VIT® Vellore Institute of Technology (Deemed to be University under section 3 of the UGC Act, 1956)	**Final Assessment Test – Winter 2023-24 Semester - May 2024**	
	Course code : BECE 304 L	Slot:G1
	Course Title : Analog Communication Systems	Time: **Three Hours**
	Course Mode **: CBL**	Max. Marks: **100**
Emp Id:11060	Faculty Name :Dr.T.Shankar	School: SENSE
	Class Number(s): VL2023240501316,1313,1302,1307, 1310,1322,1319,1305	Mobile No.:9486282025

KEEPING MOBILE PHONE/SMART WATCH, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE

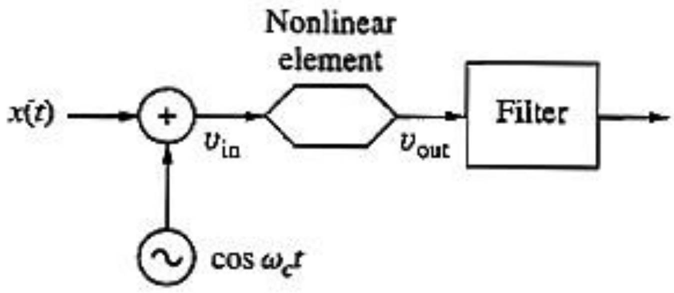
General Instructions if any:

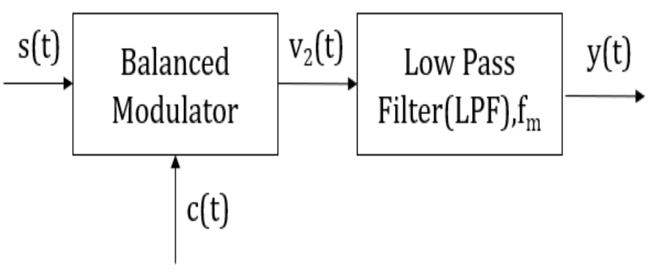
1. **"*fx* series" - non Programmable calculator are permitted : YES**
2. **Reference tables permitted : YES (if Yes, Please specify:** Scientific calculators and Bessel's table are permitted **)**

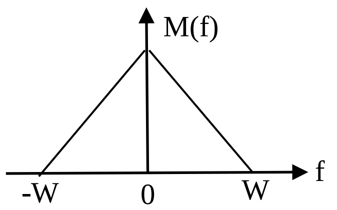
Answer ALL Questions, Each Question carries Ten Marks. (10 X 10 = 100 Marks)

Sl No	Question Text	E/A /T	Unit / Module No	Marks	BL	CO
1.	a) (i)Differentiate simplex, half duplex and full duplex. (ii)Specify the frequency ranges allotted for AM and FM broadcast. (3) a)) 1. ∅(a) $c = f\lambda$; $c = 3\times10^{8}$ m/s . (i) $f = 1000Hz$; $\lambda = \frac{3\times10^{8}}{1000} = 3\times10^{5}$ m , $l = \frac{\lambda}{4} = 75$ km. (ii) $c = f\lambda$; $c = 3\times10^{8}$ m/s $f = 200MHz$; $\lambda = \frac{3\times10^{8}}{200\times10^{6}} = 1.5$ m ; $l = 0.375$ m . b) List the need for modulation in a communication system and find the practicality of length of the antenna for the transmission of voice signal at a carrier frequency of 1KHz and 200MHz? (4) c) Calculate the theoretical channel capacity if the SNR is 40dB and the channel bandwidth is 6MHz? (3)	E	1	**10**	**2**	**1**

