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DESIGN AND SIMULATION OF EXTERNAL MODULATION TECHNIQUE BASED RADIO OVER FIBER (ROF) COMMUNICATION SYSTEM

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ABSTRACT
AOptical fiber backhaul providing high speed interconnection to a large number of antenna base stations, so Radio over Fiber (RoF) is one of the next generation technologies in optical fiber communication systems that support efficient convergence of wireless and optical access network structure. Also, promising solution for increasing demand for larger transmission bandwidth with voice, data and multimedia service for fixed and mobile users. In (RoF), light is modulated by using a radio signal and sent over an optical fiber link to simplify wireless access. This project is focused on the investigation and performance analysis of externalmodulation, variations in Q-factor and BER with respect to fiber length at wavelength (1310) nm using (Optisystem 7.0) simulation software.Simulation results have been included to show the comparative performance evaluation of parameters like maximum Q-factor, minimum BER, eye height and threshold with respect to bit rate and fiber length for different modulation techniques. Simulation results show that the proposed system exhibits desired performance with external scheme. This paper also suggested optimal tradeoff between bit rate and fiber length for the particular system.

KEYWORDS: (RoF) communication system, Modulation, BER, Q-factor, OptiSystem 7.0 software.

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. [1].

II. RADIO OVER FIBER(ROF) SYSTEM
Radio over Fiber (RoF) for Wireless Communication isOne of the major access network solutions for future high-bandwidth wireless communicationsystems based on optical fibers for the transmission of radio signals. In RoF, the radio signal is used for intensity modulating an optical carrier. Figure (1) shows the simplified block diagram of a ROF link [2].

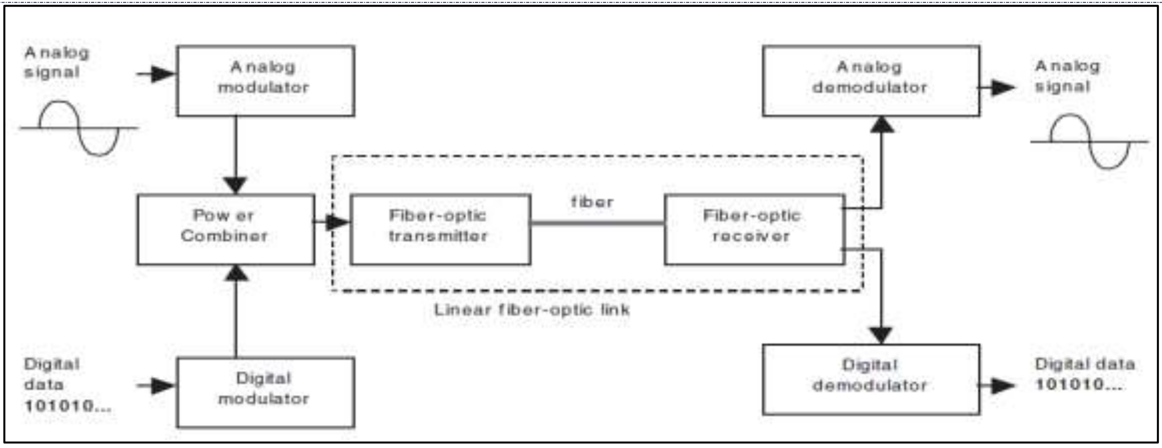

Figure (1): Block diagram of fiber-optic link transports modulated RF signals.

Some of the advantages and benefits of the (RoF) technology compared with electronic signal distribution are (Low Attenuation loss, Large Bandwidth, Low RF power remote antenna units (RAUs) , Dynamic resource allocation, Centralized upgrading,Multipath fading effects are minimized ,and Immunity to Radio Frequency Interference)[3]. The applications of (RoF) technology are in (Satellite communications, Mobile radio communication, Broadband access radio, Vehicle communication and Wireless LAN with mobility support) [4].

III. ROF - OPTICAL MODULATION TECHNIQUES

There are two different approaches for optical modulation in the fiber optic link, direct modulation and external modulation. Each has its own advantages and disadvantages.

