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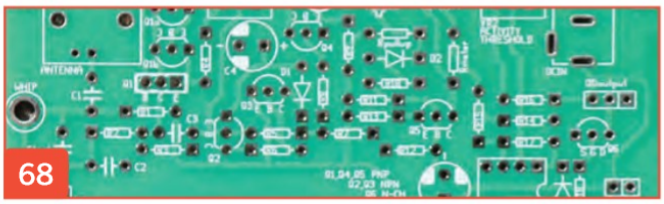

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Portable VHF Operating
Design by Kevin, M6CYB

RadCom THE RADIO SOCIETY OF GREAT BRITAIN'S MEMBERS' MAGAZINE
Managing Editor: Edward O'Neill, M0TZX, edward.oneill@rsgb.org.uk
Technical Editor: Matthew Smith, M0VWS, matthew.smith@rsgb.org.uk
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.

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New Products

The HW20V 20m antenna

A new Grazioli Antenna vertical 1/2λ antenna for the 20m band. Extremely robust construction in AW6063-T66 aluminium alloy and CNC machined parts from solid stock. Supplied with high-quality 304 and 316 stainless steel fasteners for long, rust-free operating life. High input power, up to 3kW continuous. All-mode. The tubes are extremely accurate on both diameters and also on the wall thickness, ensuring a precise fit. The HW20V antenna connector is not the commercial SO-239 type used by most manufacturers. The connector is designed and built directly by Grazioli Antenna; it has a true 50 Ohm characteristic impedance and is rated up to 500MHz. The body is made of CW614N nickel-plated brass, while the pin is plated in 24K gold to avoid oxidation. The insulating material is PTFE. The assembly is protected by a special elastomer hood that prevents water and humidity infiltration. The HW20V is available through Radio World via www.radioworld.co.uk and priced at £249.95.

Kraken SDR

The previous version of KrakenSDR was known as KerberosSDR, which was successfully crowdfunded on Indiegogo. KrakenSDR improves upon KerberosSDR in several important respects:

Automatic calibration hardware: it is no longer necessary to manually disconnect antennas during calibration. It all happens automatically when you change frequency. This will allow for KrakenSDR stations to be remotely operated. Five channels: KrakenSDR has five channels instead of four, which greatly improves direction finding accuracy. Low-noise design, USB Type-C ports and rugged, CNC-milled enclosure: the KrakenSDR is built for high reliability in the field. Bias tees on all ports allow for LNAs and other devices to be powered easily. Software upgrades: custom Android app that can automatically determine the location of a transmitter and provide automatic turn-by-turn navigation to the transmitter location. Five-channel, coherent-capable RTL-SDR, all clocked to a single local oscillator. 24MHz to 1766MHz tuning Range. 4.5V bias tee on each port. Core DAQ and DSP software is open source and designed to run on a Raspberry Pi 4. Direction-finding software for Android (free for non-commercial use). Custom antenna set available. The Kraken SDR is available through Martin Lynch and sons, www.hamradio.co.uk, priced at £449,99.

Acom's new clever ATU

The Acom 06AT 1.5kW remote Auto ATU & four-Way Switch, powered by all Solid State Acom amplifiers.
ACOM 06AT is an automatic antenna tuner for HF + 6 m with integrated four-way antenna switch. The tuner automatically selects one of four available antenna outputs (as assigned in bands by the operator) and matches up the line impedance of the selected antenna output by transforming it to 50 Ohm with SWR below 1.5:1 at the tuner input (typically below 1.3), providing an optimum load impedance for the amplifier. The ACOM 06AT tuner is specifically designed and developed to work exclusively with the ACOM series of solid state (transistor) amplifiers, eg ACOM 600S, 700S, 1200S or ACOM 2020S.

Available from Martin Lynch & Sons Ltd for £1150.00 via www.HamRadio.co.uk/06AT

Kracken Antenna

A set of five magnetic mounting antennas that can be used with the Kracken SDR for direction finding. The magnets are strong enough to secure the antennas to the roof of a moving car. Fully matched SMA cables.

- 5x Magnetic Mount Bases
- 5x SMA Tees, for mounting the whip antennas onto the base
- 5x SMA antenna for 100Mhz -1GHz.
- Available from Martin Lynch and sons, www.hamradio.co.uk, priced at £169,99.

Antennas

The Antennas column is a little different this month as I have decided to talk about one way in which I spend a fair amount of my free time: fixing antennas, in my garage.

We all love to operate with brand new well-made and cleverly designed antennas; however, it may not be within the reach of all of us to go out and spend hundreds of our well-earned pounds on a brand new antenna and, in addition, I thought some may like the idea of a little project post the seasonal events. I am going to 'up-cycle' a used Syro 27-4 Yagi beam antenna, making it into a quick-to-deploy and easy-to-use 10m beam for using on field day. When the weather gets better, and I can get out a bit more, I will report on the success of the build, or lack of, if that's the case. Then, I will report on what I've learned in attempting it.

This is the first part of two for this project. In this part we will go into the theory and maths behind the modifications and then, in the next part, talk about the practical task and the work needed. The Yagi antenna was invented in Japan, with results first published in 1926. The research was originally done by Shintaro Uda and published in Japanese. This was presented for the first time in English by Yagi (who was either Uda's professor or colleague, I am not sure which). Yagi went to America and gave the first English talks on the antenna, which in turn led to its popularity. Hence, even though the antenna is often called a Yagi antenna, Uda most probably invented it. If you know the history then please write in and let me know.

With our desired 10m field day antenna, being fairly similar to the original factory specifications, in terms of operating frequency, there should not be much work involved in the physical changes. Of course, we must apply some Yagi theory in order to understand how the changes we make will affect the antenna and its operation. In what way does changing the physical size of the different parts of the antenna have an effect on it? I will find out. Let me start by explaining that I am no expert on this subject, I have only a basic knowledge of Yagi theory, but I think that, combined with what I can research, it will be enough to complete the task.

Let's start by taking a look at the specifications of the original doner antenna, the Siro SY27-4.

- Sirio SY 27-4, 4-element Yagi (Beam) Antenna
- Horizontal polarization, factory tuned at 11m, mid-band
- Elements equipped with waterproof jointing sleeve
- Made of aluminium alloy 6063 T-832
- Frequency range: 26.9-27.5MHz
- Impedance: 50ohm unbalanced
- Gain: 11dBd, 13.15 dBi
- Bandwidth at SWR 2:1, 600kHz
- Max. power: 1000 watts (CW) continuous

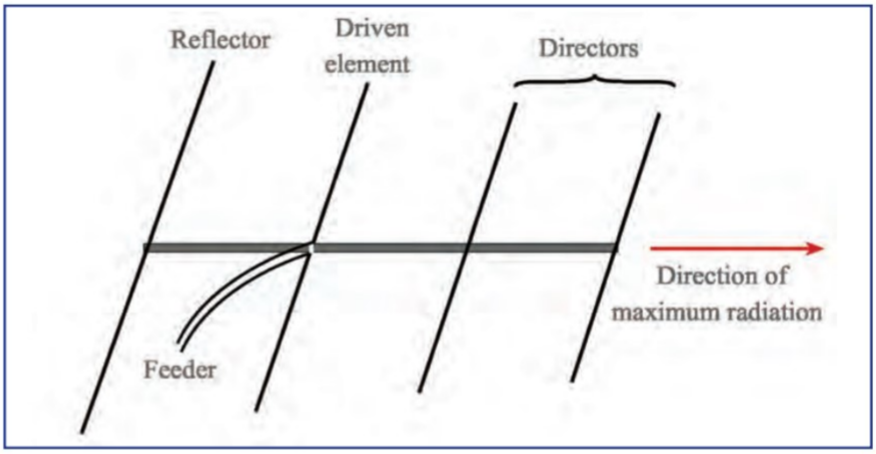

FIGURE 1: Basic concept of a Yagi antenna showing the reflector longer and the directors shorter than the driven element.

It's clear from above that we are starting with a good antenna to begin with, and this would be true had I brought a new one. As stated before, this article is about up-cycling a used one. There will be many things to consider when making the adjustments to the antenna I will use.

So what's a Yagi antenna? And why should I use one on field day? Yagi antennas utilise a mutual coupling between standing-wave current elements to produce a travelling-wave unidirectional pattern. Yagi antennas consist of an array, made up of a dipole and usually 2 or 3 additional closely coupled elements. The elements in the Yagi antenna are usually welded to a conducting rod or tube at their centres (but of course they may be removable, as are the ones on the SY27-4). Let's start by saying that every Yagi antenna is comprised of 4 parts. Part 1 is the *driven element*; this is the part to which we will feed our signal from our radio. Part 2 is the *reflector* this is the part that sits behind the *driven element*. Part 3, of which there may be many, are known as *directors*. They sit in front, with reference to the direction of radiation, of the *driven element*. All of the above are then united by Part 4, *the boom*. This part of the Yagi runs along the centre of the antenna and holds everything in place. The boom of the antenna is an important part, as it is responsible for spacing the other parts correctly from each other.

One of the major keys to understanding the way in which this type of antenna functions is understanding the *phases of the currents flowing in the different elements of the antenna*. The parasitic elements (all other elements other than the driven element) of the Yagi antenna operate by re-radiating their signals in a slightly different phase to that of the driven element. In this way, the signal is reinforced in some directions but cancelled out in others. As the additional antenna elements in the Yagi are not directly driven, but pick up power from the driven element, these additional elements are referred to as *parasitic* elements. Accordingly, the amplitude and phase of the induced current cannot be completely controlled. It is dependent upon their length and the spacing between them (the job of Part 4, the boom) and the dipole or driven element. This means that it is not possible to obtain complete cancellation in one direction. Nevertheless, it is still possible to obtain a high degree of reinforcement in one direction, with a high level of gain, but also to have a high degree of cancellation in another to provide a good front-to-back ratio. The Yagi antenna is able to provide very useful levels of gain and front-to-back ratios, and this is what's important for a field day antenna. More on that later.

To obtain the required phase shift, an element can be made either inductive or capacitive. Each type of reactance has a different effect.

Inductive: if the parasitic element is made inductive (the current in the element lags behind the voltage) the induced currents are in such a phase that power is reflected away from this element. This causes the antenna to radiate more power in the opposite direction. An element that does this is called a *reflector.* This is Part 2 of the antenna as discussed above. The element can be made inductive by tuning it below resonance. This can be done by physically adding some inductance in the form of a coil or, more commonly, by making it longer than the resonant length. Generally, it is made about 5% longer than the driven element. Usually only one reflector is used, the addition of further reflectors makes only a slight improvement.

Capacitive: If the parasitic element is made capacitive (the current in the element leads the voltage), the induced currents are in such a phase that they direct the power radiated by the entire antenna in the direction of these elements. An element which does this is called a *director*. It can be made capacitive by tuning it above resonance. This can be done by physically adding some capacitance to the element in the form of a capacitor, or more commonly by making it about 5% shorter than the driven element. These elements are Part 3 of our Yagi antenna. If we add more directors to the antenna this increases the directivity of the antenna, increasing the gain, but at the expense of beamwidth. When we add directors, each additional director is reduced slightly in length. For us to know what changes we must make to our donor antenna, we must understand why we need to make those changes.

If we break down the Yagi antenna to its parts, we will find that part 1, the driven element, is very similar to a dipole. In most cases a half-wave dipole. The dipole is the simplest type of antenna from a theoretical point of view. It consists of two conductors of equal length oriented end-to-end with the feedline connected between them. Dipoles are frequently used as resonant antennas. If the feed point of such an antenna is a short, then it will be able to resonate at a particular frequency (similar to the way in which a guitar string functions). Using the antenna at around the resonant frequency is advantageous in terms of feedpoint impedance (and thus standing wave ratio), so its length is determined by the intended wavelength (or frequency) of operation. The most commonly used is the centre-fed half-wave dipole which is just under a half-wavelength long. The radiation pattern of the half-wave dipole is maximum perpendicular to the conductor, falling to zero in the axial direction, thus implementing an omnidirectional antenna if installed vertically (as in the case of a typical FM broadcast station for example) or a weakly directional antenna if horizontal (as is the case for our Yagi antenna or a G5RV type of antenna). When this dipole is combined with the other parasitic elements (Parts 2 & 3), we get a much more directional antenna. We can see from the information above that the physical size of the dipole in our Yagi dictates what the frequency of operation will be. We must work out what changes we must make to the dipole (driven element) part of our antenna to make it resonant at the middle of the 10m band. Then, we must adjust the parasitic elements as such that they are in line with the 5% we discussed earlier, making them either inductive or capacitive, and this depends on their function within the Yagi.

This is where we start to look at some maths. Yes, you knew that time would come soon enough in an article about antennas. I will keep it simple, for my sake not just for yours, and because all we need here are the basics. There are two sets of calculations we need to look at, one which gives us the length of each of our elements (Parts 1, 2 & 3) and another which dictates how they should be spaced out along Part 4, the boom. We know already that the longest element is the reflector, as this (to make it inductive) should be 5% larger than our driven element, and we know that the shortest part will be our director, at 5% shorter than the driven element. It therefore makes sense to work out the size of the driven element first, then we can look at the parasitics afterwards. To do this we need to look at some basic calculations. For these calculations we need some inputs. These are what we call wavelength (Lambda) or λ, carrier frequency or f, and the velocity of propagation in air, or c.

The formula we will use is given as λ=c/f or wavelength = velocity of propagation in air divided by the carrier frequency. This gives us our Lambda (λ), or wavelength. Now, as I am building this antenna for my own use, and for field day next summer, I am going to use the middle portion of the 10m band, the SSB area of the band. According to the RSGB band plan for the 10m band **[1]**, this will be 28.50MHz. We already have a value for c, 300,000Km/s. For the purposes of this experiment (and that is what this is), we will use c=300. This leaves us with the following: λ=300/28.5 or 10.53 or 10 metres, as its more commonly known. We have discussed how the driven element of the Yagi is essentially a half-wave dipole. So now we have Lambda (λ) =10.53 we can divide Lambda by 2 to get our half Lambda or λ/2=5.25 meters. Which we can assume to be a half wavelength at 28.5MHz. The issue here is that there are many things that can affect the way a dipole works (any antenna for that matter), the maths is all very well with the antenna in free space, without any ground influence or local buildings etc. Due to other influences that we won't go into right now (end effect etc), the actual values are as follows: reflector element=0.495xλ, the driven element=0.473xλ, the director element=0.440xλ. Using these values, we have the recommended sizing for our three elements (in metres):

Reflector element	= λ x 0.495 = 5.12m
Driven element	= λ x 0.473 = 4.98m
Director element	= λ x 0.440 = 4.63m

We must not forget here that these measurements in metres are for the complete length of each element. As each one of these elements is in physical terms two sections, each extending outwards from the boom centre, we must divide the values above by 2, to get the value for each half element. Giving us the following:

Reflector element	= 5.12m x 0.5 = 2.56m
Driven element	= 4.98m x 0.5 = 2.49m
Director element	= 4.63m x 0.5 = 2.32m

You may by now have also noticed that I have only given the dimensions for three elements. Your observation would be correct. For the purposes of field day, turning this into a 3-element beam makes it a little easier to assemble in the field and lighter to carry. This is of course at the expense of forward gain and front-to-back ratio. With only one director element the antenna won't be as directional as before. But is this really an issue? That's another discussion and more on that next time. Now on to our second calculation for the antenna, the boom spacing calculations. This part is also fairly straightforward, we take the calculated Lambda from before and we use the following formula: driven element to reflector = λ x 0.125, driven element to director = λ x 0.125.

