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Hands on OFC Link Engineering Implementation for STM-1 ITI Make, STM-4/16 Tejas Make

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Abstract- The main objective of this project is to detect and correct the losses of the optical fiber cable due to breakage in the transmission medium while linking the optical fiber cable In the older days we used trunk cables, coaxial cable and microwave cables for transmission of the signals between one point to another point communication by using these trunk cables,coaxial cable and microwave cables the rate of loss while transmission and reception is more and reliability is also less, and the installation cost is more and also this are not suitable for long distance communications. To overcome all this problems PDH systems by using optical fiber cable has been developed. This PDH system is first implemented system in optical fiber cable. This PDH system uses its own clock frequency system for its operation and this PDH systems uses bit inter leaving process for transmission of data. This PDH system having some limitations, those are this is asynchronous. The maximum capacity of this system is 565.5Mb/sec. This is suitable only for point to point (or) short distance communication. This media system is manually controlled. The accuracy of this PDH system is less. Apart from all this advantages mentioned above, the SDH also have various management capabilities such as performance management, security and access management, and the event or the alarm management. So we can clearly make a distinction between PDH and SDH systems, so that as per the need of the telecommunication, this transmission system is used. We can connect different points in ring topology in SDH system. In this project, we are mainly concentrating on link between two SDH"s and the maintenance of that link engineering through optical fiber cable.

Index Terms- Trunk cables, Coaxial cable, PDH system, SDH

I. Introduction

A major breakthrough leading to high capacity optical communications was achieved with the invention of laser in 1960. The laser acted as a narrow–band source of optical radiation suitable for use as a carrier of information. In 1966, Charles K. Kao at Standard Telecommunications Laboratories, England fabricated a low loss glass fiber, giving a loss of 1000 dB/km or so. Such a fiber could transmit light for a short distance only. But Kao suggested that purer glass materials would permit the use of fiber for longer transmission lengths. Kao had shown that it would be possible to transmit light signals over long distance using glass fiber and modulated infra–red light. In 1970 Corning glass works, U.S.A. developed a low loss fiber giving a loss of 20 dB/km. This was the second major breakthrough to make optical communication a practical reality. By 1972, losses were reduced to 4 dB/km. Today, the best fibers have a loss of < 0.2 dB/km.The amount that a ray of light passing from a lower refractive index to a higher one is bent towards the normal. But light going from a higher index to a lower one refracting away from the normal As the angle of incidence increases, the angle of refraction approaches 90o to the normal. The angle of incidence that yields an angle of refraction of 90^o is the critical angle. If the angle of incidence increases a more than the critical angle, the light is totally reflected back into the first material so that it does not enter the second material. The angle of incidence and reflection are equal and it is called Total Internal Reflection. By Snell's law, n1 sin1 = n2 sin2. At angle greater than the light is reflected, Because reflected light means that n1 and n2 are equal (since they are in the same material). The angle of incidence and reflection are equal. These simple principles of refraction and reflection form the basis of light propagation through an optical fiber.The optical fiber has two concentric layers called the core and the cladding. The inner core is the light carrying part. The surrounding cladding provides the difference refractive index that allows total internal reflection of light through the core. The index of the cladding is less than 1%, lower than that of the core. Typical values for example are a core refractive index of 1.47 and a cladding index of 1.46. Fiber manufacturers control this difference to obtain desired optical fiber characteristics. Most fibers have an additional coating around the cladding. This buffer coating is a shock absorber and has no optical properties affecting the propagation of light within the fiber. Figure shows the idea of light traveling through a fiber. Light injected into the fiber and striking core to cladding interface at grater than the critical angle, reflects back into core, since the angle of incidence and reflection are equal, the reflected light will again be reflected. The light will continue zigzagging down the length of the fiber. Light striking the interface at less than the critical angle passes into the cladding, where it is lost over distance. The cladding is usually inefficient as a light carrier, and light in the cladding becomes attenuated fairly. Propagation of light through fiber is governed by the indices of the core and cladding by Snell's law. Such total internal reflection forms the basis of light propagation through a optical fiber. This analysis considers only meridional rays- those that pass through the fiber axis each time, they are reflected. Other rays called Skew rays travel down the fiber without passing through the axis. The path of a skew ray is typically helical wrapping around and around the central axis. Fortunately skew rays are ignored in most fiber optics analysis.

