



OFDM-RoF System at 60GHz for Full Duplex Communication

Nitha George¹, Annie George²

Final Year M.Tech Student, Dept. of Electronics, Rajiv Gandhi Institute of Technology (RIT), Kottayam, India¹

Assistant Professor, Dept. of Electronics, Rajiv Gandhi Institute of Technology (RIT), Kottayam²

Abstract: 2×2 MIMO Radio over Fiber system with OFDM modulation at 60 GHz is presented in this paper. 60-GHz technology is considered as a best solution for multi Gb/s applications because of the wide 7 GHz spectrum. 4 QAM and 16 QAM modulation system is employed and transmitted over 25 km and received with data rate upto 69 Gb/s. Optical coupler is utilised to implement the 2×2 MIMO system. Also the optical carrier was recovered from the millimetre wave produced for Full Duplex application. Eye diagrams and constellations are used to evaluate the efficiency of the system.

Keywords: radio-over-fiber (RoF), Full Duplex system, Multiple-input-multiple-output (MIMO), Orthogonal Frequency-Division Multiplexing (OFDM).

I. INTRODUCTION

As there is a wide expansion of number of wireless communication users and the bandwidth necessity, moving to higher frequencies i.e., from radio frequency to millimeter frequency is the significant solution to the congested low frequency spectrum [1]. However this migration invites some major bottlenecks. The millimetre wave carriers can provide high bandwidths, but suffer from a low propagation range, which would require a large number of Radio Access Points (RAPs). Hence, network operators have to split large cells into smaller cells to meet the increasing demand of bandwidth per user, where increasing the number of Base Stations (BSs) results in an increase in the infrastructure costs. The concept of RoF means to transport information over optical fiber by modulating the light with the radio signal. RoF technique has the potentiality to be the backbone of the wireless access network. The concept of RoF is illustrated in fig 1. The choice of modulation schemes for 60 GHz radio is highly dependent on the propagation channel, the use of high gain antenna/antenna array, and the limitations imposed by the RF technology [3]. If the delay spread of the underlying propagation channel is high, then an orthogonal frequency division multiplexing (OFDM) is an excellent option of modulation since OFDM can effectively turn the frequency selective channel into flat fading channel by dividing the high-rate stream into a set of parallel lower rate substreams. This simplifies the equalization technique for multi gigabit wireless system [4].

Compared with the Time Division Duplex (TDD) and the Frequency Division Duplex (FDD), the Full-Duplex scheme transmits and receives simultaneously in the same frequency band, which can significantly improve the throughput and the spectrum efficiency.

Full duplex system can be formed by making use of wavelength reuse same frequency band, which can significantly improve the throughput and the spectrum efficiency. Full duplex system can be formed by making use of wavelength reuse techniques in RoF. Here a part of the downstream signal is reused for the uplink transmission of data. There are different methods for wavelength reuse [5]. Optical filtering at the base station is the one of the techniques for wavelength reuse. It requires wavelength sensitive devices such as optical filter or interleaver (IL). In this project such a RoF system is implemented by generating OFDM modulated millimetre-wave signal at 60GHz. At the Base station, a rectangular bandpass filter is used to reflect the carrier for uplink transmission while passing the optical mm-wave signal to downlink receiver. Using the proposed architecture, bidirectional 10Gb/s data was successfully transmitted over 25 km for both upstream and downstream simultaneously.

II. EXPERIMENTAL SETUP AND RESULTS

Fig 2 schematically depicts the experimental setup of the system employing single-electrode Mach Zehnder modulator. The system uses Optisystem for simulation. The baseband data is $2^{31} - 1$ length pseudo-random binary sequence (PRBS). This data is next OFDM modulated. The length of inverse fast Fourier transform (IFFT) was 512. The subcarrier number of the OFDM signal was 296, so the signal bandwidth was 6.9375-GHz. Each subcarrier was modulated with the 4-QAM and 16-QAM format. Then, the baseband OFDM I/Q signals were upconverted with an electrical I/Q mixer. Hence, an OFDM signal occupying 7-GHz bandwidth at a center frequency of 21.5



GHz was obtained. The spectrum of the OFDM signal is shown in figure 3. The OFDM signal was combined with a 39-GHz sinusoidal signal before being sent into the MZM.

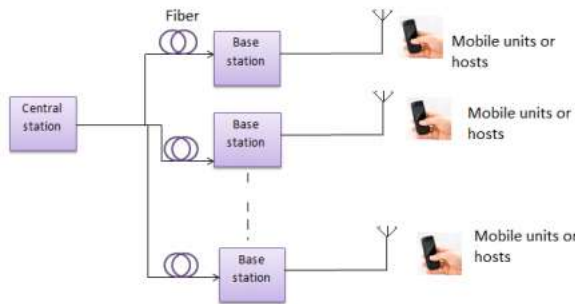


Fig. 1: Concept of RoF System

The MZM was biased at the null point to achieve optical double sideband with carrier suppression modulation. The

