, it's possible to measure the voltage or current maxima and minima to find the s.w.r. When the current levels are used, then the value is referred to as the i.s.w.r., and when voltage levels are used, it's called v.s.w.r. The more common measure quoted is v.s.w.r. and is often used interchangeably with s.w.r.

The value of the v.s.w.r. is the ratio of the maximum voltage over the minimum voltage, or V_{max}/V_{min}, but, we can also calculate the v.s.w.r. from knowledge of the two impedances involved. If Z_L is the load impedance and Z_O is the transmission line characteristic impedance, then v.s.w.r. is the greater value divided by the smaller. So, if $Z_L > Z_O$ then v.s.w.r. = Z_L / Z_O or, if $Z_L < Z_O$ then v.s.w.r. = Z_O / Z_L. For example, if Z_L is 200Ω and Z_O is 50Ω, then the v.s.w.r. is Z_L/Z_O = 200/50 = 4:1.

An implication of the repetitive nature of the voltage and current waveform in Fig. 1b is that a value equal to the actual load impedance 'appears' every half wavelength along the line. So, if the load is 100Ω, measuring the impedance at half wavelength intervals will show the same value of 100Ω. Another implication of this fact is that transmission lines form the basis for impedance transformation, frequently found in λ/4 transmission line transformers.

Various Frequencies

If you measure the v.s.w.r. at various frequencies you will find a situation like that shown in **Fig. 3**. The v.s.w.r. drops to a low value at the resonant frequency of the antenna, rising at frequencies above, and below, resonance. If the antenna and transmission line impedances are matched, (at resonance) then the v.s.w.r. will dip to 1:1, but all other cases mean that v.s.w.r. will be above 1:1. Note that finding the v.s.w.r. minima finds the resonant point only, not that the antenna is matched.

Mismatch of the antenna means more than just a high v.s.w.r. (often a symptom of some other problems) causing signal loss or problems to the transmitter. For example, many modern radio transmitters include an automatic level control (a.l.c.) circuit. It measures the reflected r.f. power, hence by implication the s.w.r., and starts reducing transmitter power as the mismatch increases.

Many a.l.c. circuits come in to action with an s.w.r. of 1.5:1 or above, and power shut-down begins, the effect increasing until the transmitter may be completely shut down when the working into an s.w.r. of greater than 2.5 or 3:1. I've seen a '100 watt' transmitter actually put out less than 1W because of a.l.c. action.

The v.s.w.r.-versus-frequency curve of Fig. 2 is relatively common for antennas such as dipoles and verticals that don't include any tuning elements. On higher Q antennas (narrower band) the v.s.w.r. rises more rapidly than shown in Fig. 2. On lower Q antennas the v.s.w.r. rises more slowly either side of resonance. These antennas are broadband, so are more useful in some situations.

Be careful of spurious claims of broadbanding, however. There is one way to lower the Q (making the antenna more broadband) and that is to increase the resistive losses. This broadens the bandwidth but costs more in losses into the bargain than keeping the v.s.w.r. situation as in Fig. 2.

Over and Over

We keep hearing one old v.s.w.r. myth over and over again: you can 'cut your coaxial cable to reduce the v.s.w.r. to 1:1'. How many people have cut the coaxial cable and watched the v.s.w.r. reduce to 1:1, so they cannot be convinced this is an error? I've heard of one dealer who kept very short length coaxial patch leads to insert into the line at the transmitter in order to find the correct length that reduced the v.s.w.r. to 1:1! Ahhh...well! But the measurement isn't real, it's a measurement artifact only making it appear to be true.

The only really proper way to reduce the v.s.w.r. to 1:1 is to tune the antenna to resonance then - match the antenna feedpoint impedance to the transmission line impedance. For a centre-fed half-wavelength dipole, or a bottom-fed quarter-wavelength vertical, the proper way to resonate the antenna is to adjust the length of the radiator elements to place the correct minimum v.s.w.r. point at the desired resonant frequency.

The textbook formula used to calculate antenna dimensions gives only approximate lengths, the real value is found from experimentation on the particular antenna after it is installed. Even commercial antennas are adjusted this way. On certain mobile antennas, for example, this trick is done by raising (or lowering) the radiator while watching the s.w.r. meter.

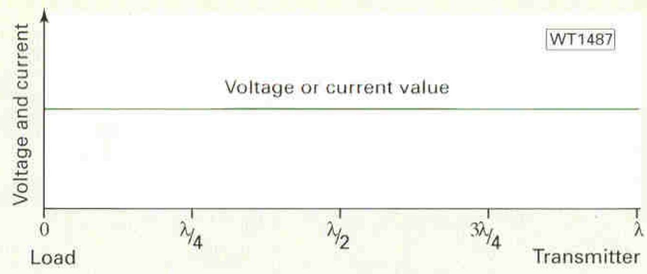


Fig. 2: A perfectly matched load has flat voltage and current values, representing, at any point on the line, the characteristic impedance of the line.

Not a Good Match

Even after finding the resonant point, the feedpoint impedance may not be a good match to the transmission line. A mismatch will result in this case. Ideally, impedance matching should be carried out at the feedpoint of the antenna. Antenna tuners intended for coaxial cable are little more than 'line flatteners', that cannot really 'tune the antenna'. Rather they reduce the v.s.w.r. that the transmitter 'sees' looking into the transmission line allowing it to work properly. And of course many an.t.u.s also provide some harmonic attenuation.

Used by many amateurs (myself included) an antenna matching unit (tuner) is connected at the output of the transmitter. I use either a Heath SA-2060A or an MFJ Differential Tuner between my Kenwood TS-430 and the 25m or so of coaxial cable to my Hustler 4BTV. However, **I don't pretend to be tuning the antenna**, the TS-430 is a solid-state rig, and the p.a. stage isn't terribly tolerant, shutting down with a high v.s.w.r. The purpose of the a.t.u. is to reduce the v.s.w.r. seen by the transmitter.and to heck with the actual mismatch at the antenna.

The best form of a.t.u. is one that both 'helps' the transmitter and also resonates to the signal frequency, preventing harmonics from getting out. A dirty little secret is that some a.t.u.s are actually variable high-pass filters, and these must be used with a low-pass filter ahead of them if spurious signals are to be kept 'at home'.

A better approach is to use an antenna tuning unit or impedance matching transformer mounted right at the feedpoint of the antenna. This method matches the antenna feedpoint impedance to the transmission line impedance, causing the v.s.w.r. to drop to 1:1.

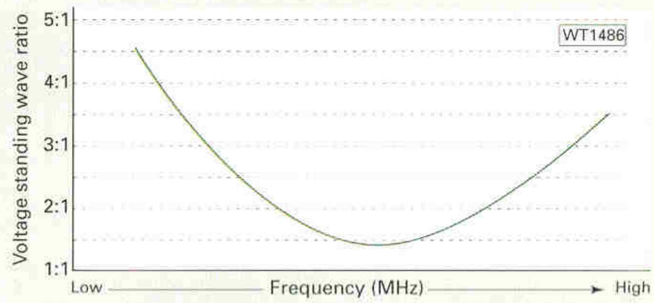


Fig. 3: A plot of frequency against v.s.w.r. for a typical antenna. The lowest point is the resonant frequency of the antenna, and the v.s.w.r. gives the amount of mismatch.

Conclusion

The role of v.s.w.r. or s.w.r. is **very important** in radio and communications. It can make or break some installations, and is always a factor in the types of antennas typically used by Radio Amateurs.

◆ **THREE BAND ANTENNA**

One Wire - Three Bands

The late Denis Payne G3KCR describes a three band dipole that has excellent characteristics on the three Amateur bands of 14, 21 and 28MHz.

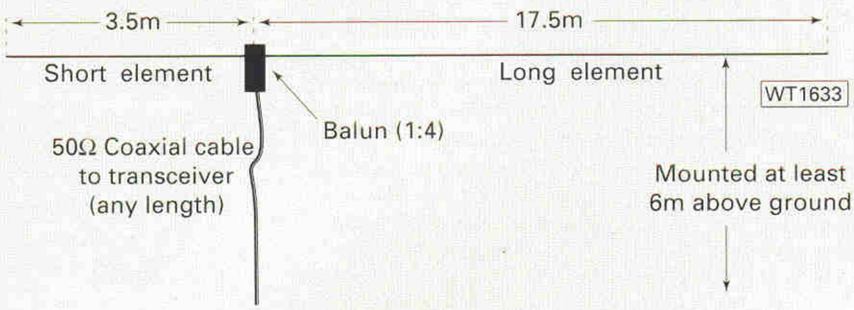


Fig. 1: The simple layout for the asymmetric dipole covering 14, 21 and 28MHz.

I have been using a Windom antenna, fed via a 4:1 balun, for some time on the 14, 21 and 28MHz bands. One advantage of this antenna is the feed-point, being close to one end it reduces the sag and the feeder length. But, in the spirit of experimentation, I decided to try variations as I wanted a better match for all three bands and felt certain that there had to be a better solution.

My Aims

To achieve my aims on all three bands the antenna would have to be about 20m long. Initially, finding a point off-centre which offered a similar radiation resistance was by 'guesstimation'. The mounting height was also important and six metres was chosen as the starting point. I also found that I would still require the use of

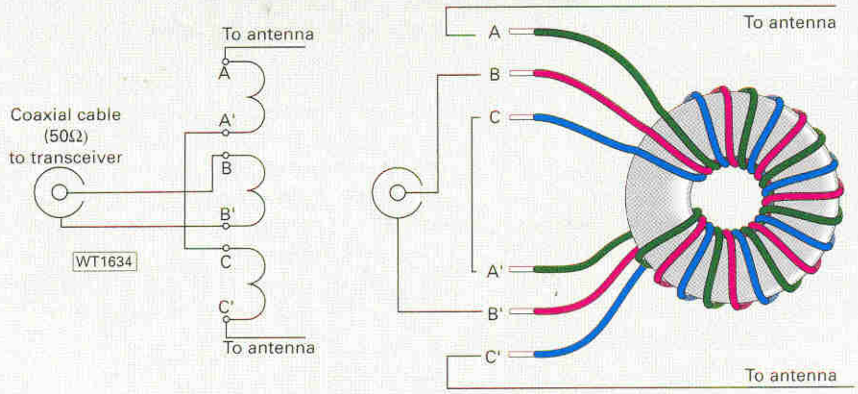


Fig. 2: These should make winding the trifilliar 1:4 balun much easier.

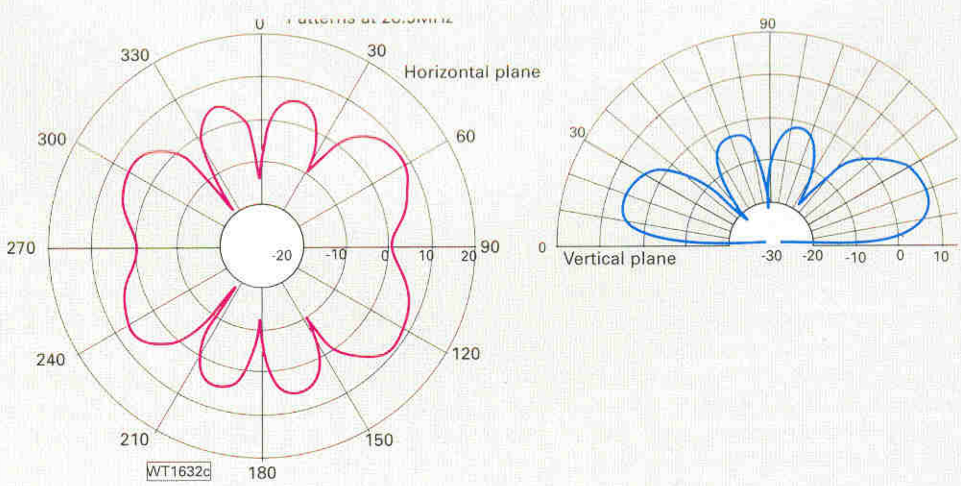


Fig. 3a: The vertical and horizontal radiation patterns at 14.2MHz.

a step-up balun at the feedpoint. In the end, I selected the 4:1 balun which would match the 50Ω coaxial cable to the 200Ω feedpoint. Having found the best position for 14MHz and adjusted the overall length, I found that it was also close to a match on 21 and 28MHz.

My next step was to adjust the feed position and length for optimum performance on all three bands. After several experiments, I found that the best overall length was 21m as I've shown in **Fig. 1**. This length gave s.w.r. figures of less than 2:1 when fed 3.5m from one end for all three bands.

