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A Review – OFDM-RoF (Radio over Fiber) System for Wireless Network

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***Abstract*— In future generation wireless and mobile communication system must be increase with high quality bandwidth service for inaccessible area. The recent wireless network providers require high transmission bandwidth with voice, data and multimedia service for fixed and mobile users. The recent and upcoming wireless system has different modulation technique, such as Orthogonal Frequency Division Multiplexing (OFDM), Wideband Code Division Multiplexing (WCDMA) and also it has many demand. This demand is to be satisfied for wireless system using Radio over Fiber (RoF) technique. This paper is a review implementation of OFDM to RoF system have been analyzed and proposed method discussed.**

***Keywords* — OFDM, RoF, Radio over Fiber, RF, QAM.**

I. INTRODUCTION

Nowadays due to the various demands of system and mobile users with data capacity for wireless communication have been adequately provided by voice and data services. The demand of the broadband services today has much research on millimeter communication for wireless access network in terms of speed, efficiency of Radio Frequency (RF) devices. The wireless system as suffered many losses in the transmission as well as atmospheric attenuation, to overcome these problem use of Radio over Fiber system, it has low attenuation, electromagnetic interface, and large bandwidth. Wireless coverage of the user domain has various essential part of fixed and mobile broadband communication network. In order to offer integrated with many of demand into mobile broadband and fixed services. The wireless LAN offering up to 54 Mbps in 2.4 to 5 GHz carrier frequencies, 3G mobile networks offering up to 2Mbps in 2GHz, and 4G offering up to 40 Mbps in 2-8 GHz carrier frequencies and in recent day main wireless standard such as IEEE 802.16 mobile and fixed WiMAX offering 2-66 GHz. Current worldwide coverage of wireless network has many advance multiple accessing technologies. [1, 2]

In recent, Orthogonal Frequency Division Multiplexing (OFDM) is an emerging technology for high data rates at particular new and upcoming mobile generation and fixed broadband. OFDM is a multicarrier transmission; it congenial for frequency channel selection with high data rates. This technique transforms a frequency selective with wide band channel into a group of non-selective narrowband channels, which make large orthogonality in frequency domain.

Radio over Fiber (RoF) system could be the answer to many demands of the wireless network. It is suitable technology for wireless network and provides a low cost configuration, because the optical modulated signals are transmitted to the base station carrying to the fiber without significant loss and reach the mobile user via RF transmission. The organization of paper includes an overview of OFDM system, RoF technique and combination of RoF-OFDM. And to analyze the implementation of RoF-OFDM system and proposed method has been taken from various methodologies.

A. Radio over Fiber (RoF)

Radio over Fiber system is very attractive technique for wireless access network, because it can transmit microwave and millimeter wave through optical fiber for long and short distance. It is also possible to support WLAN and current 4th generation mobility network. Radio over Fiber system, it is the integration of RF and optical network and it increase channel capacity of mobility and application systems, as well as decreasing cost and power consumption. This system provide radio access has a number of applications to merge in the recent and next generation wireless systems includes Central Site (CS) and Remote Site (RS) connected to an optical fiber link, and signal is transmitted between CS and RS in the optical band through RoF network. This architecture as the BS to different network units is present, as shown in Fig. 1. [2, 3]

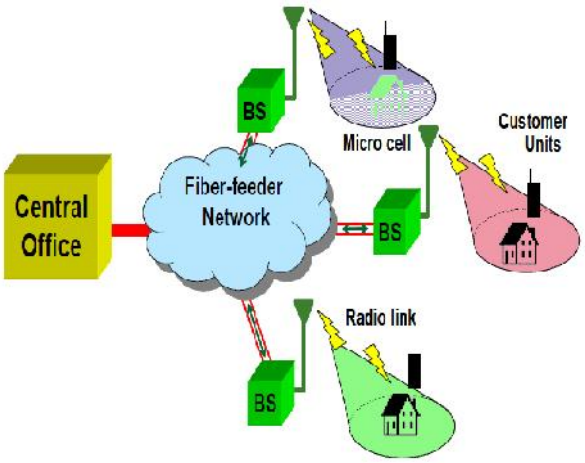

Fig. 1 Radio over Fiber

The establishment of Radio over Fiber system provides radio access and number of advantages including the ability

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to deploy small, low-cost remote antenna units and ease of upgrade for future explore. It reduces the deployment and maintenance costs of wireless networks while providing low power consumption and large bandwidth for very attractive technique in the wireless access. In addition, RoF technology enables such as macro-diversity for handover. The block diagram of RoF as shown in the following Fig. 2

