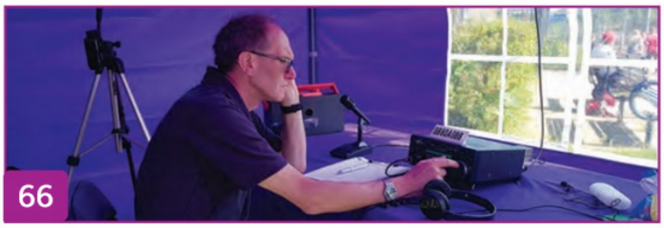
Contents

August 2023

News and Reports

Regulars

Reviews



Features

Technical Features

Rockall DXpedition
Design by Kevin Williams, M6CYB

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

Managing Editor: Edward O'Neill, M0TZX, edward.oneill@rsgb.org.uk
Interim Technical Editor: Peter Duffett-Smith, GM3XJE
Layout and Design: Kevin Williams, M6CYB, kevin.williams@rsgb.org.uk

All contributions and correspondence concerning *RadCom* should be emailed to: radcom@rsgb.org.uk. Alternatively by post to *RadCom* Editor, 3 Abbey Court, Fraser Road, Priory Business Park, Bedford MK44 3WH Phone 01234 832 700.

RadCom is published by the Radio Society of Great Britain as its official journal and is sent free and post paid to all Members of the Society. **The September 2023 edition of *RadCom* is expected to arrive with most Members by 18 August 2023** although this can take up to a week longer in some cases; international deliveries can take longer still.

The online *RadCom* is at www.rsgb.org/radcom/
RadCom Plus is available to RSGB Members online at www.rsgb.org/radcom-plus
RadCom Basics for Members new to the hobby can be found at www.rsgb.org/radcom-basics/
Abbreviations and acronyms we use are listed at http://tinyurl.com/RC-acronyms

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

www.facebook.com/theRSGB
Twitter @theRSGB

New Products

MyDEL Ham Bag

This 'go bag' is very popular with portable operators, hikers, cyclists and motorcyclists.

- Green or black version available
- Can be used over the shoulder or around the waist
- Great storage capacity for such a small bag
- Easily takes the Icom IC-705 and accessories
- Main compartment: width 27cm, depth 13cm, height 18cm (approximately)
- Five secure zippered pockets / one drawstring pocket
- Ideal for SOTA or POTA.

Available at hamradio.co.uk/hambag for £44.95.

New tri-band handhelds from Wouxun in stock at Moonraker

Two new handheld transceivers which are packed with features including cross-band repeat, Vox, scrambler, priority channel, compander and more. Both have dual reception and come with a high-contrast backlit screen.

The menu boasts all the useful features of battery saving mode, voice guide, GPS (GPS-SW), priority channel, scanning modes, CTCSS/DCS and FM broadcast receive.

KG-Q332 Tri Band 6m/2m/70cm £149.95

KG-Q336 Tri Band 4m/2m/70cm £159.95

Available via: moonrakeronline.com

Digirig mobile USB isolator

Use cases:

- Eliminate audio noise caused by ground loops by isolating your PC from yoru transceiver
- Remove hum noise in USB audio devices
- Protect PC by isolating USB test equipment such as JTAG debuggers, USB oscilloscopes and programmers

Features:

- Signal isolation up to 2.5kV, power isolation up to 1.6kV
- Up to 1W load capacity, not recommended for charging drawing over 180mA
- Supports USB 2.0 Full/Low Speed. USB 2.0 High Speed Devices are not supported
- Uses ADUM3160 for signal and B0505S for power isolation

Available at hamradio.co.uk for £29.99.

Prosistel PST-27DB VHF/UHF 2kW beam

Dual-band antenna, 5 elements VHF, 8 elements UHF

Specifications:

- Horizontal or vertical polarization
- Band 144-146MHz, Gain: 8dBd, F/B >24dB
- Band 430-440Mhz, Gain: 8dBd, F / B>14dB
- SWR <1:1.2, impedance: 50Ω, connector: N or SO239
- Max power: 2kW
- Boom length: 153cm, weight: approximately 2.5kg
- Wind area: 0.12m^2, max wind: 130km / h
- Accepts mast 40-50mm, material: 6060T6 aluminum, stainless steel nuts and bolts

Available from hamradio-shop.co.uk for £139.95

Antennas

In last month's article, we looked at the Half-Square antenna and how this could be adapted to become a voltage-fed multi-band antenna. By 'voltage-fed', I mean that the feed-point impedance is high, perhaps thousands of Ohms, so the voltage is 'high' and the current is 'low'.

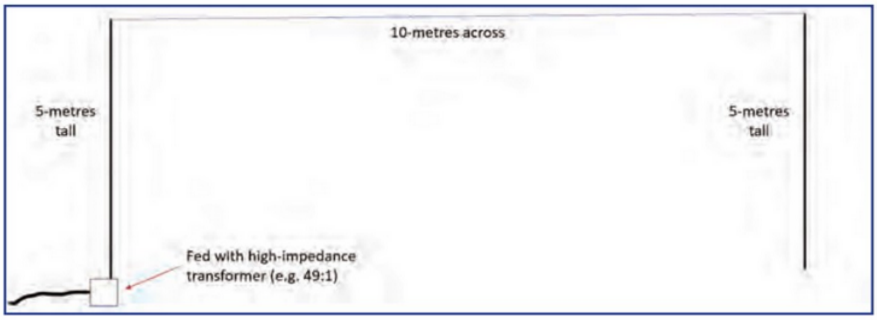


FIGURE 1: **The 'traditional' Half-Square configuration, voltage-fed with a high-impedance transformer at the base of either leg. This example provides us with four harmonically-related bands of operation (7MHz, 14MHz, 21MHz and 28MHz).**

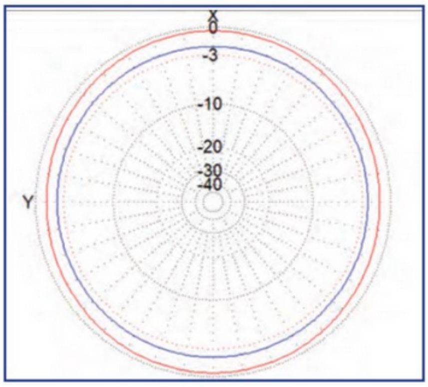


FIGURE 2: **A comparison between the Half-Square antenna (in blue) and a flat-top dipole at 5m above ground level (in red). The dipole has a slight advantage at the useful 70° take-off angle for short-hop contacts around the UK and Europe.**

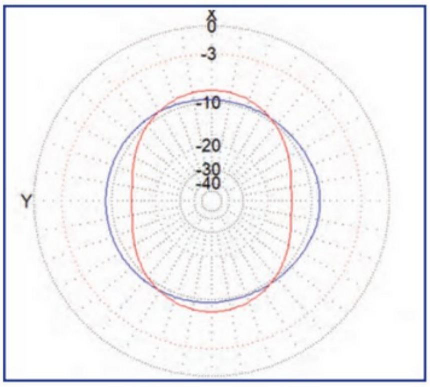


FIGURE 3: **A comparison of the azimuth pattern at 20° take-off angle at 7MHz. Note the greater gain of the Half-Square antenna (in blue) compared with the flat-top dipole (in red), at both the far ends of the antenna.**

This is in contrast with 'current fed', in which the feed-point impedance is low, typically 50Ω, so the current is 'high' and the voltage is 'low'. This month, we are going to examine the antenna against alternative low-height antennas, how we could alter its horizontal/vertical configuration, and whether the antenna could be made to cover even more bands. Again, we will be using antenna modelling software (MMANA-gal), along with the usual caveat that each installation has its own unique challenges and influences. Nevertheless, a base line can be uncovered by such a study. I must at this point also apologise for not having had the opportunity to operate this antenna in the past month (as promised in last month's related article). I aim to do this in the coming weeks.

Just as a quick recap, the Half-Square antenna is a full-wavelength of wire, with the traditional configuration being two vertical quarter-wavelength legs at either end, with a half-wave-long horizontal wire between them. On the full-wavelength frequency, as these two vertical radiators are being fed in phase by the top horizontal wire, the antenna provides good vertical polarisation.

You may also recall that we determined that, by feeding this antenna at the base of either leg, we have a situation where the antenna is now fed at a high-voltage and low-current point (ie is 'voltage-fed'), and by using a 49:1, 56:1 or 64:1 impedance transformer, we can allow the antenna to present a good match to 50Ω on not just the full-wavelength frequency, but also on its half-wave, one-and-a-half-wave and two-wavelength harmonically-related bands (**Figure 1**). Thus a 20m (66 feet) long antenna would provide us with a good match on 7MHz, 21MHz and 28MHz as well as its full-wavelength frequency of 14MHz.

Comparisons with other antennas at the same maximum height of 5m

Being fed at 30cm above ground level, and being just over 5m in height, this configuration of the Half-Square antenna is suited to locations which require a low-profile, low-height antenna. It would therefore be useful to compare its performance against other antennas which meet, but do not exceed, this stealth-like height.

Figure 2 shows a comparison at 7MHz of the azimuth pattern at a take-off angle (elevation) of 70° (useful for short-hop/inter-G QSOs) for the Half-Square antenna (in blue) with a flat-top horizontal dipole at 5m above ground level (shown in red). Both antennas deliver their greatest gain at higher take-off angles, and are more-or-less omni-directional in coverage at those higher take-off angles. At 70° elevation, the Half-Square antenna exhibits a gain of 6.5dBi broad-side on compared with the dipole's 8.2dBi, barely reducing to 6.2dBi off the vertical ends of the antenna compared to the dipole's 7.5dBi.

As the take-off angle reduces, so the flat-top dipole loses much of its omni-directional characteristic compared with the Half-Square antenna. At 20° take-off angle, the Half-Square antenna's gain is 1.6dB below that of the dipole in the broad-side direction, but has 5.3dB more gain than the dipole off the vertical ends of the antenna (see **Figure 3**). As we may expect, at 5° take-off angle, both antennas are weaker than a quarter-wave vertical antenna with a fair ground system of sixteen quarter-wave long ground radials on average soil conductivity. However, the Half-Square antenna exhibits improved gain off the ends peaking at -8.7dBi (a respectable 3dB down on a quarter-wave ground-mounted vertical antenna) compared with -14.1dBi for the flat-top dipole (it might be worth noting that -3dB represents half an S-point on your S meter).

The current patterns of these respective antennas (see **Figure 4**) reveal the reasons for this contrast. The Half-Square antenna generates a mixture of horizontal polarisation (shown in blue) and vertical polarisation (shown in red), the latter being radiated mostly from both 5m vertical

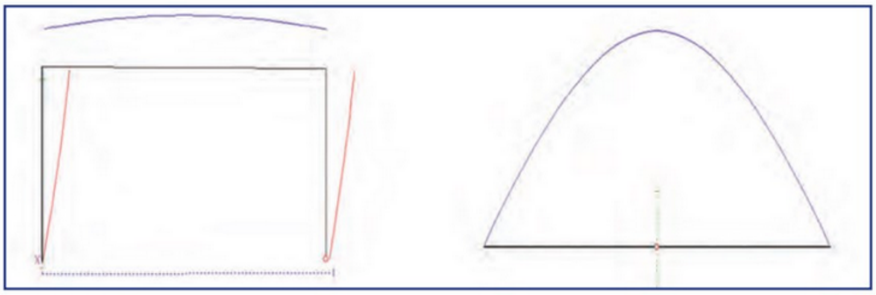


FIGURE 4: A comparison of the currents in the Half-Square antenna (left) and the flat-top dipole (right). Note the appearance of vertical polarisation (in red) for the Half-Square antenna, as well as horizontal (blue).

FIGURE 5: A slight increase in gain is apparent at higher take-off angles on 7MHz as the antenna height is lowered.

Configuration	90°peak gain (dBi)	70°peak gain (dBi)
5-10-5	6.8	6.5
4-12-4	7.5	7.2
3-14-3	8.1	7.7
2-16-2	8.7	8.3

elements. The dipole generates predominantly horizontal radiation, giving it the edge at higher take-off angles, but this diminishes as the take-off angle requirement lowers, when both the omni-directional nature of the radiation pattern, and the greater gain at lower take-off angles of vertical polarisation, begin to win through.

For the 14MHz to 28MHz bands, let's take as our benchmark the Half-Square antenna (for DX-chasing) using a 5° take-off angle. At 14MHz and 21MHz, we will compare it with both a ground-mounted quarter-wave antenna with 16 quarter-wave ground radials, and with a flat-top dipole again mounted at 5m above ground level.

At 14MHz, the Half-Square antenna has superior gain (-2.7dBi) broad-side on compared with the other two antennas, but does have appreciable nulls, especially in the direction of the side opposite that fed by the transformer, making it weaker than the vertical antenna in that direction. The ground-mounted quarter-wave antenna is, as we would expect, omni-directional in azimuth, with a gain of -5.9dBi at a take-off angle of 5°. The flat-top dipole, mounted as it is at a quarter of a wavelength above ground, has mediocre performance at this low take-off angle (-9.7dBi peak broad side on, with nulls of -18.2dBi off the ends).

At 21MHz, again at 5° take-off angle, peak gain for the Half-Square antenna radiates in the directions of the four corners of the antenna (between -3.3dBi and -4.3 dBi), and is only marginally below the gain (-5.9dBi) of the omni-directional ground-mounted quarter-wave antenna at its lowest point of gain on the side of the feed point. Polarisation of the Half-Square antenna is predominantly vertical on this band. The dipole, at 5m above ground level, is 3/8 of a wavelength high. Gain is better broad-side on (-7.2dBi) than it is off the ends (-18.9dBi), but is consistently lower at this take-off angle than that of the Half-Square antenna. It should be noted that it is possible, on this band, to elevate a quarter-wave vertical to be fed at around 1.3m above ground, and doing so may improve gain by around 0.5 dB.

