Open Innovation

Terahertz Technology Research Center

Director General HOSAKO Iwao

The terahertz band corresponds to electromagnetic waves at frequencies ranging from roughly 100 GHz to 10 THz, which lies between so-called radio waves and light waves. Electromagnetic waves in this region have so far been difficult to generate and detect. As a result, the terahertz band remained unused and unexplored. The Terahertz Technology Research Center has concentrated NICT's diverse activity in R&D ranging from materials to systemization and has driven forward with the research and development of cutting-edge measurement technology to support the realization of terahertz wireless communication systems. In addition, by working with organizations such as the Terahertz Systems Consortium, we will promote joint studies with industry and academia and contribute standardization aimed at improving the environment so that the terahertz band can be used effectively (Fig. 1).

Core technology for terahertz radio testbed

To realize 100 Gbps-class terahertz communication technology, we are developing technologies to generate terahertz signals based on fiber-radio and advanced optical fiber communication technologies. In FY2019, we studied a technique for generating a single ultra-wide-band signal by combining multiple transmitters, each having a limited bandwidth. We used digital signal processing to partition a single-carrier multi-level modulated signal with 85 GHz bandwidth (modulation rate of 80 Gbaud) into three frequency bands, and assigned them to each of three transmitters with bandwidths of under 45 GHz. We then tested a method to receive and demodulate them together as a single, wideband signal at the receiver. A schematic diagram and spectral distribution for the system are shown in Fig. 2. Comparing the received and demodulated signal with the one transmitted using a single wideband transmitter showed that the wideband signal can be generated by partitioning the bandwidth, with no particular degradation.

Fundamental technologies for terahertz spectrum measurements

In spectrum measurement, we require an octave-spanning bandwidth (0.3—0.6 THz) to enable measurement of spurious signal characteristics specified by the Radio Regulations. Our goal is to establish fundamental technology able to take spectrum measurements more quickly and accurately than previously, while handling this bandwidth in a single instrument. One method that has been proposed to realize this is to convert to multiple bands using a filter bank that partitions the measurement band into several equal bands, and to measure each of the partitioned frequency bands simultaneously using frequency comb signals as local oscillators. In FY2019, we conducted experiments to check the multi-band spectrum measurement concept using technology elements developed earlier (Fig. 3).

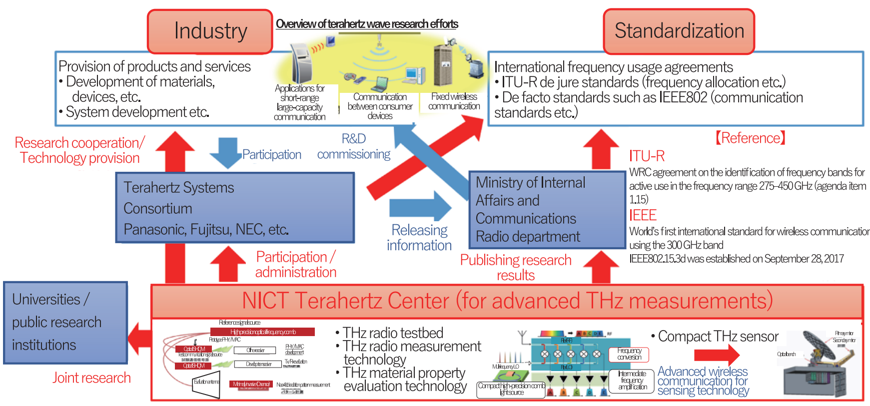

Fig.1 : Overview of Terahertz Technology Research Center

International standardization activities

We performed standardization activities according to WRC-19 agenda item 1.15, "Identification of frequency bands for use by administrations for the land-mobile and fixed services applications operating in the frequency range 275–450 GHz," achieving the following results in FY2019:

(1) Completed ITU-R report SM.2450, "Sharing and compatibility studies between land-mobile, fixed and passive ser-

