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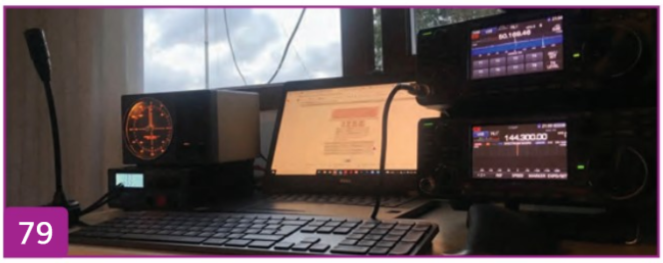

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Cover image: The Camb-Hams contest site for VHF NFD, courtesy Dr Colin Smithers, G4CWH and Nigel Otter.
Designed by Kevin Williams, M6CYB

RadCom THE RADIO SOCIETY OF GREAT BRITAIN'S MEMBERS' MAGAZINE

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New Products

Anytone AT-5555 PLUS

The Anytone AT-5555 PLUS now has the new the Rx noise reduction option. With a completely newly designed PCB board, the Anytone AT-5555 PLUS is one of the most modern and up-to-date 10m radios on the market. Updates and new (menu) functions: VOX, CTCSS/DCS codes, Rx compander, noise gate, Rx noise reduction (extra PCB inside the radio), program cable connector on the backside of the radio (program cable is optional) and extra ventilation holes on the top and bottom cover. It is available from stock at £169.95 plus p+p. www.moonraker.eu

The SV4401A

The SV4401A is a handheld Vector Network Analyser (VNA) with frequency range of 50kHz ~ 4.4GHz. It can be used for S11 and S21 measurements. The S21 dynamic range is 75dB, while the S11 dynamic range is 50dB. Suitable for antenna testing of MF/HF/VHF/UHF bands, it can also be used to measure filters, amplifiers and other RF components. The SV4401A supports a variety of display options including VSWR, group delay, resistance, Reactance, etc. It also supports TDR function, which is useful for cable measurement. It has a metal case, and the RF interface is an N-type female connector (N-to-SMA adapters included). The screen is a 7in high-brightness IPS capacitive touch screen, which allows use clearly in the outdoors and adopts a full touch screen design. With four physical buttons, users can quickly set frequency range and other settings. The unit has a built-in 8GB memory card, measures 190mmx130mmx30mm and is priced at £389.95. The VNA is available from Martin Lynch & Sons, www.hamradio.co.uk.

Xiegu XPA-125B

The Xiegu XPA-125B is the perfect linear amplifier for a 1–5W transceiver and will give up to 100W output. It can produce up to 125W on HF and 90W on 6m. The built in automatic antenna tuner unit and power amplifier unit of the XPA125 can be used independently of each other as either an automatic antenna tuner or a separate power amplifier. The tuner can handle 14-500Ω loads in the HF bands and 50MHz. Band selection is manual to make it the perfect accessory for the Yaesu FT-817/8ND, Icom IC-705 and other 1-5W output devices. The large back-lit LCD display shows input/output power, SWR, voltage, current, temperature, amplifier status as well as warning messages making operation of this modern amplifier simple and user friendly. The serial connection allows you to connect to a computer to update the firmware. The amp is available from Nevada at www.nevadaradio.co.uk/product/xiegu-xpa-125b/.

Vine Antenna RST-TP5 & TP3

The Vine Antenna RST-TP5 Straight Magnetic Morse Key and RST-TP3 Twin Paddle Magnetic Morse Key. These new keys have been specifically designed for both base and portable operation in mind. The heavyweight base of the TP5 is magnetic so it can be attached to the side of your transceiver when using the key for portable operation. The TP3 uses a twin ball bearing design and features brass contacts for added reliability in the field. Priced at £169.95 the RST-TP5 and RST-TP3 keys can be purchased from LAMCO at www.hamradio-shop.co.uk.

The SPS5041X

The SPS5041X is a 40V, 30A, 360W DC power supply. The SPS5000X-series is a programmable switching DC power supply series that provides a wide range of output power using single-channel and multi-channel output configurations, coupled with constant power capability. This series of power supplies includes sixteen models, with voltages up to 160VDC and power to 1080W. The SPS5000X supplies can be connected in series (2 units) or in parallel (3 units) to meet the requirements of 0~320V and 0~270A, with a maximum combined power of 3240W. The SPS5000X series has a high brightness 2.4in OLED display and a user-friendly interface. The SPS5000X provides high resolution voltage and current settings, adjustable slew rates, sequence programming from the front panel or over the standard LAN/USB interface, analogue control, and over-voltage, current, power and temperature protection. The SPS5000X series of power supplies are available from Telonic at www.telonic.co.uk.

[Please note that all the products shown here have CE certification where appropriate - Ed]

Antennas

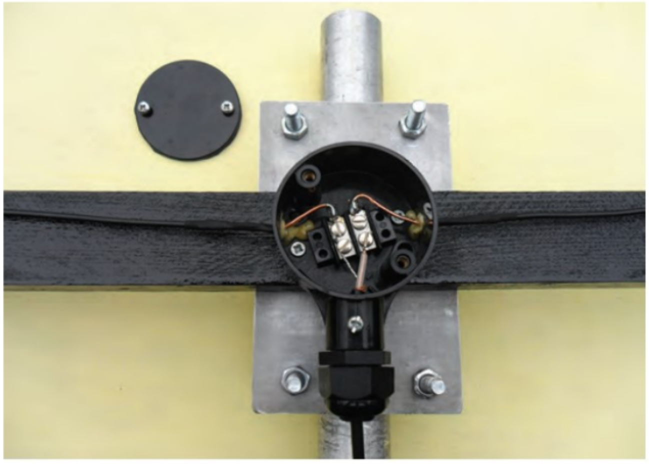

PHOTO 1: The 10m and 6m band antenna's dipole centre made from a single-way conduit box.

PHOTO 2: An example of one of the tuning rods and its bush mount used for the antenna.

PHOTO 3: An example of one of the 25-turns loading coils used for the antenna.

A Compact Dual-band Loaded Dipole

Several readers' messages have been received recently asking how the range of a dipole could be extended to cover more than one band. A technique to extend the range of a dipole using loading coils was summarised in Antennas several years ago **[1]**. Therefore, it is worth returning to this theme using an example of a 6m band dipole that was modified by adding loading coils to allow it to be operated on the 10m band.

10m and 6m bands loaded dipole calculation overview

A dipole is a convenient antenna for getting active on a specific band. However, it is possible to modify a dipole to enable it to resonate on another band by adding an appropriate loading coil into each leg of the dipole, giving a two-band antenna. This technique was covered in depth previously in Antennas [1], therefore only an overview is given here. **Figure 1** illustrates the concept of a loaded dipole intended for use on both the 6m and 10m bands. This antenna was constructed using sturdy insulated stranded copper wire, which allowed a loading coil to be directly wound into each leg of the dipole. In Figure 1, the antenna's actual values are shown and not the theoretical values used in the calculations below. The half wavelength ($\lambda/2$) 6m dipole is the section of the antenna running between the two loading coils as shown in Figure 1. The dipole's design length was calculated in metres (m) using the $\lambda/2$ dipole equation **[2]**:

$$\text{Length of a } \lambda/2 \text{ dipole (m)} \approx \frac{(150 \times 0.95)}{f}$$

Using f = 50.15MHz, this gives a design length of approximately 2.84m, giving each dipole leg a design length of about 1.42m. When operating on the 6m band, the loading coils' inductance presents a high enough reactance to effectively isolate the short wire sections beyond the loading coils. This allows this section of the antenna to act as a 6m band $\lambda/2$ dipole. To tune the antenna to the 10m band, a series resonant tuned circuit is formed between each loading coil and the short wire extending beyond it. The short wire's length has the effect of making it act like a capacitor, which then resonates the circuit. A design frequency of 28.4MHz was used to calculate the loading coil's inductance when the short wire's design length was 0.5m. Essentially, each dipole leg comprises two wire portions of 1.42m and 0.5m, with each portion having its own reactance. At 28.4MHz, the longer 1.42m wire portion presents a relatively low inductive reactance, while the shorter 0.5m wire portion offers a relatively high capacitive reactance. Adding these two reactances together allows the loading coil's theoretical inductance to be calculated, from which the number of turns required can be determined **[3]**. When the calculations were run for the theoretical antenna, this gave each loading coil as needing 27 turns when wound on a 20mm diameter former. However, and as shown in Figure 1, it was found that the actual antenna's 6m dipole had each leg at 1.49m long, the two loading coils were each 25 turns and the length of each short wire was 0.33m. This gave the length of the actual antenna as 3.79m, as shown. Re-running the $\lambda/2$ dipole equation again for a frequency of 28.4MHz gave a dipole of length 5.02m. Therefore, using the loading coil technique has reduced the length of a 10m dipole by about 1.23m (ie a length reduction of about a 25%).

Construction

Figure 2 shows the arrangement used to build the antenna, which was made from 1.6mm diameter sturdy insulated stranded copper

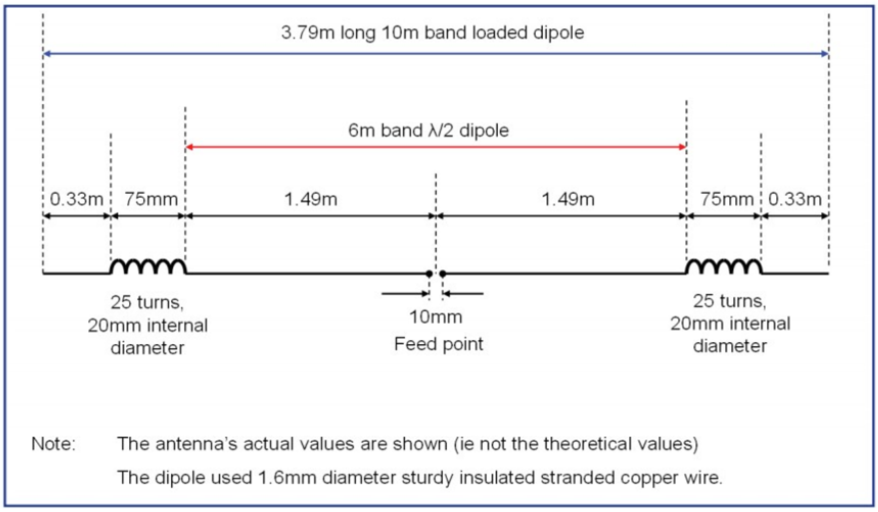

FIGURE 1: The dimensions used for the actual 10m and 6m bands antenna.

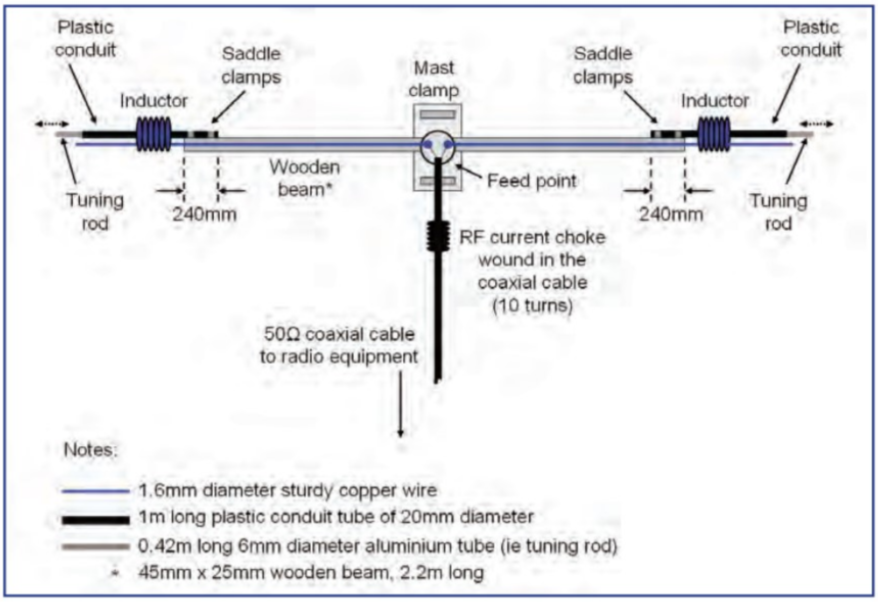

FIGURE 2: Concept of the physical layout for the for the 10m and 6m bands antenna.

wire. To support the antenna, a 2.2m long 45mm x 25mm wooden beam and two 1m long 20mm diameter plastic conduit tubes were used. Each plastic conduit tube was held in place 240mm from the ends of the wooden beam using two saddle clamps that were screwed to the beam and a retaining wood screw. This allowed each plastic conduit tube to suitably extend beyond the wooden beam to support a loading coil and the remainder of the wire. The antenna's dipole centre was made from a single-way plastic conduit box. Two suitably-sized holes were drilled either side of the conduit box to take single-core copper access wires, with these connected to a block terminal that also allowed the coaxial feeder cable run from the radio equipment to be connected. Sealant was applied around where the access wires entered the conduit box to waterproof the arrangement. Two holes were drilled into the base of the conduit box to allow it to be attached to the centre of the wooden beam using wood screws. The stranded copper wire used to make the antenna was soldered to the access wires, with heat shrink then shrunk over the joints to protect them. These conduit boxes are available with a lid and gasket that provides a convenient way to weatherproof everything. **Photo 1** shows the dipole centre's construction for reference. A clamp was constructed to allow the antenna to be attached to a mast, which was made from 6mm thick aluminium plate. Four suitably-sized holes were drilled into the plate to allow it to take two U-bolts, with two more holes drilled to allow the plate to be attached to the antenna's wooden beam using wood screws. The U-bolts were selected to fit the mast used.

To fine-tune the antenna, this was done by using an adjustable tuning rod at each end of the antenna. Each tuning rod was made from 6mm diameter aluminium tube whose length was 420mm, which allowed the rod to extend through the loading coil. To hold the tuning rods in place, two bushes were made from scrap plastic supports (once used to support a new washing machine when being transported). Each bush's diameter was reduced to allow it to be a flush fit inside its 20mm diameter conduit tube. Self tapping screws were used to secure the bush and its tuning rod in place as shown in **Photo 2**. During tuning, it was found that each loading coil needed 25 turns when wound onto the 20mm diameter conduit tube. The loading coils were held in place using cable ties as shown in **Photo 3**.

Balun

The antenna was fed using 50Ω RG58 coaxial cable that included a current choke 1:1 balun formed by winding the cable into an inductor **[4]**. The balun comprised ten turns of the cable with an internal diameter of 50mm and was held together using cable ties. The balun was situated as close as practical to the dipole's connection.

