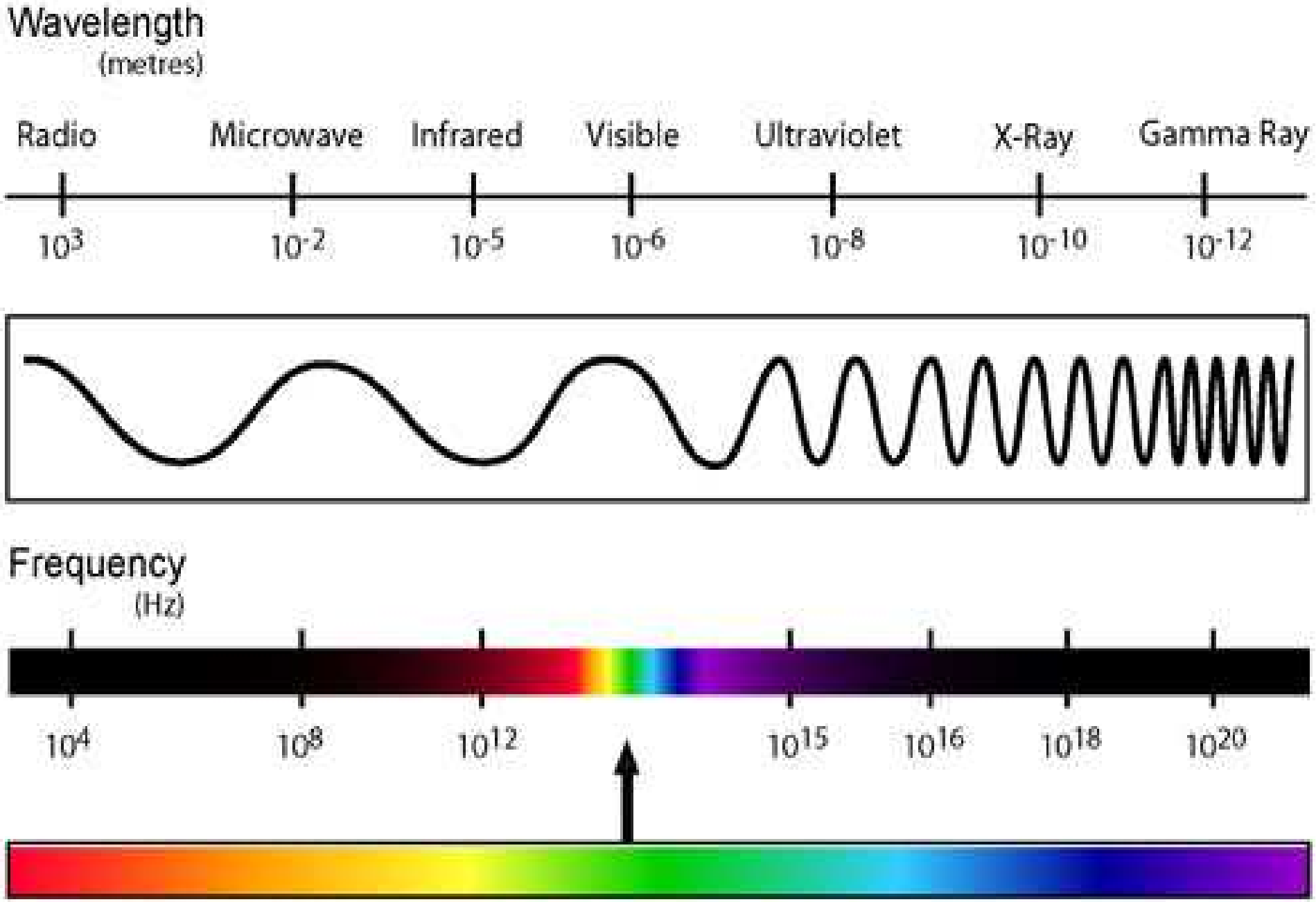
