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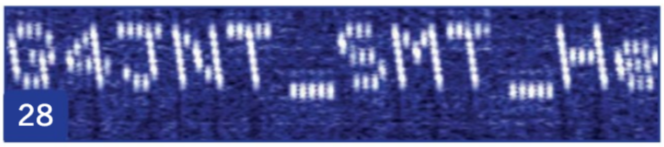

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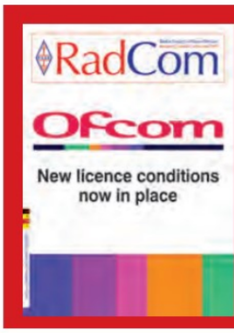

New licence conditions now in place
Cover design by Kevin Williams, M6CYB

RadCom THE RADIO SOCIETY OF GREAT BRITAIN'S MEMBERS' MAGAZINE
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RadCom is published by the Radio Society of Great Britain as its official journal and is sent free and post paid to all Members of the Society. **The May 2024 edition of *RadCom* is expected to arrive with most Members by 19 April 2024** although this can take up to a week longer in some cases; international deliveries can take longer still.

The online *RadCom* is at www.rsgb.org/radcom/
RadCom Plus is available to RSGB Members online at www.rsgb.org/radcom-plus
RadCom Basics for Members new to the hobby can be found at www.rsgb.org/radcom-basics/
Abbreviations and acronyms we use are listed at http://tinyurl.com/RC-acronyms

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New Products

Kenwood TH-D75

After a long wait, Kenwood has introduced the TH-D75E, a VHF/UHF handset that promises to take amateur radio communications to a new level. It features integrated digipeater, dual receive, wideband capability and multi-mode capability.

The new TH-D75E is the logical evolution of Kenwood's popular TH-D74E dual-band handheld. Not only is the housing design of the TH-D75E reminiscent of its predecessor, but also the UI design and user guidance largely follow the proven concept. The device complies with IP54/55 standards and is thus protected against the ingress of dust and rainwater.

Product Name:	TH-D75E
TX Power [W]:	5W
Supported Bands:	2m, 70cm
Brand:	Kenwood
Antenna Connector:	SMA plug
Bluetooth Interface:	Yes

Available from Martin Lynch & Sons via hamradio.co.uk/thd75 for £789.

QuietRadio has launched Aziloop, a groundbreaking electronically-rotatable dual-mode antenna system for LF and HF reception

Aziloop's unique Stepped-Azimuth™ technology creates an electronically-rotatable receive antenna with 72 headings in K9AY mode or 36 bi-directional headings in loop mode. Primary frequency coverage is from 20kHz to 10MHz, with secondary coverage up to 30MHz. QuietRadio supply the LCU (Loop Control Unit), the CIU (Common Interface Unit) and the Windows control software. The antenna, comprising a pair of orthogonal wire loops plus a ground for K9AY mode, is sized by the user.

Key features:

- Electronically rotatable in 5° steps with a response time of just 60ms, the antenna itself remaining fixed
- A single coaxial cable carries all signals to and from the antenna-mounted LCU making upgrades a snip
- Selectable 18dB preamp and 18dB attenuator (in 6dB steps) giving 36dB of level control to optimise sensitivity versus dynamic range in any situation
- Four selectable seven-pole pre-selection filters to give your receiver an easier life
- Finely adjustable K9AY load from 250Ω to 950Ω in 50Ω steps
- Windows app with intuitive, uncluttered UI, putting control where you want it – on the same screen as your SDR
- Local control via USB, or remote control from anywhere using the ethernet server in the CIU or a local PC in server mode, with a remote PC as client
- Two undedicated I/O channels with optional PTT based receiver protection
- Omni-rig support for filter selection, PTT sensing, I/O control, and rig-sync

Applications include low angle DX-reception (K9AY mode) or NVIS / medium distance reception (loop mode), and basic DF work. Also, local interference reduction, thunderstorm mitigation and co-channel separation by adjusting antenna mode and azimuth. In some cases, nulls can exceed 30dB.

Aziloop is currently on offer to UK customers for £399 (list price £459) from quietradio.co.uk

bhi Launches new wireless noise-cancelling headphones

Industry-leading, noise-cancelling specialist bhi has just added a new product to their noise-cancelling product range. The NCH-W are over-ear, wireless, noise-cancelling headphones designed to reduce the effect of external ambient background noise, enabling a more enjoyable listening experience. The headphones are now available and join their other headphones, NCH Wired Noise Cancelling Headphones and HP1 Wired Stereo Headphones.

The new NCH-W noise-cancelling headphones are premium Bluetooth headphones which use advanced noise cancellation technology to block out up to 25dB of ambient sound, letting you enjoy your audio without distraction – whether you're travelling on a noisy aeroplane, train or trying to focus in the office. The adjustable headband and high-quality ear pads form a perfect seal around your ears, providing all-day comfort while also enhancing noise isolation. Easy-to-reach controls allow you to adjust volume, skip tracks, take calls, and toggle noise cancellation on and off with just a touch. With up to eight hours of battery life per charge and a 10m wireless range, the NCH-W headphones give you the freedom to roam while staying connected to your device. With all its features the NCH-W are a great choice for any office, home, or outdoor application.

- Output power: 30mW
- Bluetooth v5.0 technology with a wireless distance up to 10m
- Active noise reduction: 18dB to 25dB
- Charging time: 2.5h
- USB charge: 5V DC
- Wireless frequency: 2.401 to 2.480GHz
- Frequency response: 20Hz to 20KHz
- SNR: ≥75dB
- Active noise reduction 18 to 25dB

Available from bhi-ltd.com for £39.95 including VAT. Call 01444 870333 for information and advice.

Antennas

An antenna which allows access to the 40m band, with minimal need for horizontal space, is a prerequisite for those living with a small garden, or who wish to use a small footprint when it comes to deploying an antenna in a portable arrangement.

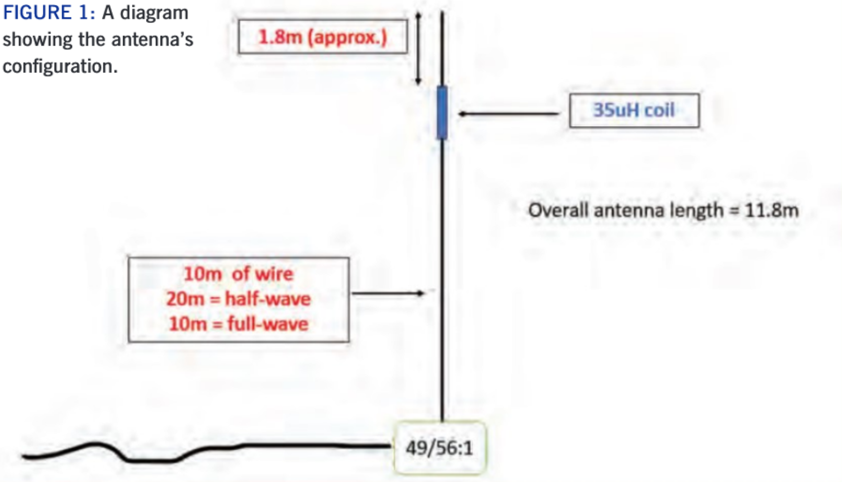


FIGURE 1: A diagram showing the antenna's configuration.

Vertical antennas are often used in these situations, with the caveat that either elevated or ground radials are used, thus adding to the horizontal space required for operation.

There is, however, a compromise solution available for consideration. This antenna requires minimal horizontal space (just for the coaxial cable) and, in its vertical configuration, a minimum height of approximately 12m, thus enabling its use at a portable location or at home by using a tree or a non-conductive 12m pole to hang the wire from. The antenna is, therefore, quick to deploy, produces some useful low-elevation-angle radiation, and provides access to 20m and 10m, as well as 40m, without using an external ATU.

Antenna outline

A modelled diagram for this antenna is shown in **Figure 1**. It is fed using a high-impedance transformer at its base, typically a 49:1 or 56:1 impedance ratio. These transformers are readily available commercially, and plenty of guides exist online as to how to construct one for yourself. The version I used was a home-made 56:1 transformer, made by a good friend, who has researched extensively into the most-efficient options to allow for relatively-low losses from 10m through to 40m. A 50Ω coaxial cable is then simply connected to the transformer, with the additional option of using a common-mode choke anywhere from 2m or more away from the transformer, or connecting a 2m-long counterpoise to the transformer's ground-lug. I usually adopt the former practice, although I have yet to encounter any RF issues when choosing not to use a choke or counterpoise at 100W SSB.

As Figure 1 indicates, thanks to the high-impedance transformer, the antenna provides coverage for three harmonically-related bands. The 20m band is covered as a full-sized end-fed half-wave antenna, the 40m band as a shortened end-fed half-wave antenna (around 60% of its full size), and on the 10m band there is also a good match to 50Ω as a full-wavelength antenna. All three bands are fed at the high impedance end of the antenna, thus necessitating the use of this high-ratio impedance transformation from around 2,500 to 3,000Ω to near 50Ω. The coil positioned at the top of the 10m-20m portion of this antenna has a dual purpose. By achieving an inductance of around 32-35μH, this coil acts not only as a loading coil for 40m, but also as a resonant trap for 20m.

The coil itself is easy to construct. A section of PVC pipe makes a good former for a coil. There are online calculators **[1]** available to help you determine the number of turns required, based on the diameter of the coil (including the diameter of pipe and wire combined), the thickness of wire used, and the inductance sought after. In my case, I used some spare 35mm PVC piping left over after doing some plumbing work, and 0.4mm thick insulated wire. By using the online calculator, I was able to determine that an inductance close to 34μH could be achieved by using 39 tightly-wound turns of this wire around the pipe, allowing for 4cm from beginning to end of the coil. The calculator suggests that should provide an inductance of around 34.5μH. I drilled two small holes approximately 5cm apart from each other into an 8cm-long piece of PVC pipe, using a 4mm drill. Having fed a small 4mm bolt and washer through the first hole, I then attached the wire to a 4mm ring terminal, and then to the bolt, using a 4mm nut to secure it. I was able to wind 38 complete turns before attaching the wire to a bolt at the other end. Attaching each of the probes from my Peak Atlas LCR45 meter onto opposite bolts, I found I had achieved an inductance of 33.4μh, close enough!

Modelling performance

Using MMANA-gal modelling software, we can obtain a good idea as to the behaviour exhibited by this antenna on the 40m, 20m and 10m bands.

40m band

The omni-directional pattern associated with a vertical antenna is revealed in **Figure 2**. We use a 5° elevation angle for comparison between a full-sized ground-mounted quarter-wave vertical antenna, with eight quarter-wave ground radials, and our shortened end-fed half-wave vertical antenna. The quarter-wave vertical antenna is approximately 2dB better than our shortened end-fed half-wave antenna. This is largely because of the reduced efficiency of the end-fed half-wave antenna through shortening of its length. However, the shortened half-wave antenna is within an S-unit of the full-sized quarter-wave antenna at this low elevation angle, and is a contender for working some DX contacts on 40m along the early-morning grey line, and in the late evening. Where this, and typically vertical antennas as a whole, suffers is in comparison with a low horizontal dipole for higher elevation angles. A low inverted-V full-sized half-wave dipole exhibits gain approaching 5dBi or 6dBi at 75° elevation. Our antenna, with its bias towards lower elevation angles, exhibits -15dBi at this same higher elevation angle, or around 3.5 S-units weaker than the dipole.

20m band

This antenna shines on 20m. As a full-sized vertical half-wave antenna, it produces good low-angle

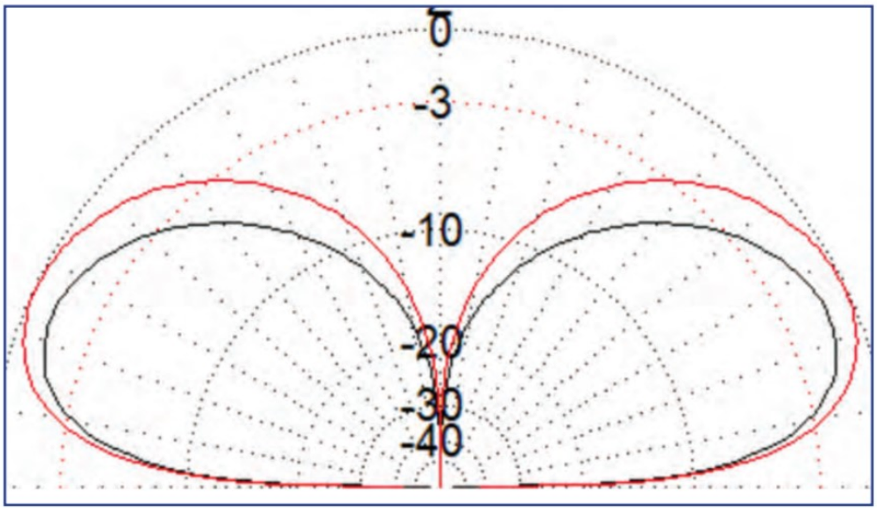


FIGURE 2: The full-sized 40m quarter-wave antenna (red) is around 2dB better than this antenna (black) at a 5° elevation angle.

