FIBER OPTICS CHARACTERISATION AND TRANSMISSION LOSS MEASUREMENT

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PROGRAM PHYSICS WITH ELECTRONICS
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ABSTRACT

Fiber Optics Characterization and Transmission Loss Measurement

The objectives for this study are to compare the transmission signal characteristics from transmitter and receiver through different type of fiber optics by using the laboratory experiment set. Besides that, the attenuation loss for this fiber optics was compared and which is the best fiber optics for the transmission line among them was identified. All the fiber optics used was up to the length of 3.2 meter. The relationship between the voltage and current can be determined by adjusting the potentiometer at the fiber optics transmitter SO4201-9L. The characteristics of the transmitting diode for wavelength 875 nm and 950 nm are similar, which is quadratic increased with x-axes variables. The frequency response for transmitter is linear for both wavelengths. But the frequency response of the transmission line is quadratic decreased as frequency increased. The upper limit frequency of the transmission line is 300 kHz and its determining factor is fiber optics detector. Plastics fiber optics type A, B and D show the clear increase of length-dependent attenuation as the fiber length and the wavelength increased. Compared to glass fiber type C, it has the lowest length-dependent attenuation but highest coupling attenuation among others. This is because the lost of the light absorption and scattering during the transmission are minima and thus low length-dependent attenuation. The high coupling attenuation is because of the loss at the broken end of fiber optics during the cutting process and the loss at the connection between transmitter-fiber, fiber-fiber and fiber-receiver. The coupling attenuation is not dependent on wavelength. Glass fiber optics (type C) is the best for optical transmission.

ABSTRAK

Matlamat kajian ini adalah untuk membandingkan sifat-sifat isyarat yang dihantar melalui pelbagai jenis gentian optik dengan menggunakan peralatan yang sedia ada di makmal. Selain itu, kehilangan cahaya dalam gentian optik semasa perhantaran isyarat adalah dibandingkan dan gentian optik yang terbaik dalam penghantaran isyarat infra merah dapat ditentukan. Panjang kesemuaan gentian optik adalah dalam lingkungan 3.2 meter. Hubungan antara voltan dengan arus dapat ditentukan melalui penyelarasan pengawal voltan dan arus yang terdapat pada papan pemancar SO4201-9L. Sifat-sifat diode pemancar adalah serupa, iaitu kadar arus meningkat secara kuadratik dengan peningkatan voltan. Tindak balas frekuensi pada pemancar bagi kedua-dua panjang gelombang 875 nm dan 950 nm adalah linear. Tindak balas frekuensi semasa penghantaran isyarat adalah menurun secara kuadratik dengan peningkatan frekuensi. Had frekuensi atas laluan penghantaran ialah 300 kHz dan faktor yang mempengaruhinya ialah penerima gentian optik. Gentian plastik jenis A, B dan D menunjukkan peningkatan kehilangan cahaya yang jelas apabila jarak pemisahan dan panjang gelombang ditingkatkan. Berbanding dengan gentian kaca jenis C, ia mempunyai kesan kehilangan cahaya yang paling rendah pada jarak tetapi kehilangan cahaya yang paling tinggi pada sambungan. Hal demikian adalah disebabkan oleh kehilangan tenaga yang minima pada penyerapan cahaya dan penyerakan semasa penghantaran isyarat. Kehilangan yang tinggi pada sambungan pula disebabkan oleh permukaan yang tidak rata pada gentian optik semasa pemotongan dan kehilangan pada sambungan pemancar-gentian, gentian-gentian dan gentian-penerima. Kehilangan pada sambungan tidak bergantung pada panjang gelombang yang dipancarlan. Gentian kaca (jenis C) merupakan gentian optik yang paling baik digunakan dalam penghantaran isyarat optik.

