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Lecture - 1
13-1-2026

Lecture - 2
25. 1. 2026

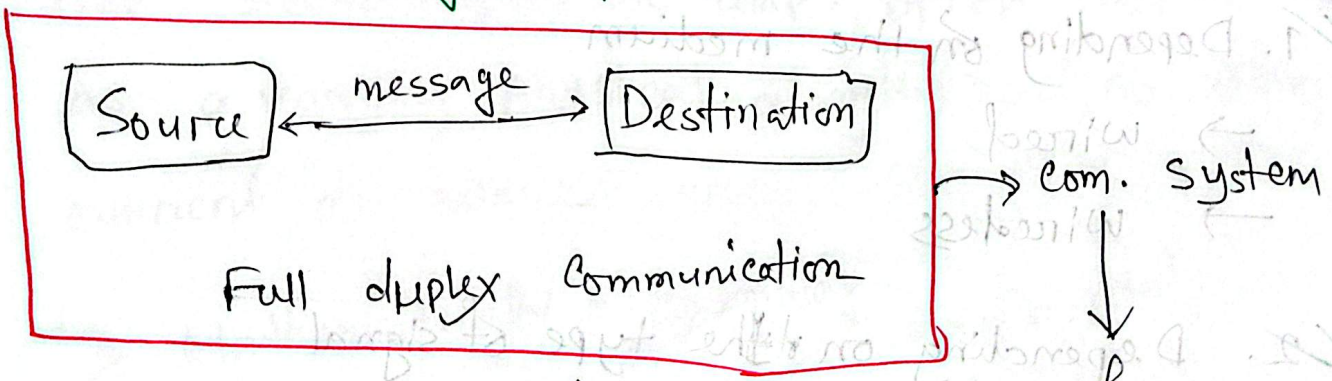
Communication Engineering Fundamental Noise.

It is a specialized branch of $\frac{ECE}{ece}$ that focus on research, design, development and maintenance com. system

মেয়েদের high frequency
ছেলেদের low "

Scope / Application:

Communication System:

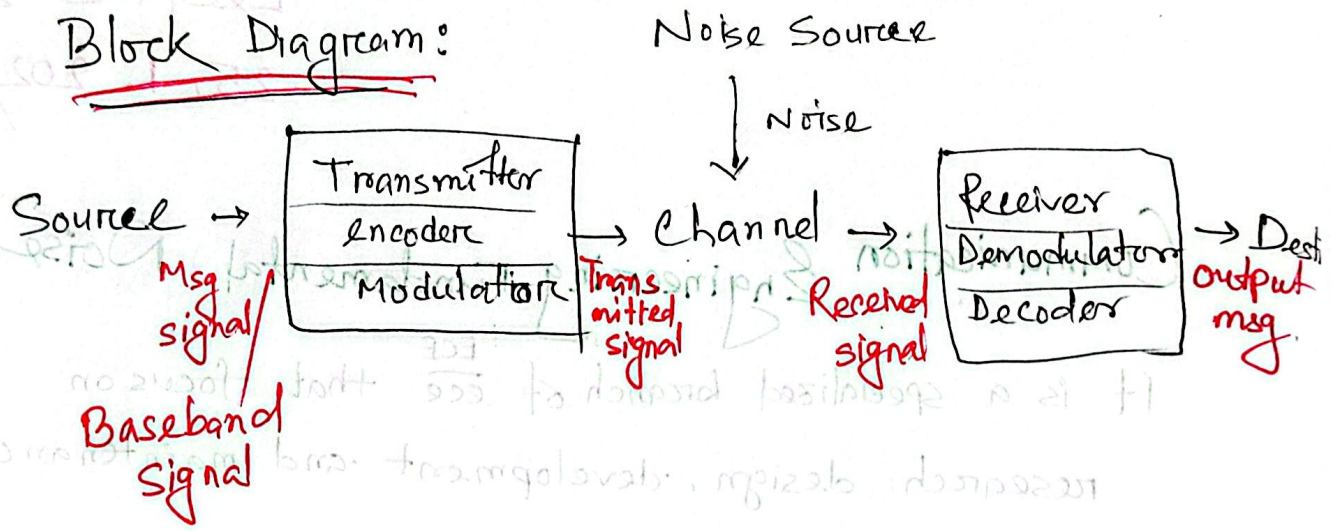


Combination of hardware and software

Communication System is a subset of com. Engineering

Anywhere. Anytime. Any device → Triple A

Block Diagram:



Channel :

① Guided Media : Wires, fiber optical

② UnGuided Media : Wireless

Types of communication

1. Depending on the medium
   - → Wired
   - → Wireless

2. Depending on the type of signal
   - → Analog communication
   - → Digital communication

Effectiveness of com. System :..

1. Delivery : নির্দিষ্ট জায়গাতে পৌঁছানো সঠিক জায়গায়.
2. Accuracy : কোনো error থাকবে না.
3. Timeliness :
4. Jitter

S ⟷ D দুইটি Packet এর সর্বোচ্চ দূরত্বে যে সময় লাগে এর মাঝে যে সময়টুকু দরকার সেটাই delay.

