CHAPTER 1

INTRODUCTION

1.1 Background

Telecommunication is the transmission of signals over a distance for the purpose of communication. In modern times, this process almost always involves the sending of electromagnetic waves by electronic transmitters but in earlier years it may have involved the use of smoke signals and drums. Today, telecommunication is widespread and devices that assist the process, such as the television, radio and telephone, are common in many parts of the world. There is also a vast array of networks that connect these devices, including computer networks, public telephone networks, radio networks and television networks. Computer communication across the Internet, such as e-mail and instant messaging, is just one of many examples of telecommunication.

Telecommunication systems are generally designed by telecommunication engineers. Early inventors in the field include Elisha Gray, Guglielmo Marconi and John Logie Baird. Elisha Gray (August 2, 1835 – January 21, 1901) was an electrical engineer and is best known for his development of a telephone prototype in 1876 in Highland Park, Illinois. Guglielmo Marchese Marconi (25 April 1874-20 July 1937) was an Italian inventor, best known for his development of a practical radiotelegraph system, which served as the foundation for the establishment of numerous affiliated companies worldwide. John Logie Baird (August 13, 1888 – June 14, 1946) was a Scottish engineer. He is best known as the inventor of the first working electromechanical television system. In recent times, optical fibre has radically improved the bandwidth available for intercontinental communication, helping to facilitate a faster and richer Internet experience. And, digital television has eliminated effects such as snowy pictures and ghosting. Telecommunication remains an important part of the world economy[1].

1.2 Fiber Optic

An optical fiber is a glass or plastic fiber designed to guide light along its length by total internal reflection. Fiber optics is the branch of applied science and engineering concerned with such optical fibers. Optical fibers are widely used in fiber-optic communication which permits digital data transmission over longer distances and at higher data rates than other forms of wired and wireless communications. They are also used to form sensors, and in a variety of other applications.

Figure 1.1: Optical Fiber

The operating principle of optical fibers applies to a number of variants including multi-mode optical fibers single-mode optical fibers, graded-index optical fibers, and step-index optical fibers Because of the physics of the optical fiber, special methods of splicing fibers and of connecting them to other equipment are needed. A variety of methods are used to manufacture optical fibers, and the fibers are also built into different kinds of cables depending on how they will be used.

Optical fibers became practical for use in communications in the late 1970s, and since then several technical advances have been made to extend the reach and speed capability of optical fibers, and lower the cost of fiber communications systems[2].

1.2.1 Advantages of fiber optic cable

1. Can be used over greater distances due to the low loss, high bandwidth properties.
2. It can be used for 2km without the use of a repeater.
3. “Their light weight and small in size, which makes them ideal for applications where running copper wires, would be impractical.
4. Due to the fibers being non-conductive, it can be used where electrical isolation is needed.
5. The fibers are doing not pose a treat to the environment, such as in a chemical plant where a spark could cause an explosion.
6. For security reasons, as it is very hard to tap into a fiber cable to read data signals [3].

1.2.2 Disadvantages of fiber optic cable

Although there are many advantages there are a few disadvantages that would effect the installation of these cables these are:

1. It is much more costly than other cables to install.
2. It is relatively difficult to install [3].

1.3 Optical fiber communication

Fiber-optic communication is a method of transmitting information from one place to another by sending light through an optical fiber. The light forms an electromagnetic carrier wave that is modulated to carry information. First developed in the 1970s, fiber-optic communication systems have revolutionized the telecommunications industry and played a major role in the advent of the Information Age. Because of its advantages over electrical transmission, the use of optical fiber has largely replaced copper wire communications.

The process of communicating using fiber-optics involves the basic steps which are creating the optical signal using a transmitter, relaying the signal along the fiber, ensuring that the signal does not become too distorted or weak and receiving the optical signal and converting it into an electrical signal.

The optical fiber can be used as a medium for telecommunication and networking because it is flexible and can be bundled as cables. Although fibers can be made out of transparent plastic, glass, or a combination of the two, the fibers used in long-distance telecommunications applications are always glass, because of the lower optical attenuation. Both multi-mode and single-mode fibers are used in communications, with multi-mode fiber used mostly for short distances (up to 500 m), and single-mode fiber used for longer distance which called links. Because of the tighter tolerances required to couple light into and between single-mode fibers, single-mode transmitters, receivers, amplifiers and other components are generally more expensive than multi-mode components.

