× Phase describes the position of the waveform relative to time 0.

Q) A sine wave is offset 1/6 cycle w.r.t time 0. what it is phase in degree and radians.

Ans 1 complete cycle is 360°.

$\therefore \frac{1}{6}$ cycle is

$\frac{1}{6} \times 360 = 60^\circ = 60 \times \frac{2\pi/360}{} \text{ radian} = \frac{\pi}{3} \text{ rad}$

$= 1.046 \text{ rad}$

Wavelength and Period

× Wavelength b/w successive crests of a wave, especially points in a sound wave or electromagnetic wave.

× measured in metres (m)

× In frequency domain only single representation is enough.

× A complete sine wave in the time domain can be represented as a single spike in frequency domain.

- Frequency domain is more compact and useful when we are dealing with more than one ~~sine~~ sine wave.

Signals and Communication

- A single-frequency sine wave is not useful in data communications.
- We need to send a composite signal, a signal made of many simple sine waves.
- According to Fourier analysis, any composite signal is a combination of simple sine waves with diff. frequencies, amplitudes and phases.

Composite signals and Periodicity

- If composite signal is periodic, decomposition gives a series of signals with discrete frequencies.
- If composite signal is non-periodic, decomposition gives a combination of sine wave with continuous frequencies

Study to analyse the graph.

Bandwidth and Signal Frequency

× Bandwidth of a composite signal is the diff. blw the highest and lowest frequencies obtained in that signal.

× If in frequency domain, a continuum of signal ⇒ composite non-periodic signal

× gap 400 diff freq?

× If in frequency domain, discrete signal ⇒ composite periodic signal

× Bandwidth = $f_h - f_l$

B = Bandwidth

f_h = highest frequency

f_l = lowest frequency

★ Frequency should be in increasing order in frequency domain graph

★ middle frequency have peak value?

27/9/21

Digital Signals

- discrete levels
- $\log_2 L$ bits
  where L represents the level.
- Eg: 8 level:
  $\log_2 8 = \log 2^3 = \underline{3 \text{ bits}}$
  Each level represented using 3 bits.
- Higher ~~amount~~ number of levels then higher amount of data can be sent.
- No: of bits transferred in a second ⇒ bit rate.
- 9 levels: $\log_2 9 = 3.57$ (round up) $= \underline{4 \text{ bits}}$
- 24 lines with 80 characters in each line with 100 ~~bits~~ pages per second. Assume 1 character = 8 bits. Find bit rate.

Ans: ~~100×9~~ 1 char → 8 bits

80 chars ⇒ 80×8

24 lines ⇒ 24×80×8

100 pages ⇒ 100×24×80×8

= 1.636 Mbps

× Bandwidth:

low pass channel ⇒ frequency starts at zero.

wide band width ⇒ any range of frequency can be selected and used to transmit signal.

narrow bandwidth ⇒ range of frequency allowed is less than wide bandwidth.

× Majority digital signals are non-periodic.

Harmonics

× Harmonics can be even or odd.

× Reconstruction of digital signal at receiver side done by harmonics

× A digital signal is a composite analog signal with an infinite bandwidth.

Baseband transmission using a dedicated medium.

preserves the shape (all pptes of I/p signal) ~~is~~ of digital signal is possible with low pass channel with an infinite or very wide bandwidth

x ~~A harmonic~~ A harmonic is a signal or wave whose frequency is an integral (whole-number) multiple of the frequency of some reference signal or wave

x If f is the frequency, 3f and 5f are odd harmonics, the combined one i.e f + 3f + 5f ~~or~~ is closer to the data.

x In baseband transmission the required bandwidth is proportional to bit rate, if we need to send bits faster, we need more bandwidth.

x Normally harmonics are first, third, fifth

x If the available channel is a bandpass channel, we cannot send digital signal directly to the channel, we need to convert digital signal to an analog signal before transmission

Broadband transmission using modulation

x lines are designed to carry voice with a limited bandwidth - bandpass channel

* convert digit signal from comp to an analog signal and send the analog signal.
* install two converters to change digital signal to analog and vice versa at the receiving end - modem.
* digital cellular phones convert analog voice signal to digital signal.

