Electrooptic sensing for antenna characterization and propagation investigation at THz band

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***Abstract* – We show the two applications of an electrooptic sensing which is based on a nonpolarimetric frequency down conversion technique at terahertz frequency band. We demonstrate the near-field measurement and far-field characterization of a Cassegrain antenna at 300 GHz. We also demonstrate the visualization of a wave packet propagation in a free space at 120 GHz.**

***Keywords* — Antennas, wave packet, propagation, near-field, far-field.**

I. INTRODUCTION

The beam quality of millimeter-wave (30–300 GHz) and terahertz wave (THz waves: 0.1–10 THz) is an important parameter to achieve high data rates in wireless communication applications and accurate and reliable target detection in radar applications. Electric field measurement using electrooptic (EO) sensor is a promising technique to investigate and characterize the beam quality or radiation pattern of the antenna because of a minimum disturbance to the field to be measured. Recently, we proposed a nonpolarimetric EO frequency down conversion technique [1], self-heterodyne technique [2], noise cancelling technique [3], and photonic frequency tracking technique [4] and demonstrated the near-field visualization at microwave [5], millimeter-wave [6] and THz wave [7, 8, 9] region. In this paper, we show the two applications of the EO sensing at THz band; near-field measurement and far-field characterization of a Cassegrain antenna at 300 GHz and visualization of a wave packet propagation in a free space at 120 GHz.

II. MEASUREMENT SYSTEM

Figure 1 shows the measurement system using an EO sensor. The system is based on the nonpolarimetric EO frequency down conversion technique [1] and self-heterodyne technique. The radio frequency (RF) signal is generated by a uni-travelling-carrier photodiode (UTC-PD). The RF frequency is tuned by the difference of two laser frequency. The DAST crystal is attached to the polarization maintaining fiber (PMF) with the GRIN lens. EO probe does not contain the metal components, therefore the lower disturbance compared with the conventional open-ended rectangular waveguide probe is expected. Accuracy and fidelity of the measured distribution is evaluated in elsewhere [10]. By moving the EO probe, the amplitude and phase distribution is visualized.

