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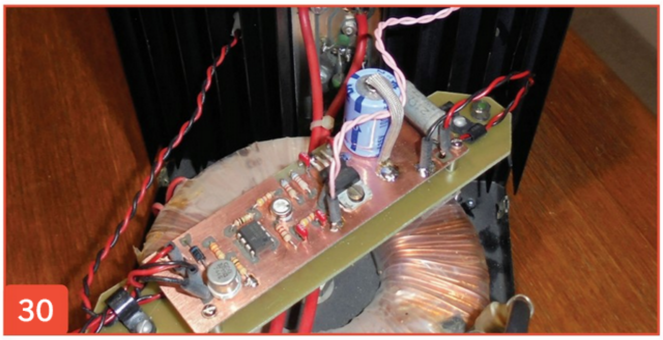

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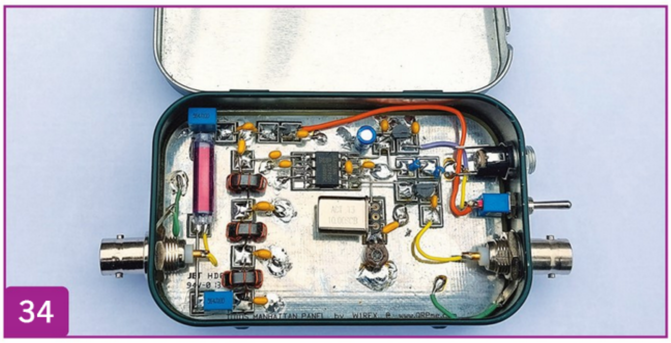

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RadCom THE RADIO SOCIETY OF GREAT BRITAIN'S MEMBERS' MAGAZINE

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Antennas

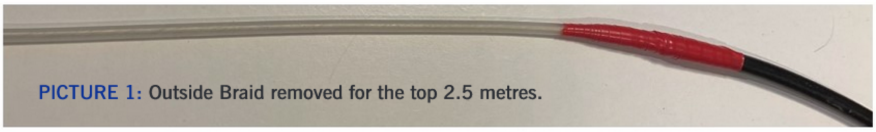
With the progression towards the next solar maximum gathering pace, higher HF bands such as 10m are becoming an ever-attractive proposition for anyone wishing to work DX.

Antennas for 10m are typically smaller in size, plus man-made interference on higher HF frequencies in urban or semi-urban areas, tends to be weaker than found on lower HF bands. Since the final quarter of 2022, the SFI and sunspot figures have both consistently been above 100, sometimes with the SFI reaching over 200. This bodes well for the higher bands and has seen 10m often having morning openings to JA and VK, with North/South America and the Caribbean becoming prominent in the afternoon towards the greyline.

Antenna design

Time then to think about an easy-to-make and deploy antenna for 10m? Perhaps an antenna you can easily transport for portable work, as well as mount as a semi-permanent antenna at home? One such design is a half-wave vertical, constructed entirely out of coaxial cable (in this case RG-58). It lends itself to the 'flowerpot' design often used by portable operators on VHF and UHF. It is a mono-band antenna, with identical gain to any commercially-bought half-wave vertical antenna. This design is also very popular with CB operators, being known there as the 'T2LT' antenna and is often used when operating portable, requiring only a simple non-conductive support of some kind, such as a fibreglass flag/fishing pole or it can be simply hung in a tree or by some other support.

The antenna is somewhat of a hybrid, in that it presents a good match to 50 ohms, meaning it has an electrical similarity to a centre-fed dipole. But it is also physically an end-fed design which manages to avoid the conundrum of how to transform the usually very high impedance found at the far end of a half-wave. It manages this through the presence of the skin effect found on the outer shield of the coax along the radiating part of the antenna and is therefore very reliant on the ability of the common-mode choke to present a high enough impedance to prevent common-mode currents making their way along the feedline to the radio. The choice of RG-58 is based upon the relatively cost-effective nature of this type of coax (currently around 60p per metre) and its lightweight properties. Any relatively light and malleable 50 or 75 ohm coax could be used. Thicker diameter coax would of course be heavier, more costly and less able to be wound as an air-choke. Moreover, coax with a foam inner should, if possible, be avoided owing to its propensity to break when being manipulated as the choke (the design of which is described further on in this article).



PICTURE 1: Outside Braid removed for the top 2.5 metres.

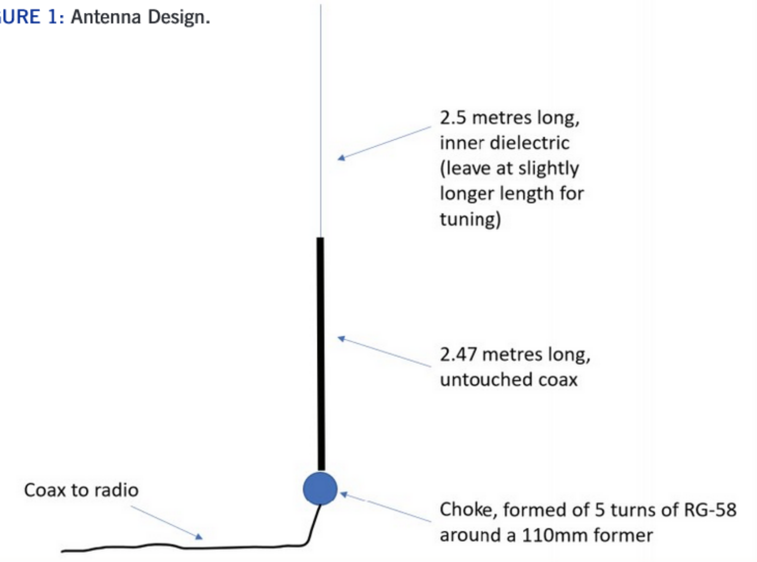
Advantages of this antenna

So why a half-wave rather than a quarter-wave vertical? Well, the performance of these two antennas is very similar, with the half-wave having a very slight advantage in terms of low-angle gain (for example at 5 degrees take-off) of around 1dBi over a quarter-wave fed at the same distance above ground, this is useful for DX contacts. Another advantage this design has over a quarter-wave is the avoidance of having to use either ground-mounted or elevated (tuned) radials. This is especially the case when using this antenna in the field in a portable situation. This antenna provides an identical radiation pattern and gain compared with its conventional vertical centre-fed half-wave cousin. It does though have one advantage over the centre-fed dipole in that, as it is physically end-fed it does not require the feedline to run as closely as possible to a 90-degree angle away from the dipole in order to avoid coupling between the feed-point and the dipole. Not always an easy task when operating portable.

Construction

The antenna's construction is relatively straightforward, you will need a minimum of 7 metres of RG-58 to construct the radiating element of the antenna, plus the all-important air wound choke. This should leave you with around 25-30cm of coax below the choke with which to fit an SO-239 or a PL-259 in conjunction with a barrel connector to connect a feedline. Alternatively, of course, you could factor in extra coax into your build and use this extra run as your feedline anyway. Using the half-wave formula of 141/frequency, in this case 28.500MHz, we arrive at a total length of 4.94m. The overall length of the radiator is typically that of a half-wave dipole, with the top half exposed inner dielectric measuring 2.5m in length (to allow for fine tuning if required, by folding back the wire slightly) and the untouched bottom half of the coax measuring 2.47m long. This 28MHz version of the flower-pot antenna is constructed by first measuring out the minimum of 7 metres of RG-

FIGURE 1: Antenna Design.



PICTURE 2: The completed choke, with five turns of RG-58 wrapped initially around a 110mm diameter soil pipe to help construct the choke.

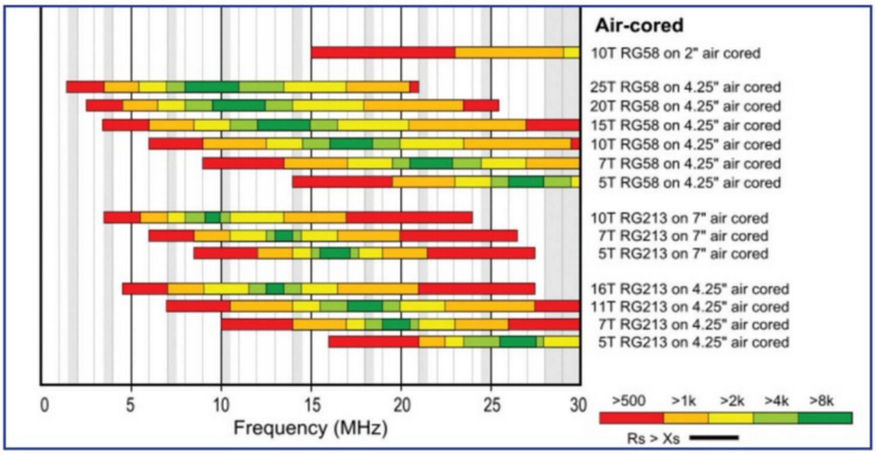


FIGURE 2: Taken from the chart published by G3TXQ (SK), showing the number of choke windings required per band.

58 coax required. Then, from one end of the coax measure and mark 2.5m (or slightly longer by 5-10 cm to allow tuning). Using a blade or Stanley Knife, GENTLY mark along the 2.5m or so length of coax, starting from the end you made the mark, back to the far end of the coax. This will help to strip back the outer shield, then go back to the mark and cut around to remove just the outer shield. The next task is to remove the now exposed 2.5m length of inner braid, taking care not to cut into the inner dielectric which covers the centre of the coax. Once you have removed this, use a small pair of scissors or tweezers to give the remaining whisps of braid a hair cut to get as clean a trim as you can. This should then leave you with 2.5m, or slightly longer, of the exposed inner dielectric.

The next stage is to measure a further 2.47m down the coax, starting from the top of the untouched coax nearest the exposed dielectric. At the 2.47m point, it would be useful to mark this with either a pen or a small piece of electrical tape. This will now be the base of the antenna and the coax following this will form the critical RF choke. This choke is at the very base of the antenna and is extremely important in preventing any stray RF making its way along the feedline to your radio. The suggested choke for 28MHz consists of 5 turns of the RG-58 around a diameter of 110mm (handily being the diameter of a soil pipe). This choke will then provide sufficient impedance at frequencies within the 10m band.

