Optical Communications

Introduction

Part1

Fiber Optic Communications
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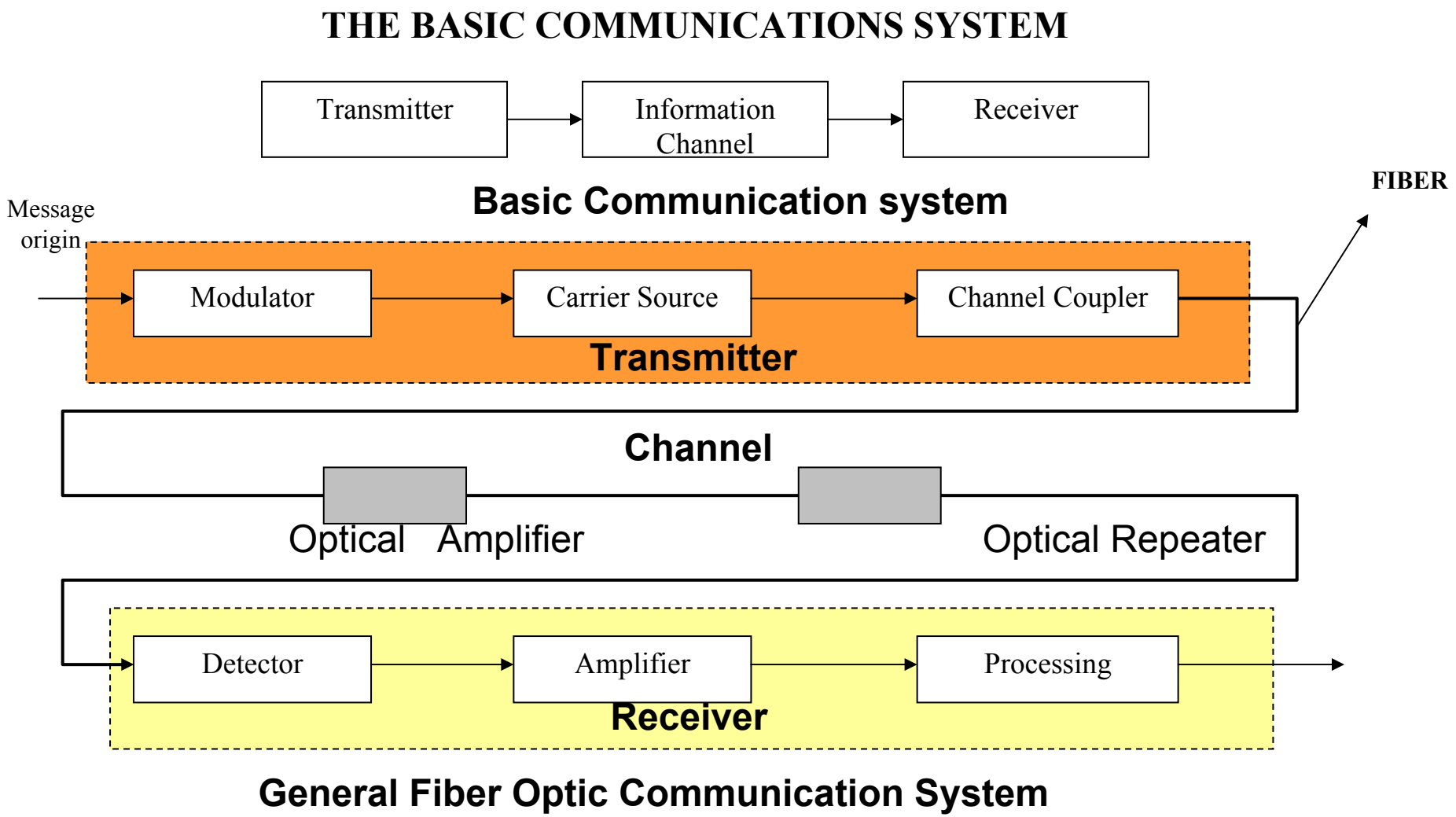
Introduction

- The information capacity of sunlight and lamps optic communication systems is low.
- The unguided laser optic communications systems have number of disadvantages: dependence on clear atmosphere, the need of line-of-sight and the possibility of eye damage.
- The guided fiber optic communications systems are free of the above advantages.

Introduction



Message Origin:
Transducer that converts a non-electrical message into electrical (Microphones, TV cameras), the message may be is already in electrical form.

Modulator (Analog or Digital):
Converts the electrical message into the proper format.
Impresses this signal onto the wave generated by the carrier source.

Carrier Source:
Generates the carrier that produced by Optic oscillators such as a Laser Diode (LD) or a Light Emitting Diode (LED).

Channel Coupler:
To feed power into the information channel (Lens for unguided systems) . It is an important Part because of the possibility of high losses.

Information Channel:

The fiber (Glass or Plastic) is the information channel with main characteristics as low attenuation and an efficient light collection to make long path communication systems.

Detector:

Photo detector converts light to an electric current.

Signal Processor:

Analog systems (Amplification + Filtration) SNR

Digital systems (Decision Circuits) BER

Message Output:

Person or Computers.

CONSTANTS:

Description	Value	Symbol
Velocity of Light	$3\times10^{8}\,m/s$	c
Planck constant	$6.66\times10^{-34}\,J/s$	h
Electron charge	$-1.6\times10^{-19}\,C$	$-e$
Boltzmann constant	$1.38\times10^{-23}\,J/K$	k

COMPUTING POWER LEVELS IN DECIBELS

In order to receive the power by detector it is important to recognize the information correctly.

