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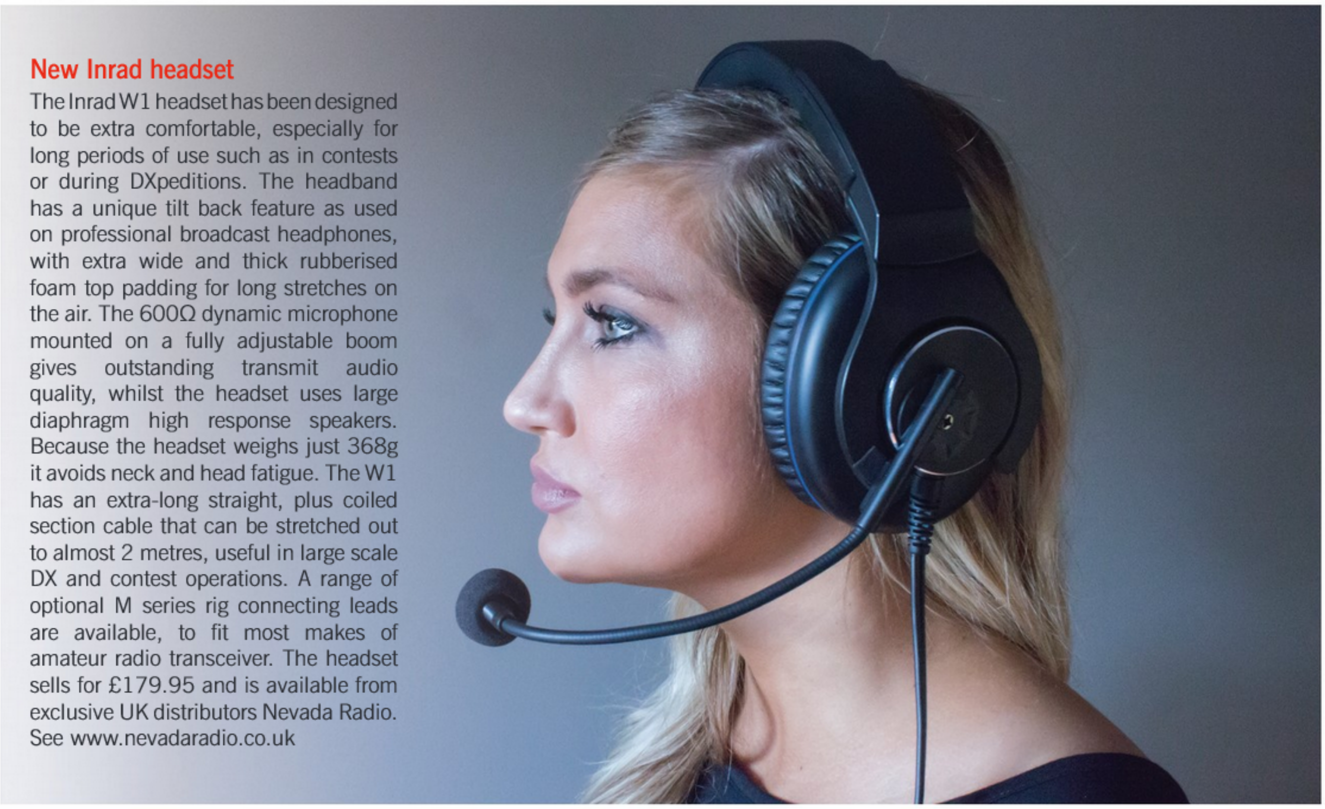
New Products



New Inrad headset

The Inrad W1 headset has been designed to be extra comfortable, especially for long periods of use such as in contests or during DXpeditions. The headband has a unique tilt back feature as used on professional broadcast headphones, with extra wide and thick rubberised foam top padding for long stretches on the air. The 600Ω dynamic microphone mounted on a fully adjustable boom gives outstanding transmit audio quality, whilst the headset uses large diaphragm high response speakers. Because the headset weighs just 368g it avoids neck and head fatigue. The W1 has an extra-long straight, plus coiled section cable that can be stretched out to almost 2 metres, useful in large scale DX and contest operations. A range of optional M series rig connecting leads are available, to fit most makes of amateur radio transceiver. The headset sells for £179.95 and is available from exclusive UK distributors Nevada Radio. See www.nevadaradio.co.uk

Remote rig control

The new MFJ-RigPi allows you to remotely control almost any modern ham radio transceiver. It's a radical new way of station control using a server. It allows multiple users and radios to interact simultaneously using any internet browser. The RigPi sells for £299.95 and is available from MFJ UK distributor, Waters & Stanton, located in Portsmouth. For more details see www.hamradiostore.co.uk The photo shows Phil Jeffery (W&S Commercial Manager) with Martin Jue, founder of MFJ, holding the new RigPi at the recent Dayton Hamvention.

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Two new antenna products

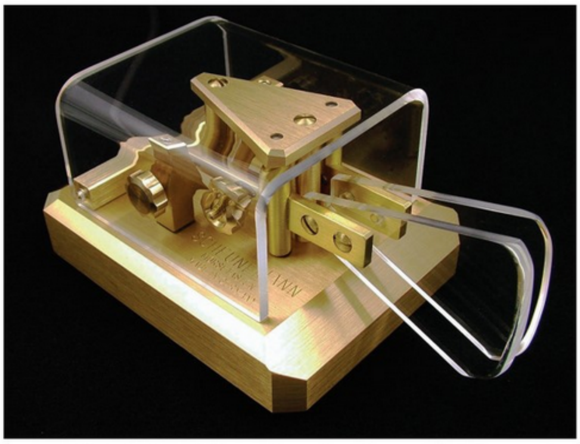
LAM Communications are stocking two new antenna products. The Skypole MAX, a heavy duty telescopic fiberglass pole for reaching heights up to 10m, has a collapsed length of 1.82m and a holdall is included. The poles are strong, can be guyed and are easy to use. They are constructed of high quality composite materials and finished with an acrylic resin with a standard plastic base cap fitted. They cost £329.95. The Skypole Junior extends to 6m with a collapsed size of 1.8m, again with a holdall. It costs £199.95. You can read more on these antennas on the LAM Communications website, https://www.hamradio-shop.co.uk/

Expert Electronics SunSDR2DX

Martin Lynch & Sons are stocking a new direct sampling HF/6m/2m transceiver with 100W on HF, 50W & 8W on 2m, the SunSDR2DX. It is small and compact and is based on the SunSDR Pro. It has a separate connector for cooling and improved supply system so could be well suited to DXpeditions. It also has separate connectors for a GPS/GLONASS antenna and external ATU. The SunSDR2DX will be available in the autumn. For further details see HamRadio.co.uk/SunSDR2DX

New Morse keys

Moonraker are now importing the Scheunemann range of Morse keys. The first to arrive is the Scheunemann Morse Dirigent twin paddle (Dirigent is German for 'conductor'). The Dirigent features a sleek new style with tapered front and separate tension adjustments for the two levers. It comes complete with tilt-open dust cover and connection cable. Large adjustment knobs for contact spacing and spring tension allow precision adjustment while preserving stability. Adjustments can be made by hand and there is no need to touch the locking screws. The contacts are convex and formed from highly-conductive coin silver. The hand-finished finger pieces are shaped for maximum comfort while preserving precise control. The base is machined from a solid block of MS-58 surgical-quality brass and is coated with a polymer that resists wear, staining, and pitting over a lifetime of use. Scheunemann paddles are supplied with an internally installed cable with stripped/tinned leads for easy installation of a connecting plug. Other stock will be added to the range as it arrives. Scheunemann Morse Dirigent costs £299.94 and more details can be found at www.moonraker.eu



WOLFWAVE Upgrade

The WOLFWAVE advanced audio processor already has bandpass filtering, noise reduction and age-related hearing correction. In a major upgrade, SOTABEAMS has added an effective Morse decoder that can decode signals from 1 to 100 words per minute. In another new addition, professional musician Chris Rolinson, G7DDN, has composed a 'startup' sound for WOLFWAVE, based on 'WW' in Morse code. Chris' composition can be heard at https://clyp.it/lw5qoigs. WOLFWAVE users can all benefit from the upgrades at the firmware page at http://www.wolfwave.co.uk/firmware. The Wolfwave advanced audio processor costs £237.50 and more details can be found at www.sotabeams.co.uk

• DMR Digital Mobile Radio

AT-D578UV DMR Dual Band Mobile Radio

Frequency Range:
Dual Band
136~174 & 400~480MHz;
66~88 &136-174MHz
Tri-band(for US only)
136~174 & 220~225 & 400~480MHz;

Function:
- Working Mode: Full duplex on UU, UV, VV, VU. Dual RX(Analog+DMR or Analog+Analog)
- **True-2-slot: Provide 2-slot communication which allows for 2 talk paths on 1 frequency; ETSI DMR Tier I and II compliant**
- Power: VHF 60W/25W/10W; UHF 50W/25W/10W
- Auto-senses digital or analog reception
- 4000 channels + VFO; 10,000 Talk groups with 200,000 digital contacts
- Support Contact Manager
- Display: 1.77 inch TFT color LCD, dual display; dual PA; dual PTT
- Bandwidth: 12.5K/25K (Analog); 12.5K (DMR)
- Weather Alerts
- VOX Function; Digital Recording and Play
- DTMF/2TONE/5TONE encode and decode
- AES256 digital encryption; Zone selection
- SMS via keyboard
- Crossband repeter function
- Ranging function between radios with GPS
- Roaming function; Talker alias function
- Emergency alarm (with GPS data transmission)
- IP connect to Motorola Repeater
- Duplexer Talk(Optional)
- Call interrupt(Optional)

Remote Control BT Mic with 2.4 inch color LCD (optional)
Allow the radio installs at any place of the car, all operations can be done by BT microphone.

AT-D578UV GPS
+ GPS/APRS

AT-D578UV BT
+ Built-in BT + BT PTT

AT-D578UV RC
+ Built-in Recording

AT-D578UV PLUS
+ GPS/APRS
+ Built-in BT + BT PTT
+ Air band etc.

Mobile with Bluetooth

Moonraker will be stocking the new Anytone AT-D578UV. The plus version features DMR/analogue FM, APRS/digital APRS, and Bluetooth and much more. It is fully compatible with modern car Bluetooth helping to provide safe mobile comms. Moonraker will program the radios with the Moonraker code plug for DMR and FM use. The price will be announced shortly on the Moonraker website, www.moonraker.eu and they are hoping for the first delivery to be in time for the National Hamfest on 27 and 28 September.

Antennas

Mike Parkin, G0JMI
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The cubical quad beam antenna

The theme for this month is the cubical quad, another form of beam antenna whose use is often encountered on the HF bands.

Background

The April Antennas column described how an electrical wavelength (λ) of wire can be formed into a square to make a resonant antenna. If a second similar square loop in added behind this loop, this forms a two-element beam antenna that is usually referred to as a cubical quad.

This form of wire beam antenna was developed in the 1940s by Clarence Moore, W9LZX. When using his Yagi beam at a high altitude and at high power, W9LZX found it suffered from problems associated with corona discharge. W9LZX reasoned that the closed loop elements of a cubical quad would tend not to suffer from such problems because they avoid the high static voltages associated with the ends of a Yagi beam's elements **[1]**.

A cubical quad beam can be more straightforward to build when compared to a Yagi beam. Consequently, the Cubical Quad beam is often favoured by antenna home-constructors.

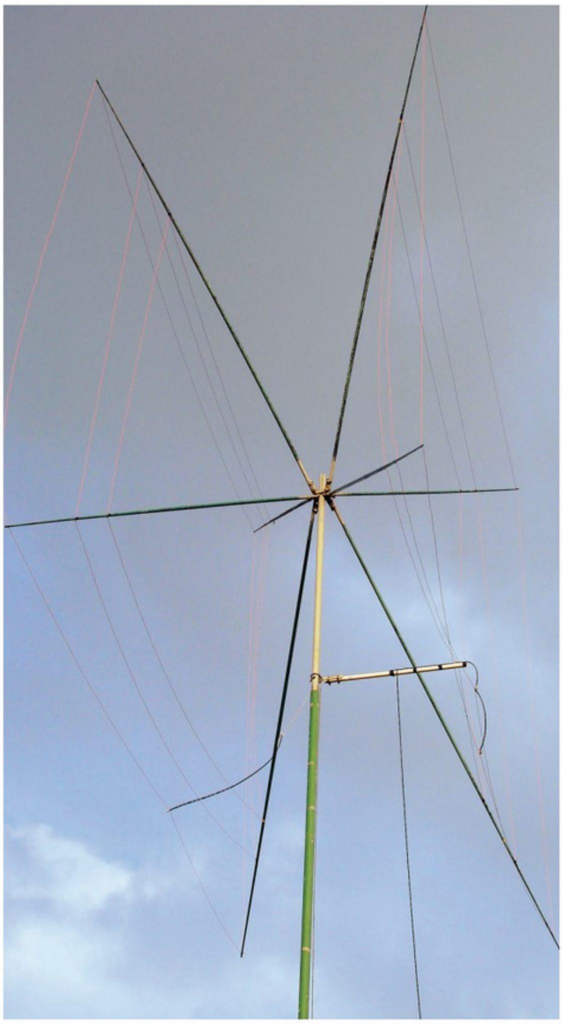


PHOTO 1: An HF multi-band cubical quad in use. Photo by Peter Dodd, G3LDO (now SK).