The gives us:
DR = λ x 0.125 = 1.31m
DD = λ x 0.125 = 1.31m
As you can see, it's pretty simple with a 3-element beam. As you add elements, the maths changes, and so the spacing

Matthew Smith, M0VWS
matthew.smith@rsgb.org.uk

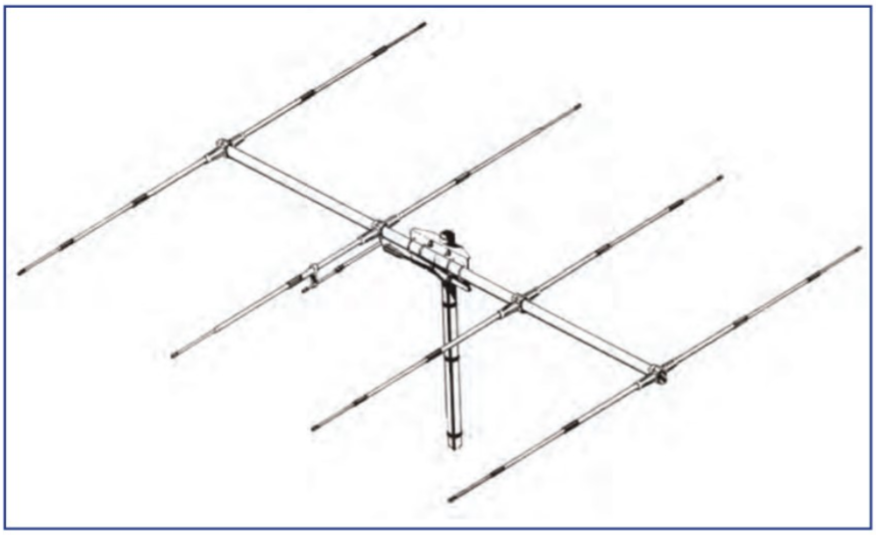

FIGURE 2: Syro 27-4 Yagi.

FIGURE 3: The Gamma Match of the Syro 27-4.

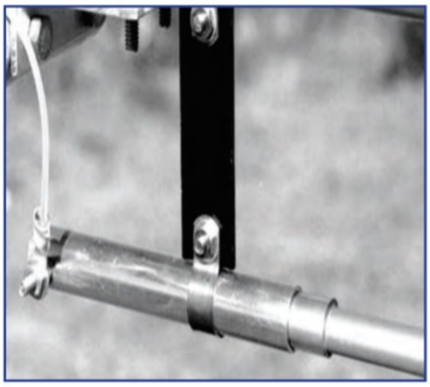

PHOTO 1: The Capacitor section of a gamma match (credit QST Magazine).

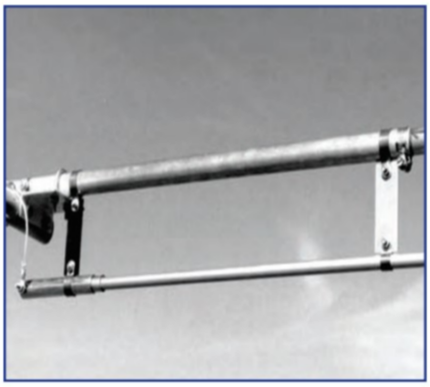

PHOTO 2: Gamma Match of a 10M Beam (credit QST Magazine).

PHOTO 3: Connecting the Coax to the antenna (credit QST Magazine).

changes. I may leave the boom section longer than needed, so that I can experiment later with the spacing. But for now, all we are concerned with is the exact spacing between the three elements, where they are located on the boom is not so important right now. Now, the original antenna boom has four aluminium sections which slide over the boom tubing and are held in place by locking screws (when complete our antenna will only use three). This is fine for use as is because it's the elements that will be removed from the boom when the antenna is not in use. And, of course, if these sections stay fixed on the boom, then there is no possibility that the boom spacing can be accidentally adjusted in the field. Assembly only means fitting the correct elements into the correct boom points, and this can be colour or numerically coded to make things easy.

One thing about this antenna that we have not discussed as yet is that the antenna by default uses a gamma match method. This is one of the simplest methods of matching a dipole to 50 ohm coaxial cable. The adjustment point to get the SWR as low as possible is around 0.05 lambda (but we will come back to that later in part two when we tune the antenna). The recommendation is that the matching rod is half the diameter of the dipole material. You could also replace the gamma match with a variable capacitor of the appropriate range. This is common in other types of antennas (eg loops) where the bandwidth is narrow. The major drawback of the gamma match is that it's there on the boom of the Yagi, in the air and therefore, inconvenient to adjust. You'll only want to use such a matching system where the SWR bandwidth of the resulting antenna is wide enough for your purposes. This is true for an antenna that's mounted up on a mast at the top of a house, but for our field day beam it's not so important. We can quite easily bring the mast down and make some small adjustments to the gamma match. I will keep the original gamma match that's fitted to the Sirio 27-4 as it should serve me well on the 3-element version and should give quite usable range at 28.50MHz.

In part two of the article, I will go through some basics about how to make the physical modifications to the antenna, the tools required, cutting and filing techniques for aluminium and the mounting method used. Once the physical modifications are complete, we can try to tune the antenna.

Interested in antennas? We are currently looking for authors for this section of the magazine. If you are interested then please get in touch via the following email address: radcom@rsgb.org.uk

Websearch

[1] https://rsgb.org/main/operating/band-plans/hf/28mhz/

Feature

Radio Blackouts & Solar Storms

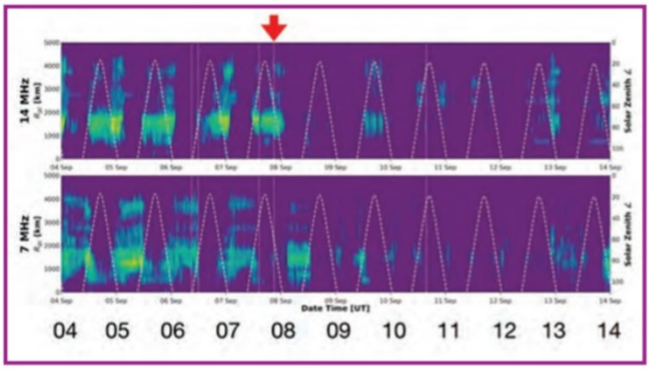

FIGURE 1: The number of Caribbean contacts logged on RBN and WSPRNet is reduced during a geomagnetic storm. Upper: 14MHz. Lower: 7MHz. Vertical axis: contact distance (0-5000km). Horizontal axis: UTC time and date (4-14 Sept, 2017). Red arrow: The storm begins at 2100UTC, 7 September. Dashed lines: Solar zenith angles show local daytime. Reproduced from [1] under a Creative Commons Licence.

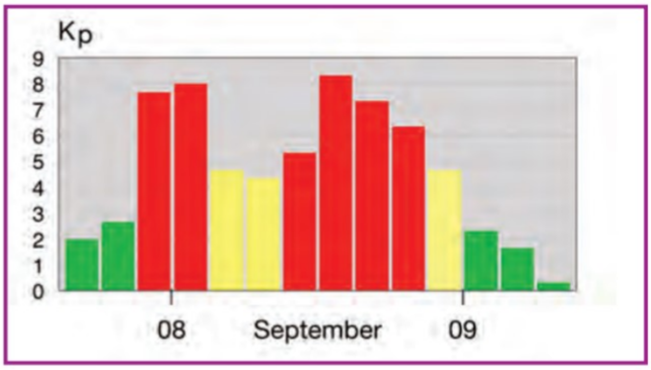

FIGURE 2: 3-hour averaged planetary K-index, Kp *vs* UTC time for 7-8 September, 2017, storm. Data from [1].

In September 2017, emergency hurricane recovery efforts by amateur radio operators in the Caribbean region were disrupted by solar storms.

A Category 5 hurricane made landfall on 6 September and, by an unfortunate coincidence, a series of geomagnetic storms began the following day. The storms affected the emergency bands on 7MHz and 14MHz. **Figure 1** is a histogram of the number of spots logged to or from the Caribbean region on the Reverse Beacon Network (RBN) and WSPRNet **[1]**. Contact distances are shown on the vertical axis (0-5000 km) *vs* UTC time and date (4-14 September, 2017). After the geomagnetic storm starts (red arrow at 2100UTC, 7 September), the 14MHz band (top figure) followed by the 7MHz band (bottom figure) are almost completely wiped out **[2]**. This geomagnetic storm ended on 9 September, but propagation problems continued. They were compounded by three smaller storms, as well as X-class flares **[3]**. Suppression of HF propagation lasted 13 days.

Geomagnetic Storms

Geomagnetic storms are disturbances of the Earth's magnetosphere caused by enhanced solar wind. The geomagnetic storms in September 2017, were caused after solar storms launched coronal mass ejections toward the Earth. The direction of the magnetic field in the solar wind allowed particles to penetrate the Earth's magnetosphere, disturb the magnetic field, and change ionospheric propagation **[2]**. Effects on the HF bands during a geomagnetic storm are summarized in **Table 1**, the NOAA G-scale for the severity of geomagnetic storms **[4a]**. Kp is the planetary K-index, derived from 3-hour-averages of magnetometer measurements on the ground by an international network of stations. **Figure 2** is a chart of Kp vs time during the 7-8 September, 2017 storm. The maximum Kp=8.33. Current values of Kp are shown on the NOAA space weather website **[4b]**. NOAA issues daily forecasts in terms of the G-scale **[4c]** as well as a three-day forecast of Kp **[4d]**.

STORM Model

The NOAA STORM Time Empirical Ionospheric Correction Model is a webpage application that gives real-time estimates of the expected change in the ionosphere during a geomagnetic storm **[4e]**. The model estimates the departure from normal of the F-region critical frequency foF2 for the current and previous day. The webpage shows graphs of foF2 correction factors in each of six different latitude sectors: 30N, 50N, 70N, 30S, 50S, and 70S. They are updated every hour, showing whether quiet-day estimates of foF2 should be revised because of a storm.

The critical frequency, foF2, is the highest frequency that can be reflected from the ionosphere when a signal is transmitted vertically. It's important because it determines the maximum usable frequency: MUF = MUF factor * foF2, where the MUF factor depends on the distance to a receiving station. For example, in summer the MUF factor for 3000km is 3.0 (Table 5.1 in **[2]**). **Figure 3** shows scaling factors for foF2 from the STORM Model for 30N latitude during a storm on 22-23 June, 2015 **[4e]**. For the green squares deviation up to 10% from the monthly mean foF2 minor or

Table 1. NOAA Space Weather Scale for Geomagnetic Storms [4a]

Level	Effects	Kp	Average Frequency Threshold in 11 year cycle
	HF Propagation		
G5 Extreme	May be impossible in many areas for one or two days	9	4 per cycle (4 days per cycle)
G4 Severe	Sporadic propagation	8	100 per cycle (60 days per cycle) (60 days per cycle)
G3 Strong	Intermittent propagation	7	200 per cycle (130 days per cycle)
G2 Moderate	Fades at higher latitudes	6	600 per cycle (360 days per cycle)
G1 Minor	None	5	1700 per cycle (900 days per cycle)

Peter DeNeef, AE7PD
HamRadioAndVision@gmail.com

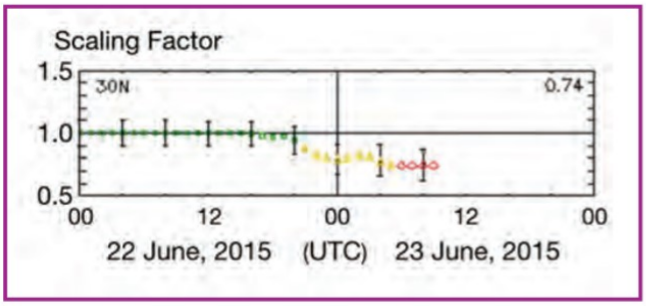

FIGURE 3: STORM Time Model scaling factors for 30N latitude during 22-23 June, 2015 storm. Horizontal axis: UTC time and date. A description of the color-coded symbols is in the text [4e], [5].

no adjustments are required. Yellow triangles deviation between 10% and 25%: significant adjustments required. Red diamonds deviation of more than 25%: substantial adjustments required. Carl Luetzelschwab, K9LA, discusses this storm in detail on his website [5].

Conclusions

Geomagnetic storms often reduce the maximum usable frequency to half its pre-storm value [2]. Figure 1 shows an example where the MUF was above 14MHz before the storm, and it fell below 7MHz. The NOAA STORM model gives useful real-time indication of when geomagnetic activity is affecting HF propagation.

