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ECE-2

Section – A

Question – 1

Q1 List the advantage of SSB modulation scheme.

Answer 1) As only one side band is transmitted, there is a further reduction in transmitter power.

2) As the carrier is not transmitted, this enables 50% reduction in transmitted power level.

3) Receiver bandwidth can be reduced by half which improves S/g to noise ratio by a factor of two.

Question – 2

Q2 Write the power relation for AM signal.

$$P_c = \frac{A_c^2}{2R}$$

$$P_{USB} = P_{LSB} = \frac{A_c^2 \mu^2}{8R}$$

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

$$P(t) = \frac{A_c^2}{2R}\left(1 + \frac{\mu^2}{2}\right)$$

$$\boxed{P_t = P_c\left(1 + \frac{\mu^2}{2}\right)}$$

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Question (3)

Que 3 Explain deviation ratio for FM signal -

FM deviation ratio can be defined as the ratio of the maximum carrier frequency deviation to the highest audio modulating frequency.

$$\boxed{m = \frac{\text{max. freq. Deviation}}{\text{no. of modulation freq.}}}$$

Qtn 4

Que 4 What is basic difference in Direct and Indirect method of FM Generation.

A1.

Direct method	Indirect Method
The carrier frequency is directly varied in accordance with the i/p baseband s/g.	The modulating s/g is used to produce a NBFM s/g & frequency multiplication is next used to increase the freq. deviation to the desired level.

Question 5

Q5 Define PSD. What is PSD of AWGN?

→ PSD is power spectral density of the s/g describe the power present in the signal as a ftn of a freq per unit freq. It is expressed in watts/Hz.

→ Thermal noise is described by zero mean gaussian random process nets that adds onto s/g ⇒ additive

→ If PSD is ~~the~~ flat, it is called white noise

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Question ⑥ write the condition for threshold in FM modulating Scheme

FM threshold is usually defined as a carrier to Noise ratio at which demodulating signal-to-noise falls 1dB below the linear relationship. condition for threshold. in FM modulating scheme :-

$$\text{FOM} = \frac{\text{SNR } i/p}{\text{SNR } o/p} \; ; \; \text{fom} > 1$$

$$\boxed{\beta > \sqrt{\frac{2}{3}}}$$

Question ⑦

Question ⑦ what are the factors affecting PCM transmission b.w?

The transmission bw of PCM is -

$$B.w \geq r/2 \qquad (r = \text{sampling rate})$$

$$r = \nu f_s$$

$$B.w \geq \frac{\nu f_s}{2}$$

$$Bw \geq \nu f_m$$

It depends upon -

1) frequency of msg s/g.
2) ν i.e ~~[illegible]~~ no. of bits.

Question ⑧

Que 8 what is sampling? Name different type of sampling?

Sampling is defined as, "The process of measuring the instantaneous values of continuous time signal, in a discreate form". The discretization of s/g is called sampling.

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Diff. sampling methods are as follows.

① Simple random sampling
② Systematic sampling
③ Stratified sampling
④ Clustered sampling

Question (9)

Q-9. Explain line coding with its different type.

The waveform pattern of voltage a current used to represent the 1s and 0s of a digital s/g on a transmission link is called line coding.

The common types of line coding are -

① Unipolar
② Polar
③ Bipolar
④ Manchester.

Question (10)

Q-10 What modulation technique is best among ASK, FSK & PSK support your answer with proper explanation?

PSK is the best modulation technique because of the following reason.

① It has a constant envelope.
② In PSK, there is less chance in changing the phase of the s/g.

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Section - B

Question - 12

Q. Derive an expression of power content in an AM wave when modulating s/g is a single tone sinusoidal s/g.

In single tone amplitude modulation

$$S_{AM}(t) = A_c \{1 + K_a m(t)\} \cos 2\pi f_c(t)$$

Let $m(t) = A_m \cos 2\pi f_m(t)$

$$S_{AM}(t) = A_c \{1 + K_a A_m \cos 2\pi f_m(t)\} \cos 2\pi f_c(t)$$

where, $K_a A_m = \mu$ (modulation index)

$$S_{AM}(t) = A_c \{1 + \mu \cos 2\pi f_m(t)\} \cos 2\pi f_c(t)$$

$$= A_c \cos 2\pi f_c(t) + A_c \mu \cos 2\pi f_c(t) \cdot \cos 2\pi f_m(t)$$

$$= \underbrace{A_c \cos 2\pi f_c(t)}_{\text{Carrier}} + \frac{A_c \mu}{2} \{ \underbrace{\cos 2\pi (f_c + f_m) t}_{\text{USB}} + \underbrace{\cos 2\pi (f_c - f_m) t}_{\text{LSB}} \}$$

Total power, $P_t = P_c + P_{USB} + P_{LSB}$

$$P_c = \frac{A_c^2}{2R}$$

$$P_{USB} = \frac{\left(\frac{A_c \mu}{2}\right)^2}{2R} = \frac{A_c^2 \mu^2}{8R}.$$

$$P_{LSB} = \frac{A_c^2 \mu^2}{8R}$$

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$$P_{(t)} = \frac{A_c^2}{2R} + \frac{A_c^2\mu^2}{8R} + \frac{A_c^2\mu^2}{8R}$$

$$= \frac{A_c^2}{2R}\left\{1 + \frac{\mu^2}{2}\right\}$$

$$\boxed{P_t = P_c\left\{1 + \frac{\mu^2}{2}\right\}}$$

$$\boxed{P_{SB} = \frac{A_c^2\mu^2}{4R} = \frac{P_c\mu^2}{2}}$$

Efficiency, $\eta = \frac{P_{SB}}{P_t} \times 100 = \frac{1 + \frac{\mu^2}{2}}{\frac{\mu^2}{2}} \times 100 = \frac{\mu^2+2}{\mu^2} \times 100\%$

$$\boxed{\eta = \frac{\mu^2+2}{\mu^2} \times 100\%}$$

Question-13

~~Q- Derive an expression of power content in an AM~~

Q- Derive the mathematical expression for single tone FM -

A) carrier s/g before modulation

$$c(t) = A_c \cos(2\pi f_c(t)) + \phi\}$$

$$c(t) = A_c \cos(\theta(t))$$

where $\theta(t) = 2\pi f_c t) + \phi$ — ①

Diff w.r.to t

$$\boxed{\frac{d\theta(t)}{dt} = 2\pi f_c}$$

for instantaneous frequency, f_i.