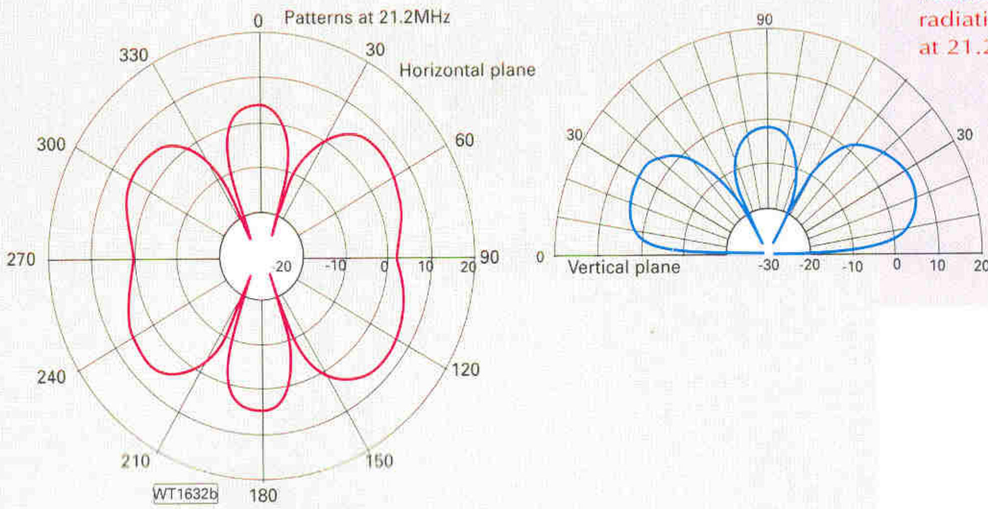


Fig. 3b: The vertical and horizontal radiation patterns at 21.2MHz.

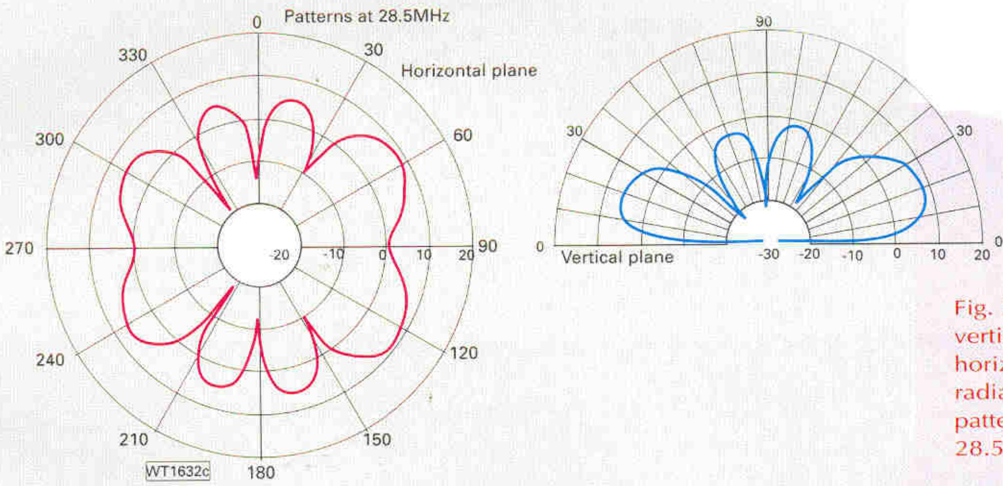


Fig. 3c: The vertical and horizontal radiation patterns at 28.5MHz.

Software Aid

Then, with the aid of software, I calculated the predicted radiation patterns for all the bands. The results appeared to be very good, copies of my printouts are shown in the diagrams. The gains shown in the patterns are with reference to an isotropic radiator (dBi), and so 2.15 should be deducted from the 'dBi' figure to find the gain compared to a dipole (dBd).

For example, the 8.35dBi gain on 28.5MHz is 6.2dBd (6.2dB better than a basic dipole), and similar to the gain of a small yagi antenna. The patterns and angles of the lobes, are subject to change due to height and nearby objects.

I found that on the 7MHz band, I had an s.w.r. reading of less than 2:1. But computer modelling showed the radiation pattern and maximum radiation were mainly vertical. To reduce the launch angle would require mounting the antenna at a much greater height than I could achieve.

Balun Building

Now to build the 4:1 balun, which consists of a toroid (Fair-Rite 43) with a diameter of 35mm. It's trifilliar wound with seven turns of (24/0.2mm) insulated flex. I used three wires with different colour insulation, which I find makes it easier to identify the windings.

The centre winding (of the three forming the balun) is connected to the coaxial cable. The other two windings in series become the feed to the antenna. The balun should be fitted into a small, but strong, plastic box.

The circuit and the general wiring are shown in the illustration of **Fig. 2**. To complete the unit, I used a long grommet through the box for the coaxial cable to prevent water entering. I also used stainless steel screws for the antenna connections to prevent corrosion.

Top Ring

I also included a fixing ring in the top of the box. This allows the antenna to have an alternative support at this point, leaving the short end to be angled downward, making the installation shorter overall. I found that this made very little difference to the s.w.r. readings and performance. However, both end should be kept clear of any metal objects such as masts.

So that's it, an easy antenna covering three popular bands with the minimum of fuss! I wish you good DX.

◆ PHIL SELWOOD G0RKF WINDS AN ANTENNA FOR THE 1.8MHZ BANDS

An Affordable Helical Antenna For Top

Flushed with the success of creating coil-loaded antennas for the 7 and 14MHz bands, Phil Selwood G0RKF set about winding one for the 1.8MHz band.

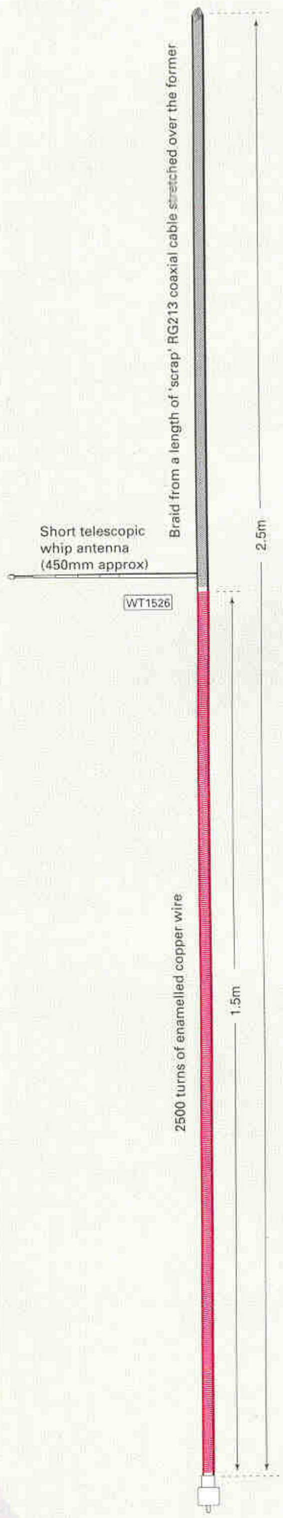


Fig. 1: The layout of the easily-made helically wound 1.8MHz antenna from Phil G0RKF. See Fig. 2 for more detail.

A seemingly impossible r.f. problem at my home location, and working nights prompted me to consider h.f. mobile operating. I had considered v.h.f. mobile, but had found few people 'on air' at the time I leave for work, or to return the following day.

A 45 minute journey, each way to work, convinced me to try h.f. operation. But what sort of antenna should I use? After reading an article by the late **Doug DeMaw W1FB**, in the August 1992§ issue of *PW*, I felt that it obviously had to be a helically wound type for each band of interest.

As I didn't want to be fiddling with controls, especially when driving, each antenna had to be resonated and matched for simplicity. I came to the conclusion that a wound antenna with a shunt capacitor for matching was the best option. I found the formula for working out the total length of wire to use for the coil $\{L = 157/f(\text{MHz})\}$ works quite well.

◆ Plastic Coated

My first antenna was one for the 14MHz band, and was built by winding plastic coated wire around a 2.5m long 10mm diameter 'kite-spar'. This was a length of glass fibre reinforced (g.r.p.) tube usually sold for the purpose of making kites. It's strong, easily available and is not too expensive.

The first antenna was fairly straight forward and needed just 11.5m of wire wound around the spar. I attached one end to the garden fence and wound on the turns keeping the wire fairly tight. Although this method was easy, you need forearms like 'Popeye' to finish the job quickly.

For my second antenna, I moved on to the 7MHz band and again wound the antenna manually. By the time I'd finished I felt as if I'd run Arnold Schwarzeneger's shoulders in for him!

◆ Aching Muscles

With aching muscles and a desire to make a 'Top Band' antenna, I decided there had to be a better way. This was to be an ambitious design, calling for 2500 turns of 0.56mm (24s.w.g.) to be wound onto a similar 10mm diameter former. A new 'power-assisted' method had to be found, as I didn't want to find myself totally 'muscle-bound' by the experience.

The answer was a 'coil-winder' using my electric drill held in a small vice and controlled in speed by an electronic speed controller built as a college project many years ago. This combination was fed from a supply controlled by a heavy duty 'press-on/press-off' switch that I could press with a foot. Things were almost ready!

Rather than count the turns as they were wound on, I worked out that the 2500 turns would cover 1.5m (allowing for them not to be exactly 0.56mm between centres).

So, the only problem left to solve was how to keep 'whipping' of the former to a minimum. That was answered with several large staples and a length of scrap wood to act as the 'lathe-bed'.

A small hole was drilled in the former about 30mm from one end and the enamelled wire was put in to clamp it in place. I marked the 1.5m point on the former with a pencil mark and placed the g.r.p. tube in the jaws of the drill and lightly knocked several large staples into the lathe-bed to hold the tube in place.

◆ Heavy Leather

For safety I had bought myself a pair of very heavy leather gardening gloves so that the moving wire would not cut into my hands. Fully 'gloved-up', I gingerly started the drill. and as the the g.r.p. tube turned the wire was fed into the spiral nicely and evenly. The idea was working.

As I reached each large staple, I stopped the drill and keeping turns in place with a few turns of tape, I removed the staple and refitted it over the wound section. On reaching the marked 1.5m point I left a longer 'tail of wire and taped the turns securely in place. (It's important to get the winding uniform and this method works very well).

The upper part of the antenna is made from a length of braiding removed from a piece of 'scrap' RG213 coaxial cable. At the top of the top of the coil, carefully scrape the enamel covering off the wire and solder it firmly in place to the braid. Secure this point with more tape and wearing the gloves carefully pull the braid back up towards the top of the former, where it's twisted together and soldered.

◆ Mounting Method

Now I had to make my choice of mounting method. I chose to fit a PL259/SO2239 as I did not have a tow-bar on the car at the time so, the SO239 socket was fitted to the lip of the tailgate*. In retrospect an 'N'-type plug and socket arrangement would have been better as they can (when fitted properly) can be waterproof. But I've managed with mine by periodically applying a petroleum jelly to the threads. **hatch-back door*. Ed.

The tailgate lip bracket is a useful mounting method on many modern hatch-back cars, when any bumper or tow-bar mounted antenna would be

Band

fouled every time the hatch-back was raised. Another advantage is that the antenna is lowered for adjustment every time it's opened too!

Tuning Method

In order to tune the antenna, first, I determined the resonance point of the antenna without the telescopic whip fitted by using a gate dip oscillator (g.d.o.) coupled to the antenna with a small two-turn loop. The frequency turned out to be just 2MHz so, my calculations hadn't been too far out after all.

The second stage of the tuning procedure only requires the telescopic whip to be fitted and the 'new' resonance point to be found. Which in my case turned out to be 1.86MHz, which is almost perfect!

Now close the whip to about half-clength and fit the coaxial cable to the socket base. Now comes the rather more tricky part - selecting capacitors at the base of the antenna to give correct matching. The type of capacitors used must be high voltage (disc ceramic) types. I've found that capacitors in the range of 300-500pF work well.

The antenna has yielded many contacts to GM, GW, GD, EI, F5, ON and EA areas, as well as local nets. So, there you have it! A cheap antenna that gives good service - and it's cheap to make. The 14MHz version cost me about £4.50, the 'Top-Band' antenna cost the princely sum of around £12.

