Testing the future

While researchers are exploring the mm wave band to deliver 5G, the question of which frequencies will be relevant still needs to be addressed – and test will be an essential contributor. By **James Kimery**.

The wireless communications industry is on the road to 5G – through which they will be defining the next generation of wireless networks. The goals and objectives for 5G are forcing researchers to change the way they think as building 5G on the founding technology of a 4G based network is not enough to deliver the jump in data rates, latency and capacity necessary to meet the needs of the three high level 5G use cases (see main image).

The Enhanced Mobile Broadband (eMBB) use case, as defined by the IMT 2020, envisions peak data rates of more than 10Gbit/s: 100 times faster than 4G. Data rates are linked empirically to the available spectrum, according to the Shannon-Hartley theorem, which states that capacity is a function of bandwidth and channel noise. With the spectrum at less than 6GHz fully allocated, higher frequencies, specifically in the mm wave range, present an attractive alternative to address the eMBB use case. But at what frequency?

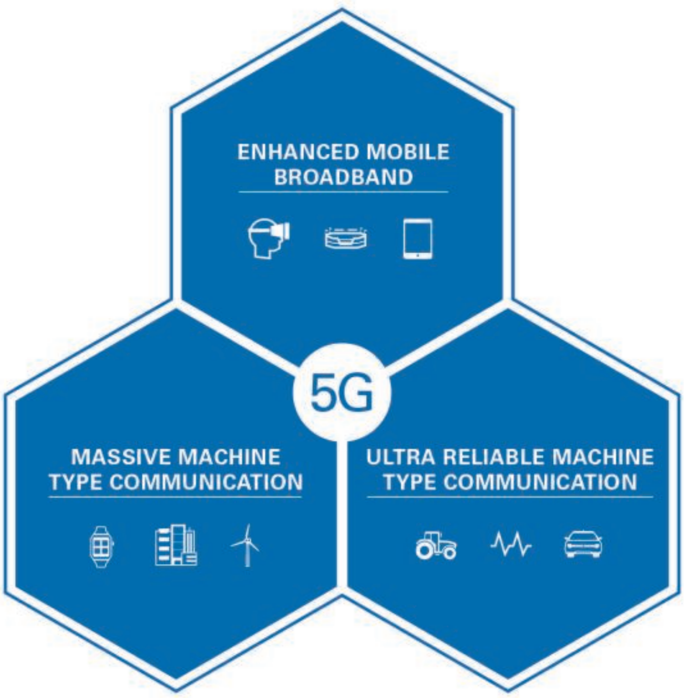
5G mobile communications will have to meet the needs of three use cases, while providing data rates of more than 10Gbit/s. The solution is likely to see mm wave technology being deployed

Spectrum options

The International Telecommunication Union (ITU) and 3GPP have aligned on a plan for two phases of research for 5G standards. The first phase defines a period of research for frequencies of less than 40GHz to address the more urgent subset of commercial needs by September 2018. The second phase, slated to begin in 2018 and end in December 2019, will address the key performance indicators outlined by the IMT 2020. This second phase focuses on frequencies of up to 100GHz. To align the standardisation of mm wave frequencies globally, ITU released a list of frequencies ranging from 24GHz to 86GHz at the recent World Radiocommunications Conference.

'Best' frequencies?

In the UK, the 'Bristol is Open' project is focusing on delivering the infrastructure and technologies needed to fully realise the IoT. As part of its work, the project is creating 'The Wireless Mile', an urban test bed for 5G wireless communications. Through research and projects such as this,



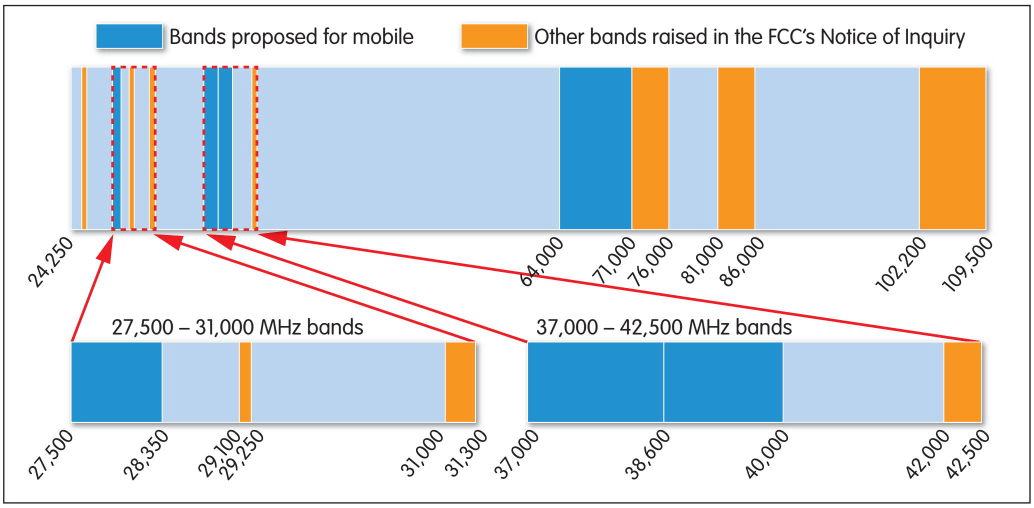
28GHz, 39GHz and 73GHz are emerging as possible candidates.

