PRACTICAL WIRELESS

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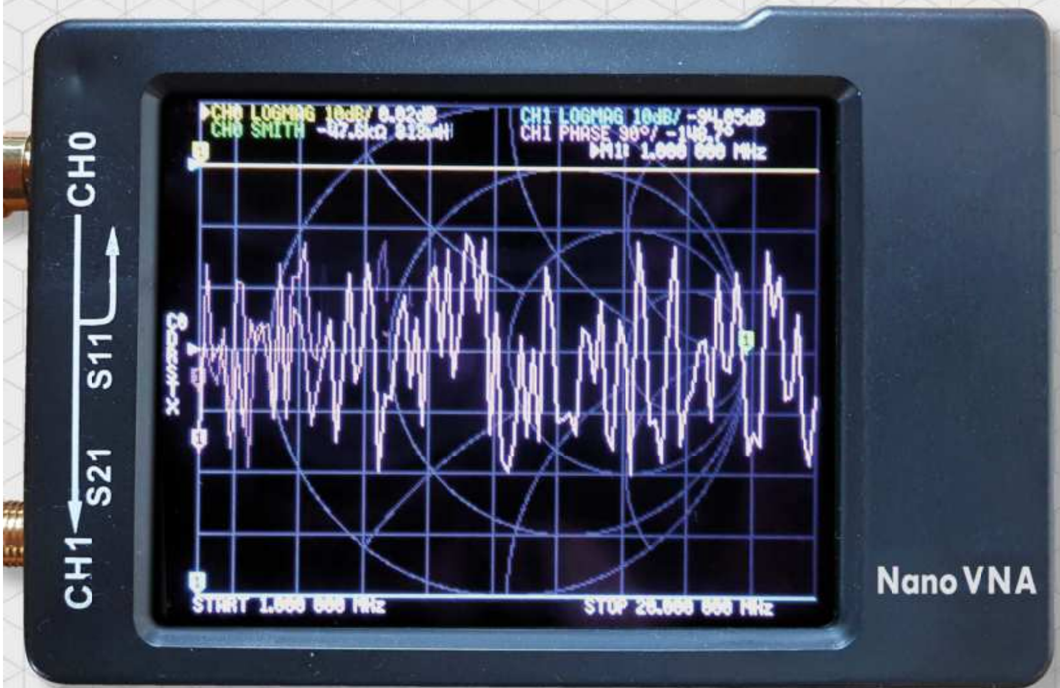

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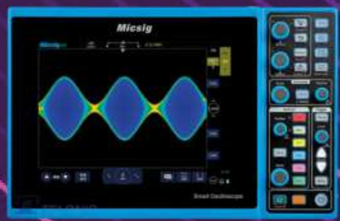

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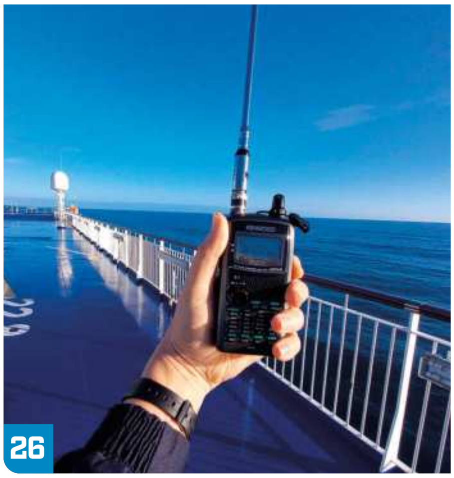

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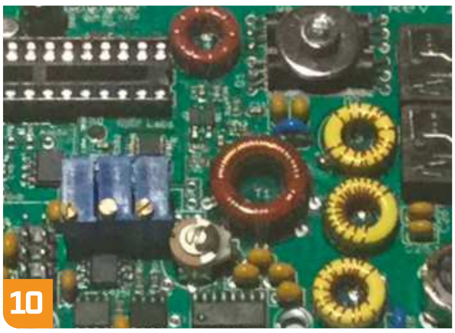


Keylines

Most readers will, during the past month, have received a missive from Ofcom by email, headed '*Important Message About Your Licence*'. Indeed, if you didn't receive it, then your email address with Ofcom is probably incorrect.

What's it About?

The email sets out Ofcom's requirements with respect to non-ionizing radiation, to follow the guidelines of the International Commission for Non-Ionizing Radiation Protection (ICNIRP). The impetus seems to be concerns stirred up by the press regarding the introduction of 5G but the rules are being applied to all radio users.

The RSGB has been in discussions with Ofcom about this for some time and has published some guidance in *RadCom*. But the email has caused shockwaves throughout the hobby. Ofcom guidance is set out in the document referenced below and is far too extensive to reproduce here. The first thing to note is that, for now at least, none of this applies to frequencies below 10MHz and neither does it apply to those using less than 10W Effective Isotropic Radiated Power (EIRP). The document includes a flowchart to help you ascertain the safe levels for your station, which will depend on the frequency, power and antenna. Which means that you may need to make multiple assessments depending on how many bands you use, whether you change your antennas from time to time and so on.

tinyurl.com/ofcom234

What to Do?

All this is off-putting and worrying. The RSGB has come under criticism for having failed to dissuade Ofcom from issuing these rules but the simple fact is that Ofcom have decided to apply them to all radio users. At least the RSGB has been involved, Ofcom has issued guidance specifically for amateur radio operators and the RSGB is recognised as a competent organisation to give advice on pre-assessed configurations. In contrast, for example, the Light Aircraft Association is incensed that they were not consulted, while all their members with radios fitted in aircraft have received the same communication. And as for small boat owners, one wonders how they are supposed to assess the risks of transmitting when, for example, entering or leaving harbour, the very time when they need to use their radios.

The situation rather reminds me of the introduction of GDPR, where radio clubs went to a lot of trouble to meet its requirements, frightened by the massive fines that were threatened, whereas in practice I know of no voluntary organisations that have been targeted. Nevertheless, it behoves us to make the necessary assessments and maintain a record ready for possible inspection. The UK is not the first country to ask its radio amateurs to assess the radiation from their antennas – Germany and France do, for example. However, the Ofcom requirements appear to be the most demanding.

To aid in assessment, the RSGB has developed a spreadsheet into which we can put our data although at the time of writing there seem to be concerns about its validity. There is time but not a lot – the new rules come into effect in May and we have six months to complete the assessments for frequencies above 10MHz and 12 months for frequencies below 10MHz. However, as it says in the latest issue of *RadCom*, there is still lots of work to do for acceptable methods to be defined and for the amateur radio community to make its assessments.

The irony in all this, of course, is that mobile phones are exempt and yet most people spend large amounts of time holding them next to their heads while emitting significant amounts of power at gigahertz frequencies!

Meanwhile, we at *PW* will monitor the situation closely and endeavour to keep readers up to date with developments.

Don Field
Editor, *Practical Wireless Magazine*

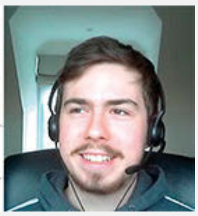
Newsdesk

Have you got something to tell our readers about? If so, then email **practicalwireless@warnersgroup.co.uk**

New from ML&S

ML&S have introduced a new bespoke design for the IC-705, the MyDEL IC-705 Carry Cage. The all-alloy precision engineered carrier wraps around the entire body of the radio giving it strength and protection in one. Add to that a built-in carry handle, removable side protectors, all in a smooth hard black satin anodised finish.
Available from stock at £139.95, inc VAT: **HamRadio.co.uk/Cage**

A very good customer of Martin Lynch kindly donated his Yaesu FT-991 to a special young radio amateur. **Tony M0TNY**, ML&S sales manager, put forward **Arved Viehweger M0KDS**, a 19-year old member of YOTA *(Youngsters on the Air)*, who has won various awards, builds his own equipment and is totally immersed in amateur radio. If you wish to view the interview by Tony on their MLandS.tv channel, it appeared in February.



RALLY NEWS: Unsurprisingly, the Dartmoor Radio Rally planned for 3 May (Bank Holiday Monday) has been cancelled due to Covid Restrictions. Also cancelled is the Hack Green sale that was scheduled for 18 April. However, there is a date for the next sale, which hopefully can go ahead on 17 October. And after deep consideration, the Cockenzie & Port Seton Amateur Radio Club have decided to cancel their Mini-Rally planned for 13 August.

SPECIAL EVENT CALLS FOR AGCW: 1 May is the 50th anniversary of the German Telegraphy Club AGCW, a well-known and very active CW club: **http://agcw.de**
Several European CW clubs will collaborate to celebrate this together with the AGCW. The Netherlands will be represented by the Netherlands Telegraphy Club (NTC) which will activate the callsign PA50AGCW during the month May. Expect special calls to be active from other countries too.

GQ EMF 390

With the requirement for radio amateurs to measure the EMF of their station, Moonraker offer the GQ Electronics Multi-Function EMF Meter.
The EMF-390 is designed to be portable. The device integrated testing features include three axis Electromagnetic Fields, Electric Field, Radio Frequency and Radio Spectrum Power Analyser. The meter is able to identify the common source from EMF measured, such as Power Line, WiFi, etc. It also comes with built-in audible and visual alarms. It can be used for EMF, EF, RF and 5G network detection and monitoring both indoor and outdoor (protected), as well as in other similar environments. It can continually monitor the radiation. When connected to a PC, PC software can download the radiation data to the computer and the user is able to analyse the data later.
GQ RF Browser is specifically designed for amateur radio, cellphone, Cell Tower, Smart Meter and WiFi RF radiation monitoring. The safety suggestion indicator provides a simple and easy way to understand overall radiation risk.
£119.99 from Moonraker: **www.moonraker.eu**

Read more radio news and reviews at www.radioenthusiast.co.uk/news

NORTH WALES RADIO GROUP: The NWARG have been very fortunate throughout the recent lockdown situation in that its members have been and still are very active and enjoying their hobby and communications among their fellow club members and other radio amateurs far and near.
Special event stations have also been organised for 2021 and the Group is certainly hoping that these will take place and UK lockdown restrictions will be lifted to enable other Group meetings to take place throughout the course of the year.
Once news broke out of the sad passing away of Captain Sir Tom Moore. A special event station with callsign GB1STM was immediately set up on 5 February till 5 March, and NWARG members made many contacts to stations across the world in memory of this remarkable man.
Another important achievement in recent months is the massive organisation and dedication in setting up a UHF Repeater on the summit of the Great Orme in Llandudno. The Llandudno Repeater Group was formed and after many months of organisation mainly from NWARG Secretary Sandra MW6ACZ and Committee member/Professional Aerial installation rigger Ted MW6ADF, GB3OR was fully operational on 9 February, see photo.
The NOV holder John Pritchard MW0JWP, made the first QSO to Ted Pierce MW6ADF on what was a very windy day high up on the Great Orme Summit Complex looking out over Llandudno Bay.
This incredible team effort from all club members has certainly achieved a milestone in the history of the NWARG, especially during this lockdown, as more amateurs are now able to access the 70cm band from most parts of the North Wales coast and out into Merseyside. GB3OR is proving to be a major success and forming more friendships through communications than ever before.
NWARG weekly nets are now being conducted and are proving to be a major success, with an increasing number of amateurs getting involved: Sunday 2pm, 3770kHz plus or minus 10kHz, Sunday 7 to 8pm, GB3OR, Weds 7 to 8pm, GB3OR Fusion, Thursday 7 to 8pm, GB3OR

NEW RSGB VIDEO SERIES: Have you passed your licence exams during lockdown? Would you like to learn some useful practical skills to help you make the most of your licence? Whether you're a new Foundation, Intermediate or Full licence holder, the RSGB has created a series of six videos that introduce you to some of the most common amateur radio construction skills you will need. You could construct a simple balun, tune a dipole using a NanoVNA or create an audio interface between your transceiver and your computer to allow you to send and receive data modes. Whatever type of practical skill you would like to try, there is something here to inspire you. The videos get more detailed through the series with a growing level of skill required.
A big thank you to Dominic M0BLF, Rob M0VFC, Nick 2E0FGQ and ESRG member Greg M0ODZ who helped to create these videos. Thanks also to Henry-James M7HJR, Lee M7MUT, Jenny M6JUT and Dave M7WUT who volunteered to learn the skills via remote teaching during the current lockdown. The videos link with British Science Week and the Society's ongoing 'Get on the air to care' campaign with the NHS – supporting wellbeing among the radio amateur community during the ongoing restrictions when radio amateurs can't meet up. They will also add to the RSGB's existing Beyond Exams suite of resources that help radio amateurs discover the diversity of amateur radio.
www.rsgb.org/practical-skills

FRANCE OVER HAULS AMATEUR RADIO TESTING: (from *Amateur Radio Newsline*) Regulators in France have announced major modifications to the nation's amateur radio exam. The government's official journal has released an outline of the changes, which were eight years in the making. France's radio exam contains 40 questions with a total time limit of 45 minutes, combining technical theory with rules and regulations. The material in France's only level of amateur radio licence is compatible with CEPT HAREC full licence requirements and a recent addition to the syllabus are questions on digital signal processing. Candidates need to get at least half of the questions correct in both the technical theory segment and the rules and regulations segment to attain a pass.

CLUB NEWS: CDXC – The UK DX Foundation will be holding its annual convention and AGM online this year. The convention will be held using Zoom on the afternoon of Saturday 8 May starting at 14:00 BST. There will be four excellent talks and there is time for Q&A after each one.
The event will be free to all members and non-members but you will have to provide your own tea and biscuits! They will have Zoom capacity for every member to 'attend' but would like to encourage non-members to view via a live YouTube stream. Full details of how to register for members on Zoom, the live YouTube link, and the event timetable will be on the CDXC website nearer the date:
www.cdxc.org.uk
As last year, the CDXC AGM will be held online again for members to participate. Papers will be available on the website from 30 April when voting will open. Voting will remain open until 23:59 BST 7 May 2021 and results will be announced at the online convention on 8 May and published online later that day. A report on the AGM will appear in the July Digest. Contact:
Chris@G3SVL.com
The Cockenzie & Port Seton Amateur Radio Club are holding their club nights on the first Friday of the month via Zoom for the present. On Friday 23 April this will be a talk on Large Scale Software Defined Radar – A Practical View by Simon Brown MM6OXH (who is based in the extreme north of Sweden working on that particular project). This starts at 19:00. The meeting ID is 511 859 4062 and the passcode 763211.

AH-705 HF/50MHz Automatic Antenna Tuner

Icom have announced that the Icom AH-705 automatic antenna tuner for the IC-705 is now available from Icom UK dealers. The AH-705 is a small portable antenna tuner that has been designed to work between the 1.8-50MHz bands. It can be powered either by alkaline batteries or DC 13.8V supply.
The AH-705 has a suggested retail price of £309.60, including VAT.

QCX Mini

Daimon Tilley G4USI builds the latest incarnation of the QCX transceiver.

Daimon Tilley G4USI
practicalwireless@warnersgroup.co.uk

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In the October and November 2019 editions of *PW* I undertook a review of the construction and use of the QCX transceiver – a kit of parts provided by **Hans Summers G0UPL** of QRP Labs. It was a very enjoyable build and an absolute joy to use for CW on the 40m band.

Since then Hans has been keeping busy and has retired the original QCX. In its place first, came the QCX Plus – a pretty much identical circuit but with a different layout, bigger PCB and a nice custom case. The Plus is, in my view, better suited for both those amateurs whose eyesight and fingers might be failing them, and also for anyone who wants to have a QRP rig that is ideally suited for shack use. It looks and feels like a more conventional rig, with controls on a front panel and all connectors on the rear. Usefully, it also added ports for CAT control and PTT.

If I am honest, I was initially a bit disappointed. I had been toying with the idea of another QCX for 20m, but the Plus did not suit my use case – I wanted it for portable and SOTA-type working out and about. To me it made more sense for the QCX to get smaller rather than larger. Apparently, a number of other radio amateurs felt the same way and mentioned this to Hans. Ever responsive, Hans responded with the subject of this article – the QCX Mini.

The Basics

Once again, the basic circuit and features remained identical to the original, keeping the useful PTT and CAT ports from the Plus too. However, the secret sauce in this recipe was the move to many components being surface mount devices (SMD). This has two advantages, the first is the ability to reduce the size of the overall package with smaller PCBs, but also, as many components are already fitted, there are far fewer components for the constructor to fit themselves, speeding up the build time.

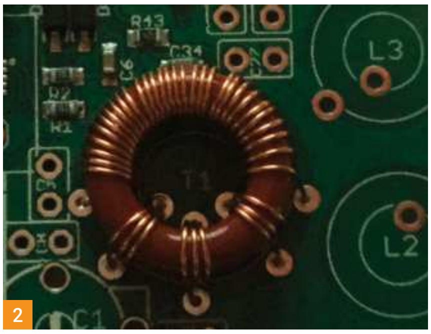
I had spotted on social media that Hans had announced a release date for the batch of the first 1,000 devices, and a date and time was announced for their release for sale. I knew that I wanted one as soon as I saw the photographs and the appointed time and date was duly entered into the diary. When 7pm on the appointed day arrived, I was already on the site, and had completed the order form, waiting for the clock to tick over, pressed 'Buy Now' and a QCX Mini was mine for the princely sum of £40. I spent an additional £14.50 on the (very nice) aluminium case and £6 on the TCXO option. Finally, there was an £8.74 courier charge – just over £68 in total.

I am really pleased Hans has shifted to courier delivery. Readers of my original article will recall that a combination of Turkish post and British Customs led to a wait of nearly four weeks for the original QCX. Within the week my mini had arrived.

Opening the Box

I opened the box eagerly and then realised just how mini the Mini really is. It is about the size of a pack of playing cards or a small mint tin. The overall dimensions are 9.5 x 6.3 x 2.5cm (3.7 x 2.5 x 1in) and it weighs just 202 grammes (7.1 ounces). The other 'mini' aspect is current consumption – Hans has got this down to just 72mA with the display backlight on and just 58mA with it off, with a 12V supply.

The second thing that struck me was how pleased I was to have ordered the optional case too. In my original article, I didn't order the after-market case as it was almost as expensive as the radio itself and I wanted to include a battery pack in the case. On this occasion however, I wanted to make the most of the small size and so opted to build an external battery pack. In this fashion, I can foresee that I might build more Minis for different bands and could take several with me on a trip out (COVID permitting!) with a single battery pack.



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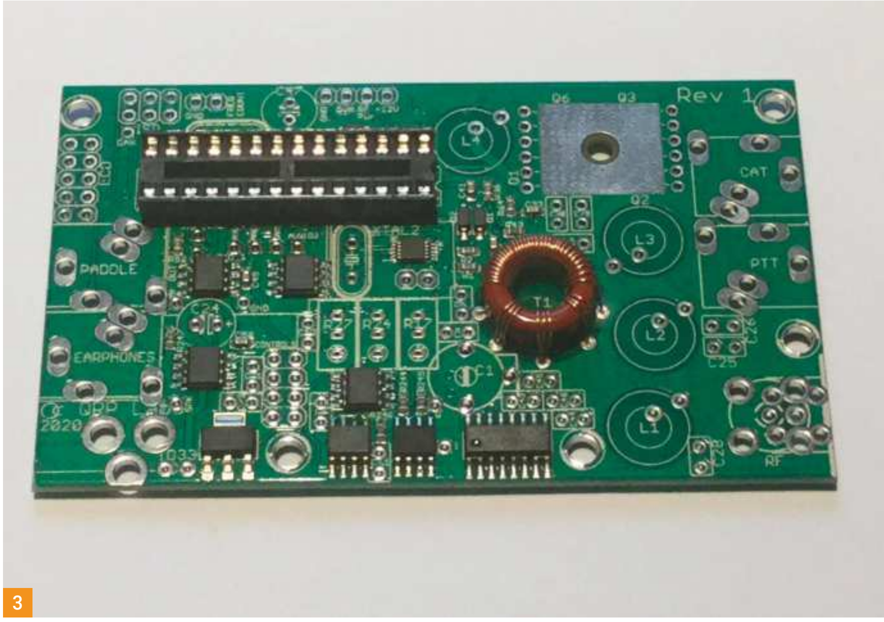
A quick check against the excellent and comprehensive online instructions showed that all components were present and correct, and the package was duly put to one side pending the Christmas break, when I hoped (having been temporarily released from home-schooling duties) to have the time and inclination to undertake the build.

Photo 1: QCX Mini on arrival. Photo 2: T1.
Photo 3: Main PCB with T1 installed.
Photo 4: Unorthodox mounting of rotary encoder.
Photo 5: Using scraps of lead to connect the LCD display.
Photo 6: The main board complete except for the ATMega.
Photo 7: The capacitor mod for the voltage regulator (see text).
Photo 8: The main board fitted in the case.
Photo 9: Using an electrostatic bag for insulation.
Photo 10: Complete and sending the first CQ.
Photo 11: Early results as seen on WSPR.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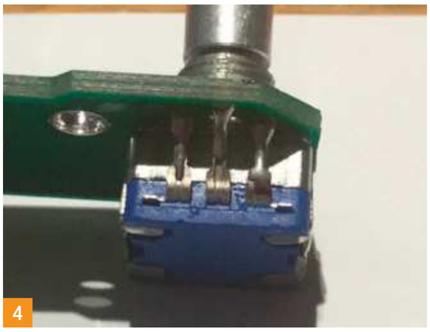
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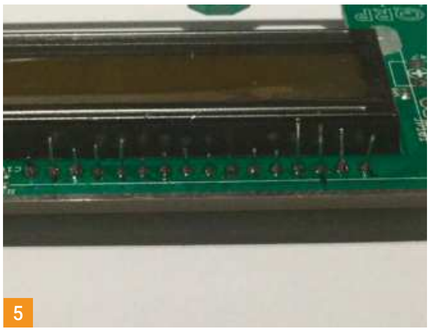
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However, I decided that Christmas was actually the time to relax and do other things, so it wasn't until the New Year when I finally decided to undertake the build.

In some senses I am pleased I waited. It became apparent through social media and the constructors' forum that there were a few potential problems with the first batch. In particular, a number of users reported that rapidly cycling power could cause component failure. Hans responded quickly and it was determined that the installed SMD capacitor for the voltage regulator was not up to the job, and a quick fix was found – the addition of a (small) 10μF electrolytic or tantalum capacitor soldered to existing components. Hans offered to send anyone who wanted one a suitable capacitor at his expense (with postage that could run to quite a bit) but in the true spirit of amateur radio, most of us either found one in the junk box or ordered one from a local supplier. The physical size of this capacitor is actually more important than the value, as it needs to nestle on the surface of the board in a gap between components. More of this later. Since the first batch of 1,000 units, Hans has made some component changes and, I believe, also changed his board supplier to improve quality. The first batch sold out very quickly, and currently (early February) you have to back-order for delivery of the second batch.

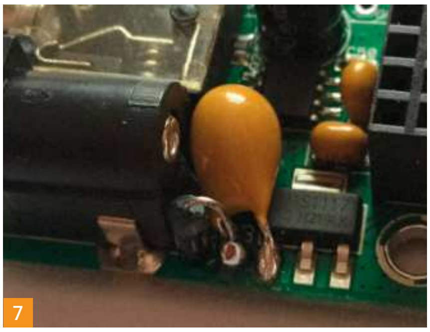
The Build

So, on to the build itself. As described earlier, there is less for the constructor to do on this build than with the previous versions, but the size did make it rather more fiddly. Of course, there is still the pleasure of winding transformer T1, the fiddliest part on my original build, but in this version other aspects were to prove equally fiddly!

One of the first instructions in the manual is not to throw away the clippings from component leads – a number of them are used later to connect the LCD display to the display PCB and, when I got to this stage, this was fiddly too, with it being especially important to ensure that they were clipped as short as possible after soldering, as there is just a tiny amount of clearance between the PCB and the aluminium case.

My kit was supplied with PCB stand-offs but, presumably due to supply issues, the stand-offs were plastic but the nuts were

"There is less for the constructor to do on this build than with the previous versions, but the size did make it rather more fiddly"



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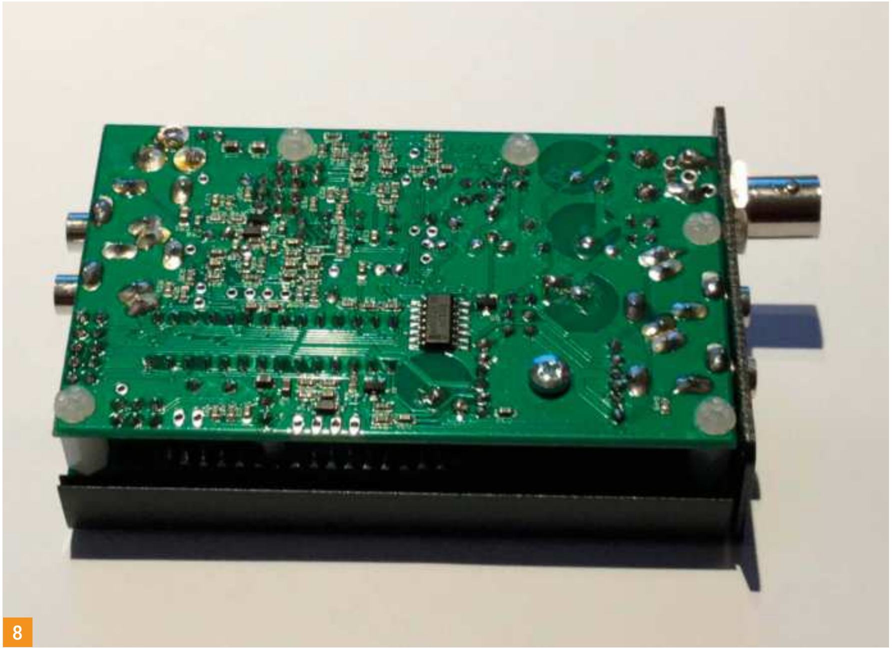
metal and this made for a few difficult moments matching the threads without crossing them. Having checked the inventory list originally, once I started the build I realised that a set of 2x4 header pins were missing. Thankfully, the parts bin in the shack held plenty from Arduino projects so these were quickly replaced.

Mostly construction passed off without incident, even though there is some unconventional mounting of components such as the rotary encoder, for example, where you bend the solder tags back through 180°, soldering them to the surface of the board rather than through-hole. Similarly, the gain potentiometer, is mounted 'in reverse' and some of the component clippings are used to extend the solder tags.

My final component to mount, before assembling the sandwich of various PCBs, was the capacitor for the voltage regulator. Hans specified in the instructions the maximum dimensions for an electrolytic. The ones I had were too big, and the ones I could find online were also a bit too big. So, in the end I opted for the smallest 10μF 16V tantalum capacitor I could find. I fitted it but then, at the next stage, it was just a little too proud and interfered with the fit of the controls board that sits directly above it. What to do? Moving it wasn't an option, and I had already brought the smallest I could find. I looked at it closely and began to wonder just how thick the tough outer coating was before reaching the 'capacitor proper'. I took a little gamble, and with a fresh blade in a craft knife started to pare away a flat surface on the top of the rounded tantalum component. I shaved a bit, tried a re-fit, and shaved some more. I kept going further than I might have liked, but I still had not broken through the tough outer coating, so felt reasonably confident that I hadn't damaged the component or drastically altered its electrical properties. Success, I could fit the controls board nice and level.

Next, I plugged the various PCBs together 'sandwich style' and test-fitted the case. Again, precision is key here. It would be easy to miss a long component lead and create a short to the case. I found a couple of leads too close for my liking and rectified that.



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Finally, before actually fitting into the case, it was time to apply power and complete the basic set-up stages. I applied a dummy load, in case the rig went straight into transmit, and 13.8V DC and gingerly switched on the PSU (there is no power switch on the rig). With the initial smoke test passed successfully, it was time to undertake adjustment and alignment.

Adjustment and Alignment

This is pretty straightforward, and no external equipment is required, all the test equipment needed is built directly into the rig. Once more, the excellent step-by-step instructions were easy to follow. I entered my band of choice, 20m, and began to adjust the bandpass filter (BPF). I immediately suspected something was wrong because I could not shift the bargraph display very much at all despite a full range of adjustment – something I recall was the case with my earlier build. Nonetheless, I proceeded with the steps, repeatedly adjusting the BPF, IQ Balance and Phase Shift for optimum readings. Once I had achieved the best I could, I connected a real antenna and listened around. You know it is bad when you can't even hear any FT8!

The manual is very clear: *"This is the number 1 cause of problems with QRP Labs kit construction: failure to remove the wire enamel"* (from the toroids).

I was a little confused here. The manual makes very clear that this is important, but Hans always achieves this not by manually stripping the enamel but by burning it off when soldering. This is the method I had adopted in the original build and this time too. I had also been diligent and tested conductivity of each wound toroid with my multimeter. I re-soldered the connections and tested again – the same issue. It took several prolonged attempts with the iron to finally burn off the enamel from what must have been an intermittent problem. If I were to build another, I would definitely take the time to gently sand the ends of the

11

wires with abrasive paper.

The joints re-made, I entered the alignment procedure again and was instantly gratified to get a better BPF filter adjustment. Further tweaking of the three (interconnected) adjustments and I was satisfied I had achieved the best I could.

Back on went the antenna and I nearly blew my ears up on 14074kHz as the beautiful sound of FT8 shouted loud! A tune around the band, and comparison with my other HF gear and I was satisfied it was all working correctly. Back on went the dummy load, on went the R-1000 receiver with maximum attenuation and there was my CW signal – it works!

I resisted the temptation to get straight down to operating, and disassembled the sandwich of PCBs as a necessary step to house them in the case. I used the anti-static bag, which is nice and stiff and quite puncture proof, that some of the components came in, and cut it to size to fit in the base of the case to act as an insulator between the PCB and the case. I am pleased to say it all fitted together beautifully and I was really pleased with how it looked and felt, and mostly, by its tiny size.

In Use

So, now complete, I connected everything up again and had a listen around the band. I answered a CQ from **Kurt SM2YIZ** and received a 579 report with my 4W into a home-made quarter-wave ground plane antenna. Further QSOs were had with stations in Slovenia and Germany. That was at 1645 and I had started the build at about 0930, so I was pretty pleased all things considered.

The QCX also comes with CW and WSPR beacon functionality and readers of my previous article on the QCX may recall that I had to undertake some frequency alignment to ensure that the display and operating frequency was accurate. This is especially important for WSPR as maladjustment can put your WSPR signal outside the recognised WSPR band such that no one will hear you.

"I am pleased to say it all fitted together beautifully and I was really pleased with how it looked and felt, and mostly, by its tiny size"

To test alignment, I did what I did before. I put out a number of CQs in CW and then went to the Reverse Beacon Network to look at my reported frequency from the skimmers that had heard me. I was very pleased to see that the reported frequency matched almost exactly with my display frequency across more than a dozen spots. Content with that, I set the rig up for WSPR beacon mode, connected it to my quarter-wave ground plane and left it to its own devices for an hour or two. Subsequent examination of an online WSPR map showed my signal getting out nicely, see **Photo 11**.

Hans has hit on yet another winner here. There are now two versions of QCX to suit individual needs – larger and less fiddly to build, as well as better suited for shack use, in the QCX Plus, and small, more fiddly to build, but a delight to take anywhere in miniature. Now, can I resist one for 30m? That said, via the QRPLabs Facebook Group I came across a post where a fellow builder had successfully used his 20m Mini on 30m too, by merely putting the 30m frequency in the second BFO. I tried it myself, put out a CQ on 10116kHz and instantly had a reply and three back-to-back QSOs into mainland Europe with good reports.

