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An Optimized Radio over Fiber (Rof) Transceiver Design

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Abstract— Emerging wireless communication networks that support new broadband services provide increased opportunities for photonics technologies to play a prominent role in the realization of the next generation integrated optical/wireless networks.Radio over fiber(ROF) systems have the unique characteristic of featuring both a fiber optic link and a free space radio path. Radio-over-fiber transmission has extensively been studied as a means to realizing a fiber optic wireless distribution network that enables seamless integration of the optical and wireless network infrastructures. In this paper optimized ROF transceiveris simulated after studying the optical transmission and reception schemes.

Index Terms— Optimized transmitter and receiver, Optimized ROF transceiver

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I. INTRODUCTION

The mobile data traffic will grow more than 1000 times compared with the end of 2010 beyond 2020.Then, establishing and maintaining a successful wireless communication link among the users with simultaneously achieved high QoS and all the proposed objectives becomes challenging and more complex in next generation. The backhaul of nearly all wireless access networks is fiber optic link. In order to support the tremendous amount of data, optical network has been evolved in respective way. The technological advancements and deployments are creating a new landscape in access networks, with an integration of wireless and optical technologies.

Emerging wireless communication networks that support new broadband services provide increased opportunities for photonics technologies to play a prominent role in the realization of the next generation integrated optical/wireless networks. It is noted that the wired and wireless seamless access communication systems play an important role to configure the resilient access network, mobile front haul and backhaul, and broadband radio relay networks.

Many applications today are moving towards in the deployment of an integrated RoF in their system such as WLAN, satellite communications and mobile broadband services. With high bandwidth, flexible and dynamic assessment, RoF is indeed a promising solution for today's communications. RoF would have a great potential in many research activities.

RoF communication systems have several types of advantages over conventional coaxial cable or wireless systems. The main advantages of the system are low attenuation loss due to the optical fiber compared to co-axial as well as wireless domain, large bandwidth around THz range compared to wireless frequency, the information signal in the form of light so the chance of radio frequency interference is very less, the installation cost is very high compared to wireless domain but the maintenance cost is less and reduced power consumption.

The major drawbacks of a RoF system are requirement for high-speed optical components, complex radio-wave generation techniques. In addition that chromatic dispersion across the fiber network becomes a problem even over a relatively small distance, so that advanced modulation and transmission schemes must be employed. These all requirements in a system leads to the development of opticalcomponents operating in the radio wave band techniques for efficient generation and transmission of radio wave signals over the optical fiber . Therefore, multiple system architectures have been proposed where such functions as signal routing, processing, handover, and frequency allocation are carried out at the CS, for BS simplification.

After a brief description about ROF, the detailed review about the simulation that was carried out is explained in the following sections. The basic optical transceiver was designed and the comparative study was done using the design to obtain the optimized design.

A. ROF

"ROF : Radio over Fiber" is defined as the fiber-optic transmission of a waveform for radio communication services without any intentional change to that waveform, where the waveform includes the complete physical information for radio communication services, such as the format of radio wave and payload. Two main features of

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ROF includes the preservation of native form of the wave and tolerance to electro-magnetic interference [1].

For typical ROF systems electrical-to-optical (E/O) conversion, optical-to-electrical (O/E) conversion and high spectral-efficient transmission are important elemental technologies.The basic block diagram of RoF is as shown in Figure1.The system mainly consists of transmitter, optical fiber and receiver. The radio frequency modulated signal is converted to optical signal and transmitted via optical fiber link. An optical receivers detects the signal and converts it to electrical signal and is demodulated to pass to the system terminal [1].

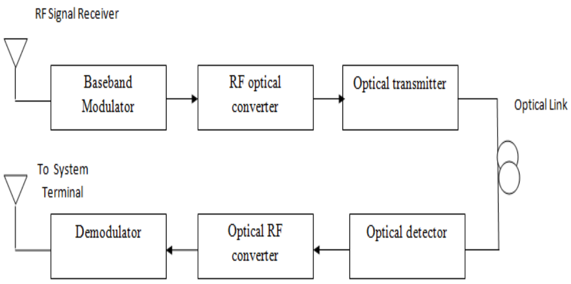

Fig 1: The basic block diagram of RoF

B. Opti System

OptiSystem is an innovative optical communication system simulation package that designs, tests, and optimizes virtually any type of optical link in the physical layer of a broad spectrum of optical networks, from analog video broadcasting systems to intercontinental backbones [5].