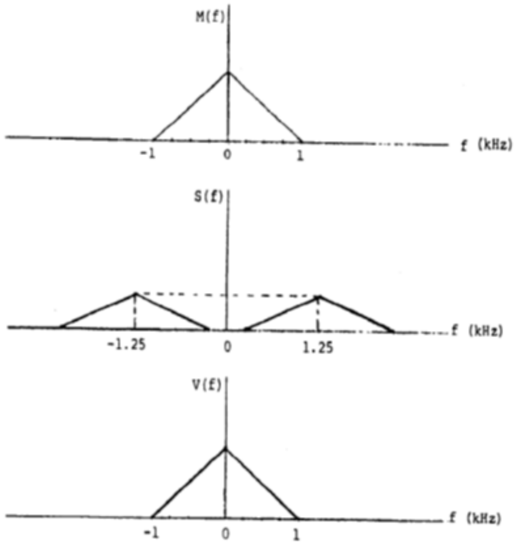
	(1) (i) Frequency range of AM + FM. [5 Marks] (a) AM Frequency Range = 535 – 1605 kHz FM Frequency Range = 88 – 108 MHz. (b) Calculate channel capacity: [5 Marks] SNR = 40 dB = 10,000. Channel Bandwidth = 6 MHz. ∴ Channel Capacity $C = W \log_2 [1+SNR]$ $C = 6\times10^6 \log_2 [1+10,000]$ $C = 79.727$ Mbps.					
2.	a) A modulating signal $10\sin(2\pi \times 10^3 t)$ is used to modulate a carrier signal $20\sin(2\pi \times 10^4 t)$. Determine the modulation index, percentage of modulation, frequencies of the sideband components and their amplitudes. What will be the bandwidth of the modulated signal? [5] **Solution:** (i) The modulating signal $v_m = 10 \sin (2\pi \times 10^3 t)$. Let us compare this with the following expression $v_m = V_m \sin(2\pi f_m t)$ Then, we get $V_m = 10$ volt, $f_m = 1 \times 10^3$ Hz = 1 kHz (ii) The carrier signal $v_c = 20 \sin (2\pi \times 10^4 t)$ Comparing this with the expression $v_c = V_c \sin(2\pi f_c t)$, we obtain $V_c = 20$ volt, $f_c = 1 \times 10^4$ Hz = 10 kHz (a) Modulation index and percentage modulation: We know that $m = \frac{V_m}{V_c} = \frac{10}{20} = 0.5$ and % modulation = 0.5 × 100 = 50 % (b) Frequencies of sideband components: (i) Upper sideband $f_{USB} = f_c + f_m = (10 + 1) = 11$ kHz (ii) Lower sideband $f_{LSB} = f_c - f_m = (10 - 1) = 9$ kHz (c) Amplitudes of sidebands: The amplitudes of upper as well as the lower sideband are given by, Amplitude of each sideband = $\frac{mV_c}{2} = \frac{0.5\times20}{2} = 5$ Volt **Ans.** (d) Bandwidth = $2 f_m = 2 \times 1$ kHz = 2 kHz **Ans.** b) An AM transmitter has an unmodulated carrier power of 10 kW. It can be modulated by a sinusoidal modulating voltage to a maximum depth of 40%, without overloading. If the maximum modulation index is reduced to 30%, what is the extent up to which the unmodulated carrier power can be increased without overloading? [5]	A	2	**10**	**3**	**2**

	It is given that the unmodulated carrier power = $P_c = 10$ kW Max. depth of modulation without overloading = 40% $\therefore\ m_1 = 0.4$ Total power in the AM signal = $P_T = P_C\left[1+\frac{m_1^2}{2}\right] = 10^4 \times 1.08 = 10.8$ kW $\therefore$ to avoid overloading, we have to see that the total power in the AM signal does not exceed 10.8 kW. When the percentage of modulation is 30%, $m_2 = 0.3$ Now, let P_C^1 be the maximum unmodulated carrier power that would make the total power in the AM signal reach the value 10.8 kW. $\therefore \quad P_T = 10.8\times10^3 = P_C^1\left[1+\frac{(0.3)^2}{2}\right] = 1.045P_C^1$ $\therefore \quad P_C^1 = \frac{10.8\times10^3}{1.045} = 10.33$ kW Hence, with a modulation index of 0.3, the unmodulated carrier power can be increased up to 10.33 kW without overloading.					
3.	The signal $x(t) = \frac{1}{2}\cos(2\pi 70t) + \frac{1}{3}\cos(2\pi 120t)$ is input to the square law modulator with a carrier frequency of 10 kHz as shown in Figure. 1. Assume $V_{out} = a_1 v_{in} + a_2 v_{in}^2$.  Figure. 1 Square law modulator (a) Calculate the centre frequency and bandwidth of the filter such that this system will produce a standard AM signal. b) Determine the values of a_1 and a_2 such that carrier amplitude A_c =10 V and modulation index is 0.5. $V_{in} = x(t) + \cos\omega_c t$ a) $V_{out} = a_1 V_{in} + a_2 V_{in}^2$ $V_{out} = a_1[x(t) + \cos\omega_c t] + a_2[x(t) + \cos\omega_c t]^2$ $= a_1 x(t) + a_1\cos\omega_c t + a_2 x^2(t) + 2a_2 x(t)\cos\omega_c t + a_2\cos^2\omega_c t$ $V_{out} = a_1 x(t) + a_2 x^2(t) + a_2\cos^2\omega_c t + a_1\left[1 + \frac{2a_2}{a_1}x(t)\right]\cos\omega_c t$ — (1) Select a filter centered at $\underline{f_c = 10\,kHz}$ with a bandwidth of $2W = \underset{(\text{max freq})}{2\times120} = \underline{240\,Hz}$ b) From equation (1), the desired term is $a_1\left[1 + \frac{2a_2}{a_1}x(t)\right]\cos\omega_c t$ $= A_c[1 + \mu x(t)]\cos\omega_c t$ Given $A_c = 10V$ $\Rightarrow 10\left[1 + \frac{2a_2}{10}x(t)\right]\cos\omega_c t$ $\therefore \boxed{a_1 = 10}$ Given $\mu = 1/2$ and so $\mu = \frac{2a_2}{a_1} = \frac{2a_2}{10}$ $\frac{1}{2} = \frac{2a_2}{10}$ $\therefore \boxed{a_2 = \frac{5}{2}}$	A	2	**10**	**3**	**2**