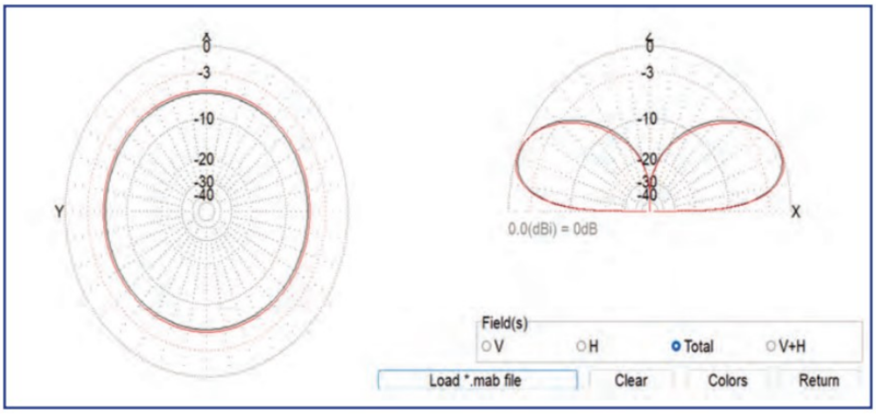


FIGURE 3: The half-wave vertical antenna compares favourably with a ground-mounted quarter-wave antenna (plus radials) on 20m.

performance which matches that of a mono-band half-wave vertical antenna, or a ground-mounted quarter-wave vertical antenna. Again, using 5° elevation as our benchmark, we see a -5.7dBi figure which matches the performance of a ground-mounted quarter-wave vertical antenna for 20m with 16 quarter-wave ground radials (see **Figure 3**).

10m band

Perhaps counter-intuitively, the largest compromise is presented on the 10m band. This antenna is a full-wave vertical antenna, and once a vertical antenna become longer than around 0.8λ on a given band, its strongest lobes begin to transfer from angles below 20° to higher elevations. In this case, on 10m, the antenna produces its best performance at around 35° elevation, which is around 15° or so higher than a typical ground-mounted half- or quarter-wave vertical antenna. Moreover, at our benchmark 5° elevation angle, performance drops from the -5.5dBi or so figure, expected from its shorter vertical cousins, to -9.0dBi. The saving grace is that when 10m fully opens, it often does so without half-measures, so DX is still workable on 10m with this antenna, albeit approaching an S-unit weaker than the other verticals mentioned. It is interesting, though, to note that when on 10m, this antenna is a slightly greater low-angled compromise than it is on 40m.

Anticipated VSWR bandwidth

The modelled 2:1 VSWR bandwidth offered by this antenna gives us few surprises. On 10m and 20m, the bandwidth is just over 1200kHz and 1110kHz respectively. This is more than ample to give coverage across the segments of the band you require. On 40m, however, as the antenna is approximately 60% of the length of a full-sized half-wave, bandwidth is much narrower, at around 70kHz. A choice therefore needs to be made between operating on the lower portion of 40m using CW or digital modes, or moving above 7.100MHz using SSB.

Further development

There is no doubt that this antenna checks boxes in terms of small-footprint HF operating and convenience when portable. Can its design be tweaked or enhanced? Here are a couple of options:

Firstly, changing its orientation from vertical to sloping markedly changes its characteristics. The antenna can be fed near ground level and slope up to a height of around 8m. This would necessitate to have at our disposal around 9m of horizontal space (less than a quarter of a wavelength). On 20m, the vertical antenna provides worse coverage at lower elevation angles, with the gain at 5° weakening to between -11.6dBi and -6.5dBi, favouring the slope. This contrasts with the figures we see in Figure 3. On 10m, however, the sloping antenna gives us with some very useful lobes, peaking in some directions at -2.2dBi. This contrasts favourably with the -9.0dBi of a vertical full-wave antenna. However, it is arguably on 40m that we see a real transformation. As a vertical, and typically for this polarisation, the vertical antenna suffers in comparison with a low-height dipole, for example, at higher elevation angles. The deficit we noted earlier was in the region of -21dBi (3.5 S-units). But by sloping the antenna, we can increase its performance at 75° elevation by around 12dB to 14dB to between -1.4dBi and -3.4dBi. This allows the antenna to offer almost the same omni-directional coverage as we had as a vertical antenna on 40m, but now to within 1 and 1.5 S-units of a low-height, full-sized dipole. There is also the added benefit that, if permissible, we need only 9m of horizontal space, rather than close to the 16m-20m we would typically need for a full-sized half-wave inverted-V dipole for 40m with an apex of between 5m and 8m above ground.

Secondly, and perhaps ambitiously, we could look at adding two tuned traps to accommodate the 15m band as a half-wave vertical antenna, and convert 10m operation into a half-wave rather

Table 1: Comparing the modelled performance of the 3-band and 4-band versions.

Band	40+20+10 version (dBi)	40+20+15+10 version (dBi)
40m	-7.7	-9.2
20m	-5.7	-6.4
10m	-9.0	-5.4

Tim Hier, G5TM
timhier@icloud.com

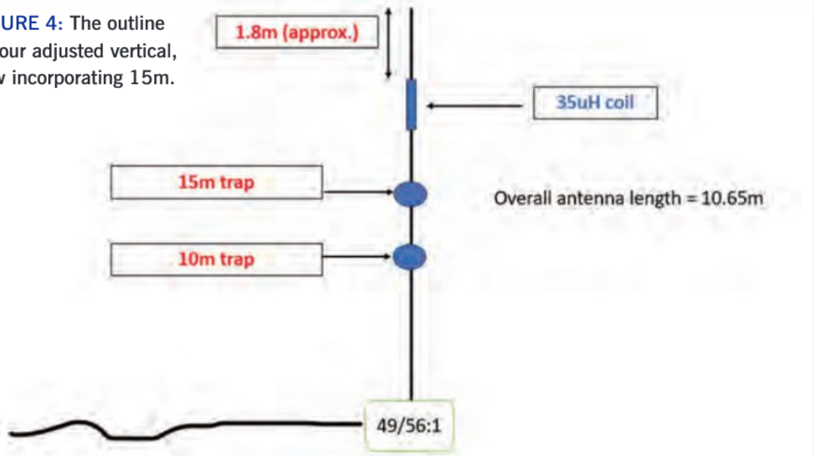


FIGURE 4: The outline for our adjusted vertical, now incorporating 15m.

than a full-wave vertical antenna. **Figure 4** shows the configuration of our modified vertical antenna. As we can see, there are now, in effect, three traps for this antenna. One is tuned to just below the 10m band to ensure that 10m operates as a half-wave. The 15m trap ensures the same for that band, albeit as a slightly-shorter antenna than a conventional half-wave. We also still have our 32-35µH coil which operates as a 20m trap and inductively loads 40m. Note that the overall length of the antenna is now shorter than our three-band original. Indeed, as I used un-insulated wire in the modelling, I would expect its final dimensions to be within the length (or very close) of a 10m fibreglass pole, thus enhancing its portability and reducing its visual impact.

As we can see from **Table 1**, through being further shortened to a length of just over a quarter-wavelength, 40m performance suffers a little, with gain reduced by a further 1.5dB. As 20m is also shortened through the loading effects of both the 15m and 10m traps, its gain is reduced slightly. However, the big advantage here is the transformation of 10m performance back into that of a half-wave vertical antenna, with low-angle gain subsequently improved by 3.6dBi. The 15m performance of this antenna, slightly shortened by the 10m trap, produces a respectable -6.1dBi gain at the 5° elevation angle.

So, overall, this is a useful antenna for portable or small-space operating. The 40m performance is undoubtedly a compromise, but still compares favourably with base-loaded mobile whips or shortened ground verticals. Its performance on the 20m band is the shining star of the three bands, and, with some tweaking, we might be able to operate on the 15m band and improve 10m into the bargain.

Signing off

I have enjoyed writing antenna articles for *RadCom,* and would like to thank the editorial team for their help and encouragement over the past twelve months. I am now stepping aside from being the regular author of this column, and would wish that the next author enjoys the process of putting their thoughts into print as much as I have.

If you are interested in writing this column, please email radcom@rsgb.org.uk

Reference
[1] Coil inductance calculator: https://66pacific.com

Contest Calendar April 2024

Ian Pawson, G0FCT

RSGB HF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Sat 6 - Sun 7 Apr	FT4 International Activity Day	1200-1200	FT4	1.8-28	Report
Mon 8 Apr	80m Club Championship	1900-2030	CW	3.5	RST + SN
Wed 17 Apr	80m Club Championship	1900-2030	SSB	3.5	RS + SN
Thu 25 Apr	80m Club Championship	1900-2030	PSK63, RTTY	3.5	RST + SN
Sat 27 - Sun 28 Apr	UK/EI DX CW	1200-1200	CW	3.5-28	RST + SN (UK/EI also send District Code)
Mon 29 Apr	FT4 Series	1900-2030	FT4	3.5-28	Report

RSGB VHF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Tue 2 Apr	144MHz FMAC	1800-1855	FM	144	RS + SN + Locator
Tue 2 Apr	144MHz UKAC	1900-2130	All	144	RS(T) + SN + Locator
Wed 3 Apr	144MHz FT8 AC (4 hour)	1700-2100	FT8	144	Report + 4-character Locator
Wed 3 Apr	144MHz FT8 AC (2 hour)	1900-2100	FT8	144	Report + 4-character Locator
Tue 9 Apr	432MHz FMAC	1800-1855	FM	432	RS + SN + Locator
Tue 9 Apr	432MHz UKAC	1900-2130	All	432	RS(T) + SN + Locator
Wed 10 Apr	432MHz FT8 AC (4 hour)	1700-2100	FT8	432	Report + 4-character Locator
Wed 10 Apr	432MHz FT8 AC (2 hour)	1900-2100	FT8	432	Report + 4-character Locator
Thu 11 Apr	50MHz UKAC	1900-2130	All	50	RS(T) + SN + Locator
Tue 16 Apr	1.3GHz UKAC	1900-2130	All	1.3G	RS(T) + SN + Locator
Thu 18 Apr	70MHz UKAC	1900-2130	All	70	RS(T) + SN + Locator
Tue 23 Apr	SHF UKAC	1830-2130	All	2.3G – 10G	RS(T) + SN + Locator
Sat 27-Sun 28	MGM	1400-1400	MGM	50, 144	Report + 4-character Locator

Best of the Rest Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange (Info)
Mon 1 Apr	IRTS 70cm Counties	1300-1330	FM, SSB	432	RS + SN (EI & GI also send country)
Mon 1 Apr	IRTS 2m Counties	1330-1500	FM, SSB	144	RS + SN (EI & GI also send country)
Wed 3 Apr	UKEICC 80m	2000-2100	SSB	3.5	6-character Locator
Sat 6-Sun 7 Apr	SP DX	1500-1500	CW, SSB	1.8-28	RS(T) + SN (SP send Province code)
Sun 7 Apr	UKuG Low Band	1000-1600	All	1.3G-3.4G	RS(T) + SN + Locator
Sun 7 Apr	WAB Data	1000-1400, 1700-2100		Data	3.5-14 RST + SN + WAB (two periods)
Wed 24 Apr	UKEICC 80m	2000-2100	CW	3.5	6-character Locator
Sat 27 - Sun 28 Apr	SP DX RTTY	1200-1200	RTTY	3.5-28	RST + SN (SP send Province code)
Sat 27 - Sun 28 Apr	UK/EI DX CW	1200-1200	CW	3.5-28	RST + SN (UK/EI also send District Code)
Sun 28 Apr	BARTG Sprint 75	1700-2100	RTTY 75Bd	3.5-28	SN

For all the latest RSGB contest information and results, visit www.rsgbcc.org

News

New licensing for a new era

New amateur radio licence conditions

Ofcom has released its final decisions following its consultation on the amateur radio licensing framework last year. Revised licence conditions became effective on Wednesday 21 February 2024. The changes to licence conditions include the optional use of Regional Secondary Locators, increased transmitter power levels and provide greater opportunity to bring newcomers into amateur radio.

There are approximately 100,000 amateur radio licences issued by Ofcom in the UK. Ofcom says that it will shortly be contacting all licensees to provide each with their new licence document. Ofcom is aiming to reissue all UK amateur radio licences by the autumn of 2024. To help this process run as efficiently as possible, please ensure that your contact details are up to date in the Ofcom licensing system.

Further updates to the amateur radio licensing framework, including the issuing of M8 and M9 Intermediate callsigns, will be rolled out in two more phases later this year and in the 2024/25 year. A video entitled 'Updating the amateur radio licensing framework: RSGB overview of key changes' is available in the Ofcom playlist on the RSGB's YouTube channel which you can find at youtube.com/theRSGB In it, RSGB General Manager Steve Thomas, M1ACB and RSGB Spectrum Forum Chair Murray Niman, G6JYB discuss the impact of the new rules. They also describe how the RSGB worked with Ofcom before and during the consultation period to arrive at the best outcome for all UK amateurs. Steve, Murray, and many people across the RSGB, have also worked hard to engage with individual amateurs, and amateur radio clubs and groups, to help them prepare for the licensing changes.

