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Ofc based communication

Method of transmitting information An optical fiber patching cabinet. The yellow cables are single mode fibers; the orange and blue cables are multi-mode fibers: 62.5/125 µm OM1 and 50/125 µm OM3 fibers, respectively. Stealth Communications fiber crew installing a 432-count dark fiber cable underneath the streets of Midtown Manhattan, New York City Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of infrared light[1] through an optical fiber. The light is a form of carrier wave that is modulated to carry information.[2] Fiber is preferred over electrical cabling when high bandwidth, long distance, or immunity to electromagnetic interference is required.[3] This type of communication can transmit voice, video, and telemetry through local area networks or across long distances.[4] Optical fiber is used by many telecommunications companies to transmit telephone signals, Internet communication, and cable television signals. Researchers at Bell Labs have reached a record bandwidth–distance product of over 100 petabit × kilometers per second using fiber-optic communication.[5] Background First developed in the 1970s, fiber-optics have revolutionized the telecommunications industry and have played a major role in the advent of the Information Age.[6] Because of its advantages over electrical transmission, optical fibers have largely replaced copper wire communications in backbone networks in the developed world.[7] The process of communicating using fiber-optics involves the following basic steps: creating the optical signal involving the use of a transmitter,[8] usually from an electrical signal relaying the signal along the fiber, ensuring that the signal does not become too distorted or weak receiving the optical signal converting it into an electrical signal Applications Optical fiber is used by telecommunications companies to transmit telephone signals, Internet communication and cable television signals. It is also used in other industries, including medical, defense, government, industrial and commercial. In addition to serving the purposes of telecommunications, it is used as light guides, for imaging tools, lasers, hydrophones for seismic waves, SONAR, and as sensors to measure pressure and temperature. Due to lower attenuation and interference, optical fiber has advantages over copper wire in long-distance, high-bandwidth applications. However, infrastructure development within cities is relatively difficult and time-consuming, and fiber-optic systems can be complex and expensive to install and operate. Due to these difficulties, early fiber-optic communication systems were primarily 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. [9] The price for rolling out fiber to homes 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 and lower in countries like The Netherlands, where digging costs are low and housing density is high.[citation needed] 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.[10] History In 1880 Alexander Graham Bell and his assistant Charles Sumner Tainter created a very early precursor to fiber-optic communications, the Photophone, at Bell's newly established Volta Laboratory in Washington, D.C. Bell considered it his most important invention. The device allowed for the transmission of sound on a beam of light. On June 3, 1880, Bell conducted the world's first wireless telephone transmission between two buildings, some 213 meters apart.[11][12] Due to its use of an atmospheric transmission medium, the Photophone would not prove practical until advances in laser and optical fiber technologies permitted the secure transport of light. The Photophone's first practical use came in military communication systems many decades later.[13] In 1954 Harold Hopkins and Narinder Singh Kapany showed that rolled fiber glass allowed light to be transmitted.[14] Jun-ichi Nishizawa, a Japanese scientist at Tohoku University, proposed the use of optical fibers for communications in 1963.[15] Nishizawa invented the PIN diode and the static induction transistor, both of which contributed to the development of optical fiber communications.[16][17] In 1966 Charles K. Kao and George Hockham at Standard Telecommunication Laboratories showed that the losses of 1,000 dB/km in existing glass (compared to 5–10 dB/km in coaxial cable) were due to contaminants which could potentially be removed. Optical fiber was successfully developed in 1970 by Corning Glass Works, with attenuation low enough for communication purposes (about 20 dB/km) and at the same time GaAs semiconductor lasers were developed that were compact and therefore suitable for transmitting light through fiber optic cables for long distances. In 1973, Optelecom, Inc., co-founded by the inventor of the laser, Gordon Gould, received a contract from ARPA for one of the first optical communication systems. Developed for Army Missile Command in Huntsville, Alabama, the system was intended to allow a short-range missile to be flown remotely from the ground by means of a five-kilometer long optical fiber that unspooled from the missile as it flew.[18] After a period of research starting from 1975, the first commercial fiber-optic communications system was developed which operated at a wavelength around 0.8 µm and used GaAs semiconductor lasers. This first-generation system operated at a bit rate of 45 Mbit/s with repeater spacing of up to 10 km. Soon on 22 April 1977, General Telephone and Electronics sent the first live telephone traffic through fiber optics at a 6 Mbit/s throughput in Long Beach, California.