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FIGURE LIST

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SYMBOL AND UNIT LIST

n_1	refractive index of core
n_2	refractive index of cladding
m	meter
mm	milimeter
µm	micrometer
nm	nanometer
A	Ampere
mA	miliAmpere
V	Volt
mV	miliVolt
mVpp	miliVolt peak-to-peak
Hz	Hertz
kHz	kiloHertz
W	Watt
mW	miliWatt
MAX	maximum
MIN	minimum
div	division
V/div	Volt per division
AC	Alternated Current
DC	Direct Current

ms	milisecond
μs	microsecond
dB	decibel
dB/m	decibel per meter
Δ	difference
Ω	Ohm
$k\Omega$	kiloOhm
θ	angle
/	per or division
$\pm$	plus minus
T	relaxation time
R_L	load resistance
I	current
U	voltage
α_C	coupling attenuation
α_{IO}	length-dependent attenuation
α	line attenuation
cm^2	centimeter square
A	G652D SM-12 fibers per tube, dry core water-blocking
B	G652D SM-12 fibers per tube, wet core water-blocking
C	OM3 - 6 fibers per tube, dry core water-blocking
D	G652D SM- 6 fibers per tube, dry core water-blocking

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

In the earlier communication system, people used visual skills like smoke signal, lamp signal, drums, and beacon fires to make the important announcements or sending messages to others within a determined distance. These methods used sound and light waves to propagate the information. Each drum beats and light beams propagate had their own special meanings. However, these can only be useful for those who get use of it. Otherwise, these will only make one might think that these merely announce the presence of camp, not sending the massage or announcements.

Using these special methods might possible to secure the information brought. This is because only their clansman will know what the massage means. Somehow, the massage sent might be wrongly interpreted and will cause the unwanted disaster occur. For example, navy ships often used the lamp signal to gain or exchange the information in order to communicate with others ships during the night time. If the crews wrongly interpret the signals, the fights will be happened cause of the misunderstanding and conflict occurs between them.

In mid 19th century, the scientist and inventor started to bring the new change and try to develop the easier way to communicate with each other far from the distance. Hence, the communication devices like telephone, telegraph and radio are successfully been invented in the western countries. However, these devices still facing some other drawbacks like its geography location, technical and instrumental problems. For example, radio device, the user needs to find a place where it can receive clearer frequency signal and technically implement that crude device to transmit or receive the information. If the user cannot detect the good signal, the information transmitted or received will be blur and noisy due to its outside interference. Furthermore, the information sent or received might be only consists limited data. Thus, it might cause them lost the important information (Optical Communication- Wikipedia, 2008).

The improvement and development in science and technologies are emerging from time to time. Communication system is therefore been refined and developed in better form to obtain more effective and efficient operation in data transmission. With the invented of communication network by using the copper cables, coaxial cables, radio waves and microwaves, the data transmission rate hence can be perform faster and is more reliable (Optical Communication- Wikipedia, 2008).

However, these applications still having their own weakness and cannot fulfill the demands requested by the technology. For example, the communication system that using the copper cables has high loss in data transmitting while the coaxial cables has low bandwidth transmission for about 500MHz. These factors will cause the errors occur due to the transmitted data is limited and not complete. Besides that, electromagnetic radiation and light source are others interferences which will influence data transmission when using copper and coaxial cables. Due to the big in size and high cost is needed for installations, maintenances, and terminations, the metal cables are thus not the optimum choices for coming integrated digital network services (Optical Communication- Wikipedia, 2008).

To overcome the weakness brought by the metal cables, new communication system is invented to transmit the data in high capacities and with minima error. This invented system is the fiber optical communication system which used fiber optics as a transmission medium. Fiber optics is the suitable transmission medium that can use for long distance networking system, for example, trunk and seabed networking, compared to the metal cables. This is because fiber optics acts as data transmission channel that does not influence by the outside interferences and has high efficiency in data transmitting (Optical Communication- Wikipedia, 2008).

Fiber optics used light sources which travel at high frequency and with speed of light as a carrier to transmit the data. When light propagates through the fiber optics, it transmits the data as well. Hence, it is fast and less errors occurs during the transmission.

Fiber optics also can be used for voices and pictures transmission at high transmission rate (Optical Communication- Wikipedia, 2008).

Fiber optical communication networks have been implemented in the advance countries like United States of America, Japan, Europe and China due to high demands of multimedia services, videoconferencing, and internet networking. Malaysia is one of the country that facing the significant change of communication infrastructures in Asia. It is therefore start to use fiber optic to build up couples of the trunk pathways all around the country. Beside that, due to high capability of fiber optics, it is thus used to link among the companies, data and telecommunication centers. The used of fiber optics as transmission medium around the Malaysia can be clearly seen when it has been invested by the entrepreneur of telecommunication networks like Telekom Malaysia, DIGI Telecommunication, Maxis, Celcom, TMTouch, Petronas and Tenaga Nasional (Utusan Malaysia, 1999, 2001).

