A system to enable multi-kilometer and sub-terahertz communications at extremely high frequency bands

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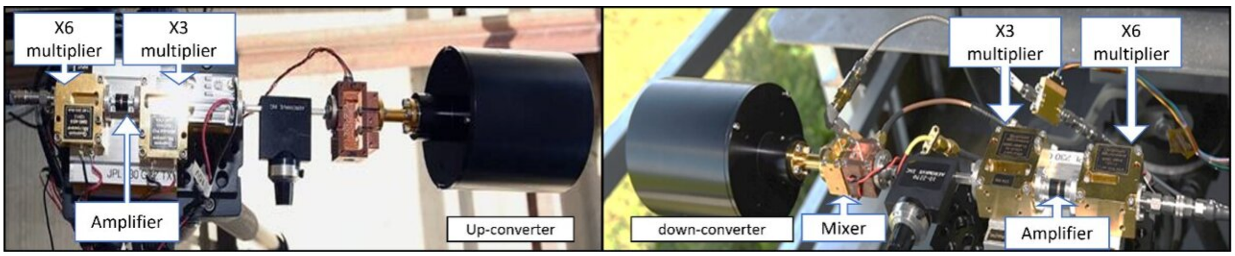

Compact transmitter and receiver for long-range communications above 100 GHz. Credit: Sen et al.

After the introduction of the fifth-generation technology standard for broadband cellular networks (5G), engineers worldwide are now working on systems that could further speed up communications. The next-generation wireless communication networks, from 6G onward, will require technologies that enable communications at sub-terahertz and terahertz frequency bands (i.e., from 100GHz to 10THz).

While several systems have been proposed for enabling communication at these frequency bands specifically for personal use and local area networks, some applications would benefit from longer communication distances. So far, generating high-power ultrabroadband signals that contain information and can travel long distances has been challenging.

Researchers at the NASA Jet Propulsion Laboratory (JPL), Northeastern University and the Air Force Research Laboratory (AFRL) have recently developed a system that could enable multi-gigabit-per-second (Gbps) communications in the sub-terahertz frequency band over several kilometers. This system, presented in a paper in *Nature Electronics*, utilizes on-chip power-combining frequency multiplier designs based on Schottky diodes, semiconducting diodes formed by the junction of a semiconductor and a metal, developed at NASA JPL.

"Frequencies above 100 GHz are traditionally not considered for communications applications because of unfavorable channel properties and lack of high-power devices," Dr. Ngwe Thawdar an AFRL researcher who carried out the study, told Tech Xplore.

"We have built a unique team here where NASA JPL brought the unique device expertise, Northeastern brought the signal processing and communications, and AFRL brought rigorous test and evaluation at scale in relevant environments. In this paper, we proved the viability of these frequencies for next generation communications applications and brought the terahertz communications technology from vision to reality."

The key goal of the recent work by Dr. Thawdar and her colleagues was to demonstrate the feasibility of communication links at frequencies above 100 GHz, for ranges over 1 km rand at data rates higher than 1 Gbps. The system they proposed exceeded their expectations, enabling communications at a range over 2km and with a data rate of over 1 Gbps.

"The key novelty of our system is the way in which we modulate the terahertz carrier signal with the information that we want to transmit," Dr. Josep Jornet from Northeastern University told Tech Xplore. "In traditional systems, a mixer (the device we use to add the information to the signal) is present at the transmitter right after the frequency multipliers that upconvert a lower-frequency signal to the terahertz band and before the antenna. In our case, we have so much power after the frequency multipliers that the mixer would simply blow up."

To overcome the power-related challenges associated with the problem they were tackling, Dr. Thawdar, Dr. Jornet and their colleagues tested two plausible solutions. The first entailed modulating the local oscillator in their system and then upconverting it to terahertz frequencies, while the second involved the modulation while the signals were half-way, through a so-called frequency multiplication process.

Both these strategies allowed them to add information and retain their desired maximum output power. Their only additional requirement was to carry out additional signal processing to pre-compensate for the distortion introduced by frequency multipliers.

"For many years, it was generally believed that terahertz communications were only feasible over short communication distances (tens of meters at most)," Dr. Priyangshu Sen from Northeastern University told Tech Xplore.

"Here, we show that with innovative technologies that are currently available to us, an intelligent combination of the different hardware building blocks and tailored signal processing, we can communicate at terahertz frequencies over several kilometers. This opens the door to terahertz communications potentially replacing costly and sometimes technically challenging optical fiber deployments, facilitating the access to ultrabroadband internet connectivity to communities that today do not have it."

The highly promising results achieved by this team of researchers could open new and exciting possibilities for communications at extremely high frequency bands. In the future, this work could inspire the study of even more challenging applications, such as the use of terahertz communications for satellite and space links.

"Now that we have shown the art of the possible at terahertz frequencies, out next step is to broaden our partnerships across the industrial base to enable next generation communications systems for both defense and commercial applications," Dr. Thawdar added.

More information: Priyangshu Sen et al, Multi-kilometre and multi-gigabit-per-second sub-terahertz communications for wireless backhaul applications, *Nature Electronics* (2022). DOI: 10.1038/s41928-022-00897-6.