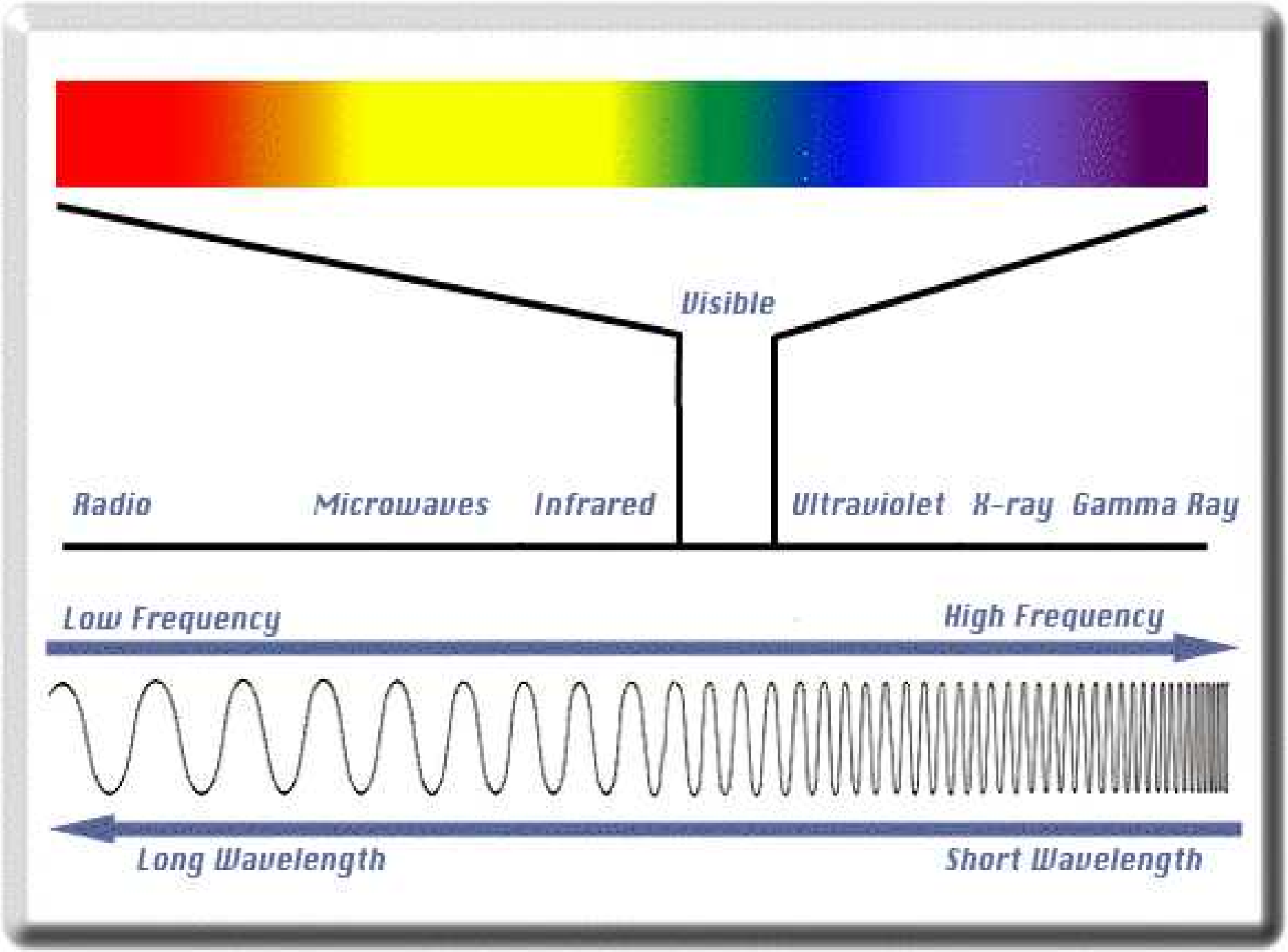
CHAPTER 1