The RSGB will continue to release information and support for radio amateurs as we all adapt to the new arrangements. You can read more details and guidance on the Ofcom website at tinyurl.com/ARFEB2024 or via the RSGB website at rsgb.org/licensing

Given that increased transmitter power limits are now available to UK licensees, all amateurs are reminded that they are required to carry out EMF assessments. To help you do this, advice and an online EMF calculator can be found at rsgb.org/emf

The RSGB Band Plans for 2024 were published in the March issue of *RadCom*. They are now also available via the RSGB website at rsgb.org/bandplans This year's changes support the new Ofcom licensing framework and guidance, particularly in the VHF and UHF bands. All amateurs are reminded to consult the Band Plans before operating.


Ofcom

General notice of decision to vary amateur radio licences

Licence variation to give effect to the new amateur radio licensing framework

Statement

Published 21 February 2024

General Notice of decision to vary amateur radio licences.

The new licensing framework

The new conditions came into effect on Wednesday 21 February and consist of four key elements:

1. Personal Licence – two-page pdf
2. Main Conditions – Booklet Ofw611
3. Coordination Conditions/Locations
4. Ofcom Guidance

Amateurs should note the new element of the 'Notice of Coordination' which is referenced by the booklet. This split follows current Ofcom practice and provides a more flexible mechanism for Ofcom to notify licensees of coordination requirements in bands where amateur radio is already subject to sharing conditions.

Various changes to callsign policy and special event stations will be implemented by Ofcom at a later date as part of their three-phased approach. Ofcom will update its guidance when these changes take effect.

As a result of representations and careful review, the final refinements compared to the December statement are:

- Updated Coordination Conditions – with significantly improved flexibility in 430-440MHz, whilst maintaining full frequency clearance requirements in 1240-1325MHz
- Geographic boundaries now updated to clarify jurisdiction and operation on UK registered ships or aircraft
- Editorial changes in the frequency schedule and 5MHz conditions
- An amendment to the definition for Gateways


Ofcom

Amateur Radio Wireless Telegraphy Licence Conditions Booklet

OFW611

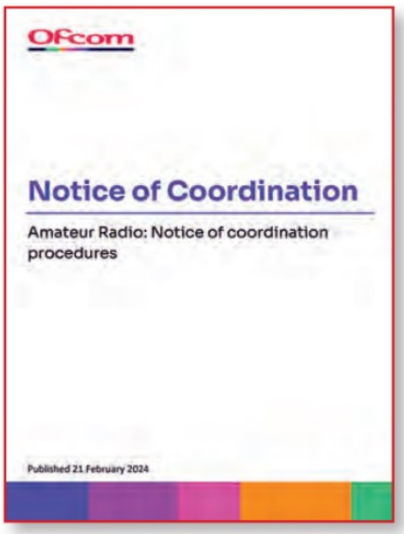
Published 21 February 2024

Licence Conditions booklet.

Useful pointers:

- Licence Review: rsgb.org/licence-review
- Licensing/Guidance/NoVs: rsgb.org/licensing
- EMF Assessments: rsgb.org/emf
- Band Plans: rsgb.org/bandplans

And remember to update/confirm your details/licence in the Ofcom portal


Ofcom

Notice of Coordination

Amateur Radio: Notice of coordination procedures

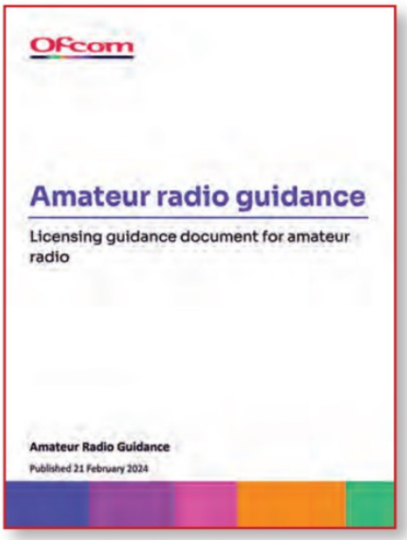
Published 21 February 2024

Notice of Coordination.

Ofcom's licence decision

On 11 December 2023, we [Ofcom] published the December Statement in which we outlined our plans to update the amateur radio licence framework, following consultation, to ensure the policies and licences meet the needs of today's and tomorrow's radio amateurs while streamlining the licensing process. Alongside this, we notified licensees of our proposals to vary all amateur radio licences to implement a number of the planned changes.

This document sets out our final decision relating to those proposals to vary all amateur radio licences, following consideration of the representations we received in response to the proposals. It contains important information and licensees should read it carefully.



Amateur radio guidance document.

What we [Ofcom] have decided – in brief

We have decided to proceed with our proposals and vary all amateur radio licences to make the following changes:

1. **Updating the licensing framework:**
   - Permitting licensees to only hold a single personal licence and requiring the revocation of lower-level licences as a licensee progresses (expected to be implemented in Phase 3 – 2024/25 financial year); and
   - Enabling greater supervised third-party use of radio equipment, by simplifying the rules.

2. **Streamlining and modernising callsign assignment:**
   - Making the use of Regional Secondary Locators (RSLs) optional;
   - Introducing the RSL 'E' for optional use by radio amateurs operating in England; and
   - Simplifying the licence terms on the use of callsign suffixes.

3. **Adjusting technical parameters to reflect the evolving needs of the hobby and provide radio amateurs with greater operating freedom:**
   - Enabling Foundation and Intermediate licensees to use internet-based technologies for remote control operation;
   - Enabling some beacon, gateway, data station and repeater use without the need for a Notice of Variation (NoV);
   - Increasing the maximum permissible power levels for all licensees;
   - Liberalising the Foundation Licence to allow licensees to build their own equipment and access the 2.4GHz and 5GHz bands; and
   - Allowing low power airborne use in some frequency bands.

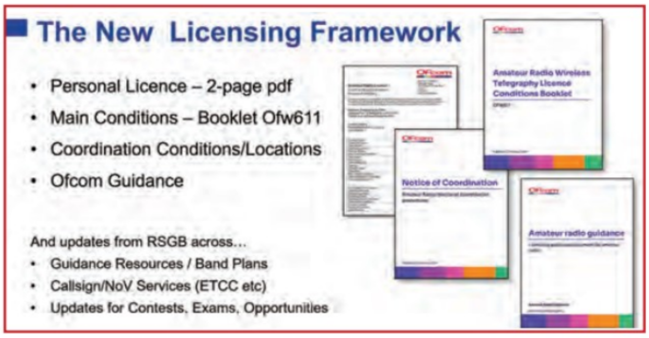
4. **Providing clearer updated rules (terms and conditions which are easy for everyone to understand):**
   - Aligning various terms and conditions with other licences that Ofcom issues.
   - Simplifying conditions to remove unnecessary complexity and making them clearer; and
   - Removing provisions unnecessary for spectrum management purposes.

We have also made a small number of additional changes in response to representations received from stakeholders.

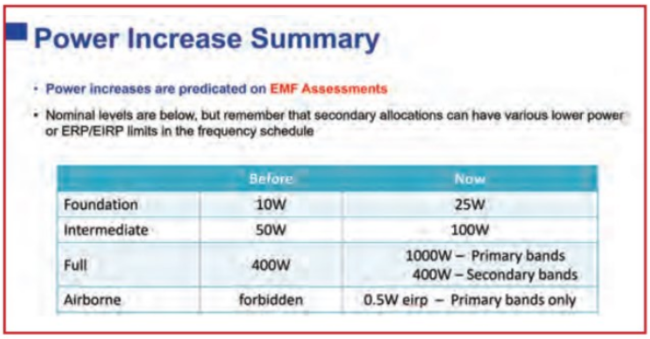
Alongside this decision we have published on our website:

- An updated version of the Amateur Radio Licence document;
- An updated version of the Amateur Radio Wireless Telegraphy Licence Conditions Booklet;
- An updated version of the Notice of Coordination; and
- An updated version of the amateur radio guidance document.

A QSO at the RSGB National Radio Centre at Bletchley Park using the new supervision opportunities.



The new licensing framework.



	Before	Now
Foundation	10W	25W
Intermediate	50W	100W
Full	400W	1000W – Primary bands 400W – Secondary bands
Airborne	forbidden	0.5W eirp – Primary bands only

Power increase summary.

For more information visit rsgb.org/licence-review

Design Notes

LF-band hardware

Back in the year 1996, radio amateurs got their first low-frequency band allocation, and were allowed to transmit up to 1W effective radiated power (ERP) in the band 71.6kHz to 74.4kHz. Back then, there was nothing in the books or magazines about operating at such low frequencies, so we all had to do basic research and experimentation on how to get going. All the equipment had to be home-constructed, and most of the technical details needed were buried in history, with articles from the pre-Internet days almost lost, apart from a few books on the subject. It was an interesting time; the Internet had just started, and an LF reflector was set up to facilitate discussion on all technical and operating matters, and for the setting up of skeds. Several years later, we lost the 73kHz band, but we gained the two bands that we have now: first 135.7kHz to 137.8kHz, with the same ERP, and then a few years later 472kHz to 479kHz at 5W equivalent *isotropic* radiated power (EIRP). There has been little technical information published since those early days of getting going at LF/MF, so we'll have a re-cap here of that development work, with some pointers on how to get operational on those bands.

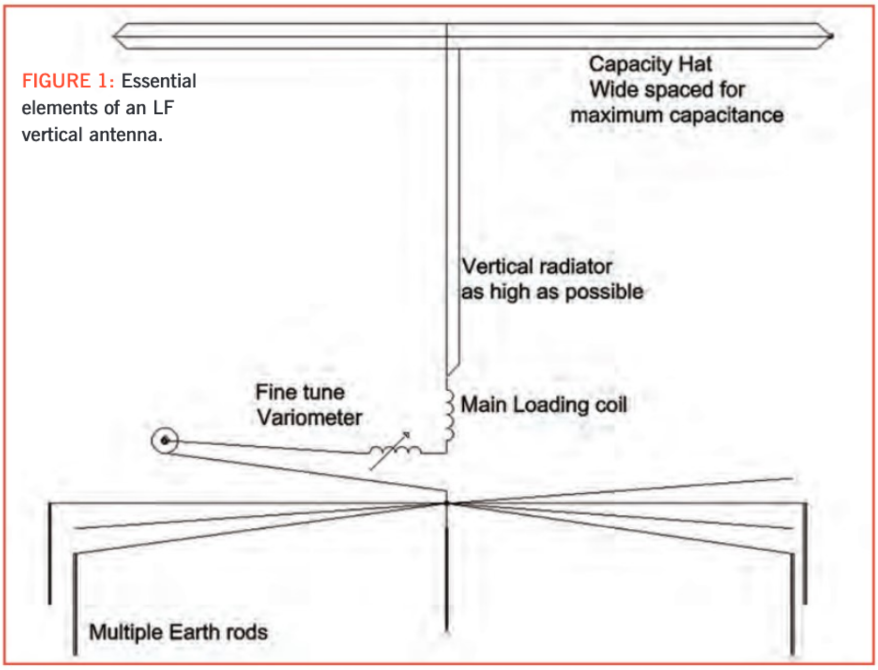


FIGURE 1: Essential elements of an LF vertical antenna.

Antennas

The antenna is almost certainly the most difficult part of operating at LF or MF. A frequency of 137kHz corresponds to a wavelength of more than 2.2km, so anything we can put up in a garden is going to be electrically very small. There are two types of antenna to consider: the loop and the vertical. If space is restricted, small loops end up appreciably less efficient than verticals, but if you have a paddock or an orchard, then a physically-large (although still 'electrically-small') loop might just prove useful, especially at 475kHz. However, most of us aren't in that position so here we'll just look at the vertical antenna.

An electrically-small vertical antenna looks capacitive, so has to be tuned to resonance with a loading coil that has to resonate with that capacitance. There has been much discussion over the placement of the coil, at the base or mid-way up. Base loading has the advantage of needing less inductance, as it has the whole of the vertical radiator to resonate with. An elevated loading coil needs more inductance, is mechanically more difficult to arrange, but can offer a slight improvement in efficiency. Base loading is by far the most popular, especially considering the sizes of typical loading coils.

In a vertical electrically-short radiator, the RF current tapers linearly from a maximum at the base (the top of the loading coil) to the top of the radiator where the current falls to zero. This taper means that the effective height of the vertical radiator is exactly half of its physical length. To improve matters, it is necessary to add capacitance to the top of the radiator in the form of a 'capacity hat'. This can consist of as may horizontal wires as possible and as long as possible. If the capacity hat were 'infinite', its capacitance would swamp that of the vertical itself and force current in that to be constant, with the result the effective height becomes the same as the physical height. In practice some compromise is needed, so the effective height ends up somewhere in the region of 0.6 to 0.9 of physical length for most practical amateur-radio installations. Why is effective height so important? We'll come to that shortly.

Increasing the antenna capacitance in other ways, for example by using multiple wires in the vertical radiator and the capacity hat, and using thicker conductors, all helps to lower the value of the loading inductance needed.