STEP INDEX MULTIMODE FIBER: This fiber is called "Step Index" because the refractive index changes abruptly from cladding to core. The cladding has a refractive index somewhat lower than the refractive index of the core glass. As a result, all rays within a certain angle will be totally reflected at the core-cladding boundary. Rays striking the boundary at angles grater than the critical angle will be partially reflected and partially transmitted out through the boundary. After many such bounces the energy in these rays will be lost from the fiber. The paths along which the rays (modes) of this step index fiber travel differ, depending on their angles relative to the axis. As a result, the different modes in a pulse will arrive at the far end of the fiber at different times, resulting in pulse spreading which limits the bit-rate of a digital signal which can be transmitted. The maximum number of modes (N) depends on the core diameter (d), wavelength and numerical aperture (NA).

GRADED INDEX MULTI-MODE FIBER: This fiber is called graded index because there are many changes in the refractive index with larger values towards the center. As light travels faster in a lower index of refraction. So, the farther the light is from the center axis, the grater is its speed. Each layer of the core refracts the light. Instead of being sharply reflected as it is in a step index fiber, the light is now bent or continuously refracted in an almost sinusoidal pattern. Those rays that follow the longest path by travelling near the outside of the core, have a faster average velocity. The light travelling near the center of the core, has the slowest average velocity. As a result all rays tend to reach the end of the fiber at the same time. That causes the end travel time of different rays to be nearly equal, even though they travel different paths. The graded index reduces model dispersing to 1ns/km or less. Graded index fibers have core diameter of 50, 62.5 or 85 m and a cladding diameter of 125 cm. The fiber is used in applications requiring a wide bandwidth low model dispersion. The number of modes in the fiber is about half that of step index fiber having the same diameter & NA.

SINGLE MODE FIBER: Another way to reduce model dispersion is to reduce the core's diameter, until the fiber only propagates one mode efficiently. The single mode fiber has an exceedingly small core diameter of only 5 to 10 nm. Standard cladding diameter is 125 nm. Since this fiber carries only one mode, model dispersion does not exists. Single mode fibers easily have a potential bandwidth of 50to 100GHz-km.The core diameter is so small that the splicing technique and measuring technique are more difficult. High sources must have very narrow spectral width and they must be very small and bright in order to permit efficient coupling into the very small core dia of these fibers. One advantage of single mode fiber is that once they are installed, the system's capacity can be increased as newer, higher capacity transmission system becomes available. This capability saves the high cost of installing a new transmission medium to obtain increased performance and allows cost effective increases from low capacity system to higher capacity system. As the wavelength is increased the fiber carries fewer and fewer modes until only one remains. Single mode operation begins when the wavelength approaches the core diameter. At 1300 nm, the fiber permits only one mode; it becomes a single mode fiber. As optical energy in a single mode fiber travels in the cladding as well as in the core, therefore the cladding must be a more efficient carrier of energy. In a multimode fiber cladding modes are not desirable; a cladding with in efficient transmission characteristic can be tolerated. The diameter of the light appearing at the end of the single mode fiber is larger than the core diameter, because some of the optical energy of the mode travels in the cladding. Mode field diameter is the term used to define this diameter of optical energy.

OPTICAL CONNECTORS Optical connectors are the means by which fiber optic cable is usually connected to peripheral equipment and to other fibers. These connectors are similar to their electrical counterparts in function and outward appearance but are actually high precision devices. In operation, the connector centers the small fiber so that its light gathering core lies directly over and in line with the light source (or other fiber) to tolerances of a few ten thousandths of an inch. Since the core size of common 50 micron fiber is only 0.002 inches, the need for such extreme tolerances is obvious.