Predicted performance

The 10m and 6m dual-band antenna was modelled using MMANA-GAL to predict the antenna's radiation patterns with the application's default ground option selected **[5]**. **Figure 3** shows the antenna's predicted radiation patterns in the horizontal and vertical planes for the 10m band (in red) and 6m band (in blue), with the antenna modelled at 10m AGL (above ground level). In the horizontal plane the predicted radiation patterns are very similar to a dipole for both the 10m and 6m bands, although the predicted radiation pattern for the 10m band has less distinct nulls. In the vertical plane, at 10m AGL the antenna's predicted radiation patterns show a series of lobes have formed on both 10m and 6m bands. The extent and the form of the radiation pattern for each band relates to the antenna's height AGL and the characteristics of the ground below the antenna. For both bands more lobes can be expected to develop as the antenna's

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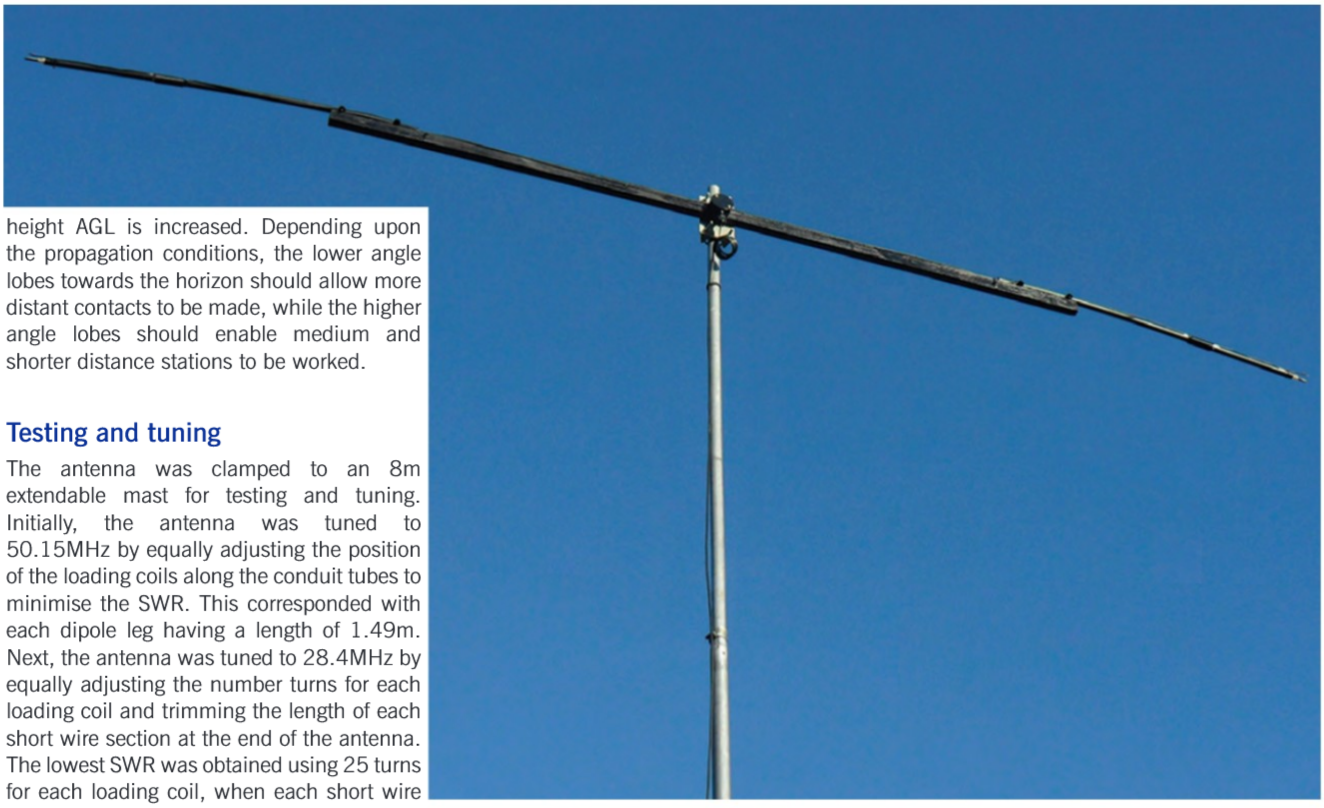

PHOTO 4: The 10m and 6m band antenna in use.

height AGL is increased. Depending upon the propagation conditions, the lower angle lobes towards the horizon should allow more distant contacts to be made, while the higher angle lobes should enable medium and shorter distance stations to be worked.

Testing and tuning

The antenna was clamped to an 8m extendable mast for testing and tuning. Initially, the antenna was tuned to 50.15MHz by equally adjusting the position of the loading coils along the conduit tubes to minimise the SWR. This corresponded with each dipole leg having a length of 1.49m. Next, the antenna was tuned to 28.4MHz by equally adjusting the number turns for each loading coil and trimming the length of each short wire section at the end of the antenna. The lowest SWR was obtained using 25 turns for each loading coil, when each short wire section had a length of 0.33m. On the 6m band, the antenna needed to be finely tuned by sliding the tuning rods into each loading coil to resonate the antenna on 50.15MHz. This was necessary because the loading coils became problematic at 50MHz, with a tendency for the antenna to resonate at about 53MHz. It is possible that the technique of loading a dipole to enable its operation on more than one band may be reaching its practical limit above 50MHz? It was also found that the use of the tuning rods had a negligible effect of the antenna's resonance on the 10m band. Once the antenna was tuned and having signed on in CW, the antenna was loaded with a transmit power of 10W on 28.4MHz, with an SWR of 1.2:1 being measured. The frequency was changed to 50.15MHz, where an SWR of 1.1:1 was measured. The transmit power was increased to 100W and the SWR continued to remain low for each band.

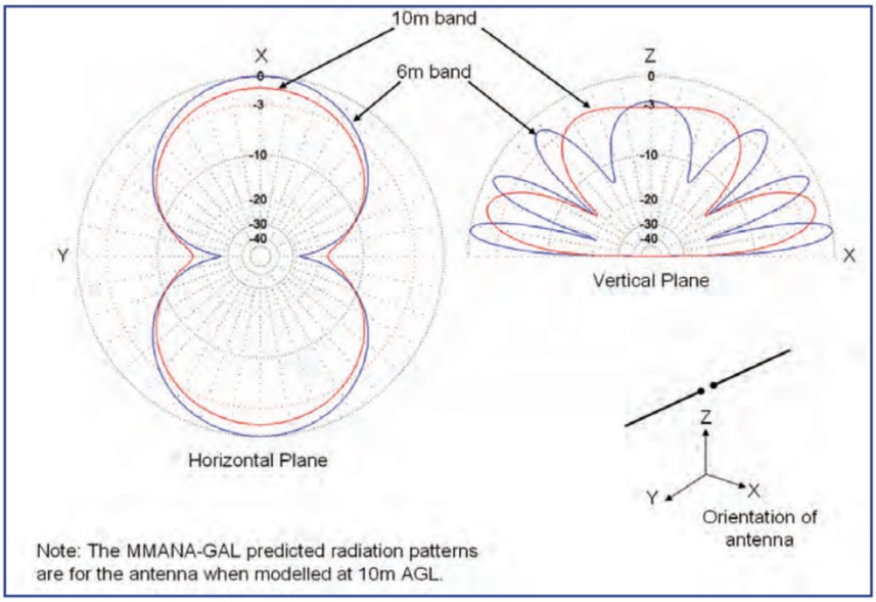

FIGURE 3: The predicted performance for the 10m and 6m bands antenna.

On air results

The antenna has been used throughout 2022 on both the 10m and 6m bands, with the antenna turned using a rotator to obtain the best results. On the 10m band many DX contacts have been made across the globe, while on the 6m band contacts were made throughout Europe during the Sporadic-E season.

Websearch

[1] RSGB *RadCom*, Antennas column: Dipoles in December 2018. Doublets in January 2019
RSGB Radio Communication Handbook 14th edition, edited by Mike Brown, G3DIH.
[2] Section 15 Practical HF Antennas. Page 15.6.
[3] Appendix A, Coil Winding. Page A.3.
[4] Chapter 14 Transmission Lines. Page 14.13.
[5] MMANA-GAL basic V3.0.0.31, freeware antenna analyzing application, by Makoto Mori JE3HHT. MMANA-GAL basic and Pro by Alex Schewelew DL1PBD and Igor Gontcharenko DL2KQ. 1999 onwards. Default ground: Dielectric 13, 5 mS/m, others 0.

Powering your station by the Sun

Inexpensive solar panels can provide free off-grid renewable energy for a small transceiver.

PHOTO 1: Twin facade-mounted 36-cell solar panels with adjustable tilt angle.

Solar energy is booming, driven by concerns about the environment, attractive VAT incentives and the rising price of energy derived from fossil fuels. In the last few years this growth has brought about substantial reductions in the price of solar panels and the associated electronic components.

Installing a grid-tied photovoltaic system that can generate all the electrical power for a house remains a major project that has to surmount regulatory hurdles as well as technical challenges and compliance issues. On the other hand, although it won't save the planet or make much of a dent in your electricity bill, a small off-grid solar setup makes an interesting little DIY project with which to experiment with green energy. And it could be useful to have a solar energy system that can run some of your station equipment and charge your mobile phone in the case of a mains power outage.

Power and voltage

Mobile transceivers that are designed to run from '12V' vehicle batteries can generally support an input voltage range of about ±15%. An off-grid solar energy system can power such a radio during the daylight hours while it tops up the battery for operation after sunset. On the other hand, for a transceiver that is designed to run from a regulated 13.8V mains power supply an inexpensive boost converter may be required to ensure reliable operation if the battery voltage falls below about 12.5V.

Including shipping to the UK, a typical small unbranded aluminium-framed solar panel incorporating 36 monocrystalline cells costs around £100. A good panel with an efficiency of 20% can deliver a peak power of over 120Wp under Standard Test Conditions (STC). Each cell generates over 0.5V and, as the cells are internally connected in series, the output of the panel typically exceeds 18V when delivering maximum power to a matched load. As the panels approximate 6.5A current sources, several of them can be connected in parallel for higher powers.

But STC peak power is almost never attained in practice. Apart from the reduced insolation caused by cloud, shading and less-than-ideal panel orientation, solar cell efficiency decreases significantly at temperatures higher than the STC value of 25°C.

Of course, the relevant temperature is that of the cells, which can be much higher than that of the surrounding air since they absorb heat as well as light. There are additional losses due to the fact that at solar elevation angles below 45° the air mass figure, which varies with the distance that the radiation travels through the atmosphere, is substantially higher than the STC value of 1.5.

Mounting solar panels

In most countries an installation with a large array of solar panels requires planning permission. Although a small DIY setup is much less conspicuous, local authority regulations should always be consulted to check whether any permissions are required. Automatic solar array sunflower trackers are available that use sensors to track the position of the Sun and drive motors to move the array to generate the maximum amount of power throughout the day. But they are expensive, their drive motors themselves consume electricity, and they are used mainly in large commercial and industrial systems. A cheaper solution is to mount the panels with a fixed azimuth and provision to alter their inclination according to the season. Since the panels give the highest power output when they are directly facing the sun, they should be oriented facing south in the northern

PHOTO 2: MC4 components. (Top) crimping tool; (middle) connectors; (bottom) assembly/disassembly tools.

hemisphere. The optimal tilt angle for fixed panels depends on the latitude of your QTH and changes with the time of year. For example, the optimal angle from the vertical varies from 10° at Aberdeen (57.15°N) in Winter to 62° at London (51.51°N) in Summer. This online calculator allows the angles to be determined for any location and month of the year: https://tinyurl.com/tiltangle

Photo 1 shows how a pair of solar panels can be mounted on the facade of a house. The upper edges of the aluminium alloy frames are secured to the wall by stainless steel hinges, while the perforated stays that set the inclination are inexpensive folding clothes hanger racks. This simple mounting arrangement allows the tilt angle of the two

PHOTO 3: Parallel interconnection of two solar panels with MC4 adaptors.

PHOTO 4: An MPPT solar charge controller has the highest efficiency.

panels to be set to 20° for Winter, 44° for Spring/Autumn and 68° for Summer at my latitude of 46.52°N. Since the solar panels are at stepladder height it requires only a few minutes to change the angle for each season.

It's important to position an array of solar panels such that no individual parts of them are shaded by other structures or foliage at any time of day and period of the year. Snow will usually slide off steeply sloping panels unless they are mounted at ground level, in which case it can accumulate in front of the cells from the ground up. The junction boxes of some solar panels incorporate series-connected blocking diodes, whereas others contain parallel-connected bypass diodes and some have both. The blocking diodes prevent an illuminated panel from passing reverse current through a defective or fully shaded one that is connected in parallel with it. (Schottky barrier diodes are used to minimise the forward voltage drop). As the cells within each panel are connected in series, any cell that is shaded will degrade the performance of the whole panel. Unless parallel bypass diodes are incorporated across each cell (which is unusual), the shaded cell becomes a hot spot that dissipates power instead of generating it. If the temperature rises sufficiently it may burn, rendering the panel useless and creating a fire risk. Bypass diodes in the junction boxes of small panels with only a single string of cells cannot mitigate this effect. They are only of use if several panels are connected in series.

Cable and connectors

Special 'photovoltaic cable' should be used for the solar panel installation as it has a double-insulated outer sheath that is resistant to ultraviolet radiation. Although 4mm^2 and even 2.5mm^2 cable has adequate current-carrying capacity for small installations, I recommend 6mm^2 cable to minimise the voltage drop at high currents. 10AWG cable (5.26mm^2) is also satisfactory. Photovoltaic cable is more supple than ordinary flexible electrical installation cable, and the 6mm outer diameter of the 6mm^2 cable is only slightly greater than that of the 4mm^2 type (5.4mm).

In the early 2000s various different connectors were used for solar power installations, but during the last ten years the MC4 connector system that was originated by the Multi-Connector division of the Swiss mechatronics company Stäubli has become a *de facto* standard. These special plug and socket connectors can be mated by hand, but can only be separated easily by the use of a tool that compresses a pair of locking fingers, see **Photo 2**. The connectors have a silicone O-ring seal giving IP67 protection against the ingress of dust and moisture and they accept 4mm^2 or 6mm^2 cable.

The normal 4mm diameter MC4 contacts are rated at 20A. Special crimping tools are available for attaching the contacts to the cable, but a satisfactory crimp can also be achieved with ordinary pliers if the joint is subsequently consolidated with solder. The connectors should never be unplugged while they are under load, since interrupting the high DC current may cause an arc that could damage the contacts.

Multibranch MC4 solid or cable adaptors are available that allow the cables from a number of solar panels to be merged separately to connect the panels in parallel. **Photo 3** shows how the cables are organised on the undersides of two panels, where the adaptors are protected from the weather. MC4 adaptors with inline blocking diodes are available. Note that the adaptors for the positive and negative cables are different. Anderson PP15/30/45 Powerpole series connectors and distribution blocks are useful for DC power interconnections inside the shack. These modular connectors have hermaphroditic flat wiping contacts but they have no latches. The dovetailed shells can be interlocked to form multipole connectors and the SuperFlex version of the contacts can accept up to 6mm^2 cable.

Solar charge controller

To interface between the solar panels and the battery, two types of solar charge controller are in common use. The more advanced Maximum Power Point Tracking (MPPT) type (**Photo 4**) is more expensive than the conventional Pulse Width Modulation (PWM) type (**Photo 5**). It can achieve somewhat higher charging efficiency, particularly if the panel array has a much higher voltage than the battery. This is obtained by using a DC-DC converter to maximise the power transfer by dynamically optimising the match between the low internal resistance of the battery and the higher characteristic resistance of the solar panels at the maximum power point, which varies with the insolation. However, manufacturers rarely provide detailed specifications of efficiency and tracking accuracy. Most PWM controllers are electrically quiet but some of the cheaper MPPT models can generate significant RF noise.

Solar charge controllers usually have an liquid crystal display (LCD) that continuously indicates the battery voltage, the status of the programmable load output, and whether the panels are charging the battery. Some models can also indicate the battery temperature, the state of charge and the actual charge and discharge currents. A menu allows the setting of parameters such as the battery type, the discharge cutoff and reconnect voltages and the float charge voltage. A programmable timer allows the load output to be enabled continuously, or only from dusk till dawn, or for a chosen number of hours after dusk. Since this feature is only useful for lighting, and there is a small voltage drop across the control circuit for this output, it is more efficient to connect a transceiver directly to the battery. However, in this case the discharge current is not measured and there is no discharge voltage limit to protect battery life.

