PERFORMANCE COMPARISON OF GRADED INDEX OPTICAL FIBER USING DIFFERENT MODULATOR

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ABSTRACT

Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communication. The use and demand for optical fiber has grown tremendously and optical-fiber applications are numerous. The Graded Index optical fiber contains a core in which the refractive index diminishes gradually from the center axis out toward the cladding. The higher refractive index at the center makes the light rays moving down the axis advance more slowly than those near the cladding. In this paper Q factor of graded index fiber is calculated and the performance study is conducted with different modulator that is with MZ modulator and AM modulator. The result reveals the ability of graded index fiber is better by using MZ modulator.

***Keywords**-Multimode fiber, Graded index fiber, Intermodal dispersion, Q factor.*

I. INTRODUCTION

The per-channel light signals propagating in the fiber have been modulated at rates as high as 111 Gigabit per second(Gbit/s) by NTTT. The first type of polymer optical fiber(POF) is crofon was introduced in 1966.For high performance multimode polymer optical waveguide is used. Polymer optical fiber has same structure as silica optical fiber. For the fabrication of POF one type of optical polymer called polymethyl-methacrylate (PMMA) is used. The main characteristic of optical fiber is bandwidth and it is limited by signal dispersion. The signal dispersion determines the number of bits of information transmitted in given period of time. The intermodal dispersion is one of the dispersive properties of the fiber. In this light through optical fiber takes one or more path hence distance may vary from one path to another.

Fiber with large core diameter (greater than 10 micrometers) may be analyzed by geometrical optics. Such fiber is called *multi-mode fiber*, from the electromagnetic analysis . In a step-index multi-mode fiber, rays of light are guided along the fiber core by total internal reflection. Rays that meet the core-cladding boundary at a high angle (measured relative to a line normal to the boundary), greater than the critical angle for this boundary, are completely reflected. The critical angle (minimum angle for total internal reflection) is determined by the difference in index of refraction between the core and cladding materials. Rays that meet the boundary at a low angle are refracted from the core into the cladding, and do not convey light and hence information along the fiber. The critical angle determines the acceptance angle of the fiber, often reported as a numerical aperture. A high numerical aperture allows light to propagate down the fiber in rays both close to the axis and at various angles, allowing efficient coupling of light into the fiber. However, this high numerical aperture increases the amount of dispersion as rays at different angles have different path lengths and therefore take different times to traverse the fiber. This paper undergoes Q factor calculation of graded index fiber when light pass through different modulation format. The system transmits data to 4km with power 10dbm. It was shown that the spectrum began to be shaped by eye diagram Analyzer, was used for the performance analysis. Optisystem13 software has been used for this simulation.

II. BACKGROUND THEORY

Optical communication system using Plastic Optical Fibers(POF) have not reached their potential for a number of reasons, the rapid growth of glass optical fiber technology and because plastic optical fibers have low speed, short distance applications. Graded index plastic optical fiber is in great demand in customer premises to deliver high-speed services due to its high bandwidth, single-mode POF, optical amplification in plastic fibers, there are new POF materials with low loss and higher power and faster sources have been developed. The material most frequently used for the fabrication of POF is the thermoplastics PMMA (Polymethylmethacrylate). PMMA-SI-POF has a theoretical minimum attenuation of 106dB/km at 650nm.

The bond structure of PMMA is shown

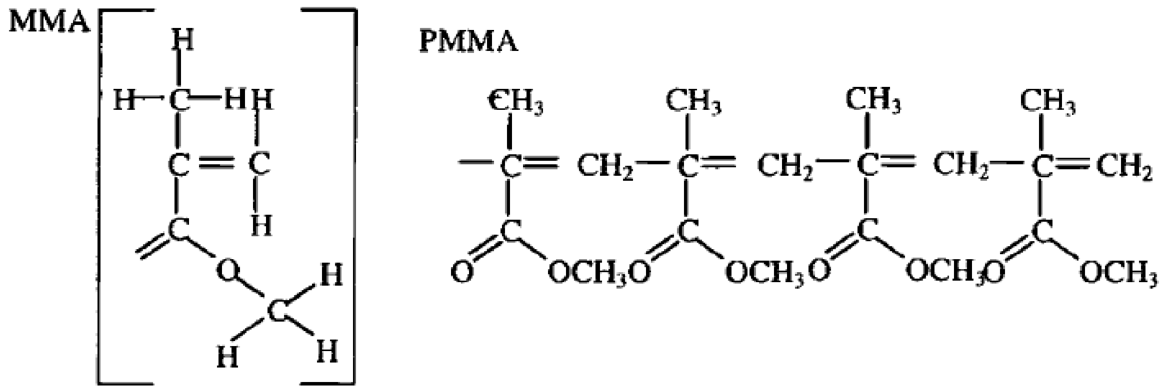

Fig.1 PMMA Bond Structure

2.1 Graded Index Fiber

The refractive Index profile describes the relation between the indices of the core and cladding. Two main relationships exist:

(I) Step Index

(II) Graded Index

The step index fiber has a core with uniform index throughout. The profile shows a sharp step at the junction of the core and cladding. In contrast, the graded index has a non-uniform core. The Index is highest at the center and gradually decreases until it matches with that of the cladding. There is no sharp break in indices between the core and the cladding.