Introduction

For years fiber optics has been merely a system for piping light around corners and into inaccessible places so as to allow the hidden to be seen. But now, fiber optics has evolved into a system of significantly greater importance and use. Throughout the world it is now being used to transmit voice, video, and data signals by light waves over flexible hair-thin threads of glass or plastics. Its advantages in such use, as compared to conventional coaxial cable or twisted wire pairs, are fantastic. As a result, light-wave communication systems or fiber optics communication systems are one of the important feature for today's communications.

THE ELECTRO MAGNETIC SPECTRUM




Visible
Radio
Microwaves
Infrared
Ultraviolet
X-ray
Gamma Ray
Low Frequency
High Frequency
Long Wavelength
Short Wavelength

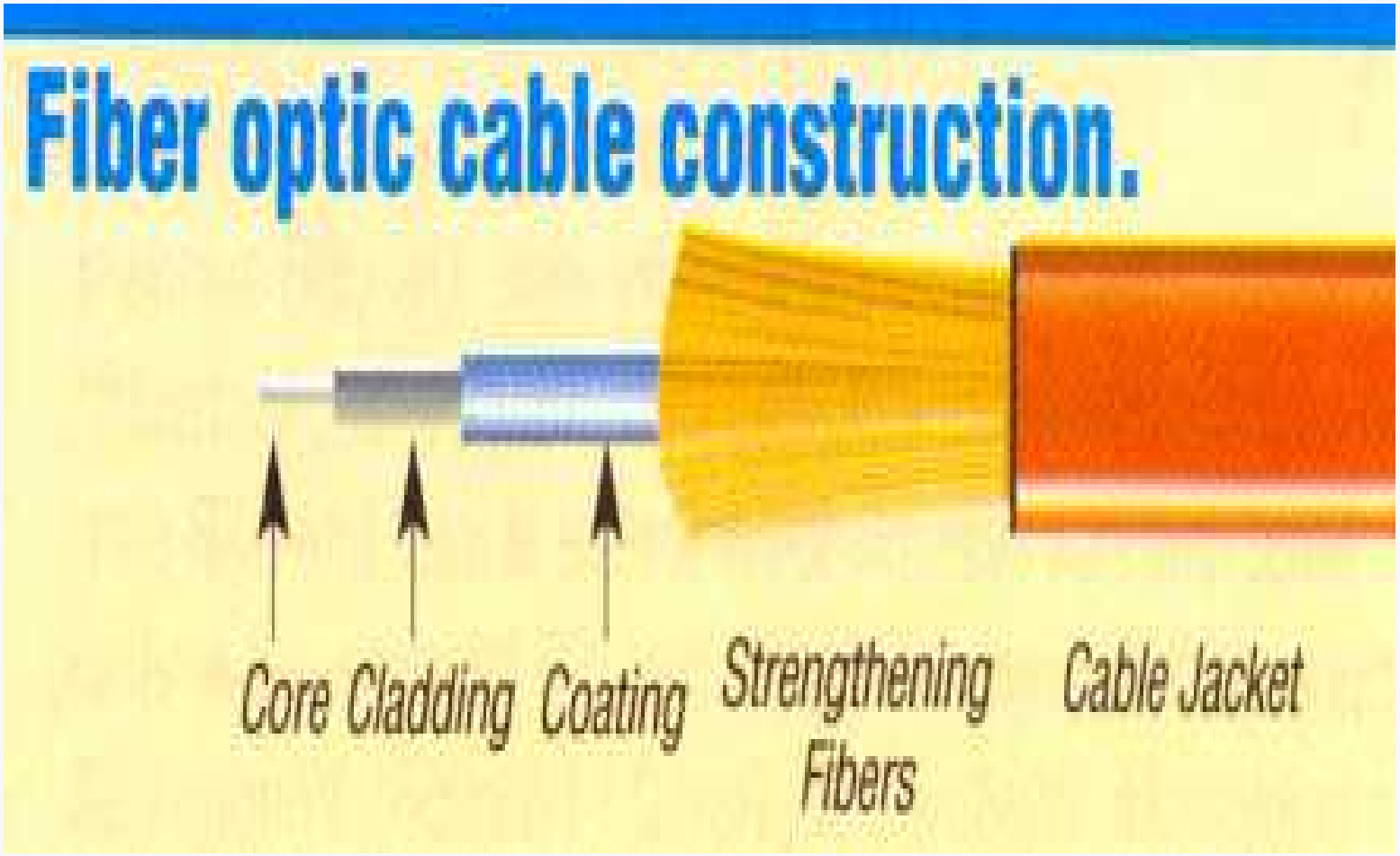


Figure 1 : Fiber Optic Cable

Historical Development of Fiber

	Year	Wavelength	Bit rate	Repeater span
First generation	1978	850 nm	50-100 Mb/s	10-km
Second generation	1985	1300 nm	1-2 Gb/s	40-50 km
Third generation	--	1550 nm	> 2.5 Gb/s	100-km

