A Research On Fibre Optic Data Transmission

Şeyhmus Yılmaz, Sultan Zavrak, Huseyin Bodur

Abstract: Fiber optic technology is a technique of sending data from one place to another by transmitting pulses of light via an optic fiber. This paper is written to provide an introductory look at optic fibre data transmission, the structure of an optic fibre and the mechanism used to carry the optical signal within the fibre, using mono-mode and multi-mode transmission methods and wavelength division multiplexing. In this paper, the advantages and disadvantages of fibre optic cables are also discussed.

Index Terms: Fiber optic, data transmission, types of fiber optic cables, advantages and disadvantages of fiber optic.

1 Introduction

In many parts of the world, the need for the bandwidth is increasing these days. The best solution for this requirement is fibre optics. Other methods such as copper, cable is transmitting data over the same channel via TDM (Time Division Multiplexing). The capacity of the channel is split up into very tiny time pieces by TDM. TDMA is being used by Fibre Optic as well. On the other hand, the pace of the information transmission is restricted duo to frequency, carrier and base of materials [1]. The frequency of optic fibre is 108 times better than the frequency of copper or wire [1]. The reason for this is that a great deal of channels can be directed down only one glass fibre [1]. In order to do that it uses wavelength multiplexing. The bandwidth of the optical fibres is fairly limitless and their signals have many various frequencies. The wavelengths that are available are split up into bands by wavelength multiplexing, every single one close to each other. So, data coming from numerous subscribers interleaved on fibre. Every unconnected channel is capable of making the transmission of information at the rates that are planned to arrive at 40 gigabits every second [1]. In addition to this, they exploit TDM.

2 Communications Systems

Fibre optic channels are similar to the channels of other systems. It consists mainly of three fundamental elements. These are a receiver, a transmitter and an information channel [1]. The information channel links both the receiver and transmitter. The transmitter creates a message and then changes it into a type which is appropriate to be transmitted. After that the transmitter sends the message to the channel. The receiver takes out the data from the channel and changes it back previous type. So that, any computer or user who receives the data can use it. At the stage of the information channel when the signal created by transmitter comes to transmitter it goes to the receiver. This stage can be seen from the Fig. 1 [1].

- *Şeyhmus Yılmaz, Düzce, Turkey, E-mail: seyhmusyilmaz@duzce.edu.tr*
- *Sultan Zavrak, Düzce, Turkey, E-mail: sultanzavrak@duzce.edu.tr*
- *Hüseyin Bodur, Düzce, Turkey, E-mail: huseyinbodur@duzce.edu.tr*

These kinds of channels could be guided such as coaxial cable, twisted-pair copper wire, optical fibre and so on or. They also could be unguided such as television, radio, microwaves and so on [1]. Cables generally have over 100 fibres [1]. That means a receiving station is going to have many of them. Even though a genuine system could be more sophisticated, the three main components do not change. They are always the same. The fundamental elements can be showed mutually with their connections by using a mono fibre system. Supposing that a fibre optic is used to transmit a telephone dialogue, the analogue signals coming from the phone are changed into digital signals. And then they send to a modulator in the system. The digital electronic signals are transformed into light pulses and these are related to the 'ons' and 'offs' of the electronic signals [1]. The light pulses signals are sent inside the fibre. After the receiver receives the light pulses, they are sent to a photo detector which changes the pulses back into analogue signals. Consequently, the signals are sent to either a convertor or a computer. The fibre transmits these signals via one channel. This is called wavelength. About 50,000 phone conservation can be added to on a channel by using TDM signal packets [1]. On the other hand, one of the most effective features is that it can send various colours at the same time. This is an ability of a fibre which is about wavelength division multiplexing (WDM). Whole wavelengths are close to infrared as every wavelength is not transmitted in that channel. The channel quantity is limited. For that reason, the channel quantity depends on the space between two channels. In other words, if the space becomes smaller, the number of channels increases. In general, an approximate length of a space between two channels is 1.6 nm [1]. The name of these kinds of systems is wavelength division multiplexing (WDM). Some wavelength division multiplexing that has smaller space (0.8 or 0.4 nm) is named dense WDM [1]. The channel of a fibre starts with a light source. It finishes with a photo detector. In general light source means that it is a semiconducting diode laser [1]. This is the main part of transmitter. Every colour and channel use a laser separately. The output of a laser is attached immediately onto the fibre within the house of laser. Nowadays, there are a lot of kinds of lasers. However, these could be single-frequency or tunable. The purpose of single frequency laser is to spread out a single colour. Tunable laser spreads out just a colour at a particular period and they can turn any colour into other types of colours. In order not to produce noise, the frequency, intensity and brightness of the output are crucial to them. These features should be steady. In order to achieve this, there is a system which is called wavelength locker. Wavelength locker detects changes in the output of the laser