Radio Round-up

OH NORTHERN LIGHT 100-YEAR CERTIFICATE: The Finnish Amateur Radio League (SRAL) is celebrating its 100th anniversary. To earn the OH Northern Light 100-year Certificate (OH-NL-100), contact 50 OH and 50 OF stations during 2021 (a special OF prefix will be launched to all OH stations on 15 September), and ten specially featured Finnish stations (multipliers). Multiplying your QSO points (maximum 100) by your multiplier value (max 10) will give you your score, a maximum of 1000 points. The ten multipliers are:
- OF2HQ to be used by the SRAL team in the IARU HF World Championship on 10/11 July)
- OF9X Santa Claus station, Old-Father-9-Xmas
- OG2B representing the OH2B NCDXF Propagation Beacon
- OH0W Aland Islands
- OH100SRAL the official SRAL centennial jubilee station
- OH2A the SRAL HQ station in Helsinki
- OH2YOTA Finland's Youngsters On The Air
- OH6SRAL used by OH6ZS when transmitting SRAL news bulletins on Saturdays
- OI3AX representing the various OI-prefixed amateur radio stations in the Finnish Defence Forces
- OJ0C Market Reef

All who score 1000 points and the top-ten continental highest scorers will receive their OH-NL-100 certificate signed by Santa Claus. A special lottery will feature additional special prizes that will be announced later. Your log extract should be sent to the Santa Claus offices
of9x@sral.fi
during January 2022. The same address will answer all questions relating to this centennial activity.

JERRY BURKE SILENT KEY: Justin G0KSC of InnovAntennas informs us that Jerry Burke, author of the NEC code (Numerical Electromagnetic Code), has passed away. Working with the US government backed Lawrence Livermore National Laboratory, Jerry worked on the development of the code from the beginning, including the now open-source NEC2 code (which is widely used in many free and low-cost antenna modelling packages) through to NEC 4.2 and onward to a complete re-write of the code now labelled NEC5. Many radio amateurs unknowingly benefit from Jerry's work, which has helped in the development and confirmation of a great number of the antennas we use today. Join me, says Justin, in raising a glass in thanks to one of the unknown heroes of our hobby.

Read more radio news and reviews at www.radioenthusiast.co.uk/news

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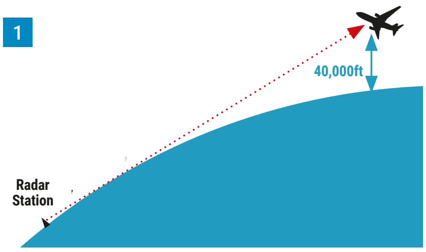

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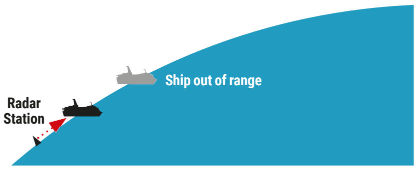

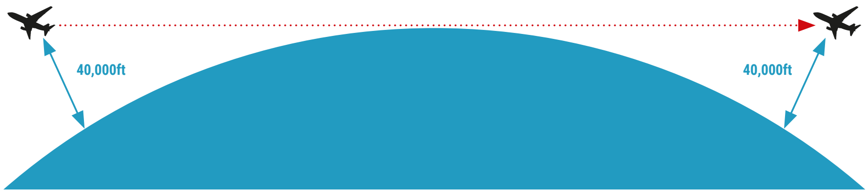

3

Passive Radar

Steve White G3ZVW explains the working of this alternative method of detection.

Steve White G3ZVW
practicalwireless@warnersgroup.co.uk

In the September 2020 instalment of *Making Waves* I described how conventional radar works, but it isn't the only kind of radar. There's another kind that works on rather different principles.

Résumé

A conventional radar such as you might find on a ship or at an airport works by transmitting high power electromagnetic pulses at microwave frequencies. In the pauses between those pulses it 'listens' for signals that have been reflected from objects within its range. Such radars typically employ a highly directional rotating antenna.

A radar system at an airport can monitor air traffic up to a couple of hundred miles away, although the range is usually limited to less than that. As **Fig. 1** shows, the absolute limit is set by virtue of the fact that there is a 'radio horizon', caused by the curvature of the Earth. The radio horizon is further than the visible (or optical) horizon, but not by a huge percentage.

For monitoring ships at sea the maximum range is much less, because the horizon is much closer than it is to an aircraft at, say, 40,000ft. As **Fig. 2** shows, a few tens of miles would be more like it, but if a land-based marine radar is located on a hilltop, the range will be greater.

Radars on board aircraft can work over greater distances, by virtue of the fact that when they are flying at high altitude their radio horizon in far away. They can detect ships up to a couple of hundred miles away. Depending on how high another aircraft might be flying, they can detect up to about 400 miles. See **Fig. 3**. Once again, the maximum distances are governed by the curvature of the Earth.

Jamming

Now, here's something to think about. If a radar station is transmitting pulses of electromagnetic energy and they are being reflected by an object – usually called a 'radar target' – back to the radar station that sent them, it stands to reason that those pulses can be detected by the target itself. Because of the frequencies involved the target can also employ a highly directional antenna, to work out which direction those radar pulses are coming from, and if you can do that, you can jam the radar by transmitting pulses back that have been delayed or altered, to mask where you are or make it appear you are not where you actually are.

Stealth aircraft are designed to reflect very little radar energy. Their shapes are angled to reflect very little signal horizontally, which is the basic direction radar pulses will be coming from. Additionally, stealth aircraft are coated in a material that absorbs radio frequency energy. Essentially, they are invisible to radar.

If only there was a kind of radar that used readily available radio transmissions, rather than a dedicated transmitter, so that a target wouldn't know it was being observed. In fact, it was discovered in the very early days of radar development that there is a way of doing this.

Passive Radar

I'm now going to take you through how a passive radar system works, step by step.

First, take a normal, everyday VHF broadcast station. As a listener you might expect to be able to hear that station up to some tens of miles away, but if you were in a high-flying aircraft, you would definitely be able to detect it much further away. Once again, it's all down to the radio horizon being further away at height. Being made from metal, the aircraft reflects and scatters a little of that VHF signal, which might then be detectable back on the ground. This was the subject of *Making Waves* in July 2020, when I wrote about how aircraft reflection can be used to work VHF DX beyond the distance that might be considered normal. So, here's the question. Can you call detecting a radio signal that has been reflected from a high-flying aircraft a kind of radar? No, you can't, but if you were to add a lot more electronics you might be able to. Here's how it works.

Say this high-flying aircraft is reflecting signals from a broadcast station that you can hear anyway, i.e. the broadcast station is quite local to you. This means your receiver will be receiving more than one signal, **Fig. 4**. The direct signal will be much stronger than the reflected signal and the chances are that an everyday radio listener would never know there is a reflected component to the signal, but that doesn't mean it isn't there. If you introduce some electronics and computing power into the equation to analyse the signal, you should be able to detect the reflected signal that is buried under the direct signal.

The first thing you need to do to turn this into a radar is measure the tiny time difference between when the direct and reflected signals were received. Using a formula that includes the speed of light (300km per millisecond), the time difference will tell you how much extra distance the reflected signal travelled. If you know the exact distance between the broadcast transmitter and where you are (which is easy using GPS), you will then be able to partly calculate where the plane must have been. I say 'partly', because we're not there yet!

There are still lots of places where the plane might be, because there are lots of places that fulfil the extra distance. If the

Fig. 1: Distance limit of an airport radar system. Fig. 2: Distance limit of a marine radar system. Fig. 3: Distance limit of an air-to-air radar system. Fig. 4: The direct and indirect signal paths from a transmitter to a passive radar. Fig. 5: The arc on which a plane might be. Fig 6: A three-station passive radar.

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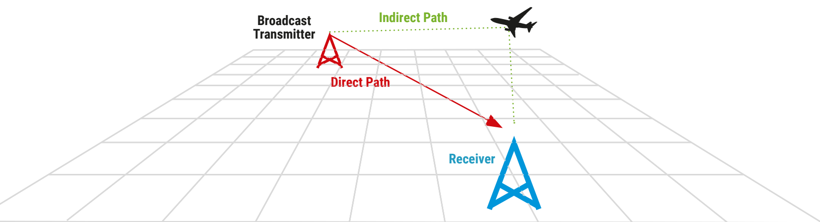

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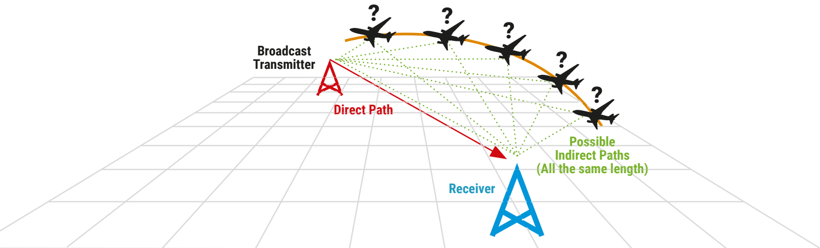

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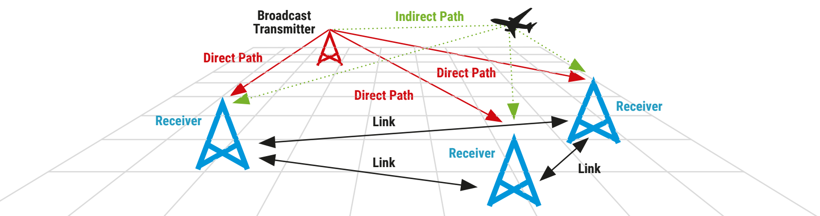

indirect signal is delayed by 1 millisecond it means that signal travelled 300km further than the direct signal. All those possible places where the plane might be lie on a curved line called an arc. **Fig. 5** shows a simplified two-dimensional arc, but in reality the arc will be three dimensional, which makes life more difficult. I have shown the plane on an arc to the right of the direct signal path, but it could just as easily be on an arc to the left. In this illustration I don't try to show that the arc is actually three dimensional, because we should also take the aircraft's height into account. Complicated! Even if we equip the passive radar system with beam antennas to tell us which side of the direct signal path the plane is, we haven't created much of a radar system yet.

Now add a second receiver and more antennas, all in a different location. If we know the distance between the two passive radar systems (easy to calculate with GPS) and link the systems together, we can now overlay the arcs. From this it is possible to be more confident about where the plane is. Now introduce a third receive system, as shown in **Fig. 6**, and you have a pretty good passive radar system. Add even more receivers and things get even better. Regular readers of *Making Waves* should by now have realised there are parallels between passive radars and the Time of Arrival systems I discussed in November 2020. But there's more! When radio signals are reflected from an aircraft that is moving, the frequency they are reflected on will be slightly different to the frequency received. This is known as Doppler Shift. If you can measure differences in frequencies you can be even more confident about where the aircraft is, plus its speed.

Noise

This feature would not be complete without me pointing out the fact that there is a significant problem with passive radar. It won't just be the target you are interested in that reflects the broadcast signal you are using as the transmitter of your passive radar. Things such as buildings, mountains and a plethora of other objects will be creating reflections too. All these reflections get jumbled up and buried in the background of the direct signal, creating a huge amount of low-level noise. A multi-station passive radar system works by discriminating between the reflections you want from all the reflections you don't. Directional antennas, with one optimised for the direct signal and another optimised for picking up signals from a higher angle (and even in the right general direction) will certainly help, but they won't get you all the way to where you want to be. The final – and crucial – part of the puzzle of how a practical passive radar system works is beyond the scope of this series, but it involves signal processing and lots and lots of computing power.

SEE PAGE 9

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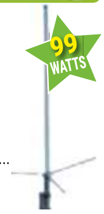

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Steve Telenius-Lowe PJ4DX
Eva Telenius-Lowe PJ4EVA
teleniuslowe@gmail.com

An Absolute Beginner's Guide to FT8 (Part I)

Steve and **Eva Telenius-Lowe, PJ4DX** and **PJ4EVA** describe their experiences starting on FT8.

Ever since I was first licensed in 1971 I have been primarily an SSB operator, indeed until just a few years ago I used SSB almost exclusively. That was the case when I moved to Bonaire and became licensed as PJ4DX at the end of 2013. Then, after a few years, I started to use CW to call DX stations that were either not active on SSB or that I found I couldn't work on SSB.

I had, however, never operated using any of the data modes. The closest I got to it was on a multi-operator DXpedition, well before the advent of FT8, when I was persuaded to cover for the RTTY operator for a while. After about an hour I had decided I did not enjoy RTTY and I have not used it since.

All this is by way of explaining that I am very much not an expert at data modes operating! However, in November last year four German radio amateurs were visiting Bonaire and operating from the next-door house to us. They were mainly using FT8 and **Eva PJ4EVA**, who had been licensed locally since 2019 but who had only made a dozen SSB QSOs in that time, saw FT8 in action for the first time and thought she would like to give it a go.

The Germans set up JTDX on our computer and configured it with our Icom IC-7300, with separate sessions for PJ4EVA and PJ4DX, and we were in business. We have now both been active on FT8 for two months at the time of writing. It has been quite a steep learning curve for these data mode neophytes, so we hope this article may help others who are also newcomers to this strange digital world, or who perhaps are also mulling over whether or not to give FT8 a try for the first time.

What is FT8?

Almost everyone has heard of FT8 by now but, for those who have been hibernating for the last few years, it was invented by **Joe Taylor K1JT** and **Steve Franke K9AN** in 2017 and rapidly became the digital mode of choice for amateurs. It is now more popular than all the other modes combined.

An FT8 transmission consists of eight tones and occupies a bandwidth of about 50Hz. It allows for the barest minimum of information to be exchanged in order to constitute a contact, i.e. an exchange of callsigns and signal reports or, to be more specific, the received signal-to-noise ratio. Often the stations' grid locators are exchanged as well. And that's it: FT8 is definitely not the mode for 'rag-chewers'!

1

FT8 signals can be decoded down to a level of around –21dB or better, allowing low-power stations, or those with limited antenna possibilities, to make DX contacts, in many cases for the first time.

Because each period is a continuous 15-second transmission with 100% duty cycle I would definitely not recommend running a 100W transceiver at 100W on FT8. I know of at least one person who blew up the PA transistors in his transceiver by running it flat out at 100W on FT8 for extended periods of time. You have been warned! I never use more than 50W from the transceiver.

Initial Set Up

The two main programs used for FT8 are WSJT-X, by Joe Taylor K1JT and his team, and JTDX by **Igor Chernikov UA3DJY** and **Arvo Järve ES1JA**. We have no experience with WSJT-X so what follows applies specifically to JTDX although we understand that the two programs are similar in operation. The JTDX program and a 51-page PDF *JTDX User Guide* can be downloaded from:

www.jtdx.tech/en

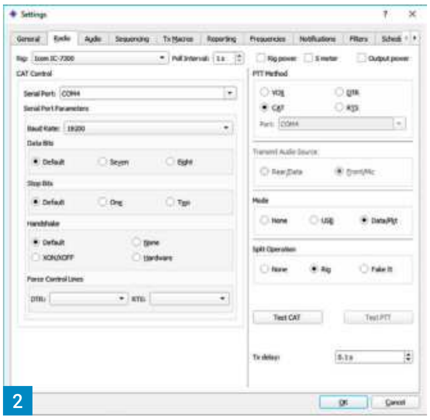
You will need an interface such as Signalink or RigBlaster between your transceiver and computer unless you are lucky enough to use a transceiver that has its own built-in sound card. Fortunately for us, we have an Icom IC-7300 so no external interface is required, the transceiver simply being connected directly to the computer with a USB cable.

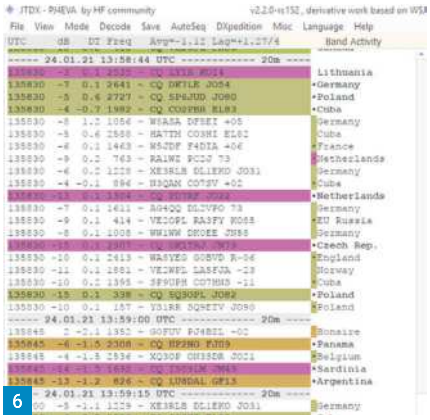
It is important that the clock in your computer is always accurate. It must be correct to within better than 1s and the way to achieve this is to use the Network Time Protocol (NTP). This keeps the clocks in tens of millions of computers around the world synchronised with internet time. If it is not already on your computer it can be downloaded from:

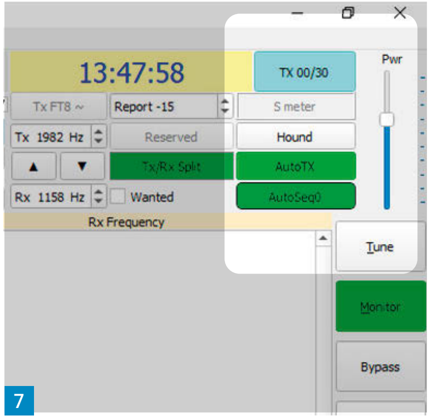
www.ntp.org

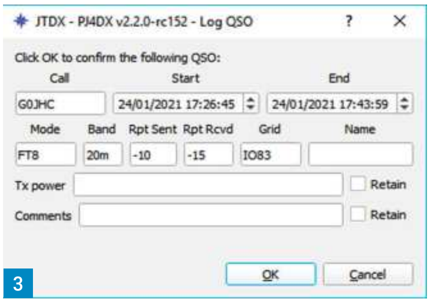
Assuming you have followed the setup instructions in the *JTDX User Guide* correctly, when you open the JTDX program you should see something like **Fig. 1**. You then need to input your callsign and four or six-character grid reference (IO91 or IO92ab for example). You do this by going to File – Settings – General. After that go to File – Settings – Radio and from the 'Rig' drop-down menu input the name of either the logging software you use or your type of transceiver. Our screen looks like **Fig. 2**.

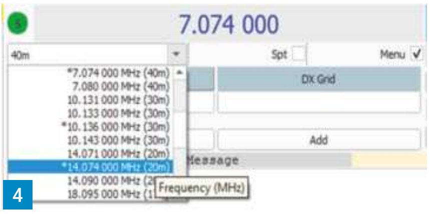
After you have started making contacts you will find that it is very useful to be prompted to log each contact and this can be done by going to File – Settings –











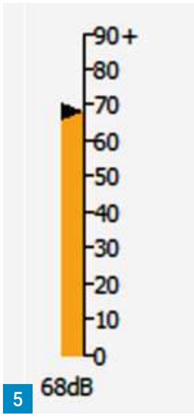


Fig. 1: When you first open FT8, the screen should look like this. Fig. 2: The Settings – Radio screen. If you operate FT8 via your station logging program, the name of that program should be used instead of the transceiver. Fig. 3: The pop-up logging screen, prompting me to log my QSO with Neil G0JHC. Fig. 4: The drop down band and frequency list. In this example the station is in the process of moving from 7074kHz to 14074kHz. The normal FT8 frequencies are asterisked. Fig. 5: The JTDX received signal strength meter. Adjust the receiver's gain so that it is reading between 60 and 70dB for optimal decoding. Fig. 6: The program decodes the entire bandwidth of the 'channel' you have selected and displays the decoded signals on the left-hand side of the screen. (The various colours can be set by the user to indicate new DXCC, zone, grid, prefix etc.) Fig. 7: The 'Tune' button (bottom right) allows you to adjust the level of your transmitted tones. Fig. 8: The IC-7300 screen, showing the small amount of ALC deflection when transmitting FT8 tones.

Reporting and ticking the 'Prompt me to log QSO' box. When the program has received sufficient information from the station being worked a logging box pops up, **Fig. 3**, and clicking 'OK' logs the QSO. JTDX creates its own ADIF log file, which is stored on the hard drive of your computer, or the contact can be logged directly into your own station logging program.

Basic Receiving and Transmitting

Go to an FT8 operating frequency by clicking on the appropriate band from the drop-down menu at the top of the screen. The normal FT8 operating frequencies within each band are asterisked, **Fig. 4**. Your transceiver should immediately QSY to that frequency and, if everything is working properly, after a few seconds you should see decodes appearing on the screen.

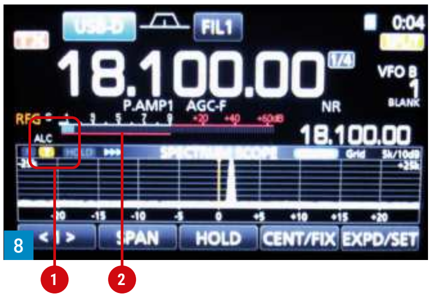
Adjust your transceiver's preamplifier(s), RF gain etc so that the JTDX received signal strength meter, **Fig. 5**, is showing about 60 to 70dB on an active band, but not higher than 80dB.

As an FT8 transmission is only 50Hz wide several dozen signals can be accommodated within an SSB 'channel' bandwidth of, say, 2.9kHz at any one time. The program decodes the entire bandwidth of the 'channel' you have selected and displays the decoded signals on the left-hand side of the screen, **Fig. 6**. The right-hand side of the screen displays only those stations that are calling you or that are on (or very close to) the receive tone frequency you have currently selected.

Now for transmitting. Turn your transceiver's power down to, say, 10W and turn off the speech processor. Select the ALC meter on your transceiver and, in JTDX, click on 'Tune', **Fig. 7**, while watching the transceiver's ALC meter. The button illuminates red while you are transmitting the tuning tone. Adjust the 'Pwr' slider control up or down so that the ALC meter just deflects. If the ALC meter is a bar graph, as in the IC-7300, two or three segments, **Fig. 8**, is about right. Any higher and your signal will be distorted, difficult or impossible to decode, and will be overly *w-i-d-e*, causing interference to other band users. The deflection should certainly always be lower than half-way across the ALC meter scale. It may be necessary to re-adjust the ALC level when you move to a different band but, once adjusted, the program should remember the correct setting for each band.

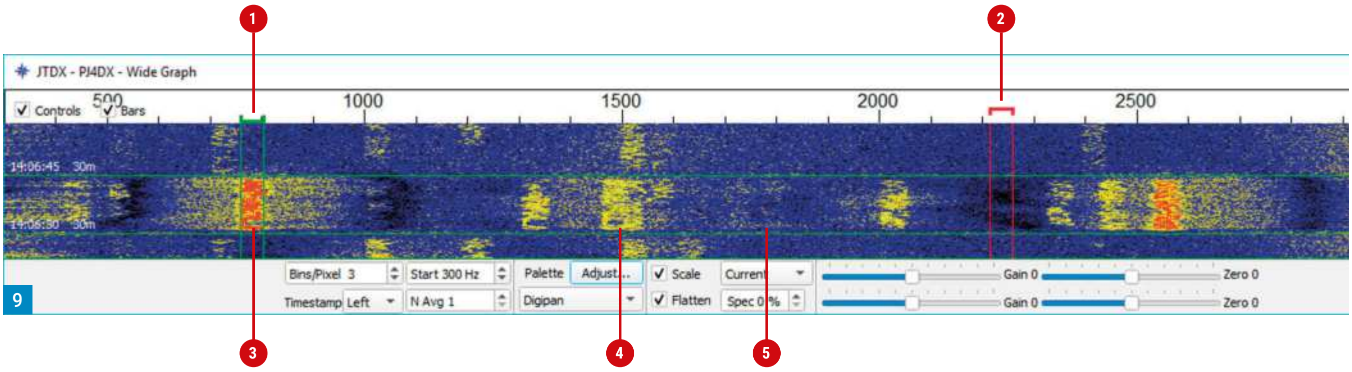
Making the Contact

To work a station using FT8 you can either



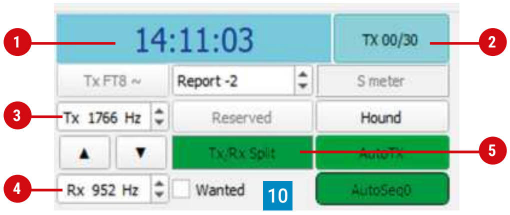
1. ALC meter selected. Only small deflection when transmitting. 2. Middle of ALC meter scale. Never transmit FT8 tones as high as this level.

call CQ yourself, call another station who is calling CQ, or call someone you have decoded who is completing a QSO with a third party. However, before you call CQ or call anyone else, it is important to select your operating frequency within the band, i.e. the audio frequencies of the tones you transmit. Here, the program's waterfall display is the most useful tool. Check the waterfall for two consecutive 15-second reception periods and select what looks like a clear frequency. In JTDX simply right-clicking with the mouse will set your transmit tones to those frequencies, **Fig. 9**. Of course, depending on propagation, you have no way of knowing if that frequency is also clear elsewhere in the world, but at least it's a start. You should cer-



1. Receive frequency (between green goalposts) 2. Transmit frequency (between red goalposts)
3. Strongest signals (red) 4. Average signals (yellow) 5. Clear frequencies/noise (blue)

1. UTC time
2. TX period toggles 00/30 and 15/45
3. Transmit tones frequency
4. Current receive frequency
5. Tx/Rx split should be illuminated green



tainly avoid transmitting on any of the yellow and especially red-coloured signals in the waterfall, such as those shown in **Fig. 9**.

The transmit frequency you select on the waterfall is also shown on the main screen, **Fig. 10**. You can enter your transmit frequency there instead, but it's rather hit and miss as you can't tell whether the frequency selected is a clear one. It's important to have the 'Tx/Rx Split' button activated (illuminated green on Fig. 10). This is because the program decodes the whole of the SSB bandwidth in one go, so there is no point in calling a station co-channel, especially if others are also calling on that same frequency. Obviously, you stand a much better chance of being heard if you are 'in the clear' (this is very different to operating 'split' on SSB or CW, where you need to call on the one frequency where the DX station is listening in order to be heard, even if that frequency is constantly being changed by the DX operator).

To call CQ yourself, simply click on the 'Enable Tx' button and the program will send a CQ call, starting at 00, 15, 30 or 45 seconds into the minute, depending on whether you have 'TX 00/30' or 'TX 15/45' selected at the top right of the screen (see Fig. 10). With luck you will then be called by one or more stations and a line or lines similar to the following will appear on the screen:

```
171245 -15 -0.2 1612 ~ PJ4EVA
M7XXX IO91    England
```

This indicates the time (hour, minute and seconds) of the transmission, the received signal-to-noise ratio (−15dB), the time differential (−0.2 seconds compared with internet time), the tone frequency the received station is using (1612Hz), your callsign (PJ4EVA in this example), the station calling you (M7XXX), the grid locator of the station calling and its DXCC entity.

There may be more than one station calling. To select the one you wish to reply to, double-click anywhere on the line with that callsign. Doing so loads the standard messages at the bottom right of the screen, **Fig. 11**.

Rather than calling CQ yourself, you could double-click on a station that has been decoded on the left-hand side of the screen and call them instead.

In either case, after that simply let the program's autosequencer ('AutoSeq') do the work for you! The program will send the messages sequentially in the order shown at each 15-second time period. If no response is received (for example if interference or fading means the station's response was not decoded) the same message will be repeated, again and again if necessary, until the response is received, after which the next message is sent:

```
M7XXX PJ4EVA -15
```

This means that PJ4EVA is sending M7XXX a report of −15dB. M7XXX then sends a report back to PJ4EVA and PJ4EVA's next transmission would be:

```
M7XXX PJ4EVA R-15
```

The 'R' ('Roger') means that PJ4EVA has now received the report sent by M7XXX. The −15 report from PJ4EVA to M7XXX is repeated in case M7XXX did not receive it on the previous transmission.

Fig. 9: The JTDX waterfall display, the most useful tool for checking band occupancy and selecting your transmit tones frequency. The green 'goalposts' indicate that the strong signal around 800Hz is being received, while the transmit frequency marked with the red goalposts around 2230Hz is on a relatively clear frequency. Fig. 10: You can also enter your tone transmit and receive frequencies directly from the main screen (see text). Fig. 11: The standard messages display. In this example PJ4EVA is calling M7XXX with a report of −15dB.

Assuming PJ4EVA receives an 'R' report from M7XXX, the next transmission PJ4EVA sends would be:

```
M7XXX PJ4EVA RR73
```

The QSO is now complete, PJ4EVA already having received an 'R' report from M7XXX and the QSO can be logged. The other station may then send:

```
PJ4EVA M7XXX 73
```

This indicates that they have received your 'RR73' transmission and therefore you know that you are also in their log.

You can now double-click on one of the other stations calling or, if there are none, you could call CQ again, in which case click on 'Clear DX', the standard messages will be cleared and the program will call CQ on the next 15-second transmission period.

In its most basic form, which is all we are dealing with in this article, that's all there is to it!

In Part 2 next month we look at some FT8 operating tips and at ways of speeding up your digimode contacts.

UHF Wideband Amplifier and Netometer

Geoff Theasby G8BMI has two more low-price offerings for the shack.

Geoff Theasby G8BMI
geofftheasby@gmail.com

Some time ago, I bought a miniature, dual-band mobile transceiver, 'as seen', labelled Moonraker MH-270M, which had blown the MOSFET output transistor. It is one of many Chinese clones, available cheaply from many sources. On being tested, the receiver worked well, but the transmitter gave only a brief 10mW before ceasing. So, when I saw a wideband 1-700MHz RF amplifier module (NWDZ RF PA2.0) online, for a very reasonable £16, I thought it might revitalise the little Tx/Rx. Opening the rig, I found that the PA was a surface mount device, below a wholly inadequate heatsink. The devices are readily available although soldering in a replacement could be tricky. There appear to be no directly equivalent, leaded, replacement devices. To remove the damaged component, I cut it up carefully in situ with wire cutters. This revealed two pads on the PCB top, and a central pad below, to which short pieces of miniature, very flexible coax (Belden 179D) could be attached, **Fig. 1**.

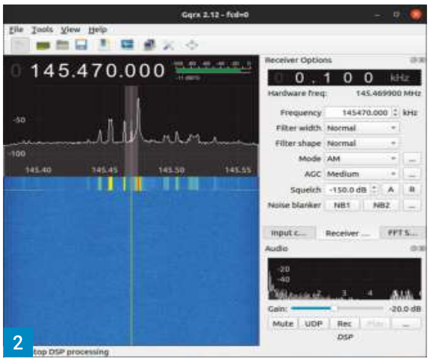
Googling the wideband amplifier, which appears to be quite well made, I found an item by YO5PBG, who realised that it got very hot, very quickly, before failing. He recommends using no more than 9V, maximum 11V, rather than the specified 12-15V, which consumes more than 500mA. At 9V it consumes a more reasonable 50mA; 80mA on transmit. Under these conditions the outboard amplifier gives 500mW at 145MHz, and 100mW at 432MHz, for a 10mW input. YO5PBG also recommends a few modifications.

https://yo5pbg.wordpress.com

Looking at the 'barefoot' transceiver output with GQRX, at 100mW output, the spectrum appears quite good, the only visible spurious is −50dB at 145MHz, and −40dB at 432MHz. The amplifier output was tapped off at the input point to the original PA, put through the outboard module, and sent back to the mobile at the Drain terminal to run it through the filtering provided.

Even so, the amplifier outputs are much less 'clean' than the transceiver alone, and may need further filtering, see the screenshots, **Figs. 2** and **3**. I cannot vouch for the little amplifier's ability to withstand the harsh electrical environment in a vehicle, even if the supply voltage is reduced from the nominal 12V as supplied to the transceiver.

1



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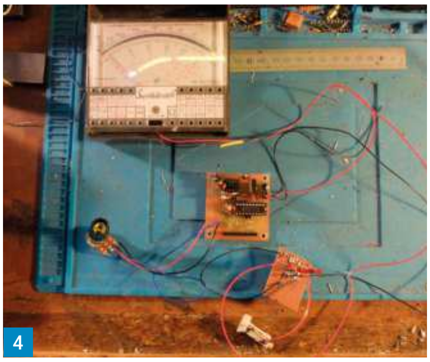

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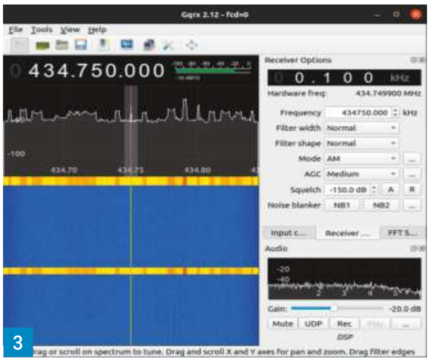

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Fig. 1 The PA module in use.
Fig. 2 Screenshot 145MHz.
Fig. 3: Screenshot 432MHz.
Fig. 4: Netometer on test.

The Netometer

Many radio amateurs use the latest solid-state equipment full of digital processing and built with today's sophisticated components and techniques, highly stable and free from earlier failings. However, there are many using obsolete or homebrew transmitters, the performance of which is often rather less than current gear can achieve.

