Design and Simulation of a Radio Over Fiber System and its Performance Analysis

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Abstract — **A Radio Over Fiber 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 simulation model developed using Optisystem 10 have integrated systems for both RF wireless and optical fiber whereby, the ROF network model consists of a central station, a remote access unit and an optical fiber link model that uses the commercially available parameters. We also investigates the variations in Q factor, BER and eye opening with respect to the wavelength, bit rate and fiber length using the simulation software.**

Keywords: ROF; NRZ Coding; RZ Coding; Q Factor; BER; Eye Height; Wavelength: Bit Rate; Fiber Length

I. INTRODUCTION

Radio over Fiber (ROF) is a newer technology where, light is modulated with radio frequency signals and transmitted over the optical fiber to facilitate wireless access and transmission. The convergence of wired and wireless networks is a promising solution for rapidly growing bandwidth demands in the communication systems,. Radio-over-fiber is a promising solution for the increasing demand for transmission capacity and flexibility, as well as offering economic advantage due to its broad bandwidth and low attenuation characteristics [1].

Radio Over Fiber is actually an analog optical link which transmits modulated RF signals. It transmits RF signal downlink and uplink, to and from central station (CS) and to base station (BS). The main requirements of a ROF link architecture are duplex operation (downlink-uplink), reasonable length and high performance optical components.

ROF systems have enhanced cellular coverage , lower attenuation losses, higher capacity, larger bandwidth and immunity to radio frequency interference. The basic configuration of a ROF link is shown in Figure, where the system consist of a central station and remote access unit (RAU) connected by a single mode fiber. Figure 1 shows a typical Radio Over Fiber System [2].

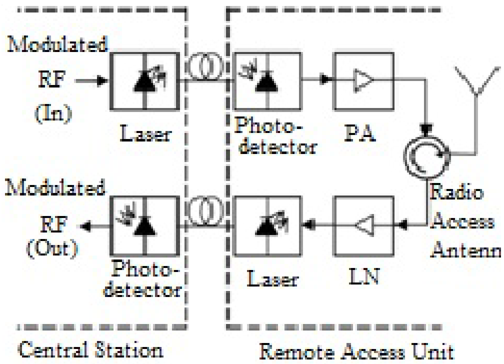

Fig 1: Typical Radio Over Fiber System

II. ROF DESIGN USING OPTISYSTEM

In present optical transmission systems, communications traffic is conveyed by optical carriers whose intensity is modulated by the communications traffic that is the optical carrier is Amplitude Modulated (AM). Generally the communications traffic used to modulate the optical carrier will have a Non Return to Zero (NRZ) format though sometimes it can have a Return to Zero (RZ) format.

There are two technologies for modulation, i.e. direct and external modulators. In direct or without external modulation format the RF signal varies directly with the bias of a semiconductor laser diode and the external modulators are either integrated with Mach-Zehnder interferometers or electro absorption modulator. Intensity-modulation (IM) is preferred mainly due to the simplicity of the corresponding optical receiver/detector that is based on a photodetector, for example a photodiode, which operates as a simple amplitude threshold detector. For particular applications, in general for the soon coming 40Gbit/s optical communication systems, it has been proposed to use other modulation formats which have greater immunity against non-linear propagation effects and also for greater polarization mode dispersion (PMD) and chromatic dispersion (CD) tolerance. These characteristics can open the road to a new design of optical transmission systems for example with higher transmission powers and longer sections free of repeaters. Figure 2 shows the simulation model of an ROF system designed using Optisystem.

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Here 2 RF signals each of 10GHz and 15GHz frequency are power combined and then modulated with optical signals from the CW laser in the LiNb-Mach Zehnder Modulator. The modulated signal is then transmitted through the conventional optical fiber with a Reference wavelength of 1550 nm and fiber length of 20 Km. After transmission through the fiber the signals are filtered using a Bessel filter and demodulated in the AM demodulator.

