Chapter One

Introduction

General Overview:

- Background on communication

- Basic optics revision

- What is an optical communication system?

- What are the advantages of optical communication?

- What are the building blocks in an optical communication system?

Why do we NEED the Communications?

Background on communication

Did you ask yourself what is the purpose of Communication System?

The purpose of any communication system is the transport of information from source to destination with the best possible quality.

Which deals with:

- Over the required distance

- To the desired destination

- Accurately (BER)

- Securely (Encryption, electrical v optical)

- Quickly

- Cost effectively

What does a communication system require?

- Transmitter (source)

- Channel (EMR, Copper Cable, Optical Fibre)
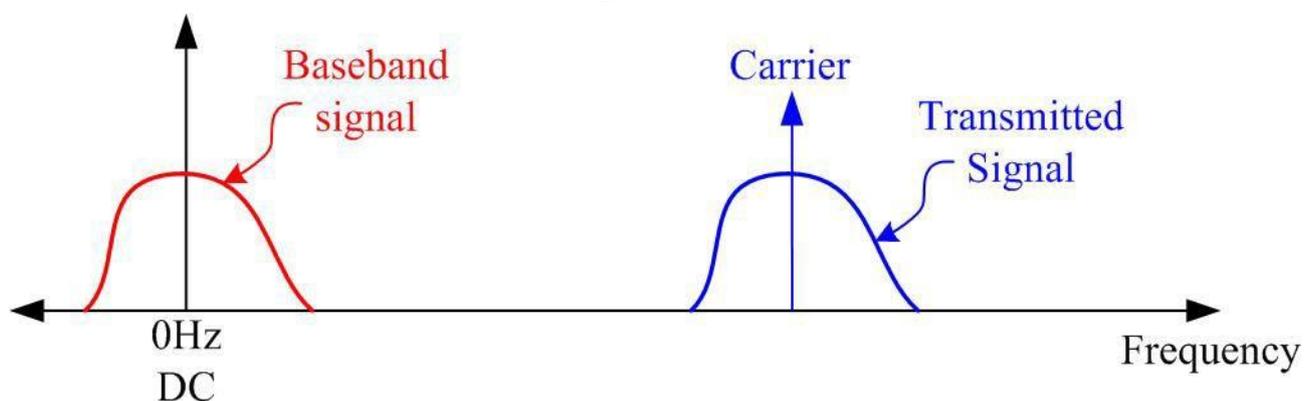
- Receiver

For more than two parties it also needs

- Switching/Routing

- Control

Channels

Channels are the medium/mechanism that conveys the information from the transmitter to the receiver

- Soundwaves (voice)

- String and a pair of paper cups

- Wired

  - Copper Cable

  - Optical Fibre

- Wireless

 - Cell/Satellite/VHF/UHF/CB/Radio (FM/AM)

Baseband Signals and Carriers

Basic Optics Revision

Light (Electromagnetic Radiation):

> ➢ An electromagnetic wave

> ➢ A particle (photon)

- It has energy: $E = hf$

- It has momentum: $P = h/\lambda$

- It has a speed: $c = 299\ 792\ 458\ m/s$

- Index of refraction : $n = c/v$

- Like other waves it has a wavelength and frequency ($f = c/\lambda$)

- It interacts with matter and electrons

> ➢ Can be created: **Emission**

> ➢ Can be destroyed: **Absorption**

> ➢ Can be redirected: **Refraction / Reflection / Diffraction / Scattering**
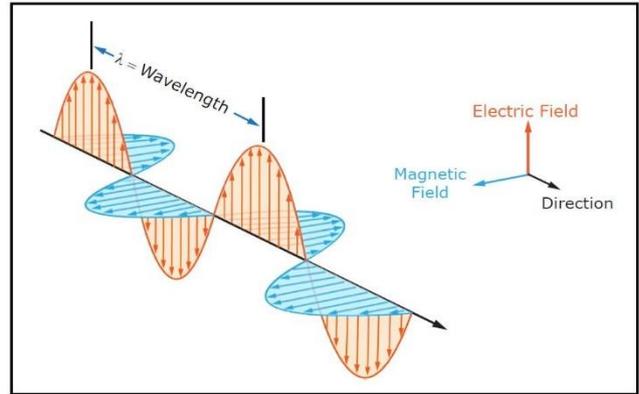
Snell's Law:

Snell's Law describes refraction as light strikes the boundary between two media:

$$n_1 sin\theta_1 = n_2 sin\theta_2$$

Refraction: Snell's Law

$n_1 sin\alpha = n_2 sin\beta$

Law of reflection

for specular reflection $\alpha = \beta$

Total Internal Reflection

When $n_1 > n_2$
Total Internal Reflection can occur if the angle of incidence is greater than the 'critical angle'
$\alpha_c = arcsin(n_2/n_1)$

Optical wave can be represented mathematically by the equation

$$A(t)cos(wt)$$

Sometimes written as:

$$A(t)exp(i\phi(t))$$

Via Fourier transform this can be expression in the time domain or the frequency domain:

$$A(t)exp(i\phi(t)) \Longleftrightarrow A(w)exp(i\phi(w))$$

Optical Intensity is given by the square modulus of the complex amplitude

$$I = |A|^2$$

Coherent and Incoherent Light:

We must first understand two terms: coherent and incoherent light.