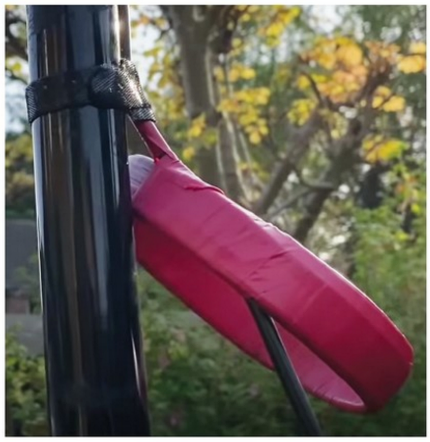
It would be useful to quickly explain the choke dimensions chosen for this antenna. The late Steve Hunt, G3TXQ undertook some detailed analysis of choke designs. According to Steve, air-wound chokes such as the one used in this design are, for the sake of practicality, mono-band in nature, as they provide a very narrow (although sufficient) impedance range. Thus, 12, 15, 17 and 20m versions of this design would not only necessitate a longer antenna radiating length, but also a choke with a greater number of windings to create the necessary impedance at these lower frequencies, although still using the same choke diameter.

Moving back to the construction, tape the coax to the pipe at the stage where the coax was marked at the 2.47m point and then wind the coax around the pipe 5 times, taking care to keep the windings as tight as you can to each other, this is important to keep the choke's impedance as high as possible. Once you have made 5 turns, tape the coax to the pipe and use electrical tape, glue or, better still, heat shrink to keep the coax winding together. Alternatively, pre-cut the pipe former to the approximate (or measured) width of the choke, and keep this as the inside of the choke, using cable ties to secure the closely wound choke to the former. This may make the choke very slightly heavier, but will nonetheless retain the choke's shape for longer, especially if the antenna is to be used as a semi-permanent installation at home. Now that the choke has been constructed, all that remains is to fit your chosen connector to the end of the feedline. Remember that any length can be used following the choke, depending upon your own operating preferences. I tend to allow a length of about 5m from the choke, to allow the antenna to be used in a portable situation. Longer lengths may favour home installations. You can of course fit an SO239 or alternatively, a PL259 in conjunction with a barrel connector to use slightly lower loss or lighter weight coax if that is your preference.

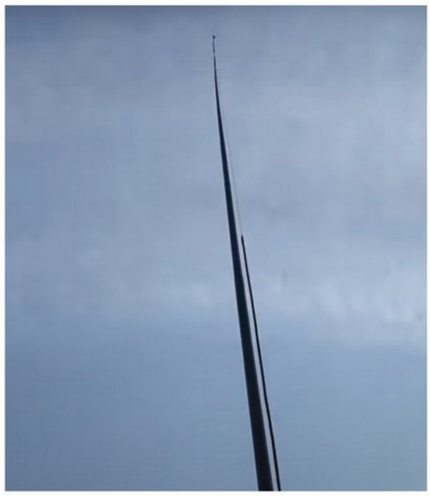
Testing and performance

The antenna was initially tested at my home QTH. A 7m telescopic fibreglass pole was used as a vertical support in the centre of my lawn and the antenna was attached using electrical tape to the top 5m portion of the pole, thus meaning that the choke and effective feed-point of the antenna was 2m above ground.

VSWR readings were very acceptable. The 2:1, or better, VSWR bandwidth was from 28.000 to 29.120MHz, with a 1:1 VSWR at 28.470MHz, providing excellent coverage of such a wide band. Mounting the antenna higher will mean that the resonant frequency will also increase, but given



PICTURE 3: Antenna tested at home.



PICTURE 4: View from the choke looking upwards at the radiating element.

Tim Hier, G5TM.
timhier@icloud.com

FIGURE 3: QSO Map linked to the contacts made on 10m.

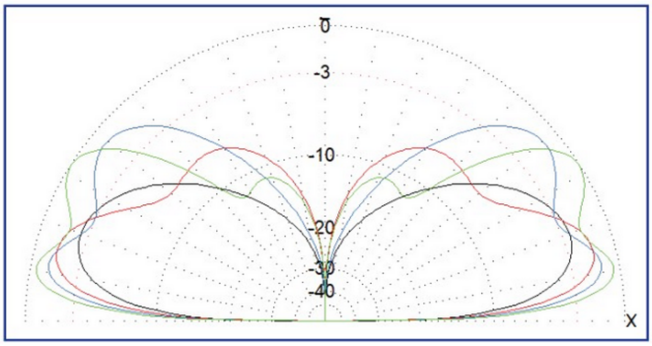


FIGURE 4: MMANA-GAL modelling software used to show the increasing gain at 5 degrees take-off.

the bandwidth presented by this antenna, this should not be too much of a concern. So to the 64 thousand-dollar question: did I make any contacts with this antenna mounted just 2m above the ground? The answer is an unequivocal yes! The antenna was put through its paces in the days leading up to and including the recent CQ WW SSB contest in late October 2022, using 100W and exclusively using SSB. With a quiet band on the Wednesday morning before the contest, I decided to call CQ. On my third CQ call I was pleasantly surprised to hear JA0XIR answer my call with a 5/5 report exchanged both ways. This shows the value of calling CQ on a seemingly quiet band! In the days leading up to the contest I made a handful of contacts into the USA and southern Europe. During the two days of the contest, 10m was full of SSB signals, with the scope on my IC-7300 showing a crammed band from below 28.300MHz to above 29.000MHz with many strong signals. I took the plunge and went on a 'search and pounce' mission, working dozens of stations in the USA, Caribbean, and South America, as well as a few in continental Europe. My operating time during the contest was limited to around 2 hours in the afternoon of both days, but even then, I enjoyed plenty of DX using this simple, home-brew, visually low-impact antenna.

I have also used this antenna as a portable option, with a good deal of DX success. Using a drive-over mast mount, I was able to deploy a 10m telescopic fibreglass pole and attached this antenna to the pole using a combination of electrical tape and re-usable tie wraps. With the feed-point already at a half-wavelength above ground (5m) and the high current portion of the antenna (the centre of the radiating portion) at 7.5m above ground, modelling suggests that it provides a very useful gain of -1.2dBi, at 5 degrees take off (useful for DX). Using MMANA-GAL modelling software, it is suggested that by using a longer fibreglass pole (in this case 12m) the subsequent higher feed-point (at 7m above ground level), would see greater gain at low angles (5 degrees). In this case, an improvement to 0.1dBi. If, however, you are deploying a shorter and lighter pole, such as a 7m pole, which would be suitable perhaps for a SOTA portable activation, then the feed-point at around 2m above the ground, would display a slightly reduced gain of -2.7dBi at 5 degrees take-off. However, this would still be preferable to using a ground-mounted quarter-wave with around 40m of ground radials (at 28MHz that would be 16 quarter-waves worth). Such an antenna typically shows a 5-degree take-off gain of -5.5dBi.

Alternative construction ideas

It would be slightly cheaper (by around £1.50) to use any available scrap wire you might have already stored up for the top 2.5m of the antenna, instead of the stripped coax with the exposed inner dielectric. A good solder connection and use of heat shrink or tape should be used to help weatherproof the join. Even with a version for 20m, such a saving would amount to approximately a meagre £3. However, a saving is a saving! To reduce the weight of the antenna still further, a thin coax such as RG-174 could be used in place of the RG-58. Additional feedline loss below the choke would be less than 1dB (assuming a feed-point VSWR of 1.5:1 or better) compared with RG-58, even with a length of around 10m. This design might be handy for SOTA operators, for example. As mentioned previously in this article, when upscaling this design for lower bands such as 12, 15, 17 or 20m, this not only requires longer radiator lengths but also an increase to the air-wound choke size. Again, thanks to the work of G3TXQ (SK) it is possible to construct versions for other bands. I have myself made versions for both 15 and 2m, with effective VSWR bandwidth and positive results.

Whilst air-wound chokes, such as those used in this design have proved effective for the band they are designed for, they are of course just that, mono-band. Once a desired band for operation drops to 17 and especially 20m, the size of the air-wound choke becomes very large and adds weight. An alternative method would be to make a simple and effective 1:1 choke balun using an appropriate toroid and windings of RG-58 or another available coax. Another choice would be to use a commercially acquired 1:1 current balun. These are not methods I have tried, but given the matchable impedance presented at the feed-point by this antenna design, I would think this would be worth experimenting with. This would certainly save on the comparatively long run of coax needed to make the choke for the 20m version, for example, and would allow a portable operator to plug in and remove different radiator lengths for various bands, using the same generic choke. There are no reasons why lower bands should not be accommodated too by this design. An appropriate choke design should allow 40, 60, 80 and even 160m to be used, albeit not as a conventional half-wave vertical owing to size.

Conclusion and summary

I have enjoyed experimenting with this antenna design. Its lightweight design and effective performance as a radial free, physically end-fed and easily matched/tuned vertical antenna means it is a very welcome addition to my antenna armoury. I look forward to further experimentation with alternative choke designs and using this and its lower-band cousins as portable antennas during the longer and lighter days ahead.

TABLE 1: Length of radiator and air-wound choke dimensions according to G3TXQ (sk)

Band	Frequency	Radiator Length	Turns	Coax Length
10	28.450	4.94	5	7 metres
12	24.950	5.65	5 to 7	8.5 metres
15	21.300	6.62	7	9 metres
17	18.130	7.77	10	11.6 metres
20	14.200	9.93	15	15.5 metres

EMC

PHOTO 1: The Pelham Battery Energy Storage System.

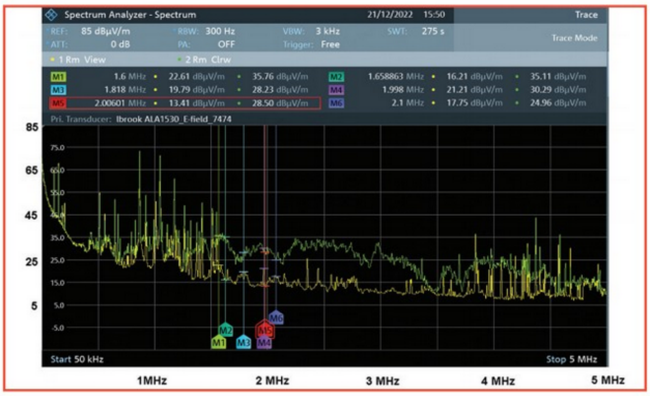


FIGURE 1: Substation RF interference measurement 50kHz - 5MHz.

Planning and the HVDC converter station

The 1000MW Interconnexion France-Angleterre (IFA2) between the UK and France has a High Voltage DC (HVDC) converter station at each end to connect the DC link to the AC electricity grids in the UK and France.

