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OFDM-RoF System at 60GHz for Full Duplex Communication

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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 upto69Gb/s. Optical coupler is utilised to implement the 2×2 MIMO system.Also the optical carrier was recovered fromthe millimetre wave produced for Full Duplex application .Eye diagrams and constellations are used to evaluate theefficiency of the system.

Keywords: radio-over-fiber (RoF),Full Duplex system, Multiple-input-multiple-output (MIMO),OrthogonalFrequency -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 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 improvethe 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 bygenerating OFDM modulated millimetre-wave signal at60GHz. At the Base station, a rectangular bandpass filteris used to reflect the carrier for uplink transmissionwhile passing the optical mm-wave signal to downlinkreceiver.Using the proposed architecture, bidirectional10Gb/s data was successfully transmitted over 25 kmfor both upstream and downstream simultaneously

II. EXPERIMENTAL SETUP AND RESULTS

Fig 2 schematically depicts the experimental setup ofthe system employing single-electrode Mach Zehnder modulator. The system uses Optisystem for simulation. The baseband data is $2^{31}-1$ length pseudo-randombinary sequence (PRBS).This data is next OFDM modulated. The length of inverse fast Fourier transform (IFFT) was 512. The subcarrier number of the OFDM signalswas 296, so the signal bandwidth was 6.9375-GHz. Eachsubcarrier 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, anOFDM signal occupying 7-GHz bandwidth at a centerfrequency of 21.5

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GHz was obtained. The spectrum ofthe OFDM signal is shown in figure 3. The OFDM signalwas combined with a 39-GHz sinusoidal signal beforebeing sent into the MZM.

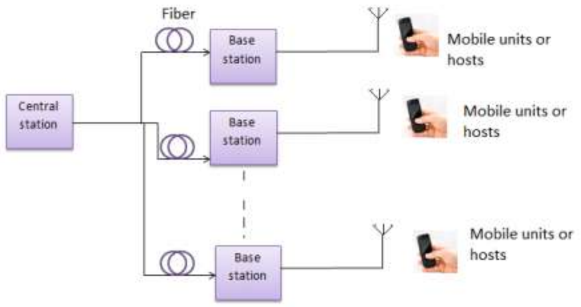

Fig. 1: Concept of RoF System

The MZM was biased atthe null point to achieve optical double sideband withcarrier suppression modulation. The laser source was acontinuous wave laser (193.1THz, 10 dBm). With thismodulation, two optical double sideband signals weregenerated 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 toremove one OFDM-modulated optical sidebands and oneun-modulated optical sideband.The filtered spectrum isshown in fig 6. The signal is then amplified by an opticalamplifier (20-dB gain, 4-dB noise figure). After fibertransmission of 25 km, the optical signal was evenly splitby 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 separateIF 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 viaa LiNbO3-MZM driven by the required uplink data.

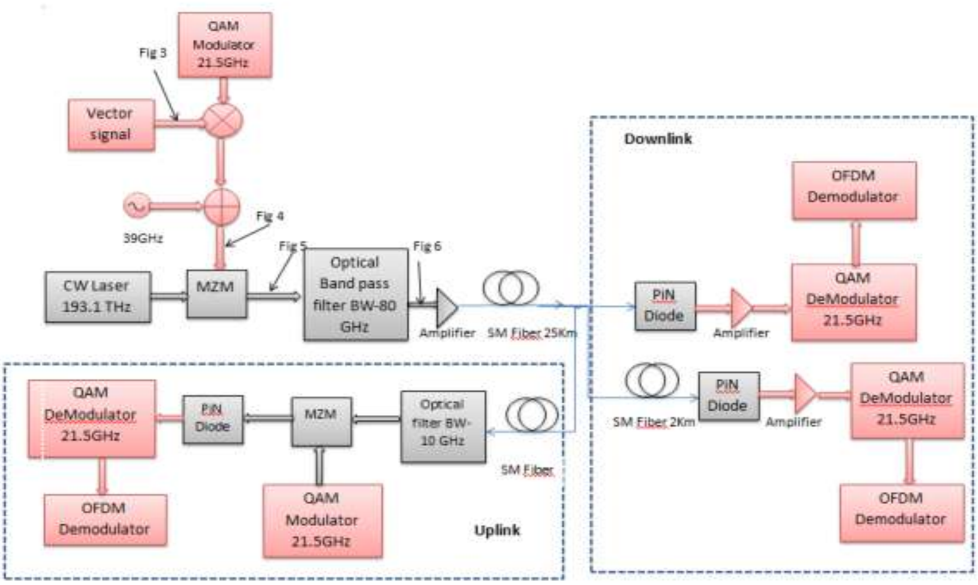

Fig. 2: Experimental setup. MZM:MachZehnder Modulator, CW:Continuouswave,SM: Single Mode