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Contest Calendar February 2023

Ian Pawson, G0FCT

HF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Mon 6 Feb	80m Club Championship	1900-2030	SSB	3.5	RS + SN
Sat 11 Feb	First 1.8MHz	1900-2300	CW	1.8	RST + SN
Wed 15 Feb	80m Club Championship	1900-2030	PSK63, RTTY	3.5	RST + SN
Thu 23 Feb	80m Club Championship	1900-2030	CW	3.5	RST + SN
Mon 27 Feb	FT4 Series	1900-2030	FT4	3.5	Report

RSGB VHF Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange
Wed 1 Feb	144MHz FT8 AC (4 hour)	1700-2100	FT8	144	Report + 4-character Locator
Wed 1 Feb	144MHz FT8 AC (2 hour)	1900-2100	FT8	144	Report + 4-character Locator
Sun 5 Feb	432MHz AFS	0900-1300	All	432	RS(T) + SN + Locator
Tue 7 Feb	144MHz FMAC	1900-1955	FM	144	RS + SN + Locator
Tue 7 Feb	144MHz UKAC	2000-2230	All	144	RS(T) + SN + Locator
Wed 8 Feb	432MHz FT8 AC (4 hour)	1700-2100	FT8	432	Report + 4-character Locator
Wed 8 Feb	432MHz FT8 AC (2 hour)	1900-2100	FT8	432	Report + 4-character Locator
Thu 9 Feb	50MHz UKAC	2000-2230	All	50	RS(T) + SN + Locator
Tue 14 Feb	432MHz FMAC	1900-1955	FM	432	RS + SN + Locator
Tue 14 Feb	432MHz UKAC	2000-2230	All	432	RS(T) + SN + Locator
Thu 16 Feb	70MHz UKAC	2000-2230	All	70	RS(T) + SN + Locator
Tue 21 Feb	1.3GHz UKAC	2000-2230	All	1.3G	RS(T) + SN + Locator
Tue 28 Feb	SHF UKAC	1930-2230	All	2.3G	RS(T) + SN + Locator

Best of the Rest Events

Date	Event	Times (UTC)	Mode(s)	Band(s)	Exchange (Info)
Wed 1 Feb	UKEICC 80m	2000-2100	SSB	3.5	6-character Locator
Sat 11 - Sun 12 Feb	CQ WW WPX RTTY	0000-2359	RTTY	3.5-28	RST + SN
Sat 11 - Sun 12 Feb	PACC	1200-1200	CW, SSB	1.8-28	RS(T) + SN (PA send Province)
Sat 18 - Sun 19 Feb	ARRL International DX	0000-2359	CW	1.8-28	RST + tx power (W send State, VE send Province)
Wed 22 Feb	UKEICC 80m	2000-2100	CW	3.5	6-character Locator
Fri 24 - 26 Feb	CQ 160m DX	2200-2200	SSB	1.8	RS + CQ Zone (W send State, VE send Province)
Sat 25 - Sun 26 Feb	REF Contest	0600-1800	SSB	3.5-28	RS + SN (F send Dept No./overseas prefix)

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

EMC

PHOTO 1. A typical 400kV National Grid substation.

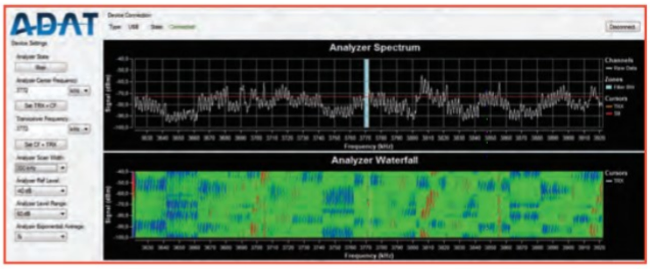


FIGURE 1: Unidentified QRM source from Germany.

Renewable energy

The threat posed by climate change and the need for measures to reduce harmful emissions of greenhouse gases are widely accepted. These measures include increasing the amount of energy produced from a wide range of renewable sources including solar PV, onshore wind farms and offshore wind farms. From an EMC perspective, renewable energy sources should not affect radio communications if they are well engineered for EMC but, as we know, some renewable energy sources do generate radio interference. This might be regarded as pollution of a different type of environment, the electromagnetic environment, that is the radio frequency spectrum. The RSGB EMC Committee has received enquiries from Members asking for advice about proposed developments nearby such as solar farms, wind farms or High Voltage DC (HVDC) converter stations.

Wind farms

Some onshore wind farms and high voltage DC (HVDC) converter stations have been reported to emit RFI in the 1.8MHz amateur band and in some cases 3.5MHz and above. Some offshore wind farms feed AC directly into the National Grid whereas others bring DC ashore with an onshore HVDC converter station that converts DC to 50Hz AC to feed the National Grid. Planning applications for such developments normally include an assessment of acoustic noise and Electromagnetic Fields (EMF) at DC and at 50Hz. In the case of onshore wind farms, the moving blades reflect and scatter radio signals so the effect on domestic TV reception and any nearby airport radar systems is also considered. The only project where we have seen RFI specifically mentioned is the 1000MW HVDC converter station for the IFA2 interconnector between Fareham in Hampshire and Normandy in France. The HVDC converter station is sited next to an airfield at Daedalus and an Airfield Compatibility Report was produced. A planning condition relating to Radio Frequency Interference was imposed, to prevent radio frequency interference to users of surrounding land and buildings.

If you hear about a proposed wind farm or HVDC converter station development at the consultation stage then you may wish to complete a feedback form or online survey as part of the pre-application consultation or you may be able to attend a public meeting. In any case, you could state that you are a licensed radio amateur and that you receive weak radio signals on various frequencies. It is useful to list some amateur bands that are of particular interest to you, but it is advisable to use megahertz not metres as metres can be misunderstood. You could say that you are concerned about possible Radio Frequency Interference (RFI) affecting your reception of amateur radio signals following reports of RF interference on the 1.8MHz Amateur Band from some onshore wind farms including Tween Bridge Moor, Thorne near Doncaster, South Yorkshire (see also *RadCom* Dec 2017 pp 38-39). Your comments and others would be included in a Statement of Community Involvement that is included with the planning application.

If a planning application has already been submitted then anyone can comment on the planning application, either for or against the proposal. You can only comment on planning grounds and comments must be made in writing within 21 days of the date on the published notification letter, site notice or local press notice, so you have very limited time.

There will be a list of planning grounds that can be considered and one that may be applicable is noise and disturbance resulting from use. In this context, 'noise' refers to acoustic noise which may include a humming sound but it could be argued that 'disturbance' also includes electromagnetic disturbance, that is RFI. If the edge of the solar farm is close to your QTH, you could ask the local planning authority to impose a condition about Radio Frequency Interference, to prevent radio frequency interference to users of surrounding land and buildings. The developer would be required to give details setting out how the development will be designed to ensure that the electromagnetic disturbance arising from use of the site does not prevent radio and telecommunications equipment or other equipment outside the site from operating as intended. This means in effect, showing how the development meets the "Essential Requirements" of the Electromagnetic Compatibility Regulations 2016 **[1]**.

Solar farms

A typical solar farm application might comprise ground-mounted photovoltaic solar arrays and battery-based electricity storage containers together with substation and inverter/transformer stations. Solar farms have a potential for radiating RFI at HF and possibly up to VHF if optimizers are used on the solar panels.

If each solar panel generates 250-400 watts then between 2500 and 4000 solar panels are required to generate each megawatt. So, that's a total of 125,000 to 200,000 solar panels for a 50MW solar farm. If each panel has an optimiser, that's a lot of optimisers and some optimisers have been reported to generate RF interference **[2]**.

An application for planning permission for a solar farm with a capacity of 50MW or more is considered to be a nationally significant infrastructure project and such applications must be submitted to central government and determined by the Secretary of State for Energy. An application for planning permission for a solar farm with a capacity of less may be considered by a Local Planning Authority under the Town and Country Planning Act. This may explain why a number of proposed solar farms have a capacity of 49.9MW.

As with other planning applications, any comments that you make need to be on planning grounds. You could make similar comments to those for wind farms above, but you could refer to HF and VHF, especially if you have a directional antenna that can point towards the solar farm. You could also ask for an assurance that optimisers will not be fitted to the panels.

Grid Substations

A Member located north of Buntingford in Hertfordshire reports that starting around the beginning of November 2022, he experienced significant noise on the 1.8MHz amateur band making it impossible to work all but the strongest stations. He spent several days radio direction finding in the local area, but results were inconclusive. He then mentioned the noise on the Chiltern DX Club reflector and another radio amateur said that he started to get the same noise at the beginning of November. After taking several bearings towards the Essex border, it appears that the noise is coming from the National Grid substation at Stocking Pelham, on the Herts/Essex border, about seven miles away.

Our Member reports that the RF noise appears to be radiated from something on site and it does not appear to be carried by the high voltage overhead lines (believed to be 400kV and 132kV). He is aware of another substation in Oxfordshire which has been radiating similar QRM and this too is ruining top band (1.8MHz) reception over similar distances. He comments that with grid substations peppered around the country – the National Grid website says there are about 300 of them – this could render the 1.8MHz band unusable for all but strong local contacts in many parts of the country, if this new technology is rolled out to all substations. In his opinion, it is surely unacceptable to have to suffer this level of QRM over at least a 10km radius and he asks what can be done.

We have added Stocking Pelham to the list of sites to investigate along with Bolney substation in Sussex and one in Oxfordshire. It is not clear whether there is a fault or some new type of device that generates an RF field.

Planning permission was also granted in 2016 for development of a Battery Storage Facility with 50MWh storage capacity. This is connected to the Pelham Substation. This was completed in December 2017 but it has recently been refinanced. It consists of 27 inverters and 150,000 lithium-ion battery cells. A 132kV connection links the project to the 400kV substation nearby. At the time of writing, it is not known whether or not the RFI that has been reported from Stocking Pelham is in any way related to the battery storage facility. Plans have also been submitted for a 49.99MW solar farm covering an area of 177 acres at Berden Hall Farm near Stocking Pelham.

If you hear of any planning applications related to developments at large Grid substations, similar to the type shown in **Photo 1**, then these may change the EMC characteristics. You could comment as mentioned above about preventing Radio Frequency Interference to users of surrounding land and buildings. If you are told that CIGRÉ limits will be used then you could point out that these are not derived from CISPR standards and they may be too high to protect weak signal amateur radio reception (see also December 2017 *RadCom* pp 38-39). If you are told that they aim to reduce the electromagnetic disturbance level to below the existing background disturbance level then you could ask how this background level is measured. In some cases at MF/HF, it is not the background atmospheric noise level that is being measured but the noise floor of the measuring system with a somewhat noisy 60cm diameter active loop antenna.

UK EMC Regs

According to **[1]** "The Electromagnetic Compatibility Regulations 2016 implements into UK law an EU Directive (2014/30/EU) on electromagnetic compatibility (commonly called the EMC Directive). The EU Withdrawal Act 2018 preserved the Regulations and enabled them to be amended so as to continue to function effectively now that the UK has left the EU..." At the time of writing (December 2022), there are separate Statutory Guidance notes for Northern Ireland and for Great Britain,

It is worth noting that the Essential Requirements are unchanged:

"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."

Space based solar power

The Space Energy Initiative (SEI) is working on a project called Cassiopeia, which plans to launch very large satellites into a high Earth orbit. These would harvest solar energy and beam it back down to Earth using wireless power transmission on microwave frequencies **[3]**, **[4]**. An advantage of putting solar panels in space is that they generate electricity almost 24 hours a day with no loss due to the Earth's atmosphere or clouds. Disadvantages include the cost of launching satellites and how to get the power back to Earth. The frequency allocation would need to be co-ordinated with ITU-R and it would also need high efficiency RF power amplifiers and high efficiency 'rectennas', that is antennas with rectifiers.

A power of 2GW is proposed and failsafe beam targeting would be required to control the direction of the transmitted beam. This also raises some questions about spectrum utilisation. How much power would be radiated outside the allocated frequency band including harmonics and phase noise sidebands. What effect would this have on such things as 2.4GHz wireless LANs and radio astronomy?

What is it?

The SDR plot in **Figure 1** arrived via the IARU Region 1 EMC Committee from a German radio amateur, Ulfried, who sent it to all colleagues of the German EMC group asking if anyone knows what kind of QRM source that might be.

We don't know either, do you? If you count the number of peaks, there are 50.5 peaks in 100kHz bandwidth from 3630 - 3730kHz so the spacing is 1.98kHz. The frequency is not very stable as the red lines are not straight. The vertical time scale of the waterfall display is not known but it seems to have a regular block pattern. This qualifies for the category of 'QRM-Art'.

Websearch

[1] Electromagnetic Compatibility Regulations 2016:
https://www.gov.uk/government/publications/electromagnetic-compatibility-regulations-2016

[2] PV Magazine, solar panel optimisers:
https://www.pv-magazine.com/2021/12/23/solaredge-growatt-found-in-breach-of-swedish-electromagnetic-rules-some-products-banned-from-sale/

[3] BBC News, How solar farms in space might beam electricity to Earth:
https://www.bbc.co.uk/news/business-62636746

[4] European Space Agency - Solaris preparing for Space-Based Solar Power:
https://www.youtube.com/watch?v=8ScTbb-43A4

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

Design Notes

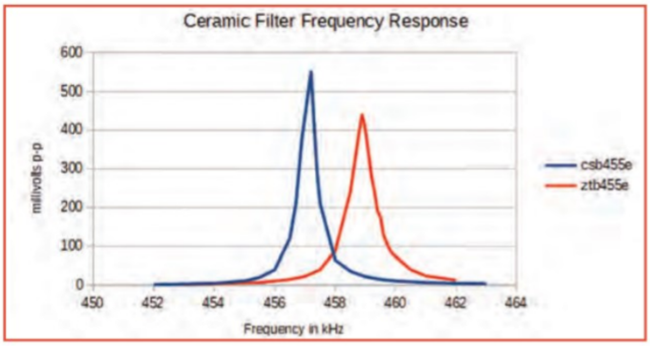


FIGURE 1: **Frequency response of the two resonators used in G7WJK's very narrow band IF amplifier.**

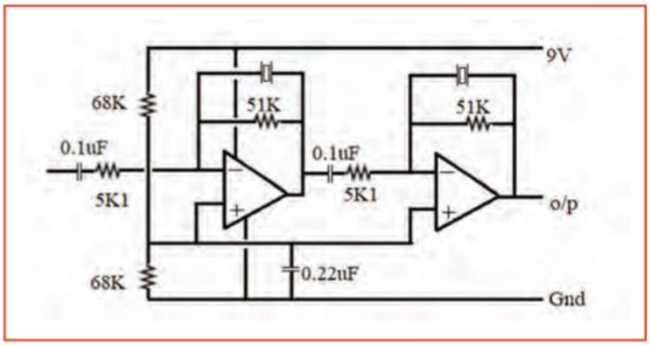


FIGURE 2: **Circuit diagram of the narrow band IF amp.**

What is Amateur Radio All About?

If you read this magazine, and indeed any of the (now sadly fewer in number) other publications dedicated to amateur radio, you would be forgiven in thinking it is all about HF, or just occasionally VHF operating, exchanging reports or the occasional brief chat using voice or morse; in other words, having *kew-ess-ohs*. OK, so the vast majority may want to do just this, exchange a few codes and numbers with their fellows, sometimes going up the hills or into the open air to do so and add a bit of variety. Some just want to rag chew, although listening to the airwaves these days the number of ops just chatting for the sake of it seems to be diminishing. It all seems a rather sad state of affairs. Surely there's more to amateur radio than having kew-ess-ohs. Or there should be. If your interest is in radio, electronics, propagation, and the technology behind it. Why is a contact not considered to be a proper one if it doesn't include two-way communication and an exchange of a report? Which seems to be a mandated requirement to qualify as a kew-ess-oh. Here at 'JNT comms I have often been known to set up a beacon or test transmission using some new mode or method, and go out for a drive with a receiver in the back of the car, or ask others to listen in. Why is that not considered 'proper'? Or just send a carrier and during a phone call or internet chat turn it on or off, asking if the other end can detect it. And then of course there is the whole beacon network, and the reverse beacons. But using these never seems to count, does it? It's not having a real kew-ess-oh, even if another station may be involved. In spite of the effort the beacon keeper has made to put that hardware on air. The moon bounce, or EME community always test their systems by listening to their own echoes – with a 2.5 second transit time that is quite a practical proposition. And I was at G3PLX's QTH back in 1998 or thereabouts when he demonstrated around the world propagation, monitoring his own transmissions after the 140ms round trip on 21MHz, then a second time around, then a third, all stacking up. That wasn't having a QSO but it was amateur radio, pushing technology in a way few others had. The high-altitude ballooners unfortunately can't use amateur bands for their work due to the licence restrictions, so have to use low power licence-free frequencies, but they would if they could. Then there's telemetry, remote operations, control, playing with modulation and coding, testing stuff, anything that uses radio and RF in unusual ways. And so it goes on, all sorts of interesting experiments and trials to be had. But if you don't make two-way communication with another station, it's not deemed real amateur radio is it? Rant over.