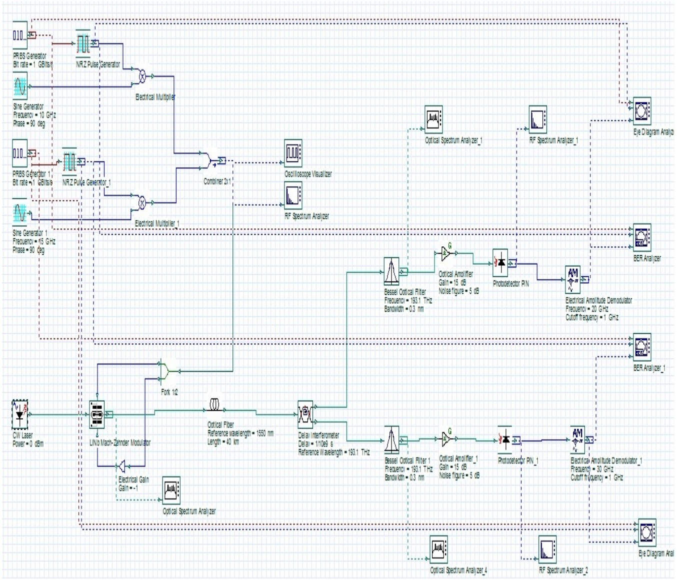

Fig 2 : Simulation Model of an ROF system

III. Results And Discussion

A. Bit Error Analyser

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 [3].

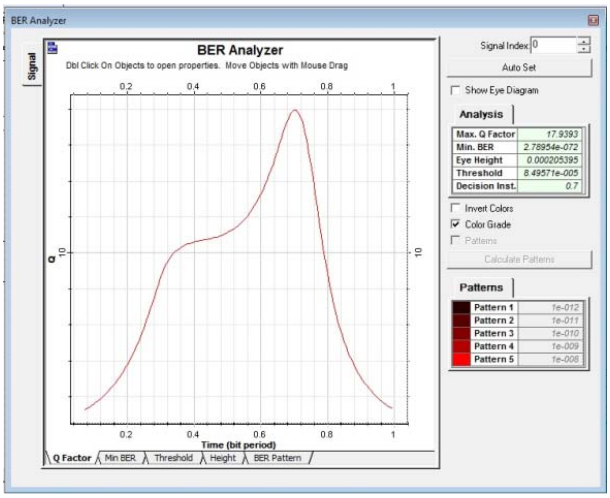

Fig 3: Bit error analyzer for 10 GHz RF signal

B. Eye Diagram Analyser

The Eye Diagram Analyser block of the Optisystem 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 intersymbol interference (ISI) and noise appears as a closure of the eye diagram [5]. Figure 4 shows the eye diagram of the 10GHz RF signal

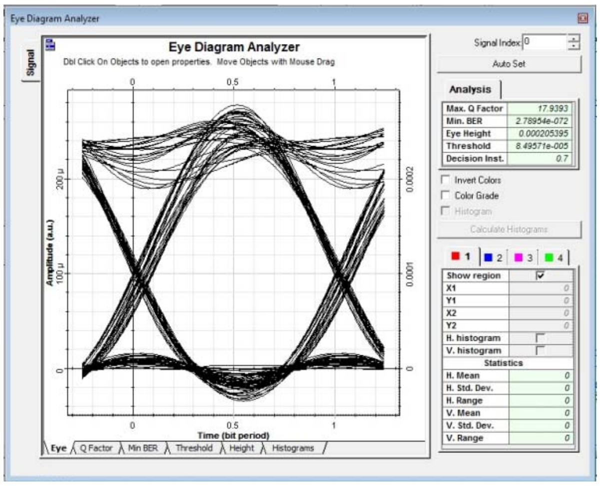

Fig 4 : Eye Diagram analyzer for 10 GHz RF signal

C. Graphical Results for NRZ Coding

Non-Return-to-Zero (NRZ) and Return-to-Zero (RZ) are the 2 most common modulation formats used in communication. Here in this paper we perform analysis using NRZ coding

(i) Varying Bit Rate

From the graph shown in Figure 5 it can be observed that the maximum Q factor, is following a 6th for the 10 GHz signals.