29/9/21

* Fourier analysis is a tool that changes a time domain signal to a frequency domain signal and vice versa.
* Fourier transform is a mathematical function that can be used to show the diff. frequency components of a continuous signal.
* Every composite periodic signal can be represented with a series of sine and cosine functions.
* Fourier series:

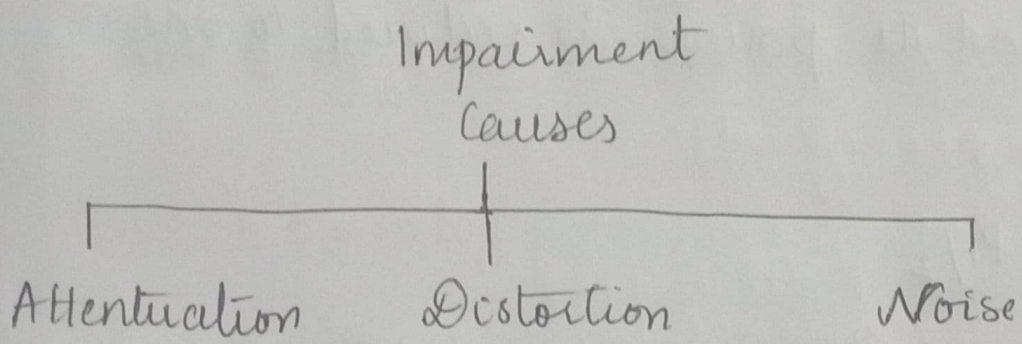
$$s(t) = A_0 + \sum_{n=1}^{\infty} A_n$$

Fourier Transform

- It gives the frequency domain of a non periodic time domain signal.

Transmission Impairment

- Signal travel through transmission media, which are not perfect.
- The imperfection causes signal impairment.



- What is sent is not what is received.

Attentuation

- Means loss of energy → weaker signal
- When a signal travels through a medium it loses energy overcoming the resistance of the medium.
- Amplifiers are used to compensate for this loss of energy by amplifying the signal.

* Amplifiers ⇒ regenerates the signal.

* To show the loss or gain of energy, the unit "decibel" is used.

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

P_1 = input signal

P_2 = output signal

* A signal travels through a transmission medium and its power is reduced to one half

P_1 , $P_2 = P_1/2$

$$dB = 10\log_{10}\left(\frac{\frac{P_1}{P_2}}{P_1}\right) = 10\log_{10}\left(\frac{1}{2}\right)$$

$$= 10\log_{10} = 10 \times -0.3010 = \cancel{-3010}\ \underline{-3.010}$$

$$= \underline{-3\,dB}$$

(minus indicates loss)

* $P_1 \rightarrow P_4 \Rightarrow -3 + 7 + -3 = \underline{1\,dB}$

Q) The loss in a cable is defined in decibels per kilometer (dB/km). If the signal at the beginning of a cable with -0.3dB/km

has a power of 2mW. what is the power of signal at 5km?

Ans. Loss ~~dB~~ = -0.3 dB/km

~~$P_1 = 2mW = 2 \times 10^{-3} W$~~

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

loss at 5 kms = $-0.3 \times 5 = \underline{-1.5 dB}$

$P_1 = 2mW$

$dB = 10 \log_{10} \frac{P_2}{P_1} = -1.5$

~~$\Rightarrow$~~ $-1.5 = 10 \log \left(\frac{P_2}{P_1}\right)$

$\frac{-1.5}{10} = \log_{10} \left(\frac{P_2}{P_1}\right)$; $-0.15 = \log_{10} \left(\frac{P_2}{P_1}\right)$

$\frac{P_2}{P_1} = 10^{-0.15} = \underline{0.71}$

$P_2 = 0.71 \times 2mW = \underline{1.4mW}$

Ocstortion

x signal changes its form or shape.

x distortion occurs in composite signals.

x phax out

Noise

× Different types of noise:

① Thermal - random noise of electrons in the wire creates an extra signal.