Delay **Constant**

↳ যত কম হবে তত ভালো

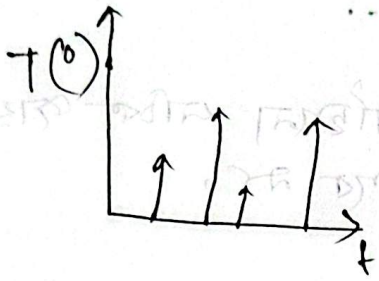
Delay এখন বার বার চেঞ্জ হয় সেটাই- Jitter.

↳ Variation in packet

Signal : একটা function of one or more variable that carries information about physical phenomenon like Sound, light, or temp. often represented as a varying physical quantity such as voltage current or wave

→ Mathematically → Analog → Digital

$x(t)$ or $x[n]$



Analog signal

Wave Signals:

Amplitude: Maximum displacement

Frequency: এক S এ কয়টুকু cycle
unit Hz

Wavelength: λ

Time Period:

$$f = \frac{1}{T}$$

$$c = f\lambda$$

[f বাড়লে T কমে]

Speed: $S = vt$

Phase: দুটো উপর কত নিচে position

$$x(t) = A \sin(2\pi ft + \Delta\theta)$$

Analog and Digital Signals.

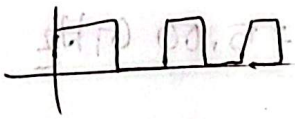
- Continuous signal → Any value within a given range
- discrete signal → binary digits (0, 1)

Aperiodic

~~Apericidio~~

Periodic and Non-Periodic Signal

- Periodic → whole signal কে certain time পর পর repeat করে।
- Non-Periodic → repeat করে না



Composite Signal

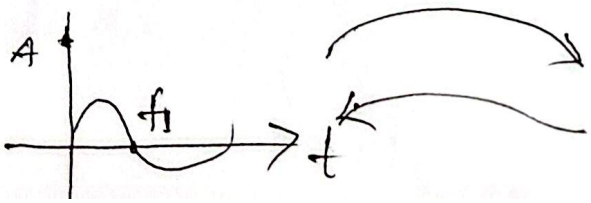
Fourier.

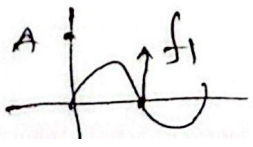
যখন signal একসাথে দুইটা ভিন্ন ফাংশন receiver এর কাছে তখন বুঝতে সমস্যা হয় Fourier Solve করে দেখা

Time Domain vs Frequency Domain signal

amplitude changes with time

amplitude is disbuted drover different frequencies





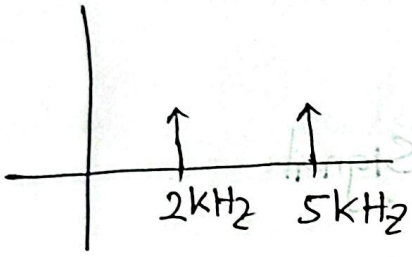
Signal and Properties

Lecture-3

27.1.2026

→ Bandwith : Range of frequency.

Maximum − Minimum = Band



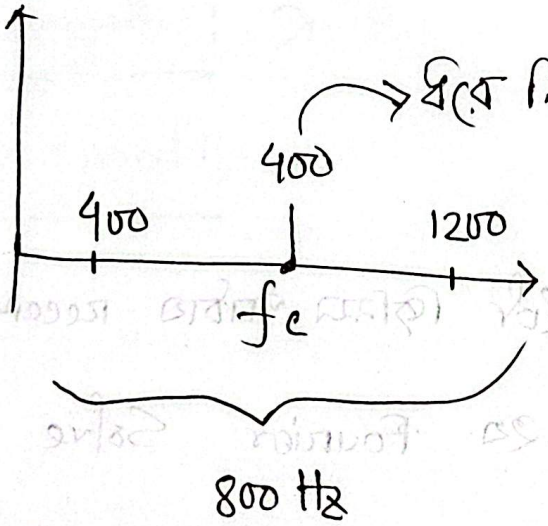
f_c = Centre frequency

$$Bw = f_{High} - f_{Low}$$

Wifi এর

2.45 GHz

5.00 GHz



→ ধরে নিতে হবে এই frequency

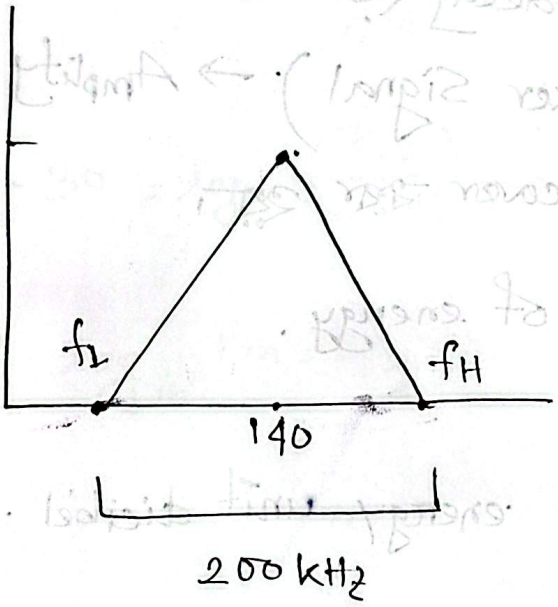
$\pm f_c = 400$ Hz

Example -3

$f_c = 140$

$B = 200\ kHz$

$A = 20$



$f_H - f_L = 200\ kHz$

$\therefore f_H = 240\ kHz$

Transmission - প্রতিবন্ধকতা

└ Signal impairments

  └→ cause ~~due~~ attenuation, distortion and ~~nos~~ noise.