OPTICAL FIBER PARAMETERS As with any type of Transmission System, there are certain parameters that affect the system‟s operation. Optical fiber systems have the following parameters. 1. Wavelength 2. Frequency 3.Window 4.Attenuation 5.Dispersion 6.Bandwidth 7.Numerical Aperture.

ADVANTAGES OF FIBER OPTICS: Wide Bandwidth The information carrying capacity, which increases with the bandwidth of the transmission medium, is very large in fibers. The bandwidth available on a pair of single mode fibers is in the order of several GHz. Thus, thousands of circuits can be carried on the fibers whether the information is voice, data or video or a combination of these. Low LossBandwidth is an effective indication of the rate at which information can be sent. Loss indicates how far the information can be sent. As a signal travels along a transmission path, be it copper or fiber, the signal loses strength. This loss of strength is known as attenuation. In a copper cable, attenuation increases with the modulation frequency: the higher the frequency of the information signal, the greater is the loss. In an optical fiber, attenuation is flat loss is the same at any signaling frequency until a very high frequency. Thus, the problem of loss is much more in a copper cable as information carrying capacity increases. Fig shows the loss characteristics Vs the channel bandwidth for fibers, and coaxial cable. Loss in coaxial cable increases with frequency, whereas loss in the optical cable remains flat.

II. Existing Work or Literature Survey

The Plesiochronous Digital Hierarchy (PDH) is a technology used in Telecommunications networks to transport large quantities of data over digital transport equipment such as optic and microwave radio systems. PDH allows transmission of data streams that are nominally running at the same rate, but allowing some variation on the speed around a nominal rate. PDH networks run in a state where different parts of the network are nearly, but not quite perfectly, synchronized i.e. there is no synchronization between any two links. The term plesiochronous is derived from Greek plesio, means near and chromos means time.The PDH system effectively develops the idea of primary multiplexing using time division multiplexing (TDM) to generate faster signals. This is done in stages by first combining (multiplexing) E1 or T1 links into what are known as E2 or T2 links, and if required, going even further by combining (multiplexing) E2 or T2 links, etc.This multiplexing hierarchy is known as the Plesiochronous Digital Hierarchy (PDH). Plesiochronous, meaning "almost synchronous," relates to the inputs that can be of slightly varying speeds relative to each other and the system‟s ability to cope with the differences. These groups of signals can be transmitted as an electrical signal over a coaxial cable, as radio signals, or optically via fiber-optic systems. As such, PDH formed the backbone of early optical networks. The aggregate signal can be sent to line at any stage of the hierarchy, using the appropriate transmission medium and modulation techniques.

In February 1988, an agreement was reached at CCITT (now ITU-TS) study group XVIII in Seoul, on set of recommendations, for a synchronous digital hierarchy representing a single world wide standard for transporting the digital signal. These recommendations G-707, G-708, G-709 cover the functional characteristic of the network node interface, i.e. the bit rates and format of the signal passing over the Network Node Interface (NNI).For smooth transformation from existing PDH, it has to accommodate the three different country standards of PDH developed over a time period. The different standards of PDH are given in Figure The first attempt to formulate standards for Optical Transmission started in U.S.A. as SONET (Synchronous Optical Network). The aim of these standards was to simplify interconnection between network operators by allowing inter-connection of equipment from different vendors to the extent that compatibility could be achieved. It was achieved by SDH in 1990, when the CCITT accepted the recommendations for physical layer network interface. The SONET hierarchy from 52 Mbit per second rate onwards was accepted for SDH hierarchy.

