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Abbreviations and acronyms we use are listed at http://tinyurl.com/RC-acronyms

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Updating the amateur radio licensing framework: overview of key changes

Here are some updates from Ofcom on the proposed changes to amateur radio licensing.

What you need to know

Amateur radio licences will be changing in 2024. We [Ofcom] are maintaining the three-tier licensing structure and lifetime licensing regime but have decided to introduce changes to enable greater operating freedom for people using amateur radio while making the process of getting and using a licence simpler and more consistent.

The following paragraphs provide a high-level summary of the changes we plan to make to the amateur radio licensing framework following our recent review and consultation. The changes affect our overall licensing framework and rules on a number of areas including callsigns, technical parameters (such as power levels and when a Notice of Variation is required); and the licence format, terms, and conditions. Full detail can be found in our 2023 Statement **[1]** and Notice of Variation documents **[2]**.

Timetable for implementing the changes

To implement many of our decisions we need to make changes to all existing amateur radio licences. This means that many of these decisions are subject to the outcome of the statutory processes for varying existing licenses. We have therefore decided to start the statutory process to vary all amateur radio licences by publishing a General Notice **[3]** which sets out the proposed licence variations. Licensees can provide representations on these proposed changes by 5pm on 22 January 2024. Ofcom will consider all representations that have been provided after this date and decide whether to go ahead with our proposals. We may decide to vary the licences in accordance with our proposal, or with some modifications.

We will publish our decisions on the Ofcom website no later than February 2024 and vary the standard licences used for new licences at this point. The new rules will also apply for all licensees from this time, meaning all licensees may operate under the new terms and conditions applicable to their licence class. We will issue new licence documents to all current licensees. As there are around 70,000 amateur radio licensees, you may not receive your new licence immediately but, following the variation update, you may operate under the new rules as set out in the new terms and conditions booklet, which will be published on the website.

Phase 1 changes – new callsign rules and greater flexibility

We plan for the new terms and conditions and following changes to come into effect when we have completed the licence variation process. This is planned for February 2024. Under our new policies, and subject to the licence variation consultation and decision process, we plan to introduce the following changes:

Callsigns and suffixes

- The use of Regional Secondary Locators (RSLs) will become optional, removing the mandatory requirements for RSLs from the licence. If you wish to continue using one, you are able to do so, and they remain a valid callsign format. For licensees using a '2' format callsign, it will remain mandatory to insert an RSL.
- If you are a Foundation or Full licensee, you will be able to use the RSL 'E' in your callsign if operating in England, if you wish.
- You will no longer be required to apply for an NoV to your licence if you wish to use a 'special' RSL, when designated by Ofcom.
- We will amend the licence so licensees can use any suffix, so long as the station remains identifiable. It's important to note that suffixes fall under the Wireless Telegraphy (Content of Transmissions) Regulations **[4].**
- New applicants will only be allowed to hold one personal licence (excluding any Club licence).

Power levels and airborne use

- Foundation licensees will be able to transmit at 25W PEP and Intermediate licensees at 100W PEP, in bands where the Full licence currently permits operation at 400W PEP. Full licensees will be able to transmit at 1000W PEP in bands where amateur radio has a primary allocation.
- All licensees will be able to transmit airborne in primary amateur radio bands. There is a maximum power limit of 500mW EIRP.

Enabling more flexibility within the licence

- Many Notices of Variation (NoV) will be embedded into the licence terms and conditions, so a NoV will not be needed for some activities which currently require a NoV. This includes the deployment of some beacons, repeaters, and gateways as detailed below.
- As a licensee you will be able to allow unlicensed individuals to use your radio equipment under direct supervision. You will remain responsible for ensuring they comply with your licence conditions.
- The rules on remote and unattended operation will be updated. As well as this, Foundation and Intermediate licensees will be able to use the internet for remote control operation.
- For most repeaters, beacons and gateways you will no longer require an NoV (powers over 25W will still require an NoV). Licensees will have to carry out an interference assessment to prove that they have minimised the risk of interference to other users. For powers above 5W, a callsign must be obtained from the RSGB. *See also Note 1, p.13.
- A new Data Station mode of operation will be introduced. This is to allow the authorisation of a wide variety of other data systems, mainly machine-to-machine operations. This provision will permit the following types of operation under the licence: APRS, UIView/Packet, data/trunk links, and RF mesh networks.
- As a Foundation licensee, you will be able to build your own equipment and access the 2.4GHz and 5GHz bands. There is a maximum transmit power of 2W in these bands.
- We will align various terms and conditions with other licences that Ofcom issues, simplifying many of the conditions, removing unnecessary complexity and making them clearer. We will also remove several provisions from the licence that are not required for spectrum management purposes.

Phase 2: Changes to new Intermediate callsigns, SES rules and restrictions on the number of callsigns an individual may hold will be implemented later in 2024

We plan for these changes, which require modification to our licensing platform (or some other Ofcom action) to be implemented in 2024. Should the timings change, we will provide an update.

- We will cease issuing the '2' series of callsigns for Intermediate licensees and will instead issue 'M8' and 'M9' callsigns. Existing holders of '2' series callsigns will be able to transfer their callsign to the new M8 and M9 format at the same time. Although we will encourage this,

this will be voluntary. For those who continue using a '2' format callsign, you will have to continue to input an RSL into your callsign.

- Simplified the rules around Special Event Stations will be introduced, enabling a more flexible authorisation. We plan to fully automate the process, resulting in a quicker response for licensees.
- We will place restrictions upon the number of callsigns an individual can hold. For personal licences, this will be limited to one in line with our decision to only allow radio amateurs to hold only one personal licence.
- For Full (Club) licences, you will be able to start applying for additional callsigns (up to 5).

Phase 3: New licensing platform required
We plan for these changes to be implemented later in the 2024/2025 financial year, unless otherwise stated. We will provide updates should this change.

- For existing licensees, once we have implemented the new licensing platform, we wil look to revoke any lower-class, or duplicate, licences in phase 3. When you progress to the next licence class, your previous licence will be revoked. If you already hold multiple licences, you can either surrender them now or Ofcom will contact you at a later date to do so.
- We will be updating our mechanisms for online revalidation as part of our Licensing Platform Evolution.
- As a licensee, in the future you will be able to change your callsign periodically. This will be limited to once every five years to maintain identification of a station.
- From the time the new licensing platform is launched, new applicants will be able to choose from any available callsign when applying for a licence on the online portal. We will also allow the re-issue of old callsigns after a five-year 'cooling-off' period at this time.

References

[1] https://www.ofcom.org.uk/consultations-and-statements/category-2/updating-amateur-radio-licensing-framework
[2] https://www.ofcom.org.uk/manage-your-licence/radiocommunication-licences/amateur-radio/amateur-radio-info/licensing-updates
[3] https://www.ofcom.org.uk/manage-your-licence/radiocommunication-licences/amateur-radio/amateur-radio-info/licensing-updates
[4] https://www.legislation.gov.uk/uksi/1988/47/made

Summary

On 11 December 2023, we [Ofcom] published a statement setting out our decision to proceed with updating the amateur radio licensing framework to better meet the needs of today and tomorrow's radio amateurs. This decision followed our June 2023 consultation, which attracted nearly 1500 responses, and we made some changes to our plans in light of comments received. The planned changes aim to provide greater operating freedom for radio amateurs, while making the rules as clear as possible by simplifying and removing any unnecessary restrictions.

This is the first step in updating the regulatory framework. In order to implement many of the decisions set out in the statement we must vary all amateur radio licences. We have published a General Notice which sets out the proposals for this. As set out under the process set out in the Wireless Telegraphy Act 2006, licensees will have an opportunity to make representations regarding the licence variation. It is important to note that this process is not re-opening the policy consultation process but does allow radio amateurs to provide representations on these proposed changes by 22 January 2024.

After considering any representations received, we will publish our final decision within one month of the closure date for representations. This will explain whether we have decided to vary all amateur radio licence classes to include the updated licence conditions. The changes will come into effect from when we publish our decision, and we will take a staggered approach. At the same time, we would replace the Amateur TLC with the Amateur Conditions Booklet. We will then begin contacting licensees to provide them with their new licence document. Due to the volume of licences this process may take some weeks to complete.

The changes, if we proceed with making them, will be implemented in three phases::

Phase 1 (Licence variation required) – proposed implementation by end of February 2024

- Allow third party supervised operation
- RSL use optional and allow wider use of 'E' for England
- Special RSL notification
- Callsign suffix provisions
- Increased transmit power
- Foundation and Intermediate use of the internet for remote control links
- Incorporating beacon, gateway, data and repeater NoVs into the licence
- Allowing Foundation licensees to build their own equipment, and access 2.4GHz and 5GHz bands
- Permit low power airborne use
- Update and alignment of the licence terms and conditions

Phase 2 (Licensing platform modification or other Ofcom action required) - we plan for this to be in 2024

- New Intermediate M8 and M9 callsign prefix
- Restriction on the number of callsigns
- Liberalisation of the use of the Special Event Station NoV

Phase 3 (new licensing platform required) – we plan for this to be later in the 2024/25 financial year

- Improvements to the online revalidation process
- Holding of a single personal licence and revocation of lower licence as a licensee progresses
- Choice of wider range of unused amateur callsigns via the online portal
- Ability to change callsign periodically

Further information on the proposed changes and the General Notice can be found via the ofcom.org.uk website and rsgb.org/licence-review

***Note 1: Frequency Coordination Notice & Procedures**
A key change resulting from the Ofcom consultation is a new document that will be referenced by the licence called "Coordination Notice & Procedures". It will replace Schedule-2 of the licence for several bands, as well as radiuses around designated key locations.

Within this, Ofcom states: "Licensees wishing to deploy a repeater in 430-440MHz or 1240-1325MHz will need to obtain a clearance approval from Ofcom as they will need to be coordinated Primary Users such as MoD and CAA before any transmissions may begin." This is similar to the current process managed by RSGB-ETCC.

At present there is no exemption for low power (<5W ERP) systems. However, this an area of ongoing discussion.

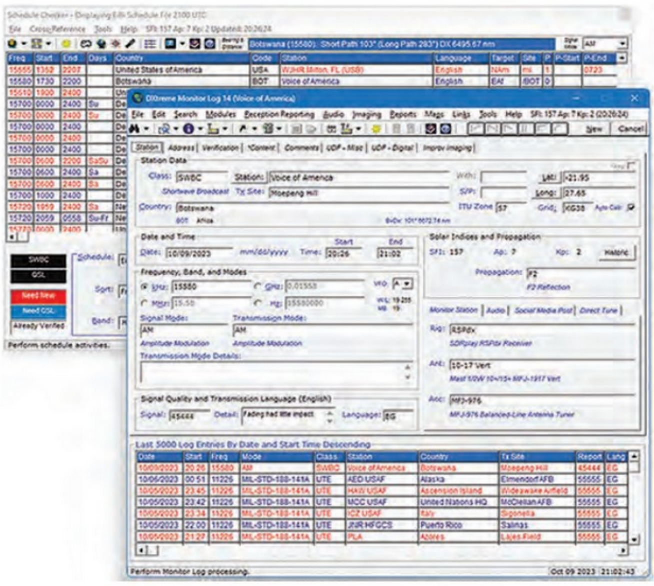
New Products

DXtreme Monitor Log 14™

DXtreme Software™ has released a new version of its popular logging program for radio and TV monitoring enthusiasts: DXtreme Monitor Log 14. Its familiar, uncluttered, industry-standard Windows interface lets listeners and DXers log the stations they've heard using features that enhance their monitoring enjoyment.

New features in this version include: a Signal Modes field to let users specify the signal mode their receiver is tuned to; a Transmission Mode Details box to allow users to type free-form information about the transmission mode received, such as baud rate, bandwidth, etc; support for tracking Maidenhead grid squares and much more.

For more information, visit https://www.dxtreme.com or write to bobraymond@dxtreme.com



Moonraker Titan 10m mobile transceiver

The Moonraker Titan 10m Multimode is a 40W FM/SSB/CW and 12W AM transceiver.

Specification:

- Frequency range: 28.000 to 29.700MHz
- Mode: AM/FM/USB/LSB/PA
- Output Power: LOW 4W, Middle 8W, High 40W
- Step: 5Hz, 10Hz, 100Hz, 1KHz, 10KHz, 100KHz
- ASQ on/off
- ECHO on/off
- Output power adjustable
- Hi-cut on/off
- Beep on/off
- Dual Watch
- Noise Blanker on/off
- ANL build-in
- Scan
- Roger Beep
- LCR (Last Channel Record)
- Mic gain adjustable
- TalkBack
- Scan list
- TOT
- Digital RFG adjustable
- A-RFG (Auto RFG)

Product soon to be available at https://moonrakeronline.com

Rigol DHO800 Series Oscilloscope

RIGOL is pleased to introduce the all-new ultra-portable 12-bit high-resolution digital oscilloscope DHO900/800 series.

The series provides guaranteed product performance while maintaining a small, slim, and portable design.

The devices are equipped with a Type-C interface and can be powered by a power bank, further enhancing user experience, and efficiently meeting various application needs.

The DHO900/800 series ultra-portable high-resolution oscilloscope, as an economical digital oscilloscope, will better satisfy testing requirements in areas such as electronics, embedded design, power supply design, and fundamental research. This greatly improves testing efficiency, providing engineers with powerful assistance right at their fingertips.

To read more about these products, visit https://telonic.co.uk

Antennas

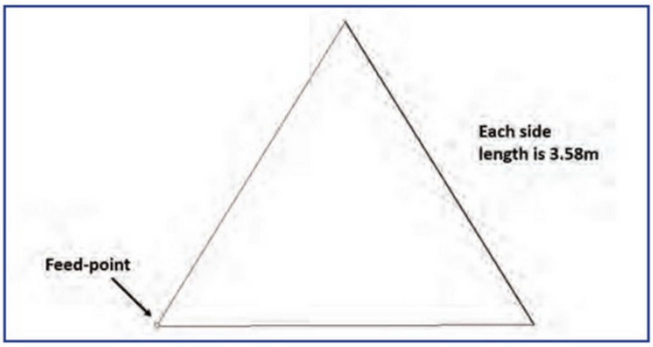


FIGURE 1: Configuration of the vertically-polarised delta loop for 10m, with a centre frequency of 28.450MHz.

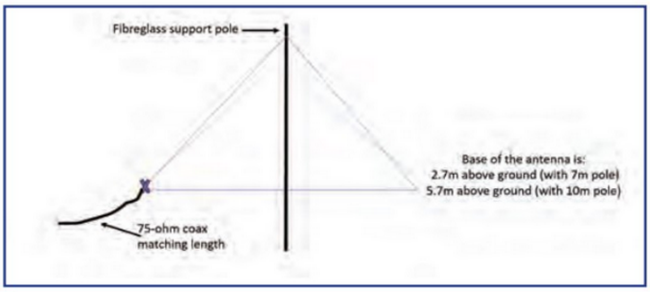


FIGURE 2: Supporting the delta loop using fibreglass poles.

With spring on the horizon, thoughts often turn to emerging out of a warm shack and working at a portable location. As we are still on the rising pathway towards increasing sunspot numbers, the upper HF bands should open with greater regularity and reliability.

The delta-loop antenna

The 10m band is a favoured band for many and, as well as quarter- or half-wave vertical or dipole antennas, the comparatively small size of the delta-loop antenna is seen as an attractive option. With that in mind, let's look at the delta loop for use in conjunction with 7m and 10m fibreglass poles. The former is lighter, and is favoured by those operating on SOTA summits and suchlike. The longer length is often used more by those choosing to set up for a weekend's field day, or for operating from a vehicle with a drive-on mast holder.

The delta loop for 10m

The overall length of a delta loop can be determined by using the formula 306/f m, where f is the centre frequency in MHz. This formula confirms that, for 28.450MHz, the overall length of the antenna is 10.75m. Here we make the assumption that each side has the same length – an equilateral triangle – although some limited variance away from this is not a huge issue.

Figure 1 shows the configuration of the delta loop for use within the SSB portion of the 10m band at 28.450MHz. In this case, the antenna is fed at the bottom left-hand corner, giving predominantly vertical polarisation. In many cases, the feed point for vertical polarisation is a quarter of the total wire length down one side of the loop from the apex. This puts it close to, but somewhat above, one of the bottom corners. I have chosen to use the bottom corner itself to feed the loop, as this provides a more-convenient location mechanically when using the loop in the field. When mounted at a height of 2.7m above ground level, this version of the delta loop presents a feed-point impedance of roughly 125Ω. By feeding it with 75Ω coaxial cable (such as RG-59), using lengths which are odd multiples of a quarter cable wavelength (the velocity factor, VF, for this type of coaxial cable is 0.66), we can get a very good match to 50Ω (see **Table 1**).

Table 1: The lengths of 75Ω coaxial cable required to provide a close match to 50Ω for the vertically-polarised loop.

Number of quarter wavelengths	Length (m) (VF of 0.66)	Impedance	VSWR
1	1.77	47	1.07
3	5.32	48	1.05
5	8.87	49	1.03
7	12.42	50.3	1.03

Vertical polarisation at different heights

The use case is to examine how this vertically-polarised delta loop might perform using a 7m or 10m fibreglass pole as its centre support. **Figure 2** shows how a fibreglass pole could be used to support the antenna, using either of these two options. Note that the top of the delta loop is not supported by the tip of either length of fibreglass pole, as this may cause too much physical stress, leading to a break at this very-thin part of the telescopic pole. Instead, in both cases, the top of the antenna is supported by the top of the penultimate section of the pole. This means that, in the case of the 7m and 10m pole respectively, the tip of the antenna is approximately 6m and 9m above ground level.

Using the 7m pole

Using MMANA-GAL modelling software, we can estimate the antenna's pattern and gain at a 5° take-off angle. It is useful to use the probable gain of about -5.5dBi in an omni-directional pattern, at a take-off angle of 5°, of a quarter-wave ground-mounted vertical antenna as a benchmark.

When fed at one of the low corners, the antenna provides predominantly vertical polarisation. **Figure 3** shows both the azimuth and elevation far-field plots; the pattern is not quite omni-directional, but shows increased gain in directions broadside-on to the loop, peaking at a respectable -2.7dBi. The gain is lower, but still useful, in the orthogonal directions. Note that the gain at the side directly opposite the feed point is slightly greater than that at the side where the feed point is situated.

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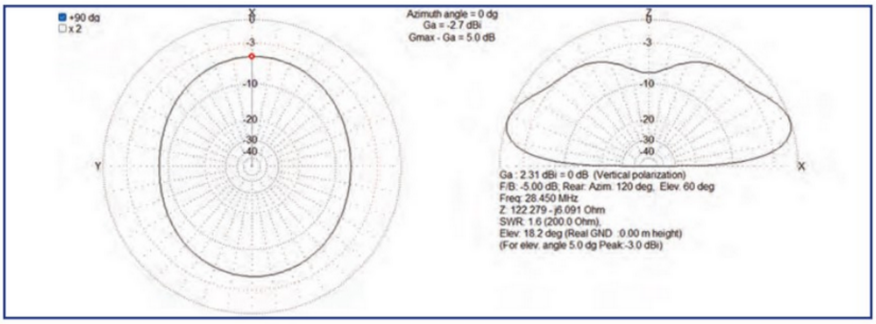

FIGURE 3: Azimuth and elevation patterns for the vertically-polarised loop using a 7m support pole.

