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# OFDM Signal Improvement Using Radio over Fiber for Wireless System

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***Abstract*— Orthogonal frequency division multiplexing (OFDM) as a modulation technology, it transmit over both wireless and optical channel, and it distribute the data over a large number of subcarrier can be overlapping. It achieved RF signal for the long haul transmission using RoF system. The RoF (Radio over Fiber) system is referred to increase the high orthogonality of the OFDM modulation signal for the wireless network. It used for the next generation both fixed and mobile network. OFDM for wireless along with RoF can be used for short distance and long backhaul network with high data transmission. This paper we present the new model up-converting 10 Gb/s OFDM signal on 7.5 GHz carrier frequency over 60 km SMF was applied for the modulation such as QAM. The result RF signal bandwidth is increase for wireless network and this model execute from optisystem simulation software.**

***Keywords-OFDM, RoF, RF,Radio over Fiber, WiMax, WDM.***

## I. INTRODUCTION

Nowadays the wireless signal may loss for the channel at the time of data transmission. So the current wireless communication systems need to increase high capacity to the access network. The Radio over Fiber (RoF) system is useful to increase high capacity and subcarrier frequency to the recent wireless systems. It support both optical and wireless network. In wireless network, RoF is the next generation wireless broadband with high speed data transmission and increase high capacity channel of RF modulation. So the next generation wireless system using RoF is very convenient, because it has many of the application to improve RF modulation such as WDM, OFDM concepts. In RoF system the optical carrier is directly modulated at the wireless carrier frequency between base and substations. So the modulation concept is used for future mobile and fixed broadband communications, that the optical and wireless are merged by using OFDM. Because the both of the application are OFDM is coincide. The electrical signal is used to modulate the optical source, as the result the optical signal is carried out the Optical Fiber link to the remote station. By the time of data deliver the radio signal directly modulated to the optical link, this time the power consumption is reduced while such as high frequency radio carriers at the antenna side.

The advantage of this system using to various mobile and fixed broadband networks like 3G, 4G, WiMax, and the advanced protocols may support in the upcoming wireless network system such as mobile generations. [1, 2, 3]

### A. *Overview of Radio over Fiber*

Radio over Fiber system, 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. RoF system provides radio access has a number of applications to merge in the recent and next generation wireless systems. It has a Central Site (CS) and a Remote Site (RS) connected to an optical fiber link. The optical signal transmitted between CS and RS in the optical band through RoF network. This model as the BS from optical to electrical (O/E) conversion and electrical to optical (E/O) is present, as show in Fig. 1.

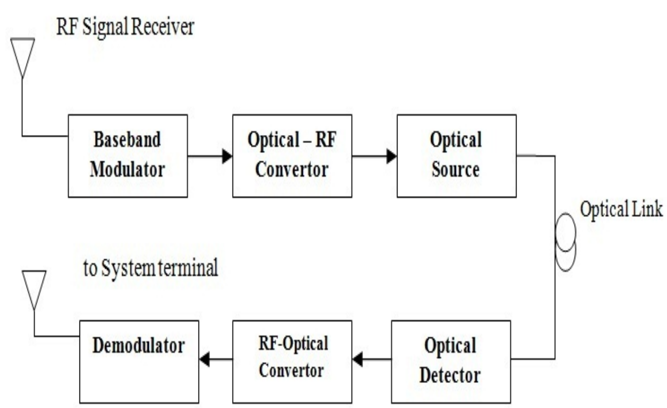


Figure 1: Block diagram of Radio over Fiber

The RoF system to transfer the data through optical signal and it modulated to convert RF signal. The light modulation can be sent directly to the radio signal. Most of this modulation method used on backbone of the wireless network system. RoF system provide easily to service broadband network both fixed and mobile standard. The wireless LAN (WLAN) offering 54 mbps at operates the carrier frequency 2.4 – 5 GHz and the 3G/UMTS system provide 2mbps at 2-8GHz carrier frequencies. The WiMax offers 75mbps for fixed and 10mbps for mobility at 2-66GHz frequencies. So it needs to increase the minimum frequencies more than 6GHz for indoor applications. The need for increasing capacity is using from the applications of RoF system. The OFDM signal is used for wireless systems and WDM signal used for Optical link. In this project used to increase capacity for OFDM systems [2, 3].

