U19CS012

Subject Name: DIGITAL COMMUNICATION (DCOM) EC209
Admission Number: U19CS012
Full Name: BHAGYA VINOD RANA
Division: A
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Q1) Transmitter and Receiver of two seperate balance modulators
⇔ two carrier waves of same freq, but differing in phase by 90°.

① QAM (Quadrature Amplitude Modulation)
A signal in which two carriers shifted in phase by 90 degrees (i.e. sine and cosine) are modulated and combined.

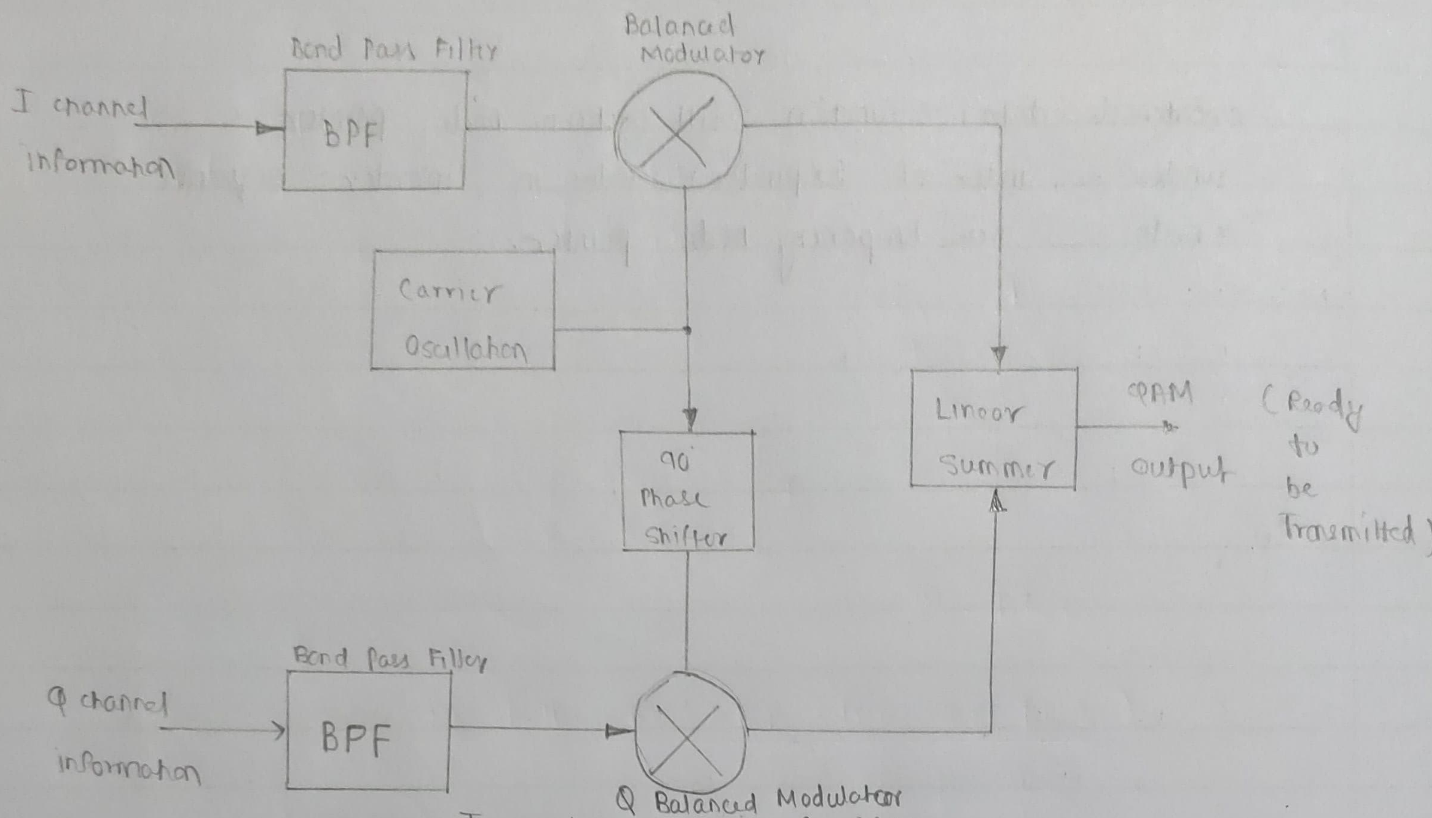
② One signal is called In-phase or "I" signal (sine)
other signal is called quadrature or "Q" signal (cosine)

