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Simulative Analysis of RSOA based Bi-Directional Radio over Fiber Communication System Employing CPFSK Technique

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ABSTRACT: In this paper, we have investigated the bidirectional Radio over Fiber system based on Reflective Semiconductor Optical Amplifier (RSOA) in which 10Gbps continuous phase frequency shift keying (CPFSK) signal is used for downlink and 1Gbps/NRZ re-modulated on-off keying (OOK) signal by RSOA for uplink. We have demonstrated the influence of varied CW laser source power from -3dBm to 3dBm and optical fiber length of 10Km, 15Km and 20Km on both downlink and uplink signal in terms of obtaining optimal values of Q-factor and BER. The simulation results showed that with increase in a source power lead to degradation of the Q-factor for both downlink and uplink because of the non-linearity in an optical fiber.

KEYWORDS: RoF, RSOA, CPFSK, MZMand EDFA.

I.INTRODUCTION

Radio over fiber technology is a combination of two traditional wireless and wire transmission methods that offers low attenuation and large bandwidth. Moreover, optical fiber has capacity to handle high bit rate traffic and also provide massive bandwidth which makes it perfect for next generation networks [1]. RoF is a promising solution for providing high mobility in wireless communication networks [2]. In RoF systems, wireless signals are transported in optical form between a central station and a set of base stations before being radiated through the air. The standard optical fiber, which offers low attenuation of 0.22 Ps/Km for 1550nm wavelength, is used to provide radio link [3]. The laser diode convert analog RF signal into optical signal and then fed into a bidirectional optical fiber which is connected with receiver side of the base station and photo detector again convert optical signal to electrical signal which is amplified and radiated by remote antenna units (RAUs) and vice versa process is followed by previous process [4]. To meet the demands high data rate networks, we need different modulation techniques such as FSK, DPSK, OQPSK, CPFSK and so on which offers good quality factor and minimum BER. Continuous phase frequency shift keying (CPFSK) shows better results in terms of quality factor as compared to other modulation techniques. Therefore, CPFSK scheme is used to modulate the downstream signal for high bit rate [5]. The frequency reuse concept is implemented in RoF systems by using bidirectional reflective filter (BRF) and reflective semiconductor optical amplifier (RSOA) at base station. But RSOA is preferred over BRF not only because of its modulating nature but also it act as an amplifier. The CPFSK modulated signal is re-modulated with NRZ data format by using RSOA, which we called as on off keying (OOK) for uplink [6].

Jianxin Ma et al. demonstrated simulative and performance analysis of signal sideband (SSB) millimeter wave generation with BPSK data format in full duplex RoF system and also shows the influence of modulation index on signal [7]. Satbir Singh at al. evaluated the simulative analysis of SCM/ASK bidirectional RoF system in terms of Q-factor and BER. He also shows the effect of CW laser source power on both uplink and downlink signal at different fiber length and bit rate [8]. Harpreet et al. investigated the WDM RoF-PON by using SCM/ASK modulation technique over a fiber length of 25km in terms of Q-factor [9].

Fady I. El-Nahal et al. investigated the performance analysis of RoF systems based on RSOA in terms of Q-factor and

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BER by using 1Gbps offset quadrature phase shift keying (OQPSK) for downlink and 1Gbps/NRZ re-modulated OOK signal for uplink. In the paper he also demonstrated the influence of input power on RSOA gain [10]. In another paper, he demonstrated RoF system with differential phase shift keying (DPSK) concept and also investigated performance analysis of bidirectional RoF model in terms of BER [11]. Further, Guangming Cheng et al. investigated a novel approach for bidirectional radio-over-fiber systems by utilizing external modulator and an optical interleaver for generating dual octupling-frequency optical millimeter waves for two base stations over a distance of 60Km [12].
There are many simulative analyses of RoF system done with different modulation techniques by varied different parameters. In this paper, we investigated the bidirectional RoF system based on RSOA by using CPFSK modulated signal for downlink and re-modulated OOK signal for uplink. This paper is further divided into four sections. In section 1, the schematic model is proposed. Section 2 includes the simulative setup of bidirectional RoF system. In section 3, results and discussion with different parameters has been presented. Section 4 includes the conclusion of this work.