A controller usually has two or more USB sockets providing 5V at around 2-3A for charging devices such as mobile phones. The controller itself typically has a small current drain of around 5-10mA. Solar power monitors, often with Internet or Bluetooth

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PHOTO 5: PWM charge controllers are cheaper than the MPPT type.

PHOTO 6: A DC circuit breaker is required to isolate the solar panels from the charge controller.

connectivity to mobile phone apps, are available to display additional information about the system performance, such as the state of charge, time to go and historical and statistical data.

Batteries

With the appropriate type and rating of charge controller, either lead-acid or lithium-ion batteries can be used in a small solar system. Shallow-cycle acid-flooded lead or gel vehicle batteries are not ideal for this type of service because they are designed to deliver a very high cranking current for a few seconds, while remaining on float charge or tiny discharge at all other times. Due to the Peukert Effect, the actual Ampere-hour capacity of these batteries is much less than the nominal value if they are used to supply a significant current for a lengthy period of time.

Deep cycle Absorbent Glass Mat (AGM) batteries suffer less from this effect and have a better cycling performance. Nevertheless, to prolong their life they should never be discharged to less than 50% of their capacity or to less than 12V. Ideally, a 100Ah battery should be charged at about 10-20A. To avoid any possibility of the vent valve blowing due to overpressure, it is preferable not to charge sealed batteries at above 14.2V.

Although lithium-ion batteries are considerably more expensive than lead-acid ones, prices are falling steadily and they offer several advantages, such as lighter weight, a flatter discharge curve, low self-discharge rate and negligible Peukert Effect. Cobalt- and nickel-free LithiumFerroPhosphate (LFP) batteries are a popular choice for solar energy systems as they are thermally stable and can typically support over 3000 charge/discharge cycles. Unlike lead-acid batteries they should not be fully charged, but preferably operated between 10% and 90% of capacity. The optimum charging voltage for LFP batteries is about 14.1V and some have an integrated battery management system that protects and controls them. To avoid performance degradation in low winter temperatures, sealed lead-acid batteries will normally be housed indoors. Although the operating range for LFP batteries is -10°C to 55°C, they cannot be charged at temperatures below freezing.

Protection

All battery circuits should be protected with appropriately rated fuses or overcurrent circuit breakers. A solar charge controller will normally have internal overcurrent and reverse polarity protection, as well as over-discharge protection for the programmable load output. It should also prevent the battery discharging through the solar panels when they are not illuminated, even if they have no blocking diodes. However, the controller can be damaged if it is connected to live solar panels without the battery present. Hence a circuit breaker of adequate rating should be installed between the panels and the controller. (See **Photo 6**). The circuit breaker should be opened before the battery is disconnected from the controller and only closed again after a battery is reconnected. The short circuit current of a small solar panel can exceed 10A. The circuit breaker must be of the type that is designed to interrupt a DC current in spite of the arc that is created when the contacts open. It should be appropriately labelled, and its use understood by all members of the household. An AC circuit breaker is unsuitable since rapid arc extinction in this type relies on the zero crossings occurring twice per cycle.

When many solar panels are connected in parallel, individual fuses can be connected in series with each of them for safety in the case of a failed (or non-existent) blocking diode. Some authorities may specify that a circuit breaker must be located in a readily accessible position outside the building. Insulated caps should be fitted to any exposed battery terminals to protect from accidental short circuit and the battery should be placed in a plastic tray capable of retaining any electrolyte leakage.

While facade-mounted solar panels normally don't require an earth connection, local regulations may require that a safety ground be provided for a rooftop installation where there is a risk of a lightning strike. The codes may also specify that the cables must not be in contact with the roofing material.

In a severe storm, solar panels can suffer extensive damage from very large hailstones as are often encountered in Europe. If such a storm is predicted, hinged facade solar panels can be dropped to the vertical position but even this will not guarantee that they won't receive damaging hailstone impacts during high winds.

Experimenting

As with many other enjoyable amateur radio projects, a small photovoltaic system offers interesting opportunities for practical experiment and innovation. For example, lightweight flexible, foldable and roll-up thin film solar panels are now available at affordable prices, making it possible to try out 3D arrays with novel geometries. Inexpensive single- or dual-axis solar trackers for small systems can be based on the extensive amateur experience with tracking OSCAR satellites.

Other possible activities include experimenting with methods of mitigating the RF noise that can be generated by solar energy system components, the power requirements of different operating modes, cooling solar panels to increase their output, evaluating solar charge controllers, transmit/receive control of charging, the effect of dust and automatic cleaning, lightweight solar-powered emergency radios, wide bandwidth MPPT, reflective concentrators, and passive solar trackers that can track the sun without an added energy source.

Xiegu G106 HF transceiver

The G106 is the latest HF transceiver from the Xiegu stable. It's a QRP rig offering 5 watts on the 10 to 80m bands.

I am quite a fan of Xiegu transceivers. I have reviewed them all for various radio magazines and own both the X5105 and the G90. I should be clear here that Xiegu radios are not perfect, just as my FTDX10 is not perfect. Perfection is in the eye of the beholder and the use to which you put your radio. That said, Xiegu do provide an awful lot of radio for the money.

I was pleased, therefore, when Sinotel offered me a review unit of the brand new Xiegu G106, due to be released in the UK in Autumn this year. The G106 is a 5 watts (minimum) HF QRP transceiver, covering the 10 to 80m bands. The unit also provides general coverage receive from 0.55 – 30MHz, and coverage of the FM broadcast band from 88 – 108MHz.

PHOTO 1: The Xiegu G106 front panel with liquid crystal display, similar to the GM1 version.

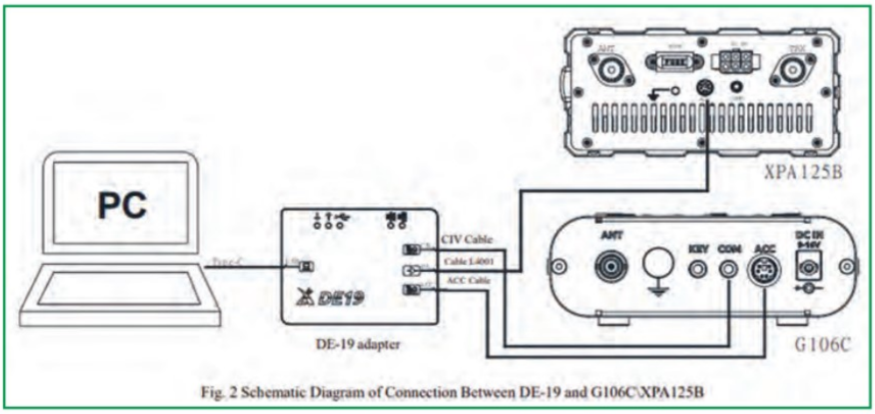

FIGURE 1: The DE-19 interface uses a single USB C cable to the PC.

Out of the box

When I unboxed the unit I was pleasantly surprised at the comparatively small size and the design, which has rounded edges. It is pleasing on the eye, measuring in at 120 x 40 x 135mm and weighing 720g. Included is a microphone and a power lead terminated in a coaxial plug to suit the rig. No COM port cable was provided, unlike with many other Xiegu rigs, and this is needed for CAT control and digimodes.

On the front panel is a volume control, mic socket, four menu buttons and the large VFO control. The front controls are given protection from knocks and bumps by means of the case extending forward flush with the control's uppermost surface. On top and just to the rear of the fascia is a power button, a mode button that also activates a pre-amplifier stage, and an up/down band button that also doubles as a tuning step change control. On the rear is a BNC antenna connection, a ground screw terminal, key socket, COM port socket (3.5mm), 8-pin mini-DIN accessory socket and a co-axial power socket. Stand-by current is specified at 0.37A and transmit current at 2.8A max.

In use

Powering the device up for the first time, I immediately noticed the similarity of the display to the existing Xiegu G1M transceiver, which appears to share an identical layout and design, albeit with the colours inverted. As a monochrome display, it is easy to read in bright sunlight and there is an option to turn the backlight on and off.

The menu is simple to access and use, by pressing one of the four menu buttons under the display. These give access to memories, VFO switching, CW filters and settings, display options and the FM broadcast band. The VFO control is used to cycle the menu options for these buttons.

I began by tuning around on CW and using the CW filters, which has options of 500, 250 and 50Hz. The 50Hz filter could be useful on a busy band, but there is quite a lot of 'ringing' in this setting, which means I would use it sparingly. I went on to have a number of successful CW contacts and the volume available is plenty.

Using the display control on the menu I was able to choose from three display types – both VFOs, S-meter and panadapter; both VFOs and panadapter, or just a single VFO with a large panadapter display. This latter display proved most useful, but it was when using this that I noticed a discrepancy. The panadapter for an SSB signal lines up with the tuning mark correctly, either on the upper or lower side, but when tuning CW, the tuning line is off by the CW offset of, in my case, 800Hz. You basically need to tune for the audio and almost ignore the panadapter for CW, which is a shame, but should be an easy firmware upgrade fix at some point.

Another shortcoming on CW was the QSK facility. The rig arrived set with this at 0 milliseconds, but there was a whacking audio thump from the speaker in between dots and dashes that was very intrusive. I set about experimenting with the QSK delay but without much success. Effectively to eliminate the audio click, you have to accept that QSK is not usable and that you cannot listen at all between characters. The QSK

PHOTO 2: Rear panel of the G106 with connectors shown.

PHOTO 3: The DE-19 USB to radio interface uses a USB C connector towards the PC for CAT control and audio.

delay ended up at 250ms. This is not a major issue and the rig still handles CW QSOs perfectly adequately, but if you are a full or semi-break-in fan, you will be disappointed. Hopefully Xiegu will address this in a future firmware release. Like both the G1M and the G90 there are no CW keyer memories.

SSB brought a few contacts, although it is not my preferred mode, and the small and cheap microphone appeared adequate – I had no negative audio reports, but you should note that there is no speech compressor available.

I was a little frustrated by the use of the band button as the means to adjust the tuning step of the VFO. In order to do so you must press and hold the Band Up or Band Down button for a full two seconds! This is far too long, and 0.5 second would be more than long enough. It therefore became a little frustrating when moving through two or more steps. Hopefully Xiegu can correct this too in a future firmware upgrade.

Digital modes

The rig is suitable for digimodes and Sinotel sent me the Xiegu DE-19 adapter, which will retail at £48.99 and is also compatible with the G90. This adapter performs a similar role to the CE-19 adapter for the X5105 and G90, using the same rig connections via the 8-pin mini-DIN. However, it appears to be an improved version, as it interfaces to the computer via a single USB-C type cable, keeping cable clutter a little more under control. The DE-19 came with all the required (three) cables to connect the rig to the PC and was easy to set up. An additional L4001 cable is required if you also wish to use the XPA-125B linear amplifier. I connected and made digital QSOs easily and the rig performed well in this mode with no noticeable drift on WSPR mode. A picture of the unit and a connection diagram is included here.

Tests into a dummy load gave power output indications of between 6-9 watts, with 9 watts available on the 12m band, 8 watts on 15 and 20m, 7 watts on 80m and 6 watts on 17, 30 and 40m bands. Interestingly, the 60m band is not specified as a band capable of transmission on this rig. Testing into a dummy load though revealed 7 watts output between 5331 and 5405kHz, which I believe corresponds to the US band plan. Here in the UK, our allocation ranges from 5258.5 to 5406.5kHz. Hopefully the EU shipped version will give full 60m coverage but I cannot confirm this.

Prices

With a launch price from Sinotel of £329, it is worth considering where this new model sits in the Xiegu line up. At the cheapest entry level is the G1M, a very similar SDR radio with a nearly identical display, similar form factor and the same power output. The G1M retails at £239, £90 less, but is only a four band HF radio, covering 80, 40, 20 and 15m bands. It also only has a single 800Hz CW filter, although semi-break-in keying was better than the G106. The G106 audio output is stronger and clearer than the G1M, thanks, in part, to a larger speaker.

At £399 is the G90, the next model up from the G106, followed by the X5105 at £499 and the X6100 at £575. The G106 is at the entry level, but sat almost in the middle of the price gap between the G1M and the G90. This seems fair enough, given the extra band coverage.

There are, therefore, a number of features not present on the G106 that do feature on the G90. These include the lack of an ATU, no noise reduction or adjustable filters (other than CW bandwidth), and whilst there is a pre-amp there is no attenuator. A tilt bail at the front would also improve operability.

Conclusion

Overall though, the rig was simple to use and operate and many QSOs were possible. There were no major bugs discovered and I was thinking of taking the rig with me in the caravan on our visit to the Commonwealth Games, when I suddenly realised that there is no headphone socket. That put paid to that idea, as operating CW in a caravan with my wife and two kids would be impossible. This seems a real oversight, and a headphone socket is even included on the G1M. Checking the manual seemed to show a speaker output to the microphone, which had a 3.5mm socket, but that does not appear to work. One possibility, if headphones are important to you, is the 8 pin mini-DIN socket on the rear, for digimodes. This obviously provides an audio output – maybe one could connect headphones that way to resolve the issue? I cannot help thinking that the lack of a headphone socket is a fairly fundamental mistake, especially if one wanted to use the rig in a portable or field-day type of environment.

Despite this, the G106 remains a good rig for a modest investment of £329 and in a small and neat package, perfect for the shack, car or portable. Of course, at this price, the fact that it comes with a 12-month warranty might give it an edge over a quality piece of used gear, at least for peace of mind. Given the rig's compact size and comparatively low weight, it struck me that the addition of a suitable carry-strap would make this a neat and light pedestrian portable set-up. There does not appear to be a designed facility for this, but it would not be difficult to achieve with a little ingenuity.

Overall though, I think that the price point of this radio is so close to the G90, which has a wealth of additional features, that I would advise you to consider carefully the difference in features and price before making a decision. Despite this, the G106 would certainly get you on the air perfectly well in a smaller and lighter package, and, like other Xiegu products, it represents real value for money.

The Xiegu range is available direct from www.sinotel.co.uk or from https://moonrakeronline.com, www.nevadaradio.co.uk or https://hamradiostore.co.uk.

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Feature

A WSPR70 Antenna Comparison Experiment

The WSPR 70 project provided an opportunity to compare antennas.

Patrick, G0HYT and I (Phil, M1GWZ) are both members of Echelford ARS in North Surrey/Middlesex. This is not the only thing we have in common. We inhabit similar suburban domiciles with similar gardens; live only 2.5 miles apart as the photon flies; both have a love of the SOTABEAMS WSPRlite transmitter and we both operate multi-band antennas.

There is one significant difference in the last of these statements; while Patrick has a DX Engineering Hustler 8BTV eight-band *vertical* antenna with around 30 ground radials, I operate with a homebrew off-centre-fed *horizontal* multiband dipole antenna. The latter consists of a 20m wire fed at *one-sixth* of the length from one end via a 1:4 RF transformer and ferrite choke. The average height of the horizontal wire above ground is about 8m (as is the top of Patrick's vertical). This antenna has resonant frequencies coinciding with the 40, 20, 15 and 10m bands (and 6m too, although we didn't test that high) and has allowed DX QSOs in all of those bands. Anything not conforming to those bands (ie WARC allocations) requires the use of an LDG AT-200 matching unit. Thus we have set out on previous occasions to compare WSPR results from the two antennas, at 200mW power. The opportunity to contribute to the call in *RadCom* to carry out similar tests at 50mW (70mW ERP?) and proudly to share our 'Q' prefixes for the Jubilee month of June with the rest of the world was just too good to pass up and by 10am on the 1 June we were both on the air.

We agreed at the outset that the suggestion of 70 minutes operating time was unrealistic

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FIGURE 1A.

FIGURE 1B.

FIGURE 3A.

