

# Comparative performance analysis of Different optical Modulators in Communication Systems

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**Abstract-** In this paper a comparative performance analysis of different optical modulators is presented. An optical signal of 1550 nm has been transmitted over the range of 50 to 90 km. Simulation results reveal that Mach Zehnder Modulator (MZM) provides better quality transmission over the range of 80 km, outperforming the Optical Phase Modulator (OPM) & Directly Modulated (DM) Laser.

**Keywords:** Mach Zehnder Modulator, Optical Phase Modulator, Bit Error Rate.

## I. INTRODUCTION

The world has shrunk in the past few decades due to revolution in telecommunication system and technologies. Earlier voice was the prime information to be transmitted; now a days voice as well as data are transmitted in a large volume across the globe. To cater the increasing demand of ultra fast broadband service, large bandwidth is required. The optical fiber has got the best bandwidth in the business[G Keiser 2008]. An optical modulator is a device which modulates amplitude or phase or polarization of a beam of light. The beam may be transmitted through free space, or propagated through optical fibre.

Direct modulation[Varghese Thomas etal. 2015] is the easiest way to perform modulation of intensity of a light beam, current driving the light source, e.g. a laser diode is modulated. Due to high bandwidth "chirping" effect, direct modulation is avoided. External modulation techniques[Varghese Thomas etal. 2015] are extensively used for transmission of optical signal. External modulators may modulate both the intensity and the angle, i.e. phase or frequency, of the optical carrier. The commonly used external intensity modulators are Mach Zehnder Modulator (MZM), Electro absorption modulator (EAM) and Optical Phase Modulator (OPM). MZM [Ed L. Wooten etal. 2000] has been popular among the because of its highly improved performance and easy implementation. The input waveguide in MZM is split up into two waveguide interferometer arms. When a voltage is applied across one of the arms, a phase shift is induced in response through that arm. When the two arms

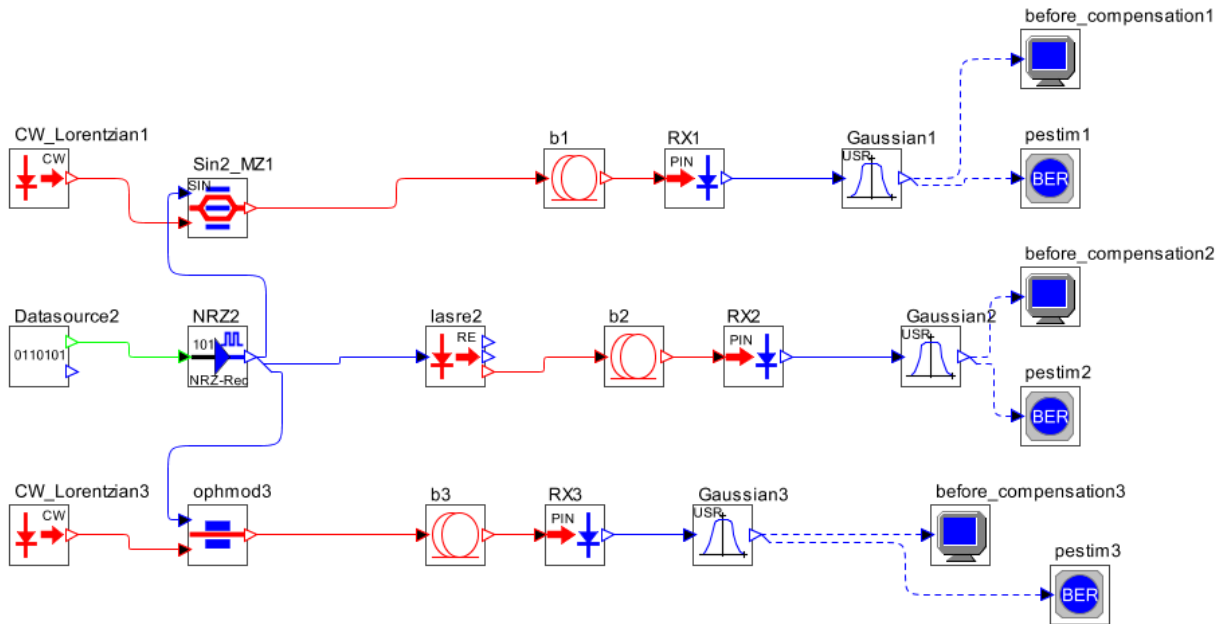
are recombined, the phase difference between the two waves is converted to an amplitude modulation.