Light emitted by normal means such as a flashlight or a bulb, is *incoherent* or the photons of the many wave frequencies of light are oscillating in different directions. It is not a stream of light. *Coherent* light is a beam of photons (almost like particles of light waves) that have the same frequency and are all at the same frequency. Only a beam of laser light will not spread and diffuse. In lasers, waves are identical and in phase, which produces a beam of coherent light.
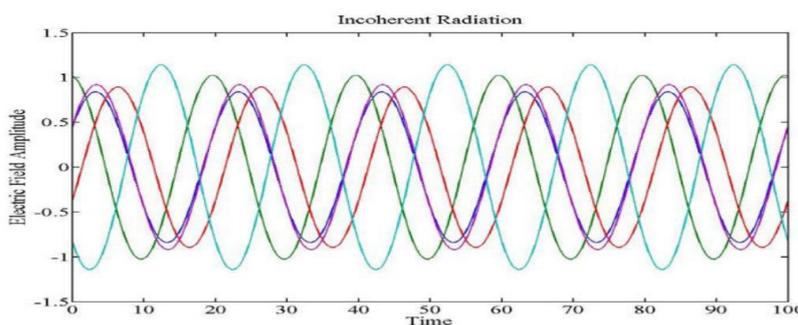
**Incoherent Light**
•Light blubs
•LEDs
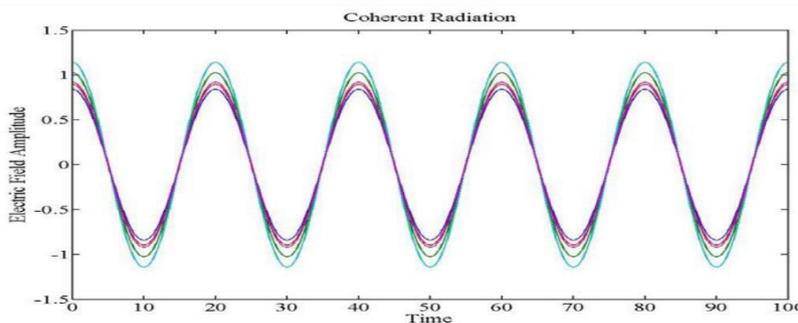
Coherent Light
•LASERS

Lasers are basically excited light waves. Light is a component of the electromagnetic wave spectrum. The name itself stands for Light Amplification by Stimulated Emission of Radiation.

There are many types of lasers that use gases such as helium, neon, argon, and carbon dioxide. Lasers also use semiconductors (Galiodium and Arsenic), solid-state material (ruby, glass), and even chemicals (hydrofluoric acid) in their operation.
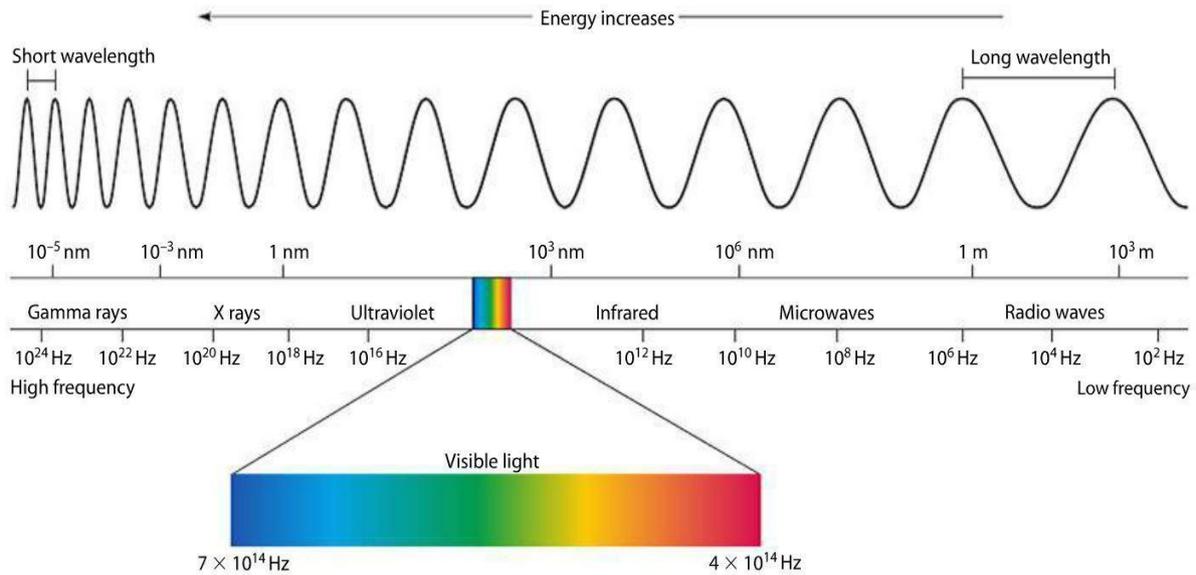
- **Visible light extends from 400 to 700nm.**

- **Optical communications operates around 850nm, 1310nm, 1550nm.**

The electromagnetic spectrum.

	Frequency $\nu = \omega/2\pi$	Wavelength λ_{vac}
AM Radio	10^6 Hz	300 m
FM Radio	10^8 Hz	3 m
Radar	10^{10} Hz	0.03 m
Microwave	$10^9 - 10^{12}$ Hz	0.3 m- 3×10^{-4} m
Infrared	$10^{12} - 4 \times 10^{14}$ Hz	$3 \times 10^{-4} - 7 \times 10^{-7}$ m
Light (red)	4.6×10^{14} Hz	6.5×10^{-7} m
Light (yellow)	5.5×10^{14} Hz	5.5×10^{-7} m
Light (blue)	6.7×10^{14} Hz	4.5×10^{-7} m
Ultraviolet	$10^{15} - 10^{17}$ Hz	$4 \times 10^{-7} - 3 \times 10^{-9}$ m
X-rays	$10^{17} - 10^{20}$ Hz	$3 \times 10^{-9} - 3 \times 10^{-12}$ m
Gamma rays	$10^{20} - 10^{23}$ Hz $\rightarrow$	$3 \times 10^{-12} - 3 \times 10^{-15}$ m $\rightarrow$