DESIGN AND COMPARISON BETWEEN DIRECT AND EXTERNAL MODULATION OF RADIO OVER FIBER (ROF) COMMUNICATION SYSTEM

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ABSTRACT: *Radio-over-Fiber (RoF) technique is a combination of the optical networks and microwave. RoF technique uses optical fiber as background technology because of the tremendous benefit it offers. The generation of the future mobile and wireless communication scheme must be raised with great quality bandwidth service for the area that is not accessible. The current wireless system the service providers needs a high bandwidth for voice, data and multimedia services for fixed and mobile users. The simulation design using Optisystem10 has combined systems for both the optical fiber and RF wireless, whereby the RoF system model contains a central station, remote access element and an optical fiber link that utilizes the commercially available parameters. In this paper, the performance of the RoF systems is investigated and compared by using the direct and external modulation techniques. The direct modulation technique, is easy to demonstrate and has a low cost, but it cannot provide a high gain because of the laser limitation. On the other hand, the external modulation laser, which operates in continuous wave mode. This method can provide a high gain, but it is complex and expensive. Also, the different performance parameters, such as Q-factor, Bit Error Rate (BER), and power received with fiber lengths at wavelength 1310 nm using the simulation software are investigated.*

Keywords: Radio Over Fiber (RoF), Radio Frequency (RF), Q factor and Bit Error Rate (BER).

1- INTRODUCTION

Nowadays various demands of system and mobile users with data capacity for wireless communication have been adequately provided by voice and data services[1, 2].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 [3].The wireless system has suffered many losses in the transmission as well as atmospheric attenuation, to overcome these problems use of Radio over Fiber system, it has low attenuation, electromagnetic interface, and large bandwidth[4, 5]. Wireless coverage of the user domain has various essential parts of fixed and mobile broadband communication network. In order to offer integrated many of demand into mobile broadband and fixed services[6, 7],the WLAN provides up to 54 Mbps at frequencies 2.4 to 5 GHz carrier, 3G mobile networks that offer up to 2 Mbps at 2 GHz, 4G offering up to 40 Mbps in carrier frequencies 2-8 GHz and on the last day the standard wireless key, such as IE 802.16 WiMAX mobile and fixed offers 2-66 GHz[8, 9]. The current global coverage of the wireless network has several advanced multi-access technologies. Radio over fiber for wireless is one of the essential network access solutions for high-speed wireless communications systems in the future[10]. RoF depend on the optical fibers for the transmission of radio signals among the BSs and MSC, this communication system is usually referred to as a Radio over Fiber (RoF) [11, 12].In the RoF, the radio signal is used for the intensity modulating an optical carrier[13].Figure1demonstrations the basic diagram of the RoF link. The radio signal is changed into the optical signal (electronic-to-optical converter) at the central station [14, 15]. The optical signal is communicated over optical fiber and discovered at the base station [16, 17]. The RoF technique awards a lot of features ;the processing of complex signals are concentrated in the central station (CS)so, the general system is cost-effective, remote terminal (BS) is very simple, passive and compact so it is transparent to air and easy maintenance, and low attenuation loss; the optical fiber shows very low loss. Thus RoF that considers the backbone technology can be used to transfer microwave waves or millimeters from a central station to base stations. Line of sight (LOS) operation (reducing the effects of multi-path fading) as signal is performed by fiber optic losses occurring during wireless transmission systems are avoided to greater amplitude and immunity for radio frequency interference: It is a very attractive feature of fiber optics, which also supplies privacy and security[18].The scheme is very cost-effective because of the localization of signal processing in CS ,modest base station and high system reliability due to the simple and passive structure of the base station [19].This system be able to simply assist high dense populated area like dead-zone area, shopping mall and airports. Also, the highways can be wrapped economically and efficiently, the structure can backup multiple wireless standards. Given the nature of high-bandwidth fiber optics, broadband services are more possible for using this technology [20, 21]. The centralized CS can decline the number of handover inside the cells. Radiated power from antenna is very low due to Pico and Micro cells construction. The system is more immune for human body due to low radiated power of antenna that makes and also decreases the power consumption of the mobile battery. Interference in the same channel can be reduced to a large extent due to low radiation capacity [22-25].