Some of the planning documents make an interesting case study in EMC and planning. The wording of planning condition 14 below could be adapted for use when commenting on EMC aspects of other developments including other HVDC converter stations, solar farms and wind farms. The IFA2 HVDC converter station was built next to an airfield and the building is well screened to reduce emissions of RF interference. This was a requirement of Fareham Borough Council Planning Decision Notice P/16/0557/OA, which includes condition 14 of the IFA2 planning permission. This states the following:

"14. No development relating to the erection of the converter station buildings shall take place until details setting out how the converter station buildings will be designed and implemented to ensure that any electromagnetic disturbance arising from the use of the site does not prevent radio and telecommunications equipment or other equipment outside the site from operating as intended" has been submitted to and approved in writing by the local planning authority. The development of the converter station shall not be carried out other than in accordance with the approved details. REASON: "To prevent radio frequency interference to users of surrounding land and buildings."

There are some documents available on the Fareham Borough Council planning website **[2]** that include detailed technical information about EMC. To find them, search for Ref. P/16/0557/DP/A. These include "Radio and Telecoms Interference and EMF Assessment (Condition 14)" which is a report by ABB on electromagnetic disturbances from a HVDC Modular Multi-level Converter (MMC). In addition, there is also "Condition 14 TUV" which is a review by TÜV Süd Product Service of condition 14 submission - Radio Frequency Interference. This reviews Electromagnetic Fields (EMF) at power frequency (50Hz) and also EMC which is relevant to potential radio frequency interference with electrical/electronic equipment. In October 2021, we asked Fareham Borough Council planning whether they had received a copy of the results of tests that were done in November 2020 in order to verify that condition 14 has been complied with, whether these test results had been published and where we could find them. Their response: "On review of the detailed wording of condition 14, set out below, there is no requirement of the applicant to submit to the planning authority any data or test results from the operation of the converter station. Pursuant to this condition, the applicant had to submit, and get written approval, of the building design so as to ensure that the buildings wouldn't, by virtue of electromagnetic disturbance, prevent the use of radio and telecoms equipment outside of the site. The condition simply requires construction to be undertaken in accordance with these details. There is no requirement in the condition to provide further evidence of this or for further testing once operational. To that end we have not sought data or test results from the applicant from 2020 and nor do they have to submit them to us".

To summarise, planning condition 14 required the converter station buildings should be designed to ensure that any electromagnetic disturbance arising from the use of the site does not prevent radio and telecommunications equipment or other equipment outside the site from operating as intended. After it became operational, tests were done to show that this requirement has been met but there is no requirement to submit test results to the planning authority, ie Fareham Borough Council.

Battery energy storage systems

Some grid connected Battery Energy Storage Systems (BESS) are connected to the National Grid and these are used to compensate for fluctuations in the electrical output of intermittent sources of renewable energy such as solar farms or wind farms **[1]**. This is sometimes called 'load levelling' or 'peak shaving'. A number of BESS in the UK have a peak output power of 49.9MW as this is just under a threshold of 50MW where a different planning process applies.

A BESS not only contains storage batteries but also inverters. For example, a number of inverters may convert DC at typically 1000-1500VDC to 50Hz AC at a power of 2MW for each inverter. These inverters use switching power supply techniques with high power Integrated Gate Bipolar Transistors (IGBT) switching hundreds or thousands of amps. An example of a BESS is the Pelham battery storage project on the Hertfordshire/Essex border near Bishop's Stortford. This was mentioned in Feb 2023 EMC Column and is shown in **photo 1**. This BESS consists of 26 central storage units with noise reduction package and 26 medium voltage blocks. 'Noise reduction' in this context refers to audible noise not RF interference. There is a public footpath that goes past the BESS at Stocking Pelham and it can be seen from Photo 1 that the BESS is housed in metal containers so it is well screened from radiating RF interference. The only way RF might get out would be via any overhead wires but measurements with a portable receiver showed that the 1.8MHz RF interference was not coming from the BESS.

FIGURE 2: Substation RF interference measurement zero span mode, 100ms span.

FIGURE 3: Substation RF interference measurement zero span mode, 20ms span.

Measurement bandwidth

If you go out searching for a source of RF interference using a portable receiver, what is the best receiver bandwidth to use? Some RFI sources such as harmonics from a clock oscillator in digital equipment are known as ‘narrow band’ sources. These occupy a bandwidth that is small compared to the receiver bandwidth. If you are looking for a narrow band source of RFI, then it is best to use the narrowest possible receiver bandwidth as this reduces the receiver noise so that it is easier to detect the RFI. Most RF interference sources are known as ‘broadband’ sources however. These occupy a bandwidth that is larger than the receiver bandwidth. If you reduce the receiver bandwidth, it reduces the receiver noise and the atmospheric noise but it also reduces the power received from the RFI source so it gives no advantage when searching for broadband RFI. It might appear that increased bandwidth doesn’t give any advantage but if the broadband interference is also impulsive interference, then wide bandwidth is an advantage. This is because an impulsive source typically produces short impulses of RFI with a fast rise time. A narrow receiver bandwidth slows down the rise time of these short impulses and this can make the source more difficult to identify. Another tip is that it is usually better to use AM demodulation rather than SSB/CW.

Examples of impulsive sources that transmit short bursts of RFI include Powerline communications (PLC) and arcing on electric power distribution networks.

Substation RFI

As mentioned in Feb 2023 *EMC* Column, measurements have been made of a source of RFI on 1.8MHz at Stocking Pelham on the Hertfordshire/Essex border. Using AM detection, this sounded just like the sort of 100Hz buzz that you get from a switching power supply but it was affecting reception of weak signals on the 1.8MHz amateur band 10km away. The measurements below were made from a public road 850m North of the edge of the substation. A Wellbrook ALA1530 active loop antenna was used with the RSGB Rohde & Schwarz FPC1500 spectrum analyser. The loop antenna had previously been calibrated by RSGB EMC Committee so we can relate the output of the loop to RF field strength. This is known as the antenna factor and we programmed it into the spectrum analyser. The measured spectrum is shown in **Figure 1** above. A loop responds to the H-field or magnetic field but we have expressed the field strength as the equivalent E-field or electric field The units are dB(μV/m), that is decibels relative to 1 microvolt per metre. This is common practice in EMC measurements although ideally we would display the magnetic field strength.

The yellow trace was with the loop aligned for minimum signal from the sub-station and the green trace was with the loop aligned for maximum signal. This gives an indication of the direction of the source but it is important to note that the lowest level of the yellow trace represents the measuring system noise floor, not the background atmospheric noise at this rural location. There are several reasons for this, not all the RFI is nulled out as it is not a point source, pre-amplifier noise in the active antenna, spectrum analyser noiset, spectrum analyser local oscillator phase noise rises below 2MHz. At 1.MHz for example, the field strength at 850m distance from the edge of the sub-station is 28.23dB(μV/m) rms in Hz bandwidth. EMC limits from 150kHz - 30MHz are specified in 9kHz bandwidth and if we scale 300Hz to 9kHz it is equivalent to approximately 43 dB(μV/m) rms in 9 kHz. There is a proposed limit for electricity substations called Cigré publication TB 391 and Limit 2 applies to 400kV substations. At 1.8MHz, this limit is 48.23dB(μV/m) at a distance of 200m from the nearest energised point of the sub-station whereas our approximate measurements indicate a similar field strength at a distance of 850m from the edge of the substation.

Zero span

A spectrum analyser can be set to a ‘zero span’ mode so that the trace displays the amplitude of the RF signal (linear or in dB) against time. In this case, zero span mode was used at 1.9MHz with 100kHz Resolution Bandwidth (RBW). This is much wider than we would normally use for communication but it gives a clearer picture of impulsive interference with fast rise and fall times. The results are shown in **Figures 2** and **3**.

In Figure 2, the sweep time is 10ms per division and 100ms across the screen. There is an irregular impulse every 10ms but every other impulse is usually longer. Figure 3 zooms in on one of the longer impulses at 2ms per division and 20ms across the screen. This shows two bursts of RFI separated by 10ms and the longer burst lasts approximately 2ms. Zero span mode shows that the bursts of RFI are irregular and this is a characteristic of arcing rather than electronic switching devices. The repetition rate is 100Hz which suggests that the source is on one phase only in a three phase network. The alternating longer and shorter bursts of RFI suggest that the arc has different characteristics on positive and negative half-cycles.

All this points to a fault on one phase rather than some sort of electronic switching converter that would operate on all three phases with a repetition rate of 300Hz. The RSGB EMC Committee is in contact with National Grid about this matter.

Websearch

[1] National Grid, What is battery storage? https://www.nationalgrid.com/stories/energy-explained/what-is-battery-storage

[2] Fareham Borough Council Planning https://www.fareham.gov.uk/casetrackerplanning/

Dr David Lauder, G0SNO
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Review

The Icom IC-T10 144/432MHz FM Handheld

I've said it before and I will say it again. Like it or not, the entry of the various Chinese manufacturers into the amateur radio handheld market has set a 'value' standard against which other units tend to be measured.

It's fair to say that those same Chinese handhelds do not always score so highly on the 'quality' standard – although some are very good indeed.

How then, does the new handheld from Icom, score? At the time of writing, Icom has two handhelds on the amateur radio market, the excellent ID-52E for D-STAR/FM and the new entrant, the IC-T10 which I'm looking at in this review.

What does Icom say about the IC-T10?

"The IC-T10 VHF/UHF dual-band Amateur handheld radio is built to the high-quality commercial spec that you would expect from Icom. The radio features a clear, easy-to-use layout, rugged commercial build, IP67 dust-tight specification and waterproofing, 1500mW loud audio and long-lasting Li-Ion battery life all making it an ideal radio for beginners and seasoned amateur radio enthusiasts alike.

Its strong Mil-Spec build and range of features will also make it a practical dual-band radio for voluntary amateur radio emergency services such as Raynet."

The features are listed as:

- 5W RF output in 144MHz and 430MHz.
- Large speaker provides 1500mW loud and intelligible audio.
- IP67 dust-tight and waterproof construction.
- Up to 11 hours operating time with supplied 2400mAh (typ.) Li-Ion battery pack.
- Home button on top panel provides quick access to calling channel.
- FM broadcast Rx: 76-108MHz.
- Built-in CTCSS/DTCS for repeater operation.

PHOTO 1: **IC-T10 charging.**

- 16 DTMF autodial memories.
- Priority, program, memory, skip and tone scan capabilities.
- Free downloadable CS-T10 programming software.
- Optional HM-222HLWP speaker microphone provides loud audio.
- DC power operation with optional AD-149H power supply adapter.
- Total of 208 memory channels with six-character channel names.
- Direct-conversion system eliminates IF stages.