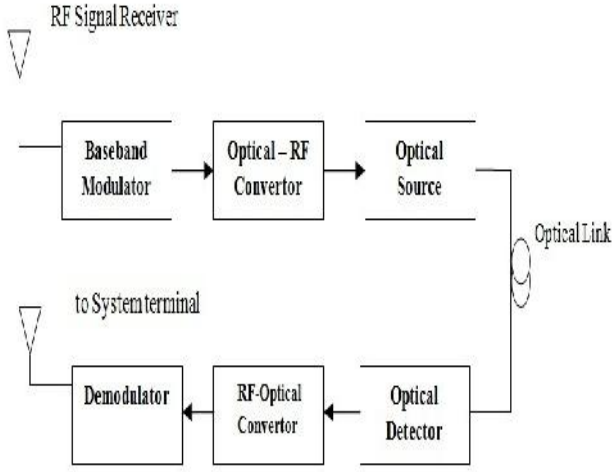

Fig. 2 Block diagram of Radio over Fiber [3]

There are many benefits of this system. Some advantages will be given, [3]

1. Low Attenuation loss
2. Large bandwidth
3. Immunity to Radio Frequency interference
4. Easy installation and maintenance
5. Reduced Power Consumption
6. Dynamic resource Allocation

And some applications are given below, [1, 3]

1. Satellite communications
2. Mobile radio communication
3. Broadband access radio
4. Multipoint Video Distribution Services (MVDS)
5. Vehicle communication
6. Wireless LAN with mobility support.

B. Orthogonal Frequency Division Multiplexing (OFDM)

The OFDM has very high spectrum data efficiency. It designs to improve the system capability and it transmitted distance over optical fiber and RF. It is consider being promising technology for high-speed optical and wireless transmission. OFDM is a multicarrier transmission technology that transmits a high-speed data stream by splitting it into multiple parallel low-speed data channels. In wireless system, OFDM is a first emerged as physical layer technology, as it proved effective solution to inter-symbol interference (ISI) caused by the spread of wireless channels. It now adopted into many recent wireless systems such as WiMAX, LTE, WiFi. [3, 4]

OFDM is a special class of the multi-carrier modulation (MCM) scheme that transmits a high-speed data stream by dividing it into a number of orthogonal channels, referred to as subcarriers, each carrying a relatively-low data rate. Compared to WDM systems, where fixed channel spacing between the wavelengths is usually needed to eliminate crosstalk, OFDM allows the spectrum of individual sub carriers to overlap because of its orthogonality, as depicted in Fig. 3. [4]

Furthermore, the inter-symbol interference (ISI) of the OFDM signal can be mitigated as the per-subcarrier symbol duration is significantly longer than that of a single-carrier system of the same total data rate. [4]

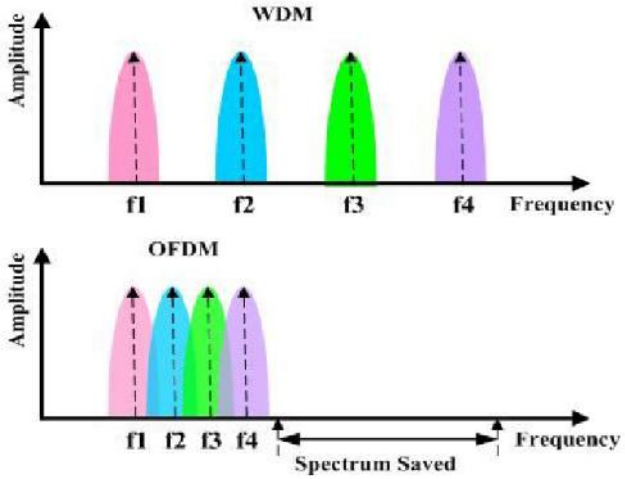

Fig. 3 OFDM Signal [4]

OFDM signal is formed using the Inverse Fast Fourier Transform (IFFT), and it adding a cyclic extension and performing to get a spectral modulator. From the OFDM transmitter, the current signal modulation format that is QPSK, QAM is to send IFFT transformation. And the modulation signal send to next level of D/A converter. The demodulator format the data send inverse of FFT transformation then to user as shown in the following Fig. 4. [4]

