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RESEARCH ARTICLE/ARAŞTIRMA MAKALESİ

SOFTWARE SIMULATION FOR 20Gbps RoF ARCHITECTURE OVER SSMF USING VCSEL AND RZ AS MODULATION FORMAT BASED ON WDM

Humam HUSSEIN[1]
[1]Altınbaş University, Electrical and Computer Engineering, School of Science and Engineering Istanbul.
Essaibrahimessa@gmail.com ORCID No: 0000-0001-8452-4511

Dogu Cagdas ATILLA[2]
[2]Altınbaş University, School of Engineering and Natural Sciences,
Electrical and Electronics Engineering, Istanbul.
Cagdas.atilla@altinbas.edu.tr ORCID No: 0000-0002-4249-6951

Essa ESSA[3]
[3]Kirkuk University, Department of Computer Science, Kirkuk.
Essaibrahimessa@gmail.com ORCID No: 0000-0003-3045-0371

Cagatay AYDIN[4]
[4]Altınbaş University, School of Engineering and Natural Sciences,
Electrical and Electronics Engineering, Istanbul.
cagatay.aydin@altinbas.edu.tr ORCID No: 0000-0002-1895-0333

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Abstract

Radio-over-Fiber (R.o.F) is considered as a technology where it can modulate the light with radio frequency signals (R.F) and transmit through fiber optic cable to simplify and transfer wireless access. According to increasing demand of high bandwidth of communication networks, (R.o.F) considered as an efficient and practical solution. In this paper, we will have proposed and shown the performance of RZ modulation formats and radio frequency with a specific type of laser that is vertical cavity surface emitting laser (V.C.S.E.L) with two channels and sent the signals on one single-mode fiber (S.M.F) by using wavelength-division-multiplexing (W.D.M). The bit rate of each channel is 10Gbps, so the cumulative bit rate on SMF is 20 Gbps. The average results of our experience from our simulation for two channels are Total Output Power dBm (6.53388), Max Q- Factor (6.67182), Minimum BER ($3.43236*10^{-11}$), OSNR (dB) (29.6399). All the average values are good and acceptable, we get on it because we using attractive components and there is compatibility between all components. The simulation and performance test of RoF was done using Optisystem 7.0.

Keywords: RoF, RZ, SMF, VCSEL, WDM.

WDM TABANLI 20Gbps RoF MİMARİSİ İÇİN VSSEL VE RZ KİPLEME BİÇİMİ KULLANARAK BİLGİSAYAR BENZETİMİ

Özet

Fiber üzerinden Radyo (R.o.F), ışığı kablosuz frekans sinyalleriyle (R.F) modüle edip kablosuz erişimi kolaylaştırmak ve aktarmak için fiber optik kablo üzerinden iletebileceği bir teknoloji olarak kabul edilir. İletişim ağlarının yüksek bant genişliğine olan talebinin artmasına göre (R.o.F) verimli ve pratik bir çözüm olarak kabul edilmektedir. Bu makale de, RZ modülasyon formatlarının ve radyo frekansının performansını, iki kanallı dikey boşluklu yüzey yayımlı lazer (VCSEL) olan ve belirli bir tek modlu fiberde (SMF) gönderilen belirli bir lazer türünde olan bir lazer performansı önerdik. Dalga boyu bölmeli çoğullama (WDM) kullanarak. her bir kanalın bit hızı 10 Gb / sn'dir, bu nedenle SMF'deki kümülatif bit hızı 20 Gb / sn'dir. İki kanal için simülasyonumuzdan elde ettiğimiz deneyimin ortalama sonuçları Toplam Çıkış Gücü dBm (6.53388), Maksimum Q Faktörü (6.67182), Minimum BER ($3.43236 * 10^{-11}$), OSNR (dB) (29.6399) şeklindedir. Tüm ortalama değerler iyi ve kabul edilebilir olmuştur. Tüm bileşenler arasında uyumluluk vardır. RoF'nin simülasyonu ve performans testi, Optisystem 7.0 kullanılarak yapılmıştır.

Anahtar Kelimeler: RoF, RZ, SMF, VCSEL, WDM.

1. INTRODUCTION

Nowadays, there is an increasing need for broadband bandwidth services that leads to ever-increasing data traffic on these services [1]. In addition to the high-speed, symmetric and guaranteed bandwidth requirements for future video services, next-generation-access-networks are leading the converging needs of wireless services and wired. (R.o.F) is considered an integration of microwave and optical networks is a possible solution to increase the mobility, capacity and reducing the charges in the access network via (R.o.F) [2]. The (R.o.F) concept means transferring information on optical fiber cable via modulating light with the (R.F). This modulation is able to be made immediately with the radio-signal or at an intermediate frequency (IF). (R.o.F) has the capability to be the backbone of the wireless-access-network. This architecture could give many benefits like Transparency and scalability [3].