In this work design and comparison between direct and external modulation of RoF using Optisystem software also investigate the differences in Q-factor, power received and BER with different fiber lengths at wavelength 1310 nm.

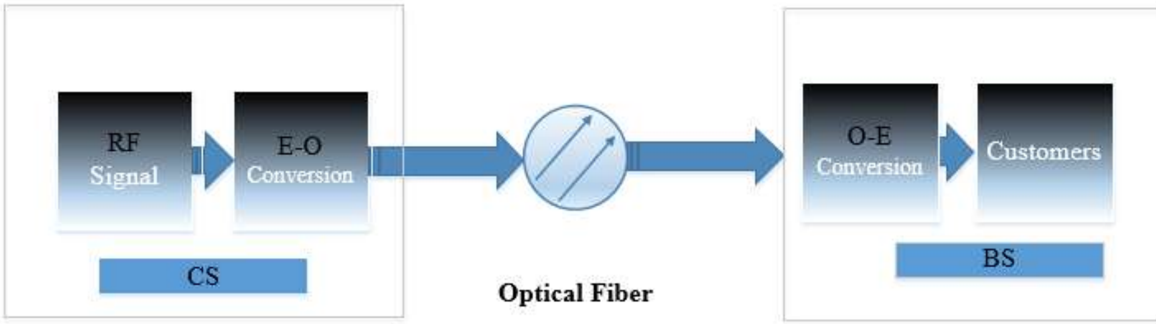

Figure 1: Simple ROF link.

2-EXPERIMENTAL SETUP

2.1 Design of RoF with Direct Modulation System

Figure 2 shows the simulation of the RoF with direct modulation using OptiSystem software. The CS contains laser source (L.D) with frequency was set at 1310 nm and power 15 dBm and Pseudo Random generator at 2 GB/s combined with NRZ encoder. The signal incoming from Pseudo generator is encoded by NRZ, this signal passes into electrical PM at different frequency carriers 5 and 10 GHz, the function of PM is a modulated signal incoming form NRZ. The modulated signal enters into direct modulation, the laser diodes emit light at frequencies 1310 nm and the resulted signals are transmitted along with optical carrier from the laser diodes then transmitted over SMF with a distance of 5 to 25 Km. The base station consists of optical amplifier, it amplifies the optical signal, filter and receives signal by photo detector (PIN). The PIN detector was used to convert the optical signal to the electrical signal, thereafter the electrical signal is demodulated by using electrical phase demodulation. The BER analyzer and electrical carrier analyzer were used to calculate the BER value, Q-factor, and power received.