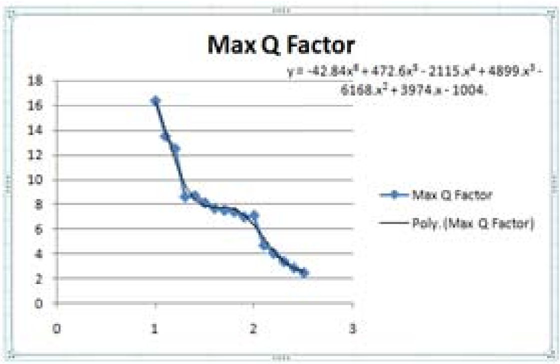

Fig 5: Maximum Q Factor Vs Bit Rate for 10GHz RF signal

From the graph shown in Figure 6 it can be observed that the minimum Bit Error Rate (BER) remains almost constant for different bit rates in case of the 10 GHz signal.

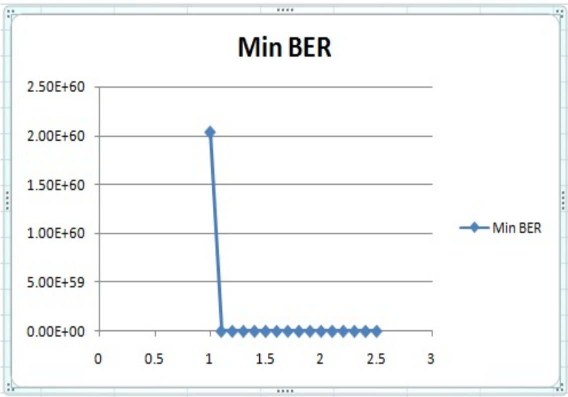

Fig 6: Minimum Bit Error Rate Vs Bit Rate for 10GHz signal

The plot between eye height and bit rate follows a 6th degree polynomial for the 10 GHz signals as shown in Figure7.

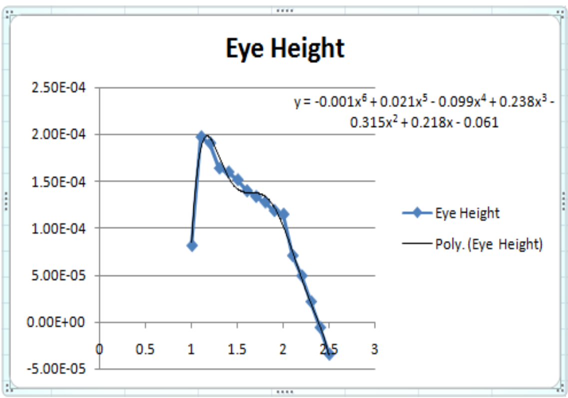

Fig 7: Eye Height Vs Bit Rate for 10GHz RF signal

From the graph shown in Figure 8 it can be observed that the threshold value, is following a 6th degree polynomial for 10 GHz signal.

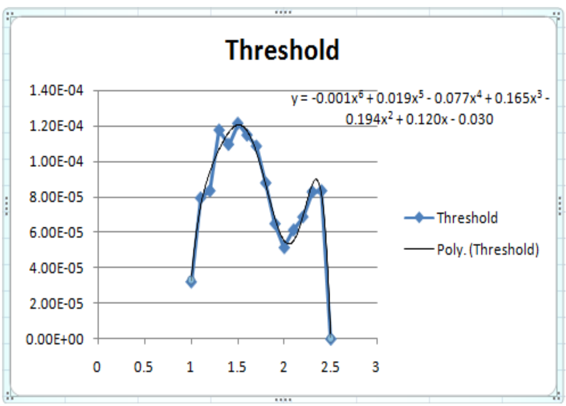

Fig 8: Threshold Vs Bit Rate for 10GHz RF signal

(ii) Varying Fiber Length

From the graph shown in Figure 9, it can be observed that the maximum Q factor decreases almost linearly with respect to the fiber length for the 10 GHz RF signal.

