Contents

July 2023

News and Reports

Features

Technical Features

58

30

Regulars

Reviews

3Y0J Bouvet DXpedition
Design by Kevin Williams, M6CYB

RadCom THE RADIO SOCIETY OF GREAT BRITAIN'S MEMBERS' MAGAZINE
Managing Editor: Edward O'Neill, M0TZX, edward.oneill@rsgb.org.uk
Interim Technical Editor: Peter Duffett-Smith, GM3XJE
Layout and Design: Kevin Williams, M6CYB, kevin.williams@rsgb.org.uk

All contributions and correspondence concerning *RadCom* should be emailed to: radcom@rsgb.org.uk. Alternatively by post to *RadCom* Editor, 3 Abbey Court, Fraser Road, Priory Business Park, Bedford MK44 3WH Phone 01234 832 700.

RadCom is published by the Radio Society of Great Britain as its official journal and is sent free and post paid to all Members of the Society. **The August 2023 edition of *RadCom* is expected to arrive with most Members by 14 July 2023** although this can take up to a week longer in some cases; international deliveries can take longer still.

All material in *RadCom* is subject to editing for length, clarity, style, punctuation, grammar, legality & taste. Articles for *RadCom* are accepted on the strict understanding that they are previously unpublished and not currently on offer to any other publication. Unless otherwise indicated the RSGB has purchased all rights to published articles. No responsibility can be assumed for the return of unsolicited material. See www.rsgb.org/radcompix for info on taking photos for publication.

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

RADCOM (ISSN No: 1367-1499) is published monthly by the Radio Society of Great Britain and is distributed in the USA by RRD/Spatial, 1250 Valley Brook Ave, Lyndhurst NJ 07071. Periodicals postage pending paid at So Hackensack NJ. POSTMASTER: end address changes to RADCOM c/o RRD, 1250 Valley Brook Ave, Lyndhurst NJ 07071

www.facebook.com/theRSGB
Twitter @theRSGB

New Products

Introducing the HM-249 hands-free kit

The HM-249 is a new simple hands-free kit designed for vehicle operation* using selected Icom mobile radios. This new product consists of a main PTT button with RJ-45 modular connector, a remote PTT button and a microphone. It is compatible with selected Icom digital and analogue two-way radios and LTE and amateur radio mobiles (IC-2730E, ID-4100E, ID-5100E) as well.

Installation of the HM-249 is straightforward with each PTT and the microphone having a 3M type seal on the back to let you attach it to your desired position. The large PTT switch button also has a screw hole for a solid attachment.

HM-249 product features:

- Small PTT button with 2.5m connection cable. Attach to your gear stick or place it near the steering wheel.
- Microphone with 2.5m connection cable. Attach to the car sun visor etc.
- Large PTT switch button which has an LED and lights up when transmitting. It has an RJ-45 type modular microphone connector to connect with the mobile radio's microphone jack.

The HM-249 is now available for sale with a suggested retail price of £108 inc VAT.
* Guidance about the use of radio equipment in vehicles can be found on the Icom website:
icomuk.co.uk/The-Use-of-Radio-Equipment-in-a-Vehicle/4133/1876/
For more information visit www.icomuk.co.uk

Chameleon lightweight end-fed sloper antenna

The CHA LEFS is a six-band, no-tuner, High Frequency (HF) antenna for use on the 80, 40, 20, 17, 15, 12 and 10m amateur radio bands. It is a minimalistic design, is constructed from lightweight components and is intended for the serious backpacker and outdoor adventurer. Leave the tuner and SWR meter at home – just bring a radio and a pair of boots!

The CHA LEFS is designed for the trail. The sturdy line winder with integral high-efficiency impedance matching network transformer, ultra-thin 20-gauge PTFE antenna Kevlar wire, and 50 feet (15.2m) of lightweight Micro 90 paracord enables highly-portable six-band operation without the extra bulk of an antenna tuner. It can even do Near Vertical Incident Sky wave (NVIS) communication! The CHA LEFS is perfect for backpackers, hikers, bikers, campers, and survival communication. Get one for your next expedition!

The toroid uses a 14-gauge solid-core wire with a FEP sleeve covering. Typically referred to as FEP, Fluorinated Ethylene Propylene is a type of fluoropolymer commonly extruded as both an insulation and jacket material for wire and cable. FEP exhibits outstanding resistance to chemicals, has a wide temperature range and excellent electrical properties.

The end of the wire is also equipped with a nylon insulation ring.

Specifications:
Bands: 80m to 10m
SWR (with the bands shown above): less than 2.0:1
Power: 250W CW, 500W SSB
RF Connection: UHF socket (SO-239)
Length: 63ft (19.2m)
Weight: 1.5lbs (0.7kg)
The antenna system consists of:
1 X CHA LEFS (63' /19.2m long tinned Copper Kevlar PTFE (Teflon) (-70°C to 150°C) wire
1 X 50' MICRO 90 Paracord
Available from www.hamradio.co.uk for £239.99.

President Digimike noise reduction microphone

The Digimike microphone is designed to make your modulation as clear as possible in all modes (AM/FM/SSB) by eliminating the background noise. In order to optimise the performance of your Digimike NRC (noise reduction circuit) microphone, please carefully read the user's manual and note the following points:

Key features/ specifications:

- NRC Levels
- Up/down function
- Type: electret
- Connector: 6-pin President wiring
- The filtering level from 1 to 5 (maximum level) must be fixed with your correspondent (during any QSO) who will confirm the optimal sound balance
- Keep the Digimike at a minimum distance of 10cm (4 inches) and avoid direct contact between the Digimike and your mouth
- The Digimike will also work optimally with VOX usage (if your radio is equipped with the VOX feature)

Available from www.moonrakeronline.com for £69.95 plus £4.95p+p.

Antennas

The mono-band Half-Square antenna

An antenna design which is rising again in popularity is the so-called Half-Square. Traditionally, these have been configured as mono-band antennas. This version of the half-square is fed with 50Ω coaxial cable in one of the upper corners of the antenna, with the coaxial cable braid attached to the vertical leg and the centre conductor to the horizontal wire which also forms the other vertical leg of the antenna. The use of a choke is recommended, to prohibit any common-mode currents on the coaxial cable, as otherwise the braid of the feeder becomes part of the antenna and affects the radiation pattern. It is also recommended to run the coaxial cable as perpendicularly as is possible from the antenna, for as far as possible. Consequently, the antenna is fed at a high-current point with low impedance and is usually a good match to our 50Ω coaxial feeder.

The antenna itself is a full wavelength long on the desired band of operation. Thus, for 14MHz the antenna would be approximately 20m (66ft) in length, 40m (132ft) for 7MHz, and so on. As **Figure 1** shows, for 14MHz, the two vertical 'legs' of the antenna are a quarter-wavelength long (5m each) with the horizontal part of the antenna being a half-wavelength long (10m). This, of course, can be scaled for whichever band you care to use. Whilst this scale of vertical/horizontal represents the 'ideal' or traditional setup, small adjustments can be made to the vertical/horizontal lengths with minimal real-world impact. Rudy Severns, N6LF, in his contribution to the *ARRL Compendium* (vol 5 1996), demonstrated that adjusting the horizontal length (and thus accordingly the vertical lengths) by a reduction or increase of 20 per cent, whilst maintaining the overall dimensions of the antenna to be a full wavelength, reduced the gain by no more than 0.6dB. This is a useful consideration for those of us who may well have limited space, for example at our home QTH.

A practical advantage of this configuration is that the antenna provides some good low-angle gain, despite the highest point being at the relatively-low height of a quarter-wave above ground. Usually, we would associate any antenna with a horizontal portion at this relatively-low height, as having unsuitable properties when it comes to chasing DX. For example, a horizontal dipole, we are told, should be erected as near to a half-wavelength above the ground as possible to produce a good broad-side gain at a low take-off angle for chasing DX. The Half-Square antenna, however, provides a good amount of vertical polarisation, and so suffers less from being a low-height antenna (see **Figure 2**). This is a result of the two vertical radiators being fed in phase with each other by the top horizontal wire. Another positive aspect of this version of the Half-Square is that the current maximums are in the top corners, well above ground level, and therefore the antenna does not require the good ground radial system and the feed arrangements that a pair of conventional phased quarter-wave verticals antennas would require.

The broadside gain provided by this antenna is accompanied by deep nulls off the edges, meaning that it is quite directional, and care should be taken to orientate it to ensure the desired direction for maximum gain. The gain at the low take-off angle of 5° peaks at -2.6dBi which is around 3.5dB better than a ground-mounted quarter-wave with a good ground radial system.

An inconvenience sometimes cited about the corner-fed Half-Square antenna (much like the vertical centre-fed dipole) is the need to ensure that the coaxial cable runs perpendicular to the horizontal and vertical portions as far as possible away from the antenna, to avoid any interaction between the coaxial cable and the antenna. This, together with the choke/balun at the feed-point, should ensure that there are no antenna currents flowing along the outside of the coaxial feeder. We

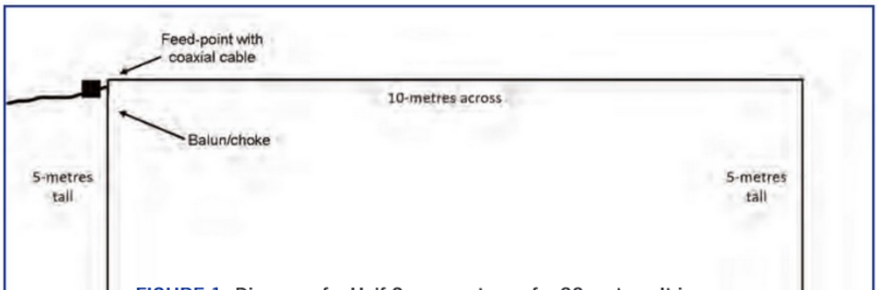


FIGURE 1: Diagram of a Half-Square antenna for 20 metres. It is corner-fed with coaxial cable and a choke/balun, thus making the antenna mono-band for 14MHz.

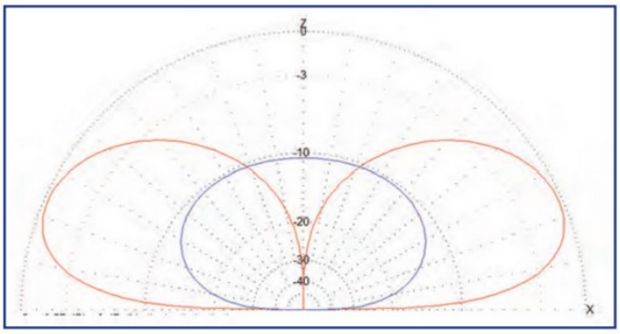


FIGURE 2: Dominance of vertical polarisation (in red) compared with horizontal polarisation (in blue) for the corner-fed Half-Square antenna.

Tim Hier, G5TM.
timhier@icloud.com

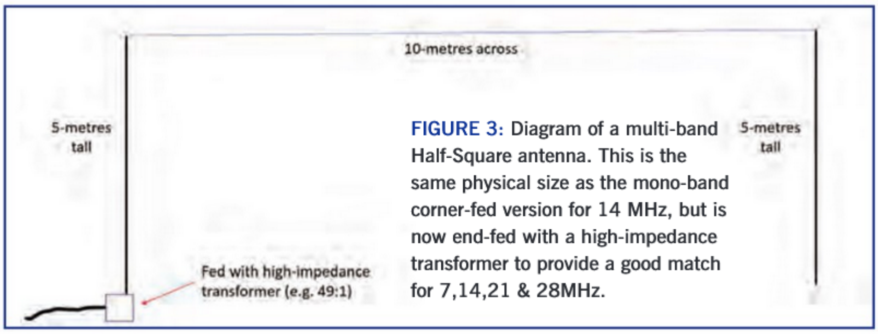


FIGURE 3: Diagram of a multi-band Half-Square antenna. This is the same physical size as the mono-band corner-fed version for 14 MHz, but is now end-fed with a high-impedance transformer to provide a good match for 7,14,21 & 28MHz.

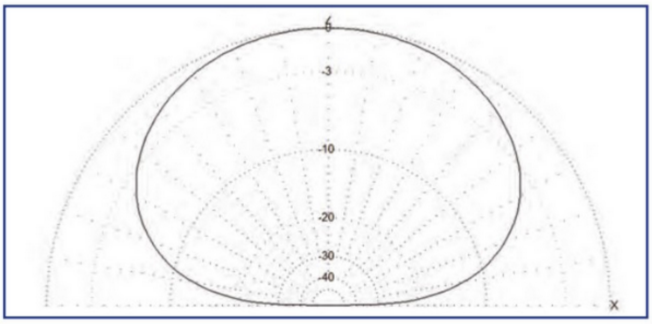


FIGURE 4: **The far-field total-power radiation pattern for 7MHz, showing typical low-dipole properties ideal for short-hop contacts.**

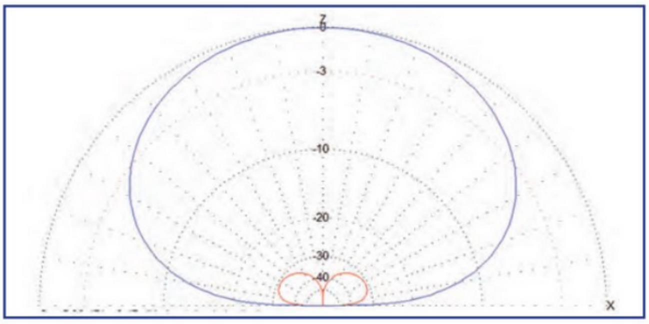


FIGURE 5: **Confirmation that, on 7MHz, the multi-band Half-Square antenna is dominated by horizontal polarisation (blue), rather than vertical polarisation (red).**

have a useful antenna, but one which provides us with only single band operation. However, there is a way of converting the mono-band Half-Square antenna into a space-saving multi-band antenna.

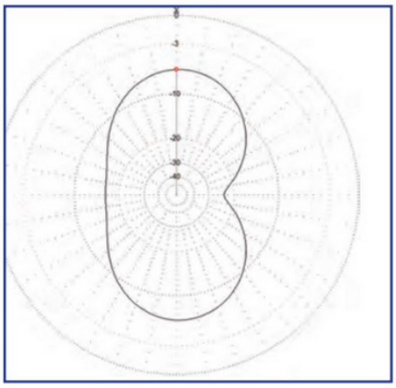


FIGURE 6: **The total-power azimuth pattern on 14MHz at an elevation of 5 degrees. This also provides confirmation that peak radiation is broadside to the antenna when the Half-Square is a full-wavelength in length.**

The multi-band Half-Square antenna

By feeding the 14MHz version of this antenna at the base of either leg, we have an antenna which is now fed at a high-voltage and low-current point (**Figure 3**). This presents a challenge to match this antenna to 50Ω because of the very high impedance found at the end of what is, in effect, a full-wavelength of wire (typically 2,000 to 4,000Ω). Arguably, the simplest way to overcome this potential obstacle is by using a high-impedance transformer at the feed-point. Typically, these are of the ratio of 49, 56 or 64:1, and should be able to provide a reasonable match to 50Ω. These transformers, popularly known as end-fed half-wave transformers, can be made at a relatively-low cost, with many designs and tutorials available on-line, and are also widely available for purchase ready-made. There is plenty of debate (sometimes robust in nature) about the proficiency of various designs for these transformers, particularly with reference to their efficiency on the higher HF bands, but they still are a useful option.

Perhaps their most useful transformation of feeding at the end is that the antenna will now operate on several bands. It is a full wavelength long at 14MHz but also resonates at other harmonics. So, our 20m-long wire which produces our previous mono-band Half-Square on 14MHz, now becomes a multi-band antenna for 7MHz (as a half-wavelength antenna), 14MHz (as a full-wavelength antenna); 21MHz (as a one-and-a-half wavelength antenna) and 28MHz (as a two-wavelength antenna). So, where does this leave us with in terms of the characteristics for each band?

