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Sub-Carriers Multiplexing at Various Data Rates on Radio Over Fiber Systems

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Abstract- **The need of increased capacity transmission systems has motivated the interest on multiplexing techniques that involves transmission of multiple signals through a single fiber. It provides high capacity transmissions at lower costs for Radio over Fiber (RoF) systems which enable fiber based wireless access. In this paper an attempt has been made to design and simulate a SCM system with three users. The investigations of the system are done at different bit rates to report the performance of system in form of various performance metrices like Q factor, BER and Eye diagram. The investigations reveal that with increasing bit rates and number of users in the system the quality factor of the system is affected and the eye height is also decreased.**

Index Terms- **Sub-Carrier Multiplexing (SCM), Radio over Fiber (RoF), OptiSystem, Fiber based wireless access, High capacity, Low cost.**

I. INTRODUCTION

Radio-over-Fiber (RoF) is a technology which uses optical fibers for the transmission of radio frequency (RF) signals. RoF makes it possible to centralize the RF signal processing functions in one shared location called headend and then to use optical fiber which offers low signal loss to distribute the RF signals to the remote access units (RAUs). These systems can be used to distribute GSM signals. RoF has the special characteristic feature of having both a fiber optic link and a free space radio path. Fiber based wireless (Fi-Wi) access facilitates high-capacity multimedia services in a real-time basis. The variations in Q factor, BER and eye opening with respect to the wavelength, bit rate and fiber length have been investigated[1]. RoF can be used for improvement in BER in WLAN to increase reliability, and flexibility of the system[3]. RoF uses optical fibers and optical fibers offers enormous bandwidth for high capacity transmission which is difficult to do in electronics systems, this makes the bandwidth of electronics systems to limit the utilization of the enormous bandwidth offered by optical fibers. Therefore, Sub-Carrier Multiplexing (SCM) is used to increase optical fiber bandwidth utilization.

Sub-Carriers Multiplexing (SCM) is a method of combining many different communication signals so that they can be transmitted through a single optical fiber. First an electrical baseband signal is mixed with a high frequency signal which generates a sub-carrier signal, then a number of sub-carrier signals are combined to modulate carrier light. Other methods for SCM are also possible[2]. SCM is also used as a variant of wavelength division multiplexing (WDM). In a WDM system, first we convert a baseband signals into optical form using optical modulation for each signal separately and then we combine these signals using optical MUX for the transmission through the fiber. But, in SCM first we modulate baseband signals electronically after that we combine these signals using electronic MUX and then we use this combined signal for the modulation of carrier light. At receiver end we use reverse process as we used at transmitter. Since, in SCM systems we are using electronic modulation and components like MUX, DEMUX etc, therefore the cost of SCM systems is lower than the cost of pure WDM systems.

This paper is divided into five sections. In 1st section we have had a brief introduction of Radio over Fiber systems and Sub-Carriers Multiplexing method. In 2nd section we study the block diagram for the SCM system which we used in this paper. 3rd section will provide details for the experimental setup and the software used for the simulation. In section 4 we will compare the results of the simulation for different data rates. Finally conclusion comes in section 5.

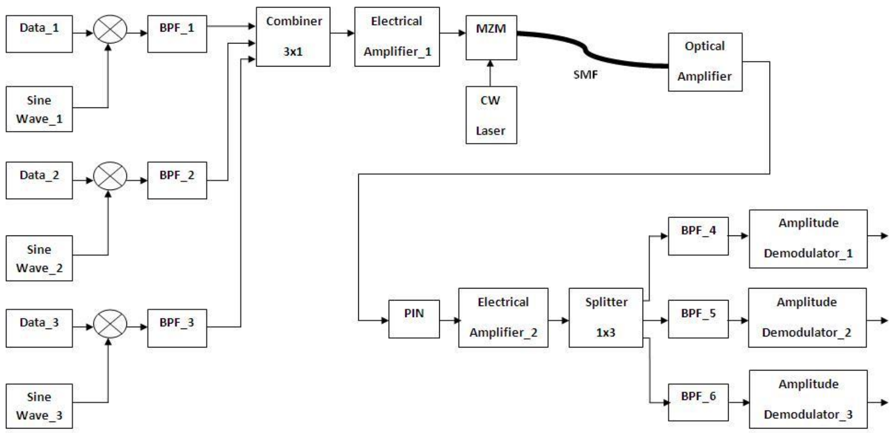

Fig.1. SCM block diagram with 3 users

II. BLOCK DIAGRAM

Fig. 1 shows the block diagram of the setup which we used in our simulation. Here we multiplexed three sub-carriers from three different users. Then this signal is modulated, transmitted and received. All the outputs are observed at amplitude demodulator. We can divide this diagram into three portions, transmitter, channel and receiver. Here single mode fiber (SMF) is used as a channel, so the portion before SMF completes a transmitter and the portion after SMF is a receiver.