OptiSystem is a stand-alone product that does not rely on other simulation frameworks. It is a system level simulator based on the realistic modeling of fiber-optic communication systems. It possesses a powerful new simulation environment and a hierarchical definition of components and systems. Its capabilities can be extended easily with the addition of user components, and can be seamlessly interfaced to a wide range of tools [5].

II. METHODOLOGY

The objective of this paper was to design and simulate an optimized Radio over fiber (RoF) using opti system software. Fig 2 outlines overall steps detailing the methodology of the entire design.

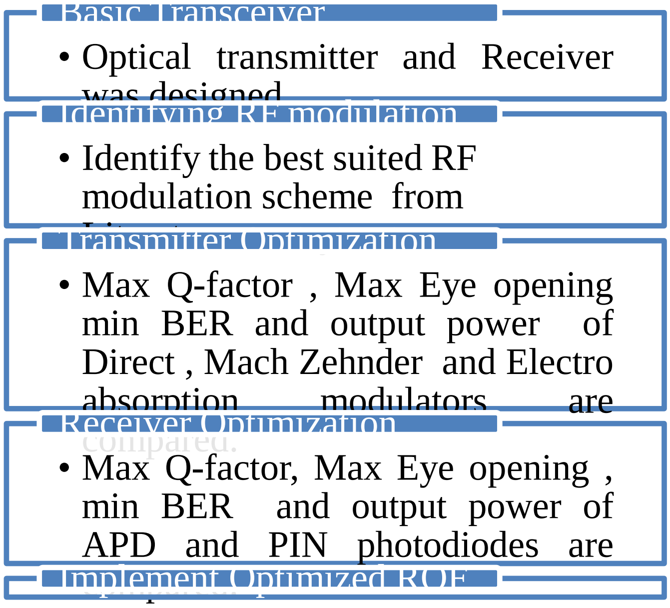

Fig 2. Methodology

A. System Model

The system mainly consists of transmitter, optical fiber and receiver. For the system transmitter is considered as central station in which all the activities such as coding, multiplexing and modulation are done. The receiver is the base station which consists of small antennas known as remote antenna unit.

The system consists of a random bit generator and all generated bits are coded by using QAM coders, after that modulated by using OFDM modulator. Then the electrically modulated signals are passed through optical modulators/transmitter where all the electrical signals are converted to optical domain. After that optically modulated signals are transmitted through the optical fiber. The transmitted and received optical signal parameters measured using optical spectrum analyzer. In the fiber the signal quality and amplitude reduces. Then at the receiver, the optical signals are detected by using photo detector and after that signals are demodulated to recover the data.

B. RF Modulation

QAM (quadrature amplitude modulation) is a method of combining two amplitude-modulated (AM) signals into a single channel, thereby doubling the effective bandwidth.The great advantage of electrical OFDM modulation is that, it avoids the interference and multipath propagation in the wireless channel as well as reduces the dispersive and attenuation effects of fiber. Many schemes of OFDM are available [4]. OFDM uses multiple sub-carriers to transmit low rate data streams in parallel. The sub-carriers are modulated by using Phase shift Keying (PSK) or Quadrature Amplitude Modulation (QAM) and are then carried on a high frequency microwave carrier. The frequency of input signal used was 40GHz and QAM-OFDM had 4 subcarriers and 64 FFT points. This is similar to conventional Frequency Division Multiplexing (FDM) or Sub-carrier Multiplexing, except for the stringent requirement of orthogonality between the sub-carriers. Coded OFDM offers very robust communications with the frequency diversity those results from channel coding and interleaving. Each of OFDM has been developed to support wireless communication systems such as WLAN, DAB, and DVB and future wireless systems such as the 4th generation cellular systems. OFDM modulation as electrical modulation reduces the intersymbol interference in wireless domain and removing the fiber losses due to dispersion. Then OFDM with QAM modulation is used for RF modulation [2].