RoF- link with Direct modulation

The most straightforward method for modulation is to directly modulate the laser source. Due to the requirements of bandwidth and efficiency, only semiconductor lasers are of practical interest for direct modulation [5]. A unique feature of semiconductor lasers is that the semiconductor laser can be modulated directly by modulating the excitation current. As shown in Figure(2) for a semiconductor laser, the output power of light intensity increases linearly with the injection current above threshold. For the injection current[5]:

$$I = I_O + i(t) \qquad ,P_O = P_O + P(t)(1)$$

Where :(I_O,P_O) is the bias point for the direct modulation of the semiconductor laser. The direct modulation scheme can be configured as shown in Figure(2).

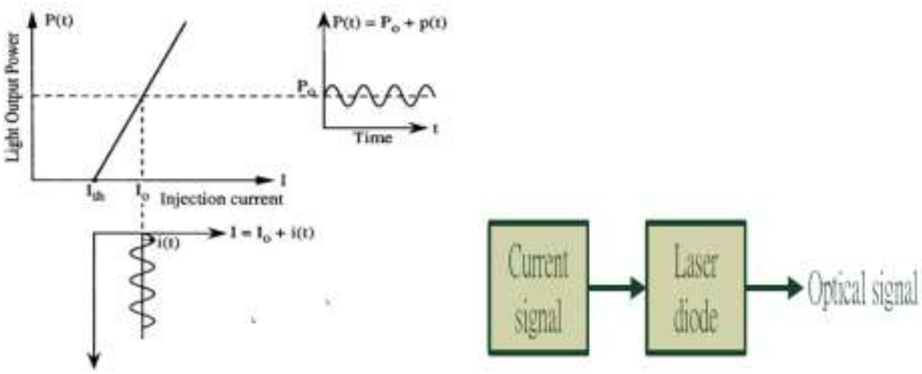

Figure (2):Currenttransition function of directmodulated semiconductor laser [6].

RoF link with direct modulation system is simulated using Optisystem7.0 software as shown in Figure (3).

