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Polarization Mode Dispersion System LMS Algorithm Based on Feed-Forward Compensation System Balance

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***Abstract*— The waveguide is a structure that guides the waves, such as electromagnetic waves or sound waves. Each type has a different type of wave waveguide. The original and most common way is to carry a high-frequency radio waves, in particular microwaves hollow conductive metal tube. Waveguides have different geometries, can be restricted in one-dimensional energy, as in two dimensions in a slab waveguide or the fiber or channel waveguide. In addition, the needs of different waveguide to guide different frequencies: Fiber guiding light (high-frequency) will not be guided microwave (which has a much lower frequency). This research work comprises of the collaboration of Engineering and Medical Field via implementing waveguide with controlled output power to withstand tedious invasive surgeries.**

***Index Terms*—Optical FIBER, Optical Wave guide, Polarization Mode Dispersion, Feed Forward Compensations.**

I. INTRODUCTION

The waveguide is a structure that guides the waves, such as electromagnetic waves or sound waves [1]. Each type has a different type of wave waveguide. The original and most common way is to carry a high-frequency radio waves, in particular microwaves hollow conductive metal tube. Waveguides have different geometries; can be restricted in one-dimensional energy, as in two dimensions in a slab waveguide or the fiber or channel waveguide. In addition, different waveguide to guide different frequencies: the optical fiber guides the light (high-frequency) will not be guided microwave (which has a much lower frequency) [2]. The results of each group will now be described in general terms to solve the above-point input sequence of the same wavelength. This group consisted of various types of tube material, a metal layer, and a dielectric layer on its. Optional external jacket is to protect the environment from either carrier pipe perforation or improve flexibility. Sonic tension wire guided by the phenomenon has been known for a long time, as well as the sound through the hollow tube, such as a cave or a medical stethoscope. Other uses of the waveguide are between the elements of a system, such as a radio, radar or optical devices to transmit power. Guided wave detection (GWT), the basic principles of non-destructive evaluation of the many ways [3] one. Specific examples:

- Fiber optic transmission of optical signals, and for long distances and with high signal rate.

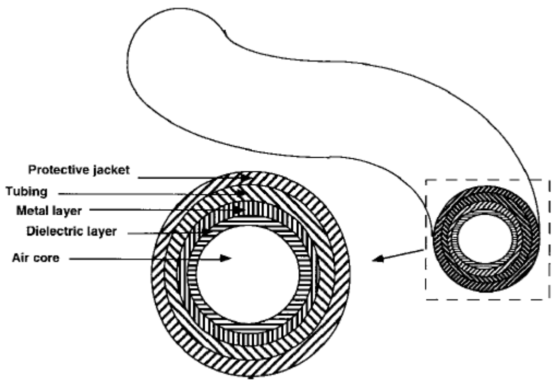


Figure 1 A schematic drawing of a waveguide showing all of its components

- From there wave formed in the microwave oven, the magnetron into the cooking chamber of the waveguide transmission power.
- In the radar, the waveguide transmitting radio frequency energy from the antenna, wherein the impedance matching needed for efficient power transmission (see below).
- a waveguide can be created called strip line on a printed circuit board, and is used to transmit microwave signals in a circuit board. This type of waveguide is very cheap manufacturing, and put into a printed circuit board having a small size.
- waveguides are used in scientific instruments to measure the elastic properties of light, sound and materials and objects. Waveguides can be placed in contact with the sample (such as in medical ultrasound), in this case, the test wave waveguide ensures power is conserved, or specimen, you can put the waveguide (as measured in the dielectric constant]) Thus, small objects can be tested and the accuracy is better.