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$$\theta(t) = \theta_i(t)$$

or. $$\boxed{f_i = \frac{1}{2\pi}\frac{d\theta_i(t)}{dt}} \quad \text{--- (2)}$$

we know, $$\boxed{S_{FM}(t) = A_c \cos \theta_i(t)} \quad \text{--- (3)}$$

From eq (2)

$$\theta_i(t) = 2\pi \int [f_i\, dt].$$

$$= 2\pi \int \{f_c + K_f m(t)\}\, dt.$$

$$= 2\pi f_c \cancel{t} + 2\pi K_f \int_{-\infty}^{t} m(t)\, dt.$$

or

$$= \boxed{2\pi f_c(t) + 2\pi K_f \int_{0}^{t} m(t)\, dt.} \quad \text{--- (4)}$$

from eq (3) & (4).

$$S_{FM}(t) = A_c \cos \left\{2\pi f_c(t) + 2\pi K_f \int_0^t m(t)\, dt.\right\}$$

Let $m(t) = A_m \cos 2\pi f_m(t)$

$$S_{FM}(t) = A_c \cos \left\{2\pi f_c t + 2\pi K_f \frac{A_m \sin 2\pi f_m t}{2\pi f_m}\right\}$$

where $\frac{K_f A_m}{f_m} = \beta$ (mod. Index)

Therefore, $$\boxed{S_{FM}(t) = A_c \cos \{2\pi f_c t + \beta \sin 2\pi f_m(t)\}}$$

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Question (11)

Q.11 The antenna current of AM broadcast transmitter modulated to the depth of 40% by an audio sine wave is 11 Amp. It increases to 12 Amp as a result of simultaneous modulation by another audio sinewave. What is modulation index due to second wave.

we know, $P(t) = P_c\left(1+\frac{\mu^2}{2}\right)$ — (1)

Since $P \propto I^2$,

eq (1) can be written as.

$$I_t^2 = I_c^2\left(1+\frac{\mu^2}{2}\right)$$

or $\boxed{I_t = I_c\sqrt{1+\frac{\mu^2}{2}}}$ — (2)

For 1st wave

$I_t = 11A$

$\mu = 0.4$

$$11 = I_c\sqrt{1+\frac{0.16}{2}}$$

$$= I_c \times 1.039$$

$$\boxed{I_c = 10.58\ A}$$

For 2nd wave

$I_t = 12A$

$$I_t = I_c\sqrt{1+\frac{\mu_1^2+\mu_2^2}{2}}$$

$$12 = 10.58\sqrt{1+\frac{(0.16+\mu_2^2)}{2}}$$

$$1.285 = 1+\left(\frac{0.16+\mu_2^2}{2}\right)$$

$$\boxed{\mu_2 = 0.641}$$

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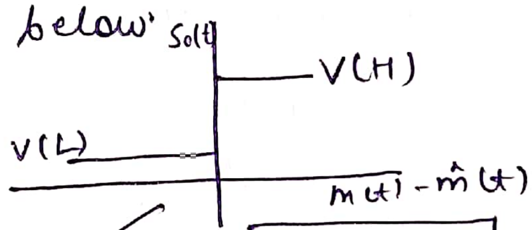
Section-C.

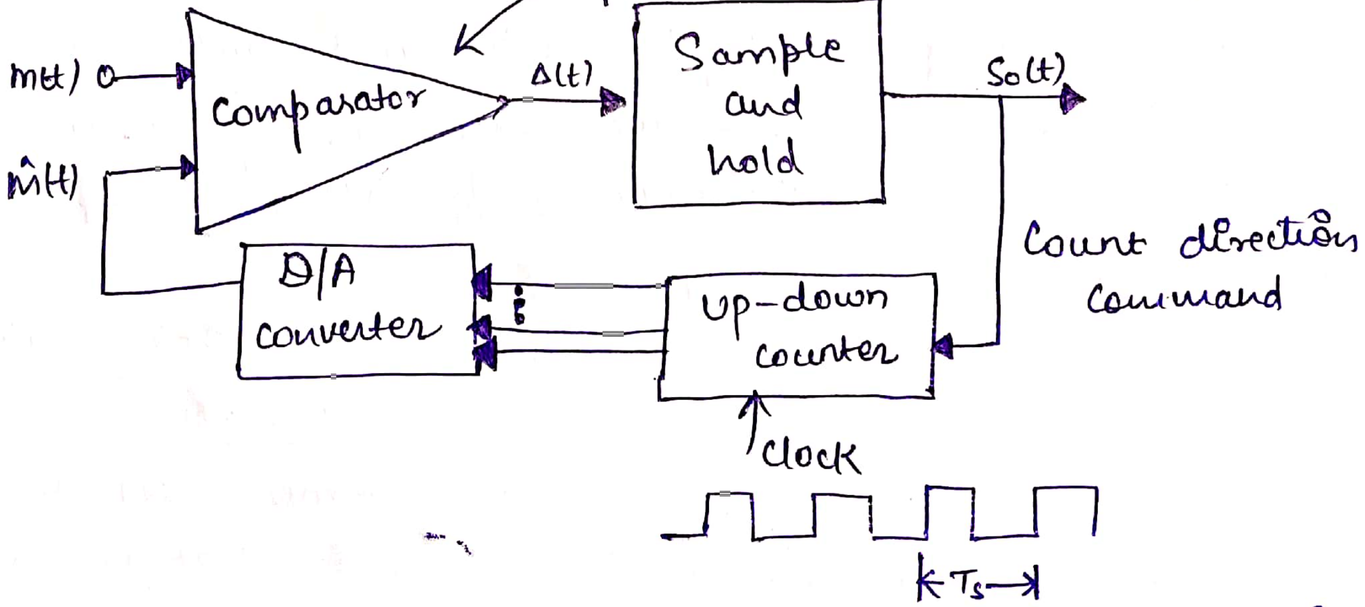
Question (16) (b) What is Delta modulation? Discuss the error in DM. How it can be overcome in Adaptive Delta modulation.

Answer. Delta modulation — Delta modulation (DM) is a DPCM scheme in which the difference signal $\Delta(t)$ is encoded into just a single bit.

→ The single bit is used to increase or decrease the estimate $\hat{m}(t)$.

→ This scheme is called linear delta modulation & is shown in fig given below.





→ The baseband sig m(t) and its quantized approximation $\hat{m}(t)$ are applied as inputs to a comparator.

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comparator -

→ A comparator makes a comparision b/w inputs.

→ The comparator has 1 fixed o/p V(H) when[∵ ($m(t) > \hat{m}(t)$)] and different o/p V(L) when $m(t) < \hat{m}(t)$.

Up-down counter -

→ It increments or decrements its count by 1 at each active edge of the clock waveform.

Counter direction -

→ Its incrementing or decrementing, is determined by the voltage levels at the "count direction command" input to the counter.

The Error in digital modulation

⇒ When the binary input, which is also the transmitted o/p $S_o(t)$, is at the level V(H), the counts up & when it is at level (V(L)) the counter counts down.

