# Design of four channel 40 Gbps WDM Radio over fiber optical system

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**Abstract:** Radio over fiber system transmits radio signals over an optical fiber cable. Radio over fiber(RoF) systems eliminates the need for using coaxial cables or any other traditionally used radio frequency(RF) transmission methods for the transmission of RF signal. RoF system takes the advantages of an optical system and applies it to RF transmission. Merits of RoF system includes longer transmission distances with minimal attenuation, high bandwidth capacity among others. In this work, a Radio over fiber system is designed for 60 GHz radio frequency signal with a four-channel wavelength division multiplexed system using optical amplifier along the transmission path. The results are analysed in Opti system software. Different parameters such as bit error rate, Optical SNR, signal power are studied by varying the distance for the RoF optical system.

**Keywords-** Bit error rate (BER), Eye diagram, Radio over fiber (RoF) systems, Signal to noise ratio (SNR), Wavelength Division Multiplexing (WDM).

## 1. Introduction

Optical Fiber Communication is the method of transmitting signal where signal is transmitted in the form of light and optical fiber cable is used as a medium for transmitting the light signal from one place to another. In an Optical fiber communication process an electrical signal is first converted in the form of light and then transmitted through the optical fiber cable and at the receiver the received optical signal is converted back to electrical signal.

One of the emerging applications of optical fibers is transmitting radio signal over optical fibers called as Radio over Fiber (RoF) communication system. In radio over fiber, technique a radio signal is modulated using an optical signal and transmitted through an optical fiber cable [1]. RoF signal has many advantages over conventional radio transmission like low losses over large distances, high bandwidth and less interference compared to electrical signal [1].

Radio over fiber find major applications in cable television and mobile radio signal transmission [1][2]. RoF systems can be utilized to expand network capacity and at the same time improve cost effectiveness of present-day cellular system [2][3]. Radio over Fiber (RoF) is structured into two main components: the Central Station (CS) and the Base Station (BS). In this network, the Central Station connects to multiple Base Stations. The CS serves as the control hub, responsible for key functions such as frequency allocation, modulation, and demodulation. This setup allows for efficient management of communication signals across the network [3][4][5][6].

The RoF system with its great advantages also suffers from serious drawbacks as the system requires advanced high-speed optical components and the intricate methods are required for radio wave generation. Furthermore, chromatic dispersion can become problematic in the fiber network, even over short distances [7].

## 2. System description

A multi-channel RoF optical communication system is realized in Opti system software. The transmitter section, receiver section and channel are described below.

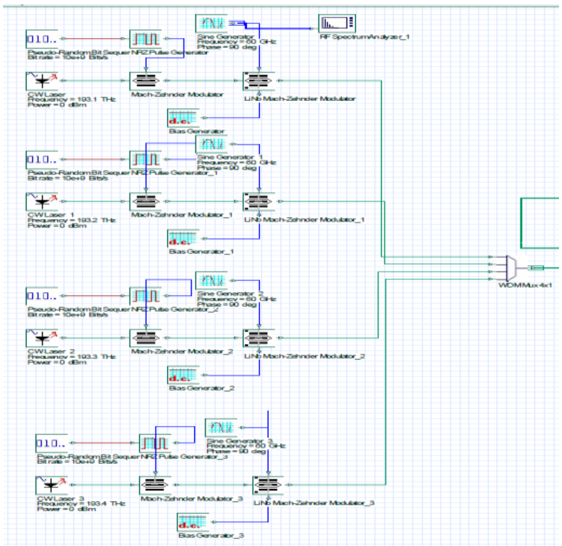

**Figure 1:** Transmitter section

The figure 1 shows the transmitter section. It consists of four channels. Each channel consists of a 10Gbps Pseudo Random bit generator to generate the input bit sequence. The output of pseudo random bit generator is fed to the NRZ pulse generator which encodes the input bit sequence in non-return to zero format. After this with the help of an MZ modulator a CW laser is used to modulate the NRZ signal obtained. The output of MZ modulator is again modulated with the help of LiNb MZ modulator to modulate 60 GHz radio signal. The output of LiNb MZ modulator of all four channel is fed to a 4x1 WDM multiplexer. Finally, the output of WDM multiplexer is passed through the optical fiber.

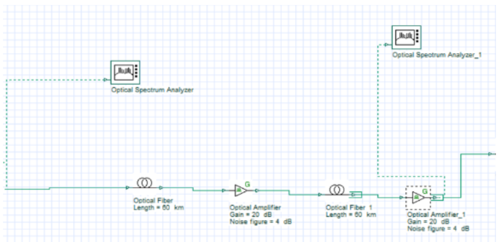

**Figure 2:** Channel

Figure 2 shows the channel of the optical communication system. From the transmitter section the output of WDM multiplexer is fed to an optical fiber which acts as channel for transmission of the optical signal. It consists of optical fiber of varying length such as 50Km, 80Km, 100Km and 120Km. In between a number of optical amplifiers are used to restore the original signal strength lost due to impairments in the channel.

