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Optical Fiber Communication

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Abstract

Fibre optics Systems are important telecommunication infrastructure for worldwide band broadband networks .Optical Fibre increases the speed of data transfer .The transmission through its high bandwidth can easily transmitted from transmitter to receiver with minimal losses. This paper deals with communication using optical fibres .Factors on which optical communication depends. The recent development in the field of optical fibre communication as well advances in the different fibre types & their properties, optical sources, detectors compatible with fibres. The current trends towards next generation.

Keywords: Broadband, Optical fibre, Bandwidth, Detectors, Optical sources, Communication.

1. Introduction

We use many modern technologies for communication in the modern world. Of these the most important one is the optical fiber communication. It refers to the medium and also the technology related to the transmission of data as light pulses on a glass or plastic wire or fiber. optical fiber carries rather more data than typical copper wire and is generally not subject to electromagnetic interference and the need to retransmit signals. Most of the telephone companies are currently using optical fiber for long-distance communication.Transmission on optical fiber wire needs repeaters at distance intervals.[1] The glass fiber needs additional protection within an outer cable than copper. For these reasons and because the installation of any new wiring is labor-intensive, few communities however have optical fiber wires or cables from the phone company's branch office to local customers. The major driving force behind the widespread use of fibre optics communication is the high and rapidly increasing consumer and commercial demand for more telecommunication capacity and internet services, with fibre optic technology capable of providing the required information capacity (larger than both wireless connections and copper cable). Advances in technology have enabled more data to be conveyed through a single optical fibre over long distances. The transmission capacity in optical communication networks are significantly improved using wavelength division multiplexing. Now a days, the optical communications up to 100 Gb/s for several kilometres have been introduced and the research is now focused to develop fibre optic system up to terabits per second (Tb/s).[2]

2. Literature Review

Fibre optic communication network has been primarily used for Distribution Automatic System (DAS) due to huge bandwidth and dielectric immunity. Hwang and choir [2] has proposed a complex network, where WLANs are linked into a fibre optic network to expand DAS in distribution lines in cost effective manner. They have designed a DAS wireless bridge for proposed communication network using IEEE 802.11 a WLAN technology and feasibility checked experimentally in terms of effective transmission speed and sensitivity of signal received .Malevich et al. have analysed optical back propagation (OBP) technique that utilised two highly non linear fibres to compensate for transmission fibre non-linear effects.ShengLi has reviewed the emerging technologies for advancing the Fibre optic data communication bandwidth for the next generation broadband networks. Alnajjar et al.[3] have proposed a smart communication platform system (SCPS) based station to verify the aptitude of system performance used to handle and support the communication network in disaster areas.Bhosale and Deosarkar carried out performance analysis of Spectral Phase Encoding optical code-division multiple-access scheme based on wavelength/time (W/T) codes and random phase codes. A novel technique was proposed by Wu et al [4]for modulation format-transparent polarization tracking and the demultiplexing to identify the polarization state independently of the modulation format. Li et al. experimentally demonstrated for the first time, millimetre-wave (mm-wave) generation in the E-band (71–76 GHz and 81–86 GHz) based on photonics generation technique. Xuet al. used a simple low cost and highly sensitivity fibre optical sensor system to measure the refractive index (RI). Wu et al.Presented a novel fibre-optic chaos synchronization system allowing bidirectional long-distance communication.Narimanov et al. [5] have developed a method to calculate the information capacity of a nonlinear channel and computed the decrease in channel capacity for fibre optic communication systems. A new methodology to design long-haul fibre optic communication systems has been designed by Pedda nara ppagari and Brandt Pearce Pham et al.experimentally demonstrated a simple, cost-effective hybrid gigabit fibre Wireless system for in-building wireless access. Recent advances in developing NOLM-basedall-optical processing techniques were presented by Boscole et al for application in fibre-optic communication. Bungeet al. have theoretically investigated aring launching scheme based on hollow optical fibre (HOF) to increase the bandwidth for multimode Gigabit Ethernet communication Taylor and Thacker et al reviewed The application of fibre optic communication for satellite communications due to its low weight, large bandwidth capacity and simple architecture for data bussing, electromagnetic interference (EMI) invulnerability and cost-effectiveness. Jamieson discussed the fibre optic system as a means of protecting communication line against the effects of nuclear explosion. Douglas et al. reviewed the concepts and the need of fibre optics network with high speed ECL systems. Fidler and Knapek performed the experimental field trials for optical communications from and to high-altitude platforms (HAPs) to transmit data at multi Gigabits per second .Zhou et al. systematically analysed the security factors of Optic based Information Communication Infrastructures (OICl) physical layer. The above literature reveals that Fibre optic communication system has huge scope for large number of applications like communication automation of electricity distribution system, military applications etc for a country like India. [6]

3. Future Trends in Fiber Optics Communication

Fibre optics communication is definitely the future of data communication. The evolution of fibre optic communication has been driven by advancement in technology and increased demand for fibre optic communication. It is expected to continue into the future, with the development of new and more advanced communication technology. Below are some of the envisioned future trends in fibre optic communication.

