A 15Gps high speed OOK receiver based on a 0.34THz Zero-bias Schottky diode detector

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Abstract— **This paper presents a 0.34THz high speed on-off keying (OOK) receiver composed of a direct detector, the external video amplifier chain and a waveguide horn antenna. To evaluate the high speed performance of the receiver, a 2^{31}-1 pseudorandom binary sequence (PRBS) is transmitted and received by the existing OOK transmitter and the proposed OOK receiver respectively. And results show an a bit error rate(BER) below 10^{-12} at 10Gbps and a bit error rate(BER) of 3.15×10^{-7} at data rate up to 15Gbps at room temperature, which proves that the receiver can well meet the requirement of high data rate OOK communication system.**

I. INTRODUCTION

Demand for ultra-high speed wireless communication has increased rapidly recent years, which accelerates the development of various Terahertz (THz) communication systems. Several systems have been demonstrated recently using the modulation scheme such as 16QAM (quadrature amplitude modulation) and high order phase-keying (PSK) [1]-[3]. But these high order modulation schemes require local oscillators and related circuits, which results in a complex system framework. On the contrary, the noncoherent on-off keying (OOK) modulation scheme, though spectrally inefficient, has a very simple architecture with low power consumption since the receiver does not need LOs (local oscillators). Several OOK receivers, transmitters and transceivers have been demonstrated with good performance [4]-[5]. However, most of these OOK scheme systems are operating at frequencies below 300GHz.

In this paper, a 0.34THz noncoherent OOK receiver is designed based on a zero-bias direct detector followed by the wideband video amplifiers. It is shown that a typical responsivity of 1400V/W has been achieved over the frequency range from 315 to 357GHz, which holds the potential to deal with 20Gbps OOK signals. And the receiver has been tested and can achieve 10Gbps communication with a bit error rate (BER) below 10^{-12}. And the 15Gbps communication is also demonstrated with a bit error rate (BER) of 3.15×10^{-7} at room temperature.

II. ZERO-BIAS DETECTOR

The 0.34THz direct detector is designed in the microstrip topology on a 50um-thick quartz substrate, which is placed inside a split block waveguide cavity. Fig.1 illustrates the waveguide to microstrip transition on the right, an impedance matching network designed according to the employed low barrier Schottky diode. The CMRC low pass filter act as an RF short, which can blocks the RF and extract the video signal as a result.

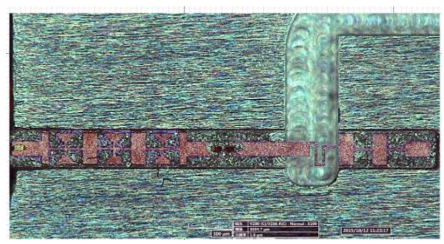
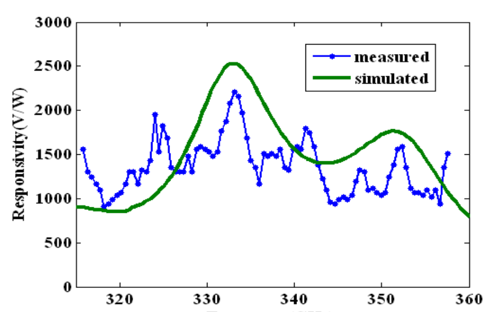
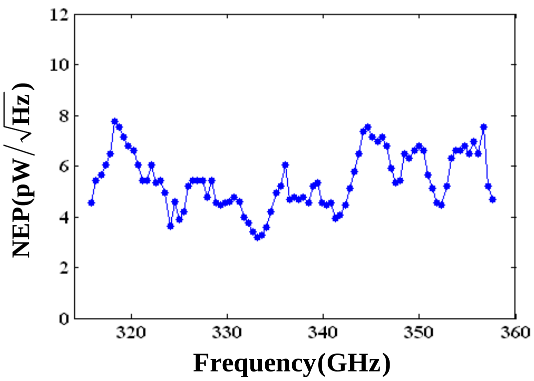


Fig. 1 Photograph of 0.34THz Schottky detector circuit on 50um-thick quartz substrate

Fig.2 (a) presents the measured and simulated responsivity of the proposed OOK detector, with an output impedance of 1MΩ. The measured responsivity into a 1-MΩ load is 910~2210V/W over the frequency range from 315GHz to 357GHz. Meanwhile, the measured output noise voltage is about 7.07nV/Hz$^{0.5}$. This results in a measured noise equivalent power (NEP) of 3.2~7.8pW/Hz$^{0.5}$ at the zero-bias condition. Fig.2 (b) shows the measured noise equivalent power (NEP).



(a)



(b)

Fig. 2 (a) measured and simulated detector responsivity versus frequency from 315 to 357GHz and (b) measured noise equivalent power of the detector.

III. 0.34THz OOK Receiver Characterization

A. Detectors and Amplifiers

Due to the absence of the 0.34THz LNA (low noise amplifier), the receiver is a zero-bias detector connected to an external video amplifier chain (Av=26) through an SMA-tee virtually. And the OOK receiver responsivity is simply the video amplifiers' gain multiplied by the detector responsivity into a 50-Ω load. Besides, NEP of the receiver is much larger than the one of the detector, because of the noise brought into by the video amplifier chain.

