Department of Electrical Engineering
Final Assignment Summer 2020
Subject: Communication Systems

Max Marks: 50

Question 1 (10)

A signal x(t) band limited by 250 Hz is sampled by an impulse train with angular frequency of f_s

a. Determine the Nyquist rate required for perfect reconstruction of signal.
b. Considering x(t) and impulse train in figure below, construct all the signals involved in sampling.
c. Determine the cut off frequency of reconstruction filter H(f) to be used for the signal given in question.
d. If the frequency of sampler is $f_s = 800Hz$, draw the resulting sampled signal s(f)

Question 2 (10)

a. Let $x(t)$ be a signal with Nyquist rate f_s determine the Nyquist rate for following
   i. $x(t) + x(t-1)$
   ii. $dx(t)/dt$
b. Let $m(t) = 10\sin 400\pi t$ is sampled at 300Hz and reconstructed using an ideal low pass filter with a cut off frequency of 150Hz. What are the frequency/frequencies present in the reconstructed signal $y(t)$

Question 3 (15)

Consider the bit sequence (0 1 1 0 1 1 0 0 0 1 1) and draw the PCM waveform for following modulation schemes

a. NRZ-S
b. Polar-RZ
c. Split Phase Manchester
d. Bi-ϕ-L
e. Dicode - NRZ

Question 4 (15)

a. A carrier wave is represented by the equation $e_c(t) = 7.5\sin 20\times10^3\pi t$. If the modulation index of wave is 0.5, draw the waveform of AM modulated waveform.
b. A sinusoidal carrier $10\cos 50\times10^5 t$ is amplitude modulated by the sinusoidal voltage of $5\cos 628\times10^3 t$ over a load resistance of 50Ω
   a. Find the depth of modulation and calculate the transmission efficiency
   b. Plot the AM wave in time domain as well as its frequency domain spectrum
   c. Calculate the total power in spectrum
   d. Calculate the percentage power in USB

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Question # 1

(a) Determine the Nyquist rate required for perfect reconstruction of signal.

$$f_m = 250\ Hz$$

$$f_s \geq 2 f_m$$

$$f_s \geq 2 \times 250$$

$$f_s \geq \boxed{500\ Hz}$$

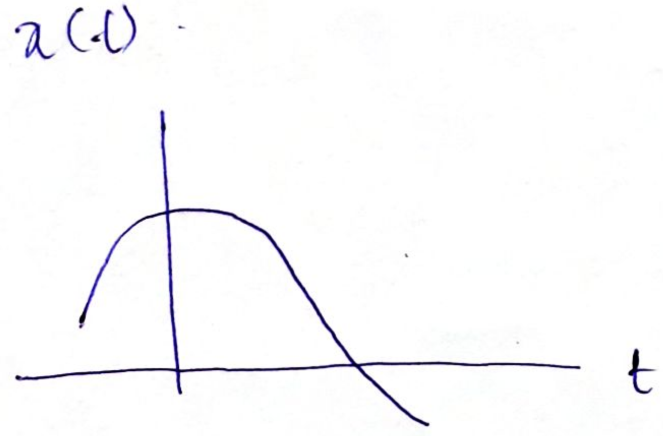
$$T_s = \frac{1}{f_s}$$

$$= \frac{1}{500}$$

$$= \boxed{2.8\ msec}$$

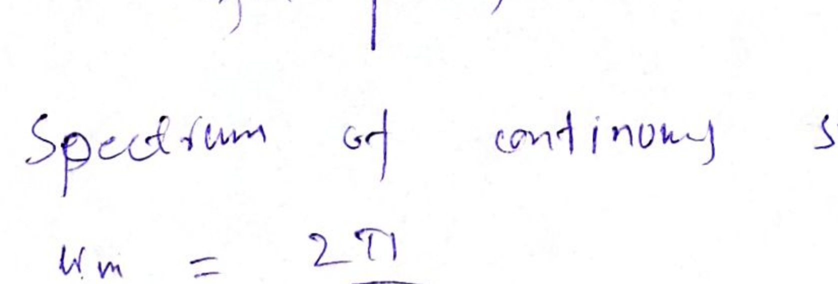
(2)

(b) considering $x(t)$ and impulse train in figure below, construct all the signals involved in sampling.



