UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ANALYSIS AND SIMULATION OF SERVICE CONTINUITY ENHANCEMENT BY USING AUTOMATIC PROTECTION SYSTEM (APS) IN FIBER OPTIC COMMUNICATION LINK

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology Bachelor's Degree in Electronics Engineering Technology (Telecommunication) with Honours

by

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DECLARATION

"I hereby declare that this report is result of my own effort except for works that have been cited clearly in the references."

Signature : ……………………………….

Name : ...…………………………….

Date : ……………………………….

APPROVAL

“I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the quality for Bachelor’s Degree in Electronics Engineering Technology (Telecommunication) with Honours

……………………………….

(Project Supervisor)

ABSTRACT

This project is about Analysis & Measurement of Service Continuity Enhancement by Using Automatic Protection System (APS) in Fiber Optic Communication Link. The APS system is important to provide protection for fiber optic communication link that have been used widely nowadays. This system will provide protection for the link and provide fast fault recovery system. The main element of the system is protection fiber and optical switches. This project will analyze the system based on some parameters of the optical switch such as insertion loss, switching time, driving voltage and other parameters of the switch. By analyzing all parameters, the best switch that used in the system can be choose and apply it to the fiber optic communication link.

ABSTRAK

Projek ini adalah tentang Analisis & Pengukuran Peningkatan Perkhidmatan Menggunakan Sistem Perlindungan Automatik (APS) di talian komunikasi gentian optik. Sistem APS adalah penting untuk memberi perlindungan untuk talian komunikasi gentian optik yang telah digunakan secara meluas ketika ini. Sistem ini akan memberikan perlindungan untuk talian dan menyediakan sistem pemulihan yang cepat. Elemen utama dari sistem ini adalah gentian optik dan suis optik. Projek ini akan menganalisa sistem berdasarkan beberapa parameter dari suis optik seperti kadar kehilangan kuasa, masa penukaranan, voltan dan lain-lain. Dengan menganalisis semua parameter, suis terbaik dapat dipilh untuk digunakan di dalam Sistem Perlindungan Automatik.

DEDICATION

This project is dedicated to

My dearest parent,

Ahmad Sarimin Bin Ahmad and Normayati Bte Abd Latef,

All my siblings, and not forget to my friend, who have

Always sincerely pray for my success and glory.

To my Supervisor,

Mr. Chairulsyah bin Abdul Wasli

Thank you for your loving and

taught so that this task can be

accomplished successfully

ACKNOWLEDGEMENT

In the name of Allah S.W.T, The Most Beneficial and The Most Merciful. It is with deepest serve gratitude of the Al-Mighty that gives me strength and ability to complete this final year project report.

First of all, I would like to take this opportunity to express my special thanks to my supervisor, Mr Chairulsyah bin Abdul Wasli for the guidance, assistance, advise, kindness and also being helpful to guide me all the way through the development and progress of my final year project. Above all and the most needed, he provided me unflinching encouragement and support in various ways.

My appreciation also goes to my friends for their advice, supervision, and crucial contribution, which made them a backbone of this project to become successfully.

Thank you for lending hands during progress of the project.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

SNR	=	Signal Noise to Ratio
APS	=	Automatic Protection Switch
GUI	=	Graphical User Interface
PTX	=	Power Transmitter
PRX	=	Power Receiver
AC	=	Alternating current
LED	=	Light emitting diode
dB	=	Decibel
dBm	=	Decibel in Mill watts
ISI	=	Inter Symbol Interface
VAC	=	Volt Alternating Current
VDC	=	Volt Direct Current
ms	=	Millisecond
ST	=	Straight Tip
SC	=	Subscriber Connector
LD	=	Laser Diode

LIST OF APPENDIX

CHAPTER 1
INTRODUCTION

1.0 Background

The objective of this process is to protect the connections passing through the failed fiber link once failure occurs. That means, routing the signals from the switching node at one side of the failed fiber link to the switching node at the other side of the failed fiber link using protection fibers. The APS process will restore the connections that use the failed link in both directions. When the fiber link failed, the failure is detected in the switching node on both sides of the failed link. Then, the APS will take over the transmission link with a lower down time to avoid the data lost. Besides that, when using the APS the failure link will be bypassed. However, APS is not used continuously. When the damaged line was restored and repaired, the transmission line will be automatically via the link to the original.