Fig.3 shows the responsivity and NEP of the receiver versus frequency over the operating frequency band. It can be seen that the receiver has a responsivity of 960~2350V/W, which is similar to the detector with a load impedance of 1MΩ. Besides, the NEP ranges from 37 to 92 $pW/Hz^{0.5}$ over 315~357GHz. And NEP of the receiver is dominated by the wideband video amplifier chain, which can be depressed by the 0.34THz LNA.

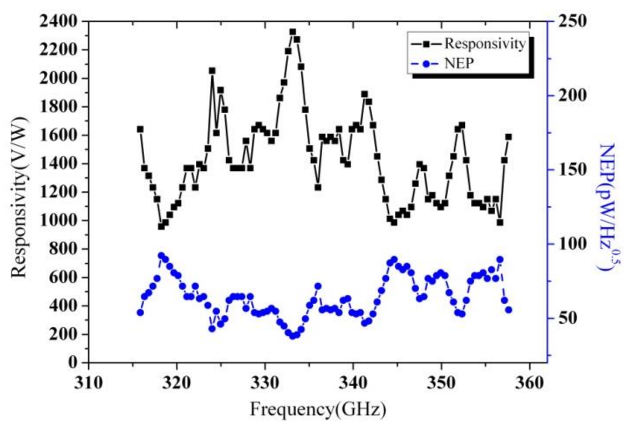


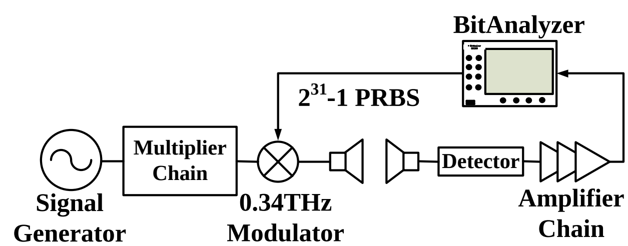
Fig. 3 The measured receiver responsivity and NEP versus frequency from 315 to 357GHz

B. BER Measurements

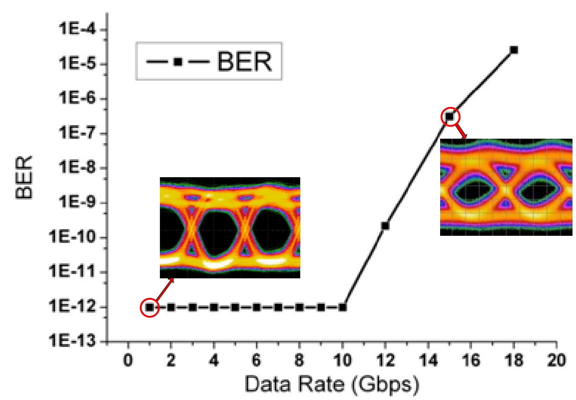
Fig.4 (a) presents a 0.34THz OOK transmitter system based on the BAC286C BER tester sending 2^{31}-1 PRBS. And a carrier frequency of 340GHz is selected. Moreover, a 0.34THz modulator in [6] is used to achieve the OOK modulation by multiplying the PRBS data with the carrier. In other words, the carrier signal passes through the modulator if the incoming data is 1; else, the modulator has no output. However, because the modulator has a finite isolation, an LO leakage exists at the output, which has a great impact on the performance of the receiver.

The OOK modulated signal is transmitted and received by the WR2.8 waveguide antennas over suitable distance. The video amplifier chain has a NF over 15dB, which is significant in the output noise of the OOK receiver. And for the lack of 0.34THz LNA at the receiver, it is difficult to realize a long distance test. Thus, in order to gain enough signal-to-noise rates (SNR), a carrier frequency of 334GHz is chosen and the output of the modulator is adjusted to -8.5dBm, which reaches the ceil of the multiplier chain. And the transmitter and receiver are set back to back during the test.

Fig.4 (b) presents the BER for different data rates, and a 10Gbps wireless communication link is achieved with a 10^{-12} BER, which is actually determined to be the lower limit because it takes a large amount of time to measure a BER <10^{-12}. And 15Gbps and 18Gbps wireless communication links are also achieved with a BER of 3.15×10^{-7} and 2.6×10^{-5} respectively. Moreover, it can be observed in Fig.4 (b) that there is a small distortion in the eye diagram at a data rate of 15Gbps, related to the BER increasing with the data rate.



(a)



(b)

Fig. 4 (a) BER measurement setup and (b) measured BER versus data rate at a carrier frequency of 334GHz

IV. Conclusion

An OOK receiver at 0.34THz has been developed based on a zero-bias Schottky diode detector with high responsivity and low NEP. And a 10Gbps wireless communication link has been demonstrated with a BER < 10^{-12} at room temperature. Also, operation has been demonstrated at a data rate up to

18Gbps with a 2.6×10^{-5} BER. Finally, performances of the receiver can be improved by reduce the LO leakage from the transmitter as well as developing the 0.34THz LNA, which are the following research.

ACKNOWLEDGMENT

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