Advances and Applications in Mathematical Sciences
Volume 18, Issue 9, July 2019, Pages 827-833

OVERVIEW OF OPTICAL FIBER

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Abstract

In present scenario a large number of data is transferred from one to another but behind this statement many things is work on or occur. Large number of data transferred required large bandwidth and high bit rates are used. So that's why prefer to optical fiber. Optical communication systems have the capability of conveying data at bit rates approx. 1 Tb/s.

1. Introduction

The optical fiber, transmission qualities is a noteworthy part in deciding the execution of the whole framework. For a good communication system three basic issues are most important factors (1) Bandwidth (BW) (2) Good signal to noise ratio (SNR) i.e. low loss. (3) Low Power Consumption Final diagram gives the mean levels corresponding to the bit-0 and bit-1 and to find the data quality. Fiber optics technology involves the emission, transmission and detection of light. Fundamental optical parameter of a material is the refractive index or index of refraction. Optical fiber preferred realizing short distance (a few meter to hundred of meter), high speed gigabits/sec. Generally electronic processor dissipates heat, if data rate is very high. So replaced in optical processor (Reversible gates are used).Another favourable position of each and every optical framework is that there won't be any need to change the electronics when data rate increases, since all signals processing and routing happens in the optical area [1]. For a high rate of data transfer, amount of energy lost is not negligible and there comes the concept of Reversible logic, another reason is lost of information for heat dissipation. R. Landauer (Landauer 1961) deduced that on losing an information bit during an irreversible logical

2010 Mathematics Subject Classification: 78A40. 78-00, 78AXX, 78A02, 78A05, 78A25, 81V80.
Keywords: polarization, characteristics of light, Optical fiber.
Received January 8, 2019; Accepted January 28, 2019

operation, system dissipates at least KTln2 Joules of heat energy. Where K is the Boltzmann's constant and T is the operating temperature [2].

2. Different Wavelength Window in Optical

Different materials, for example, germanium and phosphorus increment the refractive index of silica and are utilized as dopants for the core, while materials such as boron and fluorine which reduce the refractive index of silica, as dopant for cladding is used to. Most of the energy in the limited light towards the main part When light travels from one medium to another, it gets refracted. If we achieve higher data rate then to select a appropriate width of spectral. Shorter width pulse that means data rate is higher. Semiconductor laser pulses width is less as compare to LED about 100 times. As a result, laser-based communication can support very high data rates. Main principle behind optical fiber communication is that Snell's law. In any type of communication, less distortion wavelength range is required. Optical field ranges are 800 nm bands called "first window". The 1300 nm band, called "second window". 1550 nm (and signal Overview Of Optical Fiber bandwidth is approximately 0.1 nm, which means that the optical system is not very wide band system, partial bandwidth << 1), which is called "third window" due to the development of the erbium doped fiber amplifier (EDFA) is. EDFA can build the light in a limited band around just 1550 nm. Apart from this; there is an internal loss of approximately 0.2 dB/km internally in this window. LED is an example of optical source, there is an internal spectral width of 0.03μm-0.06μm (approximately 4THz to 8THz), and in the source of the laser diode the spectral width of 2-3 nm (approximately 0.25THz to 0.4 THz).

2.1. Amplifier

Based on the availability of amplifiers, the low-loss band at 1.55 microns is divided into three areas. The mid band from 1.53μm to 1.565μm is the traditional or C-band, where WDM systems operate using traditional erbium-doped fiber amplifiers. From 1.565 to 1.625μm the band, which is long wavelength than the C-band, is called the L-band and is being used today in the high-capacity WDM system, for the development of profit-shifted erbium-doped amplifiers Along with the amplification in this band. The band below 1.530μm, with wavelengths compared to the C-band, is called the S-band.