QAM Transmitter (Figure 1(a))

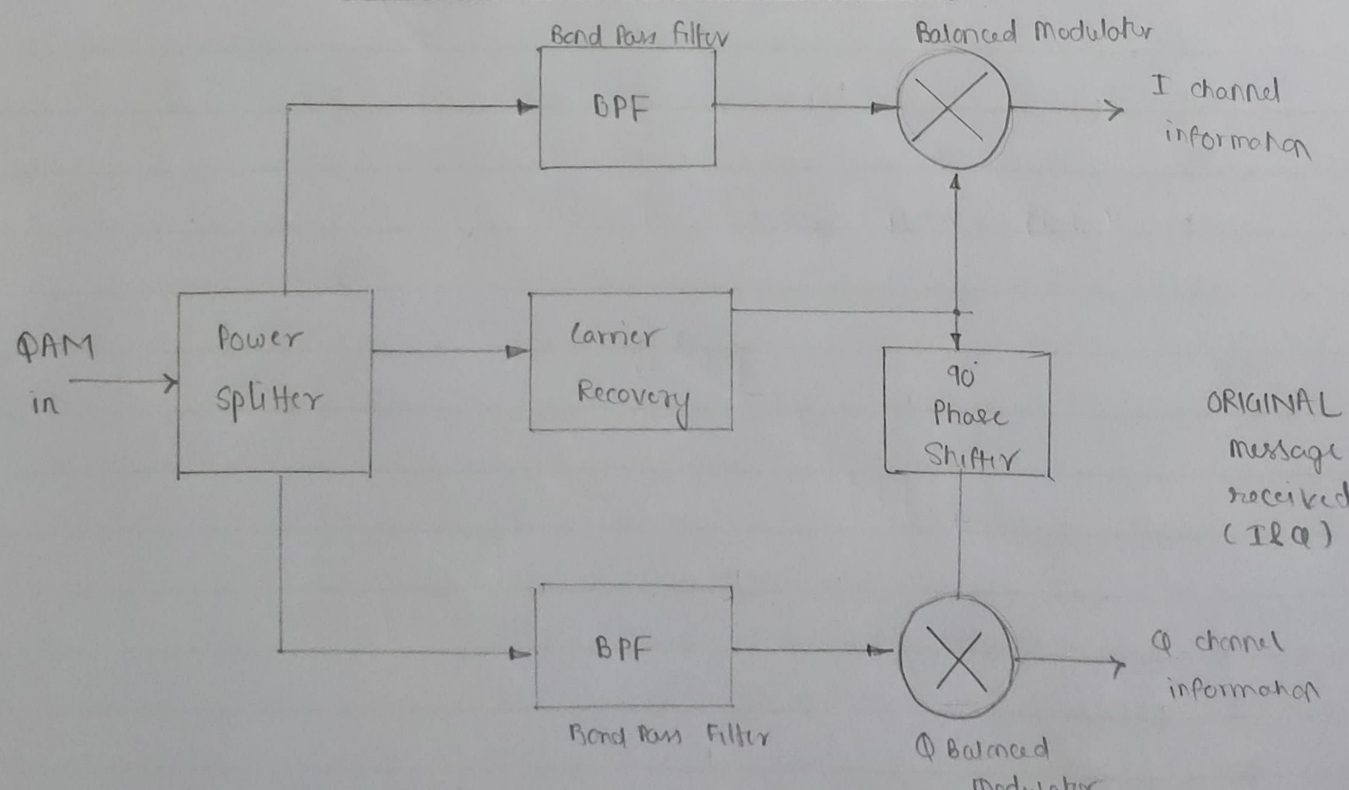
③ Idea derived from Basic QAM theory, two carrier signals with phase shift 90°. These are then amplitude modulated with two data streams known as I (Inphase) or Q (Quadrature)
(generated in Baseband processing area)

④ The two resultant signals are summed and then processed as required in RF signal chain.
RF Amplifier must be linear to preserve the integrity of signal.
Any non-linearities will alter → relative level of signals
→ phase difference

∴ Possibility of Error.