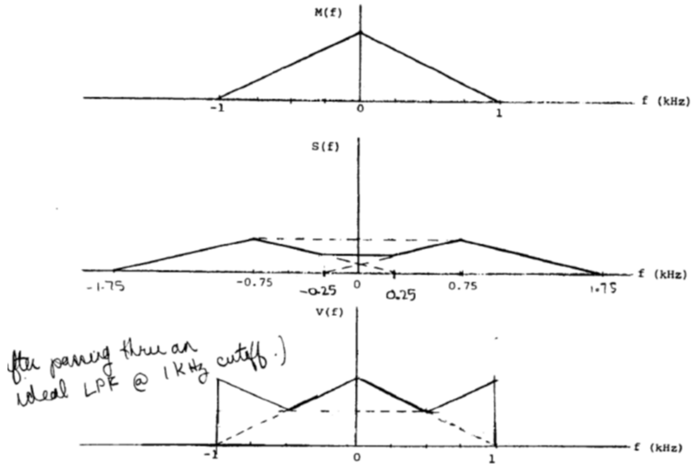
4.	a) A 400 W carrier is Amplitude modulated to a depth of 100%. Calculate the Total Power in case of SSB technique. How much Power saving (in W) is achieved for SSB compared to AM and DSBSC? If the Depth of Modulation is changed to 75%, then how much Power (in W) is required for transmitting the SSB wave? Compare the Powers required for SSB in both the cases and comment on the reason for change in the Power levels. **Case 1** Given, $P_c = 400$ W and $m = 1$. Total power in SSB, $P_{SSB} = P_c\left(\frac{m^2}{4}\right) = 400\left(\frac{1}{4}\right) = 100$ W. Power saving (in W) compared to AM $= P_{AM} - P_{SSB} = 500$ W. Power saving (in W) compared to DSBSC $= P_{DSBSC} - P_{SSB} = 100$ W. Thus we require only 100 W in case of SSB which is one-sixth of total AM power! **Case 2** Given, $P_c = 400$ W and $m = 0.75$ Total power in SSB, $P_{SSB} = P_c\left(\frac{m^2}{4}\right) = 400\left(\frac{(0.75)^2}{4}\right) = 56.25$W. The power required in this case is lower than $m = 1$ case. This infers that the total power in SSB also depends on the depth of modulation. It will be maximum, that is, one-sixth of total AM power when $m = 1$ and less for $m < 1$. b) Compute the demodulated signal y(t) from Figure 2. The Double-Sideband Suppressed Carrier (DSB-SC) modulated, s(t) = 4cos2π400t (2cos 4000πt) where the Balanced modulated carrier signal c(t) = 2cos4000πt.  Figure 2	T	3	10	3	2

	$s(t) = 4\cos(2\pi 400 t)\, 2\cos(4000\pi t)$ $c(t) = 2\cos 4000\pi t$ $V_2(t) = s(t)\cdot c(t)$ $= [4\cos(2\pi\, 2400 t) + 4\cos(2\pi\, 1600 t)]\; 2\cos 2\pi\, 2000 t$ $V_2(t) = 4\cos(2\pi\, 4400 t) + 4\cos(2\pi\, 400 t) + 4\cos(2\pi\, 3600 t) + 4\cos(2\pi\, 400 t)$ o/p of LPF $y(t) = 8\cos(2\pi\, 400 t)$					
5.	Consider a message signal *m(t)* with a spectrum shown in Figure. 3. The message bandwidth is 1 kHz. This signal is applied to a product modulator together with a carrier wave $A_c \cos(2\pi f_c t)$, producing the DSB-SC modulated signal *s(t)*. The modulated signal is next applied to a coherent detector. **[10]**  Figure. 3 Spectrum of message signal (i) Assuming perfect synchronism between the carrier waves in the modulator and detector, determine the spectrum of the detector output when: (a) f_c = 1.25 kHz (b) f_c = 0.75 kHz (ii) What is the lowest carrier frequency for which each component of the modulated signal *s(t)* is uniquely determined by *m(t)* and draw the resultant spectrum?	A	3	**10**	**3**	**2**

(a) For $f_c = 1.25$ kHz, the spectra of the message signal m(t), the product modulator output s(t), and the coherent detector output v(t) are as follows, respectively.