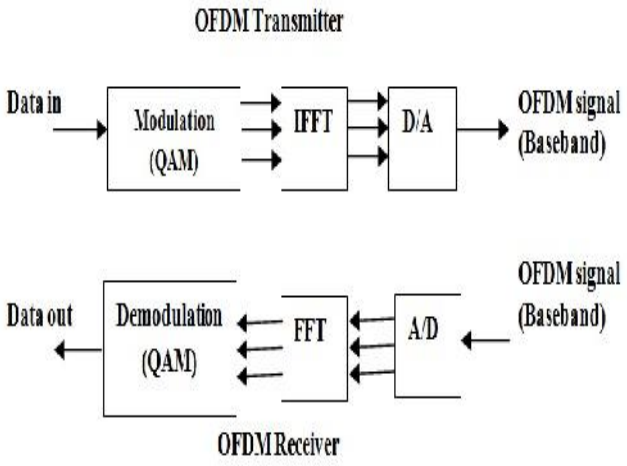

Fig. 4 Block diagram of OFDM Signal

OFDM technology has a number of advantages, as given below, [3, 4]

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1. OFDM sub carriers do not interfere with each other. It can be used for high-speed multimedia applications with lower service cost.
2. OFDM transmit a high-speed data stream by dividing it into multiple low-data-rate subcarriers.
3. It enables smooth upgrading from low-speed to high-speed transmission by simply augmenting the sub carrier and spectrum.
4. OFDM can support dynamic packet access and integrated with smart antenna.
5. MIMO system can be easily obtained with OFDM.
6. It simplifying channel estimator for different modulator scheme.
7. High spectrum efficiency can be achieved by OFDM with overlapped subcarrier arrangement, so the system capacity can be greatly increased.
8. OFDM able to protect energy loss at frequency domain.

Some Disadvantages in OFDM, it has major challenge in high peak-to-average power ratio (PAPR) caused by the symbol synthesis of multiple parallel subcarriers. This means that the transmitter and receiver components must have a wide dynamic range, such that the high PAPR signal will not be distorted. Another problem is that OFDM requires strict orthogonality between subcarriers, and thus is more sensitive to the frequency and phase noise that may interfere with its orthogonality. These problems bring difficulties in system design, and are consequently a topic of intensive research. [4]

C. *OFDM Modulation Formats:*

The optical OFDM (O-OFDM) to support high-speed transmission and advance modulation technologies are adopted into the wireless system and it achieve higher spectrum efficiency. It allows the higher data rate under the limits of current high-speed electronics and digital signal processing. The lower symbol data rate supported by multi-level modulation will be to reduction of spectrum width. Some modulation format of PSK, QAM are described below,

1. *PSK (Phase Shift Keying):*

PSK is a digital modulation scheme and that concern with the data by modulating phase of signal. M-PSK is a multilevel modulation technique; here M is a number of phases used to encode a number of bits. BPSK (Binary Phase Shift Keying), it refers to 2-PSK; here 2 phases that are separated by 180 degree are used and supported 1bit per symbol. QPSK (Quadrature Phase-Shift Keying) also refers to as 4-PSK and with $\pi/2$ Phase Shifting, as resulting 2bit per symbol. DQPSK (Differential QPSK) is the higher-order PSK formats such as 8-PSK.

2. *QAM (Quadrature Amplitude Modulation):*

QAM is modulation schemes that convey data by modulating both amplitude and phase of a signal to increase the bit per symbol. M-QAM (Multilevel Quadrature Amplitude Modulation) signal are multiplexed into two carriers of the same frequency with phase shift of $\pi/2$. 4-QAM, 8-QAM, 16-QAM, 64-QAM and 256-QAM are defined for 2,3,4,8 and 16 bit/symbol respectively. APSK (Amplitude Phase-Shift Keying) is a combination of amplitude modulation and phase modulation schemes. It can be considered under QAM.

The multilevel modulation format offer high spectral efficiency at the cost of a reduced acceptance to noise according to Shannon's law. (That is, the theoretical maximum bit rate that can be transmitted over a bandwidth limited channel in the presence of noise). The Noise based on channel conditions such as reach and signal-to-noise ratio (SNR). The subscribers with higher SNR can be loaded with higher-level modulation formats in a compact spectrum and low-level modulation formats in a wider spectrum. [4]

Bit Error Rate (BER):

