A 2×40 Gbps Wireless Communication System Using 0.14 THz Band Oritho-Mode Transducer

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Abstract—**Based on 16QAM modulation, a 2×40 Gbps wireless communication demonstration system using 0.14 THz band oritho-mode transducer (OMT) is presented in this paper. The OMT is used for polarization division multiplex (PDM) transmission of the 0.14 THz band wireless link. The measured cross polarization discrimination (XPD) of the designed OMT is more than 30 dB at 0.14 THz band, while the insertion loss is less than 1 dB. With this OMT, the wireless link succeeds in data transmission of 2×40 Gbps data over 1.5m with bit error rate (BER) < 10^{-6}, SNR > 23 dB.**

I. INTRODUCTION

TERAHERTZ, with frequency range from 0.1 THz to 10 THz, is attracting a great deal of interest for future 10~100 Gbps wireless communication systems, such as board to board communications, kiosk downloading, data center links, wireless backhauling/fronthauling.

As more and more researchers are focusing on terahertz communication, many representative communication prototypes are presented in this decade. Jun Takeuchi et al at NTT, Japan, have reported a 10Gbps bi-directional and 20Gbps uni-directional wireless communication system with finline OMT at 0.12THz band in 2010 [1]. With wire-grid polarizers, a 48Gbps wireless communication system using telecom-based photonics technologies at 0.3THz is presented by NTT [2]. Based on the combination of terahertz photonics and electronics, IAF has developed a wireless communication system at 0.237THz for transmitting data over 20m at a data rate of 100Gbps [3]. IEMN has proposed a 22Gbps THz link with UTC-PD and SBD at 0.4THz [4].

Based on 16 QAM modulation, we have been working on developing 0.14THz and 0.34THz wireless communication systems from 2011, and have already succeeded in transmission of 10Gbps signal over 1.5 km distance in offline DSP mode, in real time DSP mode, the data rate is 3Gbps [5-7]. In order to further increase the spectral efficiency and data transmission rate, PDM-16QAM modulation is adopted by utilizing waveguide OMT, and a 2×40 Gbps wireless communication system over 1.5m distance at 0.14 THz band is proposed in this paper.

II. SYSTEM ARCHITECTURE

The schematic of the 0.14 THz wireless communication system is shown in Fig. 1. The system consists of 0.14 THz transceiver front end, horn antenna, and low IF signal digital process unit. The 0.14 THz transceiver front end is based on schottky diode mixer, multiplier, filter and waveguide OMT.

In our wireless link, an arbitrary wave generator (AWG) AWG70001A is used to generate the 16QAM modulated low IF signal with the carrier frequency of 11 GHz. In the AWG, a 40 Gbps PRBS sequence is coded with RS (204, 188) firstly, and then modulated by 16QAM format with a rolloff factor of 0.4, the modulated base band signal is then digitally up converted to 11 GHz carrier frequency with the bandwidth of 14 GHz. The low IF signal from the AWG is splitted into two paths by a splitter and one path is delayed by a delay line to make this two signal uncorrelated.

Two schottky diode based sub-harmonic mixers are designed to upconvert the generated 2×40 Gbps low IF signal (4~18 GHz) to 0.14 THz band (0.133~0.147 THz), with the convert loss of 8 dB. The 0.14 THz band pass filter is used to reject the sideband signal from the mixer, and the 0.14 THz solid state LNA is used to amplify this signal to -6dBm power separately. A waveguide based orthomode transducer (OMT) with isolation of more than 30 dB is designed and used for polarization division multiplex (PDM) the modulated 0.14 THz signal. Finally, the RF signal from the OMT is radiated to free space by 24dBi gain horn antenna.

After light of sight (LOS) free space transmission of 1.5m distance, the PDM-16QAM modulated signal is received by a 24dBi gain horn antenna. Similar to the transmitter side, the received signal is demultiplexed by the OMT, and then down converted by the sub-harmonic mixer to IF band with carrier frequency of 11 GHz separately. In both transmitter and receiver, local oscillator frequency is 64.5 GHz, which is generated by a V-band quadrupler from 16.125 GHz DRO.

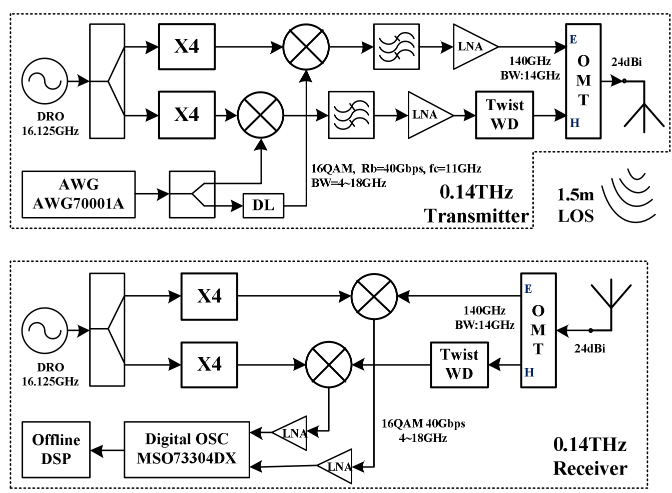

Fig. 1. Schematic of the 0.14 THz wireless communication system

The down converted IF signal is amplified to a suitable power level, and then sampled by a high speed digital oscilloscope MSO73304DX separately. The sampled signal is demodulated in offline DSP software on a workstation. The DSP procedure mainly contains digital down converting, re-sampling, matched filter, timing recovery, adaptive equalization, carrier recovery, and RS(204, 188) decoding. The decoded binary data is then compared to the original PRBS sequence to calculate the system BER performance. Due to the storage limitation of the digital OSC, the length of the PRBS sequence is no more than 2Mbit, so when there is no error bit detected, the BER is estimated to be less than 10^{-6}.

