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Noise performance and analysis of long distance Optical fibre Communication System by using Different Modulation Techniques

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Abstract

Optical fiber refers to as the medium and the technology associated with the transmission of information as light pulses along a glass or plastic wire or fiber. Optical fiber carries much more information than conventional copper wire and other wave guides. Optical fiber has been proven to have the widest bandwidth compared to any other media known, including wireless, copper wire, sonar, and even free-space-optics. Tera hertz bit rate has been demonstrated in the lab by using the standard single-mode telecom fiber. As a comparison, the entire useful radio bandwidth worldwide is only 25Gbps, a mere 0.1 percent of the bandwidth supported by a single strand of fiber. As a result, optical fiber can easily replace a large bundle of copper wires while significantly boosting system bandwidth. In optical fiber technology, single-mode fiber is an optical fiber that is designed for the transmission of a single ray or mode of light as a carrier and is used for long distance signal transmission. For short distances, multi-mode fiber is used. Single mode fiber has a much smaller core than multimode fiber.

1. Introduction

Communication in an optical fiber communication system may be defined as the transfer of information from one point to another point in form of light signals. Within an communication system the information transfer is frequently achieved by superimposing or modulating the information with a carrier which is either an electromagnetic wave generally in analog communication system and satellite communication system. However, communication may be achieved using an electromagnetic carrier which is selected from the optical range of frequencies. Optical fiber refers to the medium and the technology associated with the transmission of information as light pulses along a glass or plastic wire or fiber. Optical fiber carries much more information than conventional copper wire with high security of information. Optical fibers is compact, low-loss, immune to electromagnetic interference, secure, non-corrosive, and has almost unlimited bandwidth. Most telephone company long-distance lines are now of optical fiber. Over the past three decades fiber has become the transporting medium of choice for voice, video, and data, particularly for high-speed communications.

In recent years it has become apparent that fiber-optics are steadily replacing copper wire as an appropriate means of communication signal transmission. They span the long distances between local phone systems as well as providing the backbone for many network systems. Other system users include cable television services, university campuses, office buildings, industrial plants, and electric utility companies.

Optical fiber has been proven to have the widest bandwidth compared to any other media known, including wireless, copper wire, sonar, and even free-space-optics. Tera Hertz (10 to the 12th power) bit rate has been demonstrated in the lab by using the standard single mode telecom fiber. As a comparison, the entire useful radio bandwidth worldwide is only 25Gbps, a mere 0.1 percent of the bandwidth supported by a single strand of fiber. As a result, a single strand of optical fiber can easily replace a large

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bundle of copper wires while significantly boosting system bandwidth.

2. Optical Fiber Communication System

Communication in a general optical communication system is shown in figure 3.1, below. It consists of different components. Information Source is the digital data which is modulated by digital coding methods. Electrical transmitter is a type of transducer which simply converts the digital information into electrical signal. Optical source is a device which converts the electrical signal into the light signal or optical source provides electrical-optical conversion. Examples are LED and LASER. Optical fiber is a type of medium or channel through which optical signal (message signal) propagates. Optical detector is a device which converts optical signal into the electrical signal. Examples are PIN photodiode and avalanche photodiode. Electrical receiver consists of Equalizer and the front end amplifier as they receive electrical signal and converts the signal into the original form of signal.

. The original message signal is received at the destination.

One of the fastest growing markets for fiber optics is intelligent transportation systems, smart highways with intelligent traffic lights, automated toll booths, In its simplest terms, 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, which generates the light signal; an optical fiber cable, which carries the light; and a receiver, which accepts the light signal transmitted. The fiber itself is passive and does not contain any active, generative properties.

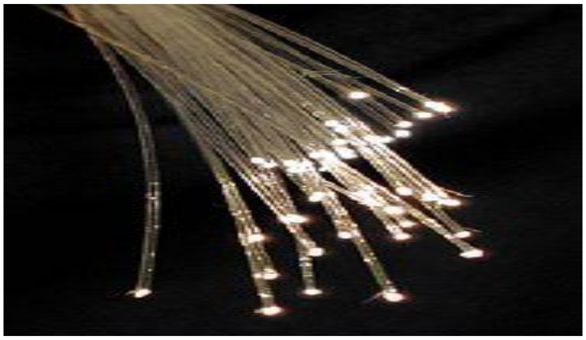

Fig: 1. Optical fiber

Optical fiber systems have many advantages over metallic-based communication systems. These advantages include:

3.1 Long distance signal transmission

The low attenuation and superior signal integrity found in optical systems allow much longer intervals of signal transmission than metallic-based systems. While single-line, voice-grade copper systems longer than a couple of kilometers (1.2 miles) require in-line signal repeaters for satisfactory performance, it is not unusual for optical systems to go over 100 kilometers (km), or about 62 miles, with no active or passive processing.