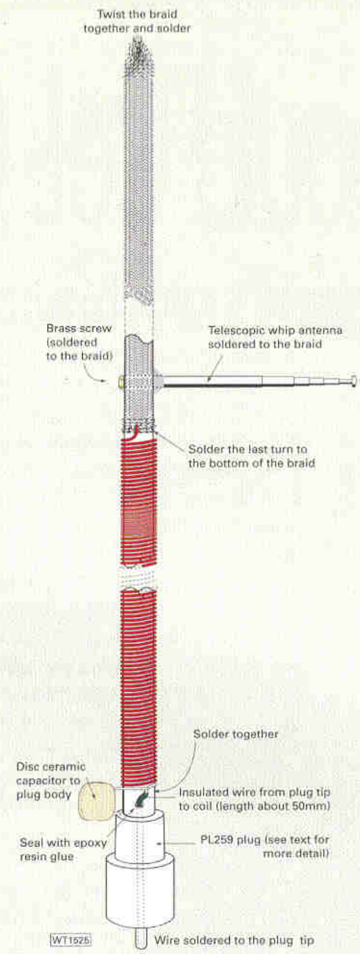


Fig. 2: More details of Phil's antenna. After completion, but before final tuning, the joints and parts of the antenna should be weatherproofed (see text).

§ 'A Portable Vertical Antenna For HF Operation' by Doug DeMaw W1FB, p34 *PW*, August 1992.

◆ **WORK THAT DX FROM YOUR MOBILE OR PORTABLE STATION**

You Should Get Out More!

Dick Pascoe G0BPS says summer is approaching and encourages you to get out into the fresh air for a session on the air in the open.

Now that summer is approaching, it's the traditional time to get out into the open and work the DX from mobile and portable stations. In many cases the station will be the car and a mobile whip for h.f. operating. Manufacturers have created many antennas for this form of operation. I have used many of the commercial mobile antennas available including the 'G-Whip', the Hustler (which I rated highly) and later the huge 'Texas Bugcatcher' (which is even better).

Whilst many of the commercial mobile antennas are quite good, none will compare with lots of wire, high up in the air. I have used kites on camp sites, poles to get long wires up in the air on demo stations and of course trees in the middle of caravan sites, as far apart as one on the outskirts of Paris and another in Liechtenstein (although not at the same time of course)!

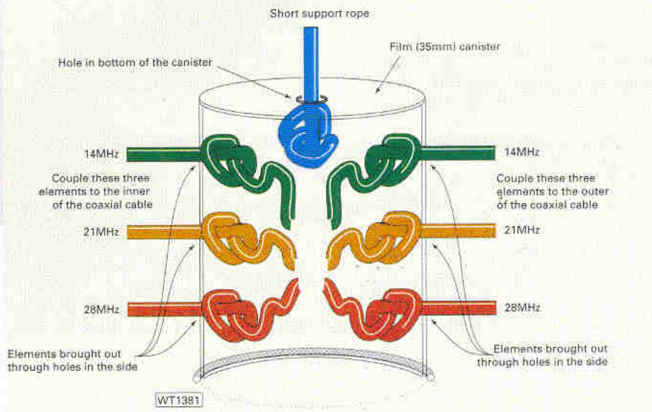


Fig. 2: A simple and cheap dipole centre made from a single 35mm film canister. The coaxial cable enters from underneath and should be secured to the support rope before the canister is filled with hot-melt glue or other non conducting filler.

One of my favourite antennas for several years at my last house was a group of three simple dipoles, often called a 'Nest of dipoles'. The three-story house with its fairly long garden was ideal for such an antenna layout. In fact, I remember one commercial antenna maker at that time who used simple medium-weight household wire to make his antennas, cutting one wire to length for 28MHz operation, another wire cut to resonate on 21MHz and the earth wire for 14MHz.

Of course the simple single-cored household wire failed after the first night and the first puff of wind; but the idea was good. I soon adapted the technique for my portable antenna too.

◆ Plastic Bottles

The first thing is to collect several large plastic bottles and cut strips of about 150×50mm. By using a sharp drill put a row of four holes in each spaced neatly. The drawing of **Fig. 1** shows the overall idea of the layout of this antenna. This is an antenna that's easy to use and to build. Each length of wire is usable on a single band. Whilst I only used lengths for 14, 21 and 28MHz, 7MHz can easily be added as well. Cutting and trimming each leg to resonance will remove the need for an antenna tuning unit (a.t.u.)!

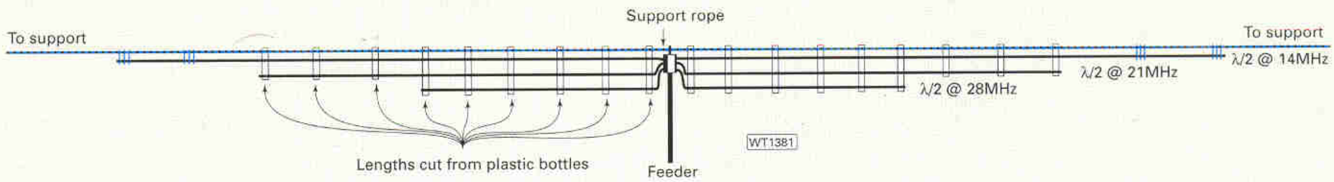
All three (or four) wires are joined together at the centre and insulated at their far end. One easy way to ensure this centre joint is insulated is to use a plastic film can as shown in the basic layout drawing of **Fig. 2**. After the joints are made, the coaxial cable is secured inside the canister, and the whole this is filled with hot melt glue.

I try to use two trees or other support poles to get both ends of the antenna as high as possible into the air. But often only one pole is available so, the antenna can be used as an inverted 'V' as shown in the illustration of **Fig. 3**.

The main difficulty encountered in using an inverted 'V' as a portable antenna is getting the centre point high in the air. I used sections of alloy tubing, each with one end swaged down so that they slot together. The sections I use are each just one metre long so fit into the boot of my wife's Corsa car easily. Rob G3XFD, the Editor, told me he uses a broom handle slotted together as a central support.

Whether you need four bands or not, even a single dipole can be used in this way. Guys will be needed if the mast is to be self-supporting,

Fig. 1: One 'dipole' three bands, all halfwave length long. A simple idea but, if each element is adjusted for the band of interest, then no a.t.u. is needed in operation.



although why not use your car for the support. The weight of the car can be used to keep the mast upright by using a metal bracket. By positioning the car wheel on the base the mast will be kept in place easily.

The *PW* Tenna Tourer base (**Fig. 4**) was designed along these lines, and was on offer in the September 1999 issue of *PW* is ideal for this type of operation.

There are many other ways of getting antennas up in the air whilst out and about. In a previous workshop I looked at the use of kites. These can be an excellent method to use. Trees are also useful! If you have two trees available don't just think dipole or long wire how about a delta loop? The 'gain' off the sides of a loop can be used to advantage by turning it.

During one demonstration event the Dover Radio club was putting up a long wire antenna. The trees had been selected and the branches chosen, all we had to do was get the wire over the tree. Some may try to throw a weight over; some would rather use a bow and arrow. My preferred method is a fishing rod with fairly heavy line. (I don't use a lead weight either).

Fruit Powered

Instead of a lead weight at the end of a line, I use fruit power! An apple or orange as the weight will do the job just as well and if it hits anyone is unlikely to do a great deal of harm. Practice will ensure that the weight drops over the required bough first time. The fruit is removed and the wire attached and the line recovered.

Warning Do NOT hold the wire at any time whilst it is running out. I saw an Amateur almost lose a finger doing this; only a rapid trip to the hospital saved his finger.

I've also found that ex-service equipment can be used to great advantage, I have a bag full of ex-army copper rods in my garage each about 1m long that screw together. They make a good vertical antenna when mounted on an insulated base. They are fairly cheap too!

Even the simple ground plane antenna can be used to advantage. A quarter wavelength of metal bolted to (but insulated from) the ground mounting bracket can be used. The mast used to raise the dipole can be brought into use as an antenna if it is insulated from ground.

Ground Base

Using a metal plate ground base with bolts in each corner, as shown in **Fig. 5**, then one or more counterpoises can be laid out on the ground. A short length of wood at the base of the mast insulates it from ground. Now all that is needed are the connections to the pole and the ground base. The counterpoise lengths will be around five metres long for the 14MHz band version, but of course the same one can be easily made up for 21 or 28MHz operation.

The feedpoint in this case is at the base of the mast with the inner of a length of 75Ω coaxial cable coupled to the mast and the outer shield to the ground plate. To make a good match to this you should use a quarter wavelength of 50Ω coaxial cable, as a matching transformer to couple this to the a.t.u.

The more radials you put out the better it will work. I remember a contest group using a simple scaffold pole as a quarter wave vertical on 7MHz. There were no radials but the sea (salt water) was just a metre or so from the base of the antenna. Rumour has it that they won their section of the contest.

When I was first licensed I used a roof rack on my elderly estate car with a scaffold pole on a base plate just out side the passenger door attached to the roof rack. Twisting the pole easily rotated the 144MHz beam at the top. The beauty of this is that it all packed away neatly on the roof rack for transport.

Whatever method you choose; try to remember that there can be high voltages on the line if high power is to be used. Make sure everything is insulated and well way from any possible sticky fingers. Especially those whose owner shouts 'what's that mister?' while holding it.

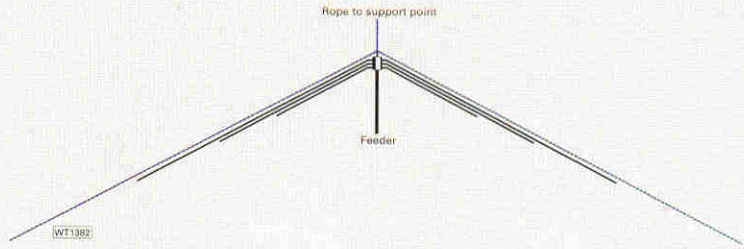


Fig. 3: The same 'Nest of dipoles' as featured in Fig. 1, may be used as an inverted 'V' system if only a single support is available.

Fig. 4: The *PW* Tenna-Tourer mobile antenna base, with its hinged socket for the mast makes single-handed antenna erection a simple operation. There were two different sizes available in the offer of September 1999's issue of *PW*. (Please contact Tennamast for further details).

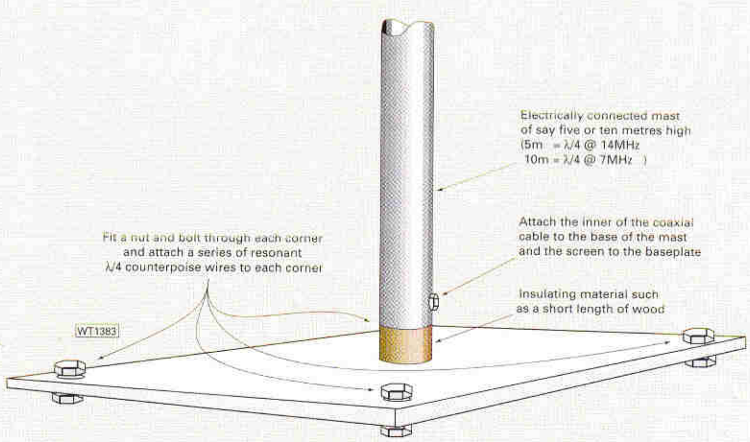


Fig. 5: A metal ground plate with radials under a metal mast can form the basis of an excellent vertical antenna on the h.f. bands as well as supporting v.h.f./u.h.f. beam antennas.

◆ HAVING A DAY OUT? TAKE YOUR HOBBY TOO!

Out & About Having Mobile & Portable

Rob Mannion G3XFD has a few suggestions and tips to try and encourage you to enjoy the hobby away from home. New to the h.f. bands? - if so you might like to join G3XFD/P on the air too!

Rob Mannion G3XFD parked at his favourite h.f. 'portable' location at Holt Heath near Wimborne in Dorset. From this location he's managed to work stations as far away as Australia and New Zealand using simple antennas and less than 20W. Find out how you can also join in and have fun!

Much of my Amateur Radio operating time is done from my car and I find 'getting on the air', as a break from a long trip to visit a club...to be very relaxing. Indeed, working 'portable' means that I can combine our extraordinary flexible hobby with many other interests.

Using relatively simple antennas, and moderately low power in conjunction with one of my Alinco DX-70s and other rigs - I manage to work a lot of DX...**without really trying**. One of the reasons for this of course...is that I can often choose some of the best h.f. sites before parking up, brewing a pot of tea and **getting on the air using c.w. (Morse)** - although s.s.b. ('phone) at around 25W has also proved remarkably successful and even using 10W and less can bring excellent results.

