Comparative Performance Analysis of Single Mode Fiber over Different Channels Using Matlab: A Survey

Prabhat Gupta, Vaibhav Purwar

Abstract— **High-definition television, the internet, dike surveillance, and endoscopy. Just a short selection out of the numerous applications in which optical fibres can fulfill key roles. All these applications are subject to the ever increasing demands of the end consumers, which often comes down to words like better, faster and cheaper. 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).**

In this paper a brief dispersion has been discussed &filtering concept is used so that a polarized signal could be transferred through a single mode fiber is analyzed using MATLAB & respective output graphs have been discussed.

Index Terms— **SMF, Dispersion, Optical power signal, PMD, Filtering**

I. INTRODUCTION

The increase in demand of energy has brought many challenges on power systems. Distributed generation (DG) is an alternative to solve these problems. DG is integration of small generators in a distribution system in order to meet required load demand by improving the voltage profile, increasing life of system, increase of reliability, minimization of power loss and improving in efficiency. DG is much economic than running a power line to remote areas and DG-unit requires less installation time and the investment risk is not so prominent. It provides power backup during system outages. The DG-unit capacity is ranges from 15 kW to 50 MW and it gains more importance when it uses of renewable energy sources such as Fuel Cells, Small wind turbines, Solar cells and Small Hydro Turbines as well as some unconventional energy sources. Significant influence of embedded distributed generators on load demand, voltages profile, power loss, economy and system reliability make a key issues for distribution system planning in the deregulated power system environment. To achieve maximum benefits the optimization of DG unit is necessary. The application of DG unit is a nonlinear optimization problem which is the determination of the size and optimal location for DG-unit to be installed on a network. It includes minimizing power loss and cost and maximizing voltages. DG-unit placement and sizing has been solved by using different approaches. A classical approach second order algorithm method used in to allocate DG-units for minimal power loss.

In analytical approaches the location of DGs are determined for the load profiles in radial systems. As another analytical method in optimal placement is obtained with unity power factor in networked and radial system as well. An analytical method is introduced based on the equivalent injection of current techniques without use of jacobian matrix, admittance matrix or inverse of admittance matrix which are proved to be problematic for the networked systems. In this paper presents an optimization technique called Artificial Bee Colony (ABC) Algorithm to find the optimal location of distributed generators in the distribution system such that the total real power loss of the radial distribution system is minimized.

The new optimization approach called Artificial Bee Colony algorithm is another meta-heuristic method to solve combinatorial problems. The Artificial Bee Colony algorithm is Meta heuristic approach inspired by foraging behaviour of honeybee swarm. As in the case of genetics and differential evolutions the external parameters such as mutation rate and cross over rate are required but as in case of Artificial Bee colony algorithm external parameter as mentioned above is neglected. This paper discuss the optimal allocations of DG are identified by Artificial Bee Colony algorithm to determine the optimal size(s) of DG to minimal the real power losses which takes the number and location of DGs as input in distribution systems. The advantages of implementation of Artificial Bee Colony method from determination of locations of DGs are less computational time and improved converged characteristics with thermal and voltage constraints are considered. DG technologies

II. LITERATURE REVIEW

Kaname jinguji (1996) [1] proposed a two port circuit configuration with ring waveguides which can realize the same filter characteristics as infinite impulse response (IIR) digital filters. This method is based on scattering matrix factorization. They also provide synthesis examples which includes an elliptic filter, a Butterworth filter, an optical filter with maximally flat group-delay characteristics, a group-delay dispersion equalizer, and a multichannel selector.

