# mmWave – the cornerstone of a high-speed connected world

## What is mmWave?

Millimeter wave (mmWave) is the band of electromagnetic spectrum with wavelengths between 10mm (30 GHz) and 1mm (300 GHz). It is known as the extremely high frequency (EHF) band by the International Telecommunication Union (ITU). Located between microwave and infrared waves on the spectrum, mmWave can be used for a variety of high-speed wireless communications applications, such as point-to-point backhaul links.

## Macro trends accelerate data growth

As demand for data and connectivity increases globally, the frequency bands currently used for wireless communications are becoming congested, driving the need to access the higher frequency bandwidths within the mmWave spectrum. There are a number of macro trends accelerating demand for greater data capacity and speed.

### 1. Big data

The volume and variety of data generated and processed every day is growing exponentially. The world relies on rapid transfers of large volumes of data at high speed every second, across myriad devices. In 2020, every person generated 1.7 megabytes of data per second. *(Source: IBM).* At the beginning of 2020, the amount of data in the world was estimated to be 44 zettabytes *(World Economic Forum)*. By 2025, global data creation is projected to reach more than 175 zettabytes. To put that into context, storing that volume of data would require 12.5bn of today's largest hard drives. *(International Data Corporation)*

### 2. Urbanisation

The UN estimated that 2007 was the year when, for the first time, more people lived in urban areas than rural areas. This trend continues and by 2050 it is predicted that more than two thirds of the world population will live in urban areas. This puts increasing pressure on telecommunications and data infrastructure in these densely populated regions.

### 3. Multi-polarity

Global crises and instability, from the pandemic to political upheaval and conflict, mean that countries are increasingly keen to develop their sovereign capabilities – to mitigate the risks of global disruption. Governments want to reduce reliance on imports from other territories, and to support the development of products, technologies and infrastructure at home.

### 4. Climate change

As the world strives to cut carbon emissions, technology is opening up new opportunities to minimise carbon-hungry travel. Today, meetings and conferences are routinely hosted online. Even medical procedures can be performed remotely, without the need for surgeons to attend the operating theatre. Such precision operations are only possible with superfast, reliable, uninterrupted data flows with low latency.

These macro factors are driving the need for ever-more data to be collected, transferred and processed globally, but also to be transferred at higher speeds and with minimal lag (latency).

### What role can mmWave play?

The mmWave spectrum offers wide blocks of contiguous spectrum, allowing for much higher data transfer. The microwave frequencies currently used for most wireless communications are becoming congested and are fragmented, particularly with several bandwidths reserved for exclusive use by specific sectors, such as defence, aerospace and emergency communications.

As you move up the frequency spectrum, there are much larger portions of uninterrupted spectrum available, with fewer reserved segments. Moving up the frequency range effectively increases the size of the ‘pipes’ available to transmit data, enabling greater data flows. As the channel bandwidths are much larger at mmWave less complex modulation schemes can be used to transmit data this leads to much lower latency systems..

### What are the challenges?

There are challenges associated with moving up the frequency spectrum. The components and semiconductors required to transmit and receive signals at mmWave are more difficult to manufacture – and there are fewer processes available. Manufacturing mmWave components is also more difficult because they are much smaller leading to requirements for higher tolerance assembly and careful design of interconnects and cavities to reduce loss and avoid oscillations.

Propagation is one of the major challenges for mmWave signals. At higher frequencies, signals are more easily blocked or degraded by physical objects, such as walls, trees and buildings. In built-up areas, this means mmWave receivers need to be located outside buildings, to propagate signals inside. For backhaul and satellite-to-ground communications, greater power amplification is needed to transmit signals over long distances. On the ground, point-to-point links must be located no more than 1 to 5 km apart, rather than the much larger distances possible with lower frequency networks.

This means that in rural areas, for example, many more cell towers and antennae are required to carry mmWave signals over long distances. Installing this additional infrastructure involves more time and cost, in recent years the deployment of satellite constellations seek to solve this issue and again these employ mmWaves at the heart of their architecture.

### Where is mmWave best deployed?

The short propagation distance of mmWave makes it ideally suited for deployment in dense urban areas where there are high volumes of data traffic. The alternative to wireless is fibre-optic networks. In urban areas, digging up roads to install new fibre is extremely costly, disruptive and time-consuming. Conversely, mmWave connections can be set up cost effectively with minimal disruption in a matter of days.

The data rates achieved by mmWave signals are comparable to fibre, while offering lower latency. When you need very fast information flows, with minimal lag, wireless links are the preferred option – which is why they are used in stock exchanges where delays of milliseconds can be critical.