laser source was a continuous wave laser (193.1THz, 10 dBm). With this modulation, two optical double sideband signals were generated after the optical modulator. The optical spectrum at the output of intensity modulator is shown in Fig5. An optical band pass filter (BW:80GHz) was utilized to remove one OFDM-modulated optical sidebands and one un-modulated optical sideband. The filtered spectrum is shown in fig 6. The signal is then amplified by an optical amplifier (20-dB gain, 4-dB noise figure). After fiber transmission of 25 km, the optical signal was evenly split by a 50:50 optical coupler. One of the optical signals was delayed by 2-km single-mode fiber to imitate for MIMO operation. After photodiode detection and amplification, two mixed OFDM signals at 60.5-GHz were down-converted to two separate IF frequencies at 5GHz. Fig 7 shows the output constellation diagram for 16-QAM. A rectangular Optical filter is used to tune the required carrier at 193.1THz. The carrier is modulated via LiNbO3-MZM driven by the required uplink data.

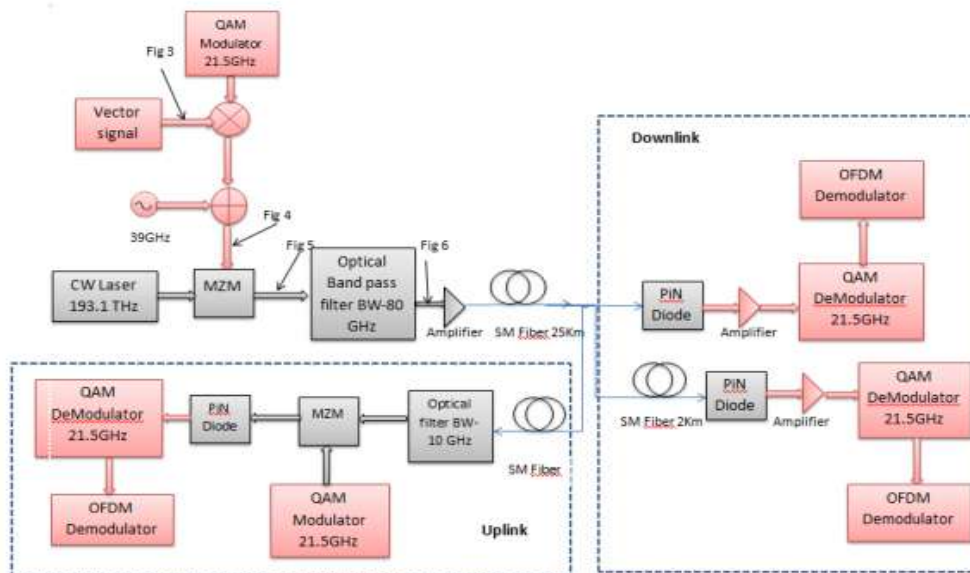


Fig. 2: Experimental setup. MZM: MachZehnder Modulator, CW: Continuous wave, SM: Single Mode