② Induced - from motors and appliances, devices act as transmitter antenna and medium as receiving antenna

③ Crosstalk - same as above but b/w 2 wires.

④ Impulse - spikes that result from power lines, lightning etc.

Signal to Noise Ratio (SNR)

× To measure the quality of a S/m SNR is often used.

× Ratio b/w two powers

Q) Power of signal = 10mW

Power of noise = 1μW.

Values of SNR & SNR_{dB}?

Ans. $SNR = \frac{10000\mu W}{1\mu W} = \underline{\underline{10,000}}$

$SNR_{dB} = 10\log_{10} 10,000 = 10\log_{10} 10^4 = \underline{\underline{40}}$

$$SNIR_{dB} = 10\log_{10}\left(\frac{P_s}{P_n}\right)$$

$P_s \Rightarrow$ Power of signal

$P_n \Rightarrow$ Power of noise.

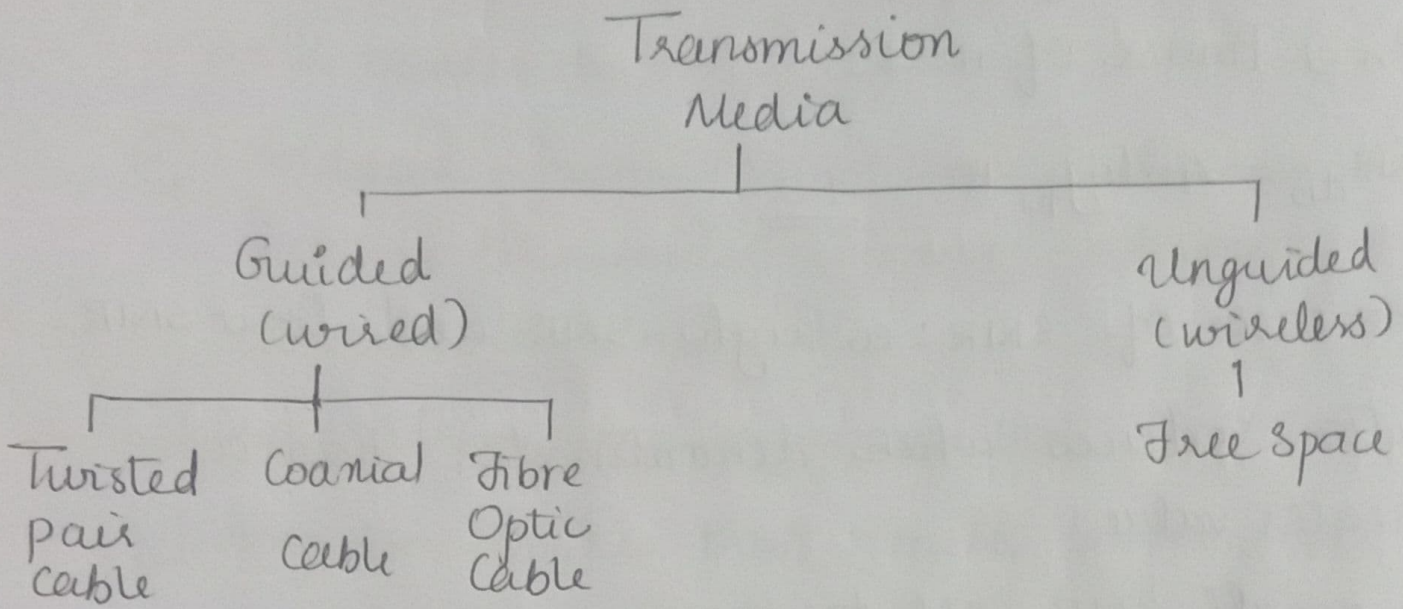
$$SNR_{dB} = 40\log_{10} 10 = \underline{\underline{40}}$$

Two cases of SNR: a high SNR and low SNR.