→ The digital o/p of the counter is converted to the analog quantized approximation $\hat{m}(t)$ by the D/A converter.

→ For a time preceding t_1, we find $m(t) > \hat{m}(t)$ so that $S_o(t) = V(H)$

→ At (t_1), when the active clock edge appears, the counter is incremented & immediately s/g $\hat{m}(t)$ jumps up by an amount equal to the step size s.

→ At(t_2), we still find $m(t) > \hat{m}(t)$, so $S_o(t)$ remains at V(H) and there is another upward jump in $\hat{m}(t)$.

→ At (t_3), $m(t) < \hat{m}(t)$. So, $S_o(t)$ becomes $S_o(t) = V(L)$ the counter decrements, & there is a consequents downward jump in $\hat{m}(t)$ by amount S and so on.

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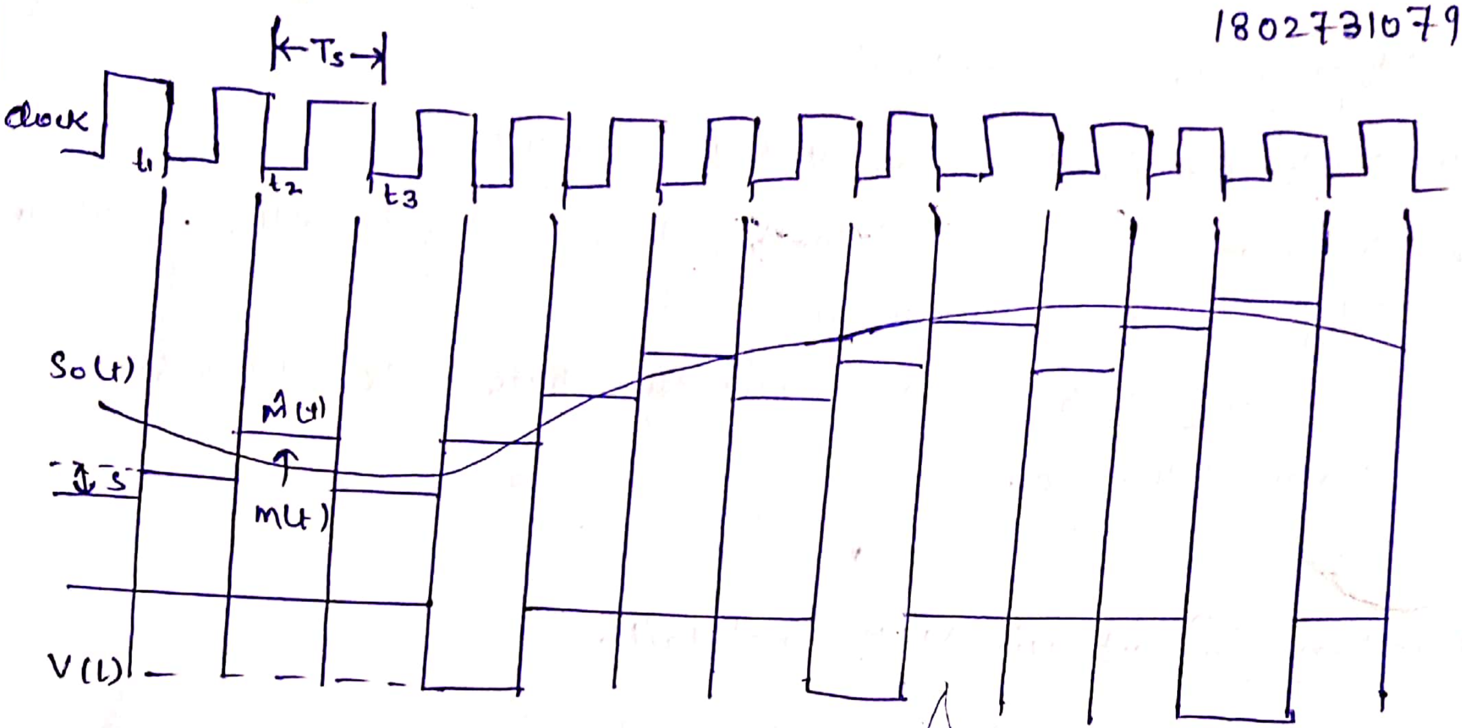
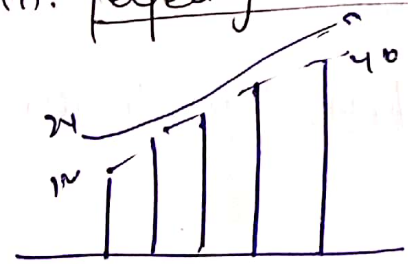


The excessive disparity b/w $m(t)$ and $\hat{m}(t)$ is described as a slope overloaded error and occur whenever $m(t)$ has a slope large than the slope S/T_2 which can be sustained by the waveform $\hat{m}(t)$

→ Slope overloaded can be avoided if $\frac{S}{T} > \left|\frac{dm(t)}{dt}\right|_{max}$.

→ The dynamic range of amplitude of $m(t)$ is too small because of threshold & overloaded effect.

(i). Perfectly Reconstruction



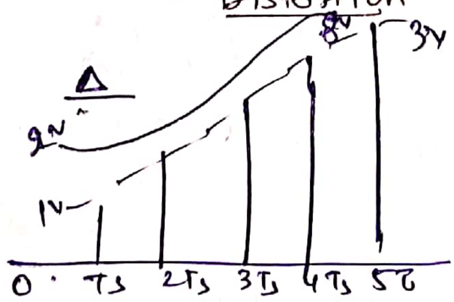
Slope of $m(t)$ = slope of Rec. Sig.

$$\frac{d}{dt}m(t) = \frac{\Delta opt}{T_s}$$

Rate of chang of msg sig

$$\boxed{Slope = \frac{\Delta}{T_s}}$$

(ii) Slope overloaded Distortion

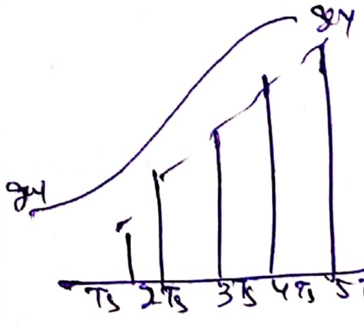


$$\frac{\Delta}{T_s} < \frac{d}{dt}m(t)$$

$$\frac{\Delta}{T_s} < \frac{\Delta opt}{T_s}$$

$$\boxed{\Delta < \Delta opt}$$

(iii) Granular



$$\frac{\Delta}{T_s} > \frac{d}{dt}m(t)$$

$$\frac{\Delta}{T_s} > \frac{\Delta opt}{T_s}$$

$$\boxed{\Delta > \Delta opt}$$

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Adaptive Delta modulation

* It is modified version of Delta modulation
* To overcome slope distortion & Granular in Delta modulation Adaptive Delta modulation used.
* Here the step size Δ of the Quantizer is constant but varies with time.