Loading coils

To get a feel for the size of loading coil needed, a good starting value is to assume 7pF per metre of wire in the vertical element, and 6pF per metre of wire in the top-hat. The capacitance is affected when multiple wires are run in parallel, and so the value is only 'rule-of-thumb', but can give a guide to planning things. Here at G4JNT, in a small suburban garden, I can manage 7m height and a longitudinal span of around 12m for the top hat. The garden is narrow, so the capacity hat has to follow its length. I use two wires spaced by 100mm for the vertical element, and three wires spaced 150mm for the top hat. This is shown diagrammatically in **Figure 1**, with a photograph of the current configuration in **Figure 2**. From the rule of thumb above, an estimate of 3 wires * 6pF/m * 12m + 2 wires * 7pF/m * 7m suggests that the capacitance could be around 310pF. With parallel conductors making up the total of wire used for the calculation, coupling between them lowers the actual value somewhat, but by how much is very much a case of 'suck it and see'. Proximity to local obstructions also changes things, sometimes in unpredictable ways. In practice, the measured capacitance to the radial system (which we'll come to in a minute) was actually measured as 210pF. Had the conductor spacing on the vertical and top hat been wider, an increase in capacitance would have been expected, but even with this arrangement, it would be unlikely to get much closer to the original estimate.

At 73kHz, 210pF needed an inductance of 22.6mH to resonate. We can use Wheeler's formula to get an approximation of the coil dimensions: $L(\mu H) = N^2D^2(0.46D + G)$ where

FIGURE 2: A picture of the 7m-high tee antenna in use at G4JNT for 137kHz and 475kHz. Two vertical conductors, spaced by 100mm, are used to get the equivalent of a thicker conductor to increase capacitance. The top capacity hat of three conductors, spaced by 150mm, runs the full 12m length of the garden. Extensive ground radials are placed under this run, several terminated with earthing rods.

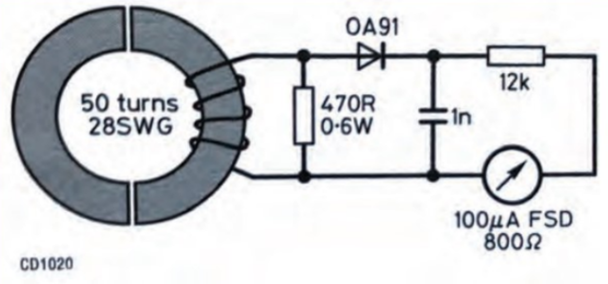


FIGURE 3: RF current monitor used to adjust a loading coil for resonance, and for assisting in determining antenna load resistance. This is Figure 6.1 from the *Low Frequency Experimenter's Handbook*, RSGB, published 2000. A more-recent equivalent can be found in [3].

N is the number of turns, D is the diameter and G the length of the coil, both in mm. I used a 300mm diameter fermentation bin on which to wind my 137kHz inductor. Plugging this diameter into the equation, and playing with the numbers, suggested it was going to need something like 400 turns spaced over a length of 500mm as a starting point. This wasn't feasible as a single layer, so some careful double-layering of part of the coil was needed, with plenty of good insulating tape. A variometer was included, consisting of 15 turns wound and glued onto a 250mm diameter plastic picnic plate. This was mounted inside the former with a spindle added so it could be turned to either oppose or add to the main coil by rotating its plane. The variometer gave an adjustment range of around 500μH, sufficient to get exact resonance once the number of turns on the main coil was optimised.

Back in 1996, small vector network analysers (VNA) were unheard of, so much experimentation was needed to get the system to resonance. This was achieved by feeding the loading coil and antenna system, after the radials and ground had been installed, using a test signal at 73kHz delivered from a MOSFET audio amplifier. Turns were then adjusted while looking for a peak in RF current using an RF current monitor such as that in **Figure 3**. This RF current-monitor design is based on a current transformer, with the antenna feed forming a one-turn primary on a toroid, and is still a favourite amongst LF operators, making for rapid tuning. After much fiddling, and the adding and removing of turns, the antenna current could be peaked at the wanted frequency. Several years later, the process was repeated for 137kHz, using a similar fermentation bin which needed around 150 turns of 1mm wire spread over 270mm for 6.4mH inductance. This was still long before VNAs were available to the average radio amateur.

The ground and radial system

Any vertical antenna must operate against a low-loss ground. This has to terminate the electric field lines from the vertical antenna in a manner having as low a loss as possible. The usual technique, with a single vertical radiator, is to use radials, placing as much copper on the ground around the base of the vertical element as possible, and ideally extending out to at least a distance equivalent to the antenna height. However, for a tee antenna, much of the capacitance to earth comes from the top capacity hat running horizontally, from one end of the garden to the other at my QTH. Since the electric field lines from this travel vertically downwards, several radial wires were placed directly underneath this part, with many other wires radiating out. As my garden consists of heavy clay that is quite conductive, maximum use was made of this by adding multiple earthing rods connected to the ends of the radial wires, as well as directly to the junction or feed point at the base of the loading coil. I used four 'proper' 1.2m rods close in and, to supplement these, shorter lengths of copper water pipe were bashed in as far as they would go – typically half a metre – at the ends of most of the radials. Once completed, the entire earthing and radial system was bonded to the house metalwork in a PME system using three separate 6mm^2 conductors **[1]**. The DC resistance measured using a 12V battery and ammeter between my earthing system and the house metalwork before bonding measured 4Ω. As we'll see, this was a meaningless figure at RF.

Antenna resistance and efficiency

When the antenna and ground systems had been completed, antenna measurements could begin. Antenna current measurement was already in place using the current probe, and a second diode RF voltmeter was connected to measure the drive voltage at the base of the antenna. Knowing both antenna current and voltage, the antenna drive resistance at resonance can be determined directly using Ohm's law. This drive resistance is made up from a combination of loading-coil loss, earth resistance, and a small amount of radiation resistance.

Radiation resistance, R_{RAD} , and RF current is what determines the radiated power, so by knowing the RF current, the transmitted power can be calculated from $P_{TX} = I^2.R_{RAD}$. The radiation resistance in ohms of a vertical antenna is directly related to the antenna's *effective* height, H_{EFF} , by the equation $R_{RAD} = 1580.(H_{EFF} / \lambda)^2$, where H_{EFF} and λ are both expressed in the same units (eg in m). An *effective* height for this 7m high antenna with large capacity top hat can be guessed to be in the region of 6m, thus giving a radiation resistance of $1580*(6/4100)^2 = 0.0034Ω$ at 73kHz. At 137kHz, the calculated R_{RAD} for this antenna rises to a whopping 0.013Ω. and at 475kHz to 0.14Ω.

Using measured RF current and voltage, it was found that the effective drive resistance of the antenna, once it had been carefully adjusted to resonance, was in the region of 220Ω at 73kHz, way above the DC resistance measured to the house metalwork. This is all loss resistance made up from coil losses, earth RF resistance and proximity effects of local trees terminating the antenna electric field. Subsequent measurement at 137kHz showed a loss resistance of 100Ω and at 475kHz of about 25Ω.

This effective resistance is way above the value for R_{RAD} and is in series with it. Of the RF power that is delivered to the antenna system, nearly all of it goes into heating the ground, and a bit to heating the coil. Only a very tiny fraction is radiated, and this can be determined from R_{RAD} / R_{TOTAL}. At 73kHz, this equates to $0.0034Ω / 220Ω = 0.000015$ or an effective antenna gain of -48dB. At 137kHz, the effective gain rises considerably to -38dB. However, at 475kHz, the 0.14Ω R_{RAD} and 25Ω loss resistance suggest a much-better gain of -23dB.

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FIGURE 4: This shows what can happen when 700W at 137kHz is mishandled. Here, small spark gaps were created when overlapping metal tape was used to seal the plastic cabin joints. In the vicinity of the fields around the loading coil, sparking at the joints of the tape set fire to the plastic.

A vertical antenna has directionality, giving it a gain of times 3 over an isotropic radiator **[2]**, so +5dB needs to be applied to these loss figures to get the antenna gain in dBi. These are -43dBi at 73kHz, -33dBi at 137kHz, and -18dBi at 475kHz. Achieving the licensed 1W ERP for the lower frequencies would need well over 1kW with this antenna. Some operators on the band have significantly-higher antennas with larger capacity hats, and actually can reach the licensed maximum ERP using around 1kW of RF power on 137kHz. At 475kHz the licensed power is 5W, or 7dBW EIRP, and to achieve this at G4JNT requires a more-reasonable 300W.

Loop antennas have a radiation resistance proportional to the square of the area of the loop, and therefore proportional to the fourth power of the diameter of a circle. This is why loops may be useful for larger installations, but are a non-starter for those of us with small gardens.

High voltage

This can be scary! A capacitance of 210pF at 137kHz has a reactance of 5500Ω. Applying Ohm's law, 700W of RF power into a 220Ω load resistance results in an antenna current of 1.78A. This, through the reactance of 5500Ω, develops 9.8kV on the antenna, and a massive field around the loading coil. If metalwork that might spark is in the close vicinity, in the presence of flammable material like a plastic cabin, consequences like that shown in **Figure 4** can happen. Several low-frequency operators have had fires; one needed the fire brigade to be called when a wooden shed was set on fire.

Receivers

For receive, the same antenna as that used for transmitting can be used, but in view of the large amount of externally-generated local noise in this part of the spectrum, many users have a separate receive antenna. This often consists of a small active loop that can be rotated to null out as much interference as possible. Other options commonly used are active whips (E-field probes) mounted some distance away from local noise-injection points, with their feeds very thoroughly decoupled to kill-off locally-generated interference. Interference cancellers, combining and nulling the interference input from two or more antennas, are also in use.

When the bands first became available, there were very few commercial receivers that could receive at these frequencies, and certainly nothing that would transmit. Today's receivers will usually go down at least to 100kHz, so nothing special is needed now. Back then, receiver converters were often used to up-convert LF to a few MHz for tuning on a conventional HF receiver. The converters were simple, often no more than a crystal oscillator and diode ring mixer but, in view of the capability of modern receivers, no further details are included here.

Transmitter drive sources

Transmitters are a different matter, and usually have to be constructed at home. Some SDR transmitters may offer a low-level output at 137kHz or 475kHz which may be amplified directly, but many don't. Even if other radios will tune down there on receive, they will not transmit any power. There are a few options available to generate a low-level drive waveform. One is to convert from a higher frequency that a transmitter can deliver. As is done in a receive converter, a crystal oscillator driving a mixer will suffice, and several designs can be found in various publications **[3]**.

Where a simple waveform is required, such as for on-off keyed CW, or a variable frequency fixed-amplitude data mode such FST4 or FTS4W, a dedicated RF source such as a direct digital synthesizer (DDS) can be used. Another alternative, used by a few operators, is a digital divider connected to the output of a transceiver. A 74HC390 device, for example, set to divide by 100, allows the transmitter to be run at 13.7MHz to give an output at 137kHz. Obviously, this is only suitable for CW, or constant-amplitude frequency-shift modes. If used for the latter, it must be noted that any frequency shift must to be generated at 100 times the wanted output shift.

Power amplifiers

137kHz is in the same frequency range where switch-mode power-supply units operate, so right from the start many SMPSU components were put into use, particularly ferrites for transformers. If linear mode operation is adopted via a transverter, then an amplifier can be designed along exactly the same lines as any conventional HF MOSFET design, but with the ferrite type and number of turns adjusted for the power and frequency in use. With the very low cost of MOSFET devices and ferrites used in SMPSUs, high-power amplifiers can be built relatively cheaply. Switching-type MOSFETs are not ideally suited to linear amplifiers, but they can be persuaded to work with careful biasing, and we covered this is the March 2016 *Design Notes*. However, as most operation on these LF bands is using constant-amplitude modes like multi-frequency-shift keying and CW, there is little need for linear amplifiers.

There are plenty of switch-mode amplifier designs in the literature, with power outputs ranging from tens of watts up into the kilowatt region. Kits are also available for several designs in the few-hundred-watt region. Another favourite is the highly-efficient class E design, such as the 400W design for MF **[4]**, which requires more effort to set up (an oscilloscope is mandatory) than a simple class-D switcher. The load resistance of the antenna is usually matched using a tapped transformer on the power-amplifier output, or a tap on the loading coil.

This article has only provided a brief outline, and has skated over the surface of how to get going on 137kHz and 475kHz. But I hope the information and pointers to further details will inspire more operators to try these fascinating low frequencies where home construction and a bit of thought are needed, rather than the buy-and-plug-and-play operation of HF. This month's *Data* column continues the LF/MF theme with a look at the digital modes in use at these frequencies.

References

[1] Much has been written in *RadCom* and elsewhere about PME, otherwise known as TNC mains earthing systems. In a PME system, there are potential safety issues with connecting the common earth/neutral conductor to an outside RF earth. In particular, high currents can flow if there were to be a neutral fault somewhere on the distribution cabling. But provided the bonding is done with a suitably-thick conductor it should be a safe option. If you are concerned about this, read the relevant publications available from the RSGB such as https://rsgb.org/main/files/2019/12/UK-Earthing-Systems-And-RF-Earthing_Rev1.4.pdf and elsewhere.

[2] The reflection of the vertical antenna in the ground plane makes it appear as an electrically-short dipole, which has a theoretical gain of 1.5 in free space. However, the power from the vertical antenna spreads out over half as much space than it does with a dipole in free space, so its directivity is doubled to three.