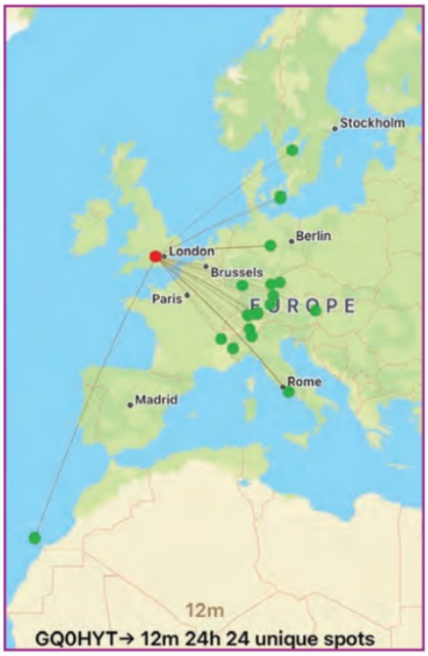

FIGURE 3B.

and unlikely to yield comparable results across bands and so each experiment was as near as possible to 24 hours of operating. In this way we worked our way down in frequency through the bands (including the WARC bands) from 10m, via 12, 15, 17, 20, 30 and ending at 40m. Although our experiments also extended to 80 and 160m, these latter bands required significant changes in antennas making comparisons difficult, so this report only concerns a comparison of the two antennas specified above. Although there are many ways to display and analyse WSPR results, the iPhone *WSPR Watch* v. 3.38 app by Peter, VK3TPM is a convenient and simple way to show results and was used to prepare the figures shown. (Note that in each case, Figure **A** is the *horizontal* wire and Figure **B** is the trapped *vertical*.)

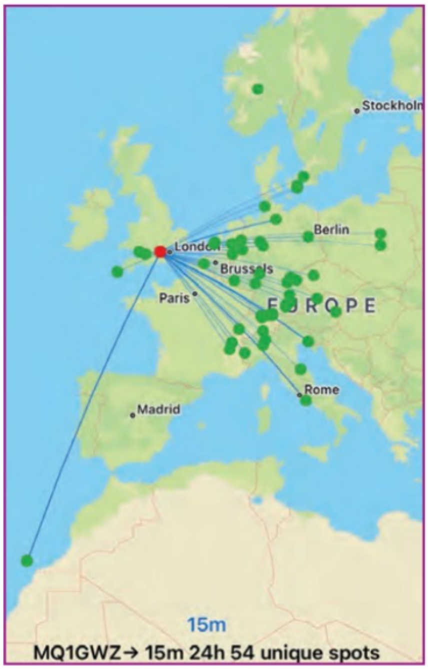

FIGURE 2A.

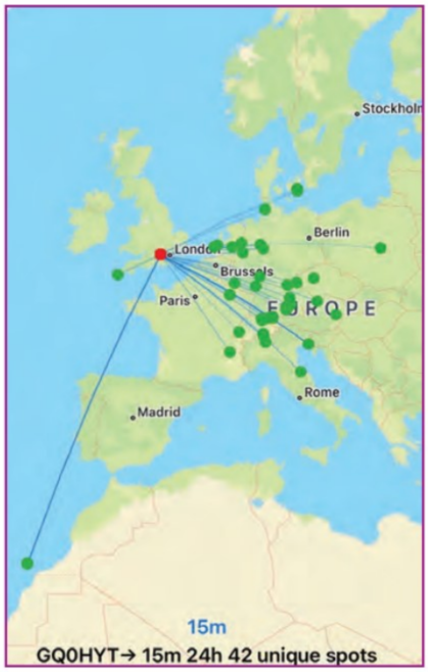

FIGURE 2B.

The results

The first day's results for 10m were somewhat disappointing; only two spots each, as shown in **Figures 1A** and **1B**, and led us to wonder whether 50mW was too low a power to use! However, 10m is notoriously variable, so we carried on. (Incidentally, we did return to 10m at the end of the month and fared no better.) After this disappointment, the following day's results on 12m came as a pleasant surprise! (**Figures 2A** and **B**.) Although the horizontal wire fared rather better than the vertical, the similarity in disposition of the spots for both aerials is immediately striking. Things picked up even more on 15m over the 3rd and 4th of the month (**Figures 3A** and **B**).

I wasn't expecting good performance on 17m for the off-centre-fed dipole as it is far from resonant at this frequency but I have had good QSOs in this band and indeed, on the NFD weekend it was our first joint foray across the pond to the USA. Despite our overall similar performances, I feel obliged to point out the freak spot I obtained from Alaska, partly because it was the first time I've had a WSPR spot there, and partly because it left G0HYT green with envy (**Figures 4A** and **B**).

FIGURE 4A.

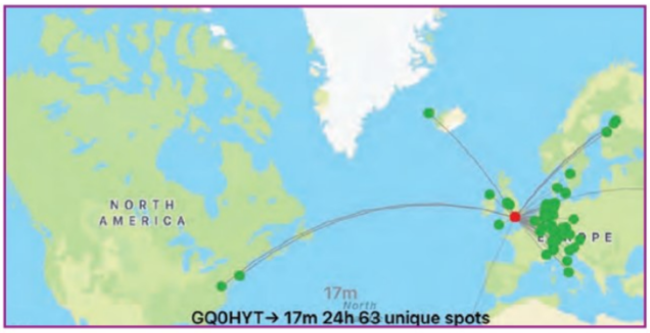

FIGURE 4B.

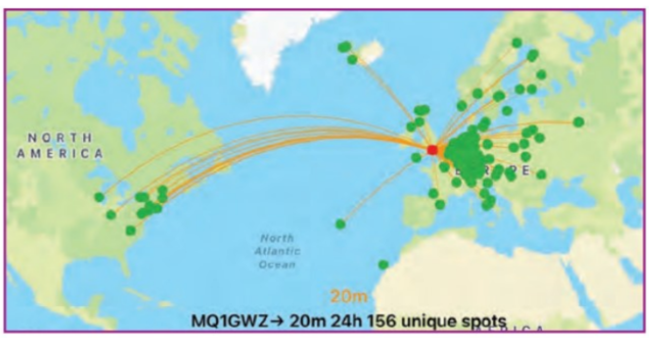

FIGURE 5A.

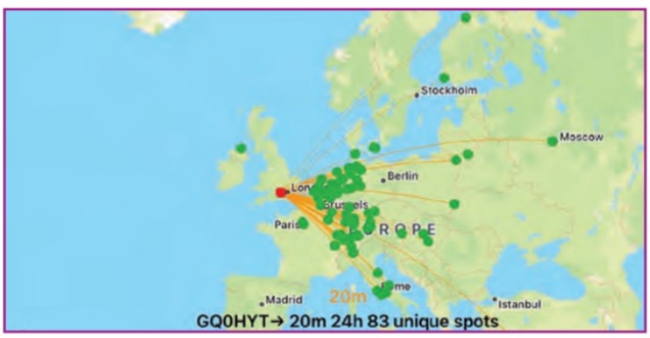

FIGURE 5B.

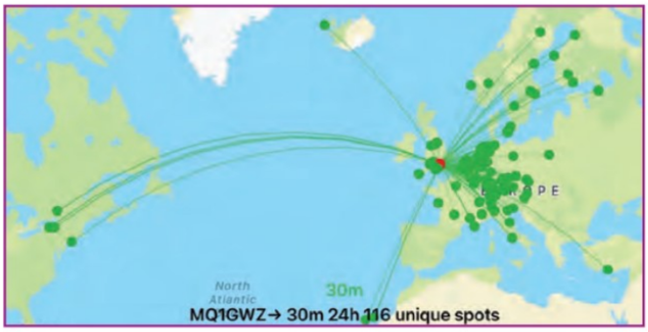

FIGURE 6A.

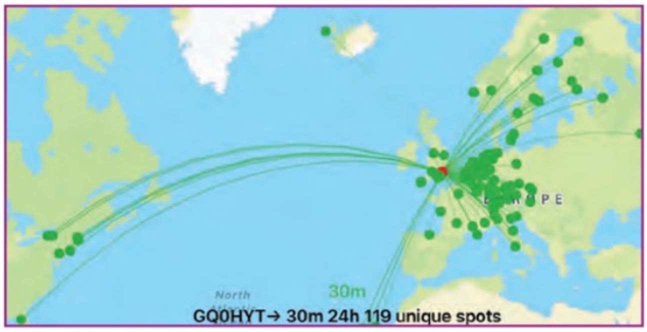

FIGURE 6B.

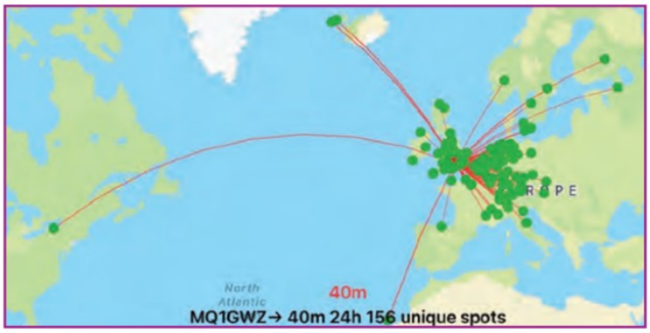

FIGURE 7A.

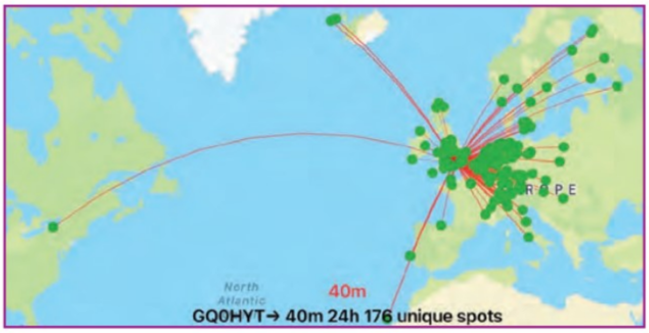

FIGURE 7B.

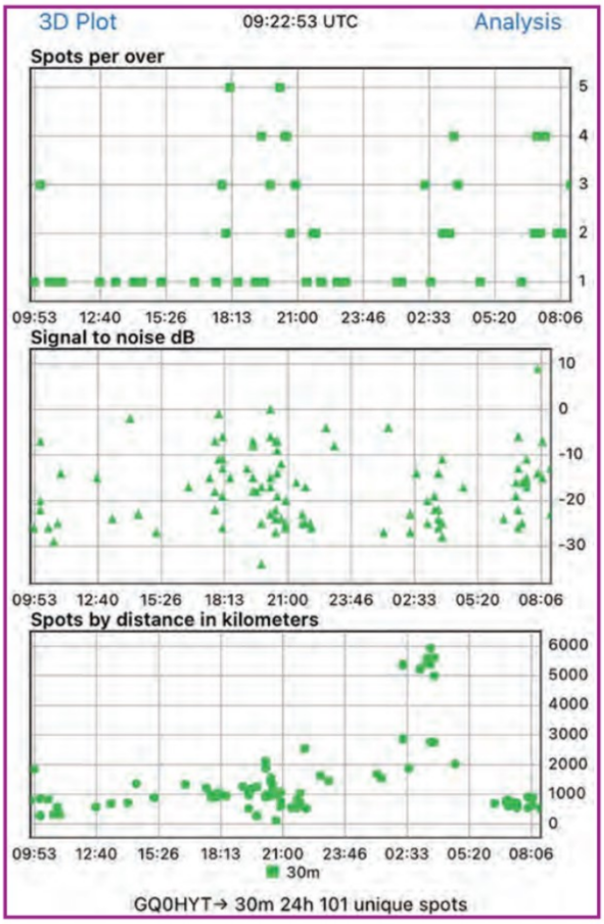

FIGURE 8.

Curiously, we got very different results for 20m, but I would mention that my horizontal wire is very much optimised for 20m operation and for transatlantic direction (**Figures 5A** and **B**). The transatlantic route really opened up for us both the following day on 30m, with very comparable results (**Figures 6A** and **B**) and finally, 'HYT gave me a 'darned good thrashing' on 40m, albeit again with remarkably similar maps (**Figures 7A** and **B**).

As mentioned previously, we continued our comparisons throughout the month, but those were more in the spirit of fun and getting our 'Q' callsigns out to the world at large. Of course, WSPR has the potential to yield much more information than just maps, and even an app such as *WSPR Watch* provides graphical analyses on request that are extremely pertinent to propagation studies but which are beyond the scope of a short article (see **Figure 8** for an example). Having said that, what were our main conclusions?

Conclusions

The biggest surprise to both of us has been the similarity between the distribution of results in most cases. These are considered to be indicative of two major factors:

1. The directionality of (particularly) horizontal antennas in a typical suburban property with surrounding buildings and trees is much less pronounced than antenna modelling software might often suggest. There is a big difference between modelling an aerial in free space over an isotropic earth plane compared with operating one in a suburban garden.

2. Any indicated directionality when examining WSPR results (other than with narrow-width beams) must allow for the distribution of WSPR receiving stations world-wide. While central Europe and the USA appear to be well-populated with WSPR receivers, places such as Asiatic Russia and (particularly) Africa are much less so, greatly restricting the chances of being spotted from those locations, thus giving a false impression of directionality and/or propagation favouring certain directions.

Most important of all, these experiments have brought us enormous fun and enjoyment for a comparatively small outlay of time and money. We intend to continue to pursue these WSPR experiments into the future as both the seasons and solar conditions change.

Design Notes

Last month we looked at rebuilding a Li-ion battery pack using controller modules purchased online.

This prompted Nick Garrod, G0OQK to write in, commenting: "I just read your article and would like to suggest a further refinement. I have just replaced 20 NiCads in an ex-army Clansman 24V 1Ah battery pack with 6 ex laptop 18650 lithium cells to give 24V at 2Ah. The new pack is considerably lighter.

"Like you, I used one of the readily available battery management boards, but a 6S 24V version. The refinement is to build the pack with 18650 battery spacers, which are available from eBay **[1]** and other online sources. These clip together in a matrix and fit over the ends of the cells to space them out into a block. The main advantage is that the bodies of the cells are no longer touching each other reducing the risk of an inter cell short if the insulation is damaged.

"Like you, I taped the completed pack, but the spacers also lift the cells away from the mounting surface. I also charged from my current limited supply, but only at 0.5A, as I was being extra cautious with the untested BMS board. I have included a link to the clips I bought, but they are readily available from multiple sources, search 18650 battery clip."

EME Echoes

The Flight Refuelling ARS EME group are very active on 10GHz moonbounce with a high power 185W Travelling Wave Tube amplifier and 3.2m dish. This makes them one of the most powerful EME stations in the World on this band. Estimated Radiated Power, EIRP, is of the order of 71dBW, or 12.5 Megawatts! But quite apart from being able to work many other stations around the world on this microwave band, including a number with just modest setups who are only able to compete by working the few 'big guns', having such a potent setup opens up possibilities of other types of investigation and research into the Moon's use as a reflector of radio signals, and even of measurement of its orbit!

The time taken for a radio signal to be transmitted from Earth, travel to the Moon and be reflected back means the reflection arrives at the antenna between 2.4 and 2.7 seconds after the transmission. The variation in time delay is because the Moon travels in an eccentric orbit around the Earth. Its distance varies from around 384,000km to 407,000km. This means it is quite possible to make a meaningful transmission using SSB voice, allow time for a proper safe sequenced Tx/Rx changeover and hear the reply. Visitors to the FRARS setup have been amazed at how they could say "Hello Moon"

PHOTO 1: 144MHz chirp generator based around an AD9852 DDS module and PIC controller. A GNSS receiver module, seen at the top, supplies timing information to ensure a start time for the chirp controlled to within less than a microsecond of UTC.