The S.D.H. standards exploit one common characteristic of all PDH networks namely 125 micro seconds duration, i.e. sampling rate of audio signals (time for 1 byte in 64 k bit per second). This is the time for one frame of SDH. The frame structure of the SDH is represented using matrix of rows in byte units. As the speed increases, the number of bits increases and the single line is insufficient to show the information on Frame structure. Therefore, this representation method is adopted. How the bits are transmitted on the line is indicated on the top . The Frame structure contains 9 rows and number of columns depending upon synchronous transfer mode level (STM). In STM-1, there are 9 rows and 270 columns. The reason for 9 rows arranged in every 125 micro seconds is as follows: For 1.544 Mbit PDH signal (North America and Japan Standard), there are 25 bytes in 125 micro second and for 2.048 Mbit per second signal, there are 32 bytes in 125 micro second. Taking some additional bytes for supervisory purposes, 27 bytes can be allotted for holding 1.544 Mbit per second signal, i.e. 9 rows x 3 columns. Similarly, for 2.048 Mbit per second signal, 36 bytes are allotted in 125 micro seconds, i.e. 9 rows x 4 columns. Therefore, it could be said 9 rows are matched to both hierarchies.

(i) Synchronous Transport Module This is the information structure used to support information pay load and over head information field organized in a block frame structure which repeats every 125 micro seconds. (ii) Container The first entry point of the PDH signal is the container in which the signal is prepared so that it can enter into the next stage, i.e. virtual container. In container (container-I) the signal speed is increased from 32 bytes to 34 bytes in the case of 2.048 Mbit/s signal. The additional bytes added are fixed stuff bytes (R), Justification Control Bytes (CC and C‟‟), Justification Opportunity bytes (s). In container-3, 34.368 Mbit/s signal (i.e., 534 bytes in 125 micro seconds) is increased to 756 bytes in 125 micro seconds adding fixed stuff bits(R). Justification control bits (C-1, C-2) and Justification opportunity bits (S-1, S-2). Detail follows: 756 bytes are in 9 x 84 bytes/125 micro seconds frame. They are further subdivided into 3 sub frames 3 x 84 (252 bytes or 2016 bits).

(iii) Virtual Container In Virtual container the path over head (POH) fields are organized in a block frame structure either 125 micro seconds or 500 micro seconds. The POH information consists of only 1 byte in VC-1 for 125 micro seconds frame. In VC-3, POH is 1 column of 9 bytes. In VC-4 also POH 1 column of 9 bytes. The types of virtual container identified are lower orders VCs VC-1 and VC-2 and higher order VC-3 and VC-4. (iv) Tributary Unit A tributary unit is a information structure which provides adaptation between the lower order path layer and the higher order path layer. It consists of a information pay load (lower order virtual container) and a tributary unit pointer which indicates the offset of the pay load frame start relating to the higher order VC frame start. Tributary unit 1 for VC-1 and Tributary unit 2 is for VC-2 and Tributary unit 3 is for VC-3,

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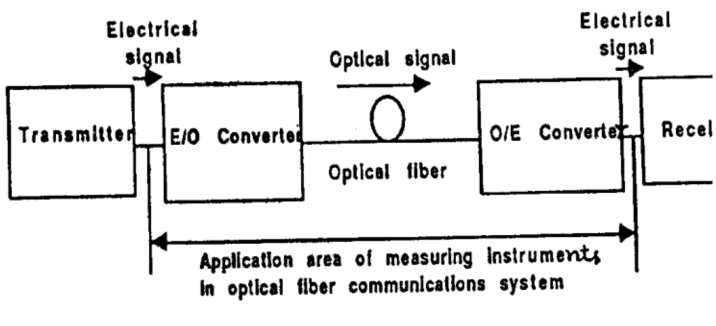
when it is mapped for VC-4 through tributary group-3. TU-3 pointer consists of 3 bytes out of 9 bytes. Three bytes are H1, H2, H3 and remaining bytes are fixed bytes. TU-1 pointers are one byte interleaved in the TUG-2.
(v) Tributary Unit Group One or more tributaries are contained in tributary unit group. A TUG-2 consists of homogenous assembly of identical TU-1s or TU-2. TUG-3 consists of a homogenous assembly of TUG-2s or TU-3. TUG-2 consists of 3 TU-12s (For 2.048 Mbit/sec). TUG-3 consists of either 7 TUG-2 or one TU-3. (vi) Network Node Interface (NNI) The interface at a network node which is used to interconnect with another network node. (vii) Pointer An indicator whose value defines frame offset of a VC with respect to the frame reference of transport entity, on which it is supported. (viii) Administrative Unit It is the information structure which provides adaptation between the higher order path layer and the multiplex section layer. It consists of information pay load and a A.U. pointer which indicates the offset of the pay load frame start relating to the multiplex section frame start. Two AUs are defined (i) AU-4 consisting VC-4 plus an A.U. pointer indicating phase alignment of VC-4 with respect to STM-N frame, (ii) AU-3 consisting of VC-3 plus A.U. pointer indicating phase alignment of VC-3 with respect to STM-N frame. A.U. location is fixed with respect to STM-N frame. (ix) Administrative Group AUG consists of a homogenous assembly of AU-3s or an AU-4. (x) Concatenation The procedure with which the multiple virtual container are associated with one another, with the result their combined capacity could be used as a single container across which bit sequence integrity is maintained.