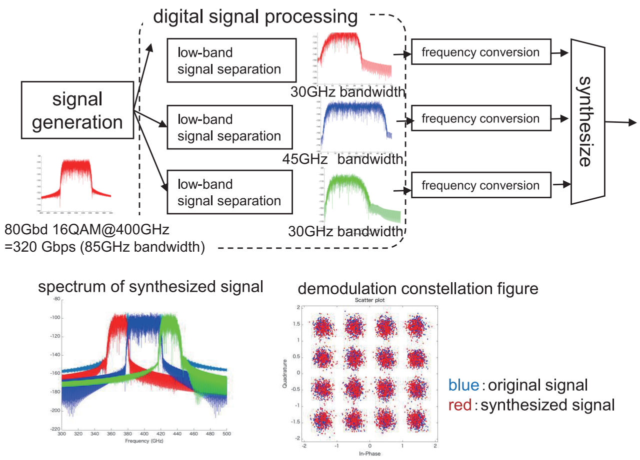

Fig.2 : Ultra wideband signal generation technology

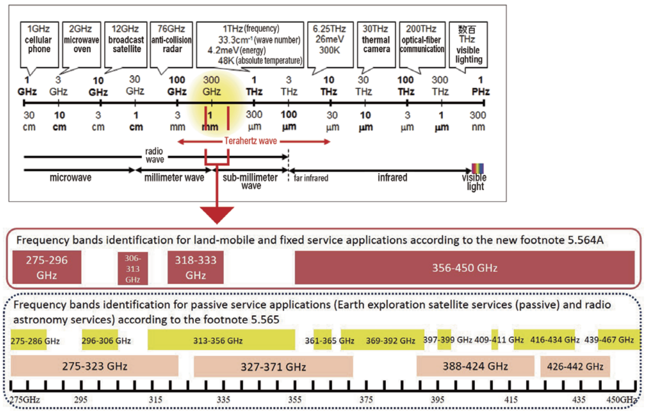

Fig.4 : Standardization of Terahertz band: WRC-19 frequency identification results

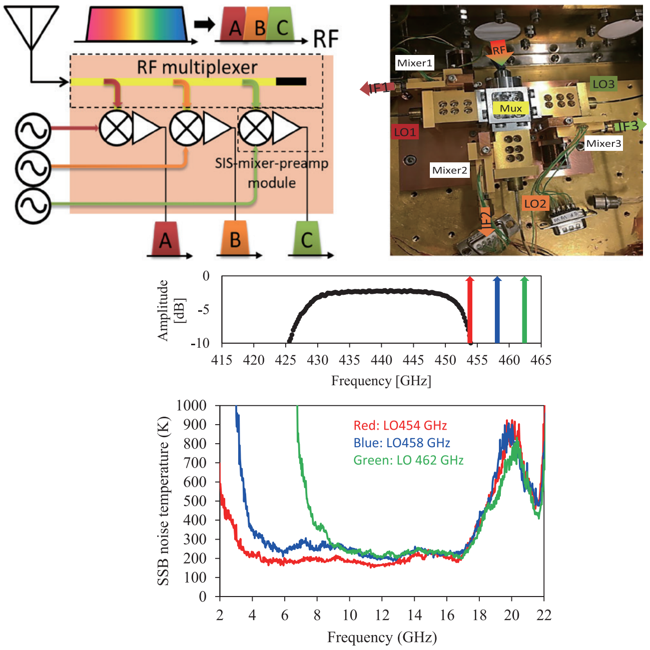

Fig.3 : Evaluation system concept for 3-band receiver and a photo of the inside of the cryostat (top), Ch.2 filter characteristics (middle) and receiver noise temperature at different LO frequencies (bottom)

Fig.5 : Advanced ICT Device Lab Workshop

vices in the frequency range 275–450 GHz," in ITU-R WP1A (Spectrum engineering technology).

(2) Completed the APC (APT joint proposal) regarding WRC-19 agenda item 1.15 in APG19-5 (APT WRC-19 preparatory meeting) and input it from the APT to WRC-19.

(3) Collaborated with the APT coordinator and CEPT coordinator in WRC-19 to add a new note identifying the four bandwidths shown in Fig. 4 (275–296 GHz, 306–311 GHz, 318–333 GHz, and 356–450 GHz) for land-mobile and fixed services applications in the radio communication regulations.

Advanced ICT Device Lab

The Advanced ICT Device Lab has clean rooms (CR) at two locations: its headquarters (Koganei City, Tokyo) and Kobe branch; each with their own specializations. The headquarters focuses research mainly on innovative device platform technologies for the Beyond 5G era and integrating optical and radio (especially high-frequency millimeter/THz signals), quantum communication device technology, and oxide semiconductor device technologies that will contribute to reducing ICT power consumption. On the other hand, the Kobe laboratory focuses R&D on elementary devices using advanced materials such as superconductor electronics, nano and organic devices, and deep ultraviolet devices. In FY2019, the Advanced ICT Device Lab recorded use by 162 researchers from 36 external organizations (using the headquarters CR). This covered an extremely wide spectrum of research fields, from fundamental research on materials to social applications of systems. To provide a place for generating innovation through organic interaction among these researchers from different fields, we started the Advanced ICT Device Lab Workshop (Fig. 5) in January 2020. It included presentations of many results from NICT's collaborative research and from research led by external facilities at universities and enterprise, and opened up active technical exchange among students and researchers from enterprise and from NICT.