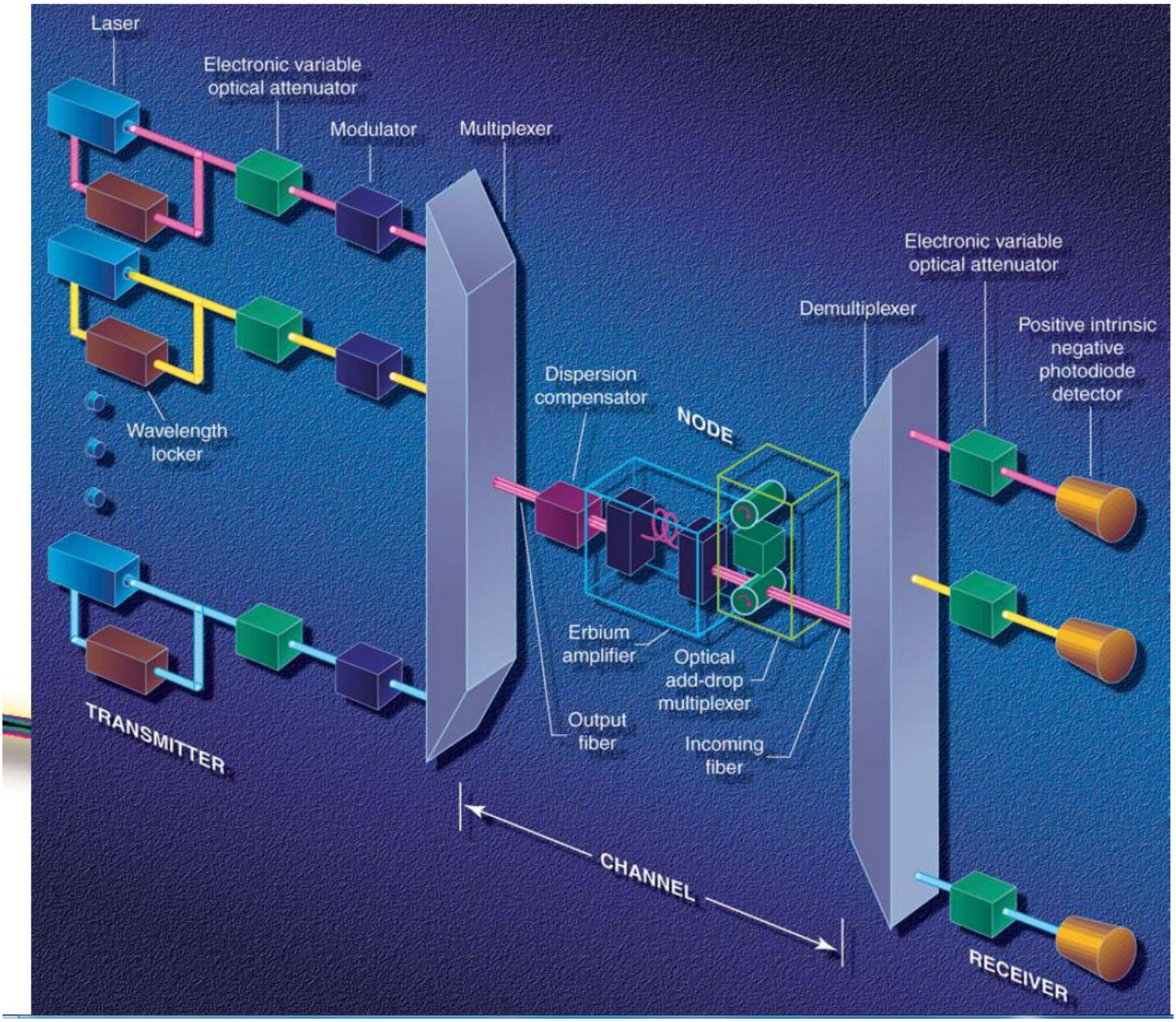

Fig. 1. *Fibre optic transmission*

After that corrects them to be remained steady. In fibre optic systems every laser has their own wavelength. They could be generated immediately in a laser. They also can be set up in their residence. This is because every wavelength locker is responsible for keeping constant a single laser. The reason for this is that the output of some lasers has different intensity. Therefore, every laser ray is sent to EVOA. Electronic variable optical attenuator aims to makes sure that the intensity of every channel is identical. The purpose of it is similar to a valve's. It controls the quantities of light lasers sends out like a valve control the amount of water. The designs of EVOA are various. An EVAO can be optical, electro-optical or based [1]. Every single one has their benefits, drawback and expenses. Since fibre optic systems will have some principles. Nevertheless, at present there are a lot of methods to make the intensity o laser constant. The multiplexer is the last element of the transmitter. A great deal of signals from various places is sent to a fibre optic by a multiplexer. The colours of the signals are not the same. In order to be transmitted, they are joined together on a single fibre. The channel is the other important component of a fibre optic channel. Normally, the only thing a channel needs is a large section of optical fibre. On the other hand, there will be a problem. The speed of the light is different. Because the signals are reduced and the light's colours scattered variously by the fibre. In order for the signal to carry on their path without any damage, the signal has to be amplified and recreated. Normal transcontinental fibres have between 80 to 100 amplifier repeater stations [1]. In addition to this, there are several spaces where extra channels require be inserting or falling to bring data from several middle target places. In order to achieve those works, repeater stations and nodes are built through the fibre (Fig. 1) [1].

3 Types of Fiber Optic Cables

Apart from the braid, coax cables look like optical fiber shown in Fig. 2 [8]. Nowadays, there are a number of types of fibre optic cables but there are many methods that categories might become different [2]. There are two main types in the optic.