Using the *MMANA-gal* antenna modelling software, it is possible to look at the radiation pattern and characteristics of this antenna on these four bands. We do this, of course, with all the traditional antenna-modelling caveats to do with variations in ground conductivity and the proximity of nearby objects, such as buildings. However, a good baseline picture can still be obtained to give us an idea of this antenna's potential, especially when used away from clutter as a portable antenna.

As a half-wavelength antenna on 7MHz, the Half-Square antenna

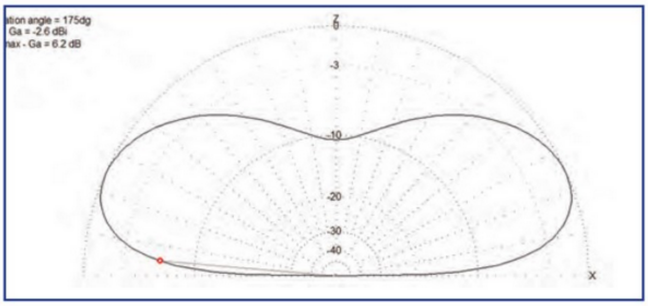


FIGURE 7: **The total-power far-field plot for 14MHz indicating useful gain of -2.6dBi broadside to the antenna.**

operates as a low dipole. **Figure 4** shows the far-field radiation pattern which you can see might be colloquially called a 'cloud-warmer'. This is not ideal for DX, but could be a nice antenna for Inter-G and contacts around continental Europe. **Figure 5** confirms the low-dipole nature of this antenna on the 40m band, with most of our RF being radiated in horizontal polarisation (blue) rather than vertical (red). This antenna's radiation pattern is largely omni-directional in nature. In short, this antenna mimics any dipole for 7MHz erected at 5m (0.125 wavelength) above ground.

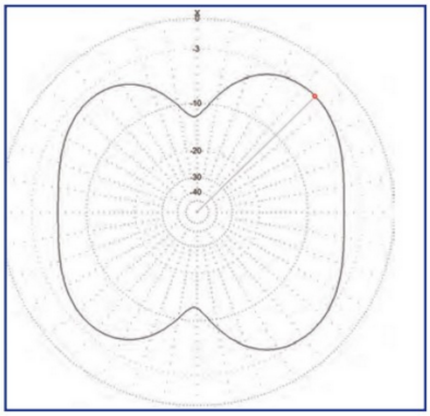


FIGURE 8: **The total-power azimuth pattern for 21MHz at 5 degrees elevation. There is very useful gain with four broad lobes at the corners.**

On 14MHz, the fact that we can feed this antenna at the base rather than in one of the top corners does little to change its character as a broad-side antenna. **Figure 6** reveals its azimuth pattern at an elevation of 5°. As we look at this diagram, note that the antenna is fed at '9 O' Clock', on the mid-left-hand side of the diagram. This means that the horizontal aspect of our Half-Square dissects the diagram running from left to right. As we can see, Figure 6 confirms that most of our gain at this low take-off angle is broad-side to the horizontal part of the antenna, just like a dipole mounted near to a half-wavelength above the ground (for the 20m band this would be 10m, or 33 feet, above ground). As per the traditional flat-top dipole, there are noticeable nulls towards both ends. In this case,

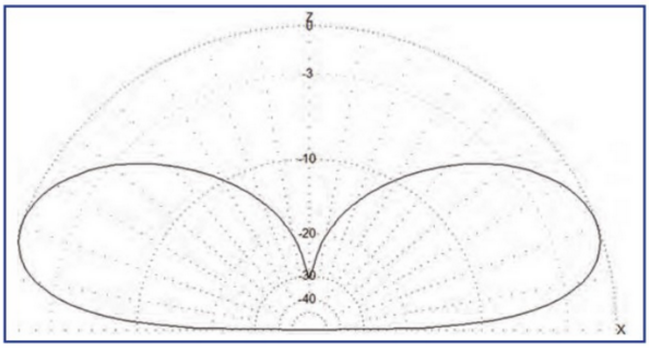


FIGURE 9: The total-power far-field plot reveals excellent gain at an elevation angle of 5 degrees on 28MHz.

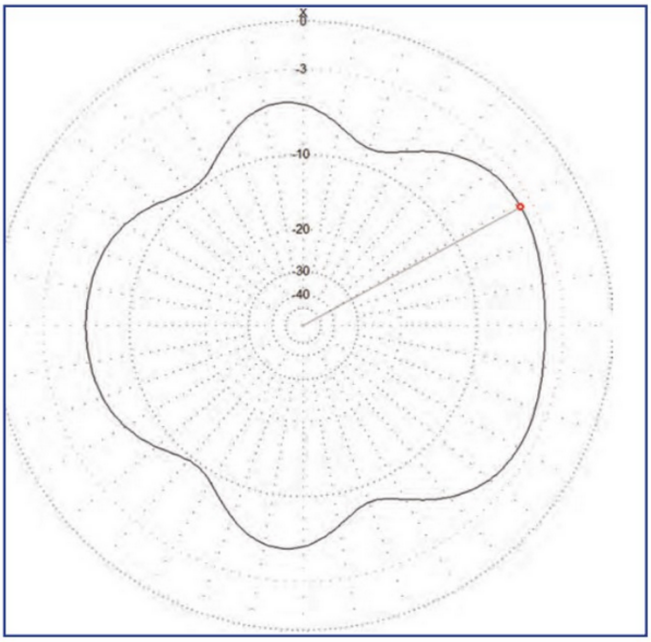


FIGURE 10: The total-power azimuth plot indicating a very good coverage for 28MHz.

modelling suggests that gain at 5° take-off reduces to -12dBi on the side that the antenna is fed and -19dB on the opposite side. Unlike on the 40m band, most polarisation on 14MHz is vertical in nature, which is exactly like its corner-fed mono-band cousin. **Figure 7** (the far-field plot for 14MHz) shows that maximum gain broadside at 5° is -2.6dBi, as per the mono-band corner-fed version outlined above.

On 21MHz, the Half-Square is 1.5 wavelengths long. At this length, you may expect to see some strong lobes and deep nulls. This is to an extent true. Unlike on the 20m band, the azimuth pattern (see **Figure 8**) shows that we now have four strong lobes from each corner of the antenna. Peak gain at 5° elevation from each corner is very similar compared with 14MHz at -2.5dBi. This is again around 3 to 3.5dB better than a decent ground-mounted quarter-wave vertical antenna. What is pleasing is that, on this band, even moving away from these strong corner lobes, the antenna still produces very competitive gain at this low take-off angle. In fact, modelling suggests that for 300 out of the 360 degree azimuthal coverage, this antenna produces gain at 5° elevation which is greater than the -6dBi we might expect from a ground-mounted quarter-wave antenna. As with 14MHz, the polarisation is heavily biased towards vertical polarisation at 21MHz at this low angle which is good for DX.

Finally, on 28MHz this antenna produces some very useful low-angle gain, and with almost omni-directional coverage. **Figure 9** shows that, at a 5° take-off angle, the 10m band has a peak gain of -0.9dBi. Gain at this low DX-friendly angle is greater than -6 dBi (our quarter-wave ground-mounted vertical baseline) for 320 out of 360° azimuth. Polarisation is once again predominantly vertical in nature, with maximum gain appearing at the opposite side from the feed-point, and broadside to the horizontal aspect of the Half-Square (**Figure 10**). These characteristics will, of course, change as we lengthen or shorten the antenna. Many operators with 20 metres (or close) of horizontal space could use this same multi-band design as a useful low dipole-like antenna for use on the 80m band and then begin to see the same broadside gain at 7MHz as a full-wave antenna. It is to be expected that a more-fractured radiation pattern will begin to emerge on 21MHz and above for this larger version, but some useful gain will emerge, nonetheless.

Final thoughts

The biggest advantage of using the Half-Square, either at home or on portable operations, is its relatively-small requirement for horizontal space. For the horizontal length of a dipole on 14MHz, we get a dipole-like antenna for 7MHz. Moreover, its relatively-short height of just 5m means that it becomes more 'neighbour friendly' and still produces a very convenient antenna system across four popular bands, without the need for an ATU. There is some debate about the need for radials at the feed-point. There is little harm in using a counterpoise attached to the ground lug of the transformer. Some suggest the use of a wide-ranging common-mode choke around 0.05 of a wavelength of the lowest band from the feed-point (so 2m from the transformer for 7MHz for the 20m version). None of these measures would harm the installation, although I must say that having used end-fed half-wave antennas quite a lot both in the field and at home, using 100W on SSB, I have never encountered any issues with RF in the shack. These measures are arguably more suitable when using QRO power levels. The avoidance of any highly-visible feeder, such as coaxial cable or ladder-line feeder, running vertically from the antenna, typical in centre- and off-centre-fed designs, is another plus point, again when slightly radio-sceptical neighbours are around!

In terms of this antenna's challenges, when portable you will need to provide two supports for the antenna. The use of two inexpensive fibreglass poles is usually the method of choice. Lightweight wire is recommended to slightly reduce wind and weight loading for both poles. At home, we may have little or no choice about how we orientate this antenna. This is especially important when using the full-wavelength frequency (such as 14MHz for the 20m length version), where our gain is very much broadside. Mounting the antenna in a largely East/West direction would reduce our ability to hear and work DX in those directions, for example. North/South would be our strongest directions. From a safety aspect, it is worth considering that the high voltage areas of this antenna will be at both of the ends and, as these are quite close to the ground, care should be taken to minimise the risks of anyone encountering these parts of the antenna while operating.

Next Time

Having had the opportunity to explore the modelled characteristics of this intriguing antenna, the next stage is to use one. The aim is to try the 20m-long version as a voltage-fed multi-band antenna for 7 to 28MHz, both at home and when portable. Will this antenna prove to be an effective short-hop radiator on 7MHz? How well will it radiate on the higher bands when chasing DX? We will also examine the extent to which changes to its traditional configuration affects its performance. We will also look at other potential configurations for this length of end-fed half-wave antenna and compare the pros and cons.

An introduction to the Node-RED visual programming language

As more of our shack equipment becomes computerised, there is a growing pressure to have some programming skills to take full advantage of the available technology.

Most conventional programming languages have steep learning curves that often deter new programmers. One potential solution is the growing number of visual programming tools, of which Node-RED, described here, is a classic example.

Node-RED origins

Node-RED is a powerful visual development environment developed by Nick O'Leary and Dave Conway-Jones of IBM's Emerging Technology group. This team of mixed-skill programmers and engineers works at the cutting edge of IBM projects. When project work is light, the team is encouraged to experiment with new technology. This forward-thinking investment of time was the catalyst for developing Node-RED. Originally designed as an aid to building prototype applications, the potential of Node-RED became apparent after its launch as an open-source project. At the core of Node-RED is the JSON (JavaScript Object Notation) message format that carries information between code blocks or nodes. This simple messaging system can convey just about any information and is also human-readable, which is a welcome bonus.

With a prototype developed and shared as open-source, many users quickly adopted the idea. Home automation is one of the most popular applications, and Node-RED launched at precisely the right time. One of the many benefits of open-source software development is the considerable development effort it attracts and the large user base to quickly tease out and correct bugs. Now we are some nine years after the original launch, and Node-RED is at version 3, a well-matured product that is still freely available as open-source software from https://nodered.org

FIGURE 1: TP-Link Kasa Wi-Fi mains plug.

Why use Node-RED?

Using a visual, flow-based programming environment, Node-RED lets us interlink standard shack components such as your rig's CAT control, antenna switching, PA switching, SWR meter, power supplies, etc. Tasks like antenna and PA switching can be managed and sequenced via a single button press from a dedicated on-screen panel. Node-RED can also search online information to help you spot activity. Another popular application is to control a remote station. As local QRM increases, there is an increasing trend to locate your station at a quiet site and operate remotely. Node-RED provides valuable tools to build a bespoke application with remarkably little programming knowledge. I will guide you through Node-RED in this series using simple but practical examples. The plan is to pass on enough knowledge for you to build your own custom applications.

Installing Node-RED

Node-RED is a cross-platform application that runs on Linux (including Raspberry Pi), Windows and Apple systems. The Raspberry Pi has become a popular host for Node-RED systems because the Node-RED processing load is light and the Pi (Model 3 or 4) provides a safe environment to experiment.

Installing Node-RED on the Pi is extremely easy, thanks to the provision of a dedicated installation script. This can be found in the Getting Started section of the Node-RED website here: https://nodered.org/docs/getting-started/raspberrypi

The Node-RED site also has installation instructions for Windows, Linux and Apple systems. Once you've completed the installation, I recommend visiting the tutorial section of their website and completing at least the first couple of flows. This is the best way to quickly learn Node-RED basics and get you up to speed for the rest of my tutorial. The key points to understand are how to wire up nodes and use the Inject and Debug nodes.

Smart Plugs and Node-RED

Wi-Fi-connected smart plugs have become readily available at very reasonable prices. For example, I use the TP-Link Kasa devices, **Figure 1**, which cost around £10 if bought singly, but the price drops just over £8 if you buy a pack of 4. These are ideal for controlling the entire station's mains-powered devices, such as power supplies, shack heaters or a kill switch. In addition to providing a simple on/off function, most now include a timer facility and can report the voltage and current

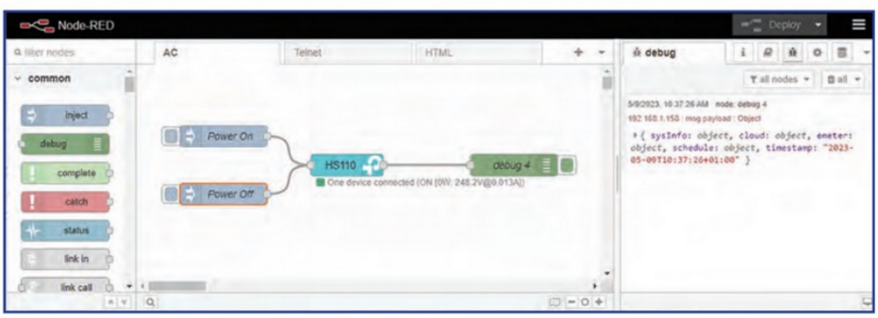


FIGURE 2: Test flow for the Kasa plug.

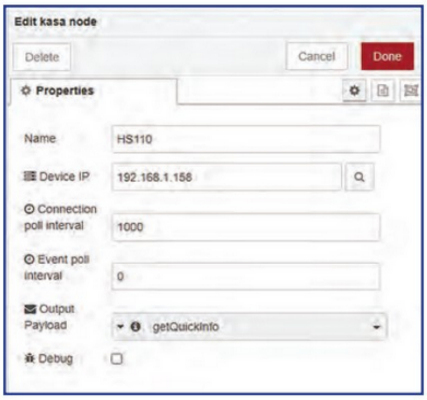


FIGURE 3: Kasa node configuration.

consumption. This is particularly useful in these days of high energy costs. I'll use the TP-Link Kasa HS110 smart plug for the Node-Red examples here. This is readily available from the manufacturer (See web links) and some online retailers. Once you have the plug, follow the manufacturer's instructions for creating a free account and connecting to your local Wi-Fi. With the plug fully functional, the final preparatory step is to find the IP address of your plug. To do this, you must access your Wi-Fi network via the router or a mobile App such as Fing. On my system, the plug showed up as a TP-Link smart plug or it may show as the model number, HS110. When identifying the plug's IP address, you should consider setting the router to allocate a static lease to prevent the IP from being reassigned. With the plug configuration complete, we can start using it in Node-RED.