PHOTO 2: The 3.2m dish used by the Flight Refuelling ARS EME Group. Courtesy John, G0API.

into the microphone, release the PTT and 2.5 seconds later hear their voice come back – modulated with the characteristic scattering, or roughness, of 10GHz reflected from this rough-surfaced, rapidly-moving body. It is this roughness and scattering, how it varies with the Moon's position in the orbit and the elevation above the horizon, that a number of EME ops on 10GHz and higher bands would like to be able to investigate and understand more.

Recently, group members G3YGF and M5RAO were contemplating what measurements could be done by monitoring reflections of a transmitted chirp signal, a linearly increasing frequency during the transmission period. Chirps are often used in radar to allow longer transmit periods with lower power. A frequency that varies linearly with time, and hence distance, might allow measurements of distance, scattering etc. that couldn't be done with a narrow carrier. G3YGF mentioned this to me, and we looked at a few of the modern DDS chips around that might be used to generate a chirp signal at 144MHz, that could be used to drive the 10GHz transverter at FRARS. An identical DDS source (or even the same device) could then generate a similar chirp at 116MHz during the receive period 2.5 seconds later, to mix the received signal from the transverter output down to a de-chirped 28MHz for input to an SDR for further analysis.

Many DDS devices have automatic chirp generation built in as this is a technique often used for many different signal processing tasks in everyday life. Unfortunately, modern DDS chips tend to be quite expensive, upwards of several tens of pounds and running into over £100 for some of them showing in the suppliers' catalogues. But even more to the point, many were not even available off the shelf due to the ongoing chip shortages affecting the semiconductor industry generally. Then I remembered the AD9852 DDS chip that 'JNT labs has used many times in the past, and even marketed short-kits of this device mounted on a PCB **[2]**.

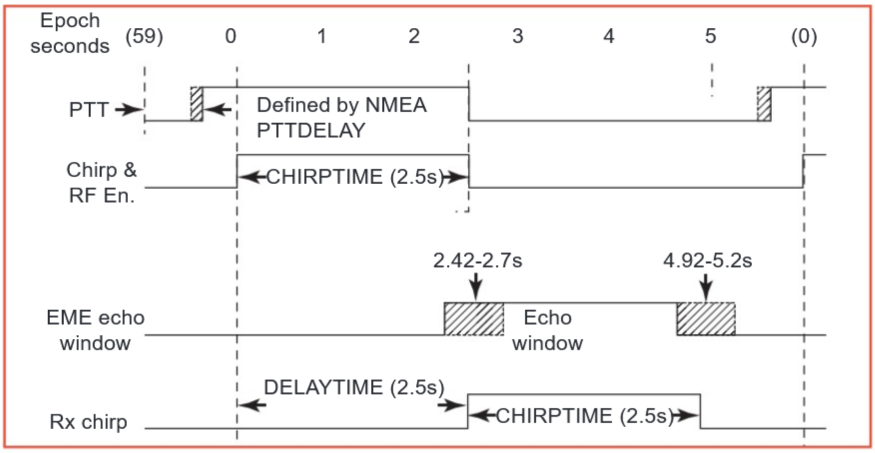

FIGURE 1: Timing diagram showing how a 2.5 second chirp transmission, EME echo delay of approximately 2.5 seconds and some dead time for Tx/Rx changeover are fitted into a six-second repeat window. The correct 6-second epoch is derived from timing carried on the NMEA data delivered from the GNSS module.

DDS Chirps

The AD9852 is quite an old device these days – I first used it in 2003 – but there are still a few of those modules sculling around on the shelves or built into old and now redundant projects. It is capable of being clocked at up to 300MHz and has an on board Phase Locked Loop (PLL) that can multiply a reference signal input by up to 20 times. The AD9852 register set contains the option to automatically generate a chirp when triggered. Quite apart from the accumulator register, essential to any NCO that has the 'frequency value' N added to it each clock cycle, there is another register in the device that optionally can contain a frequency increment. This can be a signed number, to allow up or down chirps, and its value is added to the N, or frequency, value automatically after a user-defined increment. This increment is itself determined by programming another register in the chip that works as a divider from the clock frequency. By appropriate choice of values for these two registers, a precise frequency increment can be generated every 'few' clock cycles. The result is, once triggered, a steadily-increasing frequency is generated at a rate determined by the two register values.

Unfortunately, once started there is no way to stop the chirp carrying on forever, (in practice the register just wraps round) other than by commanding it to stop by reprogramming. But in practice this is not too important. When chirps are used for timing and measurement it is usually the rate (Hertz per second) that is critical, along with the precise start time, to get accurate results. Less so the stop point.

Choosing Some Numbers

Using a DDS 'properly', ie below the Nyquist frequency at typically up to 40% of the sampling rate, means that even with the maximum clock of 300MHz, generating directly at 144MHz is not that feasible. The first alias would appear at F_{CLOCK} – 144MHz = 156MHz and would present a hairy filtering problem. Also, with only a X20 clock multiplication possible, an input from a master 10MHz reference couldn't directly give that clock speed. Thrashing the chip at its maximum clock rate also increases power consumption and lowers reliability.

However, by running the clock at 200MHz, the maximum PLL reference multiplication possible from a 10MHz input, did show great possibilities using the first alias product. By programming the DDS to generate at 56MHz, the first alias appears at F_{CLOCK} – 56MHz = 144MHz. The second alias is at F_{CLOCK} + 56MHz = 256MHz. Both this and the fundamental are easily removed by using a bandpass filter centred on 144MHz to select just the wanted term. The one thing to remember, though, is that as the wanted RF appears after a minus sign its direction will be inverted. An increase in programmed frequency results in a movement downwards at 144MHz. **Photo 1** shows the transmit source.

For the second device, the receive converter using a chirp generated at 116MHz, the same relationship can be used. Programme the device to generate at 84MHz and the first alias appears at 116MHz, with the next unwanted product to be removed sitting at 284MHz. Once again, a simple bandpass filter can remove these. Using the same alias product and clock multiplication removes one problem of generating Tx and Rx coherent chirps that accurately track together. Identical values can be used in the two chirp generating registers with only the starting value different for the two.

The EME echo delay ranges from 2.4 to 2.7 seconds, so as a nice round number, a chirp length of 2.5 seconds was used. A little bit might be lost at beginning or end of the cycle depending on the Moon's position in its orbit, but only a small fraction that wouldn't compromise measurements. Initially we thought a 1MHz wide chirp would

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be a good starting point so this was used to test the source, generating a chirp from 144 to 145MHz, although subsequently chirp widths of 10kHz to 1MHz were made link-selectable. A bit of playing around on a spreadsheet revealed that there were an almost infinite set of *pairs* of values for the two chirp registers – frequency increment and timing interval (clock divider) that would give a chirp rate of 400kHz per second for a 1MHz sweep in 2.5s. An almost arbitrary choice was made to use a frequency increment of -1Hz (remember the tuning direction is backwards for this alias product) every 25 microseconds. The auto frequency increment is then generated by diving F_{CLOCK} at 200MHz by 5000, which is the value stored in the clock divider register. In practice, although a 1Hz 'step' is asked for, as this is updated at an interval very-very much shorter than one cycle at 1Hz the DDS just sees a minor increase in rate-of-change of phase and the resulting chirp is a perfectly liner increase.

Timing Issues

The accuracy of the chirp itself is the most critical parameter, and this is determined solely within the DDS chip from a clock derived from a master 10MHz input, itself coming from a GPS-locked frequency source – that would be fine. But what about start and stop? The PIC controller driving the DDS takes in the one pulse-per-second (PPS) signal generated from a low-cost GNSS module. This is accurate to a few tens of nanoseconds of UTC, even with a small delay introduced by the PIC processor cycle time. This is more than adequate to set a precise start time. Stopping the chirp after 2.5s was a separate issue. Once started, there is a delay routine in the PIC that runs for 2.5s before issuing a stop command to the DDS. This 2.5s delay is controlled by the controller's own clock oscillator that, at the time of writing, is an independent crystal oscillator. However, the exact stop time to within a few microseconds doesn't matter, any inaccuracy of this end point is immaterial. This Tx chirp PIC controller also generates the Tx/Rx control line going to the EME transmitter / receiver system and incorporates a sequencer delay for the finite time of several hundred milliseconds needed for safe changeover.

There is a tighter requirement on the controller used for the 116MHz Rx chirp. This is also triggered from the 1 PPS generated by a GNSS module but it now has to delay the 2.5s of the echo period. This 2.5s delay has to be generated by the PIC itself before starting the Rx chirp source. Any timing uncertainty here reflects directly as a frequency shift. Take an example: assume the clock is running 20 parts-per-million out, typical of any low-cost crystal. 20 PPM timing error on a 1MHz chirp over 2.5 seconds appears as an error on the delay of 50μs. This corresponds to 20Hz error on a 400kHz/s chirp. Or in terms of a distance measurement, 15km. The solution to this was to take the 10MHz master reference and use it, via a CMOS gate connected as a buffer, as the processor clock. Now the 2.5s delay needed for starting the Rx can have the same degree of accuracy as all the DDS derived chirp parameters. For testing purposes, a switch was added that removed this 2.5s delay meaning both Tx and Rx chirps start simultaneously. This meant they could be combined in an external frequency mixer and the quality of the resulting 28MHz signal checked before it was used for real echoes.

With a 2.5s upchirp on Tx, then waiting for the 2.5s of Rx time, the total cycle is a bit over 5s. A cycle time of every 6 seconds was used with the remining one second being taken up with Tx/Rx changeover and a bit of waiting. Both Rx and Tx controllers read the NMEA timing string coming from their respective GNSS modules and time the system so the transmission starts every 6 seconds after the UTC minute, ie mm:00, mm:06 mm:12 etc. That way no manual set up is needed; just switch on and wait for the GNSS receivers to lock up and acquire correct leap second offset **[3]**. **Figure 1** shows the EME chirp timing situation graphically.

Whilst it would have been entirely in order to use the same GNSS module for both Tx and Rx, or use a trigger signal generated in the Tx to trigger the Rx delay, I just felt that looking to the future there may be some advantage to be had by adopting two completely separate independent systems. It uses an extra GNSS module, but these are low cost now **[4]**, and who knows; perhaps at some time in the future I may want to conduct propagation type experiments at 144MHz or whatever, where these two modules are used but now physically separated by a long distance.

Results

Test mode with simultaneous Rx / Tx chirps into a mixer worked immediately. The resulting decorrelated mixer output at 28MHz, when viewed on a narrow band spectrogram display, showed a signal width of appreciably under 1Hz. When averaged over a long period, sidebands at 0.4Hz due to the pulse stop and start interval, and at 0.1667s due to the six-second repeat cycle could be seen. These are entirely to be expected and in no way will affect results of echo measurements that will be looking in hundreds of Hertz to kilohertz of bandwidth.

Real echo tests also worked straight away after connecting the two modules into the FRARS EME system. A received offset of several kilohertz was seen on the received 28MHz that was commensurate with the Moon's distance at the time of the test, and its Doppler shift. A lot of thinking and work now needs to go into analysing results but it has become apparent that a single upchirp is not adequate. The effects of distance (a fixed frequency shift) and Doppler (another frequency shift) cannot be separated. To counter this an up and down chirp, a triangle, is needed for the transmit frequency pattern. The DDS chip itself cannot do this on its own; it will have to be re-programmed mid-way to change the sign of the frequency increment register. Which now means accurate timing is needed in the Tx PIC controller in the same way as it is for Rx. Now the Tx will have to be modified to run from the 10MHz master as well.

All tasks for the future, and will help keep 'JNT labs busy. But we have proved that a suitable chirp generated from hardware nearly 20 years old, otherwise sat gathering dust on the shelf, works in practice to produce reliable EME echoes with resolution sufficient to make the measurements of scattering, distance changes etc that those who understand the mechanisms can work with.

References

[1] https://www.ebay.co.uk/itm/403810472830: Li-Ion battery cell spacers

[2] http://g4jnt.com/AD9852module.pdf: AD9852 DDS Module

[3] Leap Second Issues. The time carried on GPS and the other GNSS satellite systems it not 'real' UTC. It is not corrected for leap seconds in that way that UTC has to be to keep synchronism with the Earth's unstable wobbling orbit. The leap second discrepancy between GPS time and UTC is transmitted by the satellites in its user-messages, but unfortunately these repeat only every 7.5 minutes, and sometimes even less frequently. This means a GNSS receiver module, turned on from cold and that has lost any previous data through its having time-expired, will output a time-of-day value that is a few seconds – typically two or three – in error. This state will continue for up to 7.5 minutes until the timing data will suddenly just jump and correct itself to the correct UTC value when the offset data is received. This leap second error has caused 'JNT labs untold grief over the years before it was properly appreciated, and has led to several UK beacons having a delayed timing, the received DT value, on their decoded WSJT messages.

[4] Many eBay and other online suppliers are offering GPS/GNSS modules at prices typically ranging from a few pounds to a few tens of pounds. Those by Ublox, the NEO-6 and higher families can usually be relied on and are my first choice nowadays. The very low-cost modules may well be fakes, but some recently purchased for the ludicrously low price of £6.50 each do work as they should, and are quite adequate for timing projects such as that described here.

'Annie' – When what you need is noise

In spite of what most of us have come to believe about electronic noise, there are times when having a reliable and adjustable source of noise is a good thing.

When you think about it, we most often do alignment and adjustment of communications equipment with high-quality sine wave signals, perhaps AM modulated to some degree just to make them easier to use. Such signals are, we hope, very narrow-banded. But imagine replacing a narrow-band source with one that is broad-banded. Such a source, along with a good oscilloscope or other equipment, actually helps check bandwidth and the 'shape' of a passband.

Noise sources also find use in impedance 'noise bridges,' where the broad bandwidth means that the driving signal doesn't have to be tuned (along with everything else). Some experimenters have also used software defined radio (SDR) as 'poor man's spectrum analysers' to measure filters they design and construct using noise sources.

I got started some time ago with these sources when I needed to design equipment to reduce or eliminate noise in lasers. I needed something to approximate what happens in high power laser diodes that causes huge noise problems in the lasers my company was building. My task was to design a noise modulator capable of adding specific amounts of noise to the current driving laser diodes running at up to 60A, with voltage drops of perhaps 1.5-1.7V, roughly the equivalent impedance of a piece of heavy gauge wire. All of that had to at least 'look like' pseudo-white noise (with a roughly 1/f amplitude characteristic) and run from a few Hz to well over 20MHz and be easy to use, etc. How I did the modulator is a story for another day, but along the way I learned a lot about making noise, and now I'm passing on some useful stuff.

Traditionally, there have been two ways of generating noise: either by amplifying thermal noise in a resistor or doing something similar with noisy avalanche processes in some kinds of diodes. A very useful article, both on measuring S/N ratios and on the 'resistor method' was offered by Andy Talbot, G4JNT in the September 2020 *RadCom* **[1]**. The other – diode – method has also been around for a long time. Special diodes have been manufactured specifically to make noise, and more recently, builders have turned to the humble Zener diode, noted as a voltage regulator *and* source of ample electrical noise. The Zener solution is typically the easiest to use, but perusing most published designs of, say, noise bridges, one particular circuit keeps cropping up. I tried using that one but then ran across another way to make the required noise and realised I'd been doing it – well, not 'wrong,' but let's say 'inefficiently'.