Question (19) (b) Explain MSK in detail.

Answer MSK – Minimum Shift Keying.

MSK s/g can be represented as –

$$\boxed{S(t) = S_1 \phi_1(t) + S_2 \phi_2(t)}$$

→ Where coefficient of S_1 and S_2 are related to phase state $\theta(0)$ and (θT_0) respectively.

* $\phi_1(t) = \sqrt{\frac{2}{T_b}} \cos\left(\frac{\pi}{2T_b} t\right) \cos\left(2\pi f_c t\right)$. $\quad T_b \leq t \leq T_b$
* $\phi_2(t) = \sqrt{\frac{2}{T_b}} \sin\left(\frac{\pi}{2T_b} t\right) \sin\left(2\pi f_c t\right) \quad 0 \leq t \leq 2T_b$

→ To evalute S_1, we integrate $S(t)\ \phi_1(t)$ b/w limits $(-T_b$ & $T_b)$

$$\boxed{S_1 = \int_{-T_b}^{T_b} S(t)\ \phi_1(t) = \sqrt{E_b} \cos\left[\theta(0)\right]}$$

$$\boxed{S_2 = \int_{0}^{2T_b} S(t)\ \phi_2(t) = -\sqrt{E_b} \sin\left[\theta(T_b)\right]}$$

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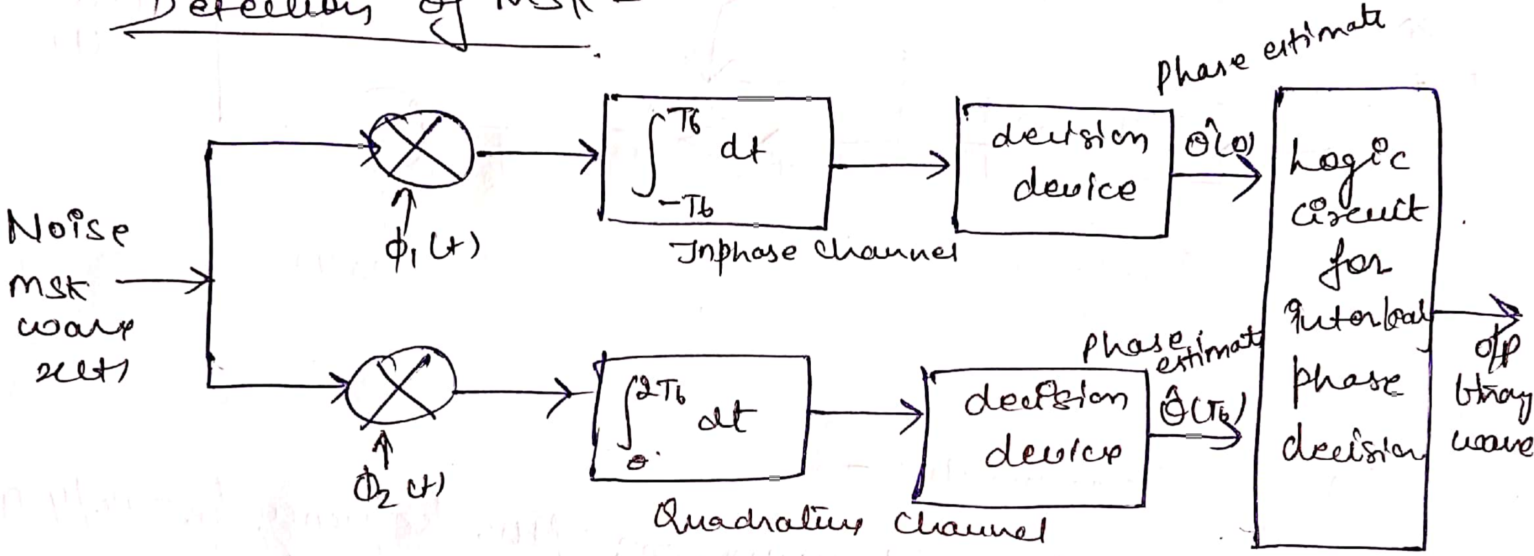
→ finally $\phi_1(t)$ and $\phi_2(t)$ are multiplied with two binary wave $m_1(t)$ and $m_2(t)$, both of which have bit rate equal to $(1/2T_b)$.

→ These two binary waves are extracted from incoming binary wave b(t). At the o/p of summer, we have msk wave (s(t)).

Detection of MSK -



MSK detector/receiver.

→ The Received Sig x(t) is correlated with locally generated of the coherent reference sig $\phi_1(t)$ and $\phi_2(t)$

→ The Resulting two channels o/p x_1 and x_2 are next compared with threshold of zero volts & estimates of phase $\theta(0)$ and $\theta(T_b)$ are derived.

→ finally these phase decision & interleaved so, as to construct original i/p binary wave b(t).

