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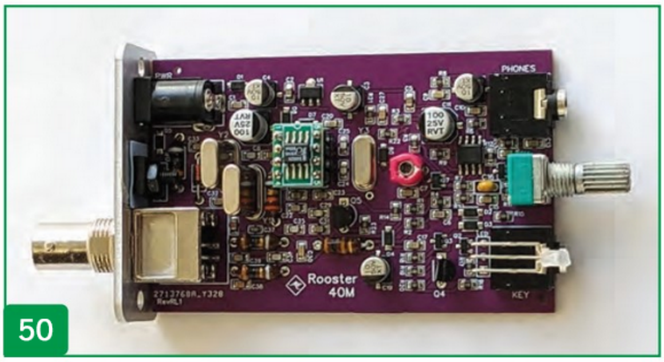

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RadCom THE RADIO SOCIETY OF GREAT BRITAIN'S MEMBERS' MAGAZINE
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RadCom is published by the Radio Society of Great Britain as its official journal and is sent free and post paid to all Members of the Society. **The April 2024 edition of *RadCom* is expected to arrive with most Members by 15 March 2024** although this can take up to a week longer in some cases; international deliveries can take longer still.

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

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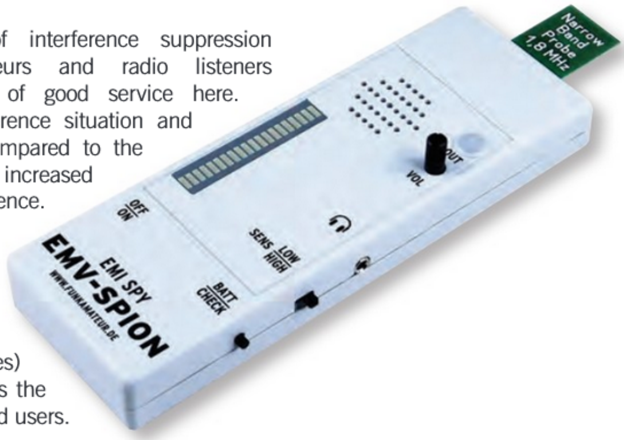
New Products

EMC spy 2.0 complete kit

Detecting sources of interference and testing the effectiveness of interference suppression measures is becoming increasingly important for radio amateurs and radio listeners today. A simple tracking device such as the EMC spy can be of good service here. The built-in speaker provides a quick acoustic overview of the interference situation and is automatically switched off when the headphones are connected. Compared to the previous model, the LF bandwidth of the demodulated signal has been increased to about 10kHz and improves the detection of pulse-shaped interference. The four search antennas do not require any additional components. Their coils are designed as conductor tracks, which makes the probes mechanically less sensitive. In addition, the EMC spy can also be used as an LF signal tracker due to the adapter board supplied. The new kit contains an SMD-assembled board, all leaded components, a machined and printed housing, as well as four search antennas (probes) and an adapter board. The pre-assembled board simplifies and accelerates the assembly considerably and makes it easy to control, even for less experienced users. For more information visit https://tinyurl.com/EMCSPY



SDRplay introduces the RSP1B

UK radio manufacturer SDRplay Ltd is introducing the RSP1B which is an enhanced version of its highly-popular entry-level SDR receiver, the RSP1A. The key advantages of the RSP1B versus the RSP1A are:

- It is housed in a strong black painted steel case instead of plastic
- It has significantly improved noise performance below 1MHz (ie for MF, LF and below), and in the 50-60MHz region. There are also noticeable noise improvements in the 3.5-5.5MHz and 250-320MHz spectrum
- It has improved signal handling at HF frequencies

The suggested retail price for the RSP1B is £127 including UK VAT. More details on SDRplay.com/RSP1B

SDRplay recently launched its free multi-platform SDRconnect software which, as well as running on Windows, will also run on MacOS and Linux/Raspberry Pi. As with the SDRuno Windows software, the emphasis is on 'plug and play' making the SDRplay receivers a low-cost way to discover or rediscover the radio hobby for anyone who already uses a computer. There are even "band buttons" for all the amateur bands!

The UK manufactured RSP family of SDR receivers cover from 1kHz to 2GHz with no gaps. They range in price from around £110 to £260 and are available directly from SDRplay Ltd, via www.sdrplay.com, or from Martin Lynch & Sons, Moonraker, Nevada, Radioworld, SDR-Kits and Waters & Stanton.

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Antennas

Verticals and horizontals

Like many, I enjoy working 40m as a portable operator. The often-faced challenge on the lower HF bands is to be able to use an antenna, which both provides a good level of efficiency, and allows us to operate in smaller-than-ideal spaces. My challenge is that the sole local location in which I can operate with a good-sized antenna for the lower bands, is at a car park on a hilltop. Luckily, the far end of the car park has a small patch of grass situated to the right-hand side, measuring approximately 5m wide and 10m deep. This is not a big space but, by parking next to it, I can use this patch. It has a grass surface, and it does not have another car-parking space within 50ft of it. The maximum useable space available is from one corner to an opposite corner of the plot; in this case, I have a maximum useable horizontal space of just over 11m.

My use-case is also governed by not wishing to carry an antenna tuner, a purely personal preference as, despite operating from a vehicle, I did not wish to carry additional equipment, as well as avoiding the extra weight and wind loading associated with using loading coils. In short, I need to 'carry light', and keep the station simple and quick to set up. Therefore, I will focus on coaxial-fed antenna options without the use of an external ATU, either at the antenna feed point or at the transceiver end.

Another portable consideration for 40m is to decide on your target audience. Verticals are often used as portable antennas because of their relatively small footprints (aside from ground radials), but they offer reduced gain compared with horizontally-polarised antennas at the higher take-off angles for working inter-G and into Europe. A half-wave dipole is often placed into an inverted-V configuration, with the apex often not much higher than 7m to 8m above ground level. Despite its superior higher-angle take-off performance compared with a vertical antenna, it also requires more horizontal space than the 11m available to me, despite the inverted-V configuration. For example, at an apex height of 7m, and using a typical apex angle close to 90° between the dipole legs, I can only squeeze in approximately 8.9m of wire per dipole leg before reaching the ground. This is too short for a 40m half-wave dipole.

Figure 1 shows a comparison between the elevation plots for a ground-mounted quarter-wave vertical antenna (red curve), modelled using MMANA-GAL with 'average' ground and with a total of 80m of ground radials, with that of a half-wave inverted-V dipole with its apex at 7m above ground level (blue curve). The comparison is also shown in **Table 1**, where the differences in gain we can expect to achieve at the two contrasting take-off angles of 5° (suitable for DX), and 75° for close-in UK and European contacts. The comparison demonstrates that the vertical antenna and the low dipole are, in many respects, different beasts. The dipole is just under 16dBi superior to the vertical antenna at 75° (two to three S-units). The inverted-V dipole performs respectably in the plane of the antenna at the 5° take-off angle compared with the vertical antenna but worsens to become over 6dBi weaker broadside-on (one S-unit). However, the ends of the inverted-V dipole are very close to the ground, and ground losses should be considered, as well as the safety aspects associated with the high voltages there. This illustrates our conundrum: how to configure an antenna which can provide a balance between achieving respectable low-angle and high-angle take-off performance. We take the 5° performance of the vertical antenna (-5.9dBi) and the 75° performance of the dipole (6.5dBi) as benchmarks.

Of paramount concern is the issue of horizontal space, and this leads us back to the 11m of horizontal space we have at our disposal. Let us examine some alternative configurations we could use as portable 40m antennas, without the need for a tuner and using coaxial cable as our feeder, which could fit into the 11m of space available.

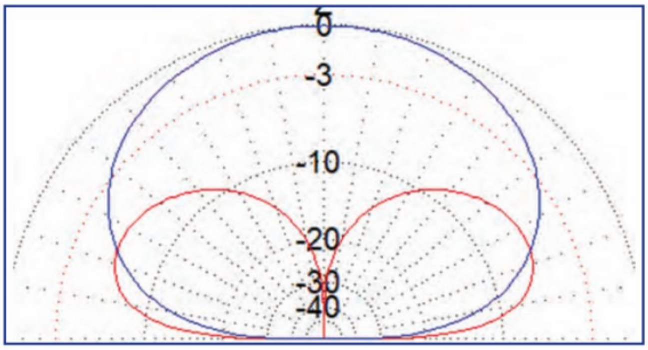

FIGURE 1: Elevation plots comparing the benchmark quarter-wave vertical antenna (red) and the inverted-V half-wave dipole (blue).

Inverted-L configuration.

Our first option is the Inverted-L configuration. This antenna is often discussed as a compromise antenna which offers useful gain at lower and higher angles because of its vertical and horizontal aspects. **Figure 2** shows the three versions of vertical and sloping lengths of the antenna which I have modelled. In each case, the antenna is fed at the base of the vertical aspect of its shape. The antenna is a half-wavelength long on 40m (approximately 20m in length) and, being fed at its greatest voltage point, requires a 49:1 or similar high-impedance transformer to provide an acceptable match to our 50Ω coaxial cable. The antenna would be deployed as an inverted-L antenna, with the vertical part supported by a telescopic fibreglass pole, and the horizontal part sloping down at an angle around 45° to fit the available space. Being portable, and often having a one- or two-hour window in which to operate, it would be time-consuming to have to deploy another fibreglass pole to maintain the horizontal part anywhere near to being a flat-top, although I can use a 1m-long electric fence support pole to guy the lower part of the sloping part of the antenna.

What would be the impact of sloping the wire rather than having it run horizontally? Typically, there should be a resulting marginal gain increase at higher angles of radiation, with a corresponding marginal reduction at low angles. The 'true' horizontal is a little better acting as a compromise between low- and high-angle performance, but sloping the horizontal part of the inverted-L should not compromise performance significantly. In this case, as a portable antenna, it is necessary to slope this wire anyway.

I have modelled three different configurations for this 20m-long antenna: 10m vertical with 10m sloping, 8m vertical with 12m sloping, and 6m vertical with 14m sloping. In each case, I have compared the gain with the benchmarks set by the vertical and dipole we examined earlier. **Table 2** shows the modelled characteristics of these antennas, with some variations of feed-point height included. Only those options which fit into the 11m of available space are listed.

Tim Hier, G5TM
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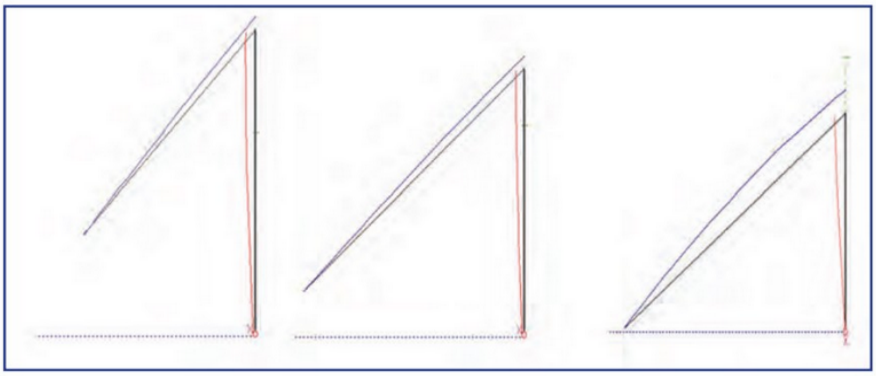

FIGURE 2: The three inverted-L configurations modelled. From left to right: 10m vertical and 10m sloping, 8m vertical and 12m sloping, 6m vertical and 14m sloping. The blue curve denotes current giving rise to predominantly horizontally-polarised waves, and the red curve denotes current giving rise to predominantly vertically-polarised waves.

Other options were also considered within the three inverted-L parameters outlined but were discounted because they required too much space to accommodate the sloping part of the antenna. When looking at the data in Table 2, it is worth considering that the maximum current flowing in our half-wave antenna is at the centre of the antenna. Depending on the ratio of the vertical to the sloping parts, and the height above the ground, the stronger polarisation switches between vertical and horizontal.

Low-angle gain

It is interesting to note that, of these four arrangements, the one with marginally the greatest overall gain at a 5° take-off angle (the first: 10m/10m) also had its maximum current at the greatest height (10m). The vertical element is longer (a quarter-wave), and this produces stronger vertical polarisation at the expense of horizontal polarisation. The fourth arrangement is almost on a par with the first, being fed 4m above ground level has, no doubt, assisted in negating some of the ground losses. In contrast, the second and third configurations have shorter vertical elements than the first and are fed closer to the ground than the fourth. Overall, despite offering more gain at 5° take-off angle, both the first and fourth configurations are still between roughly 1dBi (at their strongest) and 5dBi (at their weakest) below that of the quarter-wave vertical antenna. Neither offers the omni-directional pattern in azimuth of the quarter-wave vertical benchmark antenna. The 10m/10m configuration does come close in our modelling (and indeed would do so on-air) to matching the quarter-wave vertical antenna in the current radiated in the opposite direction to the sloping section. However, from the direction of its sloping part, the current radiated decreases, but is still within 4dBi of the vertical at this weakest direction.

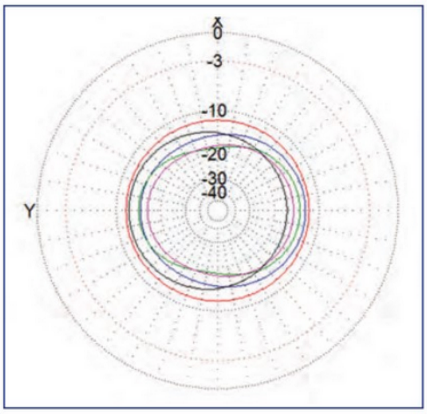

FIGURE 3: Comparing the azimuth patterns at 5° take-off angle. The benchmark quarter-wave vertical antenna pattern is shown in red, 10m/10m configuration in blue, 8m/12m configuration fed at ground level in green, 8m/12m configuration fed at 2m above ground level in pink, and 6m/14m configuration fed at 4m above ground level in black.

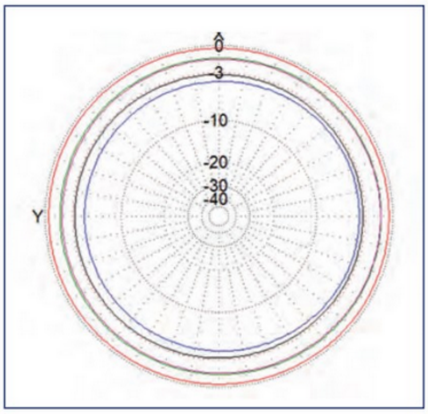

FIGURE 4: Comparing the azimuth pattern at 75° take-off angle. The benchmark inverted-V half-wave dipole pattern is shown in red, 10m/10m configuration in blue, 8m/12m configuration fed at ground level in green, 8m/12m configuration fed at 2m above ground level in pink, and 6m/14m configuration fed at 4m above ground level in black.

High-angle gain

The 10m/10m configuration is 3-4dB weaker than our benchmark dipole at 75° take-off angle. Conversely, the configuration with the (marginally) best performance at 75° take-off angle, 8m/12m, has its maximum current point at a lower 6.8m above the ground. The second and third configurations offer practically the same 75° performance as the benchmark dipole, and it is worth noting that the worst performer at this higher angle of take-off offers stronger vertical polarisation because of its longer vertical stretch. In general terms, all four configurations offer good, to acceptably-close, gain at this high angle compared with the benchmark dipole.

All four configurations are marginally weaker compared with the benchmark quarter-wave vertical antenna at 5° take-off angle compared with the half-wave inverted-V dipole at 75° take-off angle. There is a clear trade-off between higher- and lower-angle gain with the inverted-L half-wave antenna. The second and third configurations offer good alternatives to our half-wave dipole, being within 1dBi, but at 5° they are weaker by an average of 2.5dBi when compared with the first and fourth configurations, and up to 7dBi below the vertical antenna benchmark at their weakest points. To summarise, **Figure 3** shows a comparison of the azimuth patterns for these four antenna configurations, together with the benchmark vertical antenna, at 5° take-off angle. **Figure 4** does the same, but using the benchmark dipole, at 75° take-off angle.

The L-dipole

Another antenna option is the L-shaped dipole. **Figure 5** shows the proposed configuration. This antenna consists of two quarter-wave long elements (just like any half-wave dipole), with one element deployed vertically, and the other running as a horizontal or gently-sloping element from the feed point at the base of the vertical element. In this case, the antenna is adjoined to a 12m fibreglass pole, with the tip of the pole at 12m above ground level, the feed point at 2m above ground level, and the lower element gently sloping to a 1m-long plastic electric-fence insulated post, where it terminates. This configuration has the attraction of requiring only 10m of horizontal space, although care should be taken, as with the inverted-L, to use a guy rope to keep the vertical element as straight as possible to counteract the pull from the lower element.

Figure 6 reveals that this antenna has useful gain at 5° take-off angle, peaking at -5.1dBi towards the direction of the lower element, and in fact equals or surpasses the -5.9dBi of the benchmark vertical antenna within a 160° beam width in that direction.

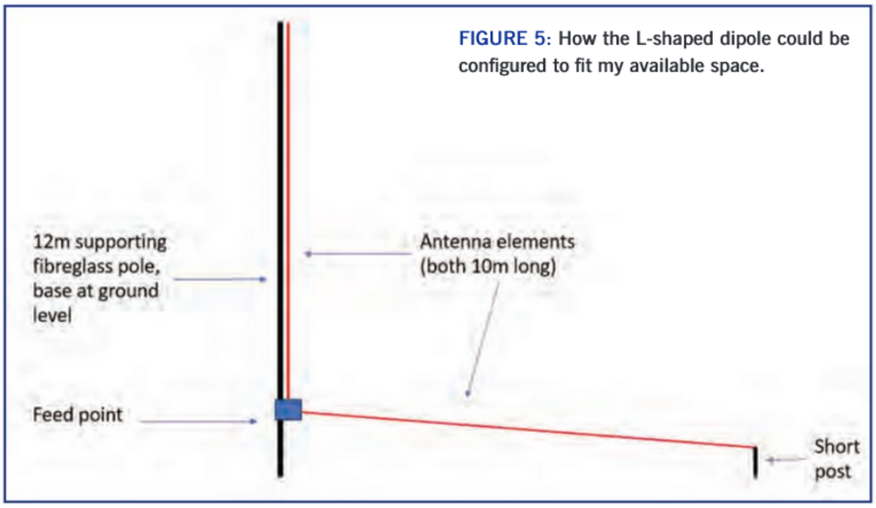

FIGURE 5: How the L-shaped dipole could be configured to fit my available space.