If we take fourier transform of signal

So



Spectrum of continuous signal.

$$W_m = \frac{2\pi}{T_s}$$

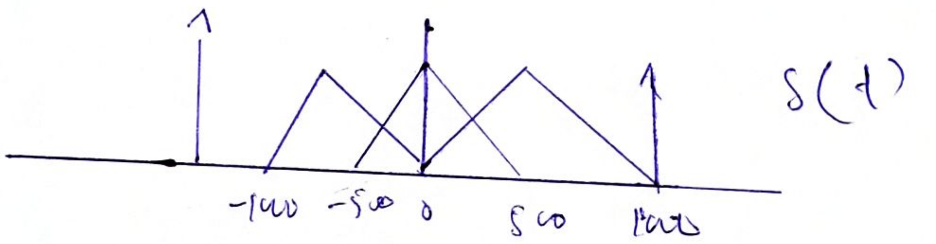
T_s shows impulse train

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

$$= \frac{1}{500}$$

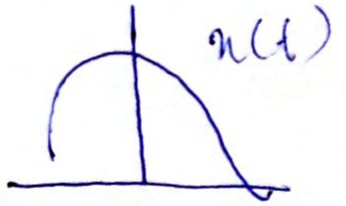
$$= 0.002$$

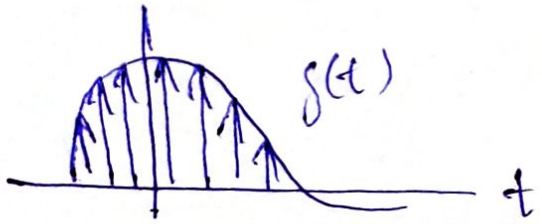
As $f_s = 500\,Hz$



Now if we multiply the x(t) and δs(t) we get sampling signal.

x(t) ⟶
δs(t) ⟶ [multiplier] ⟶ g(t)





So these are the signal which involve in sampling.

$x(t)$ (continuous signal)

$\delta s(t)$ (impulse signal)

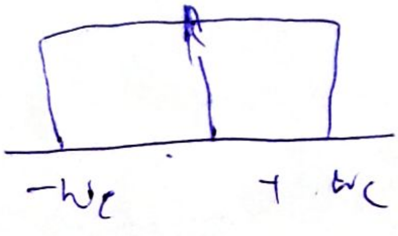
$g(t)$ (sample signal)

(5)

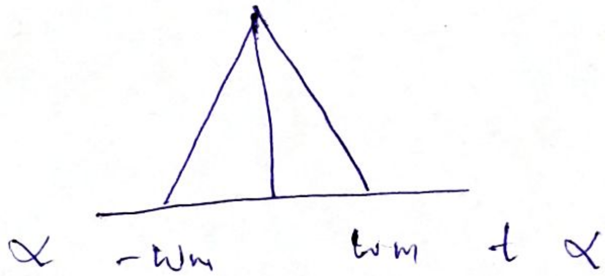
(c)

When we pass a signal from LPF

$s(t) \rightarrow \boxed{LPF} \rightarrow m_r(f)$

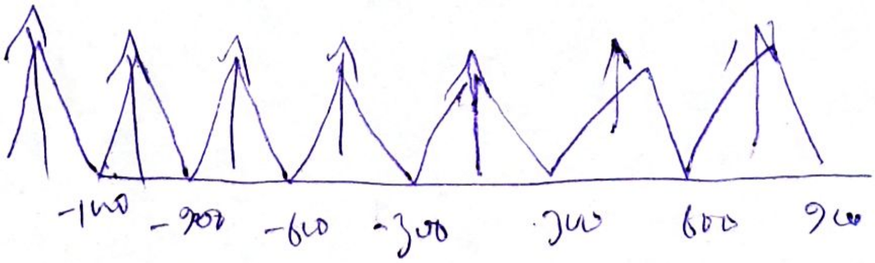


So cutoff frequency.



(d) if $f_s = 800Hz$

Resulting sample signal.



Q# 2: Let $x(t)$ be a signal with Niquist rate f_s determine the Niquist rate for the following.