1.1 Problem Statement

Currently the down time in fiber optic communication link is still too long. Thus, the down time will cause the data lose in communication. Therefore, we need to provide the shortest time and also improve the communication system in fiber optic. In order to solve this problem, APS is requested.

1.2 Objective

The main objective of this research are:

1 To analyse the continuity in Communication link of Fiber Optic using Automatic Protection System (APS).
2 To design a good performance of Automatic Protection System (APS)

3 To improve knowledge about fiber optic communication link and Automatic Protection System (APS)

4 To decrease the down time of Automatic Protection System (APS) in fiber optic communication link.

1.3 Scope Of Works

The scope work for this project is to study the literature review about Automatic Protection Switch (APS). Which is can be from reference book, article and journal. Besides that, there are also to make and design a suitable animation video to explain clearly about APS system. The animation will be use Adobe Flash Cs6 software. Other than that, find out the related theoretical formula and make a analyse the theoretical, simulation and measurement of the data that will get. The data will find from references and practical works. After all the analyse has been done, the process of thesis writing should be followed.

1.4 Expected results

The expected results from the recommended project:

(a) Enable to make attraction animation and capable simulation program.
(b) Simulation program of Automatic Protection System (APS).
(c) Analysis of all finding results.

CHAPTER 2

THEORETICAL BACKGROUND

2.0 Introduction

This chapter provides the literature review on the Automatic Protection Switch system. It is about the process, the mechanism and the parameters that effect the systems. This chapter also shows some of the manufacture that provides the Automatic Protection Switch equipment.

2.1 Introduction to Fiber Optic

The field Optical fiber communication system has existed in the past decades. Fiber optics is a part of modern communication systems, where it is very easy to find along the roads, buildings, hospitals and others. The fiber itself is a strand of silica based glass, its dimensions similar to those of a human hair, surrounded by a transparent cladding. Light can be transmitted along the fiber over great distances at very high data rates providing an ideal medium for the transport of information. Besides that, optical fiber also able to carry light over long distance ranging from a few inches to more than 100km with only little dimming. Cables that used such fibers are commonly being chosen in certain types of communication link. There are also have some single fibers that a thinner than human hair and measure less than 0.00015 inch (0.004 mm) in diameter.

The diagram shows the typical structure of a fibre used for communication links. It has an inner glass core with an outer cladding. This is covered with a protective buffer and outer jacket. This design of fibre is light and has a very low loss, making it ideal for the transmission of information over long distances. Figure 2.1 below show the structure of fiber optic cable.