(1) (a) Transmitter circuit of QAM



(1) (b) Receiver Circuit of QAM

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Let two carrier signals be

$$V_{c1} = V_c \cos(\omega_c t)$$

$$V_{c2} = V_c \sin(\omega_c t)$$

Corresponding QAM (After transmitter summation)

$$V_{QAM} = \underbrace{V_{m1} V_c \cos(\omega_c t)}_{\text{in phase}} + \underbrace{V_{m2} V_c \sin(\omega_c t)}_{\text{Quadrature}}$$

RECEIVER (QAM) (Figure 1 (b))

⑤ message signal are recovered using coherent detection.

output of Analog multiplier I phase

$$S_i = V_{QAM} V_c' \cos(\omega_c t) = \underbrace{\frac{V_{m1} V_c V_c'}{2}}_{\text{low pass filter}} + \frac{V_{m1} V_c V_c'}{2} \cos(2\omega_c t) + V_{m2} V_c V_c' \sin(\omega_c t) \cos(\omega_c t)$$

scaled version of V_{m1}

Output of Analog Multiplier + Q phase

$$S_q = V_{QAM} V_c' \sin(\omega_c t) = \underbrace{\frac{V_{m2} V_c V_c'}{2}} + \frac{V_{m2} V_c V_c'}{2} \sin(2\omega_c t) + V_{m1} V_c V_c' \sin(\omega_c t) \cos(\omega_c t)$$

In this way, we can transmit two independent message signals on the same bandwidth with help of two carrier (with 90° phase).

2.7 Transmitter & Receiver block single bit per sample digital mod.

② Waveform with mathematical expression

③ Working

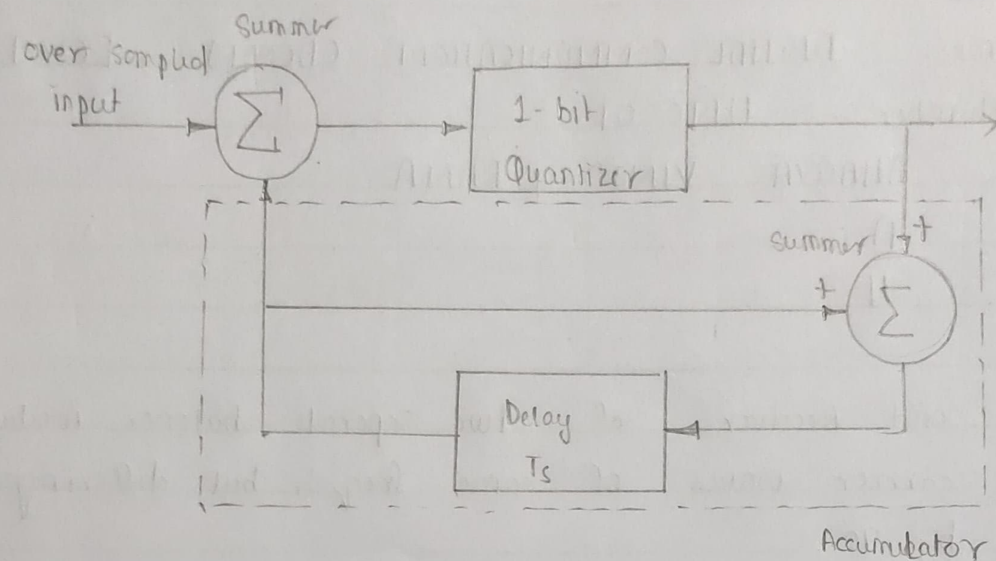
① Delta modulation (sampling rate >> stepsize after quantization)