By this classification there are three types of fibers :

(I) Multimode Step Index fiber (Step Index fiber)

(II) Multimode graded Index fiber (Graded Index fiber)

(III) Single- Mode Step Index fiber (Single Mode Fiber)

2.1.1 .Step-Index Multimode Fiber

Step Index Fiber has a large core, up to 100 microns in diameter. As a result, some of the light rays that make up the digital pulse may travel a direct route, whereas others zigzag as they bounce off the cladding. These alternative pathways cause the different groupings of light rays, referred to as modes, to arrive separately at a receiving point. The pulse, an aggregate of different modes, begins to spread out, losing its well-defined shape. The need to leave spacing between pulses to prevent overlapping limits bandwidth that is, the amount of information that can be sent. Consequently, this type of fiber is best suited for transmission over short distances, in an endoscope, for instance

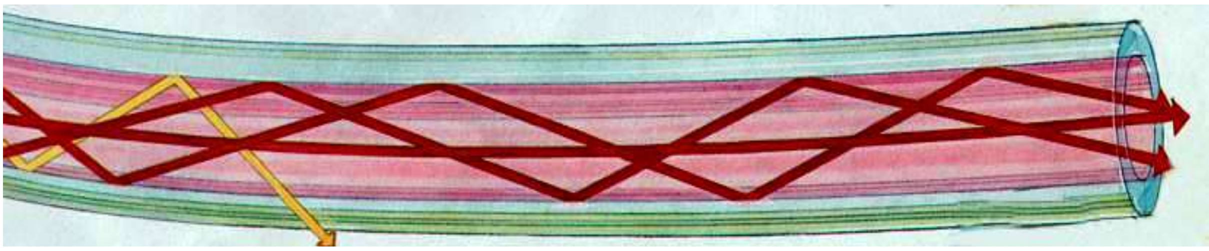

Fig.2. Step Index Fiber

2.1.2.Graded-Index Multimode Fiber

It contains a core in which the refractive index diminishes gradually from the center axis out toward the cladding. The higher refractive index at the center makes the light rays moving down the axis advance more slowly than those near the cladding

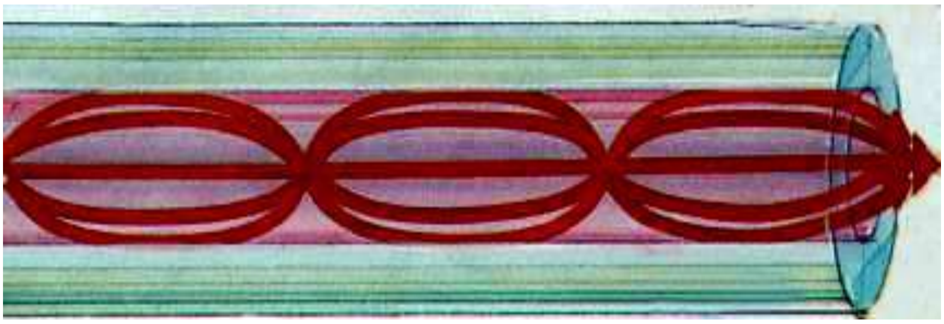

Fig.3.Graded Index Fiber

2.1.3. Single-Mode Fiber

It has a narrow core (eight microns or less), and the index of refraction between the core and the cladding changes less than it does for multimode fibers. Light thus travels parallel to the axis, creating little pulse dispersion. Telephone and cable television networks install millions of kilometers of this fiber every year.