[3] https://www.rsgbshop.org/acatalog/Online_Catalogue_Low_Frequency_43.html

[4] http://g4jnt.com/QRO_500kHz_PA_Breadboard.pdf

EMC

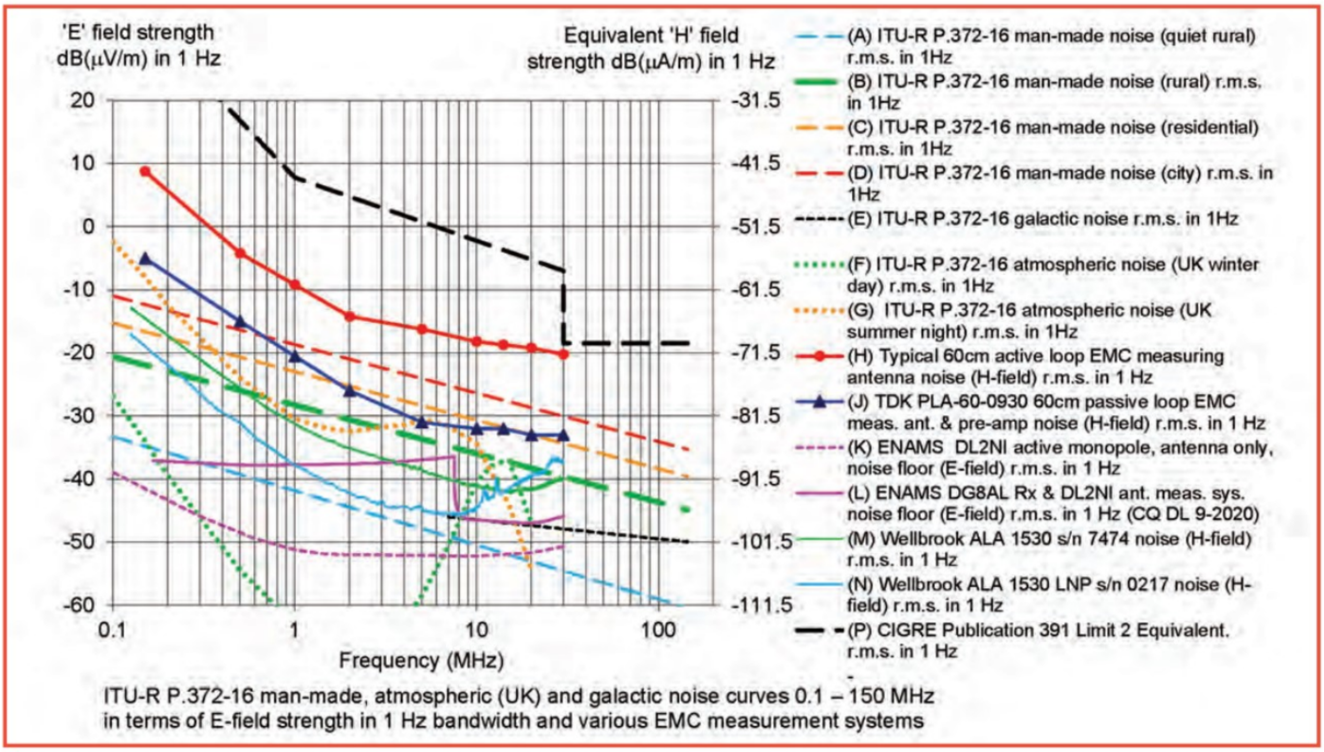

FIGURE 1: ITU-R P.372 noise levels compared to various receiving systems.

HF Noise floor

Natural and man-made radio noise levels are given by International Telecommunications Union ITU-R Publication P.372-16. The current version is 16 (08-2022) but the natural and man-made noise curves that affect amateur radio have not changed for many years. It is possible to download a copy of P.372-16 free of charge from ITU **[1]**. It is important to note that the noise levels are specified in terms of noise factor Fa, relative to thermal noise. To convert this to RMS field strength En at HF, it is necessary to use equation (7) which relates to a short vertical monopole. This is the type of antenna that was used by ITU-R to measure the radio noise at HF.

Figure 1 shows various ITU-R P.372-16 noise curves from 100kHz-150MHz. All the curves are RMS values of electric (E-Field) strength in dB(uV/m), normalised to 1Hz bandwidth. They need to be scaled for other bandwidths. The pale blue curve (A) is man-made noise at a quiet rural location. You would only find the quiet rural level far from built-up areas but you can find the wide green rural curve (B) in amateur bands at rural locations. The DARC ENAMS project has shown that rural noise levels (B) can also be measured at many residential locations, in amateur radio bands. The orange Curve (C) is the residential level and the red curve (D) is City. Atmospheric noise levels can exceed man-made noise levels in some circumstances. For example, the fine orange dots (G) show that UK summer night atmospheric noise exceeds the rural level from about 3-11MHz although it does not exceed the residential level. It is important to note that Curve (G) is derived from noise data for the UK area. We have seen other analysis that uses worldwide average data, but this will be significantly higher because of the higher incidence of thunderstorms in tropical regions.

How do you measure the background noise at your amateur radio station and how do you compare it to the ITU-R curves? The first thing you need is a receiving system where the receiver noise is significantly lower than the level of noise you are trying to measure. Ideally it should be 10dB lower or at least 6dB lower. The DARC ENAMS system achieves this using an active monopole antenna to ensure consistency with the ITU-R measurements. The purple dotted curve (K) is the DL2NI antenna on its own and the solid purple curve (L) is the overall measuring system noise floor with the DG8AL receiver and the antenna [2]. The receiver has two frequency bands with a changeover at 7.5MHz.

Other antennas shown are loop antennas. These measure the magnetic or H-field strength and the equivalent H-field strength is shown on the righthand side of the graph, assuming 'free space' conditions. The thin blue line (N) is a Wellbrook Communications ALA 1530 LNP loop of 90cm diameter. This was a special low-noise version made by Wellbrook Communications who are no longer trading. The thin green curve (M) is a standard ALA 1530 loop. Both of the Wellbrook loops have noise floors that are mostly below the rural curve.

The dark blue curve (J) is a 60cm diameter passive EMC measuring loop made by TDK, used with a pre-amp. This never gets below the rural curve and it only gets below the City curve from 1-30MHz. The red curve (H) is a typical 60cm diameter active loop antenna that is used by some EMC test laboratories. Its noise floor doesn't even come close to the city curve.

400kV sub-stations

The dashed black curve (P) is derived from CIGRE Publication 391 Limit 2. This limit is for large electrical installations such as 400kV substations and HVDC converter stations. The CIGRE limit is defined in 9kHz bandwidth from 150kHz-30MHz and 120kHz bandwidth above 30MHz. A Quasi-Peak (QP) detector is used. The RMS equivalent may be about 0-5dB lower depending on the waveform. An approximate value of -2.7dB has been assumed. Bandwidth has then been scaled from 9kHz or 120kHz to 1Hz. It is measured at 200m distance and it is approximately 35dB higher than the ITU-R rural curve. This means that, if the emissions from the substation are close to the limit, on 1.8MHz for example, then an amateur station 2km away may see emissions approximately 15dB higher than the ITU-R rural curve, although this would depend on the ground conductivity. To get down to the ITU-R rural noise level it may be necessary to go out to 6km or more.

We have read a report where measurements were made that claimed to represent the noise floor at a location but the measuring loop was the type shown in curve (H). It was not measuring man-made or atmospheric noise, it was measuring the much higher noise floor of the pre-amplifier in the active antenna!

EU Directives in UK

Three years after the UK left the EU, it is worth reviewing the history of European Directives and harmonised standards for electronic products from 1976-2020. Directives and harmonised standards that came into effect up to 31 December 2020 are still in force in the UK but there has been some divergence between UK and EU since then particularly in market surveillance. This item is written in the context of EMC but it has much wider implications for many other types of products covered by 'New Approach' Directives, including product safety of Lithium batteries, see below. This item is the author's opinion and it should not be taken as an authoritative guide to any standards or legislation.

Radio communication requires regulations that protect the radio frequency spectrum from interference. There is also a need to ensure that electronic products have sufficient immunity to unwanted operation in the presence of signals from radio transmitters and other sources of disturbance. In the 1980s, the RSGB EMC Committee, and its predecessors, mainly dealt with RF immunity issues such as breakthrough of amateur radio transmissions into TV, radio and audio systems and occasionally electronic telephones and PIR sensors for security lights and alarm systems.

There were some sources of interference to amateur reception including household appliances but these and others were regulated by European Council Directive 76/889/EEC of 4 November 1976 on 'the approximation of the laws of the Member States relating to radio interference caused by electrical household appliances, portable tools and similar equipment'. It covered a wide range of mains-powered machines with electric motors and also regulating controls incorporating semi-conductors. These include dimmer switches using triacs that generate RF interference and require suppression components. The 1976 Directive contained the full text of the EMC standard as an annex and this was similar to British Standard BS 800. It was replaced by 87/308/EEC.

An important milestone was the EMC Directive, Council Directive 89/336/EEC of 3 May 1989 on 'the approximation of the laws of the Member States relating to electromagnetic compatibility'. The was based on the 'new approach' to technical harmonisation and standards where the design and manufacture of equipment is subject to Essential Requirements.

The EMC Directive limits electromagnetic emissions from equipment so that it does not disturb radio, telecommunication and other equipment. It also governs the immunity of such equipment so that it is not disturbed by emissions from radio transmitters. Immunity requirements were introduced for the first time by the 1989 Directive. The relevant Harmonised Standards were listed separately in the OJ. It was due to come into effect in 1992 but this was postponed until 1996. It was subsequently replaced by newer EMC Directives, 2004/108/EC and 2014/30/EU.

One objective of the 'New Approach' Directives was the removal of technical barriers to trade. For example, computers sold in Germany before 1996 had to comply with the German EMC standard VDE0871 whereas for computers sold in the UK, compliance with the equivalent UK EMC standard BS6527 was optional. Another objective was to ensure equal conditions of competition for all economic operators and to protect against unfair competition, ie to create a 'level playing field'.

Market surveillance

Further to the items in December 2023 and February 2024 *EMC* Columns, Market Surveillance means ensuring that products conform to relevant legislation. With the increasing popularity of online auction websites and online market places, more and more online transactions in the UK are 'direct sales', where the product is supplied directly to the end user by suppliers outside the UK or EU. For example, car battery chargers that have been featured in the *EMC* Column in June 2020 and December 2021 are CE marked but have no radio interference suppression components. Tests show that the level of RF interference is far in excess of the relevant Harmonised standard, and they are reported to cause widespread interference on amateur radio bands.

The problem with direct sales is that they bypass economic operators responsible for compliance in the EU or UK. This can result in unfair competition, and it can also allow non-compliant products to be sold. Although products sold by direct sales are not placed on the market in the UK or EU, they are taken into service. The Essential Requirements still apply but it is very difficult for market surveillance authorities to regulate direct sales.

Regulation (EU) 2019/1020 of the European Parliament, and of the Council of 20 June 2019 on market surveillance and compliance of products, regulates direct sales by introducing the concept of a 'Fulfilment service provider' based in the EU that can be responsible for certain compliance activities. This applies in EU Member states and at the time of writing (Feb 2024) also in Northern Ireland.

Although the UK Government was not obliged to implement it in England, Wales and Scotland, there appears to be no reason why a UK version of Regulation (EU) 2019/1020 could not be implemented voluntarily if the UK Government chooses to do so.

Product safety

A member, who is also a keen cyclist, points out that EU Regulation on Market Surveillance and Compliance of Products (2019/1020) has far wider implications beyond compliance with the EMC Directive. Its scope includes compliance with various other EU Directives for many other products including the machinery Directive which covers electric bicycles, among other things. There are concerns in the UK about house fires caused by unsafe lithium battery/charger combinations used in some electric bicycles, electric bike conversion kits and electric scooters. These are available via direct sale in England, Wales and Scotland.

Our cycling Member comments that if a UK version of the EU Regulation on Market Surveillance and Compliance of Products (2019/1020) were introduced in England, Wales and Scotland, this would not only regulate non-compliant products that cause radio interference, but it could also improve consumer safety for Light Means of Transport batteries (LMT batteries), ie electric bicycles etc. Fire safety issues with unsafe lithium batteries/chargers for electric bicycles, etc could be tackled by means of a UK version of a recent EU Regulation. This is Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries. This covers a wide range of environmental and sustainability issues and also includes important regulations on battery safety.

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[1] ITU-R Recommendation P.372-16:
https://www.itu.int/rec/R-REC-P.372/en
[2] Dr. Andreas Lock, DG8AL, ENAMS - System des DARC e.V. Überlegungen zur Mess-Toleranz CQ DL 9-2020

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Book Review

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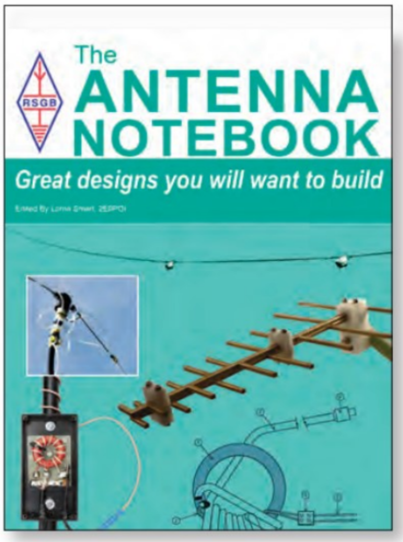
The Antenna Notebook

Edited by Lorna Smart, 2E0POI



This book delivers innovative and novel design ideas for antennas that you may or may not have heard of – based on a previous book edited by the late Giles Read, G1MFG. The art of antenna design and building has long been the domain of the advanced amateur radio enthusiast, but it need not be. The content of these pages contains a wealth of information which make the practical application of building antennas simple. Designs are based mostly upon previously-published RSGB articles but are also drawn from other sources such as the ARRL and G-QRP Club. The various chapters address possible scenarios that are likely to be encountered by amateurs. For example, you might have a small garden, no garden at all or antenna hight restrictions etc. The methods employed show that home-constructed antennas can be as efficient or better than purchased versions. An interesting example of this is the use of wire in place of aluminium elements in the construction of a beam antenna. By constructing a frame made of UPVC tubing, and stringing it with wire in a specific way, the same or better performance than with a beam can be achieved. Dipoles that are featured suit both internal and external installation in a variety of domestic situations.

