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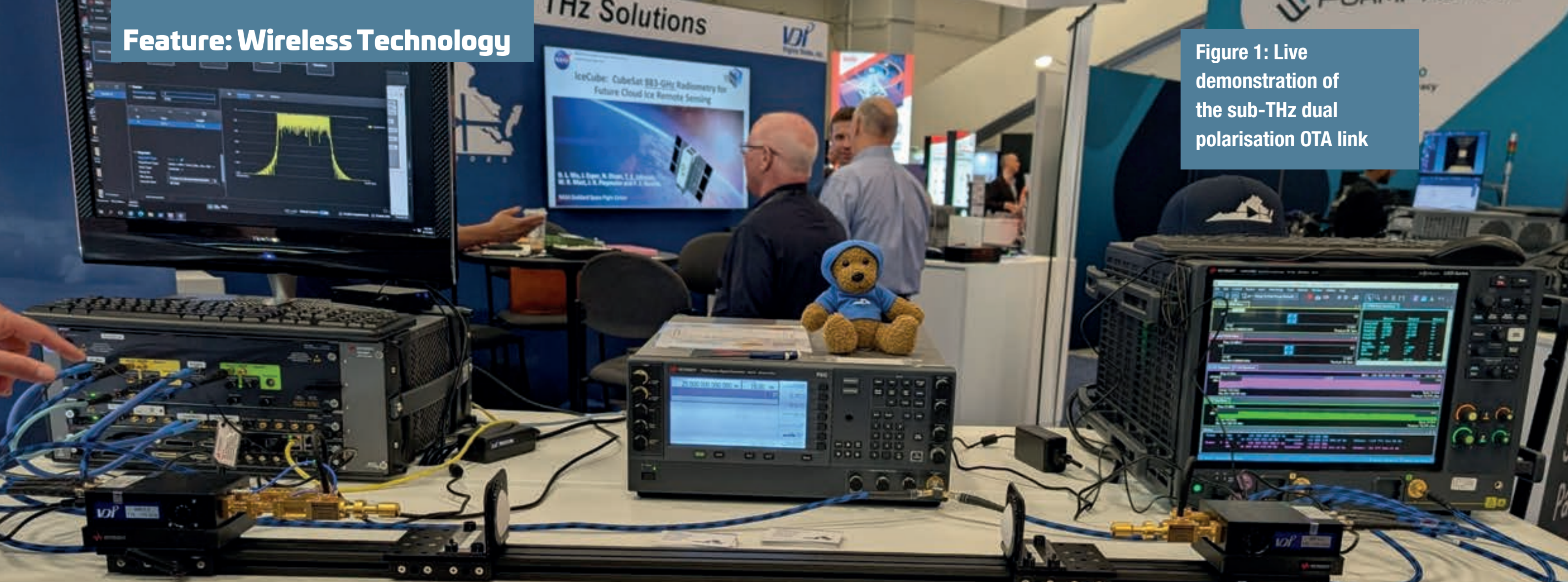

Figure 1: Live demonstration of the sub-THz dual polarisation OTA link

Doubling data at sub-THz: One link, two polarisations, twice the data

By, Greg Rankin, freelance technology writer

The promise of the sub-terahertz (THz) region of the electromagnetic spectrum, 100-300GHz, is well understood: vast swaths of underutilised spectrum and the ability to transmit data at rates far beyond what is possible at lower frequencies. While much of the development in this range remains at the R&D stage, recent breakthroughs are already expanding the reach and speed of this new technology.

With the potential to exceed 100Gbps – over 500 times faster than current 5G networks – the move into the THz bands stands to accelerate a range of advanced applications. These range from phased-array radar and autonomous vehicles, to fixed wireless backhaul and ultra-high-capacity data centre links. Yet researchers continue to explore the most efficient ways to achieve such high data throughput with real-world hardware.

As part of that pursuit, engineers in a recent live demonstration successfully transmitted two independent, wideband signals, each on an orthogonal polarisation, through a single spatial link at 142GHz; see Figure 1. By combining both signals into one beam using a high-isolation, low-loss orthomode transducer (OMT), the system effectively doubled the throughput of a point-to-point connection. A follow-up demonstration at 285GHz is already in development, with the potential to push data rates even higher.

The effort was led by Virginia Diodes (VDI) and Keysight Technologies, with Micro Harmonics providing the enabling OMT. While the breakthrough hinges on polarisation multiplexing, it is the result of a much broader integration effort. It brings together ultra-wideband mixers, sharp image rejection filters, high-frequency amplifiers and tightly engineered passive components, all optimised for operation deep into mmWave and sub-THz bands.

At the edge of the spectrum

One of the central engineering challenges in sub-THz communication is the limited availability of hardware and the underlying components required for it to operate reliably at these frequencies. VDI's contribution focused on overcoming that barrier: upconverting extremely wideband signals (20-40GHz) to higher carrier frequencies using custom diode-based mixers, then amplifying and refining those signals through carefully tuned image rejection filters and gain stages, all optimised for linearity and minimal loss.

The objective was straightforward: deliver clean, high-power, wideband signals at 142GHz and beyond that

Figure 2: OMT from Micro Harmonics

could be transmitted and received with precision. However, wide bandwidth alone was not the full story. In earlier demonstrations, the team had already shown that two independent links at 142GHz and 285GHz could operate in parallel, each moving large volumes of data over separate beams. That setup effectively doubled throughput by doubling the number of physical links.