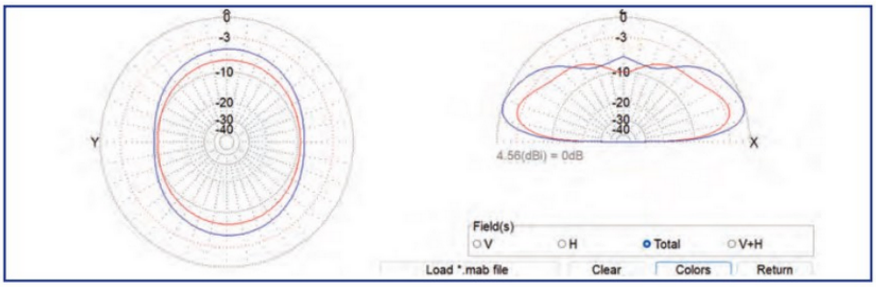

FIGURE 4: A comparison of the azimuth and elevation far-field plots when using 7m (red) and 10m (blue) support poles for the vertically-polarised delta loop.

Using the 10m pole

The antenna is mounted a further 3m above ground level. At this height, the base of the loop (and the corner feed-point) is approximately 5.7m above ground level, thus over a half-wavelength. Now we see an improvement in gain. Broadside on, the antenna has a gain of -0.5dBi at a take-off angle of 5° (an improvement of 2.2dB over the lower height), and from the sides of the loop, the respective gains in the directions of the side directly opposite the feed point, and the side containing the feed point, are modelled at -3.8dBi and -5.0dBi respectively, an improvement of a single dB in both cases. The comparison between the two cases is shown in **Figure 4**.

Horizontally-polarised delta loop

We can, of course, feed our delta loop to produce predominantly horizontal polarisation by moving the feed point to the centre of the lowest horizontal leg of the loop (see **Figure 5**). Let's compare this version of the delta loop at these two different heights with the vertically-polarised option.

Using the 7m pole, and with the antenna being fed at the centre of its base, we see that it now acts like a low dipole. At the height of its base (around 2.7m), the antenna behaves like a horizontal dipole a quarter-wave above ground level. **Figure 6** shows a comparison between the vertically- and horizontally-polarised delta loops using the 7m pole as support. The horizontally-polarised version has a peak gain of -6.4dBi at a take-off angle of 5°, 3.7dBi down on the vertically-polarised version. More strikingly, at this low take-off angle, the horizontally-polarised loop has very deep nulls off both sides, as you might expect from a dipole, measuring -20dBi at its extreme. The greatest energy is produced at much higher take-off angles than in the case of the vertically-polarised loop.

As we increase the height using the 10m fibreglass pole, we see a big improvement in the performance of the horizontally-polarised delta loop. The gain broadside-on now measures 0.1dBi (0.6dB greater than the vertically-polarised loop at this height). Note that we still have appreciable nulls from the sides of the loop and, as the antenna is now being fed at just over a half-wavelength in height above ground level (5.7m), we begin to see a classic doughnut-shaped pattern, similar to that of a centre-fed dipole at this height. **Figure 7** shows a comparison between these two loops using the 10m pole for support. Notice that the left-hand side of this diagram shows that the vertically-polarised version is much more omni-directional at 5° take-off angle, and is only fractionally down on the horizontally-polarised loop directly broadside-on. However, the right-hand side of the diagram reveals that, at still-useful angles for DX such as 10° to 20°, the horizontally-polarised version now has a distinct advantage.

Loop or vertical?

Does the loop antenna provide a better alternative to the half-wave vertical antenna? Let us compare these two antennas again, using the 7m and 10m poles as our supports when portable. The half-wave version I am using here is the 'flowerpot' or 'T2LT' half-wave antenna which does not require any radials, and is made from a single length of RG-58 coaxial cable. Electrically, it acts as a half-wave dipole.

Vertically-polarised loop versus half-wave vertical antenna

When comparing the vertically-polarised delta loop with the half-wave vertical antenna, using the 7m pole version, the half-wave vertical antenna, with its base at 2m above ground level, matches the vertically-polarised loop's peak broadside gain of -2.7dBi. However, **Figure 8** shows that, unlike the delta loop, it provides an omni-directional pattern so does not have the shallow nulls of the delta loop

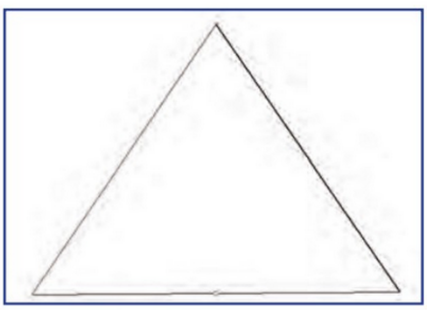

FIGURE 5: The horizontally-polarised delta loop is fed at the centre of the horizontal base leg.

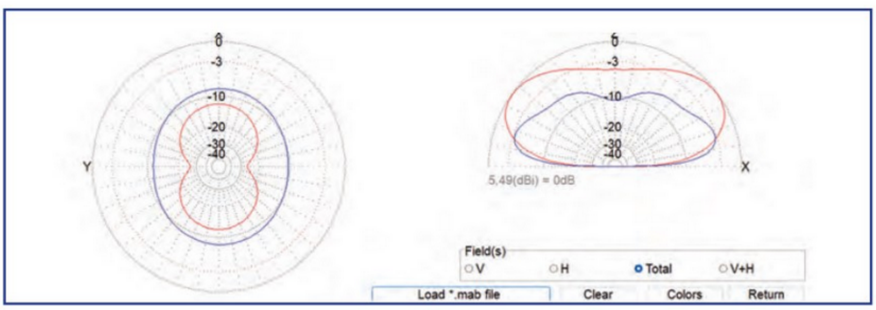

FIGURE 6: A comparison between the horizontally- and vertically-polarised delta loops using the 7m pole as support; red is horizontal and blue is vertical.

from both its sides.

When we consider the 10m support-pole version, the vertically-polarised loop has a 0.7dB advantage over the omni-directional half-wave vertical antenna, but is 2.7dB weaker from both sides of the loop; again, this is all at a 5° take-off angle. Note though, at angles between 10° and 20° (still useful for DX), the vertically-polarised loop has an advantage over the vertical antenna (see **Figure 9**).

Horizontally-polarised loop versus half-wave vertical antenna

Using the 7m support pole, with its low height above ground, the horizontal loop does not compare well at the 5° take-off angle, or indeed at any of the low angles usually required for DX communications. Its peak gain directly broadside-on is 3.7dB weaker than the vertical half-wave antenna, and this weakness is amplified as we move towards the sides of the loop (see **Figure 10**).

When we use the 10m support pole, the horizontally-polarised loop now has a 1.3dB advantage directly broadside-on compared with the half-wave vertical antenna, and again has deep nulls off its sides, showing that the omni-directional vertical antenna is better in those directions. However, as **Figure 11** shows, the loop out-performs the vertical antenna when broadside-on at angles above 5°.

Reflections

So, what does this all tell us about delta loops as alternatives for working DX when operating portable on 10m? If we intend to use a fibreglass support pole of around 7m, and if we are to choose a delta loop, then feeding it as a vertically-polarised loop must be our option. Choosing a horizontally-polarised loop at this height leaves us with a low dipole which directs our RF energy at high elevations, rather than an antenna suited for chasing low -angle DX. If we use a support pole of around 10m, especially in the case of the horizontally-polarised loop, we have an antenna which is directional in nature, and which provides useful gain broadside-on to the antenna.

If we compare the delta loop with the vertical antenna, we see three main differences. Firstly, the vertical antenna is the convenient option. It is easier to erect, easier to feed and, because of its omni-directional pattern, does not need to be turned or manoeuvred to work in specific directions. Secondly, the loop, if mounted high enough, has a slight edge over the vertical antenna in the broadside direction, and has better gain at still-useful DX angles from 5° to 20°. Thirdly, if we have a specific direction to work in on 10m, such as North America in the afternoons or VK and the Far East in the mornings, then a delta loop positioned broadside-on to the desired direction would work well.

One final factor to consider is that the horizontally-polarised loop can be a 'quieter' antenna. You can position a null in the direction of a noise source, useful if you wish to operate from home.

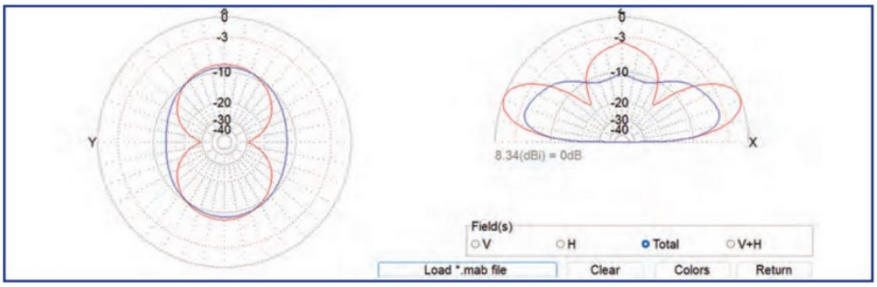

FIGURE 7: A comparison between the horizontally- and vertically-polarised delta loops using the 7m pole as support; red is horizontal and blue is vertical.

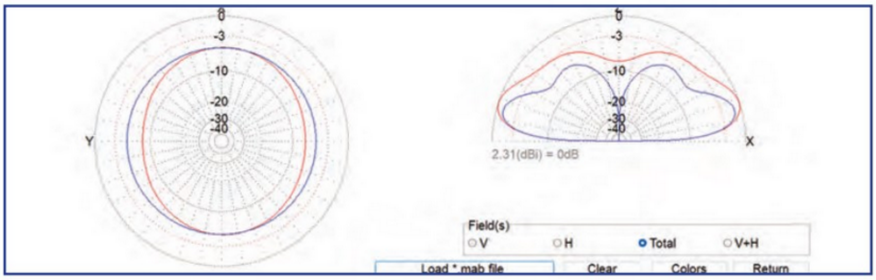

FIGURE 8: The vertically-polarised delta loop compared with the half-wave vertical antenna using the 7m pole; red is the loop and blue is the vertical antenna.

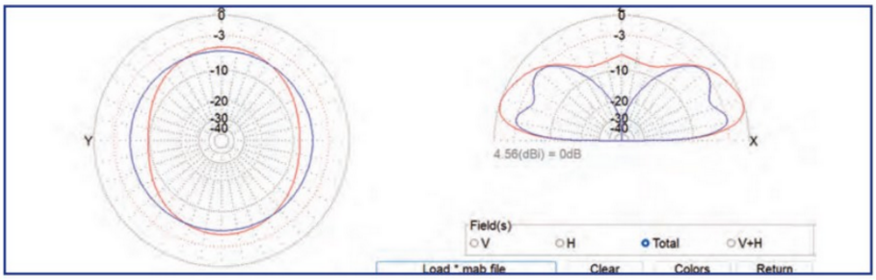

FIGURE 9: A comparison between the vertically-polarised delta and the half-wave vertical antenna using the 10m pole; red is the loop and blue is the vertical antenna.

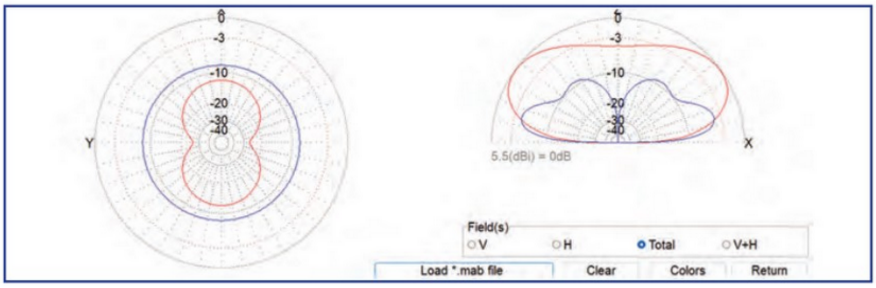

FIGURE 10: A comparison between the horizontally-polarised delta loop and the half-wave vertical antenna using the 7m pole; red is the loop and blue is the vertical antenna.

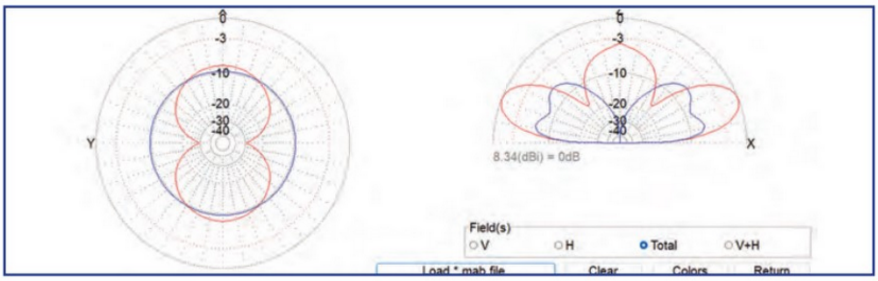

FIGURE 11: A comparison between the horizontally-polarised delta loop and the half-wave vertical antenna using the 10m pole; red is the loop and blue is the vertical antenna.

Review

ARCO smart antenna rotator controller

The ARCO smart antenna rotator controller by Microham does so much more than its description suggests. Yes, it can control your rotator, but it also has a whole host of other features that mean you may want one in your shack.

FIGURE 1: **The controller is housed in a smart black metal box with a seven-inch colour wide-screen LCD touch-screen display on the front.**

Description

The controller is housed in a smart black metal box measuring 265mm x 150mm x 125mm with a seven-inch colour wide-screen LCD touch-screen display on the front (see **Figure 1**). The total weight is 2.85kg and the controller is entirely self-contained. That is, you do not need a separate computer to run it or its display. The front panel controls have been simplified, and consist of an on/off switch, left/right (CW and CCW) buttons and a control knob. Three LED indications on the front panel show POWER (amber when on), FAULT (normally off, red when a fault is detected), and MOTOR (which turns green when the rotator is moving). Everything else is handled via the screen or via a VNC connection to your PC. Two sturdy rack-mount-style carrying handles complete the look.

Connections

On the back is a standard AC connection using the included standard power cord (see **Figure 2**). It's internally switchable to 115/240 V AC. Above the AC LINE connection is a 3.5mm stereo jack socket, which can be used to link multiple ARCO controllers together. There's a DB9 serial RS-232 computer control port, a LAN Ethernet RJ-45 port to control the unit over IP, a USB-B port (USB) for computer control, a USB-A port (FW) for key-pad connection or local firmware update, and a DB15 female (D-SENSOR) socket for digital position sensors.

The digital sensor port provides three differential lines supporting RS-485 communication, as well as single-ended, push-pull, and open-collector connections, for various quadrature encoders. With high-resolution sensors, the positioning accuracy is 0.1°. For rotator position feedback, the ARCO supports a wide range of absolute and relative sensors including rheostat, potentiometer, reed contact, Hall sensor, and PWM sensor. There are two different types of rotator connectors: a ten-position removable terminal, and a rotator connection port connected in parallel, with six conductors to connect directly to a Yaesu rotator. There's also a ground (GND) terminal, a fuse holder, and a cooling fan (which hardly ever runs).

Compatibility

But where do we start? Firstly, it will work with a wide range of Yaesu, Hygain, SPID, K7NV, and Prosistel rotators and protocols, all selectable from the menu. It also has a custom feature that lets you set it up for, well, just about anything else!

There are two versions of this controller. The 200W unit is the standard version, and the 400W unit is meant to be used with larger rotators, or for extra-long cable runs. It can handle rotators with voltages of 12V, 18V, 24V and 48V. These are all selectable via the display. The built-in VNC server provides an exact copy of the ARCO screen on your computer monitor, tablet, or Smartphone, enabling full control of the antenna rotator and antenna switches driven by ARXC relay modules directly from the computer or mobile device, regardless of whether you are connected to the ARCO locally or remotely via the internet.

Along with the manual control, ARCO offers rich connectivity for the computer using a standard RS-232 port or USB serial port which do not require the installation of any drivers on Windows 10, 11, macOS, and Linux, and an Ethernet port to enable control over the Internet. For unattended remote operation over the internet, ARCO offers an autonomous parking function, and physically disconnects all wires coming to the rotator port from the rotator hardware when the session is over, or it breaks, or if the ARCO goes to the power-down mode, in order to minimise possible damage by high static or nearby lightning during storms.

Operation

The screen presents a great-circle map of the world, centred on your QTH by way of the set-up screen. It also needs to know the date and time, so that it can compute Sun and Moon positions (which can be switched off). Calibration of the controller and antenna can be carried out in a number of ways. You can set the 0° (north) calibration point while the antenna is accurately beaming to the north, or you can select the 180° (south) calibration point, while beaming to the south. Alternatively, you can enter and register a custom azimuth (bearing) as a calibration point, or by entering the GPS coordinates of a visible distant reference point. Finally, selecting solar azimuth allows you to set a calibration point with the help of the Sun's shadow of the tower.

Once calibrated off you go. To point towards a particular azimuth, you have a number of options. You can either use the CW and CCW buttons in the traditional way, or use the knob to do the same. Alternatively, you can select a location that you wish to point at on the on-screen map, or you can enter a DXCC country

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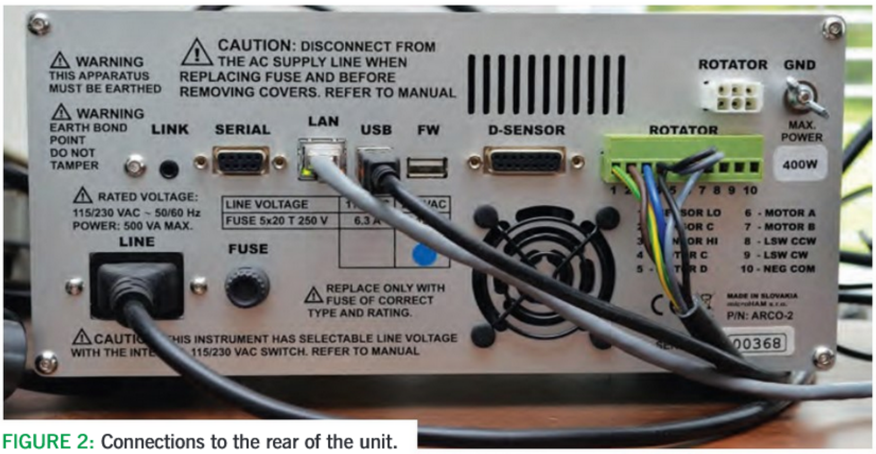

FIGURE 2: Connections to the rear of the unit.

prefix, an ITU zone or a QRA locator. Common prefixes appear on the display, and you can create your own as well. You can even enter the country using the alphabetic keypad on the screen. Finally, you can enter the azimuth heading you require in degrees.

The map can include the track of the grey-line, and also plot the location of the Sun and Moon. You can also change the displayed range from your QTH. You can select the full world map (at 12,000 miles range) for chasing HF DX, or perhaps for six meters you can select 2,400 miles range or a low-range view for two meters (300 miles). This is especially useful if you are a keen VHF/UHF operator who wants to focus just on Europe.

Other display options include a night-time mode, a geo-political mode (where entities are in different colours), or you can even load your own maps. A computed distance-to-target is displayed for all country/locator inputs. And believe it or not, we have still barely scratched the surface of what the ARCO can do.