Cubical quad overview

The cubical quad is a parasitic beam whose elements consist of closed wire loops having a circumference based on one electrical wavelength at the design frequency **[2]**. The antenna can be arranged in either a square or diamond configuration and the concept of a 2 element quad beam is shown in **Figure 1**.

Referring to Figure 1, when the antenna is fed as shown it is horizontally polarised. Feeding the antenna at the alternative feed point gives vertical polarisation. In the square configuration, the driven element can be thought of as two dipoles spaced at a quarter wavelength apart with their ends bent over and touching. Similarly, in the diamond configuration the driven element can be considered as two dipoles in a 'V' formation with their ends touching. Both configurations are examples of stacked dipoles, giving a gain of about 1dB over a two element Yagi beam. The antenna has a balanced feed point and this necessitates the use of a 1:1 balun **[3]** when coaxial cable is used as the feeder to the antenna.

As guide to construction, the approximate lengths for a two element quad in metres (m) are given by:

$$\text{Driven element } (\text{m}) = \frac{304}{f}$$

$$\text{Reflector element } (\text{m}) = \frac{311.5}{f}$$

where f is the frequency in MHz. In practice, the quad's elements should be made slightly longer and adjusted by altering their lengths to obtain the design frequency.

The reflector needs to resonate at a slightly lower frequency than the driven element. This can be done by making the reflector's loop about 2 to 3% longer than the driven element's loop. This is taken into account in the above formulae. Alternatively, the reflector can be made the same size as the driven element and tuned using a stub, as shown in Figure 1. The stub can also be adjusted to obtain the best front-to-back (F/B) ratio for the beam. The dimensions given in **Table 1** are for a cubical quad using an element spacing of 0.125λ, giving a feed point impedance close to 50Ω. However, as an alternative, using an element spacing of 0.14λ gives a feed point close to 70Ω **[4]**. The MMANA-GAL computer modelled free-space performance prediction is shown in **Figure 2**, where a gain of around 5.5dBd and a F/B ratio of about 7dB are predicted.

Table 1 provides guidance for the dimensions for 2 element quads for the 20m to 10m bands, designed in the form shown in **Figure 3**. The distance between the insulated element support points are included within Table 1 (as dimension ES). The physical lengths of the element supports should be made slightly longer because dimension ES is the required spacing.

The element supports were traditionally made from bamboo poles, although the use of fibreglass poles has now become more common. The main disadvantage of these materials is that they can be easily damaged by crushing at the clamping point. To avoid damaging the element supports' ends, a separate clamp can be made up using aluminium L-section. The length of the aluminium L-section depends on the physical size of the antenna to be supported. For a conventional 2 element HF quad a 1m long length of aluminium

L-section is usually suitable. Four clamps are required for a 2 element HF quad, with two clamps used to hold each loop's element supports in place. Two holes are drilled at the centre of each clamp to take the size of the U-bolt to be used to attach each clamp to the boom. Each element support is divided into two, with each half fixed to the ends of the aluminium L-section using hose clips as shown in **Figure 4**. Rubber or plastic tubing cushions can be used to prevent the clamps damaging the element supports' ends.

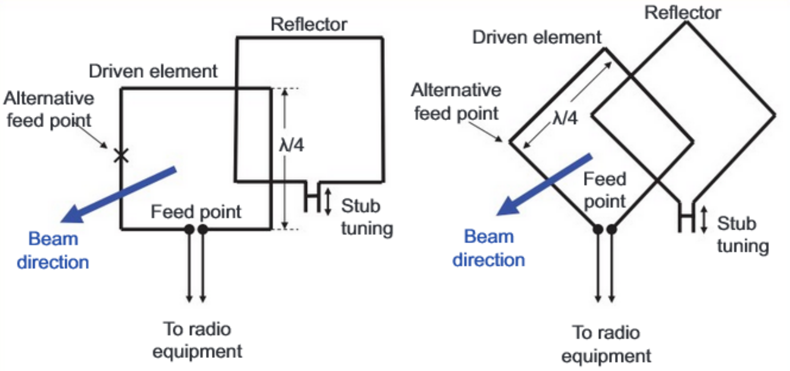


FIGURE 1: Concept of a two element cubical quad.

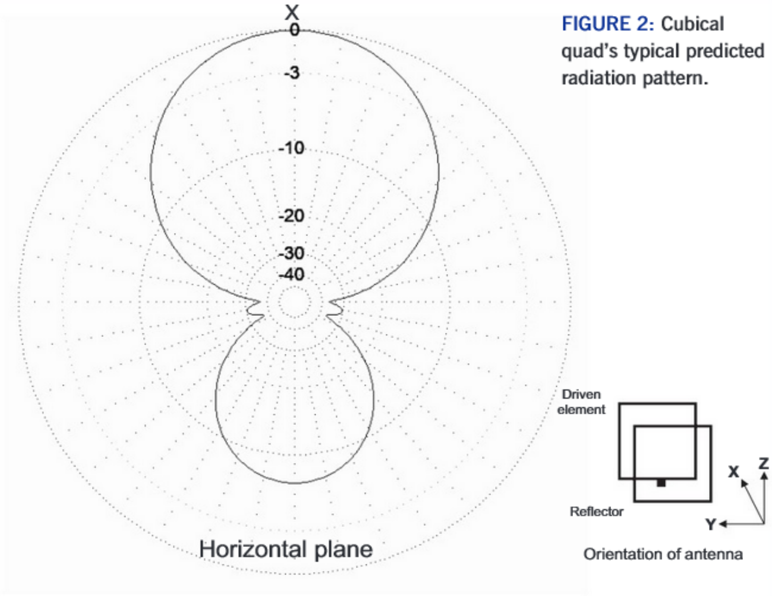


FIGURE 2: Cubical quad's typical predicted radiation pattern.

Multi-band cubical quad beams

The quad can be made into a multi-band antenna by interlacing quad loops for the different bands onto a common support structure. In this case, the length of the element supports should fabricated to carry the lowest frequency band loop. The disadvantage of this arrangement is that the wavelength spacing between the driven element and the reflector is different on each band. This problem can be overcome by using an element support structure with a modified geometry. This structure, which is devised to hold the element supports in place at the correct angles, is often referred to as a 'spider' and an example is shown in **Photo 1**. This layout requires the element supports to be longer compared to the previous arrangement.

To minimise the interaction between the beam antennas, the usual practice is to feed each driven element using separate feeder cables. Alternatively, a single feeder cable can be used, which is switched between each driven element using a suitable feeder cable relay switch.

Reader feedback: more on loaded antennas

The December 2018 and January 2019 Antennas columns summarised how the range of a λ/2 dipole or doublet can be extended to a lower frequency by connecting loading coils and extension wires at each end of the antenna as shown in **Figure 5**. This retunes the antenna allowing it to resonate at a lower frequency, so enabling operation on a lower band. For example, a dipole intended for use on 40m can be loaded to enable it to also resonate on the 80m band. This provides a means to be active on the 80m band using a much shorter antenna compared to installing a λ/2 dipole.

Nick Ward, G7OVM, has suggested an alternative approach to calculate the length of each extension wire (shown as Ext wire in Figure 5) and so the value of each loading coil required. This approach uses the vertical antenna capacitance equation **[5]**, which can be applied to conductor lengths up to an electrical λ/4. The equation is used to calculate the capacitance of each extension wire and dipole leg. Their capacitive reactances can then be determined and subsequently the inductance required can be found from these as follows:

$$C_A\,(\mathrm{pF}) \approx \frac{55.774 \times L}{\left(\ln\left(\frac{2000 \times L}{D}\right) - 1\right) \times \left(1 - \left(\frac{f \times L}{71.43}\right)^2\right)}$$

where CA is the wire's capacitance (pF), L is the wire's length in metres (m), D is the wire's diameter in millimetres (mm), f is the frequency (MHz) and Ln denotes using natural logarithms. Note that this is a metric version of the equation referred to in [5].

Using the doublet antenna in the January 2019 Antennas as an example, where the each doublet leg's length was 10.1m, each extension wire was 1.64m long, the wire's diameter was 1.6mm and f was 3.65MHz:

For each extension wire at Point A in Figure 5:

$$C_A\,(\mathrm{pF}) \approx \frac{55.774 \times 1.64}{\left(\ln\left(\frac{2000 \times 1.64}{1.6}\right) - 1\right) \times \left(1 - \left(\frac{3.65 \times 1.64}{71.43}\right)^2\right)}$$

$$\approx 14\mathrm{pF}$$

Each extension wire's reactance (X_{EW}), is

$$X_{EW} \approx \frac{1}{2\pi \times 3.65\mathrm{MHz} \times 14\mathrm{pF}}$$

$$\approx 3115\Omega$$

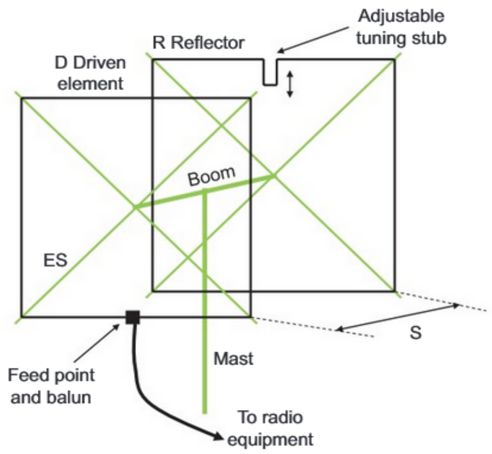


FIGURE 3: Concept of the physical layout of a cubical quad.

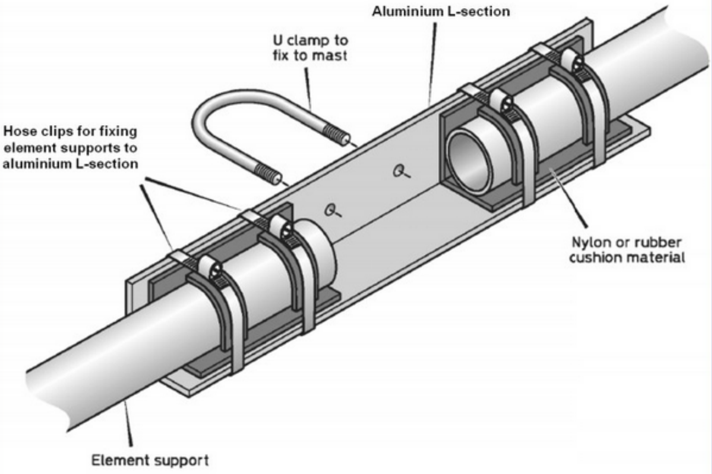


FIGURE 4: Element support (ES) clamping arrangements.

For each leg of the doublet at Point B in Figure 5:

$$C_A\,(\text{pF}) \approx \frac{55.774 \times 10.1}{\left(\ln\left(\frac{2000 \times 10.1}{1.6}\right) - 1\right) \times \left(1 - \left(\frac{3.65 \times 10.1}{71.43}\right)^2\right)}$$

$$\approx 91\text{pF}$$

Each doublet leg's reactance (X_{Leg}), is

$$X_{Leg} \approx \frac{1}{2\pi \times 3.65\text{MHz} \times 91\text{pF}}$$

$$\approx 479\Omega$$

The value of each loading coil's reactance (X_{EW}) can now be determined from

$$X_{EW} \approx \frac{2636\Omega}{2\pi \times 3.65\text{MHz}}$$

$$\approx 115\mu\text{H}$$

The calculation using the transmission line technique described in the January 2019 Antennas column gave a result for each loading coil as approximately 110μH. The vertical antenna capacitance technique has given a result of approximately 115μH and compares well with the previous calculation.

In practice, when installing a loaded dipole/doublet, the antenna usually needs to be tuned to obtain the desired lower frequency required. This is because any close objects in the vicinity of the antenna can tend to influence its resonance. Consequently, using loading coils of either 110μH or 115μH should not present too much of a difficulty because the length of the extension wires can be equally adjusted, at each end of the antenna, to tune the antenna to the desired lower operational frequency.

Thanks for the suggestion, Nick.