[citation needed] In October 1973, Corning Glass signed a development contract with CSELT and Pirelli aimed to test fiber optics in an urban environment: in September 1977, the second cable in this test series, named COS-2, was experimentally deployed in two lines (9 km) in Turin, for the first time in a big city, at a speed of 140 Mbit/s.[19] The second generation of fiber-optic communication was developed for commercial use in the early 1980s, operated at 1.3 µm and used InGaAsP semiconductor lasers. These early systems were initially limited by multi mode fiber dispersion, and in 1981 the single-mode fiber was revealed to greatly improve system performance, however practical connectors capable of working with single mode fiber proved difficult to develop. Canadian service provider SaskTel had completed construction of what was then the world's longest commercial fiber optic network, which covered 3,268 km (2,031 mi) and linked 52 communities.[20] By 1987, these systems were operating at bit rates of up to 1.7 Gb/s with repeater spacing up to 50 km (31 mi). The first transatlantic telephone cable to use optical fiber was TAT-8, based on Desurvire optimised laser amplification technology. It went into operation in 1988. Third-generation fiber-optic systems operated at 1.55 µm and had losses of about 0.2 dB/km. This development was spurred by the discovery of Indium gallium arsenide and the development of the Indium Gallium Arsenide photodiode by Pearsall. Engineers overcame earlier difficulties with pulse-spreading at that wavelength using conventional InGaAsP semiconductor lasers. Scientists overcame this difficulty by using dispersion-shifted fibers designed to have minimal dispersion at 1.55 µm or by limiting the laser spectrum to a single longitudinal mode. These developments eventually allowed third-generation systems to operate commercially at 2.5 Gbit/s with repeater spacing in excess of 100 km (62 mi). The fourth generation of fiber-optic communication systems used optical amplification to reduce the need for repeaters and wavelength-division multiplexing to increase data capacity. These two improvements caused a revolution that resulted in the doubling of system capacity every six months starting in 1992 until a bit rate of 10 Tb/s was reached by 2001. In 2006 a bit-rate of 14 Tbit/s was reached over a single 160 km (99 mi) line using optical amplifiers.[21] The focus of development for the fifth generation of fiber-optic communications is on extending the wavelength range over which a WDM system can operate. The conventional wavelength window, known as the C band, covers the wavelength range 1.53–1.57 µm, and dry fiber has 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. Technology Modern fiber-optic communication systems generally include an optical transmitter to convert an electrical signal into an optical signal to send through the optical fiber, a cable containing bundles of multiple optical fibers that is routed through underground conduits and buildings, multiple kinds of amplifiers, and an optical receiver to recover the signal as an electrical signal. The information transmitted is typically digital information generated by computers, telephone systems and cable television companies. Transmitters A GBIC module (shown here with its cover removed), is an optical and electrical transceiver. The electrical connector is at top right and the optical connectors are at bottom left The most commonly used optical transmitters are semiconductor devices such as light-emitting diodes (LEDs) and laser diodes. The difference between LEDs and laser diodes is that LEDs produce incoherent light, while laser diodes produce coherent light. For use in optical communications, semiconductor optical transmitters must be designed to be compact, efficient and reliable, while operating in an optimal wavelength range and directly modulated at high frequencies. In its simplest form, an LED is a forward-biased p-n junction, emitting light through spontaneous emission, a phenomenon referred to as electroluminescence. The emitted light is incoherent with a relatively wide spectral width of 30–60 nm. LED light transmission is also inefficient, with only about 1%[22] of input power, or about 100 microwatts, eventually converted into launched power which has been coupled into the optical fiber. However, due to their relatively simple design, LEDs are very useful for low-cost applications. Communications LEDs are most commonly made from Indium gallium arsenide phosphide (InGaAsP) or gallium arsenide (GaAs). Because InGaAsP LEDs operate at a longer wavelength than GaAs LEDs (1.3 micrometers vs. 0.81–0.87 micrometers), their output spectrum, while equivalent in energy is wider in wavelength terms by a factor of about 1.7. The large spectrum width of LEDs is subject to higher fiber dispersion, considerably limiting their bit rate-distance product (a common measure of usefulness). LEDs are suitable primarily for local-area-network applications with bit rates of 10–100 Mbit/s and transmission distances of a few kilometers. LEDs have also been developed that use several quantum wells to emit light at different wavelengths over a broad spectrum and are currently in use for local-area WDM (Wavelength-Division Multiplexing) networks. Today, LEDs have been largely superseded by VCSEL (Vertical Cavity Surface Emitting Laser) devices, which offer improved speed, power and spectral properties, at a similar cost. Common VCSEL devices couple well to multi mode fiber. A semiconductor laser emits light through stimulated emission rather than spontaneous emission, which results in high output power (~100 mW) as well as other benefits related to the nature of coherent light. The output of a laser is relatively directional, allowing high coupling efficiency (~50 %) into single-mode fiber. The narrow spectral width