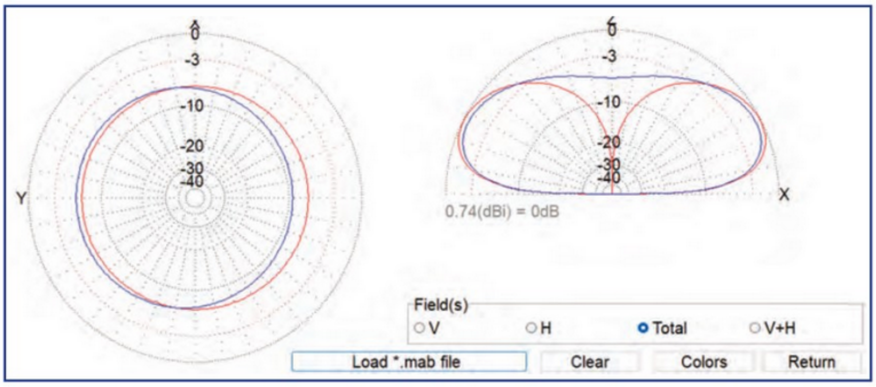

FIGURE 6: Azimuth and elevations plots, comparing the benchmark quarter-wave vertical antenna (red), with the L-shaped dipole (blue), at 5° take-off angle.

Conversely, gain (-8.5dBi) is at its weakest 180° from the direction of the lower element. The far-field plot also hints at greater higher-angle gain than the benchmark quarter-wave antenna. This is because of the horizontally-polarised nature of the lower element. At 75° take-off angle, the L-shaped dipole is a fraction under 6dBi stronger in the direction of the lower element than the benchmark vertical antenna, and is still stronger in the opposite direction, although less so. However, this is tempered by the fact that it still models as, at best, 10dBi weaker than the benchmark dipole at this higher take-off angle. This antenna is therefore a closer cousin to the vertical quarter-wave antenna than the half-wave inverted-V dipole. Nonetheless, it offers a quick-to-deploy antenna which should put less mechanical strain on a fibreglass support pole than a dipole or inverted-L. For 40m, though, you will require a 12m support pole to maintain the lower element above the ground.

Final thoughts

There are, of course, other alternatives which offer even better space-saving options. In the past, I have used a simple configuration, in which I had a binding post mounted on to a single magnetic mount on my car roof, attached a 10m-long wire, to just the red positive side of the binding post, and relied on the car roof as a capacitive ground. The wire ran up to near the top of a 12m fibreglass pole at a shallow 12° sloping angle. Efficiency was probably not at its maximum, but it meant I had a full-sized 40m quarter wave antenna with practically-zero horizontal space used, as the pole was mounted in a drive-on plate mount that my car was happily providing weight for!

Another quick-to-deploy option for 40m (as well as 20m and 10m) is an 11.8m-tall end-fed half-wave vertical antenna. Fed at the base with a 49:1 transformer, this again runs vertically up a 12m fibreglass pole. At the 10m point, a 34µH coil chokes the antenna so that it operates as a half-wave end-fed on 20m and a full-wave on 10m. It also acts as a loading coil for 40m. Bandwidth is narrower than with a quarter-wave vertical antenna, or full-sized half-wave vertical dipole (about 80kHz at 2:1 VSWR or lower), but it is another low-space option, albeit with slightly reduced efficiency.

For future 40m portable operating, I think I will consider both the inverted-L and L-dipoles as serious options. Of course, the purpose of this exercise was just to see if a compromise could be sought between higher- and lower-angle take offs and in effect maximise what could be achieved by a single antenna. The one thing we do know about 40m though, especially in terms of inter-G working, is that most of the time it is the band conditions that determine how much we can do.

Table 1: A comparison of gains at take-off elevations of 5° and 75°.

Antenna type	Gain at 5° (dBi)	Gain at 75° (dBi)	Elevation of maximum gain	Horizontal space
¼-wave vertical	-5.9	-9.3	26° (0.7dBi)	10m
½-wave dipole	-8 to -12.5	6.5	87° (6.8dBi)	>16m

Table 2: Comparing modelled data of four inverted-L configurations that fit into 11m horizontal space. BM denotes the benchmark figures.

Lengths vertical/sloping (m)	Gain (dBi) best/worst		Horizontal space (m)	Antenna height highest/lowest (m)	Notes
	5° (BM -5.9)	75° (BM 6.5)			
10 / 10 (fed at ground level)	-6.6 /-9.5	3.2 / 2.4	10	10 / 3.3	12m pole needed
8 / 12 (fed at ground level	-8.3 / -12.8	5.9 / 5.6	11	8 / 1	10m pole and 55° slope needed
8 / 12 (fed at 2m agl)	-9.8 /- 12.0	5.8 / 5.3	10	10 / 1.5	12m pole needed
6 / 14 (fed at 4m agl)	-6.5 / -10.7	3.7 / 3.6	11	10 / 0.5	12m pole needed

RTTY-operated squelch

Introduction

Monitoring our favourite HF RTTY frequencies while waiting for activity has a certain 'nuisance factor' in that when there's no actual operating going on we still hear the background (atmospheric) noise coming out of our radio's speaker. After a certain amount of time, this can get a bit annoying. How do we solve this problem? Since HF radios typically don't have a squelch circuit (because SSB modes have no carrier to detect), there's no easy way to turn our speakers off and on. Or is there?

Circuit design

Instead of relying on a carrier to act as squelch control, we can use the tones generated by RTTY itself and use those to toggle the speaker on and off via the circuit shown in **Figure 1**, using a single tone-decoder IC (the 567). The benefit of this particular IC is that it has been around a long time, long enough to have established its reliability in applications such as DTMF tone decoding many years ago (before single ICs were developed to do DTMF decoding all on a single chip). Additionally, it is inexpensive and available from the majority of component suppliers serving the home hobbyist, and it is manufactured by more than one company. For me, these features are highly desirable for my projects to keep things inexpensive and easily reproducible in the future.

There are two different methods to calculate the centre frequency, f_0 , of the 567. The easier one is discussed in the data sheets and, if the input signal is $\geq$210mV rms, the frequency can be found using the formula:

$$f_0 = \frac{1.1}{R_2 C_5} \text{ kHz},$$

where the value of R_2 is given in kΩ and lies between 6.8kΩ and 15kΩ, and $C_5 = 0.1\mu$F. The standard RTTY tones are 2125kHz and 2295kHz, although there are certain circumstances where other tone frequencies might be in use. For this project, the standard tones in amateur radio are the same ones that I have used in this circuit. No matter which tones are used though, the frequency separation is always 170Hz, easily within the bandwidth of a single 567, which makes our circuit design simpler in that we need just one (instead of two) 567s to do the decoding for us. The bandwidth of the 567 can be varied, although since we're detecting long durations of standard tones we don't need to limit the bandwidth; erroneous noise bursts will be ignored regardless of the bandwidth setting of the 567, thanks to a few more components downstream.

Once a RTTY signal is detected, it must be determined if the tone that gets decoded is just a momentary noise (or voice) burst, or if it is a longer-duration RTTY signal. To determine this, we combine the 567's output with one of the two monostable multivibrators in the 4538 package. Since the 567 has an active-low output, half of the 4538 gets triggered on the *lagging* edge of the signal trigger from the 567. This causes the not-Q output of the 4538 to go low for half a second. The two-input AND gate U4A then has two logic-high inputs (assuming a valid RTTY tone is present at the circuit input, and not a noise burst) which causes relay RLY1 to switch the radio's audio to the speaker to let us (and our computers) hear the RTTY signal.

When the signal drops, the second half of the 4538 (the other monostable multivibrator) triggers on the lagging edge of U4A's output for slightly longer than half a second to act as a 'hang timer', so that if the signal briefly fades before it re-triggers the circuit, the relay won't chatter.

The reason for using a relay is that it can best and simply handle whatever power we feed to the speaker, and it will not introduce any DC components that might enter into the circuit through other switching means. Since we're not dealing with huge power levels or high voltages, a small relay can be chosen that can easily be driven from a commonly-available switching transistor in our circuit. The primary thing to look out for is that, even though the relay is small, the coil can provide voltage spikes that might damage transistor Q2. To avoid damage, diodes D3 and D5 (see Figure 1) clamp the collector to ground or Vcc when the collector voltage goes below ground or above +5V respectively. To make sure that currents stay within the parameters of common low-cost transistors, Q3 was added to drive the status LED2 instead of having Q2 switch both a relay and LED.

On the topic of the audio output, some older (valve vintage) equipment requires a load on the output of the audio amplifier. Without such a load damage can occur to the final amplifier stage. If you're operating such a radio, the relay needs to be wired so that a load gets switched into the audio amplifier. A resistor of suitable resistance and power rating should work quite well.

This circuit operates from +5V because of the maximum operating voltage range of the LM567. If you haven't got a 5V relay in your spare-parts box, and have only a 12V relay, then make sure that it is wired to the correct supply. To keep parts costs low, D1, D2 and D4 are configured as a single 3-input OR gate instead of using an IC. Since there are no logic gates after this point, we don't need to worry about including a pull-down resistor from the junction of the three diodes to ground; without +V on the inputs, the transistors we're using just won't turn on!

Inverter U3A is shown as an IC, specifically 1/6th of a package, primarily for clarity. For those of you who, like me, don't want to waste parts (in this case five of the six inverters in that IC package), I've shown how a single transistor (Q4) and two resistors (R13 & R14) can be used as an inverter instead. The astute observer may ask why we're using Q1 and Q2 since both are fulfilling the same function? It's a matter of power handling by the device: depending upon the current draw of the relay coil, the relay might need its own transistor (or the substitution of a device capable of handling more power if both the relay and LED are driven by the same device). Also, there's the back-EMF voltage spike that occurs when the relay opens; if we hook up something in parallel to the coil (like an LED), consider what the back EMF spike will do to those additional components.

Operation

Operation of this circuit is relatively straightforward. Status LEDs (included on the circuit diagram shown in Figure 1), while not mandatory, are a great indication of what the circuit is doing. For example, if LED1 flickers, it means that the RTTY signal is either weak or off-frequency (or both), conditions under which your RTTY receiver will probably not decode reliably. The RTTY squelch circuit can be by-passed using switch SW1, and then the speaker will be activated regardless of what type of signal we're receiving.

Since we're not dealing with any mid- to high-impedance levels (such as might be seen

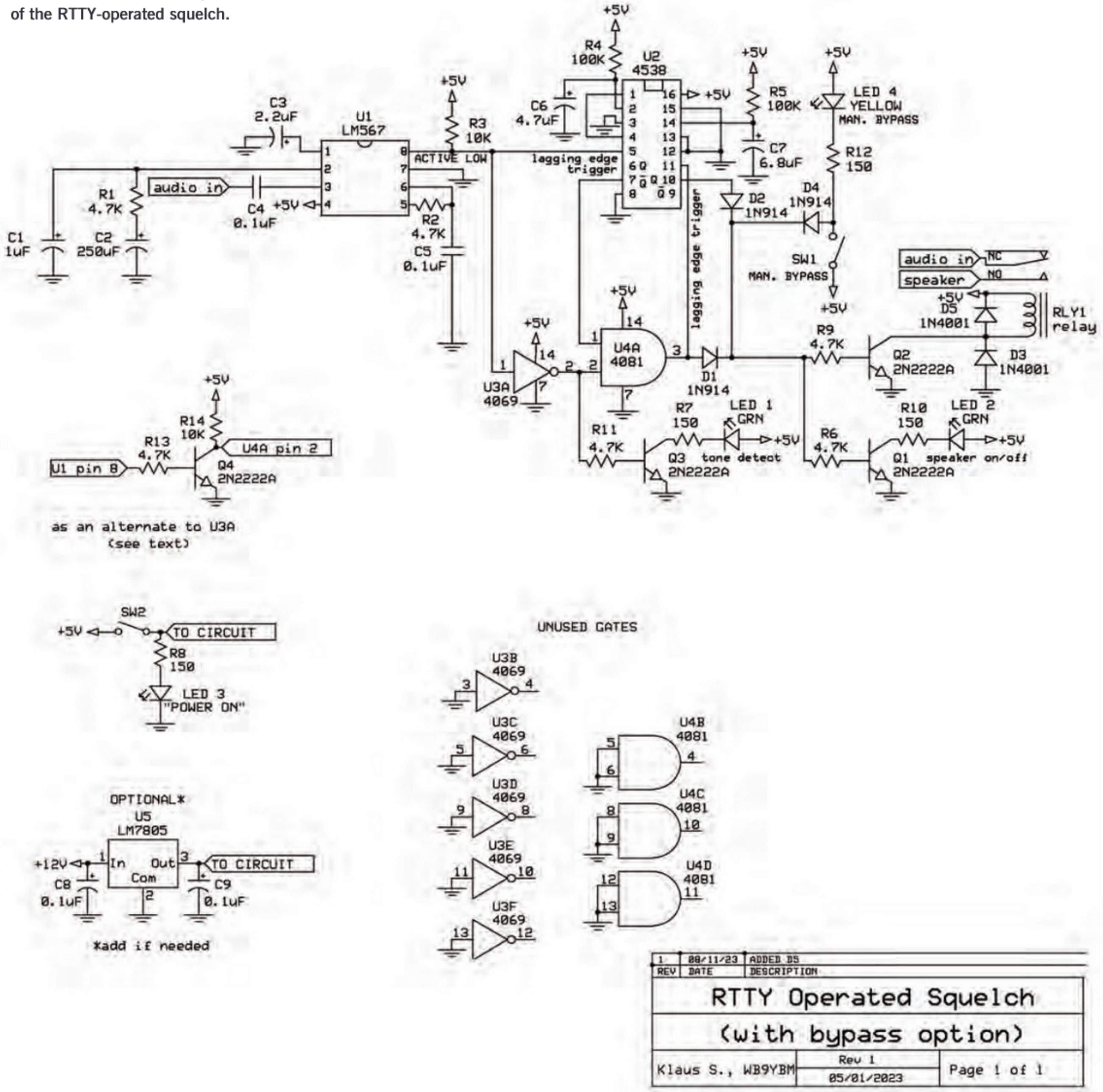

FIGURE 1: The circuit diagram of the RTTY-operated squelch.

with microphone circuits), this circuit doesn't need any special considerations under normal operating conditions, although if operating QRO or in an RF-rich environment (like a field day), at least a few precautions are always a good idea. Use a metal enclosure and ground it, and by-pass incoming and outgoing leads.

If a +5V regulator is used with this circuit (to allow operation from the +12V supply feeding other equipment on our operating bench), use one that can be mounted on a heat sink (such as the 1A package type) and mount it on the metal case or other heat-dispersing metal unit. This may be especially important if you are using several LEDs. Such a precaution might be over-kill in an air-conditioned amateur radio shack, but a bit of extra safety margin might not go amiss if we're operating during a field day on the hottest day of the summer!

Conclusion

Even though recent design techniques usually go along the route of doing everything with a programmable logic device like a Raspberry Pi, not all experimenters want to learn a programming language just for a single project, especially if simpler, more-convenient, routes exist. The components in this particular design are commonly available through multiple vendors at reasonable prices, both being requirements for reproducing the circuit as well as having spare parts that are easy to obtain.

Klaus Spies, WB9YBM
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Design Notes

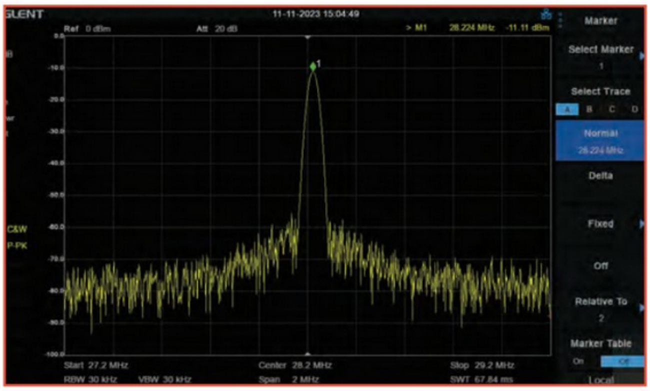

FIGURE 1: AD9850 output at -10dB with R_{SET} = 12kΩ.

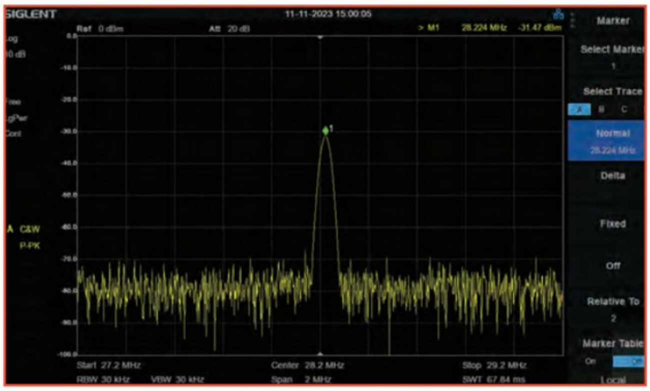

FIGURE 2: AD9850 output at -30dB with R_{SET} = 120kΩ.

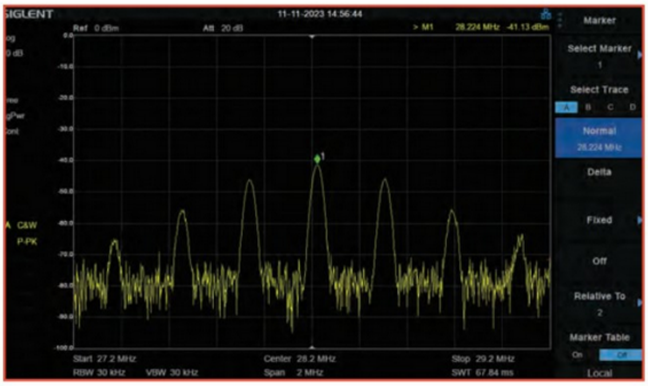

FIGURE 3: AD9850 output at -40dB with R_{SET} = 390kΩ, showing instability.

More on the BBC Computer

After the comments in the January *Design Notes* about the Z80-based BBC computer, several readers wrote in to say that the original BBC hardware was based on the Z80. Nick Garrod, G0OQK, writes: “I just read your article in *RadCom*, where you mention BBC BASIC on the Z80. Prior to selecting Acorn as their partner, there was already a BBC microcomputer in existence. This was called the Richard Russell board, after its designer who worked for BBC Designs Department, and used a Z80 processor rather than a 6502. It also ran Z80 BASIC. I helped build one when working as a trainee engineer at the BBC Wenvoe transmitter in the summer of 1981. Keith Winnard, GW3TKH machined the metalwork for the case. Richard was part of the design team for the BBC computerised transmitter monitoring system, which was all Z80-based. Wenvoe was one of the ‘monitoring information and control centres’ (MIC), the operation of which was my primary role there. I believe when the BBC approached Acorn, they wanted a Z80-based machine, but Acorn already had a prototype 6502 machine in development, the Proton, which became the BBC Micro.”

