Peter Dodd's

antenna workshop

Peter Dodd G3LDO describes how we can join him on 136kHz – once he's described getting over the antenna problems!

Suburban Antennas For 136kHz

Many *PW* readers will be aware that we now have a low frequency (l.f.) allocation of 135.7 to 137.8kHz. In this rather unusual *Antenna Workshop* I'm discussing a method for using your existing 1.8, 3.5 and 7MHz (160/80/40m) antenna on this very low frequency band. It's unusual because I'm also including some suggestions of what receiver to use and some ideas for constructing a simple transmitter.

A book I can thoroughly recommend for those interested is *LF Today, a Guide to Success on 136kHz*, (*LFT*) an RSGB publication by **Mike Dennison G3XDV**. It's available from the RSGB or from the PWP Bookshop.

The LF Antenna

The half-wave dipole length for 136kHz is approximately 1100m and a full size quarter-wave antenna would be approximately 550m high, so clearly these antennas are out of the question for us! The solution is to use an electrically-lengthened short vertical where its physical length is much less than a quarter wavelength by using inductive loading, as is done with h.f. mobile antennas. And, as with mobile antennas, a capacity 'hat' above the loading coil can be used to increase antenna efficiency.

The most commonly used antenna on l.f. is the end-fed wire fed against ground, often referred to as the Inverted L or Marconi antenna. This type of antenna is often used on 1.8MHz (160m). The antenna will work just as well if connected as a T as shown in **Fig. 1**.

As I've suggested, you can make an antenna for 136kHz simply by using an existing dipole for 1.8, 3.5 or even 7MHz. Start by connecting both conductors of the feeder together and then end feeding them both via a loading coil against ground. In this case, the near vertical feeder can be considered as vertical antenna and the existing dipole as the capacity hat.

An l.f. antenna should be designed to have as long a vertical section as possible, and a top section giving as much capacitance to ground as possible without compromising on height. However, this need not be in the classic L or T shape of the Marconi antenna, the shape isn't important. The secret is to use as much wire as possible, as high as possible – even with low power the r.f. voltages at l.f. are high so good quality insulators are required.

The Loading Coil

The loading coil is a critical part of any l.f. antenna system. Note that the coil will perhaps have several tens of kilovolts across it, so small ferrite loaded coils are unsuitable. The coil

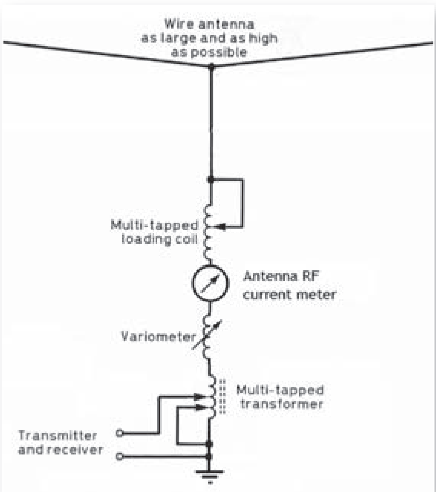

Fig. 1: Diagram of an l.f. antenna. The main multi-tapped coil needs to be large in both size and inductance (3 to 4mH). The matching transformer is wound on a T-200 ferrite ring. Match and tune for maximum noise in the receiver or maximum r.f. current on transmit.

Fig 2: Using a 7MHz centre fed dipole operate on 136kHz. The large coil former is made from a plastic manhole access point, available from builders suppliers. The smaller coil on the red box is a variometer from a vintage 500kHz transmitter.

Fig. 3: Close up of the matching transformer and the IC-706 used for testing on receive only. The IC-706 does not transmit on 136kHz.

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former should be between 50 and 500mm diameter and 200-500mm long.

The actual diameter can vary, depending on the thickness of the wire used and the inductance required. The sides of former must be parallel but it is not essential for the former to have a circular cross-section. Formers can be made from plastic piping, rolled up plastic fence material, compost bins, and plastic boxes.

Factors affecting the *Q* include the coil's size and shape, the type of wire used and the spacing between the wires. The optimum spacing between wires is the width of one wire. In practice, this is achieved by using plastic covered wire, so that the insulation on adjacent wires keeps them about one wire diameter apart.