This little device from S9plus kits here in the UK, is just the job, in that it keeps track of if, and which way, you are drifting. It also has one of the finest build/instruction manuals, written in proper English, in a coherent manner, that I have seen since the demise of Heathkit! I built the PCB in an evening, using my own components, apart from the PCB and ICs. I prepared a small daughter PCB to carry the LEDs, and also as a point of attachment for the meter and push-button leads. The finished item may use LEDs or a centre-zero meter to indicate results, or both. There is provision to use a normal left-hand zero meter, if a centre-zero type is not available.

The potentiometer in the photograph, **Fig. 4**, was fitted in place of the preset, RV1, while testing. Setup is by switching the rig to 'Transmit' (into a dummy load please) and pressing PB1 to store the frequency. Thereafter the Netometer will indicate your drift, and whether LF or HF from that frequency, until reset.

www.s9plus.com/kits.html

Class A Amplifiers

Tony Jones G7ETW offers a master class in the design of Class A amplifiers.

Tony Jones G7ETW
charles.jones125@yahoo.co.uk

This is my second article about transistor circuits. The first piece (*Transistor Basics*, in *PW's* February 2021 issue) started from square one, and built up to an Arduino-controlled switch. This piece picks up from there.

We're making a small signal common-emitter 'class A' amplifier, part of an audio signal generator circuit. As before, I shall build it up.

Stage : DC Conditions, aka 'Biasing'

Fig. 1 shows the essential 'chassis' of the amplifier, starting with a potential divider of 5kΩ across an 18V DC supply. The voltage at point B is obviously 3.6V and the current I_{bias} is 3mA.

The collector is at 9V and R3 has 1mA passing through it.

Er... why? Did I accidentally delete a paragraph? Transistors are clever things, but they're not that clever.

It's because of Ohm's Law (and nothing but Ohm's Law, m'lud). To explain, I have to work backwards.

For a collector current I_c to flow, there has to be 600mV at least between the base and emitter. The base is at 3.6V, so 3V on the emitter sounds good. No end of R4 and I_c combinations could facilitate that, but the higher the collector current, the higher the base current has to be, which makes for issues.

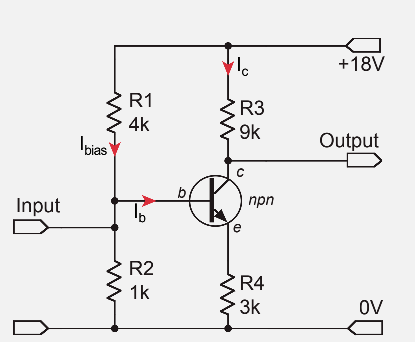
It's all a bit chicken and egg but let's just say 1mA is a good current to choose. R4 equal to 3kΩ gives us the 1mA we want.

For the output swing to be a maximum, the collector needs to start at half the supply voltage with no signal present. R3 therefore needs to drop 9V with 1mA current; this resistor needs to be 9kΩ.

Real-world designers would stop there, but for completeness let's look at the base-side again.

The transistor's current gain Beta (β) is 125. (A BC108's datasheet I saw recently gave Beta in the range 80 to 400, and I've had ones with gain over 1100! So I could have used almost any 'sensible' value.)

For I_c to be 1mA, I_b must be 8μA. This



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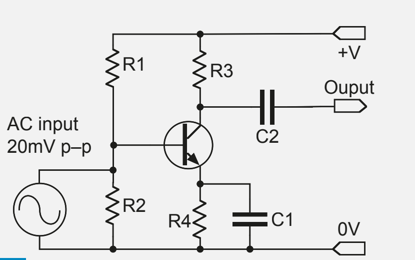

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changes the voltage on the base and emitter, but only by a tiny amount, and that does not matter. There is a rule of thumb: I_{bias} must be at least ten times I_b. (Not, as people in the media say nowadays, 'ten times more', which is actually eleven times. When I become king of the world, this woolly way of expressing ratios will be punishable by death!)

Three Resistors to Rule Them All

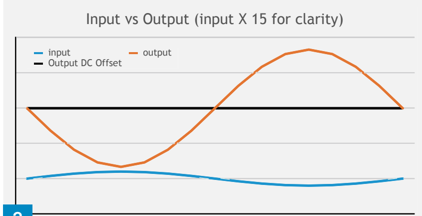
R1, R2 and R4 set the transistor's 'operating point'.

When I was first learning about transistors, this amazed me. Variations in gain, I thought, must come into this, but not so. Higher than expected gain boosts the key I_{bias} to I_b ratio, making for better biasing. And Beta would have to be very low indeed for the biasing not to work.

Stage 2: Add an Input

See **Fig. 2**, which shows the circuit with an audio-frequency signal source added. For simplicity, it's a pure AC signal with 20mV peak-to-peak output.

This superimposes a 10mV peak AC signal on the 3.6V fixed DC bias voltage on the base.



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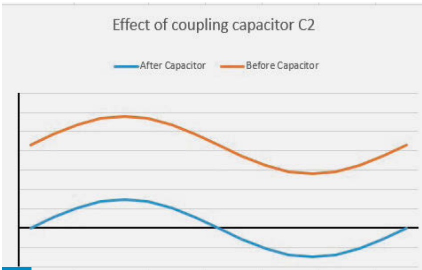

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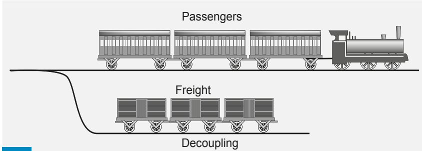

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When the input is 10mV on its positive half-cycle, the voltage is 3.61V – a difference of 0.28%. I_b rises by the same, again almost nothing. But I_c's rise is compounded by Beta, and 0.28% times 125 is 35%!

With a collector current of 1.35mA, the voltage across the R3 rises, to 12.15V, and the voltage on the collector drops to 5.85V. A positive 10mV swing on the input has been converted into a negative 3.15V swing on the collector.

Similarly, when the input is at 'minus' 10mV – and the base drops to 3.59V – the collector rises by 3.15V. **Fig. 3** shows the input and output voltages on the same graph, not to scale.

This explains R3's role and importance. Transistors amplify current, but resistors turn current into voltage. Say I'd chosen 3kΩ for R3 and kept the same 1mA no-signal current. The no-signal collector voltage would be 3V and the 'tidal' 0.35mA would move the collector by only 1.05V.

Stage 3: Purpose of Capacitors

C2 is a 'coupling' capacitor; it's there to allow the output of this circuit to be the input

Fig. 1: Class A amplifier, the bare bones. Fig. 2: Input and output. Fig. 3: Input vs. output. Fig. 4: Coupling capacitor C2 blocks the DC component. Fig. 5: The train analogy. Fig. 6: Class A amplifier from AC input point of view. Fig. 7: Class A amplifier from AC output point of view.

of another one, leaving any DC behind. **Fig. 4** shows its effect.

C1 is a 'decoupling' or 'bypass' capacitor. Decoupling capacitors provide low-impedance paths to ground for unwanted AC.

Two currents exit the emitter: I_b (8μA DC plus 0.28% AC) and I_c (1mA DC plus 35% AC).

The DC components need to and do pass through R4, maintaining the required 3V on the emitter. If the AC elements did the same, there would be a substantial 'ripple' on the emitter, which would destabilise the amplifier. C1 prevents this by grounding the emitter for AC only. (More on this later.)

These opposite-sounding terms are apt to confuse. Visualise a train with passenger carriages interspersed with unwanted freight wagons. Before arriving at a station, goods wagons are decoupled and rolled off into sidings. With the passenger carriages remaining, passengers can walk the train, **Fig. 5**.

Impedance

An amplifier's input and output impedance are important; designers don't leave these to chance. It's all about matching – a low-impedance input could load an input too much, distorting the very signal that needs to be amplified. Similarly, the output impedance of one stage of a circuit needs to match the input impedance of anything that follows.

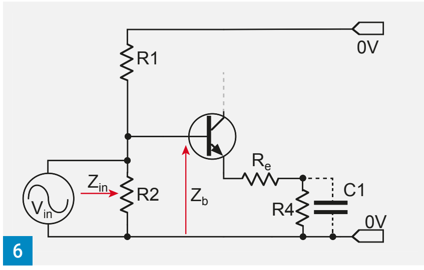
See **Fig. 6**. This is how the amplifier looks from an AC point-of-view. The supply – being DC – has gone, leaving both rails are at ground. This looks odd, but it's how this analysis is done.

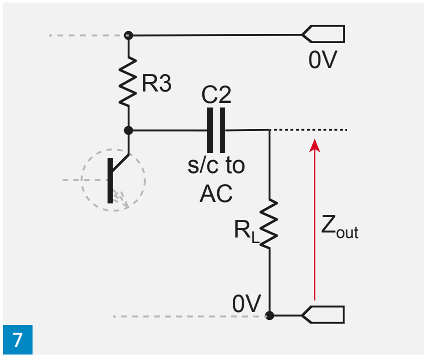
Base resistors R1 and R2 are in parallel, equivalent to 833Ω.

Ignoring C1, the input impedance looking into the base $Z_b = \beta \times (R4 + R_e)$.

I'm sorry to spring R_e on readers like that. It comes from Transistor Modelling and that's a whole subject of its own. For the present, R_e is the 'internal emitter resistance' and comes from the fact that transistors resist the flow of current and get hot. In this case R_e is only 25Ω (it is never much) and I'm going to ignore it for as long as I can.

In case it's not obvious how Beta appears in the Z_{base} expression, imagine you're the





AC voltage source. R1, R2 and the transistor (base and emitter connections only) are all in parallel. Tiny currents arise in R1 and R2 given by V_{in} divided by R1 and R2 respectively. There's no mystery there.

The base and emitter path to ground has a V_{in}-originated current element, for sure, but it's only a fraction – 1/Beta in fact – of what actually flows. V_{in} is the same everywhere so R4 must have been reduced to R4/β (from V_{in}'s point of view). This current becomes $V_{in}/(R4/\beta)$, which reorganises to $\beta V_{in}/R4$.

The overall input impedance is 833Ω in parallel with 375kΩ, which is 831Ω. R4 does not affect the input impedance unless it is small compared with the bias resistors. By careful choice of R1 and R2, Z_{in} can be chosen.

Well, to a degree. The biasing current has to be at least ten times the base current, remember. If R1 and R2 were in tens of kΩ so would Z_{in} be, but I_{bias} and I_b would need to be in μA and nA respectively! Gain would have to be higher, and the source would need be very low-noise.

Output Impedance

See **Fig. 7**. This is the AC view of the amplifier looking in at the output. With a 3kΩ load, this makes the output impedance 2.3kΩ.

Efficiency

The no-signal current is 1mA, and with a 10mV peak signal this rises to 1.35mA. What happens if the input rises? Can the collector current keep rising to amplify it? When I_b reaches 15μA, I_c will be nearly 2mA. Positive peaks on the input will take the collector down to almost 0V and negative ones will lift the collector close to the supply.

This is as far as this amplifier, biased this way and with an 18V supply, can go. 2mA is the maximum theoretical collector current, and half of this is 'wasted'. The maximum possible efficiency is 50%.

C1 and R_e affect Impedance

The circuit model in Fig. 6 shows C1 in dots. I ignored it; if I hadn't, R4 would be shorted-out. This makes the Z_b term dependent on R_e, which I also ignored.

Hmmm. This is getting tricky. Recalculating, Z_b becomes 3.1kΩ and that reduces the input impedance to 657Ω.

Except C1 isn't quite a dead short to AC; good design is for C1's reactance to be R4/10 at the cut-off frequency. That would make R4 in parallel with C1 one eleventh of the original R4 value, and R_e now isn't the determining value in Z_b!

C1 is called the emitter bypass capacitor.

C1 and R_e also affect Voltage Gain Calculations

Voltage gain $A_v = Z_{out}/(R4 \text{ plus } R_e)$

The problem jumps off the page, I hope. Ignore C1 and R_e and $A_v = 0.77$. Include them and A_v rises to about 80!

C1 and R_e are important – crucial even – in the design of a Class A amplifier, but they certainly do complicate things. I think I'll stop there.

Summary

Class A amplifiers are everywhere. From Hi-Fi to HF linears, Class A abounds, and for good reasons.

These are the identifying characteristics:

- Good biasing is essential
- Collector current flows all the time
- Full AC waveform output appearing on the collector with a DC offset
- Maximum efficiency is 50%
- Linearity is excellent (provided the input is not overdriven)
- Low to medium input impedance
- Low output impedance, very dependent on load

Conclusion

For anyone who didn't know Class A amplifiers in detail, I hope that I have shone some light in their murky corners. They are a good way in to amplifier theory, I hope you agree. My intention was to proceed to buffer amplifiers, which are often common-collector designs but we're at 1700 words and that's enough theory for one day.

Trans-Equatorial Propagation on VHF

Tim Kirby GW4VXE
longworthtim@gmail.com

Tim Kirby GW4VXE has more on trans-equatorial propagation and the results of a mini-survey about polarisation for 2m FT8 operation.

Over the last few months, I've been delighted to have the opportunity to include some information in the column about 2m trans-equatorial propagation (TEP). Living in the UK, it's something that most of us won't have had much, if any, exposure to. I know I haven't! But we certainly get the chance of some 50MHz TEP openings from time to time and, if you are lucky enough to be able to operate from other parts of the world, including the Mediterranean, then you may have the chance to look for some 2m signals.

I've also been very interested in some of the emails that I've received from one or two people who were operating back in the 1960s and 1970s, detailing some of their experiences on 28MHz TEP. Although 28MHz is firmly an *HF Highlights* band, it's a band that can sometimes behave like a VHF (rather than HF) band, so there is a lot that we VHF enthusiasts can learn on 10m.

Moving back to 2m, though, readers may remember I mentioned that a new 2m beacon (CW) has been installed in St Helena in the South Atlantic. The beacon has been up and running for a few weeks now and perhaps to some people's surprise, has already been heard quite widely.

On 1 March, ZD7GWM/B was heard in Cape Town by ZS1CF over a distance of around 3145km. It's hoped that the presence of the beacon will show that the path opens up comparatively often. A few days later, on 9 March, the beacon was heard on the coast of Namibia by V51DK, over a distance of around 2250km. **David V51DK** has a modest antenna, a Diamond X200 vertical at around 6m above ground. Given the (generally) warm seas in this part of the world, I'd hope that this path too would open up quite often.

It'll be interesting to see if the beacon may be heard in South America or the Caribbean, for example. The paths from St Helena to both those parts of the world may well be possible by marine ducting on VHF/UHF. And, of course, perhaps our friends in Cape Verde, operating D4VHF may hear the beacon.

1

There had been another report of the beacon having been received in the South of France over a distance of around 7000km, but unfortunately at the time of writing, it is looking as though this cannot be verified. The timing of the CW received does not appear to coincide with the timing of the CW that the beacon sends.

And finally, before we leave the subject of TEP for this month, I was interested to read that **David HI8DL** and **Diego LW2DAF** had been testing the new Q65 digital mode on 2m TEP between the Caribbean and South America. Q65 is included in the latest release of WSJT-X. David and Diego found that Q65 decoded much more reliably than FT8, which is useful to know.

They used Q65 submode C (Q65C) with both 15 and 30 second periods, both seemed to work well. You can see all this working on LW2DAF's Twitter stream (URL below).

This also made me wonder whether if that's the case, whether Q65 might work well for digital contacts via Aurora on 2m, when distortion/doppler shift is present.

https://twitter.com/LW2DAF

Vertical or Horizontal on 2m FT8?

A few weeks ago, **John EI7GL** asked me if I'd be interested in running a Twitter poll on whether, if people were active on 2m FT8, they used horizontal or vertical polarisation. John had been listening using a vertical antenna, in fact a Slim Jim vertical in his loft, and had been surprised to hear stations that were over 500km away.

We had 76 responses to the poll. Of those, 55% used horizontal polarisation, 33% vertical polarisation and 12% used both polarisations (I jokingly added, though not at the same time).

The sample size isn't huge, but nevertheless it suggests that a significant number of stations are using vertical polarisation.

Here at **GW4VXE** I switch polarisations and often hear more on vertical than on horizontal, although when you factor in that the vertical is omnidirectional, that's hardly surprising. The other day, I was on the vertical and saw a nice big signal from **Peter G8BCG**, we swapped reports and Peter said that he was using a 12-element Yagi, vertically polarised. So, again the message is, whether you

Fig. 1: Icom corner in PA9RZ's shack showing an IC-402, IC-705 and IC-9700 Fig. 2: PA9RZ's attractive location. Never mind the antennas, I'm looking at the boat! Fig. 3: Not a cloud in the sky! Dave M0GIW/MM on 2m FM from the Irish Sea.

have a vertical or a horizontal antenna, you should find stations to work on 2m FT8.

The 4m Band

Simon Evans G6AHX (Twyning) says that he leaves his Storno rig on 70.450MHz FM and during the lift in February, the squelch was broken by **Tom G4DFA** in Banstead in Surrey, 155km from Twyning. Simon says that he normally speaks with Tom on 80m, so it was quite a surprise to hear him on 4m. The Cheltenham club (CARA) had a 4m 'on-air' evening on 18 February, which brought out a number of stations from both the Cheltenham and Worcester areas.

The 2m Band

Jef Van Raepenbusch ON8NT (Aalter) made some nice QSOs during the month using 25W and a 5-element LPDA. On FT8, Jef worked GW3ATZ (IO83), DK1FG (JN59), M0AGJ (IO93), M0WYB (IO81), GW8ASD (IO83), F6APE (IN97), G4HGI (IO83), G1SDX (IO80), G4EII (IO83) and G4RRA (IO80). Jef also worked F6DZR (IN96) on SSB during a contest on 14 February.

Roger Greengrass EI8KN (Co. Waterford) kindly wrote with details of a very nice FT8 QSO that he made on 5 March with OE5VRL. Roger saw a CQ from Rudi at around 0815, went back to him and to his surprise, was able to complete the QSO over a distance of 1582km. Roger's signals were heard by a number of stations, with the most distant being OK2GTI at a distance of 1724km. Discussing it with Roger, our initial reaction was that this was a meteor burst, but then realised that although that was possible, it was perhaps unlikely that a meteor burst would have lasted the 1m 15 seconds required to complete the FT8 QSO. **Joe DL8HCZ/CT1HZE** suggested that the QSO was tropo, but given the high signal strengths involved, that was perhaps not the whole story (incidentally OE5VRL was 'visible' here at GW4VXE too, albeit not as strong as at Roger's, and there was definitely no tropo into mainland Europe at that time from here). In the end, Roger and I agreed that perhaps one possibility was tropo for most of the path, but with some aircraft reflection as well, allowing the signals the final 'hop' across Wales and the Irish Sea.

Simon G6AHX took part in the RSGB UK Activity Contest on 2 March, in the 10W section. He had 23 contacts in 11 squares with

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the best DX being GM3SEK (IO74). Simon also took part in the March 2m contest on 6/7 March with the best DX being DK5WO (JO30) at a distance of 584km.

Phil Oakley G0BVD (Great Torrington) was pleased to work GW0PLP in Aberporth on SSB during the month, but was disappointed not to hear anything during the UK Activity Contest.

Robert van der Zaal PA9RZ (Sassenheim) has a new Icom IC-705 and has been trying it out on the VHF/UHF bands, **Figs. 1** and **2**. Initial QSOs on the local repeater, PI2NWK, resulted in some excellent audio reports, which was an encouraging start. Robert says that it wasn't until the March contest that he really tried it out and was very pleased at one stage to have his CQ answered by **Pete G4PLZ** (JO02) at a distance of 229km. Robert was particularly pleased to hear from Pete, as he's located in an area of Norfolk that Robert knows well. Robert also worked DF0MU (JO32) at a distance of 188km and had an easy QSO with his 10W.

Highlights from the GW4VXE (Goodwick) 2m FT8 log include F4FET (JO00) and GJ3YHU (IN89) along with regular QSOs with G7GQA/P (IO92) and M0WYB (IO81). Some occasional more distant stations have been seen, OE5VRL as mentioned previously and some nice meteor bursts were received from OE3JPC (JN87). Another nice QSO, this time on FM, was with M0GIW/MM in the Irish Sea in IO61, heading from Cherbourg to Rosslare, **Fig. 3**. Dave was using a TH-D74 and an extended whip antenna and varied up to S6 here on the Pembrokeshire coast over a distance of just under 100km. I was using an FTM-400XDE and a V-2000 vertical at 10m.

The 70cm Band

Jef ON8NT made several contacts during the RSGB UK Activity Contest on 9 February with G7LRQ (IO91), G4CLA (IO92), G4ODA (IO92), G3XDY (JO02) all worked on SSB and

G3MEH (IO91) worked on CW.

Robert PA9RZ has been trying out the 10W from his IC-705 on 70cm too. A first QSO was with **Jelke PA0FEI** (JO33) a friend from Robert's university days. Jelke runs a Microwave Modules transverter at 10W, so it was a nice two-way QRP contact. Robert was pleased to work G3XDY (JO02) during the 70cm activity contest, but the contact was a bit of a struggle on that occasion. Another nice local QSO was with **Wim PA0WMX** (JO21), another of Robert's friends from university. Robert firmly prefers CW/SSB to the digital modes and says that he wants to be able to decode what hears using the software between his ears.

The 23cm Band

Roger EI8KN mentioned that he has been doing some aircraft scatter tests on the 23cm band using the new Q65 mode and hopes to have more to report before long.

Satellites

At the time of writing, both the crossband repeater and the APRS digipeater on the ISS are off-air. Following a recent spacewalk when various feeder cables were reconfigured, there has been a problem connecting the ARISS radio system in the Columbus module to an antenna. It's hoped that this can be resolved before long, possibly requiring another spacewalk (you thought it was difficult to maintain your antenna system!).

Jef ON8NT monitored the ARISS contact on 9 February with good signals as did **Kevin Hewitt ZB2GI**, who used a Baofeng UV-5 with a two-element 'rabbit ears' Yagi pointing out of the window.

Patrick Stoddard WD9EWK (Phoenix) has been continuing his experiments, with **Endaf Buckley N6UTC** using D-STAR on the AO-27 satellite. Patrick writes, "*We both have been varying our station configurations over the past few weeks. I have used the following configurations:*

1. Two Kenwood TH-D74s
2. Icom ID-4100 for uplink, Kenwood TH-D74 for downlink
3. Icom ID-4100, operating half-duplex
4. Icom ID-5100, operating half-duplex

N6UTC has used the following configurations:

1. Icom ID-880H for uplink, Icom IC-80AD for downlink
2. Icom IC-80AD for uplink, Icom ID-880H for downlink
3. Icom ID-880H, operating half-duplex.

"The ID-880H and ID-4100 can switch between memory and VFO mode, to handle the AO-27 uplink and downlink frequencies in different bands. I put 145.850MHz into two

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memory channels on my ID-4100 - one for FM, the other for D-STAR DV. When I prepare to transmit, I can change the memory channel to transmit in one mode or the other. The VFO is in DV mode, but the 'DV Auto Detect' function in the ID-4100 (and many Icom D-STAR transceivers) is enabled. DV Auto Detect allows for reception of FM signals, without changing the radio from DV to FM. This allows me to hear any FM traffic through AO-27, while attempting to make a D-STAR QSO.

"The two TH-D74s, despite only being 5W transceivers, work well for AO-27 D-STAR. For the uplink radio, I put 145.850MHz into both VFOs, one in FM and the other in DV mode. On the downlink radio, I do the same thing. The TH-D74 has an 'FM Auto Detect on DV' mode similar to what the Icom radios have, but appears to be sluggish in going between FM and DV mode, so having the same frequency in both VFOs on the downlink radio – one in FM, the other in DV – gets around that.

"The ID-5100 is capable of full-duplex operation in FM mode, which is great for FM satellites. Unfortunately, the radio only has one D-STAR vocoder. When transmitting from the main VFO on an ID-5100 in D-STAR (DV), the sub-VFO is muted if it is also in DV mode. Even though the sub-VFO may be muted, it can decode the data sent with the audio – the transmitting station's callsign, and the 'message' sent along with the callsign. I have seen this while using the ID-5100 through AO-27 in D-STAR. It is unfortunate that the ID-5100 lacks a second vocoder, which would support full-duplex operation in D-STAR as well as FM.

"Most of the time, N6UTC and I have made our AO-27 D-STAR QSOs from our homes. On 13 February, during a trip to the DM23/DM24 grid boundary in western Arizona, I worked Endaf that morning through AO-27 using D-STAR with my two TH-D74s. I worked other passes in FM, SSB, and packet – but getting a D-STAR QSO in the log out there was fun.

"N6UTC and I have posted videos from a couple of our recent AO-27 D-STAR QSOs. First, N6UTC tweeted a short video clip of our QSO on 7 March:

https://tinyurl.com/hvxfft4p

"N6UTC was using his ID-880H, using the buttons on the front panel to switch between the VFO and a memory channel. I posted a longer video on YouTube, which shows my calls leading up to a QSO with N6UTC on 10 March:

https://tinyurl.com/34mz4e92

"I was using an ID-4100, switching between VFO and the memory channels, as well as adjusting the frequency in the VFO, using the buttons on the microphone.

"At the end of February, N6UTC travelled to the DM06/DM16 grid boundary in central California. While up there, I made a road trip of almost 300 miles through Arizona. I first drove north of Phoenix to the DM34/DM44 grid boundary. At this location, I worked N6UTC on SO-50 and NO-84. After these two passes, I drove back to Phoenix to work N6UTC on PO-101 from the DM33/DM43 grid boundary. About 90 minutes later, I was at the DM32/DM42 grid boundary south of Phoenix in time to work N6UTC on another PO-101 pass. It was fun to work from three different locations in six grids, in less than four hours.

"As we move to springtime, more stations are getting out and operating from many different locations. A couple of weeks ago, ***Dmitry N6DNM*** *spent a week working satellites from the north shore of Hawaii's Oahu island. Dmitry was working FM and SSB satellites from grid BL11, and made a couple of attempts from BL01 west of Honolulu before flying home.* ***Tyler WL7T*** *just completed a trip through several states near the Canada/USA border, putting many more grids on the air. WL7T is now planning trips to grid EL58 at the mouth of the Mississippi River, and maybe another trip to the state of Maine where operators across both North America and Europe will have a shot at working him".*

That's it for this month. Thanks to everyone who's been in touch and if you've been thinking about sending in a report covering any aspect of VHF/UHF operation, please do, it will be very welcome indeed.

Getting Started (Part X)

Colin Redwood G6MXL
practicalwireless@warnersgroup.co.uk

Following on from last month, **Colin Redwood G6MXL** makes a linked dipole for the higher HF bands, before offering some tips for overcoming mike shyness and finally welcoming some very relevant new videos for beginners from the RSGB.

Last month I discussed a number of aspects of operating away from home. For several years I have been meaning to get round to making a linked dipole, **Fig. 1**, for the higher HF bands that also covers the 6m band. I already own the SOTAbeams 20/30/40/80m linked dipole, which I have used with good results on several outings as well as holidays and a mini DXpedition.

I was looking for something that would ideally cover 6, 10, 12, 15 and 17m. I was particularly keen to get a lightweight antenna that I could use during the summer Sporadic E season (May to August) to cover 6, 10 and 12m when operating away from home. As SOTAbeams don't produce a linked dipole for the higher HF bands, I decided to build one myself using SOTAbeams parts.

Feeder

I was in two minds whether to use RG58 or RG174 feeder. Essentially the decision was lower loss with RG58 vs. lighter weight with RG174. Not only would RG58 be heavier to transport but also put an extra strain on a lightweight flexible mast, particularly when blowing about in the wind.

At 50MHz, a 10m length of RG174 has about 1dB extra loss compared to RG58. In both cases losses at lower frequencies are less. My existing SOTAbeams linked dipole uses RG174 and I have had good results with it.

I'll leave readers to decide which feeder to use, but make sure you order an appropriate centrepiece.

I ordered the necessary hardware and feeder from SOTAbeams and awaited its prompt arrival. In the meantime, I visited their website to remind me of the construction of the balun at the feedpoint:
www.sotabeams.co.uk/balun-toroid

Balun

I wound the balun, which I found straightforward, **Fig. 2**. SOTAbeams have several designs for the plastic centrepieces. I ordered the one described as a replacement for the SB Band Hopper, which uses RG174 feeder. I wanted to use the largest hole in the centrepiece to slide on to the mast. I used the three holes on one side that form a small triangle, to feed the feeder through,

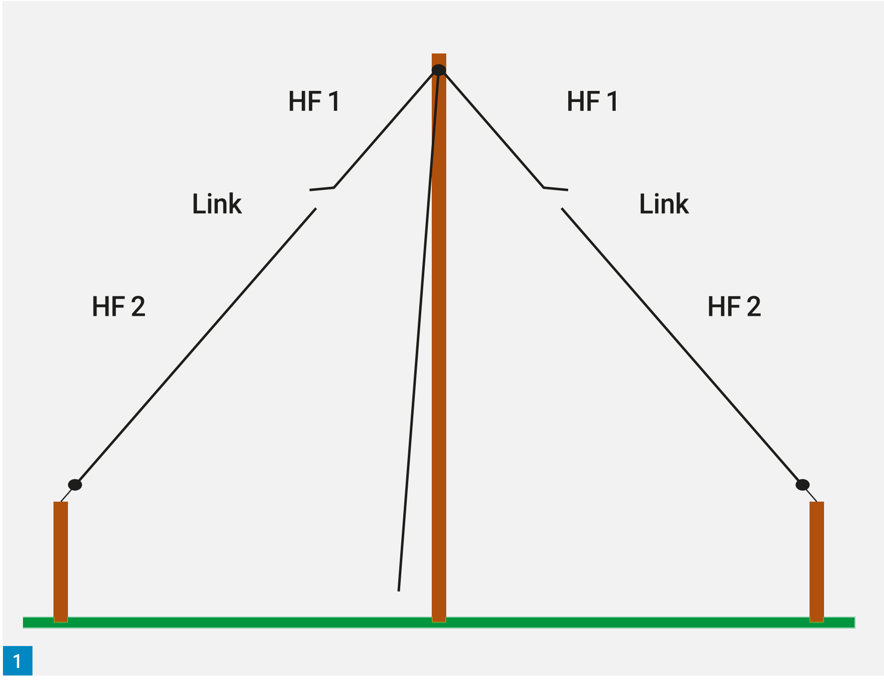

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Fig. 3. This followed the assembled linked-dipole I already had for the lower bands.

Calculations

Initially I calculated the lengths of the various wires using the SOTA Mapping Project Linked Dipole Antenna Designer. I found that the suggested allowance for connection length (50cm for the highest frequency band and 30cm for the other lower frequency bands) to be somewhat excessive:
www.sotamaps.org/extras

I found the dimensions from **John Parfrey M0UKD's** website were a better indicator for the overall length needed for each band. However, you'll need to subtract the cumulative lengths of the higher frequency bands from the cumulative length of the next lowest frequency band (e.g. 10m incremental wire length = 10m per M0UKD – 6m per M0UKD).
https://tinyurl.com/47rtkp8n

Table 1 shows suggested starting lengths. These are based on M0UKD's calculated length with an allowance of an extra 5cm (10cm for the highest frequency band) at both ends of each wire. This should ensure that each is longer than needed (see Matching below). If you have any doubts, cut the wire longer – just make sure it is the same each side!

Cutting the Wire

With the exception of the wires for the highest frequency, at both ends each wire is tied in a knot around an insulating separator and soldered to a croc clip. Don't forget to tie the wire to the insulating separator and slide the crop clip cover over the wire before soldering the end to the croc clip, **Fig. 4**. In addition, you'll need to match it. Starting with a wire that is known to be too long can help if you only have an SWR meter to measure.