For the transmission process three separate pseudo random bit sequence (PRBS) generators are used to generate separate data for three users. Then these data signals are multiplied with three different carrier signals by using electrical multipliers. By doing so, data signals have modulated three carrier signals with different frequencies. This modulation will convert baseband signals into band pass signals with unwanted range of frequencies. To remove unwanted range of frequencies, the outputs of multipliers are applied to the band pass filters of desired frequency and bandwidth. Then outputs of three band pass filters are combined using 3x1 combiner and this combined output is then amplified and applied to mach zehnder modulator (MZM) to modulate the carrier light of optical light source, that is a continuous wave laser. This modulation will convert electrical signal into optical signal which will be transmitted through a single mode fiber and this completes the transmission process.

After transmission data will pass through channel that is a single mode fiber (SMF) which carries data from transmitter to receiver. At receiver side a photodetector is used to detect the optical signal and convert it back into electrical form. After converting into electrical form signal is amplified using electrical amplifier and a 1x3 splitter is used to split this signal into three sub-carriers. These sub-carriers are applied to band pass filters to select three different carrier frequencies which were initially used for the modulation at transmitter end. Then in amplitude demodulator which is a combination of local oscillator and low pass filter (LPF), synchronous detection process is used to get baseband data from modulated band pass signal. This is called synchronous because modulated signal is multiplied with its carrier frequency which gives data signal with high frequency components. LPF is used to remove these high frequency components and at the output of LPF we get the baseband data signal which was transmitted and this completes reception process.

III. SIMULATION SETUP

Simulation setups are designed according to block diagram given in fig. 1. All the simulations are performed on OptiSystem v 7.0. To generate digital data NRZ coding schemes are used to convert outputs of PRBS generators into electrical signals. For band pass filters we used Bessel filters and transimpedance amplifiers are used for electrical amplifications. For the transmission of data three different carrier frequencies 10 GHz, 15 GHz and 20 GHz are used. At both transmitter and receiver ends, the frequencies of band pass filters are set to the frequencies of carrier signals they are filtering and bandwidths are set to 2*Bit Rates. For amplitude demodulators frequencies are same as for band pass filters and bandwidths are equal to Bit Rates that is half of the bandwidths of band pass filters. In all the simulations single mode fiber (SMF) of 40 Km length is used.

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IV. RESULTS AND ANALYSIS

The outputs of the simulation are shown below. These outputs are taken from second user. A comparison table is given below from which we can compare the outputs at different bit rates.

A. Outputs for 0.5 Gbps

Fig. 2. and Fig. 3. show BER and Eye Diagram for 0.5 Gbps data rate. From the figures we can see the value of Max Q factor touches 21.4323 and Eye height reaches .492995. The value for Min. BER for 0.5 Gbps is 3.30305e-102.

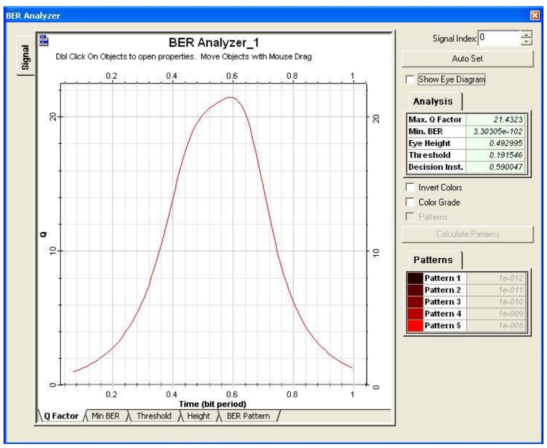

Fig. 2. Bit error rate for 0.5 Gbps

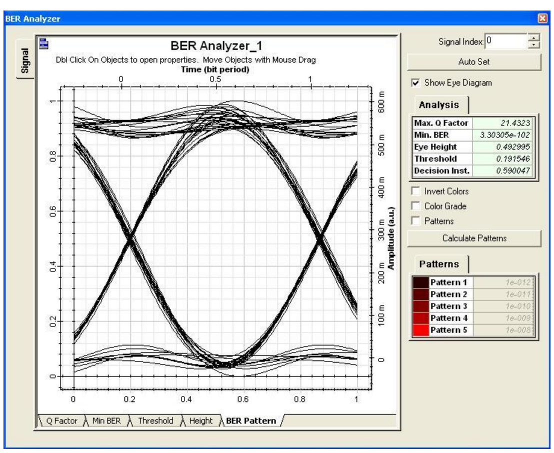

Fig. 3. Eye diagram for 0.5 Gbps

B. Outputs for 1 Gbps

Fig. 4. and Fig. 5. show BER and Eye Diagram for 1 Gbps data rate. Here from the figures the value of Max Q factor is 20.2433 and Eye height reaches .443316. The value for Min. BER for 1 Gbps is 1.96592e-091. As compared to the 0.5 Gbps there is a little change in the performance of the system.