A dedicated Kasa Node-RED node is available for this range of smart plugs, which makes using the plug very easy. The node is titled 'node-red-contrib-tplink 1.0.1' and can be installed from the Node-RED website. Here's the step-by-step installation guide:

1. From the Node-RED main screen, go to the menu in the top right (three horizontal bars) and select Manage Palette
2. Click on the Install tab and enter kasa in the search bar

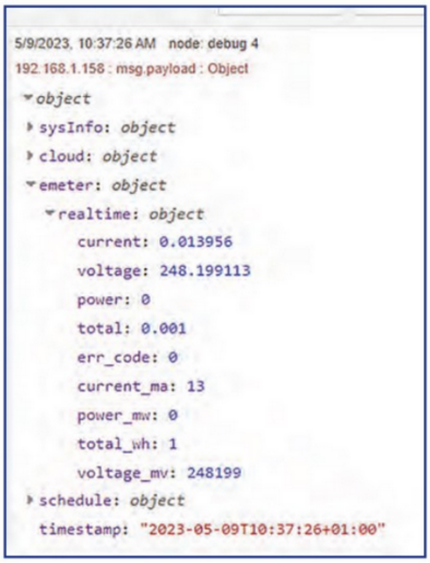


FIGURE 4: Kasa power consumption message.

3. This will return several matching items, but you should click the Install button next to the one titled node-red-contrib-tplink
4. You will see a panel where you can open the documentation or choose Install. Press Install to complete the installation.

When the node installation is complete, look through the list of nodes on the left of the Node-RED screen, and you will see a new section titled Devices with the kasa node listed below.

To familiarise yourself with the Kasa node, I suggest you create a simple test flow, as shown in **Figure 2**. This comprises two inject nodes, the Kasa node and a debug node. The Kasa node needs to be configured as shown in **Figure 3**, by double-clicking on the node. The name can be whatever you want to call the plug (I used HS110), whilst the Device IP is the IP address of the plug on your Wi-Fi network. The connection poll sets how often (in ms) Node-Red checks to see that the connection is still alive; 1000ms (1 second) is plenty here. The Event poll interval sets the retrieving of events from the plug and is not used in this example, so can be set to 0 to disable it. Finally, the Output Payload determines what information is returned from the plug after every event, ie when the plug is turned on or off. I've chosen QuickInfo for this test application as it summarises everything the plug can measure.

Next, we need to configure the two Inject nodes. Double-click the first Inject node and give it the name Power On. Click the drop-down next to payload, select Boolean, and set it to true. Click done to close it, then open the second Inject node. This node should be called Power Off and set the payload to Boolean and false.

With the flow created and configured, the next step is to deploy it. You will need to get in the habit of hitting the Deploy button after every change to any part of the flow. If you don't, the changes are not implemented. I've wasted many an hour confusing myself by forgetting to press Deploy! Once deployed, open the debug panel by pressing the debug symbol to the right of the Node-RED display, and you will see a message generated every time you click a button on the inject nodes. The message payload is a JSON object packed with information. If you click the small arrows in the message, you can open up each section of the message to reveal the data stored within. For example, I've shown the power consumption information in **Figure 4**. In the next article, I'll show you how to build a dashboard for your plug(s).

Controlling relays

For many amateur radio applications, relay control is essential, ie antenna and PA switching. Node-RED provides all we need to control many popular network-connected relay modules. In my example, I'll be using the ESP32LR20 Wi-Fi relay unit from UK manufacturer Robot-Electronics, **Figure 5**. Robot-Electronics produce a wide range of relay boards that are well constructed and reasonably priced. The relay boards are also well documented and the firmware is freely available on Github. They even include details on programming the relay boards using the popular Arduino IDE. The ESP32LR20 range connects to the network via Wi-Fi and features multiple access methods,

FIGURE 5: Robot Electronics ESP32LR20 relay module.

TABLE 1: ESP32LR20 HTTP COMMANDS

HTTP Command	Action
?Rly1=0	Relay 1 off
?Rly1=1	Relay 1 on
?Rly1=2	Toggle state of relay 1

Mike Richards, G4WNC
ptamike@hotmail.com

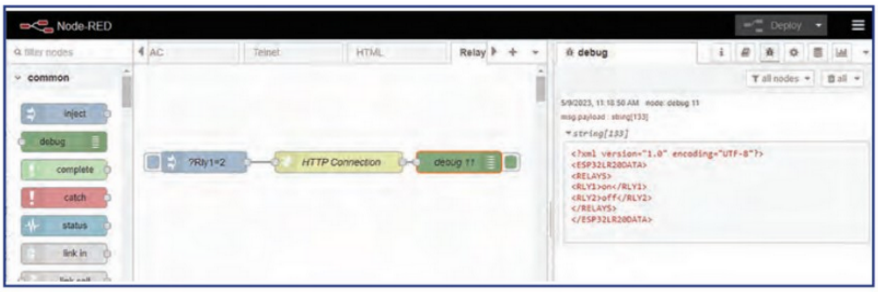


FIGURE 6: Test flow for the relay board.


FIGURE 7: Relay board Inject node configuration.

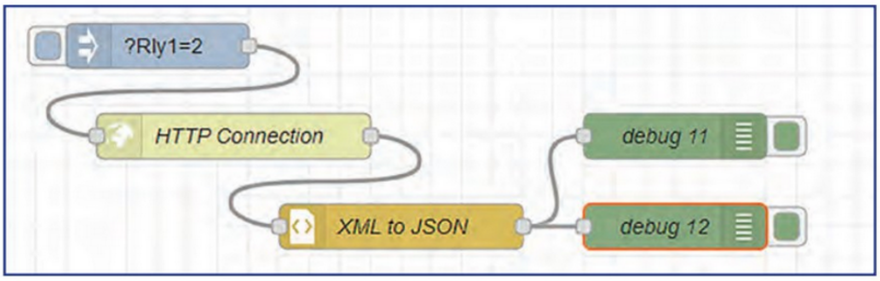


FIGURE 8: Relay flow with XML parser added.

including HTTP, TCP and smartphone apps. For my example, I'll use HTTP access because it's easy to implement in Node-RED and confirms the relay state after every command. This is particularly useful if you're trying to sequence a changeover and must ensure one relay action is complete before making the next. The HTTP commands for the ESP32LR20 are straightforward, as shown in **Table1**. This shows the commands for one relay but is replicated for each relay in the set using Rly2, Rly3, etc.

To send this command, we have to add it to the IP address of the relay. For example, in my setup, the ESP32LR20 has an IP address of 192.168.1.112. To switch relay 1 on, I send:

192.168.1.112/?Rly1=1

Let me show you how easy it is to control this relay module in NodeRED. The blocks we will be using are contained in the default Node-RED installation, so we don't need to add any new ones. The first node to configure is the HTTP Request Node. You'll find this in the Network section of the nodes panel. Here are the steps:

1. Drag the HTTP Request node onto the flow and double-click to open the configuration panel.
2. Set the Method to GET and enter your relay's IP address in the URL box but add /{{{payload}}} immediately after the URL with no space. This will add whatever we put in the payload to the end of the IP address.
3. Set the Payload box to ignore. This may sound a bit counterintuitive, but we've already forced the payload to be added to the URL, so we don't need it added again.
4. In the Return box, use the drop-down to select a UTF-8 string. This defines how the response from the relay board is handled.

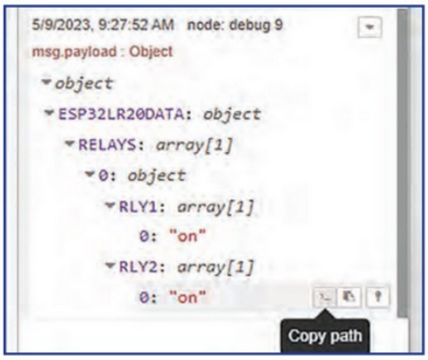


FIGURE 9: The JSON message from the relay flow.

5. At the bottom of the panel, choose a suitable name. I used HTTP Connection.

To test the connection, add Inject and Debug nodes **(Figure 6)**. Double-click the Inject node to open the configuration **(Figure 7)**. In the box next to msg.payload use the drop-down to select string and enter ?Rly1=2. Click the small cross of the msg.topic line to delete it. Click Done. Next, wire the Inject node to the left-hand side of the HTTP connection node. Double-click the Debug node to open the configuration panel. Set the output to msg.payload, click Done followed by Deploy to activate the flow. If all is well, every time you click the inject node button, relay 1 will toggle. If you look at the Debug message and click the small arrow, you will see the XML message from the relay board. Although the message is buried in formatting, you can read the state of the relays. This is vital information that reports the state of the relays after executing the previous command. However, we need to process the XML message to make it easier to work with. This is a simple task that uses the XML parser node. This will be found in the Parser section of the Nodes panel. Drag the node to the flow and insert it between the HTTP node and Debug node **(Figure 8)**. Open the configuration and ensure the Property field is set to msg.payload. Click Done followed by Deploy. You will now find that the message in the debug window is a JSON object, so you can click the small arrows to step down through the information **(Figure 9)**. If you hover your cursor over the on/off entry in the Debug window you will see a small side menu that will let you copy the path to that item. This is a great time saver as you can quickly access parts of any JSON message. To test this, navigate to a part of the message you want to access, ie the "on" message for relay 1. Use the popup side menu to select copy path. Now drag a new debug node onto the flow, wire it to the right-hand side of the XML parser and open its configuration. Delete any text in the Output box and paste in from the clipboard (Ctl V). Click Done followed by Deploy and try toggling the switch again. This time you will see that the output from your new debug node will show "on" or "off". This nicely illustrates the power of using JSON as the messaging system in Node-RED.

Summary

In this first article, I've shown you how to control a mains plug and a relay board, plus introduced you to the power of JSON messaging. Next time, we'll build a Dashboard GUI (Graphic User Interface) and show you how we can process information from Node-RED.

You can watch a recording of Mike's RSGB Tonight@8 presentation on Node-RED via the RSGB's YouTube channel: youtube.com/theRSGB

Web Links

[1] TP-Link UK Store: https://ukstore.tp-link.com/collections/smart-plug
[2] Node-Red Tutorial: https://nodered.org/docs/tutorials/first-flow
[3] Node-RED website: https://nodered.org/

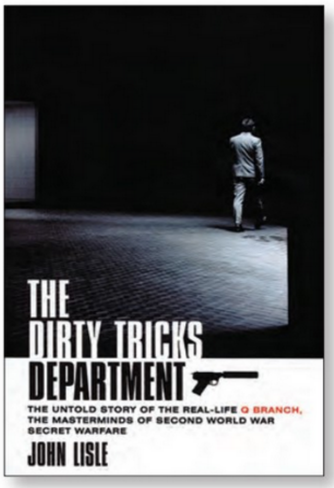
Book Review

RadCom Team radcom@rsgb.org.uk

The Dirty Tricks Department

The Untold Story of the Real-life Q Branch, the Masterminds of Second World War Secret Warfare

By John Lisle



Many of us have heard the phrase 'the truth is stranger than fiction', or something similar. John Lisle's fascinating book takes the reader through the adventures of Stanley Lovell, an industrial chemist who was invited by the head of the Office of Strategic Services (OSS) in the USA to lead a team that developed "dirty tricks" for use in times of conflict and war. The OSS was the intelligence agency of the United States during World War II and was a forerunner of the Central Intelligence Agency (CIA) – something that I didn't know before reading this book.

Among many others, the book includes chapters on psychological warfare, camouflage and truth drugs. I found the chapter titled 'Undercover Missions' enthralling. In it, the reader learns about how agents were selected, the backstories that were developed to give them credibility, the disguises they used and the missions that they were sent on. As a fan of spy thriller books and films, I couldn't help but read on.

Since we are usually only exposed to mere fictional tales of espionage, being able to read about the endeavours of real agents, and their training and exploits, made me sit up and take notice.

I very much enjoy reading books about World War II and am particularly interested in the technology used at the time. *The Dirty Tricks Department* helped me to fill in some holes in my knowledge. At several points during my reading, I paused and thought about devices that I had seen in films or imagined while reading novels. So, it was thrilling to learn that many of these devices were based on, or at least were inspired by, actual pieces of kit that were used long before I was born.

The hardback edition of the book, read for this review, is beautifully presented. The cover is unusual and draws the eye, encouraging the reader to open the book and start reading. The interior is set out with a clear structure and accessible font. These features make the book a visually-appealing prospect that would be a welcome present to all of those who are interested in the tactics used by organisations to influence the course of global affairs via espionage and non-conventional means.

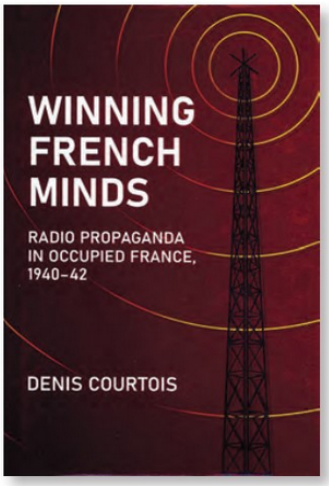
RadCom readers are likely to enjoy the discussions about the gadgets that were deployed. The book is also highly likely to appeal to those who are interested in World War II history. Whilst turning its pages I remembered stories about the Special Operations Executive (SOE), a secret British organisation that was created during World War II to undertake espionage, sabotage and reconnaissance in occupied Europe. *The Dirty Tricks Department* was an enjoyable read, from a different perspective.

Size 166x240mm, 352 pages, Hardback, ISBN: 9781 8039 9264 8, Non Members: £22.99, RSGB Members: £17.99 *- £5.00 OFF the usual rrp*

Winning French Minds

Radio Propaganda in Occupied France, 1940–42

By Denis Courtois



Most readers of this review will already be aware that is it almost impossible to underestimate the influence that radio technology had on World War II. So much has been written about the efforts of the teams at Bletchley Park in compromising signals intelligence. This alone is an endless source of interest for some, while others enjoy reading about the wartime equipment that was used. There is no shortage of material to read on these subjects. *Winning French Minds* deals with a subject that is, perhaps, not discussed as much – the importance and influence that radio propaganda had on the course of the war.

To my embarrassment, I must admit that I knew little about this subject before reading this book. Of course, I had read about Joseph Goebbels and the effectiveness of German propaganda during World War II. Apart from that, I had heard recordings of Lord Haw-Haw on YouTube and that was about it!

Winning French Minds gave me an insight into the need for Allied propaganda – something that I hadn't previously considered. I enjoyed reading about the strategic importance of winning the hearts and minds of the those in France through targeted radio propaganda. Afterall, if everyone had chosen to sympathise with the invaders, then Europe may well have ended up looking very different upon the conclusion on the War.

The book sets out the evolution of radio propaganda throughout 1940 to 1942 and the impact this had on society. It was fascinating to read about the development of the different radio stations that were broadcasting during the War.

As a radio amateur I thoroughly enjoyed being transported back to the time and being reminded that radio had a different role to play, aside from sending, receiving and decrypting logistical and operational traffic.

The book is well presented and includes sections of black-and-white propaganda schedules and colour photographs of print media that were used at the time to influence civilian life. These compliment the radio-related content and provide a useful contrast that helps the reader to understand how important radio was in the 1940s. With there being no internet or social media to influence the population, radio really was of vital importance in shaping the attitudes of the population.

In my opinion, many readers of *RadCom* will enjoy this book, particularly those who are interested in World War II history and the important place that radio played in shaping its events and eventual outcome.

Size: 159x254mm, 256 pages, Hardback, ISBN: 9781 6362 4146 3, Non Members: £39.99, RSGB Members: £23.99 *- 40% OFF the usual rrp*

Kanga
QRP Pocket Transmatch

PHOTO 1: The finished ATU.

