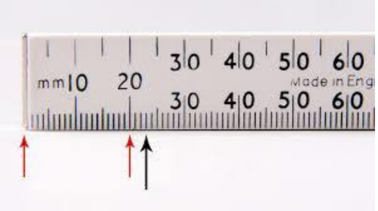
RTT TECHNOLOGY TOPIC
February 2017

New-UWB

Last month we discussed the positive impact of technology and commercial innovation on the delivery economics of the satellite industry. Much of the present focus is on Ka band high throughput satellites. This is the band into which the US operator community is initially planning to implement 5G.

However there is also substantial innovation taking place in the millimetre band either side of the automotive radar bands at 70 GHz including component and system innovation that will yield performance gain for the terrestrial backhaul used in these bands and the 5G networks and satellite constellations being launched or planned.

These millimetre wavelengths (4 millimetres = 70 GHz) support super compact fractional beam width antenna arrays, one of the key enabling technologies required to deliver power efficient 5G wide area wireless broadband.



This month we turn our attention to regulatory innovation at 60 GHz and the implications for wide area terrestrial and satellite systems. Specifically we look at the possibility of implementing low power ultra-wide band radio as an additional local connectivity option – we call this New-UWB.

In July 2016, the FCC Spectrum Frontiers proceeding released a new unlicensed band from 64 to 71 GHz immediately above the existing 60 GHz unlicensed band (57 to 64 GHz in the US, 57 to 66 GHz in Europe). The 15 GHz available between 57 GHz and 71 GHz meets the FCC definition of ultra-wide band as being a pass band equal to or greater than 20% of the centre frequency. 15 GHz is equal to 23% of the fractional bandwidth at 64 GHz.

Short pulse ultra-wide band radio transceivers have been deployed for many years in the radar industry and are widely used today, automotive radar at 24 GHz being one example.

In February 2002, the FCC issued the ultra-wideband ruling allowing technology commercialization and setting agreed radiation limits for ultra-wide band radio. Two standards emerged and the industry battle that followed effectively prevented UWB from gaining sustainable market traction.

15 years on the European Commission has issued a mandate to ETSI to produce harmonized standards for UWB as part of the work stream for the Radio Equipment Directive. This covers ground probing radar, tank detection radar, sensors and in building location but also includes communications applications.

It would therefore be plausible to consider US and European UWB as a viable option for an extended 60 GHz band. The proximity to automotive radar at 77 GHz suggests that there may be direct technology and market translation opportunities which would help deliver market and technology scale. Coexistence with existing Wi-Fi systems at 60 GHz would be possible and suggests the combination of Wi-Fi and UWB merits study as an option for 5G complementary connectivity.

Read on

Global Wi-Fi Spectrum and standards at 60 GHz

60 GHz unlicensed spectrum allocations are not harmonized globally. China has a comparatively constricted band from 59 to 64 GHz with a secondary band at 45 GHz with the two bands technically addressed by the 802.11aj standard. For all other markets, the 60 GHz Wi-Fi band plan and functional extensions are formalized in the 802.11ay standard. This includes provision for up to four channels each of 2.16 GHz.

Some countries including Australia have only 2.5 GHz available (between 59.4 and 62.9 GHz) and therefore would have single channel deployment. Other markets including the US and Europe could have all four channels available with bonding as an option.

Legacy UWB including radiation limits

15 years ago, one of the two UWB competing standards was based on multi band orthogonal frequency division multiplexing; the alternative option was direct sequence spread spectrum.

The FCC UWB radiation limits were set depending on the frequency of operation as shown in the table below.

FCC UWB Radiation Limits for Indoor and Outdoor Communication		
	Indoor	Outdoor
Frequency in MHz	EIRP in dBm	EIRP in dBm
960-1610	-75.3	-75.3
1610-1990	-53.3	-63.3
1990-3100	-51.3	- 61.3
3100-10600	-41.3	-41.3
Above 10600	-51.3	-61.3

These are low limits but even so existing incumbent owners of spectrum in the UHF band, L band, C band, and X band (above 10 GHz) and Ku-band (between 12 GHz and 18 GHz) were never enthusiastic about sharing expensively acquired spectrum with a new technology which by definition co-existed beneath their respective pass bands.