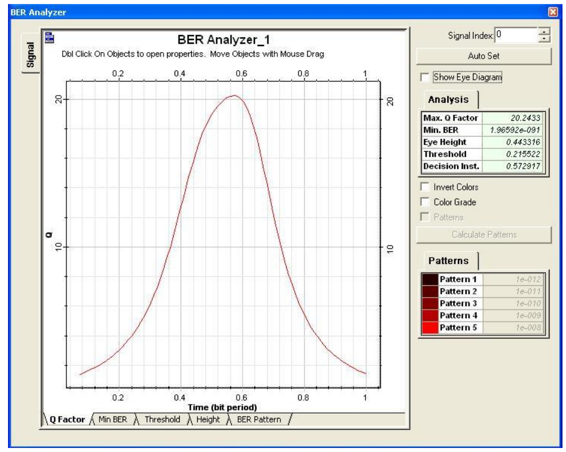

Fig. 4. Bit error rate for 1 Gbps

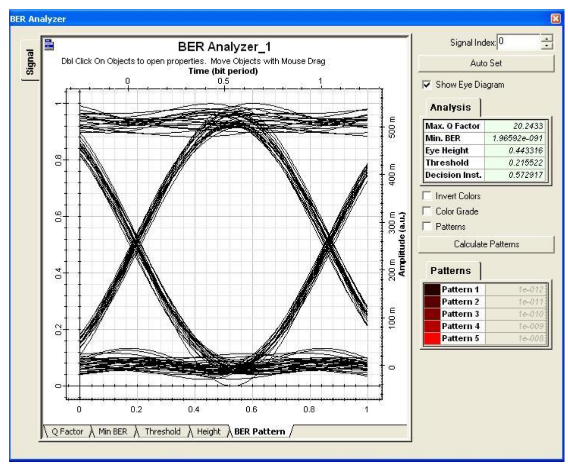

Fig. 5. Eye diagram for 1 Gbps

C. Outputs for 1.5 Gbps

Fig. 6. and Fig. 7. show BER and Eye Diagram for 1.5 Gbps data rate. The values for Max Q factor, Eye height and Min. BER are 18.1874, .427519 and 3.23584e-074 respectively. As compared to the 0.5 Gbps and 1 Gbps bit rates the performance of the system decreases by a small amount.

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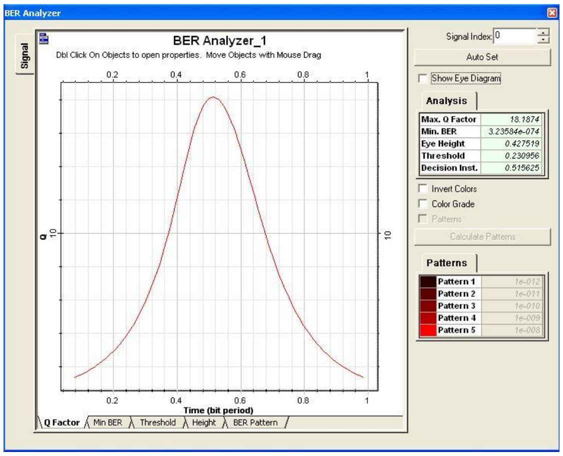