What about choosing h.f sites? A few words of advice might be a good idea - to help those of you who've just joined us on h.f., before I describe the techniques I use for my 'Out & About' work.

◆ Careful Parking

Careful parking really comes into its own for portable Amateur radio operations on h.f. With care, you should be able to overcome what on the face of it seems to be the disadvantages of operating with relatively low power together with less than ideal antennas.

Even though you may not be able to get to the sea on an every day basis...you can take advantage of it when on holiday. Very often, if you don't mind not getting a good sea view yourself from the car, you'll be able to find a spot in a seaside car park where the all-important antenna gets a good view. That's the approach you need...enabling the excellent over-water propagation to take effect.

I've also found that it often helps a QSO even if you can only glimpse the sea in the distance as is the situation with my favourite site (heading photograph). At this site, if I get out of the car and look into the distance I can just glimpse the sea off the Needles, together with the downlands on the south-

Fig. 1: Rear view of the G3XFD 'travelling Amateur Radio station', showing the 144MHz whip (left) and the 7MHz Pro-AM h.f. whip (removed when travelling). The Toyota Yaris MPV is equipped for h.f. and v.h.f. operations. The internal lay-out of vehicle provides many 'nooks and crannies' for stowing equipment. The Yaris is fitted with air conditioning and is also provided with picnicking and tea & coffee making facilities (Well he does spend a lot of time driving!). And yes, the 'TGV' of the number plate was especially chosen...even though he doesn't try to race real TGV trains when in France! (See text).

Fun

western tip of the Isle of Wight. It provides an excellent take-off for DX, especially on 18MHz.

Travelling inland...far from the sea? Don't despair...there are many locations which you can use to advantage. Lakes, large reservoirs and river estuaries can help. And if you can get a temporary earth wire or even a trailing radial wire down (**take care if you're in a public place - ensure you don't compromise your, or other people's safety**) you can improve the chances of good DX.

To illustrate what I've just mentioned regarding inland 'wet' and lakeside sites...I should (with the risk of losing my parking place) say that **Staunton Harold Reservoir** - a large totally man-made lake - between Melbourne, Derbyshire and Ashby-de-la-Zouch near the Leicester Show venue is an excellent site for h.f. working. It also provides a delightful picnic spot.

There are many lakes in England and Wales, and many lochs and lochans in Scotland and Irish Radio Amateurs **are spoilt for choice** (just look at the map of EI/GI to see what I mean!). There are also many sites where the ground is wet - which will help ground reflection and provides a better earth.

Try to avoid parking under trees...use them with care to support antenna halyards perhaps...**but don't park underneath**. This isn't a good radio technique and it can be dangerous in bad weather.

Remember also (when using long h.f. whips and portable masts) that power lines - the seemingly ever present 33 and 11kV three phase power lines, **can be exceptionally low over farmland and above or near roads in the countryside.** Several years ago a Radio Amateur was tragically killed whilst erecting a temporary mast when he accidentally made contact with an overhead power line. So please do be very careful!

Finally on this topic, if you're intending to operate your Amateur Radio from a public car park, be prepared to ask permission from the attendant. At these locations it's best to find a place away from other vehicles because your transmitted r.f. might set off badly designed car alarms or effect radio operated key system - so be aware of potential problems.

Aantennas & Earths

Simple antennas can prove surprising results when operating portable on h.f. For many years I carried a 40 metre length of pvc covered 7/0.22mm (seven strand of 0.22mm diameter copper) wire as a convenient portable 'long wire' antenna, stored on a small cardboard cable drum. Available from any hardware outlet this wire makes a good 'rough & ready' antenna, in conjunction with an antenna tuning unit (a.t.u.).

A push-in earth point is a good idea too...a long bladed thin crosshead screwdriver is excellent for this job. Being flat-sided it will penetrate the ground easily and my experience suggests it's best to connect the earth directly to your a.t.u.

Nowadays I favour another approach, as shown in **Fig. 1**. The antenna on the right-hand rear side of my car is the 7MHz version of the Pro-AM mobile whip and it's one of the easiest to set-up and use antennas I've ever had.

Although the mag-mount antenna base isn't visible in the photograph, it's one of the triple-magnet types which are freely available from literally any Amateur Radio dealer. It provides an excellent base for my collection of Pro-AM h.f. antennas (I've got a set of them for the 3.5, 7, 14, 18 and 21MHz bands).

Because the magnetic mount does not provide an earth to the vehicle chassis, when I'm on the air I link it to the rig in the car with a crocodile clip 'flying lead'. I also carry a roll-out length of wire to provide a radial system which is laid out above the ground - taking care that neither passers-by or myself can trip over it!

Antenna Tuning

As supplied, the American made Pro-AM mobile whips are tuned to cover the high ends of the bands they cover. This of course reflects the fact that the antennas are really aimed at the very busy h.f. mobile market in the USA. However, in practice even though the whip for 7MHz was designed to tune-up effectively **above 7.1MHz** (the USA band extends above 7.1MHz) it's extremely easy to adjust it to the European allocation (just a 'tweak' is needed).

I then required some method of tuning to save me the effort to get in and out of the vehicle (something which is increasingly difficult for me to do). Fortunately, following a very successful trial the MFJ-945E Mobile Antenna Tuner, **Fig. 2**, proved ideal for the purpose (The review appeared in the April 1999 issue of *PW*).

The little a.t.u. has proved to be truly excellent for portable working. It provides a useful in-line s.w.r. meter and also allows me to tune the antenna anywhere on 7MHz without getting out of the car...until I want to change bands! It's an exceptionally easy system to use and the newer model (contact **Waters & Stanton Plc** on **(01702) 206835** for price and availability) now also covers h.f. and 50MHz.

So...why don't you take your hobby with you on a day out? Many Amateurs are used to parking up on hill-tops or other good v.h.f. take-off points and getting busy on their radios. But why not try it on h.f. too...it's great fun...I've enjoyed it for many years!

Fig. 2: If there's any 'Secret' to the flexibility of the mobile/portable antenna system used by G3XFD...he says it's thanks to this little unit. The MFJ-945E has proved itself to be extremely useful indeed (see text).

Fig. 3: Some of the items G3XFD considers to be essential when operating 'portable! Firstly there's the kettle of course! Secondly, the trusty Trio 9000 multi-mode 144MHz rig, and Rob's 7MHz Pro-AM antenna, and a smaller h.f. whip. The sturdy metal unit in the background is the well-known Tennamast Tenna-Tourer drive-on mast base. This will support a lightweight metal mast up to 10m high, or one of the fibreglass 'fishing rod' type 10m masts available from *PW* advertisers Sycom. (A photograph of the Tenna-Tourer base in use appears in the 'You Should Get Out More' article on page 15).

◆ IMPROVE YOUR MOBILE OPERATING BY MOVING THE ANTENNA LOCATION

Where To Put It!

Peter Dodd G3LDO tries to answer the awkward question of just where do you fix your h.f. mobile antenna for the best results?

For h.f. mobile operating the main question is just **where to put the antenna on a modern vehicle**. It can be fixed to the roof on a luggage rack or by using a hatchback or tail gate mount. Otherwise it can be mounted low down on the vehicle on a tow bar or a special bracket fixed to the underside of the vehicle.

In this article I'll be using computer modelling to try to answer the antenna mounting question. I will also try to ascertain if the size of the vehicle affects h.f. antenna performance and if there's an optimum antenna location for mobile working.

So, just where would be the best location be? As the antenna radiation and ground resistances are in series, E^2R losses are important and for best effect the radiation resistance should be as high as possible.

If I assume that a maximum safe height for a roof mounted mobile antenna is between 2.5m to 3m, then the available antenna length is reduced by the height of the vehicle. This results in a physically short antenna with a relatively low radiation resistance, although the point of maximum radiation is on the highest part of the vehicle.

I suggest the use of an antenna mounted low on the vehicle such as a tow bar. As then a longer antenna can be used that has a theoretical greater radiation resistance because radiation resistance of an antenna is proportional to its length.

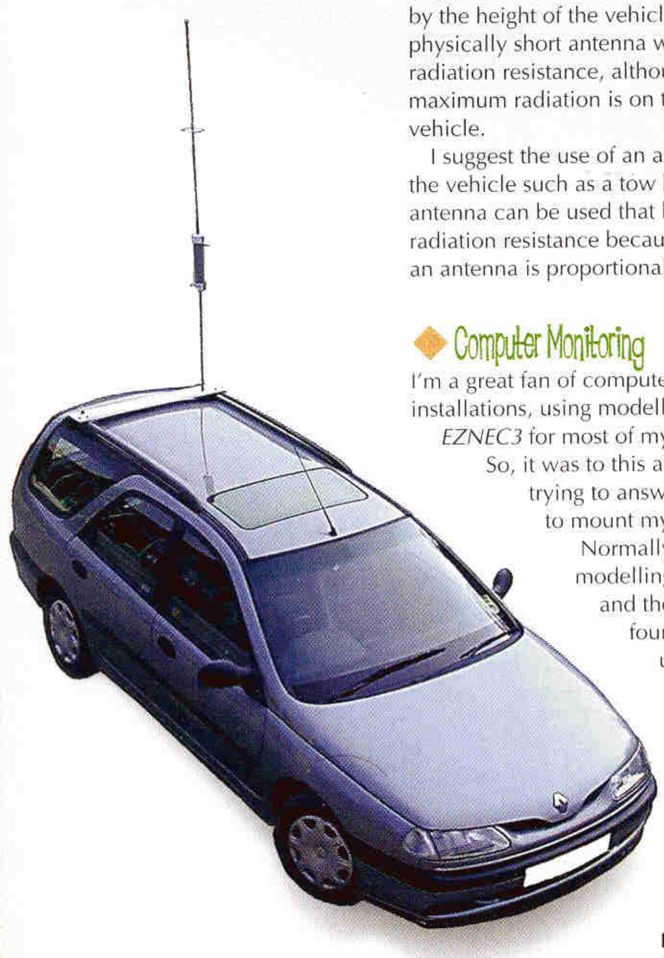


Fig. 1. The Texas Bugcatcher mounted on a special antenna rack, which in turn is fixed to the luggage rack, photographed while Peter visited the Amberley Industrial Museum, in the South Downs. Among the many attractions is a radio museum, featuring domestic, military, commercial and Amateur Radio equipment (website: www.amberleymuseum.co.uk)

Computer Monitoring

I'm a great fan of computer modelling for antenna installations, using modelling software called *EZNEC3* for most of my antenna installations. So, it was to this aid that I turned when trying to answer the question of where to mount my mobile antenna.

Normally the software is used for modelling conventional antennas and their environment, but I've found that a wire grid can be used for simulating a solid conductive surface such as a metal vehicle body. My vehicle is a Renault Laguna estate, which is 3.8m long, 1.4m wide and 1.45m high, and is shown in **Fig. 1**.

A wire model of the vehicle was constructed and it's shown in **Fig. 2**. The model does not have the exact dimensions of my vehicle because the model was constructed from similar sized rectangles for simplicity.

The model was placed so that the base of the vehicle body was 150mm above the ground. The *EZNEC* manual states that the minimum height should be good down to at least 0.005λ which, at 30MHz, is just about the dimensions chosen.

Antenna losses using can also be modelled and loading coils frequently have a significant amount of loss, (though it's best determining by measurement). An informed estimate is usually adequate if measurements are not available. Air-wound inductors typically have *Q* figure in the range of 200-400 or so, which gives the equivalent series loss resistance about 1/*Q* times the reactance.

The Texas Bugcatcher antenna, which I selected as the test antenna, uses a fair high quality loading coil and so, I used a *Q* value of 400 for the model. The calculated feed impedance figures, compared well with measured values.

The vehicle I^2R losses were included by specifying Zinc (rather than copper) as a wire loss parameter. Usually there is a coating of such material on the metalwork of the vehicle to provide corrosion protection. Zinc was also specified for the antenna element because the Texas Bugcatcher, in common with many commercial mobile antennas, is made of stainless steel.

The model also indicates that there can be a fairly high currents flowing in the vehicle metalwork. It's known that some antenna configurations can interfere with the electronic engine management systems in some vehicles ... the models also show that the vehicle is part of the radiation system of a mobile antenna.

Measurement Verification

Computer modelling is now in common use both by professionals and amateurs alike. However, I nevertheless felt that it would be useful to try and gain some verification by practical measurements of feed impedance and signal strength.