Wi-Fi and UWB Co-existence at 60 GHz

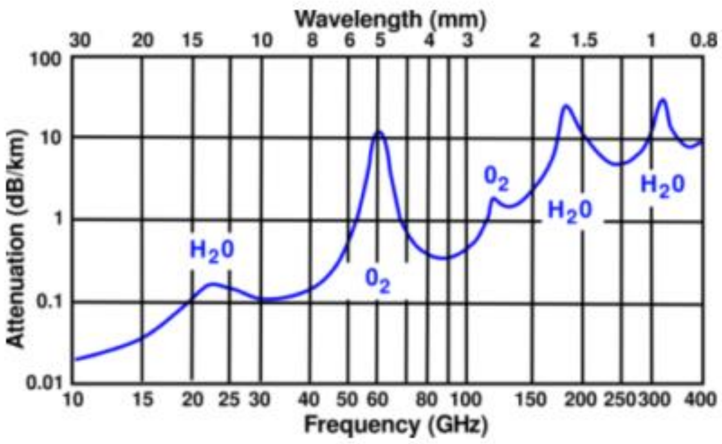
So will the story be different at 60 GHz?

We should first clarify some naming issues. The millimetre bands are either described using the IEEE Standard 521-1984 radar band naming regime in which V band covers 40 to 75 GHz and W band covers 75-110 GHz. This has the merit of being consistent with describing 1-2 GHz as L band, 2-4 GHz as S band and 4-8 GHz as C band.

However these bands are also used for point to point microwave which uses a naming regime based on waveguide dimensions with E band stretching from 60 to 90 GHz. E band was formally established by the ITU at the WARC 1979 World Radio Conference but mostly ignored until 2005 when the FCC issued a light licensing regime that permitted E band radios to operate up to 3 watts. Confusingly both naming regimes are used in the technical literature.

Whatever naming regime is used, the coexistence issues remain the same. Implementing UWB in the 15 GHz pass band between 57 and 71 GHz suggests an opportunity to exploit the15 dB of attenuation difference across the band, a function of the oxygen resonance line. Conveniently the attenuation of the UWB signal would be at its highest around 60 GHz which is where the Wi-Fi bands are centred.

Oxygen resonance line



UWB adjacency to 5G licensed spectrum at 71 to 76 GHz

At the upper end of the proposed FCC unlicensed spectrum allocation is the fixed and mobile band of 5 GHz of contiguous spectrum between 71 and 76 GHz.

This is paired with 81-86 GHz and is either divided into 19X 250 MHz channels with 125 MHz of guard band either side of the pass band (CEPT) or 4 X1.25 GHz channels (FCC). Either option could be a potential candidate for 5G deployment.

The lower spectral density of UWB potentially reduces co system interference. There would also be higher resilience to 5G interference due to the system bandwidth and spreading gain of the wide band signal.

Automotive radar spectrum and standards at 77 GHz

The 77 GHz automotive radar band consists of two sub bands, 76-77 GHz for narrow band long range radar and 77-81 GHz for wideband short range radar.

Compared to automotive radar at 24 GHz, 77 GHz radar provides better angular resolution due to the reduced spacing between antenna elements.

The higher carrier frequency means that the Doppler frequency increases proportionally relative to the velocity of the target. This results in higher speed resolution. Range resolution depends on the modulated signal bandwidth; the wider the bandwidth, the better the range resolution.

Power outputs/spectral densities for 77 GHz pulsed and frequency modulated continuous wave (FMCW) radar are specified by ETSI for Europe and the FCC for the US. For the FCC, the state of the vehicle determines the restrictions on allowed output power. For a stationary vehicle, the spectral density in any direction must not exceed 0.2uW/cm^2 in any direction.

For a moving vehicle, the allowed spectral density is 60uW/cm^2 looking forward and 30uW/cm^2 for side looking and rear looking directions. The maximum field strength determined by the FCC is 500uV/m at 3m distance equivalent to an EIRP power spectral density not exceeding -51.3dBm/MHz.

The ETSI specifications are shown in the table.

