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 (3 mm to 30 μm in wavelength), 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, we are developing a terahertz-wave signal generating technology based on radio-over-fiber technology, with advanced optical fiber technology. In FY2018, we achieved increased the bandwidth with optical frequency comb signals, with the goal of generating high-frequency terahertz signals. Specifically, we increased the total bandwidth using a method of synchronizing and linking multiple independently driven optical frequency comb signals. We built a feed-forward frequency synchronization loop, as summarized in Fig.2. We expect that we will be able to apply this technology to a system that will generate wide-band terahertz signals with high spectral purity.

Fundamental technologies for terahertz spectrum measurements

In spectrum measurement, we require an octave (0.3-0.6 THz) ultra-wide bandwidth in order to measure spurious signal characteristics, as specified in radio regulations. We aim to establish fundamental technology that will enable high-speed, highly-accurate spectrum measurements

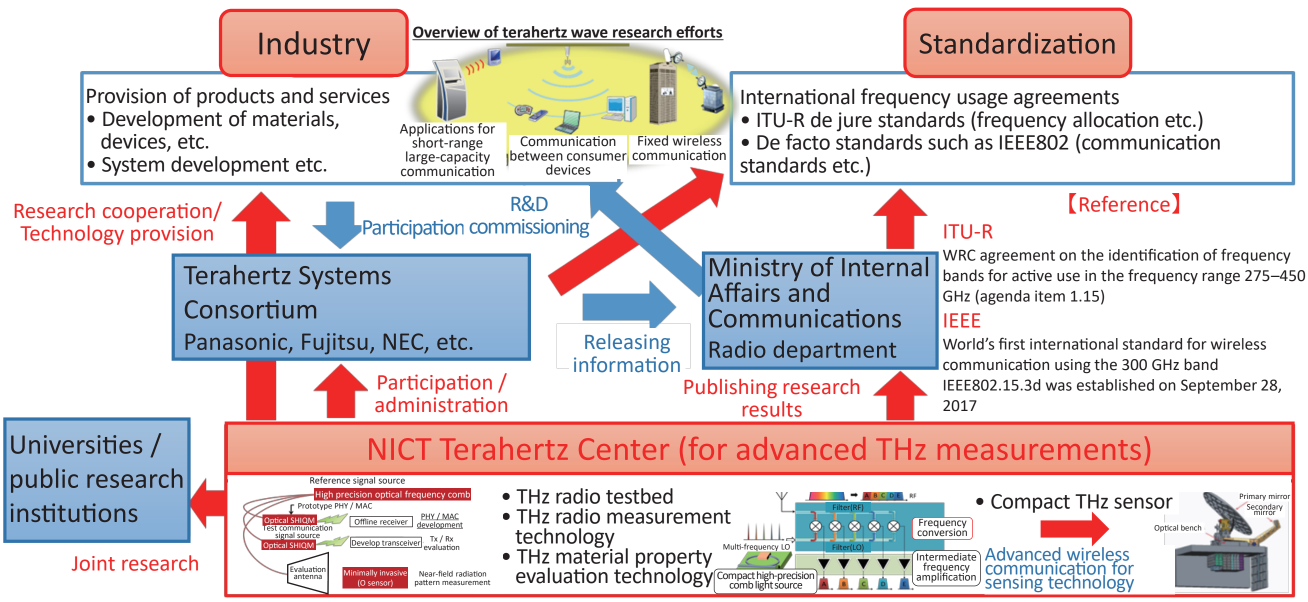

Fig.1 : Overview of Terahertz Technology Research Center

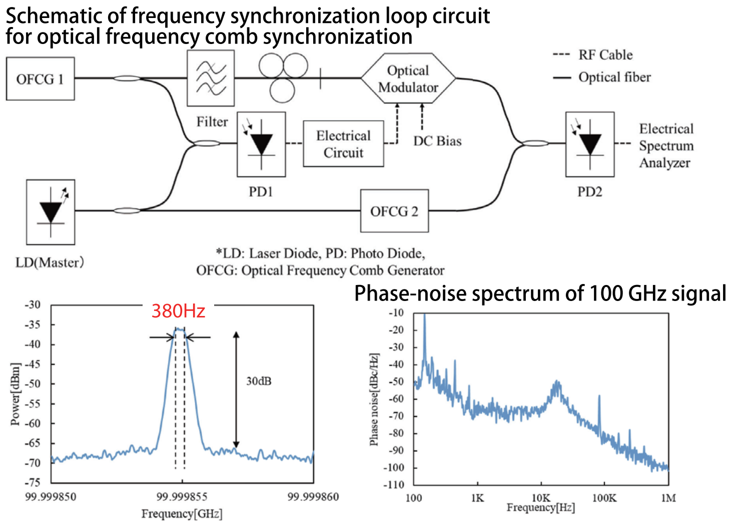

Fig.2 : Overview of optical frequency comb synchronization system and obtained 100 GHz signal frequency fluctuation and phase noise spectrum