Attenuation → Signal decay হয়

(weaker signal) → Amplify দ্বারা recover করা হয়।

→ loss of energy.

To show loss or gain energy unit deicibel is used

$$dB = 10 \log_{10}(P_2/P_1)$$ → কোনটি হলো Gain কত ও loss

Example 1 :

$P_1 \;=\!=\; P_2 = \frac{1}{2} P_1$

$\therefore \; dB = 10 \log_{10} \left(\frac{P_2}{P_1}\right)$

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

$\Rightarrow 10 \log_{10} \frac{1}{2}$

$= -3 \; dB$

Multiple হইলে —

$P = VI$

$P = I^2R$

$P = \frac{V^2}{R}$

Voltage হইলে — 20

ক্ষমতা হইলে — 10 } দুইবার Multiply dB

$$dBm = 10 \log_{10} \left(\frac{P_2}{P_1}\right)$$

$$\Rightarrow -30 = \log_{10} \left(\frac{P_2}{P_1}\right) \rightarrow 1mW$$

$$10 \log_{10} \left(\frac{P_2}{P_1}\right)$$

$$\Rightarrow \log_{10} Pm = -3$$

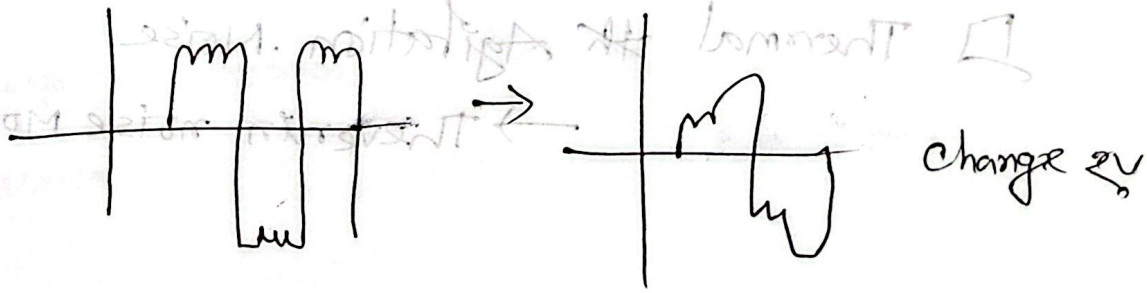
$$Pm = 10^{-3} mW$$

$$10 \log_{10} \left(\frac{Pm}{1mW}\right)$$

$$= 10 \log (10^{-3})$$

$$= -30$$

Distortion : Sender Receiver



Noise

(i) External → বাহ্যিক।

(ii) Internal – Channel এর ভিতরে

Thermal Agitation Noise

Resistance

Noise power can be represented by

$$P_n \propto T \delta f = KT \delta f$$

K = Boltzman constant = $1.38 \times 10^{-23}\ J K^{-1}$

T = Absolute temperature

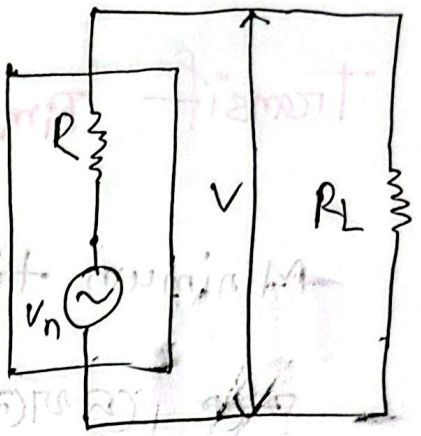
δf = Signal bandwith.

☐ Thermal ~~th~~ Agitation Noise

→ Thevenin noise Model

$$V_L = V_n * \left(\frac{R_L'}{R_s + R_L}\right)$$

$$= \frac{V_n}{2}$$



White noise- পুরো channel জুড়ে Bandwith থাকলে।

Shot Noise।

Active device → External power ব্যবহৃত হয়, Transistor MOSFET, FET, OP-Amp

Passive → ~~x~~ Power প্রয়োজন হয় না।

~~Did~~ Diode

$$i_n = \sqrt{2 e i_p \delta f}$$

e = charge of electron

i_p = direction

Transit Time noise :

Minimum time -লাগে বহুদূরে কোন লাগলে তবে যেখানে noise create হয় তখন তাকে transit time noise.

Signal to Noise Ration and Noise figure.