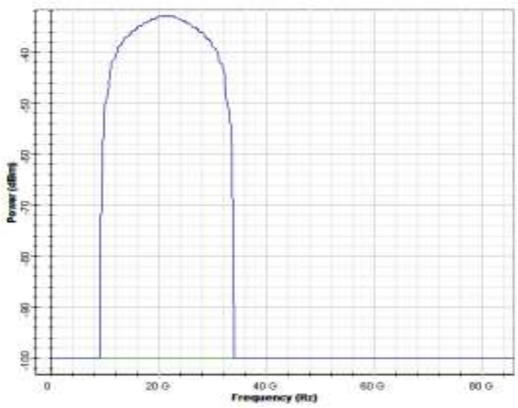

Fig. 3: 21.5GHz OFDM signal

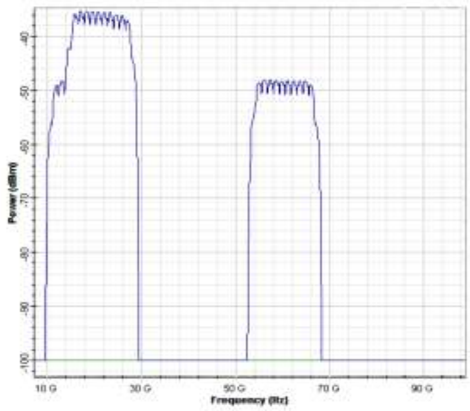

Fig. 4: Output of Multiplier

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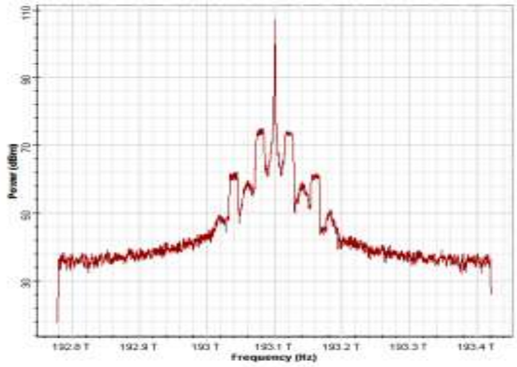

Fig. 5: Output waveform of MZM

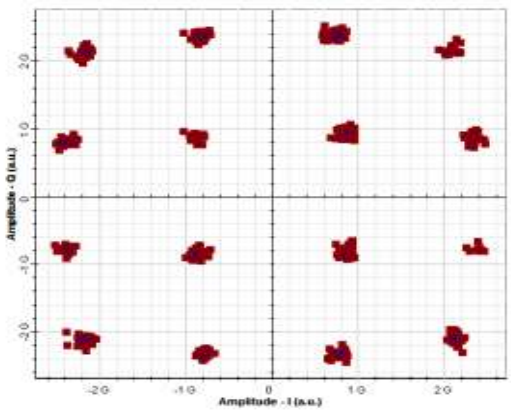

Fig. 7: Constellation Diagram of 16QAM Downlink

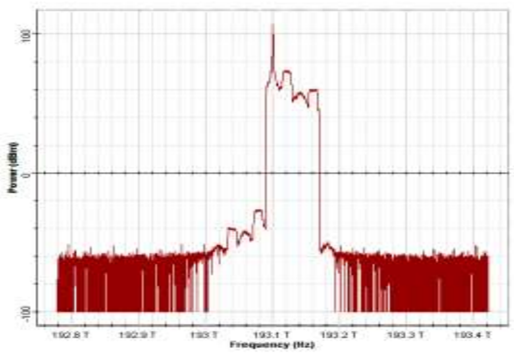

Fig. 6: Output of Filter

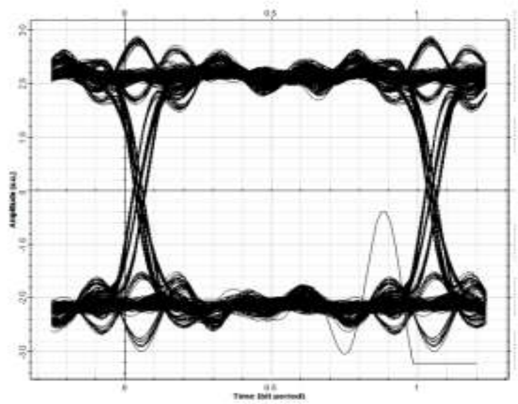

Fig. 8: Eye diagram for 4-QAM

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

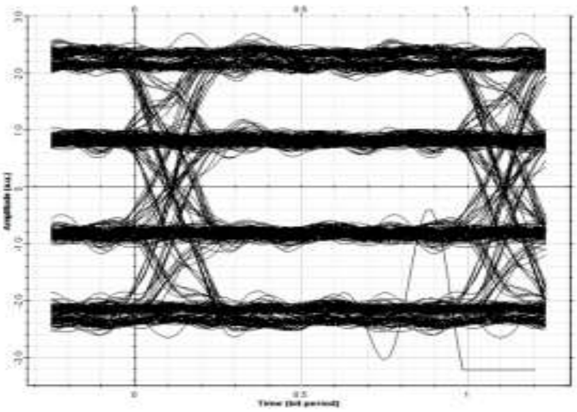

Fig. 9: Eye diagram for 16QAM

III.CONCLUSION

In this project a full duplex OFDM-RoF system is proposed at 60 GHz. Baseband data is modulated with4-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 producedcan be used for transmitting downlink data and carrierreusing for upstream data. In this proposed scheme,single electrode MZM is used for double side-bandmodulation. Since only single arm MZM is used , thisRoF system is cost-effective.

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