References

ARRL Antenna Book 23rd edition, edited by H W Silver, N0AX:
[1] Chapter 11 HF Yagi and Quad Antennas, Section 11.8, pages 11-30 to 11-39
[5] Chapter 21 Mobile and Maritime HF Antennas, pages 21.2 to 21.3

RSGB *Radio Communication Handbook*, 13th edition:
[2] Section 15, Practical HF Antennas, pages 15.35 to 15.38
[3] Section 14, Transmission Lines, pages 14.12 to 14.15

RSGB *Radio Communication Handbook,* 5th edition:
[4] Chapter 12 HF Aerials, pages 12.76 to 12.77

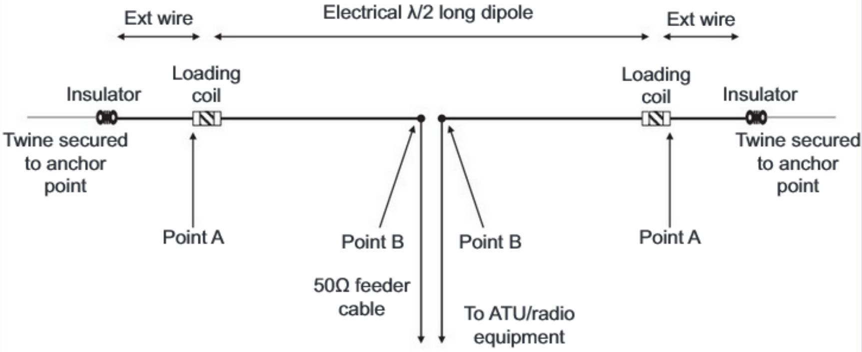


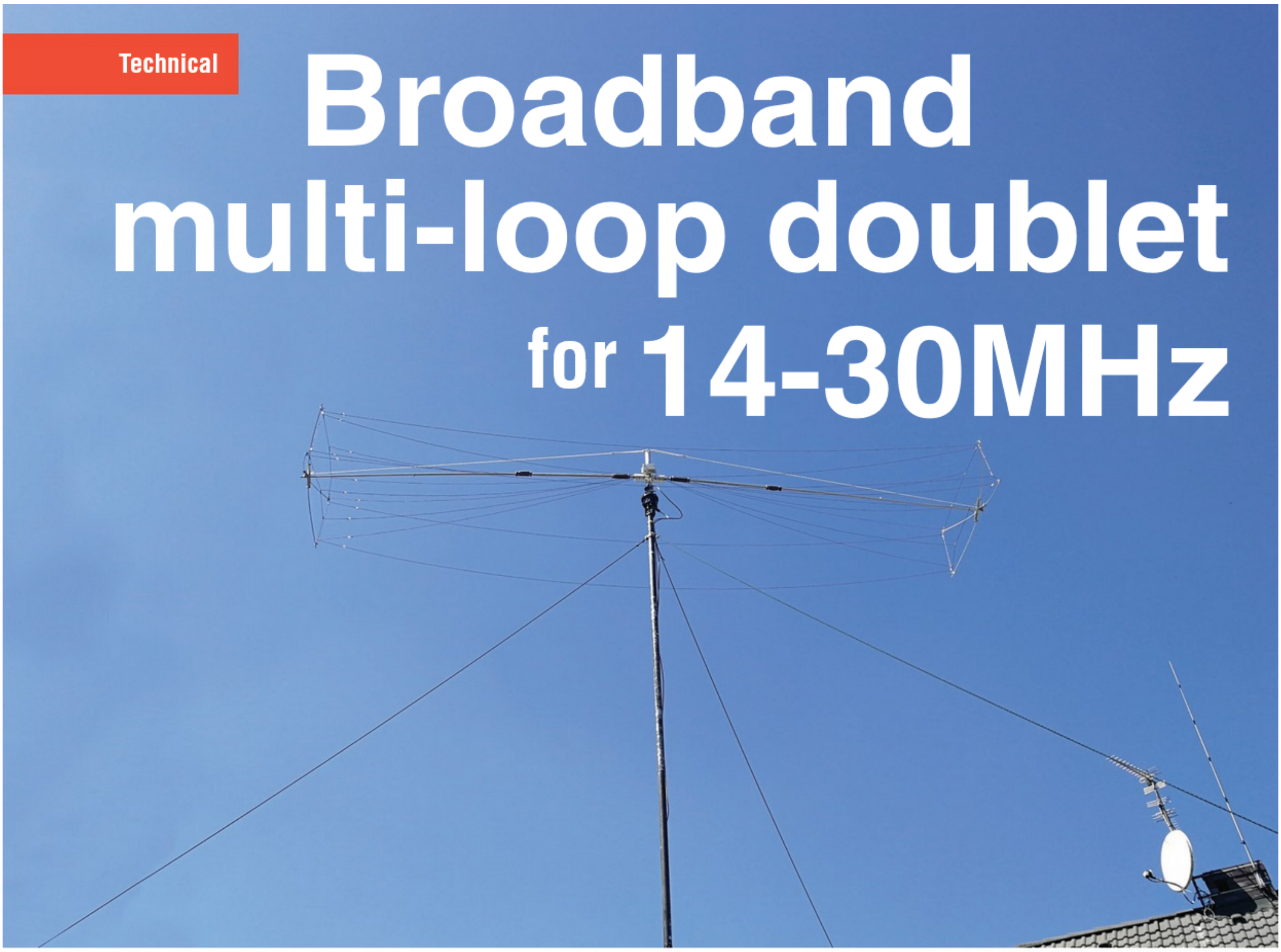
FIGURE 5: Concept of using loading coils and extension wires to increase the operating range of a λ/2 dipole or doublet antenna.

TABLE 1: Dimensions for a two-element quad beam for the upper HF bands using 1.6mm diameter wire. Refer to Figure 3 for D, S, R and ES. Dimensions calculated using MANNA-GAL, giving a free-space gain of around 5.5dB.

Frequency, MHz	14.2	18.14	21.25	24.96	28.50
(S) Element spacing (m)	2.64	2.07	1.77	1.50	1.32
(R) Reflector length (m) ‡	5.47	4.20	3.66	3.12	2.73
(ES) Element support length (m)	3.87	2.97	2.59	2.21	1.93
(D) Driven element (m) ‡	5.35	4.28	3.58	3.05	2.67

‡ Note that these dimensions are for one side of the quad. The total length of the element is *four times* this figure.

Broadband multi-loop doublet for 14-30MHz



Introduction

My garden is not large and my antenna mast is so constructed that it is difficult to move an antenna up and down without a help of several fellow hams. So, it's no wonder that I wanted a small but broadband antenna that could be hoisted once and left on the rotator at the top of the mast without any trimming. Moreover, I wanted an antenna with horizontal polarisation. I already have a multiband vertical antenna in the corner of my garden but this antenna is electrically quite noisy. So, I needed a physically small antenna with horizontal polarisation, with a gain comparable to a dipole and large bandwidth to avoid trimming. There are not too many such antenna designs out there. When antennas are shrunk to fit in limited space, they almost always suffer from reduced gain and narrow bandwidth. This is especially true for multi-band designs. The Multi-Loop Doublet is an interesting exception from that rule. It is compact and yet provides surprisingly good performance from 14-30MHz.

Jacek Pawłowski, SP3L
sp3l@wp.pl

PHOTO 1: The aluminium structure of the antenna can be assembled even in a small backyard.

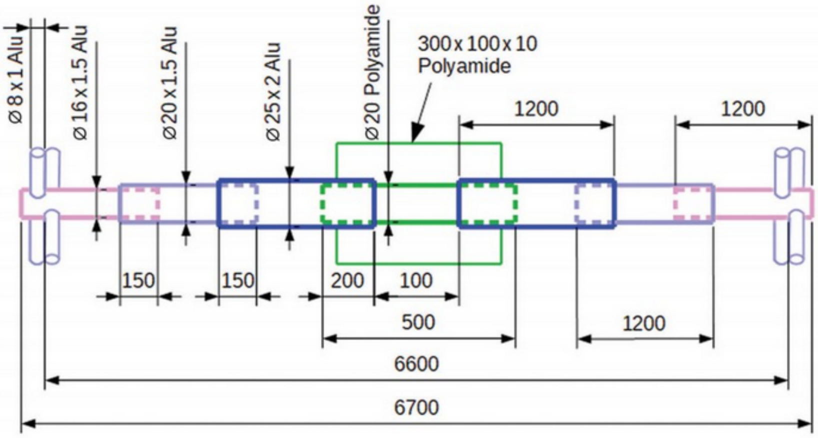


FIGURE 1: Dimensions of the aluminium tubing in millimetres. Drawing not to scale.

PHOTO 2: Central part of the antenna structure. A polyamide plate and rod as well as U-clamps were used to join the two legs of the doublet.

PHOTO 3: Two crossing tubes are attached to the end of every leg. They will support a copper wire frame 0.6m high and 1.2m wide.

PHOTO 4: Centre of the end-frame.

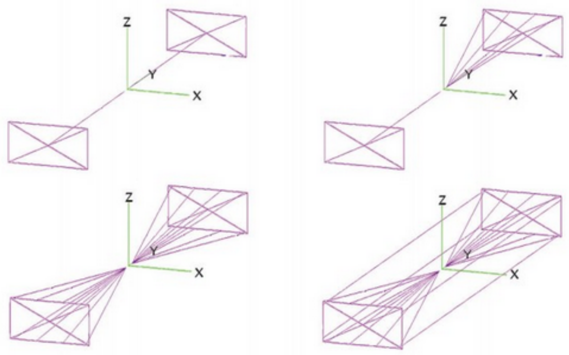


FIGURE 2: How to route the wires in the Multi-Loop Doublet.

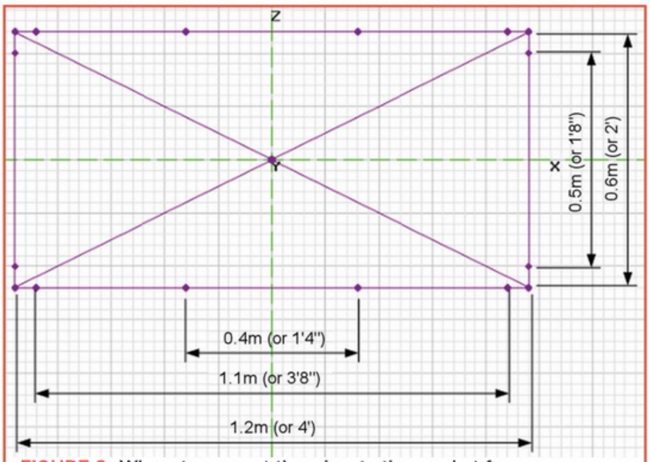


FIGURE 3: Where to connect the wires to the cap-hat frames.

Mechanical design

The Multi-Loop Doublet is made from aluminium tubes and copper stranded wires. Theoretical antenna dimensions are 6.6 x 1.2 x 0.6m (22' x 4' x 2') but when making it, one must add some mechanical margins. So, its real dimensions are larger by about 50mm (2"). Such compact size of the doublet allows you to assemble it even in a small back yard.

In this article, I am using a simplified formula to convert metric to imperial units. Instead of the precise formula 1ft = 0.305m, I am using 1ft = 0.3m. And instead of 1 inch = 25.4mm, I am using 1 inch = 25mm. If you follow imperial unit dimensions rather than metric, your Multi-Loop Doublet will be 1.7% larger than mine. This is absolutely acceptable for this particular antenna because its performance is not very sensitive to its size. But you should not do that when converting dimensions of resonant antennas.

The main structure of the antenna is made of aluminium tubes. If we forgot about the wires, the antenna would look like a regular dipole with a feed point in its centre and two capacitance hats on its ends. The tubes forming those 'cap-hats' cross at 26.5 degrees, so that their ends can support a rectangular wire frame 0.6m (2') high and 1.2m (4') wide. **Photos 1, 2** and **3** show the antenna under construction and **Figure 1** shows the dimensions of the tubes and the polyamide components.

The thickest tubes are 25mm in diameter. You may start with 1 inch tubes if only such ones are available in your country and select appropriately thinner ones for the rest of the doublet legs. All the tubes used for creating the antenna legs are 1.2m (4') long. The thinnest tubes used to stretch the end-frames ('cap-hats') are 1.5m (5') long. Those were the standard lengths in the online shop from where I ordered them. Such short tubes make it really easy to prepare them for the final assembly. You can do that even in a tiny workshop or in a garage.

The vertical pole is 50mm (2") in diameter and about 0.9m (3') long. That was a tube I already had. But you may prefer to use a longer tube, for example 1.2m (4'). That will makes it easier to stretch the ropes pulling up the antenna ends. The pole also serves as a support for the balun enclosure.

PHOTO 5: Leg tubes were slipped one into another and secured not only with hose clamps but additionally with rivets. Riveting is pretty simple if you have riveting pliers and use suitable aluminium rivets. Be aware that rivets can start to work loose after a period of time swaying in the wind.

PHOTO 6: How the wires were connected to one another.

Once you have rectangular wire frames created at the ends of the legs, you connect four wires between the feed point and the top and bottom horizontal wires of end-frames. Finally, the corners of the opposing end-frames are connected with 6.6m (22') long wires. It sounds a bit complicated, so I created a drawing explaining this idea step by step. See **Figure 2**. **Figure 3** shows where exactly you should connect the wires to the end-frames.

Various types of clamps were used to mechanically join all components of the antenna. Additionally, I used riveting as a way of securing that the antenna will not warp and the tubes will not slide one into another. **Photos 4, 5, 6, 8 and 8** document my approach.

The four bulges on the antenna legs looking a little bit like traps are in fact four pieces of tube insulation. I put them there to be sure that the copper wires will not get in direct contact with aluminium tubes, which could trigger galvanic corrosion. Your antenna can do quite well without them.

PHOTO 7: A small aluminium plate and a galvanised steel clamp create a corner of the end frame. Do not forget to use Cu-Al washers in all spots were copper wire would touch aluminium plate or tube. Also be aware that the clamps may degrade over time.

