QAM-32/0.588 THz communication using electronic Schottky transceivers

Guillaume Ducournau[1], Pascal Szriftgiser[2], Denis Bacquet[2], Emilien Peytavit[1], Mohammed Zaknoune[1], Rédha Kassi[1] and Jean-François Lampin[1]
[1]IEMN, U.M.R C.N.R.S/ University of Lille, Villeneuve d'Ascq, CS 60069 France
[2]PhLAM, UMR CNRS 8523, Université Lille 1, F-59655 Villeneuve d'Ascq Cedex, France

***Abstract*— We report on THz communication system using vectorial modulations schemes above 500 GHz. Using schottky-based electronic technologies at 588 GHz, potentialities of high-level multi-carrier modulation schemes for wireless links are analyzed. The wireless link is composed of an emitter with sub-harmonic mixer for up-conversion from 294 to 588 GHz and carrier modulation. A pumped zero-bias detector is used at reception. Mono-carrier signaling is realized using for up to 32-symbol modulation scheme and multi-carrier THz transmission is also achieved using several modulation schemes in parallel.**

I. INTRODUCTION

THz region is nowadays strongly envisaged for communications applications [1]. Several systems have been reported in the THz range, based on photonic (photomixers) or electronic technologies [2-4]. Even if the THz range is featuring a wide available bandwidth, higher spectral efficiency (bit/s/Hz) links are already investigated. We propose here the first investigation of vectorial scheme above 500 GHz using schottky technology, for up to QAM-32 modulation scheme or multi-carrier signaling using a combination of QAM and PSK-n signals.

II. RESULTS

The emission circuits are depicted by fig. 1 and 2. The emission of the 588 GHz carrier is realized using a sextupler driven by a F_0=16.3375 GHz synthesizer (reference signal). The 98 GHz signal (90 mW) is then tripled (294 GHz, 4 mW) and drives an up-converter. The receiving circuits (fig. 2) are first composed of a zero-bias detector (ZBD) with three ports (LO, RF and rectified DC) operated using a LO in addition to the THz modulated signal.

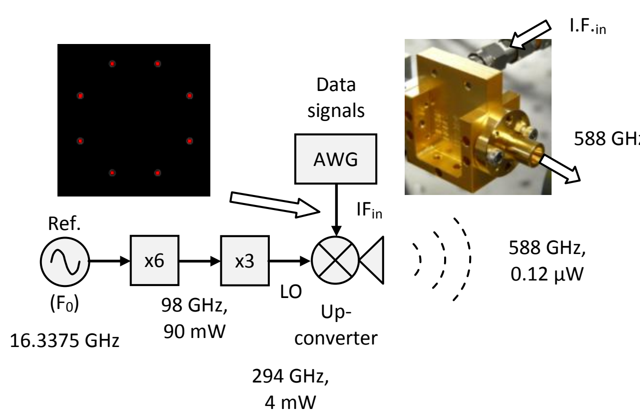

Fig. 1. Architecture and view of the Tx circuits.

After down-conversion in the ZBD, baseband amplifier is used to recover required power level for detection. As Tx and Rx circuits uses the same frequency reference, the detection can be directly realized using a real-time oscilloscope, for constellation analysis and error vector magnitude (EVM) evaluation.

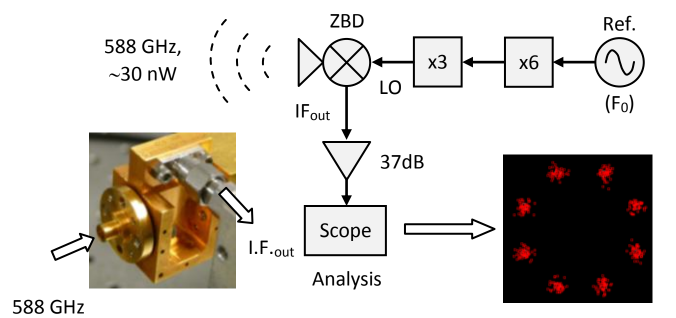

Fig. 2. View of the Rx circuits.