↓

SNR = $\frac{P_s}{P_n}$

Noise এর Power কোন

$F = \frac{\text{input SNR}}{\text{Output SNR}}$

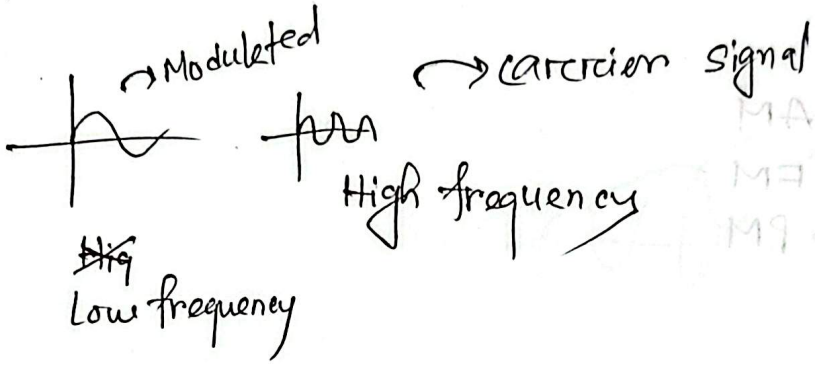
input SNR-কোন

Electronic Communication Systems by George kennedy and Bernard Davis

Lecture-4
1.2.26

Amplitude Modulation

Modulation and demodulation



Modulation is a process of varying the characteristics of a carrcier signal in accordance with a message signal.

→ low energy based signal কে high destination - পাঠানো.

Modulation

1. Send data at far distance
2. ↓ λ $\propto \frac{1}{f}$ ↑

Antenna size = ↓ $S_{ant} \propto \lambda$ ↓

3. Remove interference by modulating at different frequency

4. Multiplexing

Types of Modulation

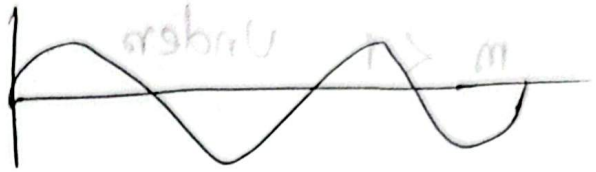
① Analog
- → AM
- → FM
- → PM

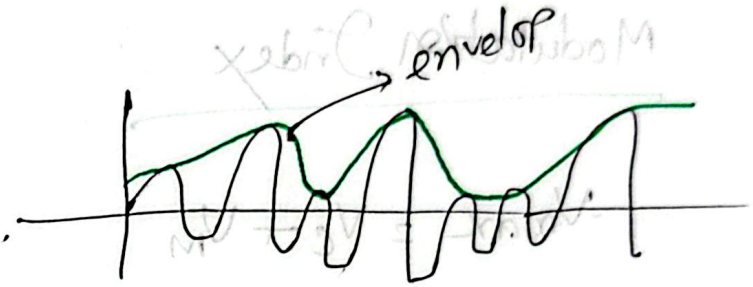
② Digital
- → ASK
- → FSK
- → PSK
- → APSK
- → QAM

✓ Based of Message Signal, carrier signal এর কিছু না কিছু changed করাই হলো Analog Modulation

✓ Carrier and Message signal কে Super impose করা → Modulation

Amplitude Modulation





Message signal $v_m = V_m \sin(\omega_m t)$

Carrier " $V_c = V_c \sin(\omega_c t)$

Modulated " $v = (V_m + V_c) \sin(\omega_c t)$

$$V_c \sin(\omega_c t) + \frac{mV_c}{2} \cos(\omega_m - \omega_c)t - \frac{mV_c}{2} (\omega_m + \omega_c)t$$

Carrier | Lower band | Upper

$\sin A \sin B = \frac{1}{2}\cos(a-b) - \frac{1}{2}\cos(A+B)$

Modulation index: $m = \frac{V_m}{V_c}$

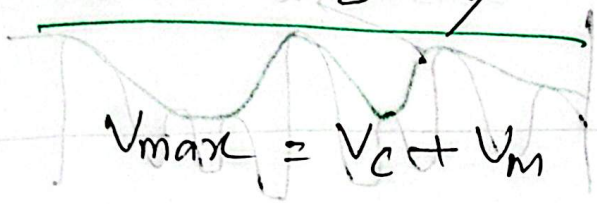
সমান হলে 1
V_m বড় হলে > 1
V_c বড় হলে < 1

$m = 1$ · Perfect modulation (ideal)

$m > 1$ over " (low signal)

$m < 1$ Under "

Modulation Index



$$V_{max} = V_C + V_M$$

$$V_{min} = V_C - V_M$$

$$V_C = \frac{V_{max} + V_{min}}{2}$$

$$V_M = \frac{V_{max} - V_{min}}{2}$$

✓ Modulation index

$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

Power of AM Signal

$$P = VI$$

$$= \frac{V^2}{R}$$

$$= I^2 R$$

$$P_{AM} = P_C \left(1 + \frac{m^2}{2}\right)$$

Lecture-5
3.2.26

Carrier এর Amplitude কে Message signal এর তথ্য দিয়ে মডিউলেট করা -Amplitude Modulation.