Finally, at 28MHz, the Half-Square antenna has good lobes in various places around the antenna at 5° take-off angle. Peaks in gain are in the directions of the corners opposite the feed point (-2.0dBi). Rarely at any point in its azimuth pattern is the gain lower than the -5.9dBi of the omni-directional quarter-wave antenna. A half-wave ground-mounted vertical antenna for 28MHz is just 5m long, and has an omni-directional gain in azimuth of -5.1dBi at this low take-off angle, so is marginally better than the Half-Square antenna over some azimuths. The dipole for 28MHz mounted 5m above ground is a half-wave above ground level. Gain at 5° take-off angle is better as a result, with a maximum gain of -3.7dBi broad-side on, and deep nulls off the ends (-17.8dBi).

Varying the configuration: shorter vertical sections and a wider horizontal section

So, what if we change the configuration of the Half-Square antenna? Do we still call it a Half-Square antenna? Semantics aside, let us assume that there is the need to reduce the height of the antenna. Let's analyse the probable changes in the antenna's behaviour when altering the 5-10-5m (vertical-horizontal-vertical) configuration to 4-12-4m, 3-14-3m and 2-16-2m, and compare the results. The last configuration was considered in case of the need for a fence-high antenna.

At 7MHz, we can see that the peak gain of the Half Square antenna at our desired 70° take-off angle increases as the antenna's horizontal part gets lower (see **Figure 5**). These changes are far from dramatic, but are nonetheless apparent.

The 14MHz band is the band with the greatest changes in behaviour. At a 5° take-off angle, as the antenna is lowered and the horizontal part becomes longer in proportion to the vertical sides, the main lobes change from being broad-side on to the antenna as seen in the usual 5-10-5 configuration, to become predominant off the ends of the antenna (**Figure 6**). The peak broad-side gain reduces as the antenna is lowered from -2.7dBi (at 5m) to -3.5dBi, -6.5dBi and -10.9dBi respectively for 4m, 3m, and 2m height of the horizontal section. In contrast, the end-lobes increase from -13dBi to -11.0dBi, -6.8dBi, and -4.6dBi respectively. Vertical polarisation is still dominant, even when the horizontal part is at 2m above ground level, although horizontal polarisation does increase slightly as the antenna is lowered in height. Overall peak gain at 5° take-off angle is around 2dB lower at a height of 2m. Peak gain is at higher take-off angles as we lower the antenna's height (**Figure 7**).

At 21MHz, again at a 5° take-off angle, as the horizontal part of the antenna gets lower, the overall azimuth pattern changes so that peak lobes gradually move away from the directions of the four opposing corners and surround the antenna to its ends. Horizontal polarisation does increase too, but is still the junior partner compared with the vertical polarisation. As on 14MHz, the angle of peak overall gain increases as the antenna is lowered.

At 28MHz, at a 5° take-off angle, given that even when the horizontal portion is 2m above ground level, the end vertical sections are still

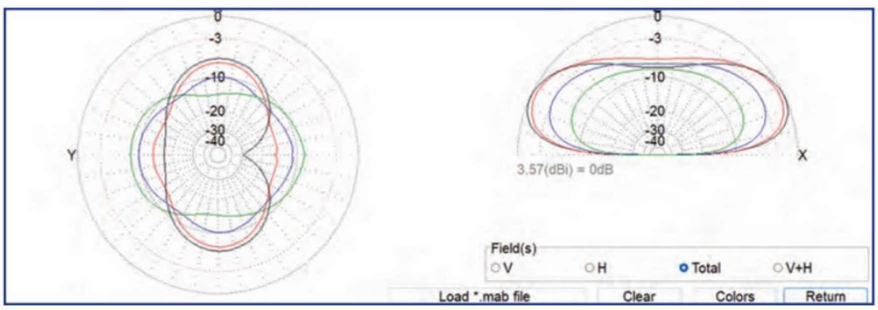


FIGURE 6: Key: black 5-10-5; red 4-12-4; blue 3-14-3; green 2-16-2. Note how the main lobes change as the antenna gets lower.

Tim Hier, G5TM
timhier@icloud.com

FIGURE 7: On 14MHz, the peak gain increases as we reduce the height of the antenna.

Configuration	Take-off angle of peak gain (°)
5-10-5	24.7
4-12-4	26.5
3-14-3	29.7
2-16-2	36.6

FIGURE 8: Table showing how the height:length ratio changes the gain on the 40m band. Figures in red denote that gain is mostly through vertical polarisation. Figures in blue denote that horizontal polarisation is prevalent.

Configuration	70°peak gain (dBi)	5°peak gain (dBi)
7-6-7	5.3	-7.6
6-8-6	5.9	-8.0
5-10-5	6.5	-8.4
4-12-4	7.2	-8.9
3-14-3	7.7	-8.6
2-16-2	8.3	-7.3

FIGURE 9: Table showing peak gain at a take-off angle of 5°per configuration for 14MHz, 21MHz and 28MHz.

Configuration	Peak gain (dBi) 14MHz	Peak gain (dBi) 21MHz	Peak gain (dBi) 28MHz
7-6-7	-4.2	-2.2	-3.8
6-8-6	-3.4	-3.1	-2.5
5-10-5	-2.7	-3.3	-2.0
4-12-4	-3.5	-3.1	-3.0
3-14-3	-6.3	-2.6	-2.0
2-16-2	-4.6	-4.3	-1.3

almost a quarter-wavelength long. In addition, the take-off angle of the main lobe remains very similar to when the antenna is 5m high, (28.7° at 2m above ground level compared with 20.6° at 5m). Horizontal polarisation increases slightly at lower height, but is again weaker than vertical polarisation.

Varying the configuration: shorter horizontal section and longer vertical sections

On 7MHz, if we lengthen the vertical sides and thereby reduce the horizontal portion of the antenna, we begin to see some noticeable changes. **Figure 8** shows that, as we do this, we see a reduction in horizontal-polarisation gain at higher angles (in this case at 70°), culminating with a 7-6-7m configuration, where vertical-polarisation gain becomes greater than horizontal. We also see a slightly more omni-directional pattern as the antenna height increases in relation to horizontal, with the slight difference in gain between broadside and end-antenna gain almost entirely cancelled.

On 14MHz, 21MHz, and 28MHz, vertical polarisation is usually predominant for all configurations, as is shown in the table at **Figure 9**, but horizontal polarisation also contributes almost as much in some cases. You may well notice that some of the figures in this table are coloured in blue or red. Blue denotes when we have the two vertical lengths corresponding closely to a pair of quarter-wave verticals; red denotes the same for two vertical lengths which correspond closely (or closest) to a half-wave. Looking at this table, on 14MHz the 5-10-5 (traditional Half-Square antenna) configuration sees two quarter-waves in phase, and this is a large factor in the higher gain at 5° take-off angle on that band. Similarly, we see this to be nearly the case for 21MHz where both the 4-12-4 and 3-14-3 configurations straddle either side of a quarter-wave antenna for 15m. At 28MHz we see a similar behaviour for the 3-14-3 and 2-16-2 configurations.

Additionally, for 21MHz the 7-6-7 configuration sees a pair of half-wave verticals (or close to it) producing the highest gain. Here, the 7-6-7 set-up allows for good vertical polarisation, but also some useful horizontal polarisation as the horizontal part of this configuration, despite being a fraction short of a half-wave long at 6m, is at a height of a fraction over a half-wavelength from the ground, and thereby produces additional gain.

Useful low-angle gain is available on 28MHz using the 5-10-5 configuration with two vertical half-wave sides. Here, the antenna produces a current maximum along the two vertical sides as per a half-wave and two further current maxima, each at a 25% point along the top of the horizontal part.

The multi-band non-resonant Half-Square antenna

In contrast with the 20m long end-fed Half-Square antenna, three popularly-used non-resonant lengths (17.7m, 16.2m and 12.5m) in an end-fed Half-Square antenna shape require the use of an UNUN and an ATU. This is likely to incur some extra losses. A well-designed end-fed transformer, which would be used with the 20m-long Half-Square antenna, would incur a loss of around 1.5dB at most across all four bands. For an average overall system loss, it would be useful to add a further 1.5 to 2.0dB to the feed-line loss figure to take into account potential further losses in the ATU and any UNUN used. For any non-resonant versions, a feed-line length of 13m will be modelled, along with the choice of RG-213 coaxial cable. It is also supposed that any ATU would be used at the shack-end of the coaxial cable, rather than at, or near the feed point. The antenna configuration will revert to our original 25%-50%-25% arrangement.

At 7MHz, as the Half-Square antenna moves below a 3/8th wave in overall length, it shows reduced gain compared with the half-wavelength, and places strain on the feed-line in terms of the VSWR. The 12.5m long Half-Square antenna has a VSWR at the feed point of 466:1, and a modelled feed-line loss of 6.4dB. Gain at a 70° take-off angle is around 3.2dB down on the 20m long version, and slightly less uniform in its omni-directional gain pattern.

At 14MHz, when the antenna is shrunk to a 12.5m version, the gain at 5° take-off angle reduces from the peak gain of -2.7dBi of the 20m long version to -8.8dBi. Gain is still highest broadside on for all these versions. When we consider the two longer non-resonant versions, gain is much closer to the 20m long antenna, and we have a much higher VSWR at the feed-point (53:1 and 58:1 respectively). Overall system/feed-line loss is estimated at 4dB for these two longer non-resonant lengths.

At 21MHz, the VSWR at the load varies between 14:1 and 30:1 for the three non-resonant lengths. Feed-line/system loss averages 3dB. Despite this, peak gain at 5° take-off angle is similar at the 12.5m length, because this shorter length is closer to a full wavelength so that gain and far-field patterns are close to those at 14MHz in the 20m long version.

At 28MHz, the main challenge is to get a good match to 50Ω. The 17.7m and 12.5m versions have VSWRs of 16:1 and 20:1 respectively. However, the 17.7m version has a higher peak gain at a 5° take-off angle than the 20m long traditional version. The azimuth pattern is similar to that of the 20m long version.

Conclusions

Next month, I will conclude my look at the Half-Square antenna by installing one at home and testing it out on SSB and (I hope) also on WSPR. The installation configuration will include some of the lessons of this month's look at the antenna, and I am eager to see how it performs.

Review

AnyTone Ares II

PHOTO 1: **Front panel view of the Ares II.**

PHOTO 2: **Rear panel view of the Ares II.**

We are well into solar cycle 25 and there has been some spectacular DX on the 10m band. So, naturally, many radio amateurs are turning their attention to this band to see if they too can work the world, as others have done before.

There are many attractions to mono-band rigs, which include simplicity, lower chance of breakdown, increased portability, and so forth. The down-side is that a mono-band rig confines you to a single band, and if this is 'dead' you have a problem, and when solar-cycle 25 fades, you will have a rig that gathers dust until solar-cycle 26 starts up. Many of you may know that I like QRP operating and making my own equipment, but the construction of a simple QRP portable transceiver for the 10m band demands more-precise construction practices and attention to detail than for a rig designed for, say, the 80 or 40m bands. I was therefore very excited when I heard about the AnyTone Ares II 10m transceiver and was eager to test it.

The rig

On opening the box, I was quite surprised by the size of the transceiver; it was much larger than I had expected for a single-band rig. It measures 287 x 200 x 61mm, and is thus larger than some multi-band transceivers, such as the Yaesu FT-891 or Xiegu G-90. It weighs 1.5kg and has a front panel with plastic chromium-effect knobs. There is a moving-coil S meter which also serves as a power indicator on transmit (**Photo 1**). On the rear panel is a SO 239 socket, a power socket, a PC programming port, external PA jack, an external speaker jack, and a large heat sink for the power transistors (**Photo 2**).

The rig comes with a four-pin press-to-talk microphone with channel-up and channel-down buttons, a power lead with spare fuses, and a mounting kit that includes a microphone hanger. There is a quick-start guide as well as a QR-code link to download the full instruction manual, which is the first thing I did after placing the rig on my bench and connecting it to 13.8V supply.

My initial impression was that of a radio that was a throw-back to the height of the CB era of the 1980s or 1990s. It reminded me of going to a friend's house in East London and working a trucker crossing the Nullarbor Plain in Australia using a CB radio not dissimilar in appearance to the Ares II. Given the detailed instructions about mounting it in a vehicle, I formed the view that the manufacturers (Qixiang Electron Science & Technology Company) had envisaged it as a radio primarily for mobile operation. The Ares II can operate using USB, LSB, AM and FM. It undoubtedly also has a number of CB features, such as an ECHO function and a forty-position rotary switch to select channels which is below the two-digit display.

Whilst it might sound complicated, selection of the 360 available channels is reasonably straightforward, but it is a three-stage process. Firstly, go to the three-position *band switch* which allows selection of low and high channels within the 10m band. It also allows selection of the weather channels.

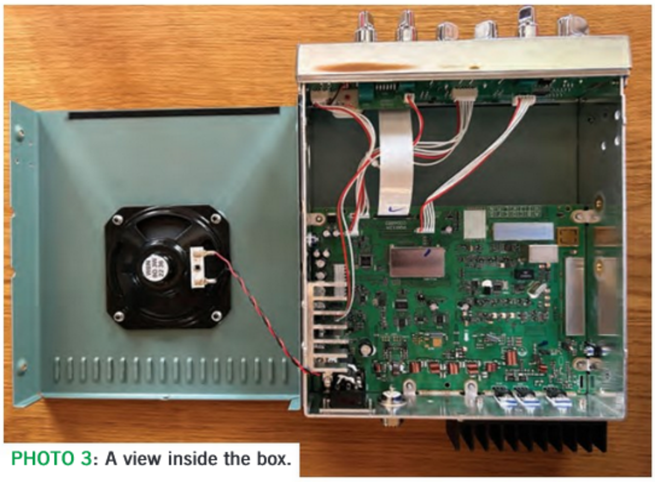


PHOTO 3: **A view inside the box.**

Having selected, for example, the *low* setting, you must then choose a block of 40 channels using a six-position rotary switch which groups the channels between A and F. Having done this, the 40 x 5kHz channels available within say group C, is selected using the 40-position rotary switch below the display; position 1 is the lowest frequency and position 40, the highest. In the *high* band position only three groups of 40 channels (A to C) are available, to ensure that you do not go out of band. Confused? As with all things, it is easy to get the hang of it within a few minutes.