A phase modulator is an optical modulator that modulates the optical phase of a laser beam. Optical Phase Modulator has found important applications because of its advantages over MZM. It is different from MZM in a way that OPM signal would generate a phase modulated signal that has a constant envelope which can not be directly detected by a photo detector. So the same has to be converted into intensity modulated signal. It also eliminates the bias drifting problems existing in a MZM [M. J. LaGasse 1997].

An optical signal at 1550 nm wavelength has been transmitted over the fiber in a range of 50 to 90 km. Direct modulation and external modulation using MZM and OPM have been employed before transmitting the signal so as to observe the effects of modulation techniques on the quality of signal received at other end of fiber.

## II. SIMULATION SET UP

Data source generates binary signal which is streamlined through NRZ modulation [M.I.Hayee and A.E.Willner 1999] and converted to corresponding electrical signal. CW laser generates 1550 nm light signal which is fed to MZM and OPM modulators to produce modulated signal. Three identical channels are utilized, comprising of optical fiber and pin receiver and Gaussian filter. Finally BER tester and electrical scope is used to observe the output. Parameters for optical fiber, detector and filter are kept same. All lasers operate on same wavelength so that output may be compared rationally. Bit rate of data source is kept at 10 Gbps. The light signal has been generated at a power of 1mW. PIN photodiode with quantum efficiency of 0.8 and dark current of 0.1 nA has been utilized. Optical power meter is used before optical detector to measure FWM optical power. BER meter is used at the detector output to observe BER. Electrical scope is used to observe eye diagram of the detected signal.



### III. RESULT DISCUSSION

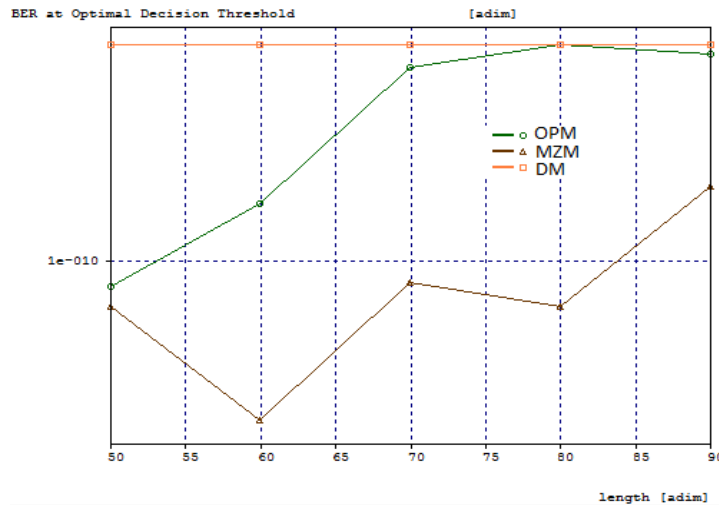


Fig. 1: BER vs. distance for MZM, OPM & DM based signals.

Table. 1 : BER performance of optical modulators at different length of fiber.

Optical fiber Length (In k.m)	BER		
	DM	MZM	OPM
50	$2.2 \times 10^{-2}$	$9.6 \times 10^{-13}$	$9.2 \times 10^{-12}$
60	$2.2 \times 10^{-2}$	$8.6 \times 10^{-17}$	$2.1 \times 10^{-8}$
70	$2.2 \times 10^{-2}$	$3.4 \times 10^{-12}$	$3.1 \times 10^{-3}$
80	$2.2 \times 10^{-2}$	$9.6 \times 10^{-13}$	$2.2 \times 10^{-2}$
90	$2.2 \times 10^{-2}$	$1 \times 10^{-7}$	$9.3 \times 10^{-3}$