Bells and whistles

The set-up menus allow you to enter 'ramp-up' and 'ramp-down' speeds so that the rotator is slowly energised or de-energised. This can be useful with large arrays as it prevents sudden shocks from being applied. This is also configurable, with ultra-fine gradual speed ramps, significantly reducing inertial stress to the rotator, tower and antennas. A gradual speed control uses an auto-adapting procedure, which dynamically changes with resistance caused by wind or ice. You can even set an azimuth setting for PARK, which the controller will automatically move to after a certain time (programmable between 1 and 99 hours). Firmware updates are available and are free to ARCO owners.

In summary

You are probably realising by now that this is a very powerful controller. It has been designed for radio amateurs who want more than a point-and-click rotator controller. If you are serious about your DXing, then it allows you to beam towards a location instantly by entering the prefix or ITU zone. Want to use the long path instead? No problem, just click it on the display. Want to work European DX on VHF? No problem, just enter the Maidenhead locator.

If you are thinking of purchasing, I urge you to download the 49-page user manual from www.microham.com and read it thoroughly. Only then will you know if the controller is for you. The ARCO Smart Antenna Rotator Controller costs £799.99 and is available from Martin Lynch and Sons. Our thanks to them for the review model.

Contest Calendar February 2024

Ian Pawson, G0FCT

RSGB HF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Mon 5 Feb	80m Club Championship	2000-2130	SSB	3.5	RS + SN
Sat 10 Feb	First 1.8MHz	1900-2300	CW	1.8	RST + SN
Wed 14 Feb	80m Club Championship	2000-2130	PSK63, RTTY	3.5	RST + SN
Thu 22 Feb	80m Club Championship	2000-2130	CW	3.5	RST + SN
Mon 26 Feb	FT4 Series	2000-2130	FT4	3.5-28	Report

RSGB VHF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Tue 6 Feb	144MHz FMAC	1900-1955	FM	144	RS + SN + Locator
Tue 6 Feb	144MHz UKAC	2000-2230	All	144	RS(T) + SN + Locator
Wed 7 Feb	144MHz FT8 AC (4 hour)	1700-2100	FT8	144	Report + 4-character Locator
Wed 7 Feb	144MHz FT8 AC (2 hour)	1900-2100	FT8	144	Report + 4-character Locator
Sun 11 Feb	432MHz AFS	0900-1300	All	432	RS(T) + SN + Locator
Tue 13 Feb	432MHz FMAC	1900-1955	FM	432	RS + SN + Locator
Tue 13 Feb	432MHz UKAC	2000-2230	All	432	RS(T) + SN + Locator
Wed 14 Feb	432MHz FT8 AC (4 hour)	1700-2100	FT8	432	Report + 4-character Locator
Wed 14 Feb	432MHz FT8 AC (2 hour)	1900-2100	FT8	432	Report + 4-character Locator
Thu 15 Feb	50MHz UKAC	2000-2230	All	50	RS(T) + SN + Locator
Tue 20 Feb	1.3GHz UKAC	2000-2230	All	1.3G	RS(T) + SN + Locator
Thu 22 Feb	70MHz UKAC	2000-2230	All	70	RS(T) + SN + Locator
Tue 27 Feb	SHF UKAC	1930-2230	All	2.3G	RS(T) + SN + Locator

Best of the Rest Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange (Info)
Wed 7 Feb	UKEICC 80m	2000-2100	SSB	3.5	6-character Locator
Sat 10 - Sun 11 Feb	CQ WW WPX RTTY	0000-2359	RTTY	3.5-28	RST + SN
Sat 10 - Sun 11 Feb	PACC	1200-1200	CW, SSB	1.8-28	RS(T) + SN (PA send Province)
Sat 17 - Sun 18 Feb	ARRL International DX	0000-2359	CW	1.8-28	RST + TX power (W send State, VE send Province)
Fri 23 - 25 Feb	CQ 160m DX	2200-2200	SSB	1.8	RS + CQ Zone (W send State, VE send Province)
Sat 24 - Sun 25 Feb	REF Contest	0600-1800	SSB	3.5-28	RS + SN (F send Dept No/overseas prefix)
Wed 28 Feb	UKEICC 80m	2000-2100	CW	3.5	6-character Locator

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

QRP deep dive

After posting several pictures of my QRP setup on social media, I have been asked about the details by other radio amateurs, such as "What's that power supply you are using?", or "What's that black box on top?", etc. In the hope of inspiring others to go QRP too, I offer the following article.

FIGURE 1: **The radio, ATU, and digital interface unit, strapped together using Velcro.**

Some history

Not long after obtaining my Foundation licence, I decided that I would like to work portable on HF. I'm not one for hiking up hills and doing that sort of thing, but I wanted something I could quickly stick in the car, drive somewhere, and then operate, either using a mobile whip antenna or a simple inverted V. The whole lot needed to be light enough to carry if I needed to do that. I bought myself a new Yaesu FT-817ND and, having done my research, I paired it up with the brilliant LDG Z817 automatic antenna tuning unit. From the offset, I had decided to use a wide Velcro strap to attach the LDG Z817 on top of the radio. I then linked the radio and ATU together with the shortest coaxial lead that I could make up. This combination quickly became my main radio, because it was so easy to move about, take from place to place, and set up in minutes.

Initially, I used it at home with a small mains-powered power supply. On sunny days, I would want to operate in the garden, and so I started using a couple of Yuasa NPC17-12, 17Ah batteries. They were good, but big and heavy, and not really suitable for portable operating. If I took the radio in my vehicle, a Toyota Land Cruiser, I could use the accessory socket, rated at 10A, so I didn't see running the FT-817 off it as an issue. And so my days of operating QRP (and portable) were born.

More equipment needed

I discovered an interest in FT8 and other digital modes, so I added the excellent G4ZLP Digimaster Pro 3 data interface. I still think that these are amongst the best data interface units around. Mine is powered from the USB cable which plugs in to my laptop, or in my case a Windows 10 tablet. The Digimaster Pro 3 enabled me to run any of the data modes, including RTTY, SSTV, FT8, FT4, etc. I strapped the data interface unit on top of the Z817 ATU using the same wide Velcro strap (**Figure 1**). To keep everything tidy, I neatly coiled the cables and used more, smaller, Velcro straps to secure them (yes, I like Velcro!).

The radio setup was now looking good, but I needed to ditch those heavy Yuasa batteries in favour of something smaller, lighter, and more practical. I opted for a lithium-polymer (LiPo) battery because of its extended discharge profile, whereby the output voltage is sustained for much longer, and will only really begin to tail off when the battery gets close to its fully-discharged state. At the time, LiPo batteries were the most-common choice. More recently, lithium iron phosphate (LiFePo) batteries have become popular, partly because the LiFePo batteries are supposed to be more stable when charging them. I chose to use a Turnigy MultiStar 4-cell battery, giving 14.8V and 5.2Ah (**Figure 2**). At 5.2Ah, this was going to give me plenty of running time, as the FT-817 only draws a maximum of 2A on full-duty-cycle transmit, and a lot less on SSB. To keep the battery charged, I opted to get the Quanam E4 Cube 50W balanced charger (**Figure 3**). I chose this charger because it was inexpensive, and it was also capable of handling 2, 3 or 4 cell batteries. If you are going to use LiPo batteries, then you definitely need to have a balanced charger. **Follow the charging safety instructions**. Nobody wants a raging inferno in their shack.

As LiPo batteries are made up of cells, with each of them having a voltage of 3.7V, I selected a 4-cell battery, as a 3-cell one would have only given me 11.1V. When fully charged, LiPo batteries usually charge to well over the operating voltage, and in my case this was around 16.6V. Therefore, it was necessary to use a voltage regulator. I chose a

FIGURE 2: **My LiPo battery of choice for lighter-weight portable operations.**

FIGURE 3: **The LiPo battery charger.**

step-down regulator with an LCD display unit from AliExpress, rated 12A constant voltage and current (**Figure 4**). You can adjust the output voltage and current using tiny pre-set potentiometers. I've been using this one for a while now and I have not detected any interference at all from it. The LCD display is clear, so that you can monitor the status of your battery. As I use it with the LiPo battery, I use an XT60 connector on the input, so the battery can plug straight in. On the output, I opted to use a cigarette lighter type socket so that I could retain the existing power lead I already had for the FT-817.

Digital modes

Now that I had a light and easily-portable setup, with plenty of battery power to give me a good few hours of operating on SSB, I turned my thoughts to those digital modes. Humping a hefty laptop around with you isn't great and somewhat detracts from your portable station. Despite having several laptop computers, I bought myself a Jumper EZPad Mini 8-inch Windows 10 tablet computer, which was relatively inexpensive, and much lighter (**Figure 5**). As soon as it was delivered, I downloaded WSJT-X on it and hooked it up in my shack to give it a try on FT8. You can watch the video of me doing this on YouTube **[1]**.

The EZPad Mini 8 is ideal for portable digital operating. Whilst not the fastest tablet in the world, it's more than adequate to run WSJT-X on it. The excellent thing about this tablet is that it comes with two micro USB ports, which means I can use one port for connecting to the DM Pro 3 digital interface, and the other I can use to charge the tablet from a small lightweight battery power-pack, thereby significantly increasing operating times. To connect the DM Pro 3 to the tablet, I use a micro USB to USB A converter lead.

The battery power-pack which I use for charging the tablet is a TP-Link TL-PB10400, which has a massive 10400mAh charging capacity. I bought this power-pack quite a few years ago, mainly to use with my Android 7-inch tablets, which I use for moving-map GPS tracking when I go flying. It has both 1A and 2A USB socket outputs, a 4-LED battery monitor, and even a handy bright LED flashlight. I've used it with the EZPad Mini 8 for several hours, and it has never run out of juice yet. Unfortunately, these have now been discontinued, but I'm sure there are other similar items on the market.

Portable operating

When operating QRP and portable, I frequently use my Land Cruiser which is fitted with a Rhino Roof Tray, and has a Diamond SG7900 antenna permanently mounted on one side for the 2m and 70cm bands. It also has a mount which I use for my collection of Ampro mobile whip antennas that I carry around in the back of the wagon. I have one for each band. I also have some Hustler RM resonators, with the MO-2 and MO-3 mounts, which cover 80m, 40m and 20m. For operating outside of the wagon, I have a Spiderpole Mini 10m fibreglass pole, which I use with a homemade 40m inverted V, fed at the centre with a 1:1 balun and a run of 20m of RG58 military-grade coaxial cable. This antenna performs extremely well and seems to tune across all of the HF bands from 80m to 10m with the LDG Z817 ATU. I've also tried it with my Kenwood TS590S and again, it seems to tune across all bands with just the internal ATU on that. Several other operators weren't convinced until I demonstrated it to them, and then they were quite amazed.

QRP operating

Despite obtaining my Intermediate licence fairly soon after getting my foundation licence, I enjoyed operating QRP so much that I decided to continue with just 5W. I have worked stations all around the World on both SSB and FT8. I find the challenge of working QRP far more interesting than being able simply to work a station on higher power. I think it hones your operating skills

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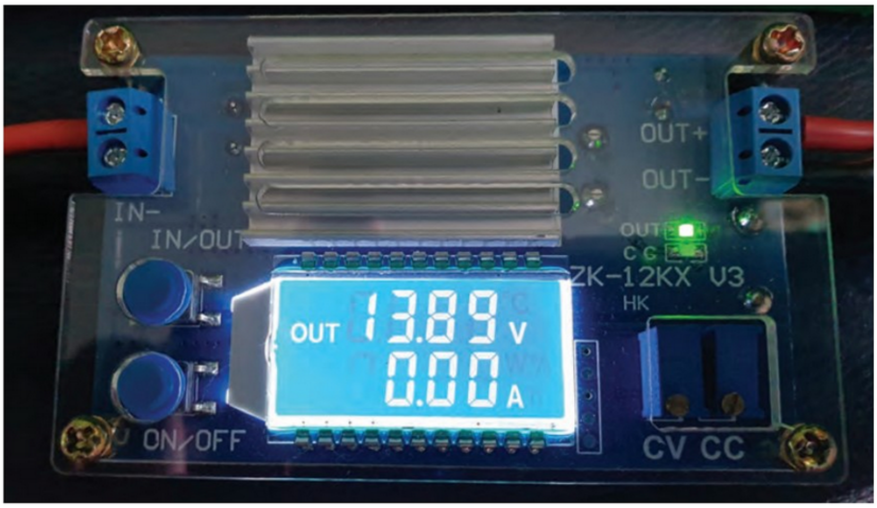

FIGURE 4: The voltage regulator from AliExpress.

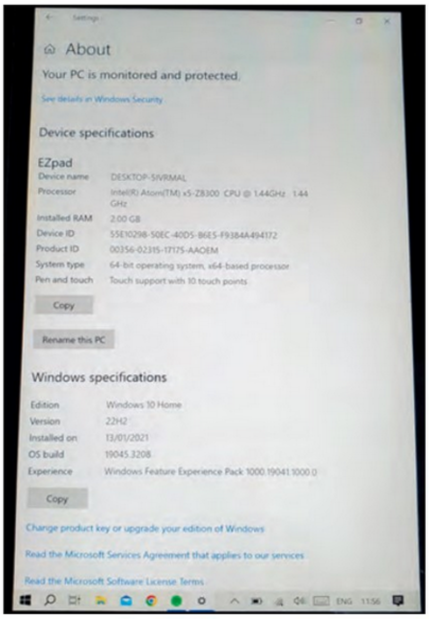

FIGURE 5: The EZPad Mini 8 tablet computer.

and give you a better understanding of propagation and operating conditions. But it also requires incredible patience and a sense of determination, both of which provide you with excellent rewards. I find the best tool for operating QRP is your ears. It's more about listening, learning and understanding, perhaps something which more of us radio amateurs should do. I've learnt that, with QRP, calling CQ is usually pretty fruitless. Unfortunately, a lot of radio amateurs don't seem to listen for the weaker signals, so you usually have to be lucky and you can waste hours calling CQ with little or no response. I've found that it's far better to search and pounce. Quite often, it's not about listening for those big 5/9+ signals, but looking for those weaker signals that no-one else seems to be responding to. Frequently, I'll call them and they will come straight back to me. Yes, you might only be 5/4 to each other, but you'll get a QSO and won't have to endure stations calling over the top of you.

With the stronger and DX stations, it's all about listening to how they are operating. Most operators are creatures of habit and will maintain the same calling and operating patterns. Listen and learn where the gaps are between the station calling CQ or QRZ, and the cacophony of responses; sneak your call in just when the cacophony stops. Although it's often debated, I've always found it useful to append my call with 'QRP' at the end. An operator may hear that and respond. You may still get the QRO station calling over the top of you, but a good operator at the other end will usually ask everyone else to be quiet whilst they try and work you. Be persistent. Sometimes I've sat waiting and calling for over 30 minutes to work a DX station, but when you do finally get through, you'll appreciate the reward. Again, a much-debated subject is calling with just the suffix of your callsign. In general, I disagree with this practice, but I feel it may be acceptable when working QRP. Let's face it, calling "two echo zero Whisky Hotel Quebec QRP" is a bit of a mouthful when you're trying to bust a pile-up, so I think it's acceptable just to use "Whisky Hotel Quebec QRP" in that situation. Obviously, I revert to my full call if I get a response.

If you are lucky enough to get called, apart from that sense of achievement and excitement, remember to keep your overs short. You are QRP and conditions can change rapidly on HF, so now is probably not the best time to ramble on trying to fit in all your information. Keep it short, and gauge how easily the other station is hearing you. Get the signal report in on your first over, and possibly your name. If it seems like the other station is finding it easy enough to work you, then you can add your QTH, working conditions, etc. on subsequent overs. If it's a DX station, then be mindful that there are probably loads of other stations waiting, and they won't take kindly to you waffling on, especially if they can't hear you, so they will just start calling over the top of you.

I would suggest that, for working QRP, it is worthwhile 'talking it up' when using your microphone. Remember that your transmitter output on SSB is directly proportional to the level of audio. Although most transceivers will have some sort of microphone gain setting, I've always found that using a more assertive voice works far better than talking gently in to a microphone. Some may disagree, but it's always worked well for me and I've never had a poor audio report.

Learning with QRP

I'd use your QRP operating as great opportunity to learn about propagation, and which bands to use when. Learn the general opening and closing times of bands and phenomena like grey-line, Sporadic-E and tropospheric propagation for the higher bands. Grey-line propagation can provide the opportunity to work excellent DX, especially on 20m. I once worked the Falkland Islands on 20m SSB with 5W on my FT-817 and Ampro mobile whip using grey-line propagation. Needless to say, I was pretty chuffed with that and I think it's probably one of the best QSOs I've ever had.

When tuning around the bands, make a note of stations you hear, their frequencies, and their signal strengths. That way next time you tune past them, you'll be able to see if their signal strength is coming up or going down, which may help you decide whether or not you try to work them. I've often used this trick, and on my second pass, their signal has improved enough for a QSO.

Working QRP is not easy, it takes practice, dedication and patience. It will be filled with frustration at times but ultimately it will be rewarding. Over time, it will become easier and should never fail to give you enjoyment. Don't be afraid to experiment with different antennas and find out what works for you. With the help for Rob, G4ZAM, I've recently been experimenting with a kite antenna, which has been great fun and a learning curve for both of us.

I hope that you have found this article interesting and inspiring and I look forward to working some of you on the air; QRP, of course!

References

[1] https://youtu.be/jv-JkKTGmfU?si=R7dZE-eX9ybtoDQv

Data

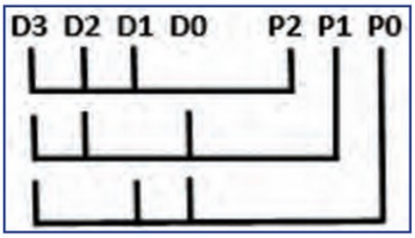

FIGURE 1: The combination of data and parity bits checked to generate the simple Hamming (4,7) FEC code.

Hamming code error correction

One of the simplest Forward Error Correction (FEC) methods, and one of the few that is easy to describe, is the (4, 7) Hamming code. In this code, four data bits are taken at a time. The parity (the number of '1's in the group tested being odd or even) is tested across three different sets of triplets of these bits to generate three additional parity bits. The various combinations of which data bits are used to make up each of the parity bits can be seen in **Figure 1**. Parity check 0, P0, works with data bits D0, D1 and D3, P1 with D0, D2 and D3 etc. Consider what will happen if one data bit is corrupted in transmission. Only those parity bits associated with that one damaged bit will be set and an examination of the combinations tested show that a different set of parity test results will be generated for each bit corrupted in transmission. The use of three additional parity bits to correct four data bits to give a total of seven transmitted leads to the designation of a (4, 7) code which can correct 1 bit error in 7.