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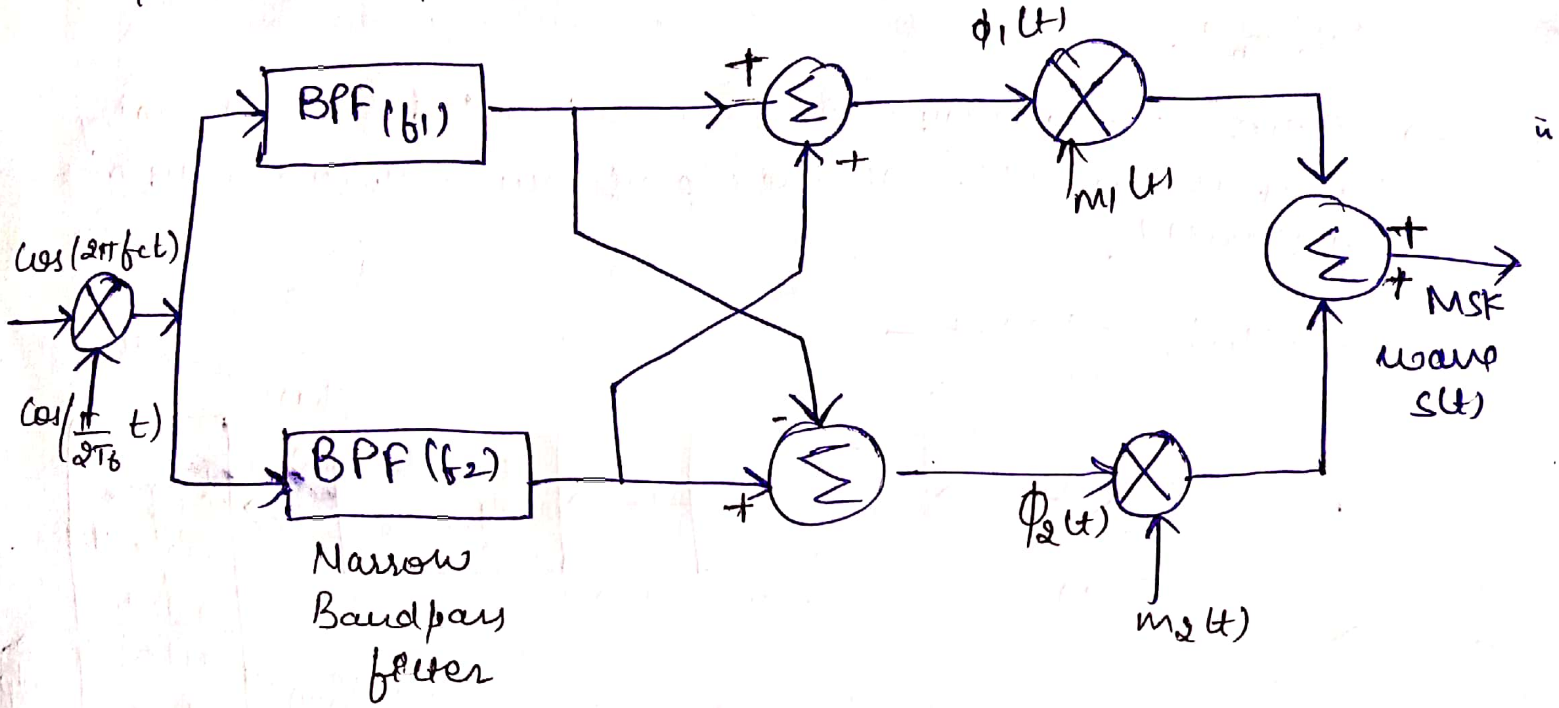
Generation of MSK -



MSK Transmitter -

* Two i/p sinusoidal waves, one of the frequency $f_c = n_c/4T_b$ for some fixed integer n_c and other frequency $1/4T_b$ are first applied to product modulator.
* This produces two phase coherent sine wave at frequencies f_1 and f_2, which are related to f_c, and bit rate $1/T_b$.

$$f_c = \frac{1}{2}(f_1 + f_2)$$

deviation ratio ← $\boxed{h = \frac{1}{2} T_b (f_1 - f_2)}$

→ These two sinusoidal waves are separated from each other by two narrow band filter one centered at f_1 and other f_2

→ Resulting filter o/p are next summed to produce the pair of quadrature carrier $\phi_1(t)$ and $\phi_2(t)$.

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Question (17)(b) Explain the Quantization Error in detail & derive the expression for max. s/g to Noise Ratio in pcm system.

Answer- Quantization error -

In uniform quantization, original continuous time function is first rounded off to several possible levels, yielding a staircase types of waveform - This introduces an error known as quantization noise/error. i.e the staircase approximation is not identical to the original continuous s/g is the difference b/w the two represents an error, known as quantization noise.

→ For a midrise, $\boxed{(q_e) = -\frac{\Delta}{2} \leq q_e \leq \frac{\Delta}{2}}$

Assuming that error is equally likely to lie anywhere in range $\left(-\frac{\Delta}{2}, \frac{\Delta}{2}\right)$, the mean square $(q_e)^2$ is given as.

$$(q_e^2) = \frac{1}{\Delta}\int_{-\Delta/2}^{\Delta/2} q_e^2 \cdot dq_e = \frac{1}{\Delta}\left|\frac{q_e^3}{3}\right|_{-\Delta/2}^{\frac{\Delta}{2}} = \frac{1}{3\Delta}\left[\frac{\Delta^3}{8}+\frac{\Delta^3}{8}\right] = \frac{\Delta^2}{12}$$

$$\boxed{q_e^2 = \frac{\Delta^2}{12}}$$

Now let peak to peak v/g is (-mp to mp), be total no. of quantizing level are L then step size Δ is given by

$$\boxed{\Delta = \frac{2mp}{L}}$$

put this value of quantizing levels in $\langle q_e^2 \rangle$

$$\langle q_e^2 \rangle = \frac{4mp^2}{L^2 \times 12} \Rightarrow \boxed{q_e^2 = \frac{mp^2}{3L^2}}$$

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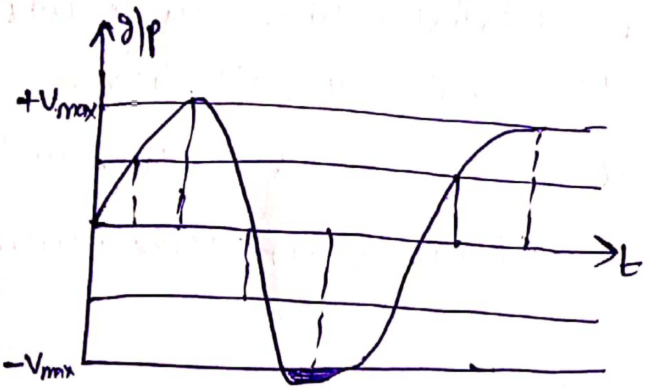
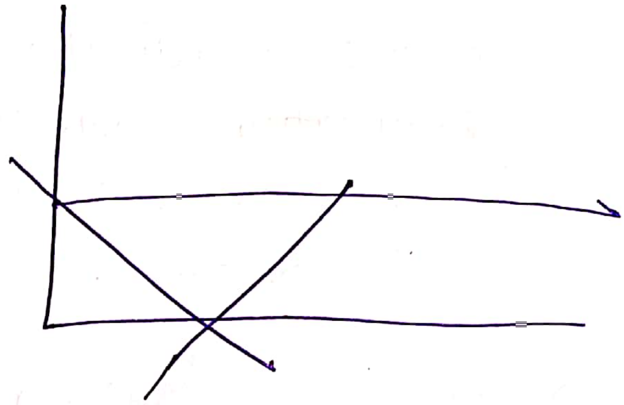
If the encoder used for decimal to binary conversion have n bits then total bits required to represent L levels can be given by

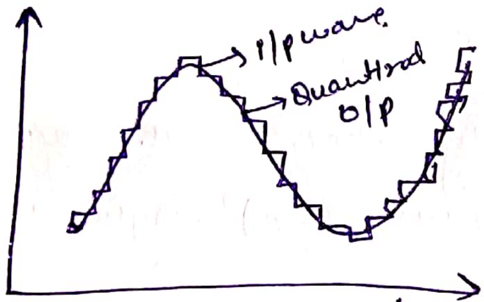
$$\boxed{L = 2^n}$$

Correspondingly, $\boxed{n = \log_2 L.}$

Quantization error $\boxed{(q_e^2) = \frac{m_p^2}{3 \cdot 2^{2n}}}$







Quantized o/p.