Although fiber optics is now widely used in optical communication system, it is also has the weakness during the data transmission. That is, the attenuation loss occurs when the data is transmitted. Loss can be defined as fiber optics is not fully functions or operate as it was made to be. Even thought this weakness has been generally solved before, it still having the minima loss during the data transmission. Hence, to overcome this weakness, further studies is needed.

1.2 PROJECT GOALS

The goals for this study are to measure the transmission signal loss by using the laboratory experiment set and to identify the factors that made it by using several types of fiber optics that can found in the industries. Besides that, it is also a good opportunity to compare which types of fiber optics have less loss and are better for the transmission line.

1.3 OBJECTIVES

The objective for this study is to compare the transmission signal characteristics from transmitter and receiver. Besides that, the attenuation loss in the different material fiber optics as the transmission pathway is compared and to identify the best fiber optics for the transmission line. On the other hands, this study can be used for future studies to overcome the signal loss of the fiber optics.

1.4 STUDY SCOPE

This study is to investigate the transmission signal characteristics of fiber optics that used to transmit in all directions and only with the nearest range of 3.2 meter. There are three aspects for investigation, that is,

1. The relationship between current, voltage and frequency response on the transmitter are observed through the infrared transmitting diode of TSTA7100 at wavelength of 875 nm and infrared transmitting diode of TSTS7102 at wavelength of 950 nm.
2. The relationship between current on the transmitter and voltage on the receiver are observed.
3. The frequency response in fiber optics transmission line and connectors is studied.
4. The attenuation loss during the transmission in the fiber optics is compared.
5. The fiber optics that has the best transmission line with minima loss is identified.

1.5 HYPOTHESIS

- For plastics fiber optics, the longer the fiber optics length, the greater is the attenuation loss.
- For fiber glass optics, the longer the fiber optics length, the lesser is the attenuation loss.
- The coupling loss of fiber glass optics is higher than the plastics fiber optics.

CHAPTER 2

LITERATURE REVIEW

2.1 FIBER OPTICS

Generally, fiber-optic cable is composed into two concentric layers. That is, the core and the cladding. Core is the inner layer while cladding is the outer layer of the fiber optics. The simple sketch of fiber optics can be seen in Figure 2.1. Core is used to transmit light during the transmission while cladding is used to keep the light ray from leaving the fiber once it enters. This causes the fiber to act as a waveguide (Kasap, 2001).

Outside the cladding, there is one more layer called jacket. Jacket layer is built up by one or more fine polymer layers. It is used to protect core and cladding layer from damage and act as shock absorber. Jacket also protects core and cladding layers from friction, abrasion, melting and other damages might be occurred. Jacket layer has no effect on the light transmission through the fiber optics. Hence, it has no refractive indexes (Kasap, 2001).

The differences between the design of core and cladding make them have difference refractive indices. Core has a refractive index of n_1, and the cladding has a refractive index of n_2. At where the refractive index of the core, n_1, is always greater than the index of the cladding, n_2. The refraction index can be measured by the given formula (Vivek, 2002, Dakin & Gambling, 1974):

$$\text{Refractive index of the medium} = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}} \tag{2.1}$$