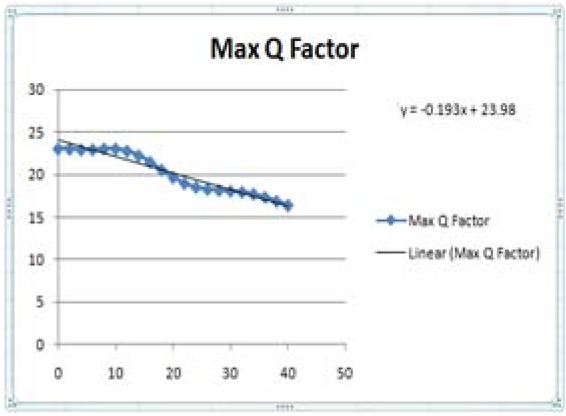

Fig 9: Maximum Q Factor Vs Fiber Length for 10GHz RF signal

From the graphs shown in Figure 10 and 11, it can be observed that the minimum BER remains almost constant for different lengths of fiber and the eye height decreases exponentially with the fiber length for the 10 GHz RF signals.

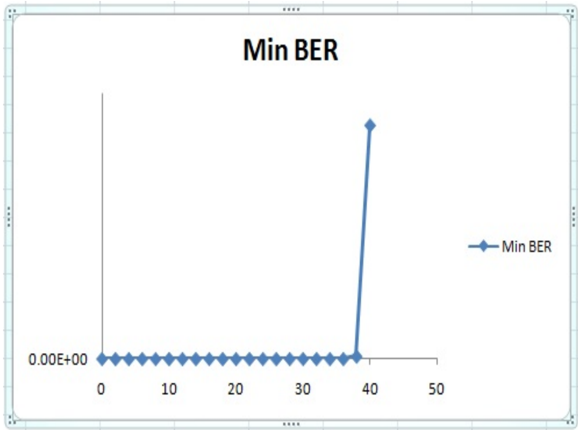

Fig 10: Minimum BER Vs Fiber Length for 10GHz RF signal

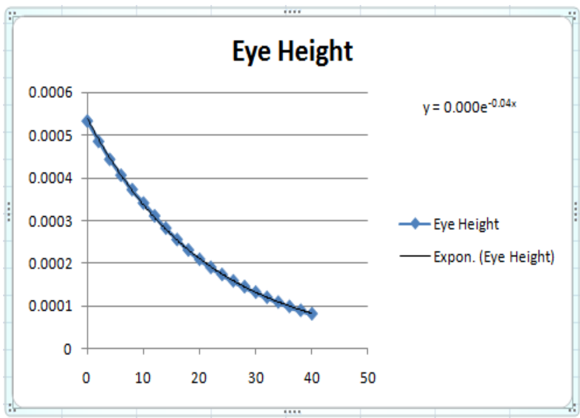

Fig 11 : Eye Height Vs Fiber Length for 10GHz RF signal

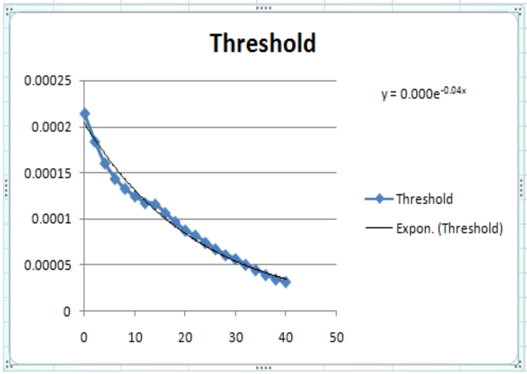

Fig 12: Threshold Vs Fiber Length for 10GHz RF signal

From the graph shown in Figure 12 it can be observed that the threshold also decreases exponentially with respect to fiber length for the 10 GHz RF signal.