Signal to Quantize Noise Ratio –

$$\boxed{\text{S/g to Quan. Noise Ratio} = \frac{\text{Normalised S/g Power}}{\text{Normalised quantize noise power}}}$$

S/g power ⇒ for a single tone msg having peak value $-m_p$ to m_p the power can be given by,

$$\boxed{P = \frac{m_p^2}{2}}$$

$\left[\because m(t) = m_p \cos \omega_m(t) \quad P = \frac{m_p^2}{2} \right]$

Quantize Noise power ⇒ $\boxed{Q_e = \frac{m_p^2}{3L^2}}$

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$$SQNR = \frac{\frac{m_p^2}{2}}{\frac{m_p^2}{3L^2}} = \frac{3L^2}{2} \Rightarrow \boxed{SQNR = \frac{3L^2}{2}}$$

SQNR in dB $\Rightarrow$ $SQNR|_{dB} = 10 \log_{10} \frac{3L^2}{2}$

$$= 20 \log_{10} \frac{3 \cdot 2^{2n}}{2} = 1.76 + 6.02\, n$$

$$\{SQNR \cong 1.8 + 6n\}.$$

Question 20 (6)

Ques Calculate the signal to Noise ratio of FM. Also calculate figure of merit.

Answer- Signal to Noise ratio -

It is defined as the ratio of s/g power to noise power at the same pt.

Therefore,

$$\frac{S}{N} = \frac{X_s}{X_n} = \frac{V_s^2/R}{V_n^2/R} = \left(\frac{V_s}{V_n}\right)^2$$

where,

S = S/g power

N = Noise power

→ The comparision of S/N ratio of i/p & o/p of a port N/w provides the noisiness indication of the N/w.

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Noise in FM System –

Let us consider that i/p s/g to the IF carrier filter.

$$\boxed{S_i(t) = A\cos\left[\omega_c(t) + k\int_{-\infty}^{t} m(\lambda)\, d\lambda\right]}$$

m(t) = frequency modulating baseband waveform.

→ we assume that s/g is embedded in additive white gaussian noise of power-spectral density $\eta/2$.

→ IF carrier filter has a b.w $\boxed{B = 2\Delta f + 2f_m}$

→ This filter passes the s/g with negligible distortion & eliminates all noise outside the B.W (B).

→ when S-N Ratio is high ↑, the noise does not affect the o/p signal power.

→ $S_2(t)$ s/g arrives at o/p –

$$\boxed{S_2(t) = A_L\cos\left[\omega_c(t) + k\int_{-\infty}^{t} m(\lambda)\cdot d\lambda\right]}$$

$$\phi(t) = k\int_{-\infty}^{t} m(\lambda)\cdot d\lambda)$$

→ for o/p discriminator –

$$S_3(t) = \alpha\omega_c + \alpha k m(t)$$

$$\boxed{\text{o/p s/g} \Rightarrow S_o(t) = \alpha k m(t)}$$

$$\boxed{\text{\& o/p s/g power} = S_o(t) = \alpha^2 k^2 m^2(t)}$$

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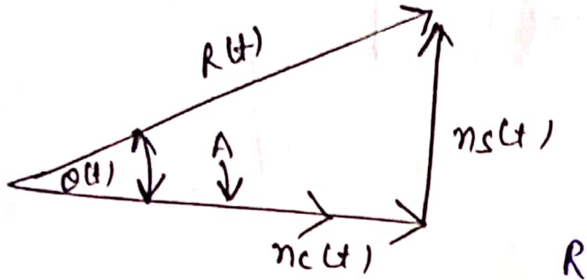
Output Noise power -

→ I/p white noise having a power spectral density $\eta/2$.

→ Let, $m(t) = 0$, i.e noise o/p $\cong$ independent of $m(t)$

→ At limiter i/p.

$$\boxed{\begin{aligned} V_i(t) &= A\cos\omega_c(t) + n_c(t)\cos\omega_c(t) - n_s(t)\sin\omega_c t \\ &= [A + n_c(t)]\cos\omega_c t - n_s(t)\sin\omega_c t \end{aligned}}$$



Phasor represents $n_c(t)\cos\omega_c t$. In Phase with the carrier phasor $A\cos\omega_c t$.

$$R(t) = \sqrt{[A + n_c(t)]^2 + n_s(t)^2}$$

Similarly, Phase, $\theta(t) = \tan^{-1}\dfrac{n_s(t)}{A + n_c(t)}$

Signal & noise forming $V_i(t) = R(t)\cos[\omega_c(t) + \theta(t)]$

$$V_2(t) = A_L\cos[\omega_c t + \theta(t)]$$

Let us assume -

$\theta(t) = \dfrac{n_s(t)}{A}$, Then $V_2(t) = A_L\cos\left[\omega_c(t) + \dfrac{n_s(t)}{A}\right]$