PicKit interface

Mike Lisle, GM4FPZ also wrote in to make similar comments on the BBC computer, then went on to mention connectors on the PicKit 4. He writes: “I was interested in your comments on Pickit programmers. I can confirm that the PICKitPlus software works well (or at least it has done for me for several years).

“I’ve been struggling to understand the claimed need for an adapter to go between the 6-pin plug used with PicKit2/PicKit3, and the 8-way connector on PicKit4. In my experience, you just need to blank pins 7 and 8 to avoid using them by mistake and then connect the 6-pin connector as before.

“My business uses PIC micros in many different products. I find the standard PIC programming cable doesn’t work for me, so I usually want a dedicated programming cable. I do have access to the correct crimp tool for the crimp tags normally used, but I prefer a simpler solution – a 6-way right-angle 0.1in-pitch connector on a bit of strip-board. I like to drill a 1.5mm hole at the end of each strip, and then feed the wires through the holes and solder on the back. That then gives a bit of strain relief for each solder joint.

“One more thought: during firmware development and testing, I tend to swap between PicKit2, PicKit3 and PicKit4, whichever is most suitable at the time. PicKit2 and PicKit3 use a mini USB connector; PicKit4 uses a micro USB connector. In order to avoid having to swap USB cables as I swap PicKit devices, I’ve fitted a mini-to-micro USB adapter to the PicKit4.”

Current sources

Last time, we touched on controlling the RF output level of the AD9850 direct digital synthesiser (DDS) chip in order to provide a cleaner CW keyed waveform. Developing his idea for keying the Cape Town beacon, Greg made some tests using different values of R_{SET}, increasing the value from the nominal 3.9kΩ for the reference 0dB level. He writes: “Today I managed to test an AD9850 DDS with varying R_{SET}; spectrum plots are shown in **Figure 1**, **Figure 2**, and **Figure 3**. These use successively R_{SET} values of 12kΩ, 120kΩ and 390kΩ, giving (ideally) 10dB, 30dB and 40dB reduction in output power **[1]**. All is OK down to -30dB full scale but, when I tried -40dB, some spurs appeared. I don’t know the details of the processing inside the DDS chip, but the current is somehow multiplied by 32. Maybe they use some kind of current mirror. Whatever it is, it seems to be

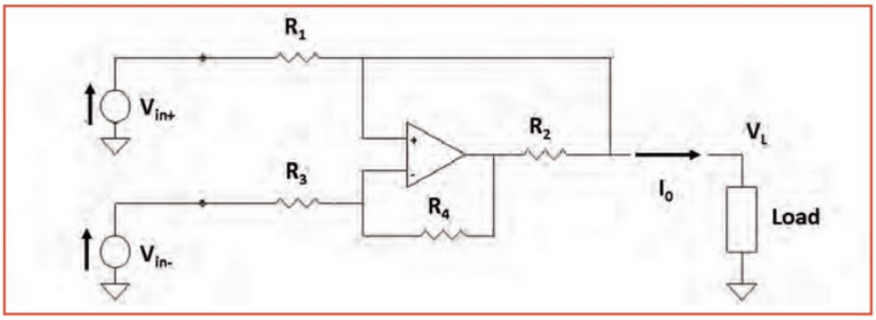

FIGURE 4: The theoretical circuit of the Howland current pump. This has been extended to allow either, or both, positive and negative control input voltages. The circuit can either source or sink current, but care needs to be taken that voltages on the op-amp pins remain within their specified limits for all values of V_L likely to be encountered.

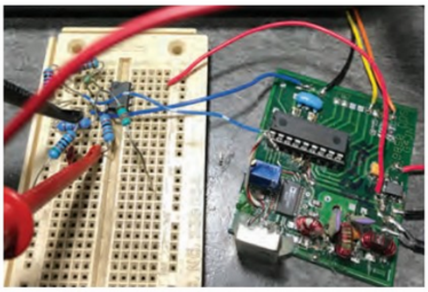

FIGURE 6: The 'breadboard' test setup for the AD9851 output-level control.

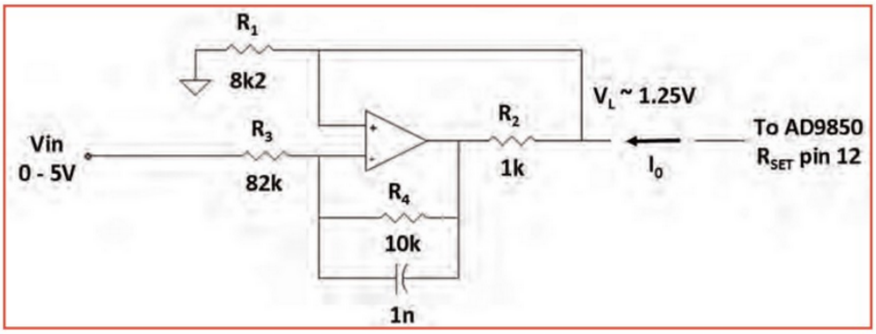

FIGURE 5: A practical application of the Howland current pump to control the output level of an AD9850 DDS using an input voltage covering 0 to +5V. The negative input has to be used as the output current, I_0, flows OUT of the DDS, and is thus negative as far as this circuit is concerned.

unstable at very low current *[but see below]*.

"The idea should still work OK for the beacon. We can either put a 120kΩ resistor in parallel with the controlled current source, or the code for the raised cosine can be modified. Either way, I believe it will work. Next stage will be to try the idea on the beacon proper and look at the spectrum of the keyed signal."

The Howland current pump

The AD9850 DDS uses a resistor, referred to as R_{SET}, going from pin 12 of the device to ground to define the current used in the sine reconstruction in the digital-to-analogue converter. A nominal 1.25V is imposed across R_{SET}, and the peak current that is generated by the DDS (ie the positive peak of the sine wave output) is 32 times the current through this resistor. The current flows out of pin 12 to ground via R_{SET}. Last time, I speculated that with a bit of op-amp circuitry, it may be possible to force a constant current proportional to a voltage input. This turned out to be quite a straightforward operation once the correct circuitry was identified. The solution is a minor adaptation of the Howland current pump **[2]**.

The basic circuit for this is given in **Figure 4**, with an additional negative input V_{in-} added. For now, ignore this additional input node and replace it with a short circuit to ground, so $V_{in-} = 0$, to give the standard Howland design. Voltage sources, by definition, have zero source impedance. The circuit is analysed in detail in the reference, but the net result is that, provided the ratio $R_1/R_2 = R_3/R_4$ is maintained, a current I_0 equal to V_{in+}/R_1 is driven through the load, *and this current is independent of the voltage, V_L, that appears across the load*. However, it is essential to make sure that the voltages on all the pins of the op-amp are maintained within its specified limits.

Such a bit of circuitry could be connected to the R_{SET} pin of the AD9850, replacing the resistor there, to provide a voltage-variable sink current that is not dependent upon the 1.25V imposed at that point. However, the fact that it has to act as a current sink does mean that I_0 in the standard Howland circuit is negative, necessitating a negative voltage input, and therefore needing a negative rail for the opamp. Negative rails add complication if they're not already present for other reasons, so adding one just for a task like this should always be avoided. Fortunately, the Howland circuit is amenable to a slight modification. V_{in-} can be used as a negative voltage input, as shown in Figure 4, with V_{in+} replaced by a short to ground, or used as part of a differential input.

Circuit analysis

Analysis of the complete circuit of Figure 4 gives

$$I_0 = V_L(R_4/(R_2R_3) – 1/R_1) + V_+/R_1 – V_-R_4/(R_2R_3).$$

When $R_2/R_1 = R_4/R_3$, the terms involving the load voltage, V_L, cancel so the output current, I_0, becomes independent of its value. With the correct resistor ratio, the overall response to both positive and negative inputs gives the differential relationship $I_0 = (V_+ - V_-)/R_1$. If V_+ is set to zero, then a negative I_0, a current sink, can be controlled by a positive voltage on V_{in-}. It may seem a little strange that only R_1 affects the transfer relationship when there are four resistors in there, but that's what the mathematics shows! However, the values of the other resistors do affect the voltages on the op-amp pins, and they need to be selected to make sure they are within allowed limits when V_L varies over its expected range.

The AD9850 DDS has a reasonably constant V_L of about 1.25V, and requires from zero to about -0.6mA (current sink) for an RF output of 32 times this up to 20mA. Using $R_1 = 8.2kΩ$ gives the required current swing for a V_{in} range of 0 to 5V on the positive input, with the negative input grounded. To avoid having to use dual supply rails, the op-amp pins all need to be above ground by a comfortable margin for the device chosen. A TLA462 device was used here as this allows operation with its output pin just a few tens of millivolts above ground, and inputs close to either supply rail. Making $R_2 = 1kΩ$ ensures that the op-amp output pin sits at around 0.8V for this value of V_L. The exact value of R_2 is not very critical, so long as it is chosen to keep the op-amp within its range. The ratio R_3/R_4 has to be equal to the ratio of R_1/R_2, so

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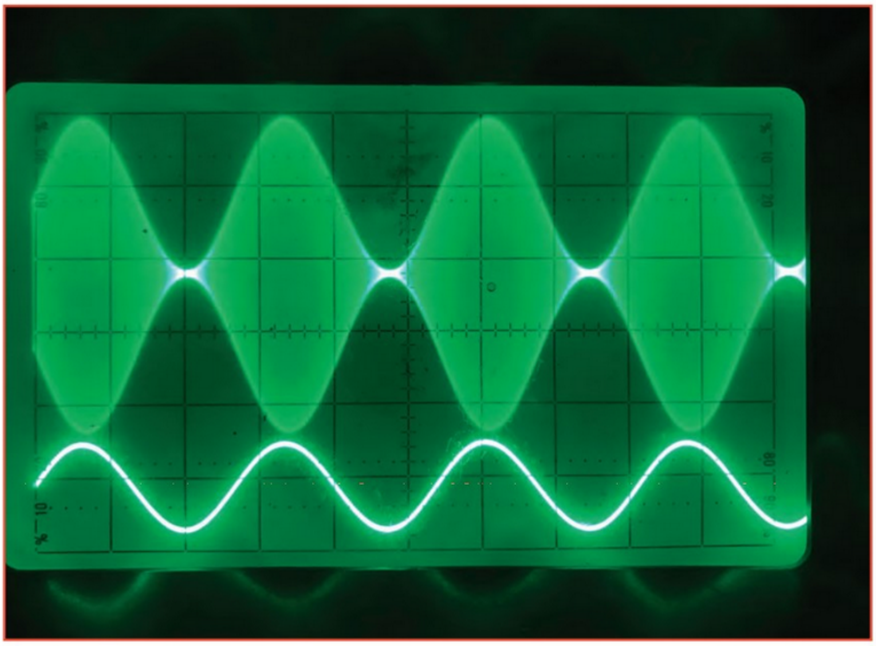

FIGURE 7: **A 100% sine-wave amplitude modulation generated using the configuration of Figure 5.**

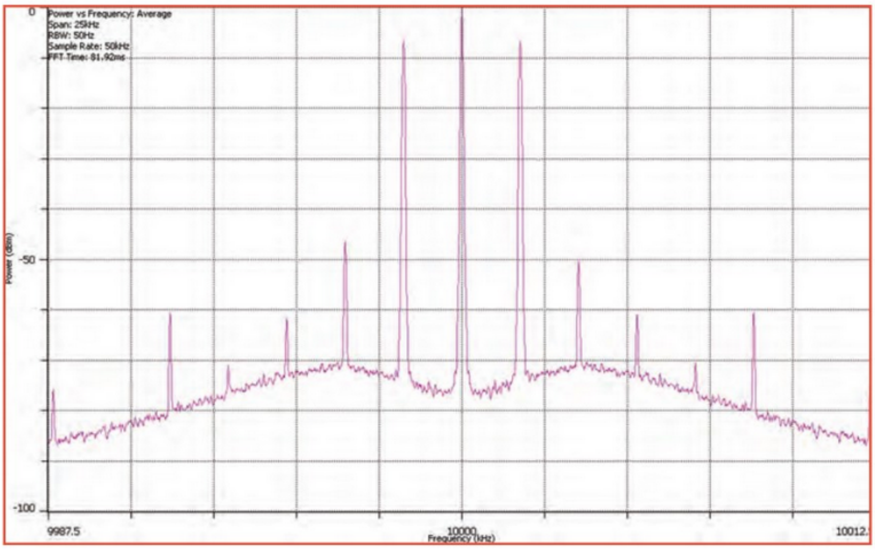

FIGURE 8: **A spectral plot of the 100% AM signal shown in Figure 7. The -40dBc 2nd harmonic sidebands are caused by non-linearity of the audio waveform source. The noise floor 'hump' is caused by the phase noise of the X6 PLL clock multiplier.**

here a ratio of 8.2 is needed for balance. To raise the input resistance to reduce the load on any driver stage, the value of R_3, which defines the input impedance, is made 82kΩ so that R_4 has to be 10kΩ. The easiest way to check voltages throughout the circuit is to use the spreadsheet in **[3]** which allows for arbitrary values of the four resistors to be chosen, and for V_L to be defined with the resultant I_0 and op-amp output voltage being calculated. The latter, along with V_L that appears directly on the input pins, needs to be checked against the op-amp data sheet to ensure it is within the operating range.

Figure 5 shows the complete drive circuit for controlling the AD9850 RF output for a maximum 20mA RF drive current from an input voltage in the range 0 to +5V. The 1nF capacitor was found to be necessary across R_4 as the circuit was unstable without it. The time constant of 10μs with R_4, resulting in a corner frequency around 16kHz, has minimal effect on audio-frequency modulation, and it is quite possible, although I have not tested it, that a smaller value of capacitor may suffice to maintain stability.

A bit of test circuitry as simple as this doesn't warrant soldering, so an old DIL 'breadboard' was extracted from the back of a cupboard, and a few wire-ended resistors were given a purpose for their continued existence here at 'JNT Labs. A photograph of the test setup can be seen in **Figure 6**. The DDS board is an old module I designed back at the beginning of the millennium, and actually contains an AD9851 device which has exactly the same R_{SET} arrangement as the AD9850. The control signal, V_{in-}, comes from an audio test generator that allows a positive offset to be added to the waveform, so getting a sine wave input that swung from zero to plus 5V was easily achieved.

Figure 7 shows an oscilloscope trace of sine-wave modulation with DC offset and amplitude adjusted for 100% AM. As can be seen, it appears to be very clean, but oscilloscope traces are notoriously unreliable in that they hide low levels of distortion artefacts. The real test can be seen in **Figure 8**, showing the RF spectrum of the amplitude-modulated waveform. The two sidebands are each 6dB below the carrier, exactly where they should be for 100% AM. The only unwanted artefacts visible in the trace are second-harmonic sidebands at -40dBc, which come from the audio generator that is known to have this level of harmonic distortion.

As an aside, the 'hump' visible in the noise floor of this spectrum plot is caused by the added phase noise introduced by the phase-locked loop X6 clock multiplier in the AD9851 DDS device. No such change in noise floor would be seen on the AD9850 which does not offer a clock multiplier.

So all-in-all, it looks as if a simple op-amp with four resistors allows a remarkably-linear voltage-to-RF-drive conversion to be made on the AD9850/51 DDS chips. The instability seen when a resistor of 390kΩ is used to set the drive current, does not appear to occur when it is defined using a current pump. At the time of writing, Greg has reported that he had also tried a similar current pump, although not an identical configuration to this one, and it appears to work well.

Notes

1. The value of R_{SET} defines the current driving the RF output circuit. As we saw in last month's *Design Notes*, there are circumstances in which the level in decibels can correctly be specified as $20\log_{10}(I_1/I_2)$, provided that no impedance change occurs in the signal path. As the DDS output current into the fixed load is directly proportional to $1/R_{SET}$, we are justified in writing that the change in output power is given by $20\log_{10}(R_x/R_y)$, where R_x and R_y are different values of R_{SET}. Substituting the resistor values used in the test, $20\log_{10}(12/3.9)$ = 9.76dB, near enough to 10dB for test purposes.
2. Howland current pump: https://www.allaboutcircuits.com/technical-articles/the-howland-current-pump/
3. Spreadsheet for current-source design: http://g4jnt.com/OPA_CurrentSource.xls

Rooster transceiver from Kanga Products

FIGURE 1: Foxx3 on left with Rooster on right.

For a number of years now, Kanga Products has sold a variety of simple, crystal-controlled CW transmitters and transceivers.

One of these was the Foxx3 transceiver which was built into a mint-tin enclosure. Daimon owns two of these units, one for the 80m band and one for the 40m band, and so he was very pleased when Paul, the owner of Kanga Products, asked him if he would like to be a beta tester to build (from a kit) and use one of his new products.

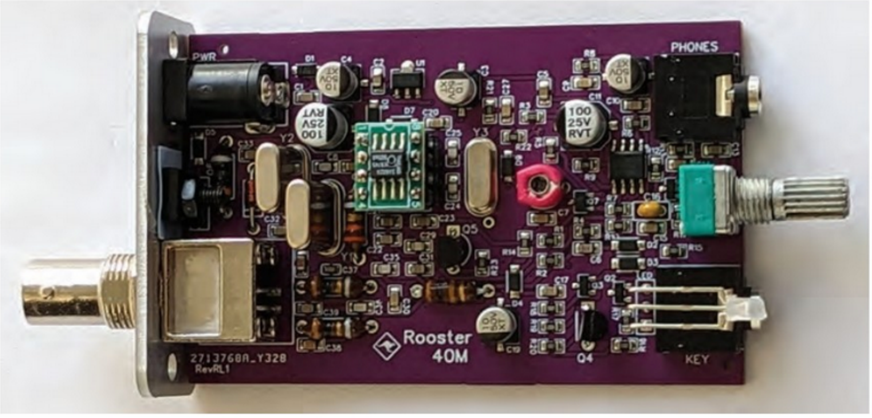

FIGURE 2: The completed Rooster PCB.

Review of the Rooster by Daimon Tilley, G4USI

The new product is called the Rooster CW transceiver, and it is designed to improve upon, and replace, the Foxx3. It comes with its own custom-designed aluminium enclosure, giving it a professional finish. **Figure 1** shows my 40m Foxx3 transceiver on the left, alongside the new Rooster transceiver.

The Rooster is a 40m-band crystal-controlled transceiver, using a direct-conversion design. This means that it is fixed to a single frequency, in this case 7.030MHz, which is the QRP CW centre of activity. It gives 2-3W output with a DC supply of 12V. There are connections on the front panel for a straight key (or external keyer), and a pair of headphones. On the rear is a 2.1mm coaxial power connector, and a BNC antenna socket. The front panel also has an RIT control for achieving the desired received CW tone. Other features include a side-tone, Tx/Rx LED, and an active audio filter. I was particularly interested in this last feature as the Foxx3 receiver section is 'wide open' and difficult to use in busy band conditions. The Rooster is based around a standard SA/NE612 front end, and has an op-amp audio amplifier as well as the active audio filter. The transmitter section also shares the NE612 oscillator, and the VFO signal is buffered before being fed to a PA stage that provides the RF output, using a 2SC1162 transistor in the final stage.