The decibel (dB) it is a measure of power in communications systems.

Fraction (P2/P1) is the power transmitted between location P1 and location farther P2.

The efficiency

$$dB = 10\log_{10}\frac{P_2}{P_1}$$

P2 and P1 must be in the same units (W or mW).

To fine P2 and you know P1

$$P_2 = P_1 10^{dB/10}$$

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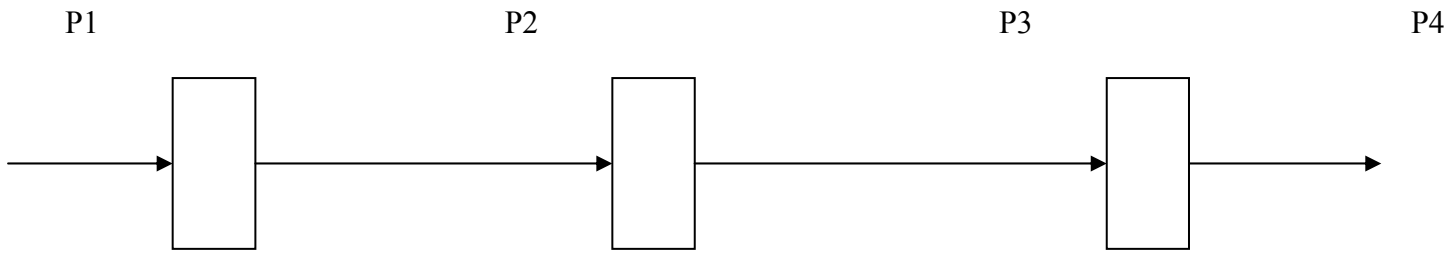

The total efficiency (dB) is the sum of the efficiencies in dBs

$$dB = 10\log_{10}\frac{P_4}{P_3} + 10\log_{10}\frac{P_3}{P_2} + 10\log_{10}\frac{P_2}{P_1}$$

NATURE OF LIGHT:

Wave Nature of Light: The light is an electromagnetic wave with a very high oscillation frequency and a very short rang

$$\lambda = \frac{v}{f} \quad \text{(m)}$$

where v is the beam velocity (in free space $v = 3 \times 10^8 \, m/s$)and

f its frequency

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The wave nature of light is used to study how the optic beams travel through fibers (Conditions necessary to guide light by a fiber.

Optical Spectrum	**Wavelength (μm)**	**Frequency ($10^{14}\,Hz$)**
Ultraviolet	0.2	1.5
	0.3	10
	< 0.4	<7.5
Visible	0.5	6
	<0.7	<4.28
Infrared	1	3
	1.5	2
	2	1.5

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Particle Nature Light: It consists of small particles called *photons*. The energy of one photon:

$$W_p = hf = (J \times s) \times Hz = \frac{(J \times s)}{s} = J \quad \textbf{(Joule)}$$

$h = 6.626 \times 10^{-34}\, J \times s$ *(Planck's constant)*

Electron Volt: is the kinetic energy acquired by an electron when it is accelerated by 1 V of potential difference.

$$1eV = 1.6 \times 10^{-19}\, J$$

Particle theory explains generation detection of light.

ADVANTAGES OF FIBER

-The basic material of glass fiber is silicon dioxide and some optic fibers are made of transparent plastic. Fibers have greater information capacities than do metallic channels.
-For long path, Fibers are cheaper to transport and easier to install than metal cable but the maintenance cost should be considered. ***Example***: ($\lambda = 125\,\mu m$)

-Weight is 6 kg/km. Loss 5dB/km) and (coaxial cable outer diameter=28.4 mm. Weight=1110 kg/km. Loss 22.6dB/km)

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-Fiber flexibility is attractive for installations containing many turns along the transmission path.
Fibers have very low transmission losses. (4 dB/km for glass fiber operating at $\lambda = 0.82 \mu m$)

-The ability to carry a large amount of information in digital or analog 44.7 Mbps for 672 voice channels. Pulse spreading limits the data rate
-Optic fibers, glass or plastic, are insulators.:
1.No electric current flow

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1.No leaks out during transmission
2.No radio frequency interference (RFI)
3.No electromagnetic interference (EMI)
4.No short circuits
5.No Common ground
-Security and privacy (no energy radiation)
-Fiber is compatible with the basic structure of wire transmission, so only moderate modifications needed.
-Fiber does not severe from chemicals or water.
-Fiber withstands extreme temperatures (800 c). Fiber cables (-25c to 65 c) are commercially available.
-Fibers are available in long lengths with minimum splices (1 km)

APPLICATION OF FIBER OPTIC COMMUNICATIONS

-Telephone systems: Fiber trunk lines connected telephone offices in Chicago. Carry 672 voice messages at distances (1 to 2.4) km.

-Underwater fiber links can be designed to span the oceans (Using repeaters): TAT8 6000 km between USA and Europe. Repeater space 50 km. Two fibers pairs (295.6 Mbps) with total capacity 40000 voice channels.

-Broadcast TV.

-Between Computers.

-Fiber optic transmission of control data is good in high voltage areas.

-Military application: Communication, Control, and satellite earth stations.