Contents

December 2022

News and Reports

Regulars

Features

Technical Features

Reviews

Cover image: Season's Greeting from the RSGB. Designed 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
Technical Editor: Matthew Smith, M0VWS, matthew.smith@rsgb.org.uk
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 January 2023 edition of *RadCom* is expected to arrive with most Members by 19 December 2022** 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 Articles for *RadCom* are accepted on the strict understanding that they are previously unpublished and not currently on offer to any other publication.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

The New FT - 710 from Yeasu

YAESU have announced a new HF/50&70MHz 100W SDR Transceiver, The FT-710 AESS.

The new FT-710 AESS is a compact design yet provides 100W output, utilizing the advanced digital RF technology introduced in the FTDX101 and FTDX10 series.

A few of the remarkable features of the new FT-710 AESS: YAESU unmatched SDR technology emphasizes the receiving performance; Band Pass Filters dedicated for the amateur bands to eliminate out-of-band unwanted signals; RF front end design with the 250MHz HRDDS (High Resolution Direct Digital Synthesizer) enables phenomenal multi signal receiving characteristics; QRM rejection is done by the dual core 32-bit high speed floating decimal point DSP for SHIFT, WIDTH, NOTCH, CONTOUR, APF (Audio Peak Filter), DNR (Digital Noise Reduction), NB (Noise Blanker) and 3-stage parametric equalizer; High resolution 4.3-inch TFT colour touch panel display. 3DSS (3-Dimensional Spectrum Stream); VMI LED (VFO Mode Indicator) placed around the VFO dial shows the current operating mode (VFO-A, VFO-B, memory mode and clarifier, split, operations); "PRESET" mode function most suitable for FT8 operation; AESS: Acoustic Enhanced Speaker System with SP-40 creates the high-fidelity audio output; External display connection terminal (DVI-D); Built-in high speed automatic antenna tuner with 100 channel memory; FC-40 auto antenna tuner; An SD memory card can be used to save the communications records, transceiver settings, the memory contents, screen images and to update the firmware; Two USB Ports (Type-A and Type-B). Other essential features are included such as CW ZIN and SPOT IPO (Intercept Point Optimization), and remote operation with network remote control system to name a few.

Specifications:TX Frequency Range:1.8MHz-50MHz (Amateur bands only) 70MHz–70.5MHz (UK Amateur bands only) RX Frequency Range: 30KHz-75MHz (Operating) 1.8MHz–29.699999MHz (Specified performance, Amateur bands only) 50MHz–53.999999MHz, 70MHz–70.499999MHz. Emission Modes: A1A(CW), A3E(AM), J3E(LSB/USB), F3E(FM). Supply Voltage: DC13.8V ±15%. Power Output: 5 - 100W (5 – 25W AM Carrier). Dimensions (W x H x D): 9.4" x 3.1" x 9.7" (239 x 80 x 247mm) Weight (Approx.): 9.92lbs (4.5kg). The Yaesu FT-710 is available from all authorised dealers for £1099,99.

Messi & Paoloni UHF Male PL259 Solder Connector compatible with ULTRAFLEX 7.

A compression design with double seal that ensures better protection against infiltration of water, humidity, and condensation. Easy installation, no braid soldering needed. In typical UHF (PL259) threaded RF connectors it is necessary to fill the centre conductor pin with melted solder, Evo's rounded Pin eliminates the problem of solder burrs. Evolution can be used conveniently up to 6000 MHz. Never has a PL come so close to the famous "N" connectors for performance and reliability.

Product dimensions: 2,1cm x 4,6cm

For More information visit www.messi.it

Create RC5-3 Rotator

The create RC5-3 is a medium duty rotator ideal for medium sized HF antennas and VHF/UHF arrays. It uses the same type of control box as the RCA5-3 which shows the rotator direction and has CCW/CW and Speed controls as well as a Pre-set control.

* Rotating torque: 6kg/m
* Brake torque: 90kg/m
* Mast size 48-63mm
* Vertical load: 400kg
* Horizontal load: 800kg
* Rotation speed: 60-150sec/60Hz
* Pre-set function: Provided
* Power requirement: 230V AC 80VA
* Weight: 5kg
* Cable: 7-core cable (not supplied)
* Requires MC-2 lower mast clamp if mounting on pole

The Create RC5-3 is available from www.hamradiostore.co.uk

Review

Moonraker SHK-1

Straight Hand Key

As readers of the RadCom VHF/UHF Column will know, I have recently been converted to the benefits and fun of Morse code, after years of phone operation on VHF and, when the Morse test was no longer obligatory, I have also worked phone the HF bands.

Lockdown provided me with an opportunity to learn this undervalued mode of operating. My granddad, who was deputy Director General of the Telegraph Service in India, would be proud of me! There is no doubt that Morse is experiencing a resurgence and the recent review of the PreppComm DMX-40 transceiver is adding to this momentum.

No short cuts

Make no mistake, learning Morse code is hard work, but the rewards are considerable. Using simple equipment and low power, communication over vast distances is possible on the HF bands. I believe that the most important component of the station to have is a good key and it is unwise to compromise on this.

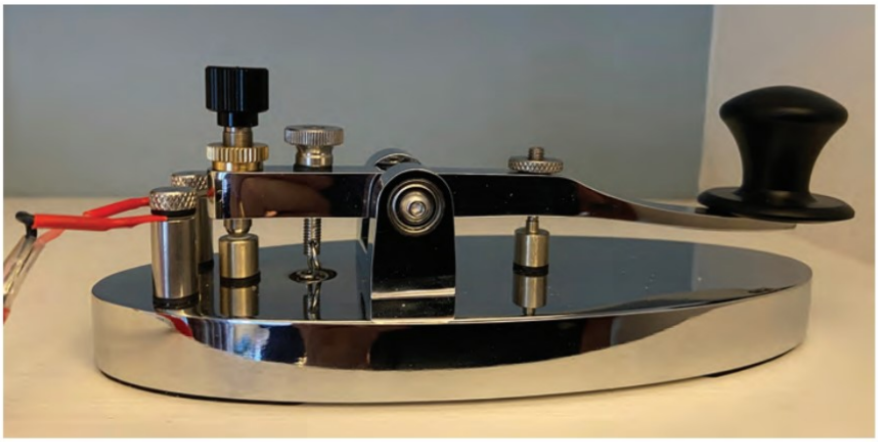
Without adopting *Mad Men* speak, everything about the SHK-1 radiates quality. On opening the box, you are confronted with a heavy, beautifully constructed Morse key. It has a chromium-plated finish that is mirror-like. The key mechanism is set on an elliptical base and, due to its weight, it does not move when the key is depressed, which is so important during sending. It weighs 1,100 grams and is fitted with rubber pads on its base. The action is positive and adjustment of the gap is easy. The key connects to the transmitter via a red cable terminating in a large 6.35mm jack plug.

In use

I have used it with my FTDX101MP transceiver as well as with my QRP Walford Electronics Ham/Hale transceiver, with equal success.

My daughter bought me an iambic key for Christmas but (don't tell her), I am now using this straight key in preference, so much so, that I have called Steve at Moonraker and asked if I can buy it. I recommend it unhesitatingly. Everyone who learns Morse will have their preference in the type of key they prefer. I am grateful to Moonraker for the loan (and purchase) of the key which costs £169.99. For further details contact Moonraker (UK) Limited on 01908 281705 or see their website: www.moonrakeronline.com

Paul Marks, G8FVK
pmarks4550@aol.com



The Moonraker SHK-1 Straight Hand Key

Moonraker SHK-1 Straight Hand Key connected to a Yaesu FTDX101MP transceiver.

Antennas

Element Construction Techniques for Beam Arrays

A beam array can be an interesting and rewarding project to build and various designs have been covered in the Antennas column. These designs have included examples of constructing dipole centres, element clamps and mast clamps [1]. Therefore, this month's theme is element construction techniques that are suitable for HF, VHF or UHF beam arrays. Within the following and to keep things straightforward, these antennas have been referred to as beam arrays that also include Yagi arrays.

Element materials

A beam array consists of several conductive elements that are supported by a boom. As the wavelength of operation increases, so the beam array's elements become longer and heavier. Therefore, as the antenna's size increases, its elements need to be of a sturdier construction to avoid them sagging under their own weight and to withstand the wind load. However, the aim is still to keep the elements mechanically strong with their weight as low as practical, while keeping their electrical conductivity as high as possible. For these reasons, most beam arrays' elements are made from aluminium tubing, which has the added advantage of being reasonably resistant to outside weather conditions. In reality, aluminium is an alloy whose other constituents can include, for example, copper, zinc, iron, magnesium and silicon (amongst others) that are added to improve the mechanical and structural properties of the material. The tubes selected for the antenna's elements and boom should be made of an aluminium alloy that is suited to external applications, with a high resistance to corrosion, of good strength, has a low weight and has good electrical conductivity. Aluminium tubing of grades 6060 T6, 6062 T6, 6063 T6 or 6082 T6, or equivalent [2] would be a desirable choice.

Elements for VHF/UHF beam arrays

At these wavelengths, VHF and UHF beam arrays have element lengths whose weight becomes less of an issue and can be made up using aluminium tubes of the same diameter. Table 1 provides guidance for 6m, 4m, 2m and 70cm band beam arrays in terms of aluminium tube suited to making their elements and booms from. Most beam arrays for the 6m and 4m bands tend to use two lengths of the same aluminium tube for each element. However, for the 2m and 70cm bands, the beam array's elements are usually made from single lengths of aluminium tube.

An example of a 3-element Yagi beam array constructed for the 6m band comprising a reflector, halve wavelength (λ/2) dipole and a director is shown in **Photo 1**. The reflector and director elements are made from two identical aluminium tubes. These were held together using a fastening that was a part of each element's clamp used to secure it to the boom support. An example of a suitable home constructed element clamp is shown in **Photo 2**, which was made from four lengths of aluminium L-section held together using M4 nuts and bolts [1]. An M5 nut and bolt

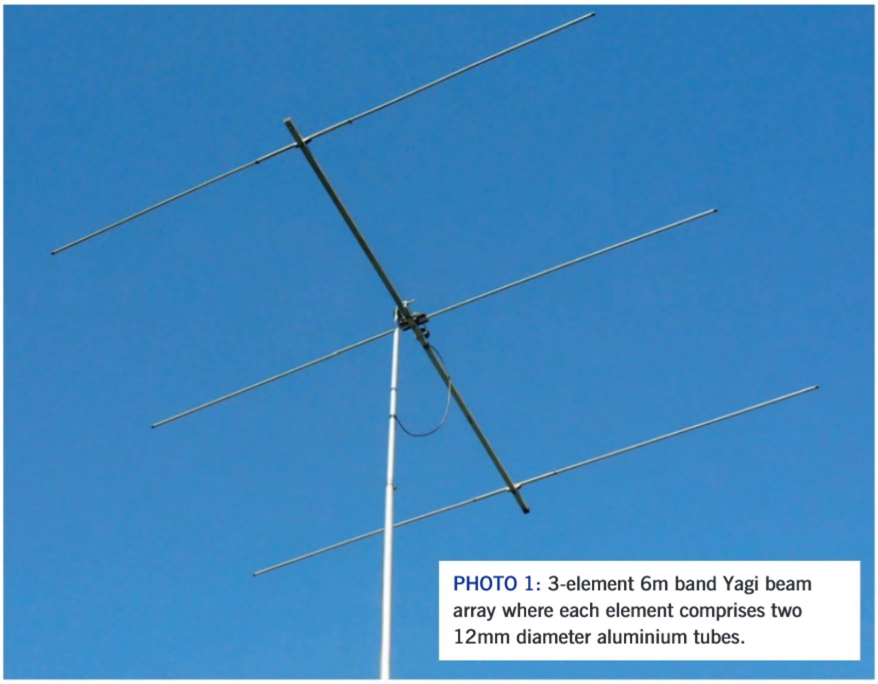


PHOTO 1: 3-element 6m band Yagi beam array where each element comprises two 12mm diameter aluminium tubes.

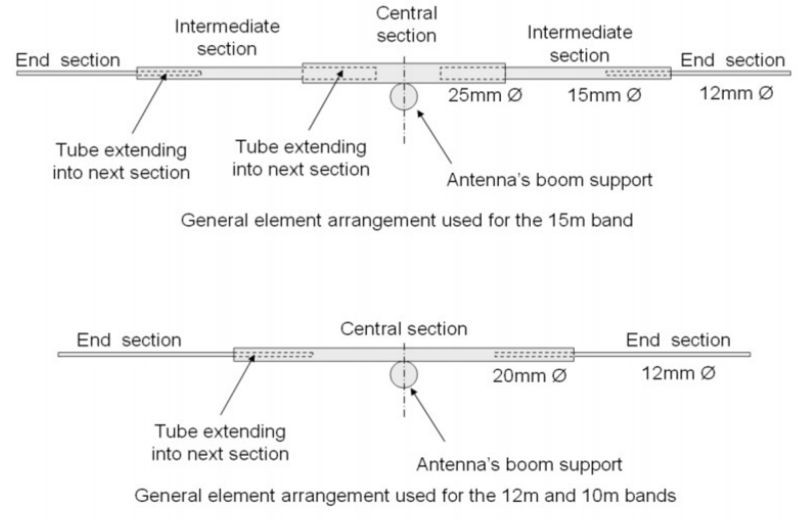


FIGURE 1: Guidance for the composite elements used for element beam arrays for the 15m, 12m and 10m bands.

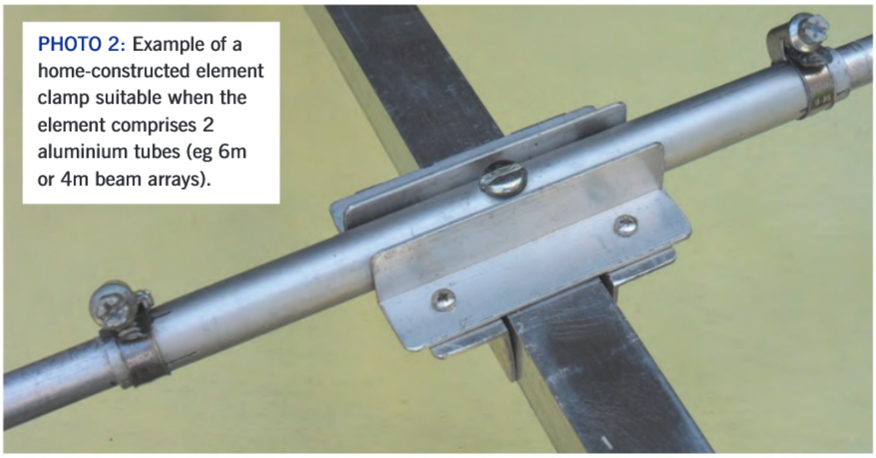


PHOTO 2: Example of a home-constructed element clamp suitable when the element comprises 2 aluminium tubes (eg 6m or 4m beam arrays).