Prove that in a ideal case 1.5 time

Ans: $P_t = P_c \left(1 + \frac{m^2}{2}\right)$

↳ এই সূত্রের প্রতিপাদন এবং 1.5 times বড় করিয়াই

Current of AM signal

$$I_t = I_c \sqrt{1 + \frac{m^2}{2}}$$

Modulation by several Sine waves

→ Multiple

$$\therefore m = \sqrt{m_1^2 + m_2^2 + \cdots + m_n^2}$$

power of the modulated signal.

$$\frac{P_t}{P_c} = 1 + \frac{m^2}{2}$$

Example

$$\frac{m'}{2} = \frac{P_t}{P_c} - 1 = \frac{10.125}{9} - 1$$

$$= 0.125$$

$$m' = 0.125 \times 2 = 0.250$$

$$m = 0.50$$

Second Part

$$m_{tot} = \sqrt{m_1'^2 + m_2'^2}$$

$$= 0.64$$

$$P_{Am} = P_t \left(1 + \frac{m'^2}{2}\right)$$

$$= 10.84 \text{ kW}$$

Types of Amplitude Modulation.

A.M

→ Double sideband Full Carrier

✓ Standard A.M.

. Lower + upper side band আছে

. Carrier ও (চলে যায় না)

✓ Contains carrier + both sidebands

→ Double side band Surpressed

→ Single Sideband (SSB)

- Only one sideband transmitted

→ Vestigial Sideband (VSB)

- lower বা upper full হবে তারটি তার এর কাছের বা তার কম।

. Used in TV broadcasting

→ Single side band - Suppressed carrier

- Carrier থাকবে না
- মডুলেশন এ ক্যারেক্টার OFF

→ Advantage of SSB-SC

DSBFC AM → total Power

$$P_t = P_c + P_{LSB} + P_{USB}$$

$$= 1 + 0.5 + 0.5 \rightarrow \text{মডুলেশন}$$

$$= 2$$

$$= 0.5$$

energy কে কমাতে পারবো।

$$\therefore P_t = P_c \frac{m^2}{4}$$

আরেকটা side band থেকে বাঁচলে problem হবে না- কারণ তারা কম।

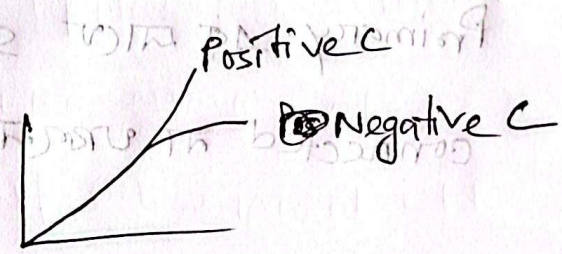
✓ Power is saved

Disadvantage.

✓ Higher cost
✓ SSB is complex

→ How explain a circuit sig Single side band?
How to generate a single side band?

Effect of Nonlinear Resistance on added signal



Non-Lin. resistance characteristics

$i \propto v$

$i = bv$ → constant

$b = \frac{1}{R}$ → resistance এর opposite → conductor. } যখন linear

যখন diode, FET, Transistor থাকবে

তখন DC component লাগবে

$i = a + bv$

$a \longrightarrow$ DC

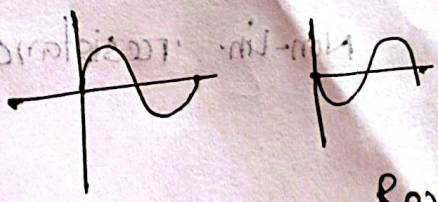
Non linear : $i = a + bv + cv^2 + dv^3 + \text{higher power}$

cv^2 Sufficient for nonlinear → যথেষ্ট

nv^n

Balanced Modulator :