The aim of this work it is to improve the performance of (R.o.F) technology, in our work we design and simulate RoF based on VCSEL with WDM to improve the broadband system by solving some problems determine the efficiency of the system performance like nonlinearity problems and to make the system flexible by using few components.

Many researchers had studied RoF and WDM like LA Johansson and AJ Seeds [4], "they report the transmission of millimeter wave (MM-Wave) via (R.O.F) demonstration by optical phase-lock loop Technical. A 36-GHz 140-Mb/s ASK modulated carrier is sent over (65km) of standard single mode fiber (S.S.M.F) with a BER less than (10^{-9})". Also Peter and Renè, [5] (Advanced-Optical-Modulation-Formats) has become a main component to design of new wavelength division multiplexed (W.D.M) optically transport networks, Lakshmi and et.al. [6], they are proposed a solution way to integrate Radio over Fiber (R.o.F) with (W.D.M-P.O.N) with bidirectional. By new polarization components.

2. METHODOLOGY

In this section, we introduce some techniques and important component that used to design our system like (RoF), (V.C.S.E.L) and (W.D.M).

2.1 Radio-over-Fiber (R.o.F)

R.o.F is a technique that Use fiber optic cable to transmit (R.F) signals from a headend to various remote antenna units (R.A.U). It consists of transmitting the radio signal from the wireless devices upon an optical carrier for distribution through a fiber optic to various remote antennas,[7].

2.2 Vertical Cavity Surface Emitting Laser (V.C.S.E.L)

The Vertical-Surface-Cavity-Emitting-Laser (V.C.S.E.L) has optical cavities perpendicular with those found in the traditional edge emitting diodes lasers [8]. This easy change in the direction of the cavity produces radical variations in many things like manufacturing and array formation. (V.C.S.E.L) has become the main device in high-speed optical local-area-networks (L.A.Ns) and until in wide-area-networks (W.A.Ns). (V.C.S.E.L) also enables high-quality data transfer in hardware and in the computer systems, including storage-area-networks (S.A.Ns) and wide-optoelectronics-fields [9].

2.3 Wavelength-Division-Multiplexing (W.D.M) Networks

(W.D.M) is a device that allows to multiple independent data streams to send them over a single fiber. By sending two or more distinct signals per fiber, so the transmission capacity will be doubling. The ability to use existing fiber optic more efficiently makes (W.D.M) device is so attractive marketing proposition. Thus, it is important to upgrade existing optical communication systems to (W.D.M) for implement the infrastructure that provide access to a majority of persons living in (urban and rural) areas, since it is often so expensive to installations a new fiber in the ground. [10].

3. SYSTEM ARCHITECTURE

properties it takes the in this system, we design RF system using return-to-zero (RZ) as shown in Eq. (1) to coded input seeding data there are three parts configure this in Figure (1).

$$E(t)=\begin{cases} 1-e^{-(t/cr)}, 0 \leq t < t1 \\ 1, t1 \leq t < t2 \\ e^{-(t/cf)}, t2 \leq t < tc \\ 0, tc \leq t < T \end{cases} \tag{1}$$

Eq. (1) is known as Return to Zero (RZ), [11].

Where c_r & c_f represent rise time and fall time respectively, t_1 & t_2, together with c_r & c_f, are numerically determinate to (generate pulses) with the exact values of the parameters c_r & c_f, the duty cycle duration is represented by t_c, finally, T mean the bit period.

The first part of three part as an illustration in figure (1) is the optical transmitter (V.C.S.E.L) laser Equations (2). this component produce optical signal in an efficiently frequency with 193.1THz, the bias current is 5mA, and the temperature is 20Ċ.

$$\frac{dN(t)}{dt} = \frac{\eta_i\left(I(t) - I_{off}(t)\right)}{q \cdot V} - \frac{N(t)}{\tau_n} - g_0 \cdot (N(t) - N_t) \cdot \frac{1}{(1+\varepsilon \cdot S(t))} \cdot S(t) \quad (2)$$

Eq. from (2) known as (V.C.S.E.L) Laser, [11].