For roof mounted measurements the antenna was mounted on a special rack, which in turn was fixed to the existing luggage rack as shown in Fig. 1. A short wire link from the frame of the antenna rack direct to the car body ensured the antenna base was properly 'earthed'.

Measurements were also taken of the same antenna mounted directly on the tow bar using a suitably constructed antenna base adapter. The antenna feed impedance was measured using a Hewlett-Packard HP4085A Vector Impedance meter. In both cases they turned out to be very close to the predicted values.

Field strength tests were made around 29MHz, chosen because with this frequency, a closer near field/far field boundary is given. As the measurement needs to be made at a positional height of at least 10° above the horizontal plane, then you can see the advantage of being closer in.

Using the Model

The first question again is: **just where is the best place to mount the antenna**? There are three situations that I considered. The first is that of a

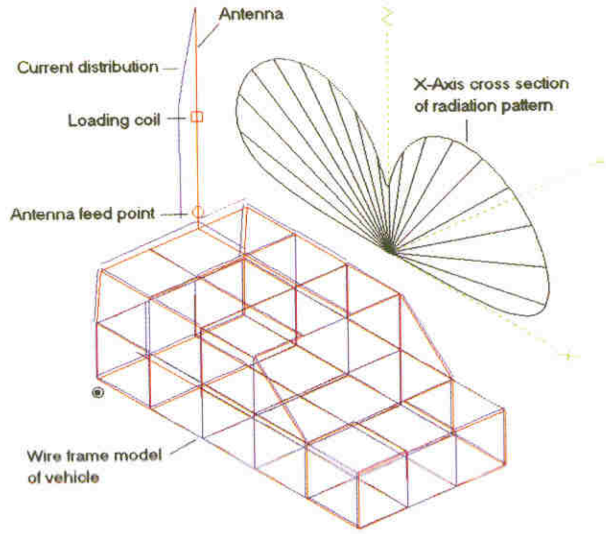


Fig. 2: Computer model of the estate vehicle and antenna shown in Fig. 1. The vehicle body is modelled using 112 'wires'. The distance between the vehicle lines (red) and its associated current (blue) line is an indication of relative current flow.

traditional tow-bar mounted 2.44m centre-loaded whip. The second is with the same antenna is mounted on the roof.

A Texas Bugcatcher antenna, fixed to the roof of a car is not a realistic system for fast motorway driving so a third option has been considered; that of a half-sized antenna around 1.4m long, with increased inductive loading.

I have modelled the roof mounting positions at the rear of the vehicle, where the antenna would be positioned in the case of hatch mount or tailgate mounts. The results are shown in **Fig. 3**. (The images are viewed from the side of the vehicle with its front to the right).

The diagram of Fig. 3, shows comparisons between roof and tow-bar mounted antennas on the 3.5MHz band. The data shows very little difference between the short roof mounted antenna and the traditional longer tow-bar mounted antenna. The roof mounted antenna has a 5dBi advantage but is not very practical for driving, though it's fine for ' /M' operating when parked up.

I've shown comparisons between roof and tow-bar mounted antennas on the 28MHz band in **Fig. 4**. The short roof mounted antenna gives as much gain at low angles as the larger tow-bar mounted antenna, though the model predicts an increase in directivity as the frequency is increased.

Good Indication

The *EZNEC* model gives a good indication of the feed impedance, with both modelled and measured values in close agreement. The measurements of field strength also agree with the predicted values, within the limits of the measuring arrangements. It's these correlations that give confidence in the field strength distributions predicted by *EZNEC*.

The computer model of the installation explained why mobile operators had not found a generally accepted optimum location on the vehicle for an h.f. antenna. One surprise was the directional effects on the higher h.f. frequencies, could be used to advantage (when you are aware of them!).

These directional advantages has been successful for **Alan Birch G4NXG**,who has **worked over 327 countries while operating mobile.** Most

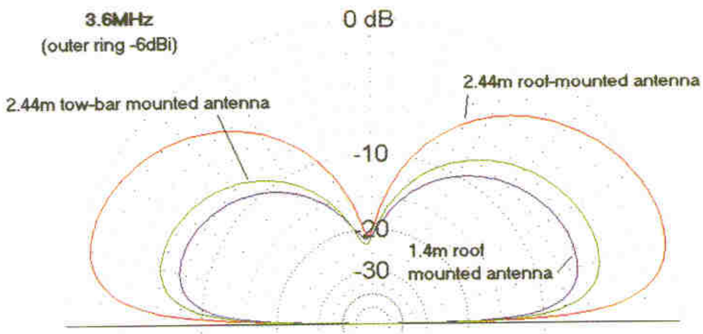


Fig. 3: When roof mounted the overall antenna length controls the maximum radiated field when used on the lower band of 3.5MHz. There is little directivity in this model, contrast this with Fig. 4.

of this operation was from a fixed site and Alan reports that his mobile station has an improved performance when being operated close to the sea.

Another operator, **Chris Page G4BUE** also mentions being aware of a noticeable improvement when operating mobile along a sea coast road. The computer model predicted marked

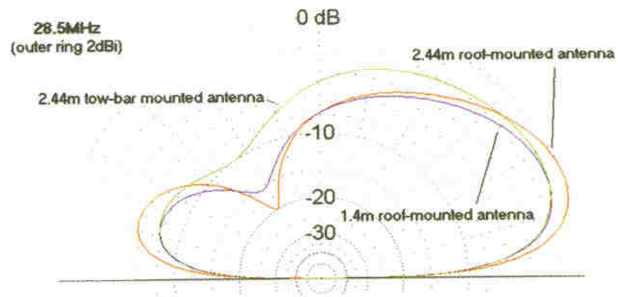


Fig. 4: On the higher bands the overall antenna length makes little signal difference, but a distinct directivity towards the front of the vehicle appears.

DX mobile performance of 3dB, plus a lower angle of radiation, provided that you are able to get fairly close to the sea.

So, now you know where to put the antenna, now get out and do it. But don't get your feet wet!

◆ THERE'S ONLY ONE ANTENNA!

Dipoles & Dipoles!

Gerald Stancey G3MCK shows his prejudice, when he says there's only one antenna for the typical amateur.

When it comes to antennas, I've been told I am prejudiced, and I have to admit, it's true. I am prejudiced when it comes to antennas. I think the dipole is the premier antenna for the typical amateur. It is cheap, easy to install, effective and is good where electromagnetic compatibility (e.m.c.) or just plain radio interference (r.f.i.) is a problem.

The many standard handbooks give charts which show in great detail the properties of dipoles. But let's see what they mean for the typical amateur who puts up a horizontal dipole at about 10m above the ground.

With a dipole up at about at 10m, the s.w.r. on 3.5MHz should be close to unity. The s.w.r. figure may rise to about 2:1 on 10MHz, and then fall back down to about 1.5:1 on all the other h.f. bands.

Hence, with such an acceptable s.w.r. figure, an a.t.u. will not normally be needed. This removes a potential source of losses and of course it's one less box in the shack.

On 3.5 and 7MHz the dipole's horizontal radiation pattern will be virtually omni-directional. This means that you don't have to consider in which direction you erect it.

On the higher bands the maximum radiation is broadside to the wire. However, it is a broad beam, the lobe is about 90° wide, so it is not too important to align the antenna correctly. (If you can select from two dipoles erected at right angles all-round coverage will be available).

◆ The Classic Dipole

The illustration of **Fig. 1** shows the layout of the classic dipole, and this is of course an ideal arrangement for a dipole. Note that the feeder comes away at right angles for as far as possible then runs close to the ground.

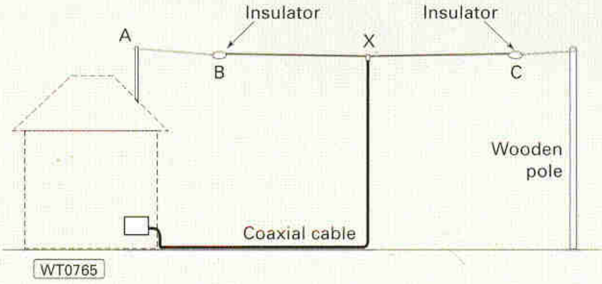


Fig. 1: This form of dipole is quite effective at h.f. and should work on all bands.

The approach illustrated minimises r.f. pick up on the outer, or braid of the coaxial cable. On the dipole length B-X is the same as C-X, point A is a support point on the house.

There are purists who may wish to insert a balun at point 'X' in Fig. 1. But this is not usually necessary on the lower h.f. bands where the ratio of the length of the dipole to the diameter of the coaxial cable is very large.

In most cases 'pick up' on the braid is more likely to be caused by the feeder running too close to the dipole. And, if this is the case, then fitting a balun will do very little to prevent this.

However, there are known cases where the inclusion of a balun has cured an e.m.c. problem so keep an open mind on this. On the other hand excluding the balun does remove one other potential source of losses and also enables you to easily test that all is well.

Now I'm coming to the perennial problem of the length of the dipole. Here you should remember that the correct length of a dipole, at any one frequency, is a little less than half a wave-length.

But, the 'little less' figure depends on the dipole's height above the ground, the diameter of the wire and the nature of the ground beneath it. (Equations are available which to some degree take account of these variables which can make the maths side easier to work out).

Happily you can ignore these equations for the length of dipoles, as all you need to do is to adjust the dipole for minimum s.w.r. using a reflectometer type of s.w.r. meter. A bridge, such as the one described by the **Rev. George Dobbs G3RJV**, in *PW* January 1997 is ideal. (A laboratory instrument, such as a Wheatstone bridge type of resistance measuring bridge is not satisfactory for this purpose).

In the real world of amateur radio, due to lack of space, it may not be possible to erect a dipole in the manner shown in Fig. 1. Fortunately however, all is not lost.

A dipole will accept quite a lot of abuse before its effectiveness is severely degraded. (There are two widely used methods of 'abusing' a dipole and these are to shorten it, or, the other method is to bend it).

In practice, either shortening or bending a dipole, will increase the losses or reduce the bandwidth. They will also lower the feed impedance which will probably show as an increase in the s.w.r.

But, on the plus side, if the length is not reduced by more than about 50% or the bending is done with care, losses should be acceptable and the s.w.r. should be no greater than two or three to one.

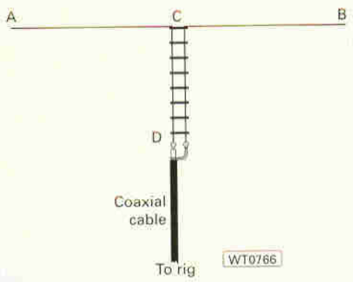


Fig. 2: Using a tuning stub (C-D) makes the dipole look like a G5RV antenna, but is still nonetheless a dipole.

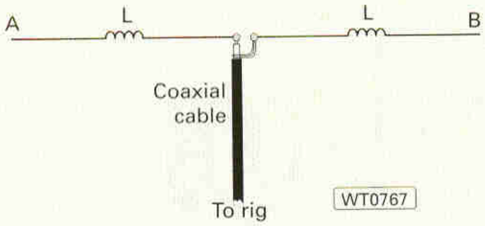


Fig. 3: The dipole elements may be physically shortened by including an inductor (L) in each side at about the 50% point.

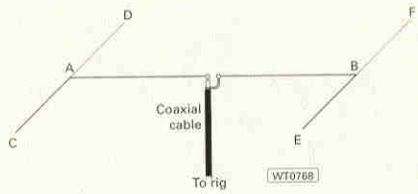


Fig. 4: Folding the ends of the dipole elements can allow a full length dipole to be fitted in the shorter overall space of a small garden.

So, let's go into various implementations of these shortening an, or, bending dipole elements. As with the full size dipole all the following configurations are adjusted to give minimum s.w.r. using a reflectometer type of instrument.

The Loaded Dipole

Physically shortening a dipole is shown in **Fig. 2**. It shows how a short dipole can be brought to resonance by means of a loading stub. **And although this antenna may look like a G5RV but beware, it isn't**. The top (AB) should be made as long as possible and the length of the stub (CD) should be adjusted for minimum s.w.r. A good starting point is to make the total length of the wire in the antenna somewhat more than half a wave-length.

The diagram of **Fig. 3**, shows the use of loading coils (shown at points L in the drawing) to achieve the same effect. The optimum point for the coils is about 50-70% away from the centre point.

A dipole such as the one shown here should be adjusted for minimum s.w.r. by trimming the end sections at A and B. For guidance, if the top is $\lambda/4$ long and the coils are in the middle of each leg then the reactance of each coil should be about 900Ω at the desired frequency.