Xuen He and et.al have employed step size controller method to achieve an efficient solution in fiber communication system is to the communication system. This work makes the use of

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PSD directed adaptive FD-LMS algorithm. This algorithm nullifies the posterior derivation of each frequency being in the FMI system with AWGN channels. The proposed algorithm has been verified by simulation results. The three algorithms namely conventional adaptive FD-LMS, signal PSD dependent noise PSD directed FD-LMS is found to be minimum. The convergence speed is improved by 48-39%. It has also been established that the convergence is faster in longer transmission distance or larger differential mode group delay. The proposed algorithms are evaluated at different system MDL. The complexity comparison for three algorithms is done in terms of needed complex multiplication. The check is formed over long distance thus simulating transmission length varying between 1000and 3000 km. The power spectral density methodology requires in complex and needs of higher order. The hardware complexity of noise PSD directed method slowly decreases with the increase in the transmission distance. It has been found practically when the step size increased from 0.001 to 0.002 Frequency domain least mean square algorithm needs simple hardware and this tends to converge efficiently. The equalizer converges to higher MSE. The noise PSD directed method iterated over 3000 km transmission on all six modes and it tends to convergence at same MSE to get the standard -10 dB normalized MSE (NMSE).The noise PSD directed algorithms require 47 blocks and the conventional algorithm needs 48 blocks.

Sean O¨ Arık and et.al [2] have proposed Long-haul mode division multiplexing (MDM) for adaptive multi-input multi-output (MIMO) equalization to reduce for modal crosstalk and modal dispersion. To minimize computational complexity, use MIMO frequency-domain equalization (FDE).Polarization division multiplexing (PDM) system use single mode fiber but its transmission effected by noise, fiber nonlinearity and dispersion In. multi-mode fiber (MMF) with multi-input-multi-output (MIMO) transmission Increasing per-fiber capacity can be achieved more readily by increasing spatial dimensionality the total number of dimensions available for multiplexing, including spatial and polarization degrees of freedom denoted by D. In first case two polarization modes of single mode fiber using D=2. This is made possible by equalization a technique goes on going up with the upward drift of D and higher group delay. In second case systems using mode division multiplexing (MDM) in MMFs (D>2) receiver, computational complexity increases because of an increase in D and because of the large group delay (GD) spread from the modal dispersion (MD). Two approaches for minimizing GD spread and controlling receiver complexity are optimization of the fiber index profile and the introduction of strong mode coupling. High group delay has been obtained in step index fiber and low group delay obtained in graded index fibers with large cores(D-). LMS algorithm and recursive version are used for MIMO FDE. It has been observed that RLS achieves faster convergence, higher throughput efficiency, lower output SER, and greater tolerance to mode-dependent loss, but gives higher complexity per FFT block. Therefore, RLS preferable for adapting to an unknown channel but LMS continuously might be preferable, depending on channel dynamics and system requirements.

Md. Saifuddin Faruk and et.al [3] have been proposed a novel adaptive frequency-domain equalization (FDE) scheme in digital coherent optical receivers, which can work with rationally-oversampled input sequences using the constant modulus algorithm (CMA). Adaptive filters play an important role in digital coherent optical receivers because they can perform signal-processing functions such as equalization, polarization de-multiplexing, and clock recovery all at once. the frequency-domain based equalization algorithm needs simple logic and computational expression. This requires lesser time the logic is to apply the processing in the blocks and fast implementation of the discrete Fourier transform (DFT) with the FFT algorithm. The proposed scheme is based on frequency-domain up sampling and down sampling the symbol-spaced error signal is obtained by the constant modulus algorithm (CMA).It has been obtained that comparison of previous scheme and proposed scheme. The equalization is done without dividing into groups. Thus, the required number of adaptive filters for dual-polarization (DP) systems is reduced from eight to four. The filter designed for the purpose is to initialize in such a way that the problem of singularity does not come on the way. The effectiveness of the proposed scheme is verified with 10- Gbaud dual-polarization QPSK transmission experiments.

Neng and et.al [4] have propounded the normalized FDE over a thousand km. distance experiment. This work makes the use of master-slave phase estimation (MS-PE) can be used to reduce the complexity of carrier recovery with minimal Q2-penalty. To provide multiplicative capacity growth on a single fiber mode-division multiplexing (MDM) has been proposed. MDM transmission using few-mode fiber (FMF) in a long haul because of mode coupling it is difficult to reduce multimode interferences multiple-input-multiple output (MIMO) equalization is required. Differential mode group delay (DMGD) is responsible for increase the algorithmic complexity of MIMO equalization. The collected DMGD grows the TDE becomes more complex, while FDE may be more feasible. The channel out consist of sharp spikes between the LP01 and LP11 modes. The MDM transmission for the first time based on NA-FDE TO increase the speed of convergence. The step size mew is responsible for the convergence speed for the specified frequency range. , Different frequencies have different rates of convergence. In NA-FDE, a normalized step size $\mu(k) = \alpha / P(k)$ is used for FDE. In both cases, an equalizer length of 1024 taps was used and same step size was used for fair Comparison. It has been observed that NA-FDE converges six times faster compared with CA-FDE at a mean square error (MSE) of 10-5.The application of NA –FDE for FMI transmission has been checked over loop over 1000 cm. In master-slave phase estimation (MS-PS) the LP01, X mode selected as master mode and LP01, X selected as phase noise. NA-FDE was found to give similar performance as a TDE but has 16.2 times reduced complexity.