III. WRITE DOWN YOUR STUDIES AND FINDINGS

Low losses, wide bandwidth, non–inductive transmission without crosstalk and highly insulated, thin and lightweight optical fiber cables have revolutionized the field of Telecommunication. Testing a Fiber–Optic based system requires special instrumentation if the link itself must be checked. The basic structure of communication system using Optical Fiber is shown in figure



Therefore, the most commonly used tests in field are Optical Power and Cable loss. The instrument needed for these tests

Multiplexing Principles The basic multiplexing principles and processing stage by stage, the information signal in C-11, 1.544 Mbit per sec is mapped. In C-12 container, the entry is 2.048 Mbit/sec. In C-2 container the entry, i.e. 6.312 Mbit/sec which is of American standard. These three containers pass through their respective virtual containers and tributary unit pointers. At TUG-2 it can be either 4VC-11 with TU-11 or 3VC-12 with TU-12 or 1 VC-2 with TU-2. The C-3 container takes the input 34 Mb/s or 44.7 Mb/s of the American Standard. These through VC-3 container and with tributary unit-3 go to Tributary Unit Group–3. 3 Nos. VC-3 with AU-3 can directly go to AUG and enter STM-frame. Similarly, 7 TUG-2 can be mapped into one VC-3. Otherwise one VC-3 with TU-3 or 7 TUG-2 can go to TUG-3 and 3 TUG-3 are mapped into one VC-4. A 139.264 Mbit/sec signal can be mapped into one VC-4 through C-4. VC-4 with AU-4 goes to AUG and then to STM-frame. The details of processing and adding pointers from the base level to VC–4 container and then to AUG and then to STM–N where the entry 2M bit/sec is shown. It can be noted that pointers gives the phase alignment between the shaded and unshaded areas, i.e. the pointer locates the position of the virtual container which are floating in the STM–frames. The processing of 34 M/bit signal through VC–3 container and going to Administrative group unit and then to STM frame. 140 M/bit signal is mapped into VC–4 container and then enter into STM frame through AUG. The details of processing 2.048 M/bit signal into VC–3 container and then directly through AUG entering into STM frame. This method is also possible.

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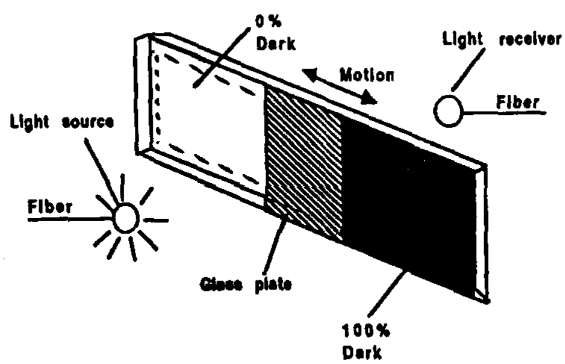
includes a calibrated light source, a light power meter, an optical attenuator, and optical Time Domain Reflectometer.The calibrated light source is the equivalent of a signal generator. It must generate light energy signals of known power levels. These light signals come out through an LED or LASER. The other requirement may be the need to vary the wave–length (frequency) of the light wave, just as a signal generator allows the user to vary the frequency. The reason for this is that optical fibers perform best at specific light wavelengths only (depending on theexact type of glass used) and the light supplied to the optical fiber must have the matching wave-length for that fiber type.