The efficiency the antenna shows, depends on the quality of the loading coils. A good design should incorporate air spaced coils made from thick wire. (When it rains or snows you may find that the antenna will not load; on such days you may be reduced to tidying the shack out).

A short dipole can be capacitively end-loaded to make it resonate as shown in **Fig. 4**. However, in practice a symmetrical layout is not usually necessary and just bending the ends (C-A or B-E) achieves the same effect.

The lighter lines A-D and B-F, shown in the illustration, are alternative directions. But if they are additional then they add greater end loading capacitance, allowing a shorter distance between points A and B for resonance on any frequency.

Bend the wires where it's convenient. The ends do not have to be bent in the same direction or plane. But try to keep the straight centre section (A to B in the diagram) as long as possible.

Bent Dipoles

Now it's time to move from loading dipoles with coils or capacitors, to bending the whole dipole. Of the 'bent' dipoles, probably the most well known variant is the inverted-V dipole. (This antenna variation can be erected with only one support at the mid-point).

Using one of the variants of the 'bent' dipole, can have a big advantage as a (socially accepted) dummy TV antenna on the roof of your house can fulfil the role of support. As the centre support carries the weight of the feeder and centre insulator, the dipole itself can be made virtually invisible by using very thin wire and mono-filament nylon at the ends without end-insulators.

Finally in the bent dipoles department, **Fig. 5** shows the Reinartz loop which is a highly bent dipole. In fact, this is so bent it resembles a loop antenna - but note that the ends of the dipole do not touch at the top. Any insulator used at this point must be of good quality as very high r.f. voltages can be generated, even at QRP power levels.

Now I'll turn to hybrid and asymmetric dipoles. And it **is perfectly** feasible to combine any of the above methods if circumstances so dictate, as **Fig. 6** shows an inductively loaded bent inverted-V dipole.

In this case it's probably desirable to place the loading coils at the point where the antenna is bent. The bent ends can, as before, go in any direction, even perpendicular to the plane of the paper.

Another feasible configuration is when a dipole can be erected with one leg straight and the other leg bent to fit into the available space. In fact, the possible variations are only limited by your imagination.

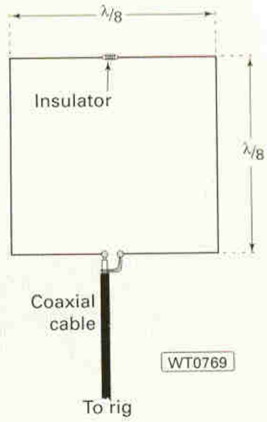


Fig. 5: Looking like a loop antenna the Reinartz loop has important differences (see text).

All Work

All the above antennas work! Which variant of the dipole is best for you, will be driven by your circumstances as all antennas interact with their environment in unpredictable ways.

It will probably be necessary to experiment to get any of them to work. If the first configuration you try doesn't work very well, then try another. This is what amateur radio is about, experimenting and trying to get good results from impossible sites.

Good luck with your trials!

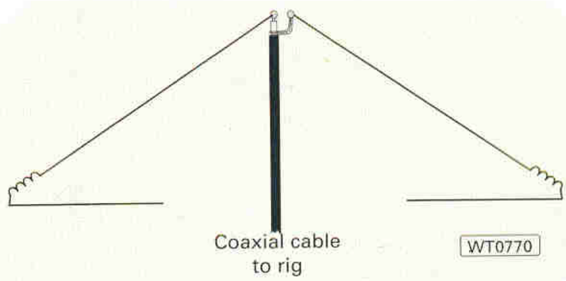


Fig. 6: Combining a loading coil into each leg of an inverted-V antenna can save a great deal of space for lower h.f. band antenna users.

◆ LOOPS, THE WHOLE LOOP - NOTHING BUT THE LOOP

Low-Down on Loops

Full-wave loop antennas offer several advantages over other types of antennas, says John Heys G3BDQ, as he tells you all you need to know about them.

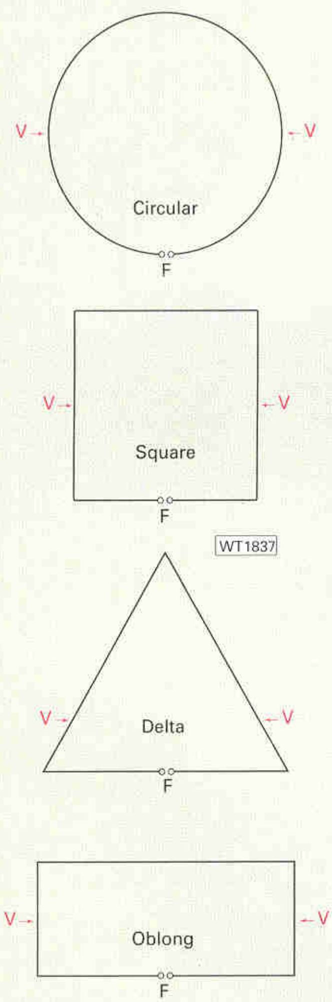


Fig. 1: Four figures having equal perimeters shown in descending order of the enclosed area. Points 'F' are the feed-points for horizontal loop polarisation and Points 'V' are the points of highest voltage and impedance.

The 1930s saw a dramatic rise in short wave broadcasting and new stations were appearing every few weeks. Not to be left out, Ecuador built a powerful transmitting station near Quito, its capital city. Situated on the Equator at an altitude of about 3600m, the rarified atmosphere and the station's high power resulted in coronal discharges from the ends of the antenna wires. The station's engineers solved the problem by developing a full-wave loop antenna, and so, the quad antenna was born.

Radio Amateurs were rather slow to pick up on this new antenna design and it was not until the 1940s that **Clarence C. Moore W9LZX** experimented with, then described the full-wave quad (square) antenna. It was soon realised that the full-wave loop could be arranged not only as a square or a diamond so, other shapes of full-wave loops appeared in antenna books.

Characteristics and Parameters

Firstly, let's have a look at some loop characteristics and parameters. The full-wave loop antenna 'family' have twice the conductor length of a half-wave dipole so some gain should be expected. Because the conductor is bent around the actual gain is not the equivalent of a pair of discrete in-phase half-wave dipoles. For a circular loop the gain will be about 2dBd (referenced to a dipole). This represents a power gain of around 1.6 times which would give an e.r.p. of 160W when a 100W output transmitter was used.

The gain (in dBd) when using a full-wave loop antenna is directly related to the area enclosed by the loop. A circular loop encloses a greater area than any other configuration which by the way, is why primitive people build their houses with circular walls. They then have the greatest floor area for the least expenditure and effort.

Four different full-wave loop arrangements are shown in **Fig. 1**. A square (or when tilted a diamond) loop has slightly less enclosed area than a circular loop. A Delta (triangular) loop has less again. The least enclosed area is when the loop is an oblong (letterbox shape). If the flattening continues we end up with a folded dipole, an antenna with the radiation characteristics of a conventional dipole, showing no gain at all.

All the full-wave loops radiate in two directions and the quad loop's gain is about 1.8dBd. A delta loop's gain will be only 1dB or less, giving its best gain figure when formed into an equilateral triangle. The feed-points marked 'F' in Fig. 1 are positioned for horizontal polarisation for the radiation from the two vertical legs of the quad and the sloping sides of the delta have anti-phase antenna currents which largely cancel out.

Vertical Polarisation

If vertical polarisation is required, the feed-points should be moved from the base of the loop antenna, to halfway up one of the vertical sides of the antenna. With a Delta antenna, the feed-point should be moved to one of the lower corners. The impedances at the points 'F' are also related to the enclosed areas of the loops. A circular loop has a feed impedance under 100Ω, rising, in the squared form, to lie between 100-120Ω.

With the equilateral delta, the feed-point impedance lies between 75-100Ω. When in a narrow or flattened form loop antennas' feed impedances rises rapidly as the flattening increases until the antenna becomes a folded dipole having a feed impedance of almost 300Ω.

The loop's maximum radiation is in two directions at right angles to the plane of the loop (looking through it). The side, or end-on radiation is minimal. It is the 'end affect' of insulators, etc., which determines a wire's resonant length which will be less than a true half or other multiple of a wavelength.

Closed loops, like all coiled wires must, however, be lengthened to maintain resonance. So, full-wave loops should be cut to a length of 306/F(MHz) rather than the more usual values used for straight dipoles.

The points marked 'V' in Fig. 1 are the high voltage and high impedance positions along the loops. Being closed loops these values are considerably lower than those found at the ends of resonant single wires. This is the factor that proved so useful in Quito. Full-wave loops must be positioned vertically, for when used parallel to the ground, the ground reflection makes almost all the radiation go skywards.

A Disaster

High angle radiation can sometimes be fine for short haul work on the 3.5 and 7MHz bands, but would be a disaster if long distance communication is your aim. Large multi-wavelength loops can however be used in the horizontal plane and they can be effective for long distance working.

Full-wave loops are little influenced by nearby trees or buildings and their lower points can be a $\lambda/4$ or less above ground. They can even give good results when made from insulated wire and are actually positioned within trees.

The turning radius of a quad loop antenna is half of that of a half-wave dipole and so, it can be erected in quite small gardens. A loop antenna installed indoors in a roof space will be less affected by the metal tanks, pipes and wires than a conventional open ended wire antenna.

First Consideration

The first consideration when thinking about using a quad or delta loop is the question "will it fit into my available space"? Fortunately, a full-wave loop will still be effective even when it is close to the ground. When its lower wire is half-wave above ground the horizontal radiation pattern of the loop will be about four degrees lower than that of a dipole at the same height.

At just $\lambda/8$ in height, which is only 2.5m (8ft), when the antenna is cut for the 28MHz band, its horizontal radiation angle will be as much as 10° lower than that of a dipole at the same height. When height is a problem, an horizontally polarised loop may be slanted at up to 45° from the vertical with little ill effect.

A quad loop antenna needs two upper tie points and its corners will all be fairly low impedance points where the insulation is not critical and where just nylon cord without insulators may be used. A delta loop can be positioned with its apex help up by a single nylon cord. The apex impedance is quite low. If the delta is inverted two upper supports are needed and again the impedance at the end points is not high.

Feeding the loop correctly may be done in one of several ways, as shown in **Fig. 2**. A tuned 'ladder' feedline made with open wires or lengths of 300 or 450Ω ribbon feeder is the most versatile feed method. However, this means that a balanced a.t.u. such as a 'Z Match' is needed.

Sometimes the eminently suitable (but now rather elderly) KW Eezimatch balanced tuners may be found at rallies and junk sales. Loop antennas may be fed directly with coaxial cable, preferably by using RG-62AU, with its 95Ω impedance (stocked by **W. H. Westlake** of Holsworthy, Devon).

A good quality 75Ω coaxial cable may also be used, though it will have to be matched to the transceiver. Many modern rigs incorporate an auto-tuner for this purpose. If a coaxial feeder is used to connect to a balanced antenna, a current balun is required to prevent r.f. currents running along the outside braid of the coaxial cable.

An easy and very effective way to make a current balun is to use clamp-on ferrites which are now available. If the cost is more important, then some of the coaxial cable itself may be wound into a four or five turn coil (about 250mm diameter) close to the antenna feedpoint.

Traditional Match

The traditional way to match a 50Ω impedance feeder to higher antenna feed-point impedance, is to use a quarter wave matching section **Fig. 3**. This critical length of 75Ω coaxial cable can be determined by multiplying the free space quarter wavelength by the velocity factor of the coaxial cable used. The velocity factor for most cables is around 0.66, but some cables have different factors. The 50Ω coaxial cable need not have any special length.

Full-wave loops fire in two directions so a pair of loops positioned at right angles to each other could give world-wide coverage. The inherent and rather low Q of full-wave loops results in a wider bandwidth than that of half-wave dipoles.

When fed from tuned line, a full-wave loop can also be induced to work on its harmonic frequencies, though it will not have the same radiation characteristics of its full-wave use, nevertheless it's still a useful antenna. You cannot use loops on their harmonic frequencies when they are fed with coax, as was discovered by my local club on one Field Day.

Full-wave loop antennas for the v.h.f. bands can be fabricated from tubing or thick copper wire and may be self supporting. Under these circumstances, circular loops may be used to get the full 2dB gain and a 95Ω feed impedance. Additional parasitic elements (loops), to make a beam can bring the feed impedance of the driven loop down to 50Ω. One full-wave loop for 144MHz was made from strips of aluminium kitchen foil, glued to a sheet of rigid plastic material.