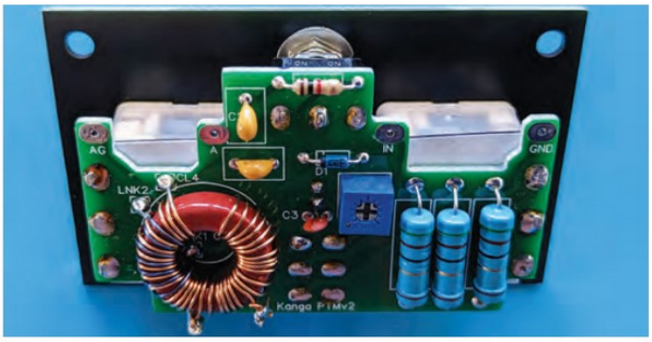


PHOTO 2: The completed PCB mounted on the front panel.

Having resisted for a long time, I recently decided to purchase an Icom IC-705 transceiver. Amongst many portable radios, my Xiegu X5105 and G90 were the most used. They are excellent radios, great value for money and benefit from excellent internal ATUs. One of the reasons I had shied away from the 705 was the lack of an internal ATU.

Most of the time, I tend to use end-fed half-wave antennas for portable work. Using one cut for 40m, also gives me resonance on the 20, 15 and 10m bands. The internal ATUs of the Xiegu rigs allowed me a degree of flexibility and would tune the antenna on every band from 80m up.

So it was with a little hesitation that I eventually decided to sell both Xiegu rigs to fund the purchase of a used IC-705. When the radio arrived, I got used to it in the shack in the first instance and so had my pick of resonant antennas. Being conscious of forthcoming portable ventures, and being unwilling to let go of the ultimate flexibility an ATU allows, I scouted around for possibilities. Whilst there are a number of automatic ATUs available for the radio, my attention was drawn to a small kit from Kanga Products, called the Kanga Pocket Transmatch **[1]**. Kanga provides a range of ATUs. The pocket version is designed for field use, with controls on the top surface.

Construction

Contact with Paul at Kanga led to him very kindly providing me with the kit version for review, although ready-built and tested versions were also available. When the kit arrived, and I had unpacked it, it was very clear that it was indeed pocket-sized, and I was pleasantly surprised with its diminutive size, measuring just 85 x 55 x 27mm. Everything was well packaged, and the box even included A4 printed instructions. Kanga's marketing material makes it clear that this is the most challenging kit they provide because of its size and the density of components to be fitted in the box. However, having a reasonable amount of construction experience under my belt, I managed to complete the job in around 90 minutes from start to finish.

The kit is of the usual transmatch construction and uses a single toroid core with two windings and two poly-varicon capacitors, amongst some ancillary components. It also includes a useful LED-based SWR indicator which uses more components than the ATU itself. BNC or PL259 connectors are provided as the input and output (your choice at time of ordering), and a switch that allows you to match balanced or unbalanced loads. Although it would be very easy to build the same ATU from scratch yourself, the real benefit of the kit is that all the components fit onto a well-designed PCB and this allows a much more compact construction than, say, veroboard or point-to-point wiring.

There are two parts of the build that might be considered tricky for some, especially beginners. One is the winding of the toroid, which uses one primary winding, tapped at 13, 6 and 13 turns, and a secondary winding of 7 turns that is nestled between some of the primary turns. The second tricky part is the density of the build to fit it into the box. That said, if you take your time and follow the instructions to the letter, you should be able to build this kit.

I have to say that the written instructions are of a very-high quality. Because the instructions for the toroid windings are in black and white, the builder is directed to the website for a high-resolution, colour version to make the winding positions clear.

Upon completion of the build, I left the shack for the conservatory where, outside on the patio, I keep a permanent end-fed random wire for summer garden working. I connected the transmatch to the radio using a short length of RG174 co-axial cable, and used a two-prong BNC terminal to connect the random wire and a 5m long counterpoise.

Matching

The operating instructions recommend a process for tuning. First, once band and mode are selected, the capacitors are adjusted for maximum received noise, and this is pretty obvious in practice. Next, the 'Tune / Operate' switch is set to 'Tune' and a carrier provided. I used FM for this. By alternately adjusting the two capacitors, the operator can adjust for minimum VSWR by seeking to dim, or preferably extinguish, the now brightly-lit LED. Once that is achieved, the manual advises that you should have a safe VSWR with which to operate. If your radio, like the 705, has a VSWR meter, you can switch to 'Operate' and fine-tune the capacitors for minimum VSWR.

Initially, I found that the process of dimming the LED did not provide as good a match as I would have liked, so a trip back to the shack was made to adjust the trimmer resistor on the board to allow for maximum sensitivity on the LED. By doing this, I found that satisfactory VSWR could be achieved using just the LED alone, although I always found I could improve on it

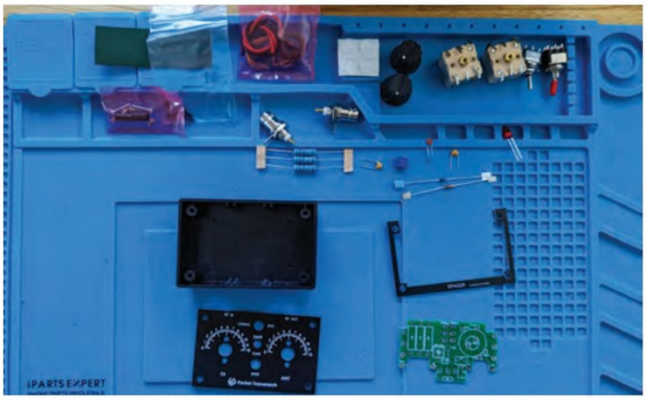


PHOTO 3: The kit parts.

through the use of the rig's own meter as a final tuning stage.

If you have not used a manual ATU before, this might sound convoluted, but I assure you that with a little practice it is actually quick, easy and effective. I found my random wire (truly random as I have no idea how long it is!) was matched by the ATU from 60m upwards. It was too short to expect a match on 80m.

Operating

Once I had the device built and tested, a week or two elapsed before I headed off for a week's holiday with friends to La Gomera in the Canary Islands. Keen to put the ATU through its paces, I decided to build an open-wire-fed doublet to take with me. I also built and took along a QRP 4:1 balun and some 3D-printed plastic spacers for the feeder. I settled on two 6.7m legs and 6.4m of wire on each side as feeder, separated by about 10cm. This design, with 6.7m legs, is supposed to give the best compromise radiation pattern for all bands between 40 and 10m, maintaining a mainly broadside pattern. More information can be found at **[2]**. The whole affair was to be supported by my 7m Sotabeams pole **[3]**.

On arrival at my location, I chose a spot to erect the doublet. I had not had time to experiment with it before the holiday, so I was not surprised when I found it a little tricky to erect, and my plastic open-wire spacers just fell off in the wind! It was not a disaster though as I had brought two other antennas. So, up went my trusty end-fed half-wave antenna which is cut for 40m but also marked at half-wavelengths for all the other higher HF bands. With a little adjustment for resonance, the antenna was working well on the 40, 20, 15 and 10m bands with negligible VSWR.

Results

As expected, because of the high impedance, VSWR on other bands was unusable so I set about seeing what the Pocket Transmatch could do. I very quickly had better than 1.5:1 VSWR on the 80, 60, 30, 17 and 12m bands with the ATU working beautifully. As before, I found the internal VSWR LED indicator useful and I would be confident in getting a safe and usable VSWR with this feature alone, but the IC705's internal VSWR meter made a big difference in minimising this where the LED could not.

I was soon operating from my location on all bands from 80m and up but compromised by my location, which was at the base of an amphitheatre with mountains on three sides. My only take-off was across the Atlantic to the North and North East. However, a good number of CW and WSJTx QSOs were made into Europe.

As the week progressed, I became more and more impressed with the little device and I was able to dance about the bands easily. I decided that I would remove the ATU on the resonant bands and so the only improvement that would suit my particular use case would be a switch to bypass the ATU on the resonant bands, although I could just as easily adjust the ATU on those bands too.

PHOTO 4: In use on La Gomera, EA8.

PHOTO 5: In use matching an end-fed half-wave antenna.

On my return from holiday, I did test the ATU with the doublet in a sheltered spot and it matched the antenna very well from 60m upwards. I just need to design better spreaders for windy days to keep wire feeder sections apart.

Conclusion

Overall, this is a great little kit. It was good fun to put together and brought the personal satisfaction that always comes with building your own device and using it on the air, as well as being quick and simple to operate. Whilst auto-ATUs offer convenience and speed, I would be perfectly content to use this manual tuner instead. I highly recommend it.

The cost is £45 for the kit, or a very-reasonable £55 for the assembled version.

My thanks go to Paul at Kanga for the loan of the review model.

References

[1] https://www.kanga-products.co.uk/ourshop/prod_7635987-QRP-Pocket-Transmatch.html

[2] http://www.n5dux.com/ham/files/pdf/W4RNL%20-%20Top%20Five%20Backyard%20Multi-Band%20Wire%20HF%20Antennas.pdf

[3] https://www.sotabeams.co.uk/tactical-7000hds-compact-heavy-duty-7-m-23-ft-mast/

Daimon Tilley, G4USI
daimontilley@hotmail.com

Design Notes

Lead-acid battery charging temperature compensation

Andy Palmer, G4VDF sent in this write-up of a battery charging system he designed which is reproduced here in full.

I recently rebuilt the power supply for the remote-control system of the 2m repeater GB3SN (145.725MHz) and the 23cm beacon GB3FRS (1296.850MHz). The supply provides a battery-backed nominal 12V supply for the GSM remote controller at the Four Marks site. The original charger unit had failed beyond repair and the battery had been ruined, so a complete rebuild with a new battery was necessary.

The equipment at Four Marks is housed in a small shed so it is subject to extreme temperature variations. Consequently, it seemed like a good idea to provide temperature compensation of the charging voltage to ensure that the new battery had a long and happy life. Most lead-acid cells require a float-charge temperature compensation characteristic of -3mV/°C per cell, so a typical 12V battery with 6 cells in series requires -18mV/°C. For the sealed lead acid type that I was using, the manufacturer specified a float charge voltage of 13.65V at 20°C. So, for example, at 0°C the voltage should increase by 0.36V to 14.01V, but at +45°C (quite likely in a closed UK shed in summer!), the voltage should fall by 0.45V to 13.2V.

These notes are not intended to describe the whole charger in detail, so they are confined to the basic method of temperature compensation. I don't claim any originality, but I haven't seen this simple arrangement described elsewhere, so it seemed worth bringing it to the attention of others. The bare bones of a charging regulator are shown in **Figure 1**. The components within the dashed lines are an example of a very simple regulator based upon the very popular TL431 which can be thought of as a programmable Zener diode. The TL431 controls transistor Q1 which is biased by RR and does the heavy lifting by passing the charging current (in the real charger Q1 was actually a MOSFET). It's perhaps worth mentioning that the regulator could be of any type, including switch mode, as long as it has a low voltage Vref feedback input in the region of 1 to 3V. The 'Vref' input of the TL431 is nominally 2.5V (the device specification states typically 2.495V but it could range from 2.44V to 2.55V). The feedback resistors RU and RL produce a scaled-down version of the regulator output voltage to the Vref input of the TL431. The device adjusts its 'cathode' (pointy end) voltage so that 2.5V is always maintained on its Vref input.

The temperature compensation is provided by an LM335. This device produces an output voltage that is directly proportional to temperature in degrees Kelvin. So theoretically at 0K/-273°C (actually -273.15°C but we'll disregard the odd 0.15° in these notes), the LM335 output voltage would be 0V. It has a linear +10mV/K temperature characteristic. Therefore, at a more realistic 0°C (+273K), the output voltage would be 2.73V, at 20C it would be 2.93V, and so on. Of course, manufacturing tolerances apply to the device so for critical applications the LM335 can be trimmed to an accurate voltage/ temperature by means of a 10k pot'. I didn't bother with trimming for the battery charger. The LM335 can operate with a supply current of between 0.4mA and 5mA, but the current should be kept as low as possible to avoid the effects of self-heating. For example, with the TO92 package, the junction to ambient thermal resistance in still air is roughly 200°C/W, so it would only need 1mA at room temperature (say 20°C so 2.93V) to produce nearly 3mW and an error of almost +0.6°C. The value of resistor RT will depend on the unregulated input supply voltage but could be around 15k for this example.

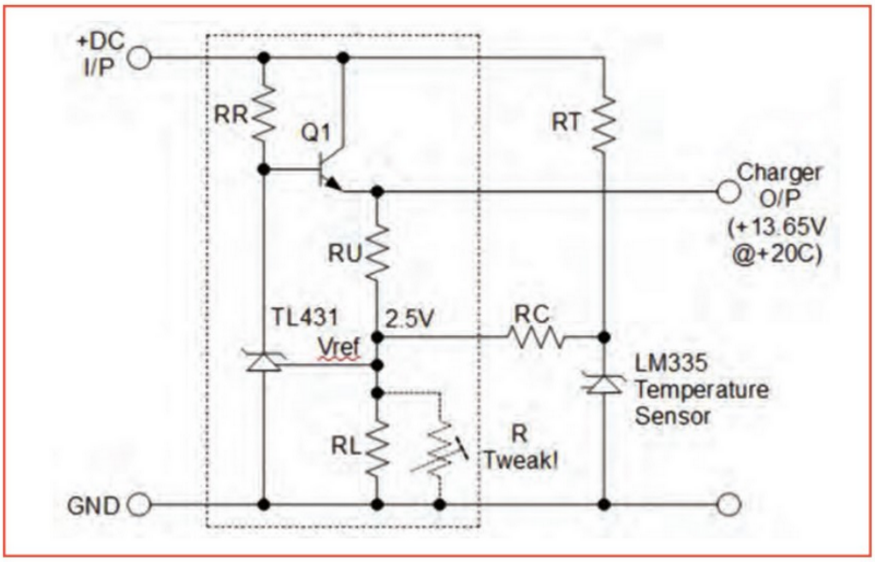


FIGURE 1: **Lead-acid battery charging temperature compensation.**

In the absence of the temperature compensation coupling resistor RC, it's a fairly simple matter to work out the values of the TL431 upper and lower feedback resistors, RU and RL respectively. They simply divide the output voltage to produce 2.5V at the Vref input of the TL431. However, the presence of RC makes things much more tricky so the resistor calculations need to be carried out in easy stages – but where to start? Well, first of all we need to consider the 'bias current' flowing into the Vref input of the TL431. It is tiny at typically 2uA (max. 4uA) but it could be significant if the values of RU and RL are made too high so the current through RU and RL is very small. A reasonable rule of thumb here seems to be to make the current through RU and RL at least, say, 100 times greater than the worst case Vref current, so that means it needs to be >0.4mA (400uA).

RU calculation:

Let's start with RU because it's the easiest. For example, it will always have 13.65 – 2.5 = 11.15V across it at 20°C. A value of 18k for RU will provide 619.444uA. This current, less maybe 2uA or so flowing into Vref of the TL431, will also flow through RL so that suggests a value for RL of around 4.05k, but this will be modified by the current from RC so we can't specify RL accurately just yet.