An Li and et.al [5] have demonstrated the use of mechanical grating based mode converters to achieve two forms of dual spatial-mode transmission LP01and LP11 and dual LP11 modes. It has demonstrated mode- division multiplexing (MDM) of LP01 and LP11 modes to generate LP11 modes (LP11a+LP11b) and even all three modes(LP01+LP11a+LP11b)over few-mode fiber (FMF)The transmission system with mode multiplexing are a very crucial problem. The mode selective devices proposed in divided into two major categories: free-space based (FSB) and fiber based (FB).Free space components are bulky in size ex liquid-crystal-on-silicon (L_{cos}) spatial light modulator (SLM). But fiber based mode selective device have compact and easiness of integration. Firstly, proposed 107-Gb/s coherent optical OFDM (CO-OFDM) transmission over a 4.5-km two-mode fiber using LP01 and LP11 modes. Secondly proposed 58.8-Gb/s CO-OFDM transmission using dual modes where the mode separation is achieved via 4* 4 electronic MIMO processing.

Sebastian Randel and et.al [6] have been demonstrated the impulse response matrix of few-mode fiber links that support the propagation of LP01 and LP11 modes over up to 1,200-km.Results are obtained by multiple-input multiple-output (MIMO) digital signal processing (DSP)in combination with differential group delay (DGD) compensated fiber spans. Equalizer is used to remove complexity in long haul transmission so two scheme must be remembered. First optical means to minimize the modal delay spread (MDS), i.e., the width of the impulse response, must be analyzed. Second In a second step, the performance complexity of efficient equalizer structures such as the frequency-domain equalizer (FDE) must be studied. It has been observed that MDS can be reduced to about 10 ns using a DGD compensated fiber span. Also, observed that the system MDL is below 5 dB after 1,200 km. characterize the channel's model delay spread and mode-dependent loss.

III. LITERATURE REVIEW

Optical Fiber is new medium, in which information (voice, Data or Video) is transmitted through a glass or plastic fiber, in the form of light, following the transmission sequence. Information is encoded into electrical signals. Electrical signals are converted into light signals. Light travels down the fiber. A detector changes the light signals into electrical signals. Electrical signals are decoded into information.

A. Advantages of Fiber Optics

Fiber Optics has the following advantages:
1. Optical Fibers are non-conductive (Dielectrics).
2. Electromagnetic Immunity:
3. Large Bandwidth (> 5.0 GHz for 1 km length)
4. Small, Lightweight cables.
5. Security

B. Principle of Operation - Theory

Total Internal Reflection - The Reflection that Occurs when a Light Ray Travelling in One Material Hits a Different Material and Reflects Back into the Original Material without any Loss of Light.