II. SCHEMATIC MODEL

Radio over fiber system has a capability to fulfill the demands of high-speed data transmission network in the field of communication. It provides an integration of broadband wireless and optical access networks. ROF facilitates wireless access network applications such as 3G, 4G, Wi-Fi and so on. Figure 1 shows the symmetric model of bidirectional RoF system. For high bit rate transmission, we use CPFSK modulation technique because it provides large Q-factor and Min BER as compared to others. In this model, for downlink data is modulated with CPFSK scheme and converted into optical signal with the help of laser diode circuit that consist of CW laser and Mach Zender modulator (MZM). Afterwards the optical signal is fed into a optical fiber which have properties of large bandwidth and low attenuation. At base station the photo-detector circuit convert the optical one into analog signal and then amplified with the help of amplifier such as erbium doped fiber amplifier (EDFA). Further, signal is radiated by remote antenna. For uplink the vice versa process is followed.

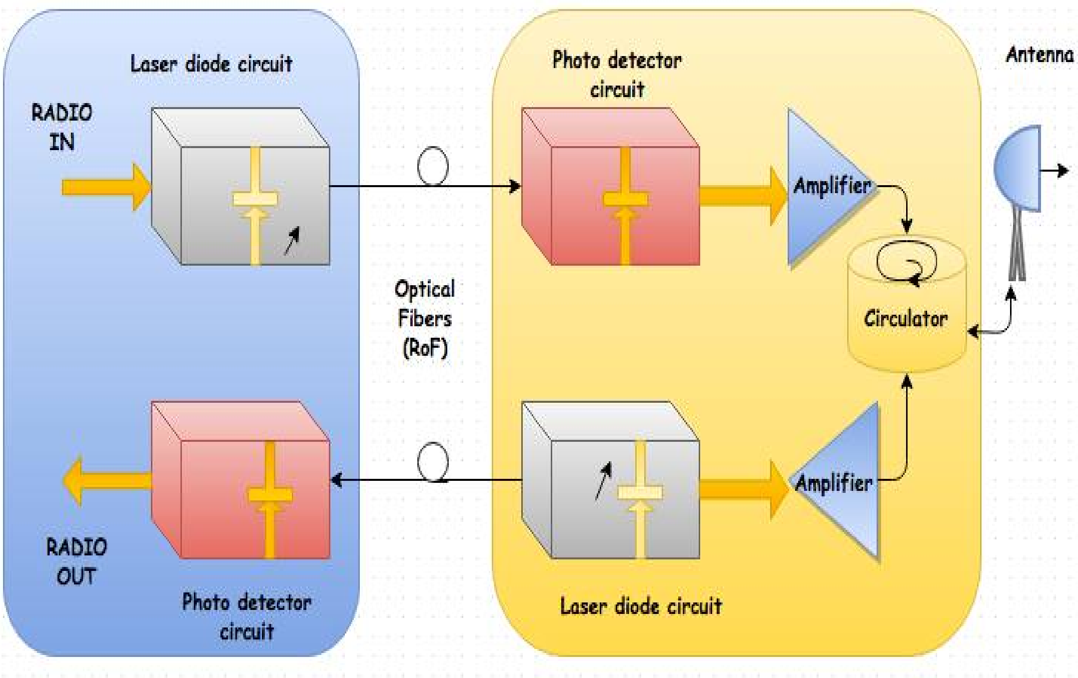

Fig.1. Block diagram of Radio over fiber (ROF).