On the h.f. bands, it is normal to use a combination of inductors and capacitors in an a.t.u. to tune out any reactance. Unfortunately, the voltages at l.f. are so large that any capacitor is likely to flash over. Any tuning must be carried out in the inductance itself – a variable inductor is required. A crude, but simple, way of producing a variable inductor is to make 'taps' on the coil every few turns. This is certainly an excellent method if you have little idea of the inductance required to tune the antenna.

A better and more conventional method of varying inductance is to make another, smaller coil that rotates inside the larger one. This works because, depending on its position, a portion of the inductance of the small coil either adds or subtracts from that of the large coil. This is known as a variometer.

When the antenna and coil resonance has been established, another coil can be constructed with a fixed inductance slightly less than is needed. Then a smaller inductance, with a variometer coil, can be placed in series with the large one and used for fine-tuning within the amateur band as shown in **Fig. 2**. Note: It's often convenient to place the large inductor outside, and beneath the antenna, and to house the variometer coil in the shack.

You may wonder why an antenna needs fine tuning in a band that is only 2.1kHz wide! The answer is that an efficient l.f. antenna is likely to have a high enough *Q* that it has a 3dB s.w.r. bandwidth of only 1kHz or so. Furthermore, the antenna's frequency will change with the seasons and the weather, due to changing losses in the soil and adjacent objects such as trees.

The simplest method of matching the coils and the antenna is to connect them to a receiver as via a tapped auto-transformer wound of a ferrite ring as shown in **Fig. 3.** The loading coil inductance and the connections on the auto transformer are adjusted for maximum noise from the receiver. When you have built your transmitter you then tune for maximum antenna current.

The Ground System

As I've already stated, a vital part of the antenna system is the 'ground' connection. This ground can be as simple as a single stake in the ground, or as complex as hundreds of radial wires. Commercial l.f. stations use hundreds of kilometres of wire spread out over a radius of several km. **Note:** Don't be tempted to use the a.c. mains supply earth in the house as this will introduce noise in the receiver and may possibly lead to circuit breakers being activated.

The efficiency of the ground connection, and hence the efficiency of the antenna itself, will depend on the conductivity of the soil around the antenna. Sea water makes an excellent ground and proximity to the sea can be a great advantage – but watch out for the incoming tide!

The most basic ground connection is a single metal stake, such as a copper water pipe, driven a metre or so into the ground. The current density is highest at the bottom of the vertical section, so the earth stake should be as close as possible to this point. This simple arrangement will get your station on the air, but should not be regarded as optimum.

In practice, successful l.f. earth systems include a mixture of earth stakes, radials and any other earthed items such as water pipes and even old copper water tanks. Ground stakes should be as long as possible. Copper water piping is cheap and easily obtainable and works fine, though it is soft and will bend when driven into hard ground.

The LF Receiver

Many modern h.f. transceivers tune down to around 100kHz, which theoretically makes them suitable for reception of 136kHz signals. However, many receivers have built in filters to reduce sensitivity at medium frequency (m.f.) because of the high powered broadcast stations in the medium wave band.

The old Kenwood TS-850 has a good l.f. receiver, which performs very well and is available these days at a reasonable price second-hand. Dedicated general coverage receivers, for example the AOR-7030, are also capable of good reception at l.f. Even the diminutive IC-706 gives a good performance on this band, see Fig. 3.

For very slow Morse (QRSS)

reception, (see below) the receiver's oscillators must have minimal drift, especially with the longer dot lengths.

Because the 136kHz band is so narrow, and to avoid interference from commercial stations close to the band, it's highly desirable to fit a c.w. filter in the receiver's intermediate frequency (i.f.). This type of filter is suitable for all modes used on l.f.

A Simple l.f. Transmitter

We now need a simple l.f. transmitter and one method of generating a stable signal in 136kHz is to use a variable crystal oscillator (VXO)/mixer as shown on page 48 of *LFT*. This circuit will work with any two crystals over 5MHz and separated in frequency by 135kHz. The trimmer capacitors are ganged together and arranged to increase one oscillator's frequency, while decreasing the other.

The exciter is inherently frequency stable because the two crystal oscillators constructed in the same enclosure are thermally coupled so, any frequency drift in one oscillator due to temperature, is compensated by the same frequency drift in the other.

The signal from the Oscillator/mixer can be keyed and filtered and amplified to produce a square wave switching stage to drive the power amplifier shown on page 7 of *LFT*. The (power m.o.s.f.e.t.) transmitter featured in *LFT* is based on a design by **Peter Schnoor DF3LP.**

An IRF630 can be used for the final stage but the IRF640 is much better choice since its on-resistance is lower and will have no problem producing 100W. This small amplifier will give even more power by using a greater supply voltage and an IRF840.