Inside the box was a well-constructed PCB but, as can be seen from **Photo 3**, there is a lot of empty space which suggests to me that the rig *could* have been made smaller and more compact.

In operation

I switched on the rig, and immediately noticed that there was no digital frequency meter to indicate the frequency. The two-digit display on the right of the front panel merely indicates the channel or serves as a *function menu.* This displays 12 functions such as 'beep', 'roger beep', 'vox level', 'VSWR level', and so forth. It can also display five error codes of which the most important seems to be *'E5',* which means that the VSWR is too high. The speaker is situated on the underside of the rig, and as I was using it on the bench, I had to prop it up on a book, so that the audio was not muffled. The receiver appeared to be sensitive, and on transmit the power output measured on my meter on FM was in the region of 20W (**Photo 4**).

I constructed an *Excel* spread sheet (**Photo 5**) to show the relationship between frequency and channel number. I also employed an RF sniffer and cheap digital-frequency meter (**Photo 6**) to check the accuracy of the transmitted frequency. In addition, I checked the frequency using my accurately-calibrated communications receiver.

I connected the transceiver to my *Ciro* magnetic-loop antenna, as with this

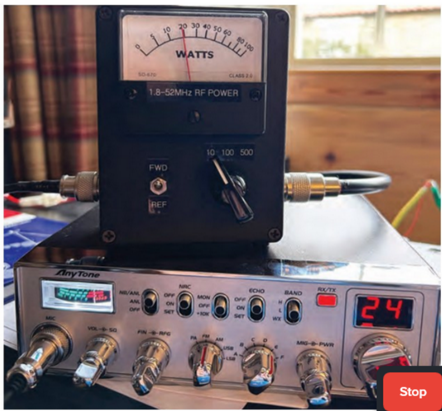
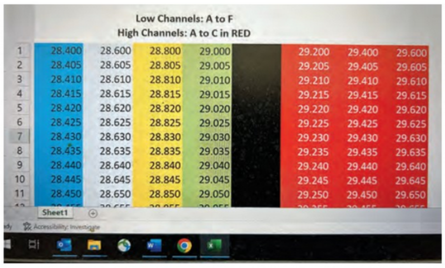


PHOTO 4: Measuring the power output.



Low Channels: A to F
High Channels: A to C in RED

1	28.400	28.600	28.800	29.000		29.200	29.400	29.600
2	28.405	28.605	28.805	29.005		29.205	29.405	29.605
3	28.410	28.610	28.810	29.010		29.210	29.410	29.610
4	28.415	28.615	28.815	29.015		29.215	29.415	29.615
5	28.420	28.620	28.820	29.020		29.220	29.420	29.620
6	28.425	28.625	28.825	29.025		29.225	29.425	29.625
7	28.430	28.630	28.830	29.030		29.230	29.430	29.630
8	28.435	28.635	28.835	29.035		29.235	29.435	29.635
9	28.440	28.640	28.840	29.040		29.240	29.440	29.640
10	28.445	28.645	28.845	29.045		29.245	29.445	29.645
11	28.450	28.650	28.850	29.050		29.250	29.450	29.650

Sheet1

PHOTO 5: The relationship between channel number and frequency.

Review


PHOTO 4: Measuring the power output.

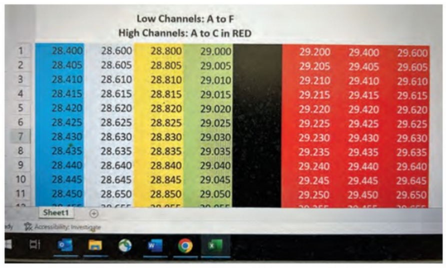


PHOTO 5: The relationship between channel number and frequency.

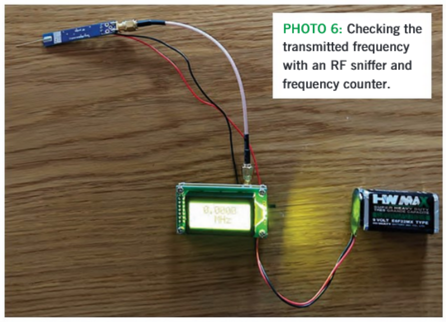


PHOTO 6: Checking the transmitted frequency with an RF sniffer and frequency counter.

I could achieve a good match without risking damage to the output stage. I first selected channel 5, *low*, on bank A and heard a station in Cyprus on CW coming though at 559. Unfortunately, I was unable to reply as there was no facility to connect a key to the transceiver, either straight or paddle. For the avoidance of doubt, although this is a 'multi-mode' device, using CW is not possible. I then decided to see if I could resolve any digital signals on 28.074MHz, and using an app on my phone was able to resolve stations operating using FT8 by placing my phone next to the rig's speaker. There is no dedicated socket to connect the rig to a computer for digital modes, but I dare say, if I actually owned the transceiver, I could have found a way to transmit and receive FT8 and other digital-mode signals.

The receiver is sensitive; the manufacturer claims a sensitivity of 0.25μV for a 10dB S+N/N ratio (giving more than 0.5W of audio output), and 1.0μV for AM and FM at ratios of 10dB and 20dB respectively. Selectivity is quoted for SSB as 6dB at 3kHz and 50dB at 9kHz, with image rejection at greater than 65dB.

I tuned to the SSB part of the band and worked Danish, German, Swedish and Romanian stations. The audio was described as being clear when I asked for critical reports. There is a very good fine-tuning control which works on SSB and, for FM and AM, an effective squelch control. I did not make any contacts using AM, but I arranged a QSO with a local colleague to whom I had lent my Yaesu FT-8900R; the audio was again described as good, with no tendency towards over-deviation.

Further information

The instruction manual could be described as 'less than comprehensive', so I decided to watch three YouTube videos about setting up and using this radio. All three extolled its virtues and how it transported the user back to the classic days of CB, and how the 'retro' look was appealing. Curiously enough, the July 2023 edition of *Practical Wireless* contained an article by Tony Jones, G7ETW, entitled *10m on a CB* in which he described how he had modified a *Midland Alan 78 plus* CB rig for 10m band operation, but encountered the same issues about channel selection as I have found with the Ares II.

Overall impression

This SSB multi-mode transceiver will undoubtedly allow anyone to get onto the 10m band and participate in the good DX associated with solar-cycle 25. The main disadvantage of it, however, is that there is no frequency counter to indicate the radio's frequency. Quite why the manufacturers omitted this is not clear to me, but perhaps, as the videos might suggest, they wanted to create a 'retro' look that would appeal to CB operators of yesteryear. I am certainly not belittling or impugning CB enthusiasts. As we all know, many radio amateurs came into the hobby via CB. However, I found myself asking whether this radio was really worth the money, especially as multi-band rigs for similar and lower prices are to be found on eBay. Clearly, Moonraker must have appreciated this major deficiency, and in their advertisement for the rig, offer (at additional cost) an 8-digit RF-sensing frequency counter to measure the transmitted frequency.

It is a pity that the manufacturer did not use what is a very good transmitter and receiver board to make a smaller, portable rig with a proper continuous tuning dial and digital frequency meter, perhaps not only covering the 10m band but also the 12m band.

I have had the privilege of reviewing many pieces of equipment for *RadCom*, some of which impressed me so much that I bought them for myself. Sadly, this transceiver is not for me.

The Ares II can be obtained from Moonraker (UK) Ltd, Unit 12, Cranfield Road Units, Woburn Sands, Milton Keynes, Buckinghamshire, MK17 8UR or at https://moonrakeronline.com. It costs £179.95 and the 8-digit RF sensing counter can be purchased separately from Moonraker at a cost of £99.95. I am grateful to Moonraker for the loan of the rig.

Paul Marks, G8FVK
pmarks4550@aol.com

An introduction to the Node-RED visual programming language, part 2

FIGURE 1: Illustration of Node-RED dashboard layouts.

In this second part of my introduction to Node-RED, I'll look at the Node-RED Dashboard and show how it can become the command centre for your projects. As in the previous article, I'll include plenty of practical examples, and complete flows will be available to download from the Node-RED site.

So far, we've looked at how to achieve simple tasks such as controlling a relay or mains plug. However, we need a more usable visual interface for practical applications to control and monitor our projects. The Node-RED Dashboard provides that functionality. You install the Dashboard like any other add-on node via the Manage Palette menu. Here's a step-by-step guide:

1. Go to the burger menu at the top right (three horizontal bars) and select Manage Palette
2. Click the Install tab and enter Dashboard in the search box
3. You will see lots of results, but the one you want is called: node-red-dashboard
4. Click Install to add the Dashboard, and click Install again on the pop-up
5. You should see a new Dashboard section in the nodes list on the left of the Node-RED screen

Dashboard introduction

The Dashboard provides a highly-configurable, browser-based interface to your Node-RED projects. When created, you can access it from any device connected to your local network, including smartphones. Access can also be extended to the wider internet, though you should take a few security precautions before taking that step. The Dashboard uses widgets to provide the functional elements to keep the programming simple. For example, there are buttons, gauges, dropdown menus, and many other common elements that you can drag onto your dashboard flow. Again, to simplify configuration, the Dashboard uses a grid system to lay out the widgets and a group system to keep associated widgets together. The layout can be further extended by adding Tabs that contain a selection of groups. I've shown a dummy application in **Figure 1**, with several widgets organised into three groups.

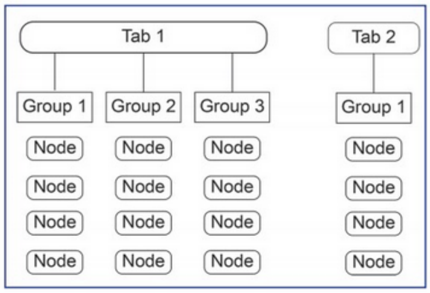


FIGURE 2: Node-RED dashboard Hierarchy.

The tab index in the top left provides access to other pages (called tabs in Node-RED). In **Figure 2**, I've illustrated the hierarchical organisation of the Node-RED dashboard. From this, you can see that building quite complex control systems is possible simply by dragging widgets onto your flow and placing them in the appropriate groups and tabs. For more detailed layout adjustment, a layout editor tool lets you change the size and position of your widgets within each Group to create a custom layout. As with most Node-RED features, it is possible to build a complete web application without writing any code. It's this feature that makes Node-RED ideal for developing custom amateur applications. I do hope you can see the potential. To help you see the Dashboard in action, I'll describe some simple applications in detail. These will all be available for download and are free to be used as the basis for larger projects.

Kasa mains plug control panel

For the first example, I'll build a control panel for the Kasa mains plug we covered last month. On the Dashboard, we'll include on/off buttons and gauges to display the mains voltage, current and a power consumption chart. Although this example is specific to the Kasa plug, most of the tools and techniques we'll be using can be applied to other nodes.

The first step is to install the TP-Link Kasa node using Manage Palette – Install from the Node-RED menu (top right 3 horizontal bars). The full node name is: node-red-contrib-tplink. Once installed, double-click the node, add your plug's IP address, and change the Output Payload to getQuickInfo. When you click Deploy, you should see a message beneath the node confirming that the plug is connected (**Figure 3**).

We can start building our control panel on the Dashboard now the plug is successfully installed. **Figure 4** shows the completed flow. The first thing we need is a couple of buttons that we can use to turn the plug on and off. Here's how to add these:

1. Go to the dashboard nodes on the left and drag two button nodes onto the flow.
2. Wire the right-hand side of each button to the left-hand side of the Kasa node.

FIGURE 3: The Kasa plug node showing the connect message.

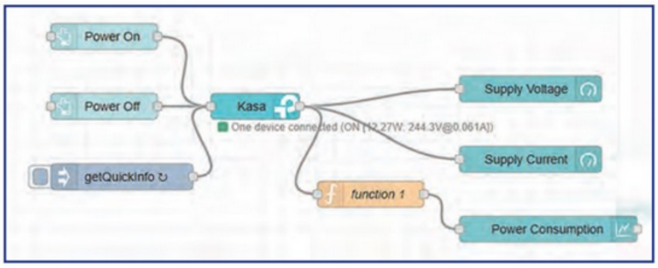


FIGURE 4: **The complete flow for the Kasa plug.**

3. Double-click on the first button to open the config panel.
4. The first step is to add a Group for your controls.
5. Click on the pencil icon next to Group to open the Group config panel
6. Enter the name of your Group, eg Kasa Plug 1
7. Next, click the pencil by the Tab field and leave the name set as Home and click Add
8. You will return to the Button config panel
9. Here you should change the Label to Power On
10. In the Payload section, choose Boolean and True. You can ignore the topic field
11. Click Done to save the configuration.

The second button is easier to configure as the Group and Tab will be preselected, but you should change the name to Power Off and set the Boolean payload to False. Click Done to complete and then Deploy to activate your Dashboard. You can now view your handiwork by adding /ui to the end of your Node-RED URL. For example, I have a Pi running Node-RED whose IP address is: 192.168.1.237:1880. To access the Dashboard, I add ui like so:

192.168.1.237:1880/ui

At this point, make sure you can operate the plug using the on-screen buttons.