1. Step index fibre optic cabling,
2. Graded index fibre optic cabling.

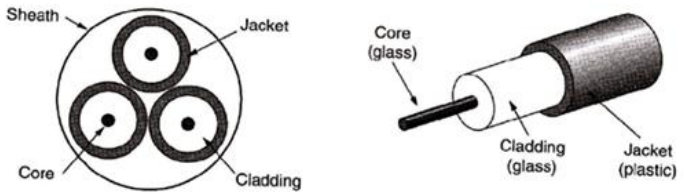

Fig. 2. *The basic structure of fiber optic cable*

The first one step index fibre optic cabling is related to cable. This cable has a step change and it is widely used. Alterations are more steadily in the second one. This kind of fibre optic cable refracts the light in the middle of the cable. In addition, optic fibres could be divided into mono mode and multi-mode. These kinds of names frequently can be come across in the literature [2], [7].

3.1 Single-mode fibre and multi-mode fibre

Light signals are transmitted over optic fibre cables. In order to carry the ray of light, one or more methods of transmission can be used by light ray. These methods are about modes and they are numeric at all times. Since there are some particular methods of sending light if the number of mode is one, the name of this mode is single mode fibre as its structure shown in Fig. 3 [6]. If the number of the mode is over one in an optical fibre, this one is called multi-mode fibre as its structure shown in Fig. 4. Single mode and multimode do not have the same physical constructor. The diameter of the fibre cores is different. The classic core diameter of the single mode can be between 8 to 10um [6]. The classic core diameter of the multi-mode can be 50 or 62.5um [5]. As a general rule, if the diameter of the optic fibre core becomes larger, the optic fibre will be able to transmit more data. At present, only single mode fibre is almost used [3] and its transmission method is made from a strand of glass fiber [3]. Because of dispersion, the range of multi-mode is restricted. As a result, it can be applied in places where the distance is not more than one kilometre [5]. On the other hand, single-mode is able to transmit about 100 km away [5].

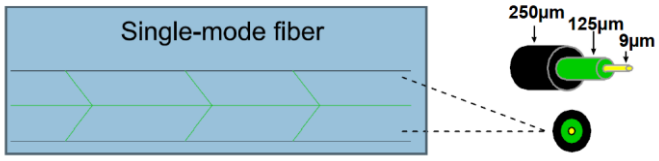

Fig. 3. *The structure of single-mode fiber*

If the speed of different modes of light or the way of them over the same optic fibre is not the same the time they reached their destination will be different. Because of this, the signals might become worse. It is called intermodal dispersion. It can be seen from Fig. 5 [6].