Primary এর সাথে secondary transformer connected না থাকলে তখন তাকে balanced বলে।



Reverse

$V_M = V_m + V_c$ { input signal voltage

$V_c - V_m$

Ne

8 Draw and explain the term of Balance Modulator.

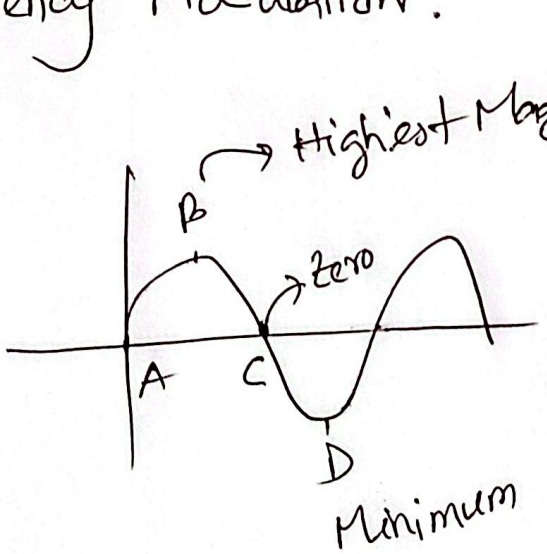
→ The phase shift Method

Lecture-6

Frequency and Phase Modulation

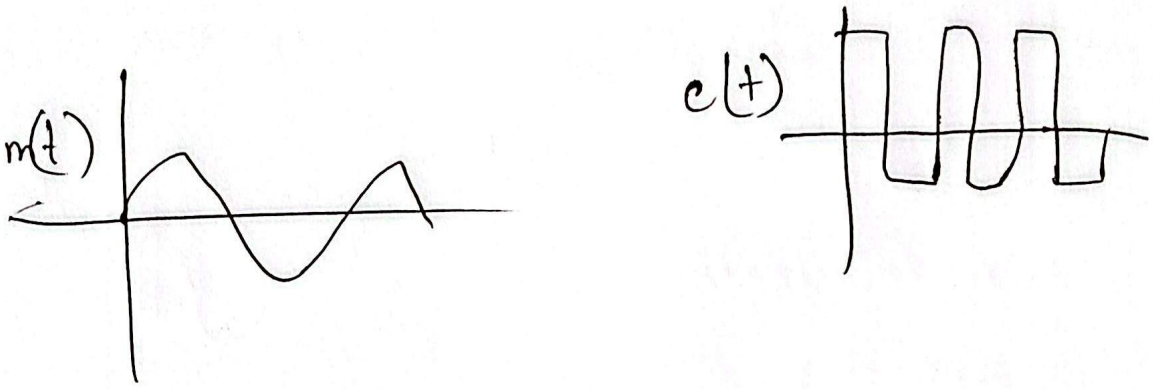
ON- 8.2.2026

Frequency Modulation:



Lecture–8
15.2.2026

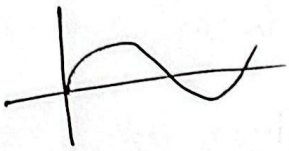
Pulse Modulation :

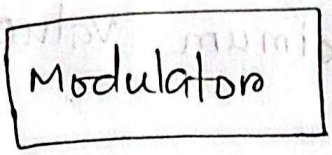


Standard Sinusoidal $x(t) = A \sin(\omega t + \phi)$

Four Parameter

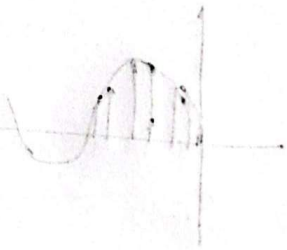
(i) Width
(ii) Amplitude
(iii) Position





Pulse code Modulation

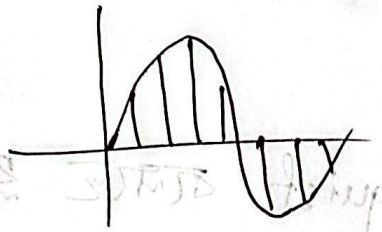
Analog-কে Digital এ রূপান্তর



1. Sampling

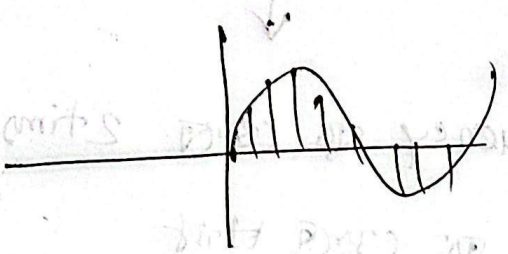
Analog signal কত সময় পর পর সেট নিব।

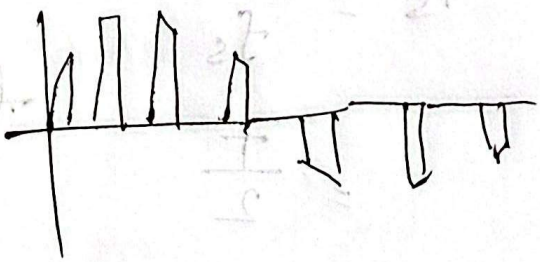
a. ideal



Stem

b. Natural ; ছোট ছোট অংশে ভাগ করতে হবে।

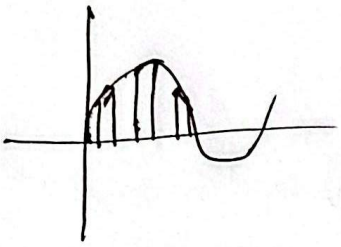




c. Flat-top Sampling.

Maximum value flap top

What are the restriction on T_s



maximum frequency
f_{max} কে বলা হয়

$f_{max} - f_{min}$

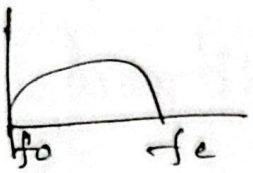
$f_s = 2f_{max}$ Nyquist বলেছে এভাবে নেয়া