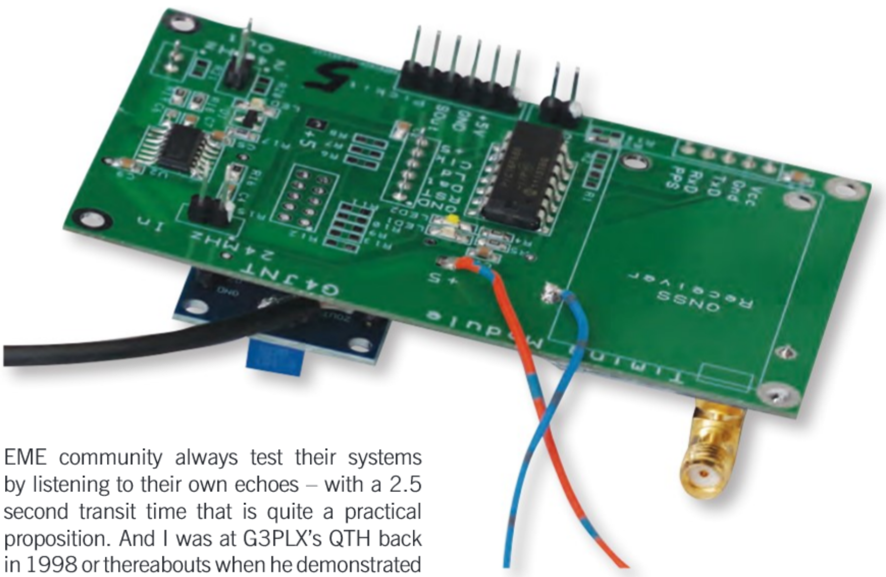


PHOTO 1: **GB3MBA Timing Module**

GB3MBA Timing Unit

In October's RadCom Brian, G4NNS, described the GB3MBA meteor Beacon project for accurate determination of meteor timings using a carrier sent on 50.408MHz. Phase two of that project is now underway, designing and writing code for automatic collection and monitoring systems that can detect, monitor, and stream data from meteor reflections. As part of that, accurate timing is needed so that multiple recordings can be correlated. A time resolution of less than one millisecond is required to be able to cross-correlate reflections. So as part of the process a timing module has been built to timestamp the recordings. The timing module

PHOTO 2: Serial-SPI converter sitting on ADF4351 synthesizer module.

uses a 16F688 PIC microcontroller and has two tasks to perform. One is to supply the monitoring hardware – probably a Raspberry Pi – with data that allows it to know real time, UTC, to within one second. Then to get the high timing resolution needed, the RF input to the monitoring receiver is supplied with pulses of RF whose timing is derived from UTC, one or two kilohertz away from the beacon reflection frequency at 50.407kHz or thereabouts. Close enough that the pulses are carried in the same audio stream from the receiver, but far enough away to not actually corrupt the wanted echo signal. That way, the actual echo is time stamped precisely and the delays inherent in SDR software, typically hundreds of milliseconds, are removed. To ensure accuracy throughout the entire system, a master 24MHz reference signal, generated from a GPSDO is supplied to the synthesizer and to clock the R-Pi. The timing module contains a buffer and splitter for this waveform. The hardware consists of a single PCB as shown in **Photo 1**.

This carries the GNSS module, the PIC with a few peripheral components and the 24MHz buffer / logic level splitter. Header connections for directly plugging into the popular AD9850 DDS module and ADF4351 evaluation boards are provided. The ADF4351 requires 3.3V logic drive so each of the four drive lines needs to be potted-down from the 5V logic used in the timing module. The AD9850 runs from 5V.

Functionality and Time Code

The GNSS receiver module generates two signals, an NMEA data stream carrying all the data wanted, and a lot more, but we are only interested in one NMEA sentence carrying UTC time, sent once per second. The GNSS module also generates a one pulse-per-second signal whose leading edge is accurate to the UTC seconds epoch to within a few tens of nanoseconds. The complete NMEA stream could be sent to the R-Pi, but since it needs to be decoded locally for the next stage, the time and date are filtered out and reconstructed into a short more precise sentence format sent on a serial interface to the 'Pi . An ident is included within the sentence, a fixed number 0 – 99, to identify which receiver is generating this stream. A typical sentence sent to the R-Pi looks like this:

05-2022/11/07*16:53:24   05 is the station unit ident.

The RF can be generated either in an ADF4351 PLL synthesizer – one of the many popular modules to be found on Ebay, or from an AD9850 DDS module, also in plentiful supply on the same site. A compile-time option in the PIC firmware selects which synthesizer type is to be used. The ADF4351 PLL synthesizer can generate directly at 50MHz and there is a convenient pin on the chip, pin 26 PDB_{RF} (power down), which when pulsed with a logic signal switches the RF on and off. At switch-on or reset the PIC programmes the ADF4351 to generate at the correct frequency then when one-PPS pulses arrive from the GNSS receiver, reads the NMEA stream and maintains internal time keeping, clocked from the PPS signal. The internal timekeeping registers are updated from the NMEA stream once per minute. The PIC drives this PDB pin to put RF on within one microsecond of the PPS leading edge for the desired pulse duration. The AD9850 DDS is slightly more difficult to pulse on and off as it has no output disable pin. Instead, the DDS is programmed with the wanted frequency for 'RF on' then reprogrammed with zero frequency for 'RF off'. To ensure high resolution timing, the Load Enable, the 'trigger' line that is always part of the SPI interface and loads the serial data sent to the DDS chip into its working registers, is activated within a microsecond of the PPS leading edge. A complete zero frequency command to turn off the RF appears after the desired pulse duration. The AD9850 cannot generate 50MHz directly when driven by a 24MHz clock so it is programmed to generate 2.407MHz, where the third image product at 2.Fclock + RF gives the wanted output. The leading edge of the RF pulse starts within a microsecond of the UTC second and the width of the pulse carries a time code so that the exact date and time can be recovered from the audio stream alone; the coding works like this. A binary '0' is represented by a pulse of 40ms duration, a binary '1' by a 100ms pulse. The minute marker at the :00 seconds epoch consists of a 300ms duration pulse. These are sufficiently different in sound that they can be differentiated and decoded manually by ear – after a bit of practice! The coding technique is similar in concept to that from the MSF 60kHz timecode transmission except that it is a bit more compact, sending just enough bits in each field for binary values of minute, hour, day etc. instead of the BCD format MSF adopts. The same flag '01111110' is used as for MSF. The bit pattern sent once per minute with each bit taking a one second time slot takes the form:

X M M M M M M H H H H H H D D D D D D m - m m m Y Y Y Y Y Y Y Y 0 0 0 0 i i i i i i - ii01111110000000000000X...

X is the 300ms minute marker followed by **M**inutes 0 – 59, **H**ours 0 – 23, **D**ay, **m**onth, **Y**ear , **i**dent, flag. The zeroes after the year and at the end of the flag could be used for future enhancements such as parity or error checking. Leap second issues with GNSS receivers were covered in December's Design notes. It was initially thought that the PUBX sentence could be used here and leap seconds corrected for, but it proved quite difficult to repeatedly poll for leap second status and simultaneously maintain accurate time keeping. So instead, a 12.5 minute timer is started at turn on and a red LED illuminated until the time period has lapsed. The serial data stream to the R-Pi is also flagged by an asterisk inserted between date and time fields while this timer is running. Since it could conceivably take up to 12.5 minutes for leap seconds to be updated this delay marker serves as a warning that there

Andy Talbot, G4JNT
andy.g4jnt@gmail.com

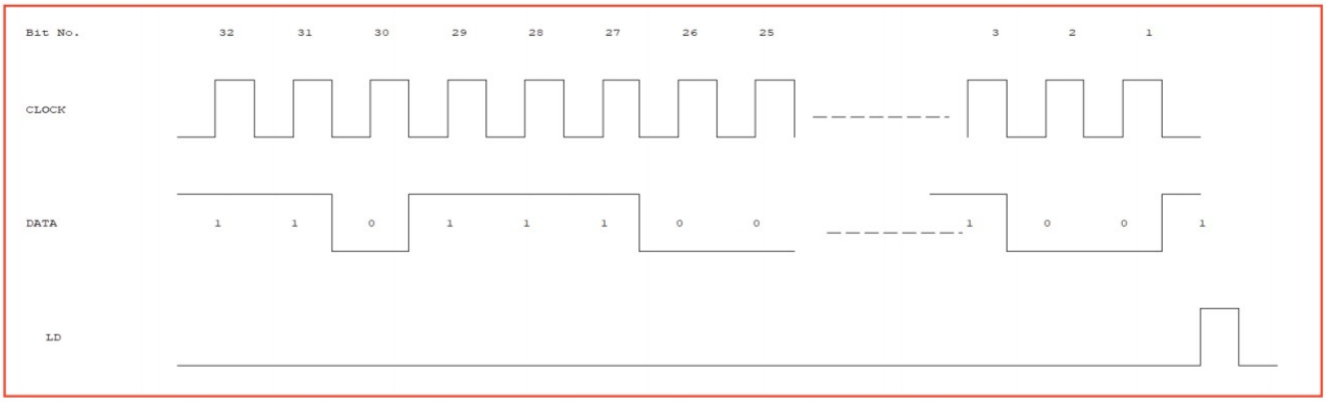


FIGURE 3: SPI Signal diagram for probably the more common format of bits used in several types of synthesizer.

could be a potential timing error of 2 or 3 seconds. It will be corrected at some point before the timeout, but the operator needs to be made aware to watch out for possible timing errors during this first 12.5 minutes after switch on.

Very Narrow Band IF Amplifier

Ned Stephens, G7WJK sent in this. "I have recently been experimenting with very narrow band IF amplifier filters and thought that the results may be of use to some of your readers. The need arose when trying to build a receiver for MSF on 60kHz, there appeared to be a carrier of some sort on a frequency around 62kHz (I don't have the means to measure it accurately). The usual tuned circuits were not up to the job of eliminating this carrier, so another way had to be found. Using a ceramic resonator local oscillator of approx. 400kHz, the wanted MSF signal was up-converted to 460kHz and fed into a two stage narrow band filter, each stage of which uses a ceramic resonator in the feedback path of half an NE5532 double op-amp. I first measured the frequencies of a selection from a batch of ceramic resonators in an oscillator and picked the two which had their frequencies closest together. Two different sets of resonators were tried in the circuit, CSB455E, with measured frequencies of 456.858kHz and 456.898 kHz, a difference of 40Hz, and then type ZTB455E with frequencies of 458.702 and 458.841kHz, a frequency difference of 139Hz.

"The input signal was 4mV p-p, and both this and the outputs were measured on an oscilloscope and therefore may not be all that accurate. At resonance a gain of over a 100 was achieved. The frequency of the local oscillator can be pulled so that when added to the 60kHz MSF signal the frequency matches that of the filter. The circuit in **Figure 2** solved the problem of the nearby carrier.

"I have not yet tried to improve the circuit, but one idea for the future is to place a trimmer capacitor in series with one or other of the resonators to tune them to precisely the same frequency. I haven't seen resonators used in this fashion before, so hope the circuit may be of use or at least provide food for thought."

Synthesizer Programming using SPI

SPI or Serial Peripheral Interface was mentioned above in the context of control of the synthesizer chip, so it is opportune to here describe a general purpose PC serial to SPI module in use at 'JNT labs for interfacing to just about any synthesizer or DDS chip. SPI itself is used for programming many device types that need external loading of data. It consists of three logic signals, data, clock and load. The data line is toggled '0' or '1' with the binary words to load into particular registers in the target chip, sent one bit after another. Each bit in turn sent on the data line has an associated toggle of the clock. Data usually, but not always, changes with the negative going clock edge, while the target chip clocks each bit in on the positive going edge. When the requisite number of bits have been sent, the Load, or LE (load enable) line is pulsed to transfer the received data into the device's working registers. The process is shown diagrammatically in **Figure 3**.

There is no set format for the SPI signalling, the number of registers that have to be set, the number of bits in a transfer, or even which clock edge is used and whether the data is sent most-significant first (the usual case) or LSB first (occasionally, just to annoy). Or whether LD has to be held low during the transfer, or just pulsed high at the end (both are often allowed, but not always). Here at 'JNT labs I made a universal module using a PIC to convert commands sent on a serial interface from a PC (actually using RS232 levels) into SPI commands to drive any specific chip. The PIC firmware has to be customised to whichever particular target device is in use but several synthesizers use similar protocols so there are minimal PIC firmware differences between several versions. The ADF4351 and ADF4150 synthesizer chips for instance use the same firmware; for the ADF5355 only a couple of lines of code need to be changed. The MAX2870 – about to undergo investigation – looks as if it can also use the same firmware. That for the AD9850 DDS is totally different in its SPI protocol. Whatever target SPI protocol is in use, a common command on the serial interface will send it. This takes the form typically (although it does vary for different target devices), of R01234567[cr]. The initial R means set a register, and this is followed by the data sent in hexadecimal and a carriage return to terminate. The PIC converts the hex data to a bit stream and sends this to the target chip. Where multiple registers are used, such as is the case in all synthesizers, the address of which register is being updated is usually embedded in the data stream. Conversely, the AD9850 DDS just needs a single stream of 40 bits to completely set it to any particular frequency.

The register set can also be stored in non-volatile memory on the PIC. This is saved after each SPI command by issuing a command on the PC interface. It means a complete register set can be sent to the synthesizer when it is booted up allowing autonomous start up at a single frequency, then allowing straightforward reconfiguration via the serial (RS232) interface. To complete a synthesizer control suite, custom Windows software has been written for several device types to calculate the register contents from any wanted frequency, clock, step size etc. then automatically send them as ASCII Hex characters to the PIC interface. It does make programming the LMX2541, ADF4351, AD9850, AD9852 and several other synthesizer chips very straightforward. **Photo 2** shows one of these modules sitting on top of an ADF4351. More details can be found on my website **[1]**.