BER may consider to the transmission channel noise, interference, distortion, bit synchronization problems, attenuation, and wireless multipath fading. RoF can be concluded that BER of BPSK is seen to be less than QPSK and 16 QAM in Analog as well as Digital Link. BPSK stands out for its BER even though it is spectrally less efficient. BPSK is a little higher than that of 16 QAM, but spectral efficiency 16 QAM is better choice for Digital Link. Digital Radio over Fiber shows improved performance over Analog link. Greater the data symbol modulation is more in the spectrum efficiency but less in the system robustness. [4]

II. OFDM-RoF SYSTEM

The combination of OFDM and RoF system (OFDM-RoF) has considered for future broadband wireless communication. The RoF system considers higher speed and long distance than other system. OFDM-RoF system model can divided into two parts that is RF OFDM transmitter and RF OFDM receiver. See Fig. 4. [3]

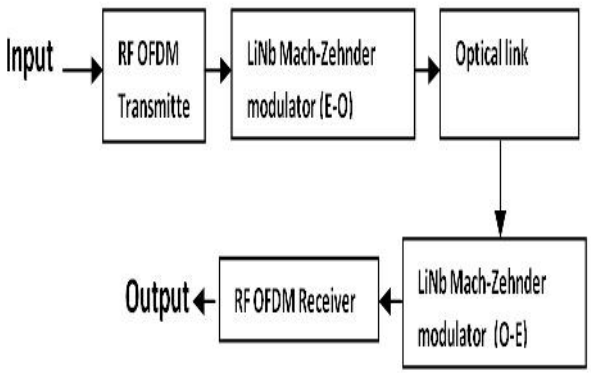

Fig. 5 OFDM-RoF System

The OFDM through RoF system is to increase modulation technique and it overcomes various limitation of the wireless transmission such as electrical power attenuation, chromatic dispersion and phase modulation through the optical link. The combination of system has many advantages for future high speed data transmission system. From the figure (Fig. 5)

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shows LiNb (Lithium Niobate) Mach-Zenhder modulator using for both Electrical to Optical (E-O) and Optical to Electrical (O-E) conversions. [3]

III. PREVIOUS METHOD

The following table.1 to be considering for different methodology has taken and the following section has been discussed about the proposed method of OFDM-RoF system.

TABLE 1 COMPARISON VARIOUS OFDM-ROF SYSTEM [3, 5, 6, 7, 8, 9, 10]

Author Name	Objectives	Tools & Parameters	Results	Remarks
Ayoob Alateeq, Mohammad Matin (March-2013)	To maintain high bit rate and provide high bandwidth using OFDM as a modulation format in RoF. BER performance of OFDM using QAM and PSK modulation.	Optiwave V.11 8-PSK, 16-PSK, 16-QAM with 20Gb/s & 30Gb/s on OFDM signal at 20GHz microwave carrier over 40km SMF used.	Both cases (20Gb/s & 30Gb/s) OFDM signal on 20-GHz microwave, 16-PSK & 16-QAM same BER.	BER when 16-PSK used might refers to the difficulty in maintaining the orthogonality in the OFDM.
Fahad Almasoudi, Khaled Alatawi, Mohammad A. Matin (June-2013)	Investigates OFDM-RoF technique in PON. RoF-OFDM-PON system provide flexible for cost effective and high data rate at last mile of wireless networks.	Optiwave V.11 Laser source 1500nm wavelength was used with 100km, 140km, 288km 4-QAM modulation for 7.5GHz carrier frequency and 10 MHz bandwidth. and Bitrate 10Gbits/s used.	From the constellation diagram, 4-QAM is clearly that the quality of the signal is much improved after using SMF (RoF).	In this study suggests that this system is not only flexible and cost effective, but also provides a significant high data rate.
M. Mahros, M. Tharwat (Dec-2012)	RoF-OFDM based physical performance of IEEE 802.11a using various channel model. In this paper also analyzed BER.	MATLAB SIMULINK model of IEEE 802.11a optical OFDM system. Modulation BPSK, 16QAM, AWGN Channel, Bandwidth 20MHz.	Here, OFDM with different modulation formats was simulated and analyzed. The BER performance analyzing by comparing input and output signal for different length.	16-QAM modulation only used. And BER performance was analyzed for given input and output signal.
Toon-Khang Wong, S.M. Idrus, and I.A.Ghani (Oct-2012)	Performance OFDM modulation technique for RoF OFDM has different modulation format. 16QAM used.	OptiSystem 8.0/9.0 16QAM, 7.5GHz carrier frequency, bit rate 10Gbps, 10-50km distance. RF signal, optical fiber channel, RF power level, bit rate and modulation format used.	OFDM-RoF system model useful to improved the performance quality of the current RF signals.	OFDM-RoF system to provide various advantages in wideband cellular systems.
R.Karthikeyan and Dr. S.Prakasam (June-2013)	OFDM signal into RoF system. Up-converting 10 Gb/s OFDM signal on 7.5 GHz carrier frequency over 60 km SMF was applied using QAM modulation.	OptiSystem and OptiPerformer. Applying 4-QAM RF Signal at 7.5 GHz carrier frequency. Upto 60Km SMF was used.	Resulting of OFDM-RoF, the RF signal improved compare with input RF signal.	Easily maintain the orthogonality at 4-QAM. In future it will increase different modulation format such as PSK, BPSK and 16-QAM.
Mohammad Shaifur Rahman, Jung Hyun Lee, Youngil Park and Ki-Doo Kim (2009)	To transmit data of RoF deployment for WiMAX with intensity modulated direct detection RoF technology. RoF technology to carry WiMAX signal between base station and RAU.	Simulink software. Channel bandwidth – 3.5 GHz. OFDM symbol – 2 Modulation – QPSK, 16-QAM, 64-QAM	Result produce with transmit diversity and without transmit diversity from the simulation for BER Vs SNR values. BER is decreased with increasing SNR value at 64-QAM.	RoF is the successful technology for transmitting WiMAX signal.