Where η_i is the injection-efficiency, V is the active layer volume, N_t is the carrier density at transparency, τ_n is the electron lifetime, g_0 is the gain slope constant, $g_0 = v_g \times a_0$, a_0 is the active layer gain coefficient., v_g is the group velocity and ε is the gain compression factor.

The seeds bits generate by the PRBSG, the sine generator used to get a RF with frequency of 10GHz, and phase with 90deg), and two LiNb MZ, the other optical transmitter consists of the same components except the sine generator_2 with frequency of (100GHz), these two optical signals are input to the WDM (2×1), the second part of this system is the transmission link consists of SSMF with 25Km, and EDFA with 5m, and the separated by the demultiplexer WDM (1×2), the final stage of the system is the optical receiver with two components. The First component of the optical receiver side is RX optical receiver, its properties (photodiode type PIN, gain=3, low pass Bessel filter (cutoff frequency(Hz)=0.75*Bitrate, depth=100dB, order=4)) Equations (3).

$$H(s) = \alpha \frac{d_0}{B_N(s)} \quad (3)$$

Eq. from (3) is known as Low Pass Bessel Filter, [11].

Where α is the parameter Insertion loss, $d_0 = \frac{(2N)!}{2^N \cdot N!}$ where N mean the parameter Order, BN(s) an n^{th}-order Bessel polynomial.

Finally, we use the BER analyzer to monitor the output signal. We can show the main layout properties and standard single mode fiber (SSMF) main properties in Table (2&3) respectively.

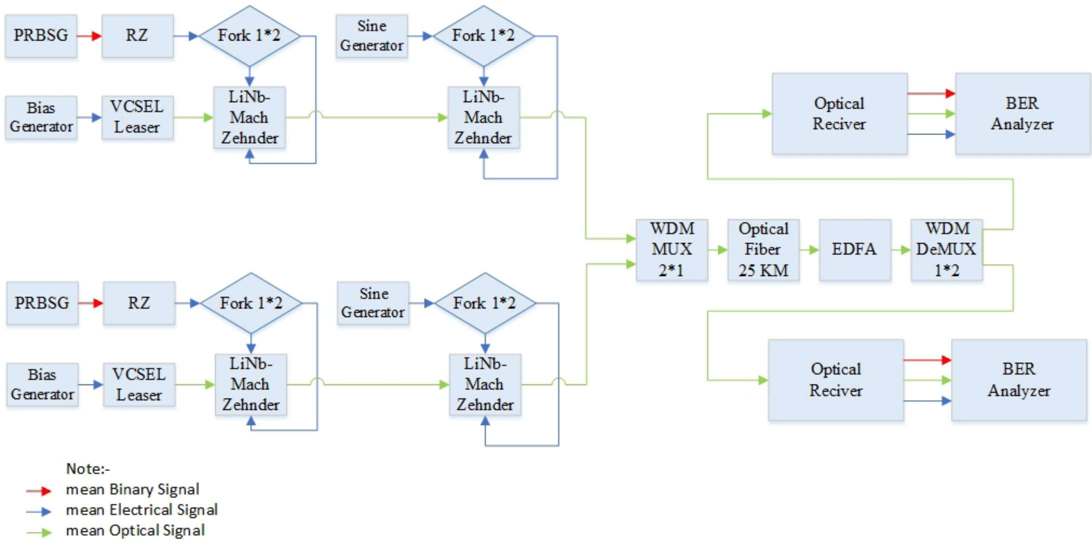

Figure 1. Show the RF based VCSEL and WDM

From Figure (1), we can show the architecture of the experiment. In this architecture, we design another RF system using return-to-zero (RZ) to coded input seeding data. In this design, there are three parts. The first one is the optical (V.C.S.E.L) leaser, this component produces an optical signal in the efficient properties. The seeds bits generate by the PRBSG, the sine generator used to get an RF with the frequency of 10GHz, and two LiNb MZ. The other optical transmitter consists of the same components except for the sine generator_2 with the frequency of 100GHz). These two optical signals are entered to the WDM (2×1). The second part of this system is the transmission link. It consists of SSMF with 25Km, and EDFA to amplify the signals, and separates the signal by the demultiplexer WDM (1×2). The last one is the optical receiver with two components. Finally, the BER analyzer to monitor the output signal.

Name	**Value**	**unit**
Bit Rate	(10000000000)	(Bits/s)
Time Window	$(1.28*10^{-8})$	(S)
Sample rate	(640000000000)	(Hz)
Sequence length	(128)	(Bits)
Samples per bit	(64)	None
Number of samples	(8192)	None

Table 1. Main Layout Properties

Name	Value	Unit
Reference wavelength	(1550)	(nm)
Length	(25)	(Km)
Attenuation	(0.2)	(dB/km)
Sequence length	(128)	(Bits)

Table 2. SSMF main properties.