> The design of modulator & demodulator is simple

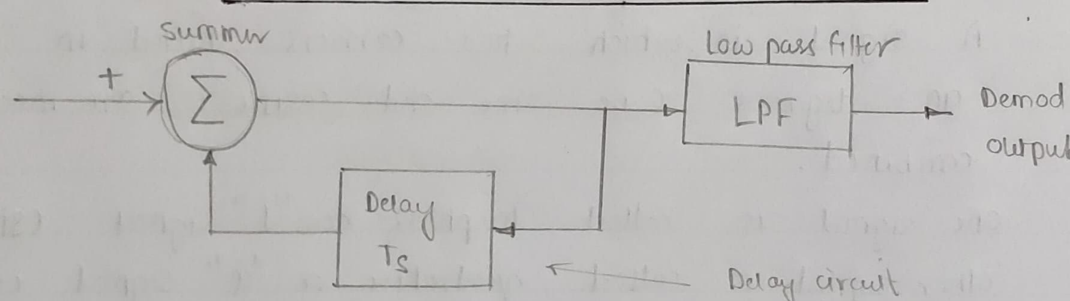
> Staircase approx of output waveform.

> bit rate can be decided by user. (Single bit/sample)

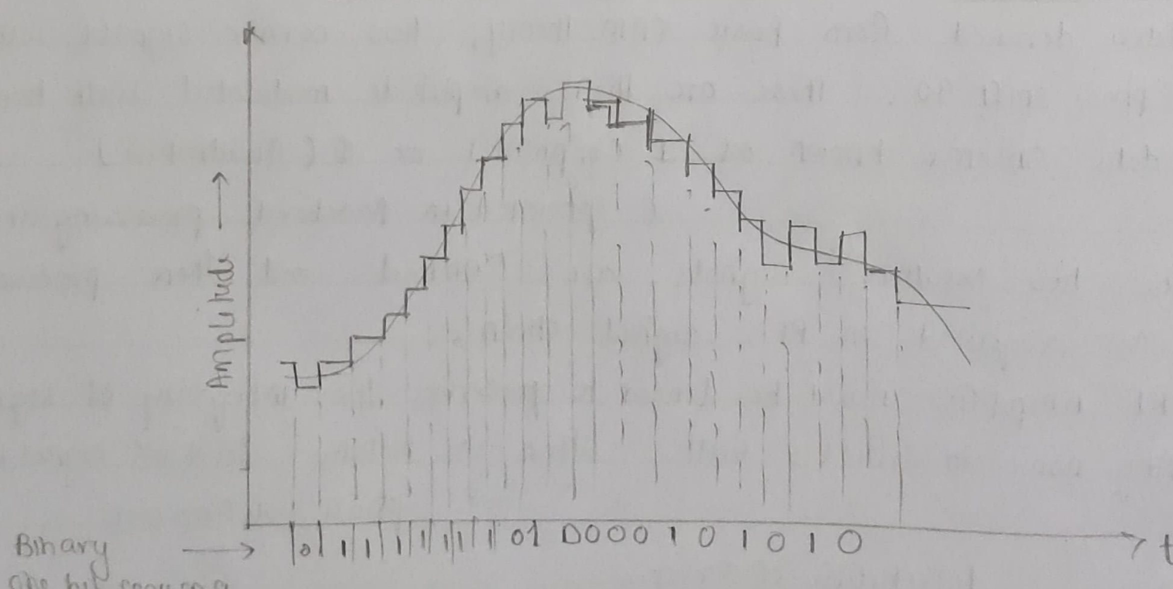
(1 bit DPCM scheme)



2(a) Delta Modulator (Transmitter Block)



2(b) Delta Demodulator (Receiver Block)



