Subject	**Millimetre Wave Progress and Innovation**		
Society	**RSGB**	Country:	**United Kingdom**
Committee	**C5**	Paper Number	**LA17_C5_31**
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1. Introduction

Experimentation in the highest frequency amateur bands is producing results and "firsts" that demonstrate the extraordinary achievements of UK amateurs dedicated to activating these mm-wave bands.

New developments in licensing in the UK are opening the possibility to experiment in the terahertz frequency ranges above 275 GHz.

2. Background

In common with many countries, the UK amateur licence enables access to frequencies at 122, 134 and 248 GHz.

- 122,25 - 123 GHz is a secondary allocation and subject to high Oxygen attenuation (similar to 60 GHz)
- 134 - 136 GHz is a primary allocation immediately below the amateur secondary band allocation at 136 – 141 GHz.
- 248 -250 GHz is a primary allocation immediately above the secondary band allocation at 241 – 248 GHz.

At 134 GHz, harmonised narrowband activity centre is nominally at 134,928 GHz, but in practice 134 and 248 GHz operation is dependent on convenient multiples from synthesised/multiplier local oscillators which are chosen for best frequency stability and low phase noise etc.

3. Key Points and Proposal

Annex 1 provides details of activities amongst the most enthusiastic constructors and operators developing and operating systems using the three highest Millimetre Wave bands in the UK. These activities include some "firsts" and are expected to provide the basis for ongoing experimentation and development.

Annex 2 provides information on licensing developments negotiated with the UK administration to provide access to even higher frequency bands in the terahertz region to encourage further experimentation. The approach used is suitable for potential requests in other countries. It is also important to note that there is demand for frequencies in 275-450 GHz from WRC-19 AI-1.15

4. Recommendations

- Member Societies should recognise the importance of the millimetre wave frequency bands as territory for experimentation and innovation.
- Member Societies should recognise that the ability to exploit these frequencies reflects the true amateur radio spirit of self-learning and training.
- Member Societies should encourage national interest-group organisations to provide a forum for efficient sharing of experiences and ideas amongst their amateur communities for the use of these bands.
- Member Societies should facilitate the organisation of events and meetings (including contests) that can allow like-minded enthusiasts to exchange ideas.
- Member Societies should take steps to highlight and promote activity and experimentation in this area with their national and regional administrations.

Note: - See also the RSGB Paper regarding the 24 & 47 GHz bands and its recommendations

Annex 1

UK Millimetre Wave Activities

122 GHz: The first UK contact in the 122 GHz band took place on 17 July 2016 between G8CUB/P and G0FDZ/P over a distance of 120 m. The CW reports were 599 both ways. The 122 GHz band is noted for its high signal attenuation due to atmospheric oxygen and water vapour attenuation. The maritime climate of the UK leads to larger water vapour absorption and other gaseous losses than in other parts of Europe. G8ACE has been continuing to experiment and has received signals up to 6,7 km in the 122 GHz band. See http://microwaves.dsl.pipex.com/ which includes numerous videos of activity in a number of millimetre-wave bands

134 GHz: G8KQW and G8ACE achieved a successful 134GHz CW contact which extended the existing UK 134 GHz distance record to 35,6 km on 16 January 2016 [3]. The key enabler for success on this extended distance record contact was lower path loss due to less water vapour attenuation; dew point temperature on 16 January 2016 was -1°C whereas on 20 September 2015 it was 14.3°C.

241 GHz: The 241 - 250 GHz bands are the highest frequencies globally allocated to amateur radio. Whilst powers and noise figures are challenging, experimentation is rising, helped by progress in lower bands such as 134 GHz and stable frequency sources. The high antenna gains available from small dish sizes facilitate portable operation, provided they are accurately aligned to accommodate the small beam angles. The first UK 241 GHz QSO took place on 19 Feb 2016 between G8CUB/P and G0FDZ/P in locator square JO01EP. The distance was 30 metres and the CW signals were 559 and 589. With signal to spare both ways an attempt was made to increase the distance to over 50 m but with deteriorating weather likely, a decision was taken to limit to 30 m as antenna alignment was taking a very long time to achieve.

Figure 1: 241 GHz Transverters for the first UK 241 GHz QSOs. *Source: Scatterpoint March 2016*

All transmitters and local oscillators were derived from surplus commercial synthesisers. Often work is carried out to "hack" these to make smaller frequency increments possible or improve performance for narrow band operations. G8CUB was using 16.0385 GHz as LO (x15) into a Tektronix mixer. G0FDZ used a 1 mm diameter hole to a slab mixer (see below) on Rx with cut-off around 175 GHz, whilst G8CUB used a piece of WR-03 – 173 GHz cut-off wave guide.

G8ACE is another millimetre wave enthusiast and has been making great progress in 2016 and pushing QSO distances out to over 400 m with the most recent tests up to 6.7 km. More information can be found at http://microwavers.org/241ghz.htm as well as http://microwaves.dsl.pipex.com/.