Unboxing

Upon unboxing the IC-T10, the first impression is of a solid and well-built unit. It feels substantial without being too heavy. The battery clipped in positively. On arrival, there wasn't much charge in the battery, so I got the charger cradle out of the box, which is also rather better made than some of the cradles that are supplied with cheaper handhelds. The transformer, which plugs into the wall, comes supplied with a variety of adapters to deal with differing styles of electricity supply sockets – which might come in handy if you are travelling abroad. I snapped the UK three-pin adapter into the back of transformer and set the radio to charge up.

After a couple of hours, the radio was showing that it was fully charged, so I started to get things set up. A simple manual comes with the radio, but you can download an 'Advanced Manual' from the Icom UK website via: https://icomuk.co.uk/files/icom/PDF/advancedManuals/IC-T10_AM_0.pdf

I did resort to the manual for guidance on how to navigate the menu. I didn't find the menu as intuitive to use as I would have liked, but I quickly got used to it. In Set Mode, you select the item you want to change by tapping the 'set' key. If you overshoot the item that you want to change, you have to go all the way through all the items again, rather than being able to scroll back.

First contact

The display on the IC-T10 is fairly small so, depending on your eyesight, you may not be able to see the contents of the display so well at a distance or at odd angles.

With those reservations noted, I set about setting the IC-T10 to talk to my Allstar hotspot and, very quickly, I had set the frequency, CTCSS tone and saved those details to a memory. You can assign a text 'label' to a memory as an alternative to the frequency, should you wish. Using my hotspot, I connected to the GB3TD repeater in Wiltshire, by Echolink and placed a call through it. Rob, G4XUT replied and kindly confirmed that the audio quality was good and sounded like me. Whilst we're on the subject of using the radio to access the Allstar hotspot, the

PHOTO 2: IC-T10 in use.

IC-T10 features DTMF memories as well as a keypad to allow you to send connection/disconnection strings as you wish.

Power

The IC-T10 has three different power levels; High, Medium and Low, corresponding to 5, 2.5 and 0.5W respectively. The low power setting of 0.5W works well with the hotspot and should ensure that battery life is good, while the high setting of 5W should be adequate to give you good coverage from a hilltop.

The rig is dual band, covering 2m and 70cm. Receive coverage is 136-174MHz on VHF and 400-479MHz UHF, FM only. There's also a FM broadcast band radio covering 76-108MHz. Many manufacturers include broadcast band reception on handhelds. Do you find it useful? I can't say I do, but I might be the odd one out! I can see it might be useful or enjoyable when out camping or similar.

Testing

Happy that the rig was working ok on the hotspot, my next test was to program up the parameters for the EI7MLR 70cm repeater, 85 miles away, across the Irish Sea. Although it's a long way off, there nothing in the way and I wasn't surprised to find that I could easily blip up the repeater outside the house on the handheld, running 5W and that my signal was quite respectable into the repeater. On receive, EI7MLR was almost full scale!

All these tests were on the 70cm band – how about 2m? Initial tests in the shack, using another source across the Irish Sea suggested that the IC-T10 wasn't as sensitive as the reference handheld in the shack. However, that turned out to be false, but the squelch circuit in the IC-T10 seemed quite susceptible to a local noise source. With the squelch open, signals were as expected. A little tinkering with the squelch settings resulted in satisfactory results (you can adjust the squelch to open, auto or levels 1 to 9) – worth bearing in mind, perhaps, if you find you are not hearing things that you ought to on 2m.

I found the receive audio quality on the IC-T10 a little on the bassy side and lacking a little in top-end response. Having accused some other rigs recently of having been a bit too concentrated on the top-end response and lacking in lower frequencies, I wonder if I am getting grumpy and hard to please. Anyway, the T10 is perfectly acceptable in regard to audio, but I found it a little 'muddy'. On the positive side, though, there is plenty of audio and, although I didn't try it, I'd guess there was enough audio to be able to listen to the IC-T10 in a car that was in motion.

Programming

If you want to program the IC-T10 from your computer, the good news is that the programming software is free. However, you will need to get the optional OPC-478UC cable. I didn't have one of those, so I can't tell you about the process. Programming the radio from the front panel proved quite straightforward and I quickly programmed up a few of the memory channels with my Allstar hotspot and the local repeaters.

Memory and band scanning is available on the IC-T10 with all the usual facilities to set channels to be skipped and so on. If you're on a repeater, there's the ability to reverse the offset, in other words, to listen on the input. Unfortunately, though, there isn't a quick button to press which allows you to listen on the input. What you'd need to do is to setup another channel in memory, with the reverse duplex function enabled. You could quickly then switch between the two channels (make sure they are adjacent to each other in the memory bank!) to see if you can hear someone on the input.

It's probably worth pointing out that unlike some other handhelds, the IC-T10 doesn't allow you to listen on two bands at the same time – it's a single receiver. Having said that, with use of memory scanning, you could easily set it up to scan simplex calling channels and repeaters on both 2m and 70cm – so that shouldn't cause a problem.

Did I like the IC-T10?

I did. I thought it was a nice, well-built handheld and I liked the robust feel of the charging cradle too. I didn't love the menu, but I quickly got used to it and the display was a touch smaller than I would have preferred. As an IP67 rated device, it can be submerged in up to 1m of water for a 'prolonged' time – a feature I did not test! However, it does mean that if you are planning to use a handheld outside or even on a small boat, the IC-T10 might well fit your requirements.

Worth the price?

The million-dollar question: is it worth the retail price of £199.95? It's true that there are many dual band handhelds which come in at a fraction of the price of the IC-T10. Are they as well built? Probably not. Icom emphasise the 'professional' build quality in their advertising and I feel this is fair. The IC-T10, although simple, feels like a higher quality radio than the cheaper ones and feels less 'disposable' – you would like to hope that it would last longer than cheaper rigs and, if it did go wrong, you could stand a chance of having it repaired. Once programmed, it is very easy to use. I feel it is most likely to appeal to an outdoors radio enthusiast who wants a robust, simple and water-resistant dual-band handheld.

My thanks to Icom UK for the loan of the IC-T10 which is available from retailers at £199.95.

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Technical

A Thermostatically Controlled Cooling System

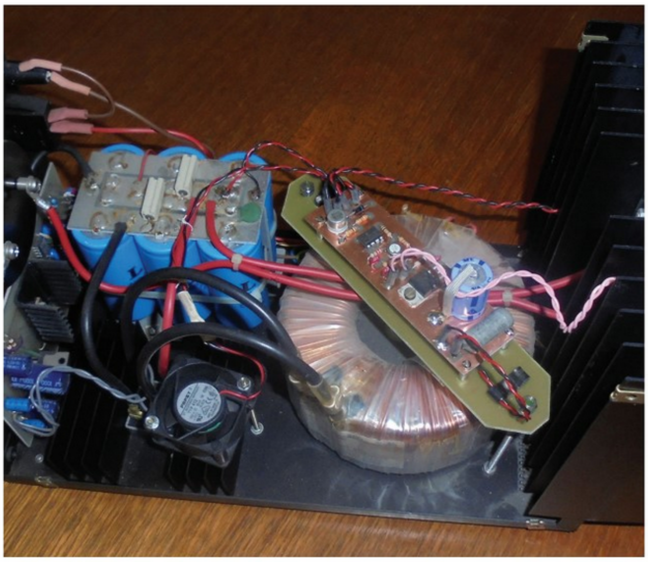

PHOTO 1: New PCB mounted inside with fan on rear heatsink.

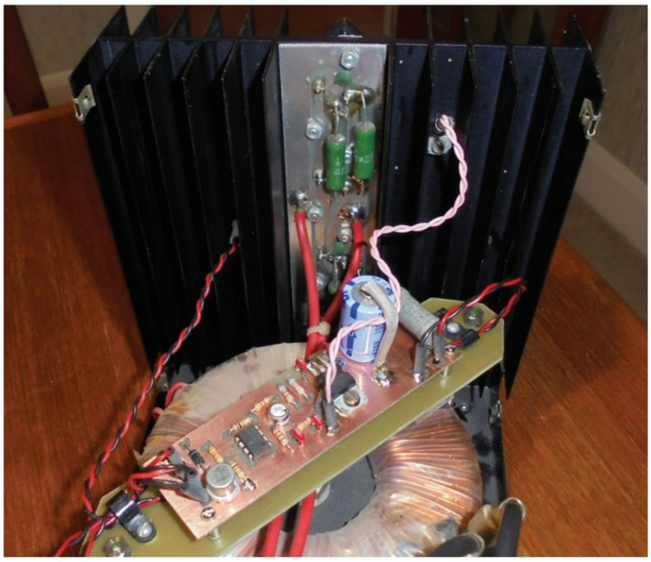

PHOTO 2: Close up picture of the PCB, note the pink thermistor wires.

My BNOS 12/25A power supply has performed well over many years but tends to run very hot on high constant power modes like FM and on one very hot summer day it shut down during an external event.

I therefore decided to add a thermostatically controlled cooling system with a fan on the rear heatsink and a small internal fan to move the air around within the enclosure. The circuit shown in **Figure 1** is based on a similar circuit used in some of my other power supplies **[1]** but with the current switching capacity increased to 200mA in order to drive two 12V fans.

Photo 1 shows the large fan on the outside of the rear heatsink and the small fan inside on the bridge rectifier heatsink – both run from 12V DC. The large fan blows cold air onto the heatsink but the internal fan blows air upwards to encourage the internal air flow ie it sucks warm air away from the bridge rectifier heat sink.

Photo 2 shows the controller board with its various connecting wires. The twisted pink connecting wires go to the temperature sensor head which is mounted on the inside of the large heatsink. The left hand red and black twisted wires go to the large fan on the external heatsink via an insulated (white) bush to protect the wires from the hot heatsink. The second pair of red and black wires on the left-hand side go to the small internal fan. The twisted red and black wires on the upper right hand end of the controller board go to the 23V supply from the smoothing capacitors – see the capacitor block on the upper left hand side in figure 1. The controller board is mounted on a piece of plain fibreglass 1/16-inch-thick sheet which is supported above the toroidal mains transformer on two lengths of 2BA threaded studding. The external magnetic field around the toroidal transformer is very low but the use of a plain fibreglass support ensures that there is no possible risk of a shorted turn with the 2BA tapped studding.