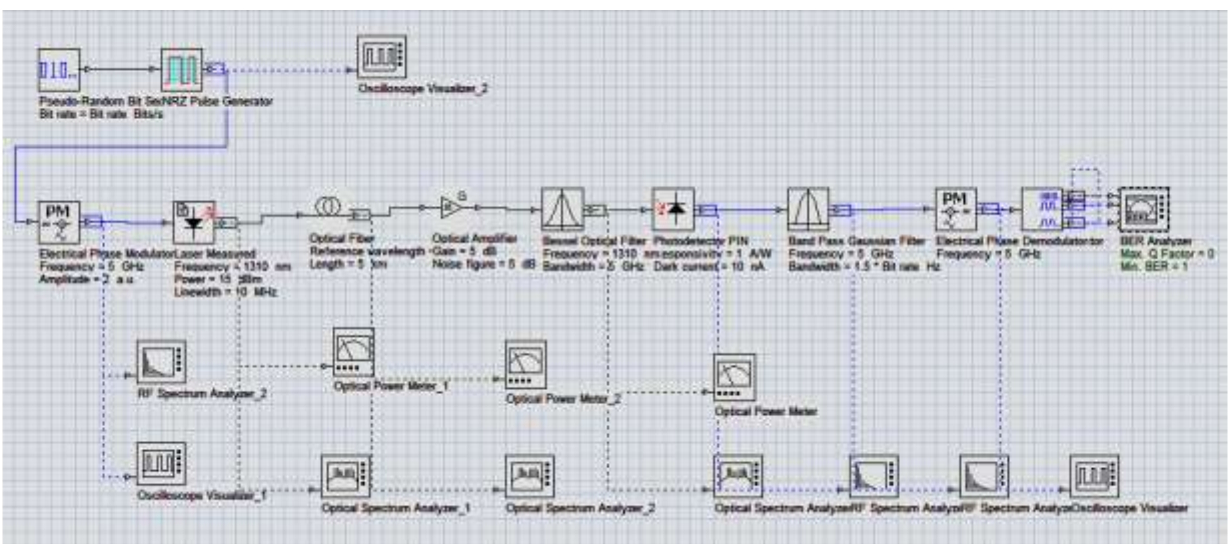

Figure 2: RoF with direct modulation system

2.2 Design of Rof with External Modulation System

In this design, the signal incoming from Pseudo generator is encoded by NRZ, this signal passes into electrical PM at carrier 5, 10, 15 GHz and the PM is a modulated signal incoming form NRZ. The modulated signal enters into MZM, laser diodes emit light at frequencies 1310 nm and power 0 dBm, the resulted signals are transmitted MZMs along with optical carrier from the laser diodes then transmitted over SMF through 5 to 25Km. PIN detector used to change the optical signal to the celectrical signal, the electrical signal is demodulated by using electrical phase demodulator. The BER analyzer and electrical carrier analyzer were used to calculate the BER value, Q-factor, and power received. The simulation layout of RoF with external modulation system as shown in the Figure(3).