References

[1] http://www.g4jnt.com/Serial_SPI.pdf and http://www.g4jnt.com/Synthesizers.htm

RSGB Band Plan 2023

The following band plan is largely based on that agreed at IARU Region 1 General Conferences, with some local differences on frequencies above 430MHz.

EFFECTIVE FROM 1st JANUARY 2023 UNLESS OTHERWISE SHOWN

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

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

472kHz (600m)	NECESSARY BANDWIDTH	UK USAGE

IARU Region 1 does not have a formal band plan for this allocation but has a usage recommendation (Note 1).

472-479kHz	500Hz	CW, QRSS and Narrowband Digital Modes

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

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

Note 1: Lowest LSB carrier frequency (dial setting) should be 1,843kHz. AX25 packet should not be used on the 1.8MHz band.
Licence Notes: 1,810-1,850kHz – Primary User: 1,810-1,830kHz on a non-interference basis to stations outside of the UK. 1,850-2,000kHz – Secondary User. 32W (15dBW) maximum.
Notes to the Band Plan: As on page 44.

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

Note 1: Lowest LSB carrier frequency (dial setting) should be 3,603kHz.
Licence Notes: Primary User: Shared with other user services.
Notes to the Band Plan: As on page 44.

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

Unless indicated, usage is All Modes (necessary bandwidth to be within channel limits).
Note 1: Upper Sideband is recommended for SSB activity.
Note 2: Activity should avoid interference to the experimental beacons on 5290kHz.
Note 3: Amplitude Modulation is permitted with a maximum bandwidth of 6kHz, on frequencies with at least 6kHz available width.
Note 4: Contacts within the UK should avoid the WRC-15 band (5351.5 - 5366.5kHz) if possible
For the latest current guidance refer to the RSGB website
Licence Notes: Full Licensees only, **Secondary User, 100 watts maximum**. Note that conditions on transmission bandwidth, power and antennas are specified in the Licence. For the latest current guidance, refer to the RSGB website
Notes to the Band Plan. As on page 44.

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

Note 1: Lowest LSB carrier frequency (dial setting) should be 7,053kHz.
Note 2: PSK31 activity starts from 7,040kHz. Since 2009, the narrowband modes segment starts at 7,040kHz.
Licence Notes: 7,000-7,100kHz Amateur and Amateur Satellite Service – Primary User. 7,100-7,200kHz Amateur Service – Primary User.
Notes to the Band Plan: As on page 44.

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

Licence Notes: Amateur Service – Secondary User.
Notes to the Band Plan: As on page 44.
The 10MHz band is allocated to the amateur service only on a secondary basis. The IARU has agreed that only CW and other narrow bandwidth modes are to be used on this band. Likewise the band is not to be used for contests and bulletins. SSB may be used on the 10MHz band during emergencies involving the immediate safety of life and property, and only by stations actually involved with the handling of emergency traffic. The band segment 10,120-10,140kHz may only be used for SSB transmissions in the area of Africa south of the equator during local daylight hours.

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

Licence Notes: Amateur Service – Primary User. 14,000-14,250kHz Amateur Satellite Service – Primary User.
Notes to the Band Plan: As on page 44.

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

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

Licence Notes: Amateur and Amateur Satellite Service – Primary User. The band is not to be used for contests or bulletins.
Notes to the Band Plan: As on page 44.

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

Note 1: 21,125-21,245 is also designated for use by amateur satellites
Licence Notes: Amateur and Amateur Satellite Service – Primary User.
Notes to the Band Plan: As on page 44.

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

Licence Notes: Amateur and Amateur Satellite Service – Primary User. The band is not to be used for contests or bulletins.
Notes to the Band Plan: As on page 44.

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

Note 1: Experimental wide bandwidth operation within 29,000 - 29,510 must be on a non-interference basis to other stations, including the amateur satellite service segment at 29300 - 29510 kHz.
Licence Notes: Amateur and Amateur Satellite Service – Primary User: 26dBW permitted. Beacons may be established for DF competitions except within 50km of NGR SK985640 (Waddington).
Notes to the Band Plan: As on page 44.

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

Note 1: Only to be used between stations in different continents (not for intra-European QSOs).
Note 2: 50.0-50.1MHz is currently shared with Propagation Beacons. These are due to be migrated to 50.4-50.5MHz, to create more space for Telegraphy and a new Synchronised Beacon Project.
Note 3: 20kHz channel spacing. Channel centre frequencies start at 51.430MHz.
Note 4: Embedded data traffic is allowed with digital voice (DV).
Note 5: May be used for Emergency Communications and Community Events.
Note 6: Digital experiments to support innovation may occur at 50.6, 51.0 or 51.7MHz with maximum bandwidths of 50, 200 and 400kHz respectively on a non-interference basis.
Licence Notes: Amateur Service 50.0-51.0MHz – Primary User. Amateur Service 51.0-52.0MHz – Secondary User. 100W (20dBW) maximum. Available on the basis on non-interference to other services (inside or outside the UK).
Notes to the Band Plan: As on page 44.

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

Note 1: Usage by operators in other countries may be influenced by restrictions in their national allocations.
Note 2: May be used for Emergency Communications and Community Events.
Licence Notes: Amateur Service 70.0-70.5MHz – Secondary User: 160W (22dBW) maximum. Available on the basis of non-interference to other services (inside or outside the UK).
Notes to the Band Plan: As on page 44.

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

144.500-144.794	20kHz	All Modes (Note 8) 144.500MHz – Image Modes Centre (SSTV, FAX, etc) 144.600MHz – Data Centre of Activity (MGM, RTTY, etc) 144.6125MHz – UK Digital Voice (DV) Calling (Note 9) 144.625-144.675MHz – See Note 10 144.750MHz – ATV Talkback 144.775-144.794MHz – See Note 10 144.794-
144.990	12kHz	MGM Digital Communications (Note 15) 144.800-144.9875MHz – MGM/Digital Communications 144.8000MHz – Unconnected Nets – APRS, UiView etc (Note 14) 144.8125MHz – DV Internet Voice Gateway 144.8250MHz – DV Internet Voice Gateway 144.8375MHz – DV Internet Voice Gateway 144.8500MHz – DV Internet Voice Gateway 144.8625MHz – DV Internet Voice Gateway 144.8750 - 144.9125 - Internet Gateways 144.9250MHz – Digital Usage 144.9375MHz – Digital Usage 144.9500MHz – Digital Usage 144.9625MHz – FM Internet Voice Gateway 144.9750MHz, 144.9875MHz To Be Decided (Note 11)
144.990-145.1935	12kHz	FM/DV RV48-RV63 Repeater Input Exclusive (Note 2 & 5)
145.200	12kHz	FM/DV Space Communications (eg ISS) – Earth-to-Space 145.2000MHz – (Note 4 & 10)
145.200-145.5935	12kHz	FM/DV V16-V47 – FM/DV Simplex (Note 3, 5 & 6) 145.2250MHz – See Note 10 145.2375MHz – FM Internet Voice Gateway (IARU common channel) 145.2500MHz – Used for Slow Morse Transmissions 145.2875MHz – FM Internet Voice Gateway (IARU common channel) 145.3375MHz – FM Internet Voice Gateway (IARU common channel) 145.5000MHz – FM Calling (Note 12) 145.5250MHz – Used for GB2RS News Broadcast. 145.5500MHz – Used for Rally/exhibition Talk-in 145.5750MHz, 145.5875MHz (Note 11)
145.5935-145.7935	12kHz	FM/DV RV48-RV63 – Repeater Output (Note 2)
145.800	12kHz	FM/DV Space Communications (eg ISS) – Space-Earth
145.806-146.000	12kHz	All Modes – Satellite Exclusive

Note 1: Meteor scatter operation can take place up to 26kHz higher than the reference frequency.
Note 2: 12.5kHz channels numbered RV48-RV63. RV48 input = 145.000MHz, output = 145.600MHz.
Note 3: 12.5kHz simplex channels numbered V16-V47. V16 = 145.200MHz.
Note 4: Emergency Communications Groups utilising this frequency should take steps to avoid interference to ISS operations in non-emergency situations.
Note 5: Embedded data traffic is allowed with digital voice (DV).
Note 6: Simplex use only – no DV gateways.
Note 7: Not used.
Note 8: Amplitude Modulation (AM) is acceptable within the All Modes segment. AM usage is typically found on 144.550MHz. Users should consider adjacent channel activity when selecting operating frequencies.
Note 9: In other countries IARU Region 1 recommends 145.375MHz.
Note 10: May be used for Emergency Communications and Community Events.
Note 11: May be used for repeaters in other IARU Region 1 countries.
Note 12: DV users are asked not to use this channel, and use 144.6125MHz for calling.
Note 13: Not used.
Note 14: 144.800 use should be NBFM to avoid interference to 144.8125 DV Gateways.
Licence Notes: Amateur Service and Amateur Satellite Service – Primary User. Beacons may be established for DF competitions except within 50km of TA 012869 (Scarborough).
Notes to the Band Plan: As on page 44.

146MHz IARU Recommendation	NECESSARY BANDWIDTH	UK USAGE

Access to this band requires an appropriate NoV, which is available to Full Licensees only

146.000-146.900MHz	500kHz	Wideband Digital Modes (High speed data, DATV etc) 146.500MHz Centre frequency for wideband modes (Note 1)
146.900-147.000MHz	12kHz	Narrowband Digital Modes including Digital Voice 146.900 146.9125 146.925 146.9375 Not available in/near Scotland (see Licence Notes & NoV terms) 146.9500 146.9625 146.9750 146.9875

Note 1: Users of wideband modes must ensure their spectral emissions are contained with the band limits.
Licence Notes: Full Licensees only, with NoV, 50W ERP max – not available in the Isle of Man or Channel Isles. Note that additional restrictions on geographic location, antenna height and upper frequency limit are specified by the NoV terms.
It should be emphasised that this band is UK-specific and is available on a non-interference basis to existing services. Upper Band limit 147.000MHz (or 146.93750 where applicable) are absolute limits and not centre frequencies. The absolute band frequency limit in or within 40km of Scotland is 146.93750MHz – see NoV schedule
Notes to the Band Plan: As on page 44.

430MHz (70cm) IARU Recommendation	NECESSARY BANDWIDTH	UK USAGE
430.0000-431.9810MHz All Modes		430.0125-430.0750MHz – FM Internet Voice Gateways (Notes 7, 8) 430.250-430.300 MHz UK DV 9 MHz reverse-split repeaters – Outputs 430.4000-430.7750 – UK DV 9MHz Split Repeaters – inputs
Digital Links 430.6000-430.9250 Digital Repeaters		430.8000MHz – 7.6MHz Talk-through (Note 10) 430.8250-430.9750MHz – RU66-RU78 7.6MHz Split Repeaters – outputs See Licence Exclusion Note; 431-432MHz 430.9900-431.9000MHz – Digital Communications 431.0750-431.1750MHz – DV Internet Voice Gateways (Note 8)
432.0000-432.1000	500Hz	432.0500MHz Telegraphy Centre of Activity Telegraphy, MGM
432.1000-432.4000 SSB, Telegraphy MGM	2700Hz	432.2000MHz – SSB Centre of Activity 432.3500MHz – Microwave Talkback (Europe) 432.3700MHz – Meteor Scatter Calling
432.4000-432.4900	500Hz	Propagation Beacons only
432.4900-432.9940 All Modes Non-channelised	25kHz (Note 11)	432.491-432.493MHz Personal Weak Signal MGM Beacons (BW: 500Hz max) 432.5000MHz – Narrowband SSTV Activity Centre 432.6250-432.6750MHz Digital Communications (25kHz channels) 432.7750MHz 1.6MHz Talk-through – Base TX (Note 10)
432.9940-433.3810 FM repeater outputs in UK only (Note 1)	25kHz (Note 11)	433.0000-433.3750MHz (RB0-RB15) – RU240-RU270 FM/DV Repeater Outputs (25kHz channels) in UK Only
433.3940-433.5810 FM/DV (Notes 12, 13) Simplex Channels	25kHz (Note 11)	433.4000MHz U272 – IARU Region 1 SSTV (FM/AFSK) 433.4250MHz U274 433.450MHz U276 (Note 5) 433.4750MHz U278 433.5000MHz U280 – FM Calling Channel 433.5250MHz U282 433.5500MHz U284 – Used for Rally/Exhibition Talk-in 433.5750MHz U286
433.6000-434.0000 All Modes 433.8000MHz for APRS where 144.8000MHz cannot be used		433.6250-6750MHz – Digital Communications (25kHz channels) 433.7000MHz-433.7750MHz (Note 10) 433.8000-434.2500 MHz Digital communications & Experiments 434.0000 Low Power Non-NoV Personal Hot-Spot usage
434.0000-434.5940	25kHz (Note 11)	433.9500-434.0500MHz – Internet Voice Gateways (Note 8) 434.3750MHz 1.6MHz Talk-through – Mobile TX (Note 10) 434.4750-434.5250MHz DV Internet voice gateways (Note 8)
434.5940-434.9810 FM repeater inputs in UK only	25kHz (Note 11)	434.6000-434.9750MHz (RB0-RB15) RU240-RU270 FM/DV Repeater Inputs (25kHz channels) in UK Only (Note 12)
435.0000-436.0000		Satellites only
436.0000-438.0000		Satellites and Experimental DATV/Data 437.0000 Experimental DATV Centre of Activity (Note 14)
438.0000-440.0000 All Modes		438.8000 Low Power Non-NoV Personal Hot-Spot usage 438.0250-438.1750MHz – IARU Region 1 Digital Communications 438.2000-439.4250MHz (Note 1) 438.4000MHz – 7.6MHz Talk-through (Note 10) 438.4250-438.5750MHz RU66-RU78 – 7.6MHz Split Repeaters – inputs 438.6125MHz – UK DV calling (Note 12) (Note 13) 438.8000 Low Power Non-NoV Personal Hot-Spot usage 439.2500-439.3000MHz UK DV 9MHz reverse-split repeaters – Inputs 439.6000-440.0000MHz – Digital Communications 439.4000-439.7750MHz – UK DV 9MHz split repeaters – Outputs

Note 1: In Switzerland, Germany and Austria, repeater inputs are 431.0500-431.8250MHz with 25kHz spacing and outputs 438.6500-439.4250MHz. In Belgium, France and the Netherlands repeater outputs are 430.0250-430.3750MHz with 12.5kHz spacing and inputs at 431.6250-431.9750MHz. In other European countries repeater inputs are 433.0000-433.3750MHz with 25kHz spacing and outputs at 434.6000-434.9750MHz, ie the reverse of the UK allocation.
Note 2: 430-440MHz FM/DV maximum bandwidths are 12.5 or 25kHz as appropriate
Note 3, Note 4: Not used.
Note 5: In other countries IARU Region 1 recommends 433.4500MHz for DV calling.
Note 7: Users must accept interference from repeater output channels in France and the Netherlands at 430.0250-430.5750MHz. Users with sites that allow propagation to other countries (notably France and the Netherlands) must survey the proposed frequency before use to ensure that they will not cause interference to users in those countries.
Note 8: All internet voice gateways: 12.5kHz channels, maximum deviation ±2.4kHz, maximum effective radiated power 5W (7dBW), attended only operation in the presence of the NoV holder.
Note 10: May be used for Emergency Communications and Community Events.
Note 11: IARU Region 1 recommended maximum bandwidths are 12.5 or 20kHz.
Note 12: Embedded data traffic is allowed with digital voice (DV).
Note 13: Simplex use only – no DV gateways.
Note 14: QPSK 2 Mega-symbols/second maximum recommended.
Licence Notes: Amateur Service – Secondary User. Amateur Satellite Service: 435-438MHz – Secondary User. Exclusion: 431-432MHz not available within 100km radius of Charing Cross, London. Power Restriction 430-432MHz is 40 watts effective radiated power maximum.
Notes to the Band Plan: As on page 44.