Modulo10 Hamming Error Correction										
	Transmitted Data and parity							Error Check Syndrome		
Symbol No.	7	6	5	4	3	2	1			
				D1+D2+D3		D0+D2+D3	D0+D1+D3	P2 - (D1+ D2+D3)	P1 - (D0+ D2+D3)	P0 - (D0+ +D1+D3)
	D3	D2	D1	P2	D0	P1	P0			
	5	2	8	5	7	4	0	0	0	0
	Received symbols with errors shown in red									
Symbol No.	7	6	5	4	3	2	1			
	5	2	8	5	7	4	1	0	0	1
	5	6	8	5	7	4	0	6	6	0
	5	2	8	5	8	4	0	0	9	9
	6	2	8	5	7	4	0	9	9	9
	5	2	1	5	7	4	0	7	0	7
	5	2	8	9	7	4	0	4	0	0
	5	2	8	5	7	4	0	0	0	0
	5	2	8	5	7	9	0	0	5	0
Double error	5	2	6	7	7	4	0	4	0	2

FIGURE 2: Hamming code generated using modulo 10 addition in lieu of parity. A set of transmitted symbols with parity appears at the top, along with a variety of scenarios with corrupted single and a double received error in the lower part. The positions of data and parity (checksum) symbols in the transmitted data enable the pattern of test results, the syndrome, to point directly to the symbol received in error.

Symbol Error Checking

That example used simple parity checks, seeing if there is an odd or even number of bits in each case, but the process works just as well if non-binary numbers are used instead, added using modulo arithmetic.

Modulo arithmetic is sometimes referred to as clock-face arithmetic where numbers count up to a maximum then reset to zero. On a 12-hour clock we work with modulo 12, so six hours added to 7 o'clock gives 1:00, not the 13 that normal addition would give. Binary parity checks can be said to be using modulo 2 addition where the only allowed numbers are 0 and 1.

For demonstration here we will use modulo 10 arithmetic so only the numbers 0 to 9 are permitted. Now, 4 + 5 = 9, but 5 + 6 = 1 since every time we pass 9 we wrap around modulo 10. Equally importantly, negative numbers wrap around adding 10 each time, so 3 – 7 = 6 as ten needs to be added to the -4 that would normally be the answer to the subtraction.

Let us now replace the four data bits in the Hamming code with modulo 10 symbols – the numbers 0 to 9, and generate the three parity symbols using modulo 10 arithmetic to the same check-pattern as Figure 1. For example, P0 = (D0 + D1 + D3) = (3 + 5 + 7) MOD 10 = 5. At this stage it is also convenient to reorder the four data symbols and the three parity ones in a particular way. Look at the top part of **Figure 2**, labelled 'Transmitted Data and Parity' where the parity symbols are placed at positions 1, 2 and 4 with the data symbols making up the other positions. If the original binary Hamming code had been shown this way, the parity bits that are set when a single bit is corrupted would show a binary pattern in the tests – the syndrome – that point directly to the bit number in error. An all-zeros syndrome means no error. In that upper part of Figure 2 the four data symbols are shown in blue and the resulting parity, transmitted alongside, is shown in red. As an exercise, check that each triplet of data bits sum to the associated parity value modulo 10.

The lower part of Figure 2 shows several scenarios where one symbol out of seven has been corrupted into a different value. The last line shows two symbols in error. Received symbol errors are shown in red with the correctly received ones in blue.

The syndrome on the right shows the resulting modulo 10 calculation of each parity symbol with its associated triplet of data symbols. Note how when there is one symbol in error, the associated parity values change and, as for the Hamming code, the location of those non-zero terms point to the symbol in error. Note also how, for single bit errors, the two non-zero values are the same and the resulting value can be added to the value of the incorrectly received data value to give the corrected one. Both error checks showing the same value indicates that a single correctable error has occurred. The final line with two errors shows different modulo sums and this is an indication that an uncorrectable double error has occurred.

Binary data

We used modulo 10 summation to demonstrate the process as we are all familiar with decimal digits, but that is of dubious value for digital communications. If instead we used modulo 16 arithmetic with symbols taking on the values 0 to 15, we can allocate a pattern of four binary bits to each symbol. Four symbols give us a useful 16 bits that can be transported. Now we have a situation where four bits at a time, in a block of 16, can be corrected. As it stands, these four do all have to be in the same symbol, but we have now developed an FEC scheme that can correct burst errors, up to 4 bits in length. Had the 16 bits been carried in a conventional binary coded FEC scheme, losing 4 successive bits in 16 would not be so easily corrected.

Performing forward error correction on symbols made up of several data bits, instead of on the raw binary data, gives us extra power and correction capability. Combine that with interleaving so adjacent bits are spread throughout the message then de-interleaved after reception, and the FEC can become very effective indeed.

The older JT65 WSJT mode, and newer Q65 one both use FEC working on symbols. Each of these take six bits at a time to give symbols in the range 0-63. The FEC arithmetic is a lot more complex in both those modes than simple modulo addition, but the general idea holds. Modulo addition is, in a very simplistic manner, related to the techniques used within Reed Solomon coding used in JT65. There is no limit to the modulo value used, so taking 10 bits at a time and working modulo 1024 would work equally well – but is not the best way of doing FEC on large messages.

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EMC

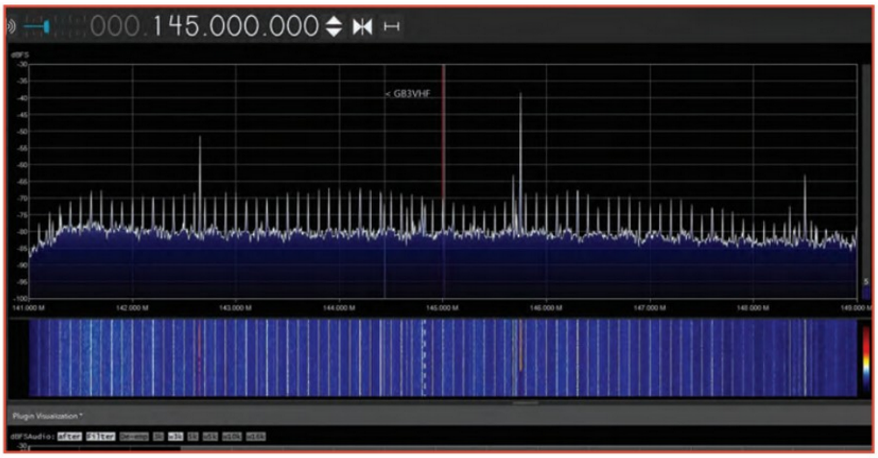

FIGURE 1: Radiated emissions from a solar PV system centred on 145MHz.

Solar PV update

There have been some interesting developments in solar PV recently. One Member who had a solar PV system fitted at his own house asked the installer for an assurance that it would not cause RF interference. There was interference and the Member reports "I backed the manufacturer into a corner and managed to get them to send their equipment for testing in a laboratory. Today I received the news that both inverters they sent had failed testing! The manufacturer has since made some changes to the design and are asking if they can try one of these modified inverters this week."

We intend to publish further information when it becomes available. In the meantime, if you are having solar PV installed at your own house, it is wise to ask for an assurance that it will not cause radio interference to your amateur radio activities. It is also worth asking to see the Declaration of Conformity or a detailed specification that lists the standards that the equipment complies with. These are likely to include the generic EMC standard EN 61000-6-3:2007/A1:2011/AC:2012 but we think that this is no longer sufficient by itself in UK or EU and that it also needs to comply with the harmonised European EMC standard EN55011:2016/A11:2020 or the identical UK Designated Standard.

Hybrid inverters

A hybrid solar PV inverter is connected to solar panels and also a large rechargeable battery. During the daytime, DC power from the solar panels can either be converted to 50Hz AC and fed into the AC mains, or it can be used to charge the battery. At night, the power from the battery can be converted to 50Hz AC and fed into the AC mains. This means that if a hybrid inverter is causing RF interference, it can be more difficult to identify because it may not stop after sunset. Instead, it may continue during hours of darkness if the battery is being used, although it may not continue all night if the battery becomes fully discharged.

Solar PV VHF noise

The October 2023 *RadCom* EMC Column showed a block diagram of solar PV installations with and without optimisers. Solar PV optimisers were first mentioned in the *RadCom* EMC Column in February 2013. This showed the results of measurements that were made in September 2012 on two solar PV systems with a total of two inverters and 26 optimisers. The main issue was VHF noise especially between 144 and 146MHz where the noise floor was raised by approximately 20dB when measured at a distance of 10m from the nearest optimiser and up to 20m from the furthest. That means that a distant station would need to increase its transmitter power by a factor of 100 to be received above the increased local noise! Some RFI on HF was also reported but we didn't get time to measure it before the Sun went in.

Optimisers are still being fitted to some solar PV systems and such systems can cause RFI at MF, HF and VHF. A Member in North Herts reports that his neighbour has recently installed a solar PV array that is believed to have optimisers on the roof. Our Member reports that during daylight hours, the solar PV system is causing wideband noise across most of the VHF/UHF spectrum as high as 440MHz. He has moved his main antenna as far as possible from the solar array to the bottom of the garden, but he describes the noise as "chronic".

He mentioned the noise to the neighbour, who said he is an engineer, and the system and inverters should be compliant. The neighbour suggested that he could wrap tin foil around the inverter, but the Member made no comment about that knowing that it was unlikely to do anything. **Figure 1** shows an SDR screenshot cantered on 145MHz. The noise is stronger than the GB3VHF beacon which is a reasonable signal at that location.

The VHF noise shown in the *RadCom* 2013 EMC Column was broadband and resembled random noise, so it blocked the whole 144-146MHz band with no way to get away from it. The interference in Figure 1 is a 'comb' of narrow peaks. Although there are spaces between the harmonics, these are all multiples of exactly 100kHz, so they coincide with some important frequencies such as the SSB centre of activity (144.300MHz), and the 2m band FM calling frequency (145.500MHz).

Our Member then made a quick dipole tuned to about 105MHz, put it on a fishing pole and held it up approximately 8 to 10m from the nearest edge of the solar panels. **Figure 2** shows part of the FM broadcast band centred on 103.8MHz on a sunny day in the summer. The narrow 'spikes' are only about -22dB relative to the 103.8MHz carrier and they interfere a lot with weaker FM broadcast stations. As the FM broadcast carrier frequencies are all on multiples of 100kHz, and the solar PV harmonics are also multiples of 100kHz, every FM broadcast station between 88MHz and 108MHz has a solar PV harmonic sitting on top of its carrier frequency. The harmonics also continue up through the VHF air band to 144MHz and beyond.

This has been reported to Ofcom and an Ofcom Engineer has visited twice with a spectrum analyser, but in November the measured level of RFI was significantly lower than it was in summer, due to the Sun being lower in the sky and tree shading. The Ofcom Engineer was only making measurements in the bands where radio amateurs are licensed to transmit so he didn't measure in the FM broadcast band. Nevertheless, if FM broadcast reception (or DAB or digital TV) suffers interference within the intended service area of the transmitter, then it is a protected service and it is possible to submit a report via BBC Reception Help. They then come back with further advice and could refer the matter to Ofcom if appropriate.

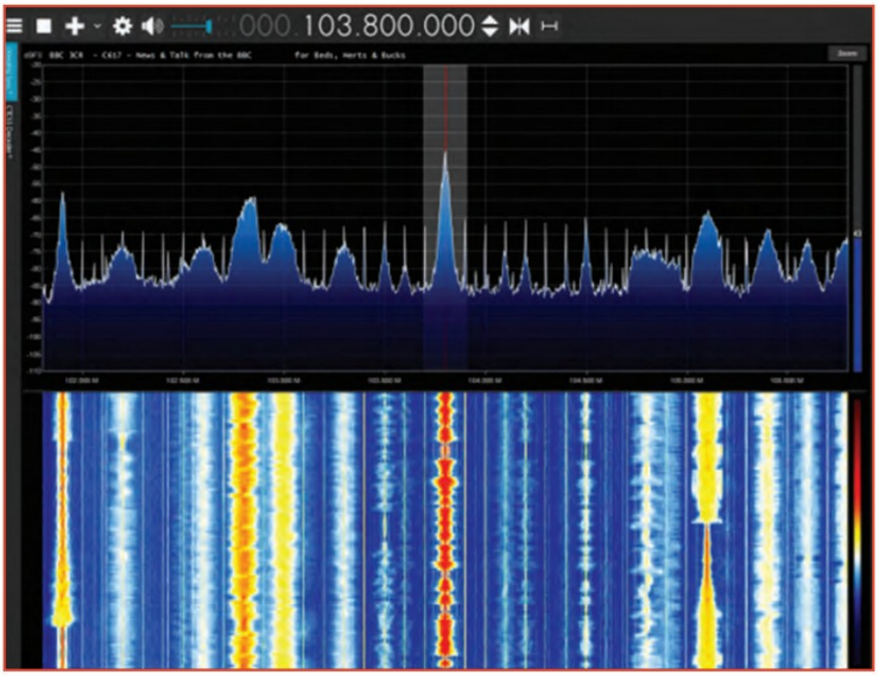

FIGURE 2: Radiated emissions from a solar PV system centred on 103.8MHz.

Market surveillance

Further to the item in December 2023 EMC Column, Market Surveillance means ensuring that products conform to relevant legislation. This not only applies to the EMC Directive but also many other European 'New Approach' Directives that require CE marking. These include the Low Voltage Directive for electrical safety, Radio Equipment Directive (RED), Restriction of Hazardous Substances (RoHS) and various other Directives including appliances burning gaseous fuels, toy safety, machinery and recreational craft. The purpose of the 'New Approach' Directives was not only to ensure product safety, but also to harmonise technical standards and to avoid technical barriers to trade in the Single European Market.

In 2008, UK regulations came into force that implemented Regulation (EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products and repealing Regulation (EEC) No 339/93 (Text with EEA relevance). This is commonly known as Regulation on Accreditation and Market Surveillance (RAMS). After the UK left the EU, RAMS was replaced by an amended version known as GB RAMS in England, Scotland and Wales whereas in Northern Ireland, the original 765/2008 RAMS remained in force and it was called EU RAMS by the UK Government.

Then on 25 June 2019, the Official Journal of the European Union (OJEU) edition L 169/1 published Regulation (EU) 2019/1020 of the European Parliament and of the Council of 20 June 2019 on market surveillance and compliance of products and amending Directive 2004/42/EC and Regulations (EC) No 765/2008 and (EU) No 305/2011 (Text with EEA relevance).

This regulation came into force in EU Member states in 2021, after the UK had left the EU, so it doesn't apply in England, Wales and Scotland but it does apply in Northern Ireland. It is interesting to compare the following two documents published by the UK Office for Product Safety & Standards:

Changes to Regulation 765/2008 on Accreditation and Market Surveillance applying in Great Britain from 1 January 2021 End of Transition Period Guidance December 2020 **[1]** and EU Regulation on Market Surveillance and Compliance of Products (2019/1020) Guidance for Market Surveillance Authorities applying in respect of Northern Ireland from 16 July 2021 **[2** and **3]**.

In the EU Regulation on Market Surveillance and Compliance of Products (2019/1020), Annex 1 lists all the "new approach" Directives including Electromagnetic compatibility (Directive 2014/30/EU):

"2.20 Article 11 sets out the activities of Market Surveillance Authorities to ensure that products conform to relevant legislation and to ensure the protection of public interest covered by that legislation. These include requiring relevant Authorities to:

- Carry out their duties and exercise powers independently, impartially and without bias
- Carry out effective market surveillance of products made available online and offline."
- "2.3 Notable definitions which were not in RAMS include:
- 'Fulfilment service provider' (Article 3.11) means any natural or legal person offering, in the course of commercial activity, at least two of the following services: warehousing, packaging, addressing and dispatching, without having ownership of the products involved. This excludes postal services, parcel delivery services and any other freight transport services.

For the purposes of the EU Regulation on Market Surveillance, fulfilment services are included as a type of economic operator and subject to any requirements placed on economic operators by the Regulation3. Under Article 4, fulfilment services can be responsible for certain compliance activities (See point 2.7)."

Compliance with EU regulations is the responsibility of an economic operator that can be a manufacturer, an importer, an authorised representative, or a fulfilment service provider, but in all cases must be established in the EU (or NI). In the case of online auction sites and other online market places, customers may be able to order products that are shipped directly from the Far East . If this happens then it bypasses existing economic operators responsible for compliance. Adding a new type of economic operator called a 'fulfilment service provider' plugs this 'loophole' but only in the EU and Northern Ireland.

By contrast, the GB RAMS regulations that apply in England, Wales and Scotland, are an amended version of the 2008 EU-RAMS so that fulfilment service providers are not responsible for any compliance activities. There are also other changes, and we are assessing the implications of these, but it appears that market surveillance may be weaker in England, Wales and Scotland than in Northern Ireland and the EU. Nevertheless, we have reports from an EU country that there is a shortage of enforcement resources to identify non-compliant products such as LED lighting and to remove them from the market.

References

[1] Regulation 765/2008 on Accreditation and Market Surveillance: Great Britain https://assets.publishing.service.gov.uk/media/5ffc2a4d8fa8f563fd0c46e9/Guide-to-rams-regulations-2008.pdf

[2] EU Regulation on Market Surveillance and Compliance of Products (2019/1020) Guidance for Market Surveillance Authorities applying in respect of Northern Ireland from 16 July 2021

[3] https://www.gov.uk/government/publications/eu-regulation-20191020-on-market-surveillance-and-compliance-of-products

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Design Notes

What does 'half an S point' actually mean?

In Brian Austin's article in the December 2023 issue of *RadCom*, after a reference to '3dB change in signal', a comment was inserted to the effect that this was 'just half an S point' **[1]**. On reading this, I was rather perturbed that several dB worth of signal change was being dismissed so summarily, and I questioned the wisdom of inserting that comment. Then I was asked to actually think about what that means, and that it is signal to noise ratio (SNR) that matters, not signal strength *per se*. Everything depends on what you're actually doing.

In the world of weak-signal working with modern digital signalling, even fractions of a dB matter; a 1dB change of SNR can make the difference between perfect decoding and nothing. This situation is commonplace in the amateur-radio world when working with the heavily error-corrected data modes within the WSJT suite. With SSB voice, when you are near the point when it becomes difficult to discern what a person is saying, 1dB makes a slight change, but barely enough to make a great difference. It needs several dB to raise a barely-copied signal to comfortable listening. But if that signal is S9 to start with, a few dB of change either way won't be noticed in terms of readability. The same obviously applies to digital signalling, but in a much more extreme way. If it is a 100% copy with plenty of margin, then a small change in signal strength is going to go completely unnoticed. So we can safely say it is SNR that matters, not actual signal strength. This is the point that I was being asked to consider after questioning the inserted comment.

FIGURE 1: **Unadulterated 'Multi-tone Hell' waveform shown on a waterfall display.**

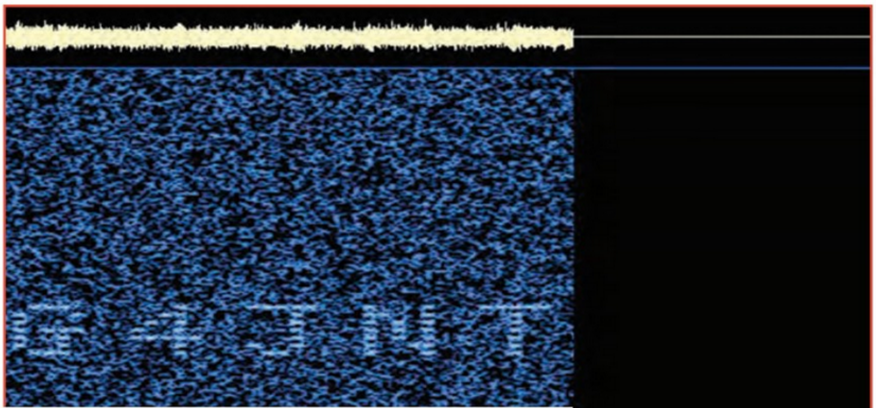

FIGURE 2: **The same MTH signal with added noise at 6dB SNR.**

What is a dB anyway?