The parcel arrived on a Saturday afternoon and, when I opened it, I was pleased to see Kanga Products' usual level of attention to detail. The kit was well packaged; there were printed

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and Bob Burns, G3OOU,
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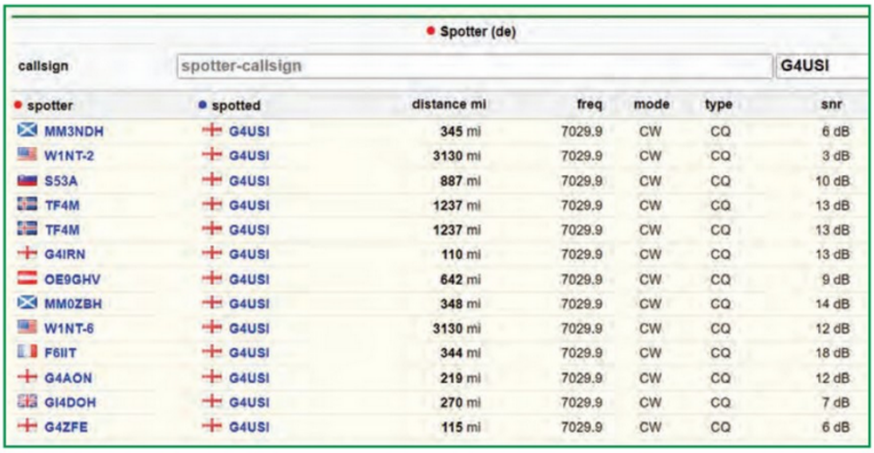
instructions, and each stage of construction had its components individually wrapped to aid the constructor. I couldn't wait to get started, and so began to build the unit straight away. As I have come to expect from Kanga Products, the instructions were first class, and I like the way that the construction has been broken down into stages, with intermediate testing at the end of many of the major stages described. This is useful to ensure that any mistakes made are rectified early, and it is a real help to both experienced and inexperienced constructors alike, providing confidence in the build as you go along.

The instructions suggest a build time of around an hour, and I managed to complete mine in a steady 50 minutes or so. There are a number of SMD components pre-installed, leaving the constructor with about 20 or so through-hole components to fit. Although it is a small product and a small PCB, there is plenty of space for your soldered joints, so the medium tip on my soldering iron worked fine. The kit uses a low-pass filter on the RF output which makes use of moulded inductors. This means that the constructor has no coils to wind, reducing the build complexity further.

Alignment requires the use of another transceiver in CW mode, or a frequency counter, a dummy load, a pair of headphones, and a key. All you need to do is to adjust a single trimmer capacitor. The instructions are very clear, so no-one should fear the alignment process! With simple direct-conversion receivers like this, it is always advisable to run them from a battery rather than a power supply, as they are susceptible to noise and hum. The rig can run from 10-14V. I used one of my 12V Li-ion battery packs for this purpose. **Figure 2** shows the completed PCB.

Having built and aligned the transceiver, I connected it to an end-fed half-wave antenna for the 80m band, and switched on. Now this was not a fair first appraisal as it was the CQWW CW contest weekend and the band was busy. Lots of signals were heard all at once on the Rooster, but then it was interesting to switch to the Foxx3. The difference was quite stark. It was clear that the receiver on the Rooster was a lot more selective, and less susceptible to the hum which I heard on the Foxx3 even with a battery supply. I put the unit away until after the contest.

On the following Monday morning, at around 0900UTC, I returned to the Rooster and switched on. I could hear a few signals at the same time, but the receiver was selective enough to allow my 'between ears' filters to separate out the signals. I could hear some CQ calls, but could tell that they were probably too far from my transmit frequency to be reached (there is no transmitter-frequency shift available). However, in a quiet moment, I connected an external keyer and paddle, and used the 'Auto CQ' facility of the keyer. There is no internal iambic keying on the Rooster, but a straight key was fine in use; the external keyer was used just to assist with CQ calls. **Figure 3** shows the first spots received on the Reverse



● Spotter (de)

callsign: spotter-callsign | G4USI

● spotter	● spotted	distance mi	freq	mode	type	snr
MM3NDH	G4USI	345 mi	7029.9	CW	CQ	6 dB
W1NT-2	G4USI	3130 mi	7029.9	CW	CQ	3 dB
S53A	G4USI	887 mi	7029.9	CW	CQ	10 dB
TF4M	G4USI	1237 mi	7029.9	CW	CQ	13 dB
TF4M	G4USI	1237 mi	7029.9	CW	CQ	13 dB
G4IRN	G4USI	110 mi	7029.9	CW	CQ	13 dB
OE9GHV	G4USI	642 mi	7029.9	CW	CQ	9 dB
MM0ZBH	G4USI	348 mi	7029.9	CW	CQ	14 dB
W1NT-6	G4USI	3130 mi	7029.9	CW	CQ	12 dB
F6IIT	G4USI	344 mi	7029.9	CW	CQ	18 dB
G4AON	G4USI	219 mi	7029.9	CW	CQ	12 dB
GI4DOH	G4USI	270 mi	7029.9	CW	CQ	7 dB
G4ZFE	G4USI	115 mi	7029.9	CW	CQ	6 dB

FIGURE 3: Reverse Beacon Network results using the Rooster at 0900UTC on 27 November 2023.

FIGURE 4: The Rooster with the Kanga-Phoenix SCAF CW filter.

Beacon Network, and the signal even crossed the Atlantic to the US.

After a few further minutes of calling, I was pleased to receive a response from David, G4HMC in Buckinghamshire and had a QSO with him. Immediately after that, I was called by Mike, M6MPC, from Glossop in Derbyshire. Both QSOs were affected by QSB, but at times both David and Mike reported a strong signal from my QTH to the west of Taunton. Another advantage of the Rooster over the Foxx3 is solid-state switching which provides good QSK, set against the relay switch-over of the venerable Foxx3.

I then turned my attention to a comparison of the two receivers. With the Rooster, I could hear three or four CW signals simultaneously, although they were clearly separated in pitch. With concentration, my 'head filter' was able to copy each separately. I then turned to the Foxx3. As well hearing a similar number of CW stations, these were difficult to copy underneath the two broadcast stations I could hear as well. One was BBC Radio Wales, and the other was TalkSport. These are both medium-wave stations broadcast from Washford, Somerset (known locally as BBC Cross) which is about 15 miles from here. Radio Wales is on 882kHz, transmitting 100kW, and TalkSport is on 1089kHz, transmitting 50kW. Both were loud and clear on the Foxx3, but completely filtered out by the Rooster. Interestingly, my 80m Foxx3 does not suffer from this breakthrough. However, the Rooster demonstrated a clear improvement in selectivity and rejection of BCI.

A couple of evenings later, in what seemed like a quiet spell around 7.030MHz, I began to call CQ. I used my end-fed half-wave antenna for 80m which was only 6m above ground level in the centre. I called for an age and saw very few spots on the Reverse Beacon Network. But then I was called by Guy, VE2QRA in New Brunswick, around 2,600 miles distant, and he reported 559 on my signal. I emailed him shortly afterwards to thank him for the QSO, and to tell him a little more about the rig. He replied that he was running 700W into a dipole at 15m height.

To summarise, not only does the Rooster offer more power output than the Foxx3, but benefits from better Rx selectivity and the addition of full QSK keying. Purely as a matter of interest, I added an external audio filter to the Rx output. It was the SCAF CW filter from Phoenix Kits (now incorporated with Kanga Products), and I inserted this between the Rooster and my headphones. It did a super job of narrowing the audio pass-band to allow single CW signals to be selected (see **Figure 4**). Even just adding the filter at its widest setting took the three or so audible CW signals down to a single one.

Overall, this was a quick and simple kit to build and is perfect for the beginner. It comes with excellent detailed instructions, and a professional-looking case. It is compact, and draws just 20mA on receive and about 400mA on transmit at 12V. Priced at £37.99, it represents good value for money. My thanks to Paul at Kanga Products for giving me the opportunity to build and test the rig.

Laboratory tests and results by Bob Burns, G3OOU

Table 1: The results of various receiver tests.

Test	Result		Comments
Sensitivity	12dB SNR (carrier on to carrier off) for 0.5μV emf		Rx input impedance not measured
Audio peak response	806Hz		Measured at 50μV RF input level
RF bandwidth	168Hz (-3dB) to 509Hz (-10dB)		Measured with a variable-frequency RF signal and fixed Rx tuning
Spurious output (7.03MHz)	-55dBm in 50Ω (3.2nW or 0.4mV)		Measured with a spectrum analyser connected to the aerial socket
Tuning range	7.029971MHz to 7.03947MHz		Not linear
Signal linearity (no AGC)	RF input	AF output	12dB SNR so AF amplitude is variable because of noise
	0dB (0.5μV)	0dB (4.5mV pp)	
	10dB	10dB	
	20dB (50μV)	20dB	
	30dB	30dB	
	40dB (500μV)	40dB	
	50dB	49dB	Onset of limiting
	60dB (5mV)	56dB	Severe limiting

Table 2: The results of various transmitter tests.

Test	Result	Comments
Output frequency	7.02997MHz	-
Power output into 50Ω load	2.55W	380mA DC consumption
Harmonic content	2nd harmonic: -37dB; 3rd harmonic -47dB	Measured with respect to the carrier power

I conducted these tests using an external 12.0V regulated DC supply. The current consumption on receive was 20mA, and on transmit was 380mA. **Table 1** shows the results of tests of the receiver.

Intermodulation and cross-modulation measurements were not conducted because of the presence of a narrow band-width crystal filter between the antenna input and the detector, which would render the measurements meaningless compared to the measured in-channel overload point. The AF filter hides a lot of the distortion products resulting from signal overload, and at +60dB RF input, the audio distortion products were well down at 32dB below the audio output signal level. Connecting headphones set to 8-15Ω to the audio output caused the output level to drop by approximately 3dB, suggesting that the audio output impedance is of the order of 4Ω. The supplier does suggest the use of an external audio amplifier to drive a loudspeaker.

Table 2 shows the results of tests of the transmitter. Sideband noise was not measured because of limitations of the spectrum analyser. Initial tests on transmit resulted in the reed relay contacts in my electronic keyer sticking closed. Investigation showed that there was a 100nF capacitor across the keying line, which was causing the reed contacts to be intermittently 'welded' together. The solution was to include a 47Ω 300mW resistor in series with the keying line. This would not be a problem with a conventional straight key or mechanical bug key. The supplier has stated that the series resistor will be added to a future batch.

I tested the unit on-air with signals from Italy and Germany clearly heard during the afternoon. A 10am CQ call resulted in a contact from my location in Coulsdon, North Surrey, with a station in Crewkerne, Somerset, with a 579 incoming signal report. The side-tone was clear, if a little loud, and I could hear stations and band noise in the key-up state. My headphones were set to high impedance (4kΩ).

The finish looks very good, with a rugged case and clear labelling. The transmitter frequency is stated on the outside of the case. Some standard silver-plated BNC plugs were a tight fit to the RF input socket, which appeared to be plated with bright nickel or chrome. The supplier has stated that standard silver-plated BNC sockets will be used in future batches.

The use of one or more stereo 3.5mm jack sockets needs a careful mention in the manual, not just in the parts list, as mono plugs may cause connection problems. I tried using a 'wall wart' 12V power supply of unknown pedigree, but the hum level on receive was excessive. A regulated bench power supply caused no such problem. The supplier states that a battery may best be used as a power source.

I did not detect any microphony on receive.

tinySA Ultra

spectrum analyser

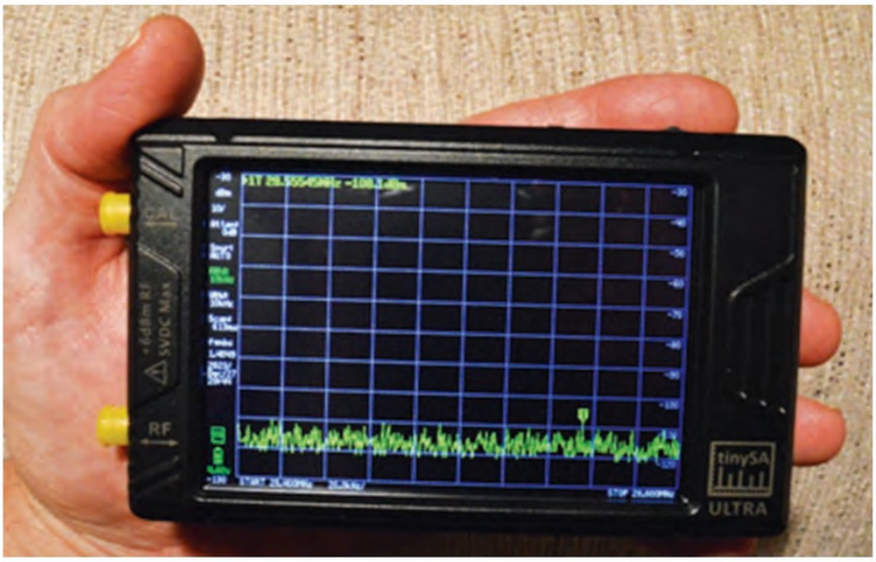


FIGURE 1: **The tinySA Ultra, a spectrum analyser that fits in the palm of your hand.**

Until recently, spectrum analysers in the amateur radio shack have been the preserve of those with space for bulky ageing dvices, or those with deep pockets for the newer models which are expensive but much more compact.

Then came fast Fourier transform (FFT) software designed to run on a few software-defined radios (SDR), such as the rudimentary spectrum analyser software for the SDRplay series. The game changed once again with the release of the tinySA spectrum analyser a few years ago, covering frequencies from near DC up to 960MHz, which was then followed in late 2022 by the tinySA Ultra, a compact, inexpensive device offering coverage up to 6GHz. This brief review will look at the features of this device, and I will give some examples of its use.

Features

The tinySA Ultra (**Figure 1**) is a diminutive device measuring approximately 120mm by 75mm and 24mm in depth. The touch-screen size is 85mm by 60mm (four inches diagonal corner to corner). It comes supplied with two SMA male connector patch leads, a double female SMA barrel adapter, a USB charging/data lead, a small telescopic whip antenna, and a touch-screen plectrum. There are three ports, two of which are SMA connectors, one to allow calibration/signal generator output and one for RF input; the remaining port is for charging/data transfer. There is an on/off button and a toggle selector which is used for scrolling through the menu and selecting peaks on the display. A headphone jack is provided which allows monitoring of AM and FM signals. The internal lithium battery provides enough power for around two hours continuous use before needing to be recharged.

The tinySA Ultra covers up to 6GHz in two ranges: 100kHz to 800MHz as standard, and 'ultra mode' which allows calibrated use up to 6GHz, although signals can be observed beyond 12GHz with reduced linearity. The maximum RF input level is +10dBm with 0dB internal attenuation selected. There are internal attenuators which provide up to 30dB attenuation, although it is always good practice to use external attenuators to avoid damage to the input circuitry. A switchable low-noise amplifier (LNA) is built into the unit. The resolution bandwidth is selectable from 200Hz to 850kHz.

The device can be configured for use as a stand-alone signal generator. The output signal in signal-generator mode is sinusoidal from 100kHz to 800MHz, with power levels settable from -20dBm to -110dBm in 1dB steps. Above 800MHz, the output is in the form of a square wave providing a useable output up to 5.4GHz. AM/FM modulation is provided in signal-generator mode, and is adjustable for both audio frequency and level. There is also provision for a frequency-sweep function. Note that it is not possible to use the instrument as a spectrum analyser when the signal generator mode is selected.

The tinySA Ultra can be connected to a PC via the data/charging port with the supplied USB cable, and can be controlled by use of free software **[1]**. Spectra can be saved as images or CSV files for processing using software such as Microsoft Excel.

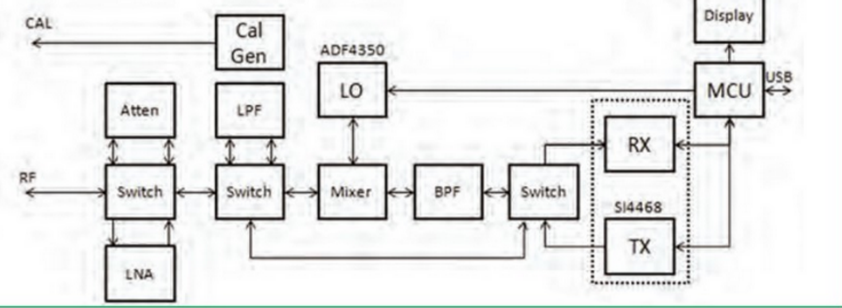
Internals

A block diagram of the tinySA Ultra is shown in **Figure 2**. The device is based around an ADF43350 wide-band phase-locked loop synthesizer chip. Below 800MHz, input signals pass through a low-pass filter; this is by-passed in 'ultra' mode (up to 6GHz), which does allow some low-level leakage from the local oscillator (around -10 dBm). The internal calibration signal generator (denoted 'Cal Gen' in Figure 2) is based on a 30MHz temperature-compensated crystal oscillator (TCXO) with selectable dividers, and is used to calibrate the instrument before use.

Setting it up

On turning the unit on for the first time, it is in 'default' mode covering up to 800MHz. If you wish to look at signals higher than this, it is necessary to activate 'ultra' mode which requires a pin code, obtainable from the tinySA homepage [1], to be entered in the configuration menu. Once activated, the 'ultra' mode remains enabled, although firmware updates may require 'ultra' mode to be re-enabled. Before use, the tinySA Ultra needs to be calibrated. The calibration menu provides two options: calibration from 100kHz to 5.34GHz using the internal TCXO signal generator, or calibration above 5.34GHz, which requires an external signal generator. Calibration using the internal signal generator is achieved by feeding a signal into the SMA RF port from the generator SMA port (marked as 'CAL') using one of the supplied patch leads. After calibration, a self-test check may then be carried out and this requires the patch lead from the CAL port to the RF port to be left in place. It is worth pointing out that there are counterfeits of the tinySA series of spectrum analysers, and they will usually fail the self-test procedure. Once the self-test procedure is complete, the unit is ready for use. Time and date may be entered from the configuration menu if required.

FIGURE 2: A block diagram of tinySA Ultra (reproduced from reference [1]).



Is it any good?

The tinySA Ultra costs a fraction of the price of most commercially-available spectrum analysers (even many older, used, examples) and the question inevitably arises: “Can something like that be any good?”. The answer is an emphatic yes, although of course it will not have the same performance as more-expensive instruments, and there will be artefacts from the local oscillator, and reduced linearity at the higher ends of the frequency range in ‘ultra’ mode. I don’t have a spectrum analyser with which to compare the tinySA Ultra, but there are numerous videos on YouTube comparing the tinySA and tinySA Ultra with more expensive instruments, the most notable perhaps being those on the channel of IMSAI guy **[2]**, and these are well worth watching before purchase to ascertain if a unit will suit your requirements. For most amateur radio stations, this analyser would be a worthwhile addition to the shack.