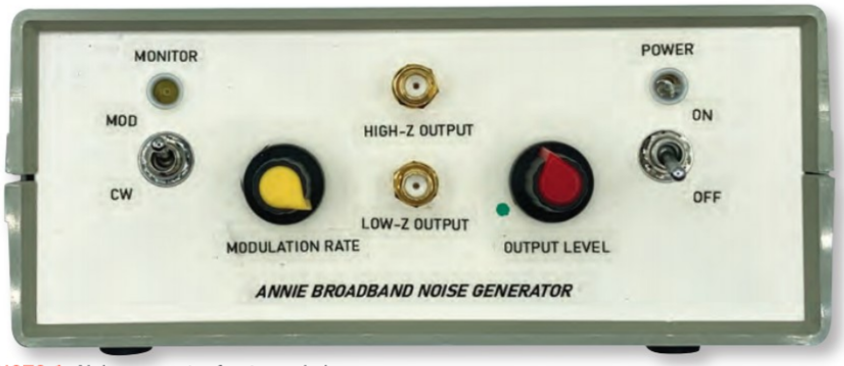


PHOTO 1. Noise generator front panel view.

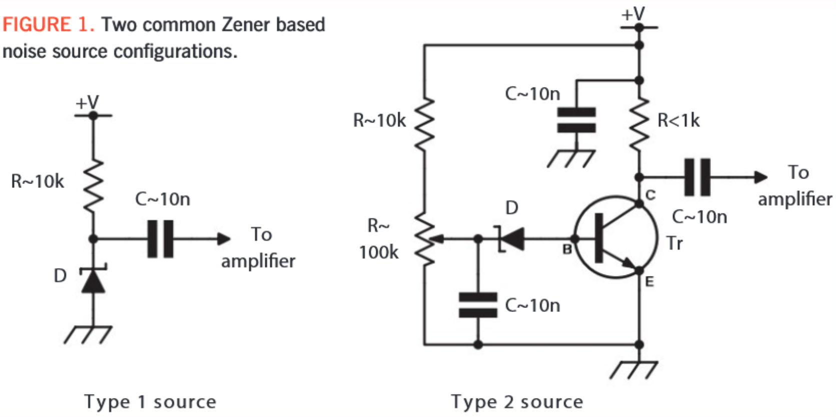
Voltage pumping vs current pumping

The schematic in **Figure 1** illustrates two ways of extracting noise from a working Zener. 'Type 1' is the way you'll find in most handbooks and articles. Its simple and straightforward construction has made it a favorite for years. The noise generated comes out as a *voltage* signal via a coupling capacitor as shown. 'Type 2' instead biases the Zener into its avalanche region (in or close to its 'knee') and the noise comes out in the *current* through the Zener and into the base of a transistor. The transistor offers some gain, though not a great deal. There are a couple of differences, apart from using current instead of voltage. The first is that in a 'Type 1' circuit you're relying on a small voltage generated across the impedance of the Zener. In a 'Type 2' circuit the current is directly pumping a device known for amplifying current, a transistor. The lack of a coupling capacitor in the basic noise generator stage is the other difference, allowing much better low-frequency performance. Even though the Type 2 circuit looks more complicated, once you try it you'll likely never go back to Type 1.

Introducing 'Annie'

Photo 1 shows the front panel of the generator described in this article. Annie is the name of another of our cats, one who went deaf some years ago and communicates with a

FIGURE 1. Two common Zener based noise source configurations.



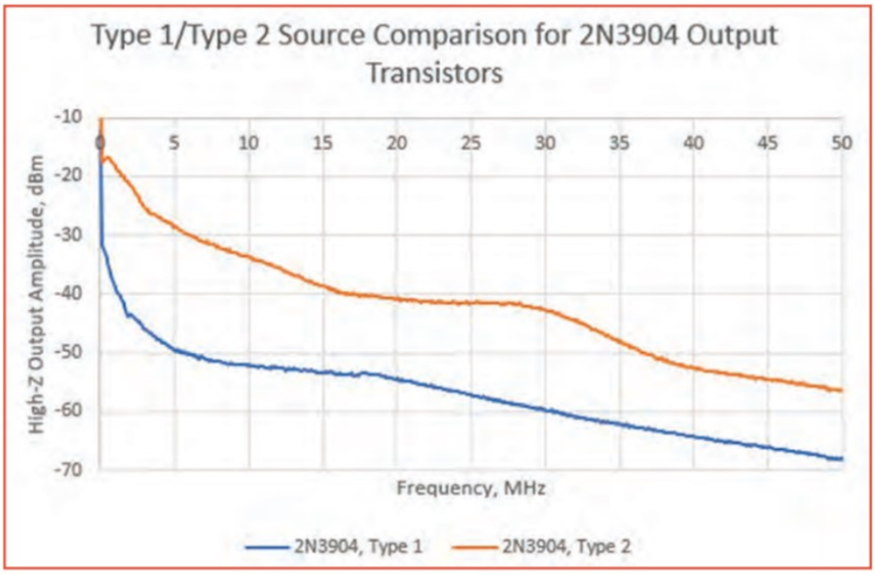


FIGURE 2. Comparison of relative output from 'Annie' noise generator for Zener configurations shown in Figure 1.

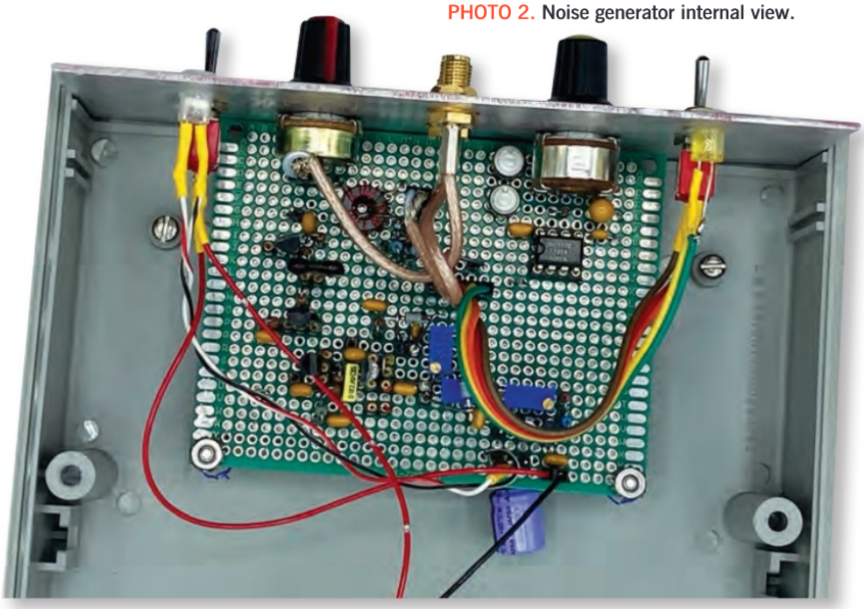
(very loud) vocalisation that's somewhere between a meow and an air raid siren. Our own in-home noise source, so the name is appropriate. It uses Type 2 generation, of course, but then a lot of work was done on the amplifier and output chains to add the functionality I need.

The output level is continuously adjustable, and there are both high impedance and low impedance outputs. I've added a much better modulator than I've encountered in some previous designs, and made it adjustable from less than 1Hz to about 480Hz. (I'm old enough now that the common 1kHz signals aren't as desirable as something closer to a '440Hz A-note.') It can also run CW when needed, and the 'Monitor' LED blinks synchronously with the modulator when operating in that mode.

Photo 2 shows the circuitry inside of Annie. As in previous circuits, I'm using prototype PCBs to build on, and I use copper-foil tape to build up a ground plane on the underside of the PCB.

I built Annie as you see her in the photos to run side-by-side tests of the two types of generation described above, but left the Type 1 circuitry out of the final schematic. **Figure 2** shows the output from both methods. When using an oscilloscope to measure the output envelopes, Type 1 output VRMS is about 370mVRMS. For the Type 2, output is about 4.8 volts RMS(!), both measured using a 1MΩ probe at the high-Z output connector with the time base set to 100μsec/div.

PHOTO 2. Noise generator internal view.



Annie's Schematic

The schematic in **Figure 3** includes all the parts necessary for the features I've described above. Where needed, more information on the parts is listed in **Table 1**. I learned early on that this generator works best when the bias supply is regulated, and I use a small LM317LZ regulator to make a 10V bias signal for the Zener (D3) and the current-amplifying transistor (Tr1). A fixed-voltage regulator is also entirely acceptable, but do make sure that it can handle over 8V output.

The amplifier based on Tr2 is a circuit I've developed for many projects. It provides about 14dB gain from near DC **[2]** to over 50MHz with minimal components. Tr3 and Tr4 form another configuration I like to use, and it's particularly useful when you're after some power (even if it is only a few mW **[3]**) and need to drive loads below a few kΩ. This amplifier design also works quite well directly into 50Ω loads, by the way. The feedback capacitor, C9, can be used to move the 'bump' in the Type 2 curve of Figure 2 to lower or higher frequencies. Sometimes I use a 100pF trimmer capacitor, but a value of 47pF to 56pF puts the bump close to 30MHz, making this unit adequate for our HF bands.

Capacitors C5, C7 and C10 are 1μF/25 or 50V units, X7R material. I find this rather high value helps support the lower-frequency output where I also need it, but more typical 10nF or 100nF units can be used if the builder doesn't need the extra bandwidth. The modulator uses the venerable 555 chip and is a 50% duty cycle on-off supply to the Tr2-Tr4 amplifiers.

Circuits trying to 'modulate' the Zener directly are never happy; the Zeners are just too nonlinear to give results as good as provided by the method described here. With direct modulation the spectral content also tends to suffer badly, as does the available output, since the 'knee' becomes a moving target and tends to emit noise somewhat erratically. Modulating the amplifier chain made a lot more sense in this case.

I bought my dual gang 100kΩ pots (PCB mount) from Amazon, and the individual pots are not entirely well matched over their entire range. Thus, the smaller 2kΩ pots were necessary to keep the duty cycle consistent with increasing frequency (as the resistance moves toward zero). I found it a

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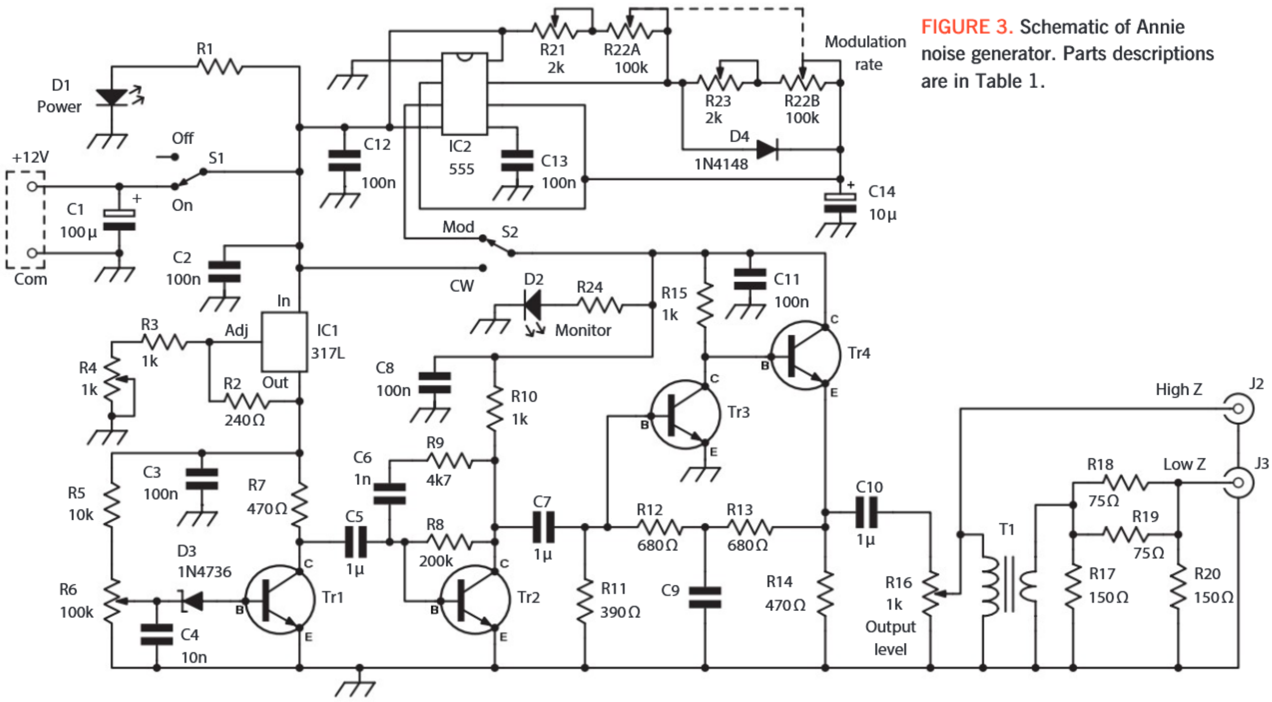


FIGURE 3. Schematic of Annie noise generator. Parts descriptions are in Table 1.

much less expensive solution than buying a very expensive dual-gang pot with 5% or better tolerance between the pots.

T1 is a small transformer that I also use elsewhere in other designs (Winding information in Table 1.). It provides a 16:1 impedance transformation, and alone helps a lot in lowering the VSWR looking into the low-Z port. However, I found that a 6dB π pad (R17-20) made a *big* difference with relatively little signal loss. Nowadays there are devices that virtually require a relatively good match to 50Ω, so this addition makes a lot of sense. I tried lower attenuation values, but 6dB seemed to work well enough and not present too much loss.

Figure 4 is the VSWR map from a NanoVNA, from 1 to 50MHz. The VSWR is consistently 'okay,' 1.5-1.8 out to beyond the HF bands. I should add that this configuration produces useful noise to at least 100MHz, depending on the transistors used. (My own parts bins include transistors that were easily obtainable five years ago, but that have gone 'obsolete,' presumably replaced by surface-mount alternatives.

Among these are devices that are meant for VHF/UHF oscillator and amplifier applications, and I love using them, since they can 'push' a good design to become something better and more useful.) Using a transistor with a transition frequency (f_T) of about 300MHz, like 2N3904, will get you easily past 30MHz in Annie's output, but using one with at least double that will push it into the 100MHz realm. Devices like MPS5179, PN3563 or 2SC1674 (and several others) are still reasonably available in the surplus or eBay markets. If you find a good supplier of one of these, buy a few. They will be useful in future projects.

Construction Notes

The photos show most of the details that are worth mentioning. The case was repurposed from a piece of laser equipment, and the PCB is a prototype board 7cm x 9cm with 0.1" hole spacing. That allows the use of the PCB mounted pots and connectors (all from Amazon, NTE and other sources).

I like to cut up SIP socket strips (eg, Aries Industries 40-0518-10, Newark/Farnell 33P9413) to make 2 or 3 pin sockets for diodes or transistors. That makes a big difference when I'm prototyping. I can easily try out different devices and compare

TABLE 1. Component descriptions of noteworthy parts in Figure 3.