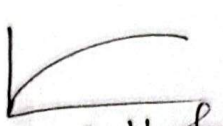
Sampling Rate → T_s

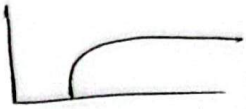
$T_s = \frac{1}{f_s}$

$= \frac{1}{2}$ frequency বড় হলে 2 times

T ছোট হবে হবে

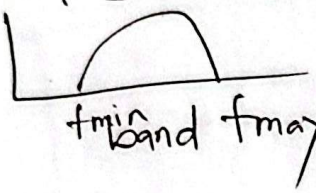


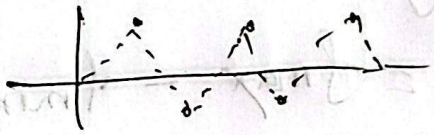


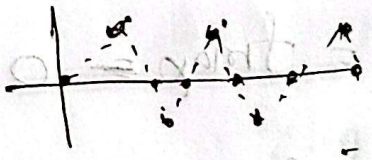


Low → Signal ০ থেকে কত হয়ে হচ্ছে

Nyquist = ~~2 fmax~~ 2 × fmax

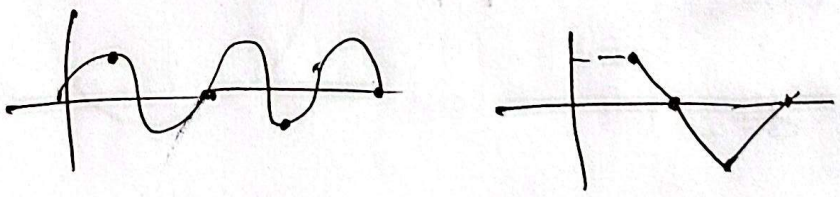


Ideal ↑ $f_s = 2 f_{max}$ → 

2×↑ $f_s = 2 \times 2 f_{max}$ →  → Point - redundancy বাড়ে

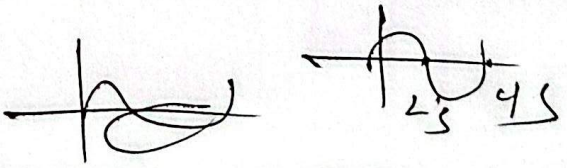
↓ $f_s = f_{max}$

→ Over sampling



Under sampling

$T = \frac{1}{f}$ frequent T তে যায়



Example

$f_{max} = 4000\ Hz$

$f_s = 2 \times f_{max}$

$= 2 \times 4000$

$= 8000\ Hz$

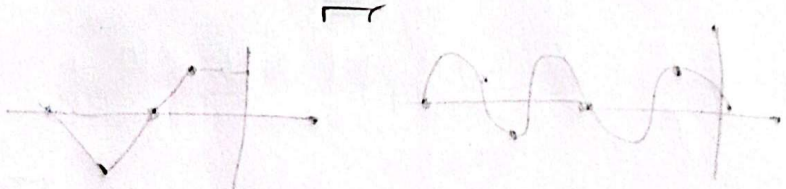
BW

$200 = f_{max} - f_{min}$

$200 = f_{max} - 0$

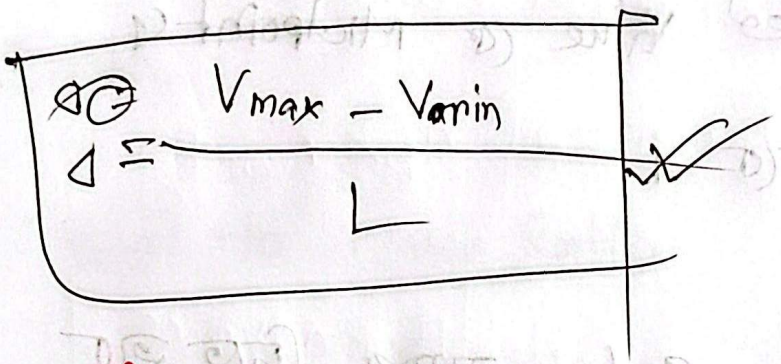
$200 = f_{max}$

$200 \times 1000 = 200000$



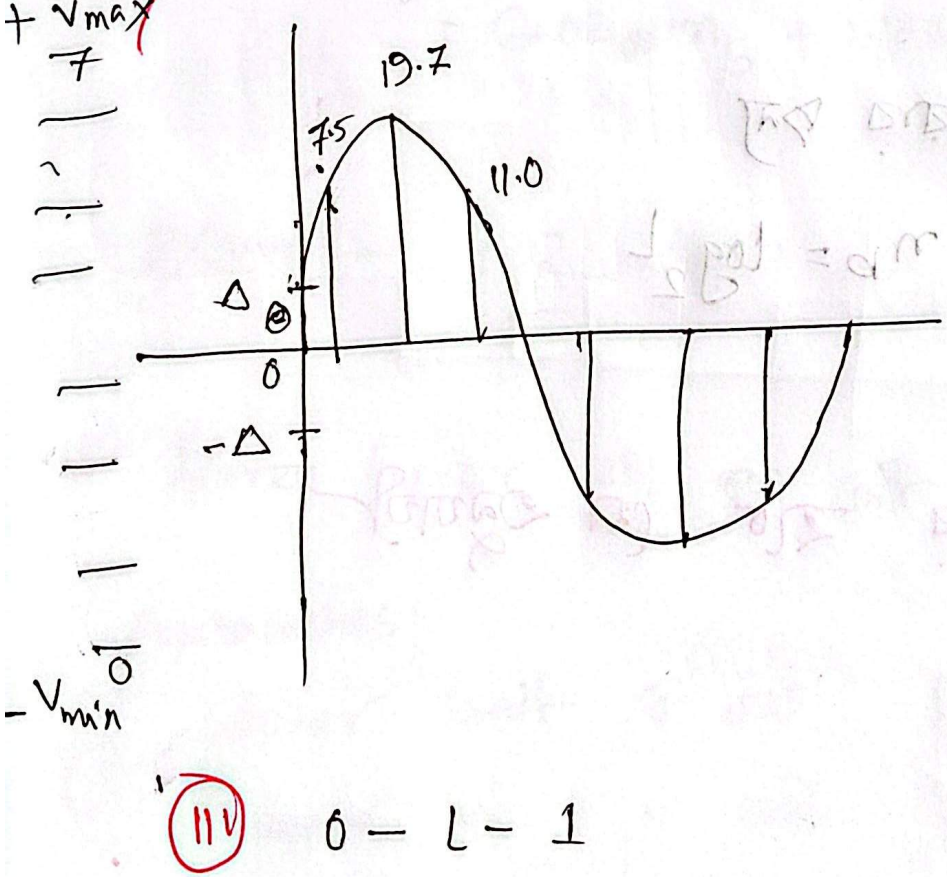
Quantization

4 th Step



(II)