The tinySA Ultra in use - some examples

Spectrum analysers can be used for many sorts of measurements, both qualitative and quantitative. A few examples of measurements at G0FVI are given here. The tinySA Ultra is good for tracking down interference because of its small size, built-in LNA, and portability.

Operating on the 13cm band (2320GHz) from home at G0FVI has proved difficult because of wideband interference producing 20dB-over-S9 signals in some directions. I initially thought that local WIFI signals were to blame, although some feedback from the Microwave Users Group suggested the possibility that my mast-head transverter was being swamped by signals from cell-phone masts, introducing undesired mixing products. A large telecommunication tower about 1km distant was thought to be the culprit, and I was able to confirm that it was by using a small PCB 4-element Yagi antenna attached to the tinySA Ultra pointing line-of-sight towards the tower. This revealed some very strong in-band signals coming from the tower (unobstructed view, with LNA turned off: see **Figure 3**).

The screen capture in Figure 3 demonstrates a useful feature of the tinySA Ultra: it has the ability to display several screen traces at once. In Figure 3, the yellow trace is set to ‘peak-hold’, allowing cumulative addition of maximum signal strengths, while the red trace displays the continuously-changing waveform captured at any moment. The interference was eventually mitigated by use of an inter-digital filter.

At G0FVI, one of the main interests is the 23cm UK Activity Contest, using a masthead solid-state power amplifier (SSPA) running at 10W. I wanted to compare qualitatively the output from my IC-9700, with a 23cm transverter, looking at the phase noise, as both have been used to feed my masthead SSPA (low phase noise is desirable in contest environments). **Figure 4** shows a screenshot of the 2W output of the transverter, CW key down (a 144MHz IF was provided from a Yaesu FT-817). A combination of an external 2W attenuator was used at the input of the analyser, together with 30dB of internal attenuation.

The screen shot in Figure 4 shows the cumulative output of numerous scans, which were carried out to smooth out the noise floor, allowing a clear display of the phase noise being generated by the transverter (the phase noise manifests itself as a rolling increase in noise on either side of the signal at 1.2962GHz).

Further reading, and where to buy

An extensive description of the tinySA Ultra and its predecessor, the tinySA, can be found on the tinySA Wiki homepage [1]. There is also an extensive series of videos by Erik Kaashoek on YouTube **[3]**. As pointed out previously, there are counterfeits of the tinySA spectrum analysers, and consequently it is prudent to purchase from a reputable dealer. The tinySA and tinySA Ultra are available from Mirfield Electronics in the UK **[4]**.

References

[1] https://tinySA.org/wiki/pmwiki.php?n=Main.HomePage

[2] https://www.youtube.com/watch?v=djhrmAFfPns

[3] https://www.youtube.com/@ErikKaashoek

[4] https://www.mirfield-electronics.co.uk/tinySA-ultra-spectrum-an-new/

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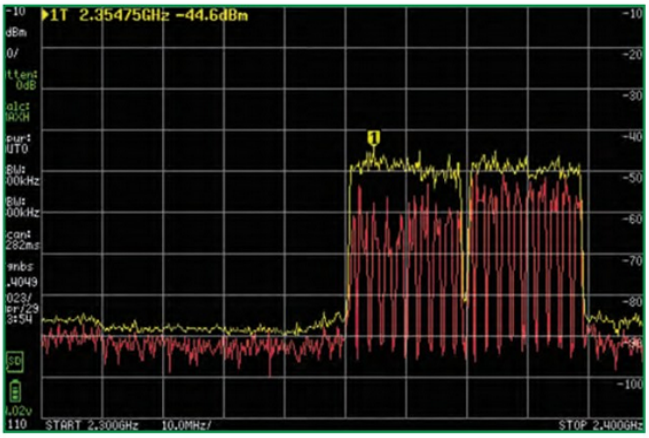


FIGURE 3: Strong interfering signals in the 13cm band near G0FVI’s home QTH.

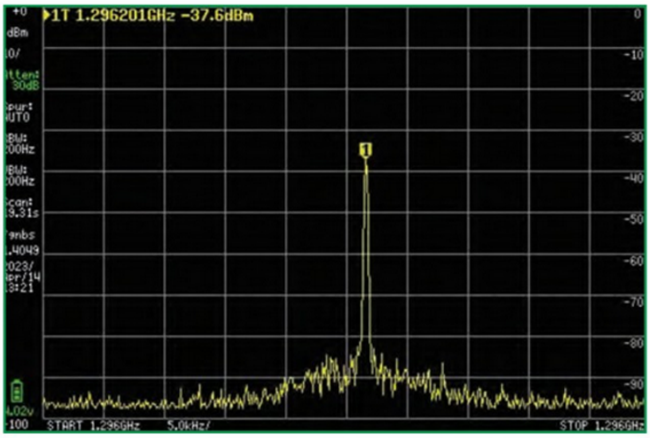


FIGURE 4: A screenshot showing the phase noise on the output from a 23cm transverter.

RSGB Band Plan 2024

The following band plan is largely based on that agreed at IARU Region 1 General Conferences. Amateurs are also referred to the general Notes to the Band Plans, on page 61. Please also refer to specific Ofcom conditions and coordination terms as appropriate

EFFECTIVE FROM 1 JANUARY 2024 UNLESS OTHERWISE SHOWN

136kHz	NECESSARY BANDWIDTH	UK USAGE
135.7-137.8kHz	200Hz	CW, QRSS and Narrowband Digital Modes

Licence Notes: Amateur Service – Secondary User. 1 watt (0dBW) ERP.
R.R. 5.67B. The use of the band 135.7-137.8kHz in Algeria, Egypt, Iraq, Lebanon, Syrian Arab Republic Sudan, South Sudan and Tunisia is limited to fixed and maritime mobile services. The amateur service shall not be used in the above-mentioned countries in the band 135.7-137.8kHz, and this should be taken into account by the countries authorising such use. (WRC-19).

472kHz (600m)	NECESSARY BANDWIDTH	UK USAGE
IARU Region 1 does not have a formal band plan for this allocation but has a usage recommendation (Note 1).		
472-479kHz	500Hz	CW, QRSS and Narrowband Digital Modes

Note 1: Usage recommendation – 472-475kHz CW only 200Hz maximum bandwidth, 475-479kHz CW and Digimodes.
Note 2: It should be emphasised that this band is available on a non-interference basis to existing services. UK amateurs should be aware that some overseas stations may be restricted in terms of transmit frequency in order to avoid interference to nearby radio navigation service Non-Directional Beacons.
Licence Notes: Amateur Service – Secondary User. Full Licensees only, **5 watts EIRP maximum**.
R.R. 5.80B. The use of the frequency band 472-479kHz in Algeria, Saudi Arabia, Azerbaijan, Bahrain, Belarus, China, Comoros, Djibouti, Egypt, United Arab Emirates, the Russian Federation, Iraq, Jordan, Kazakhstan, Kuwait, Lebanon, Libya, Mauritania, Oman, Uzbekistan, Qatar, Syrian Arab Republic, Kyrgyzstan, Somalia, Sudan, Tunisia and Yemen is limited to the maritime mobile and aeronautical radionavigation services. The Amateur Service shall not be used in the above-mentioned countries in this frequency band, and this should be taken into account by the countries authorising such use. (WRC 12).

1.8MHz (160m)	NECESSARY BANDWIDTH	UK USAGE
1,810-1,838kHz	200Hz	Telegraphy
1,838-1,840	500Hz	Narrowband Modes
1,840-1,843	2.7kHz	All Modes
1,843-2,000	2.7kHz	Telephony (Note 1), Telegraphy 1,836kHz – QRP (low power) Centre of Activity 1,960kHz – DF Contest Beacons (14dBW)

Note 1: Lowest LSB carrier frequency (dial setting) should be 1,843kHz. AX25 packet should not be used on the 1.8MHz band.
Licence Notes: 1,810-1,850kHz – Primary User: 1,810-1,830kHz on a non-interference basis to stations outside of the UK. 1,850-2,000kHz – Secondary User. 32W (15dBW) maximum.

3.5MHz (80m)	NECESSARY BANDWIDTH	UK USAGE
3,500-3,510kHz	200Hz	Telegraphy – Priority for Inter-Continental Operation
3,510-3,560	200Hz	Telegraphy – Contest Preferred. 3,555kHz – QRS (slow telegraphy) Centre of Activity
3,560-3,570	200Hz	Telegraphy 3,560kHz – QRP (low power) Centre of Activity
3,570-3,580	200Hz	Narrowband Modes
3,580-3,590	500Hz	Narrowband Modes
3,590-3,600	500Hz	Narrowband Modes – Automatically Controlled Data Stations (unattended)
3,600-3,620	2.7kHz	All Modes – Automatically Controlled Data Stations (unattended), (Note 1)
3,600-3,650	2.7kHz	All Modes – Phone Contest Preferred, (Note 1) 3,630kHz – Digital Voice Centre of Activity
3,650-3,700	2.7kHz	All Modes – Telephony, Telegraphy 3,663kHz May Be Used For UK Emergency Comms Traffic 3,690kHz SSB QRP (low power) Centre of Activity
3,700-3,775	2.7kHz	All Modes – Phone Contest Preferred 3,735kHz – Image Mode Centre of Activity 3,760kHz – IARU Region 1 Emergency Centre of Activity
3,775-3,800	2.7kHz	All modes - Phone contest preferred Priority for Inter-Continental Telephony (SSB) Operation

Note 1: Lowest LSB carrier frequency (dial setting) should be 3,603kHz.
Licence Notes: Primary User: Shared with other user services.

5MHz (60m)	AVAILABLE WIDTH	UK USAGE
5,258.5-5,264kHz	5.5kHz	5,262kHz – CW QRP Centre of Activity
5,276-5,284	8kHz	5,278.5kHz – May be used for UK Emergency Comms Traffic
5,288.5-5,292	3.5kHz	Beacons on 5290kHz (Note 2)
5,298-5,307	9kHz	
5,313-5,323	10kHz	5,317kHz – AM 6kHz maximum bandwidth
5,333-5,338	5kHz	
5,354-5,358	4kHz	Within WRC-15 Band
5,362-5,374.5	12.5kHz	Partly within WRC-15 band, WSPR
5,378-5,382	4kHz	
5,395-5,401.5	6.5kHz	
5,403.5-5,406.5	3kHz	

Unless indicated, usage is All Modes (necessary bandwidth to be within channel limits).
Note 1: Upper Sideband is recommended for SSB activity.
Note 2: Activity should avoid interference to the experimental beacons on 5290kHz.
Note 3: Amplitude Modulation is permitted with a maximum bandwidth of 6kHz, on frequencies with at least 6kHz available width.
Note 4: Contacts within the UK should avoid the WRC-15 band (5351.5 - 5366.5kHz) if possible
For the latest current guidance refer to the RSGB website
Licence Notes: Full Licensees only, **Secondary User, 100 watts maximum**. Note that conditions on transmission bandwidth, power and antennas are specified in the Licence. For the latest current guidance, refer to the RSGB website

7MHz (40m)	NECESSARY BANDWIDTH	UK USAGE
7,000-7,040kHz	200Hz	Telegraphy – 7,030kHz QRP (low power) Centre of Activity
7,040-7,047	500Hz	Narrowband Modes (Note 2)
7,047-7,050	500Hz	Narrowband Modes, Automatically Controlled Data Stations (unattended)
7,050-7,053	2.7kHz	All Modes, Automatically Controlled Data Stations (unattended), (Note 1)
7,053-7,060	2.7kHz	All Modes, Digimodes
7,060-7,100	2.7kHz	All Modes, SSB Contest Preferred Segment Digital Voice 7,070kHz; SSB QRP Centre of Activity 7,090kHz
7,100-7,130	2.7kHz	All Modes, 7,110kHz – Region 1 Emergency Centre of Activity
7,130-7,200	2.7kHz	All Modes, SSB Contest Preferred Segment; 7,165kHz – Image Centre of Activity
7,175-7,200	2.7kHz	All Modes, Priority For Inter-Continental Operation

Note 1: Lowest LSB carrier frequency (dial setting) should be 7,053kHz.
Note 2: PSK31 activity starts from 7,040kHz. Since 2009, the narrowband modes segment starts at 7,040kHz.
Licence Notes: 7,000-7,100kHz Amateur and Amateur Satellite Service – Primary User.
7,100-7,200kHz Amateur Service – Primary User.

10MHz (30m)	NECESSARY BANDWIDTH	UK USAGE
10,100-10,130kHz	200Hz	Telegraphy (CW) 10,116kHz – QRP (low power) Centre of Activity
10,130-10,150	500Hz	Narrowband Modes Automatically Controlled Data Stations (unattended) should avoid the use of the 10MHz band

Licence Notes: Amateur Service – Secondary User.

The 10MHz band is allocated to the amateur service only on a secondary basis. The IARU has agreed that only CW and other narrow bandwidth modes are to be used on this band. Likewise the band is not to be used for contests and bulletins. SSB may be used on the 10MHz band during emergencies involving the immediate safety of life and property, and only by stations actually involved with the handling of emergency traffic. The band segment 10,120-10,140kHz may only be used for SSB transmissions in the area of Africa south of the equator during local daylight hours.

14MHz (20m)	NECESSARY BANDWIDTH	UK USAGE
14,000-14,060kHz	200Hz	Telegraphy – Contest Preferred 14,055kHz – QRS (slow telegraphy) Centre of Activity
14,060-14,070	200Hz	Telegraphy 14,060kHz – QRP (low power) Centre of Activity
14,070-14,089	500Hz	Narrowband Modes
14,089-14,099	500Hz	Narrowband Modes – Automatically Controlled Data Stations (unattended)
14,099-14,101		IBP – Reserved Exclusively for Beacons
14,101-14,112	2.7kHz	All Modes – Automatically Controlled Data Stations (unattended)
14,112-14,125	2.7kHz	All Modes (excluding digimodes)
14,125-14,300	2.7kHz	All Modes – SSB Contest Preferred Segment 14,130kHz – Digital Voice Centre of Activity 14,195 ±5kHz – Priority for DXpeditions 14,230kHz – Image Centre of Activity 14,285kHz – QRP Centre of Activity
14,300-14,350	2.7kHz	All Modes 14,300kHz – Global Emergency Centre of Activity

Licence Notes: Amateur Service – Primary User. 14,000-14,250kHz Amateur Satellite Service – Primary User.

18MHz (17m)	NECESSARY BANDWIDTH	UK USAGE
18,068-18,095kHz	200Hz	Telegraphy – 18,086kHz QRP (low power) Centre of Activity
18,095-18,105	500Hz	Narrowband Modes
18,105-18,109	500Hz	Narrowband Modes – Automatically Controlled Data Stations (unattended)

18,109-18,111		IBP – Reserved Exclusively for Beacons
18,111-18,120	2.7kHz	All Modes – Automatically Controlled Data Stations (unattended)
18,120-18,168	2.7kHz	All Modes, 18,130kHz – SSB QRP Centre of Activity 18,150kHz – Digital Voice Centre of Activity 18,160kHz – Global Emergency Centre of Activity

Licence Notes: Amateur and Amateur Satellite Service – Primary User. The band is not to be used for contests or bulletins.

21MHz (15m)	NECESSARY BANDWIDTH	UK USAGE
21,000-21,070kHz	200Hz	Telegraphy 21,055kHz – QRS (slow telegraphy) Centre of Activity 21,060kHz – QRP (low power) Centre of Activity
21,070-21,090	500Hz	Narrowband Modes
21,090-21,110	500Hz	Narrowband Modes – Automatically Controlled Data Stations (unattended)
21,110-21,120	2.7kHz	All Modes (excluding SSB) – Automatically Controlled Data Stations (unattended)
21,120-21,149	500Hz	Narrowband Modes
21,149-21,151		IBP – Reserved Exclusively For Beacons
21,151-21,450	2.7kHz	All Modes 21,180kHz – Digital Voice Centre of Activity 21,285kHz – QRP Centre of Activity 21,340kHz – Image Centre of Activity 21,360kHz – Global Emergency Centre of Activity

Note 1: 21,125-21,245 is also designated for use by amateur satellites
Licence Notes: Amateur and Amateur Satellite Service – Primary User.

24MHz (12m)	NECESSARY BANDWIDTH	UK USAGE
24,890-24,915kHz	200Hz	Telegraphy 24,906kHz – QRP (low power) Centre of Activity
24,915-24,925	500Hz	Narrowband Modes
24,925-24,929	500Hz	Narrowband Modes – Automatically Controlled Data Stations (unattended)
24.929-24.931		IBP – Reserved Exclusively For Beacons
24,931-24,940	2.7kHz	All Modes – Automatically Controlled Data Stations (unattended)
24,940-24,990	2.7kHz	All Modes, 24,950kHz – SSB QRP Centre of Activity 24,960kHz – Digital Voice Centre of Activity

Licence Notes: Amateur and Amateur Satellite Service – Primary User. The band is not to be used for contests or bulletins.

28MHz (10m)	NECESSARY BANDWIDTH	UK USAGE
28,000-28,070kHz	200Hz	Telegraphy 28,055kHz – QRS (slow telegraphy) Centre of Activity 28,060kHz – QRP (low power) Centre of Activity
28,070-28,120	500Hz	Narrowband Modes
28,120-28,150	500Hz	Narrowband Modes – Automatically Controlled Data Stations (unattended)
28,150-28,190	500Hz	Narrowband Modes
28,190-28,199		IBP – Regional Time Shared Beacons
28,199-28,201		IBP – World Wide Time Shared Beacons
28,201-28,225		IBP – Continuous-Duty Beacons
28,225-28,300	2.7kHz	All Modes – Beacons
28,300-28,320	2.7kHz	All Modes – Automatically Controlled Data Stations (unattended)
28,320-29,000	2.7kHz	All modes 28,330kHz – Digital Voice Centre of Activity 28,360kHz – QRP Centre of Activity 28,680kHz – Image Centre of Activity
29,000-29,100		All Modes – See Note 1 regarding 29,000-29,510kHz
29,100-29,200		All Modes – FM Simplex – 10kHz Channels
29,200-29,300		All Modes – Automatically Controlled Data Stations (unattended) 29,270kHz – Internet Gateways Channel 29,280kHz – UK Internet Voice Gateway (unattended) 29,290kHz – UK Internet Voice Gateway (unattended)
29,300-29,510		Satellite Links
29,510-29,520	Guard Channel	
29,520-29,590	6kHz	All Modes – FM Repeater Inputs (RH1-RH8)
29,600	6kHz	All Modes – FM Calling Channel
29,610	6kHz	All Modes – FM Simplex Repeater (parrot) – input and output
29,620-29,700	6kHz	All Modes – FM Repeater Outputs (RH1-RH8)

Note 1: Experimental wide bandwidth operation within 29,000 - 29,510 must be on a non-interference basis to other stations, including the amateur satellite service segment at 29300 - 29510 kHz.
Licence Notes: Amateur and Amateur Satellite Service – Primary User: Note specific conditions apply within 50km of NGR SK985640 (Waddington)within 50km of NGR SK985640 (Waddington).