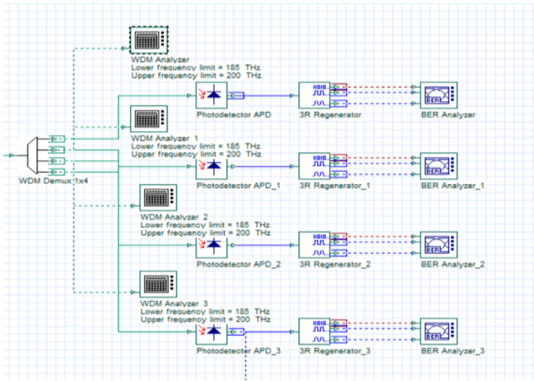

**Figure 3:** Receiver section

Figure 3 shows the receiver section. At the receiver a 1x4 WDM demux is used to demultiplex the multiplexed signal received at the receiver. After this an avalanche photodiode is used in all four channels to detect the optical signal and convert the optical signal into an electrical signal and finally recover the original input signal. Further, a BER analyser is used to analyse the received signal.

## 3. Results and discussion

Here, the output of BER analyser and spectrum analyser are analysed. It can be seen from table 1 that signal power, and SNR varies as distance between the transmitter and receiver is increased. As the distance increases, both the signal power and SNR reduces symbolizing the deterioration in signal.

| Fiber Length | Channel | Received power (dBm) | Signal to Noise ratio(SNR) (in dBm) |
|---|---|---|---|
| 50Km | 193.1 THz | 11.82 | 32.49 |
| | 193.2 THz | 11.87 | 32.54 |
| | 193.3 THz | 11.90 | 31.18 |
| | 193.4 THz | 11.93 | 31.58 |
| 80Km | 193.1 THz | 5.81 | 29.35 |

| | | | |
|---|---|---|---|
| | 193.2 THz | 5.87 | 29.41 |
| | 193.3 THz | 5.91 | 28.06 |
| | 193.4 THz | 5.93 | 28.45 |
| 100Km | 193.1 THz | 1.81 | 27.21 |
| | 193.2 THz | 1.87 | 27.26 |
| | 193.3 THz | 1.90 | 25.91 |
| | 193.4 THz | 1.93 | 26.30 |
| 120Km | 193.1 THz | -2.18 | 24.98 |
| | 193.2 THz | -2.13 | 25.03 |
| | 193.3 THz | -2.09 | 23.68 |
| | 193.4 THz | -2.07 | 24.07 |
| | | | |

**Table 1** Comparison of SNR and received power v/s distance

The eye diagram of the system can be shown in figure 4 for 50Km between transmitter and receiver for all 4 channels.

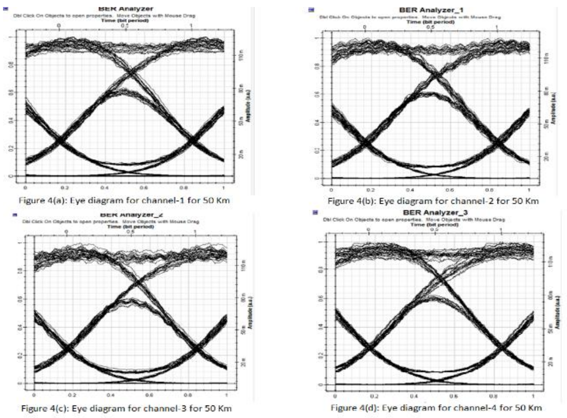

Figure 4(a): Eye diagram for channel-1 for 50 Km
Figure 4(b): Eye diagram for channel-2 for 50 Km
Figure 4(c): Eye diagram for channel-3 for 50 Km
Figure 4(d): Eye diagram for channel-4 for 50 Km

**Figure 4:** Eye diagram for 50 Km

The eye diagram for distance of 120km between transmitter and receiver for all four channels is shown in figure 5.

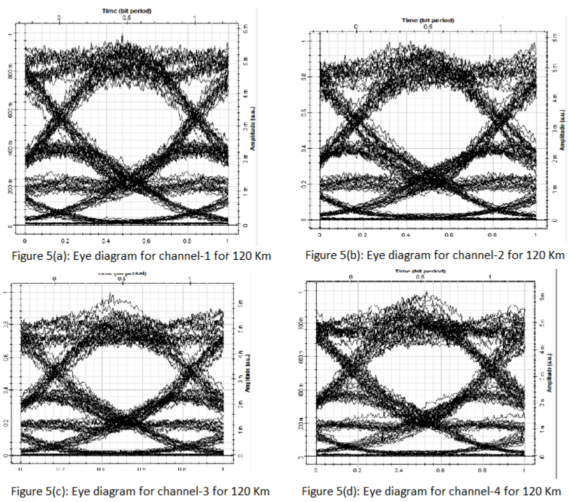

Figure 5(a): Eye diagram for channel-1 for 120 Km
Figure 5(b): Eye diagram for channel-2 for 120 Km
Figure 5(c): Eye diagram for channel-3 for 120 Km
Figure 5(d): Eye diagram for channel-4 for 120 Km

**Figure 5:** Eye diagram for 120 Km

## 4. Conclusion

In this paper, a high-speed Radio over fiber system is studied for varying optical fiber length of 50Km, 80Km, 100Km and 120Km. The signal strength and optical SNR at 50 Km is found as 11.82 dBm and 32.49 dBm for channel 1, the signal strength and optical SNR is found as 11.87 and 32.54 dBm for channel 2, the signal strength and optical SNR for channel 3 is found as 11.90 dBm and 31.18 dBm, the signal strength and optical SNR for channel 4 is found as 11.93 dBm and 31.58 dBm. As distance is widened between the transmitter and receiver the signal strength worsens, and eye diagram also deteriorates. This deterioration of signal as it travels through the channel is caused by loss of signal power because of attenuation and other phenomenon such as dispersion of light pulse.

## 5. References


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