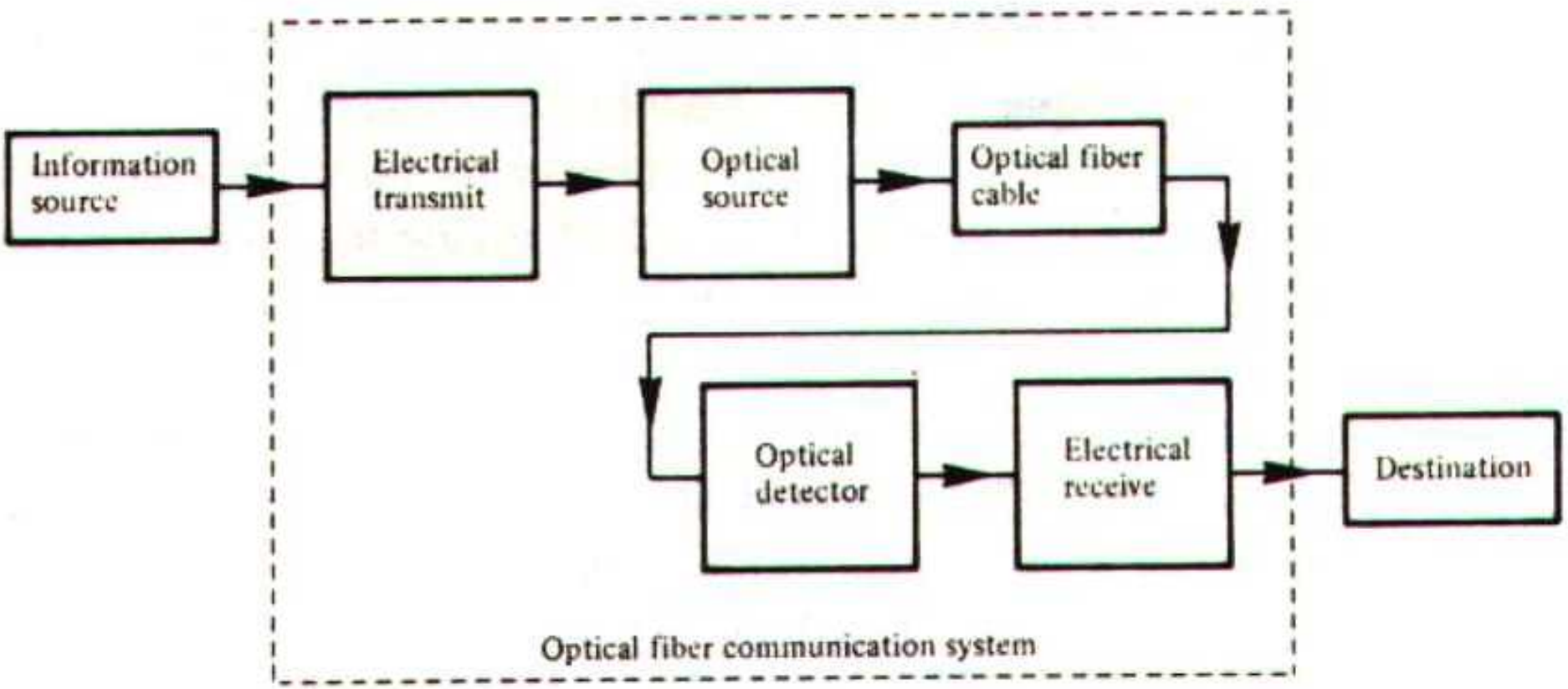
- 1550 nm lowest loss but higher dispersion than 1300 nm.
- DSF developed to have low loss and low dispersion at 1550 nm.

- At present the minimum attenuation for glass fibers is reported to be 0.16 dB/km. There are 1500 nm systems operating with repeater spacing of 150km.
- Alcatel has un-repeatered systems of 2.5 Gb/s and 622 Mb/s spanning distance of 511 km and 531 km respectively.
- WDM systems operating at 1.28 Tbit/s (128 wavelengths at 10.7 Gbit/s each) is possible today (Lucent Technology).

- An optical fiber communication system is similar in basic concept to any type of communication systems.

- Figure 1.1 shows a block diagram of a general optical fiber communication system.