RL calculation:

In order to work out RL properly we need to cheat a bit and make RC temporarily 'disappear' somehow. If RC has the same voltage at both its ends, then it's as though it doesn't exist. This condition will occur when the voltage from the LM335 is exactly the

Andy Talbot, G4JNT
andy.g4jnt@gmail.com

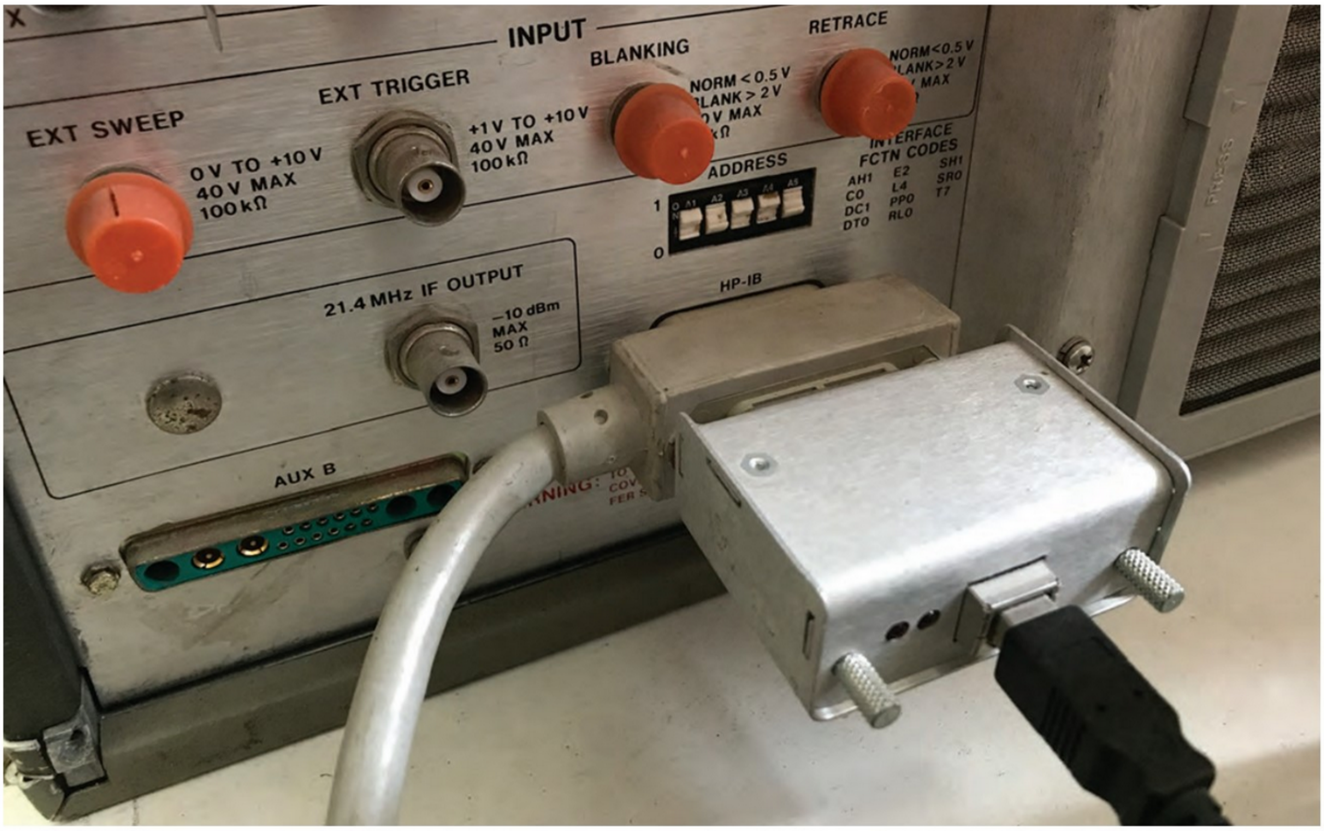


PHOTO 1: **HPIB connector with Prologix interface unit. The switches for setting the equipment address are visible just above the connector.**

same as the Vref input of the TL431. Ignoring the effects of component tolerances etc, theoretically the LM335 will be at 2.5V at a temperature of 250°K, or -23°C. And at -23°C the battery charger output voltage at the top end of RU needs to have increased to 13.65 + (-43 x -0.018) = 14.424V. So, RU now has 14.424 – 2.5 = 11.924V across it and so the current through it will be 662.444uA. Exactly the same current (less a couple of uA due to the TL431 Vref bias current which we shall ignore) will flow in RL which has 2.5V across it, so now we can calculate its value. RL works out to 3.773901375k! Hardly a nice round number but that doesn't matter because RL will be the regulator's trimming point so it will be finely adjusted later to account for tolerances in the regulator and the LM335 etc. A fixed resistor about 20% higher, say 4k7, in parallel with a trimmer of 47k, seems like a good place to start. However, for the Four Marks charger, I opted to use a parallel combination of fixed resistors for RL instead of a trimmer to improve reliability in the harsh environment.

RC calculation:

The job of RC is to introduce a small amount of additional current into RL so that the charger output voltage is brought down to the correct voltage at higher temperatures, eg 13.65V at 20°C instead of 14.424V at -23°C in the absence of RC. Again, ignoring component tolerances, the output of the LM335 at 20°C will be 2.93V so RC will have 2.93 – 2.5 = 0.43V across it. If the charger output is to be 13.65V at 20°C, then RU will have 13.65 – 2.5 = 11.15V across it and so will be supplying 619.444uA towards RL and Vref. So, RL will be getting 619.444uA from RU but the current through it needs to be higher at 662.444uA if the voltage across it is to be maintained at 2.5V. Therefore, the additional 43uA needs to come via RC. So now RC can be calculated from 0.43V divided by 43uA and this rather conveniently works out to a nice round figure of 10k!

Thinking about the relationship between RU and RC later it suddenly dawned on me that RU must always be 1.8 times greater than RC because the voltage across it always varies at the rate of 18mV/°C whereas the voltage across RC always varies by 10mV/°C. It's worth mentioning that the other convenient pair of E12 resistor values for RU and RC that provide an exact 1.8 ratio is 27k (RU) and 15k (RC).

Not all types of lead-acid batteries require the same charging regime so the manufacturers' data should always be consulted. Also, if the battery is housed in an environment that has a stable temperature, then temperature compensation may not be needed anyway. The replacement Four Marks charger includes a current limiter circuit so that it won't do itself a mischief when trying to charge a flat battery. There is also a battery-monitoring circuit that will disconnect the battery completely if the mains has failed and the battery starts to discharge below about 11V where it is likely to suffer damage. The battery and charger was originally housed in a sealed plastic box, but the replacement battery specification called for ventilation to release gasses. So, I have drilled some small holes in the box. Hopefully they are too small to allow in spiders and other creepy-crawlies!

Test equipment interfacing – old style

Users of modern test equipment, with its straightforward computer interfacing through a plug-and-play USB connection, usually have few problems getting plots of results or controlling the test set-up, usually through a manufacturer-supplied bit of dedicated software, or some simple interface downloaded from the web. But it wasn't always like this. Before test equipment was routinely computer-controlled, some sort of interface was required if you wanted to get hard copies of your results

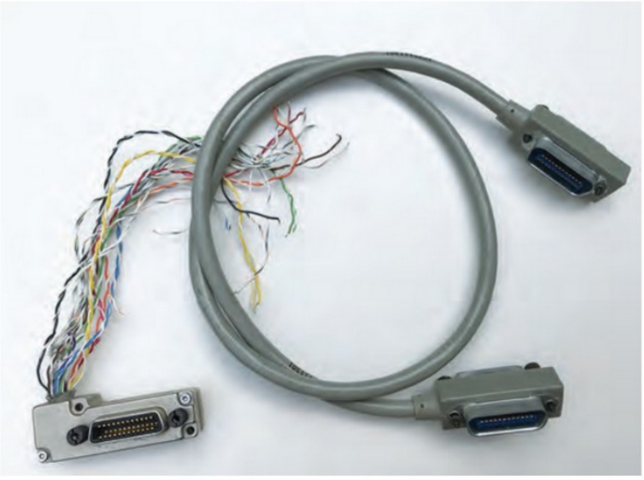


PHOTO 2: **HPIB cable cut open to show the multiple twisted pairs carrying 8 bus signals plus control.**

on a plotter or printer, or to be able to control your boxes remotely. Professional labs would often have whole racks of test equipment that all had to be operated together; for example, a synthesized signal source that might have to step through a band of frequencies, with the results tracked with a network analyser stepped across several parallel RF channels using a rack of microwave relays to select, and a power meter measuring the output of each channel, all the while monitoring temperature at different parts of the hardware. That may sound complex, but it was a real scenario 'JNT was looking after in the later 1980s.

From the 1960s, and possibly even earlier, Hewlett Packard was undisputedly the leader in test equipment manufacture and saw this problem looming. As early as 1965, HP defined a standard interface that could enable their test equipment to communicate with printers and plotters – even before the idea of a lab computer might have been feasible. When desktop computers used with test equipment did arrive – with the HP9826 and HP9845 families in the 1970s – the common interface became even more useful with whole banks of equipment able to be controlled from a single desk. HP's solution to all these multiple interconnections was the Hewlett Packard Interface Bus, or HPIB which is still in use to this day – sometimes.

The HPIB interface was clunky and slow by modern standards. It consisted of an eight-bit parallel bus using wired-OR, (resistive pull-up) so many items of equipment could sit on the same bus wires. Several control signals were included within the bus to allow reading and writing at all the different rates that might be needed. Each item of test equipment had to have its own address from 1 to 31 (0 was reserved) that had to be set to a different number for each – using DIP switches or links. A common 24-way connector was defined and leads had a special connector at each end, with both a plug and a socket. So, cascading multiple leads by just stacking connectors was a doddle. **Photo 1** shows one of these connectors plugged into the back of my spectrum analyser. The small box with the USB connector plugged into the rear of that, we'll come to shortly. The switches for setting the address can be seen just above the connector. Here it is address 18. Note the thick, chunky lead carrying the eight-bit data bus plus control signals, each on a twisted pair. Racks of test equipment used to be festooned at the back with dozens of such looped HPIB cables going from shelf to shelf. **Photo 2** shows a typical HPIB cable, and one cut open to reveal the multiple twisted pairs. The individual signals were not driven differentially, with one side of each pair connected to ground – so it is difficult to see the value of using twisted pairs on unbalanced circuitry. But HP were never known to do things the easy way!

To allow a test set such as a spectrum analyser to drive a plotter without having to use any central controller, it was necessary to set one as a master, and the other a slave. It was also necessary to define the equipment as a 'talker' and a 'listener'. In this case, the spectrum analyser would be the master and talker with the plotter the slave listener. In set-ups where a desktop computer was used, all test equipment would be the slaves and the computer the master. And in practice it was all very much more complicated still.

No standards

Although HP defined the interface bus, they made no attempt to define the format of the data to be sent over it. So, an early HP synthesizer set to address 05 that needs to be set to 35.456MHz might need the code *705,F00654530* sent to it (I'm going from memory of 40 years ago now, so that may not be completely accurate). The 705 meant address 05, and the frequency was sent in Hz, backwards. Conversely, a spectrum analyser whose centre frequency was to be set to 1547MHz might need the command *723,CF1.547GH*. Slightly more understandable, but still something that had to be formatted precisely. A more modern signal source might just need something like *05,FRQ145.525MHZ*. So, an awful lot of time and effort was needed by test engineers writing code in HP Basic for those controllers, formatting commands and their responses so the results made sense. Receiving data from an instrument was even more complicated.

As time moved on, HPIB was accepted by international standards committees and the term GPIB (General Purpose Interface Bus) was adopted as standard IEE488, with only minor changes to the original HP version. But the actual data exchange formats were never standardised. Many items of old test equipment are now in the hands of amateurs and that bulky connector on the back is an unused curiosity which can be used.

What was standardised right from the start was a protocol for plotting, initiated from the test equipment in use by pressing a button, or sometimes several buttons together. That would send a screen plot directly to an HP plotter such as the HP7470. Those were wonderful things to play with, having different felt-tip pens for each colour which it would go away and select each one in turn then draw the parts of the plot. Far more fun that just asking a computer to do it for you.

Using HPIB / GPIB at home

Figures 4 and 5 in *Design Notes* last month were from my HP8569B Spectrum Analyser, downloaded using the HPIB bus to a PC running software that emulates the HP7470 plotter. Using the HPIB interface is possible by the small box shown in Photo 1. Made by Prologix **[1]** it contains a microcontroller and HPIB interface driver and appears to the PC as a simple serial COM port. It is connected to all three of my GPIB-compatible test equipments, although only the spectrum analyser regularly gets used remotely. Appearing as a COM port means that were it necessary, writing software to drive the test equipment wouldn't be too difficult as all programming languages have full support for serial ports.

The plots can be done using software written by John Miles, KE5FX that emulates the HP7470 plotter **[2]**. Whilst not as much fun (or as frustrating) as the original plotter was to use, the software is set up in the same way getting it ready to accept an equipment-initiated download over the HPIB interface. Once the software is ready to listen, three buttons on the spectrum analyser are pressed simultaneously (one each for the trace, the axis and the on-screen labels) and the plot appears on the PC screen, to be saved as a graphics file. No pens running out of ink, getting jammed or those other joys of old.

References

[1] Prologix GPIB / USB interface https://prologix.biz/
[2] GPIB Toolkit http://www.ke5fx.com/gpib/readme.htm

Feature

A beginner's guide to low-band DXing

Most amateurs who have ventured onto the HF bands will by now have experienced working long distances with modest equipment, particularly on frequencies of 14MHz and above, and it has often been said that, for these bands at sunspot maxima, the proverbial piece of wet string will haul in the DX.

The low bands (160m, 80m and 40m, but also now including 60m and to some degree 30m) pose more of a challenge to those of us without acres of land in low-noise environments. To date, I have worked around 200 DXCC (mostly 80m and 40m SSB/CW) from a mixture of a postage-stamp-sized garden and one slightly larger. This article is intended as an introduction to working DX on these bands from a less-than-optimal location, and I will focus primarily on the 80m and 40m bands, although the other bands will be briefly discussed. Those new to low-band DXing in compromised locations will usually find that 40m will yield the best results in terms of DX worked.

The low bands – a different kettle of fish

The low bands are more of a challenge when it comes to working DX. They are, in general, bands that are more noticeably affected by both atmospheric and man-made noise, and the antennas are physically larger than those used for the higher HF bands. The bands from 160m to 40m will normally only provide worldwide contacts during the hours of darkness, although there are exceptions **[1]**. During the day, signals bound for the ionosphere usually encounter heavy absorption in the D layer which limits achievable distances, although high-angle signals often allow inter-G QSOs to take place during the hours of daylight, especially on 40m, with low horizontal antennas. This is so-called NVIS-type propagation **[2]**. At night, the D layer dissipates, and signals can proceed to the higher F layer and be reflected to Earth allowing DX to be worked. The 30m band has the characteristics of both 40m and 20m and will often provide DX for many hours during daylight.

There are subtle differences in how the low bands are affected by the sunspot cycle and season of the year. In general, 160m, 80m and to a lesser extent 40m, have been considered bands of sunspot minima as there will be lower ionospheric D layer absorption at these frequencies during times of fewer sunspots. However, this does not mean that these bands are unusable during sunspot maxima, and most major DXpeditions will usually include 80m to 40m and perhaps 160m at such times. Auroral disturbances, that occur more frequently as sunspot cycle maxima are approached, can cause complete blackouts on the lower HF bands. During blackouts such as these, it is occasionally still possible to work the odd station on 40m CW depending upon the severity of the geomagnetic storm. However, signals will be weak and distorted with a 'rasp' like sound to them (anyone who has ever worked DX on VHF during an aurora will be familiar with this!).