C. Optical Modulation

Internal and external optical modulations are the two major modulation techniques currently used. In the direct modulation scheme, the driving current to a directly modulated semiconductor laser is varied according to the data to be transmitted. In the external modulation scheme, the laser that is subjected to a constant bias current emits a continuous wave while an external modulator switches the optical power on or off according to the data stream[3]. Many external modulators are available such as Mach-Zehnder and electro absorption.

The comparative study was done on a basic transceiver design. Figure 1 shows the basic arrangement for direct modulator. Figure 2 shows basic arrangement for Mach Zehnder modulator and figure 3 is the basic arrangement for Electro-absorption modulator. The comparative study of various threemodulations are shown in Table1 based on the values obtained from simulationdone by using Optisystem version 14.0.

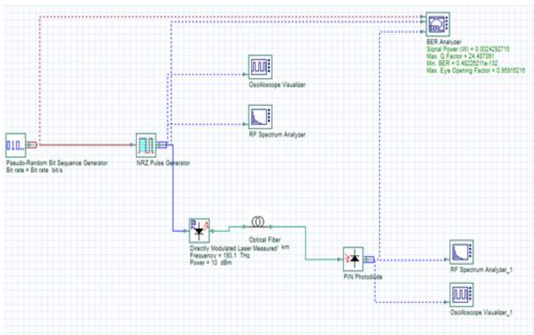

Fig 3: Direct modulation Transceiver design

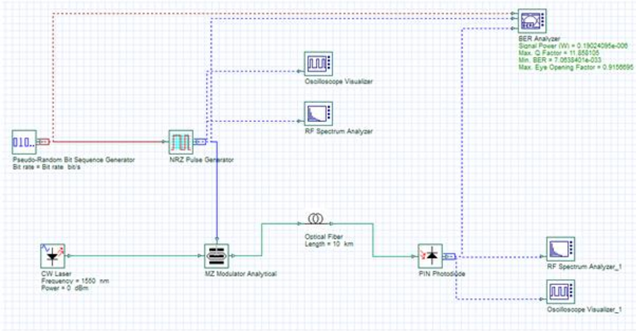

Fig 4: Mach Zehnder modulation Transceiver design

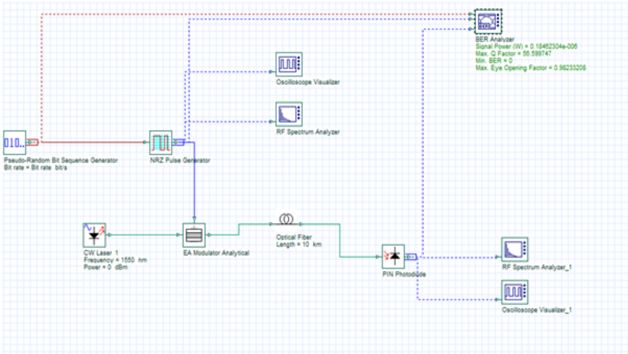

Fig 5: Electro-absorption modulation Transceiver design

TABLE1: comparative study of optical modulation schemes

Parameters	Direct	Mach Zehnder	Electro-absorption
Maximum Q-factor	24.487091	59.208362	56.599747
Minimum BER	0.48226211e-132	0	0
Max Eye opening	0.95916216	0.98311049	0.98233208
Output Signal power(W)	0.0024292715	0.18769536e-006	0.18462304e-006

From the analysisof comparative study, a high quality factor and eye opening for Mach Zehnder modulatorwasobserved. Mach Zehnder modulator was selected as optimized transmitter for the design.

D. Receiver Configuration

The modulated signal is passed through the fiber and signal is recovered by using the PIN or APD photo-detectors. Basically the APD is having the lower SNR due to the avalanche multiplication factor. Using the same simulation setup with Mach Zehnder modulator as the transmitter analyzed the photo detectors PIN and APD. Figure 4 shows the shows transceiver design using APD photodiode. Fig 5 shows transceiver design using PIN photodiode.