Matching

You'll need some way to assess whether the wire is a good match (correct length) at your chosen frequency. There are three

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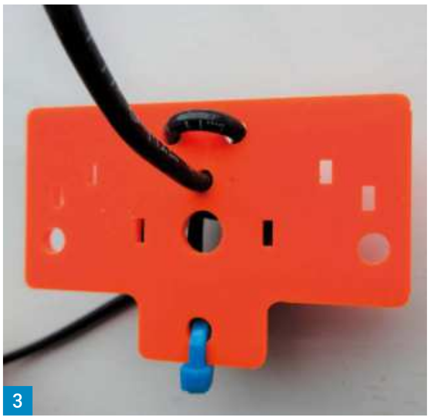

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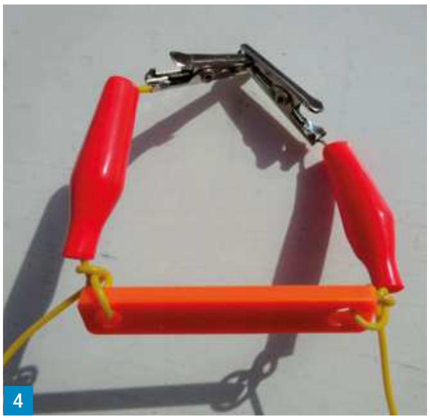

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Fig. 1: A simple linked dipole covering two HF bands. When the link is open it is resonant on the higher frequency (HF1) band. When the link is closed it is resonant on the lower frequency (HF2) band. Fig. 2: The balun on one face of the centrepiece. Fig. 3: The centrepiece (opposite face to the balun). Fig. 4: A typical link before sliding the croc clip covers into place.

ways that this can be achieved. Which one you use will depend on what test equipment you have access to. If you don't have any suitable test equipment, then, government Covid-19 restrictions permitting, it may be time to seek some help from a local amateur – perhaps through a local club. Whichever technique you use, try to get the centre of the dipole up at least one quarter wavelength above the ground and away from any surrounding metalwork before making measurements. I'd suggest doing this on a reasonably windless day to prevent SWR variations due to the wires blowing around in the wind.

Probably the simplest is to use an SWR meter. You measure the SWR, and if the SWR is greater than about 1.5:1, then you should cut a little off each leg, and re-measure. Repeat until you have the SWR below 1.5:1. If you are feeling brave, you could try to get the SWR lower, but don't get carried away, otherwise you may see the SWR start to rise again as the wire is then too short. I wouldn't struggle to get the SWR below about 1.3:1 as the local environment will vary from location to location out in the field.

A second way is to use an antenna analyser. This will enable you to see at what frequency the antenna is resonant, **Fig. 5**. If it is too low, then you need to reduce the length of the wire. Again, just cut a small amount of wire from each side and keep repeating the test. This takes time. As you get closer to your design frequency you should cut smaller lengths off each side (perhaps 2cm at a time) to get the SWR lower.

The final way is to use a Vector Network Analyser (VNA) to make the measurements. This will show a graphical representation of the antenna at various frequencies, **Fig. 6**.

Whichever method you use, you'll need plenty of time and patience – this is not something that can be completed in a few minutes! Don't forget that feeder loss can mask the extent of any mismatch, particularly with thin coax at higher frequencies. If you see the resonant frequency is above your design frequency, then the wire is too short. Don't throw the wire away as there may be some sections of the antenna that only need short lengths.

Once you have the highest frequency (shortest wavelength) section at the correct length, I'd suggest sealing the joints between the coax and the antenna wires to prevent rain getting moisture into the coax and ruining it. I used a hot glue gun to do this, **Fig. 7**.

Remember the length of the wire for each band is just the incremental length over the next highest wavelength. I decided to use different coloured croc clips for the two WARC bands (12m and 17m) to help me identify the various bands in the field. You may prefer to use different coloured wires.

After getting the central section (the highest frequency band) to the correct length, I took a chance and assembled all the remaining band sections based on the results from the calculator before testing. When I tested, I found that the lengths were too long, which entailed quite of lot of re-work. With the benefit of hindsight, I would recommend tackling one or two bands at a time. Whichever approach you adopt you should end up with a useful lightweight, multi-band antenna that covers the bands you choose.

Mike Shyness

One of the consequences of the temporary dropping of the practical elements of the Foundation Course is that for many new amateurs the actual setting up and operating a station is only encountered for real once they have passed their Foundation exam and obtained their licence. While some take this in their stride, others really struggle to feel confident operating on air, particularly if they don't have another amateur in the house.

Before going on, it's worth pointing out that this is not a new phenomenon. Prior to the introduction of the three-tier licence scheme and prior to the CB boom in the 1980s, most newcomers would have been in the same situation. There are a wide va-

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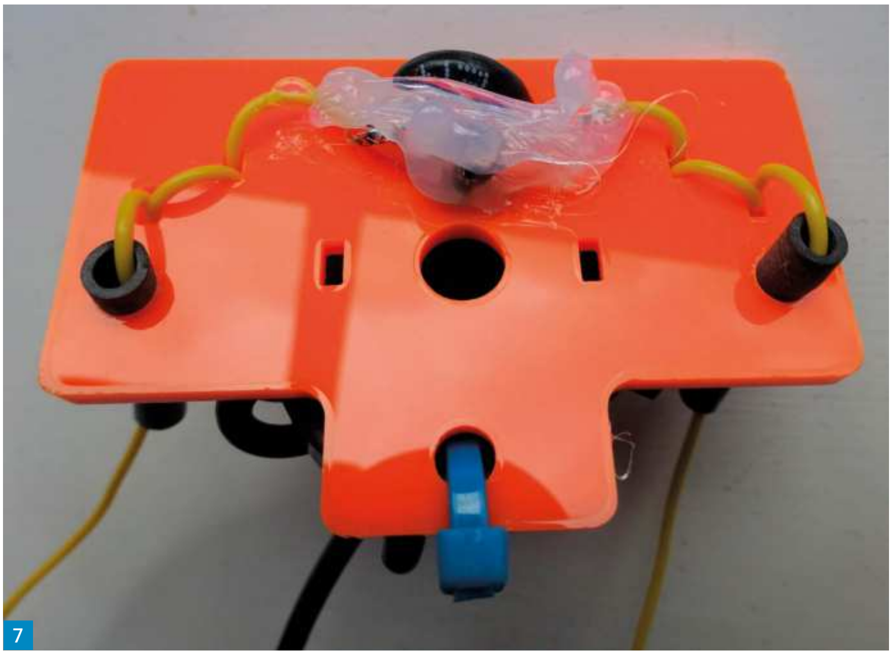
Fig. 5: The display on an antenna analyser.
Fig. 6: A typical display from a VNA showing the resonant frequency of an 80m antenna.
Fig. 7: The centre piece with the coax sealed with a hot glue gun to prevent moisture ingress.



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Band	Overall lengths for one side (m)	Incremental lengths for one side (m)	Allowance for connections (m)	Suggested starting lengths for one side (m)
50MHz	1.39	1.54	0.20	1.74
28MHz	2.48	1.09	0.10	1.19
24MHz	2.81	0.33	0.10	0.43
21MHz	3.30	0.49	0.10	0.59
18MHz	3.86	0.56	0.10	0.66

Table 1: Suggested incremental starting lengths for each band for each side.

riety of approaches, and I'm hoping that one or more of these will help newcomers make their first contacts.

Listening on the Air

For some, mike shyness is associated with simply not knowing what to say when transmitting. A period of listening on the air, to get used to the flow of typical contacts, might be all that is needed. I'd suggest avoiding contests on the HF bands at weekends, as such contacts tend to be very brief. Better I think to listen on the 'WARC' bands. To avoid contests, I'd suggest the 17m band as it is most likely to be open during the day. On the VHF bands, 2m is more likely to yield contacts than 70cm.

If you have come from a CB background, you'll notice that the operating style in amateur radio is somewhat different. Just listen to the terminology being used, and you'll soon pick up the correct amateur radio terminology and Q codes, etc.

Crib Cards

Just listening may be sufficient for some. Others may like to prepare some crib cards, based on what they have heard on the air. You could highlight the 'overs' that you speak, so that you can clearly see a road map through your first contacts. I described typical 'rubber stamp' contacts in the August 2020 issue of *PW*.

Zoom

Another more modern way is to approach a local amateur and arrange a one-to-one Zoom session with them. You could start with both the sound and video on so that you get to know each other. Then, once you are comfortable, you could try mock contacts over Zoom, safe in the knowledge that nobody else is listening. You could then go on to having mock contacts over Zoom with the video turned off. Once your confidence has built up, you could try a contact on the air, with Zoom video on or off as you feel happiest with.

If you don't know any local amateurs, I'd suggest contacting your local amateur radio club by phone or email. Ask them to put you in contact with whoever runs the Foundation Licence practical sessions in normal (non-covid) times. You'll find a list of local clubs on the RSGB website at:

https://rsgb.org/main/clubs/club-finder

Data Modes

If you really cannot get over your mike shyness, then there are plenty of ways that you can still actively participate and operate in amateur radio. The various data modes that I outlined in the December 2020 issue of *PW* can certainly be used without the need for a microphone. In fact, you don't even need to be able to hear the signals, as your computing device does the work of modulating the signal for transmission and decoding the signals received.

Morse Code

Morse code is another mode that can be used without the need to speak into a microphone. Ideally, you'll need to learn Morse code, but you can use computer programs to transmit Morse and decode Morse if it is sent well. I'd suggest having a look at **Roger Cooke G3LDI's** *The Morse Mode* column here in *PW*.

RSGB Beginners Videos

The RSGB have produced a series of short videos that readers may find useful. They cover topics such as 'Making Slim Jim antennas', 'Fitting a PL259 plug to some coaxial feeder', 'Audio Interface', and 'CAT Control'.

Two of the latest videos are particularly relevant to making the Linked Dipole that I described earlier: 'Making a Simple Balun' and 'Tuning a dipole using a VNA'. If you've not used a VNA before, it is an extremely helpful practical introduction. Further videos in the series are planned:

https://tinyurl.com/yz9etplx

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Repairing a HP Logic Probe

Dr Samuel Ritchie EI9FZB describes how he went about repairing an old but serviceable piece of test equipment.

Trying to fault-find logic circuits has always been a painful experience for me. I would use an oscilloscope to troubleshoot circuits but I soon tired of trying to hold a probe on the IC (integrated circuit) leg and then look at the oscilloscope to see the level, only to have the probe slip off the IC leg as I looked away. To quote a Hewlett-Packard (HP) brochure from the 1960s, *"Logic probes are the quickest, surest way of detecting the presence or absence of single or infrequent pulses. No adjustments are needed, and signals can be rapidly traced through circuits by monitoring only two points: the schematic and the probe tip. There is no chance the probe will slip off the intended node while the user turns his head to read a remote display"*.

Clearly the answer was to get a logic probe that allows you to keep your eye on the probe tip, its connection to the IC pin, and see an indication of the logic level by watching a light mounted just above the probe tip.

I kept my eye on a number of kits, none of which were convincing enough to buy, and recently noticed a number of sellers online offering HP logic probes. At one stage there were 12 sellers on eBay selling a variety of HP logic probes and in July 2019 I was able to buy a package of HP probes, in their storage box with all the accessories including spare tips for circa €60. The subject of this article is shown in **Fig. 1**.

The two HP logic probes in the package (there was also a logic pulser and some accessories) were the HP10525A and the HP10525T.

The A model was first advertised in the HP journal of June 1969 and was in production until 1972 at which time the T version was released and advertised in the September 1972 HP journal. Both of these A and T models were designed to work with TTL (transistor-transistor logic) and DTL (diode-transistor logic) technologies but also work nicely with CMOS (complementary metal–oxide–semiconductor) logic if you run the CMOS at 5V.

The 1973 HP catalogue has the HP 10525T with a spare tip at $110, which equates to $636 or £490 today. Two additional models were also produced, an E model for use with ECL (emitter-coupled logic) devices and an H model for high voltage logic families such as HTL (high threshold logic) and HiNIL (high-noise immunity logic) as well as discrete logic circuits and relay logic systems.

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The A model was a revolutionary product and works as follows: the logic probe lamp stays on when the probe is open circuit or touched to a high logic level (>1.8V). The lamp turns off when the tip is touched to a low logic level (<1V). Pulses between 25ns and 0.1s are stretched to turn the lamp on (for a positive pulse) or off (for a negative pulse) for a full 0.1s.

The one missing function is an indication that you are probing bad logic – something either open circuit or floating between the two logic levels. Hence the evolution of the T model within three years, which works as follows: the lamp is at half brightness for an open circuit or bad logic level, at full brightness for a steady logic high level, and off for a steady logic low. Any pulses with a width greater than 10ns cause the lamp to blink for 0.05 seconds and pulse trains up to 50MHz cause blinking at 10Hz.

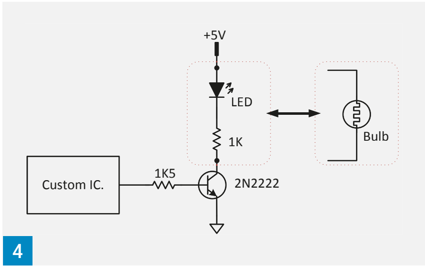
You may have noticed that I use the word lamp and this is deliberate because the HP10525 range of probes use an incandescent light bulb as the indicator. Bear in mind that visible LEDs around this time cost in the order of $200 each. The small lightbulb used in the probe is the same as that apparently used in Minuteman missiles, the B-52 bomber, Poseidon and Trident and is a 5V, 20mA design with an average life of 10,000 hours.

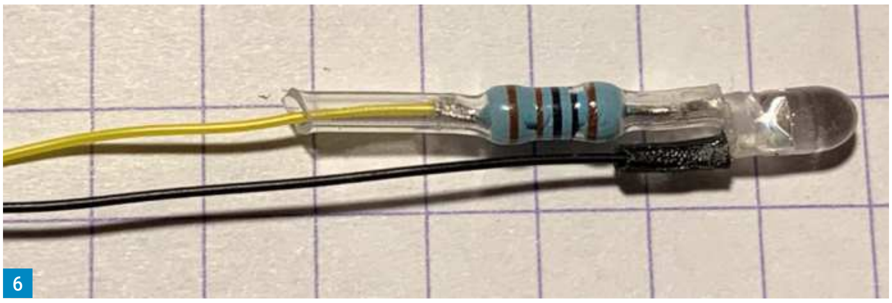
The bulb in my Model A was broken either due to wearing out or the probe failing a bounce test and even with such a pedigree I was not able to find a reliable source for a replacement or equivalent. Fortunately, LEDS are now very cheap and I chose to go down this route to repair my probe.

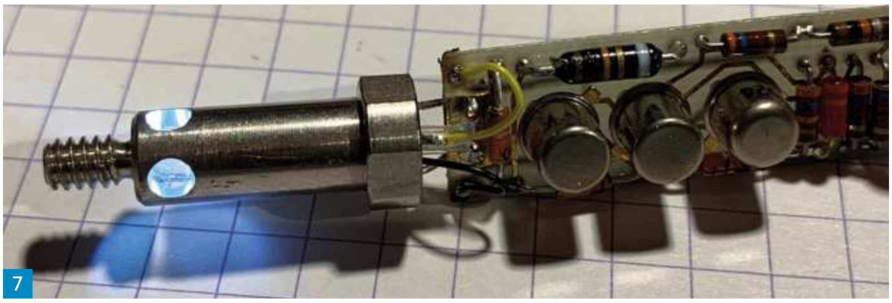
Opening the Probe

The operation and service manual for the T model is easily found online and the dismantling of the probe is the same as for the A model. You simply:

- Using your fingers, unscrew the probe tip;
- Slide the light window off the probe tip end,
- Use the probe tip point to remove the front







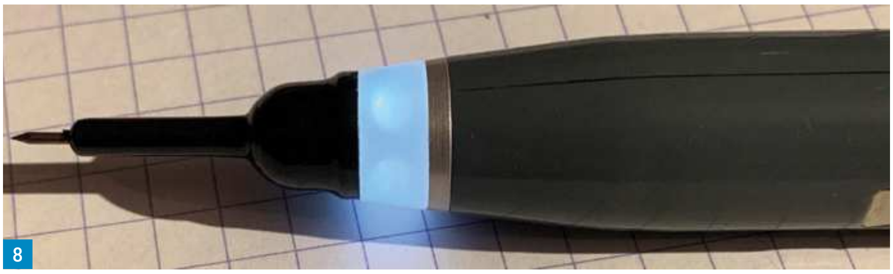


Fig. 1: The HP10525A logic probe. Fig. 2: Half shell removed. Fig. 3: Accessing the bulb Fig. 4: LED driver circuit. Fig. 5: Comparing the bulb, an untouched LED and a cropped and filed-down LED. Fig. 6: LED with current limiting resistor and wires ready for insertion. Fig. 7: LED inserted and ready for reassembly. Fig. 8: Reassembled and ready for action.

collar by gently pushing the tip point between the collar and the probe body;

- Gently push the probe tip point between body shell halves at the probe tip screw and one of the body shells will come off, see **Fig. 2**. Admire the quality of the design and especially the custom IC;
- Gently push the tip point under the rear of the probe tip screw stud and the other half separates from the PCB.

The bulb is accessed by pushing the screw stud down which let you gently pull out the bulb which is housed in the body of the stud, **Fig. 3**. Now you are in a position to replace that bulb.

The Circuit

The driver circuitry is simple and shown in **Fig. 4**. The output of the custom IC drives the transistor on or off and all that was required was to replace the bulb with an LED and a current limiting resistor. I found that a 1kΩ current limiting to 2.5mA provided enough light to ensure visibility on a sunlit workbench.

Selecting and Preparing an LED

The bulb diameter is 3mm and the diameter of the tube it fits into is only slightly larger. The smallest LED I could find was labelled as a 3mm device but that is the size of the lens and the collar is 3.8mm. Using a flat needle file I gently filed the collar to the same size as the lens, **Fig. 5**. The lens is made from an epoxy so you need to be gentle and not touch the lens as it is easily marked.

The LED I used is Radionics part number 713-3942, manufactured by Nichia with model number NSPW300DS. They cost just less than €1 each but you must buy a minimum of five through this supplier.

Remember that the long lead on the LED indicates the anode (which connects directly to +5V) and the short lead is the cathode (which connects to the one end of the 1kΩ resistor). **Fig. 6** shows my assembly using heatshrink to ensure there is no shorting to the metal case, which is firmly grounded. The wires are single strand wire wrapping wire because there is not a lot of room in the tube. I had to stagger the location of the LED and the small piece of black heatshrink or else the assembly was too bulky to fit into the tube.

Inserting the LED

It is clear what pad the anode is soldered to on the PCB as the +5V rail runs all the way across the board to the inner connector of the power lead. The other lead goes to the pin connecting to the 2N2222 transistor. A quick test, see **Fig. 7**, then reassemble and the job is done, **Fig. 8**.

End Notes

At some point the bulb in the Model T probe will go and I will be repeating this process to return that probe to service. They may be some differences as the driver is no longer a simple on-off arrangement, but that is for another day.

If it helps, I have made larger versions of the photographs on my website at: **www.samuelritchie.com**

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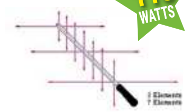

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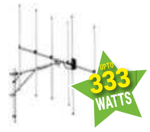

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NanoVNA: Can You live without One?

Michael Jones GW7BBY gets to grips with the handy NanoVNA, with some practical examples.

Michael Jones GW7BBY
michael@gb2mop.org

I'm looking at the NanoVNA, **Fig. 1**, a Vector Network Analyser. Vector Network Analysers are used to test components or combinations of components (networks) by measuring amplitude, phase and reflection characteristics. Typically, it might be used to verify design simulations to ensure that different stages are matched in terms of impedance. In the amateur radio world the two most common uses would be antenna and filter testing.

NanoVNA should be supplied with Open, Short, Through and 50Ω SMA calibration standards; a pair of SMA terminated test leads and a USB cable for connection to a PC or 5V charger, **Fig. 2**. In the case of the model I used (and which was reviewed by the editor in the July 2020 *PW*), there are no supplied instructions, but there is an introduction to NanoVNA on the NanoVNA.com website. There is a wealth of information on the internet, particularly on YouTube. IMSAI GUY's videos are recommended, as is the NanoVNA users group (nanovna-users@groups.io).

What is it?

A VNA is a two-port device; the ports can be used individually or together. As a one port device it works by generating a test signal, injecting it into a Device Under Test (DUT) and measuring the amplitude and phase of the reflected signal. By using both ports the transmission characteristics of a device such as a filter can be determined.

The two ports are marked as CH0 and CH1 on the NanoVNA, which corresponds to Port 1 and Port 2 on commercial VNAs. They are also referred to S1 and S2. This makes sense as the parameters tested by the VNA are usually referred to as S11, S21, S12 or S22. S11 simply means S1 out and S1 in or reflected. S21 is S2 out and S1 in or transmission. NanoVNA primarily tests S11 and S21 parameters. S12 and S22 parameters can be measured with reduced accuracy by reversing the DUT.

Incidentally, S11, S21 etc refer to Scattering parameters. These are derived from the study of optics where light rays can be seen to pass through a given lens, but not all the rays pass through the lens, some are scattered back to the light source as they encounter the back and front surfaces of the lens or discontinuities in the lens. These reflected rays are referred to as the S11 scattering parameters. The rays that pass through the lens are the S21 scattering parameters.

1

The Screen

Although small, the 2.8in screen is well designed and clear (see Fig. 1 again). Four traces are available, each trace has a different colour. The parameter to be measured by each trace is displayed in a banner across the top of the display. Unused traces can be turned off. The start, stop, centre and span frequencies are displayed in a banner across the bottom of the display.

On the left is the calibration status. From top to bottom, C*n* indicates which saved calibration, C0 – C4, is in use. The letters below this indicate which parameters have been calibrated: D, Directivity; R, Reflection; S, Source matching; T, Transmission and X, Cross-talk.

Controls

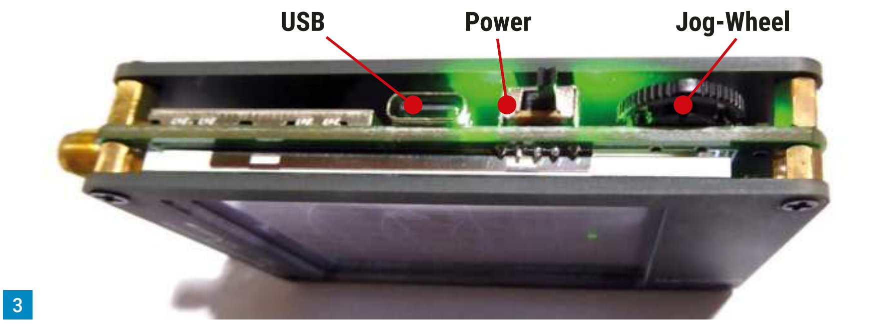
Controls are minimal. There is a jog-wheel for navigating the menus and moving markers and a power switch, **Fig. 3**. To the left of the switch is a USB-C connector. A green LED between the jog-wheel and the power switch flashes when on battery power and is steady when charging. A second green LED next to the USB port is steady and flashes slowly when USB connection is made. Strangely, it stays on for about 40 seconds after powering off.

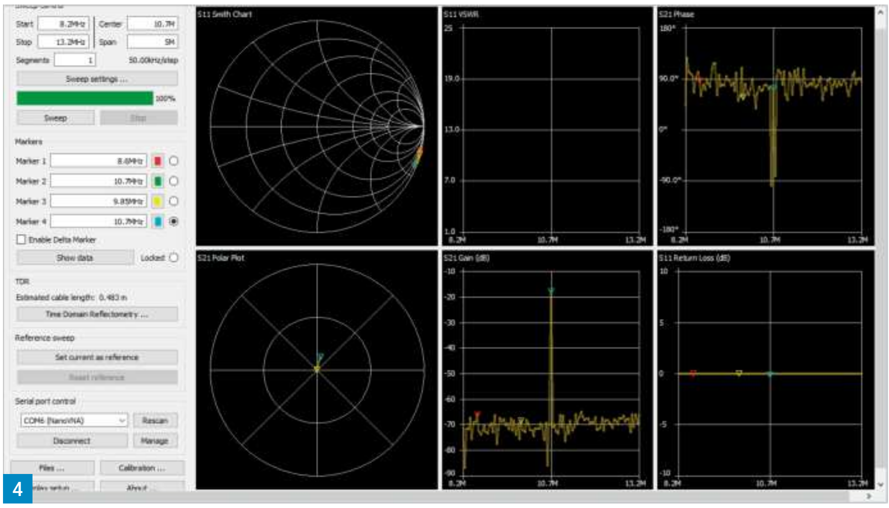
PC Control

NanoVNA can be connected to a PC using the supplied USB lead. There are a number of applications available. The most common is NanoVNA-Saver, which can be downloaded from github. Depending upon your version of Windows, you may have to download the Virtual Com Port (VCP) driver from the STMicroelectronics site.

Under PC control NanoVNA comes into its own, the larger screen and navigation by mouse makes NanoVNA an even more useful tool. Up to six different curves can be displayed, **Fig. 4**, individually rather than overlaid on top of each other. More markers can be added, each with its own dataset. The default dataset for each marker

Fig. 1: NanoVNA front. Fig. 2: NanoVNA with supplied calibration standards and SMA leads (USB cable not shown). Fig. 3: Controls and the open construction. Fig. 4: Screenshot of NanoVNA-Saver software showing the six display windows.





can be modified by adding or removing parameters such as wavelength, admittance, series equivalent L/C and so on. Colours and various properties of the display can be managed. From the 'Manage' button screenshots of the actual NanoVNA can be taken and saved as *.png files.

A very useful feature is that a scan can be performed in a number of segments, which results in a higher resolution. NanoVNA normally scans a defined frequency span by measuring 101 points. If NanoVNA was set up to scan from, say, 10 to 20MHz and the number of segments were set to 5, the NanoVNA-Saver will split that span into 5 segments of 101 points each, making a total of 505 points.

The scan rate on NanoVNA-Saver is slower than on the bare NanoVNA, probably an issue with getting data through the USB/VCP port. For viewing an SWR curve or a filter response it is fine, but if you want to adjust a ferrite core for maximum response it might be easier to do the initial adjustments on the bare NanoVNA. Increasing the number of segments per scan slows the scan rate down even more, but the results will be more accurate. I think each user will find their own optimum way of operating the software.

NanoVNA-Saver can be downloaded from: https://tinyurl.com/m6xvatvt

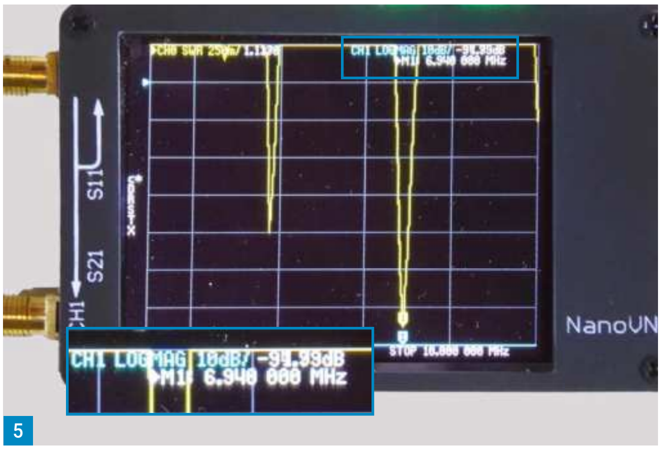
Some Simple Measurements

To find the resonant frequency of an antenna, set the frequency range, calibrate and the antenna to CH0 (S11). From the display menu select 'Format', then tap SWR for an SWR curve. More information can be obtained by assigning Trace 1 to CH0 Reactance and Trace 2 to CH0 Smith Chart. You may have to set the scale/div and reference position to get a meaningful trace. **Fig. 5** is an SWR sweep of my Off-Centre Dipole cut for the 40m band. An interesting exercise is to connect NanoVNA to an ATU and see how the SWR shifts as the ATU controls are changed.

To align a filter, set the range of frequencies and perform all calibrations, including 'Isolation' and 'Through', using the cables that you will use to connect to the filter. Connect the filter between CH0 (S1) and CH1 (S2) and hopefully there will be a nice peak representing the filter passband. Changing to Centre Frequency on the filter passband and then adjusting the span will enable you to examine the passband characteristics. The S21 gain for a 10.7MHz crystal filter is shown in **Fig. 6** (Taken from NanoVNA-Saver on PC).

A Practical Example.

I needed a 48.055MHz bandpass filter for another project. The component values have been derived from **Chris Bowick's** excellent book *RF Circuit Design*. I had the parts to hand so quickly cobbled it together on Veroboard, **Fig. 7**. Amazingly, NanoVNA presented me with a curve having a nice dip at about 40MHz. This design uses two adjustable TOKO S18 coils. As I screwed the ferrites out of the cores the dip moved to 48MHz, **Fig. 8**. I then moved the NanoVNA to my PC for some screenshots. The main



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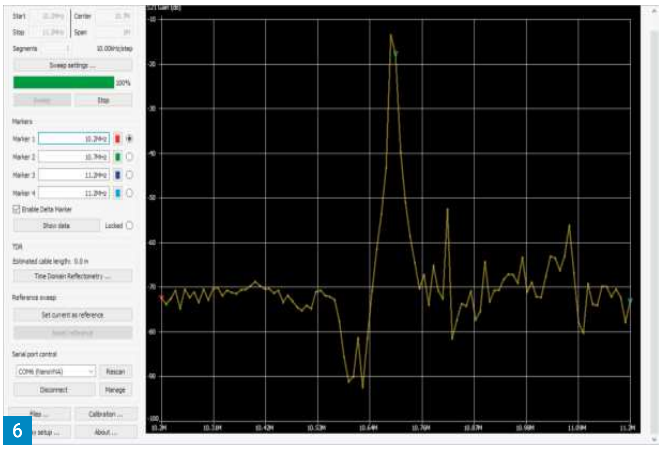
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window that I was interested in was the S21 Gain (dB) so using 'Display Setup' I disabled the other windows. This gave me a large clear trace, **Figs. 9** and **10**. There is no manual for NanoVNA-Saver, it is quite intuitive, but some very good features are not immediately obvious. Working from the top left, anticlockwise, Sweep Settings enable single sweep (default), continuous sweeping or averaged sweep. Compensation for an external amplifier can also be entered in Sweep Settings. If you are using a continuous sweep, the sweep must be stopped before the sweep frequencies can be changed. In this instance I set the unit up for a centre frequency of 48MHz and a span of 50MHz.

Next, any one of the four markers can be selected. The selected marker can then be dragged across the display with the mouse cursor. At the same time all the parameters relevant to that pointer's position are displayed in the central Data Panel. I spent a while finding the −3dB bandwidth, then I found the magic 'Analysis' button at the bottom centre of the screen (it was partially off screen on my old laptop). Click on 'Analysis', then select 'Bandpass' for my filter, and a box appears with all the necessary filter data: −3dB and −6dB bandwidths, *Q*, then for upper side and lower side −6dB and −60dB points and roll-off in dB/Octave, **Fig. 11**.

Right-clicking anywhere in the display window brings up a dialogue box to enable the display parameters to be set, or the window to be saved as a *.png file. If working with multiple windows, the display of interest can be brought up in a pop-up window that can be manipulated to examine areas of interest.

This test shows me that my 48.055MHz bandpass filter needs a bit more work to optimise the low-side skirt and I had to unscrew the cores unacceptably far to bring it to the correct frequency. Without this tool I would have had to build the complete circuit and then start changing components to achieve the desired performance.

Smith Chart

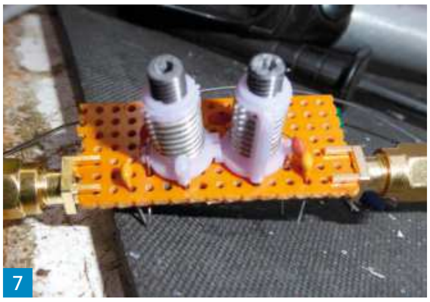
Readers will notice that some results are presented on a Smith chart. I have to admit that I have only a vague understanding of these so do not feel qualified to make any in-depth comments on them. However, what I have seen on my own unit and on the internet gives me no reason to doubt their accuracy. In fact, having NanoVNA provides me with the impetus to get to grips with Smith Charts and imaginary numbers. As a simple example, **Fig. 12** shows the inductance of a violet TOKO S18 coil with a nominal value of 0.389μH. The displayed value is 377nH. By adjusting the ferrite core the adjustment range can be seen to be from about 200nH to 388nH. Similarly, A 470pF ceramic capacitor comes out at 449pF, which is within 4.4% of the marked value, **Fig. 13**.

What else can be Done?