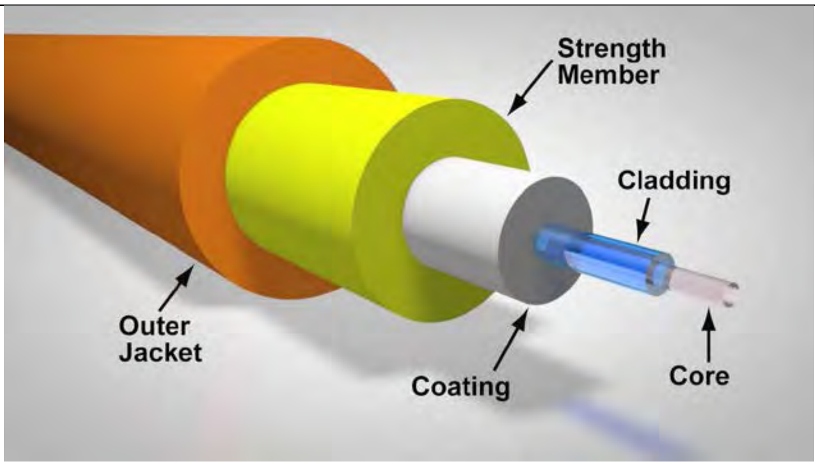

Figure 2.1 Structure of Fiber Optic

The light propagates along the fibre by the process of total internal reflection. The light is contained within the glass core and cladding by careful design of their refractive indices. The loss along the fibre is low and the signal is not subject to electromagnetic interference which plagues other methods of signal transmission, such as radio or copper wire links. The signal is, however, degraded by other means particular to the fibre such as dispersion and non-linear effects (caused by a high power density in the fibre core).

Light from a typical optical source will contain a finite spectrum. The different wavelength components in this spectrum will propagate at different speeds along the fibre eventually causing the pulse to spread. When the pulses spread to the degree where they 'collide' it causes detection problems at the receiver resulting in errors in transmission. This is called Inter symbol Interference (ISI). Dispersion (sometimes called *chromatic dispersion*) is a limiting factor in fibre bandwidth, since the shorter the pulses the more susceptible they are to ISI [Roshene McCool, 2010].

As part of a communication system, an optical transmitter will transmit information in the form of light signals. The signals are generated by a light source such as semiconductor laser or light-emitting diode (LED) at one end of the fiber and detected by a light-sensitive device at the other end which called the receiver part. A fiber optic cable can transmit much more information than an electrical type of cable such as the copper cable at the same size. A major application of optical-fiber cable is in linking two or more points. Many communication parties have installed large network of fiber optic cables across the country and under the oceans to provide information worldwide.

Fiber optic communication systems have many advantages that make them more efficient than the old systems which used copper cable as the medium for transmitting and receiving the data. One of the main advantages is they have a much larger information-carrying capacity than copper cable. Fiber optic cable can carry information signal larger than 10Giga bits per second. Other than that, fiber optic cables are not bothered by electrical interference, and require fewer amplifiers than copper-cable systems [Craig Freudenrich, Ph.D , 2009]. This will save the budget in designing the optical communication link. Other advantages in fiber optic communications link is fiber optic have larger bandwidth over a long distance. Like that has been stated earlier, fiber optic can carry high capacity information signal. The increasing of the capacity will increase the frequency and it shows that fiber optic have larger bandwidth. Generally, fiber optic has bandwidth larger than 400 MHz per km but coaxial cable only has fewer MHz per km.

2.2 Fiber Optic Element in Communication System

For gigabits and beyond gigabits transmission of data, the fiber optic communication is the ideal choice. This type of communication is used to transmit voice, video, telemetry and data over long distances and local area networks or computer networks. A fiber Optic Communication System uses light wave technology to transmit the data over a fiber by changing electronic signals into light.

Some exceptional characteristic features of this type of communication system like large bandwidth, smaller diameter, light weight, long distance signal transmission, low attenuation, transmission security, and so on make this communication a major building block in any telecommunication infrastructure. The subsequent information on fiber optic communication system highlights its characteristic features, basic elements and other details [Tarun Agarwal , 2010].

There are three main basic elements of fiber optic communication system. They are:

1. **Compact Light Source**
2. **Low loss Optical Fiber**

3. **Photo Detector**

Accessories like connectors, switches, couplers, multiplexing devices, amplifiers and splices are also essential elements in this communication system.

1. **Compact Light Source**

Depending on the applications like local area networks and the long haul communication systems, the light source requirements vary. The requirements of the sources include power, speed, spectral line width, noise, ruggedness, cost, temperature, and so on. Two components are used as light sources: light emitting diodes (LED's) and laser diodes.

The light emitting diodes are used for short distances and low data rate applications due to their low bandwidth and power capabilities. Two such LEDs structures include Surface and Edge Emitting Systems. The surface emitting diodes are simple in design and are reliable, but due to its broader line width and modulation frequency limitation edge emitting diode are mostly used. Edge emitting diodes have high power and narrower line width capabilities [Tarun Agarwal , 2010].