The season of the year heavily influences propagation on the 160m to 40m bands. During the summer months, the Sun rises higher in the sky with longer days, and this increases ionospheric D-layer absorption, and hence reduces the chances of working DX on these

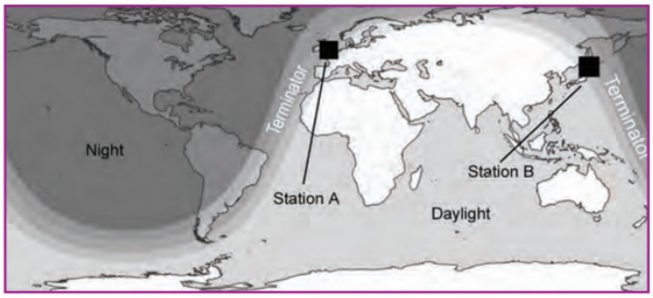


FIGURE 1: An example of grey-line propagation (from G0KYA).

bands, especially trans-equatorial propagation. The summer season also coincides with increased atmospheric storms which can be heard as distinctive 'lightning crashes' most noticeable on the 160 and 80m bands. During such times, the two lower bands can seem devoid of any activity. During the winter, the Sun is lower in the sky with shorter days, and this results in lower D-layer ionisation. The ionisation built up in the D layer during winter days disperses more quickly at sunset than during the summer. As a result of these factors, winter favours night propagation in the respective hemisphere; for example, QSOs between the UK and North America will regularly be heard during the winter months, particularly on 80m and 40m.

FIGURE 2: A QSL card for a grey-line contact by G0FVI to Hawaii.

Grey-line and other propagation modes

There are several mechanisms that can enhance propagation on the low bands, the most notable being the so-called grey-line propagation. Grey-line propagation makes longer-distance QSOs possible, and is seen at dawn and dusk when a station at one end of a path is approaching sunrise, whilst another is near sunset; for example UK (sunset) to Japan (sunrise). Whilst there is some debate as to the actual mechanism of grey-line propagation, the generally-accepted theory is that around sunset the level of ionisation in the D layer reduces as it is no longer receiving radiation from the Sun, and at the same time the F layer, which is higher up, is still receiving radiation from the Sun and is ionised to the extent that reflections can still occur. The reverse is the case at sunrise (a thorough explanation of grey-line propagation can be found in references **[3]**, **[4]** and **[5]**). For grey-line propagation to take place, there should be a path of darkness between the two stations (see **Figure 1**).

Note that the grey-line propagation is not uniform and is wider towards the poles and narrower towards the equator. The non-uniformity of the grey line itself influences the time window for stations to work DX, with the equatorial regions having perhaps only

PHOTO 1: Antenna configuration for the low bands at G0FVI.

a few minutes. Grey-line propagation does not generally follow the day/night terminator (ie lying inside the grey line), with many paths being perpendicular to the terminator, although there are exceptions such as paths from the EU to Japan. Grey-line openings are band-dependent, with 40m providing the longest time windows, particularly in winter, and often allowing long-haul DX to be worked several hours before sunset or after sunrise. Real-time grey-line displays are available online via **[6]**. The workable grey-line paths change with the time of year, and will determine which parts of the world can be worked from the UK. At the time of the equinox (21 March and 21 September), it is possible to work the maximum DX distance to New Zealand from the UK on the low bands, as the ionospheric conditions will be similar in both hemispheres. **Figure 2** shows a QSL card received by G0FVI for a grey-line contact with Hawaii, about 30 minutes after UK sunset and before Hawaiian sunrise.

Another dawn/dusk enhancement arises from a tilt in higher E and F layers. It is known as 'chordal-hop' by which low-band signals are refracted in the steadily-ionising (sunrise) or dispersing (sunset) D layer, and can then enter the tilted higher layer without any intermediate ground reflections before emerging at the opposite end of the path, much like the ducting seen at VHF and above. Just as is the case for grey-line propagation, the path is in darkness except for the dawn/dusk regions. Chordal-hop can produce very strong signals as there is no attenuation from intermediate ground reflections.

Yet another enhancement occurring on the low bands, called 'antipodal-focusing', is a result of signals radiated in a range of directions travelling toward the opposite side of the globe becoming focused at that point, with a focusing gain around 15 to 30dB **[7]**.

The propagation enhancements just discussed can allow those with more-limited low-band antennas (eg low horizontal antennas) to work some spectacular DX as high-angle signals can also be diffracted and undergo reflection in higher layers. For example, I remember vividly in the late 1990s hearing a ZL station pop out of the noise on 80m SSB at equinox with a huge signal of 30dB over nine. A multitude of G stations were calling him. A few minutes later he faded back into the noise with no one having worked him. I was using a 16.8m (55ft) horizontal end-fed antenna at a height of just 9.1m (30ft). The following day, my old university station of G3UNU (Nottingham) worked another ZL station at similar strength on 80m SSB using a low dipole.

Antennas for low-band DXing

Only a handful of stations have beams for the low bands, perhaps the most notable being that of OH8X **[8]** who at one time even had a beam for 160m. It goes without saying that such stations usually have impressive tallies of low-band DX and put out phenomenal signals. Stations with land at their disposal, who can erect horizontal beams and wire antennas such as loops and dipoles at heights of half a wavelength and greater, will in general do well on the low bands DX-wise (but subject to ground quality) as there will be significant radiation at angles of less than 30° which is conducive to working DX **[9]**. In the real world, few radio amateurs can erect horizontal low-band antennas at heights greater than half a wavelength, and consequently most opt for some kind of ground-mounted vertical antenna, or a sloping wire (which has a vertical component), to provide the low take-off angle required for working DX (for an excellent video presentation on take-off angle see **[10]**). Elevated verticals are sometimes used, but physical size often rules out this option for most amateurs.

Most verticals used on the low bands are electrically a quarter or a half wavelength long, usually requiring some sort of loading to bring to resonance as they are rarely of the correct physical length because of size constraints, quarter-wave antennas for 40m being the exception (there are a few commercial full-size 40m antennas available such as the MFJ 1792). Note that the efficiency of a quarter-wave ground-mounted vertical antenna is dependent upon the ground quality. There are numerous commercially-available vertical antennas covering the 80, 40 and 30m bands, and a few that also allow 160m operation. Some designs are better than others, particularly regarding efficiency, with the Butternut series of verticals at one time being considered as the gold standard; many DXpeditions would take along a Butternut vertical antenna. Note that most commercial vertical antennas have a much narrower 2:1 VSWR bandwidth on the 80m band in comparison with the 40m band, usually around 100kHz or less.

My first serious attempt at the 80 and 40m bands (also the 30m band using an ATU) was with a trapped Cushcraft quarter-wave multiband vertical antenna with an elevated feed-point at 3m above the ground and sloping radials down to, and along, boundary fencing at heights of just under 2m, in a garden of just 15.2m (50ft) by 10.6m (35ft). This configuration avoided the need for an extensive ground radial system and did allow me to work some reasonable DX on the 40m band from a very poor built-up location in a Nottingham suburban valley. Naturally, such a built-up site was far from ideal and was somewhat disappointing on the 80m band, although on the 40m band I worked into the Caribbean, North and South America, much of Africa, and I cracked a pile-up for 3B9C on the 30 and 40m bands, and a few far- and mid-east stations. If you have very little space for radials, are using a quarter-wave vertical antenna, and can elevate your feed point, then this is probably the best way to go

Andy Gilfillan, G0FVI
andrew.gilfillan@ntlworld.com

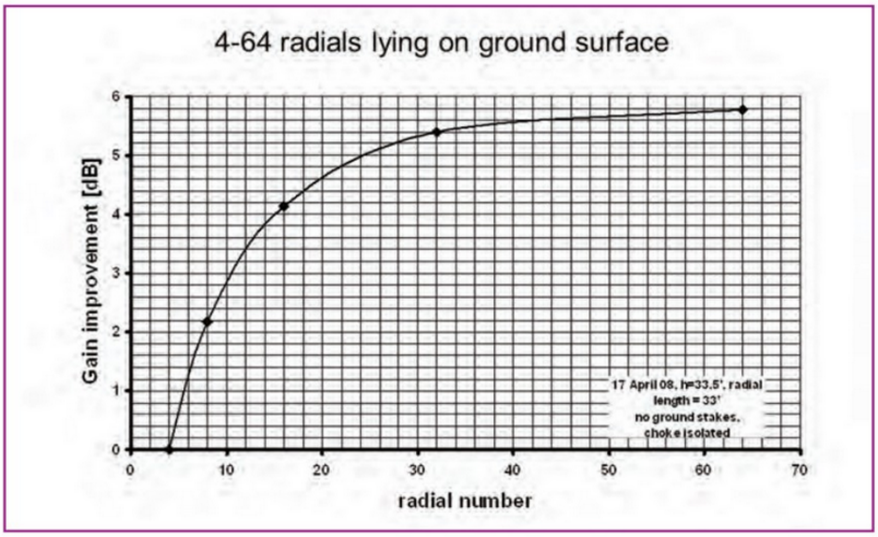


FIGURE 3: Radial number vs gain improvement from N6LF's study [16].

[11]. My present location has a larger garden of around 24.4m (80ft) by 12.2m (40ft), so I opted for an arrangement that could be configured either as a straight ground-mounted vertical antenna (a wire attached to a 10m roach pole for the 30 and 40m bands and a 12m Spiderpole for the 40 and 80m bands), or as an inverted-L or sloper antenna, fed against an extensive ground system with a remote automatic ATU (see **Photo 1**).

This current arrangement has a low profile and can be quickly deployed or taken down, something which is clearly an advantage so far as neighbours and planning regulations are concerned. The inverted-L configuration allows operation on the 80m band using either the 10m or 12m vertical components, and provides some high-angle radiation for EU and Inter-G QSOs on both the 40 and 80m bands. The sloper configuration even provides some directivity to the east. In general, longer vertical antennas produce lower take-off angles conducive to working DX, a half-wave vertical having slightly more gain than a quarter-wave vertical **[12]**. In practice, however, it is difficult for many radio amateurs to erect full quarter-wave antennas for the 80 and 40m bands, so some form of loading is normally required **[12]**. There are several configurations based around vertical antennas, including the increasingly popular end-fed half-wave (EFHW) should you choose to construct your own. Some good examples can be found in **[13]**.

Radial systems for vertical antennas

Ground-mounted quarter-wave vertical antenna configurations normally require a radial system for proper operation. A quarter-wave vertical is like a vertical half-wave dipole in which the feed-point is at ground level and reflection in the ground replaces the missing half of the dipole. As ground is generally not a good conductor of RF, a radial system is used instead. Much has been written about radial systems over the years, and is a topic that is not widely understood, often inspiring fierce debate. The general rule of thumb was always to get as much metal into the ground as possible, an approach principally arising from ground-mounted broadcast-band vertical antennas using 120 buried radial wires **[14]**. The conduction quality of the ground, both in the near field and several wavelengths away (the far field), determines the effectiveness of a quarter-wave ground-mounted vertical antenna, especially regarding DX stations where efficient low-angle radiation is desirable. Greater radial density close to the feed point improves the efficiency. The far field, where reflections from the ground augment gain, lies several wavelengths way from the feed point and not much can be done to improve ground conductivity there unless you have heaps of land or live at a seafront location (saltwater is a most effective 'ground').

Elevated quarter-wave vertical antennas require a ground plane which, in general, consists of 3 to 4 elevated quarter-wavelength radials (per band). Elevated radials need to be at least 0.05 of a wavelength above ground, ie about 2m on the 40m band and 4m on the 80m band **[11]**. Vertical base-fed antennas that are electrically half a wavelength or more do not require a radial system, relying instead on a counterpoise system usually in the form of a short single radial (or several) which prevents RF from flowing down the braid of the coax feed. As in the case of a quarter-wave vertical, the quality of ground in the far field affects the gain of a half-wave vertical.

I initially opted for a mix of radials of various lengths buried a couple of inches below the surface of my rear garden using insulated stranded copper wire. I managed to lay down a total of around 79 radials of wire before it became impractical to add more because of crowding at the feed point. In total, I had about 32 quarter-wave radials for the 40m band, 6 quarter-wave radials for the 80m band, with the rest comprising random lengths to fill the gaps. Note that radials can be bent, folded back, or loaded to fit smaller gardens. To improve current collection around the feed point, I added several sheets of galvanised steel mesh. Crowding near the feed point can be reduced by soldering bunches of radials to single wires about 30cm long which in turn are soldered together at the feed point (you can also use a radial stand-off plate **[15]**).

Not long after completing my radial system, I came across an extensive practical study carried out by N6LF summarised in QST **[16]** which demonstrated that, for quarter-wave radials over good earth, there is little point in putting down more than around 32 radials (see **Figure 3**). Over poor ground, more than 32 radials will almost certainly be beneficial for return current in the near field, although poor ground in the far field may also affect results. For gardens smaller than a quarter of a wavelength on the lowest band to be used, the old practice of getting as much metal into earth as possible still has advantages (for example, add as many radials as you can which are one sixteenth of a wavelength in length).

It is important to understand that the electrical length of any radials will be different from the free-space lengths when placed on the ground or buried below the surface. There is therefore little point in spending time trimming to calculated exact quarter wavelengths. For quarter-wave vertical antennas, the detuning of radials influences the feed-point impedance and thus the point of resonance, most noticeable with varying degrees of soil moisture content. In my own case, as I would be using a remote auto-ATU, changes in the feed point impedance are much less of a concern. If you opt for commercial antennas with fixed tuning at the feed point, you will almost certainly see some impedance changes with varying ground moisture content, although in general this can be handled by an internal ATU of a transceiver provided that any change in resonance results in a VSWR of less than 3:1.

After several years, I needed to augment the radial system following damage from various gardening activities and the addition of a patio. I had read of people using chicken wire and the like, and hit upon the idea of using builder's wall-reinforcement mesh. This can be purchased in 20m rolls of 10cm width. Mesh such as this can be rolled out and pegged down with metal tent pegs, and it offers a considerable saving in time compared with burying radials (see **Figure 3**). Mesh can be laid on lawn surfaces and will no longer be visible after a few months. There is some debate about using such mesh as it is generally manufactured from galvanised steel, which is not the best of conductors so far as RF is concerned, although Rob Sherwood, WB0JGP **[17]** carried out a study using mesh which appears to have yielded good results.

Transceivers

HF transceivers for low-band DXing should have good receiver dynamic ranges and third-order intercept points, particularly for the 40m band where high-power broadcast stations just above the band can induce inter-modulation products. Sherwood Engineering Inc. has produced an excellent table of receiver performance for a number of radios **[18]**. In general, your radio should have a dynamic range approaching 90dB or greater. Multiband shack-in-a-box radios will in often perform poorly from a DX perspective on the low bands compared to a dedicated HF radio, particularly when connected to an efficient antenna. I saw this for myself on the 40m band before the band was extended to 7.20MHz. I happened to be listening to some American stations in the top 100kHz who were perfectly audible on my Alinco DX70TH. Upon changing transceiver to an Icom 706Mk2G it was difficult to pick out the ham stations due to intermodulation from nearby broadcast stations even with the 20dB attenuator switched in.

Modern transceivers with IF DSPs can make weak signals more readable in noisy environments by using narrower bandwidths in conjunction with noise reduction. If your radio has a second antenna port, this may be useful for a separate receive antenna.

Dealing with noise

No article about the lower HF bands would be complete without a discussion on noise. The low bands are much more prone to atmospheric and man-made noise than any of the other amateur bands (with the exception of VLF). Noise can make working these bands a challenge, especially in today's electronic environment where a plethora of badly-designed gadgets, such switch-mode power supplies and VDSL, contribute to a higher noise floor than previously existed. If you find that noise interference is hampering reception, there are several possible remedies. Obviously the first step would be to see if the noise can be mitigated or removed. This will usually involve finding the source (but make sure that any interference is not coming from your own abode) **[19]**. Often this involves approaching neighbours where possible. Where it is not possible to remove or mitigate interference, consider building a receive-only magnetic loop. Receive-only magnetic loops are favoured by low-band enthusiasts as they are less prone to pick up man-made noise and have the directivity of a dipole, so interference from a noise source may be considerably reduced by rotating the loop to 'null' the noise. Commercial magnetic loop antennas tend to be expensive, especially those designed for high transmit power. Building receive-only or lower-power loops is quite straightforward and numerous designs have been published **[20]**.