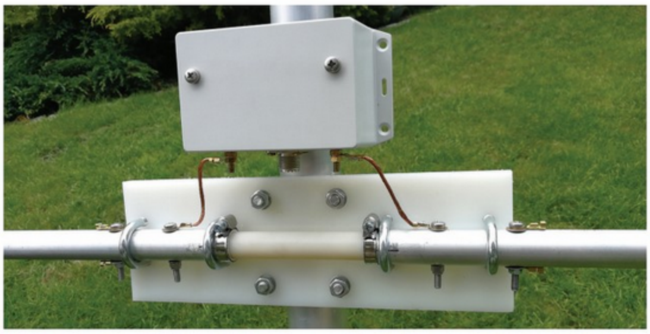


PHOTO 8: The antenna feed point. The balun is attached to the vertical pole with two plastic clamps. Note that Al-Cu washers were used in all the points were an aluminium component contacted copper wire.

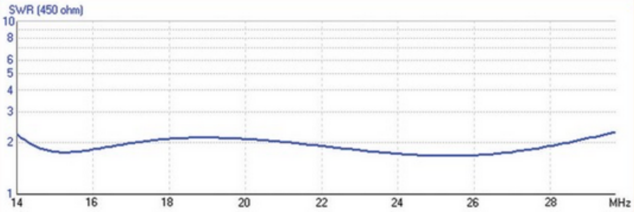


FIGURE 4: Multi-Loop Doublet SWR simulated in free space.

Electrical design and performance

The Multi-Loop Doublet is a result of many hours of computer modelling. My goal was to design an antenna of small size, mass and wind load without sacrificing too much gain and bandwidth performance.

I think you will agree that the size is quite OK. The antenna length (6.6m) is closer to a 25MHz dipole rather than 14MHz band dipole.

To keep the antenna wind load as low as possible, I made the doublet height just 0.6m (2ft). Going lower than that would increase SWR. If you do not care too much about the wind load, you may improve the already quite good SWR performance by doubling antenna height to 1.2m. In such case, the end-frames would be rather square than rectangular.

I do not know exactly how heavy the Multi-Loop Doublet is but I was able to lift it with one hand. So, I guess its mass is 5-7kg (10-14 pounds).

The antenna SWR simulated at its feed point is presented in **Figure 4**. In free space it varies very little in the 14-29.7MHz range – from 1.7:1 to 2.3:1. You will need a 9:1 balun to match this antenna to a 50 coaxial cable. I used a Guanella type balun, built on three FT140-61 cores. Its schematic is shown in the **Figure 5** and its construction details are shown in **Photo 9**. All three transformers were threaded on a short piece of a PVC tube and the tube was fixed in the enclosure with two screws. Copper stranded wire in high voltage isolation was used to wind all three transformers. Eight turns were required.

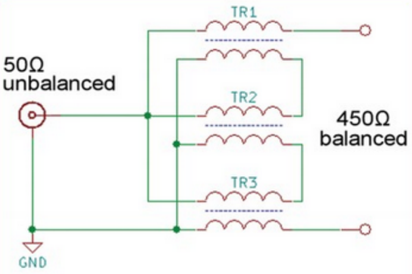


FIGURE 5: The 9:1 Guanella balun used in the Multi-Loop Doublet.

Figure 6 reveals the simulated gain of the antenna. It changes from 1.77dBi at 14.0MHz to 2.79dBi at 29.7MHz. The antenna has slightly smaller gain than a half wave dipole up to 19.5MHz, slightly higher above this frequency. Even if you take into account losses in the coax, the

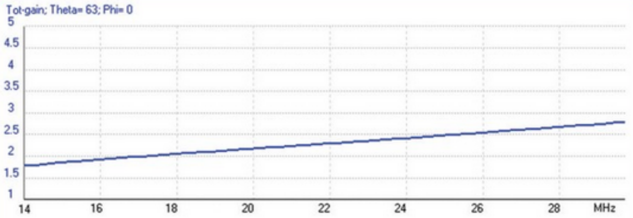


FIGURE 6: Antenna gain simulated in free space.

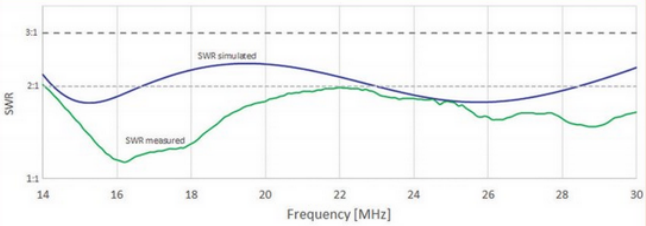


FIGURE 7: Simulated and measured SWR in the whole range. Note: when measured, the antenna was fed with 40m of low loss coaxial cable similar to RG-213.

Multi-Loop Doublet with a typical length of a feed line should not be more than 1dB below a dipole at 14MHz. Such difference is virtually undetectable on the short wave bands.

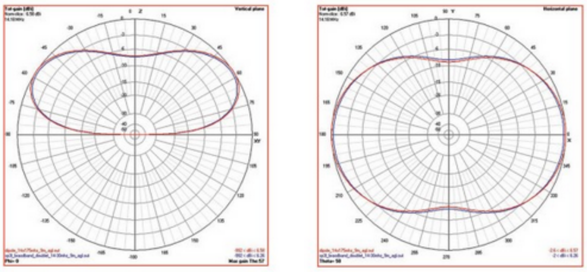
Figure 7 compares the simulated SWR with the actual measurements. Please note that for the purpose of the comparison, this time the antenna was simulated not in free space but installed 9m above average ground. In such conditions, its maximum theoretical SWR increased from 2.3:1 to 2.4:1. The simulation proved that the installation height had little effect on SWR.

The actual SWR measured at the transceiver end of the feed line agreed quite well with computer model but with some shift to higher frequencies. I think three things may be accountable for that. I did the simulations with all wires being made of 2mm diameter copper, but the real antenna has some of them made with thicker aluminium tubes. Also, some deformation of the antenna shape happened near its end-frames. Due to tension from hanging wires, the end-frames were pulled towards the centre of the antenna. You may see this deformation in **Photo 10**. In this way, the Multi-Loop Doublet became a little shorter than its calculated length. Finally, in my simulations, I neglected the losses in the balun. It is not easy to include them when modelling the antennas.

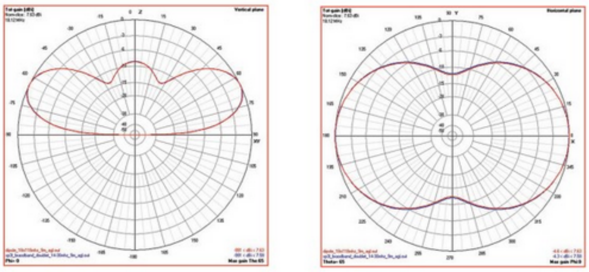
Naturally, the actual SWR measured near the transceiver had to be lower than that at the feed point because the real feed line is not lossless. In my case, with my RG-213 type coaxial cable, the SWR was reduced to 2.1:1 and lower. In practice, you can use the Multi-Loop Doublet with a transceiver not equipped with antenna tuner and be confident that you will not destroy your radio. However, if your transceiver has an ATU, it is always better to switch the tuner on. This will reduce the power dissipated in the final amplifier.

The Multi-Loop Doublet bi-directional radiation patterns are very similar to the half wave dipole patterns. At higher bands the lobes become slightly narrower and stronger – and that is what one expects from a doublet. You can see all that in **Figure 8 A-J** in which the doublet is compared to half wave dipoles installed 9m (30') above the ground.

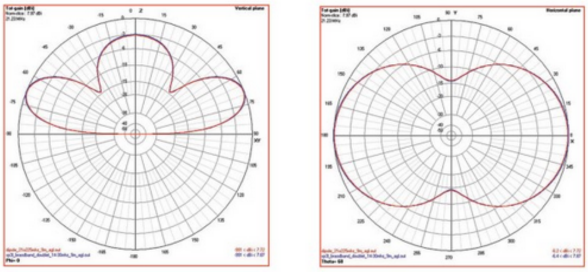
The antenna worked as expected from the very beginning. It did not require any trimming and once I had programmed the internal antenna tuner in my transceiver, I still haven't had to re-tune in the six months or more that I have been using the Multi-Loop Doublet.



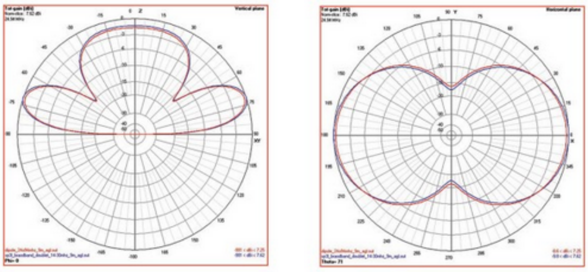
A, B: 14.18MHz, norm-slice 6.58dBi. Left: V plane, right: H plane.



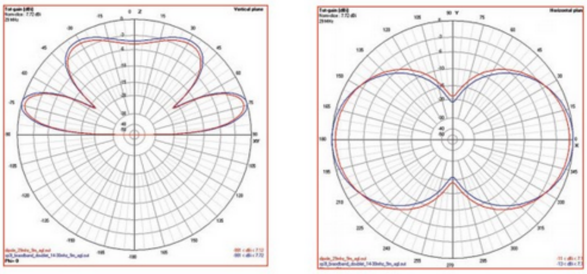
C, D: 18.12MHz, norm-slice 7.63dBi. Left: V plane, right: H plane.



E, F: 21.23MHz, norm-slice 7.87dBi. Left: V plane, right: H plane.



G, H: 24.94MHz, norm-slice 7.62dBi. Left: V plane, right: H plane.



I, J: 29MHz, norm-slice 7.72dBi. Left: V plane, right: H plane.

FIGURE 8 A-J: Radiation patterns of the Multi-Loop Doublet (blue) compared to half wave dipoles (red) simulated 9m (30') above average ground.

The other antenna I could compare the Multi-Loop Doublet with was my 7-band ground plane vertical. The doublet had always better signal-to-noise ratio, what is quite normal when a horizontally polarised antenna is compared to a vertically polarised one. In my case, the noise floor was often reduced by as much as 2 S-points (12dB). It happened that I had worked a DX station on the doublet and when I switched to the GP, I could hear nothing but noise on the frequency.

Moreover, the Multi-Loop Doublet TX signal is stronger by about 1 S-point. That's also a difference predicted by theory if only the doublet is 1/2 wavelength or higher above ground. This 1 S-point (6dB) is a huge difference when you try to make a contact with a distant station. I have been using the Multi-Loop Doublet successfully on all 5 bands from 20 to 10m for more than six months now and despite poor propagation I was very happy with it. For example, having only 100W output, I was able to break through a pile-up and make a contact with KH7.

The Multi-Loop Doublet has already survived a few really windy periods without any problem. So, I think it is not too delicate. Thicker tubes would make it stronger but heavier and I did not want to do this.

Conclusion

The Multi-Loop Doublet is a compact broadband antenna that you can assemble in a small back yard or even on a flat roof of your building. Its longest segments are only 1.5m (5') long so you can pre-manufacture them almost anywhere. Hoisting it is easy because of its small mass. Additionally, its load wind is not high. In consequence, a heavy-duty rotator is not required for this antenna. Something smaller, lighter and cheaper would do.

Right after final assembly it works without any trimming and its SWR on 5 amateur bands is so low that, in most cases, you will be able to use it with a solid state transceiver not equipped with internal antenna tuner. The Multi-Loop Doublet performs like a half wave dipole on any frequency in the 14-30MHz range. For best performance, mount it 9m (30') or higher above the ground.

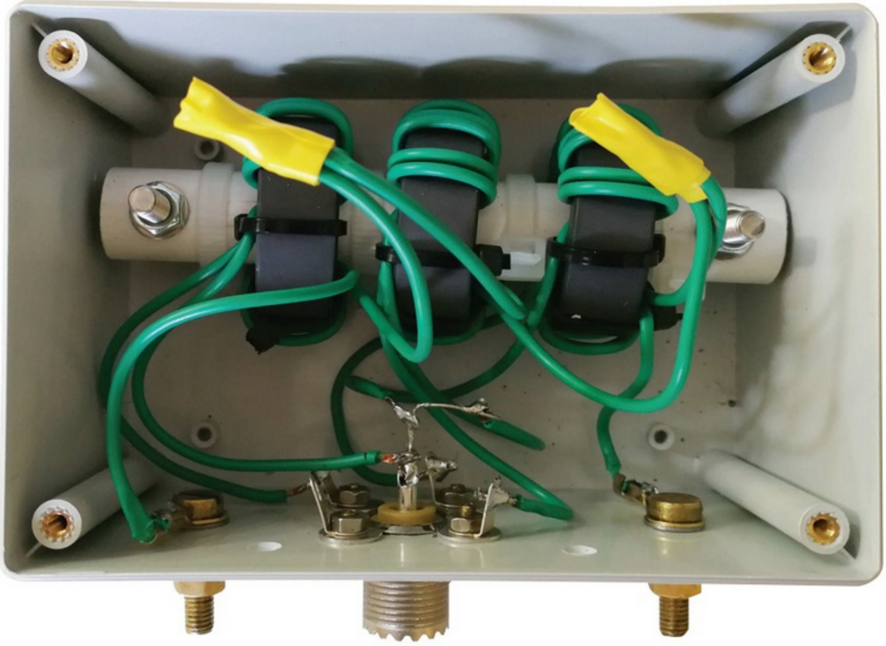


PHOTO 9: Details of the balun assembly.