Figure 1.1


Information source
Electrical transmit
Optical source
Optical fiber cable
Optical detector
Electrical receive
Destination
Optical fiber communication system

- Information source provides electrical signal to the transmitter comprising of an electrical stage which drives an optical source to modulate the light wave carrier.

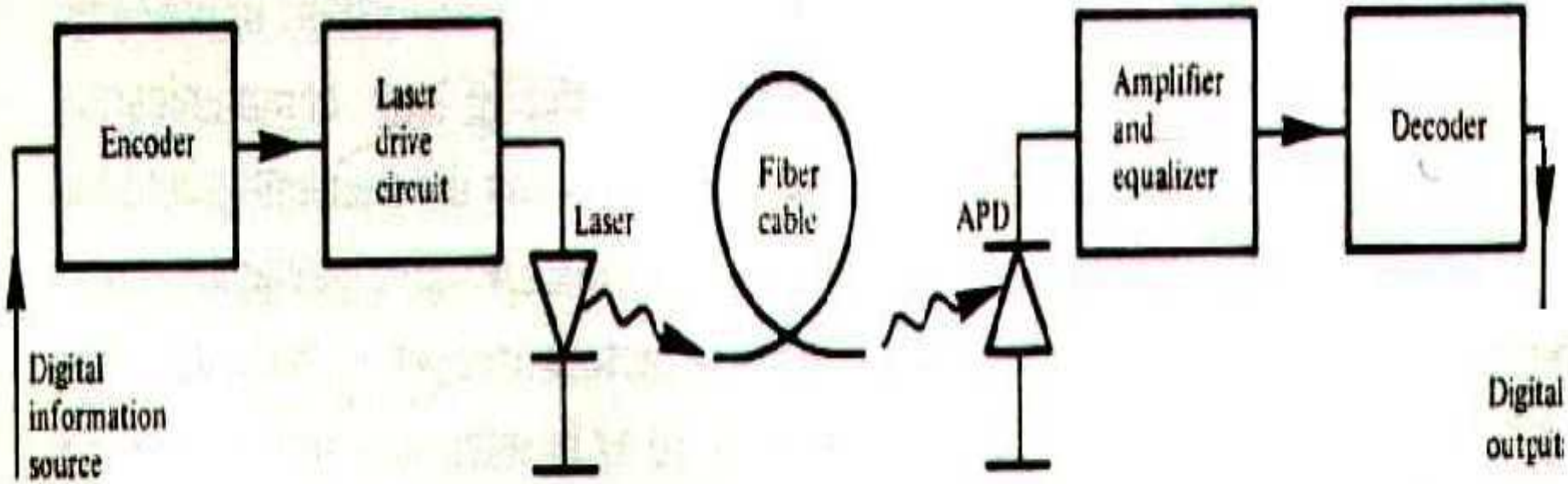
- The optical source which convert electrical to optical signal may be either a semiconductor injection laser diode (ILD) or light emitting diode (LED).

- Transmission medium consists of an optical fiber cable and the receiver consists of an optical detector.

- Photodiodes (p-n, p-i-n, or avalanche) are utilized for the detection of the optical signal or the optical to electrical conversion.

- At present the signal processing is usually performed electrically.

Figure 1.2



A digital optical fiber link using a semiconductor laser source and an avalanche photodiode (APD) detector.

- Input digital signal from information source is suitably encoded for optical transmission.
- Laser drive circuit directly modulates the intensity of the semiconductor laser with the encoded digital signal.
- A digital optical signal is launched into the optical fiber cable.
- The avalanche photodiode detector (APD) is followed by a front-end amplifier to provide gain, linear signal processing and noise bandwidth reduction.
- The signal obtained is then decoded to give the original digital information.

Advantages of Optical Communication System

- **Enormous potential bandwidth**

The optical carrier frequency in the range 10^{13} to 10^{16} Hz yields a far greater potential transmission bandwidth than metallic cable systems (i.e. coaxial cable bandwidth up to around 500 MHz) or even millimeter wave radio systems (i.e.systems currently operating with modulation bandwidths of 700 MHz).