Photo 3 shows the components required to construct the temperature sensor plus the Araldite, or similar, two-pack epoxy adhesive used to retain the thermistor inside the tubular solder tag. The solder tag is a 2BA or equivalent type made of thick metal to accelerate the heat flow. Two types of NTC thermistor **[2]** and **[3]** have been used which have different body sizes and slightly different temperature to resistance characteristics but both fit into the solder tag barrel and have proved satisfactory in operation. Cut the thermistor wires back to about 10mm in length and solder them to one end of the twisted pink wires – insulate the bare wires and solder joints with thin sleeves to prevent short circuits and make sure that the sleeved joints will easily fit inside the barrel of the solder tag. Mix a sufficient quantity of two-pack adhesive and use it to pack the solder tag barrel full, then slowly

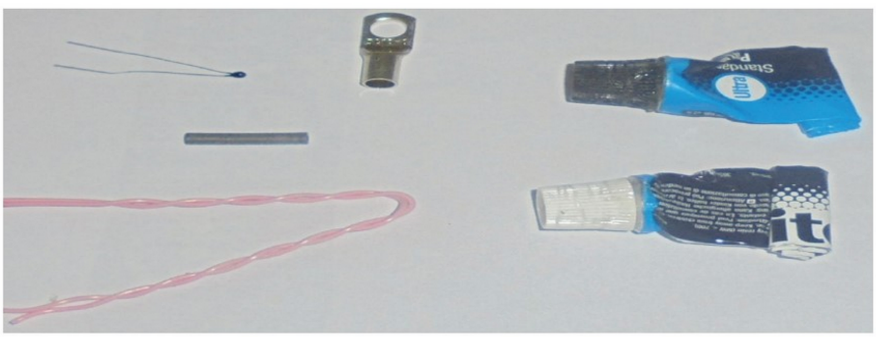

PHOTO 3: Assembly of the thermal sensor.

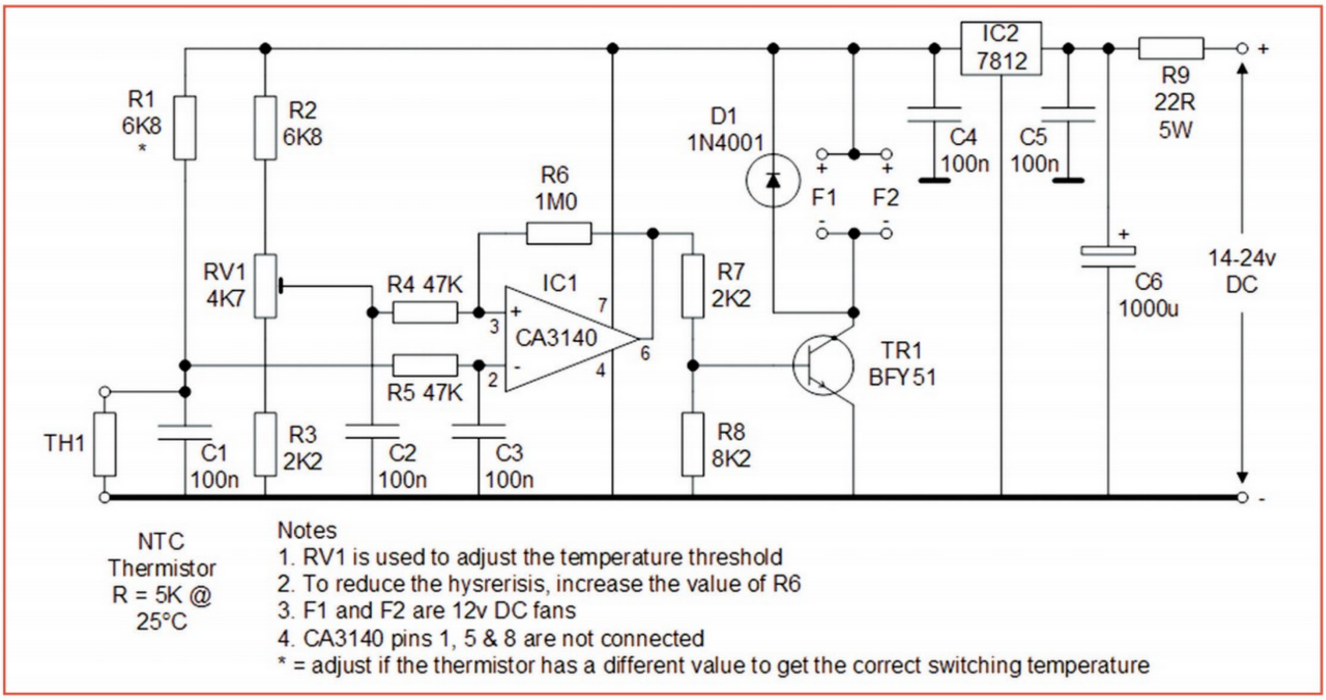

FIGURE 1: The schematic drawing.

push the thermistor all the way into the adhesive. Make sure that the insulated connecting wires are enclosed by the adhesive to remove any strain on the thin thermistor wires during later construction.

Remove any excess adhesive and leave the assembly in a vice or similar retainer with the connecting wires held pointing upwards while the adhesive hardens – this normally takes about 24 hours. Try to avoid getting the adhesive on your skin and thoroughly wash any off with soap and water.

The controller circuit in figure 1 uses CMOS operational amplifier IC1 to compare the voltages from two potential dividers, one containing the thermistor temperature sensor TH1 and one containing the operating temperature setting RV1. IC1 is configured as a Schmidt trigger with a small amount of hysteresis to prevent oscillation at the switching point. RF decoupling has been provided. As the temperature of the thermistor sensor TH1 increases its resistance falls reducing the voltage at the junction of TH1 and R1 and when that voltage falls below the voltage at the slider of RV1 the output of IC1 at pin 6 goes high turning on TR1 and activating the fans. When the temperature of TH1 falls, the reverse happens and the fans are deactivated. Resistor R7 provides sufficient base current for TR1 to ensure that the saturated collector emitter voltage is 600mV or less when the fans are running. The controller circuit is fed from an unregulated 23V DC supply from the BNOS PSU which the onboard 7812 regulator will reduce to 12V. A 22ohm 5W wire wound resistor was added in series with that supply to reduce the energy dissipated in the 12V regulator – this resistor will not be required with a 14-16V supply but the 7812 should then be a low drop out type. RV1 is used to set the temperature at which the fans commence operation and the hysteresis means that there is a small difference in the temperature at which the fans cease operation, preventing any oscillation at the switching threshold. RV1 is currently set so that the fans operate at a heatsink temperature of about 45-50ºC but do not operate just due to a high ambient temperature. After about 15 minutes of continuous fan operation the BFY51, 7812 and 22ohm resistor are just warm to the touch.

Components:

- the printed circuit board is made from 0.062inch thick double sided copper clad fibreglass material
- all fixed resistors except R9 are 250mW or 330mW 5% carbon film through lead types
- RV1 is a cermet pre-set
- the 100n capacitors are wide tolerance multilayer 50V ceramic or disc ceramic leaded types
- the (now very old) BFY51 may be replaced with any TO5 npn transistor that will pass at least 200mA collector current with a DC current gain of at least 30
- the 7812 regulator is mounted directly onto the top copper layer of the printed circuit board without an insulating mica
- The 1000uF electrolytic is a conventional 25V working leaded type – select the working voltage as appropriate for your particular power supply
- R9 is a 22ohm 5W wire wound lead type
- The large fan is 90mm by 90mm and the small fan is 40mm by 40mm and the total fan current is 180mA

Fan fixing arrangements are left to the individual constructor and fan operation is very quiet. When testing the finished item make sure that the fans do cycle on and off to establish that sufficient cooling has been provided. If you find that transistor TR1 is getting too warm then use a TO-5 push on heatsink.

References:

[1] https://www.qsl.net/g3oou temperaturecontroller.html and https://www.qsl.net/g3oou/ps23powersupply.html and https://www.qsl.net/g3oou/ps25powersupply.html
[2] Rapid Online thermistor: https://www.rapidonline.com/Catalogue/Search?Query= TKS TTC0510KSY 5Kohms at 25C
[3] Farnell thermistor 1672367: https://uk.farnell.com/w/c/circuit-protection/thermistors/temperature-sensing-compensation-ntc-thermistors?ost=thermistor

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Design Notes

SMPSU filtering

We all know the issues with Switch Modes PSUs and interference, that they should have filtering that minimises the chances of noise getting to the outside world and kill interference. So let's take a brief look at some of the specific components used to do this. SMPSUs directly rectify the AC mains which is then chopped at a high frequency, tens to hundreds of kHz, to allow small transformers and inductors to be used to isolate and step this down to a useful level. The high-speed switching generates harmonics and transients that extend to HF and VHF frequencies, so need to be filtered to avoid them leaking back onto the mains and DC wiring and then radiated, with interference to radio reception. The filtering on the DC low voltage side is not too difficult to arrange, with liberal use of RF chokes and bypass capacitors rated just for the DC voltage and current the PSU generates, so we don't need to say any more about that here. However, the components used to filter the mains input do need to be rated properly. **Photo 1** shows two SMPSU modules; a large unit forming the Power Factor Correction (PFC) circuitry taken from a defunct 28V PSU and the smaller PCB from a laptop computer power supply rated at around 30 watts. **Figure 1** shows the input circuitry for the larger module, some version of which usually forms the basis of the input filtering on all SMPSUs.

From the mains input on the left, after the obligatory input fuse, there is a bleed resistor to safely discharge capacitors when unplugged and a varistor to clamp mains-borne transients. The first component of the filtering proper is the 220nF capacitor labelled Cx – we'll come to the terminology shortly. Then comes a common mode choke. This is the same sort of thing, and works the same way, as a current mode 1:1 balun seen on the feed to so many antennas. The main difference here is that it is wound as two separated windings on the same ferrite core rather than the tightly twisted pair used at RF. This slight separation reduces the coupling between the two windings by a small amount giving a bit of common mode impedance. Designed to have minimal effect on differential current flowing normally in the pair of conductors but to offer a high inductive series impedance to currents that try to flow on both conductors simultaneously – common mode. One of those input inductors was removed from the board and measured. Each winding was about 19mH each side. When one was shorted the measured value of the other dropped to 130uH confirming tight coupling between the two, but with a modicum of leakage inductance that would present in series with the differential (main power) flow.