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III.SIMULATION SETUP OF RADIO OVER FIBER MODEL

This RoF model is setup by the simulation software optisystem. In this simulative setup, the PBRS (pseudo random sequence) generates a 10Gbps data that is modulated with continuous phase frequency shift keying (CPFSK) having a frequency of 5GHz with frequency separation 1MHz. Afterwards this modulated signal is passed from band-pass Bessel filter which have 10GHz of frequency and 15 Hz bandwidth for a channel. The CW (continuous wave) laser having frequency of 193.1 THz and power level is varied from -3dBm to 3dBm for optimization as shown in Fig.1. The output of band-pass Bessel filter and CW laser is modulated via a Mach-Zender Modulator (MZM). The symmetry factor and excitation ratio of MZM is -1 and 30dB respectively. Here pre amplification scheme is used with the help of EDFA having 20dB gain and 4dB noise figure. EDFA is tuned at a noise center frequency of 193.4THz. The CPFSK modulated signal is fed into an isolator that is a promising solution for avoiding back reflection.

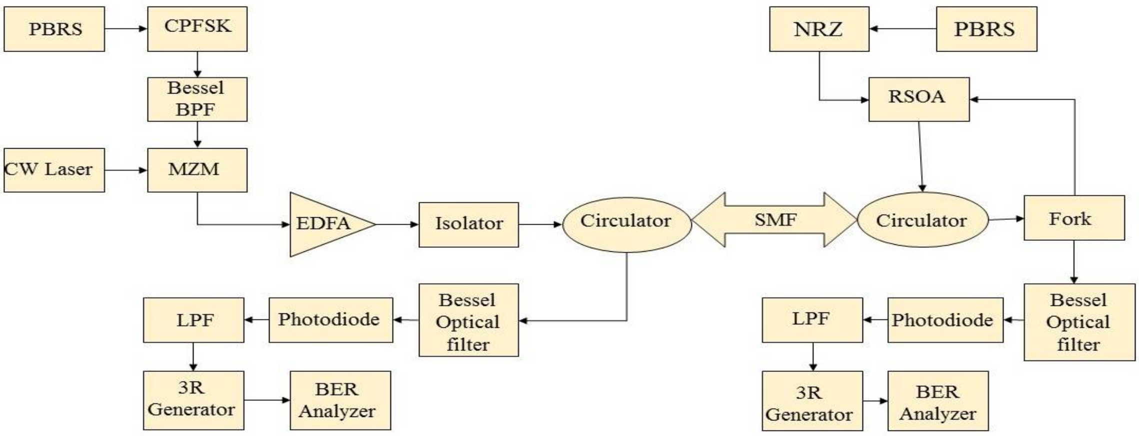

Fig.2. Block diagram of CPFSK bidirectional RoF system.

An optical circulator of 6 ports is used which directs modulated signal to a non-reciprocal output port. The signal is then transmitted through different optical fiber length of 10Km, 15Km and 20Km that have reference wavelength of 1550nm and attenuation is 0.2dB/Km. Table.1 shows the various parameters used in this simulation model. Further, the signal is fed into a 6-port bidirectional circulator.

Table 1. Simulation Parameters for the RoF model.

Name of parameters	Value	Symbols
Reference Wavelength	1550	nm
Attenuation	0.22	dB/Km
Dispersion	16.75	Ps/nm/Km
GVD parameters: β_2 andβ_3	-20, 0.008	ps^2/Km
Effective Fiber Core Area	80	μm^2
PMD Coefficient	0.5	Ps/(Km^2)
EDFA Power	10	dBm
PIN Responsivity	0.9	A/W
Channel Frequency	5	GHz
Optical Fiber Length	30 To 70	Km

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At the receiver side, fork used as optical splitter in which portion of the CPFSK modulated signal is fed to BS (Base Station) receiver. Another portion of the downstream of CPFSK from the splitter is ON-OFF Keying (OOK) re-modulated using Reflective Semiconductor Optical Amplifier (RSOA) having input and output facet reflectivity of 5 x 10^{-5} and 0.55 respectively. RSOA also eliminates the need of pre-amplification because it provides induced gain saturation. At BS receiver, the portion of an optical signal is passed from band-pass Bessel filter converted into analog signal with help of PIN photodiode having responsivity of 0.9A/W. The signal is then passed from low-pass filter to detect the actual signal from modulated one, which is analyzed using RF spectrum analyzer and BER analyzer. The re-modulated signal is again fed to bidirectional optical fiber via a 6-port circulator for uplink. At central office another circulator directs the optical signal to the receiver section.

