Multi-Gbit/s Data Transmission in Sub-Terahertz Range

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Abstract— **Two multi-Gbit/s wireless communication experiments based on Schottky technology in sub-terahertz frequency range are presented. 120GHz on-off keying (OOK) transmission is achieved within lab distance with data rate up to 12.5Gbit/s. This proof-of-concept demonstration shows the capacity and potential of terahertz communication. 220GHz data transmission is further achieved in outdoor environment by the use of quadrature phase shift keying (QPSK) modulation.**

INTRODUCTION

It is becoming highly attractive to exploit terahertz (THz) and sub-THz frequency band (100 GHz~10 THz) for high speed wireless communication since THz communication has a number of important benefits including better environment flexibility compared with the optical communication, the availability of large absolute bandwidth and small antenna aperture size. Such benefits provide increasing attractiveness in satellite cross-link in terms of space application and short-range wireless personal area networks and secure communication for ground use [1].

Although THz communication shows attractive application advantages, yet at the current stage, the enabling physical devices remain a main technical bottleneck. In order to make effort to fulfill practical cost-effective all-electronic THz communication systems, we investigated multi-Gbit/s data transmission in two frequency bands (120GHz and 220GHz) based on Schottky electronic devices, which can be readily available at a sensible price point.

Firstly, we built a simple system set-up to carry out the proof-of-concept data transmission experiment at 120GHz in short range. After this demonstration, a more complex 220GHz set-up was proposed to achieve outdoor real-time wireless transmission, which enabled operation over practical distance range.

120GHz DATA TRANSMISSION

Fig.1 shows the 120GHz transmission experiment set-up. In the experiment, on-off keying (OOK) data signals generated by a pulse pattern generator (PPG) were fed into a self-developed 120 GHz Schottky subharmonic mixer (SHM) to transmit, and the frequency down-converted data stream was analyzed using a high sampling-rate oscilloscope and bit error detector. The transmission experiment was carried out in lab environment with a distance of 0.2m (shown in Fig. 2) and the data rate could reach up to 12.5Gbit/s with eye diagrams presenting sufficient eye opening. The eye diagram at 12.5 Gbit/s is shown in Fig. 3. Good eye diagrams and bit error rate (BER) that exceeds the threshold for forward error correction (FEC) [2] were achieved, which means further digital correction can be applied to produce much lower BER which is acceptable for practical application.

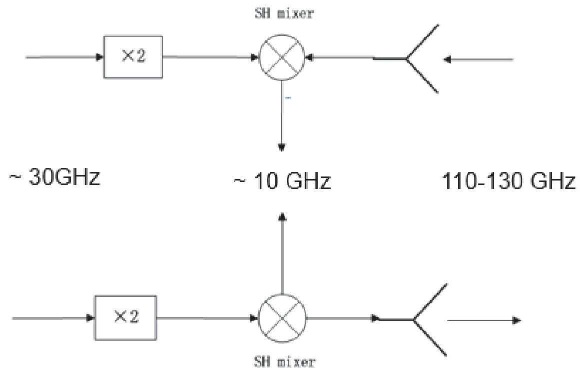


Fig. 1 120GHz transmission schematic set-up.

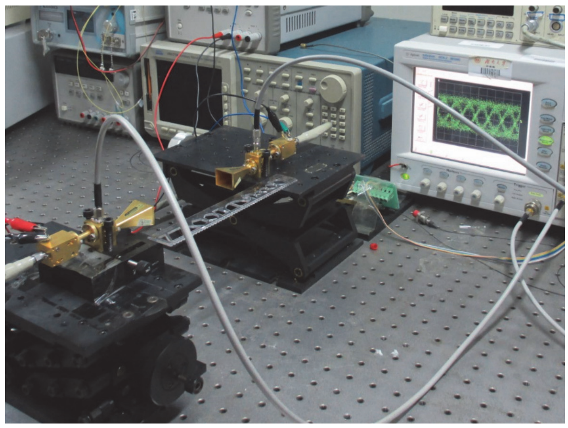


Fig. 2 Picture of 120GHz transmission experiment.

