300-GHz Versatile Transceiver Front-End for Both Communication and Imaging

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***Abstract*—Envelope-detector-based transceiver configurations are useful for both digital signal transmission and radar systems in the terahertz band. A dual-purpose transceiver is demonstrated using a 1-Gb/s on-off keying signal and 12.5-GHz-bandwidth frequency-modulated continuous-wave radar.**

I. Introduction

TERAHERTZ waves are promising for both high-speed wireless communication and precision imaging because of their short wavelengths. In practice, terahertz-band transmission with a capacity greater than 20 Gb/s has already been reported with an on-off keying (OOK) scheme [1]. Additionally, concealed material detection by the terahertz waves is useful for enhancing civil security. Short wavelengths allow small object detection at sizes comparable to the wavelength (less than several centimeters for terahertz waves). Specifically, in a frequency-modulated continuous-wave (FM-CW) radar system, the range resolution is inversely proportional to the bandwidth of the radar signal, and therefore, a broad bandwidth in the terahertz band would provide high resolution radar, unlike microwave and millimeter-wave radar. For communications, especially in OOK and radar systems, many devices in a transceiver can be shared, such as amplifiers, detectors, and transmitter/receiver separators in the antenna. However, evaluation and demonstration for communication and radar systems are independently performed because of complicated transceiver configurations.

In the paper, we configure a versatile transceiver front-end in the terahertz band connected to photonics-based transmitters for communication and radar signal generation. An envelop detector is utilized to convert from a 300-GHz OOK signal to the baseband for communication; this detector is also used as a simple radar mixer to regenerate a beat note between the original signal of the transmitter and the incoming signal from an antenna.

II. Experimental setup

Figure 1 shows the setup of the 300-GHz transceiver. Photonics-based transmitters generate a 300-GHz-band optical signal for the baseband signal transmission with a 1-Gb/s OOK and for the FM-CW radar system with a signal bandwidth of 12.5 GHz [2]. In the front-end, a high-speed photomixer (PM) based on a uni-traveling-carrier photodiode converts the optical signal into a 300-GHz terahertz-wave signal. A low-noise amplifier (LNA) amplifies the signal sent to the 3-dB Y-coupler. The amplified signal is radiated by a feeder horn antenna connected to an offset parabolic antenna with a total gain of 46 dBi. Incoming 300-GHz signals are collected by these antennas. Then, the received signal is boosted by the LNA, which is located after the Y-coupler. A Schottky barrier diode (SBD) performs envelope detection to convert the signal into a baseband signal. An analog-to-digital converter (ADC) and bit-error-rate test set (BERT) are used to evaluate the signal quality for the radar signal and communication signal, respectively. It should be noted that the Y-coupler has 20-dB isolation between the input (for the transmitter signal) and the output port (to the receiver). This isolation helps achieve a small signal leakage from the input signal to the receiver. It is important for FM-CW radar that ranging in the FM-CW scheme is performed by obtaining the beat note between the original signal and the incoming (delayed) signal. Generally, the leakage degrades the received signal quality for the communication. The 20-dB isolation did not affect the communication receiver.

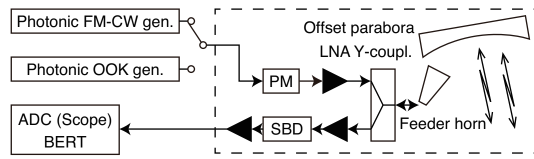

Fig. 1. Configuration of versatile transceiver frontend.

III. Demonstration

For the proof-of-concept demonstration, communication signal transmission and radar demonstration are performed. For the signal transmission, a 1-Gb/s OOK signal is used as the signal under test; its pattern is a pseudo random bit stream with a length of $2^{31}-1$. The transmitted signal from the antenna was reflected from a metal plate located in front of the antenna. Then, the reflected signal is input to the receiver. Figure 2(a) shows the observed OOK eye pattern; a clear eye opening is shown with a pulse duration of 1 ns. On the other hand, for the radar demonstration, beat note spectra mixed by the SBD with various distances of the target (a metal plate) are shown in Fig. 2(b). The FM-CW signal has a bandwidth

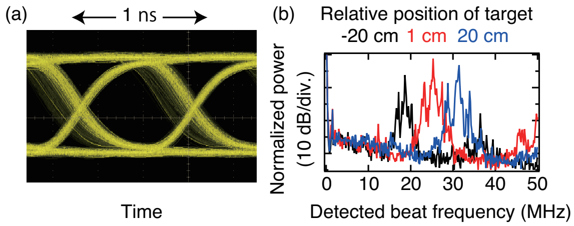

Fig. 2. (a) Observed eye pattern of 1-Gb/s signal and (b) beat frequency of FM-CW radar signal with different positions of the target.

of 12.5 GHz at a center frequency of 300 GHz [3]. Clear beat note spectra with a linear relationship between beat frequency and target distance are observed. Therefore, this configuration realizes a versatile transceiver in the terahertz band for use in radar and communications.

IV. Conclusion

We successfully demonstrated OOK signal transmission and FM-CW radar at a frequency of 300 GHz using a versatile transceiver configuration. The simplified structure is capable of using a simple transceiver to evaluate systems in advanced terahertz testbeds.

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