PHOTO 10: Tension from hanging wires slightly deformed the end structures, this made the antenna electrically shorter. That partially explains the shift of the real vs simulated SWR.

Bill of materials

1 x	Al tube 0.9 … 1.2m x 50mm OD
2 x	Al tube 1.2m x 25mm OD
2 x	Al tube 1.2m x 20mm OD
2 x	Al tube 1.2m x 16mm OD
4 x	Al tube 1.5m x 8mm OD
1 x	Al plate 1000 x 30 x 2mm
1 x	Polyamide PA6 rod 0.5m x 20mm dia
1 x	Polyamide PA6-G plate 10 x 100 x 300mm
2 x	U clamp, M8, 50mm dia
4 x	U clamp, M8, 26mm dia
8 x	Rope clamp, 8mm dia
4 x	Hose clamp, 16-27mm dia
2 x	Hose clamp, 12-22mm dia
4 x	M5x45 DIN 7985 stainless steel bolt
4 x	M5x30 DIN 7985 stainless steel bolt
6 x	M5x20 DIN 7985 stainless steel bolt
24 x	M5 DIN 125 A2 stainless steel flat washer
12 x	M5 DIN 982 A2 stainless steel self-locking nut
12 x	Cu-Al ACP 5-1 washer
16 x	Eye terminal, 5mm dia
26 x	Zinc-plated double wire rope clamp
	90m 2.5mm^2 (#13 AWG) Cu stranded wire
1 x	ABS plastic enclosure for balun
3 x	FT140-61 ferrite toroid core
3m	Cu stranded wire with HV isolation
1 x	SO-239 connector
4 x	M3x15 DIN 7985 stainless steel bolt
4 x	M3 DIN 982 A2 stainless steel self-locking nut
4 x	Eye terminal 3mm dia
1 x	PVC tube 100mm x 20mm OD
2 x	Plastic U clamps, 50mm diam
1 x	M8 eye bolt
1 x	M8 eye nut
16m	UV-stabilised polypropylene sailing line 6mm dia (for stay between mast top and element ends)
600mm	Pipe insulation
8 x	Cable ties

Earth-electrode LF & MF ‘antenna’ in the ground

Introduction

For some years I have had some success on the LF and MF bands with this hidden antenna. In fact, I have used it up to 60m, although this high it is debatable how much radiation comes from the loop in the ground and how much comes from the connecting wire. Unlike many LF and MF antennas, the neighbours and XYL don’t even know it is there!

How it works

My theory is this structure acts like a loop in the ground. Accordingly, it should get better at even lower frequencies and indeed Stefan, DK7FC has had great success with this sort of antenna at VLF and ULF. One of the German VLF amateur grabbers also uses such a structure.

Now, I am not a believer in ‘snake oil’, but this antenna definitely works. I am sure bigger, better antennas and ground systems will give better results, but *never* say you don’t have the space for a 472kHz or 1.8MHz antenna! Another positive, here at least, is a very low noise floor on receive. In some situations, this antenna may help. I have been amazed by results that *far* exceeded expectations, especially on 160m where my 2.5W from the FT-817ND has exceeded 1000km range many times on FT8.

Figure 1 shows the general arrangement I’ve used at my present home. At the old QTH the step-up transformer was *not* needed. Basically, the shack end ground uses the mains earth, although you need to check this is OK at your home (take the advice of a competent electrician on whether your domestic electrical system is safe in this configuration: the rather-common PME earthing systems are *not* suitable).

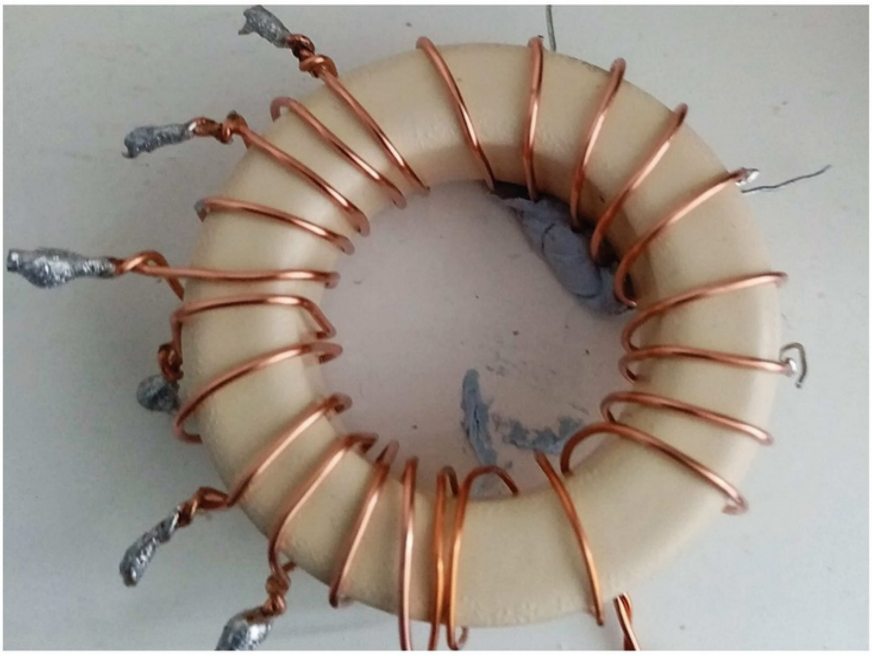


PHOTO 1: **The prototype 3C90 coil, tapped at various points to permit testing at different turns ratios.**

After the step-up transformer, the interconnecting hook-up wire (about 12m long) runs along the garden fence to an earth stake about 1m long driven into the soil. Within reason, the greater separation you can get between the two earth electrodes the better. Even with an earth stake outside my shack for the ‘local’ ground and the wire to the far ground running along the grass, there was very little difference in performance on 472kHz. This is in line with my loop theory as the loop size would not be much smaller.

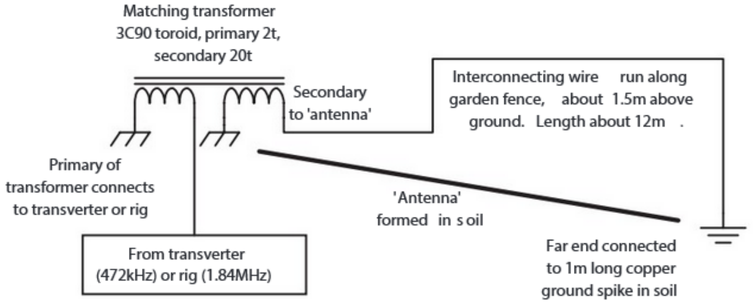


FIGURE 1: **General arrangement of the earth-electrode “antenna”. The soil between the matching transformer earth point and the second earth spike forms the antenna, *not* the connecting wire.**

Conclusions

Although this isn’t a killer-DX antenna, I frequently spot North America, the Caribbean and South America on 160m FT8. North Americans are spotted on just about every winter night on 160m FT8. On most winter nights I usually see upwards of 400 different stations on 160m FT8 Rx. On 630m with a measured ERP of just 10mW, my signal frequently reaches Norway on WSPR.

In your QTH, results may vary, but I have been amazed by this. For something this simple and of zero height, be prepared to be blown away.

Websearch

www.g3xbm.co.uk – links to my various blogs and more details of my MF equipment

www.youtube.com/watch?v=0DvGJdr1VJA – YouTube video of this structure.

Roger Lapthorn, G3XBM
rogerlapthorn@gmail.com

Pro Antennas DMV-II 80m antenna

The DMV-II 80m antenna from Pro Antennas is the latest in a line of portable antennas designed by Carl Kidd, G4GTW who also produced the Dual Beam Pro, I-Pro Home and I-Pro Traveller.

These antennas quickly gained a fine reputation and sales grew around the world. Unfortunately, in 2016 Carl suffered from ill health and the business was taken over by Tony Parkin, M0IVK, in February 2018. Carl has since recovered and continues to provide Tony with technical support.

The DMV-II is a centre fed V antenna with two loading coils to make it resonant on the 80m band. The intention is to make it easy to set up. I call it a 'V', but is really an 'M' as the two 5m telescopic fibreglass poles support the wire element, but then it dangles down at the ends.

Building the antenna

The antenna arrived from Pro Antennas very well packed and its components look like top quality. The first task is to assemble the mast-boom clamp assembly to the white fibreglass mast support, which consists of a selection of clamps on two studs with wing nuts.

The instructions warn you to use protective gloves, as shards on the fibreglass can otherwise embed themselves in your hand and cause irritation. It is a good idea not to ignore this, as I know from previous experience that otherwise you could have pricking sensations in your hands and fingers for days!

The clamp assembly proved fiddly rather than difficult to assemble, but the instructions were quite clear. Once you have built this you slip the feedpoint box onto the short mast support. The instructions say that you only have to do this once – it doesn't have to be taken apart as it can be transported to another location in one piece.

You then extend the fibreglass fishing poles and give each section a gentle twist to hold them in place. You can then slip them onto the aluminium support pieces, having removed the screw-on end caps.

You fix the 80m loading coils to the fibreglass fishing rods with the supplied elastic toggles. These are easily fitted and hold the coils firmly in place. Having done that you can add the colour-coded antenna wires to the coils, sliding the supplied small rubber tubing over the end of the fishing poles to keep the wire taut. You also get plastic clips that hold the wire to the pole, plus a couple of twists of the element around the pole are enough to keep it from sagging.


The DMV-II 80m antenna gets you onto 3.5MHz with a 'wingspan' of only about eight metres.

You can then add the secondary elements that fit between the loading coils and hang down vertically from the end of the fibreglass pole.

One thing that confused me was that the antenna elements were of unequal lengths. A quick email exchange with Tony confirmed that this was correct – he said the antenna uses a slightly offset feedpoint to help with matching.

For a permanent installation the instructions say that PVC tape can be used to fix the wire to the poles, although you would also need to provide some sort of waterproofing to the plugs as well. I recommend using PVC tape as otherwise the plugs can pull out of the loading coil as the whips move around as you push it into the air.

It is up to you as to when you want to mount it to the (not supplied) mast. I found it was easier to build the complete antenna first before bolting it on, but your mileage may vary.

The mast clamps can accommodate anything from 32-50mm diameter, but I would recommend a lighter mast if possible as it can be a little unwieldy once you try to lift it into the air, despite only weighing 3kg.

I would also recommend a ground screw (not supplied) and guys. Another pair of helping hands would also help, as trying to balance the antenna assembly while trying to tighten the guys can get a bit hairy – especially in windy weather! You can do it on your own, but it isn't easy.

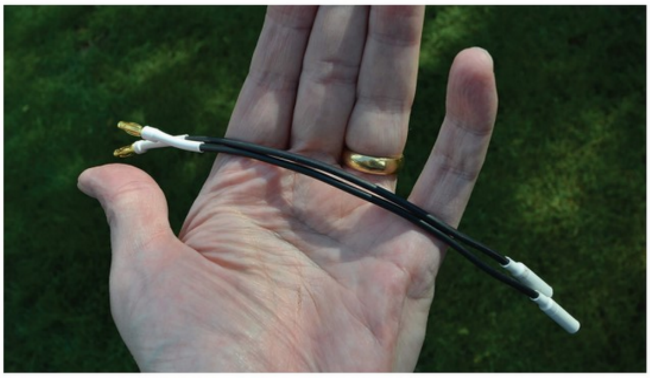
To lower the SWR the antenna comes with pairs of 50, 100, 200 and 400mm extension leads, which can be 'cascaded' to give any length of up to 750mm in 50mm increments. The instructions say that as a rule of thumb adding 50mm to each side will decrease the resonant frequency by around 20kHz, so theoretically this could give you the ability to lower the resonant point by up to 300kHz, effectively covering the whole band. It is best to measure the SWR with the antenna at the height you will operate it, as the resonant frequency will shift upwards 10-20kHz as you raise it.

Results

I set the antenna on a guyed portable mast at a height of about three metres. The antenna's instructions said it is designed to be resonant at the top end of the 80m band and I found that it had a minimum SWR of 1.2:1 on 3.800MHz, which tallies with the instructions.

I then added the 200mm extensions to the ends and the resonant point moved down to

Make sure you wear gloves to protect yourself from the fibreglass mast.



The antenna comes with an assorted of 'extenders' to move the resonant frequency down.

The DMV-II is ideal as a portable antenna for 80 metres.

3.690MHz, with a 3:1 bandwidth of 90kHz (3.718-3.63MHz).

Adding a further 400mm took the resonant point right down to 3.515MHz – just right for CW (3:1 points below 3.500MHz to 3.554MHz).

Removing the 20cm and just adding the 400mm extensions took the resonant point to 3.600MHz (3:1 points 3.556-3.639MHz).

This suggests that an ATU would be a necessity. In fact, it is better if you set it up for the section of the band you require – CW, Data or SSB, and just use the ATU to tune out the slight mismatch, perhaps up to an SWR of 3:1.