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Shikha Mahajan, Naresh Kumar (May-June 2012)	To analyze and perform COFDM based on RoFsystem. To perform 16-QAM and 16-QPSK modulation technique. To measure BER	OptiSystem Simulation Software. Applying 16-QAM & 16-QPSK, Length 2 KM	Result based on comparative analysis between QAM and QPSK at the optical link. It increases same bit rate value.	The optical amplification gives better result of the modulation technique.

IV. DISCUSSION

The table 1 shows, there are many OFDM-RoF system to compare based on different methods. The following methods provide to take different kinds of objective for further research direction.

- RoF is the flexible cost effective technique and it enables multiple functionality of reducing the attenuation, increasing high bandwidth.
- To implement OFDM signal through the RoF system.
- To produce RF-OFDM signals carrying RoF system (OFDM-RoF).
- To perform OFDM-RoF system at the different modulation technique such as QAM, PSK, BPSK.
- To found clear orthogonality in which modulation technique.
- The output of OFDM-RoF has many parameters such as Attenuation, Scattering, Dispersion, Bit Error Rate (BER) and Signal Noise Ratio (SNR).
- To compare BER rate at different modulation format.

From this analysis the problem was identified. The main problem is multiple parallel subcarriers at the transmitter and receiver component must have a wide dynamic range (Fig. 3), which is the signal will not distort. OFDM require high orthogonality between subcarrier, this problem to maintain clear orthogonality in which modulation format (m-QAM, PSK) to generate.

V. PROPOSED METHOD

From the table 1 we study OFDM-RoF system has many methodology had taken. In this section we proposed the further research method under the following Fig. 6

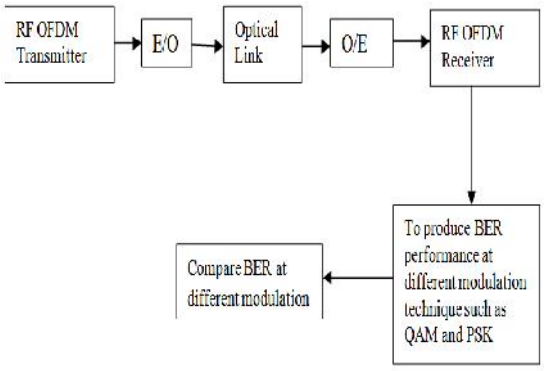

Fig. 6 Proposed Model

This system can divided into two separate models that are RF-OFDM transmitter and RF-OFDM receiver. The RF signal converted to E/O and O/E using LiNb Mach-Zenhder modulator at the suitable simulation software. At end of the output will produce BER performance at different modulation technique such as QAM and PSK. Finally it will compare BER rate at different modulation format as PSK and QAM.

VI. CONCLUSION

The review of OFDM-RoF system has been analysed. RoF system has many applications for wireless and mobile communication technologies. In this paper we conclude the modulation technique of OFDM to implement RoF system for increasing high bandwidth, low attenuation, frequent subcarrier allocation and low BER at the different modulation technique as QAM and PSK. It expected that review of this study for further research and development of newer OFDM technology to use RoF for wireless and broadband communications.

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