IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Analysis: The Effect of Inter Symbol Interference on Optical Communication System

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Abstract

Inter Symbol Interference is considered to be one of the most challenging problems encountered in fiber optical communication system. It causes increase in path loss, delay spread, degraded performance, achieving high data rates becomes impossible, and power penalty increases due to ISI increases due to shortest slot durations. This work is concerned with the "Analysis: The Effect of Inter Symbol Interference on Optical Communication System". Here we describe the technique of equalization to compensate the effect of the Inter Symbol Interference on optical communication system i.e. the effect of ISI which causes distortion in the transmitted signal .Various kinds of techniques are used one such is equalization technique, in which filters are used at the receiving end to cancel the effects of ISI in the received signal introduced by channel impulse response. Various kinds of equalizers are used depending upon the application of the system and the kind of communication channel used. The two main techniques of equalization which are used to compensate the effect of inter symbol interference (ISI) in optical communication are Zero Forcing Equalizer and Minimum mean square equalizer .This work aims at studying and simulation of both the equalization techniques and finally reaching to the result which one is the best method to compensate the effect of Inter Symbol Interference.. Apply equalizer at the receiver to undo the effect of the channel by applying an inverse filter. The First technique used is zero forcing (ZF) equalizer to reduce the effect of inter symbol interference (ISI) introduced by the channel impulse response. The second method used Minimum Mean Square Error (MMSE) equalizer to reduce the effect of inter symbol interference (ISI) introduced by the channel impulse response. Simulation result shows that the Minimum Mean Square Error (MMSE) equalizer reduce the effect of inter symbol interference (ISI) better as compare to that of zero forcing (ZF) equalizer.

Keywords: Pulse Shaping Filter, Raised Cosine Filter, Square Root Raised Cosine Filter, DCF, FBG's, EDC Equalizers, Zero Forcing Equalizers, and Minimum Mean Square Error Equalizers.

Introduction

A communication system transmits information from one place to another, whether separated by a few kilometers or by transoceanic distances. Information is often carried by an electromagnetic carrier wave whose frequency can vary from a few mega-hertz to several hundred tera hertz. Optical communication systems use high carrier frequencies (» 100THz) in the visible or near-infrared region of the electromagnetic spectrum. They are sometimes called light wave systems to distinguish them from microwave systems, whose carrier frequency is typically smaller by few orders of magnitude (» 1GHz). Fiber-optic communication systems are light wave systems that employ optical fibers for information transmission.

From last few decades Optical Communication is gaining momentum in many signal processing applications. Light plays a vital role in our daily lives. It is used in compact disc (CD) players, in which a laser reflecting of a CD transforms the returning signal into music. It is used in grocery store checkout lines, where laser beams read bar codes for prices. It is used by laser printers to record images on paper. It is used in digital cameras that capture our world and allow pictures to be displayed on the Internet. It is the basis of the technology that allows computers and telephones to be connected to one another over fiber-optic cables. And light is used in medicine, to produce images used in hospitals and in lasers that perform eye surgery.

Optical communications includes all methods of using light to communicate. An early demonstration was performed by Alexander Graham Bell [1847-1922], who showed that it was possible to modulate light by use of a membrane that vibrated in response to sound, thus demonstrating a free-space optical link. These free-space

ISSN: 2277-9655
Impact Factor: 1.852

optical trans-mission links have applications today using lasers as rapidly deployable optical links with large bandwidth capacity. However, most modern optical systems rely on guiding the light in glass fibers that exhibit exceptionally low loss. The advent of the laser was followed by extensive efforts to understand and reduce the loss of glass. In the1960s to early 1970s the attenuation of glass fiber was reduced from 1000 dB/km to 20dB/km. The chief advantage of using light is the enormous bandwidth or signal carrying capacity that arises from the nearly 200THz carrier frequencies commonly used in fiber systems. Using only a 10GHz modulation rate, a single channel optical link can simultaneously transmit 129,000 telephone calls or can transmit more than 100 standard CDs in one minute. An optical communications system includes methods of modulating, transporting, and detecting light. Therefore, optical communications relies heavily on the advances in nearly all of the other optical and photonic research areas. Optical communications systems today routinely carry 10Gbps on each wavelength, and systems using wave-length multiplexing methods have been used to demonstrate aggregate data rates in excess of ten Terabits per second on a single fiber. In addition to the increasing data rates, the reach or distance of optical links has also increased, and undersea links are common. Advances in fiber optic optical components have allowed optics to extend closer to the end user. All of these advances in optical communications have enabled the Internet to flourish. Fiber optics is a medium for carrying information from one point to another in the form of light. Unlike the copper form of transmission, fiber optics is not electrical in nature. A basic fiber optic system consists of a transmitting device that converts an electrical signal into a light signal, an optical fiber cable that carries the light, and a receiver that accepts the light signal and converts it back into an electrical signal. The complexity of a fiber optic system can range from very simple (i.e., local area network) to extremely sophisticated and expensive (i.e., long distance telephone).