also allows for high bit rates since it reduces the effect of chromatic dispersion. Furthermore, semiconductor lasers can be modulated directly at high frequencies because of short recombination time. Commonly used classes of semiconductor laser transmitters used in fiber optics include VCSEL (Vertical-Cavity Surface-Emitting Laser), Fabry–Pérot and DFB (Distributed Feed Back). Laser diodes are often directly modulated, that is the light output is controlled by a current applied directly to the device. For very high data rates or very long distance links, a laser source may be operated continuous wave, and the light modulated by an external device, an optical modulator, such as an electro-absorption modulator or Mach–Zehnder interferometer. External modulation increases the achievable link distance by eliminating laser chirp, which broadens the linewidth of directly modulated lasers, increasing the chromatic dispersion in the fiber. For very high bandwidth efficiency, coherent modulation can be used to vary the phase of the light in addition to the amplitude, enabling the use of QPSK, QAM, and OFDM. A transceiver is a device combining a transmitter and a receiver in a single housing (see picture on right). Fiber optics have seen recent advances in technology. "Dual-polarization quadrature phase shift keying is a modulation format that effectively sends four times as much information as traditional optical transmissions of the same speed."[23] Receivers The main component of an optical receiver is a photodetector which converts light into electricity using the photoelectric effect. The primary photodetectors for telecommunications are made from Indium gallium arsenide. The photodetector is typically a semiconductor-based photodiode. Several types of photodiodes include p-n photodiodes, p-i-n photodiodes, and avalanche photodiodes. Metal-semiconductor-metal (MSM) photodetectors are also used due to their suitability for circuit integration in regenerators and wavelength-division multiplexers. Optical-electrical converters are typically coupled with a transimpedance amplifier and a limiting amplifier to produce a digital signal in the electrical domain from the incoming optical signal, which may be attenuated and distorted while passing through the channel. Further signal processing such as clock recovery from data (CDR) performed by a phase-locked loop may also be applied before the data is passed on. Coherent receivers use a local oscillator laser in combination with a pair of hybrid couplers and four photodetectors per polarization, followed by high speed ADCs and digital signal processing to recover data modulated with QPSK, QAM, or OFDM. Digital predistortion An optical communication system transmitter consists of a digital-to-analog converter (DAC), a driver amplifier and a Mach–Zehnder-Modulator. The deployment of higher modulation formats (> 4QAM) or higher Baud rates (> 32 GBaud) diminishes the system performance due to linear and non-linear transmitter effects. These effects can be categorised in linear distortions due to DAC bandwidth limitation and transmitter I/Q skew as well as non-linear effects caused by gain saturation in the driver amplifier and the Mach–Zehnder modulator. Digital predistortion counteracts the degrading effects and enables Baud rates up to 56 GBaud and modulation formats like 64QAM and 128QAM with the commercially available components. The transmitter digital signal processor performs digital predistortion on the input signals using the inverse transmitter model before uploading the samples to the DAC. Older digital predistortion methods only addressed linear effects. Recent publications also compensated for non-linear distortions. Berenguer et al models the Mach–Zehnder modulator as an independent Wiener system and the DAC and the driver amplifier are modelled by a truncated, time-invariant Volterra series.[24] Khanna et al used a memory polynomial to model the transmitter components jointly.[25] In both approaches the Volterra series or the memory polynomial coefficients are found using Indirect-learning architecture. Duthel et al records for each branch of the Mach-Zehnder modulator several signals at different polarity and phases. The signals are used to calculate the optical field. Cross-correlating in-phase and quadrature fields identifies the timing skew. The frequency response and the non-linear effects are determined by the indirect-learning architecture.[26] Fiber cable types A cable reel trailer with conduit that can carry optical fiber Multi-mode optical fiber in an underground service pit An optical fiber cable consists of a core, cladding, and a buffer (a protective outer coating), in which the cladding guides the light along the core by using the method of total internal reflection. The core and the cladding (which has a lower-refractive-index) are usually made of high-quality silica glass, although they can both be made of plastic as well. Connecting two optical fibers is done by fusion splicing or mechanical splicing and requires special skills and interconnection technology due to the microscopic precision required to align the fiber cores.[27] Two main types of optical fiber used in optic communications include multi-mode optical fibers and single-mode optical fibers. A multi-mode optical fiber has a larger core (≥ 50 micrometers), allowing less precise, cheaper transmitters and receivers to connect to it as well as cheaper connectors. However, a multi-mode fiber introduces multimode distortion, which often limits the bandwidth and length of the link. Furthermore, because of its higher dopant content, multi-mode fibers are usually expensive and exhibit higher attenuation. The core of a single-mode fiber is smaller (