Now we come to another pair of capacitors, 470pF in value from live and neutral to the earth connection. These are designed to bypass common mode higher frequency components, harmonics of the switching waveform. The arrangement repeats with a second similar stage before passing to the bridge rectifier. A choke and pair of Cx capacitors do a bit more filtering before passing to the switching stage. As can be seen from the photograph, the smaller laptop PSU follows a similar strategy, using just one differential choke and fewer Cx and Cy capacitors. There are two main parts to the filtering. The larger value Cx capacitors work across the input, bypassing the lower frequency switching current – in effect they are reservoirs for the high current pulses and smoothing the mains input. This prevents components at tens to hundreds of kilohertz from getting back into the mains supply as if it were a transmission line. The common mode chokes don't do a great deal here. Since the direction of current through each side of the windings is such as to cancel the flux in the core, the only inductance they present is that of the leakage due to the not-quite perfect coupling.

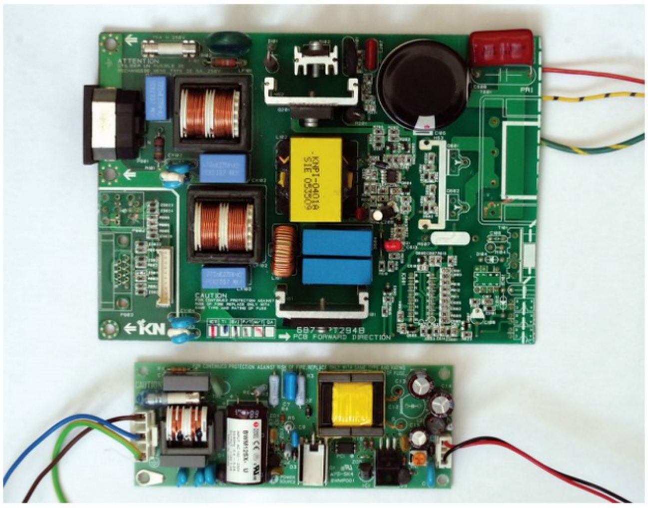

PHOTO 1: Two SMPSU modules, showing the input filtering components.

So, in effect we have a differential mode Pi filter with series elements of 130uH and shunt 220nF. The C/L network on the output side of the bridge rectifier also forms an important part of this filtering. The smaller value 470pF Cy capacitors form a common mode Pi filter. This time we are looking at common mode currents on both conductors together. The full 19mH of the series chokes comes into play and we have a four section Pi filter with series 19mH and shunt 470pF whose job is to remove the harmonic components that leak around the rectifier and get onto the input wiring as a common mode signal. These are the ones that cause most RF problems.

X and Y capacitors

So now for that terminology, and why the capacitors are referenced as Cx and Cy. Devices connected directly across the mains have to be rated for safety and failsafe operation; the wrong type of device could cause a fire if it failed the wrong way or cause a shock hazard. These are called 'safety capacitors' and there are two types, 'X' and 'Y'. X types go across the supply, where they cannot form a shock hazard if they fail. They are designed so that when they fail, they go short and blow any protective fuses. Y types connect to ground and if they were to go short could present a shock hazard, so they must always fail open circuit. X and Y capacitors are rated by peak impulse voltage and by their continuous AC rating. Y class capacitors must never allow the dielectric to be punctured and are often ceramic types. Different classes, X1/Y1 X2/Y2 have ratings appropriate for industrial or domestic usage. Reference **[1]** gives a more detailed description of safety capacitors with tables of the different class ratings. **Photo 2** shows the markings on some typical X and Y capacitors.

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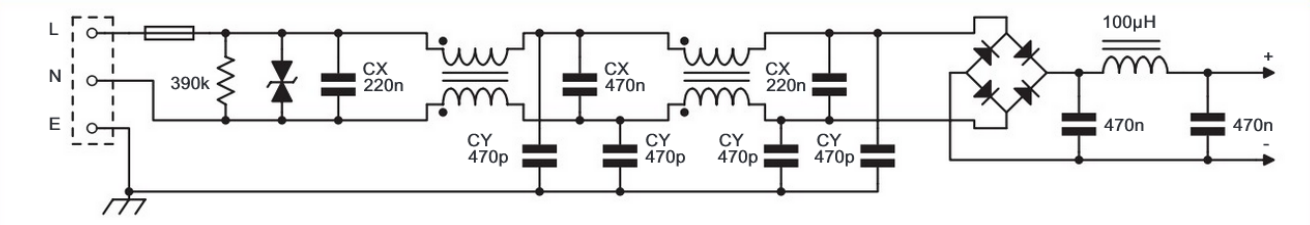

FIGURE 1: Input circuitry of the larger SMPSU module shown in Photo 1.

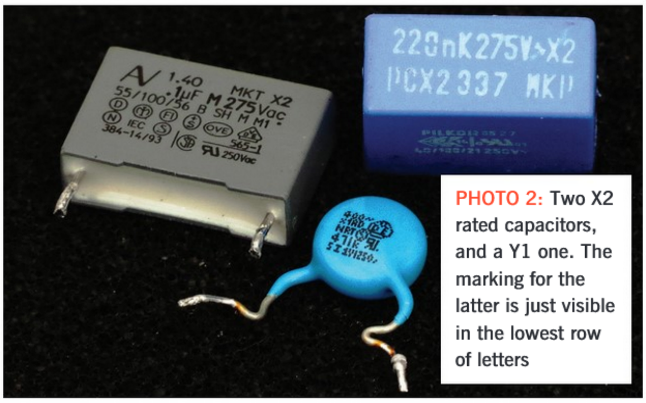

PHOTO 2: Two X2 rated capacitors, and a Y1 one. The marking for the latter is just visible in the lowest row of letters

Inverter drive for AC rotators

Older type antenna rotators such as the AR33 using AC synchronous motors often appear on the surplus market, sometimes without their controllers making them quite cheap to purchase. The motors usually run from 20-30V at 50/60Hz and have two poles with a capacitor switched between them to deliver a phase shift to one winding or the other to alter the direction of rotation as shown in **Figure 2**. Measuring one rotator showed that each winding had a DC resistance of about 2.5Ω with a reactance at 50Hz and no load of roughly 8-10Ω. The reactance measurement was very vague and the value varied considerably, downwards as the motor was loaded. The value of phase shift capacitor in most control boxes is typically in the region of 68uF and has to be an exotic non-polarised electrolytic. The reactance of this at 50Hz is 47Ω so it is clear the phase shift between the two windings when the motor is running is far from 90˚, with the current in each winding unequal; the motor is being driven very sub-optimally. What if a true 90˚ drive could be provided to each winding, using MOSFET drivers and Pulse Width Modulation? It ought to then be possible to run these rotators from a DC supply, which in turn can be derived from a 12V battery via a boost regulator module for portable operation. With a true 90˚ phase shift it should be more efficient.

PWM AC source

Ideally, AC drive using PWM would use a full bridge of four MOSFETs, two top and bottom supplying each side of a winding – otherwise known as an H-bridge as shown in **Figure 3**. This means four FETs in total for each winding. FET driver ICs exist for this very job; a full H-bridge driver can be found in a single chip such as the HIP4080. Full bridge operation means the DC rail represents the peak of the AC waveform, so to get $24V_{RMS}$ drive would require a 34V DC supply rail. This is perfect for a single motor winding (or a loudspeaker, or any load you want to drive with PWM generated AC), but for two motor windings like this the configuration cannot be used – the common connection gets in the way. What does work is a pair of half-bridge drivers with the common taken to the mid-point of a pair of capacitors across the supply rail for an AC ground; normal electrolytics are adequate. But a half-bridge configuration now means the DC supply rail becomes the peak-to-peak voltage of the AC drive, so that $24V_{RMS}$ drive now has to come from a 68V DC rail (24 * 2√2). That is a bit high for comfort but does the rotator motor really need the full 24 V_{RMS}, since it should now be operating with greater efficiency? The answer was to make a breadboard and try out what actually worked. A quadrature PWM-generated sinewave source already existed, as a baseband audio tone source for direct upconversion to RF **[2]**. The junk box yielded a pair of IR2104 half-bridge MOSFET driver chips [3]. This particular 8-pin chip is ideal for interfacing with the PIC as it has a common input that switches bottom and top FETs together, plus a separate shut-down input that turns both off. Other H-Bridge driver chips like the IR2105/6 are less suitable as they have separate inputs for switching top and bottom FETs and require either individual drive for each from the controller, or a separate logic inverter in hardware to drive both from a common signal.

As the PIC processor chip has an A/D converter on board this was used to read a potentiometer, allowing the drive frequency to be set arbitrarily in the range 30 to 85Hz. It was felt that being able to alter the drive frequency at will might show if operation of the motor at other than the normal 50-60 Hz may offer any benefit. The 18-pin chip has enough spare I/O lines left over to be used for an LCD module, so the drive frequency could be read out in real time. Another A/D input was used so the bridge supply voltage could be monitored without having to attach a separate DVM. The original sampling rate for the I/Q DDS was in the tens of kilohertz region, far higher than needed here. To generate only up to 85Hz for both the PWM and the sine lookup it could be as low as 1kHz. This low a switching frequency would minimise surface-current losses in the wires supplying the motor and reduce the potential for RF interference. To minimise the effort in re-writing code, the maximum 10-bit PWM resolution offered by the PIC device was retained, although such a high resolution sine wave is not needed here. The four IRF640 switching MOSFETs were also taken from the junk box. These are rated at 200 V with an $R_{DS(ON)}$ of 20mΩ so are somewhat over specified for this task, switching perhaps 1 – 2 Amps to the motor; they don't need to be mounted on a heatsink.