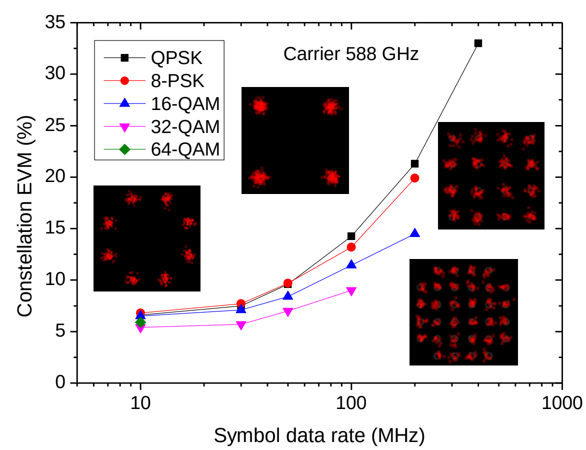

Fig. 3. Error vector magnitudes obtained versus modulation formats tested. PSK = Phase Shift Keying, QAM = Quadrature Shift Keying.

In order to take benefit of the whole baseband bandwidth and linearity of the system, a multi-carrier modulated signal transmission was tested. In that case, the IF_{in} signal was composed of three modulation schemes using 100, 200 and 300 MHz carrier frequencies with QAM-16, PSK-8 and QPSK signaling, respectively. The formats were chosen to be more complex as the frequency was increased (corresponding to a signal to noise ratio decrease). The symbol rates/powers were 25 MHz/-6.5 dBm for QAM-16 and PSK-8 and 50 MHz/-6.5 dBm for QPSK. The figure 4 shows the resulting output IF signal. Successful transmission was obtained as depicted by clearly defined constellations given in the insets of figure 4.

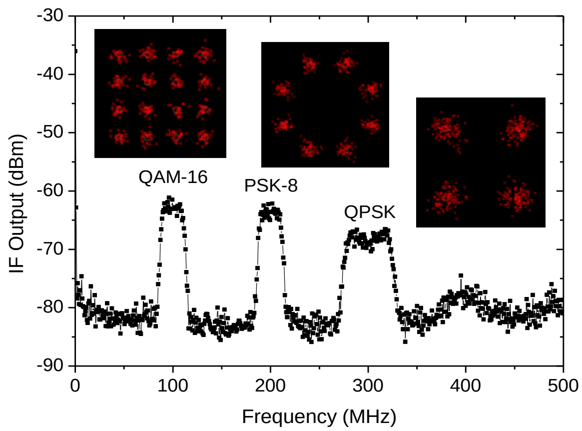

Fig. 4. Multi-carrier transmission test, for QPSK and PSK-8 data signals.

III. CONCLUSION

A 588 GHz wireless link has been presented, for mono/multi-carrier signals, up-to 32-QAM. Performances are limited by the conversion losses/available power at SHM/ZBD and system non-linearity which limits the maximal modulation index usable. Another limitation may come from residual Fabry-Pérot effect between Tx and Rx which may cause some amplitude distortion in the THz channel [5].

Acknowledgments: This work has been supported by the equipex program “FLUX”, ‘Fibre optics for high Fluxes’, “COM’TONIQ” ANR project (under grant ANR-13-INFR-0011-01) and French Renatech national platform for nanofabrication. We thank the IEMN Nano-Microwave RF/MEMS characterization centre, the IEMN-IRCICA telecom platform for baseband signal generation and detection and S. Blin/P. Nouvel from IES for supplying the Rx tripler.

REFERENCES

[1] J. Federici and L. Moeller, “Review of terahertz and subterahertz wireless communications”, J. Appl. Phys. 107, 111101, 2010.

[2] T. Nagatsuma, S. Horiguchi, Y. Minamikata, Y. Yoshimizu, S. Hisatake, S. Kuwano, N. Yoshimoto, J. Terada, H. Takahashi, “Terahertz wireless communications based on photonics technologies”, Opt. Exp., vol. 21, no. 20, 23736, 2013.

[3] S. Koenig, ,D.Lopez-Diaz , J. Antes, F. Boes ,R. Henneberger, A. Leuther, A. Tessmann, R. Schmogrow, D. Hillerkuss, R. Palmer, T. Zwick, C. Koos, W. Freude, O. Ambacher, J. Leuthold and I. Kallfass, “Wireless sub-THz communication system with high data rate”, Nature Photonics, DOI: 10.1038, Oct. 2013.

[4] J. Federici and L. Moeller, “Review of terahertz and subterahertz wireless communications”, J. Appl. Phys. 107, 111101, 2010.

[5] R. Kakimi, M. Fujita, M. Nagai, M. Ashida and T. Nagatsuma, “Capture of a terahertz wave in a photonic-crystal slab”, Nature Photonics 8, pp. 657–663 (2014) doi:10.1038/nphoton.2014.150.