### B. *Orthogonal Frequency Division Multiplexing*

The Orthogonal frequency division multiplexing (OFDM) has very high spectrum data efficiency. It design to improve the system capability and it transmission distance over optical fiber and RF. The several OFDM based access network are in the recent research, but the OFDM based on the RoF system going to recent project is OFDM-RoF for wireless system. It is modulation technique for future broadband wireless communication. Because it provides multi-path spread spectrum in the mobility support. It represents a different system design approach as a combination of modulation and multiple-access for a communication channel. And it divides the spectrum into number of equal spread spectrum at a part of one user. It is called a one frequency for single user. OFDM can be viewed as a form of frequency division multiplexing (FDM), and when it has orthogonal to share all channel at one frequency. OFDM allow the spread spectrum can overlap, because they are orthogonal and it can't interfere with other one. see Fig. 2.

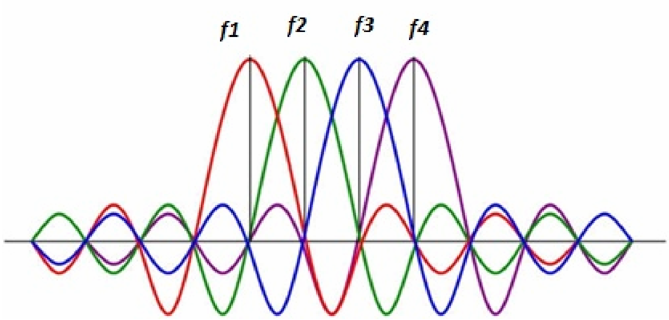


Figure 2: OFDM Specturm

OFDM uses variety of sub carriers to transmit low rate data stream in parallel. The subcarriers are modulated by using PSK or QAM and it carried on a high frequency such as 5GHz for mobile wireless broadband. OFDM is similar to the FDM, but it except for the signal requirement of orthogonality between two subcarriers. The subcarrier orthogonality can be viewed in time and frequency domain. In the frequency domain the number of cycles between each carriers are differs from BPSK, QPSK, and QAM. So the OFDM receiver calculates the spectrum values at the maximum point in the individual subcarrier without interference from others. See in the Fig. 2.

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 OFDM transmitter, the current signal modulation format that is QPSK, QAM is to send IFFT transformation. Thus the requirement in OFDM system in next level sends to D/A converter. As the demodulator format the data send inverse of IFFT that is FFT transformation. The receiving end RF signal is demodulated and transmitted to user. See in Fig. 3. [4, 5]

The Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT) techniques to implement RoF system are possible to use simple remote sites. However an optical to wireless transceivers in RoF link has many benefits to improving RF signal for wireless systems. By taking this concept have advantages for both optical and wireless communication.

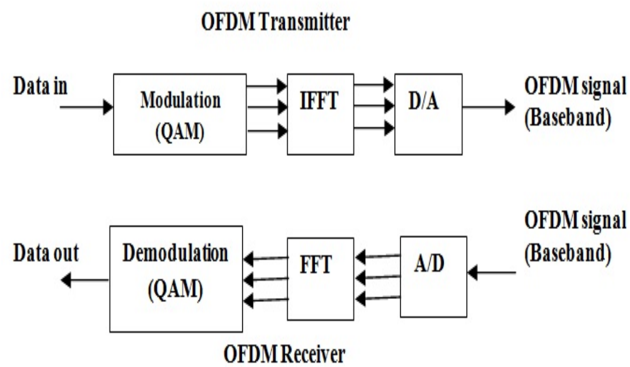


Figure 3: Block diagram of OFDM Transmitter and Receiver

From the above technique to implement OFDM signal into RoF system for increasing large channel capacity and high spectrum efficiency. This concept simulated from Optisystem software using optical components which is simplified to the current wireless network.

## II. SYSTEM MODEL

In OptiSystem simulation software, the Radio Frequency (RF) signal is carried into the RoF system and it convert optical signal for increasing channel capacity. This section includes explaining whole OFDM-RoF system model from each part of the overall system. See in the Fig. 4.