PHOTO 3: 5-element 2m Yagi beam using elements made from individual 12mm diameter aluminium tubes.

secured the element clamp to the boom, using suitable holes drilled through the element clamp and boom. Two 20-25mm long lateral cuts were made at right angles to each other at each end of the clamp's central tube, which is a flush fit with each tube forming the element. Each tube was then slid into the element clamp and held in place using hose clips. The driven element was a dipole, with a commercial dipole centre used to support each of the dipole's legs.

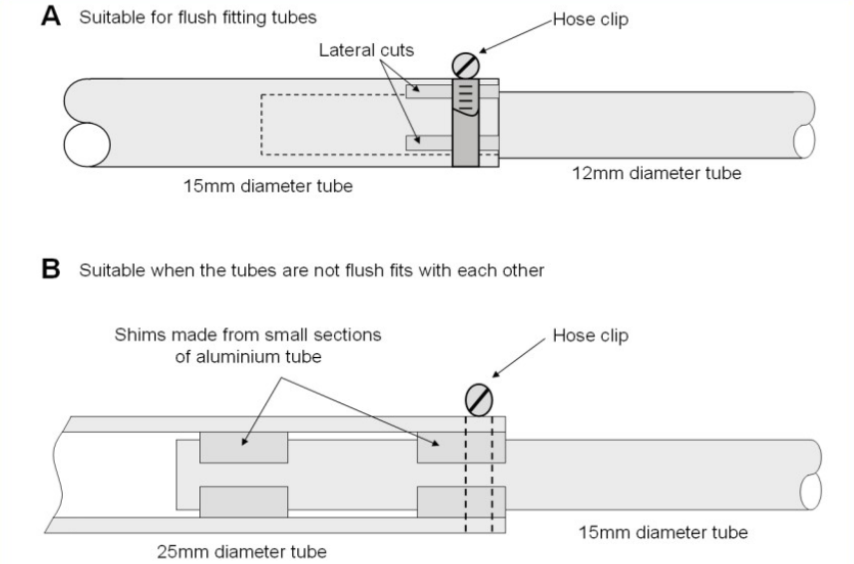


FIGURE 2: (A) A method of joining two sections of tube. (B) Joining two tube sections using shims where the tube diameters are a poor fit. A cross section is shown.

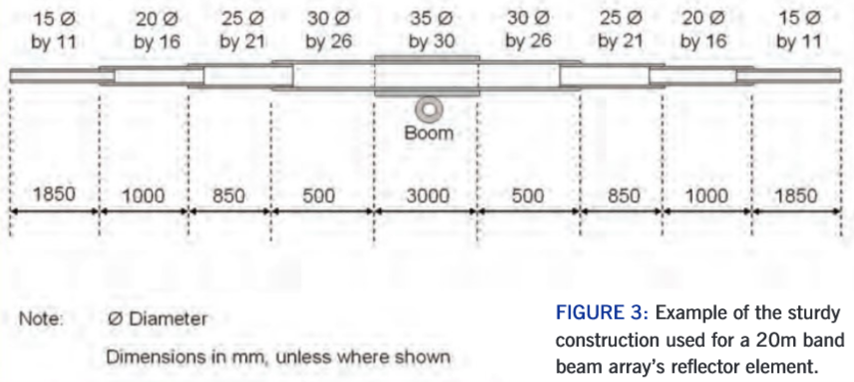


FIGURE 3: Example of the sturdy construction used for a 20m band beam array's reflector element.

Photo 3 shows an example of a 5-element 2m band Yagi beam array. The reflector and director elements are formed from single lengths of aluminium tube. The driven element was a λ/2 dipole, which used a home constructed dipole centre to support each dipole leg, which was fabricated from an electrical three-way conduit box [1]. The reflector and director elements were directly held in position using home constructed element clamps, M5 bolts and nuts of a similar construction to that previously described for the 6m Yagi beam.

Elements for HF beam arrays

The elements for 20m to 10m HF band beam arrays are much longer compared to elements used on the VHF and UHF bands because of the increase in the wavelength. As the operational wavelength increases, so the length of the elements becomes longer and their weight becomes increasingly an issue, leading to element sag and an increased wind load. To reduce their weight, these elements are often made up by using interconnecting sections of tube, whose diameters reduce towards the ends of the elements.

Beam arrays for the 15m, 12m and 10m bands often use elements made in this way and are typically comprised of two or three aluminium tubes whose concept is shown in Figure 1. Table 2 provides guidance for the bands above, in terms of the aluminium tubes that could be used to construct the elements.

To hold each element section in place, an end clamp can be made by laterally sawing two cuts, at right-angles to each other, across the

Mike Parkin, G0JMI
email2mikeparkin@gmail.com

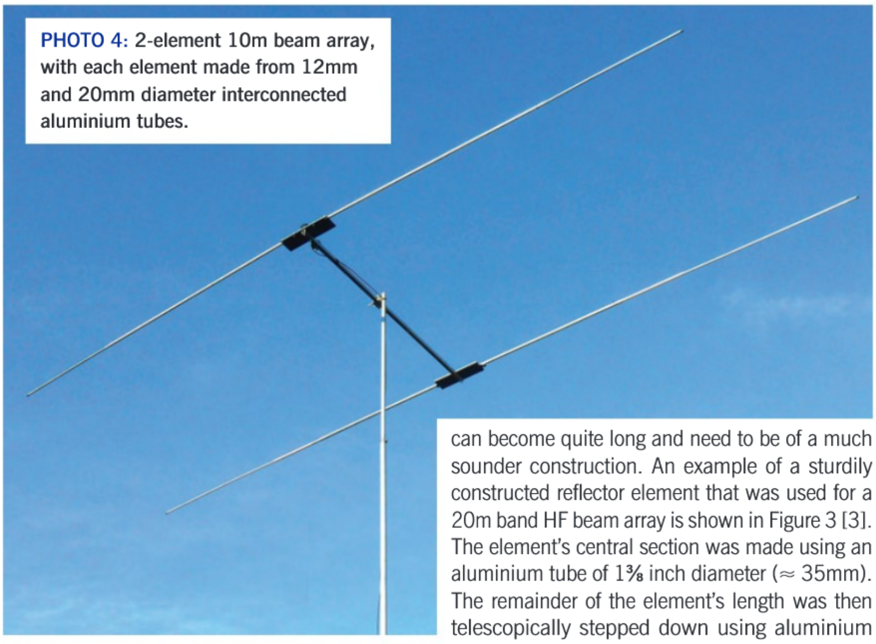


PHOTO 4: 2-element 10m beam array, with each element made from 12mm and 20mm diameter interconnected aluminium tubes.

PHOTO 5: Example of an antenna clamp suitable for use with larger HF beam arrays.

end of the larger tube to a depth of about 20 to 35mm depending on the tube's diameter. A part of the smaller diameter tube is then slid down inside the larger tube and a hose clip is used to secure the inner tube in place [3]. The concept of using this technique is shown in Figure 2A where the 15mm and 12mm diameter tubes are interconnected to form a section of an element. It is not always possible to obtain aluminium tubes that are good flush fits with each other and it may be necessary to make up and insert aluminium shims between the larger and smaller diameter tubes as shown in Figure 2B [3]. A short section of aluminium tube is used for each shim with a section removed down its length, enabling it to be a snug fit between the larger and smaller diameter tubes. The smaller diameter tube is then secured in place using the same clamp and hose clip arrangement as described previously. These clamping arrangements have the advantage that the element's length can be adjusted when tuning the antenna. The boom used to support the beam array's elements could be made from a length of 30mm diameter (or larger) aluminium tube, with a wall thickness of at about 2mm (or more).

Photo 4 shows an example of a two-element beam array constructed for the 10m band. The reflector and dipole elements were made from interconnecting 20mm and 12mm diameter aluminium tubes. 15mm diameter shims were used to enable each 12mm diameter tube to be held in place inside the larger 20mm diameter tube, with these clamped together with hose clips (see Figure 2B). The beam array used a home constructed dipole centre fabricated from a three-way electrical conduit box, with a nylon plate and saddle clamps used to support the dipole centre to reduce the physical load on it [1].

Elements for 17m and 20m band antennas can become quite long and need to be of a much sounder construction. An example of a sturdily constructed reflector element that was used for a 20m band HF beam array is shown in Figure 3 [3]. The element's central section was made using an aluminium tube of 1⅜ inch diameter (≈ 35mm). The remainder of the element's length was then telescopically stepped down using aluminium tube sections of diameter 30mm, 25mm, 20mm and 15mm as shown. Each element section was held in place using an end clamp as described previously (see Figure 2A). The two lateral cuts made to create each clamp were to a depth of about 20 to 35mm depending on the larger tube's diameter. A part of the smaller diameter tube was slid down inside the larger tube and secured with a suitable hose clip. This technique has the advantage of enabling the length of the element to be adjusted when tuning the antenna.

HF beam arrays tend to require element clamps that are capable of supporting the element's weight and wind loading placed upon it. These element clamps need to be of a much sturdier construction than those used for VHF/UHF beam arrays. An example of an element clamp used for a 25mm diameter element clamped to a 35mm diameter boom is shown in **Photo 5**. This element clamp was made using U-bolts and a 6mm thick aluminium plate.

Reference

[1] RSGB Radcom, Antennas: HF dipole centres, mast clamps, boom supports in August 2017. VHF/UHF dipole centres in February 2016. VHF Element clamps in September 2018 and March 2021. UHF dipole centres and element clamps in September 2021. HF beam dipole centres and element clamps in February 2021.

[2] Yagi Antennas Explained by M. Parkin, G0JMI. Chapter 4 Building Yagi Beam Arrays, page 44. Published 2021 by RSGB.

[3] RSGB Radio Communication Handbook, 14th edition, edited by Mike Browne, G3DIH: Section 13, Antenna Construction Techniques, pages 13.2 – 13.4.

Table 1: Suggested aluminium tube sizes for a VHF/UHF beam array's elements and boom.

Band	Element		Boom	
	Tube diameter	Tube wall thickness	Diameter or square section side	Wall thickness
6m	12 to 15mm	2mm	25mm	2mm*
4m	12mm	2mm	25mm	
2m	8 to 12mm	1 to 2mm	20 to 25mm	
70cm	6 to 8mm	1mm	20mm	

* **Note:** Longer Yagi beam arrays require a thicker walled boom to support them, eg 3mm or above.

Table 2: Suggested aluminium tube sizes for 15m to 10m band HF beam arrays' elements using interconnected tubes for each element (see Figure 1).

Band	Element section		
	Central section	intermediate section	End sections
15m	2.5m long of 25mm diameter	1.75m long of 15mm diameter	Length as required for wavelength of operation. Tube diameter of 12mm.
12m and 10m	2.5m long of 20mm diameter	Not used	

Review

The SOTABEAMS 2m bandpass filter

Perhaps the first question that you might very reasonably ask is why you might need a 2m bandpass filter. There are a number of scenarios where you might find one of use.

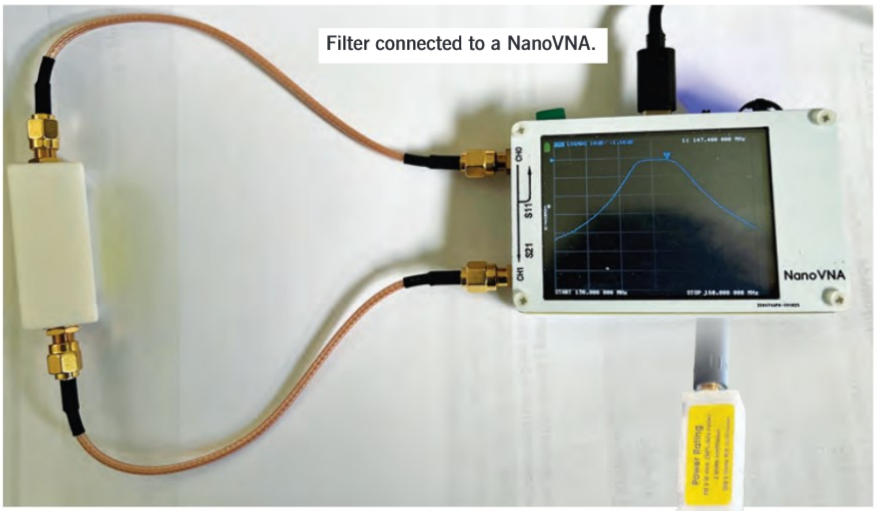
Maybe you are a keen VHF hilltop operator, participating in the Summits on the Air programme, or just someone who enjoys taking a handheld radio and operating from your local hilltop. Being a good location for radio, your local hilltop has a few masts on its summit. You've noticed when you're up there, that you suffer some interference and a high noise level on 2m and can't always hear as well as you'd like. In fact, SOTABEAMS have put together a video demonstrating the problem and the effect that the Bandpass filter has: youtu.be/FTjiym2KJko.

Perhaps you are a satellite operator and would like to reduce the amount of desensing that occurs to your 70cm receiver when you transmit on the 2m uplink.

Maybe you have a cheaper RTL-SDR receiver and find that a strong local FM radio station interferes with your reception of the 2m band.

You get the idea! A 2m bandpass filter is designed to pass only signals in the 2m band and attenuate, as much as possible, the signals out of that band.

SOTABEAMS have built such a filter and were kind enough to let us have a look at it. It is supplied ready built, in a neat case, with SMA-F connectors.



Filter connected to a NanoVNA.

Specifications

The filter is rated at 2W continuous, or 5W FM/Data (maximum continuous transmit for 90 seconds) so you can only use it with a handheld. Realistically, you probably wouldn't want to use it with a mobile set capable of higher power, as generally mobile sets have a bit more front-end filtering.

The specification, as supplied by the manufacturer is:

Filter power rating:

- FM/DATA – 5W maximum (30% duty cycle recommended, maximum continuous TX 90 seconds) – 2 W continuous.
- SSB – W PEP maximum continuous.

Filter bandwidth – 144-148MHz

Attenuation:

- In-band typically <3dB
- 433MHz >70dB
- 155MHz approx. 25dB
- FM broadcast band >70dB
- Air band >50 dB

Temperature range – 0-50°C

Weight – 25g

Other Features

- Filter supplied in a bespoke plastic case (nylon),
- Case includes guides for cable ties,
- Dimensions – 45 x 20 x 18 mm (case),
- Connectors – SMA-female both ends,
- Bright colours to make them harder to leave behind.

Performance

Looking at the attenuation figures claimed, you can see that outside of 2m, there is significant reduction to out-of-band signals, which should leave your handheld much better able to cope. For example, an FM broadcast band transmitter will be attenuated by over 70dB and the same with a 433MHz transmission. Marine band at around 156MHz is about 25dB down and Air band is about 50dB down.