The broad spectrum of over 50 antenna designs covered within the book should mean that there is something for everyone whether it be random end-fed wires or full-wave loops. The variety of materials used throughout the book is testament to the ingenuity of the radio amateur. Chopping boards, pipe clips and shelf brackets are all fair game when the design of a good antenna is at stake. Even such odd materials as Slinky Springs can be used!

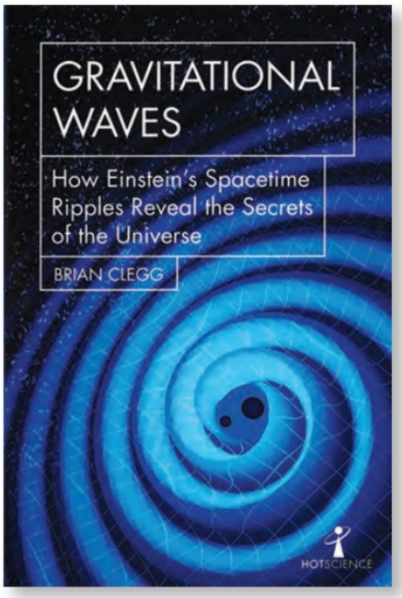
Another aspect of antenna design that is covered in the book is the use of a tuned antenna solution where antennas are designed to be resonant at a particular frequency. The book discusses the fact that receiving and transmitting antennas are fundamentally quite different and that the use of an ATU can dramatically enhance the performance of an antenna. The minimisation of reflected power is more critical for a transmitting antenna, of course, but when receiving any amount of gain that can be produced is a bonus. The book explains that an antenna can also be coupled with a pre-amplification stage to really pull in those distant signals.

This book will take you, step by step, through designs that will allow you to build a great variety of antennas – it is a very useful reference and one that will often be referred to rather than simply gathering dust on a shelf in the shack.

Size 174x240mm, 288 Pages, ISBN: 9781 9139 9552 2
Non Members: £15.99, RSGB Members: £13.59

Gravitational Waves

By Brian Clegg



Gravitational Waves (part of the same series as *Origins of the Universe* which we featured last month) seek to tell the story of the race to detect and prove the existence of this elemental force. It starts by setting out the history of gravitational waves and Einstein's theory of relativity. Two laboratories were set up to form the LIGO project or, more formally, The Laser Interferometer Gravitational Wave Observatory. The object of the investigations was to determine the existence of gravitational waves, however this was to be a most difficult exercise as the theoretical waves are very small. To put them into perspective, the size of an atom is measured at 10^{-10}m, the nucleus of an atom is (10^{-15}m) and a gravitational wave is 10^{-17}m.

Thus, the method of detection devised was that of taking a long vacuum tube, passing a laser light down it and splitting the beam, diverting the second beam and, when eventually bringing the two back together, measuring any movement between the two.

Two facilities were built to conduct the experiment, one at Livingston, Louisiana and the other at Hanford, Washington. These sites consisted of pairs of tubes 2.5 miles long, set at right angles, forming an L shape and the facilities set 1,865 miles apart. At each site, a laser passes along the pair of tubes to reflect off mirrors at the ends many times before the beams are brought together to form an optical interference pattern – a tiny set of fringes that gives a visible warning of incredibly small changes. The slightest variation of the beams will produce a detectable effect. This is the change that was expected to happen in the presence of gravitational waves.

Gravitational Waves is a fascinating read and is an interesting window into the world of particle physics. The determination and ingenuity of the scientists and physicists involved is very compelling and can be likened to the parallels in research and experimentation being done by amateurs at the forefront of the radio spectrum in SHF engineering.

Gravitational Waves is written in a clear and accessible way and does not require deep mathematical knowledge to follow it along. However, an appreciation of physics will help the reader get the most out of the book.

This book will be enjoyed anyone who wishes to expand their knowledge of fundamental forces that are becoming understood more fully as research progresses.

Size 128x196mm, 176 pages, ISBN: 9781 7857 8320 3
Non Members: £10.99, RSGB Members: £7.69 (30% OFF)

Review

DX Commander

Signature 9

I had been looking for an antenna to replace a 38-year-old Butternut vertical antenna, which had seen one too many winter storms here in Pembrokeshire.

As I asked around for recommendations, one name kept coming up: 'DX Commander'. Their antennas have gained a good reputation for performance and value for money.

What is it?

The Signature 9 is a vertical antenna which covers 10m to 40m without an ATU, and offers to cover 6m and 60m with an ATU, and perhaps even some local coverage on 2m (see **Figure 1**). Prior to the arrival of the antenna, I decided to take a look at some of the DX Commander videos **[1]** showing the assembly of the antenna. These are quite comprehensive, helpful and certainly entertaining. I must admit I finished watching the video about assembly and thought: "Crumbs, there's quite a lot to this!" It wasn't just me; Roger, GW5NF was visiting and watched the videos with me. At the end of it, he said: "Tim, you're going to be busy."

DX Commander don't send a set of instructions out with each antenna, but there's a PDF that you can download from the website **[2]**. Make sure your printer has plenty of paper and ink: it's 34 pages long! In fact, the manual you download covers all the DX Commander vertical antennas, rather than just the one you've bought, which again gives a sense of complexity. On the other hand, the download approach allows design changes to be updated immediately.

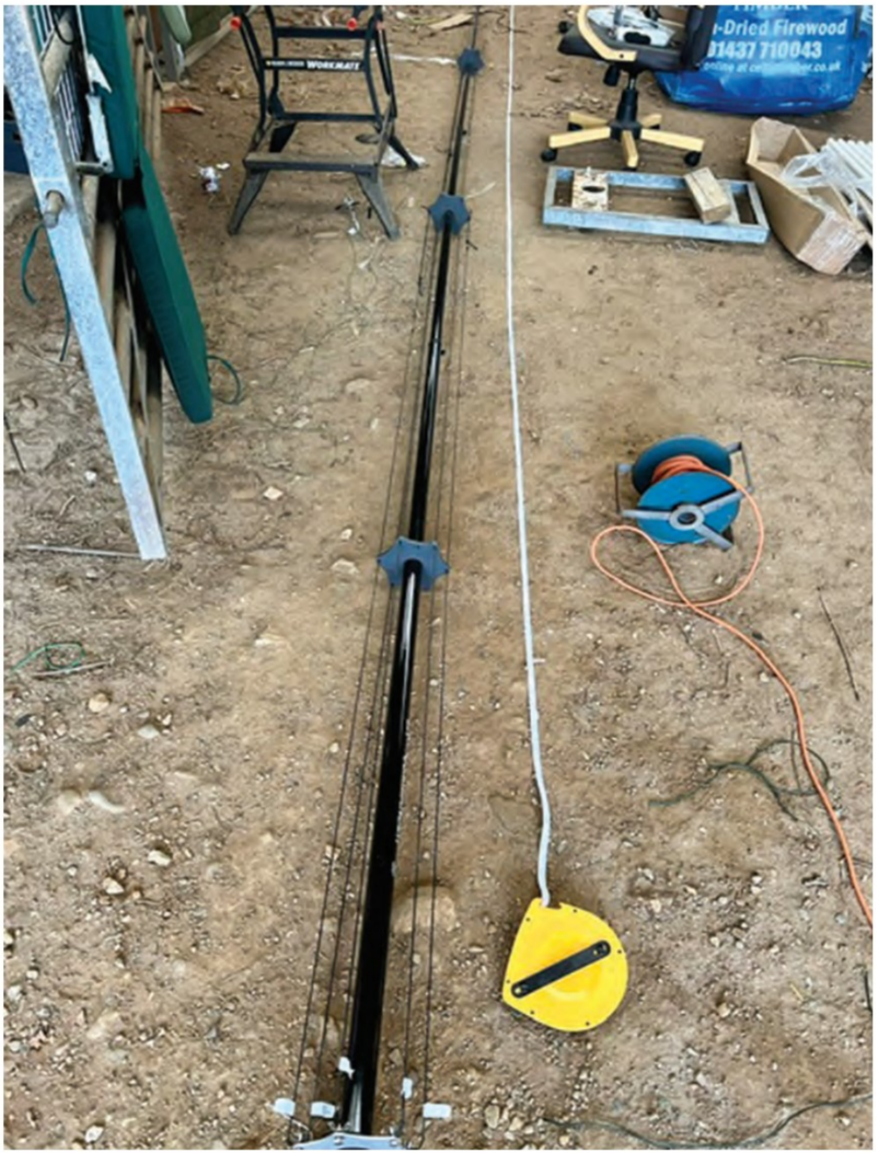


FIGURE 1: **The antenna being assembled on the ground.**

Assembly

My first task was to create a base for the antenna (see **Figure 2**). A ground post is supplied. Because of the nature of the ground here (rocky), I opted to dig a hole and set the ground post in 'Postcrete'. Callum, M0MCX, suggests that many users will not set the base in concrete, initially at least, but drive the post in and let it settle. I would have tried that approach, but for the nature of the ground here. Nevertheless, I dug a suitably-sized hole (which took a while), and then set the post in the cement, leaving it a couple of days to dry.

I began to assemble the pole while the post was setting. This was not difficult: I could just unscrew the top and pull the sections out, twisting them to secure them. As the antenna was going to be up permanently, I used the supplied clips (these are the HCL 'EzyClamps') to stop the pole sections collapsing. The clips are plastic versions of jubilee clips; you twist a screw thread which tightens the clip, but they don't bite you like a jubilee clip can! They are effective, but slightly annoying as you get used to them, especially a bit further up the pole where it narrows; do cut them down with some snips to make tightening them up a quicker job. Higher up still, I used some tape over the pole-section joints along with some cable ties, to secure the sections tightly.

Once assembled, you can then slip the driven plate at the bottom of the antenna down onto the base and secure it with a clamp, followed by the spreader plates which find their own positions on the pole, again clamping these in place. Around this time, I was looking at the instructions and wishing

FIGURE 2: Installing the ground post.

that there was a step-by-step assembly guide. There's lots of great information in the User Guide, but it's easy to miss bits and only discover later that you must go back and re-do something.

I was keen to get some elements onto the pole. The User Guide gives a cutting chart. The idea is that you cut each element exactly to the length specified. On most bands, you'll need to create what is called a 'fold-back loop'. Simply loop the wire back on itself, twist it together and tape the loop back to the main element. Once you're happy that everything tunes as it should, you can replace the tape with heat-shrink tubing to secure it. Cut the element to the lengths specified and you'll need to fit a fork connector to the end and crimp it. The instructions give reassurance that, if you don't have a crimping tool, an old blunt pair of side cutters will suffice. Once it's crimped on, fit some heat-shrink tubing over the fork connector to prevent the ingress of water. In all cases, you'll need to use a bit of shock cord (supplied) to go from the loop in the end of the element you've created up to the next spreader on the pole. See Callum's video if you're not confident with knots. Getting the right tension takes a little experimentation. Initially, I over-tensioned one of the elements and a few minutes later heard a noise like an electrical trip going off. After that, I probably under-tensioned a couple of elements, but this is quite easily adjusted. Do label your elements; it makes debugging any issues a little simpler. Callum suggests multi-coloured tape or beads.

I kept creating the elements and adding them onto the pole – quite a satisfying process. It was starting to look good. Bear in mind that the 40m element goes all the way up to the top of the pole and back down the other side to a spot around 2/3 of the way up the pole. This gives you both a quarter wave length on 40m, as well as something around a 5/8 wavelength on 15m. I was a little nervous about how the tuning would work out, but hoped for the best and carried on.

I did miss the instruction to create a tensioning loop on both the 30m and 40m elements to keep the elements nice and tight. Fortunately, this wasn't a problem; I simply went back and added a little loop to both elements, and created a tensioning section from the shock cord.

After a couple of hours of measuring, cutting, crimping and knotting, all the elements were on the pole.

Next, it was time to make some radials. Callum says that he gets more questions about radials than anything else. The instructions are quite clear that, as long as you have *some* radials, then the antenna will work, but it is better to have more radials. Do make your antenna elements first and your radials later, to ensure you have enough wire; two 100m rolls of wire are supplied, so you should have plenty.

The instructions continue: "After making your elements, and with the spare wire, make up your radials according to *any length* that fits your location. This means some can be smaller and some can be longer. It really doesn't matter."

It's suggested that you have four radials on each fork connector. As a starting point, based on the space available around the base that I had built, I decided to go for 4m long radials and have 4 sets of 4 radials. That kept me busy for another hour or so, as I cut, crimped and heat-shrunk the fork/radial connections.