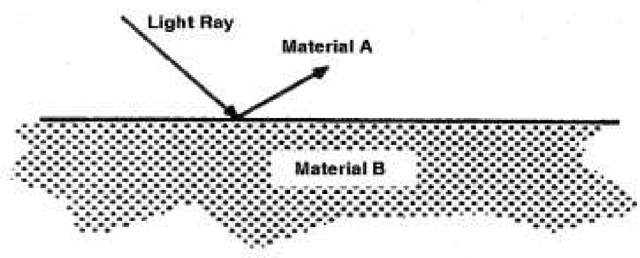

Figure 1: Total Internal Reflection

C. Theory and Principle of Fiber Optics

Speed of light is actually the velocity of electromagnetic energy in vacuum such as space. Light travels at slower velocities in other materials such as glass. Light travelling from one material to another changes speed, which results in light changing its direction of travel. This deflection of light is called Refraction. The amount that a ray of light passing from a lower refractive index to a higher one is bent towards the normal. But light going from a higher index to a lower one refracting away from the normal, as shown in the figures. As the angle of incidence increases, the angle of refraction approaches 90o to the normal. The angle of incidence that yields an angle of refraction of 90o is the critical angle. If the angle of incidence increases amore than the critical angle, the light is totally reflected back into the first material so that it does not enter the second material. The angle of incidence and reflection are equal and it is called Total Internal Reflection.

By Snell's law, n1 sin $\varnothing_1$ = n2 sin $\varnothing_2$
The critical angle of incidence $\varnothing_c$ where $\varnothing_2 = 90°$
Is $\varnothing_c = \arcsin(n_2 / n_1)$

At angle greater than reflected light means that n1 and n2 are equal (since they are in 2 are also equal. The angle of∅1 and ∅the same material), incidence and reflection are equal. These simple principles of refraction and reflection form the basis of light propagation through an optical fiber.

D. Attenuation

Attenuation is the loss of optical power as light travels along the fiber. This loss or attenuation, in fiber depends on the wavelength of the light propagating within it. There are three main bandwidth 'windows' of interest in the attenuation spectrum of fiber. The 1st window is at 800-900nm, here there is a good source of cheap silicon based sources and detectors. The 2nd window is at 1260-1360nm, here there is low fiber attenuation coupled with zero material dispersion. The 3rd window of interest is at 1430-1580nm where fiber has its attenuation minimum. Typically the telecommunications industry use wavelengths in the 3rd window which coincides with the gain bandwidth of fiber amplifiers. Signal attenuation is defined as the ratio of optical input power (Pi) to the optical output power (Po). Optical input power is the power injected into the fiber from an optical source. Optical output power is the power received at the fiber end or optical detector. The following equation defines signal attenuation as a unit of length, [7]:

$$attenuation = \frac{10}{L} \log_{10}\left(\frac{P_i}{P_o}\right)$$

where (L) is the fiber length expressed in kilometres, and the attenuation is measured in dB/km.. Attenuation is caused by absorption, scattering, and bending losses, [5]. Each mechanism of loss is influenced by fibermaterial properties and fiber structure. However, loss is also present at fiber connections. Attenuation increases with the distance through the fiber optic as illustrated in figure (2)

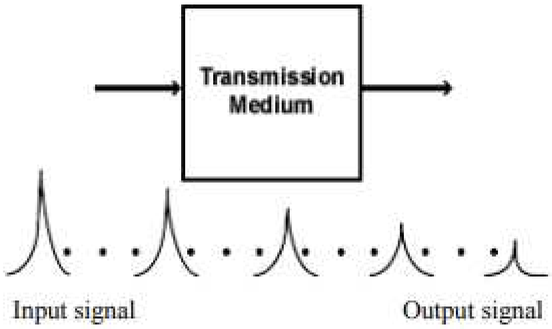

Figure 2: Input data signal attenuating as it propagates down a fiber optic

E. Dispersion

Light from a typical optical source will contain a finite spectrum. The different wavelength components in this spectrum will propagate at different speeds along the fiber eventually causing the pulse to spread. When the pulses spread to the degree where they 'collide' it causes detection problems at the receiver resulting in errors in transmission. This is called Inter symbol Interference (ISI). Dispersion (sometimes called chromatic dispersion) is a limiting factor in fiber bandwidth, since the shorter the pulses the more susceptible they are to ISI, [9]. Dispersion spreads the optical pulse as it transmits along the fiber, as shown in figure (3). This spreading of the signal pulse reduces the system bandwidth or the information-carrying capacity of the fiber. Dispersion limits how fast information is transferred. An error occurs when the receiver is unable to distinguish between input pulses caused by the spreading of each pulse, [10].

