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

Max Marks: 30

Question No. 1 **(10)**

a. How SNR is related to quality of received signal in a wireless communication system?
b. Draw and explain the basic block diagram of a communication system
c. Why is it required to modulate the signal for distant wireless communication?
d. Digital signals are not preferred for the communication over wireless communication channel despite the fact they are easy to represent and analyze. please support the statement with your argument.
e. Determine the power and rms value of $f(t) = C\cos(\omega_0 t + \theta)$

Question No. 2 **(10)**

a. Two sinusoidal signals $5\cos 2\pi 10^6 t$ and $3\cos 2\pi 10^3 t$ are desired to be transmitted over the distance of 20 kilometers. Determine the height of antennas for each signal required to receive the transmitted signals efficiently.
b. Derive the expression for effective power accumulated in the spectrum of an AM wave

Question No. 3 **(10)**

a. Draw and explain the AM waveform for less than 100%, 100% and greater than 100% modulation cases considering carrier signal $e_c(t) = 12\sin \omega t$ and a sinusoidal message signal.
b. A sinusoidal carrier has amplitude of 7 V and frequency of 1 MHz It is amplitude modulated by the sinusoidal voltage of 3.5V and frequency 5 kHz.
   i. Write the equation for message, carrier and modulated waves
   ii. Plot the AM wave in time domain as well as its frequency domain spectrum
   iii. Find the depth of modulation and calculate the transmission efficiency
   iv. Calculate the total power in spectrum
   v. Calculate the percentage power in USB

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Communication System

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Q#1

(a)

SNR: SNR is the diffrence b/w recieved wireless signal & the noise floor.

Signal to noise ratio

A high quality communication requires a high SNR. SI unit of SNR is decible (db)

$$SNR = \frac{\text{power of signal}}{\text{power of Noise}}$$

For example:

$$C = B \log_2 (1 + SNR)$$

where C is the channel capacity

$SNR = 20\,db$

$B = 4K\,Hz$

$C = ?$

Sol:

$C = B \log_2 (1 + SNR)$

putting values

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

$= 4 \times 10^3 \times \log_2 (101)$

$= 4 \times 10^3 \times 6.65$

$C = 26.60\,K$ bits/s

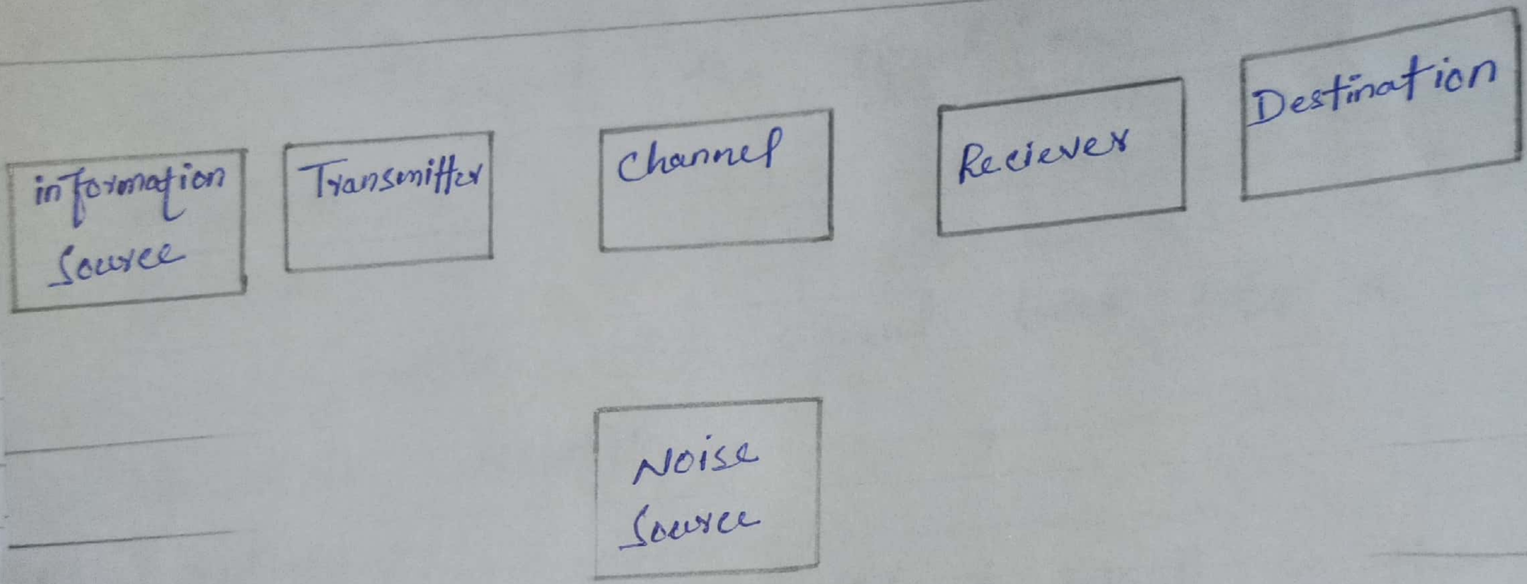
$SNR = 10 \log_2 (100)$

$= 10 \times 2$

$SNR = 20\,db$

1(b)

The block diagram of a communication will have five blocks, including the information source, transmitter, channel & destination blocks.



1) Information Source:

The objective of any communication system is to convey information from one point to the other. Information comes from information source, which originates it.

2) Transmitter:

The objective of the transmitter block is to collect the incoming message signal & convert the message into signal to be transmitted.

3) Channel:

Transport the signal over a certain medium.

4) Reciever:

Converts the signal back into a readable message

5) Destination:

It is the final block in the communication system which recieves the message signal & processes it to comprehend the information present in it.
usually, humans will be the destination block.

1(c)

The baseband signal are incompatible for direct transmission. For such signal to travel longer distance its strength has to be increased by modulating with high frequency carrier wave which doesnt effect the parameters of modulating signal.

1 (d)

If we send digital data directly through the air we will probably interfering with other transmitter so to seperate different channel the signal is modulated in a given frequency band. Obviously we can do this by digital modulation but due to harmonics we will impact other channels & our demodulation depending on the other channel & our signal will be distorted. Morever we can suffer of bandwith problem of our power amplifier which will distorted also our transmission.

(e)

$$f(t) = C\cos(\omega_0 t + \theta)$$

This is a periodic signal with period $T_0 = 2\pi/\omega_0$
The suitable measure of its size is power.
Because it is a periodic signal we may compute its power by averaging its energy over one period $(2\pi/\omega_0)$.

$$P_f = \lim_{T\to\infty} \frac{1}{T}\int_{-T/2}^{T/2} C^2\cos^2(\omega_0 t + \theta)\,dt$$

$$= \lim_{T\to\infty} \frac{1}{T}\int_{-T/2}^{T/2} \frac{C^2}{2}\left[1 + \cos(2\omega_0 t + 2\theta)\right] dt$$

$$= \lim_{T\to\infty} \frac{C^2}{2T}\int_{-T/2}^{T/2} dt + \lim_{T\to\infty} \frac{C^2}{2T}\int_{-T/2}^{T/2} \cos(2\omega_0 t + 2\theta)\,dt$$

The first term on the right side equals $C^2/2$ while the second is zero because the integral appearing in this term represents the area under a sinosoid over a very large time interval T with $T \to \infty$. This area is at most equal to the area of half the cycle because of cancellation's of the positive & negative areas of sinusoid. The second term is this area multiplied by $C^2/2T$ with $T \to \infty$. Clearly this term is zero.

$$P_f = \frac{C^2}{2}$$

This shows a well-known fact that a sinosoid of amplitude C has power $C^2/2$ regardless of its angular frequency ω_0 ($\omega_0 \neq 0$) & its phase θ. The rms value is $C/\sqrt{2}$. If the signal frequency is zero. (dc or a constant signal of amplitude C). the reader can show that the power is C^2.

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Q#2(a)

$5 \cos 2\pi 10^6 t$

$h = \frac{\lambda}{4} = \frac{c}{4f}$

$s = 20$ Km

$f = 10^6$

put the values

$h = \frac{c}{4f}$

$h = \frac{3 \times 10^{8}}{4 \times 10^{6}}$ 2

$\boxed{h = 75 \text{ meter}}$

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$3 \cos 2\pi\, 10^{3} t$

$h = \frac{c}{4f}$

$f = 10^{3}$

putting the values

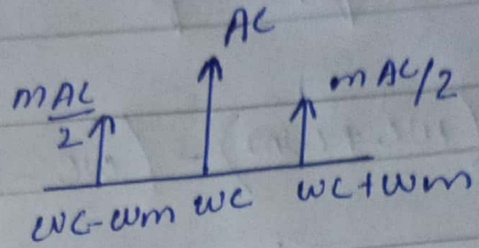
$h = \frac{3 \times 10^{\cancel{8}\,5}}{4 \times 10^{\cancel{3}}}$