IV.RESULTS AND DISCUSSIONS

The performance and simulative analysis of bidirectional RoF system is evaluated in terms of BER and quality factor (Q). The mathematical expression of BER is given below.

$$BER = 0.5\ \mathrm{erfc}\ (Q/\sqrt{2}) \approx \exp\ (-Q^2/2)/Q\sqrt{2\pi}$$

$$\text{Where } Q = (I_1 - I_0) / (\sigma_1 + \sigma_0)$$

Where I_0 and I_1 termed as average current for 0 and 1 bit and the corresponding variances. This model uses 10Gbps Continuous Phase Frequency Shift keying (CPFSK) signal for downlink but for uplink 1Gbps/NRZ OOK signal is re-modulated by the RSOA. Fig.3 shows the graph between CW laser input power and Q-factor for different optical fiber length. CW laser power varies from -3dB to 3dB for both downlink and uplink.

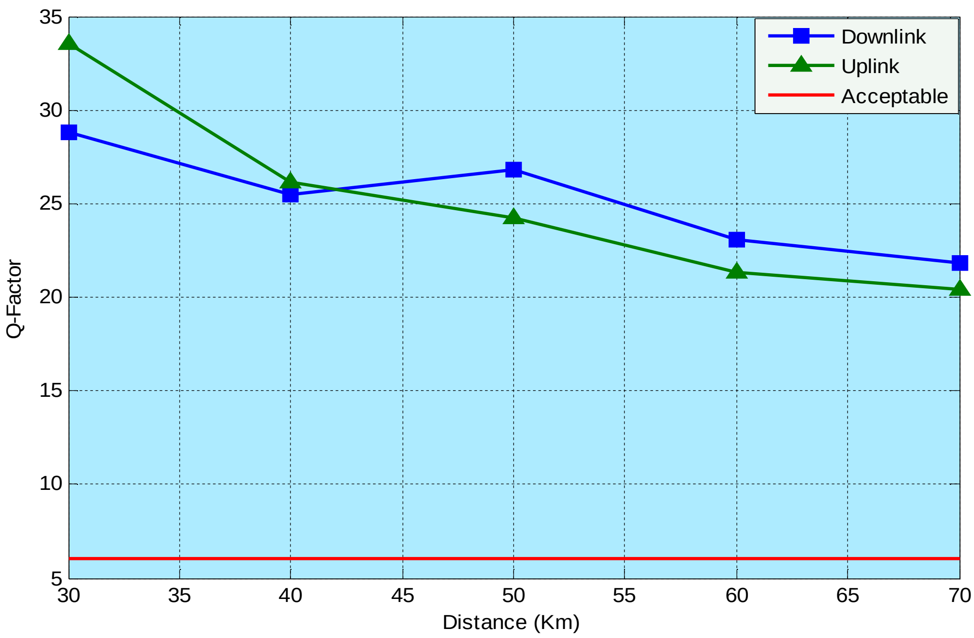

Fig.3.Q-FactorVs Different Fiber Length (Km).

As graph shows with increase in optical fiber length the quality factor of a downlink and uplink signal degrades because of 0.2ps/Km attenuation present in a fiber. The minimum Q-factor values 22.78dB and 21.03dB received at 70 km for both downlink and uplink respectively. In Fig.4 shows that BER of downlink and uplink increases as per as distance increases which leads to degrads the q factor.

