CN:

Notes

1) Transmission Impairments, Channel Capacity

Impairments : (In the Signal)

Signal → ⊓⊔⊓ ↳ Transmission Medium

i) Attenuation
ii) Distortion
iii) Noise

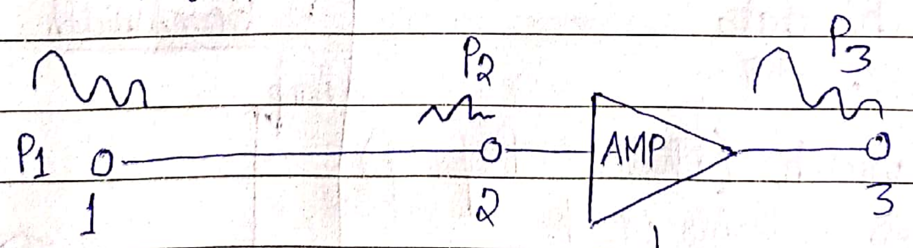
Attenuation : Loss of Signal Energy (in Decibal)

$\boxed{dB} = 10 \log_{10}(P_2/P_1)$

P_1 : Transmission Energy

P_2 : Receiving Energy

* Amplification :



↓ compensate the attenuation of the medium.

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

Ex: Energy Strength at P_2

$= 1/10^{th}$ (with respect to point P_1)

$\therefore$ Attenuation:

$$dB = 10 \log_{10}(1/10) = \boxed{-10\,dB}$$

-ve Sign : Loss of Power.

At

Point P_3 : Energy gain = 100 times (With respect to Point 2)

$$\therefore dB = 10 \log_{10}(100/1) = \boxed{20\,dB}$$

gain +ve.

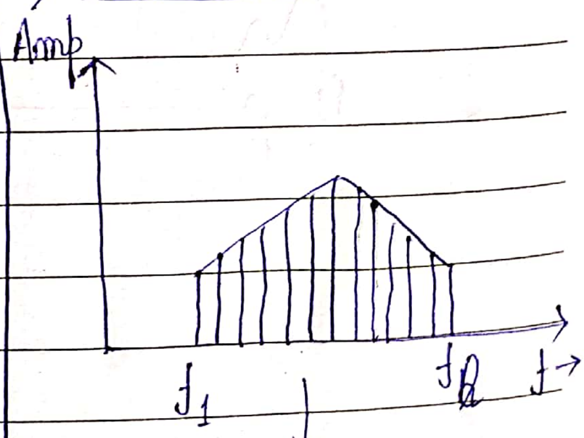
$\therefore$ The Signal Strength at point 3 (P_3), with respect to '1' can be obtained by —

$$\boxed{(-10)+20 = 10\,dB}$$

2) How Fast the data can be Sent?

i) Bandwidth (Channel Property)
ii) Numbers of levels in the Signal
iii) Noise level. (Channel Parameter)

i) Bandwidth:



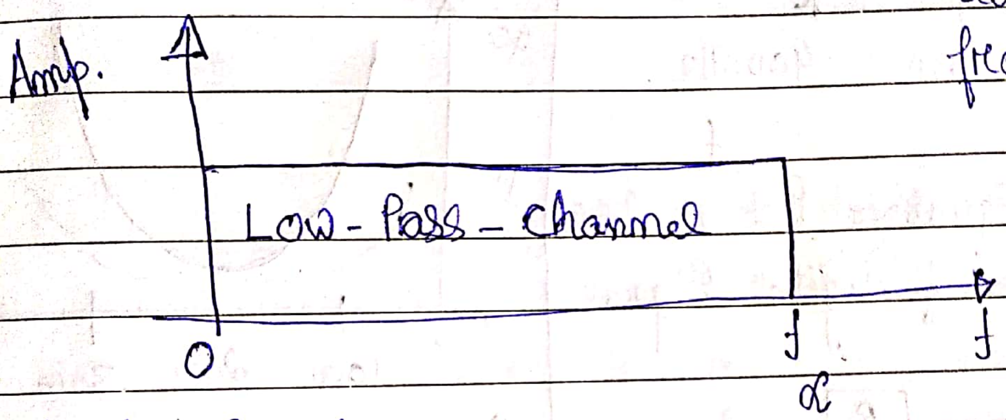
$B = f_2 - f_1$

Notes

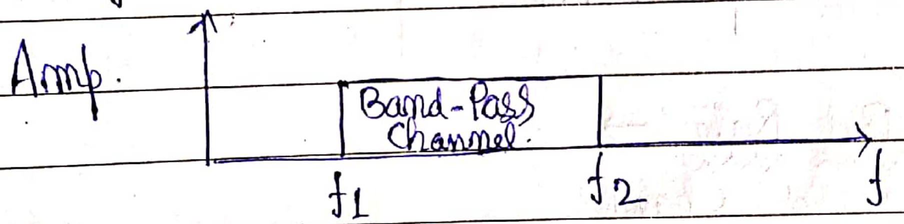
Aperiodic

Defn: Range of frequencies that a medium can pass without a loss of one half of the power (-3dB) in the signal.

Digital Signal:
↓
Low-Pass-Channel
↓
Requires a bandwidth from 0 to infinity



Analog Signal:



Distortion:

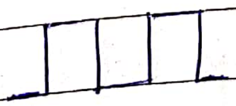
↳ Attenuation, of all the freq^n components not same.

i) No attenuation

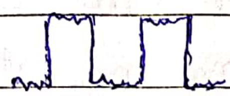
ii) Signal gets weaken

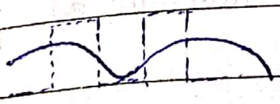
iii) Blocked.

16000 Hz.



2000 bits/sec

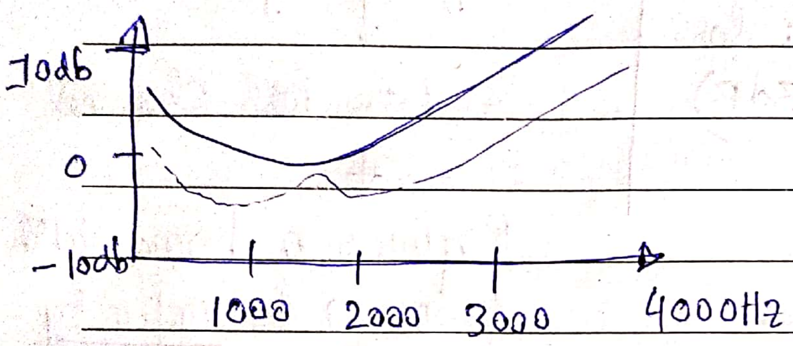




Passed through a channel

With B.W = 2000 Hz.

* Attenuation Distortion:



Equalizer:
→ With Equalizer Prob. is less in case of digital Signal.

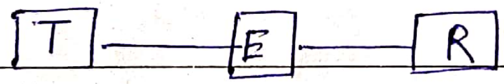
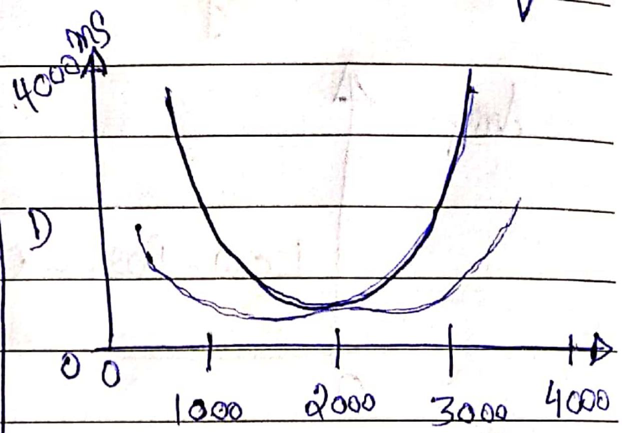


Fig. Voice grade telephone Line.