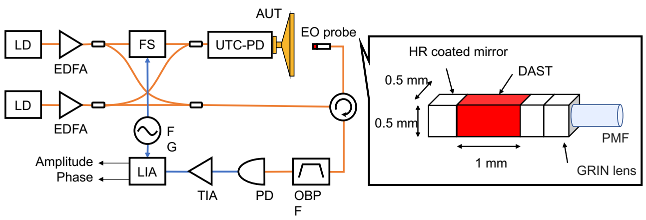


Fig. 1. Measurement setup and EO probe

III. CASSEGRAIN ANTENNA CHARACTERIZATION

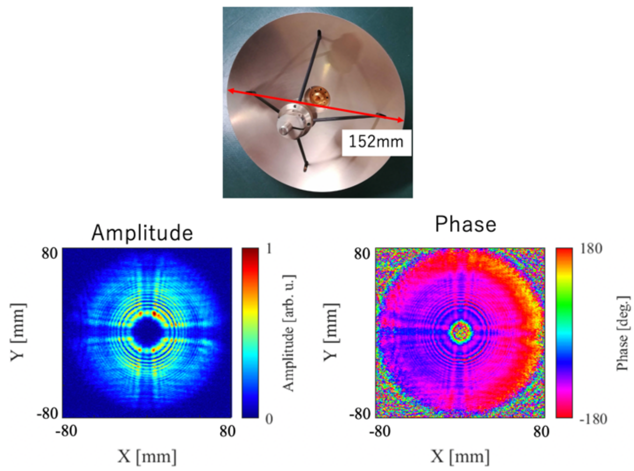


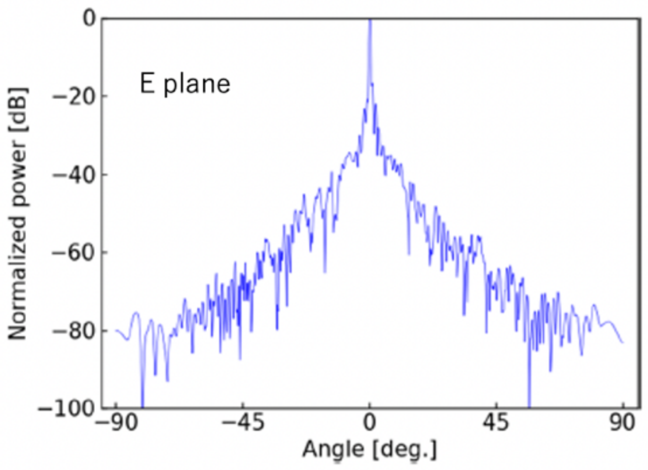
Fig. 2. Measured near-field distribution of the Cassegrain antenna at 300 GHz.

Figure 2 shows the measured near-field distribution of the Cassegrain antenna at 300 GHz. The maximum signal-to-noise ration (SNR) in this experiment was about 25 dB. Although, the convex secondary reflector disturbs not only the amplitude distribution but also the phase distribution, the measured overall phase distribution is flat.

Figure 3 shows the calculated far-field pattern in the E-plane using measured near-field data. The calculation was based on the Fourier transformation. The full width at half maximum (FWHM) of the radiated beam was 0.46 deg. and 0.40 deg. for E-plane and H-plane, respectively.

Fig. 3. Far-field pattern in the E-plane calculated using measured near-field distribution.

The small FWHM (lower divergence angle) is a key to



extend the transmission distance in the THz wireless communication application.

IV. WAVE PACKET PROPAGATION INVESTIGATION

Investigation of THz propagation phenomena is important not only for THz channel characterizations, but also for the design of THz devices which are integrated with THz transceivers and antennas for real world use. Our measurement system is based on the so-called frequency domain measurement technique, that enables the investigation of the CW phenomena. By summing each frequency component, the wave packet dynamics can be visualized.

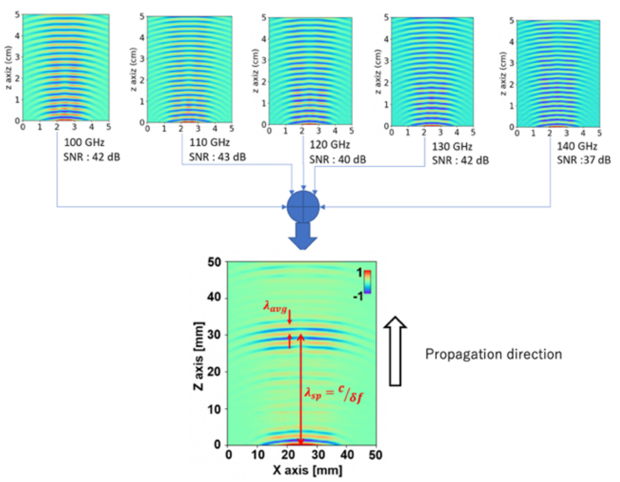


Fig. 4. Visualized wave packet.

Figure 4 shows the experimental results. We measured the amplitude and phase distribution of the 100 GHz, 110 GHz, 120 GHz, 130 GHz, and 140 GHz continuous waves, and sum them up to construct the wave packet. In this figure, z = 0 corresponds to the distance of 10 mm from the antenna surface. Adopting the state-of-the-art THz amplifier to our measurement system will extend the measurement detection distance at least up to 1.5 m.

V. CONCLUSION

Nonpolarimetric EO frequency down conversion technique together with the self-heterodyne technique enables the stable and precise EO sensing in any frequency band. The demonstrated technique can become a basic experimental tool to investigate not only the antennas but also the wave packet dynamics, which is important in the short-range THz wireless communication applications and radar applications.

ACKNOWLEDGMENT

This research is partially supported by funding from Horizon 2020, the European Union’s Framework Program for Research and Innovation, under grant agreement No. 814523. ThoR has also received funding from the National Institute of Information and Communications Technology in Japan. The author would like to thank Y. Tanaka, H. Arisesa of Gifu University; A. Kanno, N. Sekine of NICT; J. Nakajima of SoftBank for their valuable comments and help.

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