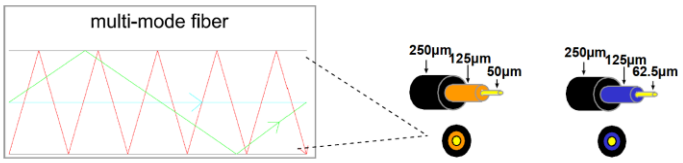

Fig. 4. *The structure of multi-mode fiber*

This problem is reduced by the structure of the optical fibre. Intermodal dispersion is removed up to 99% by using optical fibre [6]. In order to be arrived at their destination at the same time, fibre optics are using various speed for every mode. As a result, these signals are reached together. There is an example Figure 3. Ray B uses a shorter way than Ray A if the speed of Ray A is increased. In other words, the speed of Ray A becomes more than Ray B's. The problem will be solved as intermodal dispersion can be used only multimode fibre. In case of slower signal loss, the performance of the multimode fibre is worse than single-mode fibre [6] [7].

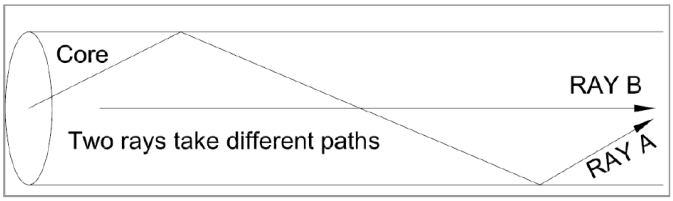

Fig. 5. *Intermodal dispersion*

3.2 The Advantages of Fibre Optic

When carrying electrical signals over the cables, sometimes it could be extreme hazards. Little sparks can be generated by the majority of electric potentials. These sparks generally do not cause any hazards. In some cases, this is not always true. They can cause a real danger in some places where there are explosive, chemical substances or oils. A huge blast can be made by a small spark. Connection and transmitting data can be prevented badly by possible spark dangerous in that kind of places. On the other hand, sparks are not created by optical fibre as current is not transmitted. It is possible for optic fibre to transmit a great deal of data between remote places speedily. We do not need any repeaters like other kind of wires. The Capacity of the data goes up by using frequency. Nevertheless, the bandwidth fibre optic is limited. However, this is surely better than coaxial wires. Normally, a bandwidth parameter of a few MHz/km is used by coaxial wires. Alternatively, optical fibre cables have a bandwidth of 400MHz/km [4]. (They are estimated statistics. These are different from wires to wires) [4]. This is one of the significant things which go to optical fibre option for data communications. Optical fibres could be put a wire to network. Therefore, terminals can be connected by it from somewhere else. When wire cables transmission capacity is raised, this usually increases the thickness and rigidity of cables. It is very hard to establish these kinds of cables in buildings where cables have to be put inside walls and wires channels. On the other hand, optical fibres are not difficult to establish as optical fibres are small and more elastic. In addition, fibre optics are able to work over the same channels without receiving too much noise like electrical wires. There is a method in order to install fibre in existing buildings is to put cables inside ventilation ducts. But the need for fire codes is that plenum