III. Waveguide OMT Module

As described above, OMT module with high isolation and cross polarization discrimination (XPD) is necessary for PDM data transmission to increase the spectral efficiency. Classical ladder transition structure based square waveguide OMT is designed, and two ladder transition for impedance matching is utilized in this OMT. The designed bandwidth is 15 GHz, and the isolation is 50 dB. Fig. 2. shows the manufactured OMT and measured XPD performance. It shows that the measured XPD is more than 30dB at 0.14 THz band, while the insertion loss is less than 1 dB.

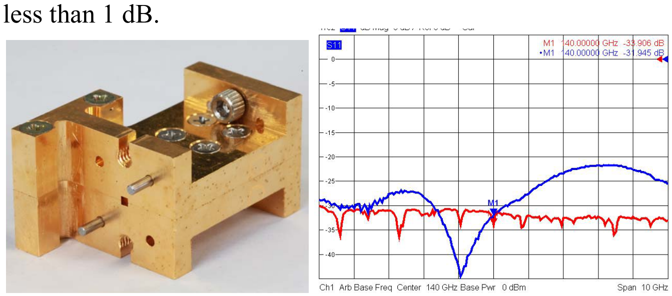

Fig. 2. 0.14 THz OMT and measured XPD performance

IV. Transmission Experiment

The photograph of the 0.14 THz wireless data transmission experiment is shown in Fig. 3. The EIRP of this transmitter is about 17 dBm, the noise temperature of the receiver is about 3000K. The measured receiving IF power is -24 dBm, and the final SNR of the signal is 23.5 dB. Fig. 4. shows the measured receiving IF spectrum and the demodulated constellation of this wireless link. The measured 99.9% signal power bandwidth of this link is about 14 GHz. Considering the data rate of 2×40 Gbps, we can conclude that the spectrum efficiency of this wireless link achieves 5.71 bit/s/Hz. There is no error bit detected in every frame transmission (2Mbit), so the BER performance of this PDM link is estimated to be less than 10^{-6}.

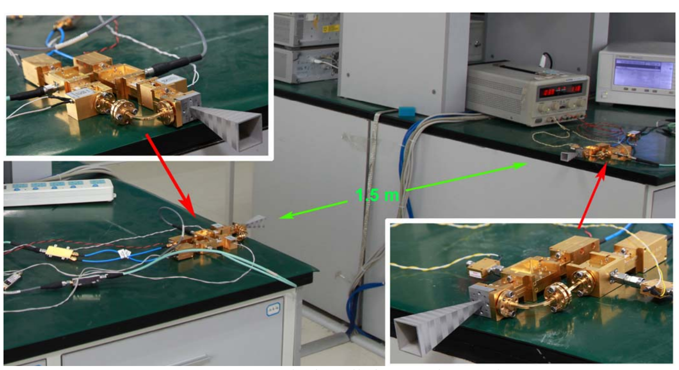

Fig. 3. 0.14 THz wireless link experimental setup

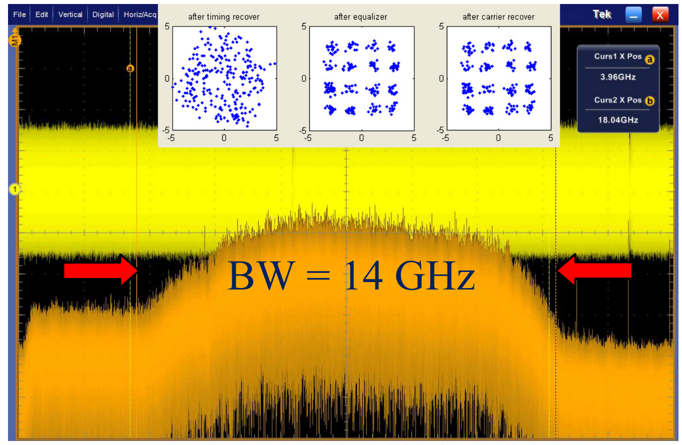

Fig. 4. IF spectrum and demodulated constellation

V. Conclusion

In this paper, we have proposed a 2×40 Gbps wireless link at 0.14 THz band with PDM-16QAM modulation by utilizing waveguide OMT. Experimental results indicate that, with EIRP of 17 dBm, the SNR of received signal is greater than 23dB, and this wireless demonstration system can transmit 2×40 Gbps data over 1.5m with BER less than 10^{-6}. The overall spectrum efficiency is increased to 5.71 bit/s/Hz.

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