(b) For the case when $f_c = 0.75$, the respective spectra are as follows:



To avoid sideband-overlap, the carrier frequency f_c must be greater than or equal to 1 kHz, The lowest carrier frequency is therefore 1 kHz for each sideband of the modulated wave s(t) to be uniquely determined by m(t).

Given :- $W = f_m = 1KHz$

i) When $f_c = 1.25$ KHz

$f_c + W = 1.25KHz + 1KHz = 2.25KHz$

$f_c - W = 1.25KHz - 1KHz = 0.25KHz$

$-f_c + W = -1.25KHz + 1KHz = -0.25KHz$

$-f_c - W = -1.25KHz - 1KHz = -2.25KHz$

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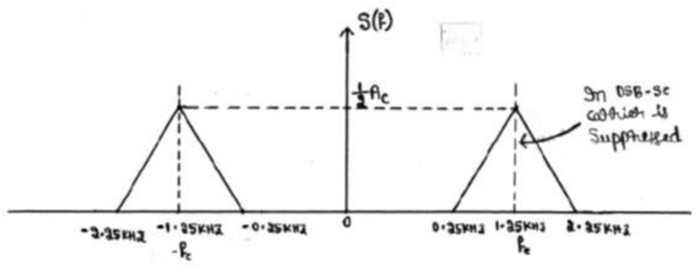
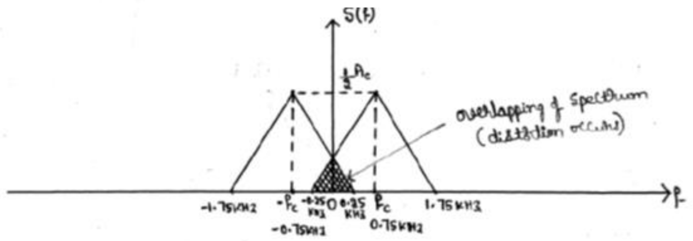


ii) When $f_c = 0.75$ KHz :

$f_c + W = 0.75\text{KHz} + 1\text{KHz} = 1.75\text{KHz}$
$f_c - W = 0.75\text{KHz} - 1\text{KHz} = -0.25\text{KHz}$
$-f_c + W = -0.75\text{KHz} + 1\text{KHz} = 0.25\text{KHz}$
$-f_c - W = -0.75\text{KHz} - 1\text{KHz} = -1.75\text{KHz}$



iii) The lowest f_c so that $m(t)$ is uniquely determined from $s(t)$ is 1 KHz i.e. $\boxed{f_c = 1\text{KHz}}$

$f_c + W = 1\text{KHz} + 1\text{KHz} = 2\text{KHz}$
$f_c - W = 1\text{KHz} - 1\text{KHz} = 0\text{Hz}$
$-f_c + W = -1\text{KHz} + 1\text{KHz} = 0\text{Hz}$
$-f_c - W = -1\text{KHz} - 1\text{KHz} = -2\text{KHz}$
</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>6.</td><td>
A block diagram of an indirect (Armstrong) FM transmitter is shown in Figure 4. Compute the maximum frequency deviation Δf of the output of the FM transmitter and the carrier frequency f_c if f_1 = 200 kHz, f_{LO} = 10.8 MHz, Δf_1 = 25 Hz, n_1 = 64, and n_2 = 48.

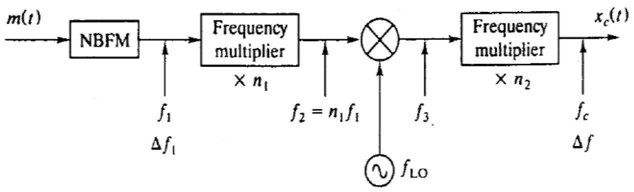


Figure 4.

