

## Basic Optical Fiber Communication System



### PHYSICS

**KEYWORDS :** Electrical pulses, photodiode and decoder.

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### ABSTRACT

*In the digital optical fiber communication system, the input electrical signal is in the form of coded digital pulses gets converted into optical pulses by laser diode. Avalanche photodiode converts these optical pulses into electrical pulses. A decoder converts the electrical pulses into the original electric signal.*

#### 1.1.1 : Introduction

Now we are in the twenty first century, the era of 'Information technology' [1-6]. There is no doubt that information technology has had an exponential growth through the modern telecommunication systems. Particularly, optical fiber communication plays a vital role in the development of high quality and high-speed telecommunication systems[3]. Today, optical fibers are not only used in telecommunication links but also used in the Internet and local area networks (LAN) to achieve high signaling rates.

#### The origin of fiber optic systems

To guide light in a waveguide, initially metallic and non-metallic wave guides were fabricated. But they have enormous losses. So they were not suitable for telecommunication. Tyndall discovered that through optical fibers, light could be transmitted by the phenomenon of total internal reflection. During 1950s, the optical fibers with large diameters of about 1 or 2 millimetre were used in endoscopes to see the inner parts of the human body.

#### Advantages of optical fiber communication

**1. Wider bandwidth:** The information carrying capacity of a transmission system is directly proportional to the carrier frequency of the transmitted signals. The optical carrier frequency is in the range  $10^{13}$  to  $10^{15}$  Hz while the radio wave frequency is about  $10^6$  Hz and the microwave frequency is about  $10^{10}$  Hz. Thus the optical fiber yields greater transmission bandwidth than the conventional communication systems and the data rate or number of bits per second is increased to a greater extent in the optical fiber communication system. Further the wavelength division multiplexing operation by the data rate or information carrying capacity of optical fibers is enhanced to many orders of magnitude[1].

**2. Low transmission loss:** Due to the usage of the ultra low loss fibers and the erbium doped silica fibers as optical amplifiers, one can achieve almost lossless transmission. In the modern optical fiber telecommunication systems, the fibers having a transmission loss of 0.002 dB/km are used. Further, using erbium doped silica fibers over a short length in the transmission path at selective points, appropriate optical amplification can be achieved. Thus the repeater spacing is more than 100 km. Since the amplification is done in the optical domain itself, the distortion produced during the strengthening of the signal is almost negligible.

**3. Dielectric waveguide:** Optical fibers are made from silica which is an electrical insulator. Therefore they do not pick up any electromagnetic wave or any high current lightning. It is also suitable in explosive environments. Further the optical fibers are not affected by any interference originating from power cables, railway power lines and radio waves. There is no cross talk between the fibers even though there are so many fibers in a cable because of the absence of optical interference between the fibers[2].

**4. Signal security:** The transmitted signal through the fibers does not radiate. Further the signal cannot be tapped from a fiber in an easy manner. Therefore optical fiber communication provides hundred per cent signal security.

**5. Small size and weight:** Fiber optic cables are developed with small radii, and they are flexible, compact and lightweight. The fiber cables can be bent or twisted without damage. Further, the optical fiber cables are superior to the copper cables in terms of storage, handling, installation and transportation, maintaining comparable strength and durability.

#### 2.2.1: RESULTS AND DISCUSSION:

Optical fibers can provide a much more reliable and versatile optical channel than the atmosphere, Kao and Hockham published a paper about the optical fiber communication system in 1966. But the fibers produced an enormous loss of 1000 dB/km. But in the atmosphere, there is a loss of few dB/km. Immediately Kao and his fellow workers realized that these high losses were a result of impurities in the fiber material. Using a pure silica fiber these losses were reduced to 20 dB/km in 1970 by Kapron, Keck and Maurer. At this attenuation loss, repeater spacing for optical fiber links become comparable to those of copper cable systems. Thus the optical fiber communication system became an engineering reality.

#### Basic optical fiber communication system

Figure 1 shows the basic components in the optical fiber communication system. The input electrical signal modulates the intensity of light from the optical source. The optical carrier can be modulated internally or externally using an electro-optic modulator (or) acousto-optic modulator[4]. Nowadays electro-optic modulators (KDP, LiNbO<sub>3</sub> or beta barium borate) are widely used as external modulators which modulate the light by changing its refractive index through the given input electrical signal.

In the digital optical fiber communication system, the input electrical signal is in the form of coded digital pulses from the encoder and these electric pulses modulate the intensity of the light from the laser diode or LED and convert them into optical pulses[6]. In the receiver stage, the photo detector like avalanche photodiode (APD) or positive-intrinsic-negative (PIN) diode converts the optical pulses into electrical pulses. A decoder converts the electrical pulses into the original electric signal.

In the digital optical fiber communication system, the input electrical signal is in the form of coded digital pulses gets converted into optical pulses by laser diode. Avalanche photodiode converts these optical pulses into electrical pulses. A decoder converts the electrical pulses into the original electric signal [5].

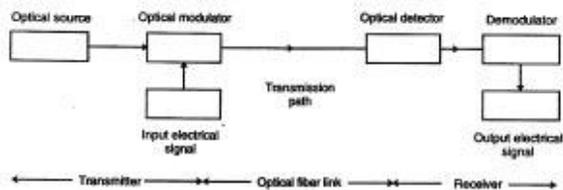


Figure 1. Basic analog optical fiber communication system.

Table 1. Different generations of optical fiber communication systems.

	Wavelength of optical source (mm)	Bit rate (Mb/s)	Repeater spacing (km)	Loss (dB/km)	Existed up to
I	0.8	4.5	10	1	1980
II	1.3	$1.7 \cdot 10^2$	50	<1	1987
III	1.55	$1.0 \cdot 10^4$	70	<0.2	1990
IV	1.55	$1.0 \cdot 10^5$	100	<0.002	2000
V (soliton based)	1.55	$> 1.0 \cdot 10^9$	>100	<0.002	

2.2.2: Different generations of optical fiber communication

Table 1 shows the different generations of optical fiber communication. In generation I, mostly GaAs based LEDs and laser diodes having emission wavelength 0.8 mm were used. From 1974 to 1978, graded index multimode fibers were used. From 1978 onwards, only single mode fibers are used for long distance communication.

CONCLUSION:

During the second generation the operating wavelength is shifted to 1.3 mm to over-come loss and dispersion. Further InGaAsP hetero-junction laser diodes are used as optical sources. In the third generation the operating wavelength is further shifted to 1.55 mm and the dispersion-shifted fibers are used. Further single mode direct detection is adopted. In the fourth generation erbium doped optical (fiber) amplifiers are fabricated and the whole transmission and reception are performed only in the optical domain. Wavelength Division Multiplexing (WDM) is introduced to increase the bit rate. In the proposed next generation (V generation), soliton based lossless and dispersionless optical fiber communication will become a reality. At that time, the data rate may increase beyond 1000 Tb/s.

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REFERENCE

[1] T Okoshi and K Kikuchi, Coherent optical fiber communication (Kluwer Academic, Boston, 1988) || [2] A Hasegawa, Optical solitons in fibers (Springer Verlag, New York, 1989) || [3] S E Millar and I P Kaminow, eds, Optical fiber telecommunications - II (Academic, New York, 1988) || [4] G P Agrawal, Nonlinear fiber optics (Academic, New York, 1989) || [5] C Yeh, Handbook of fiber optics (Academic, New York, 1990) || [6] G P Agrawal, Fiber optic communication systems (John Wiley, Singapore, 1993)