A quick refresher. A Bel is defined as a *ratio* of a factor of 10 between two *power* levels expressed in logarithmic terms. So a ratio of ten, such as 1W to 10W, is 1 Bel. A mW to a MW ratio represents 9 Bels. A Bel is too large in its own right to be useful, so we adopt a unit equal to a tenth of this, the decibel or dB. Those two numbers become 10dB and 90dB respectively. 1dB then corresponds to a power ratio of $10^{0.1}$ or about 1.259. (Multiply that number by itself ten times and see what you get!) 1dB represents a change in power level of about 26% and that's all it is. Nothing absolute, just a ratio of powers calculated from $10.\log_{10}(P1/P2)$.

Why do I keep emphasising the word 'power', whose repetition may by now be getting a little tedious? It's because there is another form of expressing dB. The ratios between voltages and currents are often expressed in dB and power is proportional to the square of these, ie $P = V^2/R$ and $P = I^2R$. When voltages or currents are expressed in dB, the resulting ratio becomes $20.\log_{10}(V1/V2)$ or $20.\log_{10}(I1/I2)$. Squaring a number is equivalent to doubling its logarithm. But now we need to be very careful how the gain of an amplifier, or any other gizmo, is specified. If an amplifier has a 'voltage gain' of 20dB (ie $V_{OUT}/V_{IN} = 10$), *and* the input and output impedances *are the same*, then the power gain is 20dB or 100 times.

This relationship only holds if input and output have the same impedance. Consider the high input impedance buffer amplifier used with active E-field probe receiving antennas. These usually comprise FET source followers with a voltage gain of one, or unity. But the input impedance is very high, perhaps 5MΩ, with the output designed to drive a 50Ω load. Unity voltage gain suggests the amplifier has $20.\log_{10}(1) = 0$dB gain, but this is clearly rubbish. For equal input and output voltages, the current in and out is given respectively by V/R_{IN} and V/R_{OUT} so we can calculate the effective *current* gain by taking 5MΩ/50Ω = 100,000. To get power gain, which is what really matters, we multiply current gain by voltage gain giving $10.\log_{10}(1 * 100000) = 50$dB. If we'd used the $20.\log_{10}$ form on input and output current, we'd have ended up calculating a value for the gain of 100dB. This is not correct, or even related to that 0dB based on voltage gain. Both are wildly out, so be very careful when using the $20.\log_{10}$ form when calculating gain or whatever, and always stop, think, think again, and make a judgement call as to whether it is a sensible calculation to make.

And a final note on decibels; noise power is usually proportional to the bandwidth within which it is measured. So when calculating signal to noise ratios, and normalising for different bandwidths, the change in noise level in dB is given by $10.\log_{10}(BW1/BW2)$.

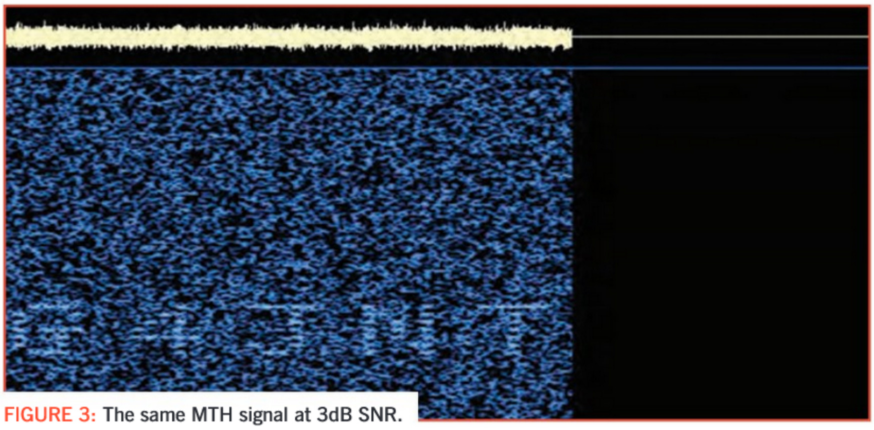

FIGURE 3: The same MTH signal at 3dB SNR.

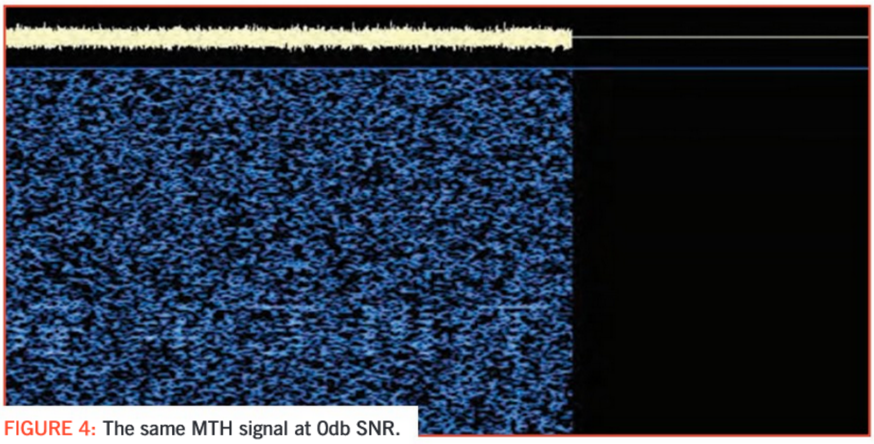

FIGURE 4: The same MTH signal at 0db SNR.

The effects of SNR change on human perception

Let's return now to the effects of SNR on signal interpretation. In a written column like this, it is clearly impossible to demonstrate SSB voice SNR effects, and how the human ear works with different levels of SNR. But there is another human-interpreted type of communication used by amateurs where the effects of SNR can be viewed on a written page. It is Hellschreiber, specifically one of the modern multi-tone variants that adopt frequency-shift keying, such as 'Multi-Tone Hell' or MTH, which is viewed on a waterfall display. The shapes of rasterised letters are converted to tone frequencies in one dimension, typically vertically for viewing on a horizontally-scrolling waterfall **[2]**. The other dimension of the letter shape is transmitted in time so it builds up as the waterfall scrolls. **Figure 1** shows a pure MTH signal as received on a waterfall display with virtually no noise present. It is probably a reasonable assumption that the average person's eye/brain interpretation of written text in a noisy environment (a speckled background) is not completely dissimilar to the ear/brain interpretation of a noisy SSB voice signal. So perhaps some SNR tests at the threshold of visibility of received MTH waveforms might realistically illustrate how SNR affects the auditory response too.

Figure 2, Figure 3, and Figure 4 show the MTH signal of Figure 1 degraded by a precisely-calibrated amount of Gaussian (white) noise. It is difficult to state the exact *absolute* SNR in these three plots, and values were selected empirically looking at the waterfall display on the edge of readability. The *relative* SNR is, however, very precisely defined as this is controlled by the amount of noise injected, set by changing a single value in software. The three plots show respectively the MTH waveform at 6dB, 3dB and 0dB SNR, ie at half S-point intervals. It's reasonably clear to see that at 6dB there is practically 100% readability, whereas at 0dB you have to strain hard so that, with no pre-knowledge of the information content, it would be difficult to see what is there. This result is arguably about what one would also expect from SSB. Having pre-knowledge, which of course we do here as it's all the same message, leads to a different outcome. But that's another story.

Effect of SNR on uncorrected data

As mentioned above, we are all accustomed to heavy error correction nowadays that results in an all-or-nothing decode using FT8, Q65 etc for a fraction a of a dB change in SNR. But if we go back in time and look at the non-error-corrected codes that we used to use, like RTTY and PSK31, we can see the effects of a few dB change in SNR versus probability of error more clearly. **Figure 5** shows a curve of SNR per bit **[3]** versus error probability for several levels of frequency shift keying (FSK). For plain RTTY with two tones, the right-most curve (M=2) is the one applicable. With no forward error correction (FEC) in place, we will assume that a bit error rate (BER) of 10^{-2}, one bit per hundred, is about the worst we can cope with. For RTTY, one in 100 bits means about one character every 13 is corrupted, or roughly one word in every three damaged in one way or another.

Figure 5 suggests that, to get 10^{-2} bit error rate for two-tone FSK, needs an SNR per bit of about 8.7dB. Raise that SNR by 3dB, and the error rate drops off the scale on the right hand side of the graph, but can be extrapolated to show something like 10^{-4} BER, or about one bit in 10000. This is roughly equivalent to one word in every 280, and is much more acceptable. So, in this threshold case, half an S point makes a lot of difference.

Reading a potentiometer

January's *RadCom* carried an article by Steve Bennett, M0YYT on switch de-bouncing. This reminded me of a problem I encountered once when trying to use a panel-mounted potentiometer to set one of several different input values to a microcontroller driving an FST4 beacon source for transmitting on LF. I needed to be able to set any one of eight different transmission speed settings from the front panel, but only had a limited number of I/O lines available on the PIC device. A switch matrix wasn't an option, but the PIC did have an analogue to digital converter (ADC) so I could use a potentiometer to set my desired input. The 10-bit ADC would only have to read eight different thresholds, so hardly a challenge, but in practice, when the 137kHz beacon transmission was running, setting the potentiometer proved to be somewhat troublesome. It was fine if I placed the knob precisely and carefully between two marks, and it usually stayed on the required setting. But being a bit sloppy about setting the value, a bit too close to the threshold and mechanical instability coupled with noise, most likely from the high E-field sitting under my LF tee antenna, caused the occasional random change in speed.

I resolved it at the time by adding plenty of decoupling and a rearrangement of equipment layout, and took more care in setting the knob, but this was hardly a satisfactory solution. A better way would be to use a similar technique to that described for switch de-bouncing last month, using a Schmitt trigger algorithm that sets different thresholds based on the memory of what setting is currently in use and which direction the potentiometer moves.

As an example, using a smaller set of values, let's have a 4-bit ADC giving values from the potentiometer of 0 – 15, and let's select from four

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different wanted states W, X, Y, and Z. Common sense tells us that ADC values of 0 to 3 result in state W, values of 4 to 7 give state X, 8 to 11 give Y and 12 to 15 give Z. This needs three test thresholds placed at 4, 8 and 12. Ideally the pot would then be set in positions so it gives a voltage to the ADC resulting in outputs of <2, 6, 10 and >14 so the voltage to be read is exactly midway between thresholds. But it is easy to get careless and select values like 4.2, or 12.3 on a continuous potentiometer. Whilst giving the desired result on a clean threshold test, a little bit of noise or instability would cause a flip into the adjacent state.

To give a multi-level Schmitt trigger action, we define three *pairs* of test thresholds. We make the first set of three higher when moving up, so choose one set of thresholds at 5, 9 and 13. Then another set lower, at 3, 7 and 11 when moving down. Now imagine we're in the lowest state, W, and the potentiometer is moved to a higher value. Going up, the next threshold it has to encounter is now 5, so that badly set example of 4.2 earlier that would have triggered a change now no longer does so. Coming down it works on the lower thresholds, so if we wanted to move from Z to Y, we would be testing for a potentiometer input below 11 rather than the 12 in a simple test.

All this may seem a long-winded and complicated way to select values from a front panel setting, but all it really means is a few extra lines of code added to a microcontroller that's already being used, and making use of an ADC that is in there anyway, and probably sitting idle. One way to ensure a more-precise manual setting of a voltage would be to replace the potentiometer with a chain of resistors forming a fixed potential divider, then use a multi-position rotary switch to select the appropriate tap. But it's all getting rather excessive and complicated, so no wonder many front panels now adopt a couple of push buttons and a display, or a touch screen for everything rather than multiple switches or potentiometers for the user interface.

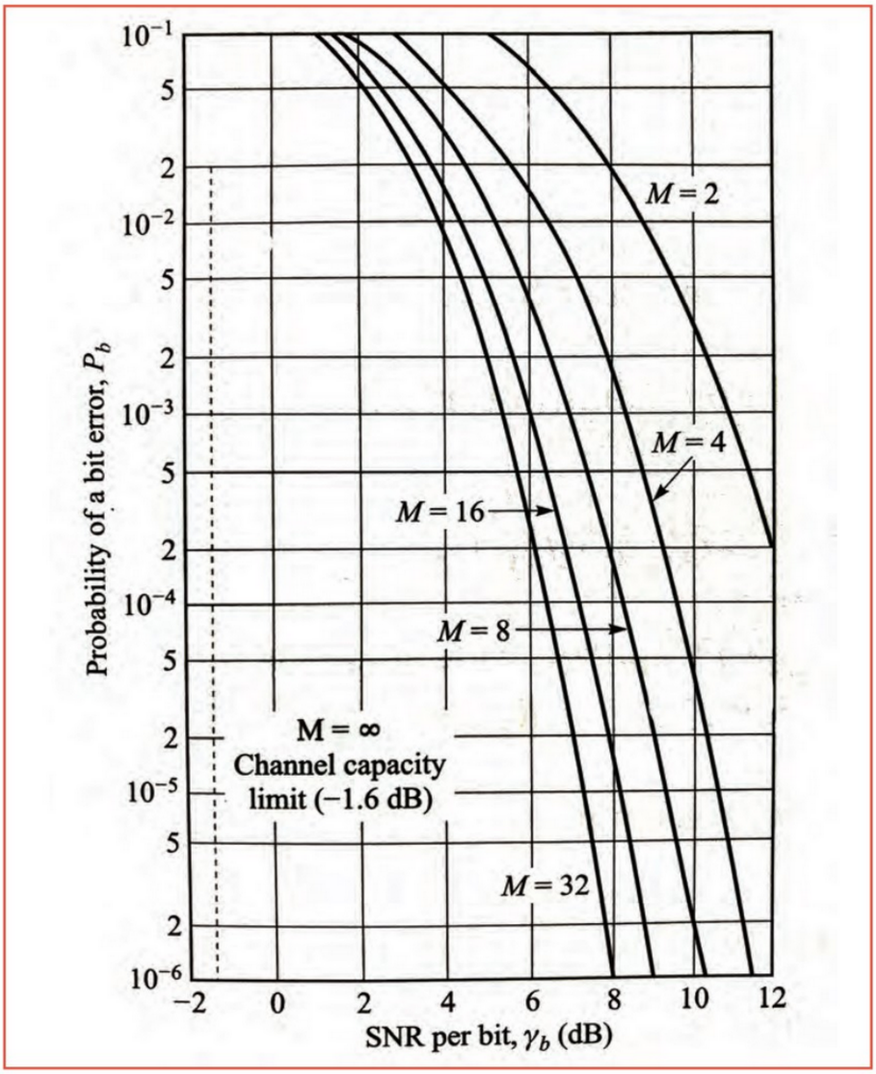

FIGURE 5: Curves of bit error rate versus SNR per bit for frequency shift keyed digital waveforms with incoherent demodulation. M=2 is the curve applicable to standard RTTY where the bit SNR is measured in a bandwidth of either 45.45Hz or 50Hz depending on the baud rate in use. Taken from *Digital Communications* by JG Proakis and M Salehi, ISBN 978-007-126378-8, Figure 4.5-2.

HF radio band-setting voltage

A more down-to-Earth application is reading the band setting voltage output from many radios, usually made available on a rear-mounted connector. This is often used by linear amplifiers and filter banks, even semi-automatic antenna tuners in some cases, to set the band of operation. It can also be read and decoded in home-brew designs to switch appropriate antennas or antenna configurations into operation automatically.

Voltages for the FT-817 HF to UHF transceiver, taken from the user manual, are shown in **Table 1**. Other manufacturers have used different voltage ranges, some of which are not even equally spaced; consult the user manual for your particular case. It can be see that, on the FT-817, with only 0.333V between each level and eleven thresholds to have to test for, even though the voltages delivered are more precise than might be the case from a front panel potentiometer, there is still scope for noise and instability upsetting the reading. If used for switching the filters in a high power linear amplifier, that could be catastrophic!

When designing any hardware to use this band-setting voltage to control external apparatus, consider an algorithm that contains memory; a sort of multi-level Schmitt trigger to add robustness to the band-selection process.

Notes

1. IARU has defined an S point to be a change in received signal power of 6dB, or four times. The S meters on most modern radios are calibrated to this standard.

2. There really doesn't seem to be another term for a 'horizontally-scrolling waterfall'. Calling it a 'river display' would be a bit silly, wouldn't it?

3. SNR per bit, or 'bit SNR', is the signal to noise ratio referred to a bandwidth equivalent to the signalling rate of the digital waveform in use. So for 50 baud RTTY, the bit SNR would be referenced to 50Hz. To normalise to the 2.5kHz bandwidth now adopted as a standard for many amateur modes, the bit SNR needs to be adjusted by $10.\log_{10}(50Hz/2500Hz)$ = -17dB. So that threshold quoted for 10^{-2} BER of 8.7dB becomes 8.7 - 17 = -8.3dB in WSJT terms. This is way above the threshold of -21dB quoted for FT8, the difference equating to a ratio of received powers of 18 times, or nearly one and a half S-points.

TABLE 1: Band-data voltages for the FT-817.

Band	Data	Band	Data
1.8	0.33V	21	2.33V
3.5	0.67V	24	2.67V
7	1.00V	28	3.00V
10	1.33V	50	3.33V
14	1.67V	144	3.67V
18	2.00V	432	4.00V

Momobeam TRI10 10/15/20 beam

The Momobeam TRI10 is a three-band Yagi antenna from a company based in Sicily. You may not have heard of Momobeam but, as its website says, the company has "Thirty years of passion and experience, an ambitious mission and that pinch of 'madness', which today finds full and well-deserved acknowledgement in international markets."

Founder Giuseppe, IT9HBT is a long-time radio amateur who lives in a windy corner of western Sicily and says he "has the ability to combine intuition and design rigour." Giuseppe knows that the antennas in Sicily must be resistant to, and perform well in, windy and salty air conditions. Giuseppe says that he has the passion, increasingly orientated towards contests, that we normally associate with Italian radio amateurs.

The Momobeam company was formed in 2011, thanks to friends "Mommo", IT9GNG; Sal, IW9FRA; and Joe, EA3KS whose contributions, Giuseppe says, in terms of encouragement, were crucial. But how did we end up testing a Momobeam antenna? Ray, G3XLG is a long-standing member of the local Norfolk Amateur Radio Club, and he was looking for a tri-band beam to replace his existing ten-year-old antenna. It had to be well built, with a low VSWR on all bands, have good forward gain, and the ability to switch bands in an instant. After weighing up the choices, the €1,240,00 (£1,078.40 at the time of writing) Momobeam stood out as a cost-effective and well-constructed antenna, and an order was placed. The good news is that the advertised price on Momobeam's website includes 48-hour postage. Also, there is no import duty to pay as the antenna is classed as a 'kit' and is therefore exempt. But please note that you do have to pay VAT at 20%, which is collected in the UK before the package can be delivered.

The antenna was delivered to Chris, G0DWV's QTH in Norfolk, where it could be built and tested against an Optibeam 17-4 and a Force 12 C31XR beam at similar heights.

FIGURE 1: The Momobeam TRI10 10/15/20 beam.