2(c) Delta Modulation waveform

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2) Working Principle

i) Delta modulation transmits one bit per sample

ii) Here present sample value is compared with the previous sample value and this results whether Amplitude will increase or decrease is transmitted.

iii) Input signal $x(t)$ ≈ approximate to step signal by delta (modulator)
Step size = fixed

(iv) The difference between input signal $x(t)$ & staircase approximate signal ⟶ 2 levels $+\Delta$ & $-\Delta$

if difference = Positive = Approximated signal increase by 1 step — 1 transmitted.
difference = Negative = Approx. signal decrease by 1 step — 0 transmitted

3) Mathematical Expressions

Principle can be explained using following eqn's

The error between sampled value and last approximated sample

$$\boxed{e(nT_s) = e(nT_s) - \hat{x}(nT_s)}$$

$e(nT_s)$ = error at present sample

$x(nT_s)$ = sampled signal of $x(t)$

$\hat{x}(nT_s)$ = last sample approximation of the staircase waveform.

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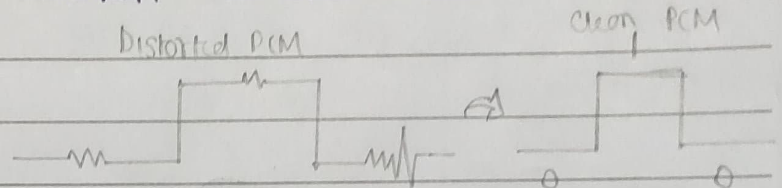
3) ① PCM control Noise and Distortion

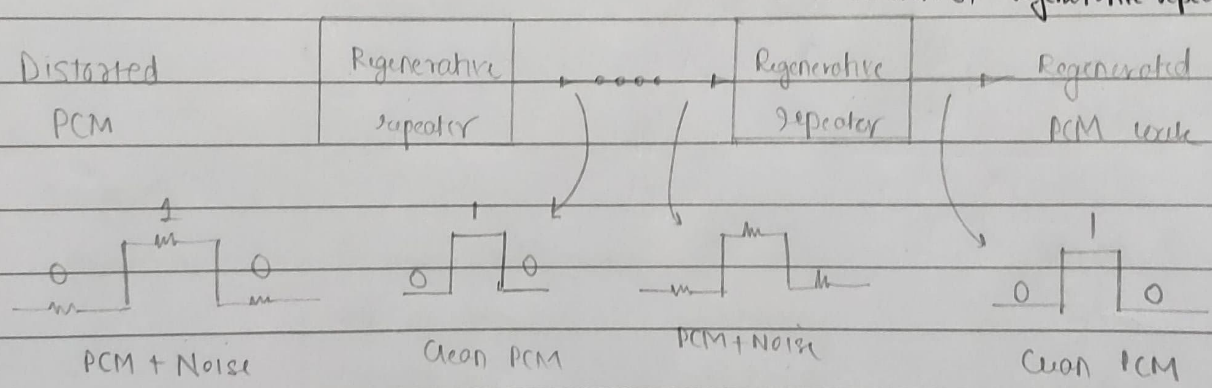
The PCM is a method to convert ~~digitally implement~~ sampled analog signal → digital (0 & 1)

The most important feature of PCM system is its ability to control the effects of distortion and noise when PCM wave travels on the channel.