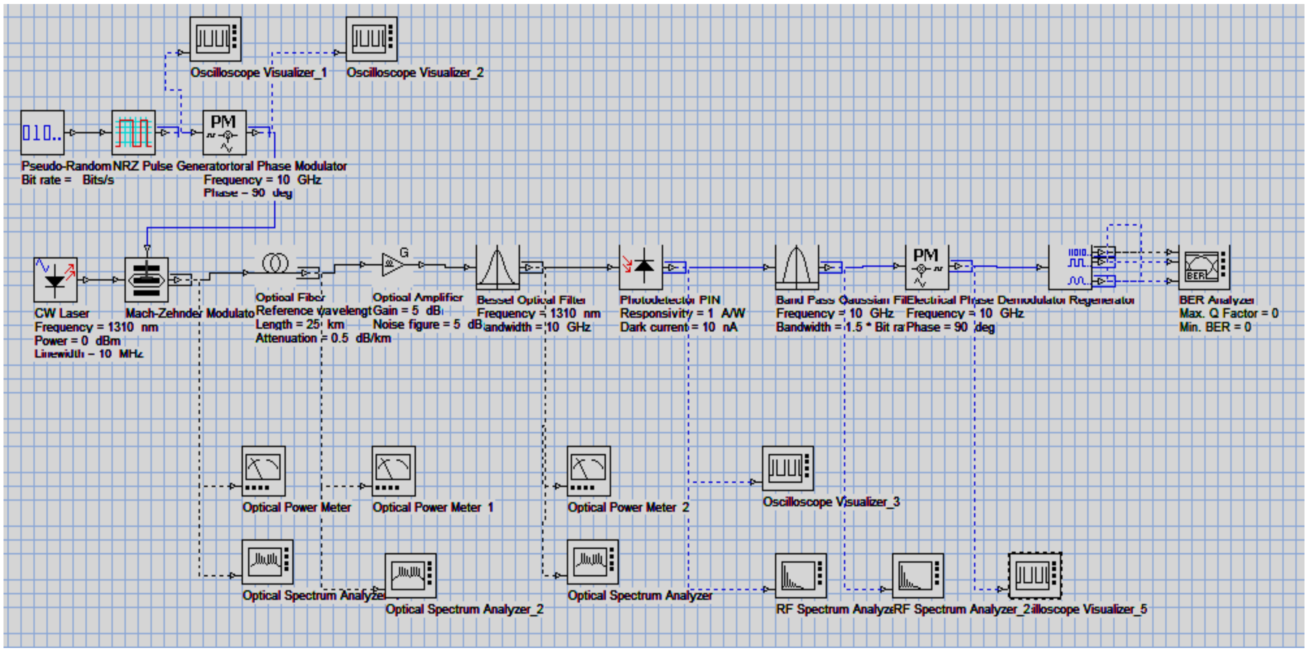

Figure 3: RoF with external modulation system

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RESULT AND DISCUSSION

The direct modulation of semiconductor lasers is a low-complexity and cost-effective technique of producing intensity modulated optical signals, it is imperfect to low-frequency electronic signals. Direct modulating a laser at great frequencies that are close to the laser's relaxation resonance frequency rises the generation of laser Relative Intensity Noise (RIN), which then gives increase to alteration in the phase of the optical signal, a result termed as phase noise. The group delay of the signal is known as the first derivative of the optical phase with reference to optical frequency, and the dispersion parameter is a measure of the second derivative of the optical phase with reference to optical frequency. Hence, the phase noise of optical signal will cause various group velocities while transmitting through a dispersive fiber. Therefore, the variations in the group velocities will cause intensity modulation of the optical signal.

In instance of digital optical communications transporting optical pulses above long fibers, the laser's phase noise resort to become the factor reducing the maximum distance before regeneration is necessary. With a view to avoid the losses imposed by the direct modulation of the laser using high-bandwidth signals, external modulators are usually used. Comparison between the direct modulation and external modulation is carried out using the values of the bit error rate (BER), the Q-factor and the power values obtained from carrier frequencies related to the length of fibers different from 5 to 25 km. the Q-factor versus distance and power received versus distance at frequency carrier 5 GHz have been plotted as shown in the figures 4 and 5 respectively, which demonstrate that the Q-factor for external modulation technique is better than direct modulation technique and the power received for external modulation technique less than direct modulation technique.