Accessing the measurements

In addition to providing remote switching, the Kasa plug supplies a host of measurements that we can display on our Dashboard. I will use the mains voltage, current consumption, and power usage for this exercise. The voltage and current will be displayed using gauges, but the power usage will be displayed on a graph to show how it changes over time. The first task is to find out how to extract the information from the Kasa plug. A quick read of the help file reveals that sending the payload getQuickInfo to the plug will trigger a reply with all we need. If you remember, we set the output payload during the Kasa node setup to getQuickInfo. That results in a message back from the plug every time it operates. The message format is JSON as used by most Node-RED nodes.

However, we need to feed specific parts of the message to the gauges and chart. To do that, we first need to see the complete message. This is easily done using a Debug node, so drag a Debug node onto the flow and connect its input to the right-hand side of the Kasa node. Hit Deploy to activate it and operate a button to switch the plug. You should see a message in the Debug panel if all is well. This message is packed with information, and the Debug node is an excellent tool for revealing and navigating these messages. If you look carefully at the message, you will see a small arrow. This arrow is used to reveal the next layer of the message. You can continue clicking arrows to expand the message further. For this example, the measurements are all contained in the emeter/realtime section of the message. If you expand the message to this level, you should see an output similar to **Figure 5**.

As you can see, the voltage, current and power are the first three results. The question now is how to extract a small part of the message to send it to a gauge. This is where the Debug node is so useful. If you hover your mouse over the target measurement, a small pop-up with three options will appear on the right (**Figure 5**). The first lets you copy the path to the message to your clipboard. Once we know the path to the message, we can paste that into the gauge so it sees only that part of the message. Here's a step-by-step guide for setting up one of the gauges:

FIGURE 5: **Expanded JSON message from the Kasa plug.**

1. Use the Debug node to navigate the Kasa plug message to voltage and use the pop-up to copy the path to the clipboard.
2. Drag a Dashboard gauge onto your flow and wire it to the output of the Kasa plug.
3. Double-click the gauge to open the config panel.
4. Select the Kasa Plug 1 Group we setup previously.
5. Set the Type to Gauge, Label to Mains Voltage and units to Volts.
6. We put our path to the JSON message in the field marked Value format.
7. Replace value in the curly brackets with the path on the clipboard. It should look like this: {{payload.emeter.realtime.voltage}}
8. Next, add msg. just before payload so it looks like this: {{msg.payload.emeter.realtime.voltage}}
9. Set the range to 220 min and 270 max.
10. Click Done and Deploy.

Repeat this operation to add a current gauge and make the units Amps and the range 0 to 15.

Using a Node-RED chart

Begin by dragging a Dasboard Chart node onto the flow, next to the gauges. Getting data to the Dashboard Chart requires some work as we can't add the message path to the Chart node as we did with the gauges. This is where we must add a tiny bit of JavaScript. The requirement here is to extract the Power reading from the JSON message and send the result to the chart as a new, simpler, JSON message containing just a topic (Power) and a payload, which is the measurement. To do this drag a Function node onto the flow and wire it between the Kasa plug and the Chart. Function nodes are handy for reconfiguring messages as they provide a simple way to add JavaScript to your flow. Here's how to extract the power reading:

1. Double-click to open the Function node
2. Change the name to Extract Power
3. Click the 'On Message' tab and enter the following code:
4. msg = {topic : "Power", payload : msg.payload.emeter.realtime.power} ;
5. return msg ;
6. Click Done to save
7. Now you can configure the Chart node as follows:
8. Change the Label to Power.
9. Set the type to Line chart.
10. Set the X axis to 1 hour.
11. Set the Y axis to a Min of 0 and a Max of 3000
12. Click Done to save followed by Deploy to activate.

That completes the basic configuration and you should see the readings update every time you operate the plug. However, we must refine several elements to create a more useful dashboard.

Mike Richards, G4WNC
ptamike@hotmail.com

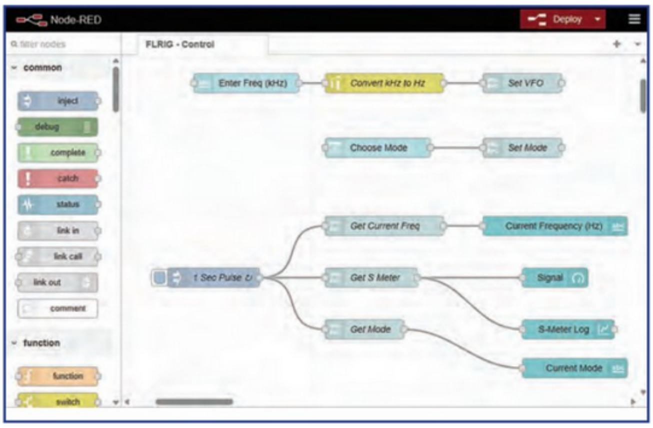


FIGURE 6: **FLRIG Node-RED flow.**

Refining the Dashboard

Our Dashboard gauges show readings to six decimal places, which is a bit silly, so we need to change that. We can do this by adding a tiny JavaScript function to the end of the message. Here's an example of the change to the Mains Voltage gauge:

{{msg.payload.emeter.realtime.voltage.toFixed(1)}}

You will see that I've added .toFixed(1) to the end of the message line. This restricts the message to one decimal place. For a different resolution, change the number in brackets. This technique works wherever we extract information from a JSON message, including the Function node we used to supply the chart.

The next improvement is to get regular updates. The Dashboard currently only updates the meters when the plug switches on or off. To get regular updates, we can add an Inject node as follows:

1. Drag an Inject node onto the flow and wire it to the left-hand side of the Kasa plug
2. Double-click the node to open the config panel
3. Change the name to 1 Second Update
4. Change msg.payload to a string with getQuickInfo as the message
5. At the bottom of the panel set Repeat to Interval and the period to every 1 second
6. Click Done followed by Deploy

You should now see the Dashboard meters updating every second.

You can also tinker with the Dashboard layout using the down-arrow in the top right of Node-RED and choosing Dashboard. Here you can change the order of nodes and change the layout.

That's as far as I'm taking the Kasa example. You can download the full flow from the Node-RED website (flows.nodered.org). Select the Flows menu and search for G4WNC to see my flows. This example is called G4WNC – Kasa Mains Plug Dashboard and you'll see that I've tidied-up the layout.

Rig control with Node-RED

For this example, I'll use FLRIG (version 2.0.01) to manage the link to the rig. I've chosen this software because it's freely available, regularly updated and works with various popular rigs. As we've already spent a lot of time on adding and configuring nodes, I'll concentrate on the specifics of the rig control nodes here. I have also provided the complete flow for download on the Node-RED site. This flow is called G4WNC – FLRIG Control (**Figure 6**). You might find installing that flow and referring to it helpful whilst reading this article. Before using this node, you must configure FLRIG to work with your rig. In addition to the basic CAT control, FLRIG also provides an XML-RPC server that can be used by other software to access your rig. XML-RPC is a messaging format, so we need to convert it to JSON to use it with Node-RED. Fortunately, a generous soul has already done the work and provided a suitable node that we can install. The node is called node-red-contrib-xmlrpc and can be found and installed via the Manage Palette menu. This will install several xmlrpc nodes, but we will use the xmlrpc call node that you'll find in the Functions section. My flow uses separate xmlrpc call nodes for each command, so you will see that Set VFO, Set Mode, Get Current Frequency, Get S Meter and Get Mode are all xmlrpc nodes. You must configure one of the xmlrpc nodes to use this flow with your rig. It doesn't matter which one; they all refer to the same configuration file. Make sure your rig is powered up and FLRIG is working before proceeding. Here are the configuration steps:

1. Double-click on an xmlrpc node to open the config panel
2. In the XML-RPC Client box click the pencil icon to open the configuration
3. Leave the name as Rig Controls but set the Host to the IP address of the machine running FLRIG
4. Set the port to 12345 and path to /
5. Click Update followed by Deploy to finish.

You should be able to open the Dashboard and control your rig!

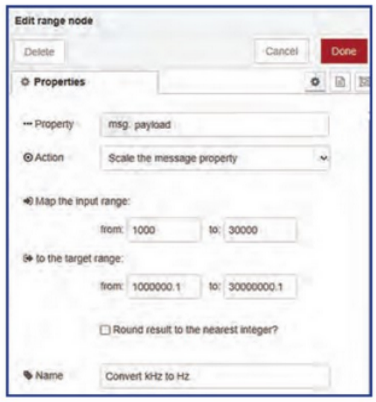


FIGURE 7: **Configuring the Range flow to scale from kHz to Hz.**

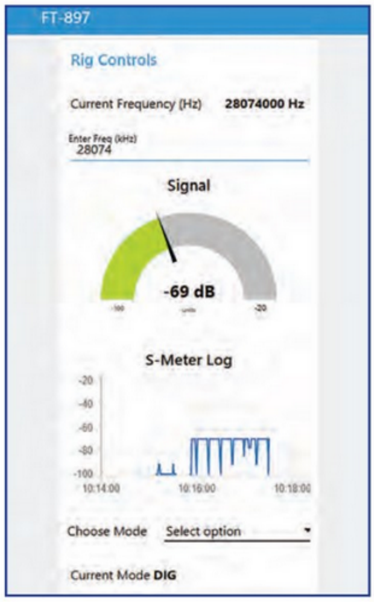


FIGURE 8: **The FLRIG Node-RED dashboard.**

Rig control notes

The FLRIG Set VFO command requires the frequency data in Hz, which is a bit tedious to type, so I've added a Range node between the text entry node and set VFO. If you look at its configuration panel (**Figure 7**), you will see it scales the input values by 1000. That means we can enter frequency in kHz, and it will be automatically scaled to Hz. The addition of the 0.1 is to compensate for an oddity in either FLRIG or the xmlrpc node and their number formats. Finding this oddity took me a while, but it solved the problem! The other new node I've used is the Dropdown node for Mode selection. This is a useful way to restrict user input to legitimate choices. I've shown the complete dashboard in **Figure 8**.

Summary

That concludes this two-part introduction to Node-RED and I hope you can see that it is an extremely versatile and easy-to-use programming tool. As more radio amateurs adopt the system, there will be an increasing number of radio-specific flows and nodes being shared via the Node-RED site. I will continue to share my flows and may provide a future article to look at some of the more advanced features, such as processing live information from the internet. If you've found this series helpful, please let me know, as it will encourage me to write more articles!

You can watch a recording of Mike's RSGB Tonight@8 presentation on Node-RED via the RSGB's YouTube channel:
youtube.com/theRSGB* – *Ed

A remote tuning unit for a cubical-quad antenna

Introduction

Over the years since I got my licence in 1961, I have built a couple of cubical-quad antennas, both of which were easily accessible to allow the stub to be tuned. Recently, I have constructed a 10m version to take advantage of improving band conditions.My new antenna sits on a P60 Versatower, and is impossible to reach by any means available to me. I remembered seeing many years ago a motorised-stub tuner in a magazine, so I decided to put some thought into making one. This would only be in place temporarily to find the correct length of the tuning stub, so it would not need to be weatherproof. After several attempts, I came up with the design described here (see **Figure 1**). Luckily, I have a small workshop, and a store of useful bits and pieces.

The entire project is made from what I had available in my house, but all the parts are readily obtainable on the internet (see **Figure 2**). The drive motor is a 24V geared unit, which works with a 9V battery. The pulley came with the motor, but Meccano pulleys are plentiful at reasonable cost. The drive cord and idler pulley are salvaged from a garage-door bolt kit, and the micro switches are standard V3-style ones, again easily available from the internet. I used some 8mm brass rod from my bits box for the tuning-stub rods, but standard copper water pipe would do fine as it's not critical.

The design of the moving shorting-bar proved a little more difficult, as smooth travel was needed. I settled on a piece of thin brass strip, 25mm wide by about 0.5mm thick, which formed easily into shape over the rods, moved nicely, and made good contact with the bars. Two pieces of 8mm copper tube were soldered to its top surface, and a wooden peg was inserted through them to clamp on to the drive cord. This peg also pushed the bar downwards onto the brass rods to make a good contact. I first tried a rubber belt in place of the drive cord, but it juddered when moving, so I replaced the belt with a cord and tensioning spring, and that solved the problem.

My original plan was to use a garage-door opening transmitter and receiver, but realising that I would need an indication of the up and down position of the shorting bar, I decided to go for a simpler wired control version. A red LED on the controller unit indicates when the slider has reached the top position, and a green one the lower. The LEDs are operated by the upper- and lower-limit switches. I used some multi-core 0.5mm cable left over from my beam-rotator installation to connect the tuner to the control unit.

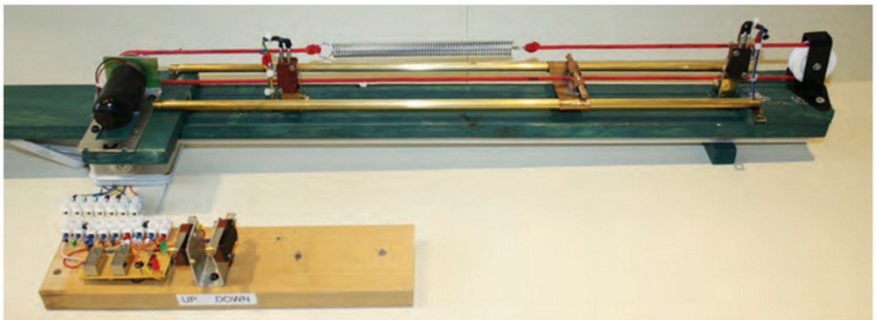


FIGURE 1: **The cubical-quad antenna tuner (background) and the controller (foreground).**

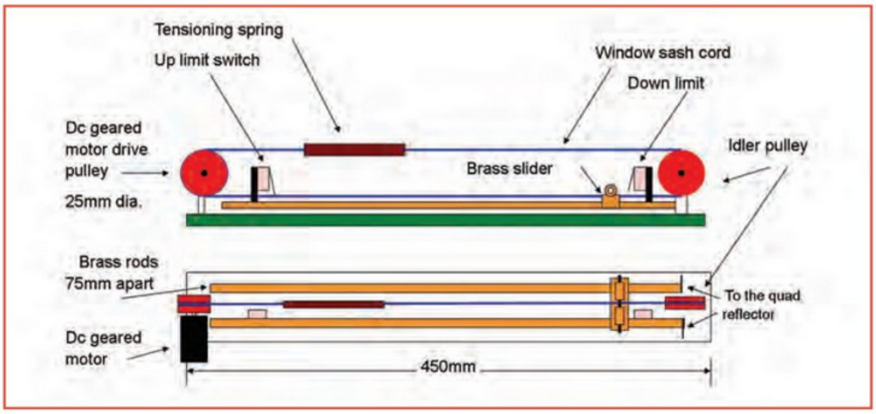


FIGURE 2: **Schematic diagrams of the side and top views of the tuner. The slider travels a maximum distance of 350mm between the top and bottom limit switches.**

The control unit

The remote control unit is shown in the foreground of Figure 1 and it uses two miniature double-pole relays with 9V DC coils; these are standard units available cheaply on eBay. I opted for V3-style micro switches to operate the relays as they gave precise control of the motor. The whole assembly is made on a small piece of Veroboard, and as the tuner would only be used once, I mounted everything on a wooden base. Seven cores of the multi-core cable connect the controller to the tuner control unit. The tuner itself is mounted on the wooden antenna support post (see **Figure 3**). It acts as a variable stub between the wires of the reflector element of the antenna.