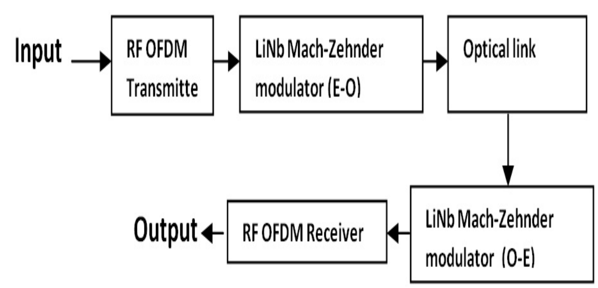


Figure 4: OFDM-RoF system model

The OFDM-RoF model can divide into two parts that is RF OFDM transmitter and RF OFDM Receiver. The OFDM through RoF system to increase modulation technique and it overcome various limitation of the wireless transmission such electrical power attenuation, chromatic dispersion and phase modulation through the optical link. The combination of OFDM-RoF system has many advantages for future high speed data transmission system. The Fig. 4 shows the various model using this project such as RF OFDM transmitter, LiNb

Mach-Zenhder modulater for E-O conversion, optical link, LiNb(Lithium noibate) Mach-Zenhder modulater for O-E conversion, RF OFDM Receiver.

### A. *RF-OFDM Transmitter*

RF-OFDM transmitter system to produce the sequence of OFDM signals using QAM, it generates the modulation using 4QAM/2bit per symbol and it carried by different frequency of each subcarrier which are the 4 subcarriers are present. The OFDM modulated produced 512 subcarriers at the position of 16-QAM (M-ary QAM position) and at the 1024 FFT points. The following Fig. 5 shows the Optisystem model of RF-OFDM Transmitter.

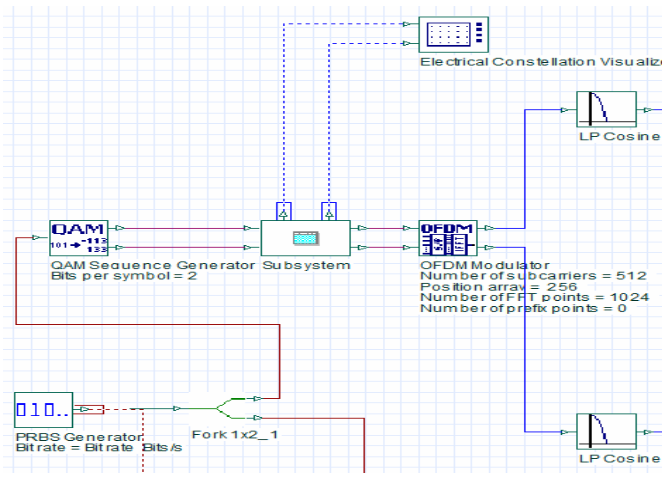


Figure 5: RF-OFDM Transmitter

From the Fig. 5 the OFDM modulator placed on the electrical signal absorption and it produce two sidebands, this signal send to the LiNb modulator for electrical to optical conversion.

### B. *Optical Link (Up and Down Converter)*

From the part of RF-OFDM transmitter, after execution of RF the signal modulation sent through the optical link before received by the RF-OFDM receiver. Here the signal feed into the optical link that is LiNb Mach-Zenhder modulater for E-O conversion is executed. The executed signal fully converted to optical OFDM for increaing upto Gb/s even for high data transmission of Tb/s. The LiNb Mach-Zenhder modulater for E-O and O-E conversion using Optisystem simulation software.

### C. *RF-OFDM Receiver*

The RF-OFDM Receiver system is the inverse process of RF-OFDM transmitter at the end of RF execution. Here the signal were received from the down coverter using optical link that is from O-E conversion of LiNb Mach-Zenhder demodulator. The receive signals gain by the electrical amplifier then demultiplexed their own carrier frequency obtain the signal output. From the block diagram Fig. 4 the receiving process the OFDM signal will be filtered to get the current baseband signal in the receiving system. The output all constellation points as shown in the following section.