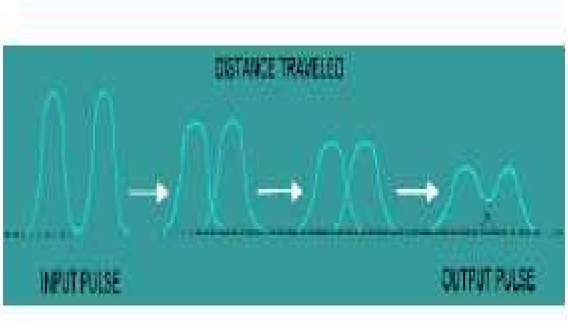

Figure 3: The dispersion along the fiber

There are two different types of dispersion in optical fibers. The first type is intermodal, or modal, dispersion (β1) occurs only in multimode fibers. The second type is intramodal, or chromatic, dispersion occurs in all types of fibers. Each type of dispersion mechanism leads to pulse spreading. As a pulse spreads, energy is overlapped, [11]. This condition is shown in figure (4).

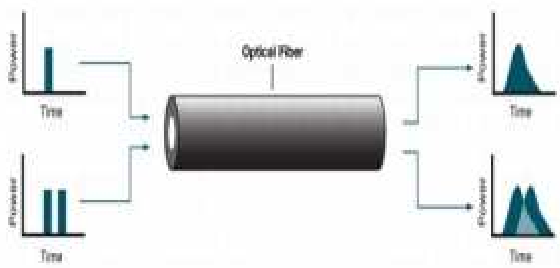

Figure 4: Pulse overlap

There are two types of intra modal dispersion. The first type is material dispersion (β2). The second type is waveguide dispersion (β3).

IV. FILTERING AND TECHNIQUES

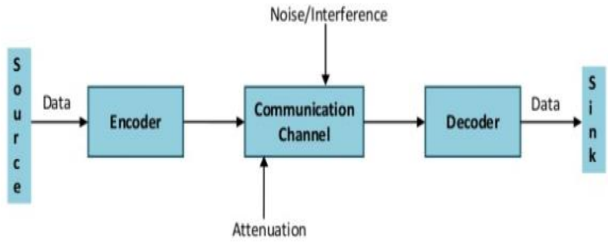

Figure 5: Representation of DWDM

Multiplexing is the process of combining two or more signals together based on space, time or wavelength division in order to increase the amount of information transmissible over a single communication channel per time.

Differential phase shift keying (DPSK) is a common form of phase modulation that conveys data by changing the phase of the carrier wave. DPSP is similar to BPSK with the only addition of differential encoder, i.e., in differentially encoded BPSK a binary '1' may be transmitted by adding 180° to the current phase and a binary '0' by adding 0° to the current phase. The block diagram of DPSK transmitter is as shown as figure 6. The first section of a DPSK transmitter is a PARALLEL-to-SERIAL converter. The circuit below shows the 8 –Bit parallel to serial converter.

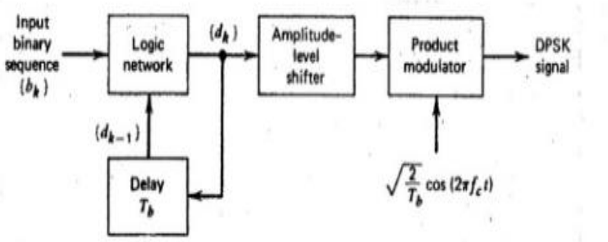

Figure 6 DPSK Transmitter

Adaptive Filter

An adaptive filter has an adaptation algorithm that is meant to monitor the environment and vary the filter transfer function accordingly. The signal and/or noise characteristics are often non-stationary and the statistical parameters vary with time. Based in the actual signals received, attempts to find the optimum filter design.

The basic operation now involves two processes:

1. A filtering process, which produces an output signal in response to a given input signal.
2. An adaptation process, which aims to adjust the filter parameters (filter transfer function) to the (possibly time-varying) environment often, the (average) square value of the error signal is used as the optimization criterion.

This example shows the inter symbol interference (ISI) rejection capability of the raised cosine filter, and how to split the raised cosine filtering between transmitter and receiver, using raised cosine transmit and receive filter System objects comm.RaisedCosineTransmitFilter and comm.RaisedCosineReceiveFilter, respectively.

V. 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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