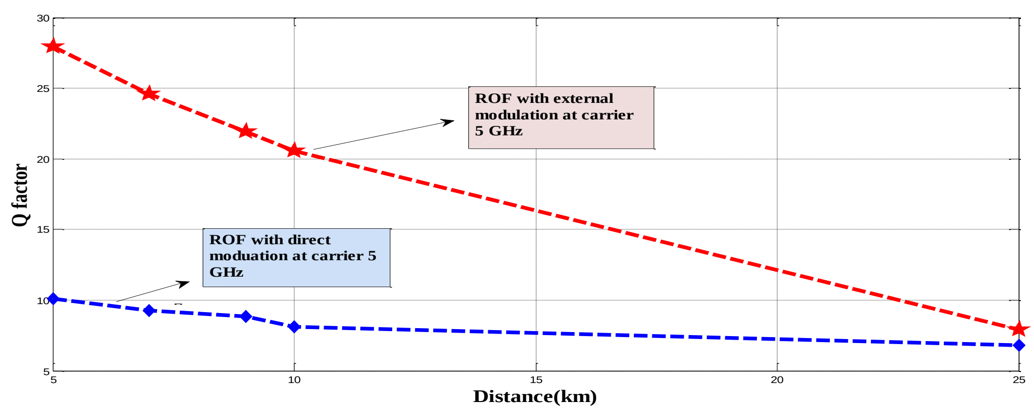

Figure 4: Q-factor versus distances

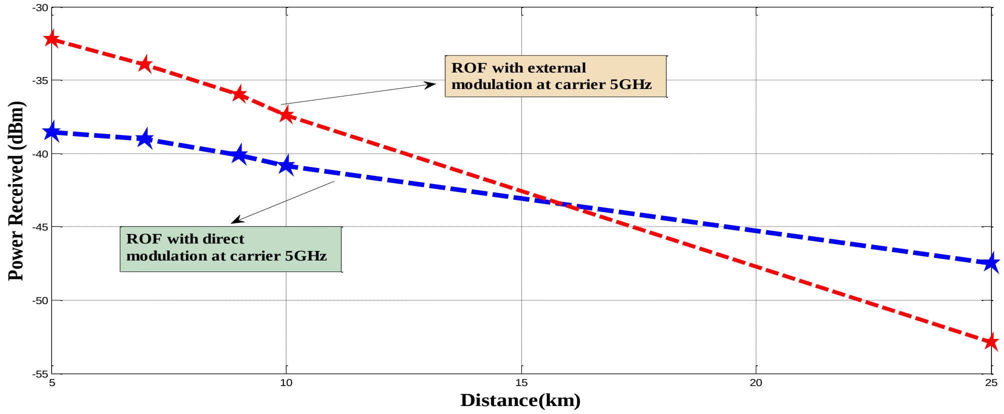

Figure 5: Power received versus distance

Figures 6 and 7 manifest the Q-factor versus distance, and power received versus distance at frequency carrier 10 GHz, respectively. These figures show that the Q-factor for external modulation technique increased when increase frequency carrier but in the direct modulation technique, the Q-factor almost remains the same and power received less than the direct modulation technique .