Now for some data

The antenna (see **Figure 1**) operates as a three-element Yagi antenna on 20m and 15m, and a four-element Yagi antenna on 10m. It consists of a main boom made of 50mm box aluminium with a total of 10 aluminium elements. The whole antenna can be split into three parts, which helps with both assembly and fitting it onto the tower. The antenna elements are mounted using blue polypropylene blocks fastened using stainless-steel bolts with Allen key heads. The antenna has two phasing lines made up of aluminium strip and these, plus other parts, are fixed using more bolts and nylon locking nuts. The antenna can be mounted on a mast of 50-60mm (2in-2.36in) diameter.

The main boom is 650cm (21.3ft) long and the longest element is 1,090cm (35.76ft). This gives a turning radius of 640cm (about 21ft). Maximum forward gain is quoted as 15.06dBi on 10m, 13.36dBi on 15m, and 12.6dBi on 20m. Reduce these by 2.15dB if you want gain figures relative to a dipole. Front-to-back ratios are quoted as 25dB on 10m and 15m, and 20dB on 20m. The complete antenna weighs in at 34kg (69lb), and the maximum wind speed that the antenna can tolerate is quoted as 160kph (99.4mph).

FIGURE 2: The antenna arrived well packed.

Packaging and installation

The antenna arrived well-packed (**Figure 2**), with polystyrene helping to protect delicate parts in the box. The antenna hardware was packed

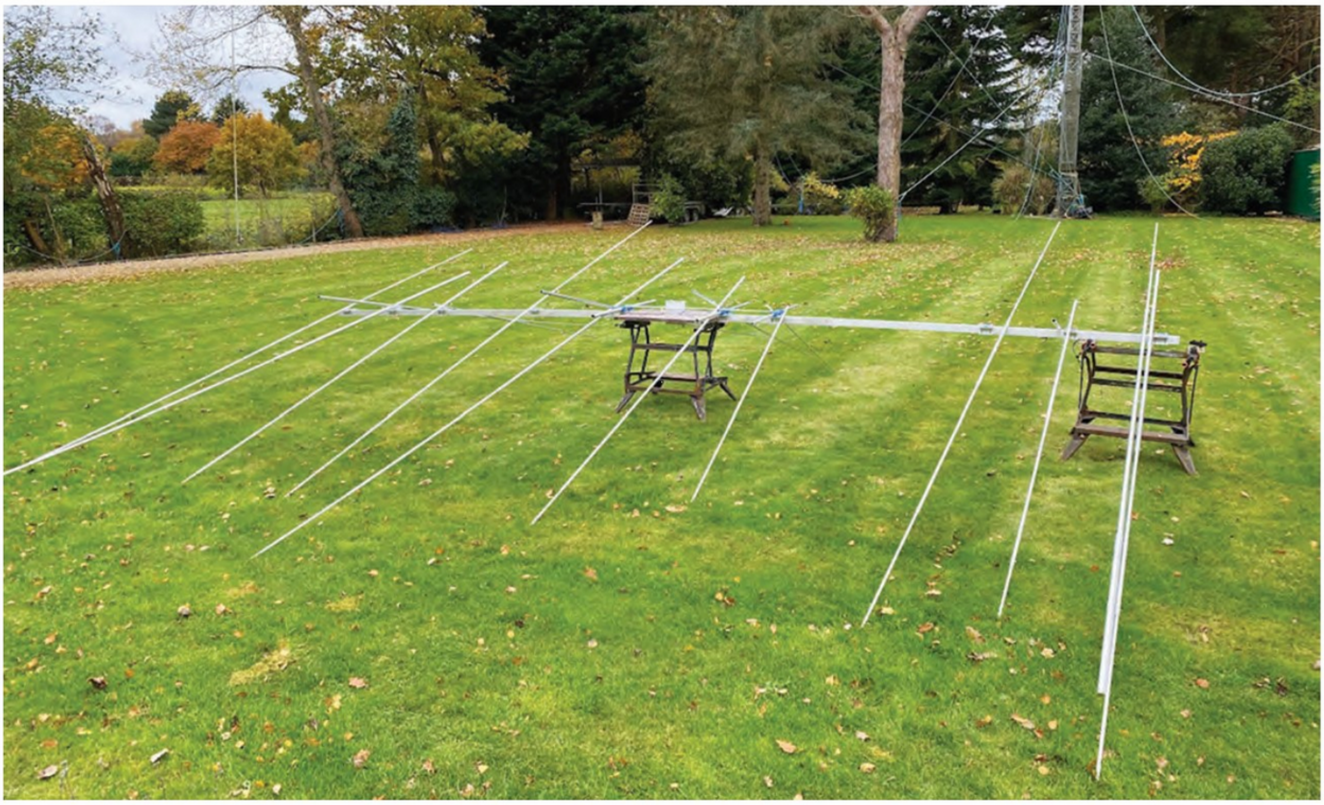

FIGURE 3: Constructing the antenna.

into separate bags, and even included a bag of spanners, which was a first for me – they've thought of everything. The instructions were clear and methodical (you can download them before buying after registering at momobeam.com). The parts were well marked with labels, and Chris and Ray both said that the antenna was easy to assemble using two 'Workmates' in Chris's garden in November (see **Figure 3**). Neither Chris nor Ray had any complaints about the construction, and the antenna went together quite easily.

The antenna includes a balun capable of 3kW. This comprises a string of ferrite cores over a length of coaxial cable, with an SO239 socket at one end, and two metal loops at the other end on a pigtail. The whole balun assembly is wrapped in heat-shrinkable material. If you need a balun that can handle more power, you can specify one capable of 5kW (+ €50) or 10kW (+ €100) when you order the antenna.

The antenna also comes with a 'Mastrant' support cord which is mounted about one metre up from the antenna and affixed with aluminium brackets. This supports a lot of the boom's weight. Once finished, the antenna was mounted on one of Chris's towers. This needed at least two pairs of hands, although it was easier with three! We split the antenna into three parts, mounting the central (feed point) section first. Then we added the forward section, followed by the aft section of the beam.

Testing

Initial VSWR tests were made at a height of about 30ft and were fine, so we cranked it up to about 60ft and took the final set of measurements. VSWR was below 1.5:1 across the whole band on 20m, 15m and 10m. At its lowest point, the VSWR was around 1.2:1 on all bands.

In tests, we found the antenna worked very well – within a few dB of G0DWV's Optibeam. The Optibeam has four elements on 20m and six on 10m. Given that this antenna had one/two elements fewer than the Optibeam 17-4, this was quite impressive. On some signals, we couldn't detect any difference. The Momobeam is also about a quarter of the price of the Optibeam, so that probably makes it a bargain. We worked the 4W8X Timor Leste DXpedition on the first call on 20m SSB – what more could you ask for?

We then focused on 10m CW beacons as these provided solid weak signals for receiving tests. Once again, we found signals received using the Momobeam were down by just three or four dB (around half an S point) compared with the Optibeam, when pointed at the 2W beacon at SV6DBG on 28.2689MHz. It was a similar story with the 5W beacon at SV2HQL on 28.2718MHz. You would have difficulty in spotting any difference with your ears when listening.

On 10m, the Force 12 C31XR was better (it does have three extra elements), but not by a huge amount. On 15m the Momobeam antenna was very slightly down (three elements versus four on the C31XR). However, on 20m they gave the same results (three elements on both antennas).

So to sum up, the Momobeam is well-constructed and easy to assemble. Its performance is very close to much bigger antennas costing more. Momobeam doesn't have a UK distributor, but you can order online at momobeam.com Remember that you will have to pay VAT. Giuseppe said that he is currently looking for a UK distributor for Momobeam antennas and would be pleased to hear from interested parties.

Thank you

Our thanks to Ray, G3XLG and Giuseppe, IT9HBT at Momobeam for the opportunity to test the antenna.

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QRP Matters

I have had a number of requests for a QRP project article, so here is one that most amateurs can have a go at: an easy-to-build forward and reverse power indicator for the HF bands. This was the Buildathon project at the 2023 G-QRP Convention.

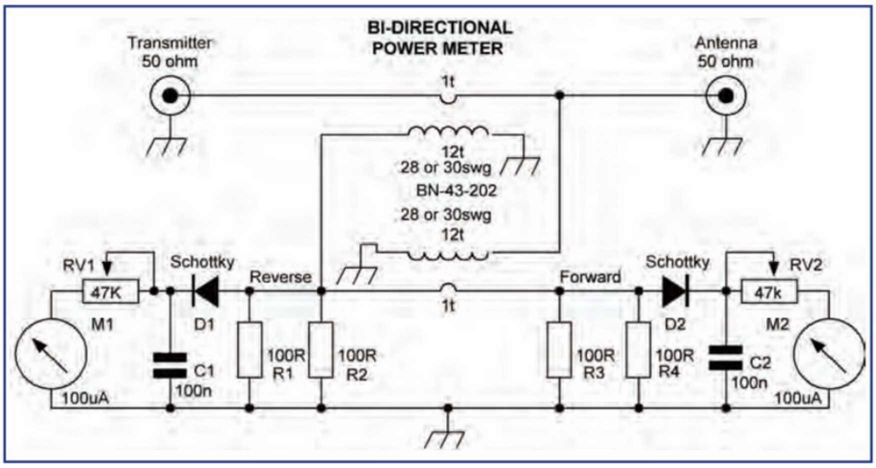

FIGURE 1: Circuit diagram.

Introduction

The original circuit by David Stockton, GM4ZNX appeared in the Winter 1989/90 edition of the G-QRP Club's journal, *Sprat*. Variations have appeared in *RadCom*, the *ARRL Handbook*, and many other publications; sometimes David even gets credited. The circuit is symmetrical and can be used either way round with no effect on function; the project is a Bi-Directional Power meter.

Originally, the transformers were wound on two wideband ferrite cores. Around 2011, an alternative method of making such a bridge was suggested by Johnny Apell, SM7UCZ. He used a single ferrite binocular (pig-nose) core to make the coupler.

It is worth noting that David's original circuit was intended to be an accurately-calibrated wattmeter, but Johnny's version was only intended to be used as an indicator of antenna matching. The version in this article (**Figure 1**) follows Johnny's lead.

This project uses a 'point-to-point' construction style. The wiring is done between sockets/tabs and copper-clad pads glued on to a copper ground-plane. G-QRP Club members can buy pre-formed 'Me-Square' pads from Club Sales [1], but anyone can make pads by cutting up pieces of PCB material (**Figure 2**).

The coupler is formed on the two holes going through the binocular ferrite core. The two 50Ω load resistors are made from two 100Ω resistors, wired in parallel. The load resistors need to be able to handle enough power to cope with the sample of the signal which, for QRP use, is not very much.

Twelve turns of 28 swg enamelled copper wire are wound through each hole of the binocular core; these are the 'pickup windings'. Two single-turn windings complete the bi-directional coupler; a single wire carrying the signal passes directly through the top hole, and the sensing winding is another single wire passing through the bottom hole of the core.

The single turn (single wire) through each hole is made with stiff 22 swg, tinned copper wire. The stiffness of these wires holds the

TABLE 1: List of parts

Parts		Notes
R1, R2, R3 & R4	4 x 1W 100 Ohms	Marked Brown Black Brown
D1 & D2	2 x 1N5711 or BAT85	
C1 & C2	2 x 100nF ceramic	Marked 104
Binocular core	1 x BN43-202	
RV1 & RV2	2 x 47k or 50k preset	
Soldering pads	8 x MeSquares	
Input/Output sockets	2 x RCA/phono sockets	
Coil wire	28 SWG magnet wire	100cm
Interconnect wire	2 colours of stranded hook-up wire	40cm of each colour
Bare wire	22 SWG tinned copper	30cm
Meters	2 x 100μA edgewise meters	
PCB material	2 x 150 x 50mm	
*M3 brass pillars	4 x 100mm long	Note: parts marks '*' are dependent on construction style and meters movements used
*M2.5 pan head screws	4 x 12mm long	
*M3 pan head screws	8 x 6mm long	
*M2.5 nuts	4	

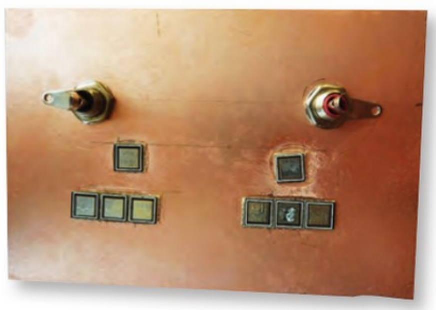
FIGURE 2: Pads and sockets.

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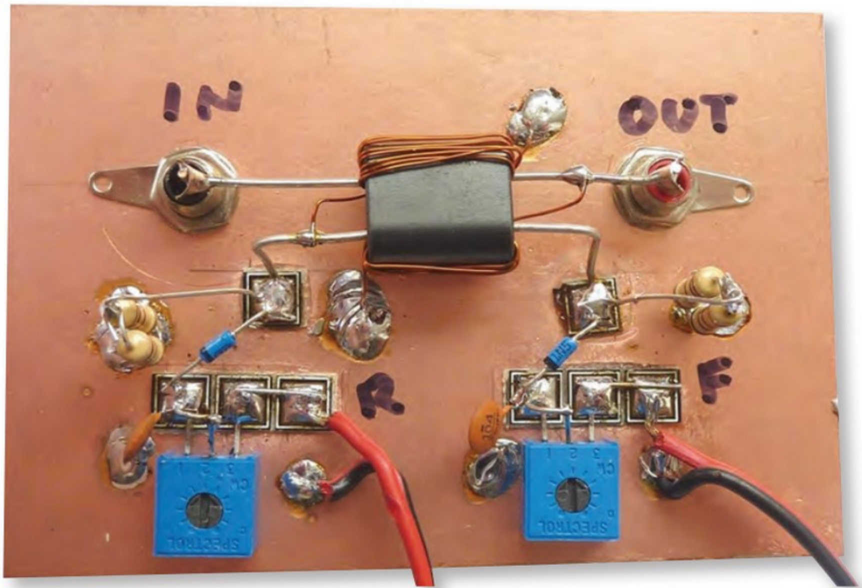


FIGURE 3: The bi-directional coupler.

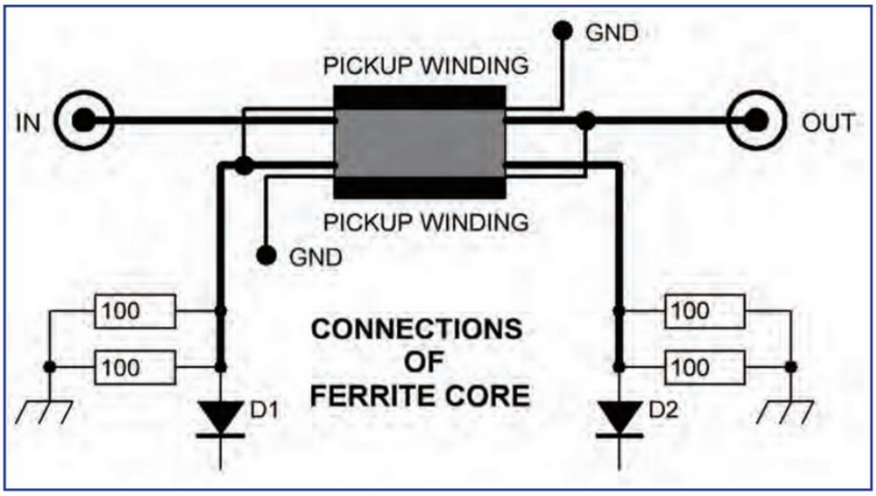


FIGURE 4: Coupler wiring detail.

FIGURE 5: Front panel.

coupler in place, as shown in **Figure 3**. The coupler is suspended between the input and output sockets. This version uses phono sockets because they are easy to obtain. You may like to change these for input and output sockets to match your own equipment.

Connecting the pickup windings in the correct place is critical. Thankfully this is easy because the physical connections exactly match the coupler layouts in the circuit diagram, but check against the coupler wiring diagram (**Figure 4**) to be sure.

The forward and reverse RF voltages that appear across the load resistors need to be converted to DC current to drive the meter movements. Our version uses a pair of Schottky diodes (1N5711 or BAT85). The preset resistors, RV1 and RV2, set the current in the meters, M1 and M2.

The meters shown in the photos were donated by Paul, M0BMN, at Kanga Products **[2]**, but similar units can be found online, or at rallies. Anything in the hundreds of micro-amps range will work. Those from 'mainstream' component suppliers tend to be very expensive, and are probably wasted on a simple project like this! Our meters were each held in place by two M2.5 x 12mm screws and nuts.

For the G-QRP Convention buildathon **[3]** we added a front panel (**Figure 5**) to enable the completed forward and reverse power indicator to be used as it stands. If you wish to house your finished project in a more substantial case, you are of course free to do so.

Four brass pillars and eight M3 x 6mm screws held the front and back panels together (**Figure 6**).

Construction instructions

The copper-clad board forms the 'back panel' of the power indicator, about 12cm x 6cm. The holes for the phono sockets should be pre-drilled and the eight pads are then super-glued to the board: two single pads and two strips of three pads. **Figure 7** shows the spacing of the pads. This can be done by measurement, or by eye (nothing is too critical).

Begin by placing the pads on the copper-clad board as shown in Figure 7. Ideally, the space between the single pads and the holes for the sockets should be equal to the space between the holes on the binocular core. The two groups of three pads should be about 2cm from the bottom of the board.

Hint: *a useful tip for placing the pads is to use a cocktail stick and some Blutack (**Figure 8**). The Blutack holds the pad on the copper side. Glue is applied on the opposite side and the pad pressed firmly in place on the board for about 20 seconds. Note that Figure 8 shows round pads but MeSquare pads are square.*

Making the coupling transformer (**Figure 9**) is quite easy but it does require a little care. Each coil requires about 50cm of 28swg enamelled wire, so prepare two lengths.

For a right-handed person, it is easiest to hold the core in the left hand and put the winding through the leftmost hole first. Pass the wire through the hole 11 more times; each time the wire passes through the hole, it counts as one turn.

Pull the wire against the side of the hole as each turn is made but avoid scratching off the enamel coating on the edges of the hole. As far as possible, make the windings lie side by side.

After winding the left-hand side, turn the core around and wind the 12 turns through the second hole and set the coupler to one side.

Bolt the phono sockets to the board with the connection tabs on the copper side.

Cut two pieces of the stiff, tinned copper wire about 7cm long. Pass one of the wires through the centre of one side of the coupler.

Place this wire between the phono socket tabs and solder in place. Pass the other wire through the remaining hole of the coupler. Bend and trim the wire ends to reach the single pads. The two stiff wires should be held parallel to the board.