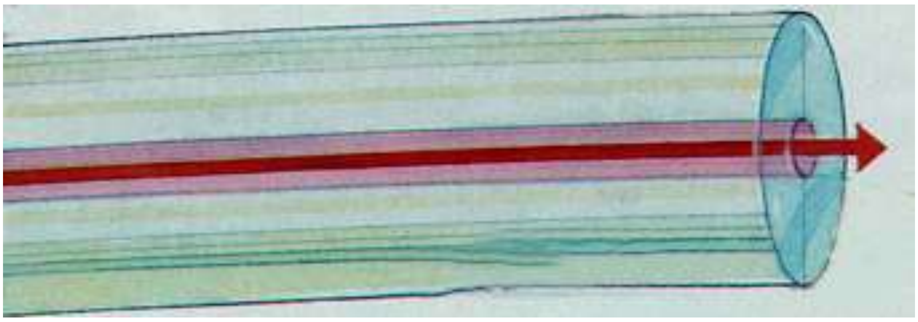

Fig.4.Single Mode Fiber

2.2. Dispersion

Dispersion is the spreading of light pulse as its travels down the length of an optical fibre as shown in figure. The varying delay in arrival time between different components of a signal "smears out" the signal in time. This causes energy overlapping and limits information capacity of the fiber.
Dispersion limits the bandwidth or information carrying capacity of a fibre. The bit-rates must be low enough to ensure that pulses are farther apart and therefore the greater dispersion can be tolerated.
Dispersion of optical energy within an optical fiber falls into following categories:

- **Intermodal Delay or Modal Delay**
- **Intramodal Dispersion or Chromatic Dispersion**
- **Material Dispersion**
- **Waveguide Dispersion and Polarization –Mode Dispersion**

2.2.1. Intermodal Delay/ Modal Delay

Intermodal distortion modal delay appears only in multimode fibers. This signal distortion mechanism is a result of each mode having a different value of the group velocity at a single frequency. The amount of spreading that occurs in a fiber is a function of the number of modes propagated by the fiber and length of the fiber Intermodal or modal dispersion causes the input light pulse to spread. The input light pulse is made up of a group of modes (MULTIMODE). As the modes propagate along the fiber, light energy distributed among the modes is delayed by different amounts. Modal dispersion occurs because each mode travels a different distance over the same time span The modes of a light pulse that enter the fiber at one time exit the fiber different times. This condition causes the light pulse to spread. As the length of the fiber increases, modal dispersion increases

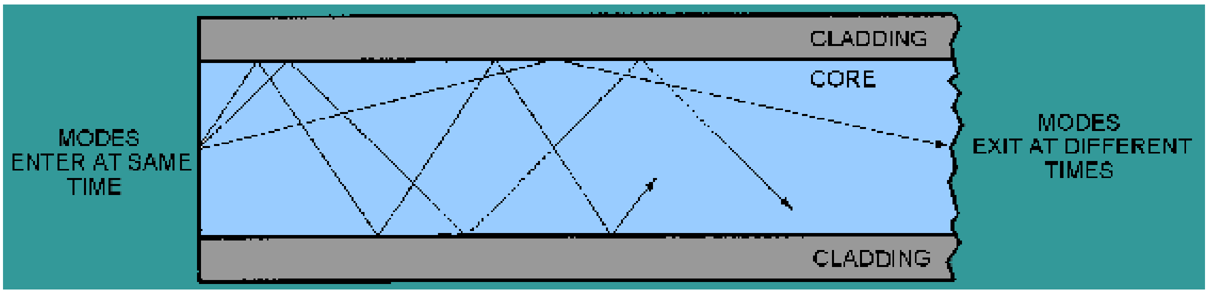

Fig.5.Intermodal Delay

2.2.2. Intramodal Dispesion

Pulse spreading that occurs within a single mode Intra-modal dispersion occurs because different colors of light travel through different materials and different waveguide structures at different speeds Also called GROUP VELOCITY DISPERSION (GVD). It can Occurs in all types of fibers Two main causes : *Material dispersion Waveguide dispersion*

A. Material Dispersion

Arises from variations of the refractive index of the core material as a function of wavelength Different wavelengths travel at different speeds in the fiber material and hence exit the fiber at different times

B.Waveguide Dispersion

Arises because a Single Mode Fiber confines only 80% of the optical power to the core The other 20% tends to travel through the cladding and hence travels faster This results in spreading of the light pulses .The amount of dispersion depends on the fiber design and the size of the fiber core relative to the wavelength of operation .In multimode fibers, waveguide dispersion and material dispersion are basically separate properties. Multimode waveguide dispersion is generally small compared to material dispersion and is usually neglected

III.SIMULATION SETUP

The optisystem software is very important will be used to model and simulate fiber optic system. The transmitted of optical system consist of Pseudo –Random Bit used to generate sequence random of bits (0 or 1)., NRZ pulse generator has an advantage on controlling bandwidth. This is due to the characteristic of the generator that the returning signals to zero between bits. Pseudo-random bit sequence generator is used to scramble data signal in terms of bit rates[16], Mach Zender- Modulator has two inputs and one output. Then the input signal is modulated with semiconductor laser that is represented by spatial Continuous Wave (CW) laser through Mach-Zehnder modulator. The spatial Continues laser diode (CW) to generate optical signals supplies input signal with 850 nm wavelength and input power variable from 0- 30dBm which is externally modulated. The pulses are launched into the fork 1xN which distributed power into three branch