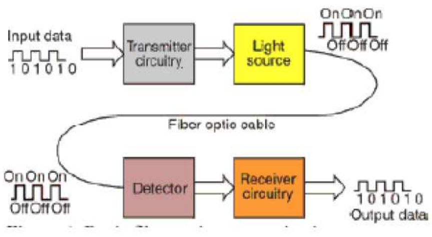

Figure 1.1: Block diagram of Basic Fiber Optic Communication System

Fig.1 Block Diagram of Fiber Optical system

In every communication few challenges are faced similarly in optical communication system the challenges faced are the actual losses of light as it travels through the fibers, maximum limitation of the bandwidth of the signals that can be carried or The Intersymbol Interference. Among all these challenges faced Intersymbol Interference is the most challenging situation.

Inter Symbol Interference (ISI)

Intersymbol Interference is a (ISI) is a form of distortion of a signal in which one symbol interferes with subsequent symbols. ISI is usually caused by multipath propagation or the inherent non-linear frequency response of a channel causing successive symbols to "blur" together. The presence of ISI in the system introduces errors in the decision device at the receiver output. Therefore, in the design of the transmitting and receiving filters, the objective is to minimize the effects of ISI, and thereby deliver the digital data to its destination with the smallest error rate possible. Basically when ISI occurs this energy leaks into other and this affects the system in various ways such as the path loss becomes more, the power penalty due to ISI increases more rapidly for highly dispersive channels due to the shorter slot duration, It becomes impossible to achieve high data rate or transmission distance in high-speed multimode Fibre-optic links for local area networks applications and these all results into degraded Performance.

Drawbacks of the Conventional Techniques

Thus to remove ISI various techniques have been used such as The traditional techniques like DCFs, FBGs, and EDC are used for removing ISI effect in optical system but these techniques were found later on not suitable because DCFS (Dispersion compensating fibers) give high insertion loss, large foot print, nonlinear effects when the input signal is high .Even multiple channels present in the optical system requires the number of DCF's to be installed making the system complex and costly. Similarly FBGs compensate the recompression of an optical signal. For different frequencies different architectures of the FBG's have to be introduced along the fiber link. Electronic Dispersion Compensation (EDC) is rendered ineffective for optical system since it is complex and also not a direct method of compensation as it involves the optical to electronic and electrical to optical conversions making the communication slow which can't be tolerated in this growing world. Even Various pulse shaping Filtering techniques are used to remove the jitter that causes ISI effect in the communication system. These jitters are the undesired deviation from true periodicity of an assumed signal in communication system .Jitter may be observed

ISSN: 2277-9655
Impact Factor: 1.852

in characteristics such as the frequency of successive pulses, the signal amplitude or phase of periodic signals .Thus we have various types of jitters such as Timing jitter where the deviation of a signal occurs from signal's timing clock to the ideal clock. Such a type of variation is known as timing variations, when variations occur slowly, they are known as wander and when they occur rapidly, they are known as Jitters. Similarly we have Deterministic Jitter, which is a type of clock timing jitter which is predictable in nature and reproducible also.

Pulse shaping technique filters the pulses which are transmitted from sender and are detected in the receiver side. At receiving end, the signals are sampled at the certain pulse interval, which tends to achieve the maximum probability of an accurate binary decision. Due to this process at the optimal sampling point, the pulses won't interfere with each other which make the fundamental shapes of the pulses.

Pulse Shaping filters here, are used to neutralize the effects of various jitters and noises present in the receiver end .When the signal's bandwidth becomes larger than the channel bandwidth, the channel starts to introduce distortion to the signal. The filters should be such that it itself does not introduce any noise or jitter. The filters that are used for performance analysis are raised cosine filter, Square raised root cosine filters. The raised cosine filters is used in order to carry out improved signal output .It is used at the receiver end in order to compensate for various jitters and noise added during transmission .The other filter used for analysis was square root raised cosine filter which also removes the timing jitter to some extent but with slight improvement in signal to noise ratio.

Proposed Work

So far various techniques have been used to remove the effect of ISI from the system but every technique has some drawbacks associated with it .In few cases the system becomes too complex and expensive and in few cases the received signal is not the same as the transmitted signal , the signal differences is due to various reasons such as when a signal is subjected to some sort of filtering then various information related components associated with the information they get lost or some time the signal still contains some distortion components in the received signals. The major disadvantage of using pulse shaping filters is that it is difficult to construct the appropriate analogue filters. Thus further work can be extended by analysing the methods to remove Inter Symbol Interference introduced by channel response by using equalizers.

Here two types of Equalizers are used which remove the ISI effect by using Mat lab as tool with version is 7.1.

Conclusion

Thus filtering the received degraded signal travelling through the optical channel with a square root raised cosine filter provides a much more amount of increase in signal to noise ratio and the most important parameter of high signal to noise ratio is the Euclidean distance , which is a distance between two symbol sequences .Thus it proven that as ISI increases the minimum distance strictly decreases this is the worst case scenario , thus we can say that ISI is not completely removed from the system [3].

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