In rural areas, the costs of installing fibre are frequently prohibitive, due to the large distances involved. As discussed above, mmWave tower networks also require significant infrastructure investment. The solution emerging here is to use Low Earth Orbit (LEO) satellites or High-Altitude Pseudo Satellites (HAPS) to bring data connectivity to remote areas. LEO and HAPS networks mean there is no requirement to install fibre or to build short point-to-point wireless networks, while still providing excellent data rates. Satellite communications already use mmWave signals, typically at the lower end of the spectrum – Ka band (27-31GHz).There is scope for expansion into higher frequencies such as Q/V and E-band, particularly for backhaul of the data to ground stations.

The telecommunications backhaul market has led the way in the transition from microwave to mmWave frequencies. This has been driven by the proliferation of consumer devices –handheld, laptop and Internet of things (IoT) – over the past decade, which has accelerated demand for more and faster data.

Now, satellite operators are looking to follow the lead set by telecoms and expand the use of mmWave for LEO and HAPS systems. Previously, traditional Geostationary Equatorial Orbit (GEO) and Medium Earth Orbit (MEO) satellites were located too far from Earth to establish consumer communications links at mmWave frequencies. However, the expansion of LEO satellites now makes it feasible to establish mmWave links and create the high-capacity networks required worldwide.

There is huge potential for other industries to make use of mmWave technology too. In the automotive sector, driverless cars will require continuous high-speed connectivity and low latency data networks to operate safely. In the medical sector, superfast and reliable data flows will be required to enable precision medical procedures to be carried out by surgeons located remotely.

### A decade of mmWave innovation

Filtronic is a leading UK specialist in mmWave communications technologies. We are one of the few companies in the UK able to design and manufacture advanced mmWave communications components at scale. We have the in-house RF engineers – including mmWave specialists – required to conceive, design and develop new mmWave technologies.

Over the past decade, we have worked with leading mobile telecoms companies to develop a range of microwave and mmWave transceivers, power amplifiers and subsystems for use in backhaul networks. Our latest products operate at E-band, this technology  offers a potential solution  for very high-capacity feeder links for satellite communications. It has been adapted and refined incrementally over the past decade, reducing its weight and cost, improving performance and perfecting the manufacturing process to increase yields. Satellite companies can now avoid many years of in-house testing and development by adopting this proven technology for deployment in space.

We work at the bleeding edge of innovation, creating the technologies in-house and co-developing in house volume manufacturing processes. We are always innovating ahead of the market, to ensure we have the technologies ready for deployment as new frequency bands are opened up by the regulators.

We are already developing W-band and D-band technologies in anticipation of congestion at E-band and significantly greater data traffic in the coming years. We work as partners with our industry clients to help them build competitive advantage through marginal gains as new frequency bands are opened up.

### What next for mmWave?

Data usage rates are only going in one direction, and technologies that rely on data are continuing to advance. Augmented reality is already here and IoT devices are becoming omnipresent. Beyond domestic applications, everything from major industrial processes to oil and gas sites and nuclear plants are turning to IoT technology to enable remote monitoring and control – reducing the need for manual intervention in operating these complex facilities. The success of these and other technological advances will rely on the reliability, speed and quality of the data networks supporting them – and mmWave offers the required capacity.

mmWave does not make sub-6GHz frequencies any less important in the world of wireless communications. Instead, it is an essential complement to the frequency spectrum, enabling different applications to be delivered successfully, particularly those that require large packets of data, low-latency and greater density of connectivity.

The case for using mmWave to deliver on the expectations and opportunities of new data-reliant technologies is compelling. But there are challenges.

Regulation is one challenge. No advancement into higher mmWave bands is possible until regulators issue licences for specific applications. Nevertheless, the forecasted exponential growth in demand means that regulators are under increasing pressure to free up more parts of the frequency spectrum to avoid congestion and interference, there are also important discussions to be had around spectrum sharing between passive applications such as weather satellites and active commercial applications, this would allow even wider bands and more continuous spectrum without the need to move to sub-THz frequencies.

When it comes to capitalising on opportunities offered by new bandwidth, it’s important to have the technology in place to facilitate higher frequency communications. That’s why Filtronic is advanced in developing W-Band and D-Band technologies for the future. It’s also why we are working with universities, government and industry to drive the development of skills and knowledge in the areas required to meet future wireless technology needs. Government investment needs to be directed into the right areas of RF technology if the UK is to lead the way in developing the global data communications networks of the future.

As a partner with academia, government and industry, Filtronic plays a leading role in developing the advanced communications technologies needed to deliver new capabilities and possibilities in an increasingly data-hungry world.