These three frequency bands have emerged for several reasons. Firstly, unlike 60GHz, which has approximately 20dB/km loss due to oxygen absorption, they are more resilient to absorption by the atmosphere. This makes them more viable for long distance communications. By combining highly directional antennas with beamforming and beamtracking, mm wave can provide a reliable and secure link. The data and research at these frequencies, combined with the availability of spectrum worldwide, make these three frequencies the starting point for mm wave prototyping.

However, the 28GHz band is not included in the ITU list. Whether it will be the long term frequency option for 5G mm wave applications has still to be determined. The spectrum's availability in the US, South Korea and

Japan, however, along with US service providers' commitment to early field trials, could push 28GHz into US mobile technology, regardless of the global standards.

South Korea's desire to show 5G technology at the 2018 Olympics could also push 28GHz into consumer products before standards bodies finalise global 5G standards.



The 28GHz and 39GHz frequency bands have been proposed for use in 5G mobile communications, but other bands are being considered

mm wave prototypes

Though the potential adoption of 28GHz for 5G may not be seen for a while, if at all, it is clearly important right now. In recent years, much research has been done on using E-band frequencies at 73GHz. In 2014, Nokia demonstrated the first over-the-air demo operating at 73GHz and has continued to evolve the prototype.

By Mobile World Congress (MWC) in 2015, the prototyping system was capable of transmitting data at 2Gbit/s using a lens antenna and beamtracking. Nokia showcased a MIMO version of this system operating at more than 10Gbit/s at the Brooklyn 5G Summit in 2015 and, less than a year later at MWC 2016, the company showed a two way over-the-air link operating at more than 14Gbit/s.

More 73GHz research is anticipated and one characteristic that sets it apart from 28GHz and 39GHz is the available contiguous bandwidth – more than 2GHz – the widest of the proposed frequency bandwidths. By comparison, 28GHz offers 850MHz of bandwidth and the two bands around 39GHz offer 1.6GHz and 1.4GHz bandwidth. As mentioned, more bandwidth equates to more data throughput and this gives 73GHz a big advantage.

To capitalise on the promise of mm wave for 5G, researchers will have to develop new technologies, algorithms and communications protocols because the fundamental properties of the mm wave channel are very different from current cellular models and are relatively unknown. The importance of building mm wave prototypes cannot be overstated, especially in this early timeframe. Building mm wave system prototypes demonstrates the viability and feasibility of the technology in a way that simulation alone cannot. mm wave prototypes communicating in real time and over the air in a variety of scenarios will unlock the secrets of the mm wave channel and enable innovation, technology adoption, and proliferation.

Challenges

There are several challenges facing the widespread adoption of mm wave for mobile access, including the availability of commercial silicon and analogue components, as well as other building blocks for developing systems; this hinders commercialisation.

Computational capacity must also increase by at least a factor of 100 to address the 5G data rate requirements.

FPGAs will be an essential technology in enabling this computational capacity; the motivation for moving to mm wave is the existence of large amounts of contiguous bandwidth.

In addition to FPGA boards, a mm wave prototyping system needs state of the art D/A and A/D converters to capture up to 2GHz of contiguous bandwidth. Some RF ICs on the market include chips that convert between baseband and mm wave frequencies, but these options are limited and mostly cover the unlicensed 60GHz band.

Engineers can use IF and RF stages as alternatives to RF ICs. Once they develop baseband and IF solutions, engineers have a few more vendor provided options for mm wave radio heads than they do for baseband RF ICs, but still not many. Developing a mm wave radio head requires RF and microwave design expertise.

An inevitability?

To address the complexity and software challenges, NI has developed the mm wave Transceiver System to provide a configurable set of prototyping hardware, along with a mm wave physical layer in source code. This layer accounts for the fundamental aspects of a mm wave system baseband and provides abstractions for data movement and processing across multiple FPGAs to simplify integration.

These tools have been designed to accelerate the transition of new prototypes into systems and products that will be crucial to the future development of 5G technology.

Though 5G's future is not yet clear, mm wave will surely be one of the technologies used to define it. The large amount of contiguous bandwidth available at more than 24GHz is needed to meet data throughput requirements and researchers have already used prototypes to show that mm wave technology can deliver data rates of more than 14Gbit/s.

But the biggest question that needs to be answered is 'which frequency will be widely adopted for 5G?'.

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