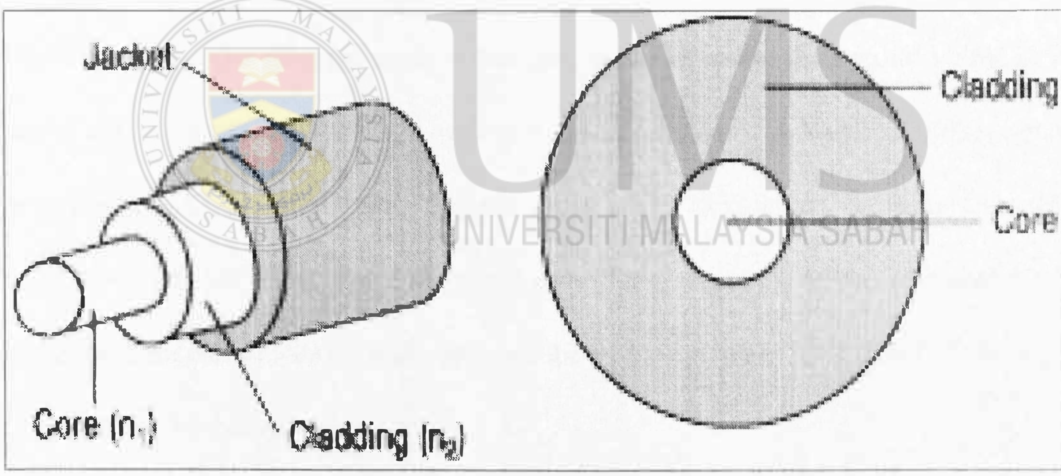

Figure 2.1 Three dimensional views and basic cross section of fiber optics cable (Schneider, 2003)

2.2 FACTORS THAT INFLUENCE THE TRANSMISSION THROUGH FIBER OPTICS

There are three factors that need to concern when light propagation through the fiber optics. The three factors are fiber size, fiber chemical materials and the way that light emitted into the fiber (Meardon, 1993).

2.2.1 Size of Fiber Optics

Fiber optics size is approximately 100 μm smaller than human's hair. It is normally stated in ratio a/b. The first value, a, is the core diameter while the second value, b, is the cladding diameter (Palais, 1992). The international standard for outer cladding for most fiber optics has 125 microns (μm) for the glass and 245 microns (μm) for the coating. This standardized for fiber optics sizes are important because it ensure the compatibility connectors, splices, and tools used throughout the industries (IEC, 2007). The sizes of fiber optics can be compared in Figure 2.2.

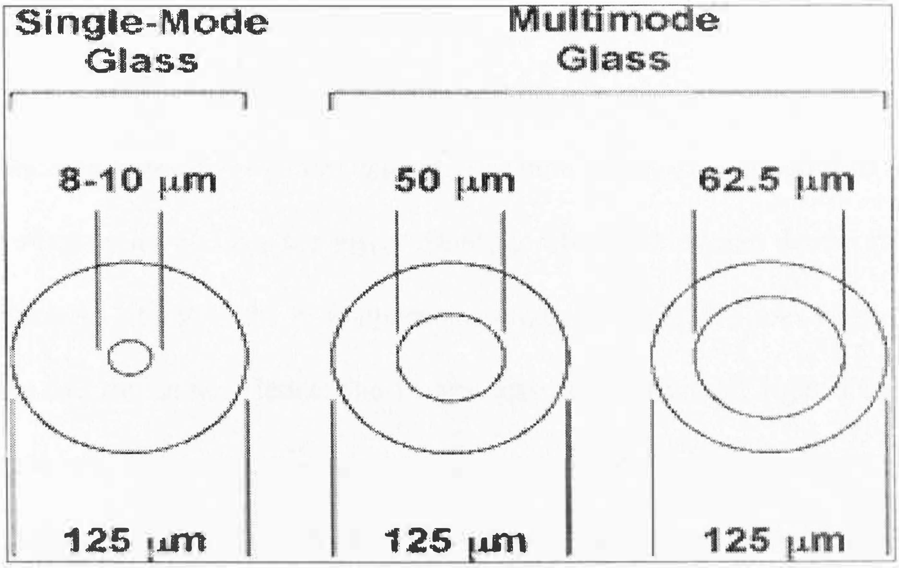

Figure 2.2 Sizes of fiber optics (IEC, 2007)

2.2.2 Material Classification

Fibers can be made up of three types of materials like transparent plastics, glass or plastics-clad silica (PCS), which has a glass core, and the plastic cladding. However, for long distance telecommunication application, glass fiber is the best choice to apply the implementation due to its lower optical attenuation. Glass fiber is made up by silicon dioxide and its core and cladding refractive indexes can change with its purities. To minimize the refractive indexes in core and cladding, boron and fluoride are used. Numerical aperture of these fibers is low, where it will give the loss from the light sources to higher fiber. The fiber loss is measured in unit dB/km (Meardon, 1993). The characteristics of fiber optics are shown in Figure 2.3. Three types of fiber mode used to propagate light. There are,