I wanted to have a look at the performance of the filter myself and used my NanoVNA to test the response. The good news is that my results were very much in line with the claimed figures from SOTABEAMS and I could see the shape factor of the filter quite clearly, with its attenuation at its least between 144 and 146MHz, but showing significant roll-off before 141MHz and after around 149MHz. This is just what you need.

If you want to use the bandpass filter in line with the factory antenna, you may need to use some SMA adapters, depending on your handheld and antenna connections. Be a little careful in this configuration as it might be possible to damage the antenna connection on the handheld if you accidentally knock the filter or antenna. Better to be using the bandpass filter in line with an 'external' antenna like a beam or a vertical and then you can use flying leads which won't place any stress on the handheld's antenna connection.

I wonder if SOTABEAMS might consider marketing a 70cm bandpass filter too. That would be handy – something I know satellite operators would find useful, as well as hilltop operators wanting to use 70cm from congested RF sites.

Filter in position between a Yaesu FT2D handheld transceiver and antenna.

Conclusion

So, if you have a need for a 2m bandpass filter – especially if you are likely to visit hilltops which have a lot of RF on them and you want to operate on 2m – this could be a great solution. The SOTABEAMS 2m bandpass filter costs £44.95 and you can order it from the SOTABEAMS website. Many thanks to Martin at SOTABEAMS for the loan of the bandpass filter.

Tim Kirby, GW4VXE
gw4vxe@icloud.com

EMC

PHOTO 1: An early Openreach Fibre to the Premises (FTTP) installation.

G.Fast immunity

As mentioned in June 2022 EMC Column, G.fast in the UK uses a similar architecture to the existing Fibre-to-the-Cabinet (FTTC) service that is used for VDSL2. FTTC uses optical fibre cable from the telephone exchange to local PCP Street Cabinets and from there, it reaches the users' premises via existing copper telephony cables. Installations of G.Fast have been on pause since 2019 and new installations have used VDSL2 or Fibre-to-the-Premises (FTTP) technology. We have received a report of a case of breakthrough or ingress into a G.Fast broadband service from an amateur radio station which may be worthwhile sharing. In an urban area in the North of England, tempers were getting frayed between the radio amateur concerned and one or two not-so-local neighbours. The radio amateur's HF transmissions were apparently disrupting the internet service in just a few of the properties in a 200m+ radius from the transmitting antenna. These were not necessarily the houses closest to the antenna and the distribution of reported cases of breakthrough seemed random. The technology concerned was G.Fast. It is worth noting that, despite the cases being spread around the neighbourhood, the relevant street cabinet to which they were all connected was just 60m from the amateur radio transmitting antenna. According to reports, the response from Openreach's engineers to the customers affected had included comments that the problem was the radio amateur's transmitter and not the broadband service, and there was nothing that Openreach could do. The radio amateur concerned tried all the conventional remedies to address breakthrough into broadband routers, such as putting ferrite cores on leads and even putting the router into a screened box but to no avail. One local case of service disruption was cured by winding back the speed of service, which effected an improvement. Then, a formal written approach directly to the CEO of Openreach resulted in a rapid reply from Openreach's Network Technology Director, who offered to initiate investigations. Over an eight-month period, a number of investigations were conducted by Openreach, which supported the view that there could be deficiencies in the Openreach G.Fast installation. During all this time there was a regular email exchange between the radio amateur concerned and the Openreach executive concerned. In the end it seems that, rather than continue root-cause investigations, Openreach accelerated the installation of fibre to the premises (FTTP) which has remedied the issue. Whilst it remains a matter of speculation, anecdotal evidence suggests that the root cause might have been a DSLAM card in the street cabinet that was particularly sensitive to RF ingress. It is understood that the way subscribers are connected to the ports on a DSLAM card can be random, which would explain why the cases were apparently randomly spread around the neighbourhood. This is an example of how a professional approach to Openreach at the right level, taking a reasonable stance, can yield satisfactory results. We would be interested to hear of any other reports of cases where amateur radio transmissions affect G.Fast broadband Internet services, with details of the frequencies and the outcome.

G.Fast frequencies

The G.Fast specification ITU-T G.9700/9701 specifies starting frequencies greater than 2.2, 8.5, 17.664, or 30MHz and it goes up to 106MHz or 212MHz. Technical information on UK implementation of G.Fast seems to be scarce but it may start above 17.64MHz, possibly at 23MHz, to keep clear of VDSL2. The G.Fast specification requires that a FAST Transceiver Unit (FTU) shall be capable of being configured to notch one or more specific frequency bands in order to protect radio services; for example, amateur radio bands or broadcast radio bands. The international amateur radio bands to be notched are referred to as IAR bands, whilst the rest of the bands to be notched are referred to as RFI bands (see [1]). We understand that with G.Fast, in the UK, amateur radio bands are always notched so this should protect amateur radio bands from emissions (egress). G.Fast uses multi-carrier DMT modulation, like ADSL and VDSL2 but the sub-carrier spacing is different at 51.75kHz. If you see noise peaks at intervals of 51.75kHz outside amateur bands, it may be G.Fast. Broadband over copper services, including ADSL, VDSL2 and G.Fast, inevitably operate with relatively weak received signals. VDSL2 uses Frequency Division Duplexing (FDD) with different frequency bands for uplink and downlink but G.Fast uses time division duplexing (TDD) where both ends use the same range of frequencies, and they switch rapidly between transmit and receive. Both ends have broadband amplifiers that not only receive wanted G.fast signals on the line but also any other signals within the amplifier passband, including amateur radio transmissions. Although G.Fast doesn't use frequencies in the amateur bands for communications, they are still amplified and fed to the Analogue to Digital Converter (ADC) which needs sufficient dynamic range to handle strong signals. Otherwise, if the ADC overloads due to a strong signal, then the G.Fast link is unusable. Voice over IP (VoIP) with no analogue POTS service at 0 - 4kHz is being introduced as the only way to provide a voice telephony service, including emergency calls. This is a matter of concern because analogue POTS is very robust with high immunity to RF whereas G.Fast (and other DSL services) have less RF immunity to ingress of RF signals from amateur radio transmissions. The above report about G.Fast immunity raises the question of what was causing the G.Fast system to malfunction in the presence of amateur radio transmissions. If engineers told customers that the problem was the radio amateur's transmitter, then they would do well to note (b) of the Essential Requirements of the Electromagnetic Compatibility Regulations 2016 (see also below).

"The essential requirements are that:
a) equipment must be designed and manufactured to ensure that the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended.
b) the equipment has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use."

EMC Regulations Post Brexit

After the UK left the EU, what has happened to the UK EMC Regulations that implement the EU EMC Directive 2014/30/EU? According to GOV.UK Statutory guidance Electromagnetic Compatibility Regulations 2016 [2],
"The Electromagnetic Compatibility Regulations 2016 implements into UK law an EU Directive (2014/30/EU) on electromagnetic compatibility (commonly called the EMC Directive). The EU Withdrawal Act 2018 preserved the Regulations and enabled them to be amended so as to continue to function effectively now that the UK has left the EU. Accordingly, the Product Safety and Metrology etc. (Amendment etc.) (EU Exit) Regulations 2019 see footnote 1 fixed any deficiencies that arose from the UK leaving the EU (such as references to EU institutions) and made specific provision for the GB market."

"There is therefore one set of UK 2016 Regulations, but some of the provisions apply differently in NI for as long as the Northern Ireland Protocol is in force. References to the 2016 Regulations in this guidance are references to those Regulations as they apply in Great Britain."

The Essential Requirements of the EMC Regulations as stated above have not changed.

CE Mark Post Brexit

Sections 8 and 9 of [2] cover Conformity assessment and marking – products placed on the GB market before 11pm 31 December 2022 and from 1 January 2023. The rules are quite complex with differences between GB and NI markets but from 1 January 2023, anyone purchasing electrical and electronic equipment intended for the GB market can expect to see the new UKCA mark and possibly also a CE Mark. Purchasers may find the UKCA marking on the product itself or during a transition period until 31 December 2025, it may be on a label affixed to the product or on a document accompanying the product. Section 12 of [2] covers Enforcement and penalties and it states,

"In Great Britain, the market surveillance authority for apparatus, in relation to protection and management of the radio spectrum is Office of Communications (OFCOM), and for other apparatus is the local weights and measures authority (trading standards)."

There is of course a possibility that we will find electrical and electronic equipment placed on the GB market after 1 Jan 2023 that doesn't have the required UKCA marking. As EMC compliance is about protection and management of the radio spectrum, it appears that if any electrical and electronic equipment that is subject to EMC Regulations is placed on the GB market after 1 Jan 2023 without UKCA marking, then it can be reported to Ofcom as not being in conformity with the legal requirements of the 2016 Regulations as amended. It will be interesting to see how much UKCA marking enforcement takes place.

FTTP

Photo 1 shows an early Openreach Fibre to the Premises (FTTP) installation, installed in 2016. The cable with the green sleeve is the optical fibre. This comes into the larger white box, which is the Optical Network Terminator (ONT). The smaller white box is a battery backup unit which is not normally fitted nowadays. The system shown has a short Ethernet cable and has no known RFI issues. The EMC characteristics of FTTP should be ideal because optical fibre does not radiate any RF interference and it is completely immune to ingress of interference. Nevertheless, this favourable EMC performance may sometimes be spoiled by a noisy switching power supply unit, as mentioned in April 2022 and June 2022 EMC Columns. A Member form Cleveland, Ohio, USA writes:

"I would like to bring an American perspective to your comments about the fibre optical to wire line interfaces. In a household with two active amateur operators and such an interface, we have NOT experienced any form of RFI or EMC interference issues thus far. Admittedly, the interface is on the long diagonal from our shack and has the bulk of the house between it and our antennas. One thing that we did do (which might be helping) is to power the interface through battery backup power supply to keep the telephone and internet connections up until our stand-by generator kicks in".

A Member in County Durham writes: "Just read the article in RadCom FTTP (we have had this for about three years) and I can report an enormous amount of noise generated by the switching PSU supplied. A combination of a shack mains filters as described during an RSGB convention, approx. 30 turns of the DC cable around a toroid and even changing the data cables to CAT 6 has largely tamed it. I found that the noise generated was being radiated around the house by the small CAT 5 network. With teenagers we have a vast number of switched mode power supplies, but this was probably about the worst of them, followed by the power supplies to the router and two additional Wi-Fi access points. It may be that they appear to be worse as the CAT 5 cable runs throughout the house and acts like an antenna, despite being twisted pairs and balanced.

On the plus side, on 160m and 80m I can hear stations that others can't hear. This it isn't the antenna, it is the low noise level where I live in rural Co. Durham, and in addition lots of ferrite.

Websearch

[1] International Telecommunication Union (ITU-T) Recommendation G.9700 (07/19)
G.9700 : Fast access to subscriber terminals (G.fast) - Power spectral density specification
https://www.itu.int/rec/T-REC-G.9700-201907-I/en
[2] Statutory guidance Electromagnetic Compatibility Regulations 2016
https://www.gov.uk/government/publications/electromagnetic-compatibility-regulations-2016

Dr David Lauder, G0SNO
emc.radcom@rsgb.org.uk

QDX Digital Transceiver

This review describes how I built, tested and then used the QDX digital transceiver from QRP Labs.

I noticed an advert for the QRP Labs **[1]** QDX Digital Transceiver in SPRAT **[2]** back in mid 2021. This looked extremely interesting, so I decided to buy one. Sales opened in December 2021 and although I tried to order, as soon as the clock ticked to the mark I still missed out. I understand that batch sold out in about four minutes. As some components had become unavailable there was a redesign delay for the second batch. Anyway, my order was held over and I eventually got my kit in May 2022.

Not a QDX Review

If you are expecting a technical review with lots of figures and graphs, this isn't it, I don't have the equipment or expertise. The documentation supplied however is extremely comprehensive both for construction and operation including a full description of the design and is available for download from the website. I have no affiliation with QRP Labs and am not providing any recommendation except to say it appears to do exactly what it says on the tin. This article is a brief appraisal of my build experience and a use case for the unit.

It's been a while…

A while that is since I built anything this small and in the meantime I have aged a little. I found the build a challenge as my hands appear to be a little less steady than the last time I built something that required a bit a dexterity and a rock steady hand.

Photos 1 and 2 show the completed board. I have to say from a casual look it does not look too bad. There are 10 toroids to wind. I did these first and found them fairly easy to do. The instructions are really comprehensive for this task. As normal for partial kits these days, all SMD components are installed as there are a very small number of people that could build this otherwise.

There are a fair number of leaded components to install, capacitors, inductors, diodes and the PA transistors as well as the connectors. These didn't present any real problems although I could have done with a slightly more pointed tip on my iron. The four PA transistors went in without too much hassle.

The inductors proved troublesome. The ones with the thicker wire were OK after scraping the enamel off they soldered fairly easily. The thinner wire was the problem. The instructions say to hold the iron on the joint with a blob of solder for 10 seconds. This didn't work for me and also my hand started to wobble forcing me to abandon the joint. At this point, near disaster struck. As I removed the iron the toroid fell out! There are copious warnings about making sure all components are correctly installed because changing a wrong component is hard and also one mention of not letting your toroid escape! The effect of course is to block up the plated through-hole and it's the very devil to get the solder out. I have a de-soldering tool and braid and it still took me a while. Having got over that nightmare I discovered another blocked hole, which must have been a previous involuntary movement while soldering one of the leaded components.

After these episodes I decided to carefully strip the enamel from all the toroids prior to soldering. This worked a lot better as I only needed to hold the iron on the joint for a few seconds. The holes are only large enough to pass the wire through so pre-tinning is not a good idea as the wire may not pass through the hole afterwards.

Photo 1. QRP Labs QDX PCB Top Veiw.

Nervous - testing, testing

The board can be built for 9 or 12 volts. I built mine for 12 volts. However, I was not prepared to apply 12V and hope for the best as I was not confident I hadn't inadvertently created a solder bridge somewhere.

I used my variable voltage lab power supply with the voltage and current turned way down, a watt meter and a dummy load. I ramped the PSU up to 9V and the status LED flickered for a few seconds then turned solid. This is correct according to the instructions. I then fired up WSJT-X and configured it as per the instructions, selected WSPR mode, enabled Tx and noted I was getting a few watts out. I ramped

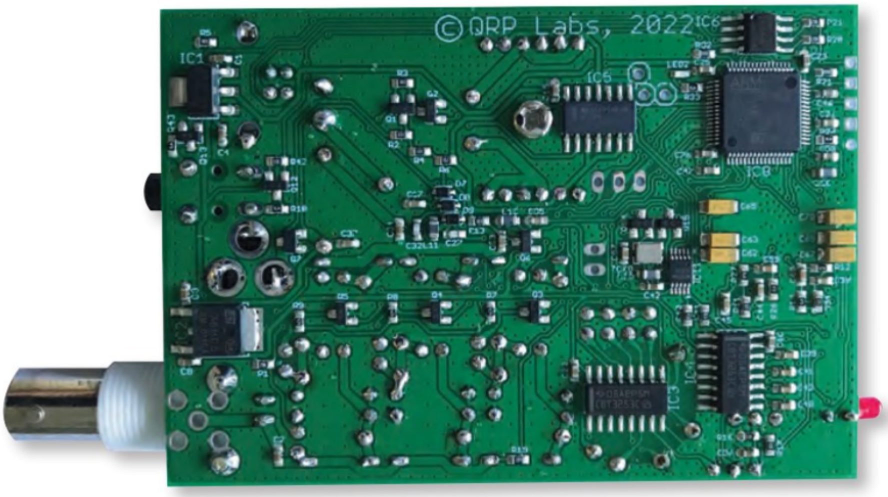


Photo 2. QRP Labs QDX PCB uses surface mount componants on both sides.