The circuit diagram of the whole system is shown in **Figure 4**. The tuner could also be operated with a double-pole centre-off changeover switch.

Construction notes

The operating length of the slider is 350mm, and the total length of the slider rods to the motor end is 450mm. The rods are fastened to the wooden base by brass "P" clips. At the bottom end, each clip also secures the connecting wires for the antenna. The limit switches are operated by the slider bar to halt it at the top and bottom ends of the rods. Red and green LEDs show when these positions are reached.

FIGURE 3: A view of the tuner mounted on the wooden support frame of the antenna.

Motor

The motor is a geared unit rated at 24V DC, but operates easily at 9V. The drive pulley is 30mm in diameter, and revolves at 12rpm. The knots on the drive cord are super-glued for strength. The interconnecting wiring is routed under the base in 16mm PVC adhesive electrical trunking, and terminates in a connection box under the motor. Cable numbering makes things a lot easier! The slider bar must make good contact with the tuning rods at all times. Use switch-contact cleaner to help reduce the contact resistance. The slider itself is easily formed from the thin brass sheet. The simple securing method outlined above also presses it on to the rods. The tensioning spring is 12mm in diameter and 150mm long under tension; when at rest its length is 80mm.

Testing

The shorting bar travels from top to bottom in about 20 seconds. The unit was installed on the antenna, connected to the reflector in place of the usual adjustable stub, and the tower then elevated. I had arranged for Graham, G4IDG, whose QTH is about 5 miles from mine, to send a carrier on 28.4MHz. I rotated the quad until the reflector was pointing directly at his QTH on a heading of 255°, with the tuner at its top position with the red LED illuminated. We established a talk-through connection on 70cm. The steady signal showed just over S7 on my Kenwood 820 (still working after almost 40 years with original 6146 valves!). The down switch was operated, and the S meter reading observed as the slider contact moved downwards. The meter reading started to fall, and was at its minimum of S6 when the slider was about six inches (15.2cm) from the lower end (I used a pair of binoculars to see this).

The next test was a signal at the same power level (70W) from my end, which gave exactly the same response at G4IDG, when operating the tuner. During the testing, it was noted that the carrier from G4IDG reduced to S0 as the antenna was turned sideways-on to his location. The driven element was then aligned towards G4IDG and a carrier at the same level transmitted from my end. He reported a signal at level S9, a three S-point difference in front to back. We concluded that the front-to-back ratio was about 18dB.

The tower was lowered and the distance from the base of the tuning stub bars to the position of the shorting bar was measured to be 6 inches (15.2cm), and this multiplied by two gave the length to be added to the reflector loop as 12 inches (30.5cm), which equates to a 2.73% increase in the length of the reflector element. The unit was removed from the quad, and the additional length of 12 inches (30.5cm) inserted into the reflector. With the tower raised, the tests were repeated, giving the same results. We did not test for forward gain, as having read up on the tuning process in a respected book, it is stated that the tuning stub has minimal effect. The VSWR was 1.4:1 at the testing frequency of 28.4MHz.

It will be noted that this tuning unit is not designed to be mounted permanently, as it is not weather proof, and is only intended to be used in dry weather for tests which only take a few hours to complete. The results would appear to justify the time taken to build it and, as usual in the true spirit of our hobby, my friends were there to give advice and encouragement to see it through to completion.

My grateful thanks go to Graham, G4IDG, Nick, G4IDK and Barry, G0GJG for their help.

John Patten, G3PIN
johnnypatten@aol.com

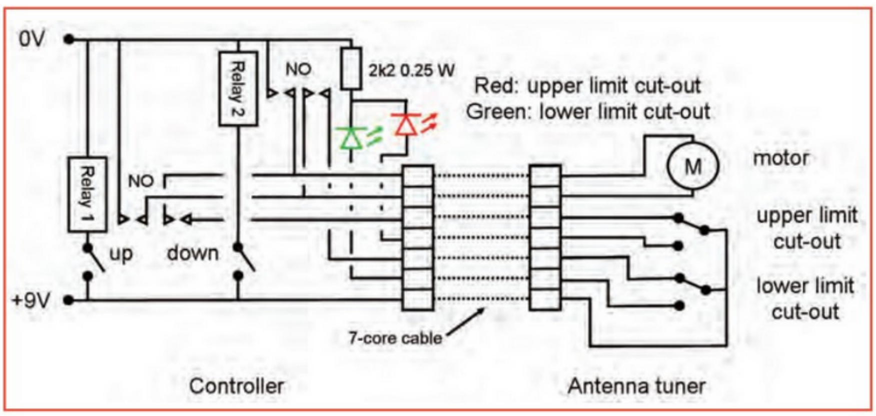


FIGURE 4: The circuit diagram of the tuner.

Design Notes

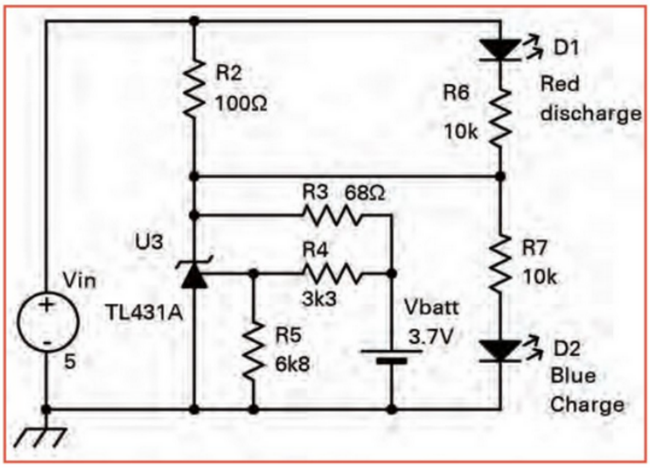


FIGURE 1: **The circuit diagram of the 'Battery Buddy' voltage and charging monitor.**

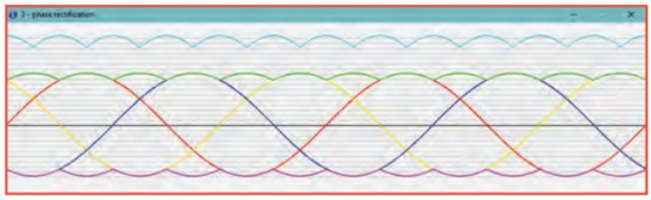


FIGURE 2: **Three-phase full-wave rectification showing the low ripple content even before any smoothing capacitors are added. The green and magenta traces are the positive and negative outputs from the rectifier, referenced to a virtual-zero voltage point. The light blue trace at the top is the actual full-wave rectified DC.**

Battery Buddy

Last month, we saw a temperature-compensated battery charger based around a TL431 device. Now, here is another project for the care and feeding of batteries using the same device. This was sent in by Steve Bennett, M0YYT, and he states that it will also appear in Sprat magazine, the journal of the GQRP club.

"Lithium Ion (Li-ion) rechargeable batteries are popular for QRP transmitters and receivers, and a commonly-used type is the 18650 with capacities up to 3500mAh; anything larger is a fake! Li-ion batteries do not like to be stored fully charged or heavily discharged. Better-quality chargers often have a feature called STORAGE, which charges, or discharges, a battery until it reaches a resting voltage between 3.7V and 3.8V, prolonging the life of the battery if it is not being used for some time.

"If your battery charger does not have the STORAGE feature, it can be provided with a simple project using a shunt voltage regulator like the TL431 **[1]**. The TL431 is an interesting device that crams a precision 1.2V Widlar band-gap reference **[2]** generating 2.5V via a bit of transistor magic, an operational amplifier, and an NPN transistor, into a 3-pin TO-92 package. Normally the TL431 is used with just three resistors to form a precision shunt voltage supply, but can be included in more-complex circuits providing higher voltages and currents.

"The TL431 is designed to be used as a closed-loop feedback device **[3]** to provide a regulated and stabilised voltage from 2.5V up to 36V. In the Battery Buddy, the TL431 operates in an unpublished open-loop mode, more similar to a voltage comparator, and uses a characteristic that is not defined in the device's data-sheet. That characteristic is the cathode-to-anode voltage when the reference pin is held at a voltage above the internal 2.5V reference; it is about 1.8V.

"Looking at the circuit in **Figure 1**, Vin is a 5V supply which could be from a USB socket, and Vbatt is the Li-ion battery voltage. Without a battery connected, the TL431 operates in its intended closed-loop mode, and the voltage at the battery terminals will be 3.7V. When a battery is connected, the negative-feedback loop is eliminated, and the TL431 is forced to operate as a voltage comparator. If the battery voltage is above 3.7V, then the TL431 cathode will fall to about 1.8V and the battery will start to discharge through the 68R resistor R3. If the battery voltage is below 3.7V, the TL431 will exhibit a high-impedance state, turned off, and the battery will start to charge from the 5V supply via R2 and R3. Because of the hysteresis in the cell voltage, the circuit will eventually slowly oscillate between charge and discharge centred on a cell voltage of 3.7V. For a visual indication, a couple of high-brightness LEDs and 10k resistors can be connected between the TL431 cathode and the 5V supply and ground. Once the Li-ion battery reaches 3.7V it can be removed and safely stored."

Ex-aircraft equipment

Every so often, you may find a piece of useful radio equipment on the surplus market that was originally built for use in (usually military) aircraft. Occasionally, rather than just cannibalising for components and spare parts, it can be tempting to try to get the thing going as a complete unit. One such example was a 100W travelling-wave-tube amplifier (TWTA) covering 2GHz to 4GHz that was donated to the Flight Refuelling ARS. TWTs can usually be persuaded to work at much-higher frequencies than they are specified for, so it was hoped this one could be persuaded onto the 5.76GHz band as part of that club's Moon-bounce, or EME, project.

The big problem with ex-aircraft equipment is the power supply. Unlike ground-based stuff that runs from 50Hz supplies, or even naval equipment that typically use 60Hz, aircraft AC supplies are three-phase at 400Hz. The much-higher frequency means that transformers are smaller and lighter in weight, by as much as eight times for a given power rating, and smoothing capacitors have lower values. Three-phase supplies are delivered routinely, even to low-power equipment, as this makes transformers and smoothing even more efficient still. The ripple frequency from a three-phase full-wave rectified waveform is 1.2kHz, so compare that with the problem of trying to smooth the 100Hz from a full-wave normal mains PSU. Furthermore, even without any smoothing capacitors at all, the ripple from a full-wave rectified three-phase supply is quite low, only some 5% of the DC voltage, as illustrated in **Figure 2**.

TWT PSU

The TWT PSU was estimated to consume about 1kW and was designed to run from a 400Hz, three-phase supply at 200V RMS. This means that 200V exists between any pair of phases as there is no neutral. Such a supply

Andy Talbot, G4JNT
andy.g4jnt@gmail.com

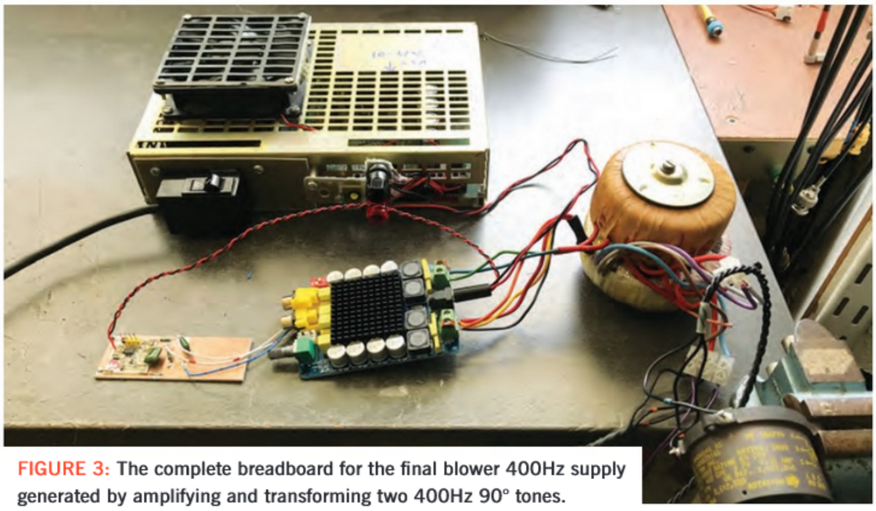


FIGURE 3: The complete breadboard for the final blower 400Hz supply generated by amplifying and transforming two 400Hz 90° tones.