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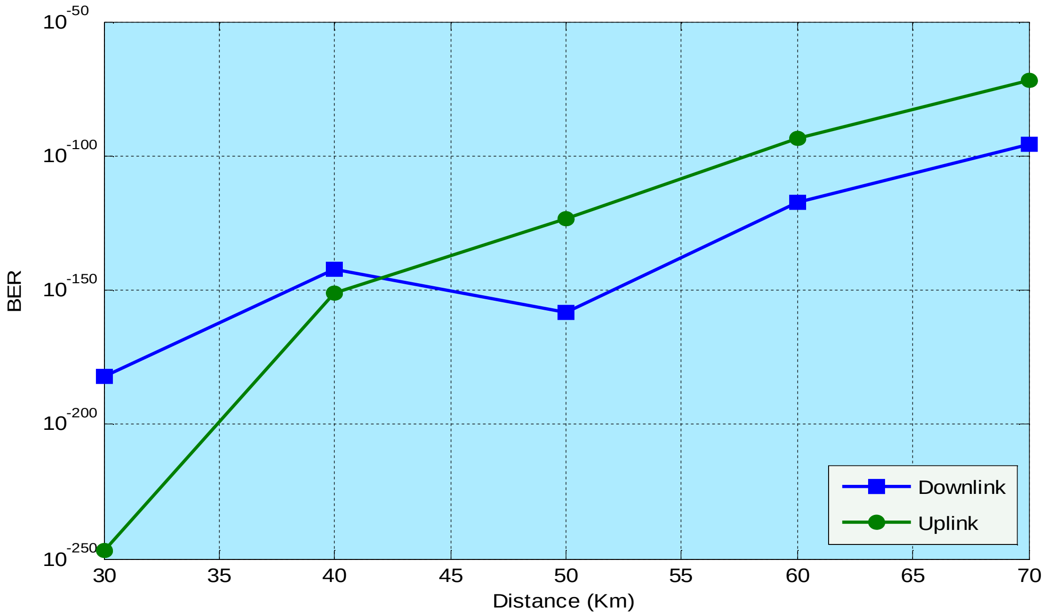

Fig.4.BER vs Different Fiber Length (Km).

As shown in Fig.5 the BER for downlink signal decreases but remain stable for uplink with increases with CW laser power and its value varies from 8.98 x $10^{-159}$to 1.91 x $10^{-102}$and 3.86 x 10^{-91} to 1.189 x 10^{-87} respectively for 50Km fiber length. But in case of re-modulated signal for uplink BER leads to decrease with increase in input power. It also shows that fiber length is directly proportional to BER.Fig.6 shows the representation of eye diagram of CPFSK downlink signal having -1dB input power for different optical fiber length which indicate as length of the fiber increase it affect the opening of eye.

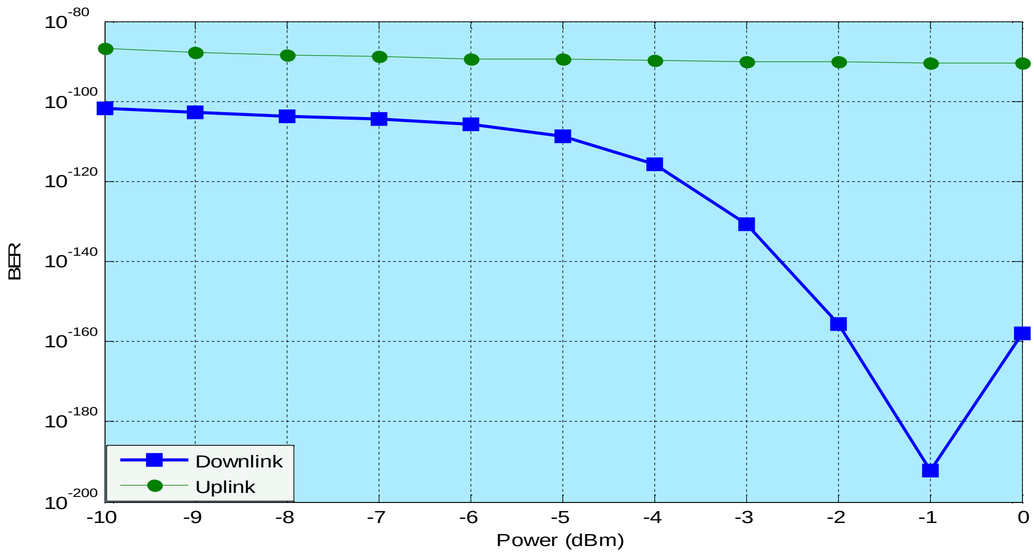

Fig.5.BER vs Different CW Laser Power (dBm).