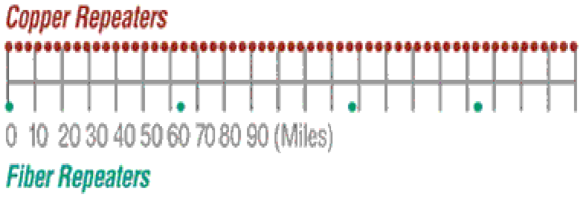

Fig: 3.3. Comparative position of repeaters

3.2 Large bandwidth, Light weight, and Small diameter

While today's applications require an ever-increasing amount of bandwidth, it is important to consider the space constraints of many end-users. It is commonplace to install new cabling within existing duct systems. The relatively small diameter and light weight of optical cables makes such installations easy and practical, and saves valuable conduit space in these environments.

3.3 Long lengths

Long, continuous lengths also provide advantages for installers and end-users. Small diameters make it practical to manufacture and install much longer lengths than for metallic cables: twelve-kilometer (12 km) continuous optical cable lengths are common. Corning Cable Systems manufactures continuous single-mode cable lengths up to 12 km, with a 96-inch reel size being the primary limiting factor. Multimode cable lengths can be 4 km or more, although most standards require a maximum length of 2 km or less. Multimode cable lengths are based on industry demand.

3.4 Easy installation and upgrades

Long lengths make optical cable installation much easier and less expensive. Optical fiber cables can be installed with the same equipment that is used to install copper and coaxial cables, with some modifications due to the small size and limited pull tension and bend radius of optical cables. Optical cables can typically be installed in duct systems in spans of 6000 meters or more depending on the duct's condition, layout of the duct system, and installation technique. The longer cables can be coiled at an intermediate point and pulled farther into the duct system as necessary.

3.5 Non-conductivity

Another advantage of optical fibers is their dielectric nature. Since optical fiber has no metallic components, it can be installed in areas with electromagnetic interference (EMI), including radio frequency interference (RFI). Areas with high EMI include utility lines, power-carrying lines, and railroad tracks. All-dielectric cables are also ideal for areas of high lightning-strike incidence.

3.6 Security

Unlike metallic-based systems, the dielectric nature of optical fiber makes it impossible to remotely detect the signal being transmitted within the cable. The only way to do so is by actually accessing the optical fiber itself. Accessing the fiber requires intervention that is easily detectable by security surveillance. These circumstances make fiber extremely attractive to governmental bodies, banks, and others with major security concerns.

3. Basic Concepts

The basic concepts of fiber optics are discussed step by step

3.1 Information transmission sequence

As depicted in figure 3.4, below, information (voice, data, or video) is encoded into electrical signals. At the light source, these electrical signals are converted into light signals. It is important to note that fiber has the capability to carry either analog or digital signals. Many people believe that fiber can transmit only digital signals due to the on/off binary characteristic of the light source. The intensity of the light and the frequency, at which, the intensity

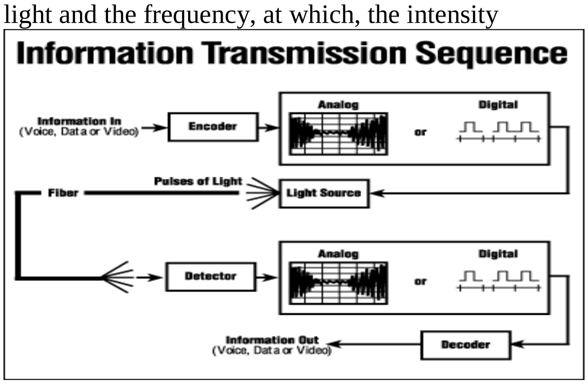

Fig: 3.4. Information transmission sequence

changes can be used for AM and FM analog transmission. Once the signals are converted to light, they travel down the fiber until they reach a detector, which changes the light signals back into electrical signals. This area from light source to detector constitutes the passive transmission subsystem. Finally, the electrical signals are decoded into information in the form of voice, data, or video.

3.2 Cross section of a typical fiber

Optical fiber for telecommunications consists of three components. These are core, cladding and coating.