II. BASICS OF FIBER PMD

A telecommunication signal propagates in an optical fiber in the form of a modulated beam or wave of light (see Figure 2). Light is a form of electro-magnetic radiation which is characterized by having a particular wavelength and frequency. The waveguides is defined as the distance between the points in the electromagnetic wave where the electric field has highest amplitude. The frequency is defined as the number of complete wavelength (or cycles) that traverse past a particular point in one second. The measure of frequency is Hertz (Hz), or cycles per second. The electromagnetic spectrum consists of many different spectral regions defined by respective waveguides; for example the visible light we are most accustomed to, ultra-violet light (UV) and the infra-red (IR) light is actually used to transmit signals in fiber optic communications. hi particular, IR waveguides in region of 1.55 microns or 1550 nanometers (nm) are used to transmit optical signals over long distances in long-haul optical telecommunications networks, because optical fiber exhibits the lowest attenuation at waveguides. All electromagnetic waves are characterized by polarization - the direction in which the electric field of the wave is oscillating. For example in electric field of light wave oscillates in the direction of X-axis so one would call such a wave, X-polarized. Clearly, electromagnetic waves could have two polarizations -along the X axis or along the Y axis, and if the electric field E is not aligned with either axis, the electromagnetic wave would contain body polarizations.

The speed at which a light wave travels through an optical medium (denoted as v) is dependent on the refractive index2 of the medium typically denoted as n. The higher the refractive index the slower the speed of light and vice versa i.e. **v=c/n** where c is a speed of light in vacuum ($c=3x10^8$ meters/second (m/s)).

1) A telecommunications signal is transported down an optical fiber in the form of a modulated beam or wave of optical light (optical carrier)

2) Light in an optical wave can have two polarizations

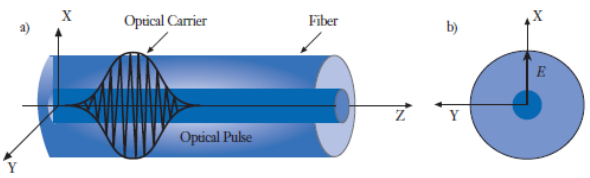


Figure 2 a) A telecommunications signal is transported down an optical fiber in the form of a modulated beam or wave of optical light (optical carrier) b) Light in an optical wave can have two polarizations i.e. two possible directions of electric field.

(a) Wavelength of the electromagnetic wave and

b) the wavelength spectrum of electromagnetic radiation (b).

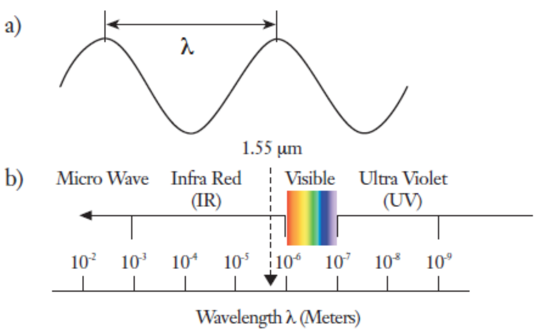
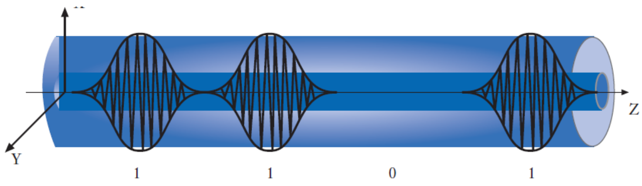


Figure 3 An optical wave which has been modulated to form the data code 1101. The diagram shows the optical carrier wavelengths encapsulated by the signal pulses. The wave is polarized along the X-axis.



digital optical communications signal consists of an optical wave which is modulated into a series of “ones” and “zeros” in order to define the coded data. An optical communications signal is illustrated in Figure 4, where you can see that a “one” is represented by a light pulse, whereas a “zero” is represented by a time period of no light transmitted.