50MHz (6m)	NECESSARY BANDWIDTH	UK USAGE
50.000-50.100MHz	500Hz	Telegraphy Only (except for Beacon Project) (Note 2) 50.000-50.030MHz reserved for Synchronised Beacon Project (Note 2) Region 1: 50.000-50.010; Region 2: 50.010-50.020; Region 3: 50.020-50.030 50.050MHz – Future International Centre of Activity 50.090MHz – Inter-Continental DX Centre of Activity (Note 1)
50.100-50.200	2.7kHz	SSB/Telegraphy – International Preferred 50.100-50.130MHz – Inter-Continental DX Telegraphy & SSB (Note 1) 50.110MHz – Inter-Continental DX Centre of Activity 50.130-50.200MHz – General International Telegraphy & SSB 50.150MHz – International Centre of Activity
50.200-50.300	2.7kHz	SSB/Telegraphy – General Usage 50.285MHz – Crossband Centre of Activity
50.300-50.400	2.7kHz	MGM/Narrowband/Telegraphy 50.305MHz – PSK Centre of Activity 50.310-50.320MHz – EME 50.320-50.380MHz – MS
50.400-50.500		Propagation Beacons only
50.500-50.700		All Modes 50.520MHz – FM/DV Internet Voice Gateway 50.530MHz – FM/DV Internet Voice Gateway 50.540MHz – FM/DV Internet Voice Gateway 50.600-50.700MHz – Digital communications 50.630MHz – Digital Voice (DV) calling
50.700-50.900	12kHz	50.710-50.890MHz – FM/DV Repeater Outputs (10kHz channel spacing)
50.900-51.200		All Modes
51.200-51.400	12kHz	51.210-51.390MHz – FM/DV Repeater Inputs (10kHz channel spacing) (Note 4)
51.400-52.000		All Modes 51.410-51.590MHz – FM/DV Simplex (Note 3) (Note 4) 51.510MHz – FM Calling Frequency 51.530MHz – GB2RS News Broadcast and Slow Morse 51.650 & 51.750MHz – See Note 5 (25kHz aligned) 51.970 & 51.990MHz – See Note 5

Note 1: Only to be used between stations in different continents (not for intra-European QSOs).
Note 2: 50.0-50.1MHz is currently shared with Propagation Beacons. These are due to be migrated to 50.4-50.5MHz, to create more space for Telegraphy and a new Synchronised Beacon Project.
Note 3: 20kHz channel spacing. Channel centre frequencies start at 51.430MHz.
Note 4: Embedded data traffic is allowed with digital voice (DV).
Note 5: May be used for Emergency Communications and Community Events.
Note 6: Digital experiments to support innovation may occur at 50.6, 51.0 or 51.7MHz with maximum bandwidths of 50, 200 and 400kHz respectively on a non-interference basis.
Licence Notes: Amateur Service 50.0-51.0MHz – Primary User. Amateur Service 51.0-52.0MHz – Secondary User. 100W (20dBW) maximum. Available on the basis on non-interference to other services (inside or outside the UK).

70MHz (4m)	NECESSARY BANDWIDTH	UK USAGE (NOTE 1)
70.000-70.090MHz	1kHz	Propagation Beacons Only
70.090-70.100	1kHz	Personal Beacons
70.100-70.250	2.7kHz	Narrowband Modes 70.185MHz – Cross-band Activity Centre 70.200MHz – CW/SSB Centre 70.250MHz – MS Centre
70.250-70.294	12kHz	All Modes 70.260MHz – AM/FM Calling 70.270MHz MGM Centre of Activity
70.294-70.500	12kHz	All Modes Channelised Operations Using 12.5kHz Spacing 70.3000MHz 70.3125MHz – Digital Modes 70.3250MHz – DX Cluster 70.3375MHz – Digital Modes 70.3500MHz – Internet Voice Gateway (Note 2) 70.3625MHz – Internet Voice Gateway 70.3750MHz – See Note 2 70.3875MHz – Internet Voice Gateway 70.4000MHz – See Note 2 70.4125MHz – Internet Voice Gateway 70.4250MHz – FM Simplex – used by GB2RS news broadcast 70.4375MHz – Digital Modes (special projects) 70.4500MHz – FM Calling 70.4625MHz – Digital Modes 70.4750MHz 70.4875MHz – Digital Modes

Note 1: Usage by operators in other countries may be influenced by restrictions in their national allocations.
Note 2: May be used for Emergency Communications and Community Events.
Licence Notes: Amateur Service 70.0-70.5MHz – Secondary User: 160W (22dBW) maximum. Available on the basis of non-interference to other services (inside or outside the UK).
Note that access to 70.5-71.5MHz by Full Licensees is also possible by NoV

144MHz (2m)	NECESSARY BANDWIDTH	UK USAGE
144.000-144.025MHz	2700Hz	All Modes – including Satellite Downlinks
144.025-144.100	500Hz	Telegraphy (including EME CW) 144.050MHz – Telegraphy Centre of Activity 144.100MHz – Random MS Telegraphy Calling, (Note 1)
144.110-144.150	500Hz	Telegraphy and MGM EME MGM Activity
144.150-144.400	2700Hz	Telegraphy, MGM and SSB 144.250MHz – GB2RS News Broadcast and Slow Morse 144.260MHz – See Note 10 144.300MHz – SSB Centre of Activity 144.370MHz – MGM MS Calling
144.400-144.490		Propagation Beacons only
144.490-144.500		Beacon guard band 144.491-144.493 Personal Weak Signal MGM Beacons (BW: 500Hz max)

144.500-144.794	12kHz	All Modes (Note 8) 144.500MHz – Image Modes Centre (SSTV, FAX, etc) 144.600MHz – Data Centre of Activity (MGM, RTTY, etc) 144.6125MHz – UK Digital Voice (DV) Calling (Note 9) 144.625-144.675MHz – See Note 10 144.750MHz – ATV Talkback 144.775-144.794MHz – See Note 10 144.794-
144.794-144.990	12kHz	MGM Digital Communications (Note 15) 144.800-144.9875MHz – MGM/Digital Communications 144.8000MHz – Unconnected Nets – APRS, UiView etc (Note 14) 144.8125MHz – DV Internet Voice Gateway 144.8250MHz – DV Internet Voice Gateway 144.8375MHz – DV Internet Voice Gateway 144.8500MHz – DV Internet Voice Gateway 144.8625MHz – DV Internet Voice Gateway 144.8750 - 144.9125 - Internet Gateways 144.9250MHz – Digital Usage 144.9375MHz – Digital Usage 144.9500MHz – Digital Usage 144.9625MHz – FM Internet Voice Gateway 144.9750, 144.9875 MHz Low power / Adhoc repeater inputs (Note 11)
144.990-145.1935	12kHz	FM/DV RV48-RV63 Repeater Input Exclusive (Note 2 & 5)
145.200	12kHz	FM/DV Space Communications (eg ISS) – Earth-to-Space 145.2000MHz – (Note 4 & 10)
145.200-145.5935	12kHz	FM/DV V16-V47 – FM/DV Simplex (Note 3, 5 & 6) 145.2250 MHz Internet gateways - and See Note 10 145.2375MHz – FM Internet Voice Gateway (IARU common channel) 145.2500MHz – Used for Slow Morse Transmissions 145.2875MHz – FM Internet Voice Gateway (IARU common channel) 145.3375MHz – FM Internet Voice Gateway (IARU common channel) 145.5000MHz – FM Calling (Note 12) 145.5250MHz – Used for GB2RS News Broadcast. 145.5500MHz – Used for Rally/exhibition Talk-in 145.5750, 145.5875MHz Low power / Adhoc repeater outputs (Note 11)
145.5935-145.7935	12kHz	FM/DV RV48-RV63 – Repeater Output (Note 2)
145.800	12kHz	FM/DV Space Communications (eg ISS) – Space-Earth
145.806-146.000	12kHz	All Modes – Satellite Exclusive

Note 1: Meteor scatter operation can take place up to 26kHz higher than the reference frequency.
Note 2: 12.5kHz channels numbered RV48-RV63. RV48 input = 145.000MHz, output = 145.600MHz.
Note 3: 12.5kHz simplex channels numbered V16-V47. V16 = 145.200MHz.
Note 4: Emergency Communications Groups utilising this frequency should take steps to avoid interference to ISS operations in non-emergency situations.
Note 5: Embedded data traffic is allowed with digital voice (DV).
Note 6: Simplex use only – no DV gateways.
Note 7: Not used.
Note 8: Amplitude Modulation (AM) is acceptable within the All Modes segment. AM usage is typically found on 144.550MHz. Users should consider adjacent channel activity when selecting operating frequencies.
Note 9: In other countries IARU Region 1 recommends 145.375MHz.
Note 10: May be used for Emergency Communications and Community Events.
Note 11: Ad-hoc Low power repeaters, 5W erp max
Note 12: DV users are asked not to use this channel, and use 144.6125MHz for calling.
Note 13: Not used.
Note 14: 144.800 use should be NBFM to avoid interference to 144.8125 DV Gateways.
Licence Notes: Amateur Service and Amateur Satellite Service – Primary User. Note specific conditions apply within 50 km of TA 012869 (Scarborough).

146MHz IARU Recommendation	**NECESSARY BANDWIDTH**	**UK USAGE**
Access to this band requires an appropriate NoV, which is available to Full Licensees only		
146.000-146.900MHz	500kHz	Wideband Digital Modes (High speed data, DATV etc) 146.500MHz Centre frequency for wideband modes (Note 1)
146.900-147.000MHz	12kHz	Narrowband Digital Modes including Digital Voice 146.900 146.9125 146.925 146.9375 Not available in/near Scotland (see Licence Notes & NoV terms) 146.9500 146.9625 146.9750 146.9875

Note 1: Users of wideband modes must ensure their spectral emissions are contained with the band limits.
Licence Notes: Full Licensees only, with NoV, 50W ERP max – not available in the Isle of Man or Channel Isles. Note that additional restrictions on geographic location, antenna height and upper frequency limit are specified by the NoV terms.
It should be emphasised that this band is UK-specific and is available on a non-interference basis to existing services. Upper Band limit 147.000MHz (or 146.93750 where applicable) are absolute limits and not centre frequencies. The absolute band frequency limit in or within 40km of Scotland is 146.93750MHz – see NoV schedule

430MHz (70cm) IARU Recommendation	**NECESSARY BANDWIDTH**	**UK USAGE**
430.0000-431.9810MHz		430.0125-430.0750MHz – FM Internet Voice Gateways (Notes 7, 8)
All Modes		430.250-430.300 MHz UK DV 9 MHz reverse-split repeaters – Outputs 430.4000-430.7750 – UK DV 9MHz Split Repeaters – inputs
Digital Links		
430.6000-430.9250		430.8000MHz – 7.6MHz Talk-through (Note 10)
Digital Repeaters		430.8250-430.9750MHz – RU66-RU78 7.6MHz Split Repeaters – outputs See Licence Exclusion Note; 431-432MHz 430.9900-431.9000MHz – Digital Communications 431.0750-431.1750MHz – DV Internet Voice Gateways (Note 8)
432.0000-432.1000	500Hz	432.0500MHz Telegraphy Centre of Activity Telegraphy, MGM
432.1000-432.4000	2700Hz	
		432.2000MHz – SSB Centre of Activity
SSB, Telegraphy		432.3500MHz – Microwave Talkback (Europe)
MGM		432.3700MHz – Meteor Scatter Calling
432.4000-432.4900	500Hz	Propagation Beacons only
432.4900-432.9940	12kHz	432.491-432.493MHz Personal Weak Signal MGM Beacons (BW: 500Hz max) 432.5000MHz – Narrowband SSTV Activity Centre
All Modes Non-channelised	(Note 11)	432.6250-432.6750MHz Digital Communications 432.7750MHz 1.6MHz Talk-through – Base TX (Note 10)
432.9940-433.3810	12kHz	433.0000-433.3750MHz (RB0-RB15) – RU240-RU270
FM repeater outputs in UK only (Note 1)	(Note 11)	FM/DV Repeater Outputs in UK Only
433.3940-433.5810	12kHz	433.4000MHz U272 – IARU Region 1 SSTV (FM/AFSK)
	(Note 11)	433.4250MHz U274
FM/DV (Notes 12, 13) Simplex Channels		433.450MHz U276 (Note 5) 433.4750MHz U278 433.5000MHz U280 – FM Calling Channel 433.5250MHz U282 433.5500MHz U284 – Used for Rally/Exhibition Talk-in 433.5750MHz U286
433.6000-434.0000 All Modes		433.6250-6750MHz – Digital Communications
433.8000MHz for APRS where 144.8000MHz cannot be used		433.7000MHz-433.7750MHz (Note 10) 433.8000-434.2500 MHz Digital communications & Experiments 434.0000 Low Power Non-NoV Personal Hot-Spot usage
434.0000-434.5940	12kHz	433.9500-434.0500MHz – Internet Voice Gateways (Note 8)
	(Note 11)	434.3750MHz 1.6MHz Talk-through – Mobile TX (Note 10) 434.4750-434.5250MHz DV Internet voice gateways (Note 8)
434.5940-434.9810	12kHz	434.6000-434.9750MHz (RB0-RB15) RU240-RU270
FM repeater inputs in UK only	(Note 11)	FM/DV Repeater Inputs in UK Only (Note 12)
435.0000-436.0000		Satellites only
436.0000-438.0000		Satellites and Experimental DATV/Data 437.0000 Experimental DATV Centre of Activity (Note 14)
438.0000-440.0000		438.8000 Low Power Non-NoV Personal Hot-Spot usage 438.0250-438.1750MHz – IARU Region 1 Digital Communications
All Modes		438.2000-439.4250MHz (Note 1) 438.4000MHz – 7.6MHz Talk-through (Note 10) 438.4250-438.5750MHz RU66-RU78 – 7.6MHz Split Repeaters – inputs 438.6125MHz – UK DV calling (Note 12) (Note 13) 438.8000 Low Power Non-NoV Personal Hot-Spot usage 439.2500-439.3000MHz UK DV 9MHz reverse-split repeaters – Inputs 439.6000-440.0000MHz – Digital Communications 439.4000-439.7750MHz – UK DV 9MHz split repeaters – Outputs

Note 1: In Switzerland, Germany and Austria, repeater inputs are 431.0500-431.8250MHz with 25kHz spacing and outputs 438.6500-439.4250MHz. In Belgium, France and the Netherlands repeater outputs are 430.0250-430.3750MHz with 12.5kHz spacing and inputs at 431.6250-431.9750MHz. In other European countries repeater inputs are 433.0000-433.3750MHz with 25kHz spacing and outputs at 434.6000-434.9750MHz, ie the reverse of the UK allocation.
Note 2: Not used.
Note 3, Note 4: Not used.
Note 5: In other countries IARU Region 1 recommends 433.4500MHz for DV calling.
Note 7: Users must accept interference from repeater output channels in France and the Netherlands at 430.0250-430.5750MHz. Users with sites that allow propagation to other countries (notably France and the Netherlands) must survey the proposed frequency before use to ensure that they will not cause interference to users in those countries.
Note 8: All internet voice gateways: 12.5kHz channels, maximum deviation ±2.4kHz, maximum effective radiated power 5W (7dBW).
Note 10: May be used for Emergency Communications and Community Events.
Note 11: IARU Region-1 recommended maximum bandwidths are 12kHz to support 12.5kHz channel spacing.
Note 12: Embedded data traffic is allowed with digital voice (DV).
Note 13: Simplex use only – no DV gateways.
Note 14: QPSK 2 Mega-symbols/second maximum recommended.
Licence Notes: Amateur Service – Secondary User. Note specific conditions within 430-440MHz. Amateur Satellite Service: 435-438MHz – Secondary User. Exclusion: 431-432MHz not available within 100km radius of Charing Cross, London. Power Restriction 430-432MHz is 40 watts effective radiated power maximum.

1.3GHz (23cm)	**NECESSARY BANDWIDTH**	**UK USAGE**
1240.000-1240.500MHz	2700Hz	Alternative Narrowband Segment – see Note 7 – 1240.00-1240.750MHz
1240.500-1240.750		Alternative Propagation Beacon Segment
1240.750-1241.000	20kHz	FM/DV Repeater Inputs
1241.000-1241.750	150kHz	DD High Speed Digital Data – 5 x 150kHz channels
All Modes		1241.075, 1241.225, 1241.375, 1241.525, 1241.675MHz (±75kHz)
1241.750-1242.000	20kHz	25kHz Channels available for FM/DV use

All Modes		1241.775-1241.975MHz
1242.000-1249.000 ATV		TV Repeaters (Note 9) New DATV Repeater Inputs Original ATV Repeater Inputs: 1248, 1249
1249.000-1249.250	20kHz	FM/DV Repeater Outputs, 25kHz Channels (Note 9) 1249.025-1249.225MHz
1250.00		In order to prevent interference to Primary Users, caution must be exercised prior to using 1250-1290MHz in the UK 1260.000-
1270.000		Amateur Satellite Service – Earth to Space Uplinks Only
Satellites 1290.000		
1290.994-1291.481	20kHz	FM/DV Repeater Inputs (Note 5) 1291.000-1291.375MHz (RM0-RM15) 25kHz spacing
1291.494-1296.000	All Modes	
All Modes		Preferred Narrowband segment
1296.000-1296.150 Telegraphy, MGM	500Hz	1296.000-1296.025MHz – Moonbounce
1296.150-1296.800 Telegraphy, SSB & MGM	2700Hz	1296.200MHz – Narrowband Centre of Activity 1296.400-1296.600MHz – Linear Transponder Input
(Note 1)		1296.500MHz – Image Mode Centre of Activity (SSTV, FAX etc) 1296.600MHz – Narrowband Data Centre of Activity (MGM, RTTY etc) 1296.600-1296.700MHz – Linear Transponder Output 1296.741-1296.743MHz Personal Weak Signal MGM Beacons
1296.800-1296.994		1296.750-1296.800MHz – Local Beacons, 10W ERP max 1296.800-1296.990MHz – Propagation Beacons only
		Beacons exclusive
1296.994-1297.481	20kHz	FM/DV Repeater Outputs (Note 5) 1297.000-1297.375MHz (RM0-RM15)
1297.494-1297.981	20kHz	FM/DV Simplex (Notes 2, 5 & 6) 25kHz spacing 1297.500-1297.750MHz (SM20-SM30)
FM/DV simplex (Notes 2, 5, 6)		1297.725MHz – Digital Voice (DV) Calling (IARU recommended) 1297.900-1297.975MHz – FM Internet Voice Gateways (IARU common channels, 25kHz)
1298.000-1299.000 All Modes	20kHz	All Modes General mixed analogue or digital use in channels 1298.025-1298.975MHz (RS1-RS39)
1299.000-1299.750 All Modes	150kHz	DD High Speed Digital Data – 5 x 150kHz channels 1299.075, 1299.225, 1299.375, 1299.525, 1299.675MHz (±75kHz)
1299.750-1300.000 All Modes	20kHz	25kHz Channels Available for FM/DV use 1299.775-1299.975MHz
1300.000-1325.000 ATV		TV Repeaters (UK only) (Note 9) New DATV Repeater Outputs Original ATV Repeater Outputs: 1308.0, 1310.0, 1311.5, 1312.0, 1316.0, 1318.5MHz

Note 1: Local traffic using narrowband modes should operate between 1296.500-1296.800MHz during contests and band openings.
Note 2: Stations in countries that do not have access to 1298-1300MHz may also use the FM simplex segment for digital communications.
Note 3, Note 4: Not used.
Note 5: Embedded data traffic is allowed with digital voice (DV).
Note 6: Simplex use only – no DV gateways.
Note 7: 1240.000-1240.750 has been designated by IARU as an alternative centre for narrowband activity and beacons. Operations in this range should be on a flexible basis to enable coordinated activation of this alternate usage.
Note 8: The band 1240-1300MHz is subject to major replanning. Contact the Microwave Manager for further information.
Note 9: Repeaters and Migration to DATV, inc option for new DATV simplex are subject to further development and coordination.
Note 10: QPSK 4 Mega-symbols/second maximum recommended.
Licence Notes: Amateur Service – Secondary User. Amateur Satellite Service: 1,260-1,270MHz – Secondary User Earth to Space only. Note specific conditions within 1240-1325MHz and within 50km of SS206127 (Bude), SE202577 (Harrogate), or in Northern Ireland.