With all this done, it was time to get the antenna up and try it out. Don't forget to place the ground plate over the ground post first, with the SO-239 connector installed in the ground plate. Carrying the antenna up to its location, I was amazed by how light it was. Lifting it up to vertical was quite easy on my own, although there was a light gale blowing, so getting the base of the pole to slip over the ground post took a few seconds longer than I'd have liked. Then, it was a case of attaching the radials and spreading them out in a reasonably uniform fashion around the base of the antenna and, finally, attaching the coaxial cable back to the shack.

Time to try it out

Excited but a little nervous, I went up to the shack and was reassured that band noise sounded encouraging. A quick transmission on all the bands between 10 and 40m showed that VSWR was perfectly acceptable on all bands. Wow! Well done DX Commander and well done me. Not being the best at following instructions, I was relieved. My first test was a 100W CW CQ on 28MHz. Admittedly, the band was quite nicely open, but the Reverse Beacon Network showed my signal being heard in Hong Kong and China amongst other places.

Over the next few days, I was like a

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FIGURE 3: The working antenna.

dog with two tails, happy at having a good antenna to play with. It was particularly nice to have resonant 10, 18 and 24MHz antennas, something I'd not had for a while. One afternoon, I heard a CW pileup on 12m with the DX signal at good strength. No callsign was being given, so I assumed it was a semi-rare station having some fun operating split. I placed my transmit about 1kHz up and tried a call. I got him first time, and it was TO8FH from Mayotte. Working T2C from Tuvulu on 20m CW a couple of days later was pretty straightforward too, and I was delighted. Many other excellent DX contacts followed on all bands from 40m to 10m, including stations such as 4W8X, ZL7A, VK9XY, VK9QO and TX7L.

In some heavy weather, my bodge around the pole joint came back to haunt me, when the pole slipped and I could see slack on the wires. This did affect the VSWR although the antenna was still usable. I ordered some extra clamps to make the joint properly. Doing it properly meant there was no more slippage. Watching the antenna in winds we consider 'modest' on the coast or on high ground, but which would probably be thought of as 'strong' inland, I tend to drop it if a significant storm is coming through. The thinner sections of the pole flex considerably from about 2/3 up the pole and, whilst they will almost certainly take a fair bit of this treatment, it probably stresses the pole as well as the elements/shock-cord sections. Of course, it's easy enough to replace an element or shock cord if it breaks, but the pole is a bit more expensive. The antenna is so light to drop to the ground that it's probably much better for your peace of mind to do that if a storm comes through. My rule-of-thumb is that if a storm is going to be over 40 knots or so, I drop the antenna rather than watch it whipping around.

The Signature 9 will handle 400W quite happily and, looking at the construction, I'm sure the increased limit for Full licence holders of 1kW would be fine on CW or SSB. If you're running data modes, you'll want to throttle things back, thinking of your PA stages, but it should cope with 500W continuous without too many problems. On 10 and 12m, Callum suggests creating a loop at the end of the elements to avoid corona discharge.

Final impressions

I wrote this review over a period of several months to get a feel of how the antenna worked in different conditions. I can only say that I have been delighted with the performance across the bands. The only band where I felt it wasn't quite so good was 15m; on this band it didn't seem quite as lively as on the other bands. I discussed this with Callum. He uses a quarter wave on 15m on some of the other DX Commander vertical antennas in the range, rather than the loaded three-quarter wave that's used on the Signature 9. Running the numbers through the computer, there didn't seem to be very much difference between the two configurations. Don't get me wrong, the antenna works fine on 15m, but I felt it lacked the 'sparkle' I saw on the other bands. On all the other bands though, I felt performance was excellent and surpassed my expectations. Construction of the antenna is actually very simple so, even if you're like me and find flat-pack and instructions hard to follow, don't worry. Callum includes the following section in the User Guide which sums it up nicely: "Please remember that all we are doing is creating resonant lengths of copper wire, held rigid on a telescopic pole using shock-cord. In the main, our element lengths will be a quarter of a wavelength long (sometimes we can use a loaded element up three quarters, giving us near 5/8 performance). We can make this as difficult or as easy as we like but if you miss a bit of the User Guide, or don't understand something, remember this is just supposed to work. And it will. The laws of physics won't change between Warwickshire and your place."

I've no hesitation in recommending the DX Commander Signature 9 vertical antenna kit to you. It's priced at £399, and can be obtained from **[3]**.

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[3] https://dxcommander.com/product-category/products/antenna-kits/

Maximum
Usable Frequencies in winter

Maximum usable frequencies for HF transmissions are higher in winter than in summer at nearly the same solar activity levels.

This seasonal variation is called the winter anomaly. **Figure 1** shows maximum usable frequencies (MUF) from July 2022 to January, 2024. Vertical bars represent median MUF calculated using midday (1200UTC) ionosonde measurements in Dourbes, Belgium **[1]**, **[2]**. Compared with summer levels, MUF is elevated during the rest of the year, so the winter anomaly is also called the seasonal anomaly. The data are for the mid-points of single-hop 3000km transmissions, based on ionosonde measurements of critical frequency foF2.

The magnitude of the winter anomaly is greater when solar activity in the 11-year cycle is high. The broken line in Figure 1 is a schematic plot of data from North America showing midday MUF during a previous solar cycle when solar activity was higher than it is now **[3]**. Monthly MUF levels in summer are similar to the data from Dourbes, while the anomaly, MUF(Winter)/MUF(Summer), is higher in the schematic.

The magnitude of the winter anomaly varies around the world. Typically, it is highest in North America. Satellite measurements of peak electron density (Ne) of the F2-region of the ionosphere show geographic variations of the anomaly in more detail than data from widely-spaced ionosondes. MUF is proportional to $(Ne)^{1/2}$. **Figure 2** is a global map showing colour contours of Ne(Winter)/Ne(Summer) measured when solar activity is high **[4]**. The winter anomaly, MUF(Winter) > MUF (Summer), is apparent in regions where Ne(Winter)/Ne(Summer) is greater than 1.0. In blue areas there is no anomaly (Ne ratio = 1.0). In white areas the Ne ratio is slightly less than 1.0. The map shows that the highest levels of winter anomaly are concentrated at mid-latitudes of the northern hemisphere.

Figure 3 shows data from Figure 2 averaged at mid-latitudes. The horizontal axis is longitude (-180° to +180°). The blue curve shows Ne(Winter)/Ne(Summer) averaged in the 40°N - 60°N latitude band. Winter anomaly is highest in North America and lowest in Eastern Europe. The red curve is for 40°S - 60°S. In comparison, **Figure 4** shows lower average Ne(Winter)/Ne(Summer) at mid-latitudes when solar activity is low.

The term 'winter anomaly' is also used for large increases in HF absorption that occur erratically during groups of days in winter. These disturbances in the D-region of the ionosphere are independent of the MUF anomaly in the F2-region. Both types of anomalies are caused by seasonal variations in the neutral atmosphere.

You can follow MUF in Solar Cycle 25 with the online PROPquest application by Jim Bacon, G3YLA **[5]**. Select the foF2 tab to see MUF *vs* UTC time for several different transmission distances. The Archives tab compares MUF on different days.

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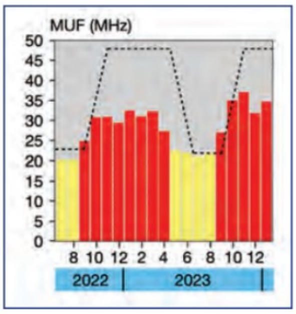

FIGURE 1: Ionosonde measurements of MUF (MHz) *vs* month (1-12). Vertical bars: monthly median MUF at 1200UTC at Dourbes, Belgium. Broken line: Schematic diagram of mid-day MUF in North America during a previous solar cycle (based on ionosonde data from [1]. Schematic data from [3]).

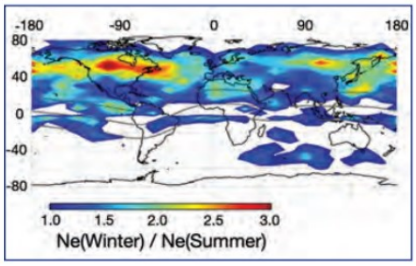

FIGURE 2: Satellite measurements of the winter anomaly in terms of peak electron density (Ne) in the F2-region during high solar activity. Color contours on a global map show Ne(Winter)/Ne(Summer) ranging from 1.0 to 3.0 (data reproduced from [4] under a Creative Commons licence).

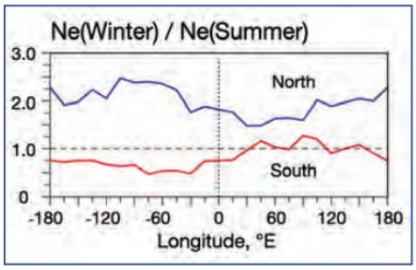

FIGURE 3: Ne(Winter)/Ne(Summer) during high solar activity. Blue line: average for 40°N - 60°N *vs* longitude (-180° to +180°). Red line: average for 40°S - 60°S (data reproduced from [4] under a Creative Commons licence).

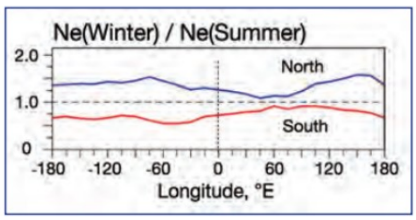

FIGURE 4: Ne(Winter)/Ne(Summer) during low solar activity. Blue line: average for 40°N - 60°N *vs* longitude. Red line: average for 40°S - 60°S (data reproduced from [4] under a Creative Commons licence).

A QRPP experiment with 10m WSPR

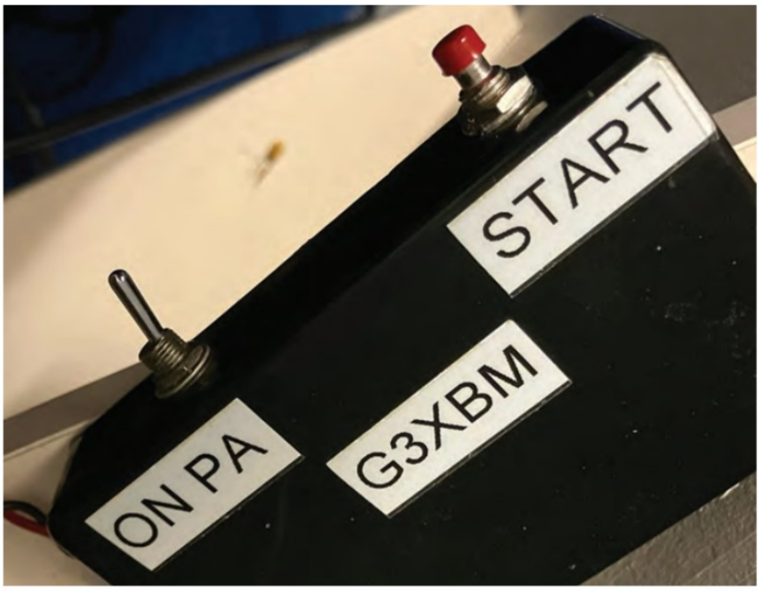

FIGURE 1: **My WSPR beacon, showing the switch to turn on and off the final-stage power amplifier.**

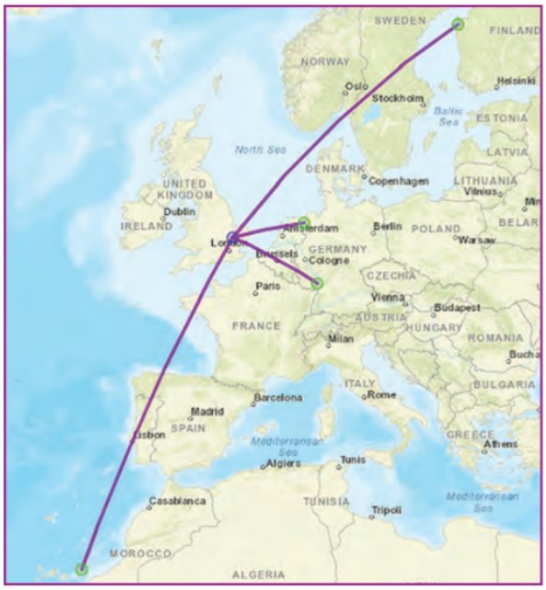

FIGURE 2: **Four WSPR spots with 500µW transmitter power.**

The 10m band is in great shape as we approach the peak of solar cycle 25.

For years, I have used a 500mW 10m WSPR beacon, so the possibility of using *even-lower* power came to mind. It would be fun to turn off the PA and try WSPR at even-lower powers, having been spotted the world over at 500mW. **Figure 1** shows my WSPR beacon, with a switch to turn on and off the final-stage power amplifier. The red button is for synchronising the beacon with the start of the universal-time (UT) minute.