A. All Optical Communication Networks

An all fibre optic communication is envisioned which will be completely in the optical domain, giving rise to an all optical communication network. In such networks, all signals will be processed in the optical domain, without any form of electrical manipulation. Presently, processing and switching of signals take place in the electrical domain, optical signals must first be converted to electrical signal before they can be processed, and routed to their destination. After the processing and routing, the signals are then re-converted to optical signals, which are transmitted over long distances to their destination. This optical to electrical conversion, and vice versa, results in added latency on the network and thus is a limitation to achieving very high data rates. Another benefit of all optical networks is that there will not be any need to replace the electronics when data rate increases, since all signals processing and routing occurs in the optical domain [9]. However, before this can become a reality, difficulties in optical routing, and wavelength switching has to be solved. Research is currently ongoing to find an effective solution to these difficulties.

B. Multi – Terabit Optical Networks

Dense Wave Division Multiplexing (DWDM) paves the way for multi-terabit transmission. The world-wide need for increased bandwidth availability has led to the interest in developing multi-terabit optical networks. Presently, four terabit networks using 40 GB/s data rate combined with 100

DWDM channels exist. Researchers are looking at achieving even higher bandwidth with 100 GB/s. With the continuous reduction in the cost of fiber optic components, the availability of much greater bandwidth in the future is possible. [13]

C. Intelligent Optical Transmission Network

Presently, traditional optical networks are not able to adapt to the rapid growth of online data services due to the unpredictability of dynamic allocation of bandwidth, traditional optical networks rely mainly on manual configuration of network connectivity, which is time consuming, and unable to fully adapt to the demands of the modern network. Intelligent optical network is a future trend in optical network development [2], and will have the following applications: traffic engineering, dynamic resource route allocation, special control protocols for network management, scalable signalling capabilities, bandwidth on demand, wavelength rental, wavelength wholesale, differentiated services for a variety of Quality of Service levels, and so on. It will take some time before the intelligent optical network can be applied to all levels of the network, it will first be applied in long-haul networks, and gradually be applied to the network edge [10].

D. Ultra – Long Haul Optical Transmission

In the area of ultra-long haul optical transmission, the limitations imposed due to imperfections in the transmission medium are subject for research. Cancellation of dispersion effect has prompted researchers to study the potential benefits of soliton propagation. More understanding of interactions between the electromagnetic light wave and the transmission medium is necessary to proceed towards an infrastructure with the most favorable conditions for a light pulse to propagate [11].

E. Improvements in Laser Technology

Another future trend will be the extension of present semiconductor lasers to a wider variety of lasing wavelengths [12]. Shorter wavelength lasers with very high output powers are of interest in some high density optical applications. Presently, laser sources which are spectrally shaped through chirp managing to compensate for chromatic dispersion are available. Chirp managing means that the laser is controlled such that it undergoes a sudden change in its wavelength when firing a pulse, such that the chromatic dispersion experienced by the pulse is reduced. There is need to develop instruments to be used to characterize such lasers. Also, single mode tunable lasers are of great importance for future coherent optical systems. These tunable lasers lase in a single longitudinal mode that can be tuned to a range of different frequencies.

F. Laser Neural Network Nodes

The laser neural network is an effective option for the realization of optical network nodes. A dedicated hardware configuration working in the optical domain and the use of ultra-fast photonic sections is expected to further improve the capacity and speed of telecommunication networks [12]. As optical networks become more complex in the future, the use of optical laser neural nodes can be an effective solution. Polymer Optic Fibers Polymer optical fibers offer many benefits when compared to other data communication solutions such as copper cables, wireless communication systems, and glass fiber. In comparison with glass optical fibers, polymer optical fibers

Provide an easy and less expensive processing of optical signals, and are more flexible for plug interconnections [13]. The use of polymer optical fibers as the transmission media for aircrafts is presently under research by different Research and Development groups due to its benefits. The German Aerospace Center has concluded that "the use of Polymer Optical Fibers multimedia fibers appears to be possible for future aircraft applications [4]. Also, in the future, polymer optical fibers will likely displace copper cables for the last mile connection from the telecommunication company's last distribution box and the served end consumer [5]. The future Gigabit Polymer Optical Fiber standard will be based on Tomlinson-HarashimaPrecoding,Multilevel PAM Modulation, and Multilevel Coset Coding Modulation.