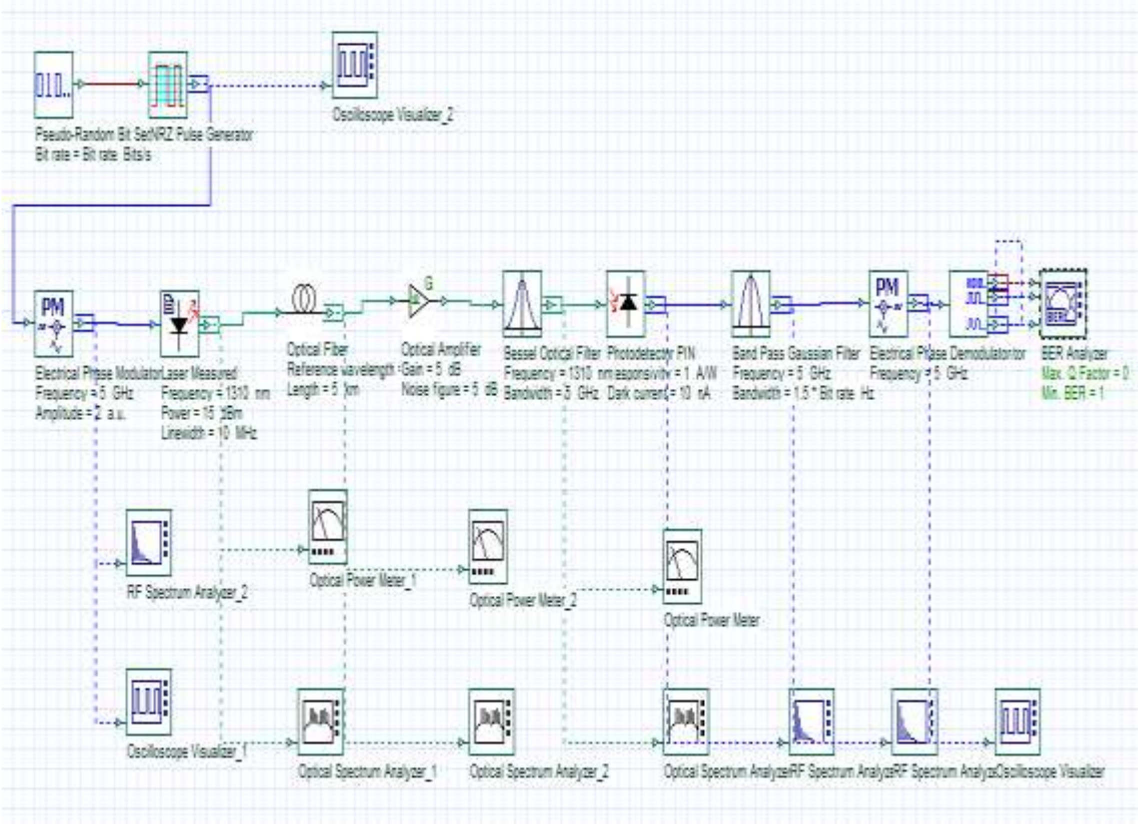

Figure (3): RoF-link with direct modulation system

Central station (CS) which consists of pseudo random sequence bit generator generating binary signals which are converted into electrical by using Phase Modulation (PM).The electrical signal converted into an optical signal by direct modulating it with a continuous wave (CW) laser diode , the central wavelength of CW laser is 1310 nm. The signal is carried over a single mode fiber (SMF) for different distances. Base station consists of optical amplifier it is amplified optical signal, filters and received signal by photo detector (PIN).

RoF-link with External modulation

Unlike direct modulation, external modulation has higher performance for wide bandwidth optical fiber communications, by using high linearity LiNbO3 external modulator to modulate signal. However the potential disadvantages is adding system complexity and high cost. Figure(4) which shows a high-speed transmitter where the laser is biased at a constant current to generate CW output, and an external optical modulator is placed next to the laser; the CW output light passes through the external modulator material whose optical properties can be modified by an applied external electric field.

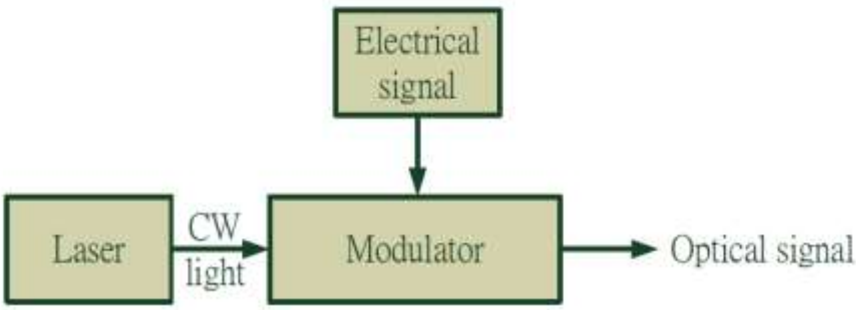

Figure (4): External modulation scheme [7]

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There are three types of external modulators: electro-absorption modulators based on the gallium arsenide or indium phosphide semiconductors, electro optic modulators depend polarized polymers, and electro optic modulators based electro optic crystals such as lithium Niobate LiNbO3, and other materials Electro-optic crystal LiNbO3, electro-optic polymers or III-V semiconductor can be used to provide bandwidths greater than 10 GHz for the external modulation. Some of these devices have modulation frequencies in excess of 40 GHz [8].RoF link with External modulation system is simulated using Optisystem7.0 software as shown in Figure (5).