III. PMD LMS BASED ON FEED-FORWARD COMPENSATION SYSTEM

Polarization mode dispersion (PMD) is a form of modal dispersion where two different polarizations of light in a waveguide, which normally travel at the same speed, travel at different speeds due to random imperfections and asymmetries, causing random spreading of optical pulses. Unless it is compensated, which is difficult, this ultimately limits the rate at which data can be transmitted over a fiber. In an ideal optical fiber, the core has a perfectly circular cross-section. In this case, the fundamental mode has two orthogonal polarizations (orientations of the electric field) that travel at the same speed. The signal that is transmitted over the fiber is randomly polarized, i.e. a random superposition of these two polarizations, but that would not matter in an ideal fiber because the two polarizations would propagate identically (are degenerate). In a realistic fiber, however, there are random imperfections that break the circular symmetry, causing the two polarizations to propagate with different speeds. In this case, the two polarization components of a signal will slowly separate, e.g. causing pulses to spread and overlap. Because the imperfections are random, the pulse spreading effects correspond to a random walk, and thus have a mean polarization-dependent time-differential $\Delta\tau$ (also called the differential group delay, or DGD) proportional to the square root of propagation distance L:$\Delta T = D_{PMD}\sqrt{L}$

D_{PMD} is the PMD parameter of the fiber, typically measured in ps/√km, a measure of the strength and frequency of the imperfections. The symmetry-breaking random imperfections fall into several categories [5]. First, there is geometric asymmetry, e.g. slightly elliptical cores. Second, there is stress-induced material birefringence, in which the refractive index itself depends on the polarization. Both of these effects can stem from either imperfection in manufacturing (which is never perfect or stress-free) or from thermal and mechanical stresses imposed on the fiber in the field — moreover, the latter stresses generally vary over time.

Simulation of DWDM Spectrum corresponding to wavelength and Attenuation

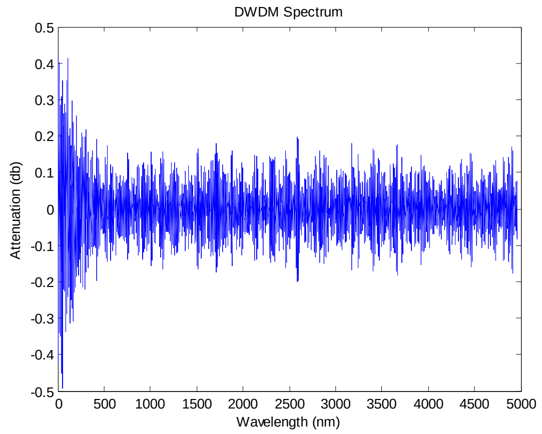


Figure 4 DWDM Spectrum corresponding to wavelength and Attenuation

Dense wavelength separation multiplexing (DWDM) mentions primarily to optical signals multiplexed inside the 1550 nm group so as to impact the skills (and cost) of erbium doped fiber amplifiers (EDFAs) [6][7], that are competent for wavelengths amid concerning 1525–1565 nm (C band), or 1570–1610 nm (L band). EDFAs were primarily industrialized to substitute SONET/SDH optical-electrical-optical (OEO) regenerators that they have made usefully obsolete [8]. EDFAs can amplify each optical gesture in their working scope, even though of the modulated bit rate. In words of multi-wavelength signals, so long as the EDFA has plenty impel power obtainable to it, it can amplify as countless optical signals as can be multiplexed into its amplification group (though gesture densities are manipulated by choice of modulation format).

IV. SIMULATION OF RESPONSE OF SINGLE VERSUS MULTI-WAVELENGTH THROUGH WAVE GUIDE

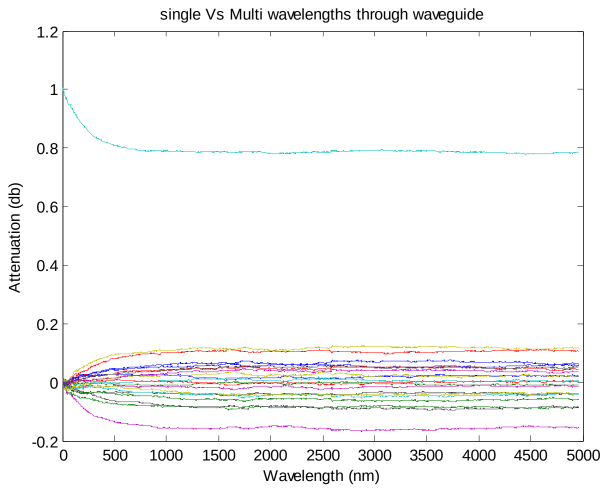


Figure 5 Response of single versus multi-wavelength through wave guide.