ETSI Fixed antenna structure EIRP and OOB emissions for 77 GHz automotive radar		
Band	**76-77 GHz**	
EIRP (FMCW)	50 dBm (mean)	55 dBm (max)
EIRP (Pulsed)	23.5 dBm (mean)	55 dBm (max)
3dB Beam width (Typical)	5 degrees	
Out of Band (OOB) emission	73.5 -76 GHz	0 (dBm/Hz)
	77-79.5 GHz	0 (dBm/Hz)

Regulatory agencies have been encouraging migration to the millimetre band by restricting emissions in the 24 GHz band so 24 GHz systems are likely to be phased out over time at least in Europe.

5G and automotive radar

Previous technology topics have highlighted the technology commonalities between automotive radar at 77 GHz and 5G implemented as a FDD band (71-76 GHz paired with 81-86 GHz). The spatial signal analysis required to detect and determine angular received power in 5G fractional beam width antenna arrays is similar to the signal processing required in automotive radar.

The typical inter site distance of dense urban 5G is equivalent to the 150m to 200m range needed in forward looking automotive radar.

Additionally there are potential RF hardware and transceiver architecture commonalities with the opportunity to amortise RF investment across the telecommunications and automotive industry. VW and Ford each spend $12 billion a year on R and D with an increasing percentage of this budget spent on connectivity and autonomous safety systems. This has already yielded low cost single chip radar modules capable of working in harsh environmental conditions.

Automotive radar and UWB

There are also similarities between automotive radar and UWB. Both systems use short pulses (the shorter the pulse duration the wider the occupied bandwidth) suggesting that UWB/automotive radar synergy could be significant.

Summary

The FCC allocation of 15 GHz of unlicensed spectrum between 57 GHz and 71GHz could potentially re-energize UWB technologies with the potential to realise added value without introducing discernible interference into existing and future 60 GHz Wi-Fi or spectrally proximate 5G or satellite systems. Specifically this includes the potential 5G FDD paired bands at 71-76 and 81-86 GHz.

Presently this is a US initiative but the recent European Commission mandate to ETSI to develop a harmonised UWB standard suggests a more broadly global opportunity.

Technical and commercial synergy with automotive radar at 77 GHz and the opportunity to meet possible future automotive connectivity requirements may also make UWB more sustainable in the longer term.

New-UWB should at least merit study within present and future 5G research.

More broadly, the FCC decision potentially implies a shift of focus from licensed to lightly licensed, or more likely, unlicensed spectrum, at least in the millimetre band above 60 GHz.

The technical rationale for this is that free space propagation and surface absorption losses combined with low output power and, in the case of UWB, low spectral density will eradicate coexistence issues.

While this may be true for local area 10 milliwatt Wi-Fi and UWB at 60 GHz, it is not true for wide area higher power mobile broadband progressive point to point networks using highly focused fractional beam width antennas and particularly not true for bands outside the 60 GHz oxygen resonance absorption band.

The commercial rationale is that unlicensed spectrum will help reduce delivery cost. While this is also theoretically correct, in practice mobile broadband operators will need 5G to scale geographically to larger radius macro cells in order to be economically viable. It is hard to see how adjacent users, including for example automotive radar at 76-81 GHz, would be willing to accept adjacent unlicensed spectrum without OOB emission limits that would invalidate the 5G macro cell business model.

Additionally all unlicensed spectrum allocation to date including 60 GHz has been based on a TDD band plan. This would introduce potentially expensive time domain interference issues for wide area 5G and would compromise the sensitivity required to maximise data rates and data reach. It would also require all base stations to be co-sited. This is unlikely to be technically or commercially practical. Wide area 5G will only be technically efficient if deployed in an FDD band plan.

Last but not least, while the auction process has been far from perfect, it remains theoretically at least, a market efficient mechanism for establishing spectral asset value.

This will be necessary both in Ka-band at 28 and 38 GHz and above 70 GHz in order to arrive at equitable and acceptable commercial arrangements with incumbent users including military terrestrial and deep space radio and military and automotive and civilian radar systems.

New UWB is therefore only part of an emerging centimetre and millimetre band story but presents an intriguing prospect of three band 5G centred on 250 MHz channel rasters implemented on a paired FDD duplex at 28 and 38 GHz, a paired duplex at 71-76 and 81 to 86 MHz and a TDD band at 92-95 GHz all of which could be integrated with power efficient ultra-wideband local area connectivity.

This is a different interpretation of 5G to the prevailing European approach which is initially at least, focussing on sub 6 GHz spectrum. We will be revisiting this discussion in future technology topics and podcasts.

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Published by Artech House

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