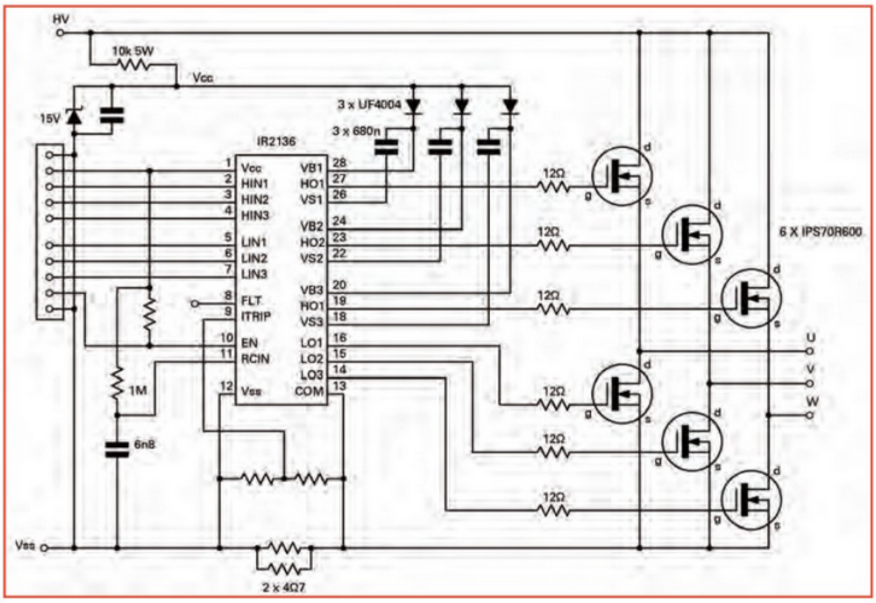


FIGURE 4: The driver and FET bridge part of a three-phase source using pulse-width modulation. The six FET drive signals come from a waveform generator going to the connections shown on the left.

floating from ground is called a 'delta feed', as the phase voltages are 120° apart, and when represented by phasors form the three sides of a triangle or delta shape. A 'weak neutral' may exist, created artificially merely for leakage detection and protection against short circuits, but is not designed to carry any current. Any neutral current in such an arrangement is often considered to be a fault that can be arranged to trip a circuit breaker. This configuration is in contrast with the 'star'-connected domestic mains supply, with 400V between phases and 230V from each to neutral / ground.

Initial thoughts about getting this TWTA going centred around generating the 400Hz, 200V, 1kW supply from some sort of off-the-shelf inverter – it would be the easiest solution. But looking at suitable units soon killed that idea – they are not cheap! So the circuit diagram was examined to see what it did with the incoming supplies. Three main areas were evident. For the high-power parts of the PSU, consisting of switch-mode inverters and regulators for all the tube's high voltages, the 200V supply was directly rectified with no isolating transformer, using six diodes in a three-phase bridge. The 200V RMS full-wave rectified AC voltage generates around 280V DC. With no isolation from the incoming mains, the resulting DC supply must be isolated from the chassis, and this was clearly evident from the circuit diagram, with just a few EMC and filtering capacitors going from any part of this bit of the circuitry to chassis.

A small transformer plus bridge rectifier supplied a 3-amp rated linear regulator, taking it down to 24V, and this was referenced to the chassis as the 0V rail. The remaining item was a small and very potent cooling fan that had to run from the 200V input. These fans are so efficient, spinning at over 19,000 RPM and producing a massive airflow from a tiny volume, that it would be near impossible to find a 50Hz or DC replacement to do the same job. So the 400Hz supply for that would have to be generated. The blower can be seen bottom right of **Figure 3**, held in the vice.

A voltage of 280V DC, isolated from ground, is not that difficult to obtain, if you are careful and want to play games with electrical safety. Just use a Variac from the mains, a bridge rectifier, and some big 450V electrolytic capacitors. Having a large isolation transformer in the circuit as well makes it a lot safer, and I found one. It turns out the FRARS group already had such a non-isolated PSU that could supply 280V at 10A. This had been built by a member some years ago for just this sort of task, so that could be pressed into service. The input to the 24V regulator could be just any old switch-mode power supply unit delivering a few amps at 28V, and several suitable PSUs were available sitting on the shelf; one rated at 5A is shown in use in Figure 3. So that just left the blower motor supply to be generated. That had to be 400Hz 200V AC three-phase.

To prove the blower was working, G3YGF initially used a 100W Hi-Fi amplifier fed with a 400Hz tone stepped up in a mains transformer to around 200V **[4]**. This single-phase supply was connected to two of the three motor terminals; remember that it is a delta supply with no neutral. A capacitor of around 0.5uF went from one side of this output to the other terminal to give a very rough approximation to a three-phase supply. This was good enough to get the motor running. He reported that "yes, it ran well, generated huge airflow and was incredibly noisy with ear-damaging high-frequency noise. Ear defenders would be essential." Power consumption appeared to be in the range 20W to 40W. Although it was all working, the bulky Hi-Fi amplifier was inconvenient, and a simple capacitor generating a far-from-perfect three-phase supply just wasn't 'the done thing'. So a proper solution was needed.

Generating three-phase power

Initial thoughts turned towards using six MOSFETs in an H-bridge from the 280V DC rail. The three-phase waveform could be generated in a PIC using pulse-width modulation, with the outputs from this converted to driving the FETs in an IR2136 3-phase Hi/Lo side bridge driver chip. **Figure 4** shows the circuit diagram of the driver section of this arrangement. Separate drive signals are needed for top and bottom FETs, so the PIC generator has to deliver six separate signals which come in on the connector shown on the left of the diagram. Driving an inductive motor, the synthesized sine waveform does not have to be terribly clean and a stepped sine approximation is more than adequate. The six drive signals were generated in a 120-entry lookup table in the PIC,

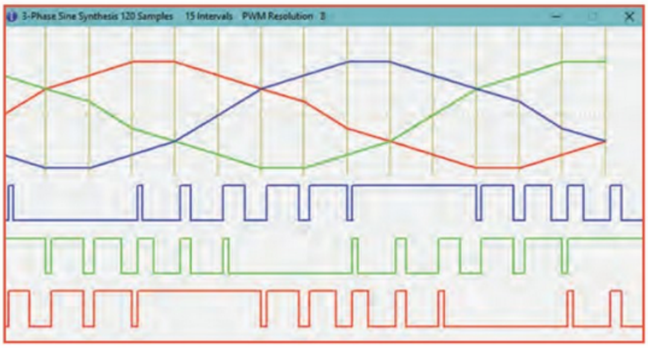


FIGURE 5: A diagrammatic view of pulse-width modulation, delivering a stepped sine-wave approximation. The control signals for the upper- and lower-FET drive are generated from a 120-long look-up table sampled at 48kHz in a PIC microcontroller

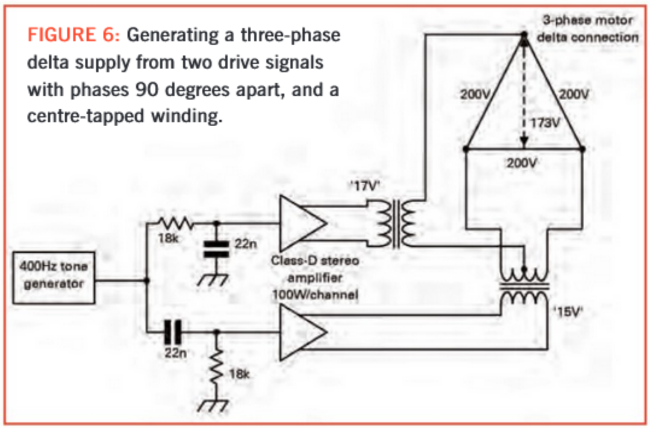


FIGURE 6: Generating a three-phase delta supply from two drive signals with phases 90 degrees apart, and a centre-tapped winding.

clocked at 120 * 400Hz = 48kHz. **Figure 5** shows the PWM and resulting stepped sine-wave approximation. The software used to generate that plot also produces the lookup table that is copied into the PIC assembler code.

The circuit was constructed on a 'bread board' and tested with the blower fan, using a fully-isolated laboratory high-voltage PSU. It did work, blew hard, and was indeed very noisy for a couple of minutes, then just stopped. On testing, it was found one of the FETs had blown; this was replaced but then another FET popped. The IPA70R600 devices were well within their ratings of 700V and 6A, so it was clearly high-voltage spikes and switching transients that were destroying them. The correct procedure would now have been to carefully lay out a proper PCB, paying attention to having short fat tracks and plenty of decoupling, adding properly-designed and placed 'snubber' components (a snubber is a device that is used to limit, or 'snub', voltage transients). This would have been an awful lot of work just to get a blower going! Furthermore, one area had been completely forgotten in the rush to test it: all this would have to be powered from the 280V raw floating DC supply from rectified mains. The low-voltage power supply for the PIC and driver chip would have to come from this somehow. A 10k 5W dropper from the 280V supply, and a 15V Zener diode served for now. I had a very cold, uneasy feeling about this.

So the three-phase H-bridge idea was abandoned and thoughts returned to stepping up the voltage using a conventional transformer. A quick perusal of the web showed several small class-D switching amplifier modules that could be purchased quite cheaply. The one shown in the middle of Figure 3 is specified for a 12V to 36V DC supply, and can deliver up to 100W per channel into 8W speakers. This was tested from a 24V supply, using one channel and G3YGF's solution, using a 15V toroidal transformer to step up with a phase-shift capacitor. This showed it worked, driving the motor with a single-phase supply when run from a 24V DC input. The 400Hz tone into the amp came from a modified G4JNT audio keyer module **[5]**. But could a proper three-phase supply be generated by a bit of ingenuity using two audio channels from a stereo amplifier, fed with signals having the appropriate phases and amplitudes? Yes, it was possible.

Quadrature three-phase synthesis

Look at the diagram in **Figure 6**. Each dot or vertex of the triangle is an input connection to the fan motor. The three-phase 120°-shifted delta supplies are represented by the three straight lines between each, forming the sides of the triangle. A 200V RMS power supply is connected to the two bottom terminals; let's call it the 'horizontal phase'. Adding a centre tap on the winding delivering this now gives us a mid-point on the base of the triangle directly below the upper third terminal. We generate a second signal, 90° phase-shifted (the 'vertical phase') and connect this between the centre tap (mid-base of the triangle) and the upper terminal. Pythagoras tells us the length of the vertical line is $\sqrt{3}/2$ of the length of each side, so the drive needs to be 0.866 * 200V = 173V. The net effect of supplying these two drive signals is exactly the same as delivering the three-phase drive.

We now have to generate a pair of voltages at 400Hz, in quadrature, one at 200V and the other 173V. Input drive to the amplifier comes from the same tone generator, but now going via two R-C networks, each using 18k resistors and 22nF capacitors, for a turn-over frequency of 400Hz. One network is configured as a high-pass CR, and the other as a low-pass RC, so the resulting phase shift between them driving the amplifier inputs is 90°.

Two toroidal transformers were to hand, both having split primaries for 115/230V mains input; that provided the centre tap. One transformer was rated to deliver 17+17V and the other 15+15V. In each case, both low-voltage windings were paralleled and connected to each output of the stereo amplifier. The 15V transformer was configured to drive the two bottom terminals as, when run backwards, it would generate a higher voltage than the same drive voltage applied to the 17V transformer. The latter was connected between the upper motor terminal and the centre tap on the 15V transformer. The ratio between 15V/17V is 0.882, so not quite the 0.866 wanted, but near enough to not warrant any extra amplitude trimming.

And it worked wonderfully. Turning up the volume control caused the motor supply voltage to get up to 200V easily across the bottom pair, with the voltage measured across the other pairs of terminals being around 206V and 190V – quite good enough. The amplifier was only supplied with a tiny heat sink and ran a bit too warm, running into its own thermal protection after a period of several minutes at full power. This was easily cured by adding a tiny CPU blower fan to the heat sink, or just placing it in the airflow from the blower under test.

So now all that remains is actually testing and getting the TWTA running – but that is for another time.

References

[1] https://www.ti.com/lit/ds/symlink/tl431.pdf?ts=1683960517313&ref_url=https%253A%252F%252Fwww.google.com%252F
[2] https://www.allaboutcircuits.com/technical-articles/introduction-to-bandgap-voltage-references/#:~:text=The%20Widlar%20Bandgap%20Reference&text=Scaling%20the%20emitter%20areas%20of,bias%20current%20of%20the%20transistors
[3] https://industrial-electronics.com/sams_prac_p-s_ckts_4.html#:~:text=The%20closed%2Dloop%20system%20is,%2Dtype%20closed%2Dloop%20regulator
[4] Although designed for 50Hz, mains transformers will work quite happily with 400Hz waveforms, especially toroidal ones. The frequency is still low enough that additional copper losses due to reduced skin depth are insignificant, and any potential additional eddy current loss in the core is offset by the eight-times lower flux density.
[5] PIC tone generator: http://g4jnt.com/MicrowaversAudioKeyer.pdf

EMC

Solar PV QRM

Renewable energy sources such as solar photovoltaic (PV) panels are becoming increasingly popular. Prices have fallen in recent years and several grant schemes and incentives are available. While the environmental benefits of solar PV systems are well known, we have some reports of a downside which is less well known. This is radio interference on amateur radio bands and other frequencies including AM, FM and DAB radio broadcasts. This shouldn't happen if the systems comply with the Essential Requirements of the Electromagnetic Compatibility Regulations 2016 **[1]** but we are receiving an increasing number of reports of interference to amateur radio reception caused by solar PV systems.

If you are planning to have a solar PV system installed then it would be worth notifying the installation company in writing that you are a licensed radio amateur or short-wave listener and that the solar PV system must not cause interference to amateur radio bands, long, medium and short wave AM radio broadcasts, FM radio broadcasts, DAB broadcasts or 2.4GHz Wi-Fi.