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

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

Note 1: Local traffic using narrowband modes should operate between 1296.500-1296.800MHz during contests and band openings.
Note 2: Stations in countries that do not have access to 1298-1300MHz may also use the FM simplex segment for digital communications.
Note 3, Note 4: Not used.
Note 5: Embedded data traffic is allowed with digital voice (DV).
Note 6: Simplex use only – no DV gateways.
Note 7: 1240.000-1240.750 has been designated by IARU as an alternative centre for narrowband activity and beacons. Operations in this range should be on a flexible basis to enable coordinated activation of this alternate usage.
Note 8: The band 1240-1300MHz is subject to major replanning. Contact the Microwave Manager for further information.
Note 9: Repeaters and Migration to DATV, inc option for new DATV simplex are subject to further development and coordination.
Note 10: QPSK 4 Mega-symbols/second maximum recommended.
Licence Notes: Amateur Service – Secondary User. Amateur Satellite Service: 1,260-1,270MHz – Secondary User Earth to Space only. In the sub-band 1,298-1,300MHz unattended operation is not allowed within 50km of SS206127 (Bude), SE202577 (Harrogate), or in Northern Ireland.
Notes to the Band Plan: As on page 44.

2.3-2.302GHz IARU Recommendation	NECESSARY BANDWIDTH	UK USAGE

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

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

Note 1: Users of wideband modes must ensure their spectral emissions are contained within the band limits.
Note 2: Full licensees only with NoV, 400 watts maximum, not available in the Isle of Man. Note additional restrictions on usage are specified by the NoV terms. It should be emphasised that this is UK-specific and is available on a non interference basis to existing services.
Notes to the Band Plan: As on page 44.

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

Note 1: Stations in countries which do not have access to the All Modes section 2,322-2,390MHz, use the simplex and repeater segment 2,320-2,322MHz for data transmission.
Note 2: Stations in countries that do not have access to the narrowband segment 2,320-2,322MHz, use the alternative narrowband segments 2,304-2,306MHz, 2,308-2,310MHz and 2400-2402MHz.
Note 3: The segment 2,433-2,443MHz may be used for ATV if no satellite is using the segment.
Licence Notes: Amateur Service – Secondary User. Users must accept interference from ISM users. Amateur Satellite Service: 2,400-2,450MHz – Secondary User. Users must accept interference from ISM users. Operation in 2310-2350 and 2390-2400 MHz are subject to specific conditions and guidance In the sub-bands 2,310.000-2,310.4125 and 2,392-2,450MHz unattended operation is not allowed within 50km of SS206127 (Bude) or SE202577 (Harrogate). ISM = Industrial, scientific and medical.
Notes to the Band Plan: As on page 44.

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

Note 1: EME has migrated from 3456MHz to 3400MHz to promote harmonised usage and activity.
Note 2: Stations in many European countries have access to 3400-3410MHz as permitted by CEPT ECA Table Footnote EU17.
Note 3: Amateur Satellite downlinks planned.
Licence Notes: Amateur Service – Secondary User. Subject to specific conditions and guidance.
Notes to the Band Plan: As on page 44.

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

Licence Notes: Amateur Service: 5,650-5,680MHz – Secondary User. 5,755-5,765 and 5,820-5,850MHz – Secondary User. Users must accept interference from ISM users. Amateur Satellite Service: 5,650-5,670MHz and 5,830-5,850MHz – Secondary User. Users must accept interference from ISM users. Unattended operation is permitted for remote control, digital modes and beacons, except in the sub-bands 5,670-5,680MHz within 50km of SS206127 (Bude) and SE202577 (Harrogate). ISM = Industrial, scientific and medical.
Notes to the Band Plan: As on page 44.

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

Note 1: Deleted.
Note 2: Wideband FM is preferred between 10,350-10,400MHz to encourage compatibility between narrowband systems.
Note 3: 10,450MHz is used as an alternative narrowband segment in countries where 10,368MHz is not available.
Note 4: 10,000-10,125MHz is subject to increased Primary user utilisation and NoV restrictions.
Note 5: 10,475-10,500MHz is allocated ONLY to the Amateur Satellite Service and NOT to the Amateur Service.
Licence Notes: Amateur Service – Secondary User. Foundation licensees 1 watt maximum. Amateur Satellite Service: 10,450-10,500MHz – Secondary User. Unattended operation is permitted for remote control, digital modes and beacons except in the sub-bands 10,000-10,125MHz within 50km of SO916223 (Cheltenham), SS206127 (Bude), SK985640 (Waddington) and SE202577 (Harrogate).
Notes to the Band Plan: As on page 44.

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

Licence Notes: Amateur Service: 24,000-24,050MHz – Primary User: Users must accept interference from ISM users. 24,050-24,150MHz – Secondary User. May only be used with the written permission of Ofcom. Users must accept interference from ISM users. 24,150-24,250MHz – Secondary User. Users must accept interference from ISM users. Amateur Satellite Service: 24,000-24,050MHz – Primary User: Users must accept interference from ISM users. Unattended operation is permitted for remote control, digital modes and beacons, except in the sub-bands 24,000-24,050MHz within 50km of SK985640 (Waddington) and SE202577 (Harrogate).
ISM = Industrial, scientific and medical.
Notes to the Band Plan: As on page 44.

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

Licence Notes: Amateur Service and Amateur Satellite Service – Primary User. Unattended operation is permitted for remote control, digital modes and beacons, except within 50km of SK985640 (Waddington) and SE202577 (Harrogate).
Notes to the Band Plan: As on page 44.

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

Licence Notes:
75,500-75,875MHz Amateur Service and Amateur Satellite Service – Secondary User.
75,875-76,000MHz Amateur Service and Amateur Satellite Service – Primary User.
76,000-77,500MHz Amateur Service and Amateur Satellite Service – Secondary User.
77,500-78,000MHz Amateur Service and Amateur Satellite Service – Primary User.
78,000-81,000MHz Amateur service and Amateur Satellite Service – Secondary User.
Unattended operation is permitted for remote control, digital modes and beacons, except within 50km of SK985640 (Waddington) and SE202577 (Harrogate).
Notes to the Band Plan: As on page 44.

134GHz (2mm) IARU Recommendation	UK USAGE
134,000-134,928MHz All Modes	
134,928 -134,930 Narrowband Modes	IARU Region 1 Preferred Centre of Activity
134,930 -136,000 All Modes	

Licence Notes: 134,000-136,000MHz Amateur Service and Amateur Satellite Service – Primary User. Unattended operation is permitted for remote control, digital modes and beacons, except within 50km of SK985640 (Waddington) and SE202577 (Harrogate).

THE FOLLOWING BANDS ARE ALSO ALLOCATED TO THE AMATEUR SERVICE AND THE AMATEUR SATELLITE SERVICE

122,250-123,000MHz – Amateur Service only, Secondary User
136,000-141,000MHz – Secondary User
241,000-248,000MHz – Secondary User
248,000-250,000MHz – Primary User

Note 1: Access to frequencies >275 GHz by Full Licensees is also possible by NoV.
Notes to the Band Plan: As on page 44.

NOTES TO THE BAND PLAN

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

472-479kHz: Access is available to Full licensees only – see licence schedule for additional conditions.

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

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

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

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

10MHz: SSB may be used during emergencies involving the immediate safety of life and property and only by stations actually involved in the handling of emergency traffic.

The band segment 10120kHz to 10140kHz may be used for SSB transmissions in the area of Africa south of the equator during local daylight hours.
News bulletins on any mode should not be transmitted on the 10MHz band.

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

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

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

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

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

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

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

Technical

Wireless Morse Keys – Part 2

Following on from my article in the January 2023 issue of RadCom, here is further information, particularly for readers wishing to construct the units:

Components

MOSFET Q1 in the sender units is for protection against a reversed power supply connection. A ZVN4424 MOSFET has been chosen for Q1 because it has a very low gate threshold voltage. The more readily available ZVN3306 will work but probably drop out when the battery voltage gets low.

If you can trust yourself never to fit the batteries the wrong way round, omit Q1 and instead, insert a link between the source and drain connections.

The values of the passive components are not critical. Capacitors are all multilayer ceramic types.

The PIC16F505 is fitted in a 14-pin socket. The full part number for the DIL version of the processor is PIC16F505-I/P.

The nRF24L01 module can be soldered directly into the board but it's probably better to fit it in a 2 x 4 pin socket (I used two 4-pin SIL sockets side by side, cut from a long strip).

The units are housed in flanged boxes, 70 x 50 x 29mm from RS Components but, of course, you may choose to use a different type.

The two push buttons on the iambic sender unit have 24mm long actuating rods which protrude through holes in the box lid. The buttons were purchased from eBay. Alternatively, standard low-profile buttons could be fitted on the board with separate actuating rods running through holes in a guide block or bracket fixed inside the box lid.

Although connectors are shown for the board external connections, they may be omitted and wiring directly soldered to the boards. This will make assembly a little fiddlier but thereafter the units should rarely need to be opened.

Stripboard Preparation

The layout diagrams show a component-side view of the boards with a 2.5mm grid. The copper tracks on the underside of the boards run vertically for the whole length of the boards although, for clarity, only the active sections are shown as blue lines on the diagrams.

The blue "X"'s indicate where the tracks should be cut. For this, I use a 4mm drill bit fitted into an old control knob. Just press into the hole to be cut and give it a twirl.

PICTURE 1: Underside of Basic Sender Board.

The red lines on the layouts are wire links fitted on the top of the board.

Picture 1 is of the underside view of the basic sender board. Note the cut-out at the bottom of the board. This provides clearance under the antenna of the nRF24L01 module.

Because there is only 2.5mm between rows of pins on the nRF24L01, it is necessary to cut the stripboard tracks between adjacent holes. The easieast way I have found to do this is using a small burr in a Dremel type tool. Another way is to cut the tracks at alternate holes on either side of the connector (see the blue crosses on the iambic sender layout); solder the nRF24L01 socket in place to the uncut holes and then, using thin wire, solder links on the track side of the board between the isolated pins and the tracks they should be connected to.

Before applying power to a board, do check thoroughly with a multimeter that the board connections match the schematic and that there are no short circuits between tracks.

Unit Assembly

Picture 2 shows the iambic sender unit assembly. The battery holder is fixed by double-sided tape to the inside of the box lid. To give clearance for the battery holder, note that the layouts of the sender boards are arranged so that there are no high-profile components on the right-hand side of the board.

PICTURE 2: Iambic Sender Unit.

I suggest that lithium type AAA cells, such as Energizer Ultimate are used as they have a much flatter discharge characteristic and longer shelf life than alkaline cells.

To attach the sender units to my Morse keys, I mounted each unit at one end of a thin plywood plate which was then secured by screws or double-sided tape to the underside of the key base.

PIC16F505 Programming

Instructions on how to program the PIC505 chips together with the necessary hex files can be found in the folder at https://tinyurl.com/24hddnez

The folder also contains the MPLABX project files and notes on the project software.

Ray Scrivens, G3LNM
rayscriv2@gmail.com

Review

MYDEL Windcamp Gipsy HF antenna

The complete Gipsy Antenna pack.

The MYDEL Windcamp Gipsy is a portable wire dipole antenna that covers a range of 5-50MHz (60m to 6m).

It is very compact and comes in a sturdy canvas bag. To give you some idea of size, the antenna bag came neatly packed in a cardboard box measuring 145 x 80 x 105mm and weighs just 0.65Kg. Unpacking the bag reveals just three components – a 100W maximum 1:1 balun, plus two metal winding frames containing the 18AWG Teflon tin-plated copper wire dipole elements. The balun is very well made and has a carbon-fibre finish added to the main body. The aluminium winding frames are powder-coated in black and are quite sturdy. At one end of the balun are two screw connections for the wires and there is an SO-239 socket at the other end.

Attached to the wires are two stainless steel hooks that mate up to the balun. These have been soldered and finished with black heat-shrink tubing.

So my first thought was: how does it cover so many bands without traps, loading coils or other devices? Reading the tiny, included instructions revealed the secret. The antenna is designed to be used on the 60, 40, 30, 20, 17, 15, 12 and 10m bands. To use it, you simply unwind the antenna wire until you get the required lengths and then wrap the remaining wire around the supplied reels. To make the job easier, the wire is marked with metal clips or 'bushes' that have been attached at the appropriate points. These have been clamped onto the wire and don't move. Once spooled out, you simply clip the wire onto the reel.

It's a simple idea and the excess wire, being coiled, acts as an inductor and effectively isolates the rest of the wire from the antenna.

Antenna element reel in use.

Setting up

You just need to add some suitable coax with PL259 plugs, a centre support for the balun and cord for each end of the dipole. Windcamp supplies a small balun hanging cord.

How you hang it is up to you. A mast would be useful, or even a fibreglass fishing pole. But do bear in mind the overall weight of the antenna. A 10m pole with the last two fibreglass sections removed might be one possibility. Another alternative is to find a suitable tree. Windcamp recommends that the antenna is put up at a height of at least 6-7m. In the field, the lowest suggested height is 3-4m. It says that at lower heights the standing wave ratio will increase and the radiation efficiency will decrease. It suggests that it should be not less than a quarter wavelength high at the operating frequency. For example, on 14MHz it recommends the antenna should be not less than 5m high.

Setting the antenna up as an inverted V is also possible, as long as the angle between the elements is not less than 100-120 degrees. Otherwise, you've guessed it, the operating efficiency will decline. I don't see this as a problem at the higher frequencies but bear in mind that on 60m (5MHz) and 40m (7MHz) the antenna needs to be at 15m and 10m high respectively.

Also bear in mind that the maximum radiation will be perpendicular to the wires, so you need to consider how you erect it. That is, if the antenna runs North-South, maximum radiation will be in the East-West plane. On 60m and 40m this may not be such a big problem as it will be very much an NVIS radiator if not mounted too high. That is, ideal for close-in contacts but less effective on DX.