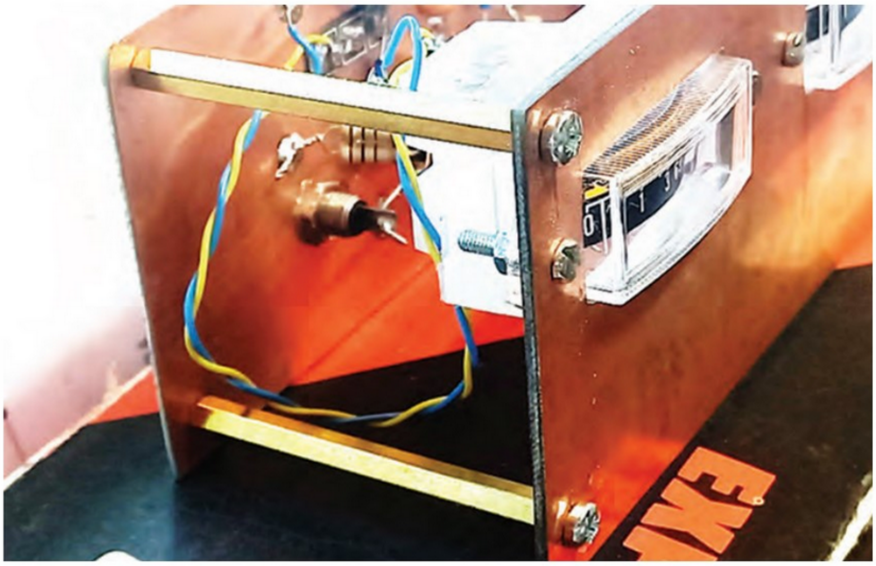


FIGURE 6: Side view.

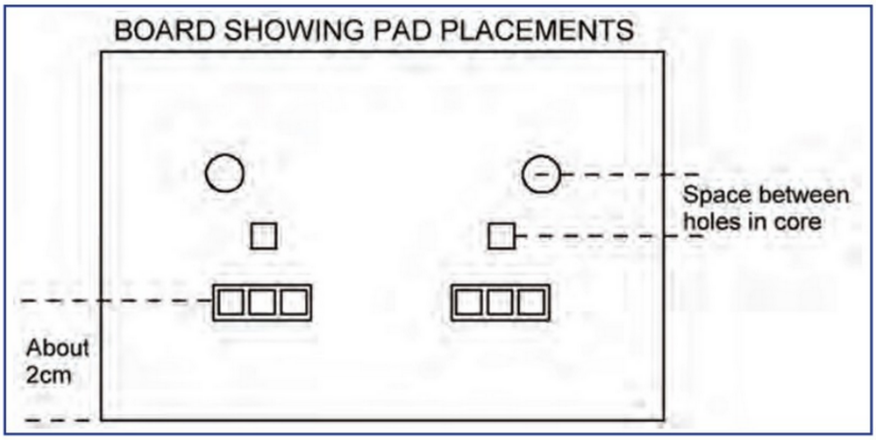


FIGURE 7: Pad layout.

Trim each end of the two 'pick-up' coils to about 2cm, scrape off the enamel to expose bare copper on the ends of the wires, and tin with solder.

***Hint**: the enamel coating of some wires will melt at solder temperature. If you apply the iron to the end of the wire, and add a little solder, you should see the enamel bubble and melt away. Move the iron back down the wire until you have enough of the wire tinned.*

The diagram shows how the 'pick-up' coils are soldered; getting this correct is critical! Each of the 'pick-up' coils is wired with one end to the opposite stiff wire and the other end to ground. These connections **must** be correct.

***Hint**: at this point it is best to check continuity between the stiff wires and ground before you move on. If there is no continuity, the enamel on the ends of the 'pick-up' coils may need more attention.*

Next, form the load resistors using 2x1W 100Ω resistors in parallel for each (**Figure 10**). The leads are twisted together and soldered. Then the leads are bent to allow easy soldering.

Solder the load resistors between the single pads and ground (**Figure 11**).

D1 and D2 **must** be connected the correct way around; the black band on each diode's cathode goes to the left-most pad on the three-pad strips. Note that both groups are wired the same way. Do not be tempted to adhere to the symmetry suggested by the rest of the circuitry or your meter calibration will be problematic!

The two outer connections of RV1 and RV2 are soldered to the left and centre pads on the three-pad strips. The left-hand and centre connections on RV1 and RV2 both go to the leftmost pad in each group (**Figures 12 and 13**).

This means that, as the screwdriver control

FIGURE 8: Cocktail stick tool.

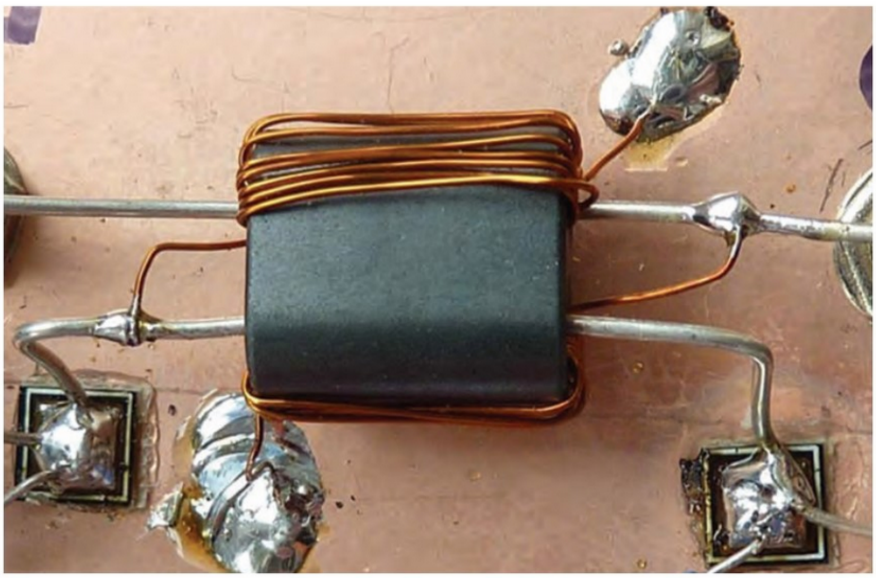


FIGURE 9: A close-up view of the coupling transformer.

FIGURE 10: Two resistors in parallel.

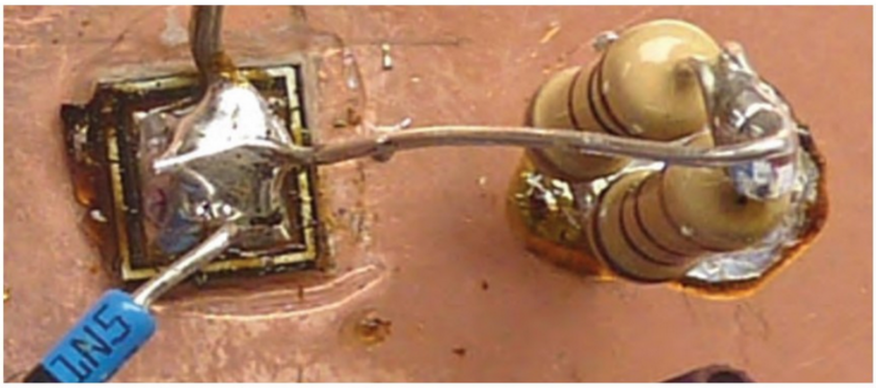


FIGURE 11: Load resistors soldered in place.

of RV1 and RV2 is turned clockwise, the meter will require more power to achieve full-scale deflection. Turning them anti-clockwise makes the meters more sensitive.

Add the bypass capacitors, C1 and C2, between the leftmost pad and ground.

Finally, take two pairs of 20cm lengths of hook-up wire (eg red and black), twist each pair together, and solder these to connect the board pads to the meters. The positive (+) meter tabs are connected to the rightmost pads and the negative (-) meter tabs are connected to ground.

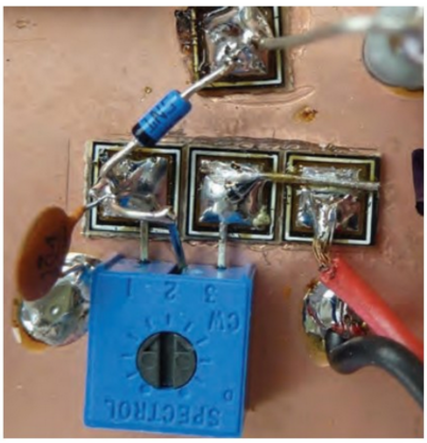


FIGURE 12: Meter adjustment parts.

Calibration

Set up with Tx connected to the IN socket and a 50Ω dummy load on the OUT socket.

Transmit your QRP power through the wattmeter into the dummy load and you should see some movement on the meter. Adjust RV2 so that M2 shows full scale for the RF power in use. Stop transmitting and reverse the transmitter and dummy load connections to the wattmeter. Now transmit again and adjust RV1 to show full-scale deflection in M1.

Switching back to the original configuration should give full-scale deflection on the M2, and zero movement on M1.

In use, connect the wattmeter between your transmitter and your antenna tuning/matching unit. Transmit and adjust the ATU/AMU so that the forward meter shows maximum current, and the reflected meter shows minimum current (ideally zero).

Front panel

Once you are happy with the calibration, you can fit the meter movements to the front panel, or box it up how you wish. **Figure 14** shows the author's 'Sunday best' version.

Your bi-directional power indicator is now complete and should provide years of good service.

Modifications

Here are some modifications you can carry out to suit your own use:

- Replace the phono sockets for your connector of choice – SO239, BNC, etc
- Replace the cheap meters for 'proper' 100μA panel meters and calibrate them for power
- Enclose the meter in a metal box
- Add a three-way, two-pole switch and additional pre-set resistors to have 1W, 5W and 10W settings
- Replace the two pre-set resistors with a dual potentiometer on the front panel to give a constantly variable maximum power setting. You could calibrate the pot settings to indicate different power levels
- Replace the meters with a microprocessor circuit and a TFT display to work out and display the forward and reflected powers, and the VSWR

References

[1] https://www.gqrp.com/sales.htm

[2] https://www.kanga-products.co.uk/

[3]https://www.youtube.com/watch?v=l_KIX839laQ

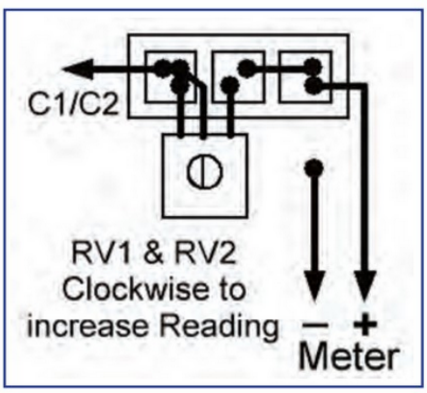


FIGURE 13: Power meter adjustment detail.

FIGURE 14: The boxed-up unit.

Motor control

This article presents a simple way to control a DC motor remote from the operating position.

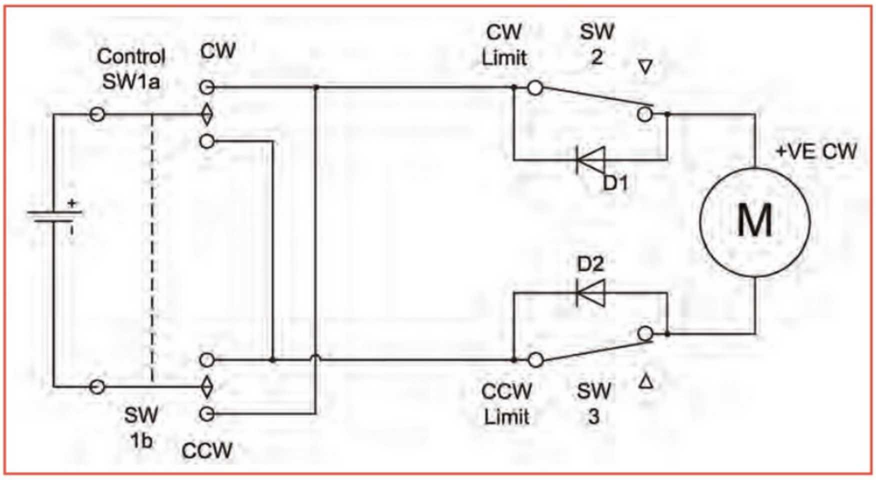


FIGURE 1: A circuit diagram of the basic scheme.

Introduction

The motor could be tuning or rotating an antenna, for example. I was prompted to write this having seen a recent article **[1]** which used an overly-complex system to tune a quad antenna. The circuit had four switches, two double-pole relays, and required seven wires to connect the control unit to the remote head. My solution uses three switches, two diodes and only two wires to the remote head. I have seen other over-complicated designs for similar applications. Many used pre-made relay boards or even H-bridge drivers.

The design presented here assumes you are using a small permanent-magnet motor, and includes limit switches to prevent mechanical over-travel. A permanent-magnet motor is reversed by simply reversing the supply. In these applications, the motor will usually have some kind of reduction gearbox or threaded-screw actuator. All switches in the circuit diagrams are shown using the convention that a triangular contact is spring-loaded OPEN in the mechanically non-activated position (normally open, NO). They are all shown in the non-activated position.

FIGURE 2: A selection of centre-off control switches of various sizes and vintages.

How it works

Figure 1 shows the basic scheme. Switch 1 is a double-pole change-over toggle switch with a centre-off position. This is often called an ON-OFF-ON switch. It may be spring-loaded to the centre position if desired. The circuit diagram shows a spring-loaded switch by the triangles on the moving contact. Switch 2 is a limit switch, and it operates when the mechanism reaches its limit with the motor running clockwise (CW). Switch 3 is a second limit switch that operates at the counter-clockwise (CCW) limit. Note that CW / CCW can be relabelled up/down, increase/decrease etc depending on your application.

Start with the mechanism in a position between the two limits. If SW1 is moved to the CW position, current flows through SW1a, the normally-closed contact of SW2, the motor (positive terminal to negative), the normally-closed contact of SW3, and returns to the supply via SW1b. Thus, the motor turns clockwise. If SW1 remains closed, eventually the mechanism operates SW2, the CW limit switch. This opens SW2 and the motor stops. While D1 is connected across SW2, it is reverse-biased and blocks current flow. To move off the CW limit, SW1 must be moved to the CCW position. Current then flows through SW1a, the normally-closed contact of SW3, the motor (negative terminal to positive), the diode D1, and returns to the supply via SW1b. When the mechanism releases the CW limit switch SW2, D1 is bypassed and the potential for CW motion is restored.

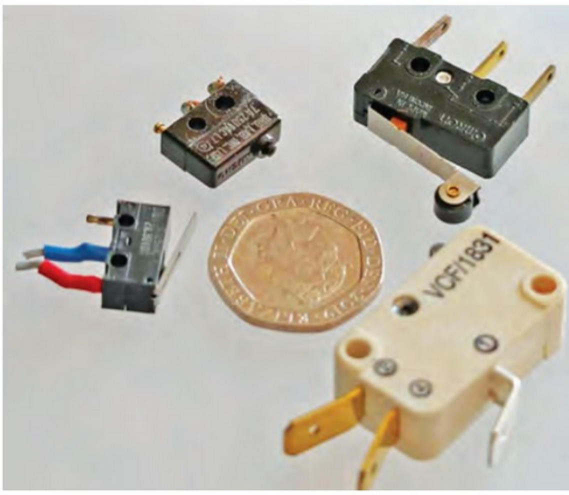


FIGURE 3: A selection of micro switches suitable for use as limit switches.

Details of the design

Figure 2 shows some typical centre-off control switches of various sizes and vintages. As an alternative to a centre-off switch, a two-position double-pole change-over switch can be used, together with a normally-open push-button switch in series with one of the common terminals. You select the direction with the toggle switch and run the motor by pressing the push-button switch. The 'test aid' box shown in Figure 2 uses this approach.

Figure 3 shows a selection of micro switches suitable for use as limit switches. Despite their small size, these can carry a current of several amps. The actuators on the switches are either a button, a lever, or roller-lever. The type which have buttons have very limited travel, and they can't be used when there is a possibility of over-travel which could damage the switch. The lever type is more tolerant of over-travel and is easier to adjust. Its main limitation is that it will not traverse a stepped actuating surface in both directions. The roller type is more expensive, but will happily run over a step and is best for use on cam-type actuators.

The circuit shown in Figure 1 lacks any indication that the mechanism has reached a limit. One option to provide this is to add a current indicator at the control end. The indicator could be an ammeter or an LED across a shunt resistor. This is, of course, indirect indication based on motor current. It is better to provide positive indication. This requires an extra connection between control and remote locations as shown in **Figure 4**. This does not tell you which limit has been reached, but works without a move being selected. We could remove the link between SW2 and SW3 normally-open contacts and add a second LED connected to SW3 NO contact to tell us what limit the mechanism has reached. This would require an extra connection between control and remote. However, a little more thought provides the circuit shown in **Figure 5**. This provides an LED for each limit, but only requires a single connection. It relies on the fact that, when you operate SW1, only one LED can be forward-biased. It does mean that the LED only comes on when the switch is operated. Because of this, it actually provides little extra information over the single LED limit indicator. Diodes D3 and D4 are required because, in some switch positions, the LEDs are reverse-biased and the typical 12V supply is higher than the reverse breakdown voltage of the LED. Without D3 and D4, the LEDs may be damaged.

We can reduce the number of wires between the control and remote to one, or two with indication, if a common ground exists between the two locations AND the motor supply is isolated from the common ground. This is shown by the dotted line in Figure 5 which is optional if the two points marked X each connect to the common ground. The isolated supply could be an additional mains supply separate from any grounded DC supply in the shack, a battery, or an isolated DC-DC converter run off the main DC supply.

Using a common ground will, however, increase any interference radiated by the motor. This is a particular issue if the tuning

FIGURE 4: Circuit diagram showing how a limit indication can be achieved with only one extra connection between control and remote locations.

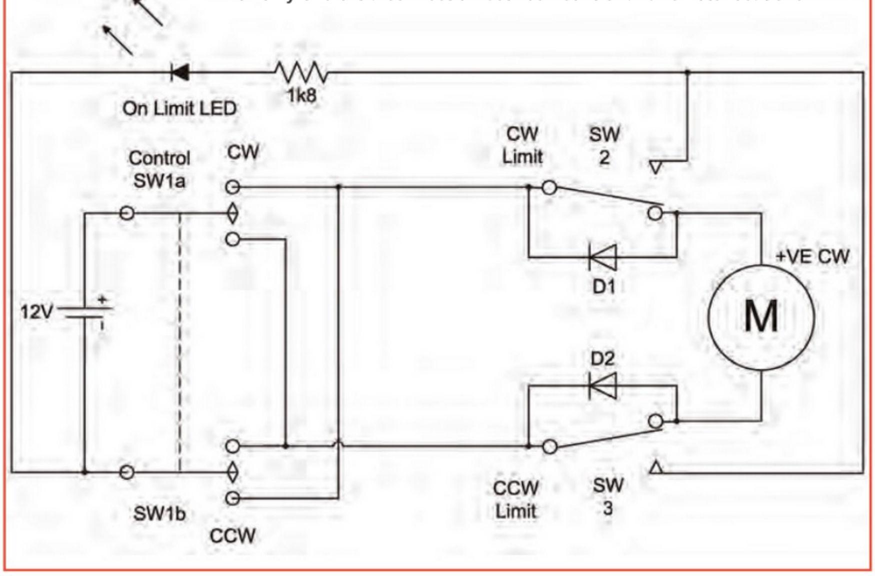
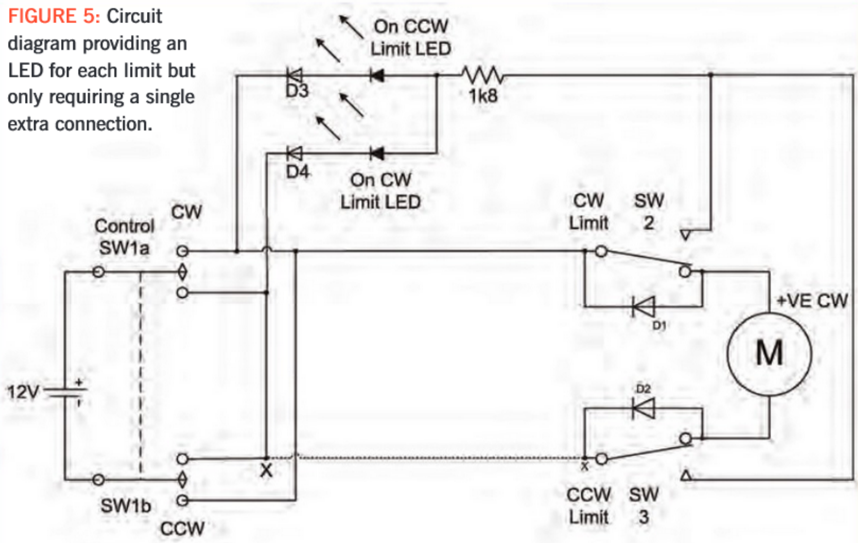


FIGURE 5: Circuit diagram providing an LED for each limit but only requiring a single extra connection.