Potential BW 50: Tbit/s

¤ Immunity to interference and crosstalk

Optical fibers are free from electromagnetic interference (EMI) and radio frequency interference (RFI). Hence the operation of an optical fiber communication system is unaffected by transmission through an electrically noisy environment and the fiber cable requires no shielding from EMI. The fiber cable is also not susceptible to lightning strikes if used overhead rather than underground. Moreover, it is fairly easy to ensure that there is no optical interference between fibers and hence, unlike communication using electrical conductors, crosstalk is negligible, even when many fibers are cabled together.

¤ Small size and weight

Optical fibers have very small diameters which are often no greater than the diameter of a human hair. Hence, even when such fibers are covered with protective coatings they are far smaller and much lighter than corresponding copper cables. This is a tremendous boom towards the alleviation of duct congestion in cities, as well as allowing for an expansion of signal transmission within mobiles such as aircraft, satellites and even ships.

RG-19/U	22.6 dB/km at 100 MHz	1110 kg/km
Silica Fiber	5 dB/km	6 kg/km

¤ Electrical Isolation

Optical fibers which are fabricated from glass or polymer are electrical insulators and therefore, unlike their metallic counterparts, they do not exhibit earth loop and interface problems. Furthermore, this property makes optical fiber transmission ideally suited for communication in electrically hazardous environments as the fibers create no arcing or spark hazard at abrasions or short circuits.

¤ Signal security

The light from optical fibers does not radiate significantly and therefore they provide a high degree of signal security. Unlike copper cables, a transmitted optical signal cannot be obtained from a fiber in a non-invasive manner (i.e. without drawing optical power from the fiber). Therefore, in theory, any attempt to acquire a message signal transmitted optically may be detected. This feature is obviously attractive for military, banking and general data transmission (i.e. computer network) applications.

¤ Low transmission loss

The development of optical fibers has resulted in the production of optical fiber cables which exhibit very low attenuation or transmission loss in comparison with the best copper conductors. Fibers have been fabricated with losses as low as 0.2 dB km^{-1} It facilitates the implementation of communication links with extremely wide repeater spacing (long transmission distances without intermediate electronics). thus reducing both system cost and complexity.

Silica Fiber	100 MHz	4 dB/km
RG-19/U	500 MHz	14 dB/km

¤ Ruggedness and flexibility

Although protective coatings are essential, optical fibers may be manufactured with very high tensile strengths. Perhaps surprisingly for a glassy substance, the fibers may also be bent to quite small radii or twisted without damage. Furthermore, cable structures have been developed which have proved flexible, compact and extremely rugged. These optical fiber cables are generally superior in terms of storage, transportation, handling and installation than corresponding copper cables whilst exhibiting at least comparable strength and durability.

¤ System reliability and ease of maintenance

These features primarily stem from the low loss property of optical fiber cables which reduces the requirement for intermediate repeaters or line amplifiers to boost the transmitted signal strength. Hence with fewer repeaters, system reliability is generally enhanced in comparison with conventional electrical conductor systems. Furthermore, the reliability of the optical components is no longer a problem with predicted lifetimes of 20-30 years now quite common. Both these factors also tend to reduce maintenance time and costs.

¤ Potential low cost

The glass which generally provides the optical fiber transmission medium is made from sand-not a scarce resource. So, in comparison with copper conductors, optical fibers offer the potential for low cost line communication. Overall system cost when utilizing optical system optical system are substantially less than those for equivalent electrical line systems because of the low loss and wideband properties of optical transmission.

Main Advantages:
Low loss
Large bandwidth

Fiber Optic Systems Applications

Voice

1. Telephone trunk for high data
   inter-office
   inter-city
   transoceanic
2. Subscriber service
   fiber-to-the home (FTTH)
   broadband services
   (multimedia, video, etc.)

Video

1. Broadcast Television
   - live events
   - TV mini cameras
2. CATV
   - source-to-headend trunk lines
   - distributions
   - subscriber taps
3. Surveillance
4. Remote monitoring
5. Fiber-guided missile
6. Fiber-to-the home

Data

1. Computers
   - CPU to peripherals
   - CPU to CPU
2. Interoffice data links
3. Local Area Network (LAN)
4. Fiber-to-the home
5. Aircraft and ship wiring - reduced weight
6. Satellite ground stations

Sensors

1. Gyroscope
2. Hydrophone-acoustic measurements in water
3. Position
4. Temperature
5. Electric and Magnetic Fields
6. Medical