Power supply

Measurements on the original $24V_{RMS}$ supply suggested a current of up to around 2.5A – 3.5A in the common lead. This was with the non-optimal phase shift introduced by a 68uF capacitor. A proper 90˚ phase shift between the windings, 'ought' to lead to better motor efficiency and reduced current consumption, allowing lower drive voltage. Being able to vary the drive frequency either side of 50Hz might also help matters. Making a finger-in-the-air assumption that PWM DC-AC conversion with minimal resistive losses would be close to 100% efficient, that original current consumption suggested a DC power of up to 60 Watts for normal operation, about 1.2A from a 50V rail giving $18V_{RMS}$. A popular boost converter module available on Ebay uses the XL6009 chip in a ready to go module, specified for up

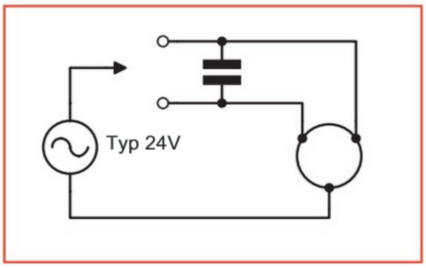

FIGURE 2: **Conventional capacitor phase shift used on AC rotator motors.**

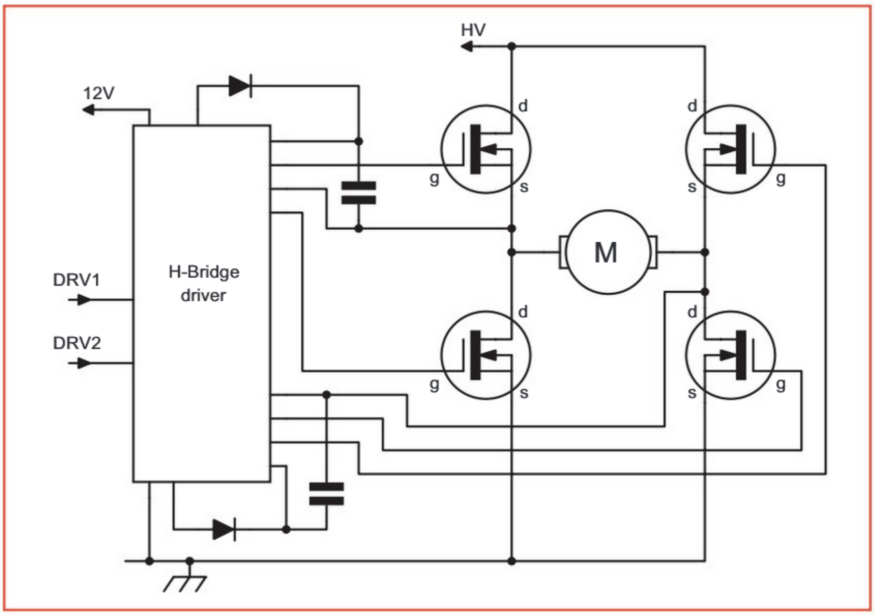

FIGURE 3: **Driving a single phase AC load using Pulse Width Modulation via a full wave or H-Bridge**

to 63V output, adjustable with a trim-pot **[4]**. The chip is rated for a switching current of 4A which at 12V input would yield only 48W at whatever supply voltage was selected, so barely sufficient – but a good starting point for test purposes. That chip has current limiting built in, providing protection from overload. Always a good thing to have when breadboarding!

Test results

Initial tests to find the optimum drive voltage and frequency were done on a rotator in the shack with no load. Unsurprisingly, the motor performed best with frequency set in the range 45-65Hz. Lower drive frequencies than 40Hz caused current to rise rapidly and the PSU go into limiting. Much higher than 70Hz and the current fell due to the increasing reactive component of the windings. The optimum frequency seems to be around 55Hz. The unloaded rotator worked perfectly well with 35V DC supply, equivalent to $12V_{RMS}$, drawing a current of around 1 to 1.5A *from the 12V input*. So, a far-lower power consumption than with the original capacitor phase shift. This rose to close to 3A with the rotator stalled against the end stops. Increasing drive voltage just caused a rise in current consumption with no obvious speeding up of the rotator. Torque, tested by grabbing hold of the moving assembly and trying to stop it by hand, was much improved by an increase from 35 to 40V. When used to drive the rotator up the mast with a 2.3GHz antenna on it, supply voltage was set to 40V. That rotator hasn't been serviced or lubricated for some time so may be a bit stiffer than the one used un-loaded for initial testing. It rotated satisfactorily with a current consumption from the 12V input of around 2.5-3.5A, sometimes running into current limit when the wind blew or some other loading appeared. It was clear the XL6009 module was working only just within its capabilities and would probably be pushed if a heavier antenna load were to be placed on it. The FETs are being very underrun in this situation. Even with no heatsink they barely rose above room temperature after several minutes of rotation testing. The 2200uF capacitors did get slightly warm. The ones used are a couple of decades old, designed for SMPSU output filtering, so are low ESR for that era, but their age makes them probably not perfect for this task. But they did the job.

Conclusions and further development

This module has so far been tested with just lightweight antennas although the FETs are capable of switching a higher current if the power supply current rating is increased. A higher drive voltage up to 50-60V could be used if necessary, generated from a suitably rated boost converter. More details, including speed control options will appear next time.

Silicone sealant

The topic of silicone sealant and RF cropped up on the GQRP thread. John, GM4EIW asked "I'm making a Flarm extension antenna and I would like to use clear silicone sealant in the mount surrounding the antenna. Is silicone impervious to RF? I'm sure somebody will have experience, it operates at 860MHz". Mark, G0NMY replied "One issue we found (in the past), silicone sealant gives off an acidic oil film as it is curing. This can lead to corrosion of copper in coaxial cable etc. We had a few failures as one installer kept injecting silicone sealant into the drop box thinking he was waterproofing. Which being honest you would think the same. If you lick your finger so you can smooth out the silicone (stops it sticking to your finger) then lick the same finger again, you get a salty taste. I recently saw a video on YouTube of a ham who had acquired a used 70cms Parabeam antenna and the feed point had been filled with silicone and left. Over the years the metal connections inside had corroded quite badly. Anyway, just be aware of this issue. I'm not sure if it's all brands of silicone but it's worth knowing." Neil, G4DBN then commented, "Neutral cure sanitary silicone without antifungal preservative doesn't liberate acetic acid at all. Avoid RTV. Neutral cure versions usually liberate various alcohols. Use clear or translucent rather than white or brown as the filler might be something less good as a dielectric than titanium dioxide. The loss tangent of the clear sealant I use is better than many plastics and only ten times worse than PTFE / Rexolite / UHMWPE. It has a relative permittivity similar to polystyrene. I use it at 5.7 and 10GHz to seal Rexolite lenses into waveguide so I think it's fine for use at VLF through to SHF. Not sure about DC creep effects, so avoid fields of kV per mm! Most neutral cure silicones use an oxime cure with something like butanone oxime to make the polymethylsiloxane polymers."

References

[1] X/Y capacitors https://www.allaboutcircuits.com/technical-articles/safety-capacitor-class-x-and-class-y-capacitors/

[2] PIC PWM I/Q DDS Design Notes, RadCom October 2022

[3] Beware, the HIP2104 device available from the same suppliers as the IR2104 is also a half bridge driver, but a completely different chip with different connections unsuitable for use here. It is unusual to see similar type numbers used for different devices aimed at a broadly similar task.

[4] Search "XL6009 Boost converter".

Review

Begali CW Machine

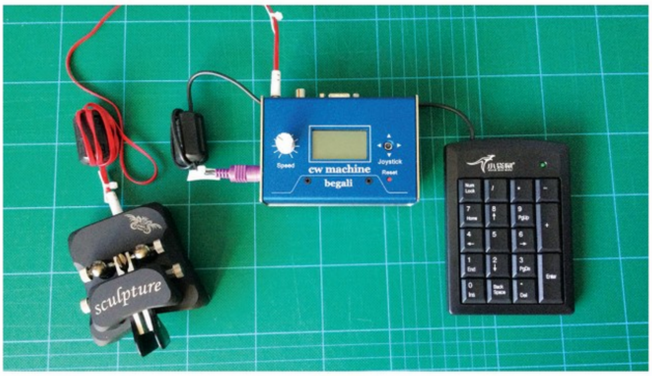

PHOTO 1: **CW Machine and peripheral devices.**

PHOTO 2: **CW Machine, front view.**

The Begali CW Machine is not a new product but is, perhaps, not as well-known as it should be. It appears on the Begali website [1] where it can be purchased. It is made in the USA by Ulrich Steinburg, N2DE from where it can be shipped anywhere in the world. Ulrich has been continuing its development for more than ten years.

What is the CW Machine?

The CW Machine has been described as a system, such is its range of functions. There is probably no single function of the CW Machine that cannot be found elsewhere. Somewhere one or another feature may be found in other hardware or software. What is special, though, is that here it is all packaged and integrated in a single device. And that is what makes it unique.

Physically, it is a single device in a metal enclosure measuring about 113mm x 78mm x 32mm (4.5"x3"x1.25") with four rubber feet (see **photos 1** and **2**). The controls are well spaced on the front panel with a keyboard socket on the left-hand side of the enclosure. The remaining connectors are spread across the top of the unit (see **photo 3**).

It is solidly made, weighing in at 300g.

The hardware supplied includes a PS/2 numeric keypad and a key cable, plus an optional COM-to-USB connector. When using the USB connector and a computer, the device is powered by the computer. Otherwise, a nominal 12V DC supply is required, terminated in a 2.5mm barrel connector. 9-25V is stated as its limits, and it runs happily on a 9V PP3 battery. Once powered up, my CW Machine was fully operational without the need to install any firmware. There is no power switch and, when connected to a power source, the CW Machine activates on a touch of its joystick or a tap on the left paddle of an attached Morse key. It draws about 20mA in normal use and shuts down when power is removed. There is an internal lithium battery (CR2450) which will keep the clock running when removed from external power.

Its functions are wide ranging, and may be categorised as follows:

- iambic memory keyer
- keyboard keyer
- CW Trainer
- remote keyer
- contact logger

The CW Machine is extensively documented, with over 200 pages of documentation provided in PDF format. It is supplied with a number of options, all of which are firmware defined. My own choice was to opt for the CW Trainer, alongside the standard keyer and logger functions. The device was supplied with a CD with current firmware releases, two Windows applications – CW Machine Manager and CW Trainer Manager, plus these PDF manuals:

- CW Machine
- CW Machine Hardware
- CW Machine Manager – user guide for Windows
- CW Training – user guide

There is also an interesting and useful short book included. It is a PDF called *Learning CW with the Begali CW Machine*. This is by Carlo Consoli, IK0YGJ, author of *Zen and the Art of Radiotelegraphy*.

Why would you buy the Begali CW Machine?

My opening comment probably explains why a Begali CW Machine is a good purchase: it does everything you will need, whether you are a beginner, an improver or an expert. And whether you are operating at your main station, out portable or working remotely.

It is clear that over a number of years, N2DE has not simply refined the CW Machine, he has added so many small yet valuable touches. For instance, in copy training mode the pause function – common to most trainers – can additionally stop, backing up a word. This is so useful, without fiddling to find the start of the missed word.