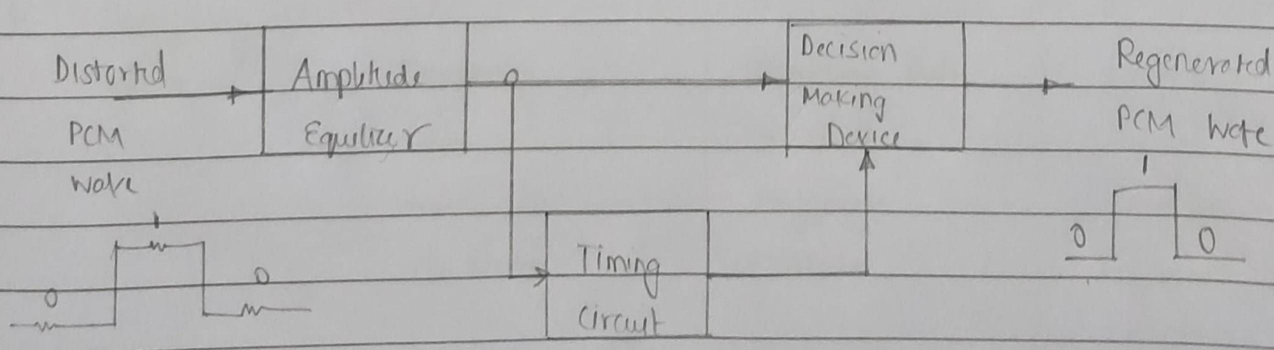
PCM Transmitted PATH



(8) (c) waveform of regenerative repeater

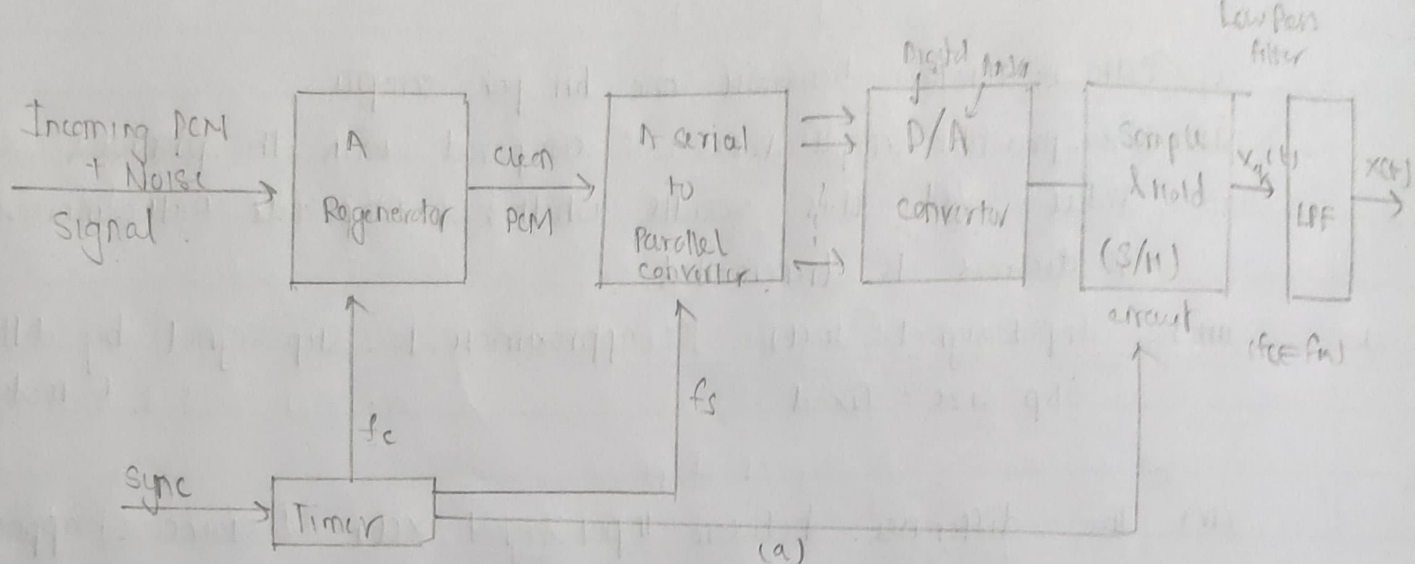


(8) (a) PCM Path



(8)(b) Block diagram of Regerative Repeater

(3)(d) Whole process



3(d) PCM Receiver

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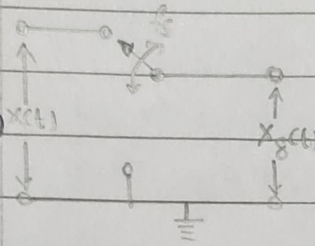
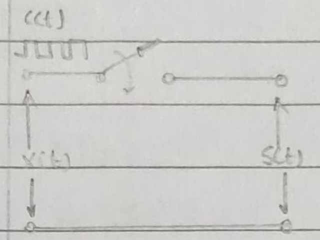
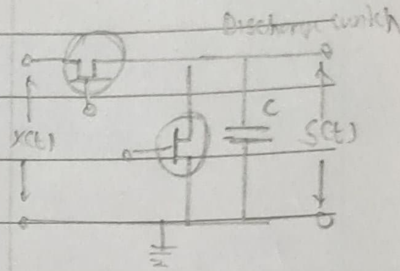
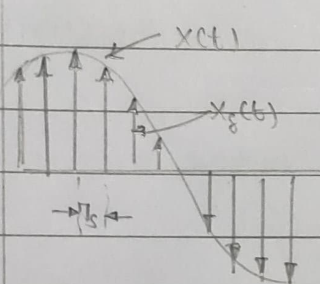
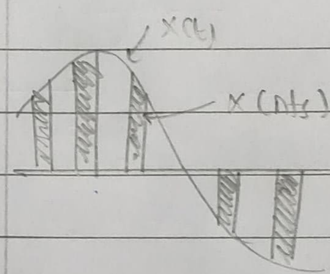
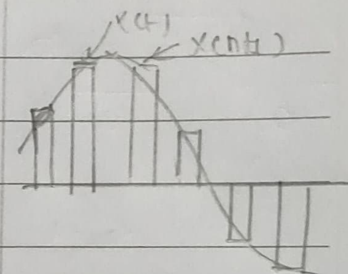
4.

Sr No.	Parameter of comparision	Ideal or Instantaneous Sampling	Natural Sampling	Flat top Sampling
1	Generation Circuit (circuit of sampler)			
2	Waveforms involved			
3	Sampling principle	It uses multiplication by an impulse function	It uses chopping principle	Sample & Hold circuit