* Delay Distortion:→
i) For Guided Medium
ii) Velocity of Propagation Varies With Freq^n



i) Equalizer.

Imp: Nyquist Bit Rate:→
Assume Noiseless Channel
Max^m bit Rate (Nyquist Bit Rate)

$$\boxed{C = 2.B.\log_2 L}$$

C: Channel capacity
B: Band width
L: No. of Signal levels used in a Signal.

* Baud Rate:→ Bit interval.
(Signalling Rate)
↳ No. of distinct Symbols transmitted per Sec

Ex: Baseband Digital transmission =

$L = 2$ 0V   0V

1V   0.5V

1.0V

2.0V

MAX Baud Rate =

$$\frac{1}{\text{Element Width (in Sec)}} = 2B$$

* Bit Rate / Info Rate :

(l)

Actual equivalent no. of bits transmitted per Sec

l = Baud Rate x Bits per Baud

= Baud Rate x N

= Baud Rate x $\log_2 M$

Note: For binary Encoding Bit-Rate / Baud Rate Same;

l = Baud Rate.

Ex: telephone channel having bandwidth = 4 kHz. Assuming there is no noise determine the ch. capacity for —

i) 2   ii) 128

Ans:

i) $C = 2.B.\log_2 2 = 2B = 2 \times 4000$

= 8000 bits/s

= 8 Kbits/s

ii) For you to Solve.

Notes

Noise: B + Noise

↓ ↳ Limitation due to noise

Characteristics of channel.

0.5 V ⟹ Send.

+.5 V ⟹ Noise

1 V ⟹ Received.

Noise becomes more problamatic if the no. of levels increases.

Signal-to-noise Ratio:

P: Average Signal Power

N: Average Noise Power

$$\boxed{\frac{S}{N} = \frac{P}{N} \qquad \left(\frac{S}{N}\right)_{dB} = 10 \log_2\left(\frac{S}{N}\right)}$$

Shannon capacity: (Noisy Ch.)

Highest Data rate for a noisy channel —

$$\boxed{C = B \times \log_2\left(1 + \frac{S}{N}\right)}$$

$C = 0$ Extremely noisy channel

* Nyquist Bit Rate, Shannon Capacity

The smallest one needs to be considered as channel capacity.

Scanned with CamScanner

Ex 1 A channel has B = 4 KHz. Determine the channel capacity for each of the 'S' to 'N' ratios —

i) 20 dB   ii) 30 dB   iii) 40 dB

i)

$$C = B \log_2\left(1 + \frac{S}{N}\right)$$

$$= 4 \times 10^3 \times \log_2(1 + 100)$$

$$= 26.6 \text{ kbits}$$

ii) For you   iii) For you.

Same

Ex 2: i) Determine the Max^m information rate for 4-level Encoding

B = 4 KHz, L = 4, S/N = 30 dB

Nyquist Bit Rate = 16 Kbps

Smallest 1

Shannon Capacity = 39.8 Kbps

∴ The Information Capacity = 16 Kbps.

ii) L = 128

Nyquist Bit Rate = 56 kbits/s

Shannon Capacity = 39.8 Kbps

H/W

Q: The digital Signal is designed to permit 160 kbps for a bandwidth of 20 KHz.

a) No. of levels = ?   b) S/N = ?

Notes

* Types of Noise:

i) Thermal : $\boxed{N = k.T.B}$

Boltz M. constant, temp., B.W

Copper (Molecule levels Movement of Electrons)

ii) Intermodulation

↳ Signals of diff^n frequencies share the same Medium

iii) Crosstalk : Due to unwanted coupling of two Medium.

iv) Impulse Noise:

Lightning, Electrical Spark (Environment)