If you live next to open space (farmland, woodland etc), consider deploying a Beverage antenna supported on bamboo cane. These can dig out weak signals from noise, both man-made and atmospheric, and can be orientated to optimise their directional properties **[21]**. You might also like to try running a wire a few metres or so off the ground along the bottom of a boundary fence to form a receive-only loop. Such a loop will in general respond to high-angle signals, but can be useful for grey-line propagation. An old friend of mine (G0SWG/HS0ZLW) tried this from his 30.5m (100ft) garden, and found he could hear DX on the 160 and 80m bands, noting one evening that a station calling CQ DX at the top end of the 80m band who appeared not to be being heard by UK stations, was in fact being answered by several DX stations that he was unable to hear himself!

Noise cancelling devices such as the MFJ 1026 **[22]** may be useful, although it should be noted that these will only cancel one noise source at a time and require a receive antenna to be placed as close as possible to the interfering signal.

A radio with an IF DSP and an effective noise-blanker system is also advantageous for reception on the low bands in today's noisy environment. I have found that the Yaesu noise blanker system found in the FTDX series of radios is effective for reducing locally-generated noise. Do note that noise-reduction and noise-blanker functions are often more effective with front-end attenuation, and most of the time it really isn't necessary to have the internal radio preamplifier engaged on the low bands. Use of a web-based SDR may also be useful for reception as these are often situated in low-noise environments **[23]**.

Contests and FT8

Contests and FT8 are two words that are like the Marmite of amateur radio! I'm not a fan of HF contests myself, but they do present an ideal opportunity to work stations you wouldn't normally hear on the low bands. Remember contesters want your points and you can be sure that their setups will be optimised for pulling out weaker stations. They also won't generate the huge pile-ups that many of us simply can't compete with.

FT8 is capable of producing DX for modestly-equipped stations. It can be very interesting to call CQ and then click on the PSK Reporter website to see where your signal is being heard **[24]**.

Conclusion and recommendations

This short article is intended as an introduction to DXing on the lower bands and to encourage those who have never considered using those bands to have a go. It can be done from small locations or as a portable operation from better sites. Do consider getting a copy of Low-Band DXing by John Devoldere, ON4UN SK (various editions are available), considered to be the 'bible' of working DX on those bands. This book includes the 160m band which has not been covered here.

Acknowledgements

Thanks to Steve Nichols, G0KYA for supplying the grey-line diagram.

References

[1] Steve Nichols G0KYA, Radio Propagation, RSGB 2016, Chapter 8
[2] Steve Nichols G0KYA, Radio Propagation, RSGB 2016, pp 62-63
[3] Steve Nichols G0KYA, Radio Propagation, RSGB 2016, pp 59-61
[4] http://www.norfolkamateurradio.org/Talks/G0KYA%20Greyline_Propagation.pdf
[5] John Devoldere ON4UN, Low-Band DXing, ARRL 1995, second edition chap 1, pp 1.5-1.8
[6] https://dx.qsl.net/propagation/greyline.html
[7] John Devoldere ON4UN, Low-Band DXing, ARRL 1995, second edition chap 1, pg 1.9
[8] https://www.lb3hc.net/archives/1270
[9] ARRL Antenna Book, 18th edition, ARRL 1998, pp 3.10-3.12
[10] https://www.youtube.com/watch?v=59zjsw36ve4
[11] Vertical Antenna Classics, ARRL 1997, pp 108-112
[12] https://www.qsl.net/l/lu7did/docs/QRPp/09.pdf
[13] HF Antennas for Everyone, RSGB 2012, chapter 2
[14] Brown et. al., Proceedings IRE, June 1937, pg. 753
[15] https://www.dxengineering.com/parts/dxe-radp-3
[16] Rudi Severns N6LF, QST March 2010 pp 30-33
[17] http://www.sherweng.com/documents/GroundScreen-sm.pdf
[18] http://www.sherweng.com/table.html
[19] https://rsgb.org/main/technical/emc/experiencing-emc-interference/
[20] HF Antennas for everyone, RSGB 2012, pp 222-241
[21] John Devoldere ON4UN, Low-Band DXing, ARRL 1995, second edition chap 7 pp 7.1-7.24
[22] https://mfjenterprises.com/products/mfj-1026
[23] http://www.websdr.org
[24] https://pskreporter.info/pskmap.html

Technical

Extending a ground-plane antenna

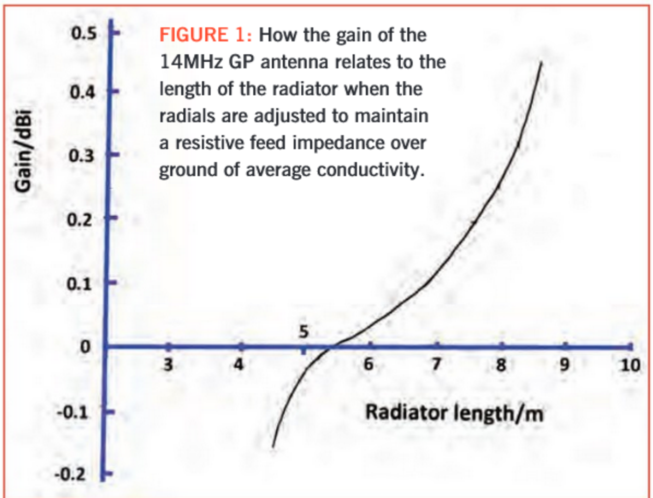


FIGURE 1: How the gain of the 14MHz GP antenna relates to the length of the radiator when the radials are adjusted to maintain a resistive feed impedance over ground of average conductivity.

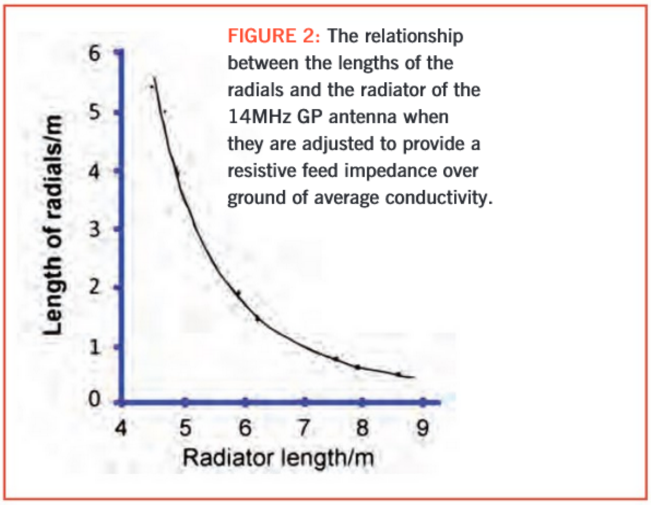


FIGURE 2: The relationship between the lengths of the radials and the radiator of the 14MHz GP antenna when they are adjusted to provide a resistive feed impedance over ground of average conductivity.

In his book [1], John Lenahan, K0RW shows how to achieve a 50Ω resistive feed impedance at a ground-plane (GP) antenna by using the complementary relationship that exists between lengths of radials and radiator.

This relationship was mentioned in my earlier *RadCom* article: *All we need to know about GP antennas*. John's method is to lengthen the radiator beyond a quarter wave, causing it to have a greater radiation resistance accompanied by inductive reactance. Shortening the radials, which then contribute only capacitive reactance compensates to make the feed point a pure resistance. This eliminates the need to find the suitably-rated capacitor or feeder stub that I proposed. The antenna may then be driven from a 50Ω source via a braid choke. This is usually made by winding several turns of coax through a ferrite or iron dust toroidal core or it may also be simply a coil formed from several turns of coax. It is necessary because the junction of the radials is no longer at ground potential and the feeder itself would otherwise look like another radial. If we make the radials even shorter and lengthen the radiator to maintain a resistive, but higher, feed-point resistance, it would appear to be another convenient technique for fitting the GP antenna into a severely-restricted space.

A half-wave GP

Let us see how far reducing radial lengths can be taken to minimise the necessary site area for the accommodation of a GP antenna without sacrificing radiation performance. The radiator is expected ultimately to have a length of half a wavelength, when there will be no radials left against which to drive the antenna! A GP antenna for 14.25MHz was modelled in which the radiator was 25mm diameter and four radials were each 15mm diameter. The technique also works for two radials. The feed-point height was 2m above a ground of average conductivity. **Figure 1** shows how the gain increases at 14MHz as the radiator is lengthened whilst radials are shortened to maintain a resistive feed-point impedance. The potential gain advantage over real ground is shown by EZNEC to reach no more than 1/2dB over that of a quarter-wave GP antenna. This is about the same as extending a ground-mounted quarter-wave radiator to half a wavelength over the same ground. **Figure 2** shows the corresponding lengths of radials and radiator necessary to maintain a resistive feed impedance. The feed-resistance to radiator-length relationship is shown in **Figure 3**. If the radiator was a single wire, the impedances would be much greater than shown for the 25mm element. I used EZNEC but John shows how to calculate exact lengths for radials and a radiator of different diameters to ensure a resistive feed impedance. My modelled results confirmed John's principle to be consistent with my earlier experimental results when preparing my original article.

As the radiator's length approaches a half wavelength, and the radials tend towards zero length, a step change occurs whereby the radials suddenly need to be longer than a quarter wavelength. I have now to compensate for the change from inductive to capacitive reactance of the radiator. The vertical radiation pattern then breaks into two lobes of which the stronger one is at an undesirably high angle. I decided to avoid this region by accepting 0.4 of a wavelength as a safe maximum physical extension. Electrically, this is about 0.45 of a wavelength. Although increasing the radiator length did not produce much more gain, it did produce a lower radiation angle. This improved DX potential whilst minimising short-skip interference when receiving. For ground conditions of average conductivity at 14MHz, the take off angle for radials of 2m height above ground dropped from 21 degrees for a quarter-wave radiator to 17 degrees for one of 0.4 of a wavelength. A realistic maximum gain, minimum angle, and 400Ω feed resistance at 14MHz was, therefore, to have radials of 0.5m (1ft 8 inches) and a radiator of 8.6m (28 ft 2 inches). For the bands of 14MHz upwards, a radiator of length 0.4 of a wavelength is quite practical because the short rigid radials offer flexibility in mounting the antenna in a restricted location. It is essential to insulate the radials from any metal support, and prevent anyone

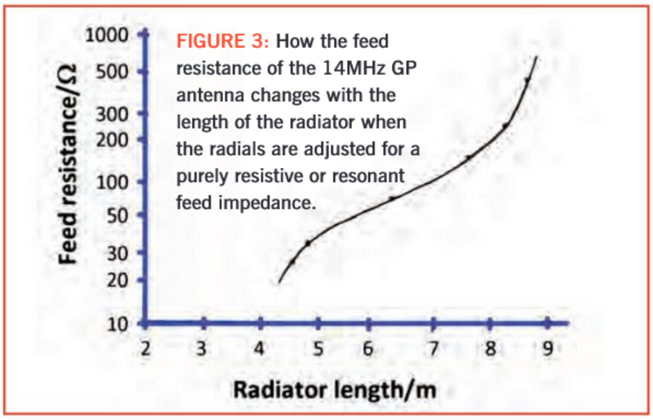


FIGURE 3: How the feed resistance of the 14MHz GP antenna changes with the length of the radiator when the radials are adjusted for a purely resistive or resonant feed impedance.

from touching them, because they will have high voltages present throughout their length.

Driving the extended GP antenna

Unless we accept a VSWR of 8 on our coaxial feeder when the radiator of length 0.4 of a wavelength has a diameter of 25mm, or a much higher VSWR when the radiator is wire, an impedance-transforming arrangement will be required to reduce the feed impedance to 50Ω. Because the short radials are a long way above ground potential, a choke that will effectively decouple the feeder braid will also be required at the antenna. It needs to have an impedance of at least an order higher than the antenna's to sufficiently restrict current on the braid of a coax feeder. Otherwise, as mentioned earlier, it will detune the antenna by, in effect, adding another very long radial. The impedance of an inadequate braid choke may be increased by tuning it for minimum braid current at the working frequency with a capacitor connected to the braid between each side of the choke. In any case, in order to feed the tubular radiator via 50Ω coaxial cable, it will be preferable to include a 9:1 impedance ratio unbalanced-to-unbalanced transformer. When a wire radiator is used, a choke and a 49:1 unbalanced-to-unbalanced transformer may be appropriate, or a shorter radiator and choke plus 9:1 transformer. It may be more convenient to choose a 25mm radiator length of 7.8m (25 ft 7 inches) with 0.6m (2 ft) radials. We should then have a feed resistance near 200Ω. This may then be driven via a 4:1 current balun without a choke as has already been tried in the USA and illustrated by John in his book. Because of the extensive measures necessary to feed the extended antenna whilst isolating the feeder braid, my choice would be a parallel-resonant isolation transformer. This offers the facility to adjust the capacitor and/or turns ratio to compensate for residual reactance caused by imprecise lengths of the radials and radiator.

Lower frequencies

The 14MHz dimensions may be scaled up for lower frequencies. For example, at 7MHz the 0.4 wavelength radiator, when radials are each about 1m long at 2.5m above ground, requires an overall height for the antenna of about 20m. This may be prohibitive in many locations. However, most of the benefits, except the protection from short skip interference that we expect from the extended radiator, may still be realised without exceeding an overall height of 12m. We may achieve this by adding a horizontal wire to make up the radiator's length as an inverted L.

Reference

[1] Antennas as Transmission lines: Linear Antenna Analysis and design requiring only algebra and trigonometry, J Lenahan, via Amazon.