1.4 Optical Source

The optical source provides the means to convert an electrical signal into an optical one. Usually the information such as audio, video, analog or digital data begins as an electrical signal and goes through the electrical-to-optical conversion for optical or fiber-optic communications purposes. The source then is the heart of the optical transmitter which prepares the optical signal to propagate down the fiber.

For communication, the source must have the appropriate wavelength, linewidth, and numerical aperture. Also required is a rapid response time and ability to produce enough power to long-distance light propagation without amplification. The source must also provide a reliable and economical solution for the electrical-to-optical conversion, while other transmitter components fine-tune the signal before it is launched down the fiber.

Many types of source are available but only a few basic types are suitable for fiber-optic communications. The most commonly used fiber-optic source are light-emitting diode (LED) and laser diodes, both of which rely on semiconductor principles of operation.

LEDs are complex semiconductors that convert an electrical current into light. The conversion process is fairly efficient in that it generates little heat compared to incandescent lights. LEDs are of interest for fiber optics because of five inherent characteristics which they are small, they possess high radiance (they emit lots of light in a small area), and the emitting area is small, comparable to the dimensions of optical fibers. Its also have a very long life, offering high reliability and they can be modulated (turned off and on) at high speeds.

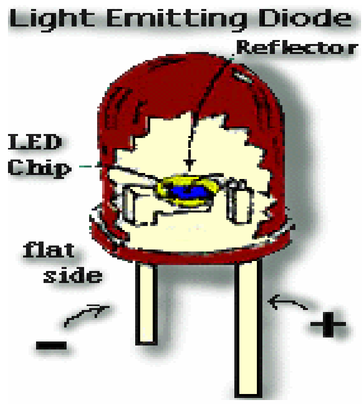

Figure 1.2: Light Emitting Diode

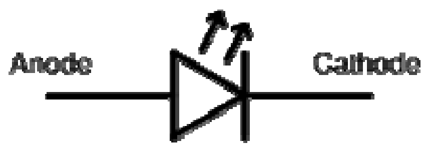

Figure 1.3: LED Schematic Symbol

LEDs are available in red, orange, amber, yellow, green, blue and white. Blue and white LEDs are much more expensive than the other colours. The colour of an LED is determined by the semiconductor material, not by the colouring of the 'package' (the plastic body).

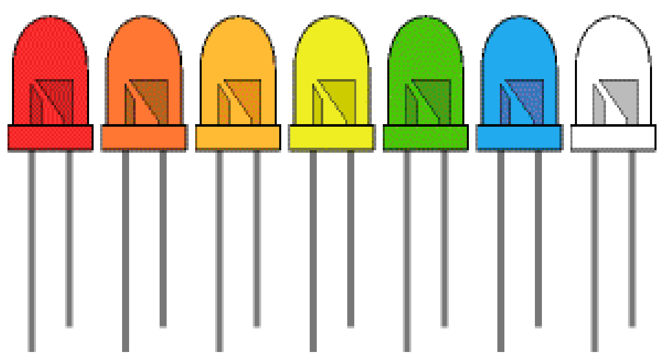

Figure 1.4: Colours of LEDs

A laser diode is a laser where the active medium is a semiconductor similar to that found in a light-emitting diode. Laser Diodes are complex semiconductors that convert an electrical current into light. The conversion process is fairly efficient in that it generates little heat compared to incandescent lights.

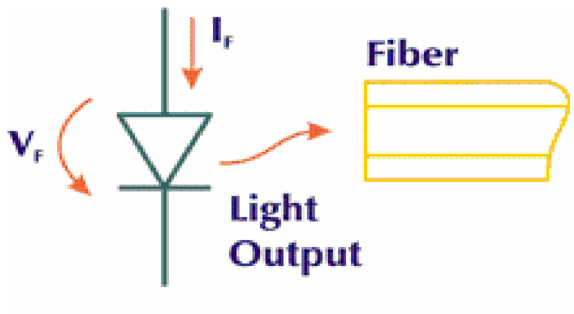

Figure 1.5: Laser Diodes Convert an Electrical Signal to Light

A major different between LED and laser diode is that the optical output from an LED is incoherent, whereas that from a laser diode is coherent. In a coherent source, the optical energy is produced in an optical resonant cavity. The optical energy released from this cavity has spatial and temporal coherence, which means it is highly monochromatic and the output beam is very directional. In an incoherent LED source, no optical cavity exists for wavelength selectivity. The output radiation has a broad spectral width.