The main difference amid multi-mode and single-mode optical fiber is that the preceding has far larger core diameter, normally 50–100 micrometers; far larger than the wavelength of the light grasped in it. Because of the colossal core and additionally the potential of colossal numerical aperture, multi-mode fiber has higher "light-gathering" capacity than single-mode fiber. In useful words, the larger core size simplifies connections and additionally permits the use of lower-cost electronics such as light-emitting diodes (LEDs) and vertical-cavity surface-emitting lasers (VCSELs) that work at the 850 nm and 1300 nm wavelength (single-mode fibers utilized in telecommunications work at 1310 or 1550 nm and need extra luxurious laser sources [9].

Solitary mode fibers continue for nearly all visible wavelengths of light). Though, contrasted to single-mode fibers, the multi-mode fiber bandwidth–distance product check is lower. Because multi-mode fiber has a larger core-size than single-mode fiber, it supports extra than one propagation mode; hence it is manipulated by modal dispersion, as solitary mode is not. The LED light origins from time to time utilized alongside multi-mode fiber produce a scope of wavelengths and these every single propagate at disparate speeds. This chromatic dispersion is one more check to the functional length for multi-mode fiber optic cable. In difference, the lasers utilized to drive single-mode fibers produce consistent light of a solitary wavelength. Due to the modal dispersion, multi-mode fiber has higher pulse spreading rates than solitary mode fiber, manipulating multi-mode fiber's data transmission capacity. Here disparate colors of light embody disparate wavelengths of light and their corresponding attenuation.

Simulation of calculation of attenuation w.r.t Wave-guide without Di-Electric layer

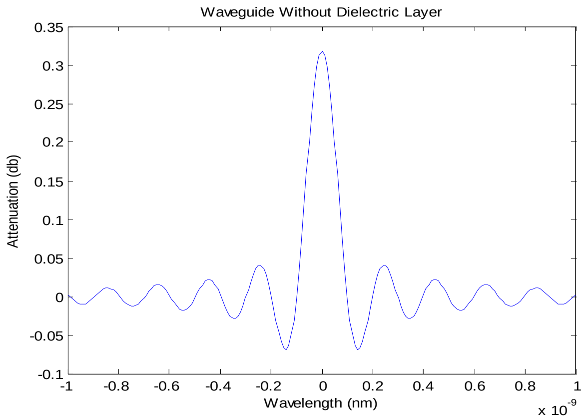


Figure 6 Simulation of calculation of dispersion w.r.t Wave-guide without Di-Electric layer

A dielectric waveguide employs a solid dielectric rod rather than a hollow pipe. An optical fiber is a dielectric guide designed to work at optical frequencies. Transmission lines such as micro strip, coplanar waveguide, strip line or coaxial may also be considered to be waveguides. The electromagnetic waves in (metal-pipe) waveguide may be imagined as travelling down the guide in a zig-zag path, being repeatedly reflected between opposite walls of the guide. For the particular case of rectangular waveguide, it is possible to base an exact analysis on this view. Propagation in dielectric waveguide may be viewed in the same way, with the waves confined to the dielectric by total internal reflection at its surface.