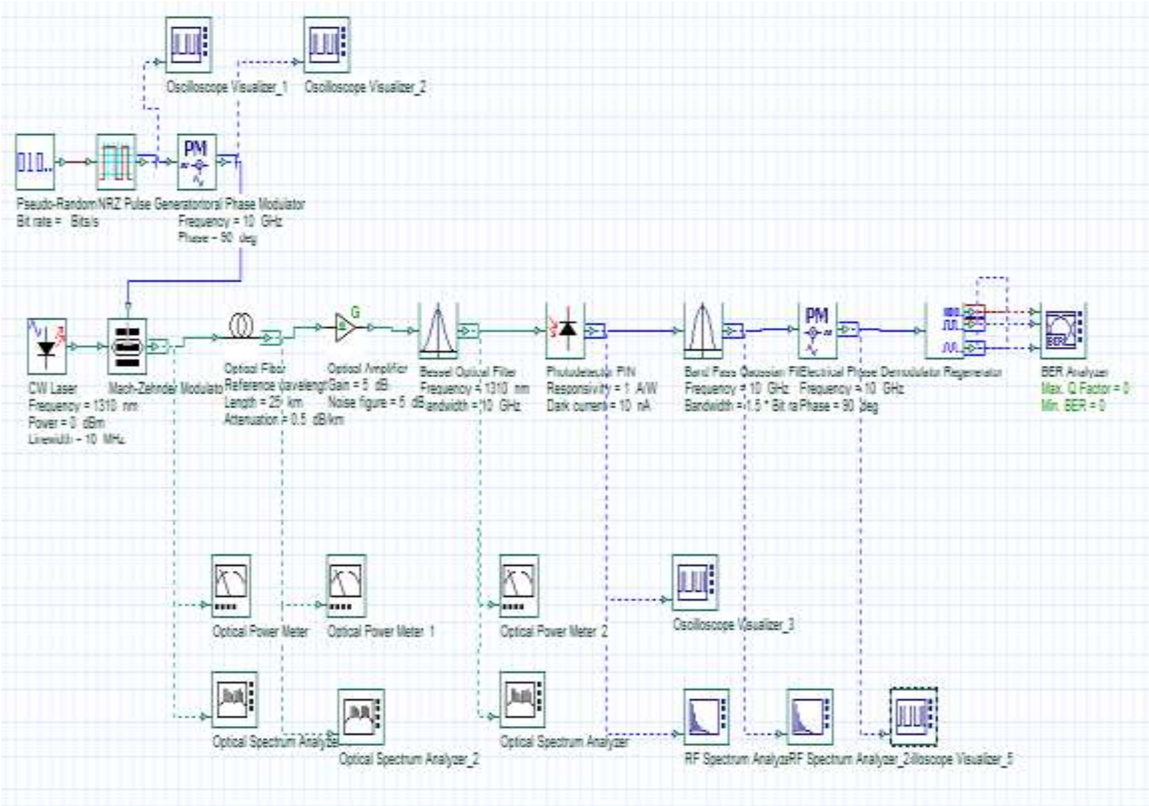

Figure (5): RoF-Link with external modulation system.

Central System (CS) which consists of pseudo random sequence bit generator generating binary signals which areconverted into electrical by using Phase Modulator (PM) in this way the electrical carrier signal is generated from. Electrical signal converted into an optical signal by externally modulating it with a continuous wave (CW) laser and a Mach-Zehnder Modulator (MZM) the central wavelength of CW laser is 1310 nm. The signal is carried over a single mode fiber (SMF) for different distances. Base station consist of optical amplifier it is amplified optical signal, filter and received signal by photo detector(PIN).In this work different modulation frequencies (5 -10) GHz was used.

IV. RESULTS AND DISCUSSION

Characterization of an optical transmission link which is one of the main criterions for the effective modeling of RoF system depends on the proper choice of performance metrics. Performance metrics should present a precise determination of system's limitation and measurement to improve the performance of the system. The most widely used performance measures are the Q-factor, BER and eye opening.

Comparison of direct & external modulation based (RoF) system.

Comparison direct &externalmodulation is done using the Q-factor values obtained from the respective carrier frequencies by different fiber length as a link ranges.Figure (6)shows Q-factor versuslink range at carrier frequency 5 GHz.

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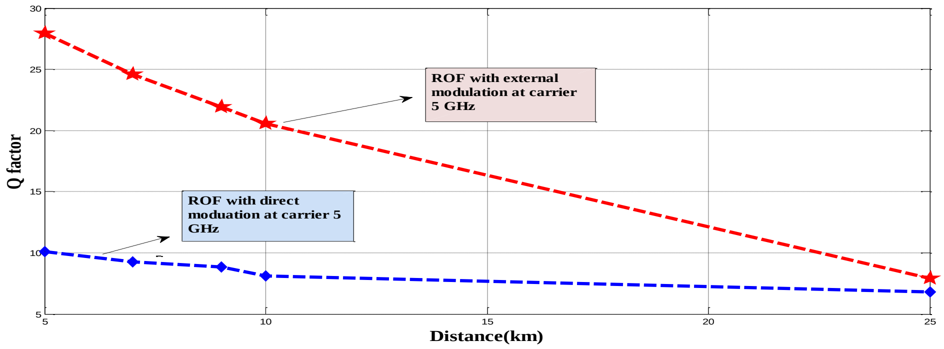

Figure (6): Q-factor Vs. link range for direct & external modulation (RoF) system.

The Q-factor versuslink range at frequencycarrier 5GHz and 10GHz graphs has been plotted as shown in Figure (7),which shows that the Q-factor for external modulation technique better than direct modulation technique.