Time domain reflectometry can be used to determine the length of a piece of coax, or the distance to a fault. Most common coax types are listed in a drop-down box. There are a lot of helpful articles on the internet to help determine the optimum sweep frequency. As a rough guide I found that a sweep from 1 to 20MHz and between 5 and 10 segments produced good results for the lengths of cables that I tested (1m to 50m). For the example shown here I just picked a random piece of coax with 90° BNCs on each end. The length came out as 2.271m, **Fig. 14.** A rough measurement with a metal tape came to a bit over 2.26m, good enough to prove it works. In addition to the length, NanoVNA-Saver gives the Return Loss. For the example shown here this was 0.09dB, therefore the actual loss to be expected over this length of cable is half of the Return Loss or 0.045dB.

Menus

The menu system goes down a few layers and takes a bit of getting used to. Menu maps are available online. Download one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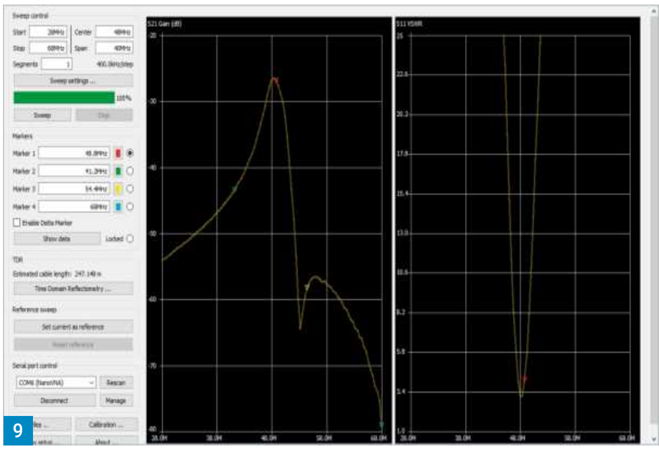
8

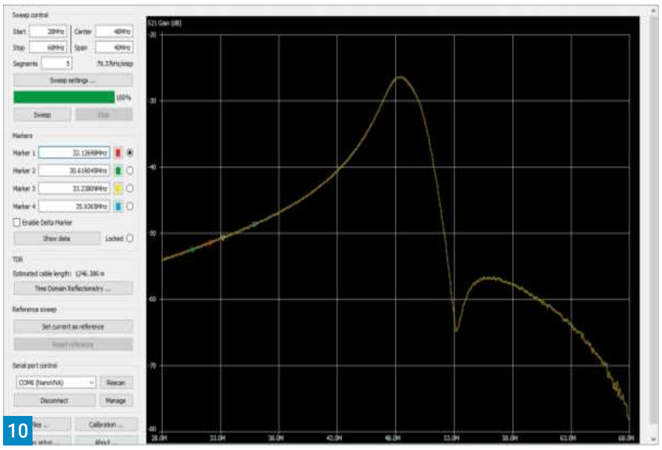
and keep it handy until you are confident about navigating the menus. An interactive Menu Map is available from:
https://tinyurl.com/4k78bvy5

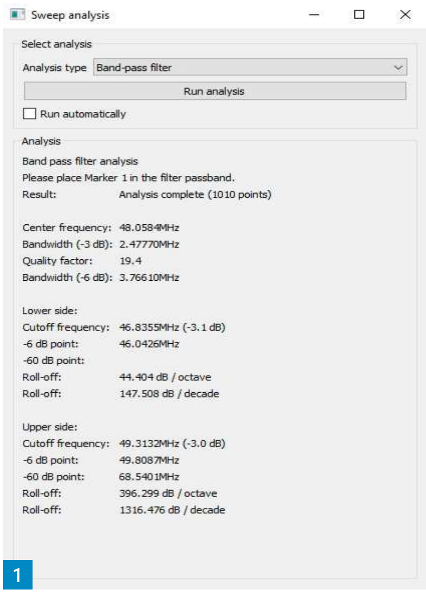
Calibration

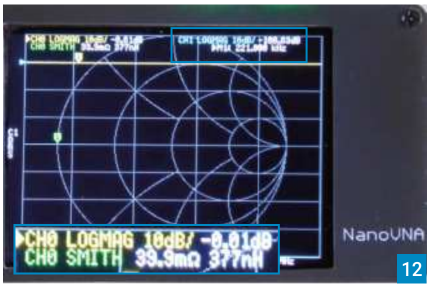
The supplied standards are used for calibration, which is quick and simple. Calibration should be carried out whenever frequency ranges or the test hardware are changed. NanoVNA plots 100 points over the frequency range to be scanned, therefore the step size needs to be optimised. For good results, pains taken with calibration will pay dividends. Calibration must be carried out with the leads and connectors to be used for connecting to the DUT as these will contribute to inductance and phase measurements. You will probably get away with some short cuts at HF and VHF, but UHF frequencies will not be so accommodating.

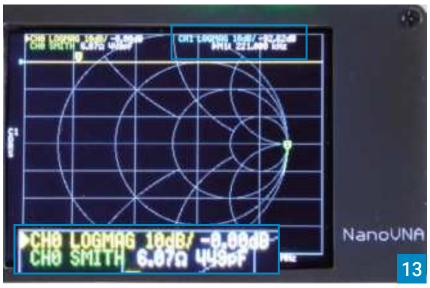
Up to five calibrations can be stored (C0 – C4) and recalled for frequently used measurements.

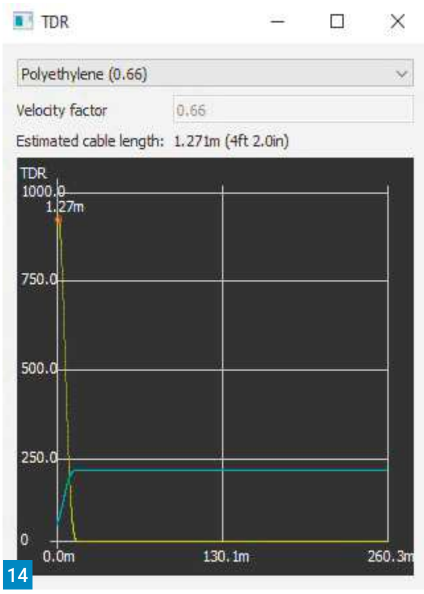












Firmware Updates

Firmware updates appear quite frequently. There are three possible upgrade file formats: HEX, BIN and DFU. DFU appears to be the easiest. There are a number of YouTube videos explaining the process. Essentially, the free DFUSE USB Device upgrade software needs to be downloaded and installed from ST Microelectronics. Follow the guide on the NanoVNA user's group's Wiki page. Before committing to an upgrade the existing firmware can be uploaded and stored on a PC in case it is necessary to revert to the original.

Limitations

Some models, like mine, are not fully enclosed: the main circuit board is sandwiched between two pieces of double-sided PCB painted black (see Fig. 3 again). With the open edges care would be needed when using the unit outdoors. Even around the workshop there is the danger damage. 3D printed cases are available on the internet. There is also a nice design published by QRPGuys: https://tinyurl.com/yewvtsew

Another small hardware issue is that the SMA connectors are likely to wear with frequent use. There is also a danger of damaging them by attaching heavy adapters and cables such as RG8 or 213 that can easily drag or pull on the SMA connectors. There are two solutions to this. One is to always use SMA cables to connect to an antenna or DUT, thus providing a degree of strain relief. The second option that occurs to me is to make a larger enclosure that allows the SMA connectors to be connected to either panel-mount SMAs on the enclosure, or perhaps BNCs.

There have been reports of NanoVNA input ports being damaged by static electricity when connecting to large external antennas. This usually occurs after stormy weather. To avoid damage either wire a couple of back-to-back small signal diodes across the input to NanoVNA, or briefly short the antenna to ground just before connecting to the NanoVNA.

Fig. 5: SWR sweep of my Off-Centre 40m dipole. Fig. 6: 10.7MHz crystal filter: S21 gain curve. Fig. 7: 48.055MHz Bandpass filter roughly assembled. Fig. 8: 48.055MHz Filter: Yellow trace is SWR, Blue trace is S21 gain. Fig. 9: 48.055MHz filter S21 gain and SWR using NanoVNA-Saver. Fig. 10: 48.055MHz filter S21 gain showing maximum window size. Fig. 11: 48.055MHz filter data. Fig. 12: Smith Chart response for TOKO S18 coil. Manufacturers nominal spec 0.389µH. 377nH shown here is acceptable considering rough lash-up. Fig. 13: Smith Chart response for 470pF ceramic capacitor Fig. 14: TDR results for length of coax: 1.271m.

Is it Expensive?

Prices seem to range from about £24.00 to £50.00. The cheaper ones do not appear to include the full calibration kit; I may be wrong about this. With little knowledge at the time of purchase I was concerned about bad clones. I ended up paying about £40.00 and never cease to be amazed by its performance.

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Top 10 FT8 Operating Tips

James Stevens M0JCQ offers his top ten tips for successful FT8 operation.

Over the last few years PSK31 and its variants were largely replaced by a new data mode, FT8. Although intended originally for use on the 6m band, FT8 has been adopted for use on pretty much every band, largely because it has proved so effective. Indeed, this data mode has truly come to dominate both the HF and VHF bands, to the extent that it is becoming rarer to find much SSB and CW activity, regardless of any other data modes on a given band! The following tips are based on my experience of using FT8 for a few years, since it was first released back in 2017. I've had 3,000+ FT8 contacts across bands from 160m right through to 70cm.

1. Stick to a Single Frequency

This is probably where a lot of beginners go wrong. Try and find a clear frequency and then stick with it, regardless of whether you call CQ or respond to others. The ***Hold Tx Freq*** option, **Fig. 1**, is your friend in WSJT-X:

This will ensure that you always transmit in the same place and, importantly, you don't keep hopping around the band (well, the channel being used for FT8).

Why does this matter? Well, you're more likely to be decoded if you're replying to another station away from his own frequency. If you move to their frequency, then you could be competing with other stations.

Also, we've all had it, where we're happily running on a frequency, then a station works you and proceeds to stay there and call CQ on 'your' frequency. It's annoying and typically the other station isn't even aware they're doing it!

2. Time Synchronisation is Key

If you've used data modes like RTTY and PSK31 in the past, then you're probably used to random receive and transmit cycles where you click a signal and transmit as soon as the other station has finished.

FT8 (and the other WSJT-X modes) demand perfect timing, so perfect it's beyond most of us to get right! If you're computer clock is off by two seconds or more, then most likely your signals won't be decoded by others, and no one else will even see your calls!

Your native Windows clock is likely to drift very quickly, unless you keep it trained to an accurate clock via the internet. I personally use Dimension4 to do this. It's free and every 30 minutes it automatically synchronises my PC clock with an accurate reference online.

3. Learn the WSJT-X Colour Coding

WSJT-X helpfully colour codes your decoded messages, so you can spot important messages quickly, **Fig. 2**.

If a new DXCC starts calling CQ, which you've not seen before, then this will be highlighted in dark purple (by default). If it's a new DXCC for you on the band, then it'll be highlighted a lighter shade of purple. Useful!

It's worth taking a look at the 'Colors' tab within the WSJT-X settings and learning these. This will allow you to quickly act on something you may 'need' such as that rare DXCC or new grid square.

4. See Where You've Been Decoded

The PSKReporter.info website is a very useful tool to find out first of all if you're getting out, and secondly where in the world you are being heard, **Figs. 3** and **4**.

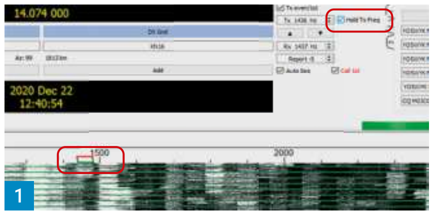
This gives you an almost real time summary of the propagation on your chosen band. It's a great way to just understand the possible HF paths that may be open at a certain time of day.

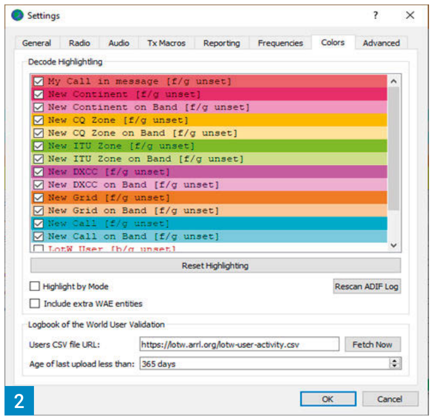
I typically have this running and check it every 20 minutes to see what I might be able to work or how propagation is changing to favour a certain area of the world. Observing this resource has allowed me to work a lot of DX.

5. Persevere

One misconception is that FT8 can be like shooting fish in a barrel, but it's not always easy to 'work the world'. The vagaries of propagation still come into play. Conditions can change quite quickly with openings appearing and fading out.

If a station doesn't respond to your call straight away, try leaving it for a few cycles.





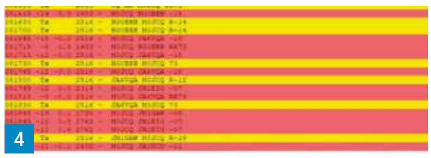
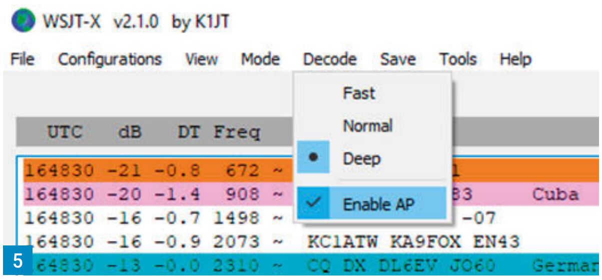


Fig. 1: Tick the 'Hold TX Freq' checkbox to stick to the same frequency. Fig. 2: WSJT-X message highlighting gives you a lot of useful information at the glimpse of an eye. Fig. 3: My messages were being received well in Japan on this day (using 20m). Fig. 4: Pileup of JA stations calling me on 20m – a nice problem to have!



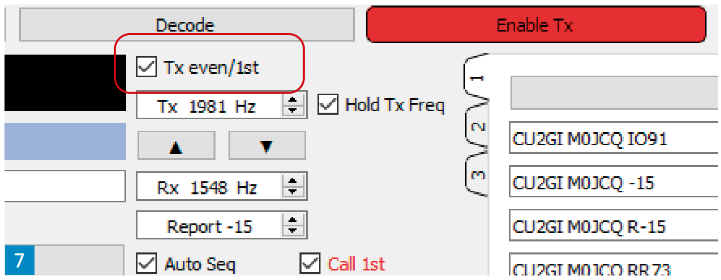
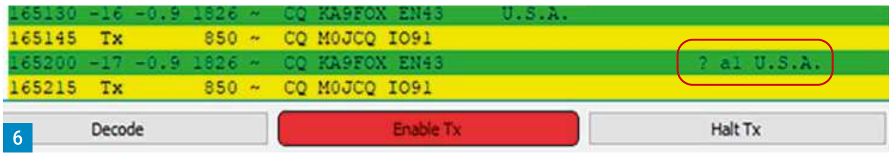


Fig. 5: How to change your decoding settings and 'Enable AP' in WSJT-X. Fig. 6: How a decoded message using AP is presented in WSJT-X. Fig. 7: How to switch TX timeslots in WSJT-X.



Conditions might just swing in your favour, then they can decode your message.

This is another great reason to operate away from the other station's frequency; you can continue calling them while they're in a QSO, without you interrupting it and you might end up possibly being worked straight after.

I used to give up a bit too quickly, but found that perseverance (especially with DX stations) usually paid off.

6. Enable 'Deep' and 'AP' Decoding

Without going into too much technical detail here, your FT8 decoding will be more sensitive if you set your WSJT-X decoding settings to *'Deep'* and *'Enable AP'*, **Figs. 5** and **6**.

Deep decoding throws more of your computer power at decoding the signal. AP (*a priori*) uses heuristics and known information to decode messages, which otherwise wouldn't be decoded.

Deep decoding comes with a performance penalty, your computer may not decode all received signals before the next time period starts. While using my old shack laptop, I found this to be a problem when decoding a busy 20m band, but after upgrading I use it all the time now. You can always drop back to 'Normal' decoding if you notice this.

Enabling AP on the other hand can introduce some unusual side effects with the decoded message. If the callsign looks funny, then it's probably incorrect. It easy to see which messages had AP applied to them. Use your brain here – if it looks funny to you, then it's probably not right!

7. Can't Decode a Strong Signal? Lower your RF Gain

Sometimes you'll see a large signal on the Waterfall, but WSJT-X can only occasionally decode it, or at worst just cannot decode any of the messages at all. The station seems to be transmitting accurately timed signals, but nothing shows up, how strange!

I've noticed this occurring during strong openings, especially during Sporadic-E season on 6m, where strong signals of 10dB+ just won't decode.

I've found that simply turning down your rig's RF Gain will allow the messages to be decoded. A simple fix, but if you've not used other data modes, you might not think to do this!

8. Change Frequency

You may find that for whatever reason you are not getting any responses to your CQ calls. This could be down to a number of factors, but it's always worth checking to see if your chosen frequency is clear within your chosen transmit timeslot.

If another station is transmitting on your frequency or nearby during your transmit timeslot, then other stations may not be able to decode your messages in order to even see your CQ messages.

Even if you still can't see anything else when just receiving during your timeslot, there could well be another station on the same frequency, which your DX is seeing but you're not.

I've found it worthwhile moving frequencies. If you're not getting much luck, it usually works.

9. Change Timeslots

If you've spent a while using one timeslot (say 'even TX'), then why not switch to the other one, **Fig. 7**? This might net you a whole new haul of stations to work.

For me this usually leads to an (initial) increase in contacts and obviously allows you to work stations not worked in your other timeslot. I tend to keep switching between these timeslots every 20 minutes or so.

A word of warning here: make sure there are no timeslot conventions on your chosen band. VHF bands have a convention where your timeslot is chosen based on your location, in order to prevent nearby stations interfering with each other, when you're all trying to receive distant and weak DX. Your RF neighbours won't thank you for breaking this convention.

10. Pay Attention to all Received Messages

WSJT-X will decode all messages across the 3kHz spectrum of the band you're using (or less depending on your radio's selected filter). This can result in many decodes on a busy band such as 20m.

I've spotted quite a lot of DX and then subsequently worked them, without ever seeing them call CQ! DX stations are often overwhelmed by stations calling them, so don't often need to call CQ.

By monitoring all messages (not just highlighted CQ messages) in the left hand 'Band Activity' pane, you might just spot some rare DX lurking. You might also notice a number of other stations calling a DX station during your receive timeslot. A simple switch to the other timeslot and you might just be able to decode and then work them.

This has netted me a number of DX stations I would have otherwise missed by just paying attention to CQ messages only (but if you are overwhelmed by the activity being seen in the left-hand WSJT window, you can opt to see only CQ messages, which can also be helpful at times).

Summary

These are my top ten operating tips for FT8 using WSJT-X. They are all based on my experience and hopefully there's something you'll find useful. There's much to learn about FT8 and the WSJT-X software, so I've only covered operating 'hacks' I've found to be of value. Have fun!

Quartz Crystal Oscillator and Tester

Ian Dilworth G3WRT describes a circuit for testing crystals.

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It is useful to have a quartz crystal tester suitable for all types of crystal. It is also handy to have as a signal source. This aperiodic (untuned) design is basically a Pierce feedback arrangement and is a reliable way of ascertaining the activity of a crystal and its operating frequency over a wide frequency range. It has been tested on a variety of crystals, mostly of series resonant mode although it also operates in the parallel mode. It works on most other common quartz cuts [2] [3]. Mounted crystals come in all sorts of shapes and sizes as illustrated in **Fig. 1**. Further details can be found in [4].

The basic design was published in 1968 [1]. I have added an interface to an activity meter. It employs three RF bipolar transistors.

The crystal sockets I have collected by visiting radio rallies over the years (as well as many of the quartz crystals) and hopefully this will become possible again when the current coronavirus crisis is over or simply advertise for your wants using *PW* member adverts. The circuit is shown in **Fig. 3**. There are no critical construction constraints but it is always good practice to keep RF connections as short as possible. It is not necessary to build in a metal box but some enclosure is desirable for longevity as with all test equipment, **Fig. 2**.

The circuit works from 1MHz to 30MHz. Some overtone crystals will oscillate at their fundamental frequency. All will show their degree of activity or willingness to oscillate. It does not work on some glass-enclosed 100kHz crystals in my possession. For these I have found the circuit shown in **Fig. 4** to be effective. Since these crystals have wired leads and are of low frequency, I use small crocodile clips to connect X1 in this case.

Many crystals are designed to oscillate in an overtone mode (multiples of their fundamental mode). This circuit will tend to favour the latter but not always. It is a good idea to monitor the oscillation frequency using a counter or a receiver or better still a spectrum analyser. If the feedback is tuned to the wanted overtone, then oscillation can be encouraged at that frequency. The basic purpose of this unit is to test whether the crystal is good.


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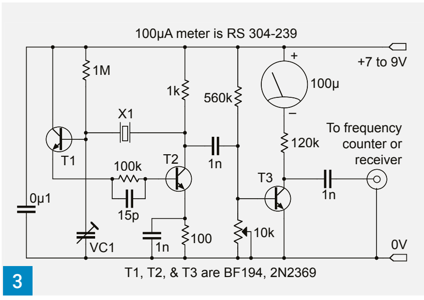

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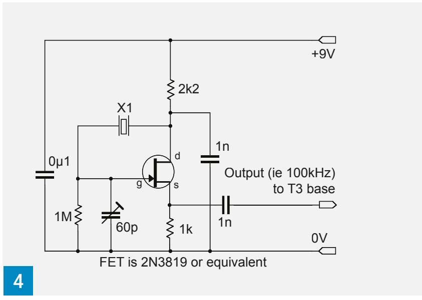

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Components

- (All resistors 1/8watt or more)
- VC1 60pF preset variable (yellow)
- All capacitors ceramic.
- T1-3 BF194, 2N2369 or equivalent.
- 100microamp meter RS 304-239.
- BNC chassis mounted socket.
- Diecast box.
- PP3 battery 9V, and connector (Amazon).
- Single pole switch.

References

[1] Electronics design 'Ideas for design', Feb 1st, 1968.
[2] https://tinyurl.com/yj77ggul
[3] https://tinyurl.com/yh23sl67
[4] Typing into google 'types of radio quartz crystal holders' reveals a vast collection.
[5] Oscillator Design Handbook (Book) edited by G.Breed K9AY, Cardiff Press, USA, first printed Oct 1990.

Fig. 1: Four common sizes of xtal sockets are used all connected in parallel as can be seen in figure (1 and 2); this is just for illustration purposes. In practice, of course, only one crystal is used at a time. I have no idea which one or more is commanding the drive level in the illustration since current indicates something is oscillating! Fig. 2: Construction. A single length of tag strip (6 locations) was used to assemble the circuit and the meter driver T3 uses the meter connections for support. The yellow potentiometer is used to adjust the bias on T3. The supply can be 7-9V. A PP3 battery is adequate and convenient for the small 10mA current drain. The hole for the partially visible yellow 60pF trimmer is easily accommodated because one side of it is grounded to the diecast box it is thus not critical in adjustment so long as the grounded side are the moveable vanes. Fig. 3: Feedback between T1 and T2 maintains oscillation and VC1 can be 60pF or so to allow a small adjustment in frequency. The T3 10k preset is adjusted to indicate about 10 microamps with no xtal. The base connections of the devices used are readily available on the web. Fig. 4: Low frequency <1MHz crystal oscillator.

Radio Round-up

ARISS HAM STATION IN COLUMBUS MODULE ONCE AGAIN OPERATIONAL: Some six weeks after going silent following a spacewalk that installed new antenna cabling, the Amateur Radio on the International Space Station (ARISS) station in the Columbus module is once again operational. The Columbus station, which typically uses the callsign NA1SS, is the primary ARISS amateur radio station used for school contacts and other activities. The problem arose after a 27 January spacewalk replaced a coax feedline installed 11 years ago with another built by the European Space Agency (ESA) and Airbus. While the specific cause of the problem has not yet been determined, a 13 March spacewalk that restored the antenna cabling to its original configuration provided the cure. The ARISS work was undertaken by astronauts Mike Hopkins KF5LJG and' Victor Glover KI5BKC.

During the spacewalk, Hopkins swapped out a cable for the Bartolomeo commercial payload-handling platform that had been installed in series with the ARISS VHF-UHF antenna feedline, returning the ARISS system to its pre-January configuration. Hopkins raised a question concerning a sharp bend in the cable near a connector, but no further adjustments were possible.

On 14 March, ARISS was able to confirm the operation's success when Automatic Packet Reporting System (APRS) signals on 145.825MHz were heard in California, Utah, and Idaho as the ISS passed overhead. ARISS team member Christy Hunter KB6LTY was able to digipeat through NA1SS during the pass. With additional confirmation from stations in South America and the Middle East, ARISS declared the radio system operational again.

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Challenging Times

Steve Telenius-Lowe PJ4DX invites readers to join the CDXC Challenges in these challenging times.

It's now six months since the monthly look at the Solar Flux Index (SFI) and Sunspot Number (SN) was introduced, so we can now have a rolling six-month check on these data. The figures shown in **Table 1** for 11 March are better than those of the previous two months, but still not as good as those of November and December last year. To reiterate, these are just 'snapshot' figures on a particular day in the month, the intention being to see a long-term trend.

	Mar '21	Feb '21	Jan '21	Dec '20	Nov '20	Oct '20	Difference
SFI:	75	72	73	81	86	73	(+3)
SN:	11	0	0	11	27	26	(+11)

Table 1: Rolling six-month Solar Flux Index and Sunspot Numbers as of 11th of each month. The final column shows the difference between March 11th and the previous month.

Challenge Yourself!

Towards the end of last year I felt there was little new to work on the bands and that I needed a new operating challenge to whet my interest. Having been primarily an SSB operator for almost half a century I solved that issue by starting to operate on digital modes for the first time. After working and confirming over 300 DXCC entities using SSB and CW, I started chasing DXCC entities from scratch all over again using FT8 and FT4.

But what if you are a dyed-in-the-wool (say) CW operator with no intention of ever using SSB or digital modes? There are still plenty of ways you can challenge yourself and reignite enthusiasm in your HF operating. In the March column I suggested that you might like to try a 'low-key' contest but I will be the first to admit that, although it's an aspect of HF operating that I enjoy, contesting is not everyone's cup of tea.

I am a member of CDXC (The UK DX Foundation), a club open to all with an interest in HF/6m DX activity. The club organises three challenges each year, with trophies, silver salvers and certificates up for grabs. The first is the year-long 'DX Marathon' in which you gain one point for each DXCC entity worked on bands from 160m to 6m (with the exception of 60m) during the course of the year. Each DXCC entity needs only to be worked once (not once per band).

The second is the 'HF Challenge', which runs during the whole of September. The principle is the same, but the only bands used are 15, 12, 10 and 6m. Finally, the 'LF Challenge' is on 160, 80 and 40m during the month of March. In the case of the HF and LF Challenges there are two sections: for CW/Phone or 'MGM' (Machine-Generated Modes, i.e. FT8, RTTY etc). Naturally, you can participate in the DX Marathon and the LF or the HF Challenges simultaneously.

Participants upload their logs to Club Log and 'league tables' are generated which are available for viewing on the Club Log website:
clublog.org/cdxc.php

I was lucky enough to win the CW/Phone section of the LF Challenge in 2019 and 2020 (**Fig. 1**). Having only recently started to operate on FT8, this year I decided to take part in both the DX Marathon and the LF Challenge using digital modes only. As of this column's deadline day, 11 March, I have worked 170 DXCC entities on all bands in the DX Marathon and 119 entities since 1 March in the LF Challenge (and I'm by no means at the top of either table).

Although the LF Challenge will be over by the time this issue of *PW* is published, it's not too late to start the DX Marathon. Look back through your log and make a note of all DXCC entities you have worked since 1 January. It should be perfectly possible to catch up with those who started at the beginning of the year. That's because there has been almost no DXpedition activity, so there have been few entities on the air that won't be activated again before the end of the year.

Anyone anywhere in the world can take part in the CDXC challenges, although the prizes are only available to CDXC members. You just need to upload your log to Club Log on a regular basis during the period of the challenge(s). More information on CDXC is available from their website:
www.cdxc.org.uk

Readers' News

It's always good to welcome another new contributor to this column, so I'm pleased to greet **Dean Rugen M5DR** from near Ormskirk in Lancashire. Dean wrote *"I enjoy chasing awards and I strive to gain them using SSB... HF operating is mainly done from the mobile. Even during the lockdown restrictions I manage to get on as I am a*

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mobile AC engineer and spend a lot of time travelling between jobs at various sites across the north-west of England. My mobile setup consists of an old 100W Alinco DX-70 transceiver and a mobile whip antenna for whichever band I choose to operate on."* Dean later sent a follow-up saying *"The month has been busy with Greek special event stations celebrating the 200-year anniversary of Greek independence. Having worked all nine SX*A callsigns I achieved the platinum diploma (**Fig. 2**). Also, another raft of special calls with the SX200 prefix are on air for another series of diplomas. Along with the Greek stations I have also gained a new diploma from the Fifth Ocean Club, 'Conquerors of the Polar Latitudes'. DX-wise it's been pretty poor... It's difficult to break any pile-up with 100W and a small whip on the van. I did manage a nice QSO with **Rami 4X6HU** while sat in a lay-by on my lunch break on 5 March."* Details of the two Greek awards Dean mentioned are at:

sv2rck.gr/SX9_1A
sv2rck.gr/200YEARS

Victor Brand G3JNB opened his February low-power CW log with NY2PO on 17m, TA1PB on 20m, RA98AE Asiatic Russia (almost 3000m/4800km) on 30m and YT76TESLA on 40m. He said: *"The Boulder 'A' index 'yo-yoed' between 2 and 21 with the bands sluggish and contesters really struggling. But on the 10th, 9K2HS kindly persevered until he copied my full call on 40m while the pile-up stood by. Next morning, I could clearly copy FK8IK New Caledonia on 20m. But by mid-month, poor band occupancy and those missing sunspots gave us lacklustre conditions for HF CW DX. Towards the close of February, the SFI rose to 81 and non-contest activity picked up. On 40m CW at 2130UTC I noticed AA3B running with the EU. My calls elicited just the odd 'G3?'. Nudging the VFO to change my note in his phones, I eventually broke through the pile-up and Bud came back with 'G3JNB hi Victor 229'! Next night, same time same band, I sat listening to a strong LU1AW/D who had a pipeline to JA; his was the first South American station I had heard for months and, similarly, on the 28th a lonely HI3Y Dominican Republic was heard CQing with no takers. Yes, things are slowly improving and, as Sherlock Holmes was prone to exclaim 'The game's afoot Watson'. Definitely".*

Kevin Hewitt ZB2GI reports that *"Gibraltar eased lockdown restrictions on 1 February, [although] the 2200 to 0600 curfew remains in force... I walked up the Rock (**Fig. 3**) on the 2nd and operated portable on 15m SSB. The log included 50+ European stations. 10m FT8 opened briefly on the 16th and 20th. I was pleased to work **Tim GW4VXE** on 40m, we usually only work each other on 6m or satellite."*

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Fig. 1: Silver salver for winning the 2019 CDXC LF Challenge using SSB and CW modes. Fig. 2: The 200 years of Greek independence award issued to Dean M5DR for contacts with special event stations in all nine call districts of Greece. Fig. 3: Spectacular sunset from the top of the rock of Gibraltar from where ZB2GI/P was operating. Fig. 4: Station inspection: a family of peacocks check out the antennas at the OS8D station. Fig. 4: The venerable G4MM callsign has been revived as GW4MM by Tim GW4VXE.

Etienne Vrebos OS8D made about 300 QSOs during the month, including about 60 with North America in the ARRL DX SSB contest at the beginning of March. He uses an Icom IC-7851 transceiver to a Hexbeam and HyEndFed wire on 40m in his wooded garden, **Fig. 4**, near Brussels Airport. Etienne lamented the limited number of 'special' stations to work recently, a situation that we all hope will be remedied when it becomes possible to organise DXpeditions once again.