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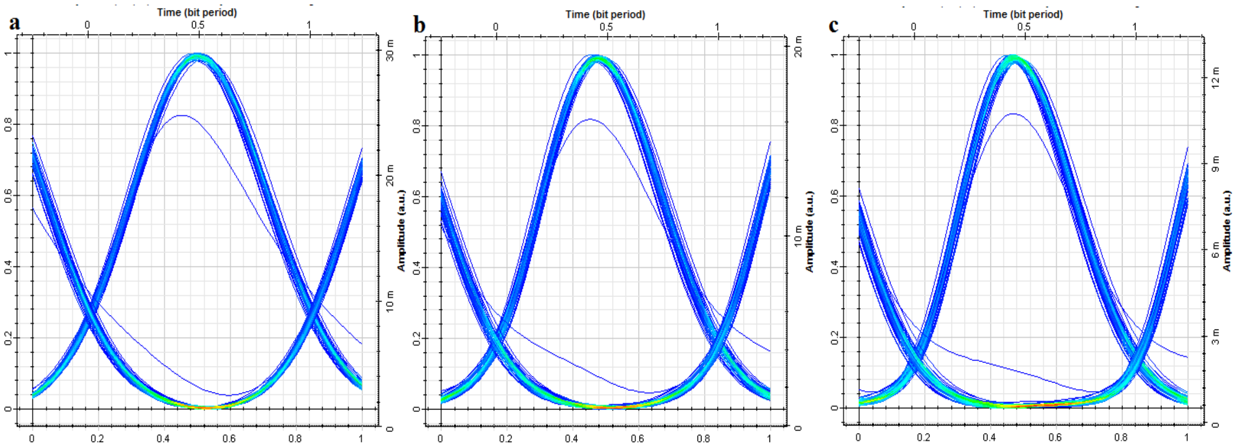

Fig.6. Eye diagram of downlink signal for different fiber length at -1dBm laser power (a) 30Km (b) 40Km and (c) 50Km

The received eye diagram for received re-modulated signal for upstream for different optical fiber length shown in Fig.6. We can see that the opening of eye is clear and opened completely but the width of eye is more as compare to downlink signal. The broadness of eye increases with increase in distance because of attenuation and non-linear effects in a optical fiber.