2.3-2.302GHz IARU Recommendation	NECESSARY BANDWIDTH	UK USAGE

Access to this band requires an appropriate NoV, which is available to Full licensees only. Please note that the current NoVs last for up to three years prior to expiry.

2300.000-2300.400MHz	2.7kHz	Narrowband Modes (including CW, SSB, MGM) 2300.350-2300.400MHz Attended Beacons
2300.400-2301.800MHz	500kHz	Wideband Modes (NBFM, DV, Data, DATV, etc) Note 1
2301.800-2302.000MHz	2.7kHz	Narrowband modes (including CW, SSB, MGM) EME Usage

Note 1: Users of wideband modes must ensure their spectral emissions are contained within the band limits.
Note 2: Full licensees only with NoV, 400 watts maximum, not available in the Isle of Man. Note additional restrictions on usage are specified by the NoV terms. It should be emphasised that this is UK-specific and is available on a non interference basis to existing services.

2.3GHz (13cm) IARU Recommendation	NECESSARY BANDWIDTH	UK USAGE
2,310.000-2,320.000MHz (National band plans)	200kHz	2,310.000-2,310.500MHz – Repeater links 2,311.000-2,315.000MHz – High speed data Preferred Narrowband Segment
2,320.000-2,320.800	2.7kHz	2,320.000-2,320.025MHz – Moonbounce 2,320.200MHz – SSB Centre of Activity
2,320.800-2,321.000		2,320.750-2,320.800MHz – Local Beacons, 10W ERP max 2,320.800-2,320.990MHz – Propagation Beacons Only
Beacons exclusive		
2321.000-2322.000	20kHz	FM/DV. See also Note 1
2,322.000-2,350.000		Wideband Modes including Data, ATV
2,390.000-2,400.000		All Modes
2,400.000-2,450.000MHz Satellites		2,435.000MHz ATV Repeater Outputs 2,440.000MHz ATV Repeater Outputs

Note 1: Stations in countries which do not have access to the All Modes section 2,322-2,390MHz, use the simplex and repeater segment 2,320-2,322MHz for data transmission.
Note 2: Stations in countries that do not have access to the narrowband segment 2,320-2,322MHz, use the alternative narrowband segments 2,304-2,306MHz, 2,308-2,310MHz and 2400-2402MHz.
Note 3: The segment 2,433-2,443MHz may be used for ATV if no satellite is using the segment.
Licence Notes: Amateur Service – Secondary User. Users must accept interference from ISM users. Amateur Satellite Service: 2,400-2,450MHz – Secondary User. Users must accept interference from ISM users. Operation in 2310-2350 and 2390-2400 MHz are subject to specific conditions and guidance. Note specific conditions apply within 50km of SS206127 (Bude) or SE202577 (Harrogate). ISM = Industrial, scientific and medical.

3.4GHz (9cm) IARU Recommendation	NECESSARY BANDWIDTH	UK USAGE
3,400.000-3,400.800MHz	2.7kHz	Narrowband Modes (including CW, SSB, MGM, EME) 3,400.100MHz – Centre of Activity (Note 1)
3,400.800-3,400.995		3,400.750-3,400.800MHz – Local Beacons, 10W ERP max 3,400.800-3,400.995MHz – Propagation Beacons Only
3,400.000-3,401.000MHz	200kHz	3,401.000-3,402.000MHz Data, Remote Control
3,402.000-3,410.000 All Modes (Notes 2, 3)		Wideband Modes including DATV Repeater Outputs

Note 1: EME has migrated from 3456MHz to 3400MHz to promote harmonised usage and activity.
Note 2: Stations in many European countries have access to 3400-3410MHz as permitted by the CEPT ECA Table.
Note 3: Amateur Satellite downlinks planned.
Licence Notes: Amateur Service – Secondary User. Subject to specific conditions and guidance.

5.7GHz (6cm) IARU Recommendation	NECESSARY BANDWIDTH	UK USAGE
5,650.000-5,668.000MHz Satellite Uplinks		All Modes Amateur Satellite Service – Earth to Space Only
5,668.000-5,670.000	2.7kHz	5,668.200MHz – Alternative Narrowband Centre
5,670.000-5,680.000		All Modes
5.755.000-5,760.000		All Modes
5,760.000-5,762.000	2.7kHz	Narrowband Modes (including CW, SSB, MGM, EME) 5,760.100MHz – Preferred Centre of Activity
5760.800-5760.995 Propagation Beacons		5,760.750-5,760.800MHz – Local Beacons, 10W ERP max 5,760.800-5,760.995MHz – Propagation Beacons Only
5,762.000-5,765.000		All Modes
5,820.000-5,830.000		All Modes
5,830.000-5,850.000 Satellite Downlinks		All Modes Amateur Satellite Service – Space to Earth Only

Licence Notes: Amateur Service: 5,650-5,680MHz – Secondary User. 5,755-5,765 and 5,820-5,850MHz – Secondary User. Users must accept interference from ISM users. Amateur Satellite Service: 5,650-5,670MHz and 5,830-5,850MHz – Secondary User. Users must accept interference from ISM users. Note specific conditions apply within 50km of SS206127 (Bude) or SE202577 (Harrogate). ISM = Industrial, scientific and medical.

10GHz (3cm) IARU Recommendation	NECESSARY BANDWIDTH	UK USAGE
10,000.000-10,125.000MHz All Modes		Note 4 10,065MHz ATV Repeater Outputs
10,225.000-10,250.000 All Modes		10,240MHz ATV Repeaters
10,250.000-10,350.000 Digital Modes		
10,350.000-10,368.000 All Modes		10,352.5-10,368MHz Wideband Modes (Note 2)
10,368-10,370MHz Narrowband Telegraphy EME/SSB	2.7kHz	10,368-10,370 Narrowband Modes (Note 3) 10,368.1MHz Centre of Activity
10,368.800-10,368.995 Propagation Beacons	10,368.750-10,368.800MHz – Local Beacons, 10W ERP max 10,368.800-10,368.995MHz – Propagation Beacons Only	
10,370.000-10,450.000 All Modes		10,371MHz Voice Repeaters Rx 10,425 ATV Repeaters
10,450.000-10,475.000 All Modes & Satellites		10,400-10,475MHz Unattended Operation 10,450-10,452MHz Alternative Narrowband Segment (Note 3) 10,471MHz Voice Repeaters Tx
10,475.000-10,500.000 All Modes and satellites		Amateur Satellite Service ONLY

Note 1: Deleted.
Note 2: Wideband FM is preferred between 10,350-10,400MHz to encourage compatibility between narrowband systems.
Note 3: 10,450MHz is used as an alternative narrowband segment in countries where 10,368MHz is not available.
Note 4: 10,000-10,125MHz is subject to increased Primary user utilisation and restrictions.
Note 5: 10,475-10,500MHz is allocated ONLY to the Amateur Satellite Service and NOT to the Amateur Service.
Licence Notes: Amateur Service – Secondary User. Foundation licensees 1 watt maximum. Amateur Satellite Service: 10,450-10,500MHz – Secondary User. Note specific conditions apply within 50 km of SO916223 (Cheltenham), SS206127 (Bude), SK985640 (Waddington) and SE202577 (Harrogate).

24GHz (12mm) IARU Recommendation	UK USAGE
24,000.000-24,050.000MHz Satellites	24,025MHz Preferred Operating Frequency for Wideband Equipment 24,048.2MHz – Narrowband Centre of Activity 24,048.750-24,048.800MHz – Local Beacons, 10W ERP max
24,048.800-24,048.995 Propagation Beacons	24,048.800-24,048.995MHz – Propagation Beacons Only
24,050.000-24,250.000 All Modes	

Licence Notes: Amateur Service: 24,000-24,050MHz – Primary User: Users must accept interference from ISM users. 24,050-24,150MHz – Secondary User. May only be used with the written permission of Ofcom. Users must accept interference from ISM users. 24,150-24,250MHz – Secondary User. Users must accept interference from ISM users. Amateur Satellite Service: 24,000-24,050MHz – Primary User: Users must accept interference from ISM users. Note specific conditions apply within 50 km of SK985640 (Waddington) and SE202577 (Harrogate).
ISM = Industrial, scientific and medical.

47GHz (6mm) IARU Recommendation	UK USAGE
47,000.000-47,200.000MHz	47,088.2MHz – Centre of Narrowband Activity
47,088.000-47,090.000 Narrowband Segment	47,088.8-47,089.0MHz – Propagation Beacons Only

Licence Notes: Amateur Service and Amateur Satellite Service – Primary User. Note specific conditions apply within 50 km of SK985640 (Waddington) and SE202577 (Harrogate).

76GHz (4mm) IARU Recommendation	UK USAGE
75,500-76,000MHz All Modes (preferred)	75,976.200MHz – IARU Region 1 Preferred Centre of Activity
76,000.000-77,500.000 All Modes	
77,500-78,000 All Modes (preferred)	77,500.200MHz – Alternative IARU Recommended Narrowband Segment
78,000-81,000 All Modes	

Licence Notes:
75,500-75,875MHz Amateur Service and Amateur Satellite Service – Secondary User.
75,875-76,000MHz Amateur Service and Amateur Satellite Service – Primary User.
76,000-77,500MHz Amateur Service and Amateur Satellite Service – Secondary User.
77,500-78,000MHz Amateur Service and Amateur Satellite Service – Primary User.
78,000-81,000MHz Amateur service and Amateur Satellite Service – Secondary User.
Note specific conditions apply within 50 km of SK985640 (Waddington) and SE202577 (Harrogate).

122GHz (2.5mm) IARU Recommendation	UK USAGE
IARU Recommendation 122,250-122.251 MHz Narrowband modes	IARU Region-1 preferred centre of activity
122,251-123,000 MHz All modes	122,256 / 122,400 MHz - UK centre of activity

Licence Notes:
122,250-123,000 MHz Amateur Service only - **Secondary User.**
Note specific conditions apply within 50 km of SK985640 (Waddington) and SE202577 (Harrogate).

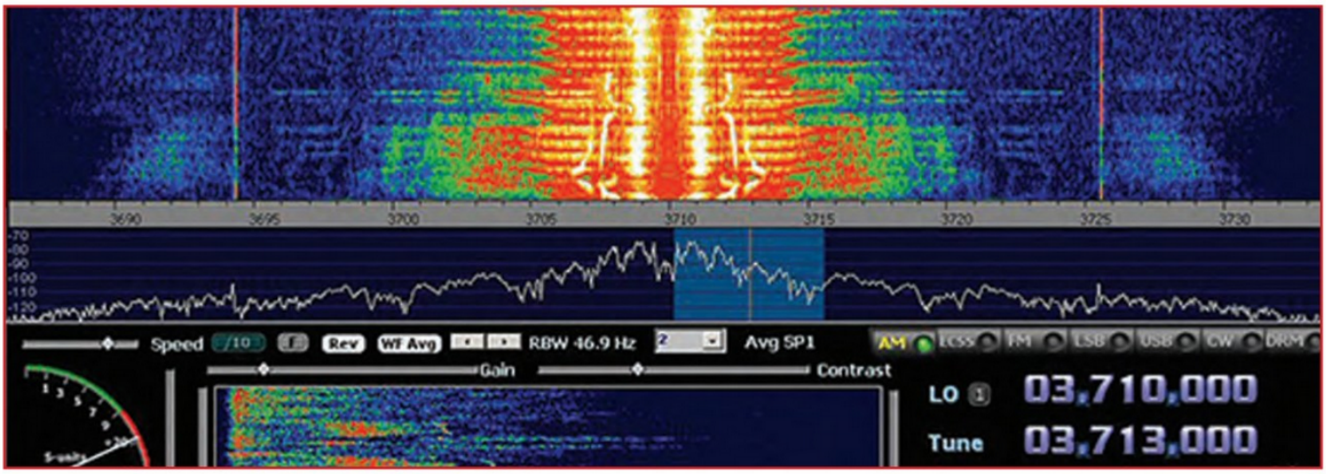
134GHz (2mm) IARU Recommendation	UK USAGE
134,000-134,928 MHz All modes	134,256 / 134,400 MHz - UK centre of activity
134,928-134,930 Narrowband modes	IARU Region-1 preferred centre of activity
134,930 -136,000 All modes	
136,000 -141,000 All modes	

Licence Notes:
134,000-136,000 MHz Amateur Service and Amateur Satellite Service - Primary User.
136,000-141,000 MHz Amateur Service and Amateur Satellite Service - Secondary User.
Note specific conditions apply within 50 km of SK985640 (Waddington) and SE202577 (Harrogate).

241GHz (1.2mm) IARU Recommendation	UK USAGE
241,000-248,000 MHz All modes	241,600 MHz +/-IF - UK centre of activity
248,000-248.001 MHz Narrowband modes	IARU Region-1 preferred centre of activity
248,001-250,000 MHz All modes	248,800 MHz +/-IF - UK centre of activity

Licence Notes:
241,000-248,000 MHz Amateur Service and Amateur Satellite Service - **Secondary User.**
248,000-250,000 MHz Amateur Service and Amateur Satellite Service - **Primary User.**
Note specific conditions apply within 50 km of SK985640 (Waddington) and SE202577 (Harrogate).

Notes to the Band Plan
Note-1: Access to frequencies >275 GHz by Full Licensees is also possible by NoV



RBW 46.9 Hz
LO 03,710,000
Tune 03,713,000

For more information visit rsgb.org/bandplans

NOTES TO THE BAND PLANS

ITU-R radio regulation RR 1.152 and Recommendation SM.328 (extract):

Necessary bandwidth: For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

Foundation and Intermediate Licence holders are advised to check their Licences for the permitted power limits and conditions applicable to their class of Licence.

All Modes: CW, SSB and those modes listed as Centres of Activity, plus AM. Consideration should be given to adjacent channel users.

Image Modes: Any analogue or digital image modes within the appropriate bandwidth, for example SSTV and FAX.

Narrowband Modes: All modes using up to 500Hz bandwidth, including CW, RTTY, PSK, etc.

Digimodes: Any digital mode used within the appropriate bandwidth, for example RTTY, PSK, MT63, etc.

Sideband usage: Below 10MHz use lower sideband (LSB), above 10MHz use upper sideband (USB). Note the lowest dial settings for LSB Voice modes are 1843, 3603 and 7053kHz on 160, 80 and 40m. Note that on (5MHz) USB is used.

Amplitude Modulation (AM): AM with a bandwidth greater than 2.7kHz is acceptable in the All Modes segments provided users consider adjacent channel activity when selecting operating frequencies (Davos 2005).

Extended SSB (eSSB): Extended SSB (eSSB) is only acceptable in the All Modes segments provided users consider adjacent channel activity when selecting operating frequencies.

Digital Voice (DV): Users of Digital Voice (DV) should check that the channel is not in use by other modes (CT08_C5_Rec20).

FM Repeater & Gateway Access: CTCSS Access is recommended. Toneburst access is being withdrawn in line with IARU R1 recommendations.

Beacons Propagation Beacon Sub-bands are highlighted – please avoid transmitting in them!

MGM: Machine Generated Modes indicates those transmission modes relying fully on computer processing such as RTTY, AMTOR, PSK31, JTxx, FSK441 and the like. This does not include Digital Voice (DV) or Digital Data (DD).

WSPR: Above 30MHz, WSPR frequencies in the band plan are the centre of the transmitted frequency (not the suppressed carrier frequency or the VFO dial setting).

Transmitter setup and Linearity: Close attention should be given to power amplifier linearity to control the final transmitted bandwidth and avoid spectral regrowth affecting adjacent users. In particular this can be a major issue when operating digital modes. It is recommended that operators do not use more power than is necessary, and that care is taken to ensure sound cards, interfaces, and other equipment are properly set up so as to minimise the potential for interference.

CW QSOs are accepted across all bands, except within beacon segments (Recommendation DV05_C4_Rec_13).

Contest activity shall not take place on the 5, 10, 18 and 24MHz (60, 30, 17 and 12m) bands.

Non-contesting radio amateurs are recommended to use the contest-free HF bands (30, 17 and 12m) during the largest international contests (DV05_C4_Rev_07).

The term 'automatically controlled data stations' includes Store and Forward stations.

Transmitting Frequencies: The announced frequencies in the band plan are understood as 'transmitted frequencies' (not those of the suppressed carrier).

Centre of Activity (CoA): A guide to where users of a particular mode or activity tend to operate. The bandplan does not give such users precedence over other modes or activities.

Unmanned transmitting stations: IARU member societies are requested to limit this activity on the HF bands. It is recommended that any unmanned transmitting stations on HF shall only be activated under operator control except for beacons agreed with the IARU Region 1 Beacon Coordinator, or specially licensed experimental stations.