The previous Tables (1 and 2) shows the Main Layout Properties and the SSMF main properties. as seen above (10 Gbps) will be transmitted over (25 Km) SSMF.

4. EXPERIMENT RESULTS

In this experiment at the transmitter side, we use (V.C.S.E.L) with a wavelength of 1552.52nm, the (W.D.M) offer multiple input users at the same link, increasing bandwidth up to 20Gb/s over 25km, the results obtained from this architecture appear in Table (3).

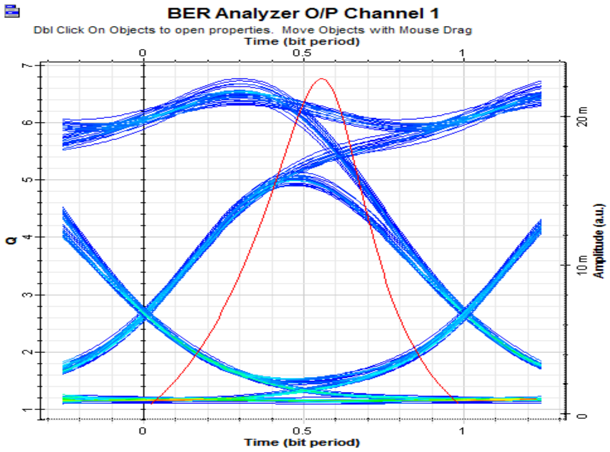

Figure 2. Shows the Q-factor vs. Time vs. Amplitude for the outputs from the first channel, @VCSEL, WDM, RZ, 10Gb/s, and 25Km SSMF.

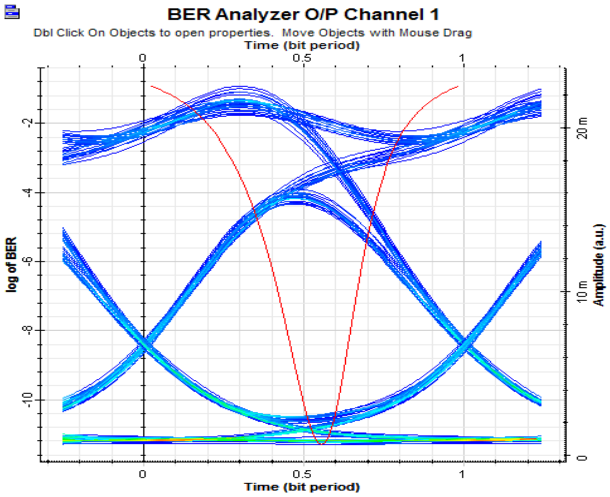

Figure 3. demonstrates the log of BER vs. Time vs. Amplitude for the output 1550nm, @VCSEL, WDM, RZ, 10Gb/s, and 25Km SSMF.

A good eye opening performance show in Figures (2 and 3) for a data rate of 10 Gb/s over optical fiber length equal 25km, the good eye opening for the received signals at the received side for the channels are well and demonstrate there are no ISI, and no crosstalk. The x-axis shows the values of the bit period (the intervals between transmitted bit), The bit time refers to ellipse time to one bit to be out from the network, while the amplitude measures the change over the single carrier, and the Q indicates the value Q-factor the high peak in the red color curve show the Q-Factor at this iteration.

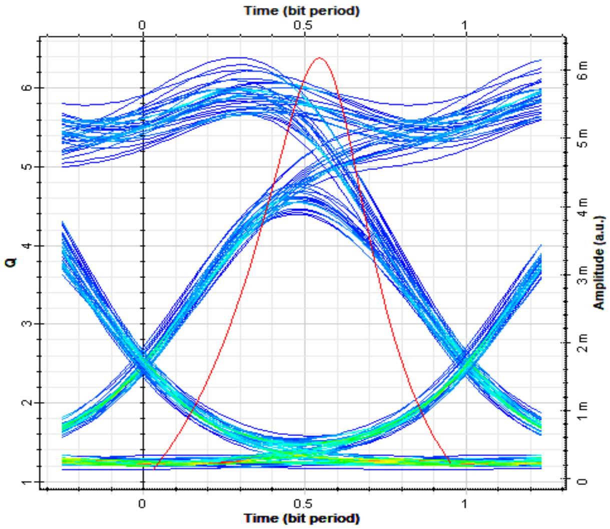

Figure 4. shows the Q-factor vs. Time vs. Amplitude for the output of the second signal, @VCSEL, WDM, RZ, 10Gb/s, and 25Km SSMF.