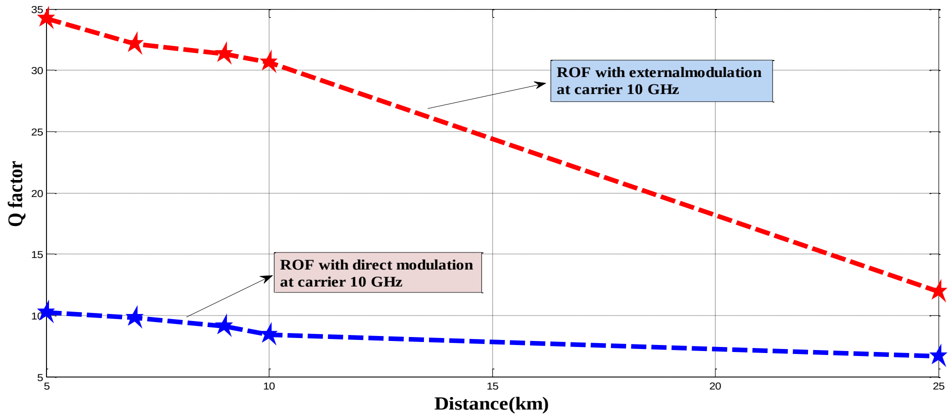

Figure (7): Q-factor Vs. link range for direct & external modulation RoF system with 10GHz carrier frequency.

External Modulation results & discussions

In digital transmission the number of bit errors is the number of received bits of a data stream over a communication that have been altered due to noise, interference distortion bit or synchronization errors. The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval.

The Eye Diagram Analyzer block of the Optisystem 7.0 software displays multiple traces of a modulated signal to produce an eye diagram. In telecommunication, an eye pattern, also known as an eye diagram, is an oscilloscope display in which a digital data signal from a receiver is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep. It is so called because, for several types of coding, the pattern looks like a series of eyes between a pair of rails [4]. An open eye pattern corresponds to a minimal signal distortion. Distortion of the signal waveform due to inter symbol interference (ISI) and noise appears as a closure of the eye diagram.Based on the simulation data extracted from Table (1).

Table (1):Q-factor and Minimum BER for (5GHz &10GHz)RF- modulation frequencies at different link ranges.

Distance Km	Q - factor		BER	
	5GHz	10GHz	5GHz	10GHz
2	11.4	27.2	$1.56 * 10^{-30}$	$2.69 * 10^{-163}$
4	9.6	18.8	$3.6 * 10^{-22}$	$3.05 * 10^{-79}$

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6	7.9	13.7	$7.4*10^{-16}$	$2.90*10^{-43}$
8	6.6	10.6	$1.2*10^{-11}$	$8.55*10^{-27}$
10	5.6	8.6	$6.8*10^{-9}$	$3.37*10^{-18}$

Performance of Bit Rate Vs Maximum Q-factor for (5GHz &10GHz) RF- modulation frequencies at different link ranges as shown in Figure (8).

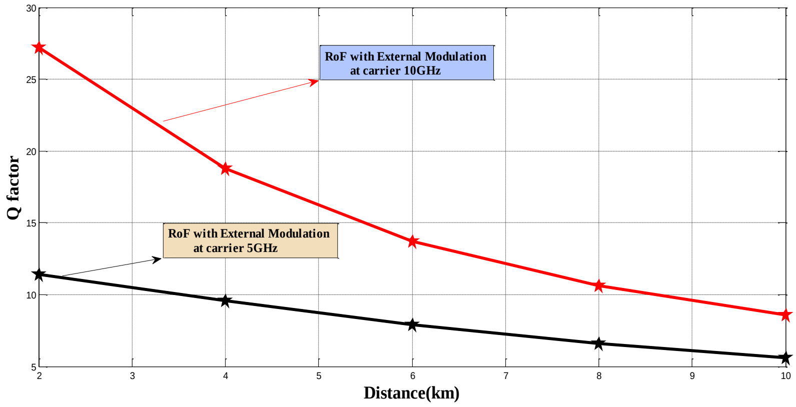

Figure (8): Q-factor for (5GHz &10GHz) RF- modulation frequencies at different link ranges.

Performance of Bit Rate Vs Minimum (BER) for (5GHz &10GHz) RF- modulation frequencies at different link ranges as shown in Figure (9).