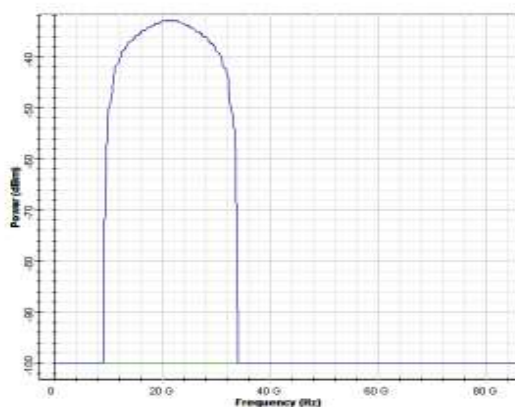


Fig. 3: 21.5GHz OFDM signal

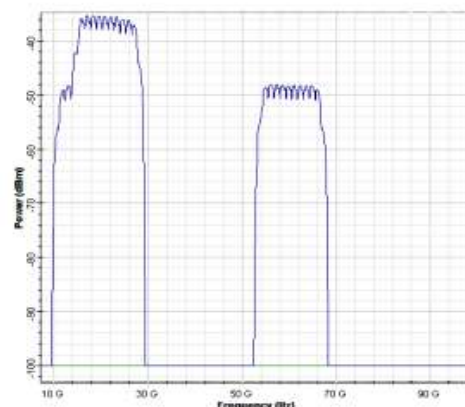


Fig. 4: Output of Multiplier

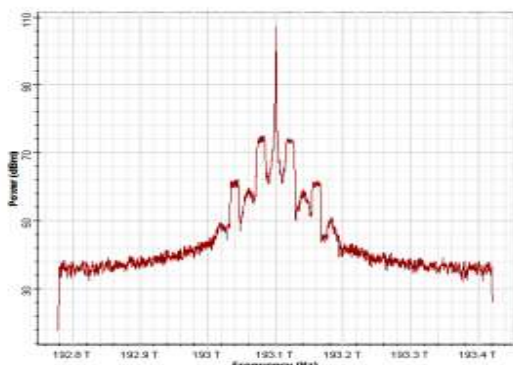


Fig. 5: Output waveform of MZM

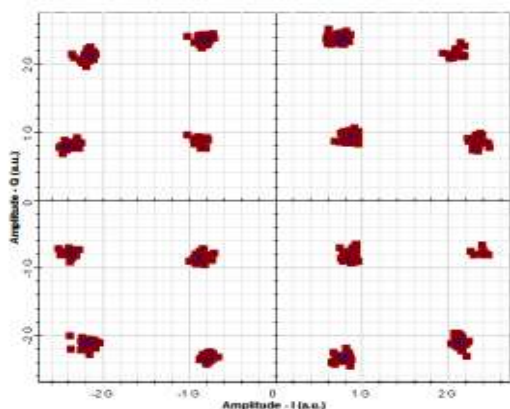


Fig. 7: Constellation Diagram of 16QAM Downlink

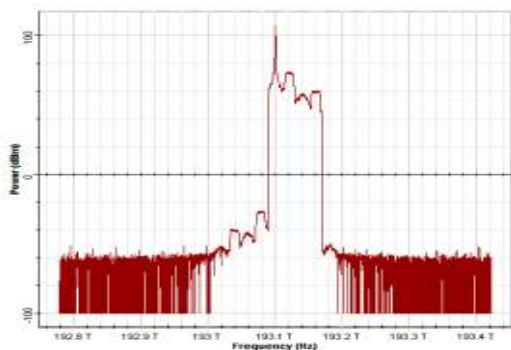


Fig. 6: Output of Filter

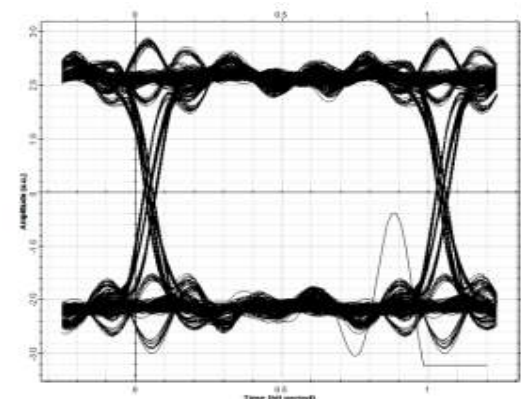


Fig. 8: Eye diagram for 4-QAM

A 3R generator and eye diagram analyser are used to find the eye diagram of the downlink receiver. Fig 8 and Fig 9 show the eye diagrams for 4-QAM and 16-QAM downlink respectively. We get an open eye diagram which shows that reliable communication is possible.

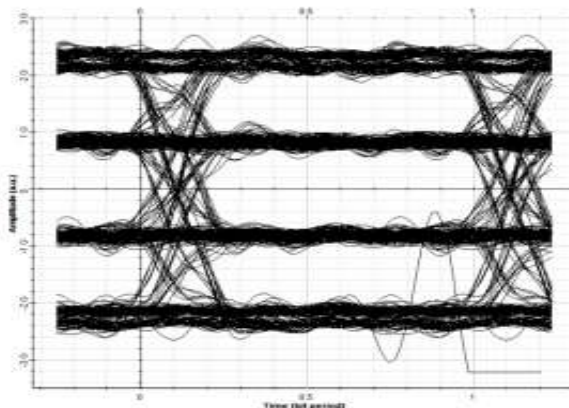


Fig. 9: Eye diagram for 16QAM

III. CONCLUSION

In this project a full duplex OFDM-RoF system is proposed at 60 GHz. Baseband data is modulated with 4-QAM and 16-QAM OFDM signals and is transmitted over 2km and 25-km fiber resulting in high data rate of 69 Gb/s. Also the optical millimeter wave produced can be used for transmitting downlink data and carrier reusing for upstream data. In this proposed scheme, single electrode MZM is used for double side-band modulation. Since only single arm MZM is used, this RoF system is cost-effective.

REFERENCES

- [1] S. K. Yong and C. C. Chong, "An overview of multi-gigabit wireless through millimeter wave technology: Potentials and technical challenges", *EURASIP J. Wireless Commun. Netw.*, vol. 2007, no. 1, p. 078907, Dec. 2007
- [2] M. Wei et al., "60GHz Radio-over-Fibre Wireless System for Bridging 10Gb/s Ethernet", presented at the 36th European Conference Exhibition Optical Communication, Brussels, Belgium, Paper Tu.3.F.6, 2008
- [3] Z. Jia, J. Yu, and G. K. Chang "A full-duplex radio-over-fiber system based on optical carrier suppression and reuse", *IEEE Photon. Technol. Lett.*, vol. 18, no. 16, pp. 17261728, Aug. 2006
- [4] C.-T. Lin, J. Chen, P.-T. Shih, W. Jiang, Jr., and S. Chi, "Ultrahigh data-rate 60 GHz radio-over-fiber systems employing optical frequency multiplication and OFDM formats," *Lightwave Technol.*, vol. 28, no. 16, pp. 22962306, Aug. 15, 2010
- [5] W. J. Jiang et al., "32.65-Gbps OFDM RoF signal generation at 60 GHz employing an adaptive I/Q imbalance correction", 36th Eur. Conf. Opt. Commun., pp. 13, 2010