Optical TDR: Using test instrumentation to test your fiber optic cable plant without understanding how they work can be disastrous. While today's instruments are accurate and easy to use, they all require adequate knowledge of their operation and "quirks" to get good data. As an example, we have seen several instances where users of OTDRs (Optical Time Domain Reflectometers) accepted the automatic results of the instruments without evaluating the displays (or perhaps not knowing how to interpret the displays.) The data was highly misleading and the consequence of the bad data was very costly.The reason was simply that the OTDR was being used outside of its normal operating parameters and the interpretation of the display is critical to understanding what is happening in the cable plant. In this section, we will examine the OTDR in detail and show examples of good and bad data. Then we will try to give you guidelines on using them.If you are going to use an OTDR, try to get training from the manufacturer or at least read the manufacturer's manual thoroughly - until you understand it fully. That will help you operate the unit properly. Much of the information here is not included in the manual, which generally only tells you which button to push. This article will help you understand how the instrument works, how to interpret what it is measuring and keep you from being misled by it. The OTDR is an important tool to characterize a fiber‟s attenuation, uniformity, splice loss, breaks ad length. Its main advantage is one–port operation at the fiber input with no need to access the fiber output. These are measured by launching an optical pulse into one end of the optical fiber and detecting reflected pulses (back–scattered light) returning to the instrument. The measuring conditions, items and measured results are displayed on CRT.An optical pulse is launched into one end of fiber. This optical pulse, on encountering microscopic non–uniformities of route, will cause light scattering in all directions. If the size of non–uniformity is much less then, the scattering phenomenon is governed by Rayleigh scattering principle (Scattering coefficient = 1/λ4, i.e. light scattering decreases as the wavelength increases) out of this scattered light a portion of it, i.e. back scattered light, may reach back to the fiber input. In fact, due to limited numerical aperture of the fiber, only a portion of back scattered light reaches the fiber input.

Continuity test: The simplest is the continuity test, to find out whether there is any break in fiber. It requires only a light source and optical power meter. Some light only coupled into the cable and some should be come out the other end. The test is a good or bad test which doesn‟t indicate anything about the cable loss. The light source and power meter do not have to be calibrated or accurate for this simple test. A simple flashlight Is used as the light sorce, and the light coming out can be seen by eye. This is not a recommended practice because in a multi fiber bundle the fiber technician looks into may not be the one with the flashlight at the other end. Instead it may be an active fiber that has a laser LED as it source and eye damage can result. The flashlight and eye should only be used for a single stand of fiber, when the entire length of fiber is visible and there can be no mistakes. Cable loss: To check the cable loss, a measured amount of light energy at a specific wavelength is coupled into the cable, and the amount of output light power is measured. the cable loss is the specified in decibles.since the amount of energy coupled into cable must be known, the light source must be calibrated or the power meter must first be used to measure the output of the source directly and then the output through the cable using the same source.