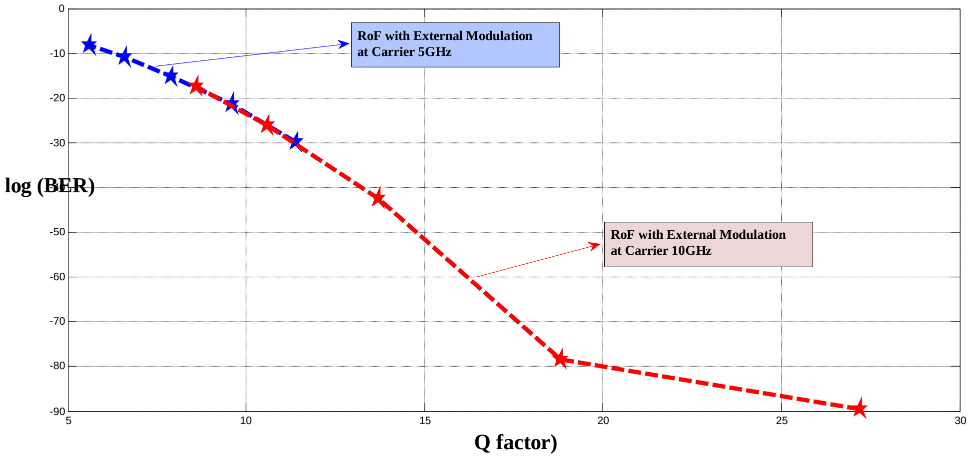

Figure (9): Minimum (BER) for (5GHz &10GHz) RF- modulation frequencies at different link ranges.

Proposed (RoF) system was successfully modeled and simulated using Optisystem 7.0.Figure (10) illustrated the received optical signalafter 10 km fiber length (a): at BS 1 with (5GHz)RF- modulation frequency, and(b): at BS 2 with (5GHz)RF- modulation frequency respectively.

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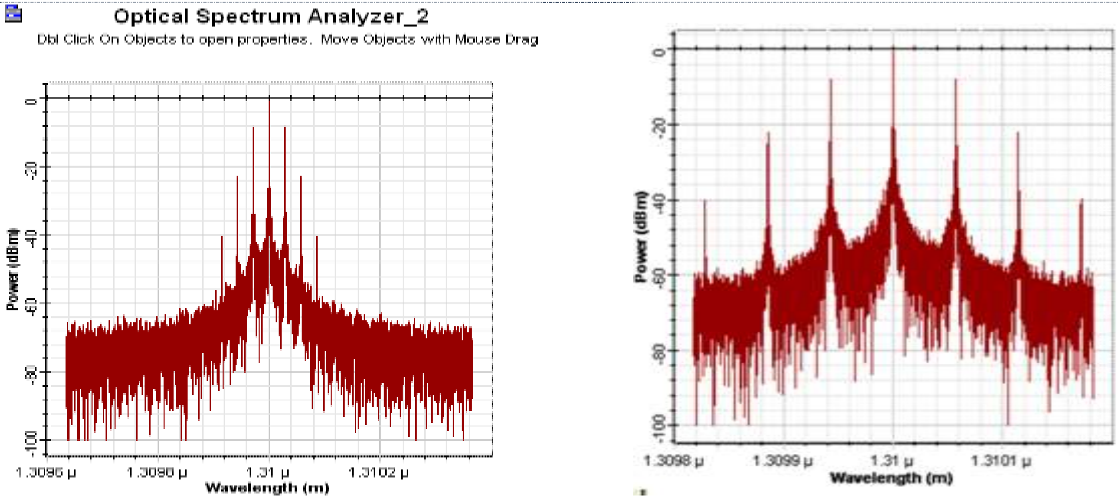
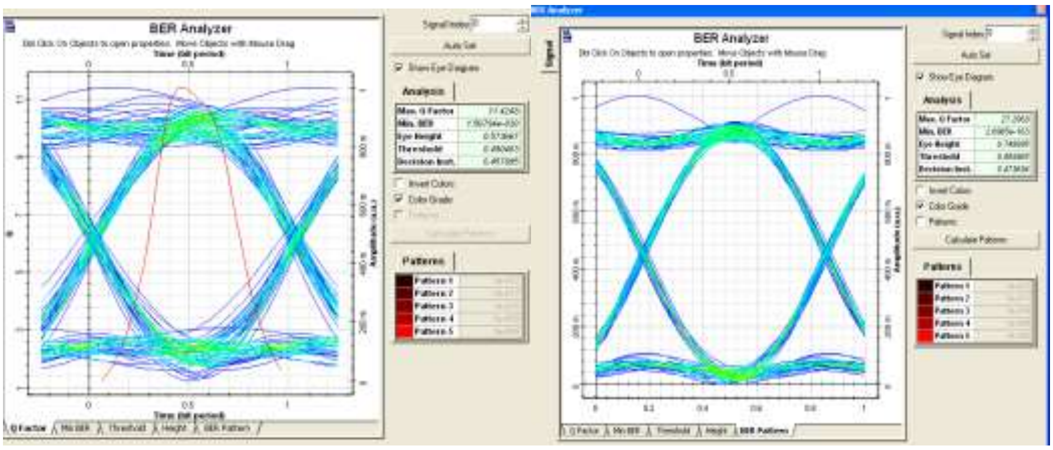


