A Review on "Optical Fiber Communication System"

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***Abstract* - Optical fiber communication system is the most modern mode of communication. The important transmission impairments associated with long distance high bit rate optical fiber communication systems include fiber dispersion, fiber polarisation mode dispersion (PMD), Nise accumulation from amplifiers and the interaction between them. This paper presents a review of optical fiber communication systems.**

Index Terms - **Impairment, and PMD**

1.INTRODUCTION

Optical Fiber communication system is described from the first principles beginning with the basics of dispersion on bulk medium, this concept is applied to propagation of a pulse in an optical fiber. The most modern mode of communication started from 40 to 50 years back. We can say that the last 3 decades the development of the first-generation optical fiber communication systems in the early 80's, the optical fiber communication technology, which has developed rapidly to achieve larger transmission capacity and longer transmission distance.

The important transmission impairments associated with long-distance high-bit-rate optical fiber communication systems include fiber dispersion, fiber Kerr nonlinearities, fiber polarization mode dispersion (PMD), noise accumulation from amplifiers and the interaction between them. How to achieve optimal systems is being studied extensively around the world. However, the complicated interaction between the impairments make the study on the optical fiber communication systems a challenging task. We focus on the

2. A SIMPLIFIED SYSTEM MODEL

As most optical fiber communication system nowadays uses intensity modulation-direct detection (IM/DD), we focus on this kind of systems in this dissertation. A simple multi-span fiber system is shown in Figure 1.

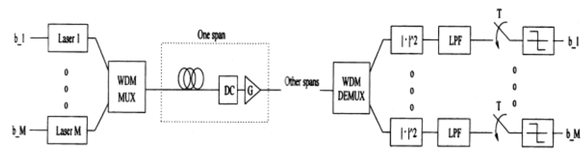

Figure 1: A schematic of a fiber optical communication system

At the transmitter side, single or multiple lasers are used as the transmitters which send out on-off modulated pulses streams over M frequencies. Directly modulating laser diodes or external modulators can be used. A power booster based on Erbium-doped fiber amplifier (EDFA) or semiconductor optical amplifier (SOA) is also used right after the transmitter in some systems. If WDM is used, a multiplexer (MUX) is needed before transmitting the signals through fiber spans.

Each fiber span consists of a piece of single-mode fiber (SMF) or dispersion-shifted fiber (DSF) followed by an optical amplifier (G) and a dispersion compensator (DC). The optical amplifier is used to compensate for the fiber attenuation with the cost of introducing a considerable amount of ASE noise. Since fiber dispersion broadens the signal pulses, a dispersion compensator is usually used to reduce this effect. Each fiber span could be the same or could be different. An especially important case is systems using dispersion management where fiber spans with dispersion of opposite signs are both used to achieve optimal operation exploiting the interaction between dispersion and nonlinearities. However, as was said earlier, the optimal system design is not known yet and it also strongly depends on the system parameters. We will further address this issue in this dissertation.

At the receiver side, the signal is passed through a WDM demultiplexer (DEMUX), which is effectively an optical filter bank, to separate the signals, if WDM is used. In each branch the signal is photodetected and sampled at the bit rate, then passed through a threshold device to restore the information bits. The photodetector can usually be modeled as a square-law receiver whose output is proportional to the intensity of the optical signal.

The optimal receiver using a photodetector is to put an optical matched filter (MF) before the photodetector. However, optical filters with such narrow bandwidth are usually not available with present techniques. What is usually done is to put a narrow-band electrical filter before the sampler to further reduce the noise from the much wider optical filter. As always, synchronization is needed for the receiver to work correctly.

In this dissertation, we focus on the nonlinear effects from the fiber. To do this, the transmitter is usually modeled to send out Gaussian or super-Gaussian pulses with controlled chirping. The receiver assumes perfect synchronization together with optical and electrical filters of commonly used bandwidth.

The main conclusion of our study is that the spectral line and polarization scrambled DOP act as smooth surrogates for the eye opening (or bit-error ratio) objective function. This result is obtained by comparing the performance of the compensators with different local and global optimization algorithms, and by statistical studies that compare the location of local and global maxima of the three different objective functions. We show that the best trade-off between computational cost and performance is obtained using the polarization-scrambled DOP objective function with a multilevel optimization algorithm. This algorithm uses a global genetic algorithm followed by a local conjugate gradient algorithm. Preliminary work compared the performance of the simple compensator with the three objective functions but used only local optimization algorithms and did not compare the structure of the objective functions.

Optical fiber communication systems have attracted more attention in the recent years, because of the outstanding advantage of optical fibers. The most significant merit of an optical fiber is its enormous bandwidth. An optical fiber communication system uses a very high carrier frequency around 200 THz which yields a far greater potential bandwidth than a cable system; coaxial cables have a bandwidth up to approximately 500 MHz. In optical systems, this carrier frequency is usually expressed as a wavelength, 1.55 μm. This enormous bandwidth provides the potential to transmit signals at a very high speed.

3.CONCLUSION

An EDFA (Erbium-Doped Fiber Amplifier) can regenerate weak signals, but it makes the dispersion worse since the dispersion effects accumulate over the multiple amplifier stages. Therefore, the current task of optical fiber communication system design is to solve the fiber dispersion problem, especially PMD. There are many techniques developed for PMD compensation in both the optical domain and the electrical domain. Early strategies to reduce PMD were focused on reducing the intrinsic PMD of the fiber by altering the manufacturing process. This led to the low and stable values of PMD in the new generation of single mode fibers being manufactured. More recent efforts have been examining ways in which lightwave systems can be designed to better accommodate otherwise unacceptable levels of PMD and thus make full use of the existing embedded fiber base. Such strategies include reduction of ISI (Inter-Symbol Interference) by electronic equalization in the receiver and optical equalization using an automatic polarization controller at the receiver or transmitter.

Winters proposed a strategy for PMD compensation using optical equalization. He used a polarization controller to adjust the polarization into a fiber to one of the PSPs (Principal States of Polarization) of the fiber. The receiver detects only one of the PSPs to eliminate first-order PMD. A method to track the changing PSPs using a gradient search algorithm was also presented in his paper. The advantage of optical techniques is that they can be bit rate independent,

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