Other possibilities include mounting the antenna as a vertical radiator or as a flat-top dipole if you have two trees to play with.

The only downside, as I see it, is the antenna is ideal as a monoband radiator ie on one band and one band only. Yes, it will work on other bands, but you have to unfurl the dipole elements each time you wish to change bands and then adjust the support cords accordingly. During testing, this proved not to be a big problem. I used a 10m fishing pole with the top two sections collapsed. I just left the cord on the original reels and put a slip knot in to secure it at the appropriate length.

Dipole centre mounted on a pole.

This antenna really is an experimenter's delight as there is no 'wrong' way to install it, but some will be better than others. But put the effort in at the beginning, get it as high as you can and it will pay dividends.

The instructions say that you can expect a minimum SWR of 1.2:1. In testing I came close to this, but usually ended up around 1.3:1 or 1.4:1. On 30m I did get to 1.2:1 on 10.116MHz. As the antenna is a full-size dipole expect performance to be good – I quickly worked Steve at special event station GB100BBC near Cambridge on 40m SSB with an S9+30dB report.

Summary

Overall, the Gipsy outperformed my multi-band 132ft end-fed half wave (EFHW) antenna by about an S-point on all bands. This just goes to show how well a monoband dipole can perform.

I think it is an ideal antenna for portable operations and might even suit someone who needs to quickly erect and dismantle an antenna in their garden eg for contesting.

The antenna costs £71.95 plus postage and is available from Martin Lynch and Sons. My thanks to ML and S for the loan of the antenna for review.

Steve Nichols, G0KYA
infotechcomms@googlemail.com

Comet CAT-300

ATU

Front view of the Comet CAT-300 ATU.

Rear view of the Comet CAT-300 ATU.

Whilst taking the CAT-300 out of its box, the first impression I had was of a fairly chunky and well-built unit, which I find reassuring in an ATU.

The publicity material says of the unit: "*The CAT-300 is a quality 300W antenna tuner which boasts 2x antenna inputs, a very useful frequency range of 1.8-60MHz, a smart, illuminated cross-needle display and even PEP/Average power reading*".

Interestingly, in some places the upper limit of the unit is quoted as 60MHz and in others as 50MHz. I've no reason to suppose you wouldn't be able to use it at 60MHz, which might be useful to amateurs who have access to the 60MHz band (available on a secondary basis to holders of a UK Full amateur licence).

ATU practicalities

The front panel consists of a dual needle meter, power range selection (30/300W), Transmitter (TR) Tune and Aerial Tune rotary controls, Band switch, AVG/PEP power selection, Tuner in/out switch and antenna selector. The back of the unit has a coax input socket (SO-239), two coax output sockets (also SO-239), a terminal for a wire antenna, a ground terminal and a 12V input socket (to light the meter).

The band switch does not have a position for the 60m band, however, I found I was able to tune my 80m dipole up quite easily with the band switch in the 40m position.

The tuner claims to be able to match impedances between 10 and 600Ω. If you use a long wire, connect it up to the red terminal on the back panel and select Antenna 2 on the front panel switch. Bear in mind that, with an upper limit of 600Ω, you won't be able to tune 'absolutely anything', but it will give you a lot more latitude than the ATUs included in the majority of rigs (my FTDX-10, for example will cover impedances between 16.5 to 150Ω). The CAT-300 should tune most antennas that you are likely to throw at it but, if you're not sure, do a little research or chat to your dealer before you make a purchase.

A word, too, about power levels. The CAT-300 is rated at 300W. With CW/SSB it should be absolutely fine at these levels but bear in mind that FT8, FT4, RTTY etc have a much higher duty cycle so things can get quite hot. So, you'll need to drop the power to avoid damage to the ATU. The instructions point out the wisdom of tuning the antenna at low power – and not operating the band switch when you are transmitting. All good practice that you will undoubtedly be following anyway. It's probably worth saying that if you're considering running higher power, resonant antennas make your life a lot easier.

Easy to use

I found the tuner easy to use and provided a good deal of flexibility. The cross-needle meter was easy to read and I appreciated the ability to light the meter, ideal when it's a little dark in the shack. A power lead is provided to connect the ATU to your shack's 12V power supply, although it was a little short to reach my PSU on the floor! Easily sorted, of course.

Where possible, I use resonant antennas, but using the CAT-300, I found I was able to tune up several of the antennas on bands that they were not designed for. Some of them even radiated as well!

6m / 50MHz Band

The CAT-300 covers the 50MHz band. Normally, it's easier to use a resonant antenna on 6m, so an ATU doesn't often come into play. Having said that, if you are generally an HF operator, but find yourself intrigued about 6m, you may be surprised at just what you can do with tuning up a 40m dipole or similar for the band! In the Sporadic-E season, this sort of configuration would easily make contacts around Europe and possibly further afield too.

Summary

If you enjoy playing around with antennas and you'd like an ATU which is rated at a little more than 100W, the CAT-300 could fit the bill. It's a chunky, well-built unit which looks like it should last many years.

Many thanks to Mike Devereux of Nevada Radio for the loan of the Comet CAT-300. It is available for £229.95.

Tim Kirby, GW4VXE
gw4vxe@icloud.com

An improved antenna rotator controller Part 2

The RDF Doppler system V1.2

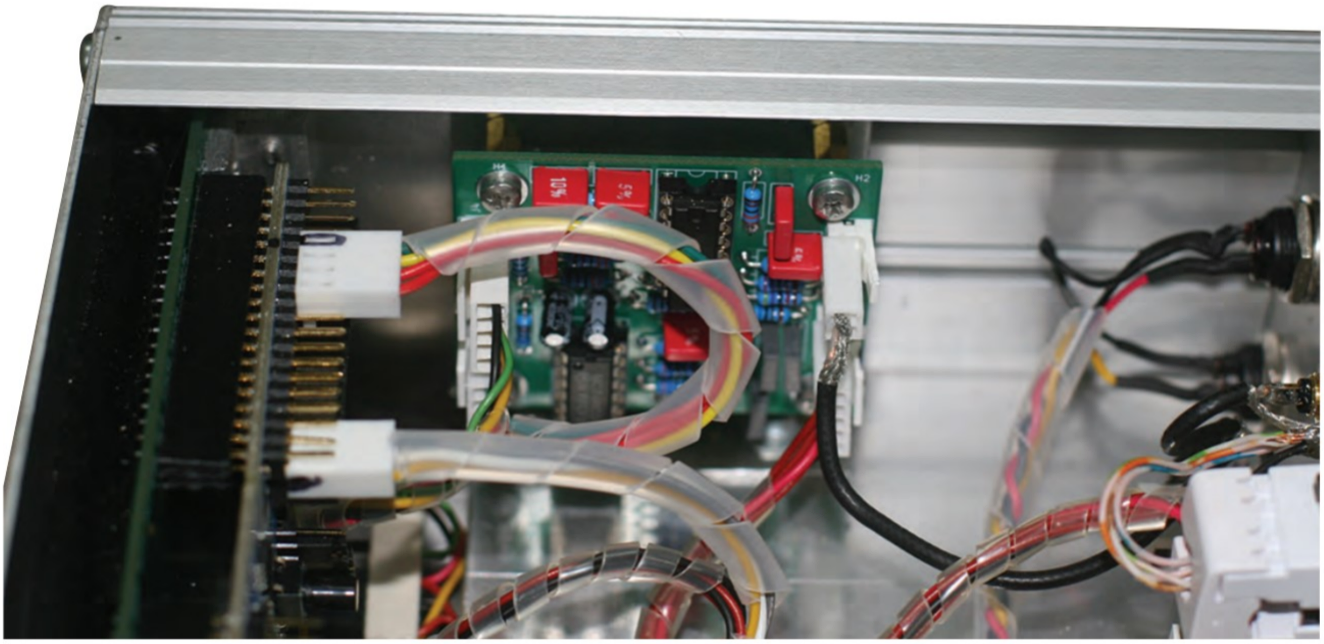


PHOTO 1: **The RDF PCB mounts neatly in the original case.**

Introduction

The first part of this article described an STM32 based controller for a Yaesu G800DXA antenna rotator. As briefly mentioned in part 1, it was decided to include a Radio Direction Finding function using Doppler. Doppler RDF is well understood and there are many articles on the web describing how it works. In 1981 I built a Doppler RDF device using analogue and logic chips plus an FM receiver and four switched vertical dipoles to simulate a rotating dipole. It worked well and there are several versions of this hardware design on the web, indeed, for old times sake, I built it again a few years ago based on an article by WA2EBY published in QST May 1999 – essentially the same as my 1980s version. I used his antenna switching design on my updated design (see photo of completed RDF control unit). With the advent of small, cheap and relatively powerful processors, I decided to create a DSP (digital signal processing) version using the same hardware as the rotator controller with the RDF firmware embedded within the rotator controller firmware. The design uses a Goertzel filter which is easy to implement in firmware and can be easily configured to detect a given frequency in a given bandwidth. Additionally, it can also measure the phase of the incoming signal which is particularly useful for RDF purposes. This article is good background reading: https://en.wikipedia.org/wiki/Goertzel_algorithm The rest of this article describes how the RDF function was implemented and used for RDF.

Hardware considerations

To generate the Doppler signal for processing means that a rotating dipole is required which feeds into an FM receiver. The Doppler signal from the FM discriminator is used to determine the heading of the incoming signal. Early RDF Doppler systems used a mechanically rotating vertical dipole, but an array of four or more sequentially switched vertical dipoles gives an adequate approximation. This is the technique used by most, if not all, modern RDF Doppler receivers. This design uses four dipoles but could easily be extended up to eight, or even more if so desired, but I doubt there would be any meaningful improvement in performance. The dipole switching design is a copy of the WA2EBY referenced above. The use of PIN diodes rather than IN914s might be beneficial – but one thing to remember DO NO NOT TRANSMIT through this array. One other important factor to be aware of is that the antenna switching needs to be a make-before-break type. In the firmware the next antenna is turned on before the preceding one is turned off. I did experiment with RF analogue switches, but they are break-before-make and led to excessive glitches in the Doppler signal. The antenna switching circuit is connected to the controller via a standard 10m Ethernet

PHOTO 2: The RDF screen displays the Azimuth Data.

cable to the RJ45 connector on the rear panel. The four signals from the STM32 controlling the state of each dipole (on / off) are buffered and current is limited by a hex inverter 74HC04 mounted on a small interface PCB. This PCB also contains a 300Hz high pass and 1KHz low pass filter. These filters remove any sub-audible tones and limit the bandwidth of the signal going into the ADC. The receiver can be any general-purpose receiver which can provide 200-1000mV peak-to-peak signal for processing by the STM32 ADC. My unit has a pre-potentiometer on the rear to adjust the audio level as required. At the most basic level, other than the receiver, dipole array and simple ADC bias circuitry, no other hardware is required. However, as mentioned above, for best performance some audio signal conditioning is required along with a digital buffer for the antenna switch – if only for no other reason than to prevent exposing the STM32 GPIO pins directly to the outside world. The LCD display and associated controls are all re-used when in RDF mode. Some of the rotator controller firmware functions are also re-used. The full details can be found at- web link [1].

Firmware

The firmware and schematic for this design is available on the web [1] and supports both rotator controller and RDF functions. Obviously, the RDF function will only work if the supporting hardware is in place. The firmware for RDF is contained within tabs called RDF and has all the key functions required. The code is well documented, and

Tim Forrester, G4WIM
tim.forrester@gmail.com

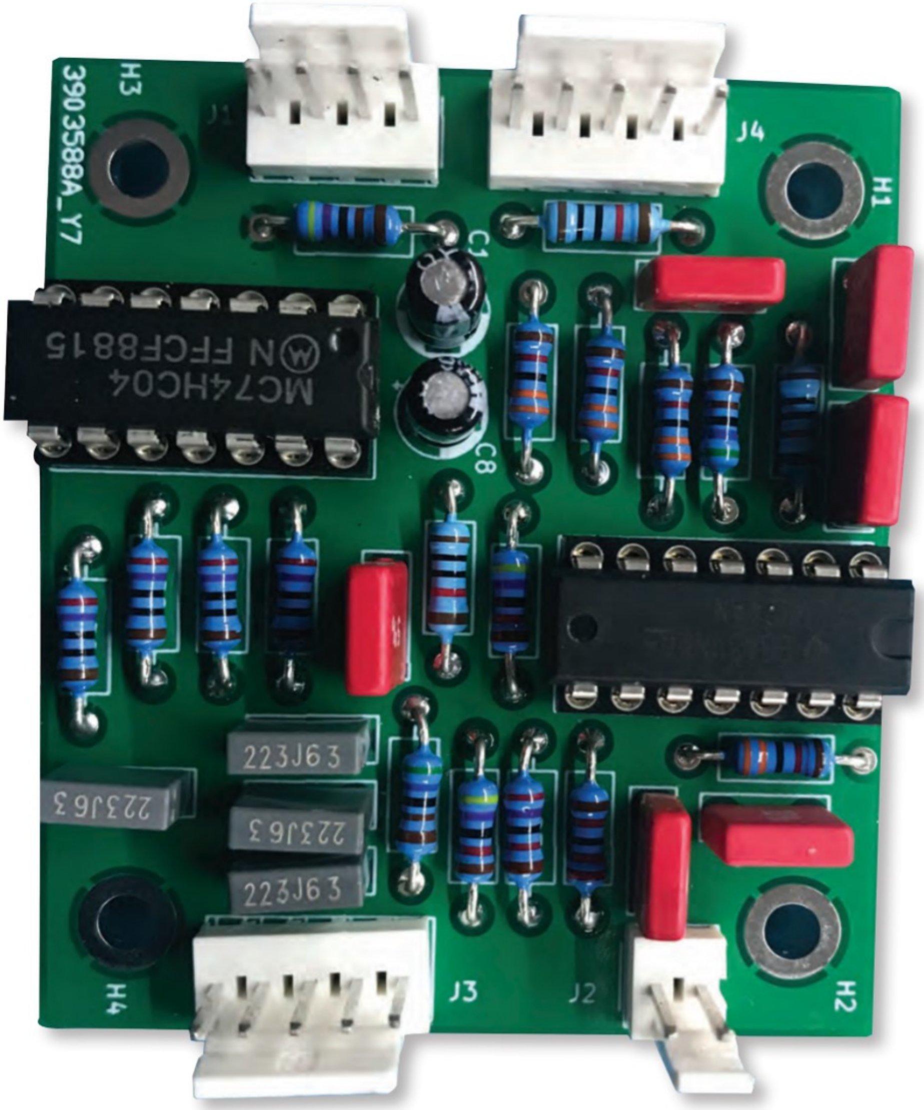


PHOTO 3: Professtional PCB construction.

the comments should explain how it works. The comments also include notes as to how long various functions take to execute. Given that the DSP sampling rate and processing must keep in step with the 'rotating' antenna timing is critical. To this end, there are two interrupt timers, one for the Doppler frequency (500Hz x 4 antennas or 2kHz / 0.5mS) and one for the sampling frequency (between 4KHz and 10KHz). To ensure they are kept in step, the counters are reset at the start of each sampling phase. The number of samples depends on the filter bandwidth and varies from 500 to 4000 depending on the bandwidth of the filter (1 to 20Hz). The firmware collects the specified number of ADC samples at the specified sampling rate into a buffer and, once the buffer is full, it is analysed by the Goertzel filter outputting amplitude and phase information. During the analysis phase the antenna 'rotation' is stopped – when listening to the Doppler tone you will hear periodic gaps at a rate set by the bandwidth, this is normal. The filter phase information is referenced to the sample rate and converted to azimuth for display. The display only updates if the azimuth has changed.