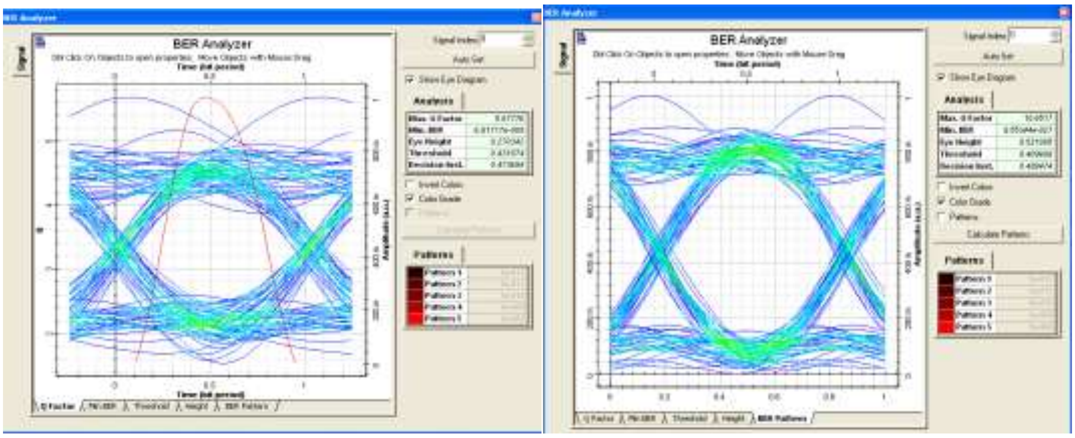
(a) :(5GHz) *(b) :(10GHz)*

Figure (10): The received optical signal after 10 km fiber length(a): at BS 1 with (5GHz)and (b): at BS 2 with (5GHz)RF- modulation frequency.

The results shown in Figure (11) depict the performance of the effect of varying bit rate on maximum Q-factor, minimum BER, eye height and threshold for (5GHz &10GHz) RF- modulation frequencies at different link ranges.



(a) :(5GHz)/ (2Km) ***(b) :(10GHz)/ (2Km)***



(c) :(5GHz)/ (10Km) ***(d) :(10GHz)/ (10Km)***

Figure (11): Eye height and threshold for (5GHz &10GHz) RF- modulation frequencies at different link ranges.

The external modulation technique with frequency carrier10 GHz the Q factor, and BER better than when using frequency carrier 5GHz because the external modulation operating for high-frequency (10 ≥ GHz).

V. CONCLUSIONS

In this paper, we have proposed a (RoF) system and simulated the transmission of 5 and 10 GHz RF signals over 2 km to 10 km standard SM fiber at wavelength of 1310 nm. The results showed the performance of (RoF) system using different modulation schemes for different data rates and fiber lengths. A small amount of deviation in the received optical spectrum due to non-linear effect. Since the central frequency is still around 193.1 THz so it will not cause severe deviation at received signal. After been transmitted for 10 km, received signal accumulated some noise, where vertical and horizontal eye opening corresponds to minimal signal distortion. Simulation results showed that with the increase of bit rate and fiber length Q-factor, eye height and threshold decrease and minimum BER increases in most instances. Comparison between internal and external modulation have been made based on the performance metrics, such as, Q-factor, minimum BER, eye height and threshold. System with external modulation displayed superior performance for maximum data rate and maximum fiber length of 10 km. Good eye diagram and low BER were achieved which implies the better performance of the system. Our proposed system is suitable for high bit rate and fiber length of 2 – 10 km with external modulation technique

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