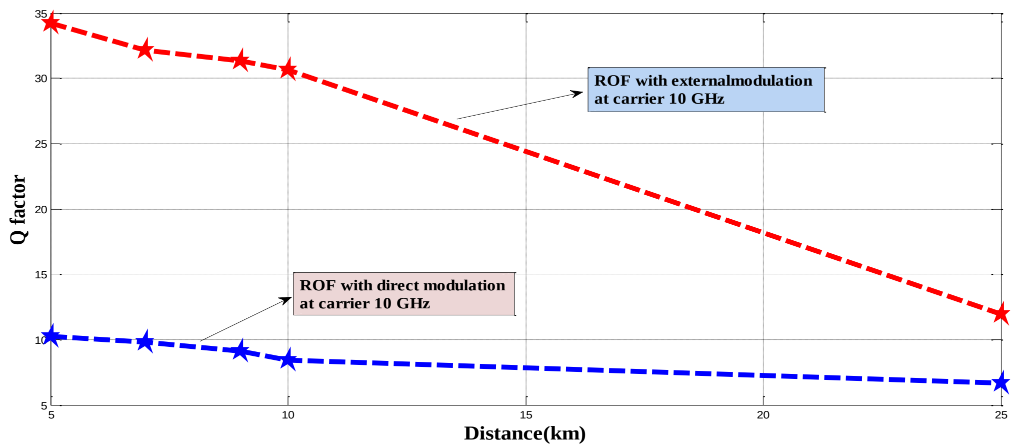

Figure 7: Q- factor versus distance

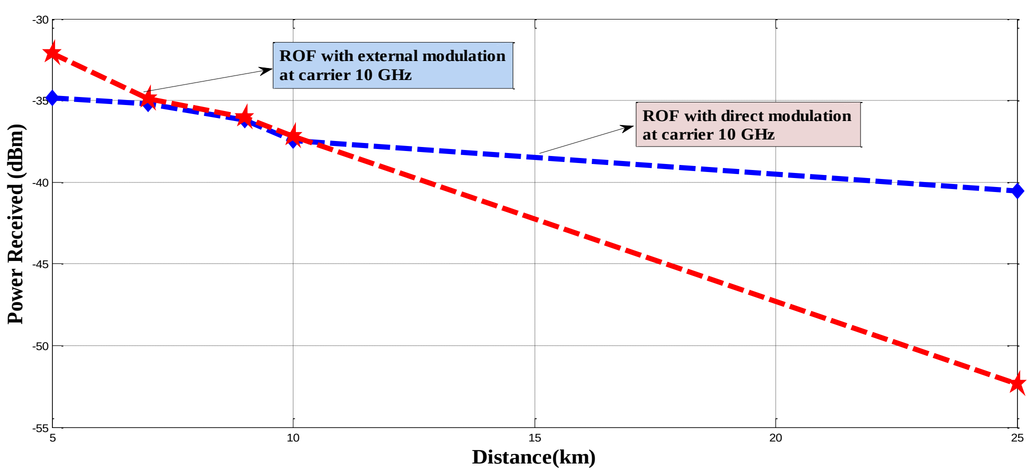

Figure 8: Power received versus distance

Figures 9 and 10 display the Q-factor versus distance, and power received versus distance at frequency carrier 15 GHz. These figures reveal that the for direct modulation technique, the value of Q-factor at distance 25 Km is about 2.5. This value is unacceptable because the minimum value of Q = 6 that will make BER less than10^{-9} but, the minimum value of Q- factor at external modulation technique at distance 25 Km is about 10. Table (1-6) show the system performance parameters with respect to the fiber length.

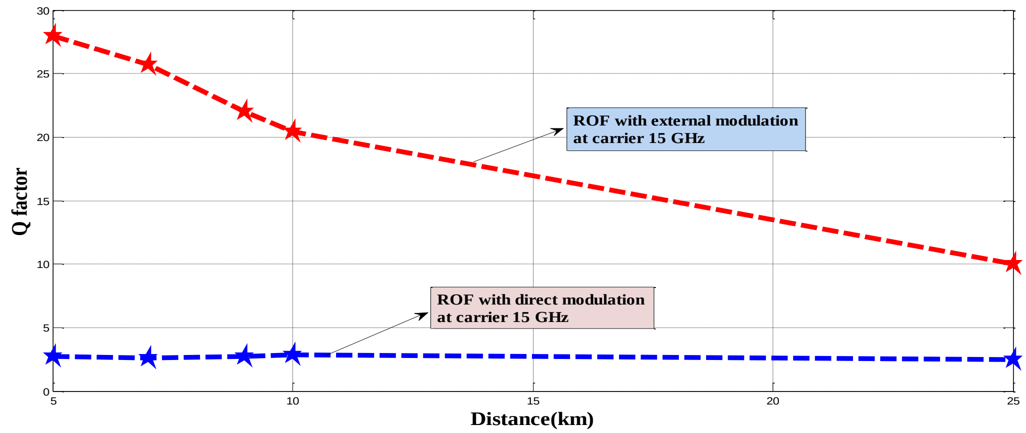

Figure 9: Q- factor versus distance

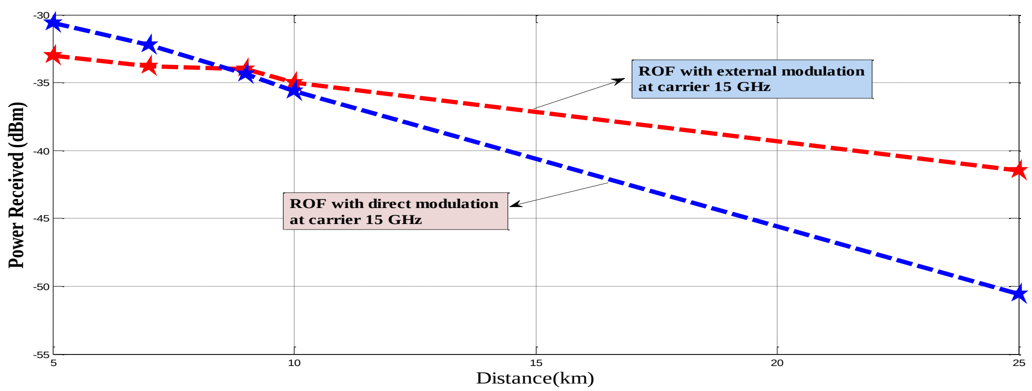

Figure 10: Power received versus distance

Table (1): Evaluation parameters of RoF with direct modulation system for frequency carrier 5 GHz