Fig. 6. Bit error rate for 1.5 Gbps

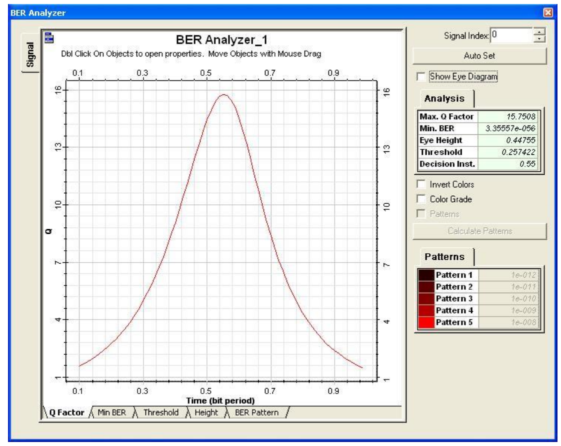

Fig. 8. Bit error rate for 2 Gbps

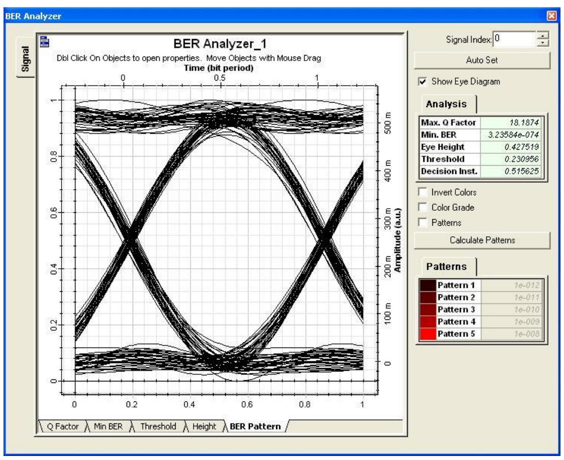

Fig. 7. Eye diagram for 1.5 Gbps

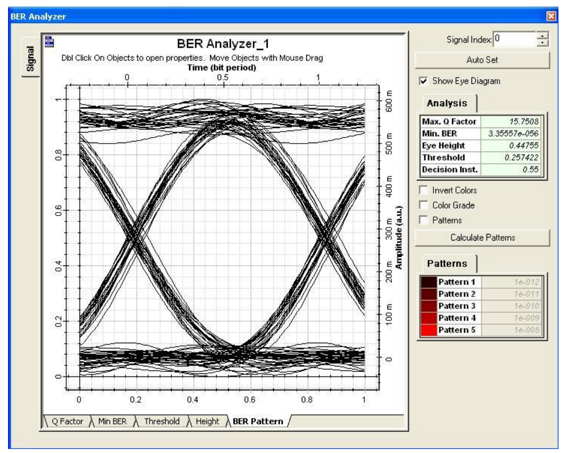

Fig. 9. Eye diagram for 2 Gbps

D. Outputs for 2 Gbps

Fig. 8. and Fig. 9. show BER and Eye Diagram for 2 Gbps data rate. Here the values for Max Q factor, Eye height and Min. BER are 15.7508, .447550 and 3.35557e-056 respectively. As compared to the three bit rates above (0.5 Gbps, 1 Gbps and 1.5 Gbps) the performance of the system further decreases, but still these values are far better than the acceptable values.

TABLE I
RESULTS' COMPARISON

Parameter / Bit Rate	Max. Q factor	Min. BER	Eye Height
0.5 Gbps	21.4323	3.30305e-102	.492995
1 Gbps	20.2433	1.96592e-091	.443316
1.5 Gbps	18.1874	3.23584e-074	.427519
2 Gbps	15.7508	3.35557e-056	.447550

Table I shows the values of Max. Q factor, Min. BER and Eye Height for various bit rates. From the table we can observe the changes in the values of Max. Q factor, Min. BER and Eye Height as we increase the bit rate from 0.5 Gbps to 2 Gbps. Max. Q factor decreases from 21.4323 to 20.2433 when the value of bit rate increases from 0.5 Gbps to 2 Gbps. This value further decreases for higher values of bit rate. Similarly the changes in values of Min. BER and Eye Height for various bit rates can also be observed.

V. CONCLUSION

Sub-Carriers Multiplexing (SCM) system for 3 users has been implemented. We can see as we increase the bit rate from 0.5 Gbps to 2 Gbps the value of Min. BER is increasing and the value of Min. BER for 2 Gbps is 3.35557e-056 which is far better than the acceptable value for a system to work, so there is a possibility to further increase data transmission rate and enable high data rates transmission to increase the capacity and performance of the system.

REFERENCES

[1] Johny, J, Shashidharan, S, "Design and Simulation of a Radio Over Fiber System and its Performance Analysis", in ICUMT, St. Petersburg, pp. 636 – 639, Oct. 2012.

[2] Gutierrez-Martinez, C., Santos-Aguilar, J., "Multiplexing Microwave Subcarriers on Dispersive- Channel Radio over Fiber Systems", in Mic. Pho. Int. Top. Meet., Noordwijk, pp. 111 – 114, Sept. 2012.

[3] Elfaki, S., Khider, I., Omer, M., Almomen, F., "Evaluation of Bit Error Rate (BER) in WLAN IEEE 802.11a with Radio over Fiber (RoF) downlink system", in Hig. Cap. Opt. Net. and Ena. Tech. (HONET), Riyadh, pp. 153 – 158, Dec. 2011.

[4] Sivapriya, A., Sivanantharaja, A., "Uplink and Downlink of RF Signals Using Optical Frequency Multiplication in Radio Over Fiber", in Int. Conf. on Info. Comm. And Emb. Sys. (ICICES), Chennai, pp. 691 – 694, Feb. 2013.