* ratio reduces when denominator has a greater value.
* So small SNR affects more

29/8/2021

Classes of transmission media



Guided Media

I Twisted Pair ~~Media~~ Cable

→ UTP - unshielded twisted pair (no metal shield)

→ STP - metal shield (shielded twisted pair)
- external interference is absorbed by metal shield.

UTP Connector

→ RJ-45 Femal

→ RJ-45 Male

→ ✗

× As gauge increases, higher frequency of data

can be carried but attentuation also increases

II Coaxial Cable

x Insulator, Plastic Cover, Outer Conductor (shield), Inner Conductor.

x Category: RG-59, RG-58, RG-11

x Connecting coaxial cables:

BNC connectors

x Performance:

Higher frequency of data → ~~higher~~ thicker → lower the attentuation.

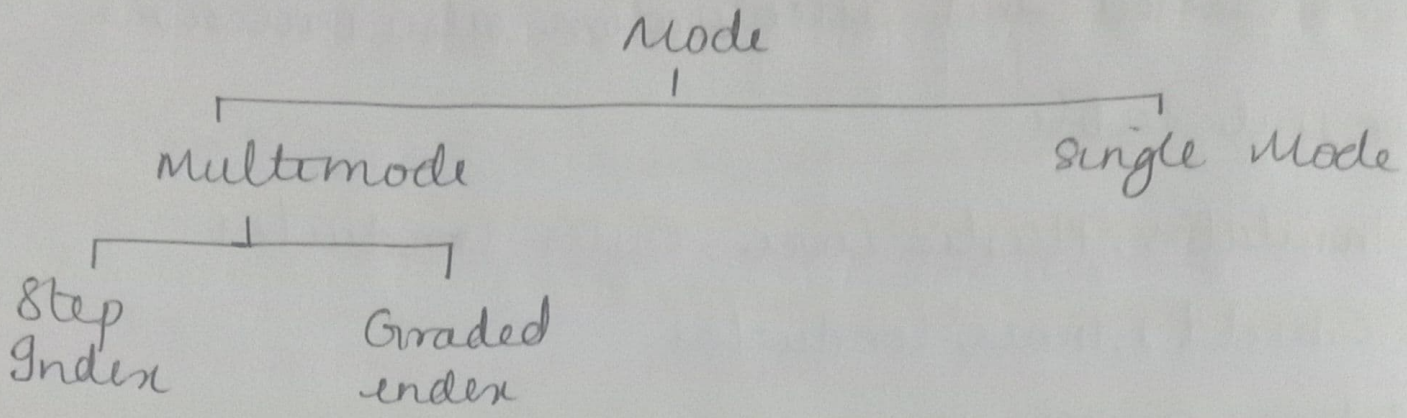
III Fibre Optics: Bending of light Ray.

x Total Internal Reflection (TIR)

x Two medium:

- one denser than the other.
- Beyond critical angle is the incident angle the entire signal get reflected, no refraction happens.

Propagation modes



Multimode

- Send at multiple incident angles greater than critical angle ⇒ Step Index
- Huge Amount of data to be sent ⇒ the core of the ~~fibre of~~ medium is reduced to bare minimum so that no TIR takes place.

Fibre Construction

- Glass or Plastic Core
- Cladding
- Plastic Buffer
- Du Pont Kevlar for strength
- Outer Jacket

Fibre Optic Cable Connectors

- SC Connector
- ST Connector
- MT-RJ Connector

Unguided Media: Wireless

- Radio Waves
- Micro Waves
- Infrared.

Propagation Methods

- Ground Propagation (below 2MHz)
- Sky Propagation (help of satellites) (2-30 MHz)
- Line of sight Propagation (above 30MHz) (oriented such a way that they are facing each other) frequency?

Wireless Transmission Waves

- Radio Waves
- Micro Waves
- Infrared.

- Radio waves are used for multicast comm: such as radio, paging s/m
- Microwaves: used for multicast comm such as cellular telephones, satellite n/ws, and wireless LANs.

* Infrared - short range comm in a closed area

Wireless Channels

* subject to more errors than guided media channels.
* One cause of error: interference
* Channels are also subject to fading and no coverage holes.