Fiber Raman amplifier provides amplification in this band. Decade of 1970s, non-liner effects such as excitement Raman and Brailoin scattering (SRS, SBS), Sullinan possibilities such as pulses etc. Recognizing the importance of fiber [3, 4]. Frequency bandwidth is related to wavelength bandwidth

$$\Delta f = \frac{C}{n\lambda^2} \Delta\lambda.$$

3. Characteristics of Light

Studying the characteristics of light plays an important role in optical. Many parameters are included-

1. Intensity (solid angle per unit)

2. Different Frequencies (color)

3. Spectral width (purity of color)

4. Most important parameter is geometrical orientation of the wave's i.e, polarization-linear, circular, and elliptical.

Fourth point describing the vector nature of light, the first three parameters of scalar characteristics, describe the vector nature of light and this is a very important parameter. Actually, the light is an electromagnetic wave and it has wave fronts, they are mainly seen in spherical and plane wave fronts. Two models of ray models and wave models are used but the reray model do not fulfill all the requirements. The ray model does not precisely anticipate that there will be a few areas in cladding even after total internal reflection. Aside from this, it doesn't predict that rays can be propelled just in particular angles in optical fibers. For accurate and finish portrayal of light dispersion inner an optical fiber, very important inflexible model, which is called wave model. The protection layer i.e, cladding does not significantly affect the circulation. Wave function $\Psi(x, t) = A \exp(\alpha t - \beta x)$. Where A wave is the amplitude, α wave is the angular frequency of rad/s, β phase constant rad/m, x is distance and t is time. The promotion of ultra short pulses in fiber can make Maxwell's equations; gradually for different envelope estimates, and for more than 5 picoseconds pulses, these equations can be rearranged to obtain the following Nonlinear Schrodinger Equation

(NSE) [5]. solve the Maxwell equation from different boundary condition to get more accurate result to wave fronts.

Maxwell's equation for source-free medium (i.e., the charging density and current density in the medium is zero): Maxwell equation divides three separate parts i.e., (a) Integral form with no magnetic media-Differential Overview of Optical Fiber form. (b) Wave Equation-Charge Conservation (c) Gauss' Law Electric-Gauss' Law Magnetic- Faraday's Law-Ampere's Law.

3.1. Modal Analysis

A. They are main attentive is velocity of various modes because that they help to which amount of pulse are stretching, i.e., to get the amount of dispersion.

B. The phase and group velocities of a mode are given as, Phase Velocity $= \omega/\beta$ and Group Velocity $= d\omega/d\beta$.

C. Variation of β as a function of frequency is the primary result of model analysis.

V-number is called normalized frequency. For the guided mode, the propagation constant between two limits β_1 and β_2. If $\beta_1 \leq \beta \leq \beta_2$ (β range can vary in wide range depending on refractive index and wavelength), then a field distribution occurs in which the core has aoscil latory behavior and cladding has a decay behavior. Then the energy is propagated with no fiber loss. Each mode has different electric and magnetic field patterns. model fields can be TE, TM or hybrid. The B-V diagram is a universal plot for a step index fiber. Usually the cut off wavelength is 30-40 nm less, which is the operating wavelength. (NA) is a powerful method to dispatch an optical fiber efficiently. Take an optical fiber and place it before the optical source, at that point how much light is gathered by the fiber from the source. So, for all practical fibers,

$$n_1 - n_2 \sim \frac{10^{-2} - 10^{-3}}{n_1}.$$

Refractive index of cladding varies only 0.1 to 1% compared to the core.

4. Loss in Optical Fiber

A more influential parameter is the information rate which the fiber can deal with since the main role here is to send data starting with one point then onto the next i.e., the dispersion (pulse widening) must be little since the information rate is inversely relative to the pulse expanding. For rapid correspondence the pulse broadening and subsequently the dispersion ought to be insignificant. The pulse broadening due to chromatic dispersion is proportional to the spectral width. In optical signal are attenuates or detoriate due to following mechanisms: (1) Due to fiber material. (Obtained by the manufacturer) (2) Inside the fiber due to micro irregularities. (3) Micro-bending losses (4) radiation losses. The two main loss mechanisms in an optical fiber are (I) material absorption and (II) Rayleigh scattering. Dispersion are two types Intra-Model dispersion and inter modal Dispersion. Intra model dispersion further divided into two types Material dispersion and waveguide dispersion.