$h = \frac{3 \times 10^{5}}{4}$

$\boxed{h = 75{,}000}$ meters

Q#2

(b) Power of AM Modulation:



$X_{AM}(t) = A_c \cos\omega_c t = \frac{m A_c}{2} \left[\cos(\omega_c - \omega_m) + \cos(\omega_c + \omega_m) \right]$

$X_m(t) = \pi A \left(\delta(\omega - \omega_c) + \delta(\omega + \omega_m) \right) + \frac{1}{2} \left[X(\omega_c - \omega_m) + X(\omega_c - \omega_m) \right]$

power = power (lower side band) + Power (upper side band) + P_c

A_c/ω_c $\qquad$ A_m/A_m

$v_{c,Rms} = v_c/\sqrt{2}$

$v_{m,Rms} = v_m/\sqrt{2}$

$P_c = \frac{v_c^2}{R} \Rightarrow v_c^2/\sqrt{2}\,R \Rightarrow \frac{v^2}{2R}$

$P_m = \frac{v_m^2}{R} \Rightarrow \frac{v_m^2}{2R} \Rightarrow \left(\frac{m v_c}{2}\right)^2 / 2R$

$\frac{m^2 v_c^2}{4 \cdot 2R} \Rightarrow m^2 \cdot P_c$

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

(11)

Bandwidth = $f_H - f_L$

$B = (\omega_c + \omega_m) - (\omega_c - \omega_m)$

$\boxed{B = 2\omega_m}$

X_1

X

X

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(12)

Q#3 AM Modulation:

(a)

$\omega_m = 2\pi f_m$

$\omega_c = 2\pi f_c t$

$$X_m(t) = A_m \cos \omega_m(t)$$

$$X_c(t) = A_c \cos \omega_c t$$

$$X_{AM}(t) = A_c\left[1 + m \cos \omega_m(t)\right] \cos \omega_c(t)$$

$\cos \omega_c(t)$ multiplied to eq

$$X_{AM}(t) = A_C \cos \omega_c(t) + X_m(t) \cos \omega_c(t) \quad -(1)$$

$$X_{AM}(t) = X_1(t) + X_2(t)$$

As we know that

$$\cos \omega_c(t) = \frac{1}{2}\left[e^{j\omega t} + e^{-j\omega t}\right] \quad -(2)$$

comparing eq (1) & (2)

$$X_{AM}(t) = \frac{A_C}{2}\left(e^{j\omega t} + e^{-j\omega t}\right) + \frac{X_m(t)}{2}\left(e^{j\omega t} + e^{-j\omega t}\right)$$

eq (3)

$$X_m(t)\, e^{j\omega_c t} \longrightarrow X(\omega_c - \omega_m)$$

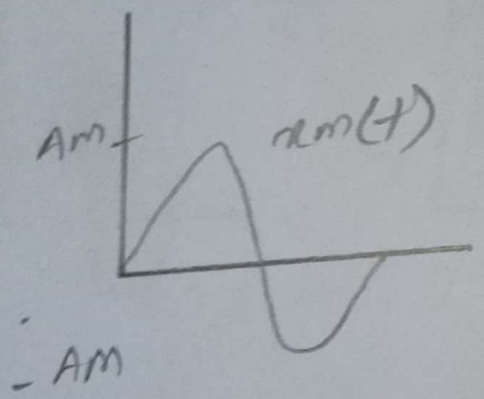
$$X_m(t)\, e^{-j\omega_c t} \longrightarrow X(\omega_c + \omega_m)$$