Tony Usher G4HZW thought that *"Ten metres has been disappointing again with a couple of openings to the south but none of the DX that we were anticipating a couple of months ago. If it's anything like previous cycles, it'll happen all of a sudden and one evening the band will be full of Ws running 10W to dipoles!"*

Reg Williams G0OOF reports that *"Conditions not too good on the bands, so concentration was aimed at FT8 mode, which usually produces a few new countries. 30m early morning around sunrise produced the usual mix of JA stations and the occasional VK. Always comforting to know that my signal is being received and responded to, although it does not always happen that way, due to propagation and seasonal conditions... There have been quite a number of contests during the month. I took a very casual part in two of them, both being on the same day, the Eurasia SSB and EUDX SSB. There was one hour between the Eurasia contest finishing and EUDX starting. No great score in either but it made a change to work in phone mode.*

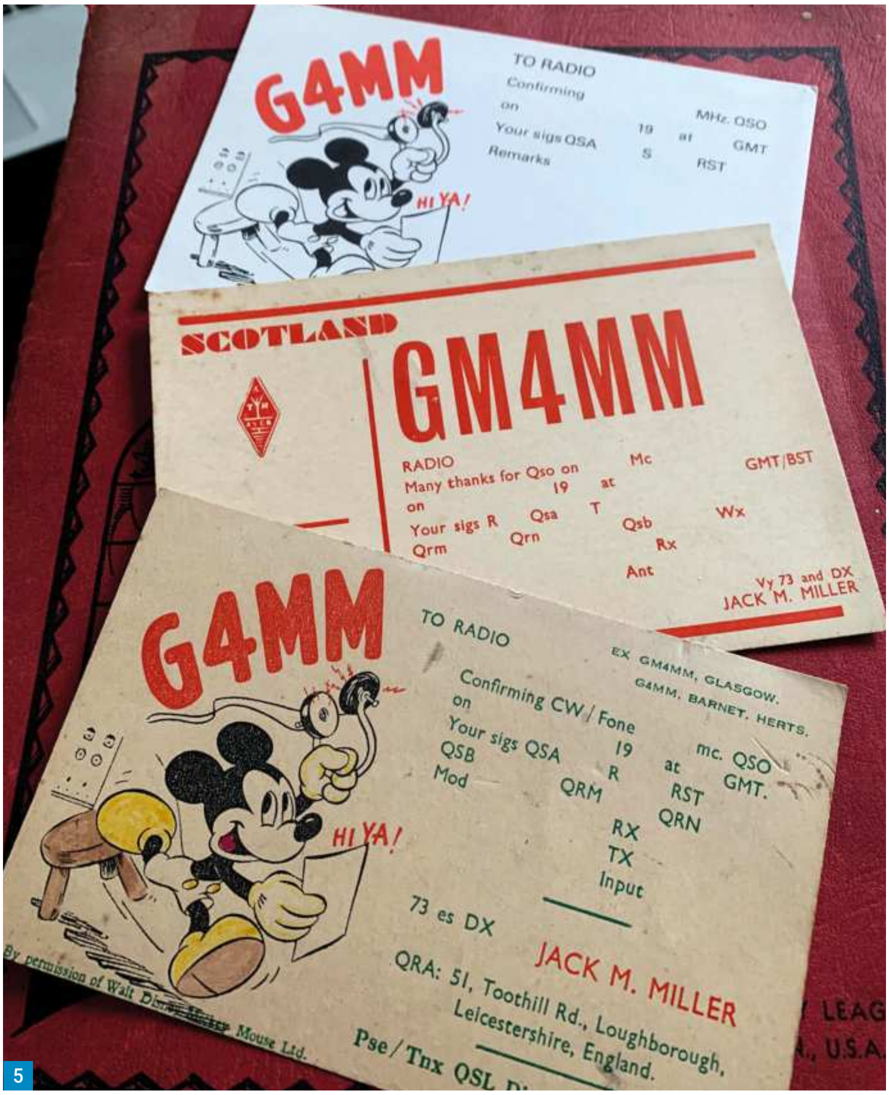
"Now that we are moving into Cycle 25 I want to get the best out of my station setup, in particular the important part, the antenna. Although I had tuned the Hustler 6BTV last year I could improve on that. I now have a RigExpert antenna analyser. I did manage to retune the antenna easily. It will come in useful for all my homebrew antenna projects plus all the other features it provides."

Owen Williams G0PHY wrote *"All the DX activity this month was during the phone ARRL DX contest last weekend. Although it's not intercontinental DX I had my best topband contact during the CQ 160m Phone contest at the end of February. I had made a quarter-wave inverted-L for topband to take part in the Shefford club net and I was lucky to get a signal to Hitchin. For the CQ contest I managed to get the vertical leg of the antenna a little bit higher than usual but the horizontal part was doubled back on itself in a V shape. I could hear plenty of stations in mainland Europe but failed to work them. I was very surprised* *when EI6JK in County Roscommon came back to me when I answered his CQ call".* Owen turned down the power level to make some contacts in the ARRL DX SSB contest. *"With 10W I managed contacts with stations in New England states plus Prince Edward Island and Ontario. The best DX at 10W was with N6AR near Orlando, Florida. All these contacts were on 14MHz. I'll be joining **Victor G3JNB** as a dedicated QRPer soon! Turning the power back up I managed contacts with Arizona, Colorado and Montana.*

"I've managed to get three ropes up into our trimmed Ash tree using fishing poles and weight to get a fishing line over branches and then hauling ropes up. The 14MHz dipole is now slightly higher and I should be able to get an antenna up for 3.5MHz."

Our *World of VHF* columnist **Tim Kirby GW4VXE** has also been spending some time on the lower bands: *"I've been playing a bit during the CWops CWT sessions on a Wednesday and what has been interesting has been the North American stations worked during the 1900UTC session on 40m. It's quite early in the afternoon there, so fun to be able to work VE3EJ, W1WEF, K4RUM and some others. You have to listen through the Europeans, of course, but the signals are good...*

*"The other exciting news is that I have a 'new' club callsign to play with, GW4MM. I knew **Jack G4MM** when I lived in Cheltenham in the 1980s and remember some nice 2m FM QSOs. However, **John G4PDQ** knew Jack well through work and, to cut a long story short, Jack left John the G4MM callsign when Jack died. Unfortunately, John is not so active in amateur radio anymore, so I rather cheekily asked him if he would mind me using the G4MM callsign and he very generously agreed to transfer the callsign to me. I'm mostly using the shorter callsign on CW – there's no advantage in a short callsign on digital modes, after all! Jack G4MM had an interesting story, having been a Voluntary Interceptor during WWII. It's really nice to be able to put the callsign on the air and I've already had some lovely QSOs with people who remember Jack from 1948 and operated from his shack and so on! Rather wonderfully, I have some of Jack's pre- and post-war logs, which are fascinating to look through, as well as some of his QSL cards (**Fig. 5**)."*



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Around the Bands

Kevin ZB2GI (and as **ZB2GI/P** from the top of the Rock) worked: **5MHz SSB:** EA9IB. **5MHz FT8:** CU6NS, TA0S, W1NG. **7MHz FT8:** K8JH, KR4V, N1NK, N6PAT, OD5ZF, W2MKM, W7DO. **7MHz FT4:** EA8OM, K1SM, KA2R. **10MHz FT8:** CS8ABF, KB2SSE, N0FW, N4MEC, PY2KNK, VE1ANU, WV8DX. **14MHz SSB:** K1GHC, KD4LT, WB8FSV. **14MHz FT4:** ZA/IN3PPH. **18MHz SSB:** AA8UK, AC3GM, K0BCC, K1RH, K2GRG, K5YDR, KC6IEH, KC7DC, N3TKE, NP2T, VE3MZD, VO1CAL, WZ5TAZ. **21MHz SSB:** 5B4AAB, EA8UN, OZ30EU. **21MHz FT8:** K8EIJ, K0HB, KC3ACQ, KK4PH, N2HYG, NU9TS, NX7U, W5WZ, W6SA. **28MHz FT8:** 4X1RU, KP4JRS, OA4AI, OD5KU, PU4JLV, PU5BOY, PY2TTE.

Etienne OS8D: 14MHz SSB: FG5GP, FM4SA, UN8LWZ, VK300D, VK3LPG, VK4KA, YC9KQB.**18MHz SSB:** CO8LY, FK4QX. **21MHz SSB:** CX5UA, CX8DS, FY5KE.

Tony G4HZW: 7MHz FT8: HI8JSG. **7MHz FT4:** EA8TL, K1SM, KK3Q, OY1R, PZ5RA, VE9HF, VO1AW, VP2ETE, W4MRJ, WA1RIW. **28MHz FT8:** 3B8CW, 4X1TI, FR4OO, ZS4JAN.

Reg G0OOF: 7MHz FT8: R9YW, YD1FRU, YV5DRN. **10MHz FT8:** 4S6NCH, C31MF, HK6JCF, JA5BEN, JX2US, OA9DVK, VK3BY.

Owen G0PHY: 1.8MHz SSB: EI6JK. **7MHz SSB:** K1RX, K4ZW, VY2ZM, W3LPL, WA2CP. **14MHz SSB:** K1TTT, K9RV, KV0Q, N6AR, N7DD, ND7K, VY2ZM, WW4LL, XL3A.

Tim GW4VXE: 3.5MHz CW: 7X4AN. **3.5MHz FT8:** V31MA, WP4SD. **7MHz FT8:** 7Z1AL. **10MHz FT8:** 9Y4DG, CO5HCM, CO7JP, HP2AT, J69DS, YB1RKT. **18MHz FT8:** 5B4AAB, ZA/IK2RLM.

Signing Off

Thanks to all contributors. Please send all input for this column to teleniuslowe@gmail.com by the 11th of each month. Photographs of your shack, antennas, or other activity would be particularly welcome. For the July issue the deadline is 11 May. 73, Steve PJ4DX.

Mike Richards G4WNC
practicalwireless@warnersgroup.co.uk

Operating Q65

Mike Richards G4WNC takes a look at the new Q65 mode in WSJT-X and has been trying out his RX888 MkII.

The Q65 mode is still very new and most of the European activity seems to be on the 6m band around 50.306MHz. An important feature of this mode is its ability to achieve long-distance communications on 50MHz when the band is closed to most propagation modes. During testing, **Joe Taylor K1JT** and **Steven Franke K9AN** were able to achieve successful contacts over a 1,100km path on most days over a six-month period. They were using Q65-30A with 300W of transmit power on 50MHz. The propagation mode for their contacts was ionospheric scatter, which is available all the time, but is best around midday and in the summer months. It's clear that Q65 has the potential to keep the 50MHz band open for much of the year.

Before I go on to detail the WSJT-X setup for Q65, I ought to mention WSJT-X Configurations. This is an extremely useful, but often overlooked, feature of WSJT-X. Those who have spent some time using WSJT-X will know that, for the best results, you must tweak a few of the settings for each mode. Sometimes this is just altering the Wide Graph display, but often there are other areas such as the colour coding of message types and tick boxes to select. Once you've customised WSJT-X to your preference, many are loath to switch to another mode, such as Q65, where further adjustments are required. The solution is to make use of WSJT-X Configurations. Each Configuration carries all the WSJT-X settings, so every tick box, slider setting, and option is saved. You can have as many different Configurations as you like, and an experienced operator is likely to use separate Configurations for each mode. The Configurations are saved in the main WSJT-X.ini file that Windows users will find in C:/Users/username/AppData/Local/WSJT-X/ . Those already using Configurations, should make sure this file is included in their regular backups. Alternatively, you can periodically make a manual copy of the file.

For those new to WSJT-X Configurations, here's a step-by-step guide to create your first one:

• Start with WSJT-X running and set up as you would normally use it, i.e. for regular FT8 contacts.
• Go to the Configuration menu and select Default - Clone. That will create an exact copy of your current setup called Default-Copy.

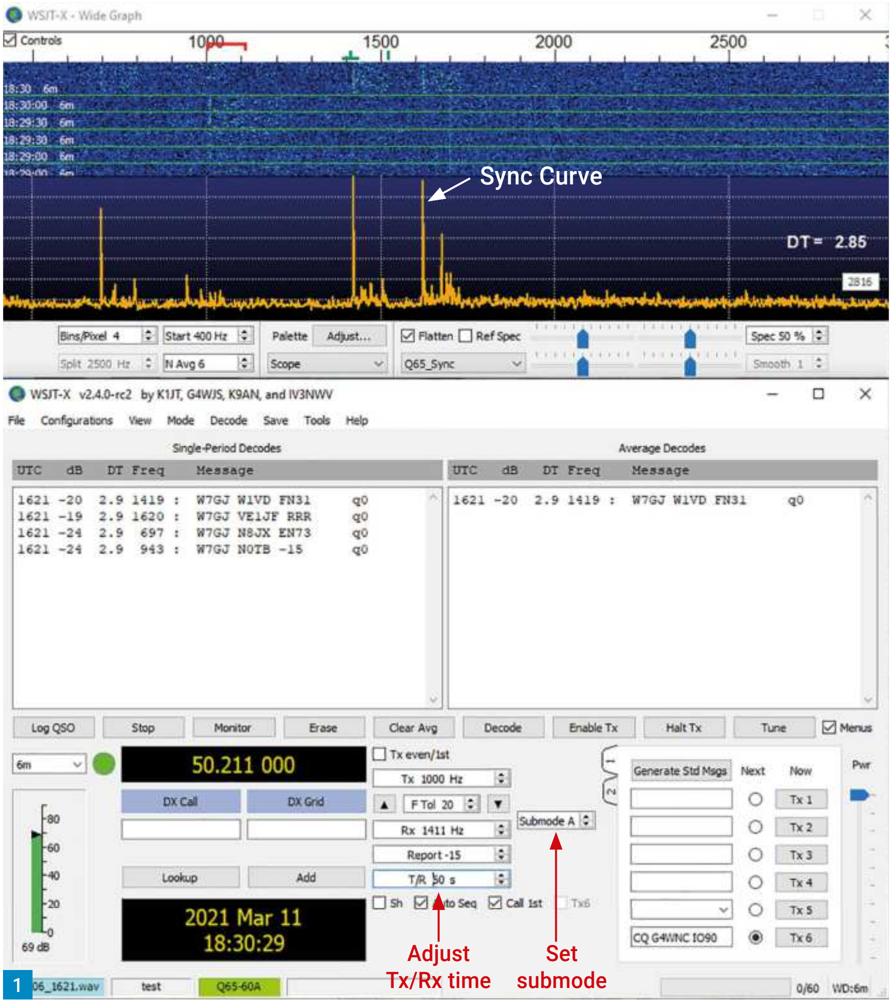
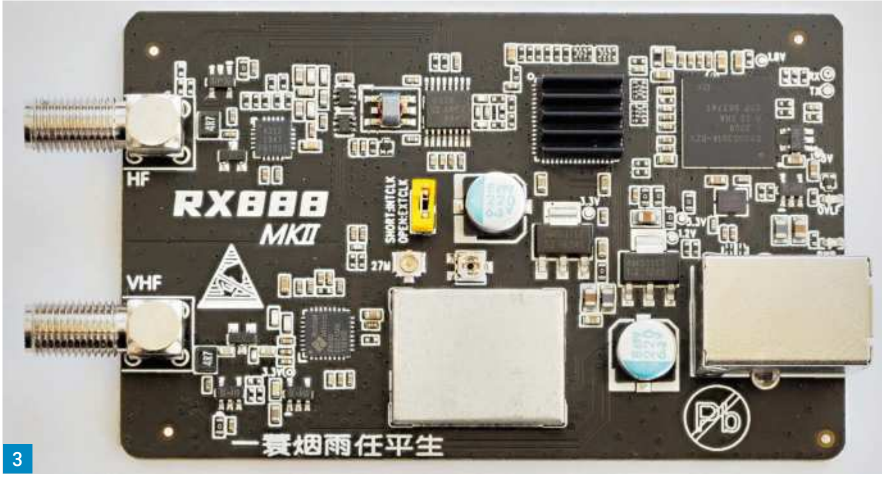


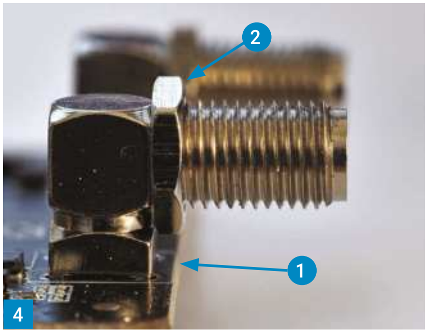
Fig. 1: WSJT-X shown set up for Q65.
Fig. 2: The new MkII RX888.
Fig. 3: The RX888 MkII PCB.
Fig. 4: SMA socket modification.
Fig. 5: RX888 MkII external clock connections.
Fig. 6: FT8 segment of 7MHz band, zoomed from 32MHz bandwidth.

• Go to the Configuration menu again but choose Default-Copy followed by Rename. This will open a dialogue box where you can enter a name for your saved setting, so call it FT8 or whatever you like. That's it, you've created your first Configuration!

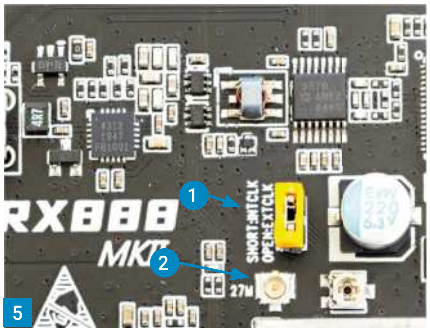
To select and use a Configuration, go to the Configuration menu, choose a Configuration and select Switch To. This will restart WSJT-X and load the selected configuration. Once you've done it, you'll wonder why you hadn't tried Configurations before!

To help get started on Q65, the WSJT-X test team have made several test recordings of Q65 signals that are available to download from here:
https://tinyurl.com/yjk8ed64





1. Socket set back from PCB edge
2. SMA nut used as a spacer



1. Clock Selector
2. 27MHz external clock input

Here's a run-through of the adjustments you need to make to play the recordings and operate Q65.

File menu – Settings – General:
Tick – Enable VHF and submode features
Tick – Decode after EME delay
Untick – Single decode

Decode menu:
Tick – Fast
Tick – Enable averaging
Tick – Auto Clear Avg after decode

Wide Graph:
Bins/Pixel 4
Start 400Hz
N Avg 5
Scope
Q65_Sync
Spec 50%

The Q65 sync mode activates an orange sync curve that you can see at the bottom of the Wide Graph, **Fig. 1**. This provides an extremely sensitive indication of the presence of a Q65 sync tone. As with other WSJT-X decoding modes, the decoder processes the selected signal, before moving on to process any other Q65 signals in the passband. As a further aid to Q65 operation, the WSJT-X team have produced a comprehensive Quick Start Guide that you can find here:
https://tinyurl.com/y4a8jyn3

The problem I see now is that many amateurs seem to be listening and not transmitting, so we need to get some signals in the air to bring the mode to life. As you will recall from last month's column, Q65 has several sub-modes, but the one favoured by the test team for 50MHz ionospheric scatter contacts was Q65-30A. That translates to a 30 second Tx/Rx period with tone spacings of 3.33Hz and a bandwidth of 217Hz. I've shown the mode configuration controls in Fig. 1. If you don't have high power available on 50MHz, Q65 can still work for you, but I suggest you change to Q65-120E as this extends the Tx/Rx cycle to two minutes in a wider bandwidth. This improves the decoding sensitivity so that your weaker signal can get through.

I shall be tuning up my Butternut vertical this weekend as I know it works well on the 50MHz band. Once it's set up I'll be putting out regular CQ calls, so do keep a lookout for me.

SDR# Update

The popular SDR# software has just undergone a significant under-the-bonnet upgrade. I say that because the main change has been to upgrade to the new Microsoft Net.5 framework.

RX888 MkII - On test

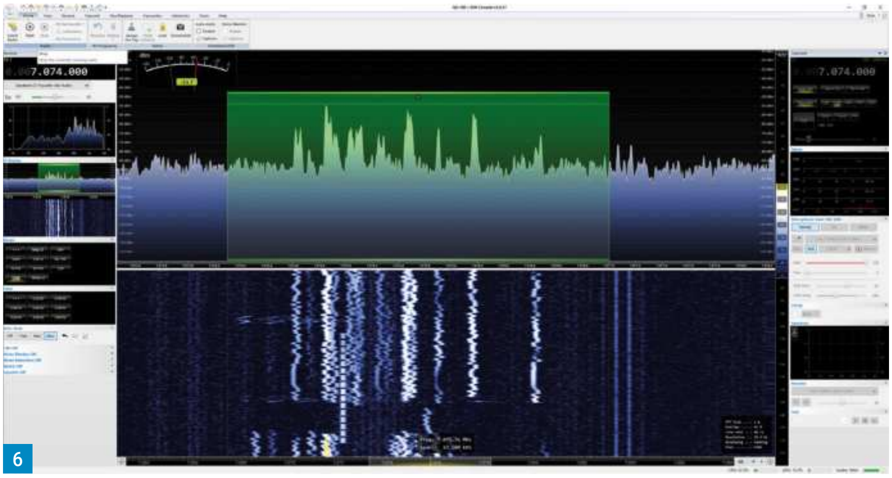
My RX888 MkII arrived a few weeks ago so I've had some time to put it through its paces. As you can see from **Fig. 2**, it looks identical to the original version, but there are important changes under the bonnet. These include the addition of a programmable gain amplifier, variable attenuator, and a better reference oscillator. The gain and attenuation adjustments were very welcome as they give the operator fine control of the input level to the ADC so that overload can be avoided. The first job for me was to take it apart so I could have a closer a look at what's changed. I've shown a photo of the new PCB in **Fig. 3**.

As with the previous model, the RX88 MkII comes in a smart black finished metal enclosure with large heatsinks on the top and sides. However, the paint finish acts as an excellent insulator, so there was no electrical contact between the ground of the PCB and the enclosure. The solution is to remove the two end panels and clean-up the mating surfaces with some sandpaper, emery cloth or similar. The MkII has the same SMA mounting problem as the original board, with the SMA antenna sockets set slightly too far away from the edge of the PCB. This puts excessive strain on the PCB if you tighten up the SMA retaining nuts. The simple solution is the use a spare SMA nut on each of SMA sockets and screw this right up to the plug body, so it acts as a spacer, **Fig. 4**. This simple fix makes it safe to fully tighten the main SMA fixing nuts to the panel.

One of the other significant MkII additions is the facility to connect an external clock source. I've shown a close-up of the PCB in **Fig. 5**, so you can better see this area. Near the centre of the board is a new miniature U.FL socket along with a pair of link pins. The link pins are used to switch between internal and external reference clocks. You can either remove the link to enable the external clock or insert it to return to the internal clock. As the switch pins don't carry the oscillator signal, you should be able to wire these pins to a small switch mounted on the rear panel so you can switch between clock sources.

The tiny U.FL socket is used to connect the external clock source. The best way to utilise this socket is to buy a ready-made short U.FL female plug to female SMA lead; these are available for less than £5 from RS Components. The U.FL sockets are tricky to use, but providing you line-up the plug correctly, it should positively click into the socket.

The external clock needs to be 27MHz and around 200-300mV pk-pk. If supplying the external clock from a CMOS compatible output such as the Leo Bodenar GPS disciplined oscillator, the direct output set to the 8mA drive strength worked well in my case. Still on the subject of clocks, the internal clock of the RX888 MkII has improved and mine was accurate to within 22Hz at 9.996MHz (equivalent to 2.2ppm) and the drift was very low. The absolute error is easily corrected in the SDR so I don't think there's any need to change to a GPS-based clock unless you're running specialist software that demands extremely tight timing.



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On-air testing was done with a Wellbrook ALA1530 loop and my Butternut HF9V vertical antenna. Although HDSDR with the latest ExtIO.dll can show the full 64MHz bandwidth (128MHz sampling) of the RX888, I used SDR-Console for most of my testing, mainly because it's a more powerful interface. The combination of the RX888 MkII and SDR-Console makes an immensely powerful combination with superb visibility of the 0-32MHz spectrum and possibly 0-64MHz in a later version. The full spectrum visibility was useful for spotting activity and band openings. When combined with the amazing zoom control, you can move from viewing 32MHz to 3kHz wide with a single slider.

In **Fig. 6**, I've shown a spectrum display of the FT8 segment of the 7MHz band, which has been zoomed from a 32MHz bandwidth! This is impressive and a great example of the flexibility offered by software defined radio. To coach the best performance from the RX888 MkII, you just need to manage the RF attenuator and PGA (Programmable Gain Amplifier) to protect the ADC from overload. Everything else is done in software!

There has understandably, been a bit of a run on the RX888 Mk II, but they should be back in stock very soon. To operate the RX888 MkII at the 128MHz sample rate, you will need to use a fast PC with up-to-date USB3 drivers because handling all that 16-bit data requires a lot of processing power. I'm currently using a PC based on an i5-4690K processor and that is able to handle the high data rates without any problems.

Eric Edwards GW8LJJ
ericgw8ljj@outlook.com

All Transistor Superhet

Eric Edwards GW8LJJ has a design for 'fun' receiver that can be built quite easily.

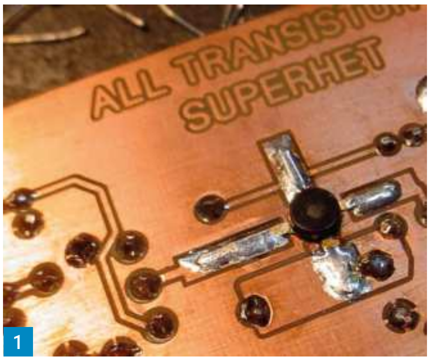
As the heading suggests, this is a receiver built using all transistors. It is a 'fun' receiver as opposed to a serious communications type. Nevertheless, good performance is obtained. Some transistors are bipolar and others are Field Effect (FET). There are no surface mount components other than the 'capstan' dual-gate MOSFET. It is very difficult to find a 'standard' fitting dual-gate MOSFET such as the once popular 40673. If these are available, they will be expensive and that's assuming they are genuine parts! The dual-gate MOSFET used in this project is readily available and easy to fit (see **Fig. 1**). I have kept to the same transistor types where possible (2N3904 for the NPN types).

Back to Basics

There are many ways to receive radio signals and they differ in the way the off-air signals are amplified, or not in the case of a 'crystal set'. The humble crystal set receives the signals that it is tuned to and they are then 'detected' to resolve the amplitude modulated (AM) station's voice or music. The 'straight set' uses stages that amplify the received signals at the frequency that it is tuned to and the amplifier stages are before and after the detector. The 'rectified' (recovered) audio is sent straight to the audio stage without any frequency conversions.

The Superhet

The term Superhet has been abbreviated from supersonic heterodyne and it can be seen that it is a combination of stages. The term 'supersonic' is an old word for ultrasonic (above audio) while heterodyning simply means mixing and in this context means that the two signals, the RF off-air and a local oscillator (LO), produce a mixed signal above the audio range and normally below the radio frequency range. In this design the heterodyned signal is 455kHz. As the superhet progressed from the early designs, higher IFs were used to reduce the image signals. Common IFs are 9MHz and 10.7MHz and to be pedantic, can this be called a superhet in the true meaning of the word considering it means producing a difference frequency (IF) in the ultrasonic range? However, the term is accepted and even for double and triple superhets where several different frequencies are used for the IFs.



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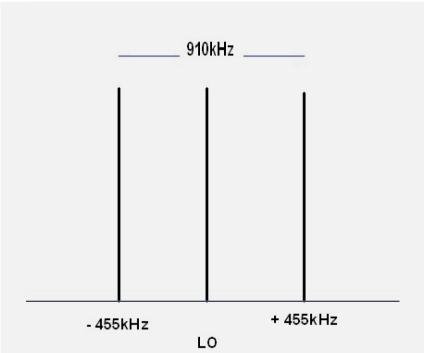
Local Oscillator

As with all LC (inductance/capacitance) oscillators there is a certain amount of drift because of heat produced when current flows though components. In this design it is kept to an acceptable minimum by using an FET as the active device and polystyrene capacitors, with several in parallel, as the passive components. Some of you may remember these as SUFLEX capacitors. The varicap (variable capacitance) tuning diodes are supplied from a zener stabilised voltage (except in the MW module) as well to help with minimising drift. During prototyping and indeed as I am writing this, I am listening to an SSB QSO on 80m and it remains reasonably stable all the way through the received QSO. After a few minutes 'warm up' it is stable as long as there are no ambient temperature changes. AM reception does not normally suffer from this because of the wider modulation bandwidth and it mainly applies to SSB and CW signals, which are very narrow and also need the carrier reinserted at the 'correct' frequency for good reception. Using two or more polystyrene capacitors in parallel in the oscillator circuit helps to reduce drift as one capacitor may slowly increase in capacitance whereas the others may drift low.

High or Low

Using 455kHz as the IF, the image frequency is 910kHz away from the wanted signal, **Fig. 2**. This means an off-air signal 455kHz



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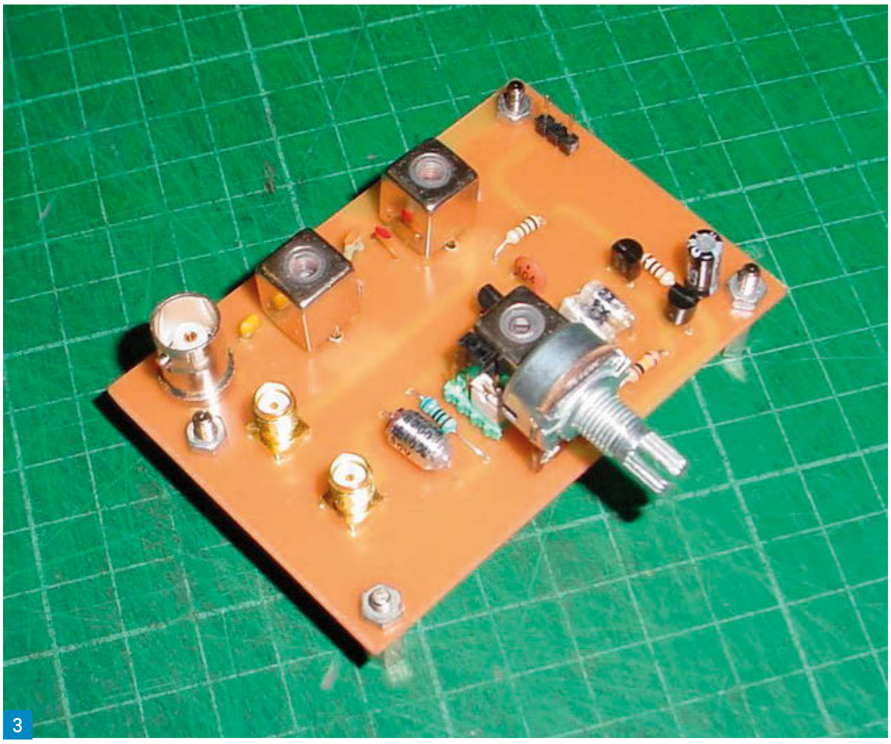

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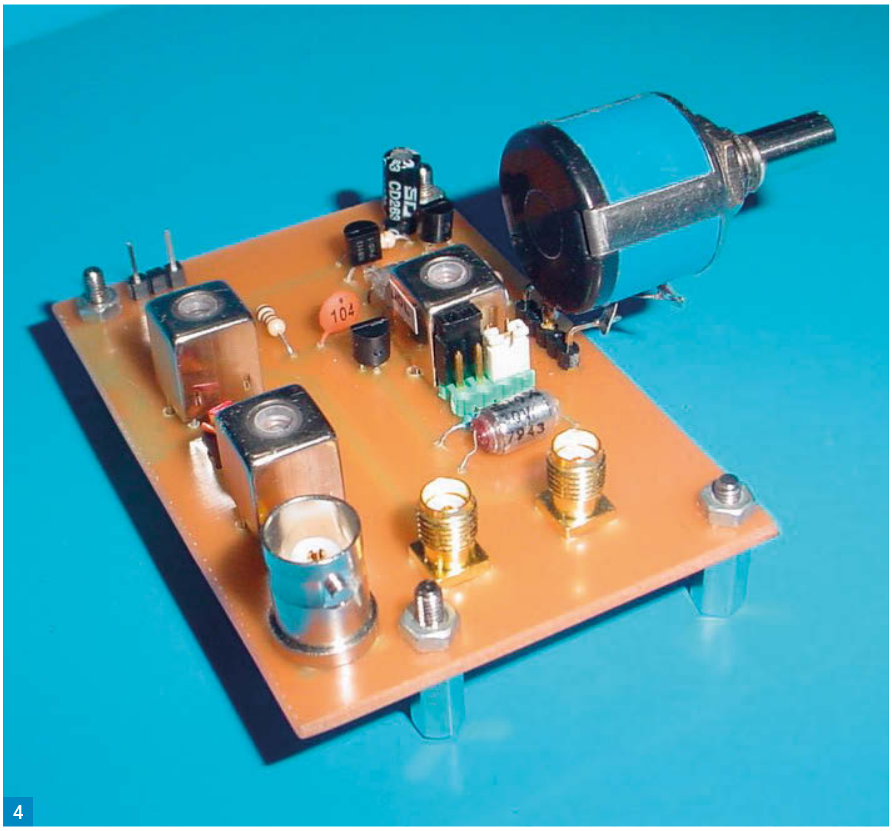

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Fig. 1: The dual-gate MOSFET in situ. Fig. 2: Wanted and image frequencies 455kHz either side of the LO. Fig. 3: The MW module. Fig. 4: Alternative ten-turn potentiometer. Fig. 5: Angle pins to locate the ten-turn potentiometer. Fig. 6: Circuit of 80m module. Fig. 7: Circuit of 160m module. Fig. 8: Circuit of MW module. Fig. 9: Main circuit. Fig. 10: 80m PCB. Fig. 11: 160m PCB. Fig. 12: MW PCB. Fig. 13: Main PCB.

higher or lower than the LO will produce a signal that can be heard because both will produce an IF of 455kHz. It can be seen that a signal 910kHz away (in the opposite direction of the wanted) will also produce a signal that can be heard.