Photo 4. QRP Labs QDX inside its case, Rasberry Pi 4 powered from PoIP Switch.

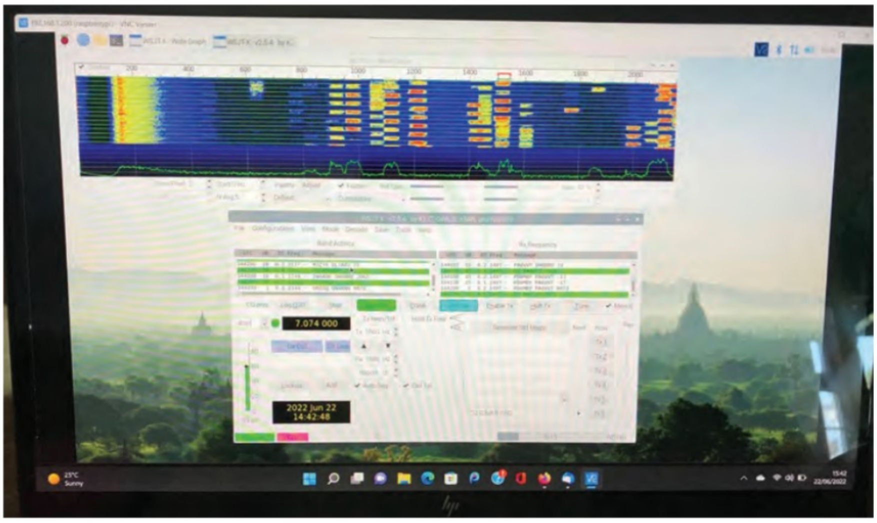


Photo 5. QRP Labs QDX in use with a laptop via VNC.

Photo 3. Pi 4 and QDX are similar in size.

the PSU up to 12V and was getting about 4.5 watts, which I was happy with being the right side of 5 watts. There are warnings about excessive power killing the PA transistors so I wanted to ensure that would not happen.

Connecting to an antenna confirmed that the receiver was operating correctly.

Hassle free

This really is a simple system to run. There is no alignment to do and everything needed is built in, which is pretty remarkable for such a small unit. All that's required is a computer with a USB interface and a digi-modes program such as WSJT-X. I teamed this little box up with an RPi 4. You can install the latest version of WSJT-X **[3]** and it works extremely well. **Photo 3** shows the unit in its custom box sitting on top of the RPi 4 as both are about the same size. **Photo 4** shows the units operational in the shack. Power is supplied to both units via the IP power switch on the left.

The RPi has VNC enabled and is connected to the house network. I can therefore connect to the IP power switch from any computer and power on, then VNC onto the RPi and run WSJT-X.

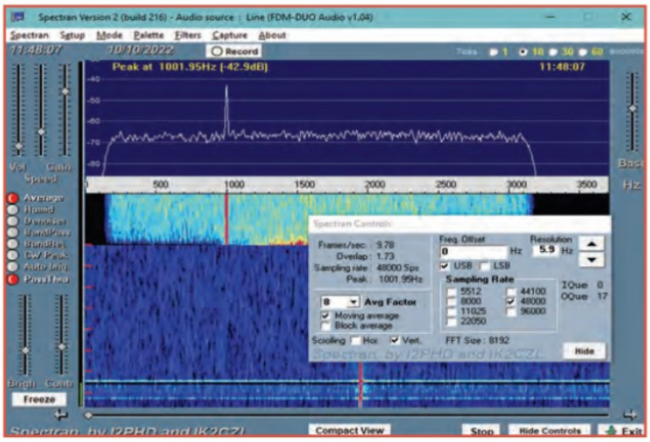
I have a small laptop that makes an ideal data terminal for use within the house, see **Photo 5**. I can also connect from the main computer or from a tablet. If connecting locally it would make sense to connect direct from a laptop or other device running WSJT-X.

Websearch

1:https://www.qrp-labs.com/
2:http://www.gqrp.com/sprat.htm
3:https://photobyte.org/raspberry-pi-update-to-wsjt-x-2-3-0/

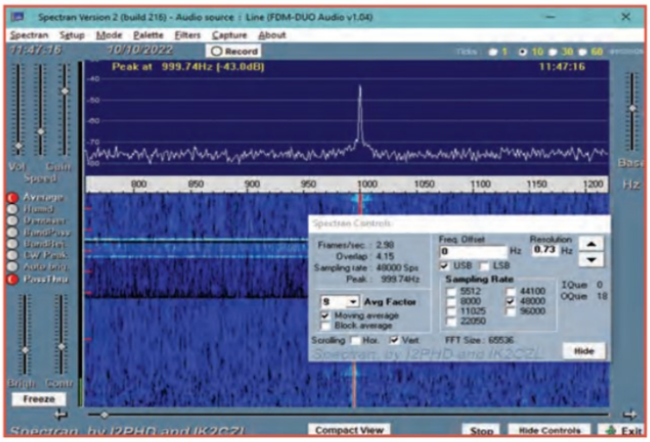
Bob Cowdery, G3UKB
bob@bobcowdery.plus.com

Design Notes



Frames/sec. : 9.78
Overlap : 1.73
Sampling rate : 48000 Sps
Peak : 1001.95Hz
Freq. Offset 0 Hz
Resolution 5.9 Hz
☑ USB ☐ LSB
Sampling Rate: ☐ 5512 ☐ 8000 ☐ 11025 ☐ 22050 ☐ 44100 ☑ 48000 ☐ 96000
IQue 0
OQue 17
8 Avg Factor
☑ Moving average
☐ Block average
Scrolling ☐ Hor. ☑ Vert.
FFT Size : 8192

FIGURE 1: 24dB S/N carrier in 5.9Hz Bandwidth.



Frames/sec. : 2.98
Overlap : 4.15
Sampling rate : 48000 Sps
Peak : 999.74Hz
Freq. Offset 0 Hz
Resolution 0.73 Hz
☑ USB ☐ LSB
Sampling Rate: ☐ 5512 ☐ 8000 ☐ 11025 ☐ 22050 ☐ 44100 ☑ 48000 ☐ 96000
IQue 0
OQue 18
9 Avg Factor
☑ Moving average
☐ Block average
Scrolling ☐ Hor. ☑ Vert.
FFT Size : 65536

FIGURE 2: 33dB in 0.73Hz.

Leap Seconds and GPS

Last time I mentioned how a GNSS receiver module can show an error of several seconds in the time it sends out on the NMEA data stream, and that this error can persist for up to 12.5 minutes until the satellite broadcasts the correct leap second correction. (The 7.5 minutes figure previously was an error). For applications where this time offset matters like in real time clocks and datamode timing, it is possible to find out the leap second correction status by reading the GNSS receiver module. The notes here apply only to Ublox modules, a different technique will be needed for GNSS receivers made by other manufacturers. A proprietary message is available from all Ublox modules that gives a summary of timing information. The message is not automatically sent out in the way the normal NMEA messages are generated, it has to be requested. This is done by sending the following message to the GNSS module on its serial input port (a pin usually labelled RXD). Use the same serial settings and baud rate as that used for the messages being received from the module. $PUBX,04*37 Which stands, roughly, for 'Proprietary UBloX, message type 04'. The final '37' is a checksum generated by exclusive ORing all the characters between, but not including, the initial $ and terminating*. The byte resulting from the XOR operation is sent in hexadecimal. After receiving this message, the module replies with a long string of the form:

```
$PUBX,04,070846.00,101022,112126.00,2231,15D,123428,-503.195,21*7A
```

This contains most of the timing information the module is operating with. Going from the left side the fields separated by commas after a repeat of the command identity are:

The UTC time in HHMMSS.SS (07:08:46 UTC), the date as DDmmYY (10/10/2022), the GPS time of the week, defined in seconds since Sunday 00:00:00 UTC (112126.00 seconds).

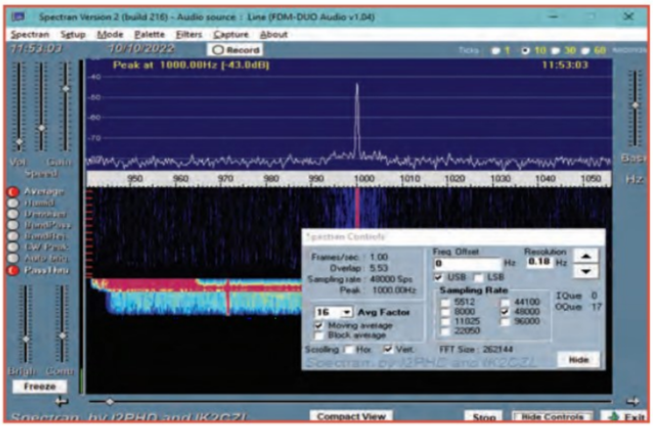
The week number since GPS day zero, defined as Midnight on 5/6 January 1980, or 00:00:00 UTC 6/1/1980 (2231 weeks). The next frame, shown underlined as '15D', is the leap second status. If the letter 'D', for Default, is present this is a pre-stored number of seconds that has not been updated from a satellite broadcast. 15 showing here is the number of leap seconds that there were since 1980, up to the time the GNSS module's firmware was written. When the correct leap second information has finally appeared in the satellite broadcast, this field changes to the current offset which at the time of writing is 18 seconds; 'D' disappears to show it is a current value and no longer a default. The fields after this relate to clock frequencies and other internal matters which we needn't consider. A typical response after leap seconds have been corrected is :

```
$PUBX,04,071506.00,101022,112506.00,2231,18,
34638,-94.855,21*37
```

To make use of this information where it is important that time be accurate to the second, at start-up the controller needs to follow this procedure: Send the $PUBX,04*37 message to the GNSS module and parse the returning data for the associated response, store this when it appears, then look at the appropriate field to get the leap second status. The correct procedure would now be to sit in a loop, continuously sending the request and wait for the 'D' to disappear before getting on with the control task proper, which could mean up to 12.5 minutes wasted with it sitting and doing nothing of any value. But we can cheat. If we take the controller's default value and know our current leap second offset from experience or past operation, the two can be subtracted to obtain an offset immediately, so the controller can start doing its main task straightaway. It will still be necessary to repeatedly poll for the leap second status since after several minutes using the calculated figure, the field will be updated and can be used as-is. Both techniques are tedious but it will have to be done if automatic leap second correction, or at least a warning of it, is essential. But if we are prepared to poll repeatedly to get leap second status a simplification can be made. As the $PUBX message already contains full UTC date and time, there is now no further need to look at any of the other NMEA messages to read the same thing.

An Arithmetical Aside.

While we're at it – let's take a look at those 'GPS time' values: Time Of Week, and week number. Using the values from the second message:



Frames/sec : 1.00
Overlap : 5.53
Sampling rate : 48000 Sps
Peak : 1000.00Hz
Freq Offset 0 Hz
Resolution 0.18 Hz
☑ USB ☐ LSB
Sampling Rate
☐ 5512 ☐ 8000 ☐ 11025 ☐ 22050 ☐ 44100 ☑ 48000 ☐ 96000
IQue 0
OQue 17
16 Avg Factor
☑ Moving average
☐ Block average
Scrolling ☐ Hor ☑ Vert
FFT Size : 262144

FIGURE 3: 39dB S/N in 180mHz bandwidth.

TOW = 112506. There are 60*60*24 = 86400 seconds in a day, so repeatedly subtract this from TOW to get the number of days since Sunday. 112506 – 1* 86400 = 26106. One day after, so it must be Monday (yes it is – with just three days to go before the *RadCom* input deadline, but you don't need to know that). Divide the remainder by 3600 to get hours; 26016/3600 = 7 hours, with a remainder of 906s, which is 15 minutes and 6 seconds making a time of 07:15:06 UTC. Exactly what the third field shows. Checking the week number is more convoluted, but by using the various date calculation functions in an Excel spreadsheet showed that adding 2231 weeks (15617 days) onto 6 January 1980 did indeed give today, 10 October 2022. Just trust me, it did! I already had a spreadsheet for just this sort of calculation.

Noise Bandwidth and Measurement

A recent discussion on the UK Microwaves Groups.IO centred around the meaning of Signal to Noise, S/N, reports sent to the Beaconspot reporting web site [1]. Some members were unsure of the meaning of the bandwidth value and didn't appreciate how important this is to make any S/N report meaningful. It is quite safe to say that any S/N report is totally and utterly meaningless unless the correct noise bandwidth is specified. But what is the noise bandwidth? It's not the IF filter bandwidth you're using. It's not the screen width of your waterfall/spectrum display. So what is it? Defining noise bandwidth and getting the correct S/N can get complicated, especially for modulated signals. Let's first take a plain carrier received and displayed using an FFT on some spectrum display – I use Spectran to look at the audio from a receiver. Figure 1 shows a plain single tone at a S/N that allows it to be heard from the receiver speaker as a noisy tone, one that most CW ops would be able to work with easily, but a level where SSB would be difficult. A sampling rate of 48000Hz has been used and the spectrum display clearly shows that an SSB type of filter has been applied, giving a roll off above 3000Hz. Averaging has been applied in order to flatten the noise display and make it easier to read off, but this is not important when measuring narrow single carriers and doesn't affect the amplitude reading. It is important, though, when looking at modulated signals – as we'll come to later. The important value for getting the S/N is the figure quoted in the settings window, 'Resolution' 5.9Hz. This is the post-FFT processing bandwidth that defines the noise level around the signal in the spectrum display. The value is obtained by dividing the sampling rate by the FFT size, here 48000Hz / 8192 = 5.85Hz. This is not the full story and we'll come to that later, it will suffice for now. We can directly read off the screen, visually averaging the jagged line, and see the noise is at a level of pretty close to -67dB. The signal takes what looks to be a single bin in width and sits at a level of -43dB (Spectran even finds this and tells us). The S/N is then just -43dB signal minus -67dB noise = +24dB in 5.9Hz bandwidth. Hold that for now. Look at Figure 2 where the signal and receiver are completely unchanged but the Spectran software has been adjusted to give a resolution bandwidth of 0.73Hz, an FFT size of 65536, eight times higher. The signal spike is still at -43dB, which is what you'd expect as it was untouched. The noise level is now reading around -76dB (I should have used more averaging – it's a bit spiky, making the estimation a bit more hit-and-miss). The noise has dropped from -67dB before to -76dB, which is 9dB lower. 9dB just happens to be eight times, exactly the amount by which the bandwidth was reduced when going from 5.9 to 0.73Hz. The S/N is now 76 – 43 = 33dB. 9dB higher than it was before for exactly the same signal. In Figure 3 the RBW has been reduced still further to 0.181Hz (48000Hz / 282144), a quarter the previous setting. Noise drops to -82dB for a S/N of 39dB which is 6dB (four times) up on before; exactly the same sort of change. Carefully look a few Hz either side of the carrier spike. Notice the slightly raised noise floor, something like 3dB above the wider spaced stuff. This is the phase noise of my 10 – 18000MHz synthesizer generating the test signal at 70.03MHz. It has a YIG oscillator and a narrow PLL loop bandwidth of a few tens of Hertz so phase noise is degraded close into the carrier. Only significant if signalling is being done in this sort of bandwidth – but we've digressed.