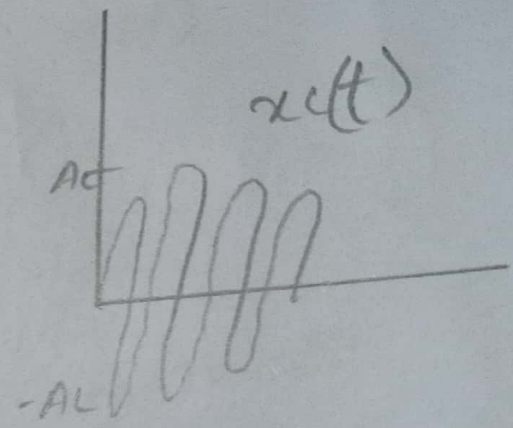
The eq (3) becomes

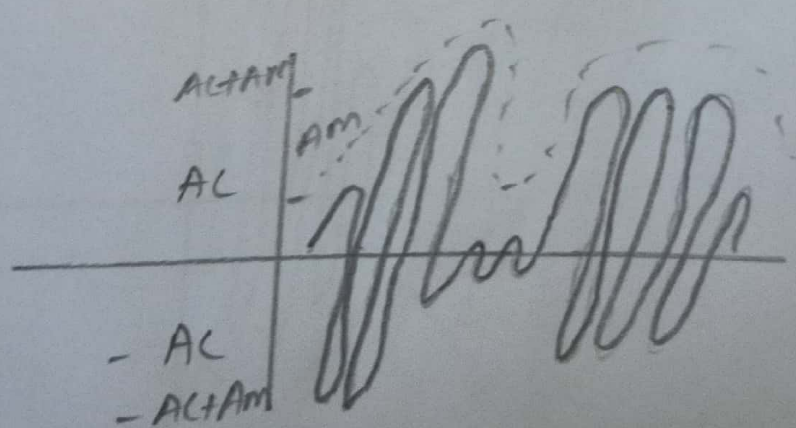
$$X_{AM}(t) = \frac{1}{2} X_m(t)\, e^{j\omega_c t} + \frac{1}{2} X_m(t)\, e^{-j\omega_c t}$$

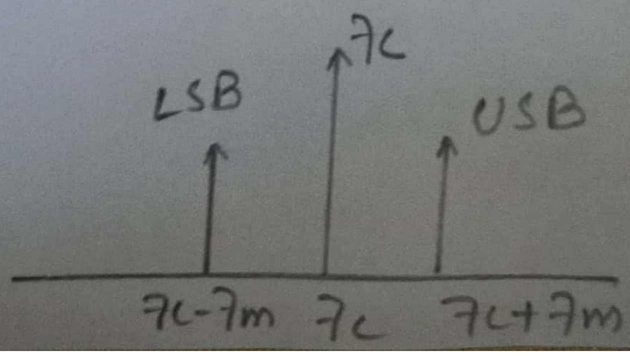
$$X_2(t) = \frac{1}{2} X(\omega_c - \omega_m) + \frac{1}{2} X(\omega_c + \omega_m)$$

$$X_1(t) = \pi A\Big(\delta(\omega - \omega_c) + \delta(\omega + \omega_c) + \frac{1}{2}\big(X(\omega_c - \omega_m) + X(\omega_c + \omega_m)\big)\Big)$$







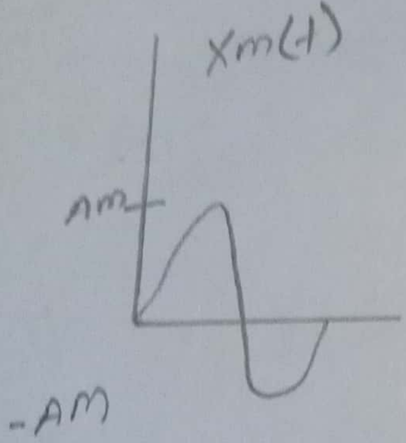


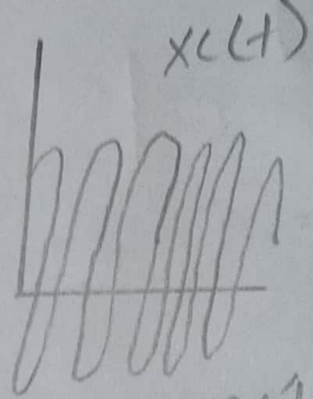
(14)