I started listening on the band at 1500UTC in May, which is not the ideal time to go DXing on 80m! Nevertheless, there were stations and around the UK signals were either equal to or no more than one S-point down on my W5GI dipole.

Noise was either equal to or down a couple of S-points on the W5GI, reflecting the fact that the DMV-II was situated further away from the house.

Extensive back to back tests with WSPR across Europe showed that the DMV-II was on average about 9dB down on the W5GI, which is amazing considering its small size.

A contact with John, G8MNY in Croydon on 3.710MHz showed that he couldn't detect any difference in signal strength between the DMV-II and the W5GI. I had a solid QSO with John for about 30 minutes.

Other QSOs showed it was either equal to or slightly down on the W5GI antenna.

60m coils

The antenna came with two other loading coils (colour coded blue) that are wound to provide resonance on 5MHz. These slotted into place on the poles and use the existing antenna wires.

Putting the mast back up I found that these gave an SWR of 1.5:1 at 5.350MHz (3:1 bandwidth 5.335-5.49521MHz (160kHz)). The wire extensions can then be used to lower the resonant point, much the same as when the antenna is used on 80m.

The Volmet signal on 5.505MHz was romping in at 20dB over S9, but try as I might, I couldn't find amateur activity on 60m. Nevertheless, the figures suggest the antenna should work as long as it is tuned properly on the frequency of interest.

Conclusion

The DMV-II 80m antenna is portable and gives you access to 80m with a 'wingspan' of less than 10m (actually 8 metres). This is unusual as a half-wave dipole for the band would be around 40m (135ft) long and a compromise 80m antenna, such as a G5RV or W5GI 'mystery antenna', would be at least 31m (102ft).

There is no doubt that you lose some performance with such a small antenna, but that is missing the point. The fact that the antenna can be folded up and put into a car boot in seconds, and then re-erected in a field or on a beach in minutes is a boon.

It might suit people with motor caravans who would otherwise miss out on 80m when out and about.

The problem with using a shortened loaded dipole is that you do have limited bandwidth and need to set the resonant point where you need it before operation. I therefore recommend you make a note of the SWR figures and resonant points with each extender. The instructions handily give you a chart to note these down.

Don't rely on an inbuilt automatic ATU to cover the whole band without adjusting the element extensions as it is unlikely to have sufficient range – mine certainly didn't.

The materials used in its construction are of a good quality and the use of heat-shrink tubing on all the supplied (gold-plated) plugs was a nice touch.

If you are into portable operation the DMV-II would make a good purchase. Or if you want to operate 80m from home, but don't have the space for a 100-132ft dipole, then it will get you on the band. But if you do this, do take care to ensure have waterproofed all the joints and use PVC insulation tape instead of the toggles and elastic to affix the loading coils.

While the antenna certainly isn't stealthy, it will get you on the band in far less space than a conventional dipole.

Tony now has a pair of 40m loading coils available for £34.

The antenna costs £238 (plus an optional £39 for the 60m coils) and is available from Pro Antennas (www.proantennas.co.uk) or telephone 0747 033 7050. My thanks to Tony Parkin, M0IVK for the loan of the antenna.

Steve Nichols, G0KYA
infotechcomms@googlemail.com

Review

HT-1A dual band QRP

Transceiver Kit

Portable setup at KH2SR using the dual band QRP transceiver in the backyard.

The HT-1A is a compact 20/40m dual band CW QRP transceiver from CRKITS that comes in either kit form or fully assembled.

I received the fully assembled model, so this review won't cover the kit building process. Even though I didn't build this one, I did take a peek inside. SMD components are used, but not to worry. All the SMD parts are pre-mounted, and you will only have to solder through hole components.

The radio features

Measuring 4.33 x 4.09 x 2.32in and weighing in at only 400g (14.12oz), the HT-1A is a great option for amateurs that enjoy portable operating in the great outdoors. It'd be a good fit for SOTA and POTA activations or even quick LTOTA deployments (Lunch Time On The Air).

It has a transmit range of 7.0-7.2MHz and 14.0-14.35MHz. Even though this rig only transmits CW, it does have the ability to listen to SSB signals. It also has an extended receive range, which covers everything between 5.9-16MHz, which means short wave broadcast reception while in SSB mode. Filter bandwidth is set at about 300Hz for CW and 1.8kHz for SSB. Spurious suppression is no worse than -50dBc.

I was impressed that the receiver is surprisingly sensitive considering the size and price of the radio. Using simple base loaded MFJ single band telescopic whip antennas with no counterpose and no grounding, I was able to copy quite a few QSOs on 20m and 40m. RF power output is 5 watts with 12 volts input power, but it can handle up to 15 volts. However, the transceiver can be powered off a 9 volt battery in a pinch if needed.

Speaking of batteries, this little guy even has room to install an internal lithium ion battery pack! Current consumption during receive is about 60 milliamps with the display backlight on and only about 45 milliamps when the backlight is off. During transmit, the HT-1A draws 1 amp.

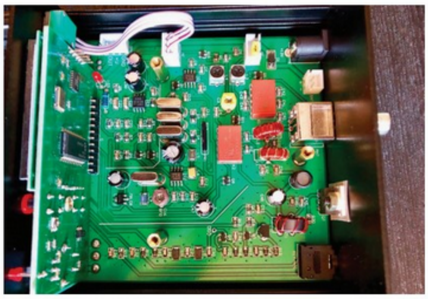
No internal speaker is provided with the HT-1A, however there is plenty of room inside the enclosure to install a small speaker and audio amplifier. I used a tiny external LiPo powered amplified speaker and a set of headphones to keep things simple.

Using the radio

The HT-1A has some great features for such a small and affordable QRP transceiver. These include: 16 user programmable memory channels, built-in keyer for iambic paddles, full break-in QSK, RIT, XIT, AGC, S-meter and even side tone selection.

The HT-1A can even automatically detect whether you are using paddles or a straight key. The built-in keyer is adjustable from 5-40 words per minutes and is set at 15wpm by default. I was able to easily fit it into a small rugged

I was able to easily fit it into a small rugged waterproof case along with a couple of single band telescopic whips for 20m/40m, a small 12V LiPo battery, headphones, a straightkey and a mini iambic key.



The internal view of the HT-1A showing how compact this 20/40m dual band CW QRP transceiver really is.

waterproof case along with a couple of single band telescopic whips for 20m/40m, a small 12V LiPo battery, headphones, a MK-11 Pocket Spy Micro Straight Key and a bulldog BD6 Mini Iambic Key, see the **Photo 2**.

I had a blast with this compact QRP rig. It's just so easy and fun to use! With an interface consisting of only 2 buttons, 2 knobs and an on/off switch, you can learn to operate the HT-1A in just a couple of minutes and without ever reading the user manual. I think this ease of use makes it a great option for 'preppers' who typically want a compact affordable emergency backup transceiver or those with an interest in emergency communications. I can also see this being a great holiday radio as it doesn't take up much space in your hand luggage. Plus, you don't have to take much time to relearn the interface if you haven't used it in a long time.

The front view of the HT-1A compact 20/40m dual band CW QRP transceiver.

The HT-1A from CRKITS should appeal to a wide demographic of amateur enthusiasts, builders, beginners, 'preppers', SOTA and especially the budget savvy amateur crowd. If you fit into any of these categories, then I highly recommend you take a close look at this great little dual band 20m/40m CW transceiver.

The kit costs $150, or $175 fully assembled, although UK amateurs should note that buying the kit abroad can result in customs charges. It can be purchased from http://crkits.com and https://qrvtronics.com/CatHAM_Radio/Products/HT-1_CW.htm

James Hannibal, KH2SR
shootanyangle@yahoo.com

Specifications:

Chassis dimensions: 110 x 59 x 104mm (not including protruding parts)

Weight: About 400g

Power supply: 9-15V DC

Current consumption:
During Rx: About 60mA when backlight is on and about 45mA when backlight is off.
During Tx: About 0.8A (at 12V)

Local oscillator: DDS, reference frequency 54MHz

Display: LCD

RF output power: About 5W (at 12V)
Rx: 5.9-16MHz continuous (peak sensitivity only in 40m and 20m bands)
Tx: 7.0-7.2MHz and 14.0-14.35MHz

Side tone: 600Hz

Keyer: Built-in, 5-40 wpm adjustable

Memory: 16 memories, user programmable

Rx mode: CW, SSB (LSB only if it is below 10MHz, and USB only if it is equal to or above 10MHz)

AGC: Audio derived AGC with S-meter to show relative strength just for reference

QSK: Full break-in

Spurious suppression: No worse than -50dBc

Filter bandwidth: about 300Hz for CW and 1.8kHz for SSB

Antenna connector: BNC

Audio connector: 3.5mm

Key connector: 3.5mm

EMC

This month we look at measuring HF RF field strength plus EMC of CCTV security systems.

What is field strength?

First let's look at what RF field strength is and why we might want to measure it. An electromagnetic wave consists of two components, an electric field (or E-field) and a magnetic field (or H-field). E-field strength is expressed in volts per metre so 1V/m means one volt RMS AC between two points in space one metre apart. In practice, field strengths of 1V/m or more are only found fairly close to transmitters. If we are measuring field strengths at a receiver from a source of radio interference then we normally measure field strength in microvolts per metre (µV/m) or dB relative to one microvolt per metre (dBµV/m).

H-field strength is measured in amps per metre (A/m), microamps per metre (µA/m) or dB relative to one microamp per metre (dBµA/m). If we are far from the source of the RF signal and far from ground then 'far field' and 'free space' conditions apply and E/H is 377Ω. This means that if we can measure the E-field then we can calculate the H-field (or vice versa). In practice, particularly at HF and below, we are normally close to ground (in terms of a wavelength) so 'far field' and 'free space' and conditions may not apply.

There are several reasons why we might want to measure RF field strength in an amateur radio EMC context:

- Measuring immunity of electronic equipment to an RF field and comparing this to EMC standards
- Measuring emissions of RF interference from a certain piece of electronic equipment and comparing these to EMC standards
- Measuring general levels of RF interference at an amateur radio station and comparing these to ITU-R Radio Recommendation P.372-13 on Radio Noise **[1]**. See also the IARU noise measuring campaign mentioned in the June 2019 EMC column.

In each case, we need some sort of *measuring antenna* where we can relate the output from the antenna to RF field strength.

HF measuring loop antennas

At VHF, UHF and above, a half wavelength dipole antenna makes a good measuring antenna. It would be possible to have it calibrated by an accredited antenna calibration lab but this is expensive. Even without calibration, a properly matched dipole gives fairly predictable results.

As we go down below 30MHz however, a half wavelength dipole starts to become too long to be of practical use as a portable EMC measuring antenna. We have two options. One is an 'electrically short' antenna such as a shortened vertical monopole; the other is a loop antenna. This article focuses on loop antennas but other types of HF measuring antenna may be the subject of a future article.

Now let's look at some loop antennas that have been used as EMC measuring antennas by the RSGB EMC Committee. These are normally used on a non-conductive tripod, as shown in the photos. A surveying tripod is also suitable as the legs are non-conductive. Metal photographic tripods are not recommended as their conductivity may affect the accuracy of the measurement.

Photo 1 shows a Schaffner-Chase HLA6120 active EMC measuring loop antenna. This is a 600mm diameter shielded loop with a built-in preamplifier powered by an external rechargeable battery box. It covers the frequency range 9kHz–30MHz and is intended for use in professional EMC testing. It has similar characteristics to the Rohde and Schwarz HFH2-Z2. Both types are suitable for testing to certain EMC standards such as EN55011 but the overall measuring system noise floor will be significantly higher than the man-made or atmospheric noise levels at most amateur radio stations, meaning it won't detect the numerous weaker signals that still cause interference to amateur communications.

Photo 2 shows a Wellbrook Communications ALA1530 active loop antenna that covers the frequency range 150kHz–30MHz. This one has been modified with a mount to fit a standard tripod thread. This can be used as an EMC measuring antenna in conjunction with the typical antenna factors provided by the manufacturer but due to the size (950mm diameter), calibrating an individual antenna requires a different technique compared to the 600mm diameter antenna shown in Photo 1.

Photo 3 shows a tuned loop antenna covering the range 1.6MHz–12MHz. This is part of a set of three tuned loop antennas that were developed a couple of decades ago for the Radiocommunications Agency of the DTI (See *RadCom* EMC December 1999). This uses transformer matching and although it has a preamplifier, this is a 50Ω preamp that can be switched in or out. It has a significantly lower measuring system noise floor than the loop shown in Photo 1 but it needs to be manually tuned to make measurements at spot frequencies. A remotely tuned version was subsequently developed.

Photo 4 shows an experimental 600mm diameter active loop that can be used in a broadband mode for fast swept measurements or in a higher sensitivity tuned mode over a limited frequency range. **Photo 5** shows the tuning capacitor and an AAA-1C preamplifier from LZ1AQ. This preamp is intended for use as a switchable active loop or active dipole but it is being used in a different way, as a switchable tuned or untuned loop. It is also intended to be used with the preamp and control board connected by a cable but in this prototype, they are both in the same box.