Tony Preedy, G3LNP
g3lnp@yahoo.com

Contest Calendar July 2023

Ian Pawson, G0FCT

RSGB HF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Mon 3 Jul	80m CC CW	1900-2030	CW	3.5	RST + SN
Wed 12 Jul	80m CC SSB	1900-2030	SSB	3.5	RS + SN
Sun 16 Jul	International Low Power Contest	0900-1600	CW	3.5, 7, 14	RST + SN + TX power
Mon 17 Jul	RSGB FT4 Contest	1900-2030	FT4	3.5, 7, 14	Report
Thu 27 Jul	80m CC DATA	1900-2030	RTTY, PSK63	3.5	RST + SN
Sat 29-Sun 30 Jul	IOTA Contest	1200-1200	CW, SSB	3.5-28	RS(T) + SN + IOTA Reference

RSGB VHF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Sat 1-Sun 2 Jul	VHF NFD	1400-1400	All	50, 70, 144, 432, 1.3G	RS(T) + SN + Locator
Sun 2 Jul	3rd 144MHz Backpackers	1100-1500	All	144	RS(T) + SN + Locator
Tue 4 Jul	144MHz UKAC	1900-2130	All	144	RS(T) + SN + Locator
Tue 4 Jul	144MHz FMAC	1800-1855	FM	144	RS + SN + Locator
Wed 5 Jul	144MHz FT8 AC (4 hour)	1700-2100	FT8	144	Report + 4-character Locator
Wed 5 Jul	144MHz FT8 AC (2 hour)	1900-2100	FT8	144	Report + 4-character Locator
Tue 11 Jul	432MHz UKAC	1900-2130	All	432	RS(T) + SN + Locator
Tue 11 Jul	432MHz FMAC	1800-1855	FM	432	RS + SN + Locator
Wed 12 Jul	432MHz FT8 AC (4 hour)	1700-2100	FT8	432	Report + 4-character Locator
Wed 12 Jul	432MHz FT8 AC (2 hour)	1900-2100	FT8	432	Report + 4-character Locator
Thu 13 Jul	50MHz UKAC	1900-2130	All	50	RS(T) + SN + Locator
Sat 15 Jul	70MHz Trophy Contest	1400-2000	All	70	RS(T) + SN + Locator + 2-letter Postcode
Tue 18 Jul	1.3GHz UKAC	1900-2130	All	1.3G	RS(T) + SN + Locator
Thu 20 Jul	70MHz UKAC	1900-2130	All	70	RS(T) + SN + Locator
Tue 25 Jul	SHF UKAC	1830-2130	All	2.3-10G	RS(T) + SN + Locator

Best of the Rest Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange (Info)
Sat 6 May - Sun 6 Aug	UKSMG Summer Marathon	All	All	50	4-character Locator
Sun 9 Jul	UKuG 24/47/76GHz	0900-1700	All	24-76G	RS(T) + SN + Locator
Sat 8 - Sun 9 Jul	IARU HF Championship	1200-1200	CW, SSB	1.8-28	RS(T) + ITU zone (UK = 27)
Sun 30 Jul	UKuG 5.7/10G	0600-1800	All	5.7 & 10G	RS(T) + SN + Locator
Sat 29 Jul	WAB 144MHz Low Power Phone	1400-1800	AM, FM, SSB	144	RS(T) + SN+ WAB area

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

Experimenting with ultra-low power WSPR

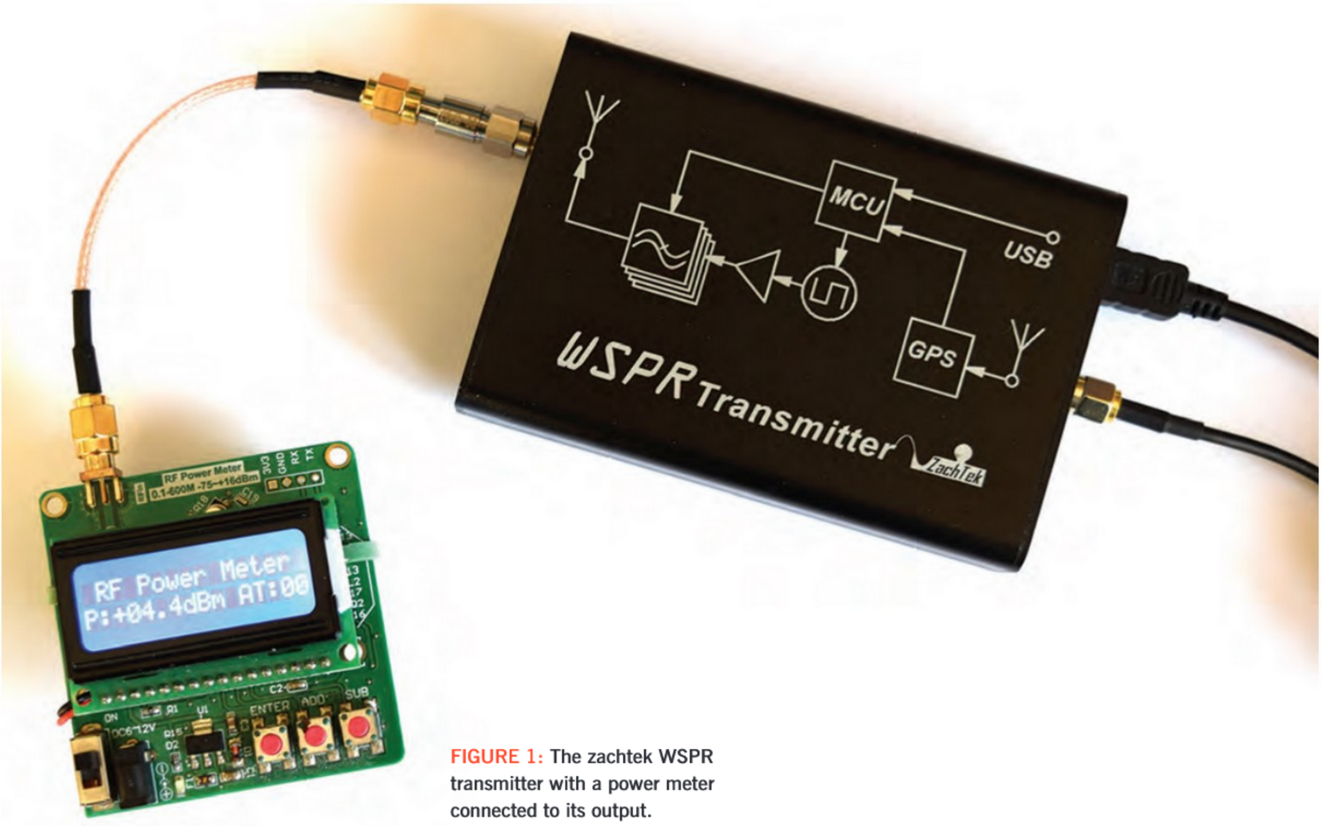


FIGURE 1: The zachtek WSPR transmitter with a power meter connected to its output.

I've been a fan of CW operation on the HF bands at low-power levels (QRP) almost since the day I was licensed in 1975. The attraction was (and still is) that QRP CW transmitters were simple to build from a handful of components and were easy to get working.

The Prologue

The thrill of communicating using something so basic (and sometimes as small as a postage stamp) served only to enhance the magic that is 'wireless'. I can thoroughly recommend membership of the *G-QRP Club* [1].

Over the years, family and work commitments have meant that I haven't always been able to dedicate much time to operating in the shack. More recently, the airwaves have become increasingly cloaked in local interference to such an extent that signals using traditional modes, such as SSB and CW, need to be received at S7 or more to stand any chance of being comfortably monitored at my QTH. As well as being a devotee of QRP, I have found myself being wooed by the various data modes, especially as they became more-easily accessible using home computers. First there was RTTY and SSTV, followed by PSK. I remember the excitement of tuning to 14070kHz and finding the (not connected) laptop decoding messages by dint of picking up the receiver's audio through the on-board microphone. What sorcery was this?

Today, FT8 accounts for a large percentage of on-air activity, and looks set to remain the mode of choice for those wishing to conduct two-way QSOs, albeit solely with the exchange of signal reports and locators. Pre-dating FT8, though, is WSPR (Weak Signal Propagation Reporter), a one-way low-power beaconing mode. These data modes – and especially WSPR – have high processing gains, and are therefore robust and resilient in the face of the high levels of interference that now affect almost all of us. I'd like to express my appreciation to the people who work hard to deliver these data modes, at no charge, allowing many of us to continue enjoying amateur radio from home, despite the QRM. I now devote much of my operatimg time to using WSPR with low transmission power.

Props

Over the years I've used many WSPR transmitters, ranging from the main-station transceiver (an Icom IC-7100 running minimum power), to a home-made VXO-controlled experimental DSB transmitter which I cobbled together on strip board, consisting of an NE602 IC, a crystal, and very little else. The WSPR tones were obtained from a tiny MP3 player (£2, including delivery, from a Chinese supplier!).

Martin Peters, G4EFE
martinlpeters@gmail.com

FIGURE 2: SMA in-line attenuators used to reduce the transmitted power levels.

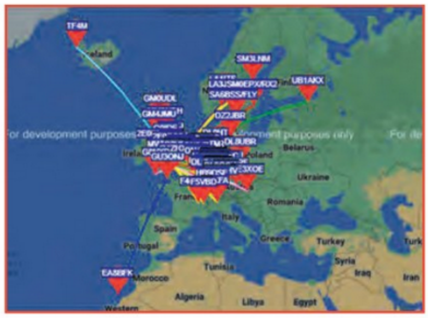


FIGURE 4: WSPR spots using 2.5mW.

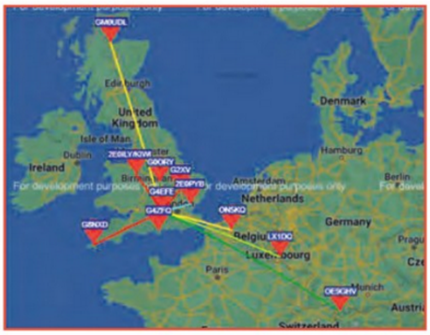


FIGURE 5: WSPR spots using 250µW.

FIGURE 6: WSPR spots using 125µW.

On the one hand, it always felt wrong to power up a desktop PC and a 100W transceiver in order to generate just a couple of hundred mW of WSPR. Perhaps this is not QRP in pure form, especially in these energy-conscious days. On the other hand, my home-made low-powered DSB transmitter did not have sufficient frequency stability, and the play-out from the MP3 player was unreliable. The solution demanded a dedicated WSPR transmitter combining a low current-draw with ease of use and long-term time and frequency stability. I settled on the *ZachTek* **[2]** WSPR desktop transmitter (see **Figure 1**). The 80-to-10 model covers all bands between 3.5MHz and 28MHz (but not 5MHz, unfortunately). There is a review of this little gem by the late Giles Read in the February 2022 edition of *RadCom*. It is a WSPR-only transmitter than runs on 5VDC, deriving its timing synchronisation and positional data from the on-board GPS receiver, and it is very easy to set up and use. Once configured using a PC, the transmitter retains its settings and the PC can be disconnected.

FIGURE 3: WSPR spots using 25mW.

The Plot

A feature in the June 2022 edition of *RadCom* invited us to take part in a WSPR experiment, running around 70mW EIRP and using our temporary GQ prefixes, as part of the Queen's Jubilee celebrations. Unfortunately, I was unable to take part, but it prompted me to run my own week-long WSPR experiment using even-lower power levels. Previously, I had run WSPR at very low levels, with some impressive outcomes, but I'd never documented or analysed the results. So, in early 2023, I decided to perform a (entirely non-scientific) series of tests by running a

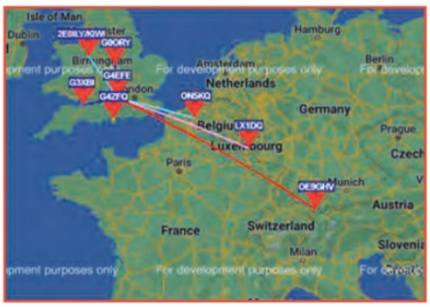


FIGURE 7: WSPR spots using 50µW.

FIGURE 8: WSPR spots using 1mW including a US spot.

WSPR beacon from my QTH in Reading (IO91) over several days, at ever-decreasing power levels until such time as no spots were reported. I used WSPRnet **[3]** to check for spots. I then calculated the greatest number of miles per Watt achieved. Having ascertained the lowest power to get me a spot, I then ran 1mW continuously for as long as it took to secure a spot from outside of Europe.

The power levels I'll be quoting refer simply to the RF output from the transmitter and do not take into account any loss or gain attributable to the antenna and feeder, the characteristics of which vary widely from band to band. The antenna I used was a full-sized 40m square loop. The highest side was at the gutter level of my two-storey house, with the lowest side at about two metres above ground. It was fed via a BALUN at one corner and about 10 metres of coaxial cable into the shack. The VSWR on 7MHz, 14MHz, 21MHZ and 28MHz was 2:1 or better. Power reduction for the tests was provided by a series of in-line SMA attenuators (**Figure 2**) from *AliExpress* **[4]**, connected at the output of the transmitter to avoid any signal leakage (the TX itself was in a well-screened enclosure).

Act I

My first task was to measure the transmitter's power output. For this, I used my tried-and-tested QRPometer from *4SQRP (Four State QRP Group)* **[5]**, which measures accurately down to around 10mW. The results varied from 330mW on 18MHz, down to 190mW on 28MHz. For the purposes of these tests, I assumed an average output of 250mW – accurate enough for our purposes.

On the first test, I ran the *ZachTek* without attenuation for 24 hours on all bands between 3.5 and 28MHz (excluding 5MHz). The result was that I received thousands of spots from more than 300 stations in over 30 countries. The best DX was 16272km (a VK5), and the best signal report as a signal-to-noise ratio (SNR) was -3dB, from France.

Having noted the results for this 'best case scenario', the plan was to drop the power level every 24 hours and collate the data until, at some point, there would be no data left to collate.

Intermission

However, before I could start, I had to find some way of measuring very-low RF output power levels. I bought an inexpensive power meter from *AliExpress*, which claims to measure from +16 to -75dBm, which is equivalent to 40mW down to, effectively, nothing at all. This is shown connected to the transmitter antenna terminal in Figure 1. But was it reasonably accurate?

To find out, I fired up my Icom IC-703 at its minimum power setting of 100mW, then injected an audio tone from the PC, using the TUNE function within WJST-X. I reduced the audio output from the PC until the QRPometer read 20mW, then slowly increased the audio level until the display just reached 30mW. When I substituted the little Chinese meter for the QRPometer, the reading was 15dBm, corresponding to just under 32mW. Finally, I inserted the 3, 10 and 20dB SMA attenuators, first singly and in combinations. The readings were all within 1-2dB of expectations, and good enough for my experiments.

Act II

Over the next week, I ran 24-hour tests across all bands, dropping the power level with each passing day (note: WSPR does not provide for the reporting of transmitted power levels below 1mW. Given that WSPR is an ideal mode for the QRP fraternity, I wondered whether this could be changed in a future release).

Results

The results of the tests are shown in **Table 1**, and in **Figures 3-8**. Having achieved over 11 million miles per Watt with 50μW, I then set about attempting to break out of Europe using a power of just 1mW. It took another week of WSPRing, and on the seventh day I was rewarded with a single spot on 7MHz by N8VIM on the east coast of the US.

The Epilogue

These experiments have reinforced my belief that WSPR is an exceptionally-effective mode for low-power beaconing, even at QRPp levels. There are masses of WSPR stations on the air on the HF bands, and several online reporting sites providing near-instant gratification. Perhaps you'll have been inspired to give ultra-QRP a go. A couple of online tools that helped me to make mathematical calculations are the *M0UKD power calculator* **[6]** and the *N9SSA Distance and Miles Per Watt Calculator* **[7]**. You may very well fare better than me; the upper HF bands are on fire, as I write.

Table 1: The results achieved at various power levels

Power	Band/MHz	No of spotters	DXCC	Best DX/km	Best SNR/dB
25mW	3.5	2	1	191	-11 (G)
	7	112	23	5580	+5 (ON)
	10	11	6	1881	-16 (OE)
	14	23	11	6714	-13 (DL)
	18	4	3	5438	-21 (TF)
	21	11	5	6131	-16 (K1)
	24	1	1	1883	-19 (OH)
	28	3	2	2141	-15 (G)
2.5mW	7	42	14	2759	-15 (ON/LX)
	10	7	4	1435	-20 (DK)
	14	10	4	1207	-17 (I)
	18	4	4	2022	-6 (DL)
	21	1	1	1629	-25 (SM)
	28	3	2	2141	-24 (G)
250μW	7	12	6	907	-11 (LX)
	10	1	1	711	-23 (GM)
	18	1	1	1083	-22 (DL)
125μW	7	5	2	307	-22 (ON)
	10	2	2	554	-19 (LX)
50μW	7	9	4	907	-6 (ON)
	10	1	1	549	-21 (LX)
15μW	10	1	1	0.4	-16 (G)

Websearch

[1] gqrp.com
[2] zachtek.com
[3] wsprnet.org/drupal/wsprnet/map
[4] aliexpress.com
[5] 4sqrp.com
[6]m0ukd.com/calculators/dbm-dbw-uw-mw-watt-kw-mw-calculator
[8] qrz.com.hr/js-html/1000mpw.htm