It is worth pointing out to the installer that the applicable regulations are The Electromagnetic Compatibility Regulations 2016 as amended by the Product Safety and Metrology etc (Amendment etc) (EU Exit) Regulations 2019. Some provisions apply differently in Northern Ireland, see **[1]** for further details. In any case, the essential requirements of the EMC Regulations 2016 remain unchanged and these are as follows:

a) equipment must be designed and manufactured to ensure that the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended, and

b) the equipment has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use.

PHOTO 1: **A recent solar PV installation with outdoor ground-mounted inverter.**

Solar PV EMC standards

In the UK, the EMC standard for emissions of RF interference, both radiated and conducted is:

BS EN IEC 61000-6-3:2021 Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for equipment in residential environments. This supersedes BS EN 61000-6-3:2007+A1:2011 and there are some changes related to DC power ports. You may come across references to the EN version of the standard (without the BS) and the IEC version. Although these are equivalent, the important point to note is the date of the version that was used for testing. This standard also contributes to UN Sustainable Development Goal 9 on industry, innovation and infrastructure because it protects radio reception.

You may also come across references to IEC EN 61000-6-4, Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments. This has higher limits than the residential version and solar PV inverters will typically comply with both IEC 61000-6-3 and IEC 61000-6-4. Look out for anything that complies with IEC 61000-6-4 but not IEC 61000-6-3 as this would only be suitable for an industrial environment, not residential.

DC power port limits

Currently EMC standards for solar PV inverters (and almost all other equipment) include limits for the levels of conducted emissions of interference into AC mains from 150kHz to 30MHz. There are also conducted emission limits for DC power ports, but these are only applicable under certain circumstances which do not include solar PV systems where the panels feed DC to the inverter. Some solar PV systems also have a separate storage battery which is connected via another DC power port.

International standards organisations are aware of this limitation. International Electrotechnical Commission CISPR Committee CIS/H deals with Limits for the protection of radio services. The committee documents are confidential, but it is possible to see the title of the following document on the CIS/H work programme: IEC 61000-6-3/AMD1/FRAG4 ED3 Amendment 1/Fragment 4: Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for equipment in residential environments - Requirements on DC power supply port CIS/H/458/CD.

The International standards-making process is inevitably slow and when a new version of a standard is introduced, there is a transition period before the previous version is withdrawn. It is likely to be some years before the current work in CISPR/H feeds through to products on the market.

DC power port RFI

Photo 1 shows a recent solar PV installation with eight solar panels on the roof. In this particular installation, the solar panels do not have optimisers which have been reported to cause RFI in some other installations. The eight panels are connected as one series string that feeds a hybrid inverter. The inverter is rated for a maximum DC input of power of 4800W from the solar panels although a 4.8kW system would require 12 panels. It is called a "hybrid inverter" because it can take 120 – 550 V DC from solar panels or 48V DC from a storage battery. It can also charge the battery. As with all inverters it is 'grid tied' meaning that it outputs 50Hz AC synchronous to the grid. This requires a multi-kilowatt switching power supply unit and these do have the potential to generate RFI unless interference filtering is adequate.

With earlier solar PV systems, one or more inverters were normally in the loft, but in this system there is a single inverter and a storage battery. These

PHOTO 2: LED lights off, good reception of BBC Radio 2 DAB.

PHOTO 3: LED lights on, BBC Radio 2, DAB service not available.

are housed in a substantial metal cabinet standing on the ground outdoors. The battery is a 51.2V lithium type with 100 amp-hour capacity so it can store 5.12 kilowatt-hours (kWh) of energy. The typical weight of the battery is about 32kg. It is possible to have up to 20kWh of battery storage on some systems.

The DC power cables from the inverter up to the roof form can act like a vertical antenna with a large capacitive 'hat'. This typically radiates most efficiently around 10MHz, although RFI on a wide range of frequencies has been reported. As the inverter and battery are well screened in a metal case, it should be possible to stop the DC power cable from radiating and the EMC Committee is currently investigating how this can be done. We would be interested to hear from anyone else who is working on this.

Radio 4 LW to close

Following an announcement by the BBC in May 2022, the 198kHz BBC Radio 4 LW transmitter is to close although the actual closure date has not been announced yet. It appears that the high-power transmitting valves are no longer manufactured. The RF transmitter power of 500kW also requires a substantial amount of electrical power from the mains. It has also been reported elsewhere that other AM radio broadcast transmitters will be closing down.

With the phasing out of AM, it will become even more important to protect FM and DAB from RF interference from sources such as LED lights and solar PV optimisers or inverters.

DAB interference

Some RFI sources have been reported that affect 144MHz amateur band and also Digital Audio Broadcasting (DAB). As DAB is digital, the effect of interference is different to an analogue radio service. If the signal-to-noise ratio gets worse due to weak signal or interference, there is quite a sharp transition from good reception to no reception at all. In between good reception and no reception, there is a transition region where there is an interference effect that has been described as "bubbling mud". If interference is severe then whole DAB multiplexes can disappear but it may not be apparent to the listener what is causing this. One case where the cause is clear is when switching on LED lighting causes interference to DAB reception.

An interesting example of this has been observed in County Durham. A kitchen had 14 halogen spotlights each consuming 50W. With a total of 700W, there was plenty of scope to improve energy efficiency. Replacing these with 14 MR16 type LED lights, each consuming 5W, brought the total power consumption down to 70W but it was noticed that when the new LED lights were switched on, the DAB radio went off.

Photo 2 shows LED lights off and good reception of BBC Radio 2 DAB. **Photo 3** shows LED lights on and BBC Radio 2 DAB service not available. The owner of the LED lights asked why this happens. I explained that the LED lighting is emitting radio interference on the radio frequencies that are used by DAB. "Does that mean that DAB is on the wrong frequency?" I was asked. "No," I replied, "It's the LED lights that are on the wrong frequency, they shouldn't be producing signals on those frequencies in the first place!"

In this case the original halogen lights used 12V MR16 type lamps each running from an electronic transformer so the replacements were 12V MR16 LEDs. As the original electronic transformers were designed for a 50W load, they may not operate efficiently with only 5W load so they were replaced with new electronic transformers. The new LED lights and electronic transformers are currently being tested to find out how much RFI they emit at VHF in amateur bands and in the DAB band. This will show how to get DAB reception working again when the LED lights are on.

EMC leaflets

The RSGB EMC Committee has produced 17 EMC Leaflets about Tackling EMC problems. These are all available online **[3]** and there is a list below.

Please note: These leaflets are provided in good faith and the Society cannot be responsible for any misuse or misunderstanding. EMC leaflets 1, 2, 5 and 8 are intended for neighbours, but only give neighbours copies of those leaflets that relate to EMC problems that actually exist.

EMC Leaflet 1: Radio Transmitters and Domestic Electronic Equipment – General EMC information sheet about breakthrough on TV, Radio, Hi-Fi.
EMC Leaflet 2: Radio Transmitters and Home Security Systems – An information sheet for neighbours or alarm installers about RF triggering of intruder alarms.
EMC Leaflet 3: Dealing with Alarm EMC Problems– Advice on how to deal with RF triggering of an intruder alarm.
EMC Leaflet 4: Interference to Amateur Radio Reception v1.0 – Advice on how to identify and find sources of RFI in amateur bands.
EMC Leaflet 5: Radio Transmitters and Telephones – All about RF breakthrough on telephones.
EMC Leaflet 7: Earthing-and-the-Radio-Amateur-Basic-v4 Updated to 2018 Regulations. Protective Multiple Earthing Advanced advice – UK-Earthing-Systems-And-RF-Earthing_Rev1.4.
EMC Leaflet 8: TV Distribution Amplifiers
For neighbours and TV aerial installers about solving breakthrough on home TV distribution amplifiers.
EMC Leaflet 9: Handling EMC Interference to Amateur Radio Reception v0.5.
EMC Leaflet 10: Avoiding Interference to Nearby Electronic Equipment.
EMC Leaflet 12: Part P and the Radio Amateur.
EMC Leaflet 14: Interference from Inhouse PLT.
EMC Leaflet 15 VSDL v4.4 February 2023.
EMC Leaflet 16: Background Noise on the HF Bands.
EMC Leaflet 17 Identifying VDSL interference using Lelantos v2.4 January 2023.

References

[1] Electromagnetic Compatibility Regulations 2016: Great Britain
Electromagnetic Compatibility Regulations 2016: Northern Ireland
https://www.gov.uk/government/publications/electromagnetic-compatibility-regulations-2016
[2] BBC Radio 4 begins information campaign to transition listeners from Long Wave:
https://www.bbc.com/mediacentre/articles/2023/bbc-radio-4-long-wave-transition
[3] RSGB EMC Committee leaflets on tackling EMC problems:
https://rsgb.org/main/technical/emc/emc-publications-and-leaflets/

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

Experiments and trials of CW practise oscillator design

Introduction

Have you had one of those projects that starts with a small idea and then takes on a life of its own and just snowballs? Well, this is one of those. It started with my volunteering in late summer of 2022 to man the CW practise table for Jamboree on the Air (JOTA) for a local scout group at Castle Hedingham in Essex. Although my Morse-code speed at the time wasn't quite up to 5wpm, it was enough to encourage the youngsters to take part and send their names and the alphabet in Morse code. At the end of the day, some youngsters had to be dragged away from the key by their mothers, so I think they had a lot of fun including me.

This set me to thinking about building a practise oscillator for myself and for future club use. So, what makes a good practise oscillator? In my case, it needed to sound clean as my hearing is not what it used to be. Too many years shooting clay pigeons as a teenager on a farm did for my hearing, and that was in the days when hearing defenders were not seen as cool. So, a nice clean low-distortion sinusoidal oscillator was called for. Easy, or so I thought, until I read up on sine-wave oscillator designs. Most provide a clipped sine wave. A good choice is a Wien-bridge oscillator, which has low distortion, but can be tricky to set up. If the gain is too low, it fails to start; if too high you run into clipping. What's needed is some active feedback to keep the output in the sweet spot. Years ago, I worked on a project that used a feedback technique for a microphone compressor, so set about designing such an oscillator using a similar feedback control-loop with Pspice simulation.

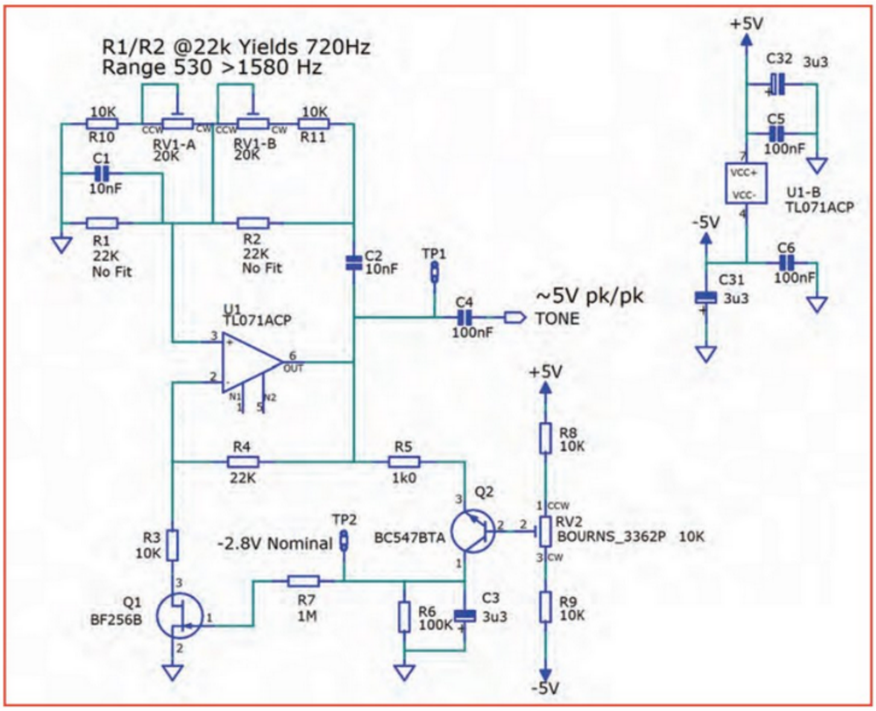


FIGURE 1: The circuit diagram of the Wien-bridge oscillator with a feed-back control loop.

The design

Pspice is a good tool for this purpose, but you have to use it with care. In my original simulation, the oscillator refused to start. It turned out that you needed to kick start it using a simulated supply transient. After that initial hiccup, the feedback circuit was optimised. I then used a 'bread board' to see if I could get it to work in the real world.

The circuit diagram is shown in **Figure 1**. The control circuit reduces the loop gain when the output voltage swings near the point at which clipping occurs. Transistor Q2 becomes forward-biased and capacitor C3 becomes negatively charged with respect to ground. This in turn pinches off JFET Q1, reducing the amount of feedback, and thus maintaining a low-distortion sine-wave output. Variable resistor RV2 allows you to set the point at which the feedback kicks in.

So, I had an oscillator design, but keying this directly was not such a good idea. The oscillator took time to settle down and for the feedback to stabilise, so a means of modulating the output was required. This leads me to the next point on what makes a good practise oscillator: the elimination of oscillator chirp! By far the best way to avoid keying the oscillator directly is to modulate the audio signal with a gain-controlled amplifier. You can realise this with a long-tailed pair and then limiting the amplifier's current with a 'current mirror'. The circuit diagram of the modulator is shown in **Figure 2**.

With no bias on the 'KEY' input (ie when the KEY input is open-circuit), the amplifier is effectively shut down; the collectors of Q3 and Q4 sit at 90% of the supply-rail voltage and, as the inputs to the op-amp are balanced, the output at TP3 is nominally 0V. Variable resistor RV4 is used to compensate for any small offset voltage at the op-amp inputs. When the amplifier is keyed (ie the KEY input is connected to ground), the amplifier gain is set by the current into Q5 base, and Q5 forms the current mirror with Q6. This keying would be instantaneous with a square-sided amplitude modulation of our oscillator. However, this is not what we want to hear on air as we normally adjust the slope of the ramp-up and ramp-down to avoid 'key clicks' which cause interference to others. In the modulator circuit, C11 slows the rise and fall times, controlling the rate of change and thus the slope of the ramp-up (and ramp-down) of our modulated audio.