Calibrating a loop

There are various standard methods for calibrating a loop antenna at HF and one of these involves radiating a signal from another loop. It is not easy to get consistent results in practice without a proper EMC test site with a metal ground plane because of unwanted coupling between the signal generator and the receiver via coaxial cables, power cables and ground loops. The directional properties of the transmitting loop also change with frequency.

It has been found that a good way to get consistent results is to build a small battery-powered crystal calibrator that produces a very low power comb of harmonics and feeds a 100mm diameter loop. This is then mounted at the centre of the loop under test, as shown in **Photo 6** where it is being used to calibrate a tuned 'bicycle wheel loop' (See *RadCom* EMC Dec 2015). The crystal calibrator is then put at the centre of another reference loop with known characteristics, such as the loop shown in Photo 1. By comparing the outputs from the two loops, it is possible to find the antenna factor of the loop under test.

This approach ideally requires a calibrated loop as a reference antenna, or alternatively a loop with predictable characteristics such as a passive loop made with coaxial cable. The two loops also need to be the same diameter. If they are different sizes then it is necessary to apply an adjustment factor.

Another way of calibrating a loop antenna up to 30MHz is by using a Transverse Electromagnetic (TEM) Cell, as shown in **Photo 7**. This one was kindly donated to the EMC Committee by a Member who used to work in EMC testing. It is intended for testing immunity of TV sets and other equipment to EN55020. For that purpose, it has to be driven by an RF power amplifier so it must be used inside a shielded enclosure to avoid radiating interference. For antenna calibration however, a fraction of a milliwatt from an RF signal generator is sufficient and poses no real interference threat.

The antenna under test needs to be no more than 700mm high including the matching box so a 'low profile' construction is needed. The antenna in the centre of Photo 7 is a shielded loop made of RG213 coaxial cable and when the results are

PHOTO 1: Schaffner-Chase HLA6120 active EMC measuring loop antenna, 9kHz–30MHz.

PHOTO 2: Wellbrook Communications ALA1530 active loop antenna, 150kHz–30MHz.

PHOTO 3: Passive tuned loop antenna, 1.6MHz–12MHz.

PHOTO 4: Active broadband or tuned loop antenna. Photos 1-4 are at approximately the same scale.

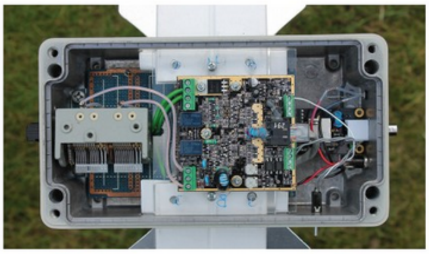


PHOTO 5: LZ1AQ AAA-1C preamplifier in active broadband or tuned loop antenna.

PHOTO 6: Calibrating a 'bicycle wheel loop' antenna using a crystal calibrator.

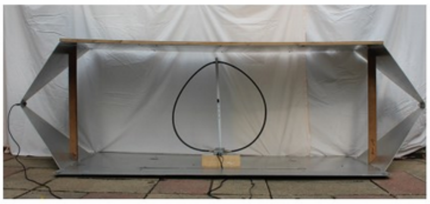


PHOTO 7: Calibrating a shielded loop antenna using a TEM Cell.

published, it should be possible for others to make one and get very similar results without the need to calibrate it in a TEM Cell.

CCTV security systems

The widespread use of CCTV security systems brings some potential EMC issues. First, the switching power supply unit. CCTV systems often run on 12V DC from an external 'dog on a lead' style power supply unit (in the style of a laptop PSU) and if this has poor RF interference filtering then it can radiate interference on lower HF bands via the long cables connecting to the cameras.

Secondly, the video signal may be radiated by the cables to the cameras. We have seen older CCTV systems that use standard definition 625 line analogue PAL video transmission over unscreened alarm cable. Some CCTV systems include so-called 'baluns' that simply connect a balanced pair directly to an unbalanced BNC connector. Such systems are likely to radiate the PAL sub-carrier frequency on 4.43361875MHz; other CCTV systems may use 525 line US NTSC standard video transmission with a 3.579545MHz colour sub-carrier. Such systems are also susceptible to patterning on the video due to nearby medium wave broadcast transmitters and may have poor immunity to breakthrough of amateur transmissions on the 1.8MHz and 3.5MHz amateur bands.

More recent CCTV systems use HD video up to 1920 x 1080p format. This may be an IP camera connected by an Ethernet network cable. Shielded twisted pair (STP) cables are available but it appears that shielded cables are seldom used. In any case, the camera is normally powered by Power over Ethernet (PoE), which feeds DC over an Ethernet cable. This requires a PoE injector that, if connected to a noisy switching power supply, can radiate RFI from the Ethernet cable.

Another way to connect a high definition CCTV camera is using Analogue High Definition (AHD). It uses Y/C signal separation and it can transmit distances up to 500m using RG59 coaxial cable or 150m using CAT5 twisted pair. A third way to connect a high definition CCTV camera is using HD-TVI, a digital transmission standard that also uses RG59 coaxial cable.

A related CCTV product is a video doorbell. This is a video intercom rather than a security camera and it allows you to see the caller and also speak to them. We have had occasional reports of RFI from wired video doorbell systems. This could be due to the video transmission, which may operate continuously, or a switching power supply unit connected to long wires.

Another type of video doorbell is the Ring Video Doorbell 2. This can be powered by an internal rechargeable battery or it can be connected to an existing wired doorbell circuit so that it operates the existing bell or chime. The wire is also used for charging the battery, but not for video transmission, so it is unlikely to affect any HF or VHF amateur bands. The video transmission only operates occasionally when the doorbell is pressed or motion is detected. It uses IEEE 802.11 wireless LAN transmission at 2.4GHz.

We would be interested to receive any other reports of RFI from CCTV systems or poor immunity to amateur radio transmissions.

Websearch

[1] www.itu.int/rec/R-REC-P.372-13-201609-I/en

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Design Notes

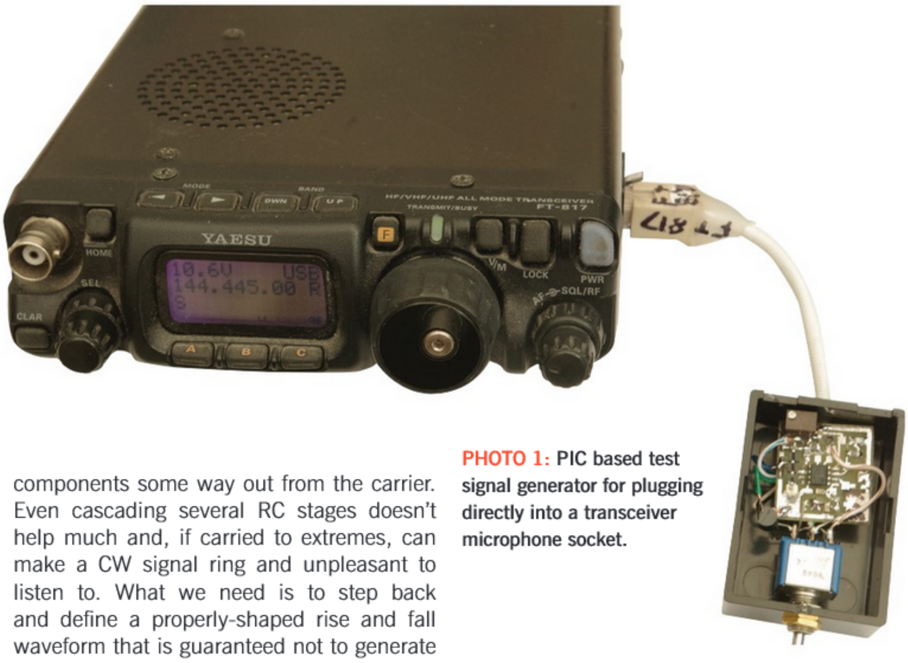

PHOTO 1: PIC based test signal generator for plugging directly into a transceiver microphone socket.

Amplitude shaping

In May's column, the problem of A1 keying and suppressing key clicks on a 23cm beacon was highlighted. The problem there was an old design where an RF multiplier chain was being hard-switched via its power supply to give on-off keying, resulting in severe QRM for local stations several hundreds of kHz either side of the carrier. So here we'll look at a few ways to overcome this using a minimum hardware solution with existing RF bits. But please note, some of these are only ideas that I've not actually tested in practice; they will warrant further investigation and testing.

Supplying a ramped supply to the RF chain for an on-off keyer in an attempt to reduce key clicks is not difficult when the RF chain probably consumes no more than a hundred milliamps or so. The power supply controller will only be operating in an in-between state for a few milliseconds during the ramp and most of the time will be hard on, supplying full power, or switched off. So a simple emitter follower current amplifier can be used to supply the varying voltage, as shown in **Figure 1**. This technique would work equally well for generating amplitude modulation (AM) although, as it would be operating at mid-point for much of the time, power dissipation could be excessive.

Instead of crudely switching the supply we could directly modulate the low level RF, an alternative we looked at in the June 2014 Design Notes. Here we used a diode ring (double balanced mixer, DBM) to control the RF level, or a PIN diode attenuator. Modulating the RF source amplitude in this way, either by the supply, at low level, or by some other means does assume that a linear power amplifier is used in order to preserve the amplitude envelope.

So we know how we can slowly ramp the RF without too much additional hardware, but how to generate the ramped waveform to drive the RF amplitude control, and what shape should this be?

Optimum pulse shape

One classic approach is the traditional RC filter, possibly implemented in an opamp. Unfortunately, for eliminating key clicks the simple low order RC filter is a poor choice. Although it may give what looks like a nice rounded rise and fall time, it still has sharp edges, as can be seen in **Figure 2**. This does not help in attenuating the signal components some way out from the carrier. Even cascading several RC stages doesn't help much and, if carried to extremes, can make a CW signal ring and unpleasant to listen to. What we need is to step back and define a properly-shaped rise and fall waveform that is guaranteed not to generate far-out key clicks and also to 'sound' good. Then we can design a shaping circuit that can generate the waveform.

There are two waveforms that meet this criterion. One is the raised cosine. This consists of a cosine curve, lifted so it rises from zero as shown in **Figure 3**. The rising and falling edges of the control signal uses the appropriate half of this curve. The rate of rise can be tailored exactly to what is wanted, usually a compromise between close-in bandwidth and how smooth the 'dits' sound. But this rate of rise is now just a single value – the 'frequency' of the cosine shape. We can give a numerical value to this. Assume a rise time of 10ms is considered 'about right' Half a cosine takes 10ms, so the full cycle is 20ms, or 50Hz. Simples!

The other waveform is Gaussian. This derives from the shape of the probability curve of this name. An exact Gaussian shape is not possible to achieve here, as the curve only reaches true zero at infinity, but an acceptable approximation is made usually when the waveform drops to 10% or 5% of its peak (20-30dB down). Filter design tables often include a Gaussian option, and it is feasible to build an RC filter around opamps that does this, although quite a few opamp stages with some complicated interconnections are needed to get the correct response. There is no equivalent in filter design tables to the raised cosine curve.

There are subtle minor differences in the spectra of the final waveforms of raised cosine or Gaussian, but these are hard to detect in practice and the choice of one shape or the other is more a matter of convenience. Near-Gaussian is possible with analogue hardware; raised cosine is not. But these days, especially in terms of component count, cost and ease of construction, it really is a lot easier to do the task in DSP with a small microcontroller. And then we can have any shape we want – and even make it user-adjustable, perhaps to compensate for a non-linear voltage / RF transfer function.

Pulse width modulation

Abbreviated to PWM, this involves generating a binary waveform – a square wave – running at a frequency *very much higher* than that of the wanted modulation, then varying the width of the 'on' part of this pulse train. Varying the duty cycle (the ratio of on to off time) in this way alters the mean or average value of the binary signals. After passing through a low pass filter to remove harmonics of the fundamental switching waveform, the result is a clean, slowly changing analogue value. As the pulse width modulated waveform is much higher in frequency than the target modulation, only very simple filtering is needed, possibly a single RC stage or opamp.

PWM is the fundamental concept behind all switch mode power supplies and accordingly there is a huge amount of support for it in the peripherals inside the majority of microcontrollers. Most PIC devices have one PWM generator, some – designed specifically with SMPSU and power control in mind – have several, independently programmable PWM units.

So we can envisage generating our analogue waveform for controlling the RF amplitude with its carefully-shaped rise and fall times inside a microcontroller, like a PIC device, using the internal PWM generator. There is no need to implement complicated filter shapes to generate the curve – we simply store a set of intermediate values in a table and step though this table at a rate that gives us the final rise time. If we had, say, 64 intermediate values in our table and wanted a rise time of 10ms, we'd need to read each of those values and send them to the PWM generator every 10ms / 64 or about every 156μs.

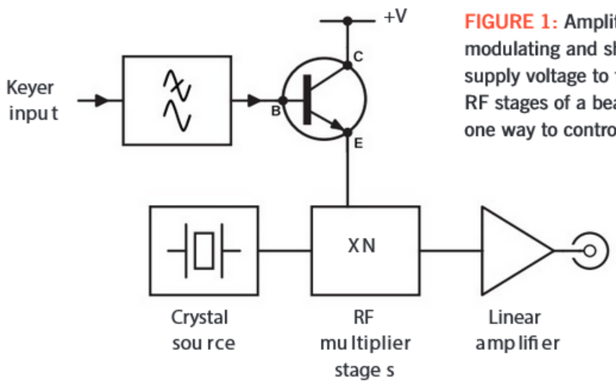

FIGURE 1: Amplitude modulating and shaping the supply voltage to the low level RF stages of a beacon source is one way to control key clicks.

