International Journal of Engineering, Science and Mathematics
Vol. 7 Issue 12, December 2018,
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, **Email: ijesmj@gmail.com**
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Optical Time Domain Reflectometerand Optical fiber Cable: Applications, Technology and FutureAspects

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Abstract: With the increased use of optical fibres for digital data transport, copper connections are being phased out. Identifying optical fibre cuts or bends with developing technologies is also critical, because we can't dig and check by binary search to see where the real fibre cut occurred. One of these technologies to check fibre cuts is the optical time domain reflectometer, which uses scattered light to check cuts or bends. This document explains how OTDR scans can be scheduled in conjunction with suggested architecture and how OTDR checks fibre cuts. Finally, the basic optical fibre communication system is briefly discussed, along with its benefits and drawbacks.The future of Optical Fibber also demonstrates how new technology can overcome the inadequacies of old technology.

Keywords: Optical time-domain Reflectometer, Architecture.

1. Introduction:

A core is usually surrounded by a transparent cladding material with a lower index of refraction in optical fibers. In optical fibers, cladding refers to one or more layers of materials with a lower refractive index that are in close proximity to a core material with a higher refractive index. The cladding confines light to the fiber's core via total internal reflection at the interface between the two. In a normal fiber, light propagation in the sheathing is inhibited. Bram van Heel, a Dutch physicist, found how to improve fiber transmission by coating them in 1953. Cladding modes, in which light propagates both in the cladding and the core, are supported by some fibers.Because the cladding of an optical fiber has a greater refractive index than the surrounding medium, which is either air or the primary polymer coating, a cladding mode is restricted to the cladding. In most cases, these modes are undesirable. Modern fibers contain a main polymer topcoat with a slightly higher refractive index than the cladding, so light travelling through the cladding is rapidly attenuated and dissipates after only a few centimeters. A double-clad fiber, which is designed to accommodate a mode in its inner cladding as well as one in its core, is an exception to this rule.Fiber-optic communication is a way of transferring light pulses across an optical fiber to transport data from one location to another. The light is modified to carry information and produces an electromagnetic carrier wave. Fiber-optic communication systems, which were first created in the 1960s, transformed the telecommunications industry and ushered in the Information Age. Optical fibers have essentially supplanted copper wire communications in core networks in the developed world due to their benefits over electrical transmission.The following are the basic steps in the fiber-optic communication process: Using a transmitter, relaying the signal through the fiber, ensuring that the signal does not become too distorted or weak, receiving the optical signal and turning it into an electrical signal are all steps in the optical signal creation process.

An optoelectronic instrument called an OTDR is used to characterize optical fibers. An OTDR is the optical equivalent of an electrical time domain reflectometer. It injects a series of optical pulses into the fiber under test and collects light scattered (Rayleigh backscatter) or reflected back from places along the fiber from the same end of the fiber. The optical fiber is identified by the scattered or reflected light that is gathered back. An electronic time-domain reflectometer monitors reflections induced by changes in the impedance of the cable under test in the same way. The return pulse strength is measured and integrated as a function of time, then plotted against fiber length.

Figure 1: OTDR

2. Working

The OTDR works in a different way than sources and power metres, which directly monitor the loss of the fibre optic cable plant. The transmitter and receiver of the fibre optic transmission link

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are duplicated in the source and metre, resulting in a measurement that closely resembles actual system loss. The OTDR, on the other hand, uses the fiber's backscattered light to indicate loss. The OTDR works in the same way as a RADAR, sending a high-powered laser light pulse down the fibre and seeking for return signals from backscattered light or reflected light from connector or splice interfaces. The OTDR perceives the light scattered by the pulse going through a portion of the fibre at any given time.Although only a small quantity of light is scattered back toward the OTDR, it is possible to make measurements over quite long distances using sensitive receivers and signal averaging. The OTDR can measure time, calculate the pulse position in the fibre, and connect what it sees in backscattered light with a real location in the fibre since the speed of the pulse can be calibrated as it moves down the fibre. As a result, it may generate a visual representation of the amount of backscattered light at any point along the fibre.The amount of power in the test pulse diminishes as it moves down the fibre in the cable plant under test because the pulse is attenuated in the fibre as it passes along the fibre and suffers loss in connections and splices. As a result, the amount of light that is backscattered will be reduced, giving a representation of the real loss in the fibre. Because the process occurs twice, once on the way out from the OTDR and once on the way back from the scattering at the test pulse, some calculations are required to translate this information into a display. An OTDR display contains a lot of information.The attenuation coefficient of the fibre is shown by the slope of the fibre trace, which is calibrated in dB/km by the OTDR. To evaluate fibre attenuation, you'll need a lengthy length of fibre with no OTDR resolution aberrations or overloading owing to high reflections on either end. When measuring loss, avoid the segment of the fibre that appears nonlinear at either end, especially near a reflecting event like a connector. In OTDR lingo, connectors and splices are referred to as "events."