(a) $x(t) + x(t-1)$

So the Niquist rate of $x(t)$ is f_s and the Niquist rate of $x(t-1)$ is also f_s because Time shifting not effected by Niquist rate.

So the Niquist rate of

$$\underset{f_s}{\underset{\downarrow}{M(t)}} = \underset{f_s}{\underset{\downarrow}{x(t)}} + \underset{f_s}{\underset{\downarrow}{x(t-1)}}$$

$$\boxed{NR = f_s}$$

(ii) $dx(t)/dt$

We Know that the Niquist rate of $x(t) = f_s$

$$\frac{d(f_s)}{dt}$$

So the derivation will not effected by the Niquist rate

So $\boxed{NR = f_s}$

Q 2 #

part (b)

Solution:

Given that:

$$f_c = 150\ Hz$$

$$M(t) = 10 \sin 400\pi t$$

$$w_m = 400\pi \ \frac{rad}{sec}$$

$$f_m = \frac{w_m}{2\pi}$$

$$= \frac{400\pi}{2\pi}$$

$$f_m = 200\ Hz$$

and

$$f_s = 300\ Hz$$

$$s(t) \longrightarrow \underset{\text{ideal}}{\boxed{\text{LPF}}} \longrightarrow m_r(t)$$

$$\Downarrow\Uparrow$$

$$S(w)$$

forier transform

$$\boxed{nf_s \pm f_m}$$

frequency components:

$n = 0 \Rightarrow \pm f_m = \boxed{\pm 200\ Hz}$

$n = 1 \Rightarrow f_s \pm f_m = \boxed{300\ Hz,\ 100\ Hz}$

$n = -1 \Rightarrow -f_s \pm f_m = \boxed{-100\ Hz,\ -500\ Hz}$

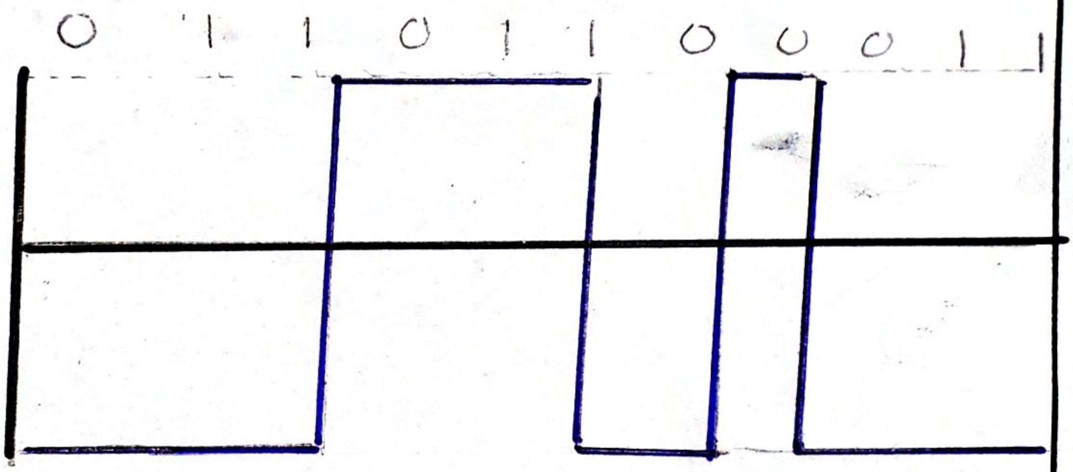
Now in output there will be the frequency in the Range of $-150\ Hz$ to $150\ Hz$

Question # 3

Bit sequence (0,1,1,01100011)