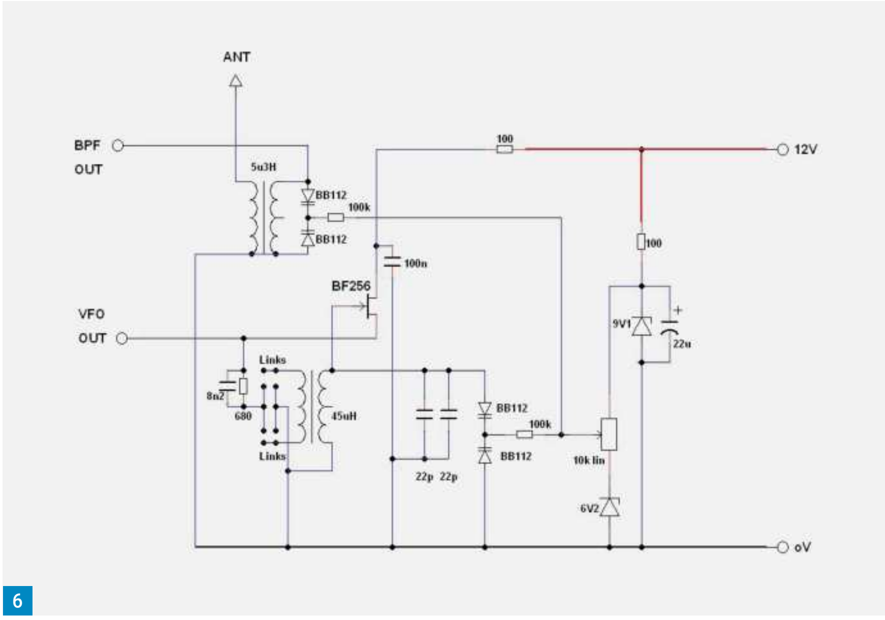
Using a low-side LO on 80m and a high-side LO on 160m places the image in relatively quiet parts of the spectrum. The image frequency for 3500kHz is 2590kHz and the image frequency for 1800kHz is 2710kHz. Compare that with a low-side LO on 160m, which would produce an image frequency in the MW broadcast band: 1800kHz minus 910kHz is 890kHz. A high side LO is also used for the MW band module. The bandpass filter (BPF) should remove or greatly attenuate any signals outside the wanted frequencies.

This low IF presents problems if a higher frequency band such as 40m is wanted. Consider the image frequency when using say, 7200kHz. The image 910kHz above will be 8110kHz and below it is 6290kHz. This could result in strong continental broadcast stations breaking through.

Let's Explain that Again

Image signals are those that can also get through to the IF stage. A signal away from the LO in either direction will produce the IF frequency, Fig. 2.

Normally this can be filtered with a tuned circuit (BPF) to only receive the wanted



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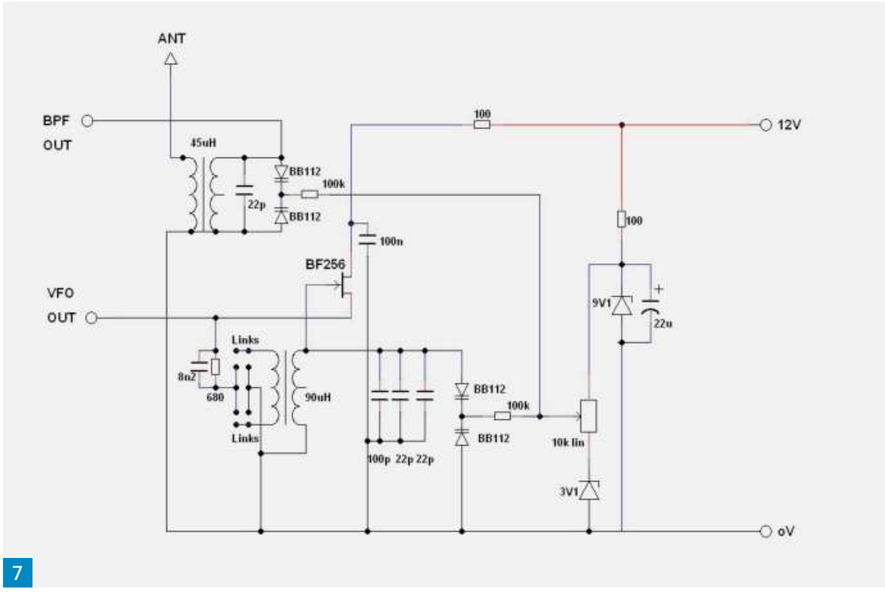

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signal. If the wanted signal is above the LO, a BPF will be tuned so that only those above the LO will get through and the signal with the same frequency distance away (455kHz in our case) from the LO in the opposite direct will be rejected by the BPF.

To check what frequency bands can be used with a selected IF, apply the 'twice frequency' rule.

With an IF of 455kHz this will be 910kHz away in the opposite direction from the wanted frequencies. With an IF of 9MHz the image frequency will be (twice 9MHz) 18MHz away from the wanted frequency. It can be seen that much higher bands can be used with a higher IF without the danger of image frequencies being heard at the same time.

Plug-In Front End

The RF BPF and the LO are on their own PCB and this is made for one band, which I will refer to as MODULES. There are three bands available, 80m, 160m and MW (**Fig. 3** shows the MW module). The BPF and LO are tracked on the 80m and 160m modules but the MW module has a fixed BPF. The tuning is done with either a standard single turn potentiometer or using a ten-turn potentiometer, **Fig. 4**. This can be a 10kΩ linear single-turn with a slow-motion drive or other gearing or a ten-turn potentiometer can be fitted. A single-turn potentiometer with PCB pins can be plugged directly into the PCB but if a ten-turn pot is used, angle pins can be connected, **Fig. 5**.

The reason for plug-in single-band modules is to reduce complications in band switching and also allows other VFOs/BPFs to be used. This also provides the main board (mixer through audio output) to be used as a second IF in a double superhet design and also as a test unit for LO and BPF experiments.

80m Module

The circuit for the 80m module can be seen in **Fig. 6**. All three modules are basically the same but there are some differences with the varicap tuning arrangements and band-pass filters. All three have a set of pins (4 x Dual) that is used to place either one of the secondary winding pins of the oscillator transformer to ground. This can be seen on the circuit – they are to the left of 45μH oscillator transformer. Links are placed to put to ground (right-hand set of links) one end of the coil and to place the 8.2nF capacitor and 680Ω resistor on the other end of the coil with the left-hand set of links. The links are placed vertically using the linking tabs as used on PC mother boards. There are differences in which the transformer windings are oriented on the former, which will alter the phase relationship between the primary and secondary windings. I have had this even with the same part numbers on the transformers and from the same supplier. The windings in the wrong phase will disable the oscillator so it has to be correct. The links make it simple to change.

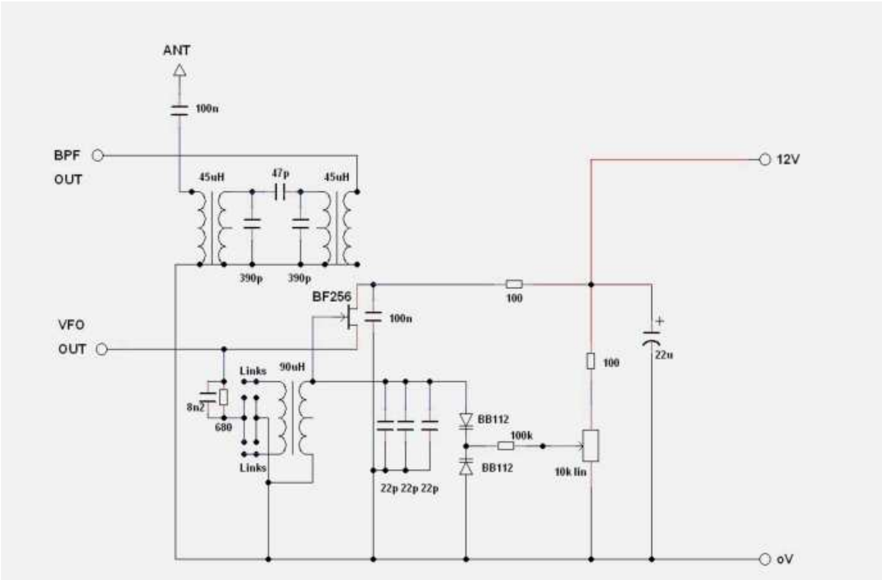
The antenna is connected to the 5.3μH transformer, which is the BPF tuned by the series connected varicaps. The tuning range is 3500kHz to 3800kHz and two varicaps in series are used because it makes the tuning linear (the voltage is connected to the two and this changes the capacitance of both at the same rate). This is better than having a fixed capacitor and one varicap because the circuit does not need a big DC blocking capacitor. The tuning of the BPF is 'tracked' with the VFO tuning because it is connected to the same potentiometer. The VFO is very simple and relies on the feedback from the transformer windings. It must be in the same phase as explained, using the set of links. There are two fixed capacitors (22pF each) used as the tuning in conjunction with the varicaps. They are used to set the band frequency, along with the transformer core setting, and the varicaps are used as bandspread. The two capacitors are polystyrene types because they offer the best frequency stability from those that have been tried. All capacitors change value with temperature changes and two are used to minimise this as they both have different drift factors so it is possible for one to compensate for the other, keeping the frequency drift to a minimum. A polystyrene capacitor (8.2nF) is also used as the feedback capacitor on the source of the BF256 Junction FET. The zener diodes at both ends of the tuning control are used to set the band edges.

160m Module

The circuit for the 160m module appears at **Fig. 7**. This is very similar to the 80m module, the difference being the transformers used for the BPF and the VFO. The BPF uses a 45μH transformer, the VFO is a 90μH transformer and the tuning range of this module is 1800kHz to 2000kHz. The BPF also has a polystyrene capacitor (22pF) connected across the secondary of the 45μH transformer. The VFO has an extra polystyrene capacitor fitted across the pair of 22pF capacitors. The 6.2V zener diode on the 80m module has been replaced with a 3.1V zener diode on this module. Otherwise, it is the same as the 80m module.

MW Module

The circuit for the Medium Wave module is shown at **Fig. 8**. This one has a different BPF to the others because there is a set bandwidth with the tuning covering the band 1.2MHz to 1.4MHz although this can be shift adjusted either side. It is a conventional circuit using a pair of 45μH transformers. The VFO is tuned with the pair of varicaps but there are no zener diodes connected to the tuning control because of the bandwidth required for the tuning. One end of the control is taken to ground and the other end to the 12V via a 100Ω resistor decoupled by the 22μF electrolytic capacitor. Three 22pF polystyrene capacitors are connected across the 90μH VFO coil (transformer).



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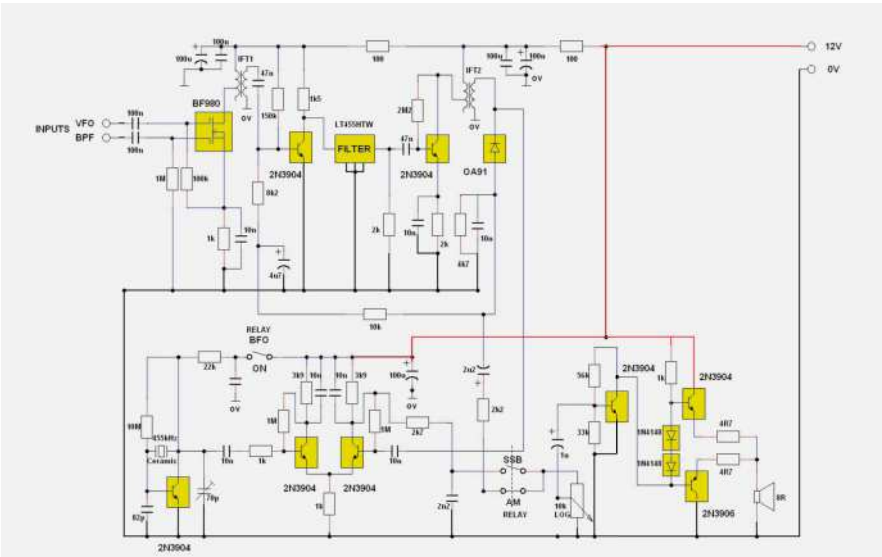

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The Main Circuit

The main circuit is shown at **Fig. 9**. The input to the circuit is at the gates of the dual-gate MOSFET, which is a mixer. This receives the VFO on Gate one and the BFO on Gate two. The output from the MOSFET is connected to the first IF transformer and is colour–coded yellow to distinguish it from the second IF transformer, which is colour–coded black. The difference being that the secondary windings have different inductance values. The second one needs a higher inductance for the correct impedance for the diode. The output from the first IF transformer is connected to a 455kHz 6-element filter type LT455HTW and has a ±3kHz bandwidth at 60dB, which is not perfect for resolving SSB signals but is acceptable. The output from the filter is amplified by the second IF stage.

AGC

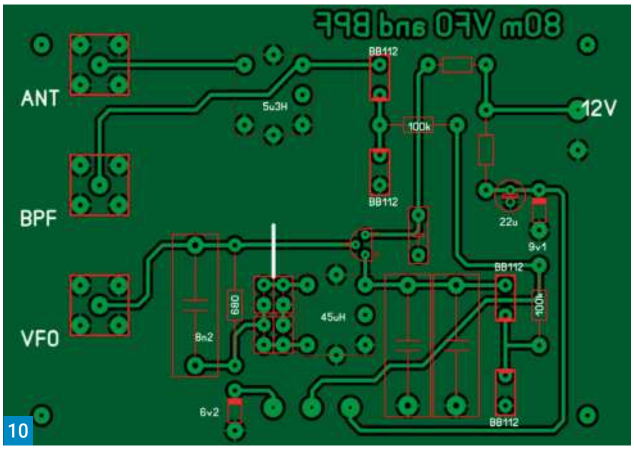
The AGC works well and measured with a Marconi model 2032 calibrated signal source produced the readings when measured at the IF output (Diode Anode) with a Hitachi 200MHz scope as in **Table 1**. It is derived from the OA91 germanium diode connected to the secondary of the second IF transformer. The rectified voltage is fed back to the first IF amplifier via the 10kΩ and 8.2kΩ resistors and decoupled with the 10nF and 4.7μF capacitors. There is a 4.7kΩ resistor connected from the OA91 anode to ground and is for the diode's bias voltage to allow it to conduct.

BFO and Long-Tailed Pair

The BFO (Beat Frequency oscillator), which is the forerunner of CIO (Carrier Insertion Oscillator), is fixed with a 455kHz ceramic resonator after setting for LSB reception by the 70pF trimmer capacitor. It uses a commonly available ceramic resonator as used in some remote controls. The circuit is simple but works well. The output is connected to a long-tailed pair, which is a common name for this type of differential amplifier.

Both 'sides' of the amplifier are the same and the circuit produces a difference (in frequency) output from the two input frequencies.

The one side receives the SSB signal and the other has a BFO input, which is



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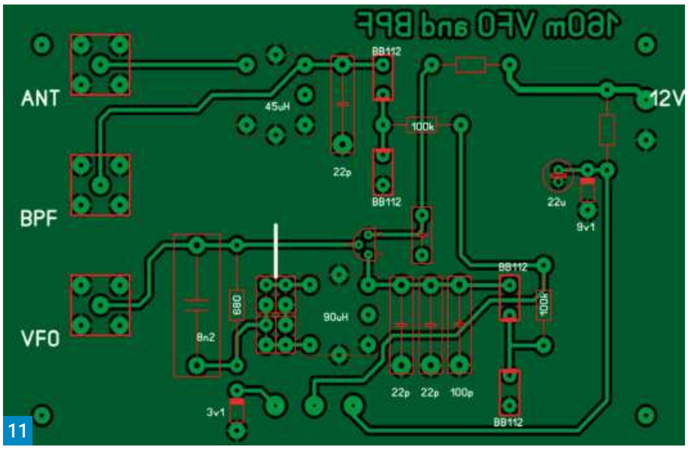

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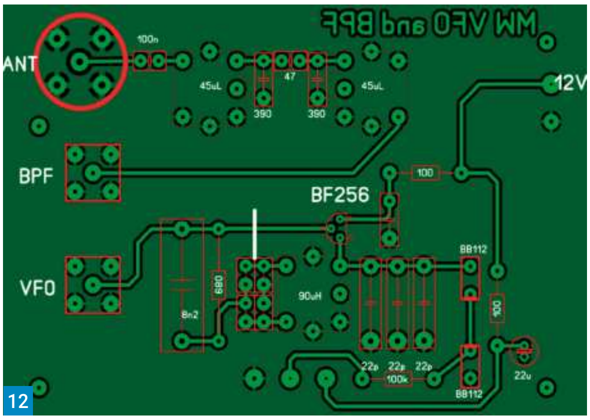

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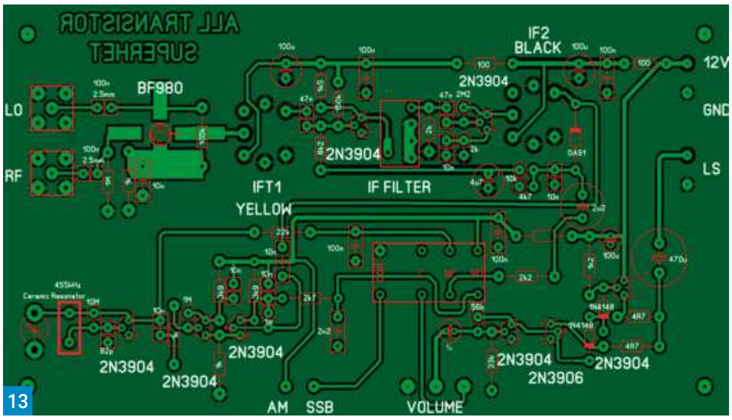

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adjusted to produce an output in the audio range. This is the same principle as the IF stage where the received off-air signal is heterodyned (mixed) with the VFO to produce a difference (intermediate) frequency at its output.

Audio Stage

The output of the product detector, along with the recovered AM audio, is connected to a set of relay contacts and is switched to the audio stage, which is a complementary pair of transistors (2N3906 and 2N3904) that are PNP and NPN types and is driven by another 2N3904. The two diodes are for the bias for the complementary pair and the outputs from the emitters are connected to 4.7Ω resistors for matching to an 8Ω speaker. There is plenty of audio for the neighbours to hear as well.

The Main PCB

The main PCB is a single-sided FR4 type and has a ground plane on the copper track side. The inputs from the LO and BPF are with SMA sockets.

These can, of course, be omitted and the outputs from the modules can be soldered directly onto the PCB. I find SMA sockets very convenient and low cost. The mixer is a capstan type BF980 and is mounted in the 4.5mm hole so that the top of the FET is sat in the hole (see Fig. 1 again). Note the underside is at the track side. The long lead (Drain) is soldered to the long track so that the orientation is correct. The first IF transformer is coded with a yellow plastic core sleeve and the second IF transformer has a black sleeve.

The ceramic resonator is at the bottom left of the PCB and the frequency is adjusted with 70pF trimmer to resolve SSB stations. The convention for 80m and 160m is that lower sideband (LSB) is used so once set it will be suitable for SSB stations on both bands.

The audio output stage drives an 8Ω speaker with good volume and a 6Ω and 16Ω speakers were tried with similar performance. The four PCBs are shown (at reduced scale) as **Figs. 10** through **13**. Drop the author a line for full-scale drawings.

Setting Up

Not a lot is needed to set this up as the IF's transformer cores are more or less at their best setting but can be peaked if needed when receiving off-air signals.

The frequency band edges can be set with a signal generator or with a comparison signal from another receiver. The BPFs can be finally adjusted when receiving an off-air signal by adjusting the coil at both ends of the bands. Tune to a signal at the bottom end of the band and adjust the BPF transformer iron dust core with an insulated trimming tool for the strongest signal. Tune to the top end of the band and adjust the core again for the strongest signal. Repeat both operations until the signal is strongest all across the band.

dBm	Voltage level	'S' reading	Output Voltage
-97	3.2μV	5	98mV
-87	13μV	7	100mV
-73	50μV	9	150mV
-53	500μV	9+20	220mV
-38	5mV	9+40	250mV

Table 1: Voltages from AGC circuit.

Is there a Kit?

As with all my articles I offer a picking list. You can choose what you don't already have. I supply the parts on the list at the cost that I paid at the time. No profit and on a cost recovery basis.

Acknowledgements

My thanks to **Ray G7BHQ** for reading over the text.

Are We Nearly There Yet?

Joe Chester M1MWD continues his quest for the ultimate rig but at the right price.

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So, are we Nearly There Yet? Yes, we are. But do you just want the answer, or would you like to hear the reasoning? And yes, it's probably about money, shed loads of it! Well not really but, as I explained last time, it's about spending it wisely. Last time, I left you with my decision to buy another transceiver. The specification was a bit raw – lots of antenna sockets, and associated T/R switching, SDR technology, and a receiver high on the Sherwood table. You would think that this is enough but, of course, it's not!

Look at that Sherwood receiver performance table. From the top down its FTdx101D, then Flex 6700, followed by FTdx10, K3S (no longer available, except used), K3 (like the K3S, no longer available new), IC-7851 (wow – dual spectrum scopes!), TS-890S, KX3 (I have one of these), ANAN 700DFLE (a true 'black box'), and FTdx5000D – that's just the top 10. For reference, my IC-7300 sits in 21st place, two places behind the IC-7610. But what does this actually mean – not in theoretical terms, but practically? The trivial answer is to buy the one on the top of the list, but it's not that simple.

Rob Sherwood NC0B has bench tested almost every transceiver available on the market over many years (see website below). He has also written extensively about how he does these tests, and on the problems modern communications receivers have, including, for example, the simultaneous handling of weak signals close to much stronger signals. This can in turn lead to several problems, including a reduction in receiver dynamic range, and the generation of intermodulation distortion (IMD). Not being a radio engineer, I'm not intending to go into these kinds issues in great detail.

www.sherweng.com/table.html

However, I do want to have a look at what the table shows, but from the small station viewpoint – the single operator working mostly from home. An often-overlooked aspect of the table is what it tells us about receiver performance over time.

Quite clearly the table shows that modern receivers are far better designed than their predecessors (or have access to more modern, high performance components). Look at the receivers at the bottom of the list – they are all receivers several years old by now, with more recent receivers at the top end of the table (in general). Probably not news to many, but it probably means that Rob's test programme works, and is a relatively good way to rank receiver performance.

The table is organised in order of the test receiver's third-order dynamic range (the second column from the right in the table.). This quantity is also called Reciprocal Mixing Dynamic Range (RMDR). This measurement tells us what happens when a strong signal gets near to a much weaker signal, causing the receiver's electronics to desensitise the reception of that weaker signal. In a sense, a good RMDR will allow us to hear a weak DX station when there is a strong signal very close. A good receiver will have a large positive value for this parameter. The Sherwood Engineering table focuses on this measurement as the key to receiver performance. If you want to see this in action, look at the amazing demonstration on **Sascha PD9Z's** web page (URL below). It's nice to see confirmation that my IC-7300 can hear a weak signal with a very strong signal only 200Hz away. In other words the IC-7300 has a good RMDR – Rob measured this at 97dB. You could say that the value of this parameter helps to decide if a receiver is 'contest grade' or 'entry level'. But there are also other equally important measurements, such as blocking dynamic range and, of course, the receiver noise floor (also known as minimum discernible signal), as well as front-end selectivity. These are also shown in the table.

http://pd9z.com/about-the-rmdr

What Does it All Mean?

So, how should we, as amateur radio operators assess these measurements? Is there one that is the key to receiver performance? Well, as I said, it's not that easy. Clearly, the receiver's noise floor is important in helping us hear weak signals in the first place. But if the receiver produces annoying intermodulation products, then this is not such good news. I think these receiver measurements are somewhat relative. They tell us in general terms that the receivers at the top of the table are probably better than those lower down. This in itself is probably a reasonable guide to help us with buying our next transceiver. As a specific example, I have both an IC-7300 and a KX3. Sherwood puts the KX3 (with a noise floor of −123dBm) in the top ten, with the IC-7300 (a noise floor of −133dBm) in the second decade. For the third order dynamic range, the figures are 105dB and 97dB respectively. But what does this say, precisely? Is the KX3 a much better receiver than the IC-7300? The measurements say it is, but these two transceivers are relatively close to each other in the table and in normal use, it would be hard to see this difference in practice. Rob Sherwood says something similar in a presentation he gave about the limits to receiver performance (URL below): *"Most of the time our radios are not stressed to their limits, and if we operate our 90dB radios properly, they perform well in most environments"*. Of course, multi-station contesters have much more stringent requirements, so these numbers really do make a difference for those operators.

https://tinyurl.com/42b64f79

The FTdx101D is at the top of the list today, with a noise floor of −127dB, and my IC-7300 is at −133dB. That's a 6dB difference, but is this important for a small station? The RMDR for both these radios is very good. And Sascha's test of my IC-7300 shows that this receiver is no slouch in this respect. In the end these are comparative figures, and very small numbers, and seriously, I doubt that without test equipment you would notice the difference in practical everyday use. Of course, it's different if you only work signals in the one S-point range routinely!

Rob Sherwood began these tests in the age of the superheterodyne receiver. Today, SDR reigns supreme, so I should say something briefly about the testing of SDR receivers. Connecting an antenna immediately to an ADC is currently not feasible (but see below), due to the limitations of the technology, the main problem being the inability to convert from the analogue domain to the digital domain (and vice versa) with a high enough rate and accuracy at the same time. Hence, all direct sampling receivers today need various active components ahead of the ADC stage. These components introduce some of the problems of the legacy hardware, and are therefore subject to testing. For SDR receivers, clearly the noise floor is still important, due to the inherent noise in the active components, and even the crystal clock oscillator in the ADC is a possible internal noise source. And I suspect that dynamic range measurements will still be required. But back to the transceivers available today.

The only truly direct sampling receiver I know of that's available today is the RX888 (version 2 currently in trials and see **Mike Richards G4WNC's** report in this issue), in the sense that it delivers the entire RF stream directly to an ADC, sampling the entire 30MHz (or more) bandwidth directly. Most commercial transceivers use what is called a hybrid architecture, with superheterodyne-like front ends before the ADC to improve selectivity, and intermodulation, and to reduce the stress on the ADC circuitry.

In Conclusion?

So, to some kind of conclusion. The FTdx101 at the top of the table clearly meets all of the requirements listed above. It has three antenna sockets, including one for a receive-only antenna, it's a hybrid SDR architecture. So, is that that then? Well, not quite. Note that Sherwood's table is only about receiver performance; it says nothing about transmission. Here, there is the usual problem of operators not using their transmitters properly, and thereby causing splatter on nearby frequencies. Not much we can do about this really. But there are other requirements that should also be on my specification – it's my specification so that's allowed, yours may be different. For example, what about an on-board antenna matching unit (ATU, if you like)? With a 10:1 matching range, like my KX3? Modern amateur radio communications are heavily into digital modes, and things like large screen displays. So, my ideal (?) transceiver needs a set of interfaces, from USB (both A and B please), HDMI for a large screen, to Ethernet for IP connectivity (whether local or remote). An on-board soundcard would also avoid the problem of needing a separate external soundcard to overcome the limitations of the audio ports on many modern computers. These kinds of ports can be created with, for example, the RigPi Station Server, or the S and Y box type interface boxes by **Bob N6TV**, or the MicroKeyer, and Rigblaster units. But if I want to reduce cabling complexity (and I do!), then I really need my new transceiver to have these interfaces on board. I've included images of three transceivers showing the rear panels for comparison – I might even tell you next time which is which!

And then there are the reviews. I suppose I could say at the outset that these are necessarily subjective. But many professional reviewers, with a long-term track record for accuracy and reliability, can usually deliver interesting reviews. This doesn't eliminate the subjective opinion, but it should offer a more balanced view – as in 'wow look at that', but also 'be aware of this'. So clearly, I need to read the reviews of all the possible rig choices I have. Indeed. But now comes a bit of an issue. Phrases like 'high-end', and 'contest grade' and even 'top of the range'. One recent review made the observation that *"if you only want a 100W radio to ragchew on your local 80m net, then a 'contest grade' rig is not for you, and there are plenty of others from which to choose"*. I think this echoes what Rob Sherwood said. OK, but what exactly does this mean in practical terms? If you need a transceiver with an HDMI socket, then it doesn't matter if it's entry level or contest level – get the one with the HDMI socket (assuming it does everything else you want). Note that the aforementioned FTdx101D requires an additional external interface purchase to provide a LAN interface. And its ATU matches only 3:1.

Continued on page 66

Murphy CR150/Navy B40D

Philip Moss takes a look at a classic set that many readers will recall.

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This radio was one of several communications receivers that fortuitously arrived at the British Vintage Wireless & Television Museum just as the previous policy of the late founder not to have such things was reversed, due to my influence. There is now a Comms Corner as I named it, with a number of important radios of Military, Commercial or Amateur Radio type.

I, and probably you, have known of this set from youth. They were advertised in many magazines ex-navy in the sixties and seventies, suggesting they did not do long service with the navy, as it is a post-war set. They have a very distinctive look, **Fig. 1**, with the bow-fronted tuning scale. That is of an interesting design. The bands slope, which is done so that the scale can be longer than one full rotation of the drum, thus allowing more frequency increments to be marked, giving higher resolution. Each scale is illuminated separately, showing only the one selected at the time. The crystal was dated 1952, the original introduction date is not known. The manual has all pages dated August 1956, and clearly is a re-issue therefore.

1

First Impressions

Examining the set for the first time – I had not encountered one 'in the metal' before – it is rather confusing. The reason is that this (D-version) was designed mainly for RTTY use. There is CW, and even AM, but it is not that obvious how to get AM out of it. I was not familiar with RTTY, so the mode switch was not understood. A later more careful examination of the mode switch revealed all. Note that AM is called R/T, Radio Telephony (as opposed to W/T, Wireless Telegraphy, though on here the more modern term CW is used). RTTY, Radio Teletype, is sent by FSK, Frequency Shift Keying. To make it more confusing there are two options for the shift frequencies. For those unfamiliar with RTTY, it is sent by sending two tones, and to make things more complicated instead of a standard for the tones, there are at least two. Well, why make things simpler when with a little thought you can make them more complicated! Things became much clearer on obtaining the loan of the manual, Navy BR1617, titled for B40D, but actually covering all five radios, both operation and service, including even how to rewind the coils – an unusually comprehensive manual.

There are five versions: starting with plain B40, then A, B, C, D, and they look rather different. The number of controls increased with each version and, additionally, the B, C and D versions had a significant cosmetic change with the addition of the black background panels under the controls either side of the tuning scales. They look much more interesting like that.