Distance (km)	Q-factor	BER	Power Received
5	10.12	1.58e-18	-38.54
7	9.24	4.58e-17	-39.02
9	8.85	2.17e-16	-40.11
10	8.11	3.32e-16	-40.87
25	6.82	3.65E-12	-47.52

Table (2): Evaluation parameters of RoF with direct modulation system for frequency carrier 10 GHz

Distance (km)	Q-factor	BER	Power Received
5	10.27	4.44e-25	-34.84
7	9.8	3.54e-21	-35.21
9	9.13	2.24e-19	-36.20
10	8.43	1.64e-17	-37.43
25	6.66	2.65e-12	-40.52

Table (3): Evaluation parameters of RoF with direct modulation system for frequency carrier 15 GHz

Distance (km)	Q-factor	BER	Power Received
5	2.73	5.889e-3	-32.99
7	2.60	4.802e-3	-33.78
9	2.702	2.791e-3	-34.016
10	2.86	1.875e-3	-34.99
25	2.51	1.525e-3	-41.49

Table (4): Evaluation parameters of RoF with external modulation system for frequency carrier 5 GHz

Distance(km)	Q-factor	BER	Power Received
5	27.96	1.77e-23	-32.21
7	24.60	2.81e-22	-33.95
9	21.94	5.21e-21	-35.97
10	20.56	3.01e-20	-37.40
25	7.89	1.41e-15	-52.86

Table (5): Evaluation parameters of RoF with external modulation system for frequency carrier 10 GHz

Distance (km)	Q-factor	BER	Power Received
5	34.22	5.82e-59	-32.14
7	32.13	4.02e-51	-34.89
9	31.30	2.44e-47	-36.02
10	30.63	1.68e-40	-37.19
25	11.94	2.21e-33	-52.36

Table (6): Evaluation parameters of RoF with external modulation system for frequency carrier 15 GHz

Distance (km)	Q-factor	BER	Power Received
5	27.93	4.72e-21	-30.60
7	25.71	5.82e-19	-32.23
9	22.01	3.80e-16	-34.38
10	20.45	2.12e-15	-35.60
25	10	11.67e-12	-50.56

4- CONCLUSION

A radio over fiber system was designed over the fiber length and simulated using the Opt system 10 program and its different parameters, like Q-factor, BER, and receiving power with different frequency carriers. Also, performance of the RoF was investigated and compared with different categories of direct modulation technique and external modulation technique. Conclusion, for the external modulation technique with various frequency carriers, the Q-factor, receiving power, and BER are better than when using direct modulation technique and less power of laser diode; for direct modulation 15 dBm and external modulation 0 dBm. Also the external modulation has a better linearity than the direct modulation because it has a wider dynamic range.

5-REFERENCES

[1] R. Karthikeyan and S. Prakasam, "A survey on Radio over Fiber (RoF) for wireless broadband access technologies," International Journal of Computer Applications, Vol. 64, 2013.

[2]H. Al-Raweshidy and S. Komaki, Radio over fiber technologies for mobile communications networks, Artech House, 2002.

[3] P. Monteiro, S. Pato, E. López, D. Wake, N. J. Gomes, and A. Gameiro, "Fiber optic networks for distributed radio architectures: FUTON concept and operation," in Wireless Communications and Networking Conference Workshops (WCNCW), 2010 IEEE, 2010, pp. 1-5.