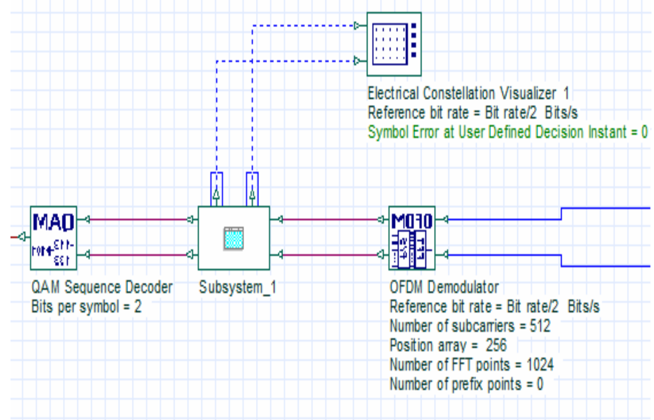


Figure 6: RF-OFDM Receiver

From the Fig. 6 shows the demodulater of OFDM signal carrier to the RF-OFDM receiver end.

## III. SIMULATION RESULT

### A. *Result of RF-OFDM Transmitter*

The RF-OFDM result shows the simulation results from the system design. At this time, the simulation can consider parameters to take, but few parameters are default, and some parameters value using from optical components of Optisystem library. The input data for the OFDM modulator have QAM modulation format. For the system performance, the base band signal analysed subsequently that is RF and optical signal analysed with RF and optical spectrum analyser respectively.

At the transmission block, the both modulation (IFFT and FFT) technique to up and down convert for the RF along with optical signal is used. For the transmission of optical, OFDM signal over up to 60km SMF was used.

After execution of OFDM modulator, the data bit signal 10Gbps at the bit sequence of 4-QAM RF signal as up converted to the 7.5 GHz carrier frequency. The output of RF OFDM spectrum signal as shown in the following Fig. 7.

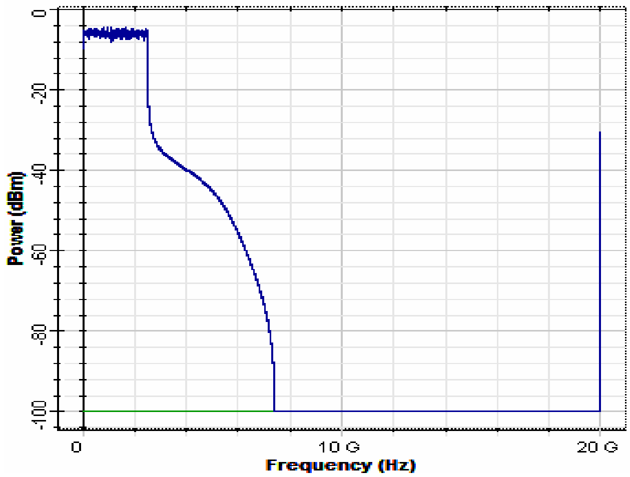


Figure 7: RF-OFDM spectrum

B. *Result of Optical Analyzer*

The result of optical analyser for both before and after filtering based band OFDM signal through the optical fiber as shown in the following Fig. 8 and Fig. 9. This is based from transmission link. The resultant before amplification the OFDM baseband signal range of laser frequency starting from 193.07 Hz and the mean value is 193.09 Hz. The amplitude power value before transmission path maximum is -37.1632 dBm and minimum is -102.992 dBm.

After filtering the OFDM signal through the optical fiber for transmitting up to 60km. The output of optical analyser signal as shown in the following Fig. 9. As the resultant after amplification the OFDM signal range of laser frequency also same like as before amplification starting from 193.07 Hz. The amplitude power value for after filtering is maximum -24.41 dBm and minimum -84.85 dBm.