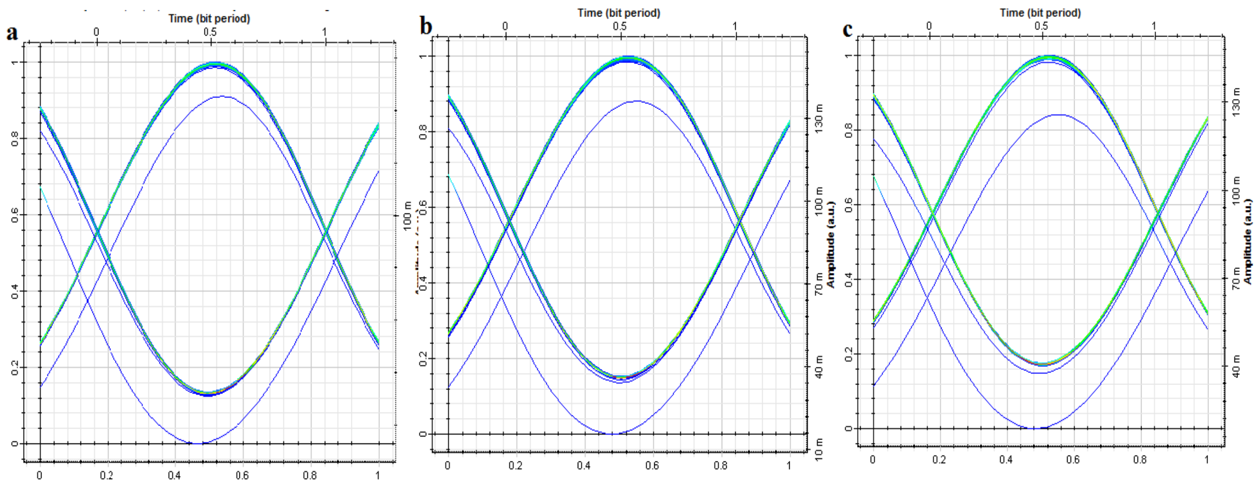

Fig.7. Eye diagram of uplink signal for different fiber length at -1dBm laser power (a) 30Km (b) 40Km and (c) 50Km

As per shown in Fig.8 the graph between input CW laser power and received optical signal at output of optical Bessel filter reflects that with increase in input laser power the output signal power also leads to increase for downlink and also for uplink because of wavelength is reuse or remodulated(OOK) by RSOA but goes almost stable after -1dBm input.

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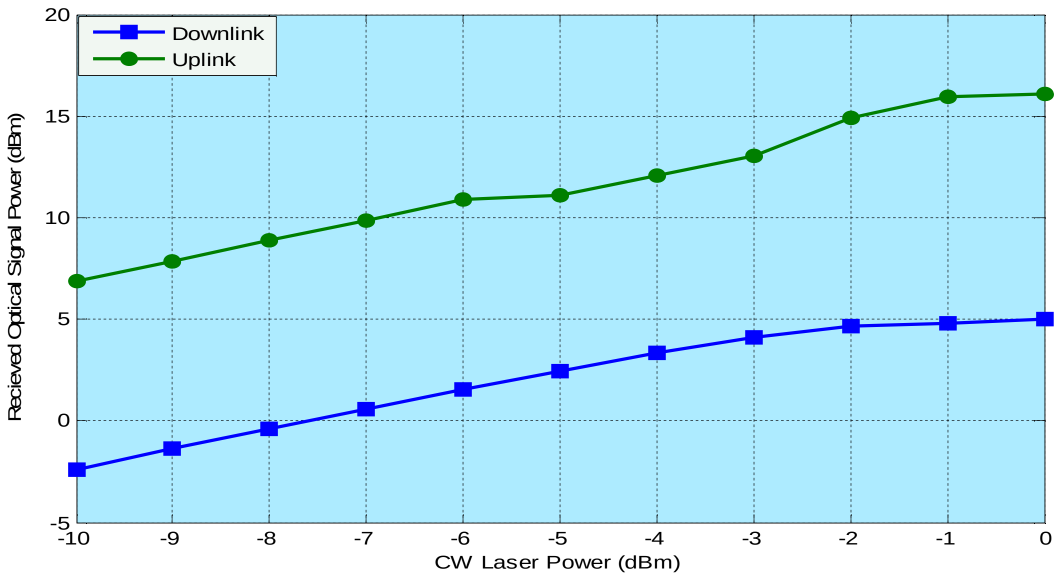

Fig.8. Received Optical Signal Power Vs Different CW Laser Power (dBm).

III.CONCLUSION

A novel bidirectional RoF system utilizing 10Gbps of CPFSK signal for downlink and an1Gbps/NRZ OOK signal for uplink has been represented. This paper deals to the performance analysis of RoF model at different optical fiber length and CW laser power from -3dBm to 3dBm. We determine that increase in optical fiber length degrades the quality factor of both uplink and downlink. Afterwards when we increase the CW laser power which lead to increase BER and decrease Q factor of CPFSK modulated downstream and re-modulated OOK signal for. We also investigate the impact of RSOA on OOK signal for uplink. RSOA not only act as a modulator but also have a nature of amplification. Results show that CPFSK bidirectional RoF system based on RSOA meets the current and future demands of high data rate traffics and cost efficient networks simultaneously.

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BIOGRAPHY

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