472-479kHz: Access is available to Full licensees only.

1.8MHz: Radio amateurs in countries that have a SSB allocation ONLY below 1840kHz, may continue to use it, but the National Societies in those countries are requested to take all necessary steps with their licence administrations to adjust phone allocations in accordance with the Region 1 Band Plan (UBA – Davos 2005).

3.5MHz: Inter-Continental operations should be given priority in the segments 3500-3510kHz and 3775-3800kHz. Where no DX traffic is involved, the contest segments should not include 3500-3510kHz or 3775-3800kHz. Member societies will be permitted to set other (lower) limits for national contests (within these limits). 3510-3600kHz may be used for unmanned ARDF beacons (CW, A1A) (Recommendation DV05_C4_Rec_12).

5MHz: Access is available to Full licensees only – see licence schedule for additional conditions.

7MHz: The band segment 7040-7060kHz may be used for automatic controlled data stations (unattended) traffic in the areas of Africa south from the equator during local daylight hours. Where no DX traffic is involved, the contest segment should not include 7,175-7,200kHz.

10MHz: SSB may be used during emergencies involving the immediate safety of life and property and only by stations actually involved in the handling of emergency traffic.
The band segment 10120kHz to 10140kHz may be used for SSB transmissions in the area of Africa south of the equator during local daylight hours.
News bulletins on any mode should not be transmitted on the 10MHz band.

28MHz: Operators should not transmit on frequencies between 29.3 and 29.51MHz to avoid interference to amateur satellite downlinks.

Experimentation with NBFM Packet Radio on 29MHz band: Preferred operating frequencies on each 10kHz from 29.210 to 29.290MHz inclusive should be used. A deviation of ±2.5kHz being used with 2.5kHz as maximum modulation frequency.

1.3GHz
The band is subject to re-planning. It is also shared with air traffic radar.

2.3GHz (2310-2350 & 2390-2400MHz)
Operation is subject to specific licence conditions and guidance – see also the Ofcom PSSR statement.

3.4GHz (3400-3410MHz)
Operation is subject to specific licence conditions and guidance — see also the Ofcom PSSR statement.

Innovation Bands: 70.5-71.5MHz, 146-147MHz, 2300-2302MHz and >275GHz
Access to these bands requires an appropriate NoV, which is available to Full licensees only.

The latest band plan information, including the master Excel files, can be found in the Operating section of the RSGB website.
Please ensure you only refer or link to the *current* Band Plans. Remove/delete any older versions you have locally or online.

See rsgb.org/bandplans

Contest Calendar March 2024

Ian Pawson, G0FCT

RSGB HF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Mon 4 Mar	80m Club Championship	2000-2130	PSK63, RTTY	3.5	RST + SN
Sat 9 - Sun 10 Mar	Commonwealth Contest	1000-1000	CW	3.5-28	RST + SN (HQ stations also send HQ)
Wed 13 Mar	80m Club Championship	2000-2130	CW	3.5	RST + SN
Mon 18 Mar	FT4 Series	1900-2030	FT4	3.5-28	Report
Thu 28 Mar	80m Club Championship	2000-2130	SSB	3.5	RS + SN

RSGB VHF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Sat 2 - Sun 3 Mar	March 144 432MHz	1400-1400	All	144, 432	RS(T) + SN + Locator
Tue 5 Mar	144MHz FMAC	1900-1955	FM	144	RS + SN + Locator
Tue 5 Mar	144MHz UKAC	2000-2230	All	144	RS(T) + SN + Locator
Wed 6 Mar	144MHz FT8 AC (4 hour)	1700-2100	FT8	144	Report + 4-character Locator
Wed 6 Mar	144MHz FT8 AC (2 hour)	1900-2100	FT8	144	Report + 4-character Locator
Tue 12 Mar	432MHz FMAC	1900-1955	FM	432	RS + SN + Locator
Tue 12 Mar	432MHz UKAC	2000-2230	All	432	RS(T) + SN + Locator
Wed 13 Mar	432MHz FT8 AC (4 hour)	1700-2100	FT8	432	Report + 4-character Locator
Wed 13 Mar	432MHz FT8 AC (2 hour)	1900-2100	FT8	432	Report + 4-character Locator
Thu 14 Mar	50MHz UKAC	2000-2230	All	50	RS(T) + SN + Locator
Tue 19 Mar	1.3GHz UKAC	2000-2230	All	1.3G	RS(T) + SN + Locator
Thu 21 Mar	70MHz UKAC	2000-2230	All	70	RS(T) + SN + Locator
Tue 26 Mar	SHF UKAC	1930-2230	All	2.3G - 10G	RS(T) + SN + Locator

Best of the Rest Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange (Info)
Sat 2 - Sun 3 Mar	ARRL International DX	0000-2359	SSB	1.8-28	RST+TX power (W send State, VE send Province)
Sun 3 Mar	UKuG Low Band	1000-1600	All	1.3G-3.4G	RS(T) + SN + Locator
Sun 3 Mar	WAB 3.5MHz Phone	1800-2200	SSB	3.5	RS + SN + WAB area
Wed 6 Mar	UKEICC	2000-2100	SSB	3.5	6-character Locator
Sat 16 - Mon 18 Mar	BARTG HF RTTY	0200-0200	RTTY	3.5-28	RST + SN + time
Tue 19 Mar	IRTS 80m Evening Counties	2000-2100	CW, SSB	3.5	RS(T) + SN + County code
Wed 27 Mar	UKEICC	2000-2100	CW	3.5	6-character Locator
Sat 30 - Sun 31 Mar	CQ WW WPX SSB	0000-2359	SSB	1.8-28	RS + SN

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

TDR pulse generator

Time domain reflectometry without a digital storage oscilloscope

I wrote about doing time-domain reflectometry (TDR) with W2AEW's method using a PP3 and a 47Ω resistor **[1]**. While owners of digital storage oscilloscopes found that the method required little investment, there were several problems. First, it was not suitable for use with a non-storage oscilloscope, and secondly, with both long transmission lines and lines with short circuits, I found that I sometimes struck a small electric arc as the resistor lead touched the battery terminal. To address these two problems, I needed to make a pulse generator which had no moving parts and which made repeated regular measurements. **Figure 1** shows a photograph of the results of my labours.

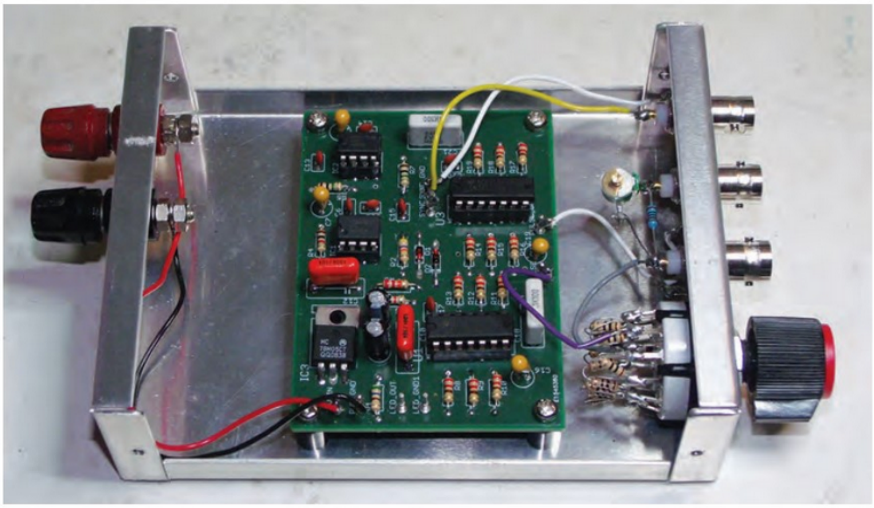


FIGURE 1: The TDR pulse generator with the top cover removed.

A TDR pulse generator

Alan, W2AEW has also published a design using a single 74AC14 to generate the square wave needed for TDR with an oscilloscope. While I could get 74AC04 NOT gates, I was unable to obtain 74AC14 Schmitt NOT gates here in Sweden, so I used the CMOS version of the 555 (LMC555) to create the rectangle wave to drive my 74AC04

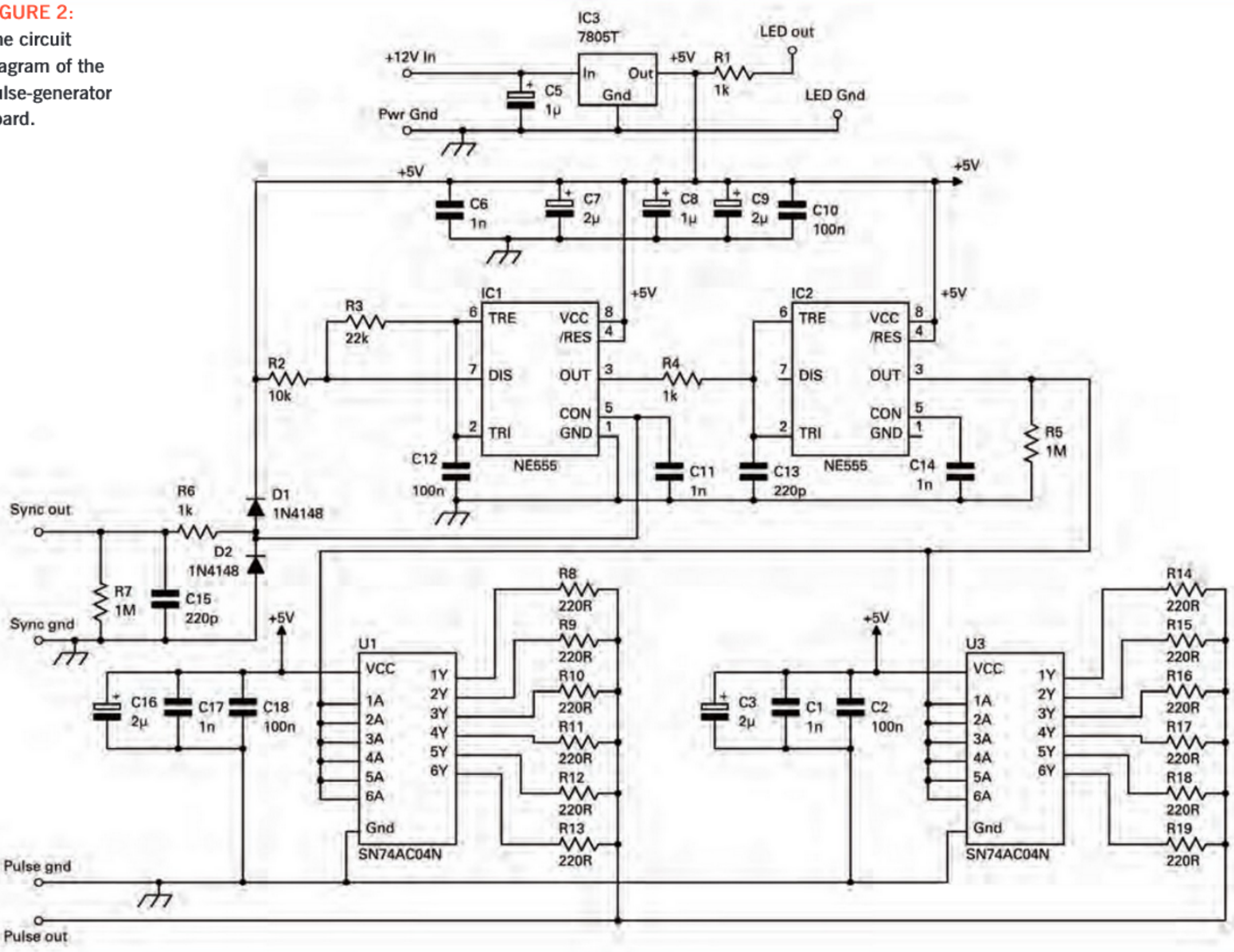


FIGURE 2: The circuit diagram of the pulse-generator board.

the oscilloscope to be connected by a patch lead of flexible coaxial cable. You will need to adjust the green variable capacitor (see **Figure 5**) to work with your patch lead. This is connected in parallel with the metal-film 10MΩ resistor, and is on the left hand side of Figure 5. The pulses are delivered from the board by the purple wire to the switch used to set the source resistance; the output of the variable-resistance network is the grey wire to the right-hand side of the BNC connector ('Line under test'), while the middle BNC connector is for connection to channel B of the oscilloscope. The best way to adjust the trimmer is to connect the oscilloscope via your chosen patch lead to the oscilloscope sensing output and another oscilloscope channel to the line output. You should adjust the trimmer to get as perfect a square wave as you can, as illustrated in **Figure 6**.

Table 1: Source resistances for the different settings.

Switch position	Rs (Ω)
1	19.1
2	29.0
3	38.6
4	48.3
5	57.9
6	68.0
7	77.2
8	87.3
9	96.1
10	107.3
11	117.4
12	126.6

Testing

I tested the TDR pulse generator using a very long 50Ω coaxial cable with solid polyethylene as the dielectric. After adjustment of the pulse generator's source resistance to match the cable's characteristic impedance, I recorded transients both with an open- and a short-circuit at the far end. **Figure 7** shows the result of averaging twelve transients together in order to reduce the random noise in each single measurement. What you see is that, for the first part of the TDR transient, the graphs are identical for the two experiments. However, when the wave reflects back from the far end of the cable, the sign of the voltage is inverted for the short circuit case which causes the voltage to go almost to zero. In the open-ended case, the voltage jumps up to about twice the value of the plateau.

When I changed to using faster oscilloscopes, such as a 50MHz Fluke scopemeter and an Agilent DSO5014A (100MHz 2 Gs/s) oscilloscope, I observed much more ringing on the rising edge of the square wave. This might have been caused by the rising edge of the square wave exciting a resonance in the patch lead, both ends of which were connected to loads close to infinite impedances when compared with 50Ω, so natural oscillation excited in it would persist for a time. Use as short a patch lead as possible, preferably, so that such oscillations lie above the maximum frequency response of the oscilloscope.

Reference

[1] Foreman, Mark R.StJ., 'Coaxial cables part one: how to check them using time-domain reflectometry'. *RadCom* October 2023

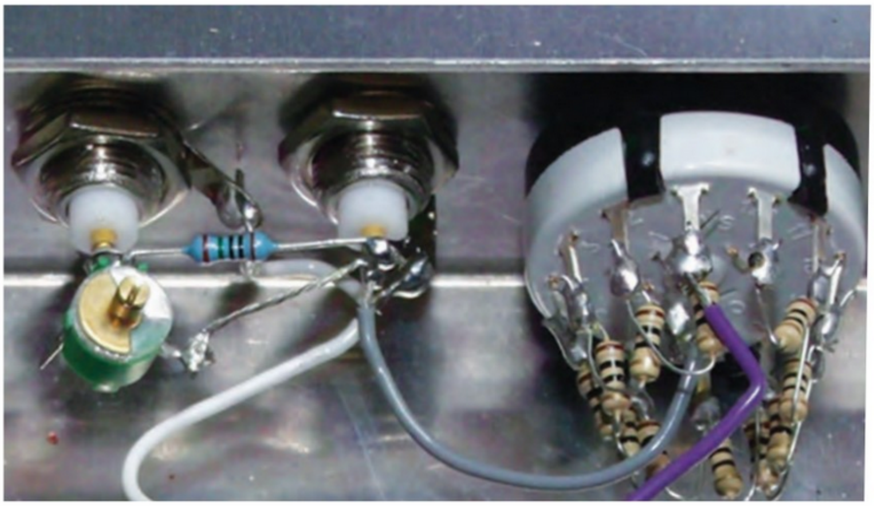


FIGURE 5: A close-up view of the variable resistance network, and the built-in x11 oscilloscope probe.

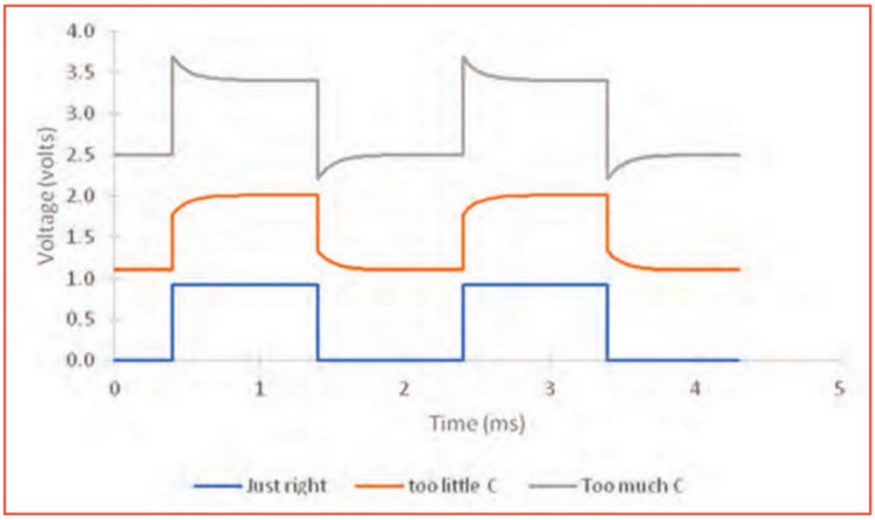


FIGURE 6: Waveforms obtained when adjusting the trimmer of the x11 probe.

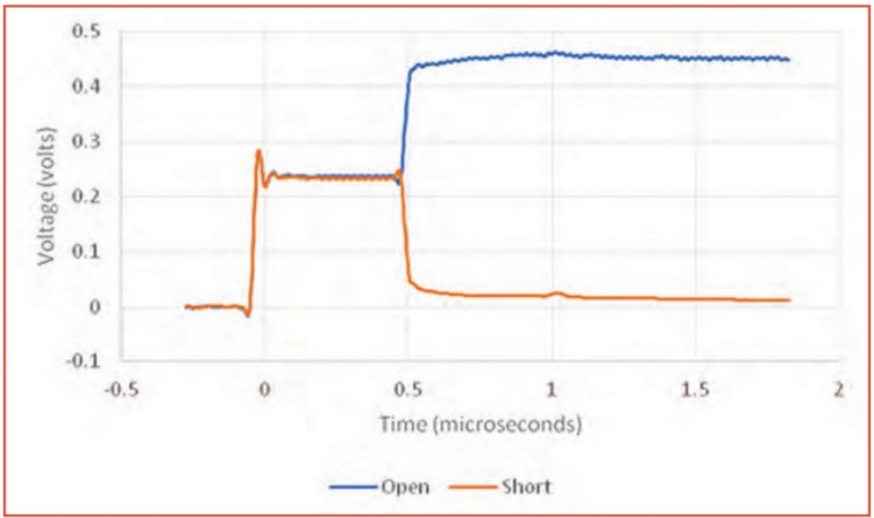


FIGURE 7: An average of TDR measurements on a long 50Ω line, terminated both with an open- and a short-circuit.