V. SIMULATION OF CALCULATION OF ATTENUATION W.R.T HOLLOW WAVE-GUIDE

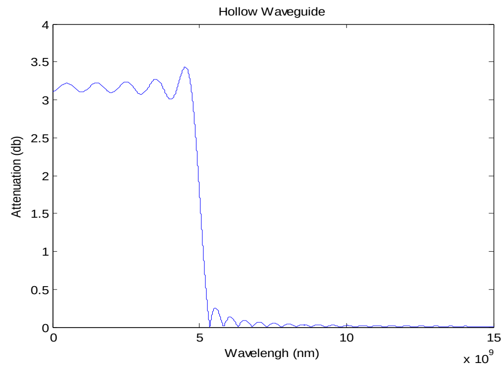


Figure 7 Simulation of calculation of dispersion w.r.t Hollow Wave-Guide

In the microwave region of the electromagnetic spectrum, a waveguide normally consists of a hollow metallic conductor. These waveguides can take the form of single conductors with or without a dielectric coating, e.g. the Goubou line and helical waveguides. Hollow waveguides must be one-half wavelength or more in diameter in order to support one or more transverse wave modes. Waveguides may be filled with pressurized gas to inhibit arcing and prevent multiplication, allowing higher power transmission. Conversely, waveguides may be required to be evacuated as part of evacuated systems. (e.g. electron beam systems).

1.4 Dispersion variation based upon wavelength (Dispersion characteristics of glass material) and Customized Power Transmission based upon time and wavelength.

First of all we will write 3 subroutine functions for GVD and PMD to be called later. In addition to this we will write another key function which will provide the dispersion coefficients for a series of wavelengths.The GVD coefficient is in ps^2/km, the wavelength array is in nm.

Algorithmic steps involved:

Now we will load the dispersion curve from the subroutine function which we have written earlier and then we will under sample the contour plot.

1) Then we will undergo polynomial expansion of GVD and additionally we will declare the speed of light i.e. $c=3*10^8$m/s. Now we will perform self steepening process.
2) Now we will write the function for phase birefringence and group birefringence.
3) Then we will change dispersion coefficient into the group velocity dispersion and to fit the available data with the BPM frequency domain.BPM stands for Beam Propagation Method. Beam Propagation Method (BPM) refers to a computational technique in Electromagnetic, used to solve the Helmholtz equation under conditions of a time-harmonic wave [10][11]. BPM works under slowly varying envelope approximation, for linear and nonlinear equations.
4) Now we will perform cubin spline data interpolation. For example: yy=spline(x,Y,xx) for interpolation , the independent variable is assumed to be the final dimension of Y with breakpoints defined by X.
5) Now we will normalize the dispersion and for this we will undergo polynomial expansion of the defined function, polynomial expansion of Beta for X Axis and polynomial expansion for Beta for Y axis.
6) Now we will define the pulse parameters in time domain and combine pump and noise seeds.
7) Finally we will plot the dispersion curve under various pulse input conditions showing the variation in output power with respect to time, wavelength and dispersion.

The complete research works with customizable output power of a wave-guide depending upon wavelength and time where the dispersion characteristics of a wave guide are analyzed depending upon wave length of the laser to be used. The specifications can be used to install a much better waveguide that can be used in controlling the output power in a more fashioned way in order to emphasize its use in medical field by supporting MIS (Minimal Invasive Surgery) [12].

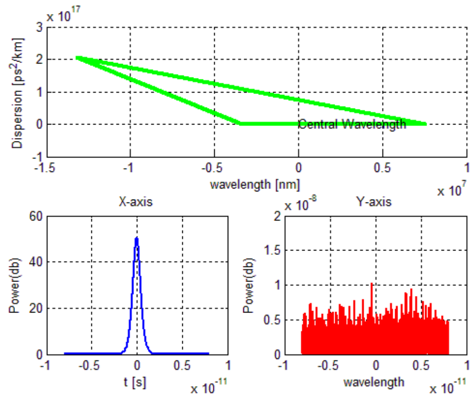


Figure 8 Dispersion variation based Wave-Length

VI. CONCLUSION

Researchers and scholars have made commendable research on fabricating perfect waveguide and there is a long list of various types of WG's. The groups participating in the race for the ultimate flexible, low-loss, high-power, and maximum reliability are in constant search for new combination of fabrication materials and methods. Although there are some types of WG's which found their way to the medical laser commercial market. The race is not yet over and there is still a lot to improve. The perfect WG is not yet introduced. so it's a long journey to establish a successful and commendable waveguide which can perform an invasive surgery with a stunningly low wavelength laser and waveguide which is of the order of mosquito needle, to facilitate painless and bloodless surgery. Though it's hypothetical in present scenario but a strong dedication and hard work of engineers will definitely make it possible one day.

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