(iii) Varying Wavelength

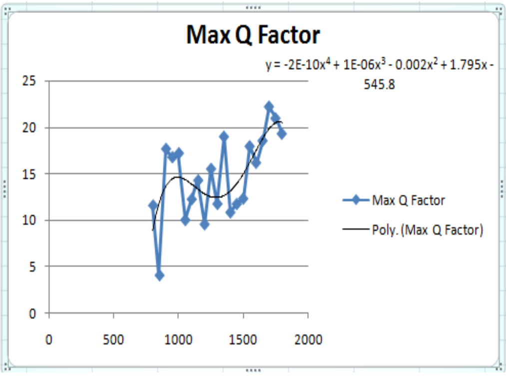

Fig 13 : Maximum Q factor Vs Wavelength for 10 GHz signal

From the graphs shown in Figure 13 and 14 it can be observed that the maximum Q factor follows a 4th degree polynomial and the minimum BER remains almost constant with respect to wavelength for 10 GHz RF signal.

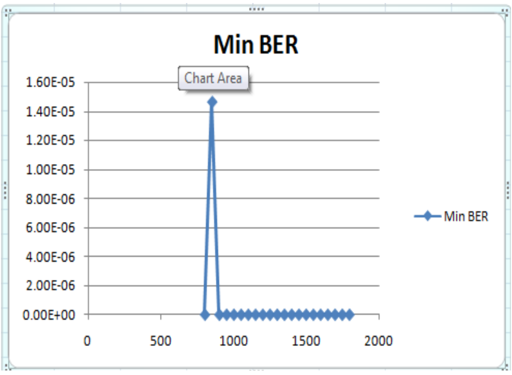

Fig 14 : Minimum BER Vs Wavelength for 10GHz RF signal

From the graphs shown in Figure 15 and 16, it can be observed that the Eye Height and threshold both follows a 4th degree polynomial with respect to wavelength for the 10 GHz RF signal.

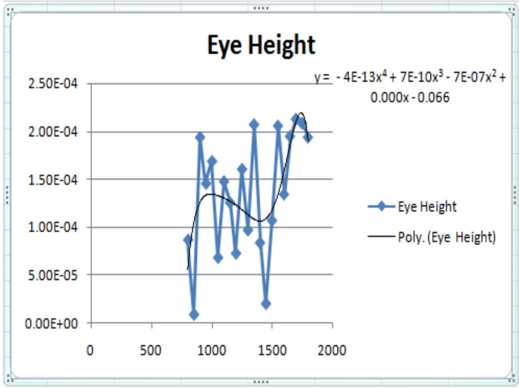

Fig 15 : Eye Height Vs Wavelength for 10GHz signal

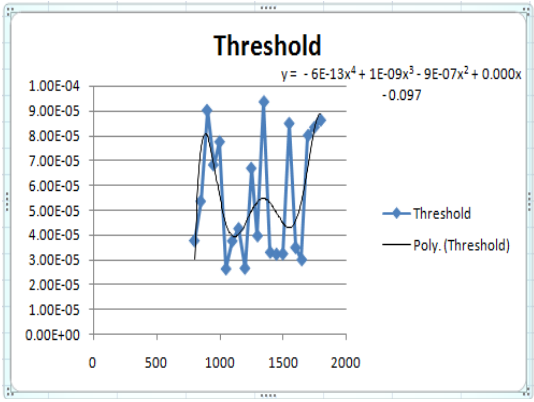

Fig 16 : Threshold Vs Wavelength for 10GHz RF signal

IV. CONCLUSION

A radio over fiber system were designed and simulated using the Optisystem software and its various parameters such as Q factor, BER, Eye height, etc were compared for different categories of coding such as NRZ and RZ coding. Due to higher peak power, NRZ may suffer from more nonlinearities, whereas RZ may suffer from more dispersion which is due to shorter pulse width. Studies shows that in general, we can operate better by using RZ modulation in high power regime than NRZ coding.

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