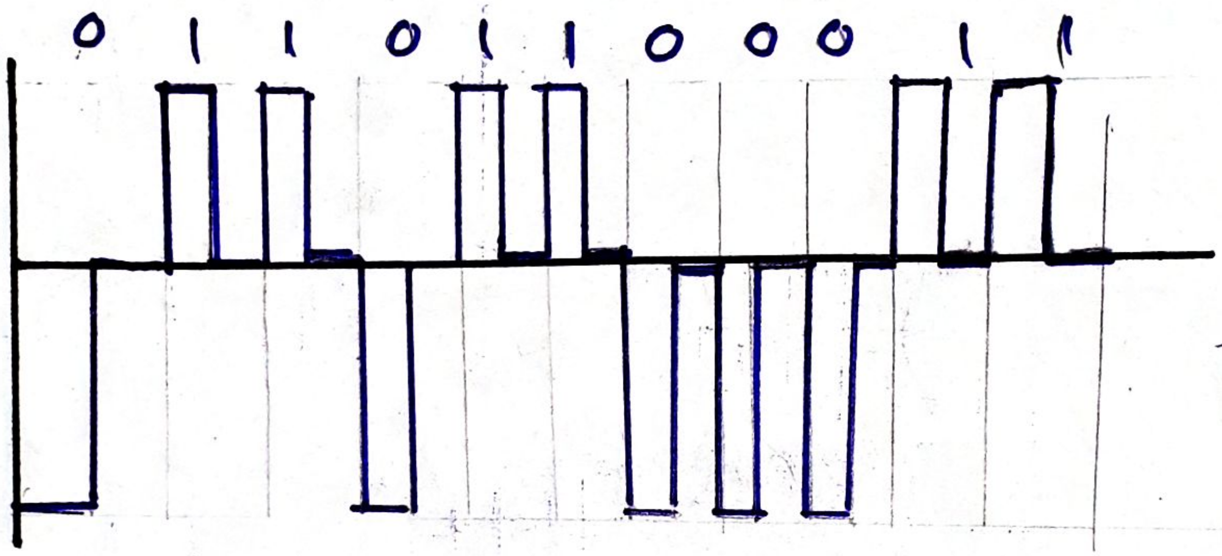
(a) NRZ-S

- "One" is represented by no change in level
- "Zero" is represented by change in level.



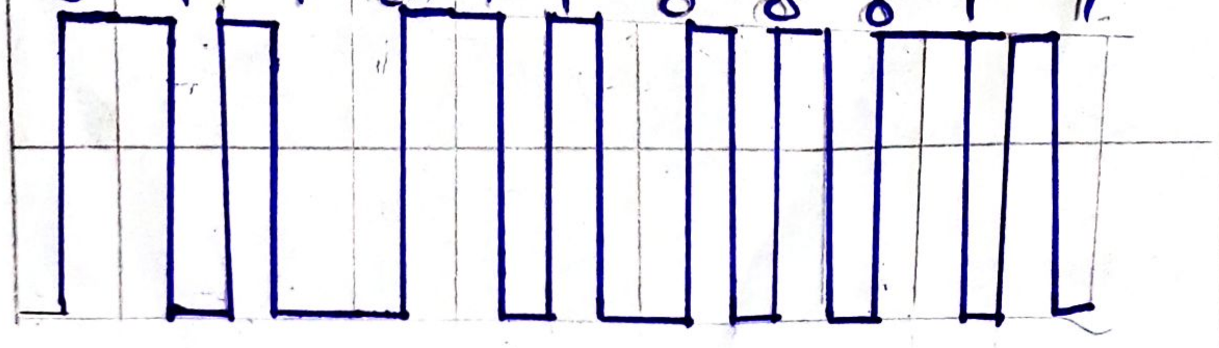
(b) polar - RZ

"One" and "Zero" are represented by opposite level polar pulses that are one half-bit in width.



(c) split phase menchester:

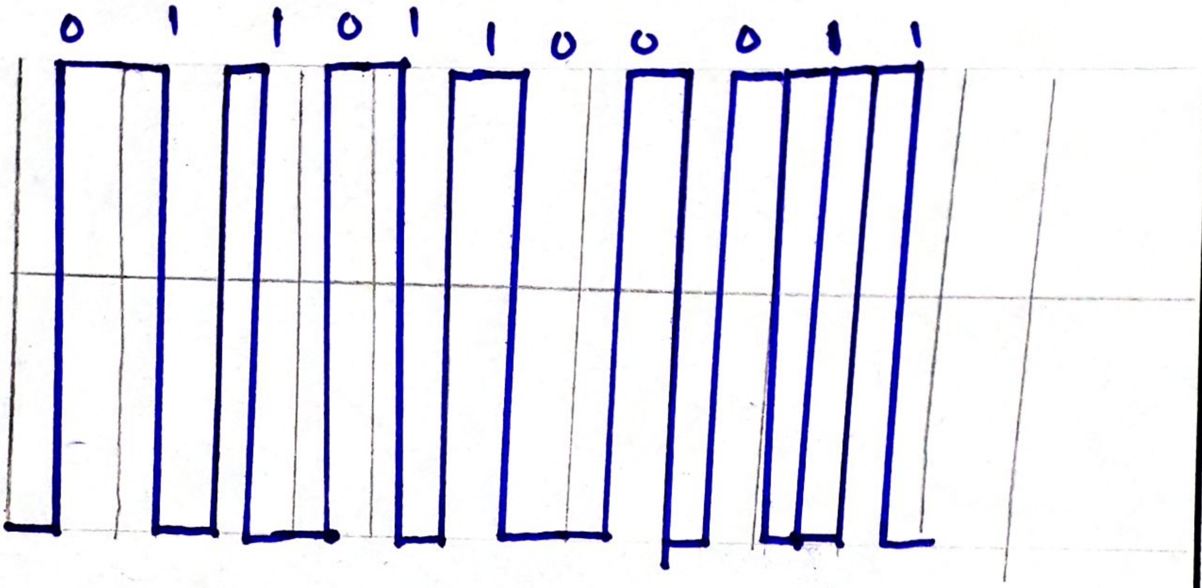
- "one" is represented by a 10
- "zero" is represented by a 01



(D) **Bi-ø-L**

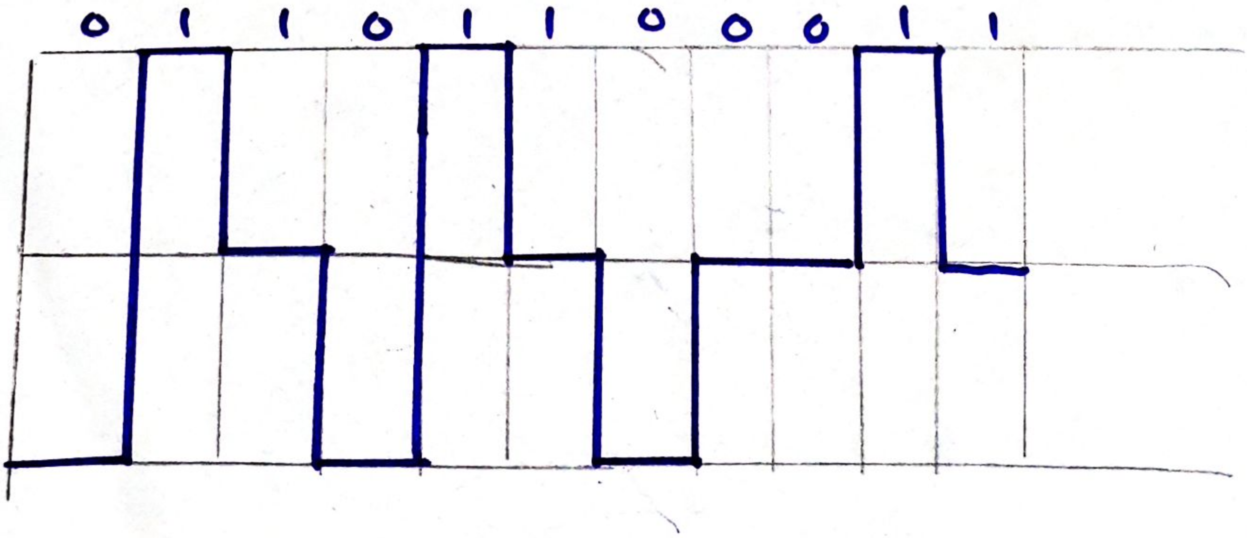
'one' is represented by a 1 0

"Zero" is represented by a 0 1



(e) **Dicode NRZ:**

- A "one" to "Zero" or "Zero to 'one'" changes polarity
- otherwise a Zero is send.