Full-wave loops are indeed versatile! They make useful antennas for the Amateur bands. ◆

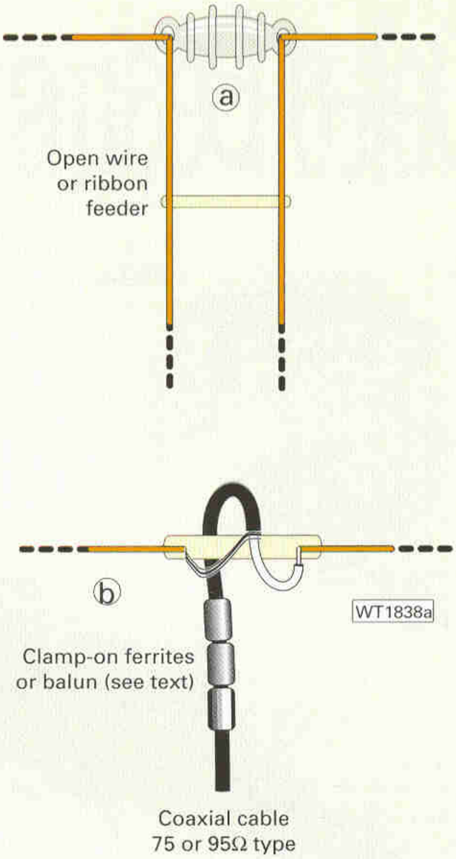


Fig. 2: Three ways to feed a full-wave loop antenna. Open wire feeder or ladder line is the most versatile and will allow operation on the higher harmonic frequencies. See text for details.

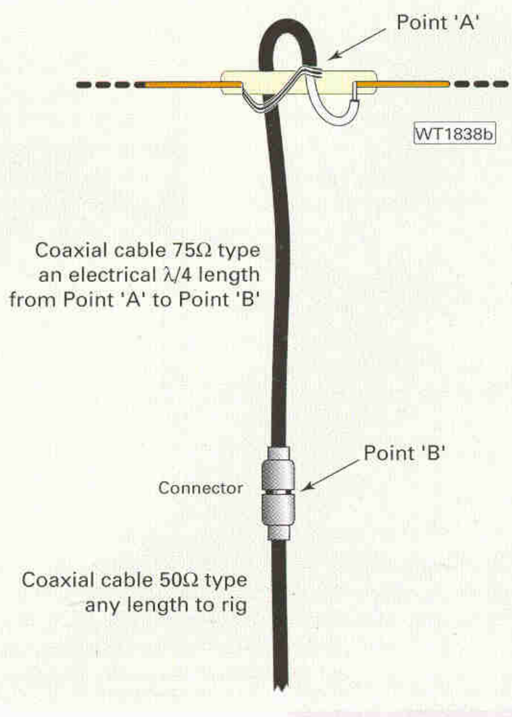


Fig. 3: How to match 50Ω impedance coaxial feeder to a full-wave loop using a length of 75Ω cable that is cut to work as a quarter-wave matching section. See text for details.

F.C. SMITH GW2DDX LOOKS AT ACHIEVING HIGH GAIN FOR GREAT DX AT MINIMUM COST.

Delta Beams for 21 & 28MHz

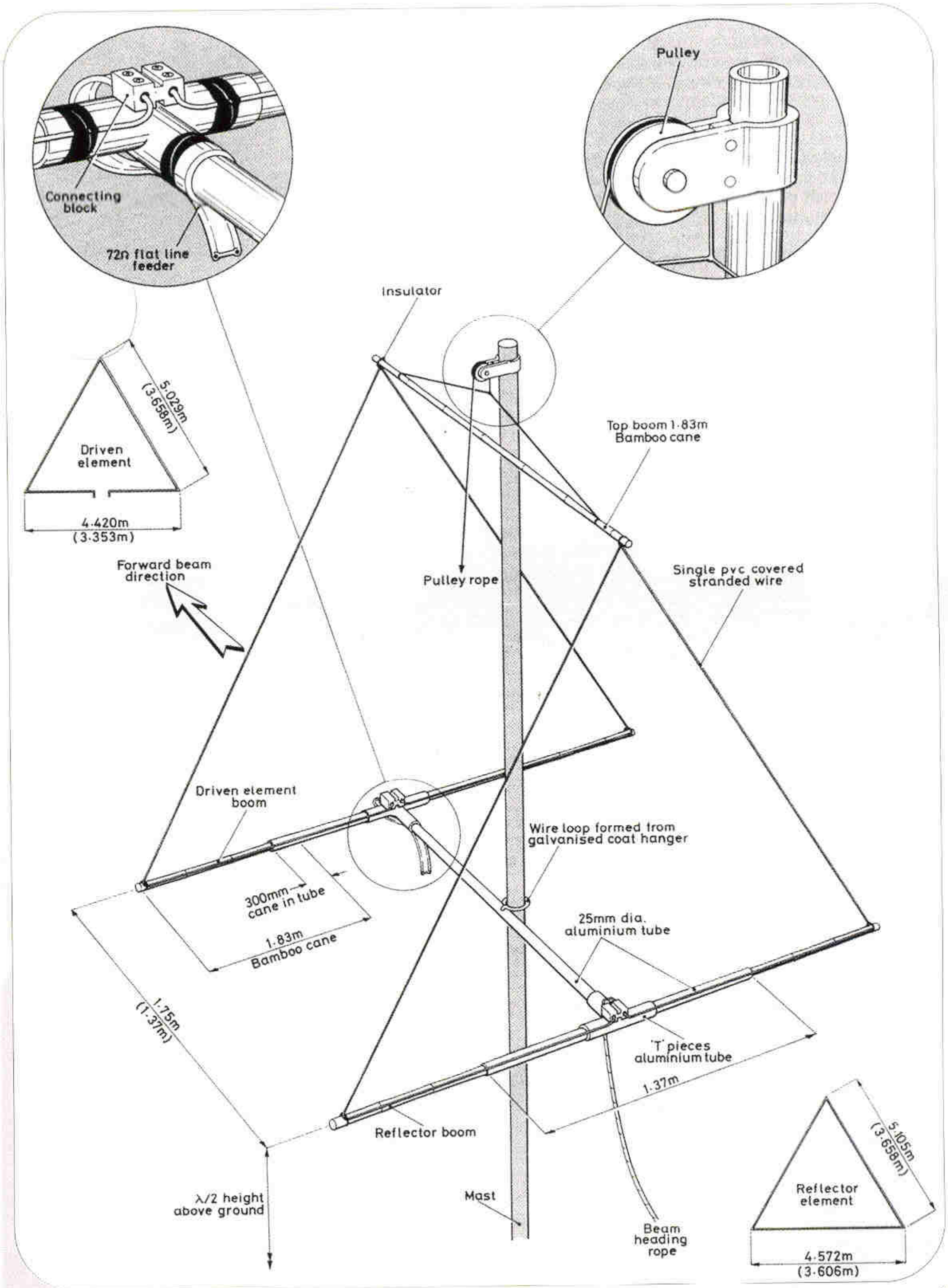


Fig 1: Constructional details. Dimentions in brackets for 10m version.

Selecting a beam for best results calls for careful thought, not least of which is cost. The Delta beams described in this article have been thoroughly tested and yielded excellent DX results, which will satisfy the most ardent DX chaser, be they a licensed Amateur or short wave listener (s.w.l.).

Delta beams possess the following desirable points:

1. A good low angle of radiation
2. Good directivity
3. Broad bandwidth
4. Easy erection and not least, low cost

The performance of the Delta 2-element beam equals the of a 3-element Yagi, at twice its height above ground. This has been corroborated by the writer whilst working DX stations in JA and V, who have exchanged exactly the same signal strength reports, but whereas the DX stations' antennas were between 12 and 15 metres above ground, the bottom leg of the Delta was only five and a half metres above ground. The gain of the Delta should be 5.5dB to 6dB, dependant reflector spacing. Let us look at the requirements for a good DX antenna.

A low vertical angle of the major lobe is paramount, if the antenna is to work DX consistently. The only factor controlling this angle is the height of the antenna above ground.

The reader may well ask: "What is the best height to obtain this condition?" and the answer is that there is no best height, with seasonal variation in propogation conditions throughout the year. For an all the year angle to work DX, between eight and 15° should be the most useful under all ionospheric conditions. This would require a 3-element Yagi to be over a wavelength high.

With Yagi type parasitic beams it is essential to have the beam at least one half-wave above ground and preferably much higher for best results. With

Quad and Delta loop beams, the height at which good DX results may be obtained can be considerably lower. The chief reason for this is that the two half-waves in the loop act in the same manner as a stacked array, with more power form the secondary lobes compressed into the lower primary lobe, enhancing the lower angle and forward gain. The author has used three Quads over the years and finds the 2-element Delta the better beam. The Delta has a broader bandwidth and improved directivity.

With the bottom leg of the Delta beam only five metres above ground level, a call to VK during most mornings brought a reply at once and this when conditions were not good. All districts of JA were worked over a period; Guam; KH6: ZL; the Solomon Islands; Papua, New Guinea (P29NBF) and to the north-west many W6 and W7s. All this with the writer's 150W Viceroy Tx, from a QTH at about 100ft a.s.l. and completely surrounded by buildings.

A word about directivity: the side lobes produced in the down wires of a Quad to some extent mask the directivity of this popular beam. I can give no factual reasons for his belief that these sides lobes would account for the better directivity of the Delta over the Quad and having used Quads as mentioned, I found that the beam heading of the loop is more definable, with the half-wave points of the horizontal pattern some degrees narrower than the Quad. It must, however, be emphasised that these observations are based purely on practical use of both these antennas types over a long period.

Of course, the 21MHz band Delta can be interlaced, as with the Quad antenna, to include the 28MHz band elements, making it a single beam for the 21 and 28MHz bands. It would then be advisable to feed each driven element separately to obtain a good feed-point match to each single beam element, with a very low standing wave ratio. The a.t.u. needed no adjustment over half the band once set.

Construction

The first stage of the construction is the assembly of the top boom member. This is fitted with insulator rings at each end to allow the element wire to pass through. The top boom is supported, as shown in **Fig. 1**, by a rope spreader and can be hauled into position at the head of the mast by a suitable pulley tope.

Next the lower boom is constructed to the dimension and layout given in Fig. 1. Originally, aluminium tubes were used but as an alternative, heavy wall plastic tubing could be substituted. Ensure the bamboo canes are a good fit inside the tubes, if not cross-pin to secure.

Having completed the boom sections, measure out the correct length of wire. for the required operating frequency, to form the driven element. This then fed over the top boom insulator, down to the lower boom ends and through the curtain rings to terminate at an electrical connector block fixed at the centre point. The reflector element is prepared in the same manner with the principal difference being a link at the connector block to provide a 'closed loop'. As an alternative, the reflector may be soldered at its centre point but this method is less useful if it is wished to g.d.o. the reflector.

The 72Ω flat line feeder is terminated to the driven element connector block with its length determined to suit individual station requirements, Before elevating the assembly fit the wire loop around the mast. This really does stabilise the beam when in the final position. Beam headings can be varied by attaching a rope to the lower boom centre point.

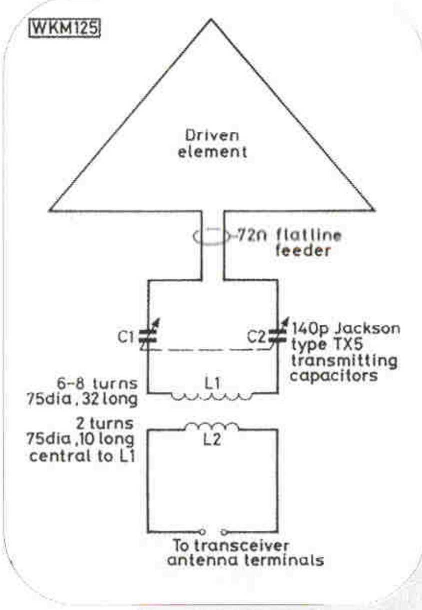


Fig. 2.

The a.t.u. shown in Fig. 2 consists of two 140pF wide spaced variable capacitors ganged together with an insulated shaft and in series with a six to eight turn coil, 75mm in diameter and 32mm long. A two turn link winding in the centre couples to the p.a. output.

A grid dip oscillator (g.d.o.) is used to set the antenna up. Tune the 21MHz band beam to 21.3MHz and the 28MHz band to 28.8MHz. The measurements given should prove to be very near the ideal. There is no need for adjustment of the reflector.