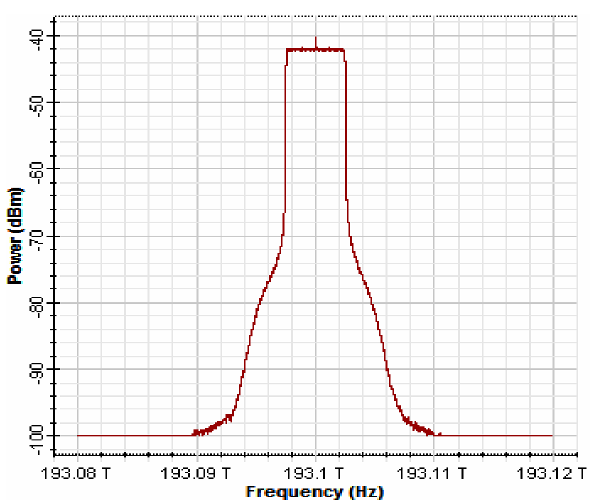


Figure 8: Result of optical analyser (before)

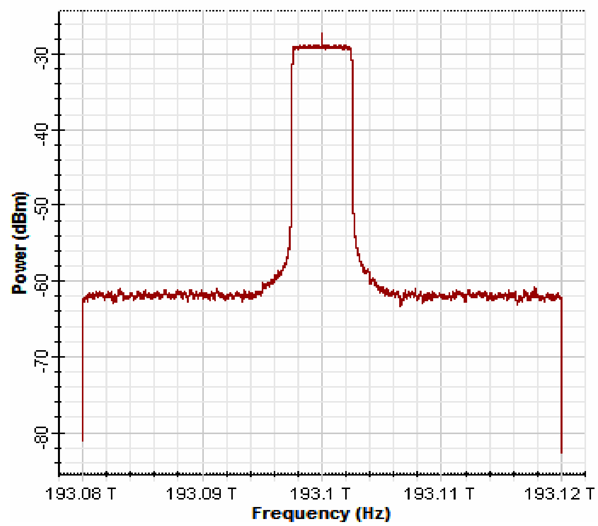


Figure 9: Result of optical analyser (after)

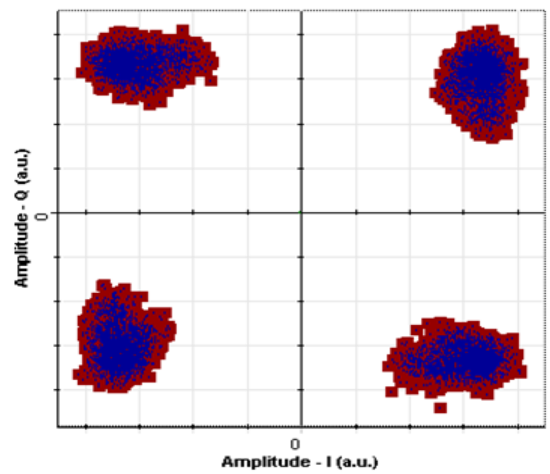


Figure 10: Constellation diagram RF-OFDM Receiver

From these two results before and after optical analyser, the optical signal fed into the SMF at carried 7.5 GHz at the RF power 0.5dBm/km. The frequency value is same but the power values are difference (based on the Fig.8 and Fig.9). That is the OFDM signal through optical fiber before transmission the power value is -3.7 dB, and after optical analyser in this value is higher than before execution -2.4 dB.

From the Fig.10 shows the overall result of RF-OFDM at the receiver end. In this result output RF signal in improved compare with input RF signal that is input RF signal maximum value is 1.1au and minimum value is -1.1au. And output RF signal that is output RF maximum value is 2.9au and minimum value is -1.05au. So the output RF-OFDM signal has improved compare with input RF-OFDM signal. It explains the OFDM signal through the optical fiber over a long distance of 60Km with electrical amplification is necessary for 10 Gbps data signal at the bit sequence 4 QAM. Here the minimum and maximum amplitude value cannot change compare with input RF spectrum.

## IV. CONCLUSION

We presented the OFDM-RoF system as achieved RF signal through the optical fiber using Optisystem simulation software. The solution of this system carried out the up-converting 10Gbps OFDM signal on 7.5 GHz carrier frequency over 60km SMF has been executed successfully using the modulation format 4QAM for OFDM system. The result shows the output of RF signal is improved compare with input value. From the result we observed easily to maintain orthogonality of OFDM signal in 4QAM format at 10Gbps data bit rate. The model of this method will be useful to increase quality of RF signal in the recent and next generation wireless communication system. In future it will increase difference modulation format such PSK, BPSK and 16QAM were found.

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