For longer distances and high data rate transmission, Laser Diodes are preferred due to its high power, high speed and narrower spectral line width characteristics. But these are inherently non-linear and more sensitive to temperature variations.

Nowadays many improvements and advancements have made these sources more reliable. A few of such comparisons of these two sources are given below. Both these sources are modulated using either direct or external modulation techniques. Figure 2.2 below shown a example of compact light source.

Figure 2.2 Compact light source

2. Low Loss Optical Fiber

Optical fiber is a cable, which is also known as cylindrical dielectric waveguide made of low loss material. An optical fiber also considers the parameters like the environment in which it is operating, the tensile strength, durability and rigidity. The Fiber optic cable is made of high quality extruded glass (si) or plastic, and it is flexible. The diameter of the fiber optic cable is in between 0.25 to 0.5mm (slightly thicker than a human hair).

3. Photo Detectors

The purpose of photo detectors is to convert the light signal back to an electrical signal. Two types of photo detectors are mainly used for optical receiver in optical communication system: PN photo diode and avalanche photo diode. Depending on the application's wavelengths, the material composition of these devices vary. These materials include silicon, germanium, InGaAs, etc.

This is all about the basic elements of the fiber optic communication system. For additional information, and for any kind of assistance, please write to us as we encourage and appreciate your suggestions, feedback, queries and comments [Tarun Agarwal , 2010]. Figure 2.3 below shown the photodetector device.

Figure 2.3 Photodetector

2.3 Loss in Optical Communication System

Each of system in communication, it's have they loss by its own. For this fiber optic communication system, they are have two types of loss. Firstly is a linear scattering losses and secondly are absorption losses.

Linear scattering losses have two types which is Rayleigh scattering losses and MIE scattering losses.

Linear scattering losses is a about the propagation of light through the core of an optical fiber which is based in total internal reflection of the light wave. Other than that, rough and irregular surfaces even at the molecular level, can cause light rays to be reflected in random directions. This is called diffuse reflection or scattering, and it is typically characterized by wide variety of reflection angles [Craig Freudenrich, Ph.D , 2009]. Figure 2.4 and 2.5 below shown the linear scattering in fiber optic cable.

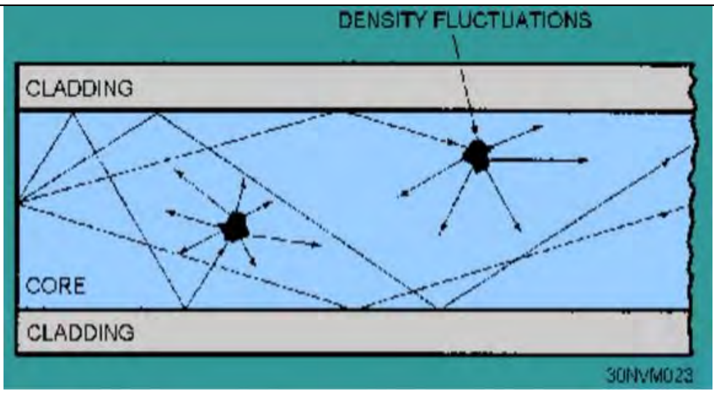

Figure 2.4 Linear scattering (reflection)