Compare equ^n -

$$V_4(t) = \alpha\omega_c + \alpha\frac{d}{dt}\phi(t)$$

$$V_4(t) = \alpha\left[\omega_c + \frac{1}{A}\frac{d}{dt}n_s(t)\right]$$

Avoid DC term -

$$V_4(t) = \frac{\alpha}{A}\frac{d}{dt}n_s(t).$$

$n_4(t)$ is $G_{n4}(f)$ given by -

$$G_{n4}(f) = \frac{\alpha^2\omega^2}{A^2}\eta, \quad |f| < \frac{B}{2}$$

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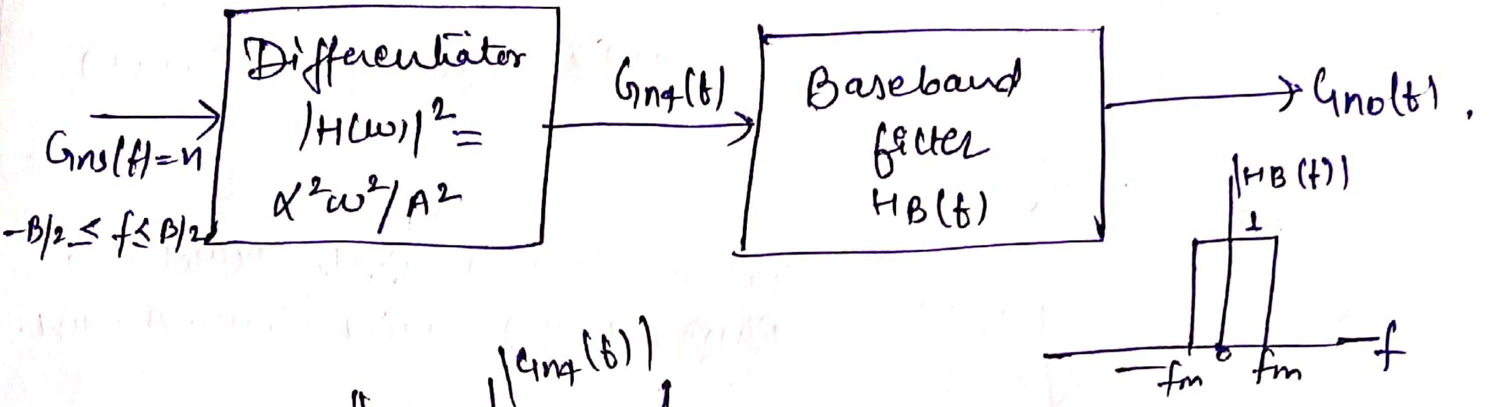
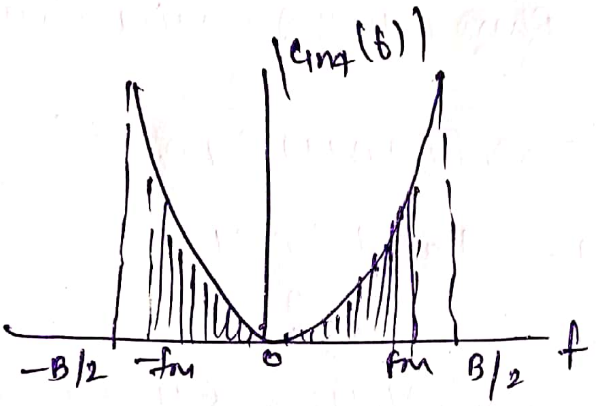
<u>o/p noise power(N_o)</u>

$$N_o = \int_{-fM}^{fM} G_{nq}(f) \cdot df = \frac{\alpha^2 n}{A^2} \int_{-fm}^{fm} 4\pi^2 \cdot f^2 \cdot df$$

$$= \frac{8\pi^2}{3} \cdot \frac{\alpha^2 n}{A^2} f^3 m.$$





<u>O/p SNR –</u>

The o/p SNR can be computed as –

$$\frac{S_o}{N_o} = \frac{\alpha^2 K^2 \overline{m^2(t)}}{\left(\frac{8\pi^2}{3}\right)\left(\frac{\alpha^2 n}{A^2}\right) f^3{}_M} = \frac{3 K^2 \overline{m^2(t)} \cdot A^2/2}{4\pi^2 \cdot f_m^2 \cdot n f_m}$$

m(t) is sinusoidal & produce a Δf.

$$S_i(t) = A \cos\left[\omega_c(t) + \frac{\Delta f}{f_m} \sin 2\pi f_m(t)\right]$$ modulating frequency.

<u>Comparing eqn</u>

$$S_i(t) = A \cos\left[\omega_c(t) + K \int_{-\infty}^{t} m(\lambda) \cdot d\lambda\right]$$ with eq above

i.e

$$K m(t) = 2\pi \Delta f \cos 2\pi f_m(t)$$

$$K^2 \overline{m^2(t)} = \frac{4\pi^2 (\Delta f)^2}{2} = 2\pi^2 (\Delta f)^2$$

Putting value of $\overline{k^2 m^2(t)}$ in eq.

$$\frac{S_o}{N_o} = \frac{3}{2}\left(\frac{\Delta f}{f_m}\right)^2 \cdot \frac{A^2/2}{\eta f_m} = \frac{3}{2}\beta^2 \frac{S_i}{N_M}$$

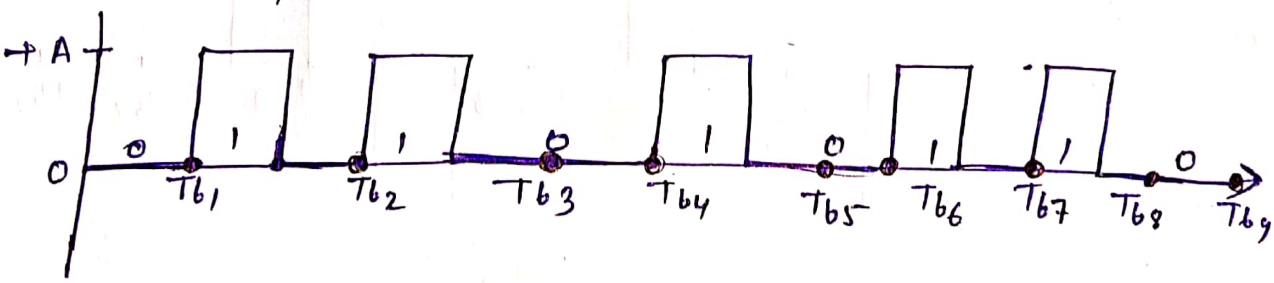
Here, $\boxed{\beta = \frac{\Delta f}{f_m} = \text{modulating Index}}$

$$\gamma_{FM} = \frac{\frac{S_o}{N_o}}{\frac{S_i}{N_M}} = \boxed{\frac{3}{2}\beta^2}$$

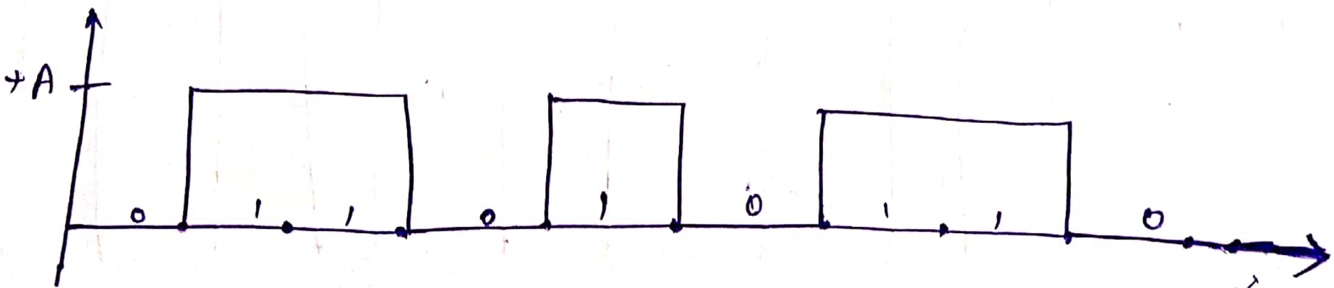
Question – '~~2016~~ 18 (a)

Questi. For a given binary sequence. 011010110, construct Unipolar RZ, Unipolar NRZ, polar RZ, Polar NRZ, AMI & Manchester format.