The way this article is written has had to allow for the fact that the circuit diagram

Fig. 1: Front view of the set, showing the curious tuning scale.Fig. 2: The turret tuner.
Fig. 3: The set as seen from the opposite side to the turret assembly. Fig. 4: Top view.

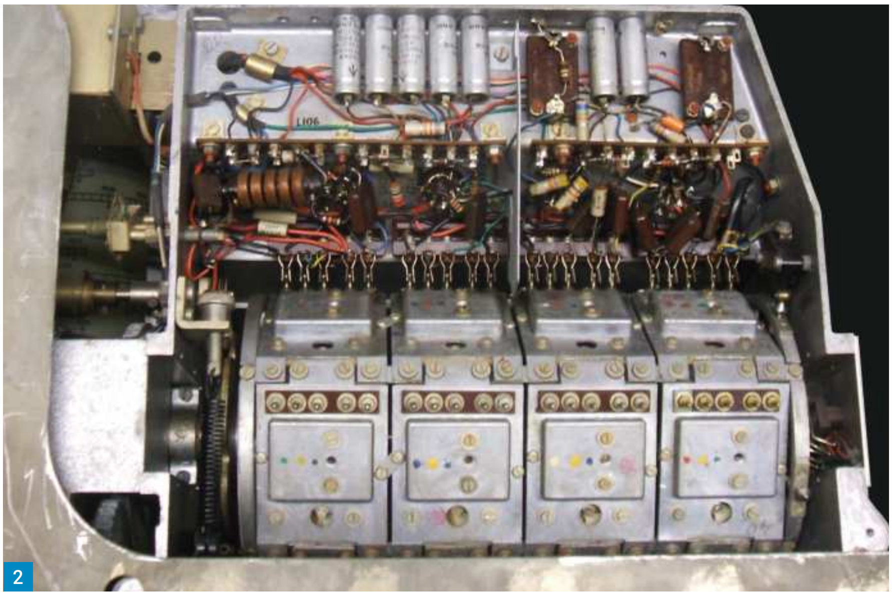
would have taken up four sides of A3, so I have referred to it but it has to be found on the web on the excellent website of The Vintage Military & Amateur Radio Society: www.vmars.co.uk

This site has a very large number of manuals of Services equipment, including test gear and also some radios not used by the Services. It is a free service. There is no need to join. For those who do not want to look it up, I hope you will be able to get the

Frequency	SNR	Frequency	SNR
650kc/s	>17dB	1.6Mc/s	16dB*
1.6Mc/s	17dB*	4Mc/s	>17dB
4Mc/s	17dB	9.5Mc/s	>17dB
9.6Mc/s	17.5dB	18Mc/s	17.5dB
18Mc/s	16.5dB	30Mc/s	>17dB

* Measured with a residual whistle and voice in the background: there was no adjacent clear frequency.

Table 1: SNR Measurements.



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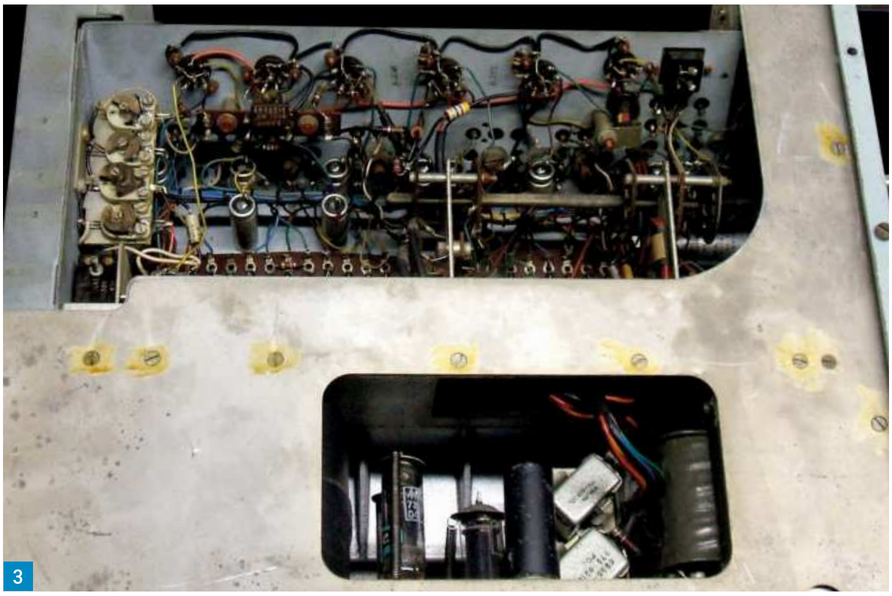

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feel of the set, anyway. The full manual there is 489 pages! To put that in perspective, the manual for a certain American power amplifier I repaired recently is also 489 pages. I found the circuits at last on page 522. No, I have not got that wrong!

Although not on the cover, there is brief mention of Receiver 62B. This set covers Long and Medium waves, and is designed for use with 'Sound Reproduction Equipment', in other words as an entertainment set when not needed for military duties.

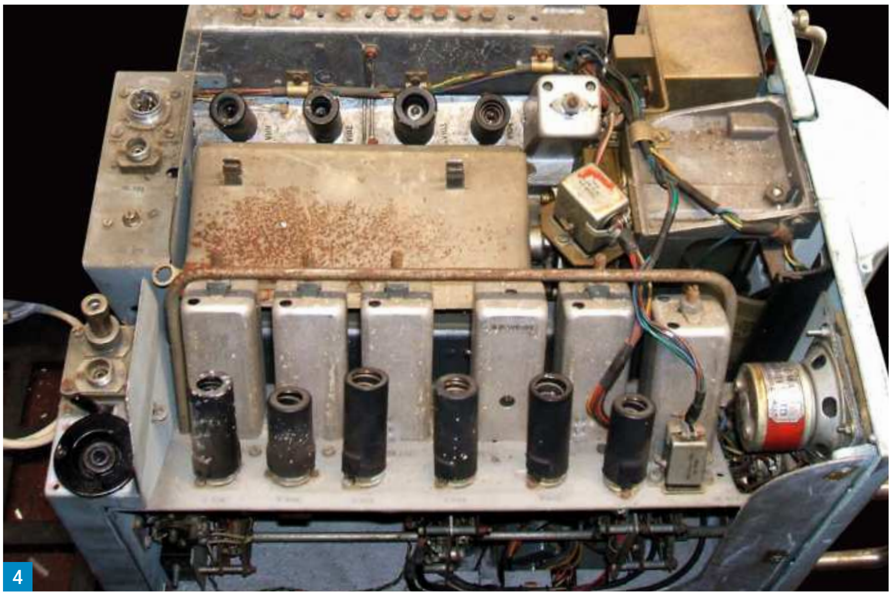
Before I go further, a note on valve types. All those used are specified using their CV numbers. CV numbers are the Armed Forces' Common Valve List types. For those not in the know, the three arms of the Services decided they would renumber commercial valve designations with their own individual numbers, and they tried to separate receiving and transmitting valves. As if the situation wasn't confused enough by the makers' having their own systems. Then they decided that they would introduce a joint-services listing system. Note that a valve may be listed under more than one CV number, but when cross-referenced, A may be equivalent to B, but don't assume B is listed as equivalent to A. Some 'valves' are solid-state devices. Next came the NATO numbers… I have used mainly the book *CV Register of Electronic Valves (including semi-conductor devices) 1963*, a book marked 'Restricted' but which appears at sales from time to time. There are also commercial equivalents books such as the Pinnacle valve book. In this article CV numbers are translated to their common ones.

Work

My initial test found the set dead. This was due to the mains switch sticking on one pole. A drop of oil cured that. Connection was a problem as it did not come with a mains-lead, and we didn't have one so in the expectation of changing the connector, I soldered the mains wire on. Yes, not very nice, but it got it going. The set kind of worked. Lots of noises and all the signs of not being well stored as is so often the case, with intermittent and noisy controls, but there was definitely life.

As said above, the first thing was to get the mains switch to connect, though strictly, getting the cover off came first. A nasty flimsy piece of metal, which fought back, and replacing was worse! You then see there is a hell of a lot in here – three chassis, with the PSU and audio on the lower, plug-in diecast one. The later models use a very nice potted mains transformer while the earlier ones had an open-frame type, which failed. Also, there are two miniature full-wave rectifiers on here. They seemed determined not to use octal valves, and had found the original rectifier was unreliable, so they used two, each on one phase only. I assume the set pre-dated the GZ34, which would seem the obvious choice for long-term reliability. The dislike of electrolytics, which became fashionable, is shown here with only paper types for HT smoothing.

So, with a drop of oil on the open-frame mains switch we had life. To remove the PSU assembly, you need to unplug some Jones plugs to the main chassis, which were not located for the convenience of the serviceman. That said, the original sets were worse. The manual refers to them having been moved to make servicing more convenient. The mains connector was replaced with an IEC. This was time-consuming because dismantling was needed to get access. The mains filter caps were disconnected as they were old. They may have been perfectly fine, but I didn't want to risk it. I tested the set to 1800V DC with my home-made PAT-tester; there was no leakage. I didn't risk going all the way to 3kV, though it would probably have been fine. I replaced the 0.001µF coupling to the output valve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grid – it could be relied on to be at least a bit leaky by now. The value was very small. This set was not intended to have a bass response, so I fitted a 0.022µF, and also R306 (470kΩ) as it had drifted a long way up. It is essential to protect both valve and PSU so in old radios the output valve grid cap is at least checked, and also the grid leak is not left if it has gone high, and this applies to military and domestic sets alike. For the AF voltage amplifier pentode V301, I replaced the screen capacitor and resistors for the reasons given above. When I tested the power/AF section on its own, I found all volts were 336. Referring to the circuit, I realised that the earth connections go through the multiway connectors, and therefore it was 'floating'. Once reinstalled, it was fine. I did some random tests of resistors on the main chassis: and as a result I changed a couple more capacitors and resistors. Very good for the age.

Testing and Using

To use this set you need to work out the connections, not as obvious as you may think. The connectors are labelled with numbers, not function. The aerial is expected to be balanced, so I modified it to be unbalanced (by the simple expedient of earthing one side) and changed the connector used, to one that wouldn't be needed, but which had a plug in it. These are a screw-on design of coaxial connector. Next the speaker output was not convenient, so I used a jack socket mounted on an adaptor plate. To actually drive the external speaker, it must be turned on, by the switch above the mains switch.

I tested some resistors. Apart from those mentioned and changed, they were found to be generally not far off value, and did not need changing. Checking leakage of some capacitors other than those previously mentioned, again I found them to be good. The same alas was not true of the internal speaker for while it was working for the initial tests, it went open circuit. A combination of damp storage and provocation by some nasty transient noises when the set was first tested. Luckily, I had one that fitted.

The AF gain was very scratchy, and sealed, so I drilled a hole in order to use Deoxit on it, which worked well. The bandwidth switch was very intermittent, again cured with Deoxit. I also 'washed its face', which made the set look rather better, and replaced two dial lamps one which had failed, and one was dull. It was a 12V bulb. Note there is a brightness control for these on the set's rear.

The crystal didn't work. On removal, which was not easy, it rattled, but on opening (this is the old-type, which was screwed together not sealed), it was found that just a bit of SRBP (synthetic resin bonded paper) was loose. The pins were cleaned, as was the socket, which was very loose.

As is my habit, I measured signal-to-noise ratios (SNR) with the set switched to AM. Measured using a Marconi TF2019 phase-locked generator, 30% modulated, 1µV PD 50Ω output, with the set adjusted for 50mW into a Marconi TF340 power meter. The results are shown in **Table 1**.

The frequencies are near the top and bottom of the range being tested. The figures all look satisfactory, and the work required to get this set going was not great, especially considering it was badly stored. It appears people think because a set is military, it is also water and damp proof and can be kept in an out-house. Not so unless it's a field set.

Circuit

A very big feature of this set, and part of the reason it is so big, is the use of a turret-tuner, **Fig. 2**. You may be familiar with these, in a very small version, used in the old band 1 and 3 TV tuners, where 'biscuits' were mounted on a drum that rotated when you selected the channel. The 'biscuit' contained the pre-tuned RF and oscillator circuits. They had studs to connect it, which ran against spring contacts that were fixed. The colour of the plastic used was why they were called biscuits, I assume.

This construction has several advantages. The connections are very short, the separate bands can be in cans to keep them screened from one another, preventing interaction, and the assembly can be made very rigid. It is however more expensive and larger. At VHF and above, you may not have a choice. Another set to use this is the Eddystone 770, where they even integrate the valve bases into the tuning capacitor to get shorter connections, and silver-plate the whole assembly.

This set is not of predictable architecture. While it has single conversion, a typical IF frequency of 500kc/s and two RF amplifiers, a triode-heptode mixer with the triode unused, and three IF stages, there are some surprises. For example, there are two volume controls, one marked gain, which is mainly the RF/IF control, but has an AF potentiometer on the back (see RV 305 & 309), the other being RV224, the conventional AF gain feeding the grid of V301, CV303 (6BA6/EF93). Note that this is a variable-mu pentode, normally associated with RF/IF amplifiers under AGC control, and is here under AGC control. A strange setup. The pure AF gain is the small knob on the left side. Further, RV309 controls attenuation after the output stage, on the secondary of the output transformer, and there are two of those, the 'usual' one being in the anode of the output valve, converting to line impedance, feeding TR303, which steps down to low impedance for the monitor speaker.

RF Stage

The RF stage is also odd. While the second RF amplifier is AGC controlled, the first is a 'straight' pentode, CV4014 (CV6064, itself equal to our familiar EF91, 6AM6, 8D3, and Z77). It, however, was subject to overloading so an unusual control was added, labelled anti-cross modulation, RV101. This is basically a manual bias control, which allows the high cathode volts developed across R104 (8.2kΩ) to be opposed by positive bias. Yes, a 'straight' valve would have more linear characteristics, higher gain and lower noise than a variable-mu type, but only, you may think, marginally, and adding a control easily misadjusted, leading to an apparently 'deaf' set. The RF tuned circuit is configured for common-aerial operation, so needs to be high-impedance at frequencies other than that the set is tuned to, to allow other sets to work on other frequencies.

Local Oscillator

The local oscillator, V104, CV4014 (EF91), is a pentode. Often these sets use a triode, or triode-connected pentode, but in this case it is pentode connected, with the coil having four connections, with both the anode and grid connections on taps, leaving the ends, which are where the tuning occurs, free from DC across them, and more importantly, less loaded by the valve impedances, thus better for getting high-*Q*. Output is taken from the anode, so the mixer, V103, CV2128 (better known as our old friend ECH81, or 6AJ8), does not load the oscillator's grid circuit. All for best stability as is the stabilised HT from V305, CV1832 (0A2 or 150C2). The oscillator configuration is Hartley, as is the BFO. The triode in the ECH81 isn't used. With RTTY using tones, it was important the set drifted little, or the decoding wouldn't work.

IF Amplifiers and AGC

As is usually the case, the IF amplifiers have variable degrees of coupling between primary and secondary, to derive the different bandwidths. The narrowest position uses a pair of crystals, and unusually they are between the first and second IF amplifiers. Usually, the maximum selectivity is in the anode coupling to the first IF amplifier, to attenuate unwanted signals as soon as possible, to prevent overloading and spurious response.

AGC is not applied to the third IF amplifier. This is quite normal. While applying it would sharpen the AGC response, there is a problem in that it would also at this high-level signal stage cause the effective level of modulation to be increased, and that would cause distortion of the signal. The final IFT (intermediate frequency transformer) is not quite conventional. The BFO signal is normally coupled into the detector via a very small capacitance, sometimes even relying on strays, but here there is a separate winding on the transformer, and it's in the anode of the BFO valve. The detectors are conventional, a capacitor from the valve's anode feeds the AGC diode, and the signal detector is fed from the transformer's secondary. This feeds an impulse noise limiter with automatic adjustment for the normal IF level, and manual adjustment of the threshold.

All four diodes are in two CV140s (EB91 or 6AL5). From then as stated the signal goes to an AGC-controlled audio pre-amp pentode, CV454 (EF93/6BA6), then the output valve CV2136 (6BW6), to be followed by the unusual transformer arrangement already described.

PSU

This brings us back to the PSU, on which I have commented. A feature again unusual is the use of two smoothing chokes, the conventional one in the HT positive, though it is mysteriously specified as 18-25 Henrys, suggesting a 'swinging' choke, but they are used with choke-input filters in class AB or B amplifiers, and would be expected to have a much wider range of inductance between the minimum and maximum currents, and a second choke in the centre-tap of the HT winding, to earth, it being a straightforward 20 Henrys, with two capacitors across it. Possibly a tuned arrangement. The manual does not expand on why things are done this way, I won't either as I don't know!

The BFO deserves some further consideration. These are normally straightforward things. Not so here. Because tones need to be generated for FSK, and there are four of them, there are four trimmers to tune the inductor to the correct pitch. The narrow position on the system switch gives a 1kHz tone and is also used for CW reception. Finally, there is a crystal-controlled position, CAl (ibrate), for zero-beating the tuning to allow the cursor to be set exactly correctly.

Sadly, I failed to take a picture of the PSU chassis, but **Figs. 3** and **4** show the set from the opposite side to the turret assembly, and an overall picture from the top. The two side chassis are separate assemblies.

Conclusions

A very solid set, not difficult to service if you have the circuit, which needed not much work considering its poor storage. It is not ideal for many amateur purposes. The particular requirement for RTTY by FSK probably does not suit modern computer-generated RTTY, though I may be wrong. For both AM and CW the filters offered are not ideal, unlike so many sets of ex-military origin, where you get the option of several bandwidths.

This all said, though, you get a hell of a lot of radio for probably not much money, and as part of our heritage it is interesting. With a nice clear tuning scale and intrinsic stability, it is well suited to the shortwave listener. For anyone who collects vintage services radios, it is a well worthwhile addition.

Continued from page 62

I started out with a what might be termed an entry-level transceiver, but one with a really good receiver, if the measurements are to be believed. And I'm happy with its performance. But, in order to do more and different things, I now need a confusion of extra boxes and cables, and hit the systems design issues. As a minimum I need even better receiver performance in order to hear the weak signals arriving here from the other side of the globe. Also, when the big contests are in full swing and the bands are crowded, a really good receiver would help me fish out the weaker and rarer DX signals under the pile-ups. And for more lowband work, I need to install a lowband receive antenna.

Now, in reality, not everyone wants to be a leading contester (I don't!), or a ragchewer (if that's a word!). It really isn't an either/or choice, is it? And even if your just ragchewing on the low bands, there are issues that require extra features on a transceiver. Like the background noise issue, and separate receive antennas to lower same. I suppose I should say that cost raises its head here. Let me be clear– you can have a lot of fun with an entry-level rig. I said something similar on that RSGB Conference video, and I believe that I have done so with my current kit. But, as I said at the beginning, there is more to do. And even though I don't need a Ferrari to go to the supermarket, if one fell into my hands, I wouldn't say no! So, a transceiver with all the 'bells and whistles', if I may use that phrase, may be what I need to improve my station's performance. All the antenna sockets, all the interface ports, everything in a single small box. All the boxes and wires in that diagram replaced with a single box! Does this exist?

In the technology business it's always the case that there is something new just around the next corner. I have actually seen this, the future, and I liked it; even spoke with the designer – didn't get to play with it, but it fills all these requirements. The lot! It's so new, it's not yet appeared on Sherwood's table! OK, so it's not really available today, but I'm not in a rush. Sunspot numbers will continue to improve. It also gives me time to convince my station manager that this is the right answer for my station (!). If I am really brave, I will tell you that approval in principle was received a while back, subject to proof that the required funds are available (where?), and without needing a mortgage, or the sale of an apocryphal arm and a leg.

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Please email: nickdewhurst@hotmail.co.uk

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OFCOM EMF Exposure Consultation

Dear Don,
It is typical of all Quangos that they appear to want to rid themselves of the troublesome administrative burdens for which they were created and, in the case of OFCOM, rid the airwaves of amateur radio activity in this country, clearing our frequency allocations for commercial use, which would become self-policed, no doubt. The RSGB is either party to this or is allowing it to happen by reacting to the current proposals in a 'too little, too late' way.

All good radio amateurs are aware of the hazards associated with radio emissions. They are minimal at worst. As is well known, this was all exhaustively researched years ago with the advent of the cellular phone era, when litigation against phone companies for damage and personal injury was threatened. It was established that radiation from cellular phones caused no measurable harm to humans, and these were microwave transmissions where the energy density of each radiated photon is greater than at VHF or below. Following the outcome of this research, a host of mobile phone antennas were erected on buildings such as The Christie cancer hospital in Withington, Manchester, where I used to work.

The Psychology of Submission
Radio Amateurs have always been aware of the need to monitor their RF output. Using software to calculate safe distances from equipment is entirely reasonable and has been part of our brief for years. Test reports were written up in our logs. For years also, OFCOM, in collaboration with the RSGB, has steadily reduced the standards both of the individual amateur record-keeping requirement (Logbooks) and of the Radio Amateurs' Exam itself in this country to the point where I doubt that new radio amateurs would understand this threat to the Amateur Radio Service or be able to produce proof of safety tests done at their station if ordered to do so. I believe OFCOM has put these proposals forward as another move towards forcing the UK amateur radio community to submit to what I suspect will be an ever-increasing amount of paperwork to justify their hobby and provide OFCOM with security of tenure. As a first move this is quite gentle, but I believe it is a form of conditioning designed to ultimately leave all radio amateurs and the RSGB without a leg to stand on when more and more restrictive and demanding rules and proposals are introduced in the future. It is sad to think that the 'British Sense of Fair Play' could cause us to relinquish a pursuit that has helped to stimulate Science, Industry and Innovation in this country for over a century.

Mains-Borne Interference
OFCOM has done nothing practical at all about this and I think it's because it has been caused, in the main, by commercial interests that promote and argue their case better than the RSGB does. The RSGB should have taken fair warning over this issue but, again, have done nothing meaningful. I suspect it's because they were unable, unwilling or unsure. We now have LED streetlights, which cause an immense amount of RF interference. Where were OFCOM and the RSGB when it came to applying EMC rules in this instance? Not only would they have done amateur radio a favour by banning the current implementation of these lamps, they would have eliminated the cost, to every council in the country, of constantly having to replace the LED driver units in lighting columns which, as well as being noisy at RF, are reportedly prone to regular failure due to overheating.

I don't expect OFCOM's motives ever to become transparent voluntarily. It should have been up to our representative body, the RSGB, to give us all as early a warning as possible (which they have simply not done about this issue), and take appropriate, timely and well-advertised measures to protect our hobby. We are all aware of the French proposal to make inroads into the 2m allocation. This threat will become more aggressive. We need a representative body that will be able to withstand such threats in the UK, not by politely and deferentially responding at the invitation of OFCOM but by a vigilant, well-informed, intelligent and vigorous defence of our hobby.

Patrick Walton M1BNH
Bury, Lancs.

*(**Editor's comment**: Thanks for raising this Patrick. As you will see, I have devoted this month's Keylines to the subject of the Ofcom missive, which, of course, doesn't single out radio amateurs but has gone to all radio users.)*
As you say, SDR and other technologies are important nowadays and much kit is built from modules rather than discrete components. And, yes, there are many facets of the hobby not covered in the syllabus. You offer an interesting and possible solution – I wonder what other readers think?)

Empathy Over Plea for Help!

Dear Don,
First, let us set the rules. I assume that you just want to understand how to use imaginary numbers and complex equations and not as a maths wrangler. After all you need not know auto engineering to drive a car.

Imaginary numbers are a device to allow you to solve some electrical problems and 'I', the imaginary number is the square root of '−1'. √−1 would be confusing in an equation, so 'i' was used.

Now you know that a square root of 'x' is the number which when multiplied by itself gives 'x' and you also know that '+' × '+' = '+', and '−' × '−' = '+' and that '+' × '−' is '−'. So to get '−1' there are no real roots, so 'i' is imaginary.

When you meet it, just think of it as '√−1' and usually you find in a problem that you end up with i times i which is '−1'.

Then you will meet two equations containing 'i', which you have to add, subtract, multiply or divide. Adding and subtracting should not be a problem, nor multiplying. Some people stumble over division – I did until an engineer I worked with pointed out that I could divide if it was X and not i, so treat it as though it was X. Any maths book will remind you how to do this.

That is about all you should need when you read something with 'i' so do not worry about advanced maths textbooks.

A Gordon
Shoreham by Sea

Dear Don,
Now, I couldn't resist wading in when I read (March 2021 issue) **Michael Jones'** plea for help' re complex numbers and Smith charts.

Complex numbers (to add to more confusion, there are hyper complex numbers too – we'd better not go there) are not meant to be actually complicated. They are merely complex when used to solve a problem mathematically. The a + bi (the i being the 'imaginary' part and a and b being the real life numbers, like when get your bank statement you check it, maybe via a calculator, it's a debit or credit) notation is commonly used as a device to illustrate whole numbers, integers, and those apparently 'imaginary' numbers.

Complex numbers nowadays are used to solve many practical problems in the real world in electrical engineering, especially AC electrical currents and, of course, electronics. Anyway, complex numbers are not really imaginary in the true sense of the word – they serve a useful purpose to illustrate and ratify problems that would necessarily be difficult to explain mathematically merely using real everyday type numbers.

Then, we have the conundrum that while every real number can be a complex number, not every complex is a real number. And, a complex number can be a real number or a number not usually associated with counting the cash in your bank account. You could make it appear as any sum you like. But you probably wouldn't be able to splash it out on a brand new rig.

As for those Smith Charts, personally, I can see no use for them nowadays. Unless, you find them appealing in some way, and want to understand how they work. They do have their uses, and they don't need any batteries to work. That said, I'd sooner go the electronic and/or suck it and see route. All that trigonometry and so on leaves me stone cold. Each to their own, eh?

Ray Howes G4OWY/G6AUW
Weymouth

Dear Don,
In response to 'A Plea for Help!' by **Michael Jones GW7BBY/GB2MOP**, in which an article along the lines of 'Complex Numbers for Dummies' is requested, might I point Michael to the excellent resources available at:
www.mathcentre.ac.uk
and search for 'Complex Numbers'. There are several articles under the 'Quick Reference' section. The articles labelled 'Sigma resource unit xxx' (articles 1 to 7) may provide the introduction he needs. As for Smith Charts, the November 2006 edition of *QST* magazine gave a good introduction:
https://tinyurl.com/99vbkeu9

There are a number of interactive Smith chart sites – use Google to find them.

Matt Gumbley M0CUV
Tonbridge, Kent

Dear Don,
I recognise **Michael GW7BBY's** situation (*Letters*, March) and feel the same over so many articles.

Having picked up a NanoVNA and trying to get to grips with it and Smith Charts, Michael's suggestion, is an example nightmare scenario. Most publications seem to assume far too detailed a background of the reader. They leap in throwing technical terms and formula at readers.

The traditional, use a dictionary and read up background, approach just sends the reader into an overwhelmed state. Heaven forbid they try the internet because that has become a digital dustbin or misinformation more often than not.

My own experience since returning to amateur radio is that it's not going so well. Heaven help anybody trying to comply with the upcoming licence EMF condition. How many really read or understood that consultation and its outcomes so far.

Phil Cracknell G0KDT
Teignmouth

(***Editor's comment***: *Thanks to all who responded to Michael's query, which has generated an amazing response, both to me and direct to Michael. Clearly it struck a chord. I will run one or more articles on this and other technical topics in the near future with the aim of taking out some of the mystery. As for the EMF directives, do read this month's* Keylines*. And, in addition, there was a helpful article by* ***John Rogers M0JAV*** *in the March issue of* RadCom.)

Liability Insurance

Dear Don,
Great to read the *Getting Started* series. As **Colin G6MXL** rightly points out, working portable in spaces accessible to the public always carries dangers. The risk to the operator of being sued for injury and/or damage to property is not trivial. I recommend looking up what has already proven to be a very popular third-party liability insurance, included as part of the annual membership, by EURAO:
www.eurao.org/ru/node/996
John Rowlands MW1CFN
Anglesey

Reforming Capacitors

Dear Don,
I was interested to read the letter from **Angus Annan MM1CCR** in the April issue where he describes the process of reforming dated capacitors. In his letter he mentions a design for a Condenser (Capacitor) Condition Tester that appeared in *PW* back in 1958.

Any readers who want to have a go at reforming capacitors and would like to construct such a device might like to look at the Vintage Radio and Restoration website where there is a design for a suitable instrument. See below.
www.vintage-radio.com/projects

From a safety point of view Angus also, quite rightly, mentions the possibility of capacitors exploding when having a voltage applied after lying about for years. Another safety point worth considering is that the capacitor may retain a charge after having a voltage applied and hence be capable of giving a nasty electric shock if both terminals are touched. Therefore, if the device used for reforming the capacitor doesn't have provision for discharging the capacitor, it is advisable to do so manually using a suitable resistor. And, of course, suitably insulated cables and connectors should be used.

Chris Murphy M0HLS
Derby

More on Mains

Dear Don,

Thank you for some more good reading, as usual. The letters from **Michael G4HZG**, **John G1RXC**, **Ian GW1AWH** and **Roger G8BNE**, who all know more than I do, are very interesting and brought out some useful information. Funnily, my letter on standards was intended (it seems not very successfully), to ask who made the various decisions, rather than the decisions themselves, but it is good that other subjects have been raised by the letter. It is nice to see how polite the letters in *PW* are, so much better than many of the dreadful blogs one stumbles across on the internet.

My point on the fuse in the plug top only protecting the mains lead was assuming that there was a fuse inside the equipment. Searching on the internet, there appears to be no other country that has fuses in their plugs. Do they have more accidents than we do?

Incidentally, the 13A plug tops have insulation part way up from the base on both live and neutral, and I think I remember that it was introduced soon after the first ones appeared, because a small child pulled a plug out with both hands, fingers touched the live and neutral, and he was killed. Checking a few days ago, I found one of the ancient ones in the house which has no insulation. I have changed it.

Do not the MCBs (or fuses) in the consumer unit protect the house wiring? As well as the RCCB feeding the consumer unit, I also installed, many years ago, one in the supply to my outside shack, and even another one going from the shack to the garage at the bottom of the garden, hoping that I was doing right. Was I? Interestingly, the only time, other than testing, that the RCCBs operate is when a very occasional wiring job is being done, the neutral wire accidentally touches the earth one.

Despite living in the States for five years, I was not aware of the problem mentioned by Ian of the heart resonating at 60Hz. Perhaps it was not recognised in the 1960s when I was over there?

Thank you, Michael for a good laugh when you mention all the knowledge and attributes required by a Ham, including Neighbourhood Negotiation and Marriage Guidance! My dear wife was always very tolerant of my radio activities. One day she was asked by an amateur, a retired GP no less, if she let me put the 35ft mast up, because his wife refused to let him do such an outlandish thing. She replied that I hadn't asked her, and what was worse, it hadn't even entered my brain to do so.

Michael GW7BBY should not worry too much about imaginary numbers. 'j' is the square root of minus one, which is impossible, hence imaginary. (It is operator 'I' in maths, but we use that for current) When combined with real numbers it is called complex (which I suppose it is).

It is often only involving phase angles and can usually be safely ignored. Or am I starting some more correspondence? (Sorry, I know I began a sentence with a conjunction, before someone picks me up for it).

Robert Dancy G3JRD
Gillingham, Kent

Next Month

in the UK's best & only independent amateur radio magazine...

MORSE TUTORS: We take a look at two Morse tutors from Phoenix Kits.
VALVE & VINTAGE: Bernard Nock G4BXD is back with some unusual Japanese sets that have found their way to the Museum.
AN ARDUINO PROJECT: Tony Jones G7ETW has an interesting project using an Arduino for various test and other purposes.
COMPLEX NUMBERS: Chris Murphy M0HLS tackles complex numbers in the first of a new series.
RECEIVER FRONT-END PROTECTION: Vince Lear G3TKN describes how to use separate receive antennas and how to protect your receiver front-end.

There are all your other regular columns too, including HF Highlights, World of VHF, What Next, Morse Mode, Notes from a Small Station, From the Ground Up and Data Modes.

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