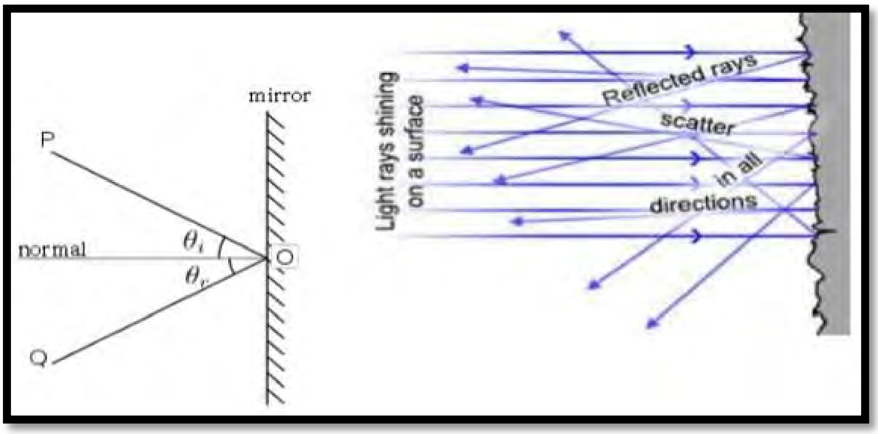

Figure 2.5 Linear Scattering

Light scattering also depends on the wavelength of the light being scattered. Basically, scattering losses are caused by the interaction of light with density fluctuations within a fiber. Density changes are produced when optical fibers are manufactured.

Rayleigh scattering is an atoms and other particles inevitably scatter some of the light that hits them. The light isn't absorbed, just sent in another direction in a process. Figure 2.6 below shown the example of Rayleigh scattering of light.

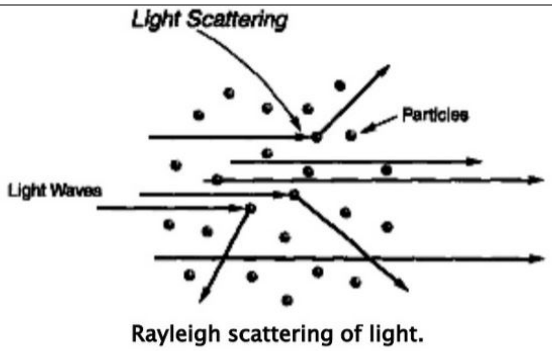

Figure 2.6 Reyleigh Scattering of light

MIE scattering means if the size of the defeat is greater than one-tenth of the wavelength of light. It also caused by these large defects in the fiber core, scatters light out of the fiber core.

The method to remove the losses of scattering is a removed imperfections due to glass manufacturing process, carefully controlled extrusion and coating of the fiber and lastly increase the fiber guidance, which depends on refractive index difference [Craig Freudenrich, Ph.D , 2009].

Second loss that will get in fiber optic communication link are absorption. Absorption is a major cause of signal loss in an optical fiber. Besides that, it's also defined as the portion of attenuation resulting from the conversion of optical power into another energy form, such as heat.

2.4 Fiber Optic Link Failures

The failure classes that are associated with fiber optic networks are classified as patch panel failures, installation failures, and construction failures [Engr Dr Mrs G.N Ezeh and Okwe Gerald Ibe, 2013].

Patch panel failures are failures that create malfunctions in the system by high attenuation. Poor connection points can cause some of these malfunctions when the fiber was terminated with the appropriate connectors. When the fiber is spliced together poorly the signal inside the fiber optic cable can have large dB losses. If the connections were not inserted in the connectors correctly or the fiber cable has fractured parts in the glass, there can be very high attenuation to no signal propagation into other parts of the communication network. This is going to possibly show communication outages within the system. Installation failures are associated with failures that are caused when installing the fiber optic network. If a fiber optic cable is bent past the specification bending radius of the cable then the cable can fail instantly or could possible fail over time. This might not be an automatic failure as mentioned but could be failures later in time as the fiber optics weaken. This mainly happens when the installer is not aware of the specification of the cable and not paying attention to what he or she is doing.

Failures in fiber optics can also be caused by improper dressing and from terminating the fiber optic connections. This kind of installation failure is sort of an overlap from a patch panel failure. When fiber optic cable connections are terminated to the cable poorly, weather it be ST connectors, SC connectors or similar connectors for example, these cables can present a point of failure in the installation process. Terminating fiber optic cable can be a very hard skill to master.

The last failure class is the failures that are related to the construction of the fiber optics networks. These cables are always going to be strung from pole to pole,