4	Sampling Rate	Sampling rate tends to Infinity.	Sampling Rate satisfies Nyquist criteria.	Sampling Rate Satisfies Nyquist criteria

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$m(t) = 10 \sin(2\pi \times 10^3 t)$

$c(t) = 20 \sin(2\pi \times 10^4 t)$

$A_m = 10 \quad f_m = 10^3\ Hz = 1\ KHz$

$A_c = 20 \quad f_c = 10^4\ Hz = 10\ KHz$

(i) μ = Modulation index = $\frac{A_m}{A_c}$, $\frac{10}{20} = 0.5$

Percentage modulation = $\mu \times 100\% = \boxed{50\%}$

(ii) frequencies of sidebands $= f_c - f_m = 9\ KHz$

$= f_c + f_m = 11\ KHz$

Ans: $(f_{LSB}) = \boxed{9\ KHz}$ (lower side band) $\boxed{f_{USB} = 11\ KHz}$ (upper side band)

(iii) Amplitude of Side Bands $= \left(\frac{\mu}{2}\right)(A_c)$

$= \frac{(0.5)}{(2)} \times (20)\ 10$

$= \boxed{5 \text{ units}}$

(iv) Bandwidth of modulating signal $= 2 * f_m$

$= 2 * 1\ KHz$

$= \boxed{2\ KHz}$

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(6) $E_c = 10V$ $f_c = 30\ KHz$