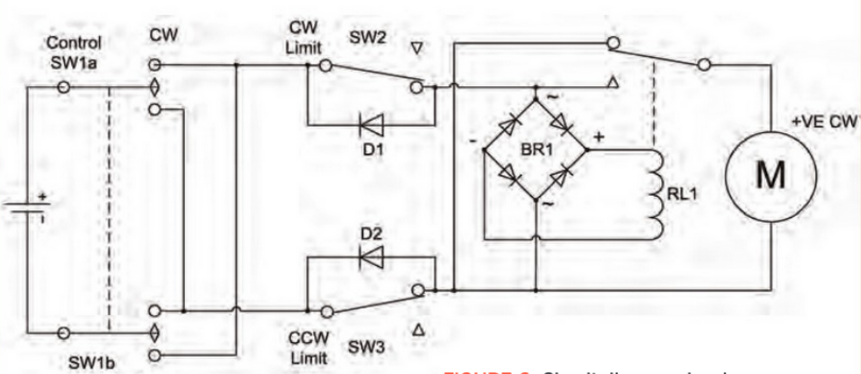


FIGURE 6: Circuit diagram showing an arrangement for electrical braking of the motor.

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of a remote antenna relies on listening to a received signal. Interference can be reduced by filtering and using a twisted pair of wires for the main current conductors. Filtering can be in a number of stages. The first is to add two small capacitors (about 10nF), one from each motor terminal to the motor case. The case should, of course, be connected to local 'ground' if possible. Next would be a series inductor in each motor connection. Additionally a capacitor across the lines and/or a common-mode ferrite ring or sleeve may be required. The exact configuration depends on the motor and frequencies of interest.

An issue that can arise, with some motors and the particular mechanical arrangement, is overrun. This happens when mechanical inertia causes the system to keep moving after the switch is released. It can make finding the correct setting difficult. An improvement can be made using dynamic braking. When the motor is rotating with no supply, it becomes a generator. Adding an electrical load also loads the mechanical system causing it to come to a faster stop. This can be achieved by adding a relay at the remote end as shown in **Figure 6**. When de-energised by either manual release of the switch or by hitting the limit switch, the relay places a short across the motor, hence providing the braking action. The bridge rectifier is required if the relay coil is polarised. Many modern relay coils are polarity-sensitive either because of built-in suppression diodes, or permanent magnets to improve sensitivity. The energy in the mechanical inertia is converted into heat in the motor windings because of their DC resistance. For small DC motors, this same resistance also limits the inrush current, so as long as the relay contacts are adequate for the motor current, they are OK for the braking current. For larger motors, or a system that constantly starts and stops, an external resistance can be added in the braking loop. As a compromise between braking effort and dissipation, the resistor should be approximately equal to the DC resistance of the motor. This can be measured with a normal ohmmeter. Rotate the motor shaft very slightly and take the lowest value. Don't take a reading with the shaft moving.

Figure 7 shows an example system. I used a motor to control a variable AC power transformer. The transformer shaft was coupled to the motor by a toothed belt. **Figure 8** and **Figure 9** show the switch actuator in the CCW and CW limit positions respectively. The limit switches are lever types.

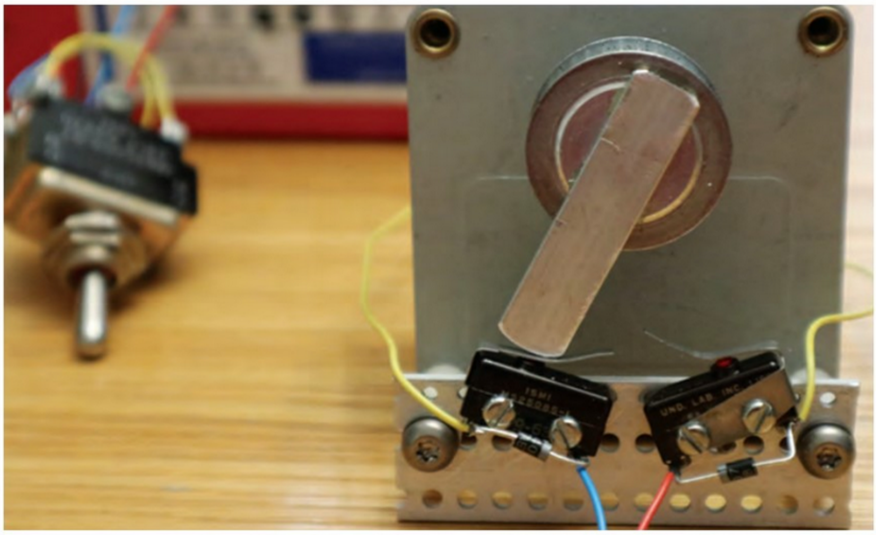

FIGURE 7: An example system.

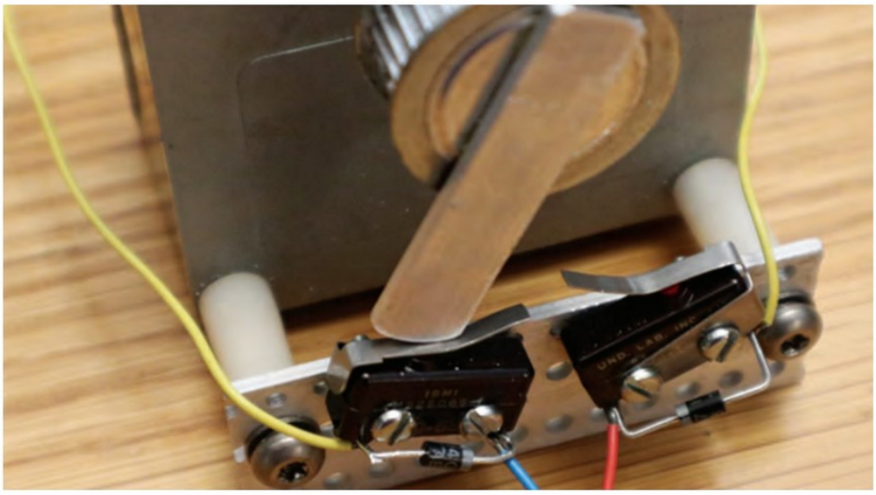

FIGURE 8: The CCW limit.

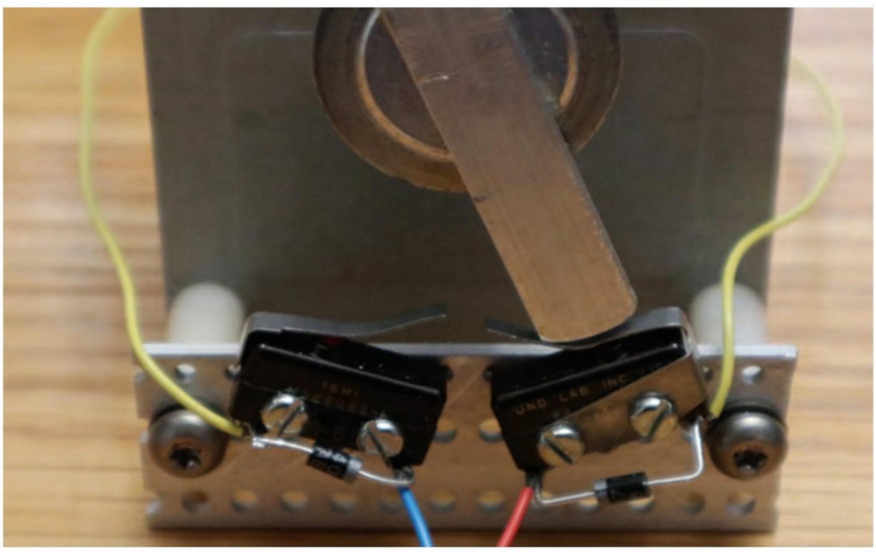

FIGURE 9: The CW limit.

Reference

[1] A remote tuning unit for a cubical quad antenna, *RadCom* August 2023.

Noise levels around the world

Having recently returned to using the short-wave bands, after many years working almost exclusively on VHF and microwave, I was once again enthralled by the ability to communicate over great distances using very little power, especially using today's digital modulation methods.

A big problem with noise

It was immediately apparent to me that there is now one overriding problem, which has slowly arisen in the last sixty years: man-made noise. Looking back in my logbook, it seems difficult to believe that world-wide voice contacts were possible with AM using valve equipment and just 20W. In the UK, the average HF station now runs between 50W and 100W using WSJT-X digital modes to achieve the same experience in coverage as that in the 1960s. This represents a deterioration of around 30dB over the last half century. But is it actually that bad and universal across the whole world? The answer is yes, it is that bad, and no it is not universally bad across the world.

Whilst testing my home-brew 20W SDR rig in the UK **[1]**, I found that I was receiving reception reports from my WSJT-X FT8 digital-mode CQ calls on 40m from much further away than I expected when I looked on the global map using PSK Reporter **[2]**. In particular, I could see that my signals were being *received* in Australia, but my many attempts to decode a reply never resulted in a single QSO. My hunch was that the noise levels in Australia were generally much lower than in the UK, and I needed to see for myself if it was true.

My experiments in Australia

So, a popular QRP rig plus 20W amplifier, an antenna, a laptop computer, and a set of digital interfaces, were packed into a suitcase and, after four flights, the kit was installed at my daughter's homestead in New England (VK2). The location is 500km from the east-coast big cities (such as Sydney and Brisbane), and is in one of Australia's low-noise regions on top of 'The Big Divide' at 3500ft asl. The region is home to several of the world's large radio telescopes and space tracking stations (one is just 5km away). **Figure 1** shows an Australian onlooker to my earlier experiments!

The first thing that I noticed after switching on was the lack of any deflection of the S-meter on the radio on all bands except 80m and 40m. It was sometimes difficult to tell if the antenna was actually connected, as there was little activity during the day on the lower HF bands. However, on the first evening, I had arranged a sked over the internet with M0ICR (at his home in the UK), who had kindly agreed to get up early to try out the 40m band. Very few stations were active on the band, but as soon as he started to transmit from the UK, he was readable using FT8, and I responded. Our activity triggered a series of return calls from Australian high-power stations who called him, and several UK stations who had heard him call me, but none of the Australian stations, including mine, were heard back in the UK at that time.

A few days later, it was time for the RSGB HF FT4 contest, and so I was ready at the start, having already heard European stations operating earlier on 40m. After half an hour of listening, and trying to work many strong European and UK stations, I gave up and left WSJT-X to itself recording the contest. An analysis of the data from the 'all.txt' log afterwards revealed that I was able to receive over a third of the 100W competitors in the UK, and many other European entrants as well. One UK station was, on average, 6dB above everyone else, but did not put in an entry (was he running 400W?). No other Australian stations took part, as the FT4 sections of the lower bands were fully occupied for the contest. **Figure 2** shows on a map the stations received by me during the contest.

FIGURE 1: An Australian onlooker!

I then spent the next three weeks on the air, mostly on 40m at the optimum times, to communicate with Europe, but despite having dozens of QSOs across the globe, I had none with the UK. Nor were my transmissions ever received in Europe except for three QSOs with Denmark, Belgium and Spain. See **Figure 3** for a map of a typical few minutes of operation, on 40m using FT8 and 20W.

What the results show

Analysis of the recorded data from the 'all.txt' file from WSJT-x revealed the reason for the variation in QSO success across the globe, and the answer to my question concerning the poor reception of my Australian signals in Europe and the UK. In the following analysis, I have made the assumption that the propagation loss through space is the same in both receive and transmit directions **[3]**. Dividing the 100s of 40m QSOs into continental regions, and comparing the received signal-to-noise ratio (SNR) in each direction, the following facts emerged from the data:

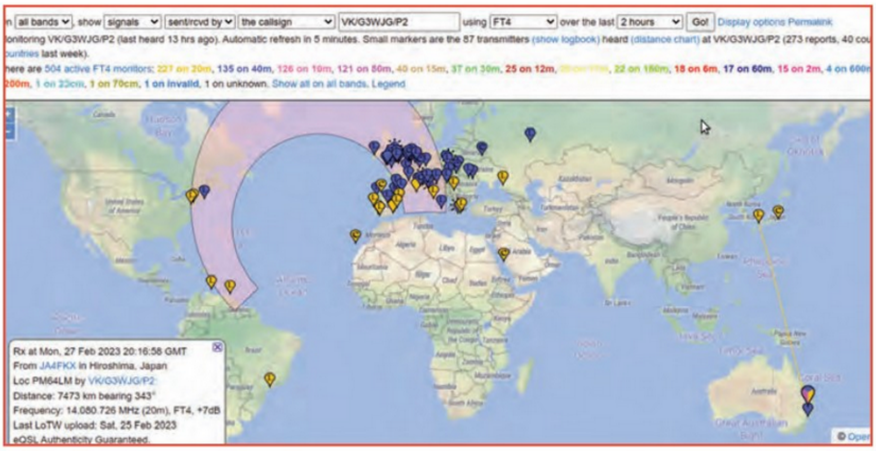

FIGURE 2: **The RSGB FT4 Contest received in Australia by VK/G2WJG/P2.**

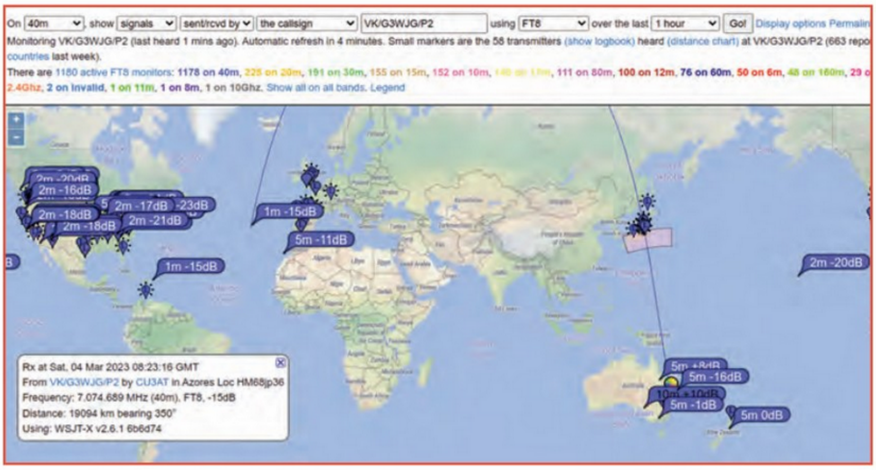

FIGURE 3: **Tx/Rx coverage of VK/G3WJG/P2 on 40m for one hour.**

Within Australia (all regions except VK5), the average SNR received at their location was 6dB worse than that for signals received from them by me. This then suggests that the average power used in Australia for FT8 is 80W, as I was using a nominal 20W throughout my stay. This makes the assumption of a similar noise level at their receive locations as mine, a reasonable assumption if most Australian stations are in rural noise environments like mine.

Turning now to North America, the 'average received SNR difference' figure in this case was 13dB, suggesting perhaps that American stations use 400W on average. This again seems reasonable. However it could also be that *the general background noise level in North America is some 7dB higher than in Australia*, and perhaps this is the more-likely explanation, if *all* the US stations aren't all using high-power amplifiers.

In Japan, the situation starts to get interesting as the 'average received SNR difference' figure rises to 20dB. Considering that Japan's legal power limit is only 3dB more than that allowed in Australia, it seems reasonable to assume that *the background noise in Japan could be over 14dB worse than that enjoyed by rural Australian amateur radio operators*.

In Europe, data is scarce, as only three of my transmissions were registered, despite hundreds of stations being received, decoded and responded to by me in Australia. However, the data suggests a figure similar to that of Japan.

In the UK, from the many 100W stations received by me during the RSGB FT4 contest, the maximum received SNR for a 100W station was +3dB. From my valid QSOs decoded from all parts of the globe, I found that the minimum practical decoded SNR of an FT8 signal was -24dB. Therefore, the best UK station has the ability to decode 100W signals from Australia, even with a local noise level some 27dB worse than that in Australia. Putting it another way, my hundreds of 20W transmissions, made during easy reception of UK activity, should have been decoded by some UK stations even if the *lowest* noise level in the UK was 20dB worse than that in Australia. But *not one* decode of my transmissions during a month was evident in the data logs from the UK. The 'best to average' signal ratio from countries where QSOs were possible was 10dB, so I suggest that *the average noise level in the UK could be approaching 30dB worse than that in rural Australia.*

Before leaving Australia, and as a further check, I recorded the levels of noise on 80m and 40m over a couple of days according to the S-meter on the radio (there being no discernable readings on the higher bands). These showed that the noise levels were around -121dBm on 80m and 40m, using a 3kHz bandwidth.

Back in the UK again, I re-installed the end-fed half-wave 80m antenna and radio equipment in the garden and shack, with the same settings and configuration as in Australia. I re-checked the S-meter level calibration on the HF bands, then measured the pure noise on a quiet part of the band on several occasions. As expected, the noise levels were high, actually *very* high. A reading of -85dBm on 40m meant that my urban QTH in the south east of the UK was *36dB worse than that in Australia.* As a further check, I then installed the antenna and radio using the same configuration at a rural UK location operating on batteries. This resulted in a 12dB reduction of the noise level, again confirming that the noise level for the *average* UK location would be close to 30dB worse than in Australia, in line with the conclusions from my FT8 experiments.

I then re-installed the same antenna and QRP 20W rig all over again, but this time in a 'typical' rural location in northern France. I measured a further improvement of 10dB in received SNR compared to my UK tests. At that location, I was finally able to hear a high-powered Australian station in QSO with other Europeans.

So there we have it folks: in the south of the UK, the noise pollution on the lower amateur bands is already the worst on the planet, and *one thousand times* worse than it is in rural Australia, and no amount of increase in transmitted power by UK radio amateurs will help improve HF communications.

References

[1] SDR Tranceiver for the amateur bands, *RadCom* Vol 97 no.10

[2] Reciprocity of HF radiowaves, *RadCom* Vol 99 no.6

[3] https://pskreporter.info/pskmap.html

Suggested other reading: ITU-R P.372-13 Radio Noise

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