IV. RESULTS AND DISCUSSION

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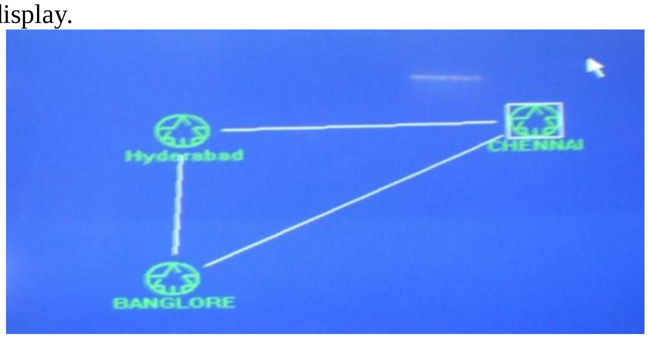
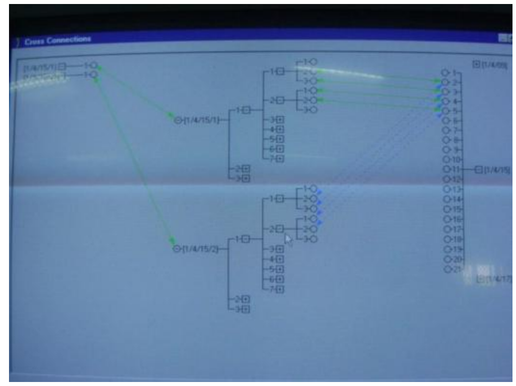
The optical fiber cable is normally having drum length of the order of 2 kms. These cables are normally used for long distance communication. The joints are made at approximately every 2 kms. For joining these cables the fiber are first jointed by using splicing machines similar to joining two glass rods. The other place where the jointing is to be made is in the equipment room where the cable is terminated. There are two types of closures for these purposes, i.e. one for underground application, the typical one which is discussed here is SC–4 splicing closure supplied by SEICOR USA and other is equipment room closure which is called Wall Splicing Closure (WSC).

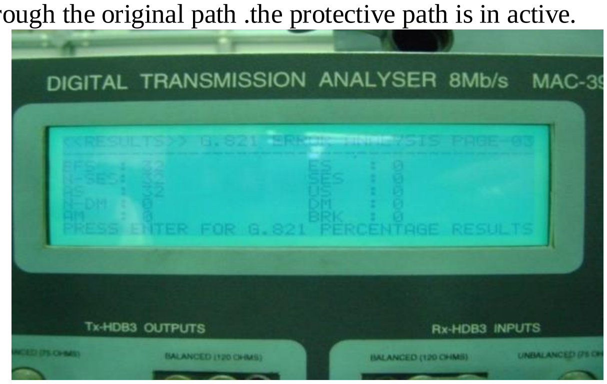
This is the SDH equipment equipped with NM2100 software loaded system administrator. The middle device shown here in this picture is DTA (digital transmission analyzer) which analyses errors in the connection and shows practically on its display.



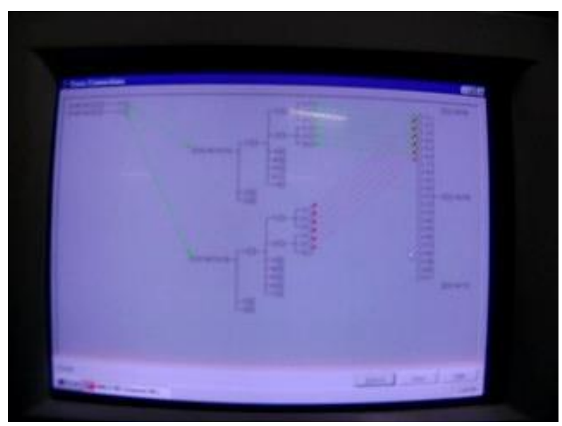
Let us assume these three stations as Hyderabad, Chennai and Bangalore Here station A is Hyderabad Station B is ChennaiStation C is Bangalore The ring is to be established between Bangalore and Chennai. One path is to directly connect Chennai and Bangalore. Other is to establish through Hyderabad, i.e. there should be connection between Chennai and from Hyderabad there will be a connection between Hyderabad to Bangalore. The figures will explain about that.



This is the figure which shows original path in green color and protection path in blue color. In this the traffic now is routed through the original path .the protective path is in active.