The WSJT/Ham Standard – 2500Hz

The same signal has now given us three different S/N values, all read off directly from the spectrum display. We can see these can all mean the same thing, but it doesn't stop them still being three different numbers – ambiguous if used for reporting as no one knows what you mean. The WSJT datamode suite introduced the concept of normalising S/N to a reference bandwidth of 2500Hz, being that of a typical SSB filter and chosen presumably so the average listener could compare with what can be heard from an SSB radio. It's a bit arbitrary and in a purely sensible mathematical and engineering world the bandwidth to use as a reference would be 1Hz. But what's done is done and we've adopted 2500Hz as a reference value to report with. To get from the S/N measured on the spectrum display it is necessary to normalise the arbitrary measurement bandwidth B to 2500Hz. As noise power is proportional to bandwidth, the scaling is simply done simply by multiplying by the ratio of B to the 2.5kHz reference. Since we're working in decibels throughout, the best way to make the correction is to add 10.LOG(B / 2500Hz) dB to the observed S/N. This ratio usually gives a negative number of dB so it's more convenient to invert the numbers inside the LOG() term and subtract the correction term, 10.LOG(2500 / B). Taking our first measurement of 24dB S/N, the normalised value is 24 - 10.LOG(2500/5.9) = -2.3dB. Taking the third example of 39dB S/N in 180mHz, the normalised value works out at 39 – 10.LOG(2500 / 0.18) = -2.4dB. The same to all intents and purposes. That this is a negative S/N in an SSB bandwidth does indeed confirm the statement in the opening section that the level selected was such that SSB would not really be possible. The normalisation explains the seemingly strange negative values quoted for the thresholds of all but one of the WSJT-X modes. The one exception is MSK144 which does actually occupy a bandwidth of around 2kHz and has a threshold sensitivity of 'plus a few' dB S/N.

Andy Talbot, G4JNT
andy.g4jnt@gmail.com

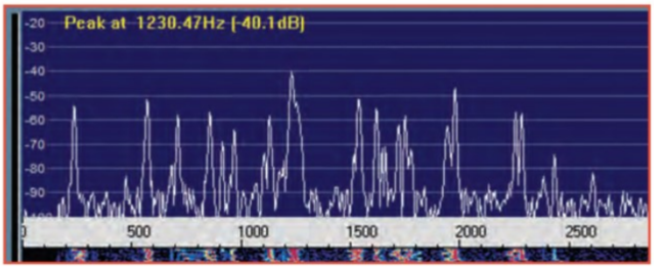


FIGURE 4: **FT8 Spectrum on the 14MHz band with no FFT averaging applied. Using a 5.9Hz resolution bandwidth.**

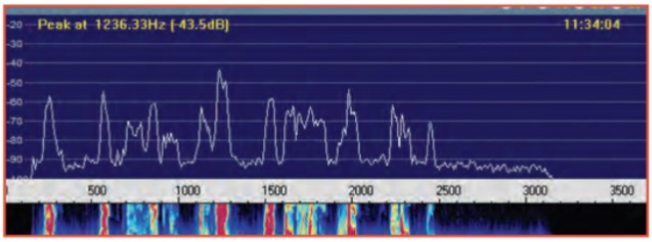


FIGURE 5: **Averaging applied to FT8 signals broadens each one out to a vaguely rectangular block with a reduced amplitude.**

Modulated Signals

Looking at single carriers is all very well, but what about wider modulated signals, occupying several FFT bins (measurement resolution bandwidths)? Figure 4 shows a single snapshot of the FT8 spectrum, recorded on 14MHz earlier today. No time averaging has been applied, and the 5.9Hz resolution FFT bandwidth means the plot shows predominately one, or perhaps two, individual tones of the eight making up any particular transmission. The tones are spaced by 6.25Hz and move around at this rate, so you can appreciate the spectrum will be a bit of a mess. But if a single spike looks clean and like a spike, as some of them do, it can be assumed to be pretty close to being a single individual tone so the S/N can be estimated as above. But if the display happens to capture two successive tones on any individual transmission with perhaps 50% of the time spent on each tone, then each would be 3dB down. The solution is to turn on averaging. Figure 5 shows the identical audio stream, recorded at exactly the same time as that for Figure 4, but now time-averaged over 16 successive FFT intervals. Each separate transmission becomes less spiky and more of a rectangular block of the 8 tones. Longer averaging produces neater blocks. Now, the height of each signal block is more representative of the total signal amplitude, but it is lower than each spike as the energy is spread over frequency. So what bandwidth do we now use? The best estimate is to use the width of each averaged block – the width of one signal with its eight tones, 8 * 6.25Hz for a total bandwidth of 50Hz. Let's do a bit of hand-wavy approximation and look at the amplitude of the largest of the signals in the two plots, the one at 1230Hz. This is not a perfect single tone spike but is not too far off one to worry about; it has an amplitude of -40dB. In the averaged plot, it's just about possible to pretend to ourselves the block for this same signal has a mean height of around -48dB. We've gone from a resolution BW of, let's call it 6Hz in Figure 4, to 8 times that or 50Hz in Figure 5. The 9dB increase in BW taken for measurement is associated with a lowering of amplitude from -40 to -48dB. 8dB reduction. That's not too far out is it? I did say it was a hand-wavy approximation. When normalising to 2500Hz S/N, we need to correct for the wider bandwidth occupied by the averaged signal to end up with a not-too-different value from that of the single carrier value in a single bin. But it is all a bit fraught, with FFT bin bandwidth, tone spacing and averaged tone bandwidth over the span of each signal, so any modulation type has to be considered on its merits and a judgement taken. And don't forget that in all this, the noise level, the real noise that is, is still defined as before, by using the FFT bin bandwidth. As an aside, look at the FT8 spectrum and see if there is any real noise level to be found in there that can be measured. One can't help but wonder just how the WSJT-X software does actually determine the noise in order to report a S/N level.

And it's All Wrong, anyway.

Spectran quotes a resolution bandwidth equal to sampling rate divided by FFT size. This is the width of an FFT bin, F^{sample} / FFT Size, but is NOT actually the real noise bandwidth in practice – it's telling lies. FFT spectral analysis software doesn't work exactly like this. The input sampled data is usually windowed, or pre-multiplied by an amplitude tailored curve over the duration of each capture interval. If this isn't done the maximum dynamic range that can be displayed is severely reduced and could go as low as just 13dB – totally useless for many practical purposes [2]. This is due to the beginning and end of each captured block of samples being randomly truncated. The windowing ensures that the beginning and end samples of each block are reduced to zero, or nearly zero, leaving those in the middle at full amplitude. What happens in between is a function of the window type. The effect of pre-multiplying the input samples before the FFT process increases the dynamic range of the resulting spectral display, but at the expense of broadening the individual spectra and increasing the resolution (and hence noise) bandwidth. There is a trade-off between maximum dynamic range possible for the FFT output spectrum and resolution bandwidth. A popular window, the Hamming window, increases dynamic range to around 43dB but broadens the resolution bandwidth to a bit under two bins. Another one, the Blackman-Harris window allows more than 80dB dynamic range but widens the plot to around 3 bins. Depending on window type that 5.9Hz we thought we were using to measure noise power could actually be 10 – 18Hz, 2 to 3dB difference. The shape that a pure single tone gives on the display also differs with window type, being neat and sharp for Hamming and fatter for Blackman-Harris. If you use a spectral display on an SDR, or a separate spectral analysis software, look for a menu selection labelled "Window Type" or something similar and play around. Correctly written software will maintain a constant plot amplitude for a pure single tone for different window types, but the noise level will change as the different windows are selected. Not all FFT software is correctly written – Spectravue for the SDR_IQ, for example, allows many window types to be selected (good!) but the displayed amplitude of a carrier changes with different window types (bad). It shouldn't. Spectran doesn't appear to offer any window type selection at all, so who knows which one it uses. There's a good chance it's Hamming, so an RBW nearly twice that shown would be a reasonable starting point for absolute S/N measurement. But it might be something else.

References

[1] https://www.beaconspot.uk/index2.php Beaconspot beacon reporting site. You need to initially register and set a password, but this is just a formality to stop the site being overwhelmed.

[2] Having said that having no FFT window with its resulting poor dynamic range is useless, this isn't necessarily the case. No window does give the narrowest frequency resolution which really is now just one bin. If the tone of interest can be centred on an individual bin and doesn't straddle two adjacent ones, it can be properly measured. This can't be done for general spectral analysis but custom data demodulators that downconvert and fine tune the input waveform can ensure this exact fit. The data rate and timing is exactly matched to the FFTs used for decoding so there is no need for windowing. FFT type demodulation is used within the WSJT suite for decoding the multiple tones. Of greater significance, all the OFDM modulations used in modern life; Wi-Fi, ADSL broadband, DAB Radio, Terrestrial TV broadcasting and 4G/5G mobile phones all adopt FFT or similar routines to demodulate the multiple carriers making up the overall signal.

Index 2022

Reviews

Book review

Regulars

Antennas, Mike Parkin, G0JMI
ATV, Dave Crump, G8GKQ
Contest Calendar, Ian Pawson, G0FCT
Contesting, Chris Tran, GM3WOJ, Ben, M7TXR & John Warburton, G4IRN
Data, Design Notes, Andy Talbot, G4JNT
EMC, Dr David Lauder, G0SNO
GHz bands, Dr John Worsnop, G4BAO
HF, Daimon Tilley, G4USI & John Petters, G3YPZ
LF, Dave Pick, G3YXM
Members' ads
Propagation, Gwyn Williams, G4FKH
QRP Matters, Steve Hartley, G0FUW
Rallies & events
The Last Word
VHF / UHF, James Stevens, M0JCQ & Paul Marks, G8FVK

Out & About Chasing Foxes

A portable Fox transmitter using an Arduino Uno and BaoFeng UV5R.

The average amateur radio enthusiast will need to depend on some sort of RFI finding skills at some point in their operating career. One method in which amateurs can develop their own RFI finding skills is to participate in some 2m Foxhunting. That activity where the kids run around with a receiver trying to find a beacon? Well, yes exactly that! The principles of direction finding have not really changed much since its development during the war. Amateur radio foxhunting gives us the ability to develop these skills in a controlled manner. Place a beacon (from now on, 'fox') in a secret location and by using a directional antenna, such as a Yagi or loop, you can begin to locate the fox. By recording on a map the bearing in degrees and signal strength of the fox's transmission, one is able to hopefully locate the fox. Then, by repeating this process until the area on the map is small enough, you can hunt for the fox on foot. As the signal strength becomes stronger you may even need an attenuator for your antenna, to sniff it out. The Fox is usually just a CW beacon running a low power transmission which repeats itself at timed intervals. If this beacon were to represent a noise source that you might be experiencing at home, causing RFI issues, the principles learned in finding the fox, would be useful in finding that same noise source at home.

What you will need

Before I get started, you will require a Baofeng UV5R or similar transceiver, an Arduino Uno and the ability to power the Arduino such as an external battery. You will need a blank PCB shield for the Arduino (bread board that is an Arduino shield shape) a 5V SPST relay, 1N4007 diode, 1k resistor, 2N2222A transistor and a dual 3.5mm/2.5mm microphone/headphone cable that will fit the UV5R (Kenwood types also fit the UV5R). The configuration of these components can be seen in **Photo 1**. It does not really matter in what position these components are located on the bread board shield, all that matters, is that the connections are correct.

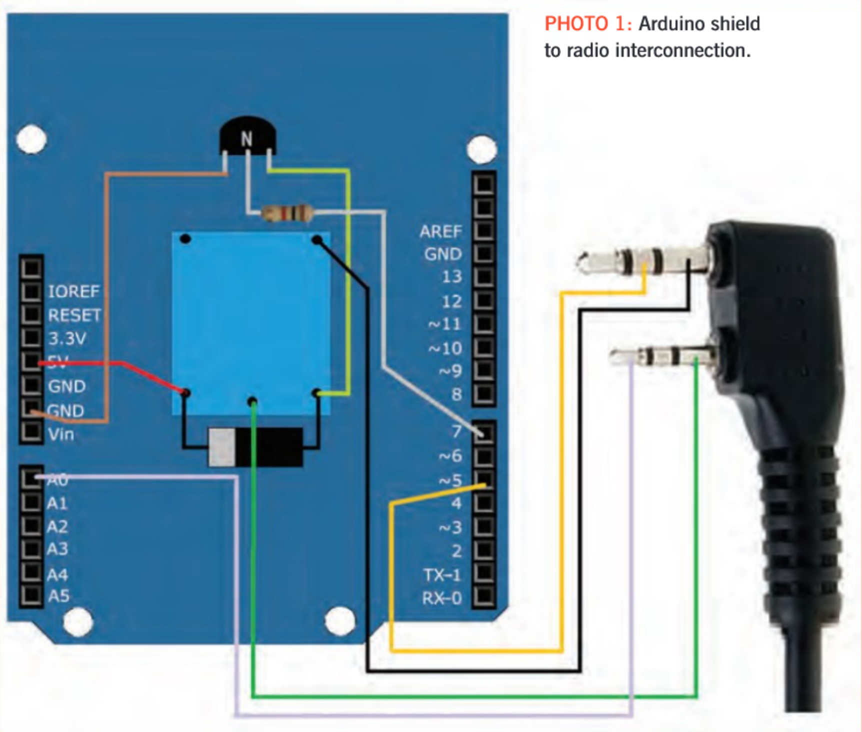


PHOTO 1: Arduino shield to radio interconnection.