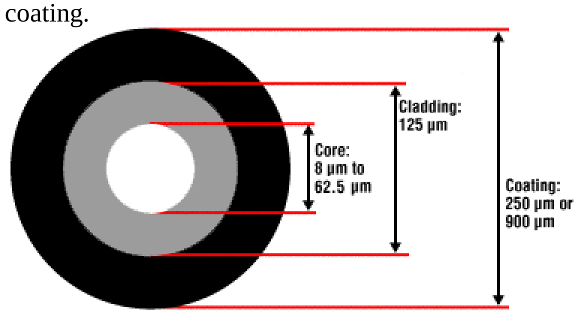

Fig: 3.5. Cross section of a typical fiber

The core is the central region of an optical fiber through which light is transmitted. In general, the telecommunications industry uses sizes from 8.3 micrometers (µm) to 62.5 micrometers. The standard telecommunications core sizes in use today are 8.3 µm (single-mode), 50 µm (multimode), and 62.5 µm (multimode). (Single-mode and multimode will be discussed shortly.) The diameter of the cladding surrounding each of these cores is 125 µm. Core sizes of 85 µm and 100 µm have been used in early applications, but are not typically used today. To put these sizes into perspective, compare them to a human hair, which is approximately 70 µm or 0.003 inch. The core and cladding are manufactured together as a single piece of silica glass with slightly different compositions, and cannot be separated from one another. The glass does not have a hole in the core, but is completely solid throughout.

The third section of an optical fiber is the outer protective coating. This coating is typically an ultraviolet (UV) light-cured acrylate applied during the manufacturing process to provide physical and environmental protection for the fiber. During the installation process, this coating is stripped away from the cladding to allow proper termination to an optical transmission system. The coating size can vary, but the standard sizes are 250 µm or 900 µm. The 250 µm coating takes less space in larger outdoor cables. The 900 µm coating is larger and more suitable for smaller indoor cables.

Once light enters an optical fiber, it travels in a stable state called a mode. There can be from one to hundreds of modes depending on the type of fiber. Each mode carries a portion of the light from the input signal. Generally, the number of modes in a

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fiber is a function of the relationship between core diameter, numerical aperture, and wavelength.

3.3 Ray theory in optics

An incident ray is a ray of light that strikes a surface. The angle between this ray and the perpendicular or normal to the surface is the angle of incidence.

The reflected ray corresponding to a given incident ray, is the ray that represents the light reflected by the surface. The angle between the surface normal and the reflected ray is known as the angle of reflection. The Law of Reflection says that for a specular (non-scattering) surface, the angle of reflection always equals the angle of incidence.

The refracted ray or transmitted ray corresponding to a given incident ray represents the light that is transmitted through the surface. The angle between this ray and the normal is known as the angle of refraction, and it is given by Snell's Law.

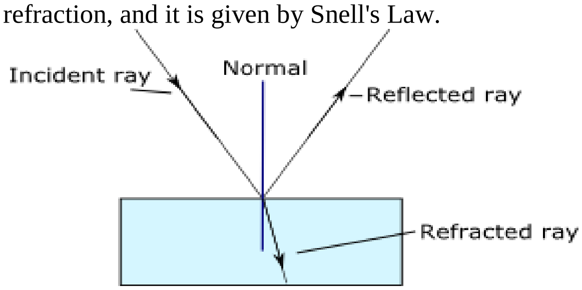

Fig: 3.6. Optical fibers rays

Two types of rays can propagate along an optical fiber. These are Meridional rays and skew rays. Meridional rays are rays that pass through the axis of the optical fiber. Meridional rays are used to illustrate the basic transmission properties of optical fibers. The second type is called skew rays. Skew rays are rays that travel through an optical fiber without passing through its axis.

4. Conclusion and Future Scope

This paper presents a comparative study of single-mode and multimode fiber in LAN environment for different combinations of modulation formats, fiber lengths and filters using eye diagrams and optical spectrums. Simulation is done using OPTISYSTEM. It is an intuitive modeling and simulation environment supporting the design and the performance evaluation of the transmission level of optical communication systems. For single-mode fiber, graphs of optical spectrum (before and after transmission) show that OSNR is decreasing with NRZ modulation format and it is almost constant or increasing with RZ modulation format. For good communication OSNR should not decrease after transmission of signal through fiber so RZ modulation format is better in LAN environment for single mode fiber. For multi-mode fiber OSNR is decreasing for both the modulation format but it is comparatively less decreasing with RZ modulation format so RZ format is also suitable in LAN environment. When there is no limit of bandwidth then single-mode fiber gives the better results with RZ modulation format in LAN environment. Multi-mode fiber is better for limited bandwidth.

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