[4] D.Wake,A.Nkansah, P. Assimakopolous, N. Gomes, M. Violasand Z. Liu., "Design and performance of radio over fibre links for next generation wireless systems using distributed antennas," in Future Network and Mobile Summit, 2010, 2010, pp. 1-9.

[5] A.Ng'oma,"Radio-over-fibre technology for broadband wireless communication systems"TechnischeUniversiteit Eindhoven, 2005.

[6] T. Shao, "Study of converged 60 GHz radio over fiber with WDM-PON access networks," Université Grenoble Alpes, 2012.

[7] E. Kodjo, "Performance Investigation of OFDM Technology for RoF systems," Master degree thesis, Wuhan University of Technology, 2012.

[8] S. W. Wong, "Development of OFDM in WDM-radio over fiber access network," Universiti Tun Hussein Onn Malaysia, 2012.

[9] B. R. Ballel and D. S. Nema, "Digital Radio over Fiber Link to Overcome Impairments in Fiber Wireless Networks," IOSR Journal of Engineering, vol. 2, 2012.

[10] B.R.Ballal and S.Nema, "Performance comparison of analog and digital radio over fiber link," International

Journal of Computer Science & Engineering Technology (IJCSET), Vol. 3, pp. 193-198, 2012.

[11] Ghafoor, S" Radio over fiber systems "Doctoral dissertation, University of Southampton, 2012.

[12]A. S. Chahine, "Simulation of OFDM over fiber for wireless communication system," 2007.

[13]E. R. kaur and E. H. kaur, "Survey: Radio over Fiber and Wireless Broadband Access Technologies," International Journal of Grid and Distributed Computing, Vol. 9, pp. 83-90, 2016.

[14]S. Li, "UWB radio-over-fiber system using direct modulated VCSEL," University of Waterloo, 2007.

[15]A. E. N. A. Mohamed, A. N. Z. Rashed, and M. S. Tabbour, "Transmission characteristics of radio over fiber (ROF) millimeter wave systems in local area optical communication networks," Int J Adv Network Appl, Vol. 2, pp. 876-86, 2011.

[16]J. Johny and S. Shashidharan, "Design and simulation of a Radio Over Fiber system and its performance analysis," in Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT), 2012 4th International Congress on, 2012, pp. 636-639.

[17]M. S. Rahman, J. H. Lee, Y. Park, and K.-D. Kim, "Radio over fiber as a cost effective technology for transmission of wimax signals," World Academy of science, engineering and technology, vol. 56, pp. 424-428, 2009.

[18]V. K. Pandey, S. Gupta, and B. Chaurasiya,n"Radio-Over-Fiber (ROF) Technology With WDM PON System," International Journal of Innovation and Scientific Research, Vol. 7, 2014.

[19]V. Vorgelegt, "Radio over Fiber based Network Architecture," PhD. dissertation, Dept. Elect., Tech. Berlin Univ., Berlin, 2005.

[20]V. Reddy and L. Jolly, "Simulation and Analysis of Radio over Fiber (RoF) Systems using Frequency Up-Conversion Technique," International Journal of Computer Applications, Vol. 133, 2016.

[21]W. AL_Smadi, "Comparison between Direct and External Modulation Methods in the RoF Analog System," 2012.

[22]P.Cheemaladinne,"Fullduplex transmission of radio over fiber using WDM and OADM technology," California State University, Northridge, 2015.

[23]J. Guillory, C. Algani, A. Pizzinat, É. Tanguy, G. Lirzin and A. Chousseaud, "Radio over fiber for the future home area networks," 2012.

[24] A. Lebedev, "Architectures for radio over fiber transmission of high-qualit video and data signals," Technical University of Denmark, 2013.

[25] H. A. E. L. A. Habib and D. R. B. ngah, "Four wave mixing non-linearity effect in wave length division multiplexing Radio over Fiber system," Citeseer, 2007.