The Circuit

Looking at **Photo 1** as a reference, you can see the blue-coloured, single-pole single-throw relay (the one that I used was an SRD-05VDC-SL-C) is in the centre of the board. The top-left connection of this relay is not connected (N/C) and the top-right connection goes to the sleeve of the 3.5mm jack on the microphone lead (black cable on **Photo 1**). The bottom-left connection of the relay goes to the 5V pin on the left of the Arduino shield (red cable on **Photo 1**). The bottom-centre connection on the relay goes to the sleeve of the 2.5mm jack on the microphone lead, dark green cable on **Photo1**. Finally, the bottom-right connection of the relay gets connected to the transistor's collector pin which, if you look at the transistor from the flat side, is the pin to the right (bright green cable on **Photo 1**). Fit the 1N4007 diode across the bottom-left and bottom-right pins (coil) of the relay, make sure the grey band (cathode) of the diode faces the 5V supply (this offers protection to the circuit from back EMF produced by the relay coil). Connect the 1k Ohm resistor to the base/centre leg of the transistor and the other end of the resistor to pin 7 (right side) of the Arduino shield. Connect the emitter/left leg of the transistor to the GND connection

PHOTO 2: Parts required for assembly.

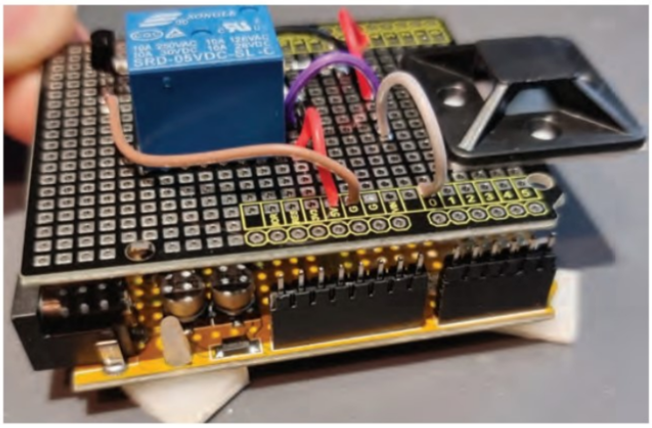


PHOTO 3: Breadboard shield mated to the Arduino.

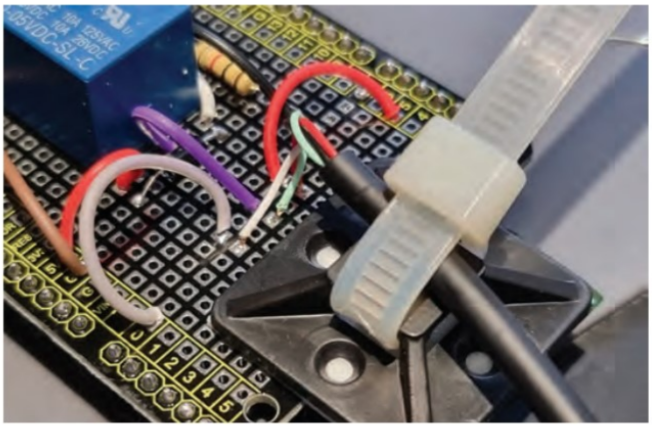


PHOTO 4: Mechanical support for the cable.

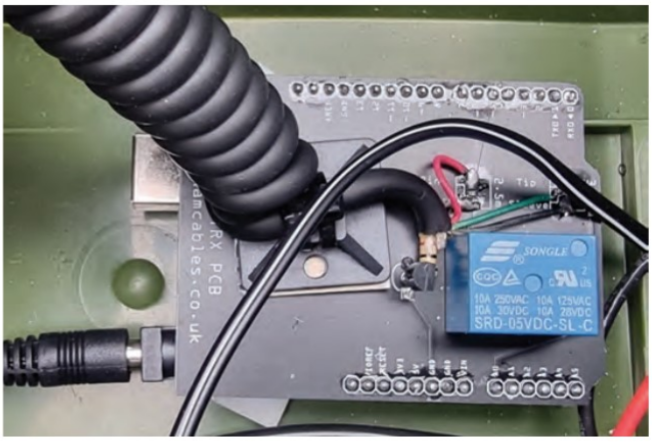
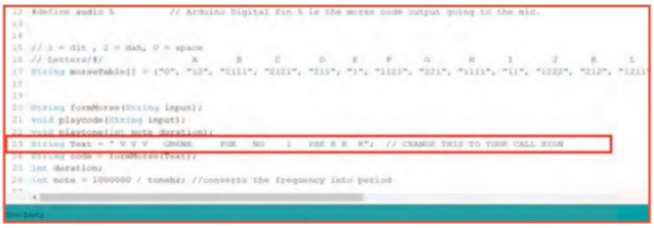


PHOTO 5: Professional PCB layout from JLCPCB.com



```
12 #define audio 5          // Arduino Digital Pin 5 is the morse code output going to the mic.
13
14
15 // 1 = dit , 2 = dah, 0 = space
16 // Letters/#/                A       B       C       D      E     F      G      H       I      J       K      L
17 String morseTable[] = {"0", "12", "2111", "2121", "211", "1", "1121", "221", "1111", "11", "1222", "212", "1211
18
19
20 String formMorse(String input);
21 void playcode(String input);
22 void playtone(int note duration);
23 String Text = " V V V   GM6DX     FOX   NO    1    PSE R R  K"; // CHANGE THIS TO YOUR CALL SIGN
24 String code = formMorse(Text);
25 int duration;
26 int note = 1000000 / tonehz; //converts the frequency into period
```

PHOTO 6: This is the most important line in the code to edit!

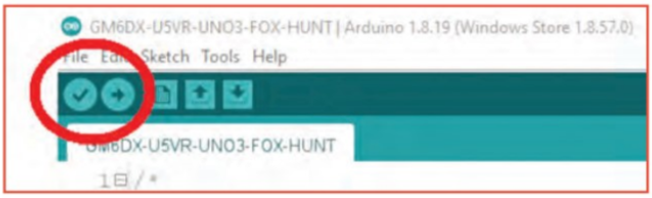


PHOTO 7: These 2 buttons compile and upload the code to the Arduino.

just above Vin on the left side of the Arduino shield. To finish off the circuit, connect the ring of the 3.5mm jack on the microphone lead to pin 5 on the board (orange cable on **Photo 1**) and the tip of the 2.5mm jack to A0 on the board (purple cable on **Photo 1**). You can see the soldering in the images. **Photo 2** shows you the items needed for the PCB along with Arduino. **Photo 3** shows the Arduino shield getting lined up with the Arduino pins for soldering. My final bit of advice is to provide some mechanical support on your PCB, a sticky pad allows the connecting lead to be cable tied to the board, **Photo 4** shows this. If making this circuit seems too much for you, then you can download my own PCB Gerber files (needed to order PCB boards) from here: https://1drv.ms/u/s!Ah8ag4r2GMzxhBLdLZQyh4MV5PoV?e=DLuTRI and order a few PCBs from online stores such as JLCPCB.com. I have found better transmission stability when professional printed PCB boards are used, in comparison to the bread board Arduino shields. You can see my first PCB version in **Photo 5**.

Program the Arduino

First you need to install the Arduino software, you can download this free at https://www.arduino.cc/en/software and remember you do not need a genuine Arduino Uno in order to program it using this software. Once you have installed the software then download my Foxhunt sketch (a sketch is like a program file) from here: https://github.com/GM6DX/FOX-HUNT. Open the sketch by double clicking it and you will see various lines with what appears to be computer style programing, this is how the sketch looks. From the top menu click TOOLS > BOARD > ARDUINO AVR BOARDS > ARDUINO UNO, (selection of the Arduino board) and then go to TOOLS > PORT and select the COM PORT in which the Arduino Uno shows up on your PC as per Device Manager. (Note I have had a few issues with non-genuine Arduino Uno devices so please ensure they use the CH340 chip). There are a few things you need to personalise in the sketch text. First of all, line 7, where you change the CW tone of the transmission. The default is 450Hz, but you can change this to 1000Hz if you wish. The next important lines are lines 16 and 17. Line 16 shows a list of letters and numbers and line 17 shows a range of 1s and 2s, in line 17 the number 1 is a 'dit' and 2 is a 'dah'. For the letter F, it is "1121". This is the look up table which the program uses to generate the tones that then get transmitted in CW. The most important edit to make here is line 23, as seen in **Photo 6**, this line of code is where the text that you want your beacon to send "V V V GM6DX FOX NO 1 PSE R R K" for example, is defined. The space between the letter groups is important and I have found that 2 or 3 spaces between letters works better for a fox, as it makes for a longer transmission. In order to change the CW speed, then adjust the numbers in the code at line 9. Once you have amended your code and

By Billy McFarland, GM6DX
gm6dx@outlook.com

PHOTO 8: IP65 enclosure and UV5R hiding

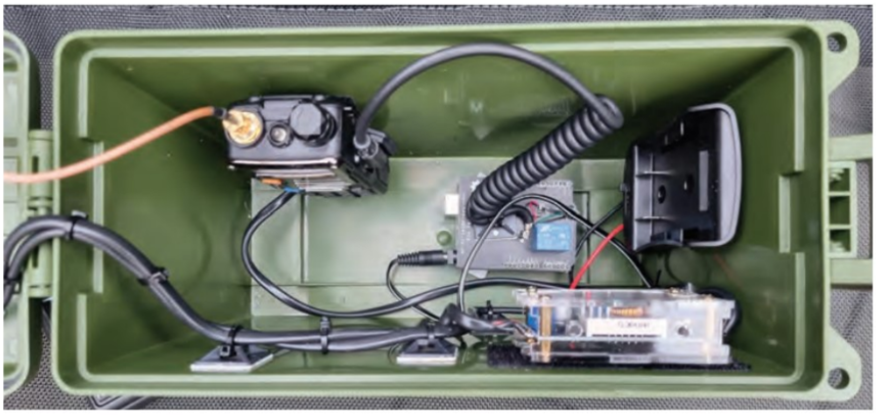


PHOTO 9: Plastic Ammo box version

are ready to send the program to the Arduino Uno then click the 'tick' button at the top left of the home screen, the code will be compiled by the software and verified. Following this, click the right 'upload' arrow as highlighted in **Photo 7**. The programming stage of the fox transmitter now complete.

Deployment and operation

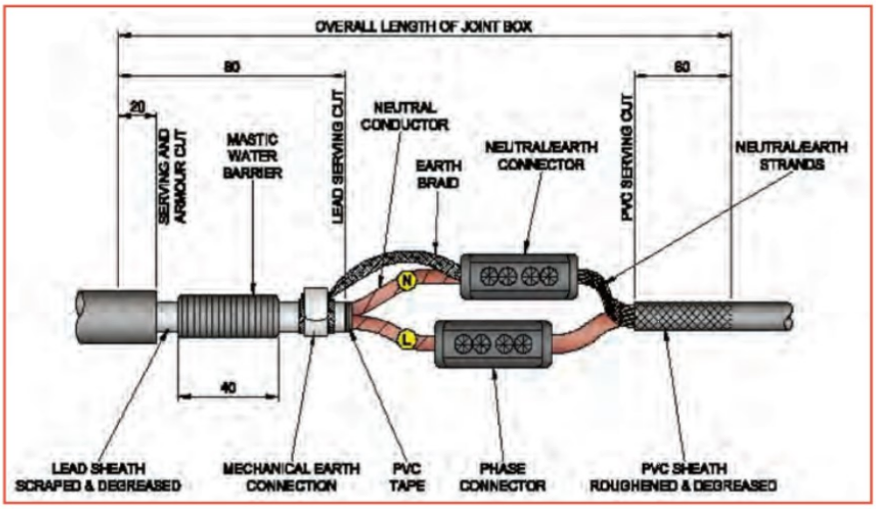
The point of a fox transmitter is that it is hidden for a period until you find it. This would suggest that the Arduino and its power supply would need to be constructed in such a way as to deal with elements of the weather. There are a few easy ways in which you can do this. The first method is to enclose the Arduino Uno and its power source, within an IP65 box. Fit a toggle switch to the outside to turn the Arduino on, with an LED to indicate that power is being supplied to the Arduino (a simple rocker switch with built in LED would also be suitable). You can see my version of this in **Photo 8** deployed by the base of a tree. In addition, I have installed a battery tray externally, so I do not need to open the IP65 housing to change the battery. The most popular solution for fox transmitters is to install the equipment (apart from antenna) within an 'ammo box'. Traditionally these would have been metal ammunition boxes, however plastic ones are used today. In **Photo 9**, you can see my version of this. The Arduino Uno and UV5R are both powered from an 18V DeWalt drill battery. The battery voltage is managed via a dedicated voltage regulator, to provide the UV5R with the correct DC supply, this just happens to be ideal for the Arduino also. An external master toggle switch will turn everything on and off and an SMA chassis mount connector is employed to mount the antenna to the lid of the ammo box. As yet, I have not had any RFI issues, but it is something you must keep in mind. Remember to make sure that the transmission frequency of the fox is suitable for beacon use, and please check your licence conditions to ensure that you are able to operate an unattended beacon. If you would like to see a demonstration of my ammo box fox transmitter then please visit here: shorturl.at/isE49. This simple and cheap method of construction will get your UV5R or similar handheld radio to function as a foxhunt transmitter, enabling you to practice your direction-finding skills and in addition, to get outside and have a lot of fun. There are certainly other methods of creating a fox transmitter, such as using an MP3 player and- VOX, however I have found this simple method to be reliable and practical. Have fun with your build and if you have any questions then please send me an email via: gm6dx@outlook.com

TNS Supply Cables

I have noticed in this year's Yearbook/Call Book the EMC Department are now advising all electrical supplies are treated as if they are PME/TNC-S Supplies, even if supplied from older TNS cables. Let me expand on this, a TNS supply or Terra Neutral Separate, is an older supply system where the consumer had a separate earth all the way back to the substation or local transformer, traditionally supplied by either a PIL, Paper Insulated Lead, with the lead covering being Earth, or by a split concentric, which is a central core covered with a copper wrap, half being insulated (neutral) and half uninsulated (Earth). Most newer supplies are TNC-S Terra Neutral Combined Separate often called PME or Protective Multiple Earth, this is a supply where the Earth and Neutral are combined on the outer copper wrap of the service cable and then don't become separate until they reach the consumers main fuse or cut-out. This combined Earth/Neutral is earthed many times along its route hence the term PME. This type of service in certain fault conditions can be dangerous for an Amateur with RF earthing, See RSGB EMC 07 for a detailed Explanation.

Now why are TNS Supplies considered unsafe? Well, DNO's (Suppliers) no longer Use PILC or Split Concentric to supply consumers, so any repairs are done in Plain Concentric or CNE, which have no separate earth, so when they repair an old TNS cable, the existing Neutral and Earth are strapped together and converted to combined earth/neutral. If you have a TNS supply, somewhere on its length a repair may have been made. In a fault situation this hybrid arrangement can have a voltage rise similar to a true TNC-S supply on the Neutral, a similar concern for amateurs with RF earthing.

In a similar vein if a new service is taken from an existing TNS main, then this will be TNC-S with a CNE cable, and again at the joint, the neutral and earth will be strapped. See Picture 1.