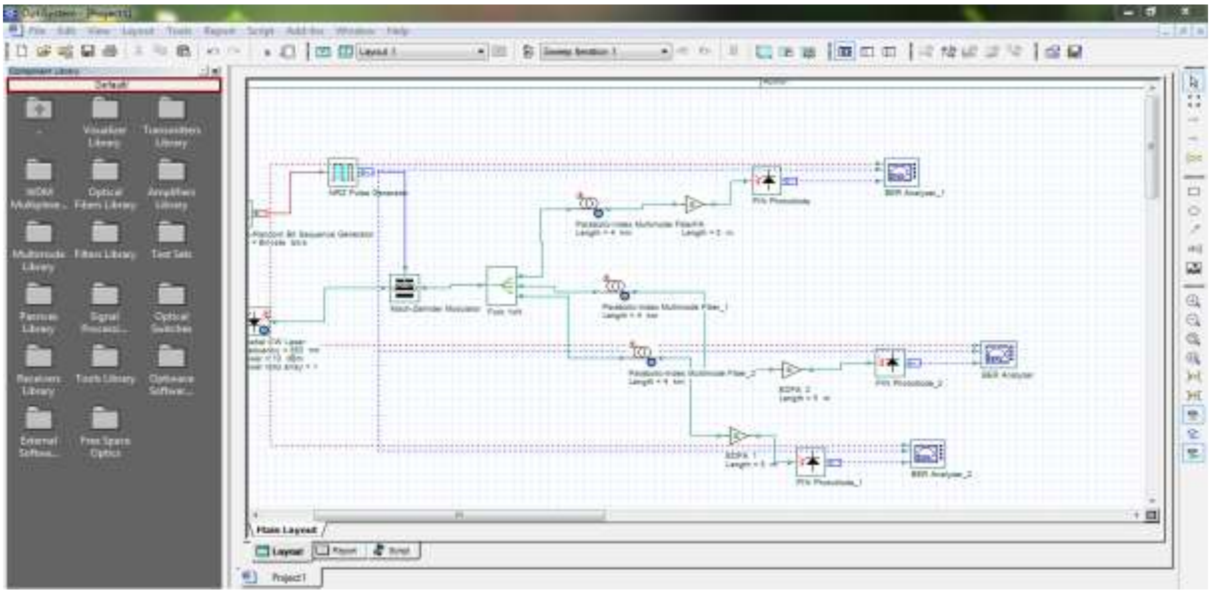

Fig.6. Simulation Set Up

In this circuit diagram instead of MZ modulator an AM modulator is inserted and analyze the performance.

IV.RESULTS

The eye diagrams and results of maximum Q. factor is shown in the figure.

Table 1

Modulator	Q Factor
MZ Modulator	39.0505
AM Modulator	10.8114

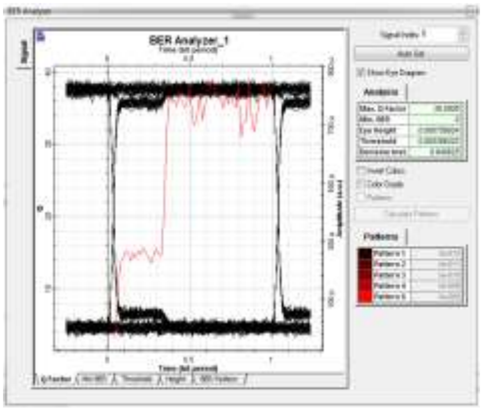

Fig.7. EYE Diagram for MZ Modulator

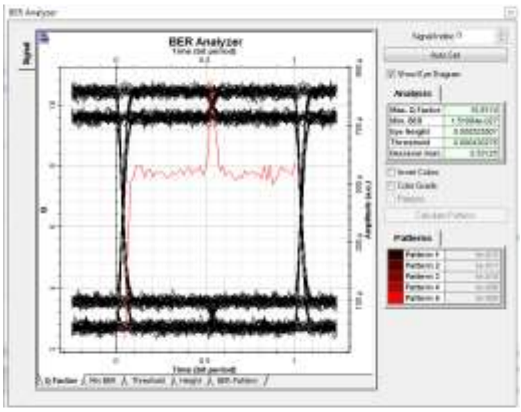

Fig.8. EYE Diagram for AM Modulator

V. CONCLUSION

In this paper, the design study to improve Q factor of transmission system. The results are valuable for improving system performance by using graded index multimode fiber. The Q factor is compared with different modulator. From the simulation results, concluded that Q factor is better for MZ modulator than AM modulator. For MZ modulator the Q factor is 39.0505 and Q factor for AM modulator is 10.8114.

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