4.1. Intra Model Dispersion

4.1.1. Material dispersion

Material refractive index changes with wavelength and along these lines causes the change group velocity. The propagation constant of light is

$$\beta = \frac{n_1(\lambda)}{C}. \tag{a}$$

Substitute the value of β in equation a, we get material dispersion

$$D_{mat} = \frac{-\lambda d^2 n}{C d\lambda^2}.$$

This dispersion is proportional to second derivative of the refractive index with respect to the wavelength. Second derivative denotes the curvature of the function, Curvature is a concept of different areas of geometry, they represent a plane, curve, straight. Glass refractive described by Sellmeier relation.

$$n_1(\lambda) = n_1 + \sum \frac{Si\lambda_i}{i\lambda_i}$$

Where Siand λ_i are material dependent constants. This dispersion is 0 at

1270.0nm.

4.1.2. Waveguide Dispersion

This is chromatic dispersion which emerges from waveguide impacts. For examining waveguide dispersion, we require $\beta - \omega$ relation.

$$V\text{-Number of an } V = \frac{\omega a}{C}\sqrt{n_1^2 - n_2{}^2} = \frac{2\prod a}{\lambda}(NA).$$

The V-number in this way is likewise assign to as the Normalized frequency. The propagation constant β has bound, $B_2 < \beta < \beta_1$

$\beta_1 = \omega n1/c$ is the propagation constant in medium having refractive index n_1.

$\beta_2 = \omega n_2/c$ is the propagation constant in medium having refractive index n_2.

$$D_{wg} = -\frac{n_2 \Delta}{C\lambda} V \frac{d^2(bV)}{dV^2}.$$

$$\text{We Calculate } Vd^2\frac{(bV)}{dV^2}.$$

The $Vd^2 \dfrac{(bV)}{dV^2}$ max. value $V = 1.20$ for the lowest order LP01 mode Consequently, in the single mode optical fiber the dispersion is most extreme around $V = 1.20$. The single mode optical fibers in this manner have V-number near yet under 2.40 so that they have most minimal conceivable waveguide dispersion. Subsequently total dispersion in a single mode fiber is 0 at 1.310µm.

4.2. Inter-modal Dispersion

Present in just multimode optical fiber. This dispersion is because of change in velocity from one mode to other. This dispersion takes place in a multi-mode fiber. The unit of this modal is ps/Km.

$$D_{\text{int}} \sim \frac{n_1(NA)}{n_2 C}.$$

The magnitude of this modal is much larger compared to the chromatic is persion.

5. Future to Optical

5.1. Reversible Gates

In these types of gate reduce to losses because every one bit of information is important, which is sent to maximum bits of information in one place to another place. Lost of one-bit information according to R. Landauer (Landauer 1961) system dissipates at least KTln2 Joules of heat energy.

5.2. Networks in Optical Communication

In such a network, all the signals will be processed in optical domains, without any kind of electrical manipulation. Another favourable position of every single optical system is that there will be no compelling reason to change the hardware when the information rate increments, as the entire signal processing and routing occur in optical domains [6].

References

[1] Colin Yao, The Future of Fiber Optic Communication, available at: www.streetdirectory.com, 2013.

[2] Vanya Arun, Ashutosh Kr. Singh, N. K. Shukla and D. K.Tripathi, Design and performance analysis of SOA-MZI based reversible toffoli and irreversible and logic gates in a single photonic circuit, Received: 29 March 2016 / Accepted: 23 August 2016 Springer Science+Business Media New York 2016.

[3] A. Hasegawa and F. Tappert, Transmission of stationary nonlinear optical pulses in dispersive dielectric fibers. I. Anomalous dispersion, Appl. Phys. LETT, 23(3) (1973), 142-144.

[4] L. F. Mollenauer, R. H. Stolen and J. P. Gordon, Experimental observation of picoseconds pulsenarro wing and solitons in optical fibers, Phys. Rev. Lett, 45 (1980), 1095-1098.

[5] G. P. Agrawal, Nonlinear Fiber Optics. Academic Press (1989; 2nd ed., 1995; Chinease translation, 1992; Russian translation, 1996; Japanese translation, 1997.

[6] Colin Yao, The Future of Fiber Optic Communication, available at: www.streetdirectory.com, 2013.