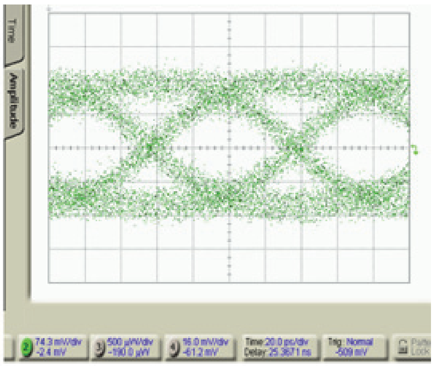
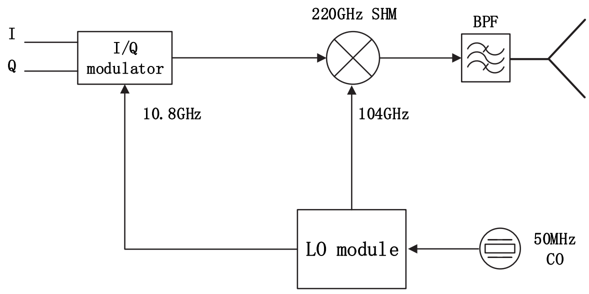


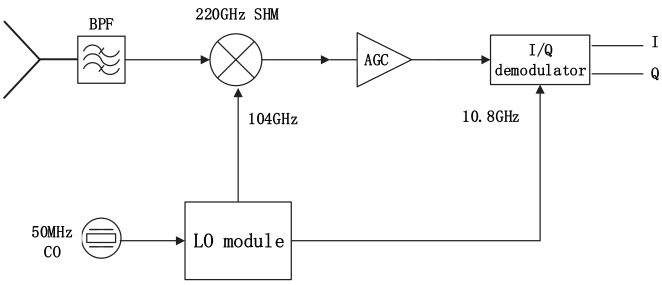
Fig. 3 Eye diagram at 12.5Gbit/s.

220GHz DATA TRANSMISSION

After the successful transmission at 120GHz, we pushed the frequency further up to 220GHz, which is an atmospheric window. Due to this merit, an outdoor transmission set-up which could enable operation over practical distance range was proposed (shown in Fig. 4). Albeit the lack of solid-state amplifiers, this drawback could be overcome by using high gain Cassegrain antennas and adopting self-developed low-noise 220GHz Schottky subharmonic mixers that could provide sufficient receiver sensitivity.



(a) transmitter.



(b) receiver.

Fig. 4 220GHz transmission schematic set-up.

In the transmission set-up, Schottky subharmonic mixers (SHM) are employed as the frequency up- and down-converters respectively at the transmitter (Tx) and receiver (Rx) ends. At the Tx end, broadband base-band signals are I/Q modulated on an X-band carrier (10.8GHz) before up-converting to the transmission frequency around 218.8GHz by the subharmonic mixer which operates in the single side band mode due to the existence of a band-pass filter (BPF) between the mixer and the antenna. The Rx end consists of the same components with its Tx counterpart except for the automatic gain control (AGC) amplifier which is designed to offset the received power variation and ensure an optimum detectable power level by the I/Q demodulator. LO signals for the Tx and Rx ends are generated in the same frequency multiplication configuration based on two 50MHz crystal oscillators (CO) separately for each end.

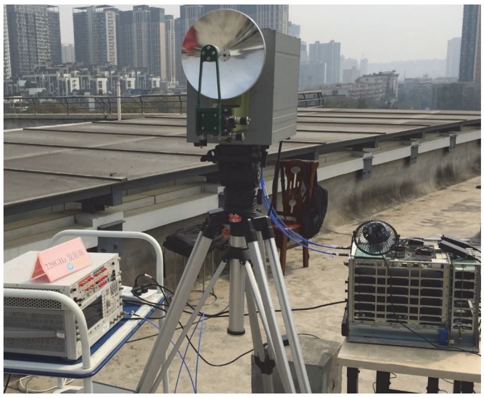


Fig. 5 Picture of 220GHz outdoor transmission experiment.

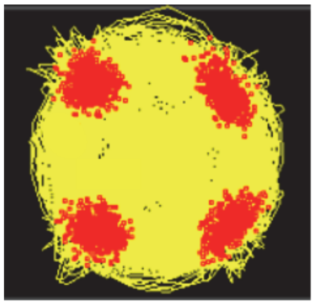


Fig. 6 Constellation diagram at 3.52Gbit/s.

The transmission experiment was conducted over a 200m distance with data rate of 3.52Gbit/s (shown in Fig. 5). The transmission quality was addressed in terms of error vector magnitude (EVM). The EVM at 3.52Gbit/s was measured to be less than 21% with the constellation diagram shown in Fig. 6. This EVM value can be translated into the signal to noise ratio (SNR) of 16dB, which exceeds the QPSK demodulation threshold. Considering the current system configuration [3], larger transmission distance and data rate are possible with proper FEC technique which can further bring 4-6 dB coding gain [2].

CONCLUSIONS

Two multi-Gbit/s transmission experiments based on Schottky technology are presented at 120GHz and 220GHz respectively. The proof-of-concept 120GHz transmission shows the capacity and potential of THz communication. The 220GHz transmission is carried out over practical distance range in outdoor environment towards future practical application. The results demonstrate the feasibility of the realization of THz communication by the use of currently available electronic technology and provide a possible technological gateway to fulfil wireless communication systems in sub-THz and THz frequency range.

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