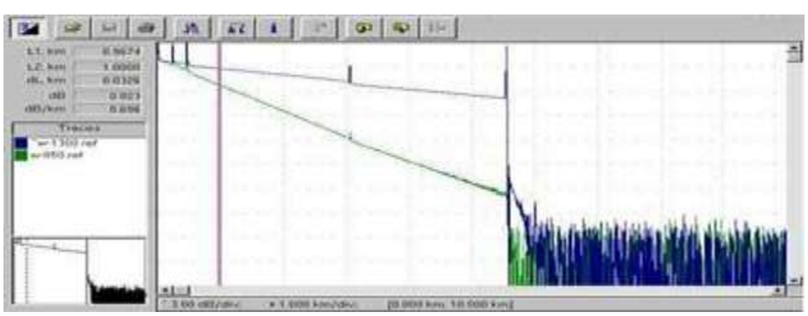

Figure 2: OTDR Graph

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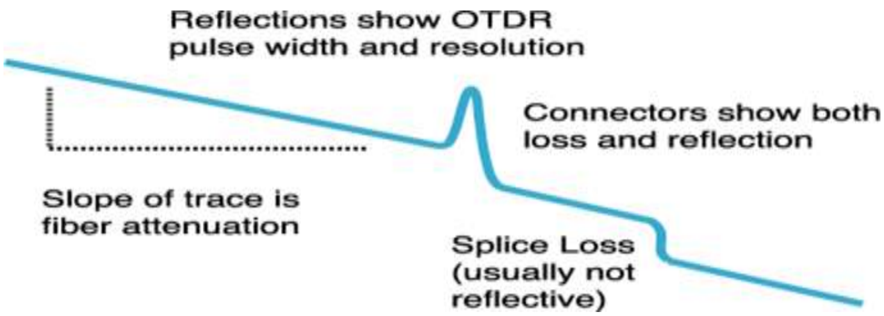

Figure 3: OTDR Graph Explanation

Connectors and mechanical splices will both exhibit a loss, but connectors and mechanical splices will also show a reflecting peak, allowing you to identify them from fusion splices. Unless the peak is so enormous that it saturates the OTDR receiver, the height of that peak will also show the quantity of reflection at the event. The far end of the peak will have a flat top and tail, suggesting that the receiver was overloaded. The OTDR's distance resolution, or how close it can detect events, is indicated by the breadth of the peak.

3. Fiber Types:

Stepindexfiber: The refractive index of the core in a step index fiber is uniform throughout and abruptly changes at the core cladding boundary. The light rays propagating through the fiber are meridional rays that cross the fiber axis at the core cladding border and propagate in a zigzag pattern.

Gradedindexfiber: The refractive index of the core in a graded index fiber is engineered to vary in a parabolic manner, with the largest value of refractive index at the core's center. The light rays passing through it are skew rays or helical rays, which never cross the fibre axis and propagate in a helical (or) spiral pattern around it. Multimode fibers and single mode fibers are distinguished by the number of modes propagating through the fiber.

4. Applications

Optical fiber is used by many telecommunications companies to transmit telephone signals,Internet communication and cable television signals. Due to much lower attenuation and interference, optical fiber has large advantages over existing copper wire in long-distance, high-demand applications. However, infrastructure development within cities was relatively difficult and time-consuming, and fiber-optic systems were complex and expensive to install and operate. Due to these difficulties, fiber-optic communication systems have primarily been installed in long-distance applications, where they can be used to their full transmission capacity, offsetting the increased cost. The prices of fiber-optic communications have dropped considerably since 2000. The price for rolling out fiber to the home has currently become more cost-effective than that of rolling out a copper based network. Prices have dropped to $850 per subscriber in the US andlower in countries like The Netherlands, where digging costs are low and housing density is high.

Since 1990, when optical-amplification systems became commercially available, the telecommunications industry has laid a vast network of intercity and transoceanic fiber communication lines. By 2002, an intercontinental network of 250,000 km of submarine communications cable with a capacity of 2.56 Tb/s was completed, and although specific network capacities are privileged information, telecommunications investment reports indicate that network capacity has increased dramatically since 2004.