Quantization codes



(III) 0 – L – 1

lecture-9

17.2.26

(I) Vmax and Vmin

+20 → Vmax

-2 → Vmin

identify করতে হবে

L = 8 → ৪টি লেভেল

$= \frac{20+20}{8}$

$= 5$

L = Quantization Level

(IV) Find the Normalized Value

$$\frac{\text{Sample Value}}{\Delta}$$

(V) Normalized Value কে Midpoint এ নিয়ে আসতে হবে।

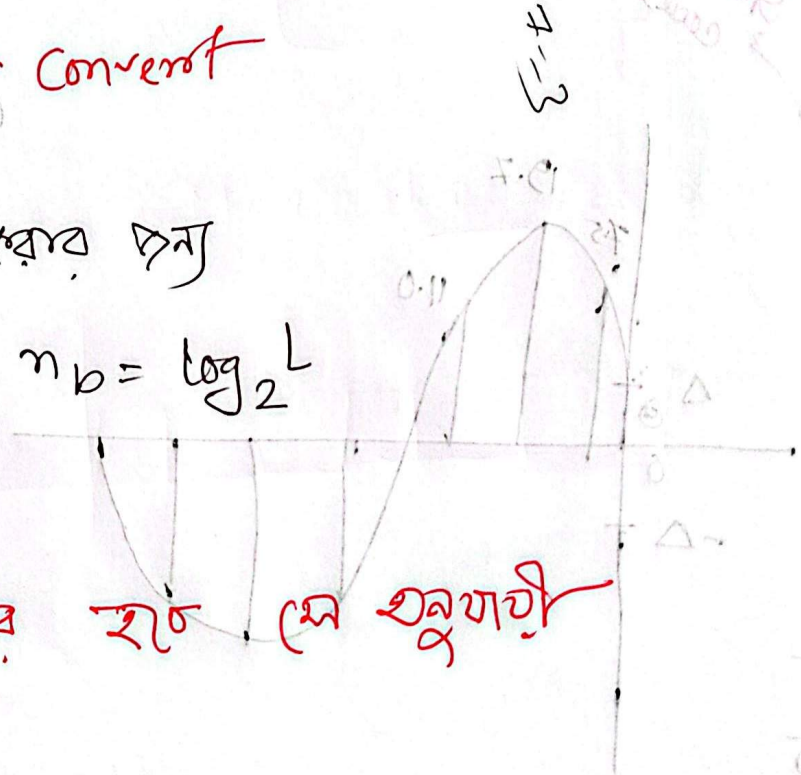
(VI) Quantization code নাম্বার দিতে হবে

(VII) Binary তে convert

(VIII) bit - বের করার জন্য

$$n_b = \log_2 L$$

(IX) যত বিট বের হবে সে অনুযায়ী encoding.



Quantization Level বাড়লে error কমবে।
→ তাহলে bits বেড়ে যাবে।

SNR

Signal to Naise Ratio

$$SNR_B = 6.02 n_b + 1.76 \text{ dB}$$

$$= 6.02 \cdot n_b + 1.76 \text{ dB}$$

Example — 4.12, 4.13

Error $\frac{1}{2}$ এর বেশী হতে পারে না।

Approaches:

① Lower limit ও কম
upper " " বেশী
amplitude

② Companding → Receiver end ও দিতে same ও

Bit rate $\Rightarrow n_b \times f_s$

~~Bai~~ Minimum required bandwith

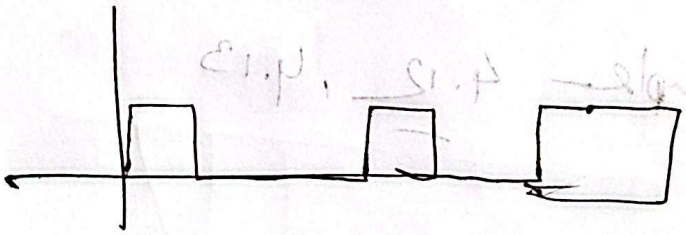
$B_{min} = n_b \times B_{analog}$

4.1kg

~~Hoot~~ [Human voice 4000 Hz]

Components of a PCM Decoder

Hold circuit



Advantage

Disadvantage

Attenuation → Signal বাধা দেওয়ার প্রবনতা।

Delta Modulation

1 থাকলে উপরে উঠবে Positive

0 " নিচে নামবে। Negative

Previous বার সাথে Difference করে।
এটাই Modulation.

Delay unit → প্রত্যেক T বার জন্য hold রাখে

Delta Pulse code Modulation