The next step was to achieve the same throughput using just one beam. That meant combining two wideband signals, each occupying 20GHz, into a single spatial path without interference, requiring clean separation between the signals throughout the entire transmission and reception process. This is where polarisation multiplexing became critical, and where Micro Harmonics's OMT proved essential to the success of the demonstration.

The reason OMT matters

An OMT is a three-port waveguide component. Two of its ports support single-mode propagation, typically rectangular waveguides, while the third, known as the common port, supports two orthogonal modes simultaneously. One is horizontally polarised, the other vertically. It is this ability to cleanly separate or combine polarisation states that makes the OMT so powerful in advanced RF systems.

Polarisation multiplexing itself is not new. It is a well-established method for doubling capacity in communication and sensing systems at lower frequencies. However, implementing it at sub-THz frequencies, especially with ultra-wideband signals, is far more difficult.

"There are very few off-the-shelf OMTs at these frequencies, and even fewer that can maintain the isolation and bandwidth we needed," said Cliff Rowland, RF engineer and head of business development at VDI. "You can't have signal leakage between the vertical and horizontal polarisations, or you'll get distortion, and you can't afford much insertion loss either, especially at these frequencies where every dB matters."

Micro Harmonics, which has been developing a complete series of millimetre-wave OMTs across all standard waveguide bands from WR-15 (50-75GHz) to WR-3.4 (220-325GHz) supplied the component that made this demonstration possible; see Figures 2-4. Their OMT combined high polarisation isolation with low insertion loss, two critical requirements for sending dual-polarised signals through the same physical channel without degradation. In this case, it enabled the system to carry 40GHz of combined bandwidth – 20GHz on each polarisation – over a single link.

That setup delivered aggregate data rates exceeding 126Gbps and, importantly, the performance held up under full system integration.

"We've made OMTs before in the lab, but never as a standalone component at this level," said Rowland. "Micro Harmonics

Figure 3: Micro Harmonics's D-band OMT

brought a high-performing part, and just as important, their team worked closely with us on the mechanical integration. Form factor, flange compatibility, port layout – all of it had to come together cleanly for this to work."

Hardware integration

The signal chain did not end at the OMT. Keysight's role was equally critical, bringing the digital signal generation, calibration and demodulation tools needed to drive and evaluate the link. Its instruments enabled the creation of high-speed, wideband modulated signals, along with the post-transmission measurement and analysis tools required to validate performance across both polarisations.

Between Keysight's digital capabilities and VDI's hardware, the demonstration formed a complete testbed for sub-THz communication using polarisation multiplexing. The result was not just a lab experiment, but a working end-to-end system capable of transmitting and recovering complex signals at over 100Gbps.

The 142GHz demonstration marks an inflection point which will continue with the development of similar architecture at 285GHz. The team is also exploring whether dual-frequency, dual-polarisation signals could eventually be combined into a single spatial path, effectively quadrupling throughput. That goal remains theoretical for now, but it is on their radar.

In the near future, the most immediate applications are in fixed wireless systems that demand extreme capacity, particularly for backhaul and infrastructure links where fibre may be impractical. High-speed, low-latency interconnects in data centres are another target, especially in modular or reconfigurable environments where over-the-air links offer flexibility.

Looking ahead, joint communication and sensing systems, next-generation automotive radar and high-resolution imaging all stand to benefit as well, if the hardware continues to advance in step with system demands. With each leap forward, demonstrations like this are helping to define not just what is possible at sub-THz frequencies but how close it is to becoming practical. EW

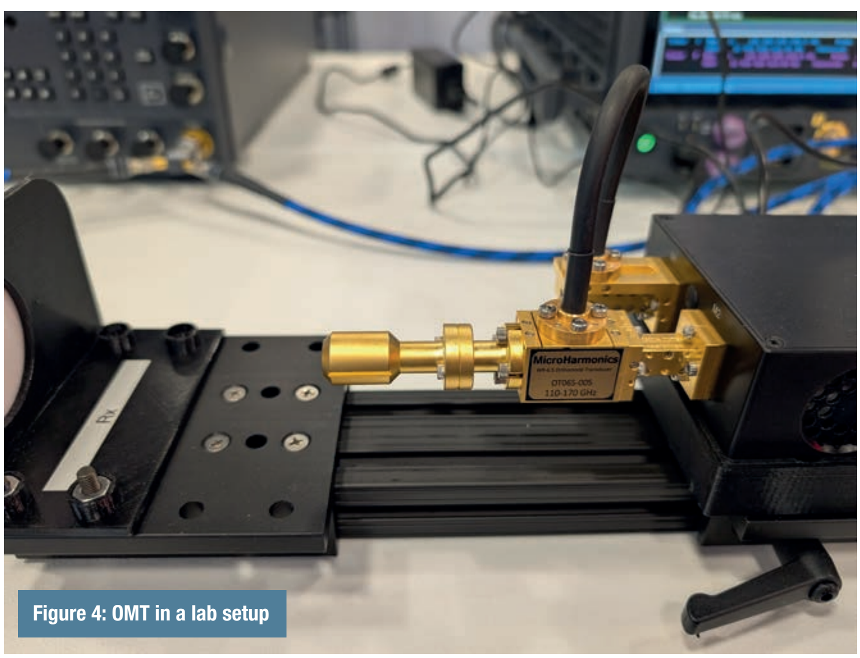

Figure 4: OMT in a lab setup