The beams are now tuned for forward gain. Tuning up is best done with the antenna between eight to ten metres above ground level and standing on a step ladder.

The beam can now have the feedline attached and be hoisted up on the mast. The ideal height for DX working, with the Delta, is at a half-wavelength above ground to the base of the beam. On the 21MHz band this will be seven and a half metres and on the 28MHz band, five metres.

◆ JOHN HEYS G3BDQ TAKES A FRESH LOOK AT THE W3EDP NINE-BAND ANTENNA, WHICH

The W3EDP Antenna (A Fresh look)

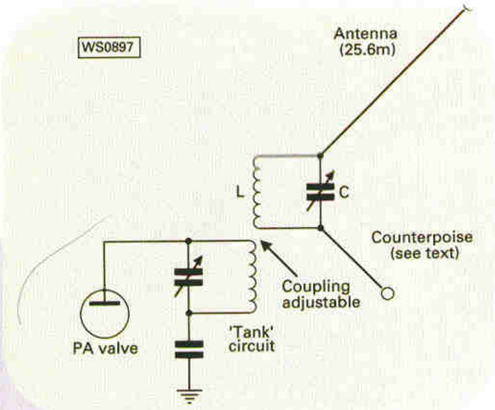


Fig. 1: The simple coupling circuit suggested by G2WD in 1936 for coupling the valved transmitters of the day to a W3EDP antenna. Although capable of extremely good matching it would be considered very complex and difficult to use, by today's amateur, needing adjustment of three interactive controls to achieve best results.

When I was first licensed in 1946, my shack was up in the attic of a boarding house on the sea front at Hastings. There was no way that I could put antenna wires more than a couple of metres above the roof but, using no more than 10W of transmitter power, one antenna gave me my first taste of DX working. Using c.w. I'd contacted stations in all continents after a few weeks. The one antenna that helped me achieve all this was the **W3EDP** antenna design developed in the mid-1930s by the holder of that call **Mr H.J. Siegel**.

◆ Unusual History

The W3EDP antenna has an unusual history. For some reason, Siegel never wrote anything about his 'own' antenna design which, when being developed, was in a world where Radio Amateurs had no rotary beams, no coaxial cables and no a.t.u.s. Long wires and resonant 'Zepp' antennas were in universal use.

The first descriptive article on the W3EDP antenna was published in the RSGB's *Bulletin* (it's now called *RadCom*) in February 1936. It was written by Siegel's friend **Yardley Beers W3AWH**. Beers produced a similar article that appeared the following month in the American *QST* magazine.

Yardley Beers told how his friend W3EDP, started his painstaking experiments by using 30.5m (100ft) of end-fed wire. He gradually reduced this inch by inch until the very best results were obtained. It is said that he used up more than a thousand feet of wire at that time.

Not liking simple end-fed wire antennas, Siegel then began 'cut and try' techniques to determine his ideal length for a counterpoise. A lot of judicious wire pruning revealed that a counterpoise length of 5.18m (17ft) gave the best results. This wire ran out at right angles to the main wire, which was only 6m (20ft) high.

Siegel then found that the antenna design worked well even when strung up close to the ceiling of the first floor room. At the time W3EDP's transmitter ran 50W input power, but in a short time his new antenna, used on 7 and 14MHz, gave him contacts with 75 countries in all continents.

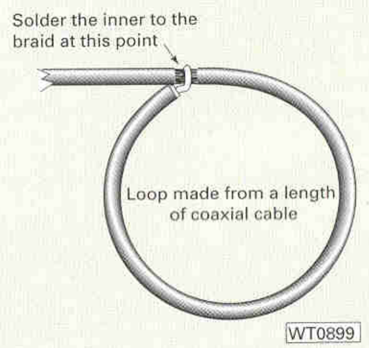


Fig. 2: An inductive, or Faraday coupling loop may be made up from a length of coaxial cable. The most effective diameter of the loop depends on the band in use, but some 150-250mm diameter is a good start point. Two loops coupled side-by-side would give almost complete 'Earth' isolation whilst allowing the r.f. energy to pass from transmitter to antenna, or vice-versa.

This was an achievement not equalled by many higher powered US stations of the time. A QSL card, dated May 12th 1935, confirming contact with G5JO by Siegel, shows that Siegel used 50W. By that date W3EDP had worked 60 countries. He was most certainly then using his new antenna.

The December 1936 issue of the RSGB's *Bulletin* carried an article by **G2WD** which detailed ways to couple the W3EDP antenna to the output stage of a transmitter. The simplest circuit can be seen in **Fig. 1** where a tuned circuit couples inductively to the valve p.a. output or 'tank' circuit. In his article, G2WD stressed that for the best results the coil L must be resonated with a small value of capacitance.

The antenna coupling circuit has no earth connection and if modified by using a link coupling could be used today. A suitable 'Faraday screen' link made with coaxial is shown in **Fig. 2**. On some bands the counterpoise is not needed and **Table 1** gives details of counterpoise lengths for the nine h.f. bands

◆ Nine Bands

Although the W3EDP antenna may be used on the nine major h.f. bands, when he developed his antenna, Siegel only envisaged its use on four bands: 3.5, 7, 14 and 28MHz. Fortunately for us, his design has since proved to be very versatile and can be effective on all our h.f. bands from 1.8 to 28MHz. No doubt it could be made to work on 50MHz too!

For use on the bands it was originally designed for Siegel's wire lengths hold good. But today for our 'new' bands gained since 1952 onwards, there must be a few changes to the counterpoise arrangements. The W3EDP antenna has a medium impedance feedpoint impedance. Having neither a very low nor a very high impedance at its feedpoint end, that is usually inside the house or shack.

Feed-points of medium impedances are always much easier to match than high or low impedance points, and they also limit any r.f. feedback problems. On some bands the antenna is best when used as a simple long wire, but on others a counterpoise will be needed. The counterpoise behaves as one leg of a very widely spaced open wire feed line making the antenna like an end-fed 'Zepp'. This puts its high impedance points well away from the operating position. As our bands are now no longer all harmonically related, a single counterpoise length will not suffice.

On 'Top-band' (1.8MHz) the antenna element is only about one sixth of a wavelength long and must be tuned against a conventional quarter wave counterpoise of about 38.65m (126ft). Although this counterpoise is short for this band, one of my local amateurs **G0AKY** has used a W3EDP antenna with success from several caravan sites in the West Country. He can put an S9 s.s.b. signal all over the UK when using it. This is good, particularly as the antenna is no more than 6m (20ft) up (usually into a convenient tree). The counterpoise wire he just lays on the ground.

Practical Considerations

Let's have a look at some practical considerations of using the W3EDP antenna, the versatility of which is remarkable. The 25.6m (84ft) wire does not have to be arranged to run out in a straight line, but can be 'dog-legged' or even arranged in the shape of a 'Z' and yet will still give good results. Bends kept in the horizontal plane are fine however, bends that bring the wire nearer the ground are not recommended. The wire may be arranged as an inverted 'L' or run out away from the shack horizontally or sloping upwards.

The antenna will still perform reasonably well when its average height is under 6m (20ft) but ideally it should not fall below this height. Its far end will always be at high r.f. potential so good end insulators are a 'must'. Just throwing the wire into a tree induces losses and detunes the system.

The counterpoise will work best when running at right angles to the direction of the main wire. But the antenna will still perform reasonably well when it isn't running in the 'correct' directions or even when the counterpoise run is bent. Remember that Siegel used an indoor counterpoise, as I did some 50 years ago. For a time I lived in a small cottage in the heart of an urban area and had no garden or even a back yard. I devised an 'invisible' W3EDP by using thin enamelled wire from an old transformer winding.

For the 'invisible' W3EDP I tied the end of the wire to a piece of modelling clay, and flung it over a neighbouring roof top. It could not be seen and it coped well with 75W of power until the wind induced metal fatigue and breakage. Whatever happened to the launch-weight I never found out!

Circuit & Matching

The simplest matching circuit can be borrowed from the original method shown in Fig. 1. A link coupling as mentioned earlier in the text can be used to connect to the transceiver via an s.w.r. meter. By sliding the link coil over 'L' the best s.w.r. reading can be found. Plug-in coils for each band or a single tapped coil can be used.

The inductance used for each band must be high and should be tuned with quite a small value capacitor. The original article suggested that on 3.5 and 7MHz no more than 30pF of capacitance is needed and this reduces to 10 or 20pF on the higher frequency bands. So a capacitor of a maximum value of 150 or 200pF would be suitable to cover all bands.

I've received letters from amateurs having trouble with the W3EDP on one or more bands. Mostly they write that they've experienced r.f. in the shack with attendant feedback problems. In most cases I've suggested that they set up the matching arrangement shown in Fig. 2. Here the antenna has no earth connection and the earth wire must be removed from the a.t.u.

The counterpoise is connected to the 'earth' terminal on the a.t.u. in the place of the station earth. When the a.t.u. itself is earthed, the W3EDP antenna is detuned, corrupting the essential working of the antenna. The braid of the connecting coaxial will of course earth the a.t.u. and to prevent r.f. running along the outer surface of this braid a current balun is needed. The layout using this option is shown in **Fig. 3**.

A suitable current balun can be made by winding the coaxial cable along a thick (12mm) ferrite rod (try about 15 turns). Another for could be tried by stacking three large ferrite toroids (the type used to counteract TVI on TV cables) and then winding the coaxial cable with as many turns as possible on the toriods. A further possibility is to slip a large number of ferrite tubing rings over the coaxial cable close to the a.t.u.

If you are using ferrite tubing 'beads', then I think using about 15 beads should be enough for the higher h.f. bands, although, for 1.8MHz working I'd use at least twenty beads. If you are using the balun method, the earth wire must of course remain connected to both the transceiver and the power supply.

Like all antennas, the higher the antenna is placed, the more effective it will be for the DX work. And in every case, where possible, it's best kept away from the screening effects of buildings or large trees.

A W3EDP does not show any marked pattern in its radiation and on the lower frequency bands is an 'All Round' radiator. Many QRP stations in the UK and overseas use W3EDP antennas and despite the low power levels used, achieve remarkable results. Don't you think it's time you tried one?

Table 1

Band (MHz)	Counterpoise (m)
1.8	8.65 (126ft)
3.5	5.18 (17ft)
7.0	5.18 (17ft)
10	7.00 (23ft)
14	1.98 (6.5ft)
18	1.98 (or none)
21	5.18 (17ft)
24	None
28	None

Table 1: With our 'modern' bands some changes are needed on the length of the counterpoise needed to give best efficiency on the bands. The dimensions are given in metres (and feet for the non-metricated).

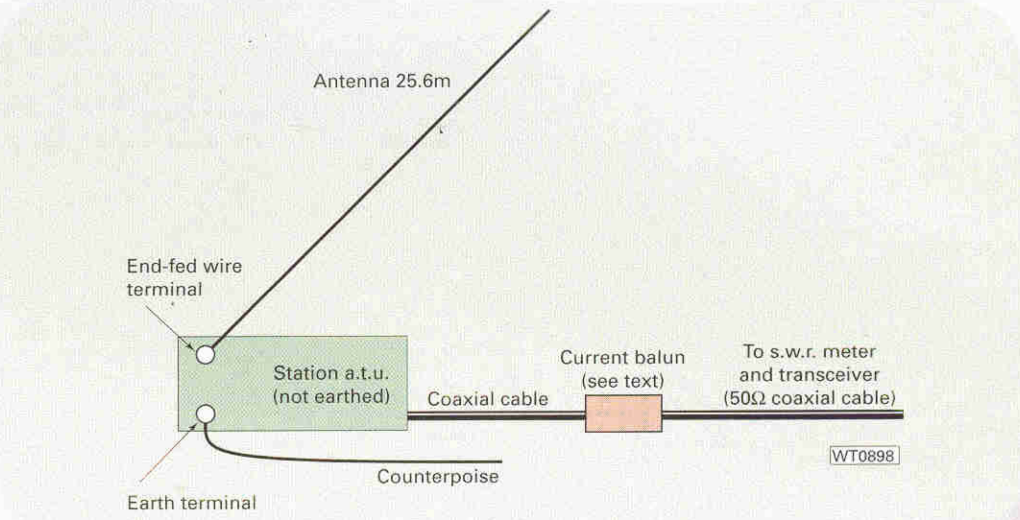


Fig. 3: The current balun used in this setup is to stop (or at least reduce by a large part) the current that would flow on the outer of the coaxial cable if the station earth cannot be isolated from the station antenna matcher/tuner.