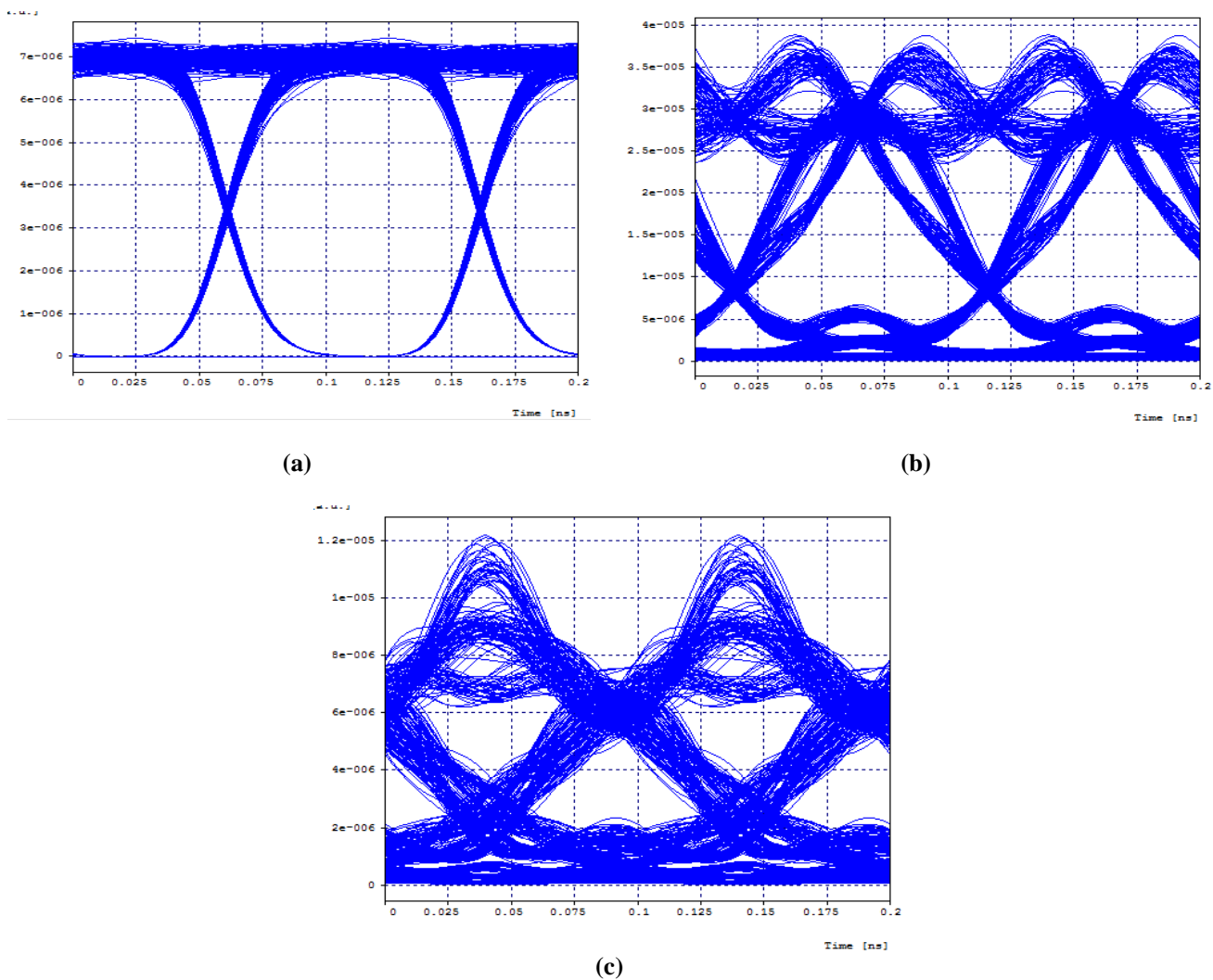


Fig. 2: Eye Diagrams at a distance of 50 km for (a) MZM (b) OPM (c) DM based signals

Figure 1 shows BER performance of modulators for different length of fiber while table 1 shows exact numerical values for the same. A very good bit error rate (BER) performance is observed in the range of 50 -85 k.m for MZM. OPM has satisfactory BER at a distance range 50-55 k.m and beyond that performance degrades. Figure 2 shows eye diagram at fiber length of 50 k.m for modulators. More open is eye, better is performance. MZM results are better as compared to OPM and DM.

**Conclusion:** An investigation of performance of MZM, OPM & DM has been reported in this paper. It is concluded that

acceptable bit error rate is achieved at a distance range of 50-85 km & 50-55 km for MZM & OPM based signals respectively. On the other hand DM based signal does not yield a good output compared to rest of the modulators. Besides it, eye diagrams also reveal that MZM mitigates impairments better than other modulator method. Further the performance may be improved by incorporating various dispersion compensation methods.

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