RDF Operation

When the controller is powered up and running it displays the default rotator controller screen. Pressing and holding CW then at the same time pressing CCW, followed by releasing both, allows access to the configuration menus for the rotator functions. Conversely, pressing and holding CCW then at the same time pressing CW, followed by releasing both switches, the unit goes into RDF mode. While in RDF mode, pressing CCW will cause it to exit RDF mode and revert to a standard controller. While in RDF mode, the controls take on different functions. Push button 1 sets the filter bandwidth in Hz in combination with the rotary control.

Push button 2 sets the Doppler frequency in Hz in combination with the rotary control.

Push button 3 sets the Azimuth calibration factor in combination with the rotary control.

Push button 4, in combination with the rotary control, allows each antenna to be selected in turn. It also allows the direction of the antenna rotation to be reversed – this is sometimes necessary if the output of the receiver audio is inverted. A brief press of push buttons 1 – 3 will toggle the function on or off. The text turns green when the selected mode is active. A long press saves the setting to EEPROM. Changing the filter bandwidth impacts the update time, eg a 1Hz bandwidth results in a 1 second update rate, a 2Hz bandwidth results in a 500mS update and 5Hz bandwidth results in a 200mS update rate. The bandwidth is set by the sampling rate/ number of samples. Bandwidths 1 to 20 are preset within the firmware but can be adjusted by using serial commands w and x. Any adjustments made are NOT stored to EEPROM. A bandwidth of 5Hz is normally adequate for most use cases. The Doppler frequency can be adjusted but typically 500Hz is adequate. Due to the relative phase shifts in the receive path, it is necessary to calibrate the heading on a known signal by using the calibrate function. Note: changing the bandwidth can affect the calibration, so only calibrate once you're satisfied you have optimum bandwidth and Doppler frequency set. The antenna test function is useful to select each antenna in turn to make sure it is working correctly before activating RDF and, as mentioned above, it can also invert the phase to ensure the azimuth indication moves in the same direction as the target. Thanks to Mike, M0ABK and Peter, M0CGA for providing test signals to check the accuracy of the measurements. The indicated heading of the received signal is most accurate when there is no voice modulation and only the superimposed Doppler tone is present. The RDF display shows heading, quality and amplitude. Heading indicates where the signal is coming from but be aware that reflections and multipath may affect the heading displayed. Quality indicates how noise-free the Doppler signal is on a scale of 1 to 9 with 9 being the best. Amplitude shows the absolute amplitude of the incoming signal, anything over 100 is adequate.

Conclusion

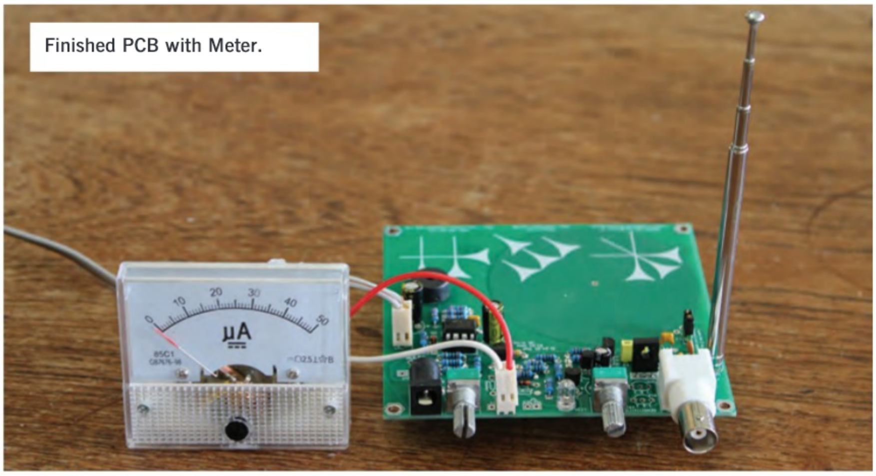
I hope this two-part article has been of interest and possibly sparked the design to build a copy. As mentioned in part 1, I have a small stock of PCBs and if there is enough demand I may also design and order a PCB for the antenna switching assembly.

Web Link [1] https://tinyurl.com/ynxpmpt8

A lightning detector

After losing a few ADSL modems to lightning, I was keen to have a cleverer method of lightning detection; ideally with a device that was not single use!

When looking for designs for lightning detectors, one inevitably comes across the web site of Charles Wenzel, a dedicated electronic enthusiast who continuously refines his designs for many things, including lightning detectors. One of his previous designs was described by Bob Radmore, N2PWP (SK) in the April 2002 issue of QST. Inspired by Wenzel's detectors, I sought to combine elements of his designs that detected flashes, output pulses, summed recent activity for display on a moving coil meter, and had a settable threshold for switching further external outputs. In addition to this, by using a spare op amp slot, I was able to add a relaxation oscillator to drive a piezo buzzer. Finally, cuneiform glyphs for Ishkur, the Mesopotamian god of storms, seemed a fitting addition to the PCB silkscreen layer.



Finished PCB with Meter.

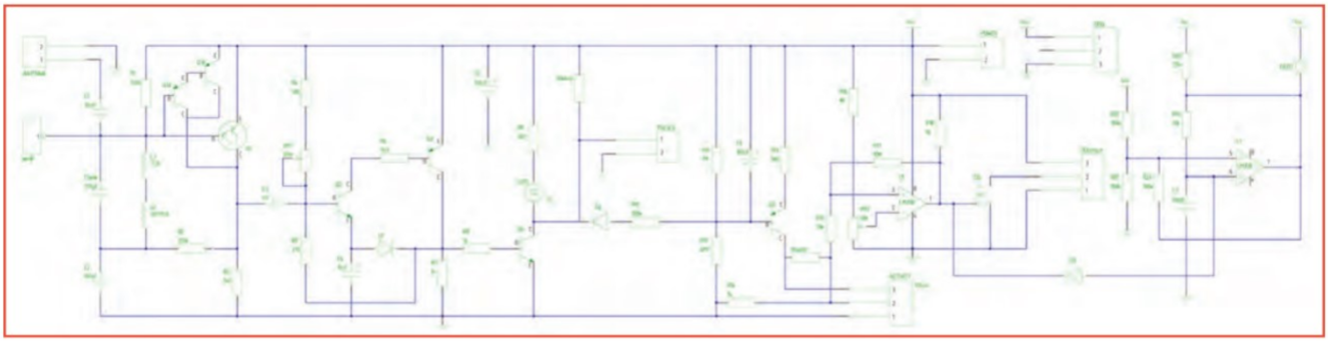
Background

Lightning discharges occur when a potential difference in the order of 10-100 million volts develops between the usually positive ground and negative clouds. The discharge of static electricity can develop currents in the tens of thousands of amperes. Lightning can also occur between clouds with differing electrical potentials. Multiple subsequent 'return' strikes can occur in short succession once a conductive channel has been created by the 'leader' strike. Application of Ohm's Law to even very substantial metal structures with resistances in the fractions of an Ohm, still result in enormous losses due to sudden heating during a very brief lightning strike lasting at most tens of microseconds. Even if assuming resistance of only 0.05 Ohms in a well-grounded metal tower, resistive heating during conduction of a 10,000A lightning strike will dissipate 5MJ in a few tens of milliseconds; turning the most resistive parts of the tower into 100MW electrical heating elements! This, simply, is why lightning can be so destructive. Lightning discharges are at the same time an enormous spark gap transmitter, generating impulse noise over frequencies from a few kHz to 300MHz, which account for the audible static crashes frequently heard on MF and HF bands. Heating of the air by the discharge creates a plasma of up to 30,000K in temperature, which can emit radiation in the x-ray band as well as the usual visible frequencies. Lower frequencies can travel much further than higher frequencies which attenuate more rapidly.

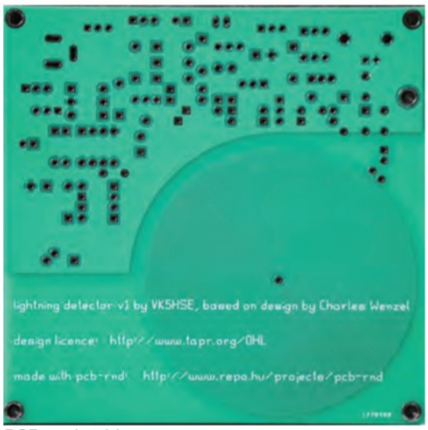
Circuit principles

Based on the aforementioned broad spectrum spark gap transmission by a lightning discharge, a tuned circuit excited by an electromagnetic impulse becomes a logical means by which lightning can be detected. L1 and C-tank form a parallel resonant MF circuit excited by either a short whip antenna or an external wire antenna connected via C1. In the absence of RF, the biasing of Q1 is set by R1, R2, and R3. Random noise containing frequencies around 500kHz (with C1=270pF) excite the tank circuit which tends towards turning off Q1 (the high gain Darlington pair transistor). If an impulse at the resonant frequency of the series resonant circuit formed by L1 and C2 is received, in the VLF band, Q1 is turned on more strongly. If Q1 turns on strongly, VR1, R5 and R7 start a down-going pulse via R8 and Q4, flashing LED1. At the same time, Q2 and Q3 form a monostable which stretches the duration of this down-going pulse produced by Q4. The constructor can stop here, skipping everything beyond Q2 if they are happy to just have a visual indication of lightning strikes, or if they plan to count the down-going pulses with another circuit, such as a microcontroller. There is a footprint for an optional pullup resistor R-pullup of 10k or so if the downstream microcontroller GPIO requires it. Between D2 and R-meter is the part of the circuit which sums or integrates recent lightning strikes, charging up C6 in the process. The RC circuit is a bit like a bucket with a hole, whereby constant drips above a certain threshold will slowly fill it, but fewer drips will allow it to empty. The charge in C6 turns on Q5, allowing current to flow through the 100uA meter movement. Between R15 and Q6, we have an LM358 op amp circuit which can be set to turn on an open drain output via Q6 if the lightning activity exceeds a threshold set by VR2. The potentiometer allows a voltage to be chosen that is compared against the voltage across the moving coil meter. If no meter is going to be installed, there is a footprint for R-meter which can be populated with a value similar to that of a moving coil meter movement, typically around 1500R (note: trying to measure the resistance of a moving coil meter risks damaging the coil if not done very carefully). Finally, the stage from D3 through to the piezo buzzer form a relaxation oscillator using the second half of the LM358. This is turned on when the threshold detector formed by the first half of the LM358 turns on and beeps the buzzer when recent lightning activity exceeds the threshold set by V2.

If a PNP Darlington is lacking, footprints



Lighting Detector Schematic.



PCB underside.

PCB topside.

have been provided for Q1a and Q1b, to allow a Darlington pair to be created by the adventurous with a pair of discrete PNP transistors instead. The keen experimenter can try larger values of inductance with the L2 connector on the circuit board by connecting it to a larger external coil. The coil on the PCB layout is a double-sided helical coil generated within pcb-rnd with a value of around 350uH. In the absence of experimentation with an external coil, the L2 footprint needs to be jumped or linked with a wire. The circuit is designed to run at 3 volts and works well with two D cell batteries. The schematic, TAPR licenced open-source hardware (OSHW) pcb-rnd PCB layout design files, and Gerber's have been supplied for the PCB shown. The PCB is a 10cm x 10cm double sided 1.6mm FR4 PCB and can be bought cheaply in batches of 10 from the usual online suppliers using the Gerber files provided.

Construction

Builders should start by deciding how many stages of the PCB will be populated. Then, install in the needed components in the following order: external connectors, an L2 jumper/header, IC socket, resistors, capacitors, diodes, the piezo buzzer, populating the transistors last. The bipolar transistor footprints have been marked on the silkscreen to show base, collector, and emitter pins, and the same applies to Q6, which has the drain, source and gate pins marked. Any common signal PNP and NPN transistors should work, and, similarly, any common N-Channel MOSFET should work for Q6, provided attention is paid to pinouts for the particular devices. A short telescopic antenna can be connected to the 3.1mm hole provided on the PCB, or an external short wire can be connected to the BNC antenna connector.

Testing

Once assembled, and transistor +/- IC orientations have been double checked, 3V can be applied. Turning VR1 should allow some flashing to be seen on LED1. Assuming you are not in the middle of a lightning storm, VR1 should be turned until the flashing just stops. This adjusts the biasing of Q4 and the associated monostable formed by Q2 and Q3. The builder can either wait for a lightning storm at this point or move the PCB coil over to a switch mode power supply (SMPS) such as one used to power a laptop. The LED should start to flash quickly when the PCB is in very close proximity to the SMPS. If the activity summing circuit and/or meter have been constructed, the meter should start to move after sustained excitation with the SMPS, and slowly move back after excitation ceases.

Conclusion

A simple yet effective lightning detector based on a design by Charles Wenzel has been presented. The ability to turn on, turn off, or disconnect shack equipment is also possible using this detector.

Construction is simplified by the use of a PCB which includes the inductor, while also allowing for experimentation with larger values of inductance if desired. The design files are open hardware, allowing clubs to order the published design very cost effectively, making it ideal for a build night or club project. The PCB layout is also available if experimenters wish to modify the design further or reference a preferred deity on the silkscreen.

Web Links

Further information including the BOM, the Schematics (inc. PCB Gerber files) and high-resolution photos visit:
https://github.com/erichVK5/erichVK5-lightning-detector

This project is licenced under the open hardware licence, see http://www.tapr.org/OHL

Further reading

Bob Radmore, N2PWP "A Lightning Detector for the Shack", QST Magazine, April 2002, pages 59-61

Chapter 6. Electromagnetic Methods of Lightning Detection https://library.wmo.int/doc_num.php?explnum_id=3184

Lightning for Climate: A Study by the Task Team on Lightning Observation for Climate Applications (TT-LOCA) Of the Atmospheric Observation Panel for Climate (AOPC) https://library.wmo.int/doc_num.php?explnum_id=6262

Erich Heinzle, VK5HSE
a1039181@gmail.com