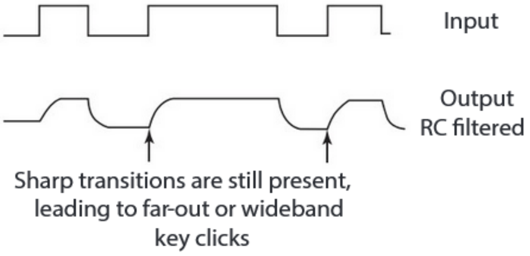

FIGURE 2: Simple RC filtering is very poor at removing far-out harmonics; sharp edges remain, so it unsuited to a key-click filter.

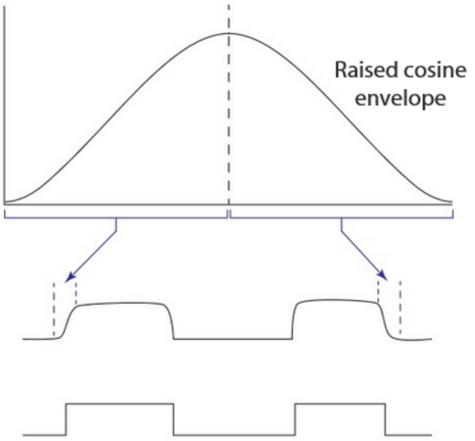

FIGURE 3: Derivation of the raised cosine shape, and how it is used for properly shaping a pulse waveform to minimise key clicks.

Many of the 'workhorse' 16F series (and some 12F series) PIC devices have a PWM generator capable of up to 10 bit resolution, which allows 1024 output levels. Maximum PWM rate is a function of the clock speed of the controller and the maximum resolution wanted. For convenience in programming, a table containing just 8 bit values is easier – this allows 256 output levels – and does mean the maximum PWM rate the chip can generate is raised. All of this family of PIC devices will run with an oscillator frequency up to 20MHz, which means that with 8 bit resolution a maximum PWM frequency of 20MHz / 256 = 78kHz is possible. That's much, much faster than the speediest Morse you'd ever want…

For a small amplitude keyer shaping the waveform going to an RF modulator, or power supply, the basic 8-pin 12F615 PIC device is well-suited. It has a PWM generator and a processor clock that can run at up to 20MHz (in practice quite a bit higher) for critical applications. However, to keep things really simple the internal RC clock running at 8MHz is ideal. This leads to a PWM sample rate, for 8 bit resolution, of 31.25kHz; this is quite adequate for keyer rise time control.

The 12F615 also has a host of other peripheral modules inside that we aren't concerned with here – and it costs less than 80p. The circuit diagram in **Figure 4** shows just how simple such a smooth ramped on-off keyer can be. The 12F615 only has 1kB of program memory, but for this basic task even if a large lookup table of 256 bytes is adopted, there is plenty of capacity for the waveform shape generator and keyer. And, of course, if this is used as a beacon source with a fixed CW message, that can be generated inside the PIC too, making for a complete standalone waveform generator and beacon message keyer.

Compensating for non-linearity

A lookup table for generating the control signal for the RF means we can also compensate for non-linear modulators. Some modulators like a diode ring mixer may well be sufficiently linear to drive with

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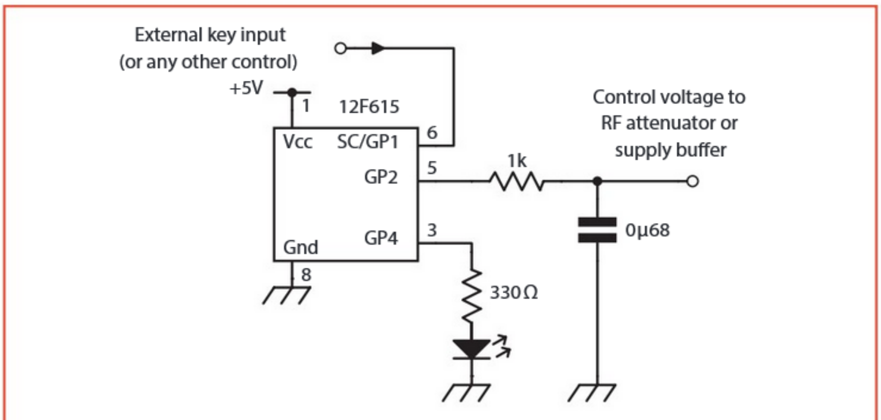

FIGURE 4: Using a small 8-pin microcontroller as an amplitude keyer, allowing a controlled drive wave by the use of PWM.

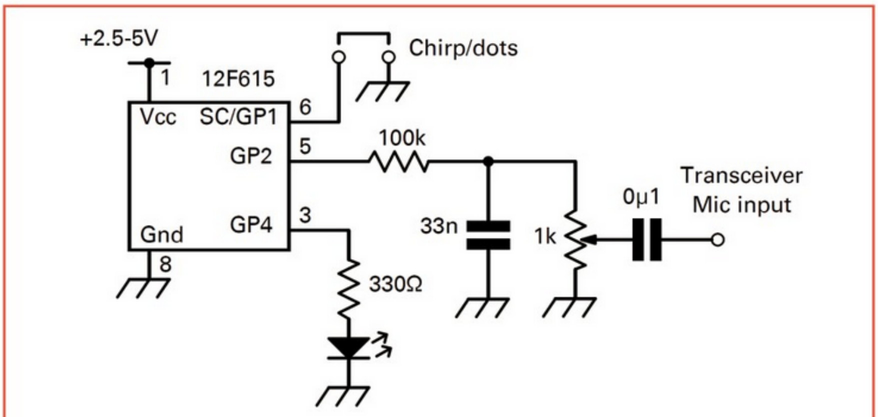

FIGURE 5: PIC based audio test signal generator, with audio generated via PWM.

a properly shaped raised cosine waveform and get the expected RF amplitude envelope – as we saw in the June 2014 article. But many modulators won't be so well behaved; a PIN diode type will be quite non-linear. Controlling the supply volts to RF multiplier stages will be an even more non-linear process.

We can compensate for non-linearity by first measuring and tabulating the RF power out versus drive voltage curve. Then, using spreadsheet tools in the way described last month, the measured results can be used to generate and modify the lookup table entries to compensate for the non-linearities. The net result is that the RF envelops follows the properly shaped waveform. 'JNT labs can't offer any actual amplitude keying examples using this idea as I've never had to do exactly this task – although it's the way I would now do an on-off keyer for a beacon if the situation arose. However, using PWM and a nearly identical circuit it is possible to produce a neat little audio test source.

Chirp and audio pulse source

While having a rather rare 24GHz QSO a few months ago, I was asked to send a test signal for several minutes at a time for the remote station to find, then to peak his dish on.

Searching for weak signals on microwaves involves swinging a dish around while also tuning over a small frequency range – not everyone yet uses fully locked RF sources. So it helps if the test signal transmitted has some sort of unique repetitive pattern, easily discerned by ear when noisy.

I was using a CW keyer module programmed to send a long string of 'e's (dots), plugged into the key socket of the FT-817 I was using as a transverter driver. So the rig had to be switched to CW mode to send this test signal. When the report came over on the talkback that he could hear me and I should now transmit, I had to switch over to Rx, change the rig to SSB and even shift the tuning a few hundred Hz to compensate for the SSB/CW offset. This was all very tedious and I found myself thinking, 'wouldn't it be nice to generate the test signal / beacon source at audio and feed into the mic socket'?

The result was a PIC-based audio generator. The PWM signal was generated in a 12F615 as described earlier and, to keep it really simple, I used the chip's internal 8MHz clock and a PWM rate of 31.25kHz. Instead of the Gaussian or raised cosine, the lookup table consisted of 256 values representing one complete cycle of a sine wave. A 24 bit counter was used as a numerically controlled oscillator (NCO), incremented at the PWM rate by a value corresponding to the wanted audio frequency. The most significant byte of the count, after each increment, is used as input to the lookup table giving the value sent to the PWM generator. The result is a PWM output from the PIC that after filtering is a clean, near perfect audio sine wave. Since it is going through an SSB transmitter with its 3kHz wide SSB filter, this PWM output doesn't even need too much cleaning up by filtering. A simple C-R filter sufficed, and this conveniently combined with the voltage attenuation needed to get down to the few millivolts needed for the radio's microphone input.

Of course, a single tone as a tuning signal is not very helpful, so just to be different, I made it generate a chirp signal, sweeping from 500Hz to 2kHz roughly once per second. Chirps are generated by slowly increasing the value by which the numerically-controlled oscillator (NCO) is incremented each time, then resetting this to the base value when the highest chirp frequency is reached.

For an alternative test signal, a series of dots at a single tone frequency could be selected using a link on a spare pin (actually, I wired this as a second position on the on-off switch).

The circuit diagram of the complete test signal generator can be seen in **Figure 5**. **Photo 1** is the finished thing in a small plastic box plugged into the FT-817 microphone socket.

The PIC code for the audio source can be found at **[1]**. The source code is included, with comments showing how the lookup table and PWM is generated, as well as the chirp signal. Frequencies and chirp rate are defined as constants at the beginning of the .ASM listing. Change these as you see fit to suit your own preferences.

Reference

[1] www.g4jnt.com/chirpgen.zip

Propagation Prediction Engine

Comparison Project

Recently whilst on an extended holiday to an exotic location (without radio equipment), I decided to proceed with a new project. I call it PPCP 'Propagation Prediction Comparison Program'.

ITU-R P.1148-1 describes the methodology I used to perform the necessary tasks. I do not have the budget of the ITU so I used their recommendation as a template for my own project.

PPCP Project

When I arrived back at my home location in G-land, I started to record the NCDXF Beacon Chain reports using the FAROS [1] automated software and my Kenwood TS-990S transceiver. I use an old XP Dell computer to run the software and connect to the rig. The logs that the Faros software builds up are read into an SQLite Database. The input program reads in the logs and discards those log entries that do not show a beacon report, the rest of the information is read into the Database and is therefore available for future analysis. After informing the rest of the RSGB, PSC committee of my efforts, they now support the project. When over at least half a solar cycles worth of recordings are available, a very good idea of which prediction engine is the best will be apparent. So, an awful lot of recording is still to do.

Comparison

The propagation engines that will be compared are; ITURHFProp [2], VOACAP, REC533 and ICEPAC. The ***itshfbc*** [3] suite includes the latter three, it also has a further little application called HFANT, useful in different circumstances. When the ITU-R P.1148 recommendation was first published, a computer program was also announced, I used that program in my *RadCom* article 'RSGB, PSC Project – ITURHFProp Predictions, Web-Page' published in August 2016, page 62. Things have moved on since then, I had to get a new computer and therefore had to install a new version of Python, the language that the original program was written in. The program and the new version of Python are not compatible, so I decided to write my own computer program but in a language that I am more familiar with, PERL.

To date I have amassed 1287 entries. The PPCP program is able to output analysis for the prediction engines, the bottom line of which appears in **Table 1**, for each engine. The four engines are treated in the same manner, ie they are set up as per program suggestions, parameters such as co-ordinates, SSN, date, are input by PPCP and are the same for each. The beacon is modelled with 100W output and a Cushcraft R-5 (I believe) aerial, this is scheduled to change before the beginning of the next cycle to a dual band discone aerial. The receive end is modelled with a dipole.

Perhaps a coincidence, but I believe not, in **Table 2** I have reproduced the appropriate columns from my 2016 article. For the sake of brevity, only the ITURHFProp results are shown.

The standard deviation outputs from 2016 and today are remarkably similar, which I am taking as a good indication that my program is doing the correct things.

Because of the low number of recordings, the figures are somewhat skewed in places. This occurs especially where there are a low number of recordings for a specific beacon, such as happens at the bottom of a solar cycle. When the cycle picks up (I'm hoping it will, eventually) and more recordings are amassed all the figures in Table 1, will inevitably change. The analysis part of the program treats all the engines the same, so these results are indeed meaningful. I am, however, expecting VOACAP in particular to give a better showing as propagation conditions change.

As this is the start of the project, any comments/suggestions would be welcomed.

TABLE 1: The specified output columns from the recommendation, with emphasis on the Standard Deviation.

	Count	Mean Difference (dB)	Standard Deviation (dB)
ITURHFProp			
Totals	1287	3.52	9.88
VOACAP			
Totals	1287	-39.19	29.82
REC533			
Totals	1287	21.92	7.81
ICEPAC			
Totals	1287	-43.36	29.38

TABLE 2: The appropriate columns from my 2016 article.

	Count	Mean Difference (dB)	Standard Deviation (dB)
ITURHFProp			
Totals	16,268	-0.02	9.51

Websearch
[1] www.dxatlas.com/Faros/
[2] www.itu.int/en/ITU-R/study-groups/rsg3/Pages/iono-tropo-spheric.aspx
[3] http://greg-hand.com/versions/

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