Typical Pilc to CNE Joint

Ian Hope, M5IJH
ian@dr.com

Authors Wanted

The RSGB is currently seeking people to help produce new books about amateur radio. Not only are we seeking those who could write a book or edit articles into a book but are also looking for technical and copy editors. In addition we are seeking freelancers who have experience of desktop publishing who can help finalise books for print and e-publication. Is any of this you?

If you think you could write for us, then the RSGB has a number of projects it needs authors for and we are happy to discuss these with new book authors and editors. We are particularly looking for those who have something to offer in new technologies and modes. We also need help with VHF/UHF projects and would also like to hear from those with experience in HF, Construction and Antennas. We would also be keen to hear your concept for a new RSGB publication and perhaps commission you to produce it.

Whatever your skills we would like to hear from you. All positions are paid on a project by project basis, so if you would just like to find out more about working with the RSGB books programme or becoming a published author or editor please send an email to authors@rsgb.org.uk and we will send you further information about working for us.

Radio Blackouts & Solar Flares

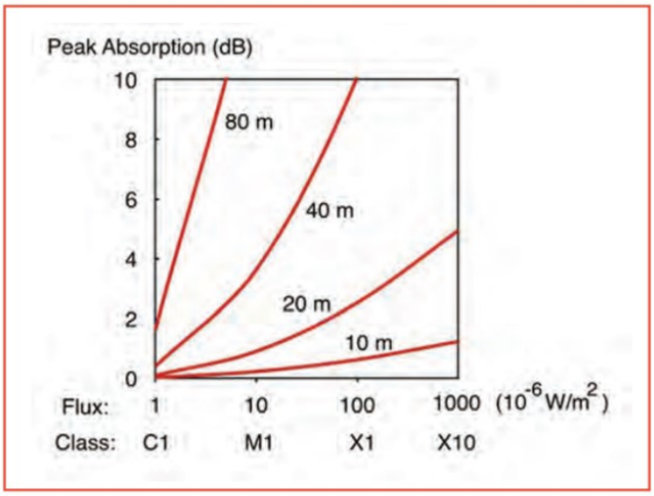


FIGURE 1: **The peak absorption for a single transit of the D region above London is shown for four HF bands *vs* the peak x-ray flux from a solar flare. The letter-classifications for flares are also shown.**

X-Rays

X-rays radiated from a solar flare can cause a disturbance in the Earth's ionosphere causing increased absorption of HF transmissions. Sudden ionospheric disturbances from flares will occur more often as solar activity increases in the current solar cycle.

X-rays from a solar flare on the Earth-facing side of the sun increase ionization in the D region (altitude ~ 60-90 km) of the Earth's ionosphere. This attenuates HF transmissions that pass through the D region, and it can cause a communication blackout **[1]**. For a single-hop transmission that refracts back to Earth from the F2 region (altitude ~ 400 km) the signal passes through the D region once on the way up and again on the way down. For a multi-hop transmission, attenuation occurs during each hop. Two computer ionosphere-models available for amateurs show how the severity of a blackout depends on the HF band, X-ray intensity, time, date, and geographic location.

Proplab-Pro

Figure 1 shows data from a D region attenuation map in the Proplab-Pro V3.2 HF Radio Propagation Laboratory program [2]. The peak attenuation (dB) for a single transit of the region above London is shown for four HF bands vs. the peak X-ray flux (W/m-2) from a solar flare. Flux levels are measured by a GEOS satellite [3]. The figure shows that attenuation is higher as the X-ray flux increases, and it is higher at low frequencies. This data is for the time and date when X-ray absorption is maximum for the year—1200UTC in London on 21 June, the summer solstice. Fig.1 also shows the letter-classification scheme for flares, defined in terms of the logarithm of peak X-ray flux. For example, an M5.0 flare corresponds to peak flux = 5 x 10-5 W/m-2. D region attenuation depends on the sun's zenith angle—the angle between the sun's rays and vertical. Attenuation decreases with an increase in the zenith angle. **Figure 2** is a map from Proplab-Pro showing contours of D region attenuation of a 40m band signal during an X1.0 solar flare at 1200UTC on the summer solstice, June 21. The sol point is the location where the sun is directly overhead (zenith angle = 0). It is shown as a yellow dot on the map at 23.5 degrees North latitude. At this location the attenuation is 12.6dB.

Attenuation falls off with increasing distance from the sol point. In the D region above London the peak attenuation is 10.1 dB. For four HF bands and an M1.0 flare, **Figure 3** shows comparisons of the peak absorption over London at 12:00 UTC on the summer and winter solstices. At low frequencies there is a significant difference between the two seasons.

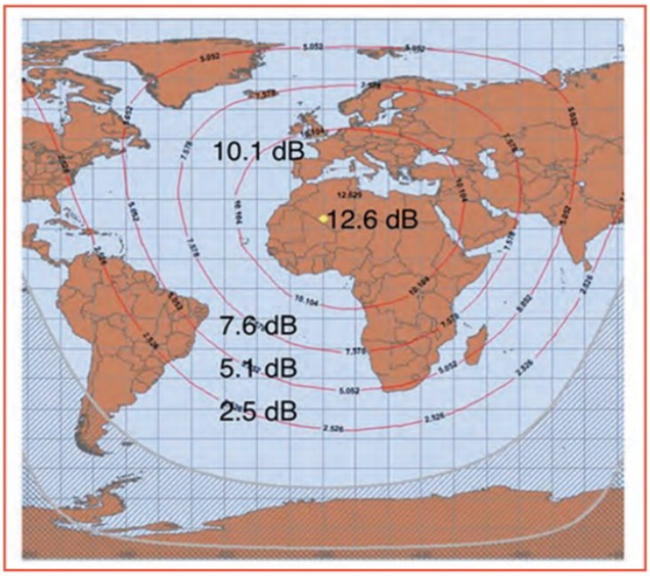


FIGURE 2: **Proplab-Pro map for the 40m band during an X1.0 flare shows contours of D region absorption (1200UTC on the summer solstice, June 21). At the yellow sol point the sun is directly overhead, and absorption is 12.6 dB.**

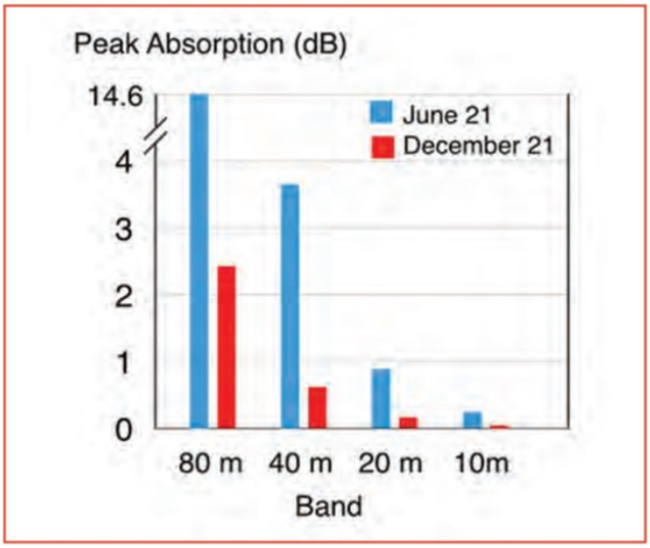


FIGURE 3: **Peak absorption in the D region above London during an M1.0 flare. Comparison of absorption for four HF bands on the summer (21 June) and winter (21 December) solstices (1200UTC).**

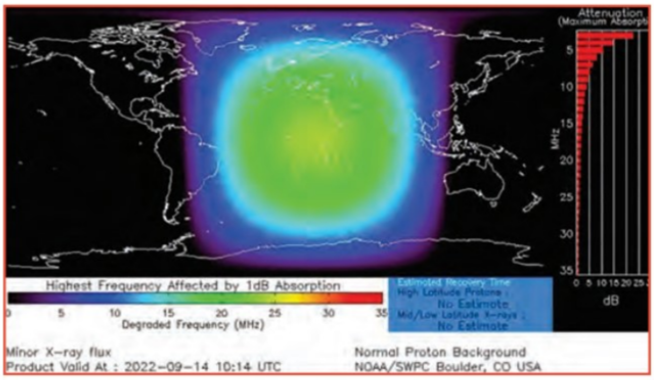


FIGURE 3: **Peak absorption in the D region above London during an M1.0 flare. Comparison of absorption for four HF bands on the summer (June 21) and winter (December 21) solstices (12:00 UTC).**

D-RAP

The D Region Absorption Prediction Model (D-RA) is an online application from the NOAA Space Weather Prediction Center, intended as guidance to understand the HF radio degradation and blackouts caused by flares **[4a]**. The map in **Figure 4** shows an M1.0 flare on 14 September 2022. Color contours show the highest frequency with 1dB of D region absorption. For example, if the highest frequency for a chosen location is 20MHz, absorption below 20MHz is greater than 1dB at that location. On the D-RAP website you can view a time-lapse animation of the map for the previous 8 hours. This correlates with charts of the X-ray flux measured by the GEOS satellite. You can also select a map showing color contours of absorption (dB) displayed for 5, 10, 15, 20, 25, or 30MHz. The D Region Absorption Prediction Model web interface also includes maps for the polar regions, where ionization is primarily due to solar energetic particles, mainly protons. GOES proton flux measurements are used for these maps.

Oblique Incidence

Proplab-Pro and D-RAP estimate absorption when an HF signal is incident vertically on the D region (angle of incidence, a = 90 degrees). Signals incident at an oblique angle spend more time in the region, so absorption is higher **[1]**. D-RAP documentation suggests a correction factor of 1/(sin a) for oblique wave propagation compared to vertical incidence **[4b]**. **Figure 5** shows the correction factor vs a (degrees). To use the correction factor multiply it times peak absorption in dB. You can estimate "a" by using Proplab-Pro ray tracing.

Table 1. NOAA Space Weather Scale for Radio Blackouts [5b]

Scale	HF Radio Effects*	Duration	Threshold	Number of events in 11-year cycle
R5 Extreme	Complete HF blackout	many hours	X20	<1
R4 Severe	Blackout on most of the sunlit side of the Earth	1 – 2 hours	X10	8
R3 Strong	Wide area blackout	~ 1 hour	X1	175
R2 Moderate	Limited blackout	tens of minutes	M5	350
R1 Minor	Minor degradation Occasional lost contact	–	M1	2000

***Sunlit side of the Earth**

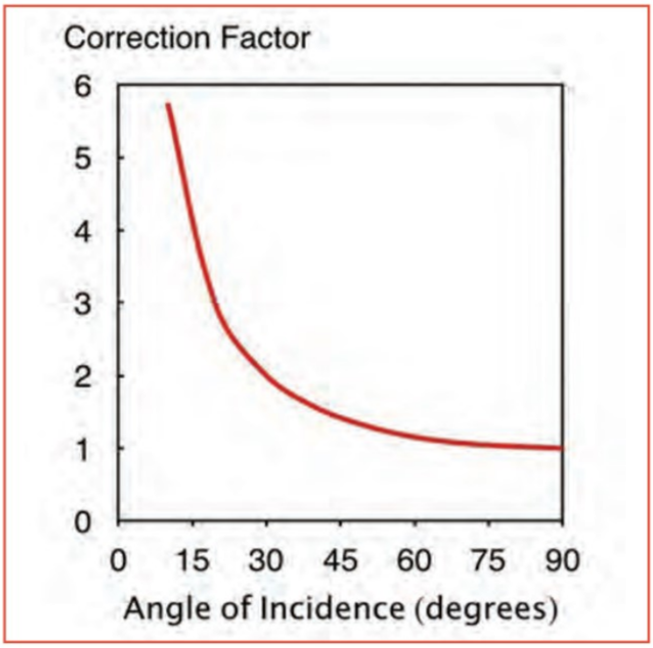


FIGURE 5: **Correction factor for D region absorption *vs* angle of incidence, a (degrees). At vertical incidence a is 90 degrees.**

Predictions

Flares erupt at unpredictable times. NOAA issues predictions for space weather conditions **[5a]**. Examples of NOAA predictions are R1 – R2: 30% and R3 – R5: 5%. The R scale used for the level of a radio blackout is shown in **Table 1 [5b]**.

Conclusions

Proplab-Pro and D-RAP use simplified semi-empirical models of the ionosphere that give useful insights about propagation. Factors that increase RF absorption due to a flare are high X-ray flux, low frequency signals, low latitude, summer season and oblique incidence of signals.

References

1: Steve Nichols, G0KYA, Radio Propagation Explained, RSGB, 2020.

2: Proplab-Pro V3.2. Solar Terrestrial Dispatch.
http://spacew.com/index.php/software

3: NOAA Geostationary Operational Environmental Satellite (GOES).
https://swpc.noaa.gov/products/goes-x-ray-flux-dynamic-plot

4: D Region Absorption Predictions (D-RAP).
a: https://www.swpc.noaa.gov/products/d-region-absorption-predictions-d-rap
b: https://www.swpc.noaa.gov/content/global-d-region-absorption-prediction- documentation

5. NOAA Space Weather Scale for Radio Blackouts
a: https://swpc.noaa.gov
b: https://swpc.noaa.gov/noaa-scales-explanation

Peter DeNeef, AE7PD
HamRadioAndVision@gmail.com

A folded dipole for many bands

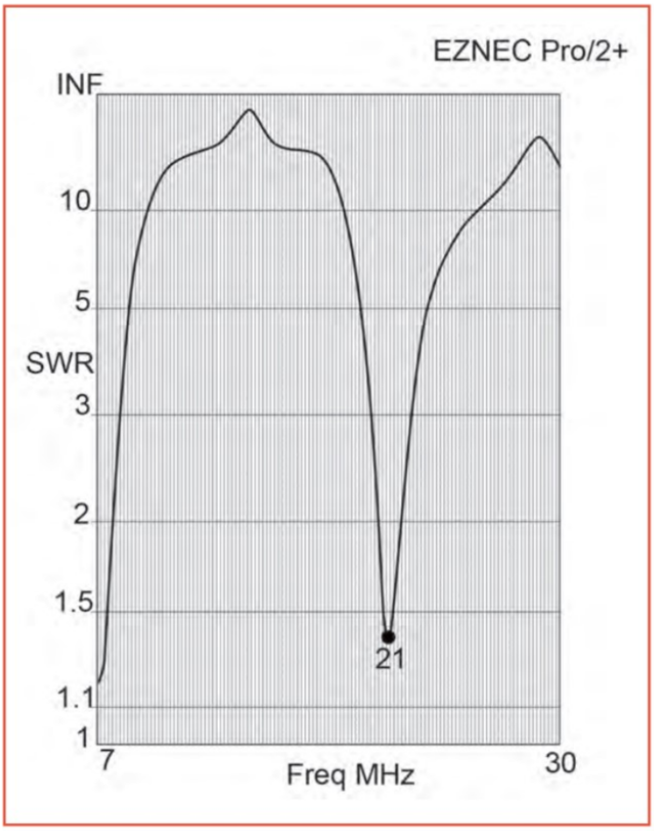


FIGURE 1: **SWR plot of 21.3MHz**

Four decades ago, I used a tubular folded dipole as the driven element in a multi band rotatable HF Yagi antenna. It featured a vacuum switch in the centre of the tube opposite the feed point. This changed the working mode from folded dipole to doublet. It occurred to me that something similar could be made with wire that might make an antenna for several bands. What follows is a 'paper' design for an antenna covering ten HF, 50MHz and LF bands, with which others may like to experiment.