Availability may be a consideration. At the moment, a number of USA-produced products, like K1EL's WinKeyer are not available in UK – and some are unavailable for delivery in the rest of Europe. N2DE ships anywhere, worldwide.

In operation the CW Machine is connected to peripherals: the supplied keypad, or a user-provided PS/2 full keyboard and a Morse key – which may be a twin paddle or single paddle side-to-side key, a cootie or a straight key. It can be connected to a DC power source and an external speaker or headphones for local sidetone. The output is sufficient to drive a small speaker and, with headphones, needs the volume turned down for comfort.

The system can also be connected to a Windows PC. This allows the user to operate the CW Machine using the Windows GUI. I have used CW Machine Manager and CW Trainer Manager on both Windows 10 and 11. The software front-end is not available on other operating systems.

PHOTO 3: CW Machine, top view.

PHOTO 4: CW Machine on a 3D-printed stand.

To review its use, it may be better to divide operation of the CW Machine into three parts:

- keyer options
- trainer functions
- operational support

Keyer options

The CW Machine Keyer was the first aspect of the system developed by N2DE. Its functions may all be accessed with the CW Machine in standalone mode, allowing it to both replace and surpass a more familiar electronic keyer. It can also be used in real-time with the CW Machine Manager application on a PC.

Set-up is straightforward using the Windows application. I would not attempt the task without it.

The configuration of the CW Machine can be completed for two different identities, making its functions available in different formats. This is clearly useful if two operators are using the CW Machine; it is also a real benefit when operating both at base, in the shack, and portable. Alongside the usual, unremarkable keyer settings found on almost every keyer, the CW Machine includes sophisticated message memory options.

The development of the message facilities includes another of the satisfying tweaks added by N2DE: tapping the dot key on the keypad sends the active identity's callsign. A useful touch when calling into a pileup.

CW Machine stores QSO data – these become fields populated in the QSO log, described separately – which are available for insertion into messages in real time. So, a QSO partner's name, QTH or RST report can be inserted into a previously-stored message stream, for example. Additionally, code keyed by the operator is merged into the sent stream, providing complete flexibility. A full keyboard can also be used with the CW Machine but I have not tried that option. The numeric keypad is used to initiate stored messages streams which, with only a little practice, works quite intuitively.

While using the CW Machine Manager, the whole process is displayed in the monitor window. In standalone mode, the characters scroll across the LCD display.

Trainer functions

CW Machine Trainer has all the options you will expect in such a system – code speed, Farnsworth spacing and so on. It paces your progress up to a maximum of 75wpm which, at my age, I will probably never achieve now!

Configuration is easily completed using the CW Trainer Manager application on Windows. Training materials are divided into ten lessons, each lesson consisting of ten messages, or strings of characters. Each message may be text, numbers, letters, callsigns, punctuation, pro-signs and special characters. Once set up, the CW Machine can then be used with a PC connection or without, in standalone mode.

While connected to a PC the CW Trainer Manager monitor window shows all code as text, generated by CW Machine or keyed by its user. As expected, a timer runs during each lesson.

In Flash Card Mode, CW Machine will send words which remain hidden for a short while, advancing head-copy. This is also extended to allow the user to copy a word, then echo it on the key. If correct, a satisfying beep confirms the word and CW Machine moves on to the next. Otherwise, it resends the word for another attempt. This seems an exceptionally powerful way to develop conversational copy and improve sending in a single exercise.

Operational support

The CW Machine Logger is, I think, unique amongst standalone keyers.

The log is created in real time, during QSOs, and stored in non-volatile memory. The CW Machine can store up to 12,000 QSO records and these are available as ADIF files on demand. Reassuringly, the log data are stored in non-volatile memory which is secure, even when the CW Machine is disconnected and the internal battery removed. There are both import and export options available when connected to a PC. Upload to LoTW and eQSL is thus straightforward when the PC is connected to the internet.

The logger works very simply – in fact it is probably more complex to explain than it is to use. Certainly, using the logger with the Windows application to start with is a big benefit; once familiar then standalone mode is no problem at all. In summary, two modes are available:

- automatic logging
- offline logging or *quiet mode*

While automatic logging is enabled information is captured automatically by the CW Machine during the QSO. It is possible, too, to record this information into the current log entry by sending it with your paddle or entering it using a keyboard. Quiet mode, which disables transmit while selected, is chosen with a single keystroke on the numeric pad, allowing keyed characters to be stored in the log record.

When a callsign is recognised from a previous QSO, the CW Machine will pre-populate fields for the log. This works differently in *contest mode* and *non-contest mode*, which may be beyond the scope of this review.

The completed log entry is written to memory by sending the pro-sign SK as you might at the end of a QSO, or entering # on the keypad.

The CW Machine also supports remote operation – an option requiring additional software. This allows a transmitter to be keyed remotely peer-to-peer, using two CW Machine devices, or integrating with other software or

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transceiver firmware, using a single CW Machine. Remote Operation is an advanced application of the CW Machine, beyond the scope of this review.

In conclusion

Pietro Begali, I2RTF has established a global reputation for design and engineering excellence. Bruna complements the hardware with excellent customer service – genuine, old-fashioned customer care. So, Ulrich, N2DE has high standards to meet, which he does, completely.

The Begali CW Machine meets a diverse range of needs. It provides a useful, richly-featured keyer for use on the air, alongside a real-time logger. It is also a complete Morse trainer, not simply for beginners and improvers: CW Trainer provides opportunities to stay sharp and maintain comfortable QRQ, if that is your choice.

On the cons side, the LCD is very small, although it is adequate.

Older versions of the CW Machine were built into a larger housing, having a sloped front panel which made the LCD easier to read and the controls more convenient to operate. Ulrich suggests using cheap notebook PC flip-up stands, a solution which seems to work well. Before I had his suggestion, however, I 3D-printed a stand which utilises the CW Machine's screw-on rubber feet for attachment and provides a convenient, sloping front panel (see **photo 4**). I can provide a .stl file to print this, on request.

The provision of a serial port – requiring a serial-to-USB adaptor for most users these days – may be criticised. As may the PS/2 keyboard connection. It has not been a major issue in practice. The peripherals connection and PC functionality has been faultless. But, perhaps, the physical connections may be a consideration for a future hardware revision.

Because it has such a diversity of features, using the Begali CW Machine takes a new user up a steep learning curve. Most aspects are, in fact, quite intuitive but taking a glance at the manual is certainly a good idea. Using the system in standalone mode, without the feedback provided by the Windows Manager applications, is only really viable once the learning curve has been climbed. In a live QSO, familiarity with the CW Machine is an essential alternative to chaos. Although, even then, simply reverting to the basic keyer functionality – and ignoring all of the available sophistication – makes it a pleasure to use anyway.

At GBP £275 ($340) it is not a trivial purchase. It is, however, worth the investment and fulfils the roles of several other single-function devices in one package.

CW Machine is sturdily made and seems reassuringly reliable. In use I have found nothing that I wanted it to do that it didn't. It is also exceptionally well supported and Ulrich seems to be always available, answering questions both promptly and clearly.

References

[1] http://www.i2rtf.com/cw-machine.html

Contest Calendar April 2023

Ian Pawson, G0FCT

RSGB HF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Sat 1 Apr	FT4 International Activity Day	0800-2000	FT4	1.8-28	Report
Mon 3 Mar	80m Club Championship	1900-2030	CW	3.5	RST + SN
Wed 19 Apr	80m Club Championship	1900-2030	SSB	3.5	RS + SN
Mon 24 Apr	FT4 Series	1900-2030	FT4	3.5, 7, 14	Report
Thu 27 Apr	80m Club Championship	1900-2030	PSK63, RTTY	3.5	RST + SN
Sat 29 - Sun 30 Apr	UK/EI DX CW	1200-1200	CW	3.5-28	RST + SN (UK/EI also send District Code)

RSGB VHF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Tue 4 Apr	144MHz FMAC	1800-1855	FM	144	RS + SN + Locator
Tue 4 Apr	144MHz UKAC	1900-2130	All	144	RS(T) + SN + Locator
Wed 5 Apr	144MHz FT8 AC (4 hour)	1700-2100	FT8	144	Report + 4-character Locator
Wed 5 Apr	144MHz FT8 AC (2 hour)	1900-2100	FT8	144	Report + 4-character Locator
Tue 11 Apr	432MHz FMAC	1800-1855	FM	432	RS + SN + Locator
Tue 11 Apr	432MHz UKAC	1900-2130	All	432	RS(T) + SN + Locator
Wed 12 Apr	432MHz FT8 AC (4 hour)	1700-2100	FT8	432	Report + 4-character Locator
Wed 12 Apr	432MHz FT8 AC (2 hour)	1900-2100	FT8	432	Report + 4-character Locator
Thu 13 Apr	50MHz UKAC	1900-2130	All	50	RS(T) + SN + Locator
Tue 18 Apr	1.3GHz UKAC	1900-2130	All	1.3G	RS(T) + SN + Locator
Thu 20 Apr	70MHz UKAC	1900-2130	All	70	RS(T) + SN + Locator
Sat 22 – Sun 23	MGM	1400-1400	MGM	50, 144	Report + 4-character Locator
Tue 25 Apr	SHF UKAC	1830-2130	All	2.3G	RS(T) + SN + Locator

Best of the Rest Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange (Info)
Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange (Info)
Sat 1 - Sun 2 Apr	SP DX	1500-1500	CW, SSB	1.8-28	RS(T) + SN (SP send Province code)
Sun 2 Apr	UKuG Low Band	1000-1600	All	1.3G-3.4G	RS(T) + SN + Locator
Wed 5 Apr	UKEICC 80m	2000-2100	SSB	3.5	6-character Locator
Sun 9 Apr	WAB Data	1000-1400, 1700-2100		Data	3.5-14 RST + SN + WAB (two periods)
Mon 10 Apr	IRTS 70cm Counties	1300-1330	FM, SSB	432	RS + SN (EI & GI also send country)
Mon 10 Apr	IRTS 2m Counties	1330-1500	FM, SSB	144	RS + SN (EI & GI also send country)
Sat 22 - Sun 23 Apr	SP DX RTTY	1200-1200	RTTY	3.5-28	RST + SN (SP send Province code)
Sun 23 Apr	BARTG Sprint 75	1700-2100	RTTY 75Bd	3.5-28	SN
Wed 26 Apr	UKEICC 80m	2000-2100	CW	3.5	6-character Locator
Sat 29 - Sun 30 Apr	UK/EI DX CW	1200-1200	CW	3.5-28	RST + SN (UK/EI also send District Code)

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