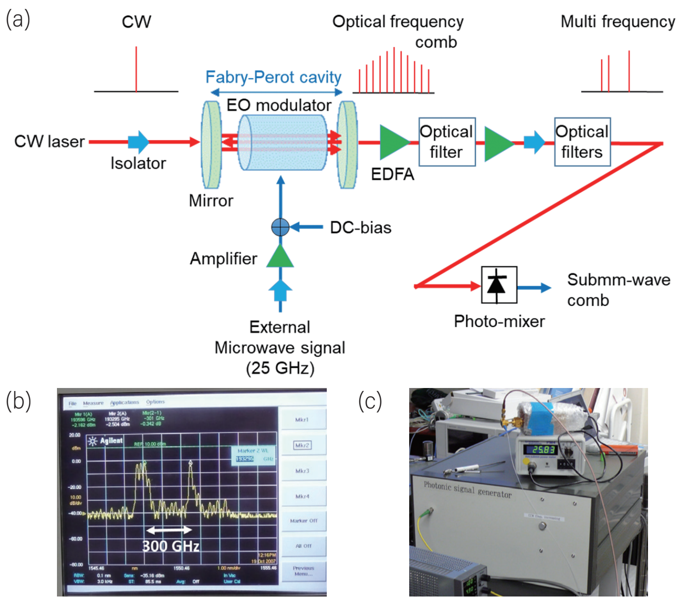

Fig.3 : (a) Sub-millimeter wave band frequency comb signal generator block diagram, (b) 1.5 μm-band optical spectrum, (c) Sub-millimeter wave band signal power measurement

over this band using a single instrument. One proposed method to achieve this is to convert input signals to multiple-band signals using a precisely-designed filter bank, and then measure all of them at the same time using frequency combs as local oscillators. In FY2016, we demonstrated a filter bank operating as designed in the 400 GHz band, and in FY2017, we prototyped an intermediate-frequency (IF)-amplifier-integrated mixer able to down-convert signals from the filter bank to intermediate frequencies. In FY2018, we developed a sub-millimeter-wave frequency comb generator using the precision optical frequency comb (Fig. 3).

International standardization

Spectrum identification above 275 GHz has been studied by the relevant ITU-R Working Parties (WPs) under WRC-19 agenda item 1.15, which considers identification of frequency bands for use by administrations for land mobile and fixed service (LMS/FS) applications operating in the frequency range 275-450 GHz, in accordance with Resolution 767 (WRC-15). This agenda item was originally proposed by NICT at the 4th and 5th meetings of the APT Conference Preparatory Group for WRC-15 and was finally input to WRC-15 as an APT Common Proposal. As a responsible group of WRC-19 agenda item 1.15, ITU-R WP1A has developed Report, ITU-R SM.2450, which summarizes possible identification bands for LMS/FS applications. Although the Conference Preparatory Meeting (CPM19-2) was held before the completion of Report ITU-R SM.2450, CPM Report on agenda item 1.15 was finalized based on contributions from Japan, Germany, USA, Canada, China and IUCAF, and seven Methods to satisfy agenda item 1.15 were included for further discussion at WRC-19, to be held in October and November, 2019. A new footnote and modified RR No.5.565 to identify frequency bands for LMS/FS applications will be agreed upon, with consensus among administrations, and included in Radio Regulations at WRC-19.

We are also continuing to participate in discussion of regulations for future terahertz radio devices in the Institute of Electrical and Electronic Engineers (IEEE) 802 standardization committee. As of July 2018, The Technical Advisory Group Terahertz (TAG THz) is in charge of this, and HOSAKO Iwao, Director of the Terahertz Research Center, is continuing to participate as the Vice Chairman of the group.

Advanced ICT device Laboratory

To promote R&D on challenging and advancing device technologies, we have formed the Advanced ICT Devices Laboratory to function as a platform for open innovation among industry, academia, and government in the field of devices.

A wide range of basic R&D activities is being done at the Advanced ICT Devices Laboratory on innovative device technologies, including integrated optical and electronic devices in the millimeter-wave and THz wave bands, deep ultraviolet optical devices, and on highly functional devices based on new materials, such as nanofabrication materials, organic photonic materials, superconducting materials, and gallium-oxide materials. Latest R&D results are being created based on organic exchange of technologies and human resources including researchers and trainees, from different organizations in Japan and overseas.