wires consist of very expensive retardant substances which release some smoke. One of the benefits of optical fibre is that it is small and therefore does not need expensive fire retardant equipment. The size of fibre, the weight of light and the elasticity of the cable simplify fibre optics to be made use of in portable projects and easily carried. Even though data communications drawbacks can be resolved by optic fibres, optic fibres cables are not necessary for all over the place. The majority of information travels over common wires. When the data is transmitted between close places, the speed of data is very low. In general, it is not useful to make use of optic fibre to send information from an individual PC and scanner since its prices will be too much. One of the most well-known kinds of noise is interference which comes from a main electromagnetism property. The flow of electricity is produced by the lines of magnetic field, because conductors are shortened by these lines. Magnetic field is created by electrons within conductors [4]. There is no interference inside coaxial cables as current makes a shortcut in conductor [4]. Signals are sent as light rather than current, so that optic fibre is resistant to EMI [4]. Therefore, signals can be transmitted in environments where transmission can be prevented by EMI. There are two methods of running magnetic fields and current induction [4]. They produce noise. In addition to this, they do not allow the data to be public. The problem can be decreased by protecting the wire like coaxial wires. However, protecting could occasionally permit the adequate amount of the signal to be tapped. There is no doubt that everyone does not wish that. Magnetic fields are not spread out within fibre optic; the fibre optic captures electromagnetic fields. Because of this, apart from cutting into optic fibres, there is no way to take signals from fibres as electromagnetic signals are not spread out by optic fibres. It is impossible for emissions to be stopped and optic fibre has an excellent ability not to be detected. As a result, the optic fibre is the best way to transmit vulnerable data securely. It is possible for metal wires to come across other signal transmission troubles, since electrical potential has not got clear differences. Producers suppose ground is uniform potential. [4]. This is sensible when soil is a mono chassis of metal. This is not very unpleasant when there is an excellent conductor in the ground, which expands within a tiny building. On the other hand, the supposed ground could be different from some volts when wires work among various buildings and even occasionally it could be some places in the identical building. The amount of the signals is low in semiconductor circuits, which cause a drawback called ground loop [4]. Fibre optic does not have these types of problems.

3.3 The Drawbacks of Fibre Optic

In order to set up optical fibres, the ability of experts is needed especially when terminating and testing stage. For example; BP Communications Limited are expert at that area, they have people to train [9]. Even though the costs of other technologies are decreasing constantly, the price of fibre optic is more expensive than other methods at the moment [10].

4 Conclusion

As a conclusion, there are a small number of drawbacks of optical fibre cables; on the other hand, the benefits of fibre optic certainly exceed its drawbacks. Optical fibre provides an amazing connection. In addition to this, it does not lose a great deal of data when carrying information between long places. Nevertheless, the technology of optical fibre is latest and it can be accessible just in particular places. That is one of the worst drawbacks if people are not in fashionable places so they are unable to use this technology. Perhaps, they wait for some time to obtain the benefits of fibre optic technology.

References

[1] G. Sanger, "How Fiber Optics Works", 2002. [Online]. Available: http://www.aip.org/tip/INPHFA/vol-8/iss-1/p18.pdf. [Accessed: 01- Dec- 2016].

[2] I. Pole, "Optical Fibre (Fiber) Cable", Radio-electronics.com, 2009. [Online]. Available: http://www.radio-electronics.com/info/telecommunications_networks/fiber-fibre-optics/optical-fiber-cable.php. [Accessed: 01- Dec- 2016].

[3] C. Hunter and C. Hunter, "How Do Fiber Optic Cables Transmit Data? | eHow", eHow, 2016. [Online]. Available: http://www.ehow.com/how-does_5179882_do-optic-cables-transmit-data_.html. [Accessed: 01- Dec- 2016].

[4] S. Imran and M. Sandrakasan, "Advantages Of Fiber Optics", Doc.ic.ac.uk, 2016. [Online]. Available: http://www.doc.ic.ac.uk/~nd/surprise_97/journal/vol4/sm27/adv.html. [Accessed: 01- Dec- 2016].

[5] Universal Networks, "What are achievable distances of single mode vs multi-mode fibre?", Universalnetworks.co.uk, 2016. [Online]. Available: http://www.universalnetworks.co.uk/faq/fibre-optic/what-are-achievable-distances-single-mode-vs-multi-mode-fibre. [Accessed: 01- Dec- 2016].

[6] Olabs Technology Limited, "Explaning Fiber Propagation Modes", 2010. [Online]. Available: http://olabstech.com/getfile/index/action/images/type/download/name/5175ead5e534a.pdf. [Accessed: 01- Dec- 2016].

[7] W. Stallings, Data and computer communications, 9th ed. Upper Saddle River, N.J.: Prentice Hall, 2011, p. 143.

[8] A. S. Tanenbaum and D. Wetherall, Computer Networks: Pearson Education, 2010, p. 123.

[9] BP Communications, "Fibre Optics Disadvantages", Bpcomms.co.uk, 2016. [Online]. Available: http://www.bpcomms.co.uk/fibre-optics/fibre-optics-disadvantages/. [Accessed: 01- Dec- 2016].

[10] S. Tee, "Optical Fiber the Backbone of Telecommunication," 2002.