In choosing an optical source compatible with the optical waveguide, various characteristics of fiber, such as its attenuation as a function of wavelength and its group delay distortion (bandwidth) must be taken into account. The relationship of these factors with the optical source power, spectral width, radiation pattern, and modulation capability needs to be considered. The spatially directed coherent optical output from a laser diode can be coupled into either single-mode or multimode fibers. In general LEDs are used with multimode fibers, since normally it is only into a multimode fiber that the incoherent optical power from an LED can be coupled in sufficient quantities to be useful. However, LEDs have been employed in high-speed local-area applications in which one wants to transmit several wavelengths on the same fiber. A technique called spectral slicing is used. This entails using a passive device such as a waveguide grating array to split the broad spectral emission of the LED into narrow spectral slices. Since these slices are each centered at a different wavelength, they can be individually modulated externally with independent data streams and simultaneously sent on the same fiber.

1.5 Objectives

The main goal of this research is to develop a new WDM system based on spectral slicing technique. The objectives of this research include: -

a) To study various methods of multiplexing techniques such as TDM, FDM, and WDM.
b) To develop a new WDM system proposed based on spectral slicing technique.
c) To develop and study the performance of a newly spectral slicing WDM system.

1.6 Problem statement

The disadvantages of WDM are cost and complexity. This is because cost for laser diode is very high. However, new developments in WDM show promise that wide band LED's can be made, thus requiring fewer LED's. Hopefully after this cost for WDM will reducing.

Wavelength division multiplexed-passive optical networks are an attractive solution for future broadband access networks; (i) they allow infrastructure sharing and just-in-time provisioning of fiber drops/terminal equipment; (ii) they eliminate the need for time-multiplexing and ranging protocols; and (iii) they provide virtual point-to-point connections with data transparency and a high degree of data security and independence.

However, WDM can be relative expensive to implement owing to the cost of the specified wavelength sources. There is also an operational cost penalty associated with managing a wide range of remotely located wavelength sources. A well known technique which has the potential to overcome these problems and reduce the cost of WDM systems is spectral slicing [4]. Earlier embodiments of wavelength division multiplexed-passive optical networks employing spectral slicing made use of LEDs for the upstream channels [5, 6]. However, LED and FP (Fabry-Perot) source are not ideal for high-bandwidth spectral slicing system owing to their low power and potentially unstable behavior [7], respectively [8].

Other problem is nonlinear fiber effects which are likely to become the main sources of performance degradation in contemporary and future fiber optical communications. The most important nonlinear effects are four wave mixing (FWM) and cross-phase modulation (XPM).

The nonlinear phenomenon of FWM requires phase matching. It becomes a major source of nonlinear crosstalk whenever the channel spacing and fiber dispersion are small enough to satisfy the phase-matching condition approximately [9]. This is the case when WDM system operates close to the zero-dispersion wavelength of dispersion-shifted fibers. Meanwhile the self-phase modulation (SPM) and XPM both affect the performance of WDM systems. They also apply to individual channels of a WDM system. The phenomenon of XPM is an important mechanism of nonlinear crosstalk in WDM lightwave systems and has been studied extensively [10].

1.7 Scope of Work

In this research we focus on the multiple access and multiplexing issues through studies performed at the physical layer. In the physical layer, the standard parameters that usually involved are the Bit Error Rate (BER), Signal to Noise Ratio (SNR), transmit power and receive power also loss.

For WDM development the study focuses on how the effect or what will happen when the transmitter source is changed from using the laser diode to LED based on spectral slicing. This will include the performance parameters such as distance, bit rate and power transmission.

From the result found using the software simulation, some conclusion will be made up. Next the comparison will be decided whether this development may be successful or not. However, as far as the scope of work of this study is concerned, the simulation results are expected to be sufficient to prove the viability of the new transmitter medium performance.