Answer – (i) Unipolar RZ



(ii) Unipolar NRZ



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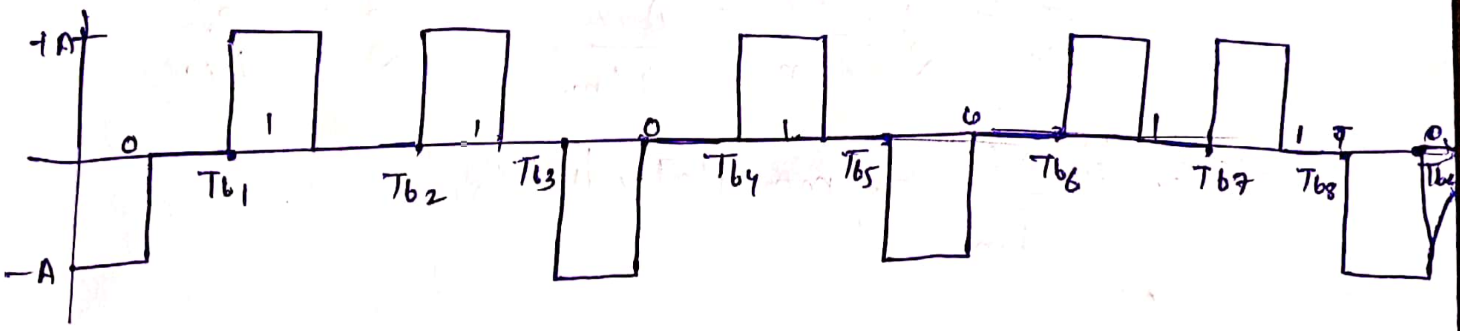
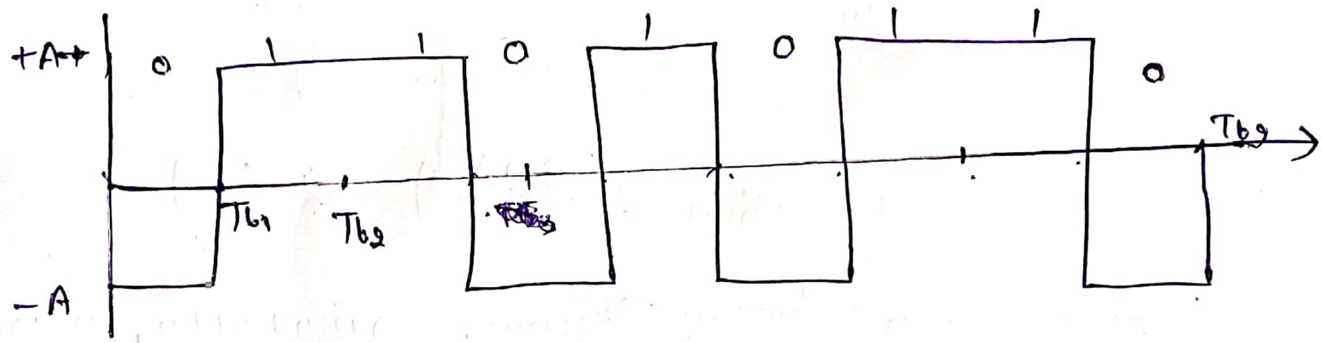
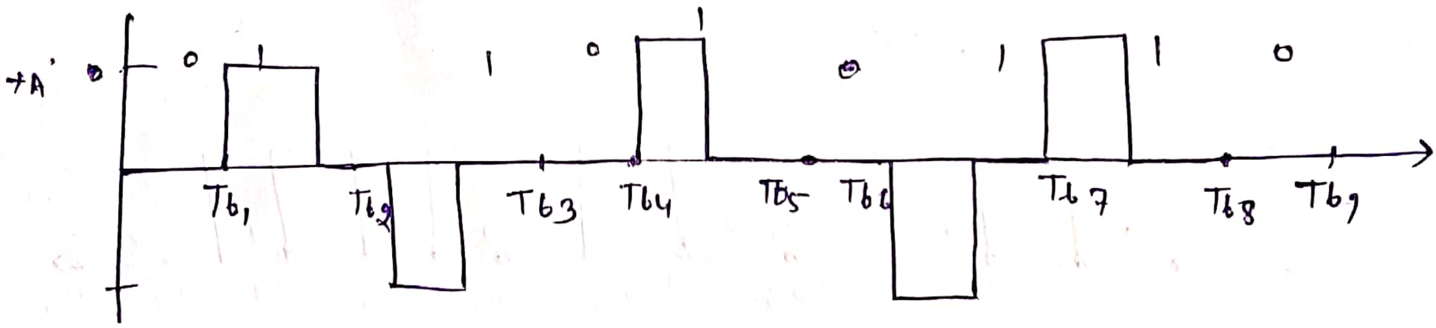
(iii) Polar RZ



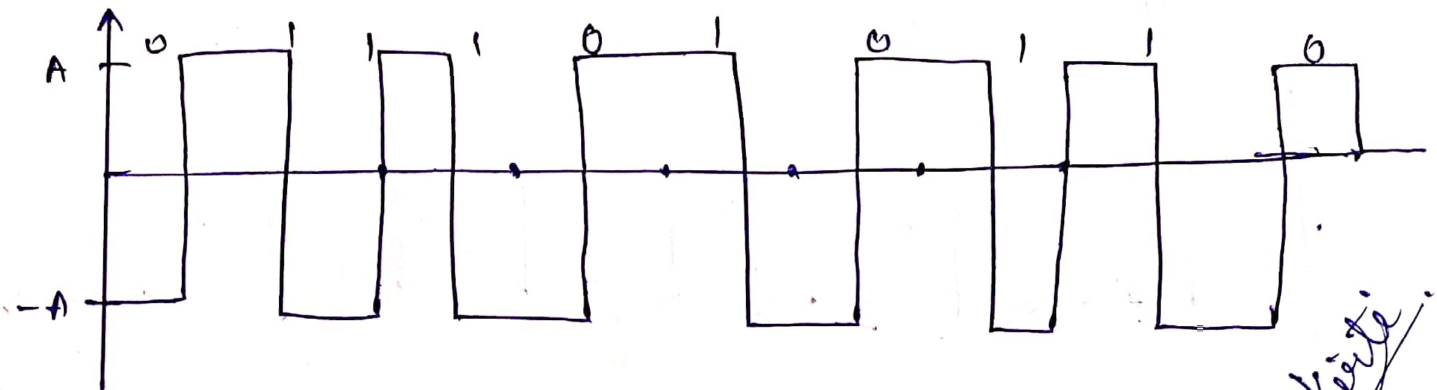
(iv). polar NRZ



(v) AMI



(v) Manchestor



Keerti