G. High – Altitude Platforms

Presently, optical inter satellite links and orbit-to-ground links exists [6], the latter suffering from unfavorable weather conditions [7]. Current research explores optical communication to and from high altitude platforms. High altitude platforms are airships situated above the clouds at heights of 16 to 25Km, where the unfavorable atmospheric impact on a laser beam is less severe than directly above the ground [12].

H. Improvements in Optical Transmitter/Receiver Technology

In fibre optics communication, it is important to achieve high quality transmission even for optical signals with distorted waveform and low signal to noise ratio during transmission. Research isongoing to develop optical transceivers adopting new and advanced modulation technology, with excellent chromatic dispersion and Optical Signal to Noise Ratio (OSNR) tolerance, which will be suitable for ultra-long haul communication systems. Also, better error correction codes, which are more efficient than the present BCH concatenated codes are envisioned to be available in the nearest future. [11]

I. Improvement in Optical Amplification Technology

Erbium Doped Fiber Amplifier (EDFA) is one of the critical technologies used in optical fiber communication systems. In the future, better technologies to enhance EDFA performance will be developed.[9] In order to increase the gain bandwidth of EDFA, better gain equalization technology for high accuracy optical amplification will be developed. Also, in order to achieve a higher output power, and a lower noise figure, high power pumping lasers that possess excellent optical amplification characteristics with outputs of more than

+20dBm, and very low noise figure are envisioned to exist in the nearest future. [10]

J. Advancement in Network Configuration of Optical Submarine Systems

In order to improve the flexibility of network configuration in optical submarine communication systems, it is expected that he development of a technology for configuring the mesh network will be a step in the right direction. Presently, most large scale optical submarine systems adopt the ring Configuration. By adopting the optical add/drop multiplexing technology that branches signals in the wavelength domain, it is possible to realize mesh network configuration that directly interconnects the stations. Research is ongoing, and in the future such network configuration will be communications.[1]

k. Improvement in WDM Technology

Research is ongoing on how to extend the wavelength range over which wave division multiplexing systems can operate. Presently, the wavelength window (C band) ranges from 1.53-1.57µm. Dry fiber which has a low loss window promises an extension of the range to 1.30 – 1.65 µm. Also, developments in optical filtering technology for wave division multiplexing are envisioned in the future. [4]

L.Improvements in Glass Fiber Design and Component Miniaturization

Presently, various impurities are added or removed from the glass fiber to change its light transmitting characteristics.[7] The result is that the speed with which light passes along a glass fiber can be controlled, thus allowing for the production of customized glass fibers to meet the specific traffic engineering requirement of a given route. This trend is anticipated to continue in the future, in order to produce more reliable and effective glass fibers. Also, the miniaturization of optical fiber communication components is another trend that is most likely to continue in the future.[13]

4. Conclusion

Fibre optic transmission has found a vast array of applications in computer systems. Some design considerations depend largely on the application. For certain terminal to terminal application, crucial factors including maximising transmission speed and distance and minimising fibre and splice loss. By contrast, connector loss becomes important in local area networks that operate within buildings. In other systems, it is important to minimise the cost of cable, with the intention of reducing the cost of terminal equipment. These system considerations make design and construction of practical fibre optic systems a difficult task. Guidelines appropriate for one system are usually not suitable for another system.

There are a number of essential points about fiber optics that have been mentioned throughout this report. As we move towards a more sophisticated and modern future, the uses of fibre optics are going to grow in all computer systems as well as telecommunication networks. Modern information systems handle ever-increasing data loads which strain the data throughput ability of information systems. Designers have made significant progress in increasing processor speeds, however progress in the design of high-speed interconnection networks has lagged so much so that the most significant bottleneck in today's information systems is the low speed of communications between integrated chips. These low speed communications networks consume increasing amounts of power in an effort to keep up with the faster processors. The slow communications speed is brought on by the small bandwidth available to existing communications networks based on the propagation of electrical signals through metallic lines.

Optical interconnections offer several advantages over metallic interconnections, they include: higher bandwidth; higher interconnection densities; lower crosstalk; crosstalk which is independent of data rate; inherent parallelism; immunity from electromagnetic interference and ground loops; the ability to exploit the third dimension; lower clock and signal skew; and a higher fan-in/fan-out capability. These advantages mean that optical interconnections have the potential to exhibit higher data rate communication, higher densities of interconnections with lower crosstalk, and lower power consumption. The shortest interconnections however, will remain electrical ones, due in part to the inverse relationship between electrical interconnection length and power consumption, and to a length independent minimum latency time inherent to optical interconnections caused by the time delays required for electrical to optical to electrical conversion.

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