Technology considerations

The system architecture for narrow band mode transverters in these bands is generally well known but the detailed implementation of component parts can be challenging and is a ripe area for innovative approaches.

For example, a key feature of the 122 GHz system was the use of a slab type mixer housing which has been recently developed by G0FDZ to make millimetre wave mixers easier to construct for numerous bands. This approach has also been used for 241 GHz and it is hoped that the slab mixer format will greatly help those who wish to venture onto the highest frequencies. Its design enables the user to easily adapt the slab to suit the required band by suitable drilling and tapping etc. without the need to obtain specific band metalwork.

Without power amplifier availability at these frequencies, the transmitter power levels tend to be less than 100 micro-watts feeding dish antennas with around 47 dBi gain. Beam widths are very narrow requiring careful alignment for successful QSOs, typically with telescopic sights.

Annex 2

Access to spectrum >275 GHz for further Experimentation

In the UK, from October 2016 licence variations were made available to allow Full Licensees access to certain spectrum blocks from 275 GHz to 3000 GHz, to facilitate innovation at the cutting edge of rf/microwave technology. The licence variation specifies frequency bands based on ITU-RR5.565, including protection zones around key UK Radio Astronomy Sites.

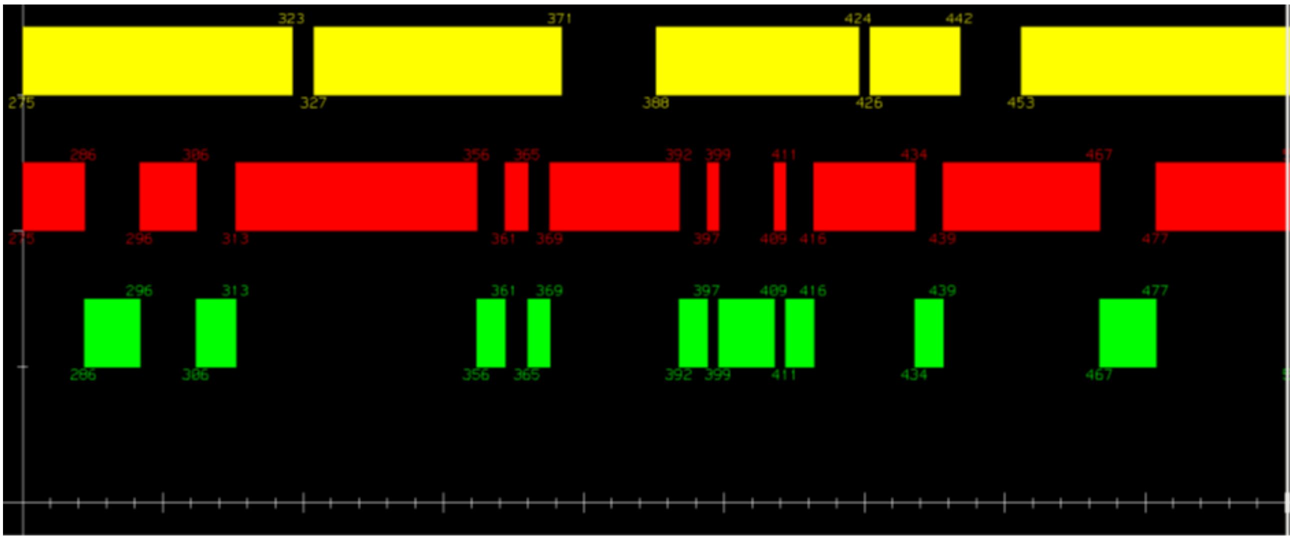

Figure 2: Sub-bands in the 275 – 500 GHz part of the full range (from www.rsgb.org)

Figure 2 illustrates the available blocks in the range 275 – 500 GHz with the

- **Yellow ranges** indicate the Radio Astronomy frequencies requiring protection.
- **Red blocks** indicate where no transmissions are allowed, essentially matching the RR5.565 identification of sub-bands for – Earth exploration-satellite service (EESS) and Space research service (SRS) passive applications.
- **Green blocks** identify the frequencies where operation is authorised although in all the cases in Fig 1 (since they overlap the yellow ranges) a separation distance of at least 20 km is required from identified radio astronomy sites. There are seven such radio astronomy sites in the UK.

Similar blocks can be derived from examination of ITU-RR5.565 for the frequencies up to 1000 GHz and in some cases, there is no overlap with the radio astronomy frequencies.

Regarding the UK case:

- Transmitter power levels up to 100 mW are allowed
- Further guidance http://rsgb.org/main/operating/band-plans/microwaves/terahertz/

Note: Part of this frequency range (275 - 450 GHz) is also currently under study as it is the topic of WRC-19 Agenda Item 1.15 for commercial fixed and mobile use.