Designator	Vaue	Notes
C5, C7, C10	1µF/25V or 50V/X7R	Newark/Farnell options include P/Ns 74AC7053 and 97M4165
C9	47-56pF	Can be replaced by trimmer capacitor. See text for discussion
D3	6.8V/400mW Zener	1N4736 used here. Recommend not to use lower power rated devices
Tr1	2N3904 or better	Devices with higher hFE will improve noise output and performance. BC546C is used here. Any devices in the BC5XXY series, with Y=C, will do nicely. Remember pinout is opposite 2N3904
Tr2-Tr4	See text for discussion	
R4, R6, R21, R23	As noted	Trimpots mounted on PCB
R22A & B	100kΩ	Dual gang linear pot, PCB mount, 0.2W rated
R16	1kΩ	Single gang linear pot, PCB mount, 0.2W rated
S1 & S2	SPDT	Panel mounted toggle switches
T1	See notes	Pri=4T, Sec-16T 28AWG enamelled wire on FT37-43 core. Do not twist wires together; this degrades high frequency performance
IC1	LM317LZ	Or equivalent
IC2	NE555	Or equivalent. Any 555 chip should work

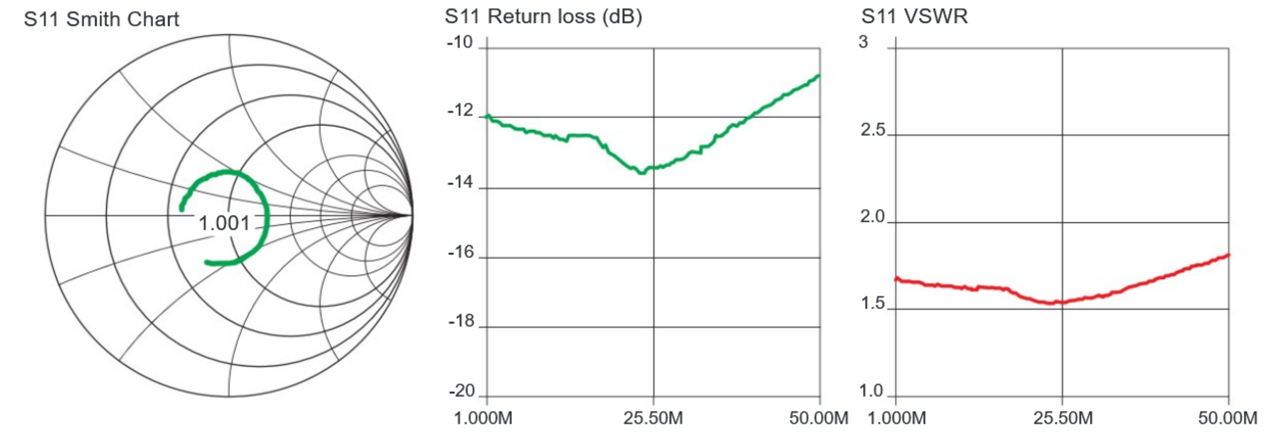


FIGURE 4. **NanoVNA maps of energised Annie Low-Z output through 6dB pad.**

performance, or replace a part that I've managed to fry (yes, it still happens!). As noted above, I like to use copper foil tape on the underside of a PCB as a ground plane and *carefully* cut away tape with a small disposable scalpel to install through-hole parts and wiring.

Resistors R1 and R24 were chosen when I settled on the LEDs to be used. I have a collection of LEDs of varying vintages, and some require more current than others. The 'POWER' LED is a nice blue one, a somewhat unusual colour in that application, but a favorite of Eileen, KI6UZJ, my patient and understanding wife.

Resistor R8, 200k is not a standard E12 value but can be formed with two 100k resistors in series.

LM317L output capacitor: Whilst the LM317L data sheet suggests an output capacitor of 1μF, experience with this design has shown the suggested 10n to be the optimum value.

I like to use SMA connectors in most equipment of this type. They're compact, easy to use, and often available for less than comparable BNC units. In my crowded lab/ station/office smaller is *often* better.

Power connections are also typical for my designs: a 5.5mm concentric power connector and, in parallel, a 1nF feedthrough capacitor. The latter is especially useful when hooking things up temporarily with clip leads for tests.

Operating Annie

In the lab, Annie is used just like another signal source. The only difference is that the output is continuous and sounds like a 'hiss' instead of a steady note, unless you use the modulation feature, then it can sound like 'hiss' mixed with a tone, depending on frequency. Another thing to note is that the circuit elements through the Tr2 - Tr4 amplifiers do allow a *small* amount of noise signal to bleed through even with the modulation in the 'off' mode.

Therefore, when doing a sensitivity test, it will be necessary to lower the output level to the point that, at low modulation rates, the 'off' noise signal is not detectable. For the unit I built, setting the output level knob to zero puts out about -121.4dBm or ~0.02μV at 14.3MHz. If you can use a 'tee' to sample the signal at that point then it is possible to measure the amount of noise required to be heard in a receiver if you have anything that can detect signal levels lower than -107dBm, the equivalent of a 1μV signal into 50Ω, well within what my Rigol DSA815-TG can do on a good day (VBW = 30Hz, RBW = 30Hz, input attenuation = 0dB, Preamp = ON, Trace = Power Avg set to 25 traces, Resulting noise floor = -146dBm or 0.001μV).

Another – and I think *very* useful – way to 'calibrate' the output is to hook Annie up to a known, high-sensitivity receiver (like my Icom IC-7300) and reduce the output to the point that it can no longer be heard. I did this in the 20m band and marked my output level with a small green dot (visible in Photo 1) that corresponds to 'one IC-7300'. I can then align a receiver to get as close as possible to optimum, and still have a pretty good idea (in a relative sense) what its final sensitivity is.

For most of us, this is more than adequate. The equipment to take such measurements to the next level is typically far beyond the budgets of most of us amateurs.

Even inexpensive SDRs are useful as 'spectrum analysers' when using the broadband output of a noise generator for excitation. There are several YouTube offerings showing filter testing and alignment, and Annie is certainly capable of any of this. **[4]**

Temperature stability

The bias voltage stability for TR1 is critical, and the completed Annie has been checked for output stability over the range 14°C to 30°C and has not shown any measurable changes.

Other applications

I designed and built Annie for two other applications. One is to try to make a more useful noise bridge to help align my 'Felix' antenna coupler (*RadCom* August & September 2022). The other application is for my development work on noise reducers – circuits that mix main antenna and phase-shifted 'noise antenna' inputs to cancel a lot of the man-made electrical noise that's now so prevalent. Beyond that, it's really surprising how often a truly broadband signal source can be just the piece of equipment that you need in the lab or shack. We think noise is a bad thing…well, it can be, but it can also be a most useful tool to optimise things so we don't have to suffer from it. It just turned out that I didn't realise this point until I had such a device to play with.

References

1: Andy Talbot, G4JNT Design Notes, *RadCom* 96 (9), September 2020, pp 30-32.

2: How close one gets to DC depends on C5, C7 and C10. I use 1μF/50V X7R non-polarised ceramic capacitors and get down to a kHz or lower. Even larger values are useful but not ordinarily necessary unless bandwidth must extend into the lower portion of the audio spectrum.

3: Several noise generators I've built using this basic design operate at my 'favourite' 24V bias. With transistors that can handle the voltage this design puts out enough to require small heat sinks on the amplifier transistors!

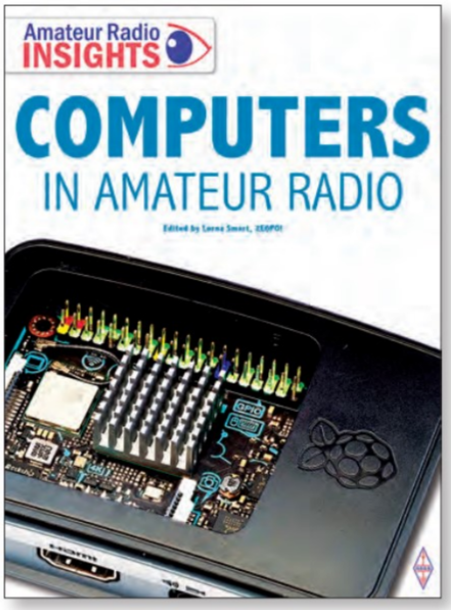
4: Typical of many other videos: https://www.rtl-sdr.com/signalseverywhere-measuring-filters-with-rtl-sdr-a-noise-source-and-spektrum.

Book Review

Two books to encourage you to realise the potential of the computer in your shack

Computers in Amateur Radio, 3rd Edition

Edited by Lorna Smart, 2E0POI



Increasingly, both experienced and newly licensed amateurs are benefitting from the addition of computers to their operating equipment. Through incorporating such devices to into amateur radio stations, modern operators gain access to a world of digital modes, enjoy enhanced visual displays and communicate with friends via internet links, to mention just a few of the possibilities. In years gone by, access to home computing was prohibitively expensive for many. However, the advent of low-cost personal devices, including smartphones, tablets and laptops, provides access for almost everyone who wants it.

With there being so many ways to involve computers in amateur radio activity, knowing where to start can be daunting. This book is extremely helpful in walking the reader through how to choose a device that is appropriate to their needs, how to find and configure software, avoid common mistakes and maximise the use of their computer gear. The inclusion of clearly laid out screenshots is invaluable and is certain to save many amateurs a lot of time and frustration.

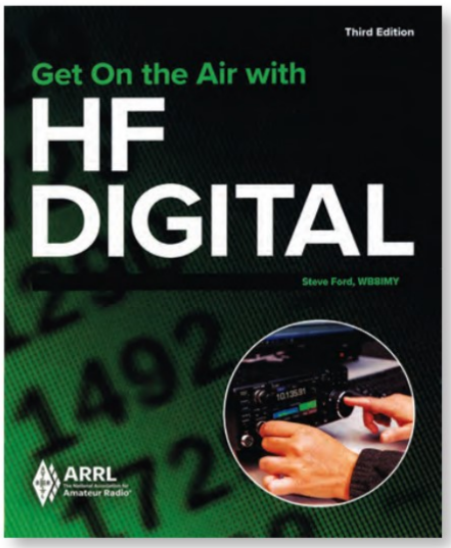
For those who enjoy developing their programming skills or building hardware projects, a superb chapter on Raspberry Pi usage is included. Different Pi models and their relative processing speeds are meticulously set out, removing the need for the reader to spend hours carrying out personal research. Be careful though! Many amateurs find developing homebrew solutions to technical challenges to be extremely addictive. It is easy to see why when you understand how much money can be saved by learning how to undertake some basic programming.

Whether you want help with choosing, installing and configuring some QSO logging software or you want to build a WSPR beacon, this handy, easy-to-read book will be an invaluable addition to your coffee table.

Size 174x240mm, 192pages, ISBN: 9781 9139 9528 7
Non Members: £15.99, RSGB Members: £13.59

Get On the Air with HF Digital, 3rd Edition

Steve Ford, WB8IMY



Many amateurs say that there is no better feeling than 'bouncing' a signal off the ionosphere and receiving a signal report from the other side of the earth. This is why the HF bands are so beloved by the amateur radio community.

In the very early days of radio, HF contacts were made using CW exclusively. Now that technological innovation finds itself in the twentieth century, a large number of modes exist to enrich the HF experience. However, with this variety of modes comes a complex suite of available software, digital interfaces and potential frustration!

So, it wouldn't it be convenient if there was book that contained everything you needed to know to get you started? Well, this handy book, from the ARRL, contains a wealth of useful information about how to set up an HF shack for modes including RTTY, FT8 and FT4, PACTOR and WSPR. Included within the easy-to-read pages are tips to ensure that the setup will not cause damage to your transceiver or cause interference to other users of the bands.

Are you interested in HF contesting but don't know the QSO formats for datamodes? Should you 'hunt', 'pounce' or 'run' in a contest? Are you an FT8 operator who doesn't know how to get the most out of their waterfall display? Can you eliminate duplicate entries in your logbook by setting up your logging software differently? These and many, many other questions are explained in clear, unambiguous language. The text is interspersed with screenshots to point out key information, leaving the reader in no doubt what they should be looking at.

In summary, this book provided me with a wealth of information that me think that I could be getting much more out of my HF transceiver. When I had finished reading, I went straight into my shack to finally get around to having a go at sending email via Winlink.

Size:184x228mm 144 pages, ISBN: 9781 6259 5159 5
Non Members: £26.99, RSGB Members: £22.94

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Review

Sharman HLP-270 Halo Antenna Review

A halo antenna is a ½ wavelength dipole antenna that has been bent into a circle with an electrical break directly opposite the feedpoint.

The new Sharman HLP-270 dual-band halo loop antenna from Moonraker covers 2m and 70cm in a small, lightweight package. It covers 140-150MHz and 400-470MHz, with an advertised gain of 4dBi on 2m and 5dBi on 70cm. The SWR across these frequencies is claimed to be less than 1.5 on both bands.

A halo antenna is essentially a half-wave dipole, bent so the dipole ends almost meet. It's almost omnidirectional and is horizontally polarised. A folded dipole/halo gives more gain than a straight dipole when mounted horizontally. With a standard dipole it makes no difference if they are vertical or horizontal, the gain is the same, albeit more directional when horizontally polarised.

Because the dipole is bent to form a square, the halo antenna has a very low visual impact, which could be a real plus if you're limited in what you can mount. This halo measures in at 11 x 11 inch (28 x 28cm) and is arranged in a square. It's also small enough for mobile use and portable/SOTA use. The weight is only 360g.

The halo comes supplied with a small instruction leaflet and the fixings needed to mount it on a mast/pole. First impressions were positive, it's well constructed. You do have some quick setup to do with the supplied Allen key, you need to set the gamma match spacing to ensure it's resonant at the desired frequencies. This is easy to do using the instructional leaflet – this took all of ten minutes.

It comes with a SO239 connector that, while ubiquitous, wouldn't be my first choice for a 2m/70cm antenna. It's also rated up to 800 watts, which isn't surprising given the solid construction, but I'd very much hope this would be a theoretical maximum power limit for such an antenna.

So, faced with having a lightweight 2m/70cm antenna to review, sunny weather and one of my favourite VHF contests on at the weekend, I decided to put the antenna through its paces. I climbed a nearby hill for the second RSGB 2m Backpackers Contest to see what I could work using just 3 watts with such an antenna. I mounted it on a short 4m fibreglass fishing pole, which proved its suitability for portable use and just how lightweight it is! I tested the SWR first of all with my NanoVNA analyser. This showed the halo to have a reasonably flat SWR of 1.5 across both the 2m and 70cm bands, but I didn't adjust the gamma match, so it may be possible to get it lower.

To try and make the most of my very limited 3 watts of SSB to the halo antenna, I matched it with a short length of LMR-400 Ultraflex coax cable connected to my Elecraft KX3 (with the 2m transverter board fitted). This would ensure I wasn't losing too much of my 3 watts before it reached the halo.

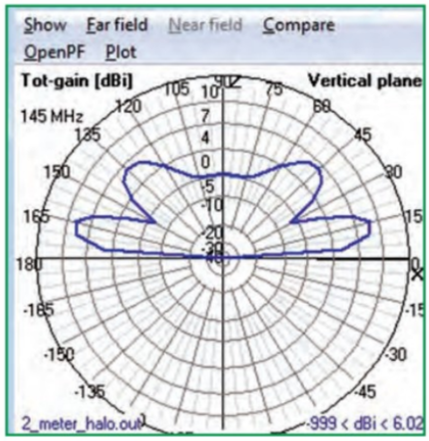
The Sharman HLP-270 Halo on the mast while testing it during the second RSGB 2m Backpackers Contest.

This clearly wasn't going to be a serious contest entry, but I worked 22 stations in 1.5 hours. With my best DX being GW1IDF/P in IO81 at 161km. I'll take that with 3 watts and not a Yagi in sight! The one that got away was GD0AMD/P on the Isle of Man, we started to exchange details, but he faded down into the noise before we could complete. This would have been a very respectable 369km with very low power to the halo. During use I noticed the halo was slightly directional, you could peak stations up an extra S-point, which is what you might expect given its omnidirectional nature.

Conclusion

The halo has surprised me, it's a cheap, lightweight, neat and compact antenna to get you onto 2m and 70cm. Is it going to perform better than a Yagi? Probably not, but if you need something that's very compact and not going to draw too much attention then this is it. I had fun testing it and it proved to be a decent little antenna. It's currently available from Moonraker for £49.95 **[1]**. Thanks to Moonraker (moonrakeronline.com) for the loan.