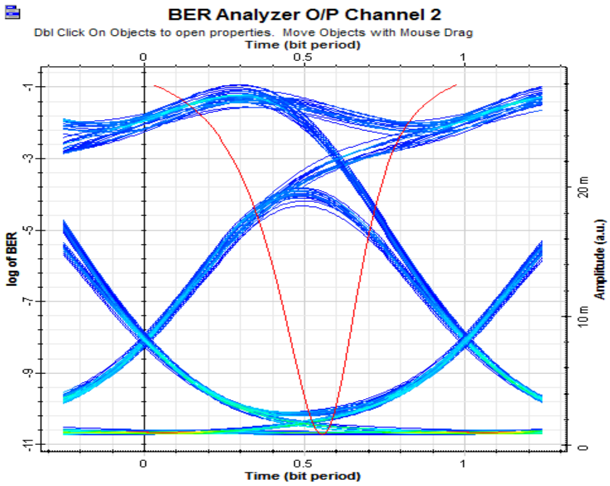

Figure 5. illustrates the log of BER vs. Time vs. Amplitude for the output of the second signal, @VCSEL, WDM, RZ, 10Gb/s, and 25Km SSMF.

While in Figures (4 and 5) shows a good eye opening of the received signals at the received side is well and demonstrate there are no ISI, and no crosstalk. The x-axis shows the values of the bit period (the intervals between transmitted bit), the amplitude is an indicate the changing in period, and the Log of BER indicate the value of BER, the high peak in the red color curve show the Log of BER at this iteration.

Channel	Total Output Power dBm	Max Q- Factor	Minimum BER	OSNR (dB)
1	-6.93174	6.95692	$1.41*10^{-12}$	29.6399
2	19.9995	6.38672	$6.72*10^{-11}$	29.6399
AVERAGE	6.53388	6.67182	$3.43236*10^{-11}$	29.6399

Table 3. Summarize Outcome from RoF Based VCSEL.

In Table 3, we show the values of Total Output Power, Max Q- Factor, Minimum BER and OSNR for channel 1 and 2, and calculate the average of every value.

Based on the previous figures (2 – 5) the RoF system has the following specifications: the average total power is (6.53388dBm), the average Max Q-Factor is (6.67182), the average Min BER equal to ($3.43236*10^{-11}$), and the average of OSNR is (29.6399dB), this is a good outcome and performance this is due to attractive characteristics of components that configure this architecture it's also can be applied on existing last mile infrastructure currently used by ministry of communication in Republic of Iraq.

Works	Modulation type	Bandwidth	BER	Reference
Previous work	NRZ	15 Gbps	10^{-12}	[12]
Our Experiment	RZ	20 Gbps	$3.43*10^{-11}$	Our Experiment

Table 4. The Comparison between previous works and our work

Table)4(, shows the comparison between the previous researcher works and our work as we see above, due to the table our result shows an attractive result compared with other researchers, this is due to selecting good components (active/passive) and good values and properties for parameters, also (we use multiple users by WDM) without need to changing the existing infrastructure.

The Bit Error Rate (BER) is an indicator is affected by the bandwidth. The increasing or decreasing is influenced by the components used in the design and vary from design to another. In our design the BER was good and very acceptable according to the components and bandwidth that was used.

5. CONCLUSION

To transfer maximum probable information and low cost and less error is the key goal of a communication system. We try to enhance the channel capacity by using RZ as modulation type and VCSEL as a light source and WDM to merging two signals and transmit them on SMF. we sent 10Gbps on each channel so the cumulative bit rate on SMF is 20 Gbps.

The most beneficial part of our system is usage fewer components to reduce the complexity and we will exploit the existing SMF to have more bandwidth by using two channels and transmit on SMF that will reduce operational expenses. The average results of our experience from our simulation for two channel are Total Output Power dBm (6.53388), Max Q- Factor (6.67182), Minimum BER ($3.43236*10^{-11}$), OSNR (dB) (29.6399).

All the average values are good and acceptable, we get on it because we using an attractive component and there is compatibility between all components. The simulation and performance test of RoF was done using Optisystem 7.0.

Conflict of Interests/Çıkar Çatışması

Authors declare no conflict of interests/Yazarlar çıkar çatışması olmadığını belirtmişlerdir.

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