Q (4)

(a) Soulution:

carrier wave = $e_c(t) = 7.5 \sin 20 \times 10^3 \pi t$

Modulation Index = 0.5

Given that $e_c = 7.5 \sin 20 \times 10^3 \pi t$ ∵ $E_c = 7.5$ volts

let us evaluate E_m from E_c since

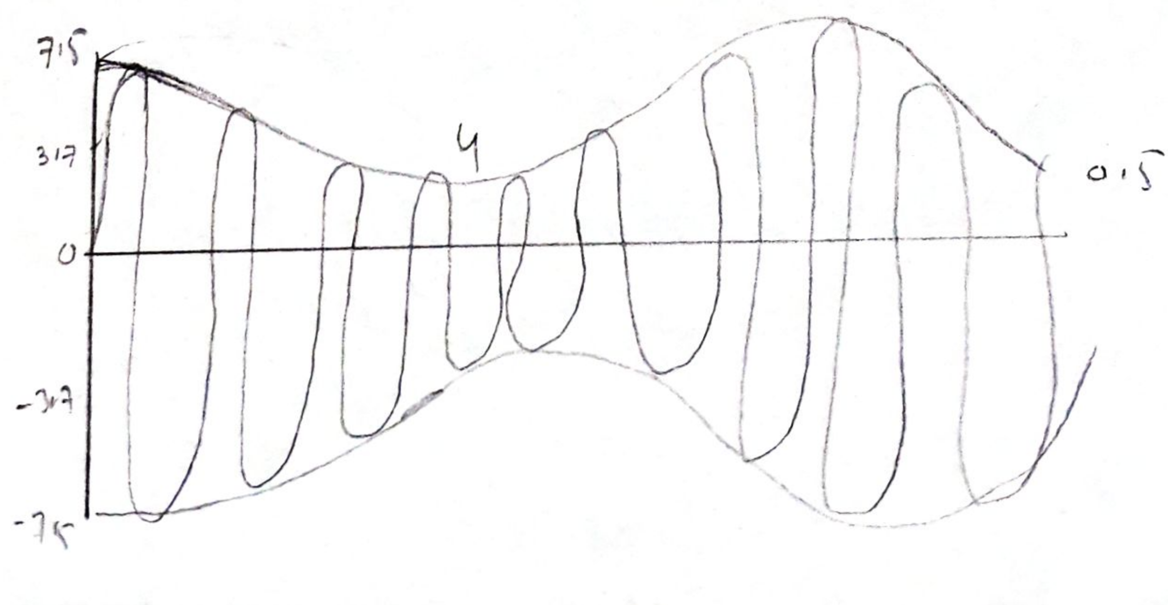
$$m = \frac{E_m}{E_c}, \text{ therefore}$$

$$E_m = m \times E_c = 0.5 \times 7.5 = \boxed{3.75 V}$$

$$E_{max} = E_c + E_m = 7.5 + 3.75 = \boxed{11.25 V}$$

$$E_{min} = E_c - E_m = 7.5 - 3.75 = \boxed{4 V}$$

A m modulated waveform:



Q # 4

(b)

Solution:

carrier signal = $10 \cos 50 \times 10^5 t$

Massage signal = $5 \cos 628 \times 10^3 t$

load resistance = 50Ω

(a) Depth of modulation:

$$m = \frac{50 \times 10^5}{628 \times 10^3} = \boxed{7.96}$$

power of side bands:

$$P_{LSB} = P_{USB} = P_c \frac{\mu^2}{4} \quad ; \quad P_c = \frac{A_c^2}{2R} = \frac{(10)^2}{2 \times 50}$$

$$P_c = \boxed{1 W}$$

$$= \frac{1 \times 7.96}{4}$$

$$P_{LSB} = P_{USB} = \boxed{1.99 W}$$

Efficieny of AM

$$\eta = \frac{P_{LSB} + P_{USB}}{P_t} = \frac{\mu^2}{2 + \mu^2} = \frac{(7.96)^2}{2 + (7.96)} = \boxed{6.3}$$

(C) Total power

$$P_t = P_c \frac{u^2}{2}$$

$$= \frac{1 \times (7.96)^2}{2}$$

$$\boxed{31.68\ W}$$

(D) power in USB %

power in USB = 1.99 W

$$\% \text{ power in USB} = \frac{1.99}{100} = \boxed{0.0199\%}$$