i) $m<1$

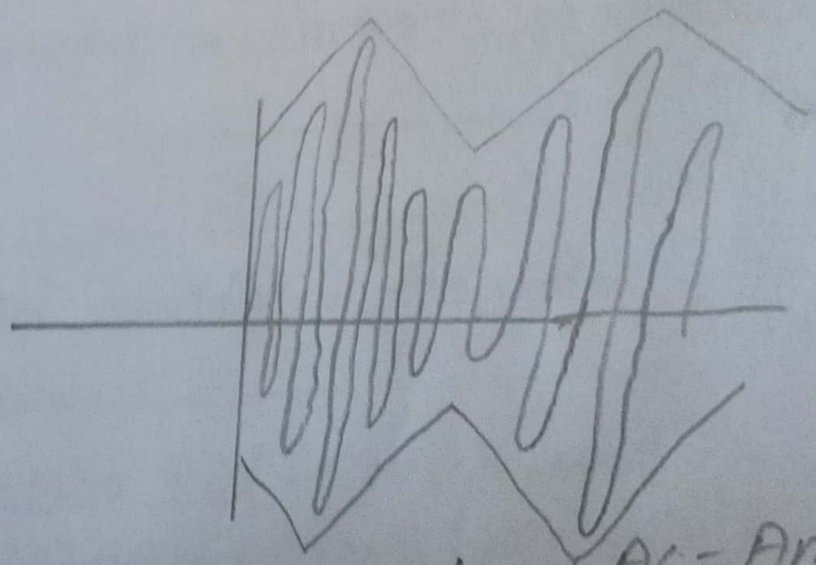
ii) $m=1$

iii) $m>1$





$m<1 \Rightarrow AC > Am$



$m=1 \Rightarrow AC = Am$

$m>1 \Rightarrow AC < Am$

Q#3
(b)

Given:

Amplitude $V = 7V$
Amp Freq $f = 1MHz$
Sinosoidal $V = 3.5V$
" Freq $f = 5KHz$

Req:

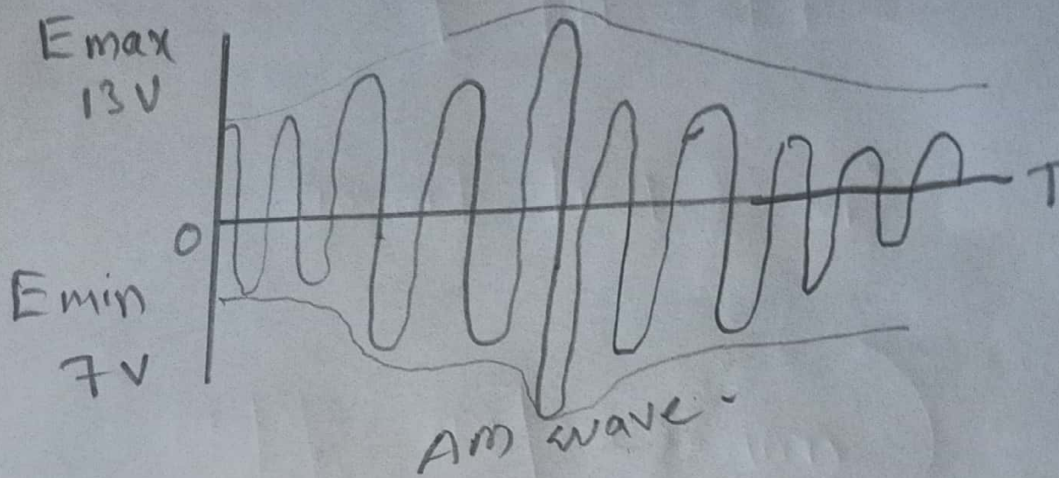
Sol: $E_c = 10V, E_m = 3V, f_c = 30\,KHz\ f_m = 50\Omega$

(i) Modulation index = $m = \frac{E_m}{E_c} = \frac{3}{10} = 0.3$

(ii) Eq for modulated Am wave & its Frequency spectrum.

$$s(t) = E_c(1 + m \cdot \cos \omega_m t) \cos \omega_c t$$
$$s(t) = 10(1 + 0.3(2\pi \times 1 \times 10^3 t) \cos(2\pi \times 30) \times 10^3 t$$
$$s(t) = 10(1 + 0.3 \cos(2\pi \times 10^3) \cos(6\pi \times 10^4 t)$$

(iii)



(iv) $f_{USB} = f_c + f_m = 30 + 1 = 31$ KHZ

$f_{LSB} = f_c - f_m = 30 - 1 = 29$ KHZ

Amplitude of each sideband =

$\frac{m}{2} \times E_c = \frac{0.3 \times 10}{2} = 1.5$ V