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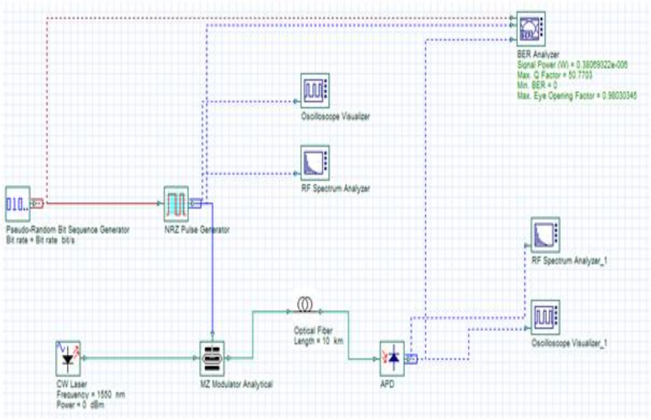

Fig 6: Transceiver design using APD photodiode

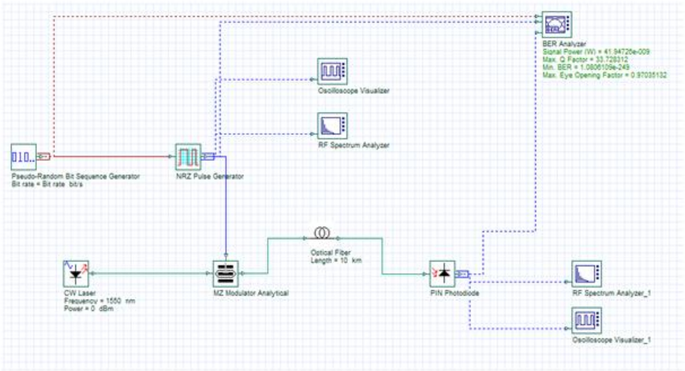

Fig 7: Transceiver design using PIN photodiode

Table 2: Showing comparative study of optical receivers

Parameters	APD	PIN
Maximum Q-factor	50.7703	59.208362
Minimum BER	0	0
Max Eye opening	0.98030345	0.98311049
Output Signal power(W)	0.38069322e-006	0.18769536e-006

Table 2 shows the comparative study of the performance of optical receivers.Analyzing the comparative simulation study, PIN photodiode was found to optimized receiver as it had more quality factor than APD photodiode. Figure 6 shows the optimized transceiver setup. Figure 7 shows the obtained eye diagram for the setup.

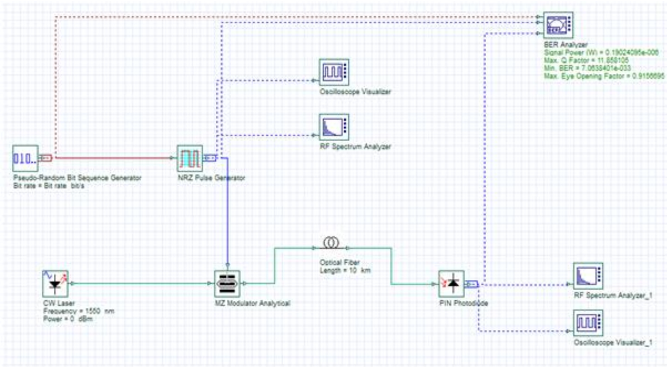

Fig 8: Showing the optimized transceiver section

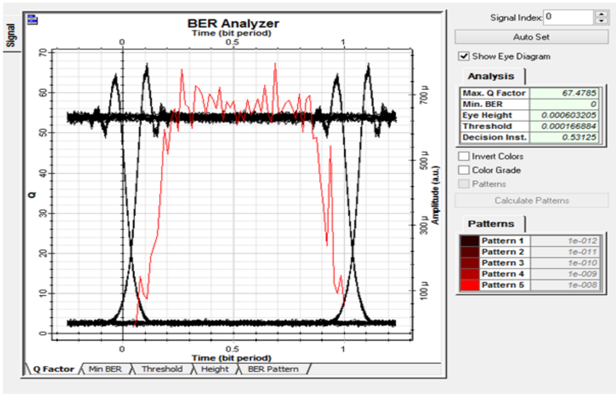

Fig 9: Eye diagram for Mach Zehnder and PIN transceiver setup and fiber length of 10km

III.CONCLUSION

In this work, a simulation based comparative study of the opticaltransmitter and receiver configurations was done. Based on the results, an optimized radio over fiber link was designed and is shown in Figure 8. It mainly consists of digital bit sequence generator, RF modulator, optical transmitter, channel and receiver.The maximum Q-factor, minimum BER, maximum eye opening and output signal power were the parameters used to compare the working of the optical transmitter and receiver.