The focus of development for the fifth generation of fiber-optic communications is on extending the wavelength range over which a WDMsystem can operate. The conventional wavelength window, known as the C band, covers the wavelength range 1.53–1.57 μm, and dry fiberhas a low-loss window promising an extension of that range to 1.30–1.65 μm. Other developments include the concept of "optical solitons", pulses that preserve their shape by counteracting the effects of dispersion with the nonlinear effects of the fiber by using pulses of a specific shape.

In the late 1990s through 2000, industry promoters, and research companies such as KMI, and RHK predicted massive increases in demand for communications bandwidth due to increased use of the Internet, and commercialization of various bandwidth-intensive consumer services, such as video on demand. Internet protocol data traffic was increasing exponentially, at a faster rate than integrated circuit complexity had increased under Moore's Law. From the bust of the dot-com bubble through 2006, however, the main trend in the industry has been consolidation of firms and offshoring of manufacturing to reduce costs. Companies such as Verizon and AT&T have taken advantage of fiber-optic communications to deliver a variety of high-throughput data and broadband services to consumers' homes.

5. Technology:

Transmitters: Semiconductors like light-emitting diodes (LEDs) and laser diodes are the most common optical transmitters. LEDs and laser diodes vary in that LEDs produce incoherent light whereas laser diodes produce coherent light. Semiconductor optical transmitters must be developed to be compact, efficient, and dependable for use in optical communications, while functioning in an optimal wavelength range and directly modulated at high frequencies. Furthermore, because of their low recombination time, semiconductor lasers can be manipulated directly at high frequencies. VCSEL (Vertical Cavity Surface Emitting Laser) and DFB are two common types of semiconductor laser transmitters used in fiber optics (Distributed Feed Back). The light output of laser diodes is frequently directly modulated, which means that a current provided directly to the device controlsthe light output.

Receivers: An optical receiver's main component is a photo detector, which uses the photoelectric effect to turn light into electricity. A semiconductor-based photodiode is commonly used as the photo detector. P-n photodiodes, p-i-n photodiodes, and avalanche photodiodes are examples of photodiodes. Due to its adaptability for circuit integration in regenerators and wavelength-division multiplexers, metal-semiconductor-metal (MSM) light detectors are also used. Before the data is handed on, additional signal processing such as clock recovery from data (CDR) accomplished by a phase-locked loop may be used.

Amplifiers: Fiber attenuation and fiber distortion have traditionally limited the transmission distance of fiber-optic communication systems. These issues have been solved by employing opto-electronic repeaters. These repeaters transform the signal to an electrical signal, which is subsequently retransmitted at a higher strength than before. The cost of these repeaters is very high due to the tremendous complexity of modern wavelength-division multiplexed signals (including the fact that they required to be installed around once every 20 kilometers). Another option is to utilize an optical amplifier, which directly amplifies the optical signal without the need to convert it to the electrical domain.

Wavelength-division multiplexing: Wavelength-division multiplexing (WDM) is a technique for increasing the capacity of optical fibers by using numerous parallel channels, each with its own wavelength of light. In the transmission equipment, a wavelength division multiplexer is required, as well as a multiplexer (basically a spectrometer) in the receiving equipment. For

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multiplexing and multiplexing in WDM, arrayed waveguide gratings are often utilized.

6. Comparison with electrical transmission

For a given system, a number of trade-offs must be considered when deciding between optical fibre and electrical (or copper) transmission. Optical fibre is typically used in systems that require more bandwidth or need to travel greater distances than electrical cabling can provide. The main advantages of fibre are its extremely low loss (allowing for long distances between amplifiers/repeaters), the absence of ground currents and other parasitic signal and power issues common in long parallel electric conductor runs (due to its reliance on light rather than electricity for transmission and the dielectric nature of fibre optics), and its inherently high data-carrying capacity. To replace a single high-bandwidth fibre connection, thousands of electrical links would be required.Another advantage of fibres is that, unlike some types of electrical transmission lines, fibre cables effectively have no crosstalk even when run beside each other over extended distances. Fibber can be laid alongside utility lines, power lines, and railroad tracks in regions where there is a lot of electromagnetic interference (EMI). Electrical transmission is commonly favoured in short-distance and low-bandwidth applications because of its:

- Lower material costs when big quantities aren't needed; • Lower transmitter and receiver costs
- Capability to carry both electrical and signal power (in specially designed cables).
- Transducer operation in linear mode is simple.
- There are no sparks, which is critical in flammable or explosive gas conditions.
- It is difficult to tap without disturbing the transmission since it does not emit electromagnetic radiation, which is critical in high-security applications.
- Much smaller cable size—important in situations where the path is constrained, such as when networking an existing building, when smaller channels can be dug and space in existing cable ducts and trays can be saved.
- Corrosion resistance due to non-metallic transmission medium

7. Limitations

- The bend radius of optical fibre cables is limited (about 30 mm). As a result, if they are twisted more, signal loss may occur. Bend resistant fibres, which have a higher bending tolerance, have just been introduced.
- Unlike copper UTP cables, which (usually) have standard Rj-45 jacks and connectors, optical fibre cables have a variety of connectors, which adds to the confusion.
- By bending ordinary optical fibre cables, some signal leakage can be created, which can be utilised to steal the information contained within them. So, while it may be difficult to do so, they are not completely tamper-proof.
- There are outdoor fiber cables but they need to be shielded well. This shielding makes them less agile/ flexible to run in all the places and it increases the cost of cables as well.

8. Future Aspects

- As wireless demand grows in the near future, making the most of limited bandwidth will become increasingly important. The Institute of Technology in Atlanta's optical networking group is demonstrating how to maximise wireless capacity and bandwidth by breaking wireless signals into separate components and then transporting them by optical fibre to their destination, where they are re-integrated. Optical fibre is used for long-range links, however wireless is used for the last few tens of metres. As a result, users may connect wirelessly at significantly higher bandwidths across longer distances than they could without using fibre.
- The terahertz band is relatively unexplored and unexploited because its range of frequencies is too high for conventional electronics and too small for semiconductor lasers and detectors, but new research to be presented at OFC/NFOEC reflects what scientists have always known - the terahertz band has great potential. One of a faculty of Institute in Berlin will explore the use of the terahertz band for applications in security, medicine, and materials science and the role telecommunications technologies play in its developments. Terahertz radiation, unlike other scanning technologies, can penetrate materials like paper, clothing and plastics and remain harmless to humans. So, terahertz spectra can indicate explosives or analyze complex pharmaceutical substances where today's technologies, such as X-rays, cannot.
- Data transmission capacity has increased dramatically in recent years, as has demand for it.

Although the current optical communication band (1.5 micron wavelength) is adequate for the time being, the massive increase in traffic projected in the future necessitates that scientists and engineers begin investigating alternative bands right once.

- IBM has created a transceiver that can enhance chip-to-chip bandwidth on printed circuit boards to 300 Gigabits per second (Gb/s), the fastest rate to date and a step toward even faster data transfer speeds in homes and businesses. The gadget, which is made up of very low-cost components that could be mass-produced in the future, has a bi-directional data rate that is roughly twice that of an earlier IBM transceiver. Two specific advancements have resulted in this higher bandwidth.

9. Conclusion

The main benefits of fiber are its exceptionally low loss (allowing long distances between amplifiers/repeaters), its absence of ground currents and other parasite signal and power issues common to long parallel electric conductor runs (due to its reliance on light rather than electricity for transmission, and the dielectric nature of fiber optic), and its inherently high data-carrying capacity. Thousands of electrical links would be required to replace a single high bandwidth fiber cable. Another benefit of fibers is that even when run alongside each other for long distances, fiber cables experience effectively no crosstalk, in contrast to some types of electrical transmission lines. Fiber can be installed in areas with high electromagnetic interference (EMI), such as alongside utility lines, power lines, and railroad tracks. Nonmetallic all-dielectric cables are also ideal for areas of high lightning-strike incidence.I detailed what OTDR is and the architecture for OTDR scheduling in my paper. Why is scheduling necessary, and how does it benefit telecom operators who are converting from copper to optical cables without having to dig to see where optical fibre cuts or damage occurred? If you have the correct instruments and follow industry testing standards, evaluating fibre optic cable plants is simple. When it comes to diagnosing difficulties, you'll need to think outside the box to come up with ways that can help you uncover issues that don't show up on typical tests. It's critical to understand how your tools function, as well as their limitations and how to work around them. So that you may call with queries, get to know the applications support personnel at your instrument manufacturer.Finally, having comprehensive cable plant documentation is really beneficial, since knowing what you're looking at makes finding problems much easier. This paper goes over the basics of optical fibre communication systems, including their basic models and varieties. Following that, it discusses the technology employed and how it differs from the typical electrical transmission system. It goes over the benefits and drawbacks of an optical fibre communication system. Finally, it depicts all of the future elements that will be available on the market, some of which have become obsolete and others which are still in use for research and development.

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