The Sharman Halo antenna close up. It comes with a proper mast clamp, but here I improvised with cable ties to fix it to my narrow fibreglass mast.



This displays the modelled radiation plot of the Sharman HLP-270 Halo on 145MHz.

Websearch

[1] https://moonrakeronline.com/sharman-hlp-270-dual-band-halo-loop-antenna

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Review

M2 LEO Pack
– a 2m/70cm satellite antenna system

The M2 LEO pack and M2 antennas in general have a good reputation in the USA and when Martin Lynch & Sons announced that they were stocking the LEO pack, we asked if we could try it out.

Peter, 2M0SQL is one of the UK's most experienced satellite operators and if there was anyone who could give the aerials a work-out, it's him. Tony Wiltshire at ML&S kindly agreed to send the LEO pack up to Elgin for Peter to look at.

Before we get into how Peter found the LEO pack, let's take a look at what M2 have to say about it.

The 436CP16 and 2MCP8A are light weight, circularly polarized antennas optimized for Low Earth Orbit (LEO) Satellite communications or other applications where a small circular polarized antenna is required. Optimum match and gain designed for the satellite band. Rear mounted for easy coaxial cable routing. A preamp can be mounted close to the antenna for almost no coax loss before the preamp, maximizing your receive performance. Computer design techniques help keep spurious side lobes down for optimum signal to noise rations. Both the 436CP16 and 2MCP8A feature the same CNC machined, O-ring and silicone-gel sealed, driven element assemblies common to all M2 Yagi Antennas. This ensures years of trouble-free performance regardless of weather. We went a step further and designed a custom LEO cross-boom to pair these two antennas together for a very manageable amateur satellite ground station.

Out of the box

On unboxing the antennas, Pete's first impression was that all the parts were very well made, all bolts and screws that are included are nicely packaged up to make the assembly process as easy as possible.

Rubber boots are used to hold the elements into the boom. Pete quickly discovered that these can be quite hard to fit and require a fair amount of force to push them into place. Although on Pete's temporary installation there was no need to use the retaining clips. If you were putting the system up permanently, you'd want to do this. Be warned, these clips can bite, so take care as you fit them!


70cm Yagi after construction was completed.


2m Yagi completed (Molly the dog shown for scale!).

The cross-boom is supplied with the antennas, which is a nice touch. Don't make the mistake of assembling the cross-boom fully before you fit it through the elevation rotator.

The manual supplied describes how to set the phasing harnesses up. If you follow the procedure exactly as described in the manual, you should find that the SWR for each antenna is good, but slight deviations from the procedure can result in high SWR values.

The antennas were connected to SHF Electronics preamps with 2 lengths of Ecoflex and then 15m of LMR400 to the shack.

How did the antennas perform?

Pete was impressed. As supplied, they are fixed Right Hand Circular Polarisation (RHCP) – there is an additional option to provide polarisation switching. With fixed RHCP you will experience periods of fading, but you quickly get used to that. Pete found that he was able to work all satellites from the moment they came up over the horizon (AOS) until they dropped under the horizon once again (LOS).

During the review period, Pete made over 500 QSOs through a wide selection of satellites and you can see from the map attached that he worked some very nice DX indeed.

Pete normally uses WiMo X-Quads in his satellite station and was very interested to see how the LEO pack compared. Very well, as it happened and Pete had a sense that perhaps the LEO pack antenna was just a fraction better on 2m than the X-Quad. Useful on the AO-7 downlink.

The ISS crossband repeater is always very busy and QSOs tend to be limited by the amount of interference that the ISS receiver is hearing. However, when the repeater was

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quiet, late at night, Pete found that he could work through the it from AOS to LOS with power as little as 2W, which is excellent.

Terrestrial operations

Can you use the antennas for terrestrial operation as well? Of course! Pete's location in the Highlands didn't lend itself to a substantial test on tropo, however they worked great for working SOTA stations. Be aware that with RHCP, you will see some polarisation loss when working stations using either vertical or horizontal polarised antennas, although in reality, signals are not usually 'perfectly' horizontal or vertical if they have been reflected from buildings, mountains or aircraft.

The only problem that Pete encountered during the review period was that when it was raining, the SWR on 70cm was increased considerably. We read around and learned that this had been noted elsewhere.

The finished installation, complete with azimuth/elevation rotator.

Conclusion

In general, we were both impressed with the results of the LEO pack. The antennas and cross-boom are well engineered and should last well even when exposed to fairly severe weather. The LEO pack is fairly expensive, but, after we had seen the quality of the antennas we felt more comfortable that they represented reasonable value for money.

The LEO Pack costs £609.95 and is available from Martin Lynch and Sons (https://www.hamradio.co.uk). We would like to thank Tony Wiltshire, M0TNY of ML&S for the loan of the antennas and his willingness to answer our questions about the M2 LEO pack antenna system.

Contest Calendar November 2022

Ian Pawson, G0FCT

RSGB HF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Mon 7 Nov	Autumn Series DATA	2000-2130	RTTY, PSK63	3.5	RST + SN
Sat 12 Nov	Club Calls (1.8MHz AFS)	2000-2300	CW, SSB	1.8	RS(T) + SN + Club info
Wed 16 Nov	Autumn Series SSB	2000-2130	SSB	3.5	RS + SN
Sat 19 Nov	2nd 1.8MHz Contest	1900-2300	CW	1.8	RST + SN + District code
Thu 24 Nov	Autumn Series CW	2000-2130	CW	3.5	RST + SN
Mon 28 Nov	RSGB FT4 Contest	2000-2130	FT4	3.5, 7, 14	Report + 4-character Locator

RSGB VHF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Tue 1 Nov	144MHz UKAC	2000-2230	All	144	RS(T) + SN + Locator
Tue 1 Nov	144MHz FMAC	1900-1955	FM	144	RS + SN + Locator
Wed 2 Nov	144MHz FT8 AC	1900-2100	FT8	144	Report + 4-character Locator
Sat 5-Sun 6 Nov	144MHz CW Marconi	1400-1400	CW	144	RS(T) + SN + Locator
Tue 8 Nov	432MHz UKAC	2000-2230	All	432	RS(T) + SN + Locator
Tue 8 Nov	432MHz FMAC	1900-1955	FM	432	RS + SN + Locator
Wed 9 Nov	432MHz FT8 AC	1900-2100	FT8	432	Report + 4-character Locator
Thu 10 Nov	50MHz UKAC	2000-2230	All	50	RS(T) + SN + Locator
Tue 15 Nov	1.3GHz UKAC	2000-2230	All	1.3G	RS(T) + SN + Locator
Thu 17 Nov	70MHz UKAC	2000-2230	All	70	RS(T) + SN + Locator
Tue 22 Nov	SHF UKAC	1930-2230	All	2.3G	RS(T) + SN + Locator

Best of the Rest Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange (Info)
Tue 1 Nov	Silent Key Memorial	0600-0900	CW	3.5, 7	RST + a SK callsign
Wed 2 Nov	UKEICC 80m	2000-2100	SSB	3.5	6-character Locator
Sat 12-Sun 13 Nov	WAE DX RTTY	0000-2359	RTTY	3.5-28	RST + SN
Sun 13 Nov	UKuG Low Band	1000-1400	All	1.3-3.4G	RS(T) + SN + Locator
Wed 30 Nov	UKEICC 80m	2000-2100	CW	3.5	6-character Locator
Sat 26-Sun 27 Nov	CQ WW DX CW	0000-2359	CW	1.8-28	RST + CQ Zone (UK = 14)

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

Technical

How does the Gamma Match work?

Many antenna books and internet sites describe how to construct a gamma match for feeding the driven element of a Yagi antenna.

Those sites and books claim it is to allow the element to be attached to a metal boom without an insulation break. It is also claimed to replace a balun when feeding an antenna with a coaxial cable. I first came across it in a 1960 *ARRL Handbook*, when I thought it to be a good idea. Many others thought the same but today there is disagreement about its effectiveness **[1]**.

How did it develop?

A delta match, shown in **Figure 1**, was an early technique for driving a wire dipole. Impedance matching to a balanced feeder required altering the length and angle of the taper. This was achieved by removing or adding spacers to the feeder and by shifting the position of the feeder attachments. When applied to an antenna made of metal tube, it allowed fixing at its centre to a metal mast or boom because no current could flow from the centre of a balanced element. It was adapted by broadcasters as a means of driving a grounded mast, as shown in **Figure 2**.

Clemens added an L network of capacitors for adjustment of the feed impedance, to overcome the mechanical difficulty of tuning by altering the position and length of the connection to a mast. A derivative of the delta and Clemens matches was later introduced to Yagi antennas. This was called plumber's delight because none of the elements required insulation at their centres, as shown in **Figure 3**. A balun was required for a coaxial feeder, however. Because no current flowed from the centre point of the driven element to the boom, it was decided that one half of the delta match could be removed and the remaining half could be driven directly with coax. Hence the gamma match as we know it.

Why does it not work?

The logical argument against it is that the gamma match adds metal to only one side of the driven element. It, therefore, has a lower impedance to that of the other side. When each half of the driven element in the example below is treated as a monopole, the standard half has an impedance of magnitude 60Ω and the half with the gamma match has an impedance of magnitude 44Ω. There are, therefore, different currents in each half, with the zero voltage point displaced from the centre of the element. Because the boom is then connected away from the electrical centre, it receives current from the element. Consequently, it radiates. This situation is compounded where the boom connects to the braid of a coax feeder and/or to a metal mast. They also receive current and radiate. During reception, the feeder and mast, plus any other antennas and their attached feeders may become the means of introducing noise.

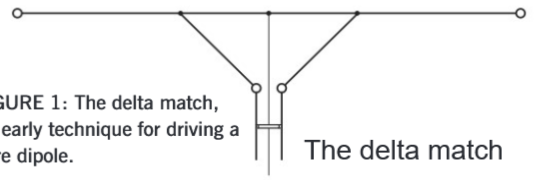

FIGURE 1: The delta match, an early technique for driving a wire dipole.

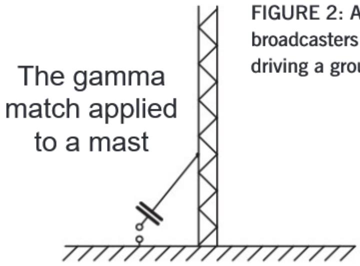

FIGURE 2: Adapted by broadcasters as a means of driving a grounded mast.

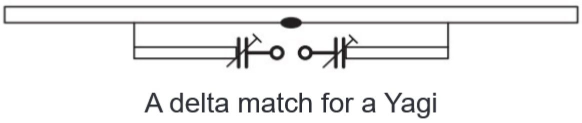

FIGURE 3: A derivative of the delta was introduced to Yagi antennas.

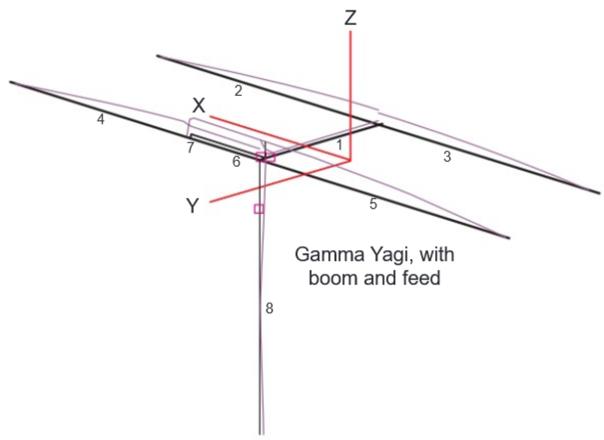

FIGURE 4: A presentation of currents in a gamma fed two elements 21MHz Yagi.

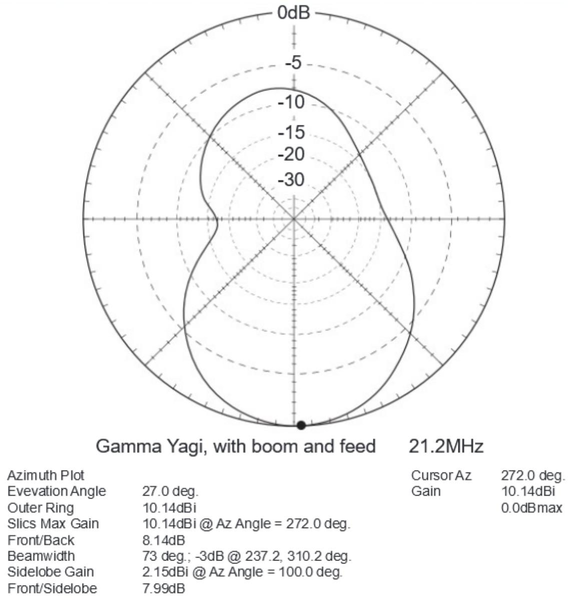

FIGURE 5: The distorted horizontal radiation pattern (HRP) due to the boom and feeder braid not being connected at the electrical mid-point on the driven element.

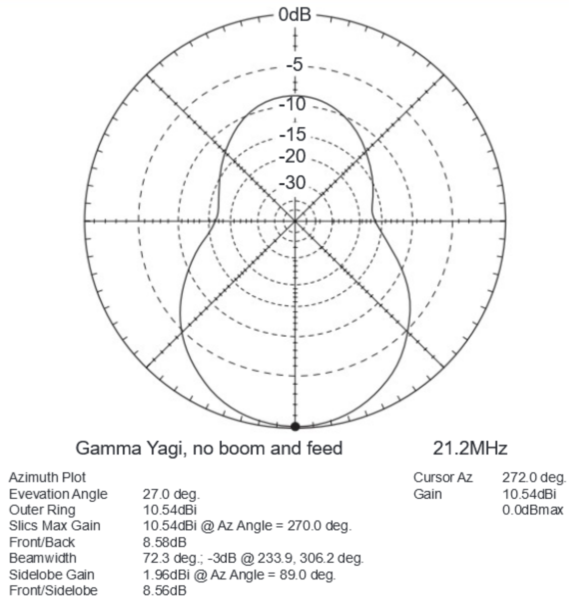

FIGURE 6: When a braid breaking choke of 660Ω reactance is introduced at the antenna end of the feeder and the driven element is insulated from the boom we obtain this symmetrical HRP.

Analysis

The argument may be settled by analysing the antenna with the help of EZNEC. **Figure 4** is a presentation of currents in a gamma fed two elements 21MHz Yagi.

This is based on the one that Mike, G0JMI built and that he described in the January 22 *RadCom,* except that a coax feeder has been added between the antenna and ground. When driven with 1 amp, current of 0.25A flows in the boom, 0.64A on the braid of the feeder and respectively 0.75A and 0.95A midway along each half of the driven element. Dissimilar currents also flow in each half of the parasitic element.

Figure 5 shows the distorted HRP due to the boom and feeder braid not being connected at the electrical mid-point on the driven element. When a braid breaking choke of 660Ω reactance is introduced at the antenna end of the feeder and the driven element is insulated from the boom we obtain the symmetrical HRP of **Figure 6.**

Conclusion

Unless we insulate the driven element from the boom and connect the feeder via an effective braid choke or a balun transformer, the gamma fed antenna will be susceptible to noise and will have a distorted radiation pattern. The difference between Figure 6 and Mike's result are most likely due to his application of MMANA-GAL that did not allow modelling of the feeder and boom.

Websearch

1 ham.stackexchange.com/questions/1804/

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Our acceptance procedure for technical articles **[2]** involves an independent review by a member of the Technical Forum, whose members are always willing to work with authors if there's something that needs more explanation or would benefit from clarifying.

Feature articles aren't assessed in that way, but most of the info in [2] still applies.

[1] www.rsgb.org/radcompix
[2] https://tinyurl.com/RC-guidance