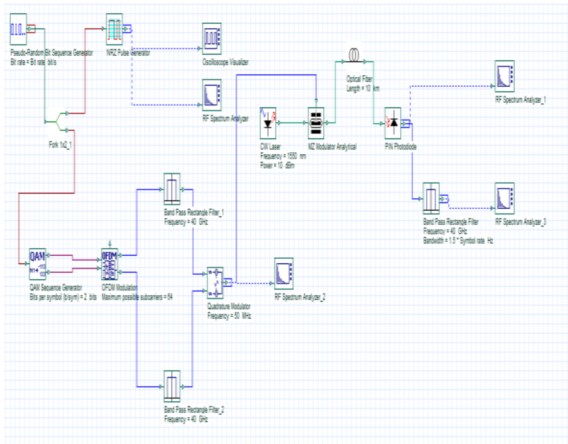

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Fig 10: Optimized Radio over Fiber link

The spectral diagram of the RF modulated signal was obtained using RF spectrum analyzer was connected after RF modulator at the transmitter end and is shown in the figure 11. At receiver end, one RF spectrum analyzer was connected to PIN photodiode and second one connected to BPF. The spectral diagram of received signal from PIN photo detector and band pas filter is shown in the figure 12. Using a band pass filter, the accuracy of the received signal was improved.

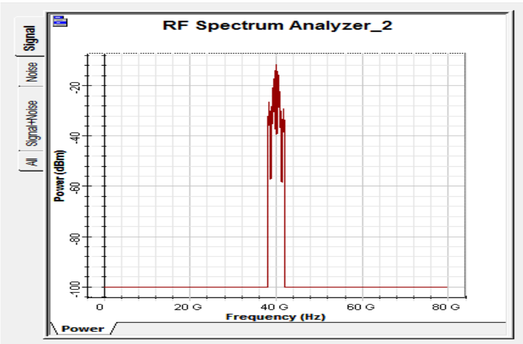

Fig11: Modulated input

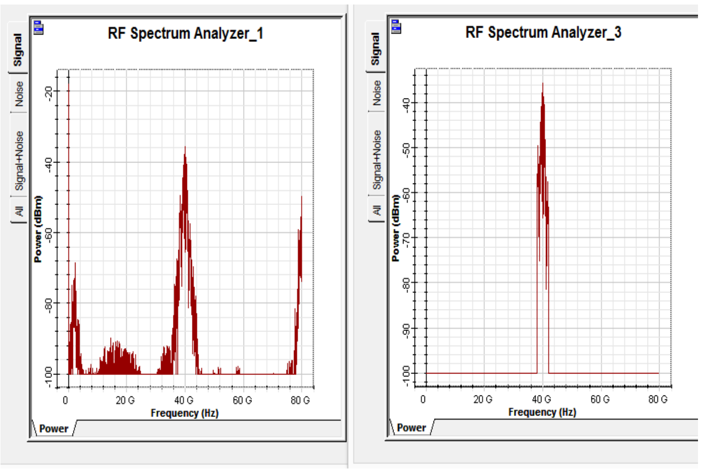

Fig 12: Receiver output

We have compared the performance of various optical transmitters and receivers and designed an optimized ROF transceiver. The gain at the output is observed. The receiver output exhibits a gain of -38dB in Figure12. It is evident that ROF technology can be used to replace complex systems using radio frequency operations.

REFERENCES

[1] Ogawa, Hiroyo, et al. "Recent standardization activities on radio over fiber technologies."Photonics (ICP), 2014 IEEE 5th International Conference on. IEEE, 2014.

[2] Joseph, Arun, and Shanthi Prince. "Performance analysis and optimization of radio over fiber link."Communications and Signal Processing (ICCSP), 2014 International Conference on. IEEE, 2014.

[3] Zin, A. M., et al. "An overview of radio-over-fiber network technology."Photonics (ICP), 2010 International Conference on. IEEE, 2010.

[4] Xu, Mu, et al. "Key Technologies for Next-Generation Digital RoF MobileFronthaulwith Statistical Data Compression and Multiband Modulation." Journal of Lightwave Technology35.17 (2017): 3671-3679.

[5] https://optiwave.com/category/products/system-and-amplifier-design/optisystem