The first mode

The folded dipole in its conventional mode of operations has a wider impedance bandwidth than a single wire dipole because of its greater effective diameter and because of compensation due to the short circuited stubs provided by each half. As the two wires are spaced further apart, making the antenna 'thicker', the bandwidth is increased. However, excessive spacing in a folded dipole can make the antenna directional unless restricted to about a tenth of the wavelength at the highest working frequency. For example, 1m would be adequate spacing for an antenna that is to cover the HF range up to 30MHz.

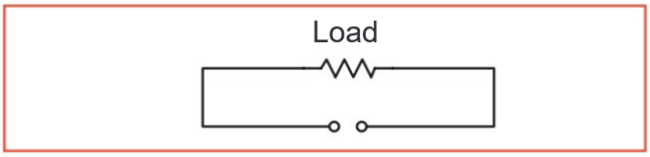


FIGURE 2: **Folded Design with load opposite to feed point**

Antenna length

A folded dipole presents a reasonable load impedance at the third and other odd harmonics of its design frequency, which in this case is 21.3MHz. This may be seen in the SWR plot of **Figure 1**. This resonance was found to be most critical and determined the length of the antenna as 2m. The total length of wire is 42m. 50MHz operation was an afterthought and is consequently not included in the plot.

The design

The design relies on two modes to provide a low SWR on several frequency bands by choice of a loading impedance that is inserted opposite the feed point as in **Figure 2**. In the past a 600Ω resistor has been used here to make what was known as a Macpherson wide band receiving antenna.

The SWR plot for this is shown in **Figure 3**. However, this would be a very inefficient transmitting antenna because on some frequencies almost all of the transmitter power will be dissipated in the resistor. In this design, the load is generally either a gap of 5cm that introduces the second mode or a short circuit.

The second mode

When the folded antenna is cut for half wave resonance at a particular frequency, or in this case three times that frequency, and its load is an open circuit, it becomes a doublet of two half waves or two full waves in bands near twice and four times that frequency, respectively. This is because the transmission lines formed by each half of the antenna are now a half wave or full wave, terminated with a short circuit at their outer ends. The short circuits are transformed to the inner ends where they effectively join the wires to make a thick, and hence wideband, doublet as in **Figure 4**. A folded dipole cut for 7MHz works in this mode at 14 and 28MHz. It also works even better in this mode at the adjacent bands of 18 and 24MHz by virtue of the reactance provided by the short circuited lines that form each half of the doublet. This effect is most significant at 10MHz where the SWR is sensitive to capacitance across the gap insulator. The SWR plot for the doublet mode up to 30MHz is shown in **Figure 5**.

Tony Preedy, G3LNP
g3lnp@talktalk.net

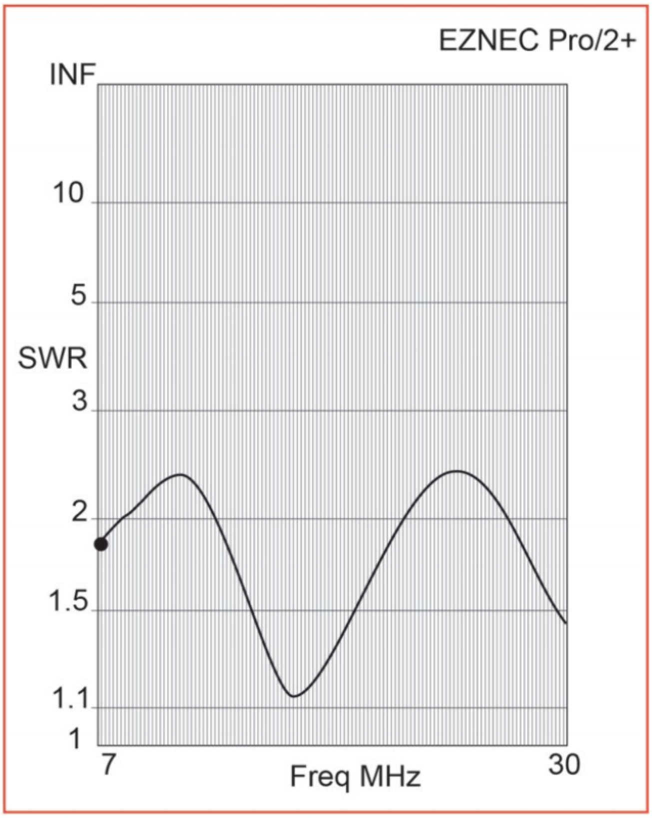


FIGURE 3: SWR plot for the McPherson receiving antenna

Lots of bands

A folded element with wires of 20m, and spacing of 1m, was shown by NEC2D software to be capable of providing a low SWR on the 5, 7, 10, 14, 18, 21, 24, 28 and 50MHz bands. To achieve this, the load is a short circuit for 7, 21 and 50MHz and an open circuit for the other bands except 5MHz. Here the best SWR requires a load of 25μH but with a good tuner the short circuit may be acceptable. Current is low in the inductor; therefore a suitable solenoid may be made by winding 0.5mm wire on an air core. Switching the inductor at a point where stray capacitance can upset the higher frequency bands is likely to be problematic. It might have to be introduced only if and when required.

Feeder impedance

Feeder impedances from 200 to 600Ω were tested in the model but the best compromise for an SWR below 5 on all bands was 300Ω. If a balanced tuner is not available a 4:1 or, better still, a 6:1 balun may be added at the output of the more common unbalanced type. However, **Table 1** shows that on many bands a tuner may not be necessary.

Adding 3.5-3.8MHz

The feed point impedance of the 7MHz folded dipole at 3.65MHz is a resistance near 300Ω with a large series inductive reactance. It may, therefore, be tuned with series capacitance to provide resonance in this band. It requires a closed gap and low value high Voltage capacitors at the feed point.

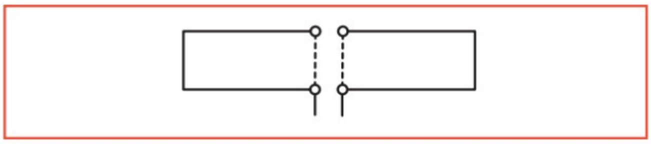


FIGURE 4: Wideband Doublet design

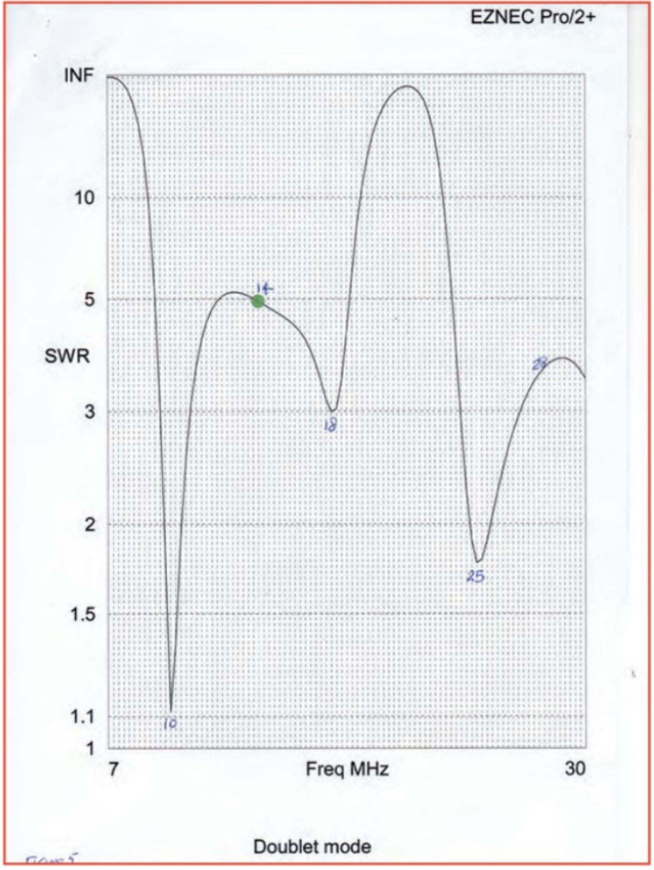


FIGURE 5: The SWR plot for the doublet mode up to 30MHz

This arrangement is likely to be much more efficient than loading a conventional short doublet with inductors because of the lower dissipative loss of capacitors. The only significant loss is that due to resistance of the wires. These should preferably be of at least 2mm diameter if this band is required. Greater diameter may be achieved without excessive weight by using the braid of foam dielectric coax cable that has a steel core. Bandwidth on this band is only about

TABLE 1: Summary of Analog Devices log detector ICs.

MHz	Load	SWR	
1.83	open	1-2.5	With respectively a 33 or 3Ω ground connection.
3.5	short	2.0	Series capacitors 25.5pF
3.8	short	4.1	Series capacitors 10.5pF
5.3	25μH	3.6	SWR =15 with the short circuit.
7.1	short	1.1	
10.1	open	1.0	
14.2	open	4.8	
18.1	open	3.1	
21.3	short	1.3	
24.9	open	1.7	
28.6	open	3.6	
50.5	short	2.8	

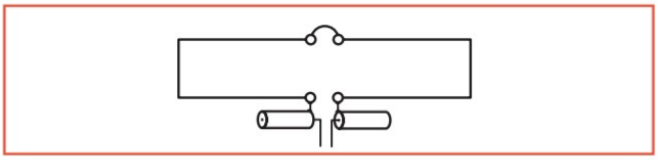


FIGURE 6: **3.5MHz Loading with coaxial 20pF capacitors**

40kHz because of the high Q factor. The capacitors are near 20pF for mid band and because of the high Voltage that they must withstand they may be formed from pieces of RG213 coax cable. As shown in **Figure 6**, these should be taped to the radiator and connected with braid to the wire and inner conductor to the feeder. RG213 provides 100pF per metre of length. Therefore for 3.5MHz, the table below shows that we need two pieces of 25.5cm. It is best to make them longer than expected, check where minimum SWR occurs and trim their length until the minimum is where you want it to be.

T connection

As a bonus, the double wires will provide effective top loading at a T antenna for the 1.8MHz and LF bands. For this we may drive the feeder with both of its conductors joined together, against a counterpoise or a ground connection via a suitable loading reactance. Maximum top loading effects results with the gap open. The antenna will then be resonant with no series reactance at 1.83MHz when the short-circuited feeder length is about 10m.

Remote switching

Links or crocodile clips may be used for shorting the capacitors and closing the load gap after lowering the centre of the antenna for band changing. Alternatively, relays may be used. The relays need to be suitable for high Voltage. The one bridging the load gap needs to have low capacitance. High voltage reed relays are preferred because of their light weight and weather resistant contacts. Control wires must be routed clear of the 300Ω feeder and, if possible, at right angles to the axis of the antenna, or they may distort the radiation pattern and/or conduct RF current into the shack.

Anticipated results

SWR figures at the radio will depend on the installed height of the antenna and the length of the 300Ω feeder. Those below are NEC2D results with reference to 300Ω at the feed point for a height of 18m (60 feet). The SWR at 1.83MHz is referred to 50Ω with 10m height.

Radiation performance

Radiation patterns are those of a doublet that has the same length and height as the folded dipole. At 24 and 28MHz, the horizontal pattern contains four lobes of typically 10dBi that are spaced ±45° about the axis of the antenna. Extra broadside lobes appear at 21MHz. At 50MHz the antenna's length is about 7 half waves, resulting in multiple lobes with the strongest of about 10.5dBi at ±30° to the axis. Otherwise, maximum radiation is broadside to the wires, but omnidirectional in T mode.

Suspension

This should be an efficient antenna for the 80m and 60m bands that requires the same space as that necessary to suspend a dipole for the 40m band. The antenna may be rigged either with the radiating wires one above the other or side-by-side. There is slight asymmetry that principally influences nulls in the radiation pattern on the higher frequencies when rigged side by side, but it does lend itself to an inverted V configuration

Contest Calendar December 2022

Ian Pawson, G0FCT

RSGB VHF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Sun 4 Dec	144MHz AFS	1000-1400	All	144	RS(T) + SN + Locator
Tue 6 Dec	144MHz UKAC	2000-2230	All	144	RS(T) + SN + Locator
Tue 6 Dec	144MHz FMAC	1900-1955	FM	144	RS + SN + Locator
Wed 7 Dec	144MHz FT8 AC	1900-2100	FT8	144	Report + 4-character Locator
Thu 8 Dec	50MHz UKAC	2000-2230	All	50	RS(T) + SN + Locator
Tue 13 Dec	432MHz UKAC	2000-2230	All	432	RS(T) + SN + Locator
Tue 13 Dec	432MHz FMAC	1900-1955	FM	432	RS + SN + Locator
Wed 14 Dec	432MHz FT8 AC	1900-2100	FT8	432	Report + 4-character Locator
Thu 15 Dec	70MHz UKAC	2000-2230	All	70	RS(T) + SN + Locator
Tue 20 Dec	1.3GHz UKAC	2000-2230	All	1.3G	RS(T) + SN + Locator
Mon 26 Dec	50MHz Christmas Contest	1400-1600	All	50	RS(T) + SN + Locator
Tue 27 Dec	70MHz Christmas Contest	1400-1600	All	70	RS(T) + SN + Locator
Wed 28 Dec	144MHz Christmas Contest	1400-1600	All	144	RS(T) + SN + Locator
Thu 29 Dec	432MHz Christmas Contest	1400-1600	All	432	RS(T) + SN + Locator

Best of the Rest Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange (Info)
1 Dec - 31 Jan 2023	UKSMG Winter Marathon	All	All	50	RS(T) + Locator
Fri 2-Sun 4 Dec	ARRL 160m	2200-1600	CW	1.8	RST (W & VE also send ARRL/RAC section)
Sat 11-Sun 12 Dec	ARRL 10m	0000-2359	CW, Phone	28	RS(T) + SN (W, VE & XE send State/Province code)
Sat 17-Sun 18 Dec	Stew Perry Topband Challenge	1500-1500	CW	1.8	4-character Locator
26 Dec 2022 -6 Jan 2023 (not a contest)	WAB Christmas Party All	All	All		WAB Book number
Mon 26 Dec	DARC Christmas Contest	0830-1100	CW, SSB	3.5, 7	RS(T) + SN (DL send DOK or 'NM')

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