The healthy condition of the ring is proved by the DIGITAL TRANSMISSION ANALYZER. The analyzer here shows EFS (error free seconds) as 32 and ES (error seconds) as 0. This ES is the determination of the health y condition of the ring.



When there is a fault or cut in the protection path, the original traffic doesn"t have any problem

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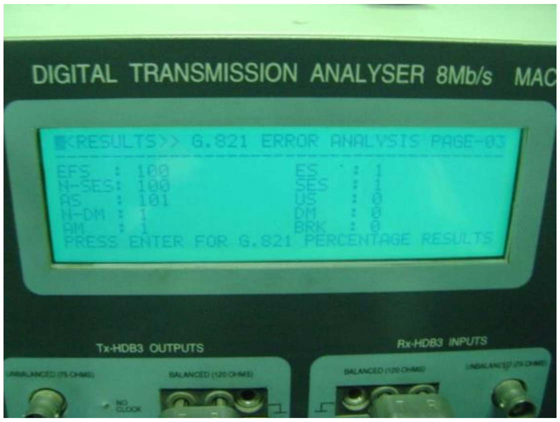
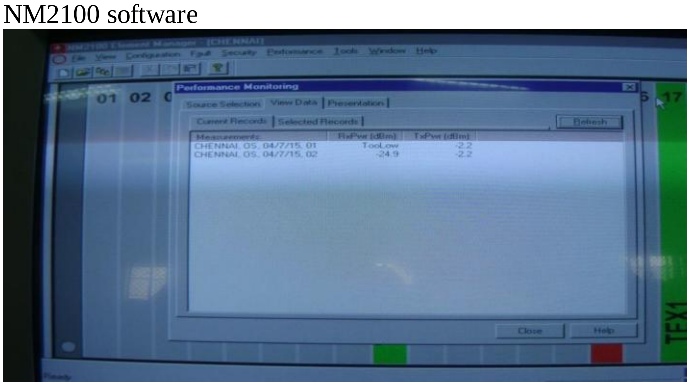
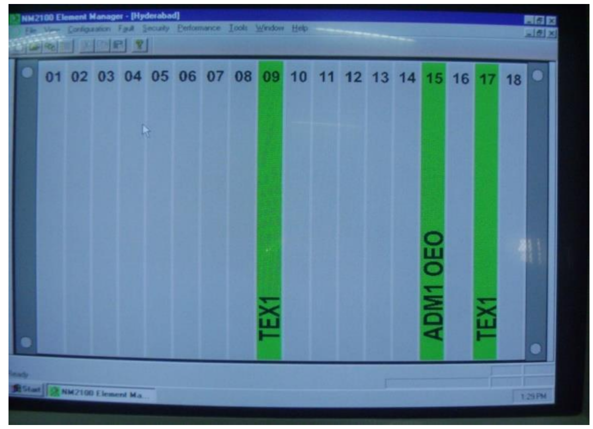


This snap also corresponds to DTA but after the error has occurred. The ES is showing the reading 1. This specifies that practically there is an error occurred in the line which needs to be rectified.When there is a fault in the original path, the traffic is routed to protected path we can analyze the errors as to where the errors are occurred, what type of errors in the NM2100 software



When these errors are corrected then the software will show the healthy condition as below



V. CONCLUSION

The basic structure and characteristics of optical fiber is studied. Basic information about SDH and STM is studied. The receiver sensitivity of a STM terminal is performed. Based on the receiver sensitivity, the cable length, number of splices, numbers of Connectors, system transmit power etc so that the total loss between the two terminals will be within the dynamic range after allowing the maintenance margin to the receiver sensitivity ate decided. From trace we can conclude that the receiver power is within the dynamic range in the established link. The fiber loss, splice loss, connector loss etc., are measured using different testing Instruments. The link established is efficient and is established considering the losses that may occur in the future. Optical fiber communication plays a major role in today‟s communication technology. These transmission medium transfers voice, data and video over long distances. By using STM 1/4/16 we can achieve the high data transmission in order of Giga bits per second.

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