The experiment

These days, 500mW seems like really high power! Remembering that a typical LED light bulb is 10W or so, even 500mW is miniscule, so 500µW seems like nothing at all. Using the tinySA spectrum analyser, the output power of my beacon was verified as being just 500µW (0.5mW). To my delight, even at this tiny power level, the signal was spotted by six stations on three continents including the USA in my first experiment. Of course, there are fewer spots than when I am using 500mW, yet it seems amazing that, even at this tiny power level, it is copied at all. Unfortunately, I did not save the WSPR map which showed these spots, so I ran the experiment again, and this time my signals were spotted in four places (See **Figure 2**). The antenna I am using is just an end-fed long wire, so nothing special. Reports received suggest that, if the receiver noise level is low enough, signals even weaker would be spotted. Maybe the next test will be at 100µW (0.1mW). By the way, please email me for details of my equipment, and my method of measuring the power, if you are interested.

Of course, it is the signal-to-noise ratio (SNR) at the receiver which determines whether or not a signal can be decoded, not the actual power level of the transmitter. WSPR provides a processing gain enabling a signal with an SNR of about -30dB to be decoded in a noise bandwidth of 2.5kHz, and 500µW is 30dB lower than 500mW, so that any station which can decode my 500mW signal with an SNR of 0dB or better should be able to decode my 500µW signals, all other things being equal. However, the variability of the 10m band ensures that all other things are *not* equal, and so we should not be too surprised by these results.

The beauty of the 10m band is that it is very wide, antennas are small, and noise levels are much lower than at lower frequencies, so even low power can go a very long way. It is wide enough to accommodate all modes, not that WSPR needs much. A WSPR signal has a bandwidth of about 6Hz. This is 6/2500 of the standard bandwidth adopted by radio amateurs for noise calculations. This fraction, expressed in decibels, is about -26dB. If 'good copy' on an SSB signal 2.5kHz wide requires, say, +10dB SNR, then the lower bandwidth of WSPR already achieves a gain of 16dB over an SSB signal, ie the WSPR signal can be 16dB, or 2-3 S points weaker for 'good copy'. This explains part of WSPR's huge processing gain compared to SSB. The rest can be ascribed to the way in which WSPR messages are constructed, and the length of time over which they are transmitted. The popular FT8 mode is a bit less sensitive than WSPR, but is still much more sensitive than CW. Using this mode, very-low power can result in two-way contacts across the planet. When the 10m band is really active, even the USA may be worked using amplitude modulation (AM) with just a few watts and a simple antenna.

So, get on to 10m and enjoy it! Even with the old Foundation power limits, working the world is possible with 10W pep of SSB and a simple antenna. In the past, antennas have been just a CB vertical or wire dipoles. I worked QRP DXCC on 10m SSB back in the 1980s. There is no need for a linear amplifier or a big beam. With 1.7MHz bandwidth available, it is extremely rare to find the band busy, with the FT8 'window' being just a few kHz wide, and the primary WSPR 'window' just 200Hz wide.

The sort of experiment described here could be replicated by adding suitably-rated external attenuators to any WSPR transmitter, but it is very important that any attenuation is put right on the output to avoid leakage from the coaxial cable.

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Porcupine
antenna accessory

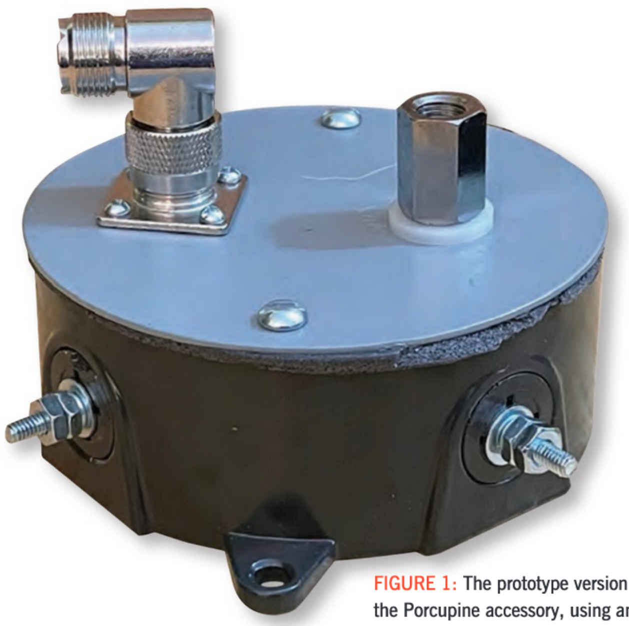

FIGURE 1: The prototype version of the Porcupine accessory, using an outdoor electrical enclosure and caulk.

FIGURE 2: The Mk2 version. This lacked additional support for heavier telescopic tubes.

I do a fair amount of HF portable operation from campsites, spanning from one to three nights per location over a one- to three-week road trip.

Generally, I select an antenna not only for given bands, but also for the space available to me, the number of trees, the terrain around my site, and how long I expect to be at the location. Also, I keep playing with different antenna designs, which means I carry them all, making the minivan a bit more cramped. “But, I might need one of them”, I say as I dust off one of the V/UHF Yagi antennas.

For some sites and lengths of stay, I may put up a 30ft (9.1m) telescopic fibreglass mast with a 40m off-centre-fed dipole. At other times, it maybe a ham-stick-like antenna that I put on top of my minivan, or throw a line to a tree. I might use a ground-mounted phased vertical antenna, a fan dipole, an off-centre-fed dipole, a linked dipole, a random wire, a V/UHF Yagi, a roll-up J-pole, in fact enough stuff to fill a couple of tote boxes and a kind of a golf bag just for antennas. And I sleep in the van too...

Simplifying the problem

A year ago, I began to think about simplifying what I carry with respect to providing me with *reasonable* adaptability. I started with a review of the items I rarely, or almost never, use; that is, things I could leave at home. Then I looked at what the antennas I use have in common. Pretty quickly, I saw the feed point as the item reproduced for almost every antenna I carry. I began sketching out what eventually became the ‘Porcupine’ antenna platform. I wanted something that could support as many dipole variations as possible, was waterproof, and was able to handle at least 100W. It must also be quick to change over to support different types of antennas, to work with wire, ham-stick type, and telescopic tube antennas, and which I could build using the few tools I have at home.

Off to the hardware store I went, and the prototype was born (see **Figure 1**). Simple and easy to use, it worked well at the campsite, but it didn’t support all the different antennas I could use. Every antenna I use includes some type of balun or unun and/or an RF choke. These items tend to make a bit of a train hanging from a feed point. I decided I wanted to have space in the box for a removable T-240-43-sized toroid to reduce the length of the train. I wanted enough space to accommodate either a homemade unit, or one of my commercial units. I decided, as part of this project, to wind my own balun. This isn’t hard to do, although it helps to have three hands. Also, I found some of the commercial ones I have are not all they promise to be when tested with a vector network analyzer.

Waterproofing

Since I live in the Pacific northwest of the United States on the western (rainy) side of the Cascade Mountains, the box had to be waterproof. I purchased a ready-made plastic box with an O-ring seal, and every fitting, screw, connector, etc used in construction is sealed on the inside with clear silicone sealant. The exposed UHF connectors on the outside are wrapped in ‘cling film’ when the coaxial cable is attached. Remember, this is a temporary installation.

Connections

The two important features of the box are the Porcupine’s ‘spines’ and ‘nose’ (see **Figure 2** and **Figure 3**). The spines are sixteen stainless-steel M4

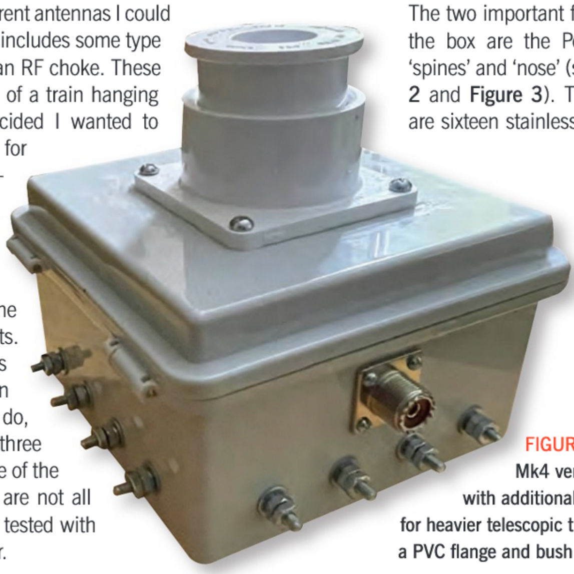

FIGURE 3: The Mk4 version, now with additional support for heavier telescopic tubes using a PVC flange and bush.

FIGURE 4: The radial field without a vertical element fitted.

FIGURE 5: A Porcupine with a 40m home-made telescopic whip, showing the extra piece of PVC pipe for additional support.

x 70mm screws to support radials or counterpoises. The screws are long enough to allow for doubling up the wires, but I only use sixteen in the field. I used hex nuts to secure the wires, but some may want to use wing nuts instead.

How long do I make my ground radials? I decided to make each of them a little over 2m long to form, roughly, a circle of diameter 4m. This seems to work adequately for 7MHz and higher, and fits in the space I generally have available at a typical state campsite (see **Figure 4**). I often sleep in my minivan, and use the tent space for my radial area when going with a ground-level vertical antenna. If elevating the vertical antenna, you will need a set counterpoises that are cut and tuned to each band. I have a linked counterpoise set to make this easier for me.

The Porcupine's 'nose' is an M10 x 70mm nut that you would normally use with whips. The nose accommodates my telescopic anten-nas, HF loading coil, and ham sticks. There is a large washer under the nose (see Figure 2) to help spread out the stress from mild antenna wobble. Additionally, I use ring terminals at the end of any random wire, end-fed half-wave antenna, or wire vertical antenna, with an M10 short bolt to affix the antenna to the platform.

Wind

Surrounding the nose is a PVC flange and bushing (see Figure 3). I use the Porcupine with my homemade 5.23m vertical aluminium telescopic antenna. When I mount this antenna, I screw it in to the platform, and then slide a 1m section of PVC pipe over the antenna and push it into the bushing. This helps support the antenna, and reduces 'wobble stress' on the box. I have a guy ring near the top of the antenna to add ropes for additional stability. I find that a length of less than 4.3m doesn't require guy lines when the wind is light.

To increase the stability of the platform for ground-level vertical antennas, I secure the Porcupine to the ground using thick tent stakes or weights,

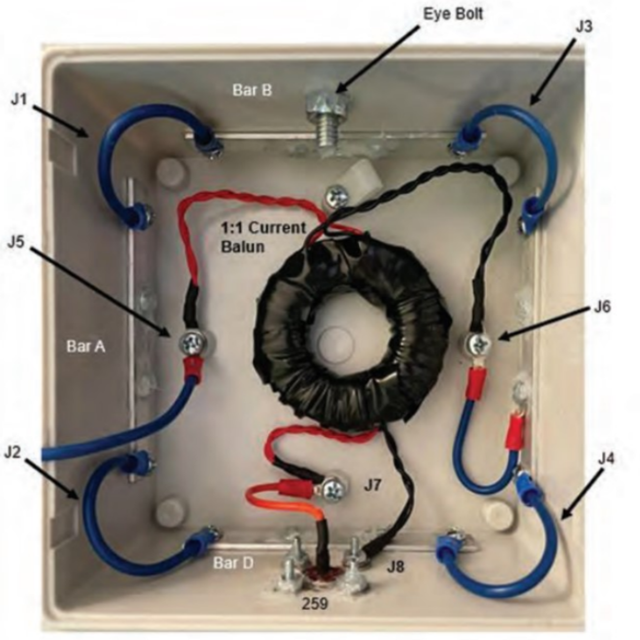

FIGURE 6: Inside of the Mk4 version. The 1:1 balun can be replaced as needed.

depending on the situation. In Figure 4 and **Figure 5**, the Porcupine is mounted on an aluminium plate with key rings to hold the tent stakes. I have also mounted the Porcupine on an old plastic cutting board, and I have a 61cm-square piece of wood that accepts the unit. The wood base has holes for the tent stakes, and four tie-down points for the antenna. The larger surface of the wood board is handy, using weights when stakes can't be used.

In use

Can you use the Porcupine for a raised horizontal dipole? Yes! I can release J1 and J2 from Bar B and D and attach J1 to J5 (**Figure 6**) and the spines become the tie points for the left and right legs of the dipole (it can support a fan dipole too). An eyelet on the box makes it easy to hoist the Porcupine to the desired height. Can the Porcupine be mounted on a mast? Yes! You just need to add a mounting plate to the back; there are screw holes already available. How about an elevated vertical wire dipole? It can handle this, but the box will need to be mounted on a mast, and remember that the coaxial cable has to run perpendicular to the antenna for a short length.

For a ground-mounted quarter-wave vertical fan dipole, you could place the box at the bottom of a mast, remove J1 and J2 from Bar B and D (Figure 6), attach J1 to J5, and use the Bar B-D spines for radials. At the top of the mast, you can mount a 2m to 5m PVC pipe to serve as the attachment points for each of the four vertical elements that connect to the spines on Bar A.

The Porcupine could also support an elevated quarter-wave vertical antenna with a counterpoise, if you build a mounting plate for it to sit on a tripod, which isn't hard. However, I haven't done this yet.

I have used the Porcupine antenna platform for over a year now, and I am pleased with it. For example, having a pair of Porcupines enables me to create a phased vertical array, which is a treat when camping. I have also made a third Porcupine to test out new modifications and additions. However, I have not yet reached the state of 'one Porcupine fits all', but I am getting there.

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