Adding iambic keying

When I reached this point playing with the bread-board versions of these two circuits, I thought it would be nice to have the capability of iambic keying – a classic case of 'design-creep'! There are a few published iambic key circuits on the web, together with messages from frustrated users tweeting that the particular circuit doesn't work! So, I picked what looked like the simplest one using a JK flip-flop IC and a quad-input NAND gate. It turns out that this was a mode-A keyer. What could be simpler?

It didn't work, and even more infuriating, not one of the published circuits explained how it was supposed to work. Taking a charitable point of view, I put it down to capacitive coupling between my bread-board sockets. I needed to fix this as I was convinced that I needed iambic capability for this project, so I set to work. At the end of a frustrating day, I found that my so-called iambic key circuit had a flaw; it produced a double pulse while clocking one of the JK flip-flops. JK flip-flops don't take kindly to noisy clock pulses when trying to clock data, so this was fixed by placing an additional RC filter (R33, C18 and D3) in the iambic clock circuit (see **Figure 3**).

Let me say a little more about iambic key circuits: for the purists there are two modes, A and B. In A mode, when both paddles are squeezed together you get the dah dit repeated and finishing on the final dit or dah when the paddles are released. In mode B, however, when both paddles are released, the circuit injects an extra element, for example if you released on a dah it will inject another dit after releasing the paddles. The choice is up to the individual, but having got used to working one way, I imagine it would be hard to change to the other.

The iambic key inputs are de-bounced by NAND Schmitt trigger circuits U7A and U7B. When a key is active low, the respective NAND gate output is driven high and applied to one side of the JK inputs of U6A. At the same time, the iambic clock is enabled from the outputs of U8B and U8A which are combined in an OR fashion. This sets the iambic oscillator clock running. When dots (Key-B) are keyed, U6A pin 10 (the J1 input) goes high and U6A pin 14 (the Q1# output) toggles to a low state. U6A pin14 stays in this low state until a dash is clocked on U6A pin 11 (the K1 input).

The U6B output state also toggles. When dots (Key-B) are applied, U6B pin 2 (the Q2# output) goes high, and it remains in this state until a dash is keyed. Upon receipt of a dash (Key-A) U6A pin 14 (the Q1# output) goes high and U6B pin 2 (the Q2# output) acts as a divide-by-two counter of the clock input at U6B pin 3.

Getting one's head around how this circuit works can be tricky, but the above explanation provides the basics and, with the addition of NAND gates U5C and U5D, one can inject dots or dashes in the data available at the KEY output.

David Allen, G8LHD
david.camtech@outlook.com

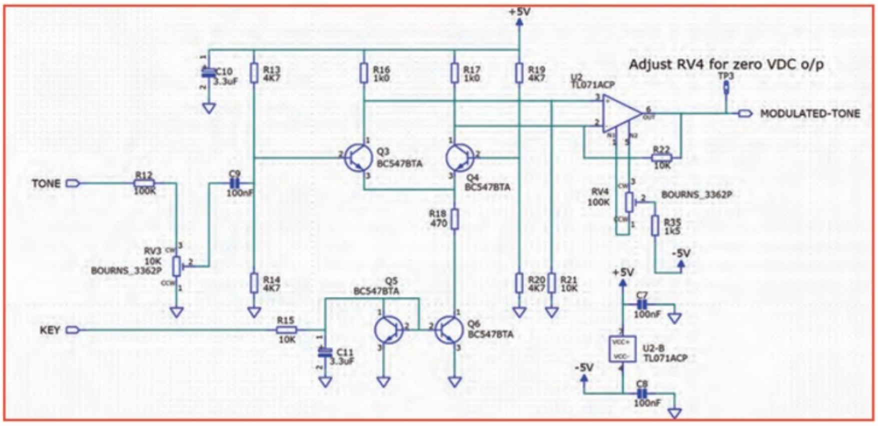


FIGURE 2: The circuit diagram of the modulator.

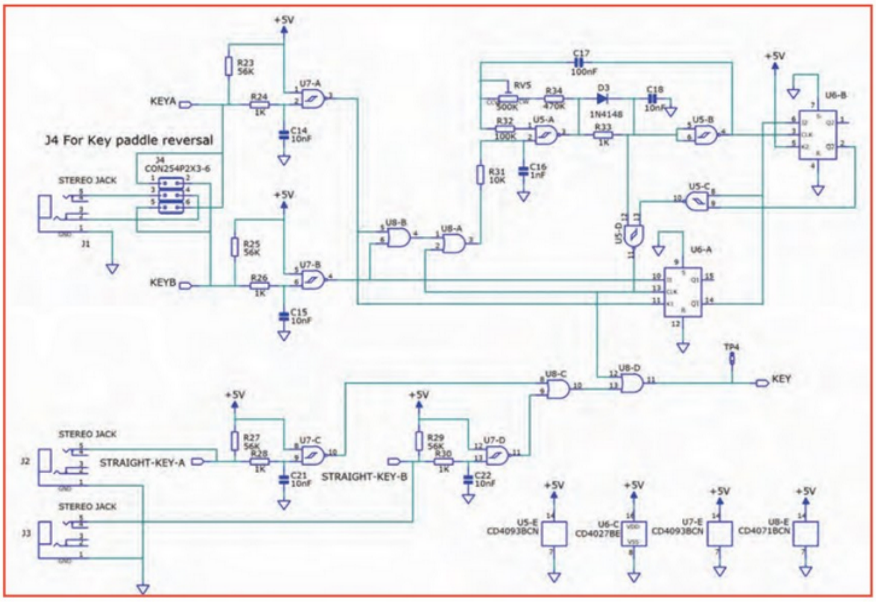


FIGURE 3: Improved iambic mode-A key circuit diagram.

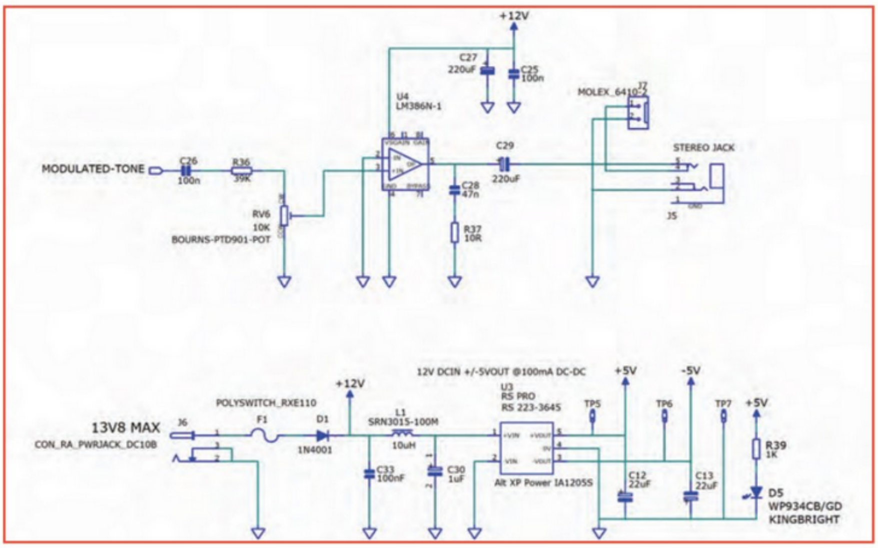


FIGURE 4: The audio amplifier and power supply circuit diagrams.

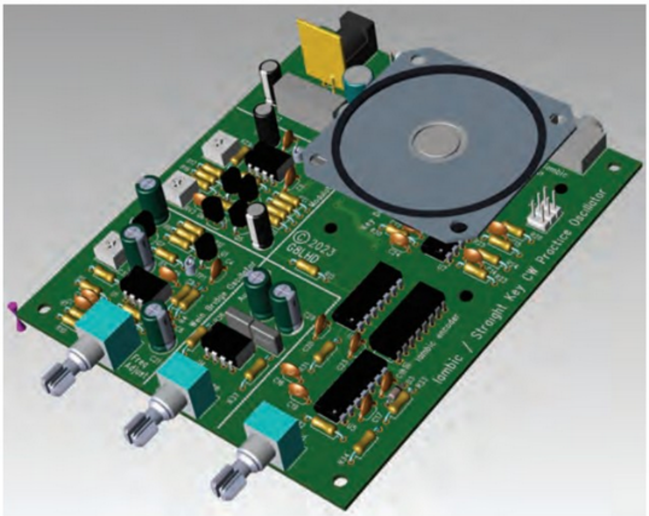


FIGURE 5: The layout as drawn by the CAD software.

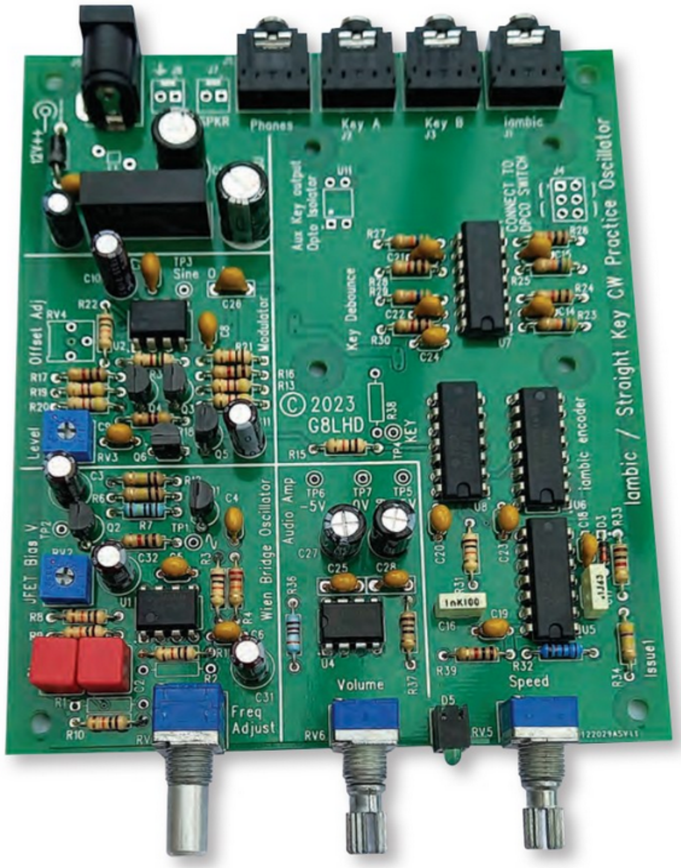


FIGURE 6: The assembled PCB before testing.

Bells and whistles

To recap, the following features make for a good practise oscillator:

- a sine wave of high purity provided by an audio oscillator with its frequency variable from about 500Hz 1200Hz;
- a separate modulator to avoid keying the oscillator directly and hence preventing chirp;
- smooth edges on the keyed audio envelope to avoid key-click interference;
- a Iambic circuit with variable speed and key-contact de-bounce;
- more than one straight key input for training sessions; and
- an audio amplifier with output for speaker.

I used an LM386N-1 for the audio amplifier which is capable of 300mW into 8Ω (see **Figure 4**). It requires just a few external components, and I have adopted the manufacturer's recommended configuration. The voltage gain of the LM386N-1 is 20, so choose a value for R36 which reduces the maximum output to a comfortable level.

In a past professional life, I used to design circuits and multilayer PCBs so it seemed only natural to take this to a conclusion and design a 2-layer PCB to accommodate these circuits. It uses leaded components to make assembly simple. The result is shown in **Figure 5**. The PCB size is 100 x 119mm and is designed to fit into a standard Hammond enclosure. Please send me an email if you would like a full copy of the schematic and layout. The assembled PCB is shown in **Figure 6**.

Testing

Like all prototypes, this one took a little teasing to optimise circuit values. The Wien-bridge oscillator and modulator worked fine. However, I had foolishly lifted the audio power amplifier circuit direct from the manufacturer's data sheet without first trying it out. To my alarm, the amplifier when driven went into oscillation at HF; one couldn't hear it on a speaker but an oscilloscope showed it clearly. After some investigation, and seeing that others had come across the same issue, I took a closer look at the audio amplifier data sheet. Buried on page 15 was an 'AM Radio Power Amplifier' with a slightly-reconfigured output circuit with a ferrite bead! So, with scalpel in hand, I cut the trace from the output pin of the audio amplifier, placed a ferrite bead across the cut, and decoupled the speaker side with a 47n chip capacitor to a convenient nearby ground. This cured the problem.

Whilst waiting for some project cases to arrive at my door, I started thinking about how to make the front and rear panels for the case, and in particular how to make some labels showing the functions. The simplest solution was to design a further set of single-sided PCBs to replace the panels supplied with the case. The advantage here was that all the holes would be pre-cut and the silkscreen process would add the embellishments I required. I carefully took all the dimensions from the 3D CAD models of the case and the PCB assembly, and entered them into the PCB CAD tool. I then set to work designing the silkscreen artwork, and added a cut-out for a slide switch on the back panel to allow reversal of the iambic key for right- and left-hand use. The panel PCBs were copper plated for screening and, fortunately, the solder-resist colour available matched the colour of the case. A new set of Gerber photo plotter data was sent to my supplier and I eagerly awaited the panels in the post. A week later, I was rather pleased with the results and the panels fitted perfectly. The final completed cased assembly is shown in **Figure 7** and **Figure 8** with the silkscreen legends as designed on the PCB CAD tool. Next-up some CW practise with some decent audio at last!

FIGURE 7: The finished unit, front view.

FIGURE 8: The finished unit, rear view.