The output from a simple l.f. transmitter can be high in harmonics, so a low pass filter is not only recommended, but almost obligatory. And as you'd expect, a suitable filter is shown on page 8 of *LFT*. The filter is a double-π filter unit with outer capacitor pairs of (10+2.2)nF, and an inner pair of (22+4.7)nF and two coils of 54μH.

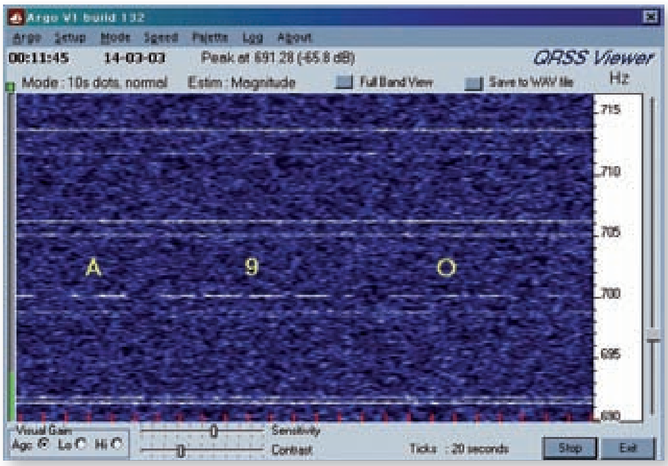

Fig. 4: A very weak signal from UA9OC using QRSS with 10 second dots viewed using Argo. The other lines on the display are sidebands from the Loran navigation system.

The two inductors comprise 59 turns of 0.8mm enamelled wire on a T157-2 powdered iron toroid. High voltage polypropylene capacitors with a working voltage of 400 to 1000V must be used. It could be built as a stand-alone unit.

Slow Morse

Very few l.f. operators send fast Morse (c.w.), even if signals are strong, because there is always a chance that others are listening at a great distance. This makes 136kHz a good place to practice your Morse.

However, there are other modes that do not require proficiency in Morse code and are designed to be machine-read, or at least displayed on a computer screen. One of these is QRSS operation, which actually uses Morse but at such a very slow speed that any received characters could be looked up in a table by the receiving station.

The QRSS method was pioneered in 1997, on the then new band of 73kHz by **Peter Martinez G3PLX** and **Andy Talbot G4JNT** and enabled the reception of G4JNT's callsign in Morse over a distance of 393km. The transmission was such, that it had just 1 milliwatt (1mW) effective radiated power (e.r.p.) and the signal was completely inaudible at the receive end.

To achieve the QSO, the transmission sending G3PLX DE G4JNT, using a Morse dot length of 80 seconds, took three hours to transmit. Some idea of the dot length and signals-to-noise improvement can be seen in **Table 1**.

Three hours to send a couple of callsigns may not sound very practical, so in practice a dot length of three seconds is the default mode. This allows a meaningful two-way contact to take place in less than an hour. Slower speeds are used, but usually only for intercontinental DX.

The mode was christened QRSS by Mike Denisson G3XDV because "extremely slow c.w." was rather cumbersome. Because QRS is used in Amateur Radio to mean "slow Morse", QRSS is "very slow Morse", using the similar Q-code grammar adopted when QRP (low power) was extended to make QRPP (very low power).

Some time after the G4JNT-G3PLX record-breaking test, it was found that freely available software originally written to analyse birdsong could be employed, using the software in association with a computer soundcard to decode the signals.

Nowadays, several Amateurs have produced soundcard software specifically for l.f. use, including *Argo*, *EasyGram*, *Spectran* and *SpecLab*. These are capable of displaying Morse with dot lengths from less than one second to over 100 seconds. Some also provide audio filters and facilities to decode other types of transmission. An example of a very weak signal using *Argo* software is shown in **Fig. 4**.

Well, that's how easy it is to get going on 136kHz! So, can I hope to work some more of you there? ●

Table 1

Speed	**Optimum bandwidth**	**S/N Ratio ***
12 w.p.m.	10Hz	0dB
4 w.p.m.	3.33Hz	+4.8dB
3 sec/dot	0.33Hz	+14.8dB
60 sec/dot	0.0165Hz	27.8dB

Table 1. Signal rate, bandwidth and signal to noise ratios relative to to a 12w.p.m. transmission.