$E_m = 3V$ $f_m = 1\ KHz$

$R = 50\ \Omega$

(i) Modution Index = $\mu = \frac{E_m}{E_c} = \frac{3}{10} = \boxed{0.3}$

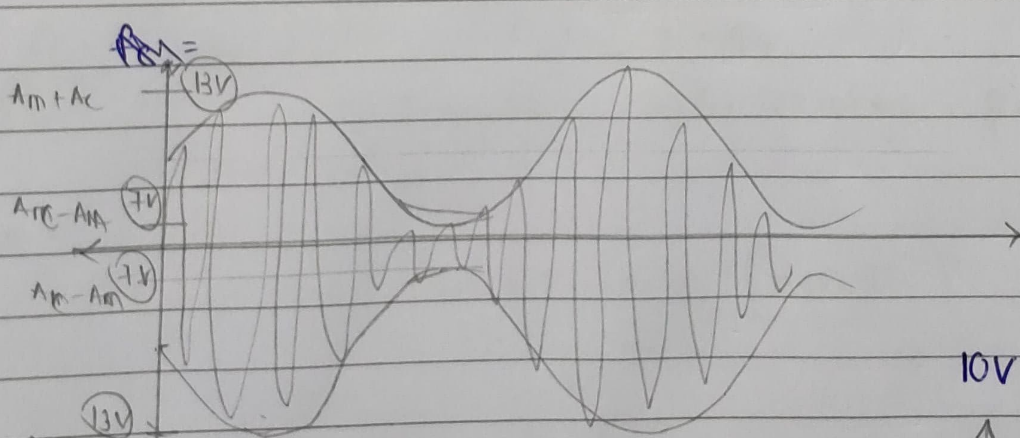
(ii) Equation of Modulated wave

$$S(t) = A_c\,[1 + \mu \cos(2\pi f_m t)]\,\cos(2\pi f_c t)$$

$$= 10\,[1 + 0.3 \cos(2\pi (1000)(t))]\,\cos(2\pi\ 30\times10^3\ t)$$

$$= 10\,[1 + 0.3 \cos(2\pi (10^3)\ t)]\,\cos(60\times10^3\ \pi t)$$

(iii)



(Modulated wave)

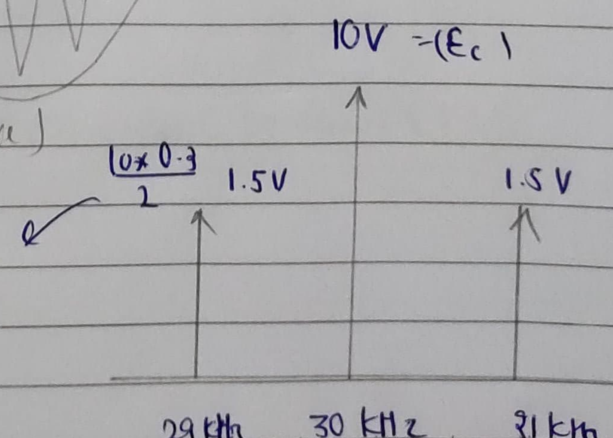
(iv)

$f_c = 30KHz$

$f_{LSB} = 29\ KHz$

$f_{USB} = 31\ KHz$

$\left(\frac{\mu A_c}{2}\right)$



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(7) $f_c = 20\,MHz$ $\quad E_c = 5\,V$

$f_m = 400\,Hz$ $\quad \Delta f = 10\,KHz$ $\quad \beta = \frac{\Delta f}{f_m} = \frac{k_f A_m}{f_m} = 25$

$= k_f A_m$

FM =

$$s(t) = A_c \cos(2\pi f_c t + 2\pi k_f \int m(t)\,dt)$$

$$= 5 \cos(2\pi (20\,MHz) t + 2\pi k_f \int m(t)\,dt)$$

PM

$$s(t) = A_c \cos(2\pi f_c t + \beta \cos(2\pi f_m t))$$

$(\beta = k_p A_m)$

$$= \left[5V \cos(2\pi (20\,MHz) t + 25 \cos(2\pi (400) t)) \right]$$

$f_c = 20 \times 10^6\,Hz$ $\quad E_c = 5V$

$f_m = 2000 + 400 = 2400\,Hz$ $\quad \Delta f = 10 \times 10^3\,Hz$ $\quad \beta = \frac{10\,KHz}{2.4\,KHz}$

$= \boxed{4.167}$

FM =

$$5 \cos(2\pi (20\,MHz) t + 2\pi k_f \int m(t)\,dt)$$

PM = $5 \cos(2\pi (20\,MHz) t + 4.167 \cos(2\pi (2400) t))$

X