Solution:

$$\Delta f = (\Delta f_1)(n_1)(n_2) = (25)(64)(48)\,\text{Hz} = 76.8\,\text{kHz}$$
$$f_2 = n_1 f_1 = (64)(200)(10^3) = 12.8(10^6)\,\text{Hz} = 12.8\,\text{MHz}$$
$$f_3 = f_2 \pm f_{LO} = (12.8 \pm 10.8)(10^6)\,\text{Hz} = \begin{cases} 23.6 & \text{MHz} \\ 2.0 & \text{MHz} \end{cases}$$

Thus, when $f_3 = 23.6\,\text{MHz}$, then

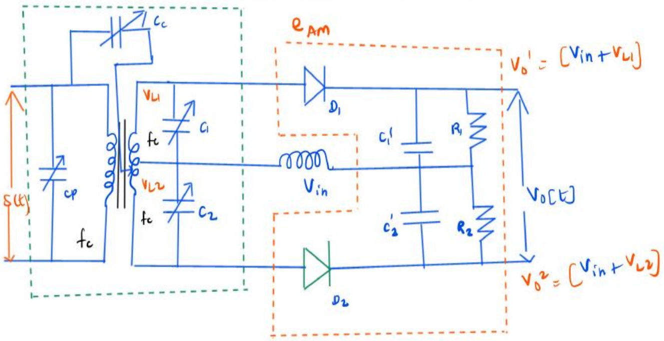
$$f_c = n_2 f_3 = (48)(23.6) = 1132.8\,\text{MHz}$$

When $f_3 = 2\,\text{MHz}$, then

$$f_c = n_2 f_3 = (48)(2) = 96\,\text{MHz}$$
</td><td>A</td><td>4</td><td>10</td><td>3</td><td>3</td></tr>
</table>

7.	Draw and explain Foster-Seeley Discriminator circuit to demodulate FM signal.	E	4	**10**	**2**	**3**

Foster - seeley Discriminator:



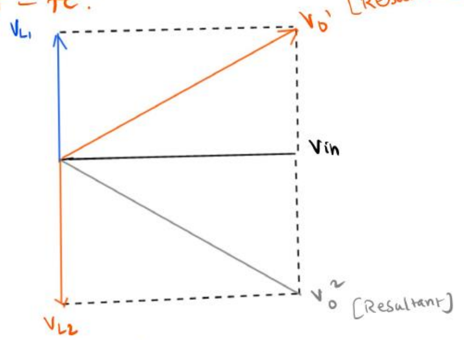
$$V_o[t] = V_o' - V_o^2$$

Advantages of Coupling Capacitor

* Block the DC voltage from primary to secondary.

* Couples the primary frequency to center tapped inductor.

(i) $f = f_c$:

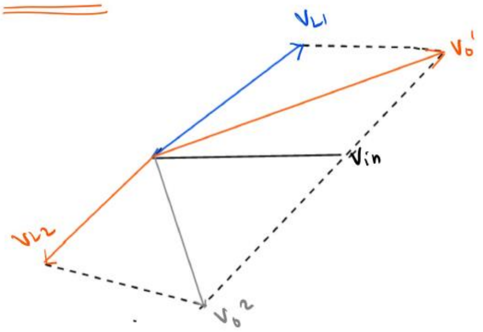
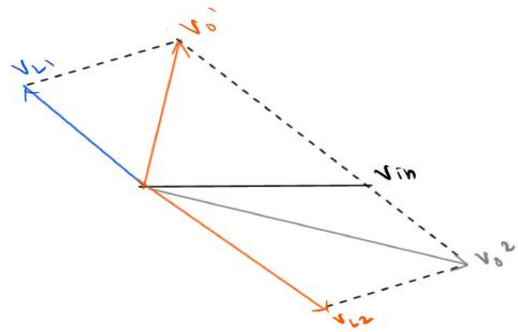


$V_{L2} \rightarrow 180^\circ$ phase shift of V_{L1}.

$$|V_o'| = |V_o^2|$$

$$|V_o'| - |V_o^2| = 0$$

$$\boxed{V_o(t) = 0}$$

	II) $f > f_c$:  $V_o(t) = \|V_o^1\| - \|V_o^2\|$ $\|V_o^1\|$ magnitude is higher than $\|V_o^2\|$ $\boxed{V_o(t) > 0}$ III) $f < f_c$:  $V_o(t) = \|V_o^1\| - \|V_o^2\|$ $\|V_o^1\| < \|V_o^2\|$ $\boxed{V_o(t) < 0}$ Advantages: i) 3 tuned circuit tuned @ f_c No circuit complexity ii) Linearity is better. Disadvantages: i) Limiter cannot be used [limiter is used to remove the noise] ii) Costly					
8.	a) Explain the operation of superhetrodyne receviver with neat diagram and it is advantage and disadvantage compare with TRF receiver. [7] b) Compare high-level modulation and low-level modulation of AM broadcast transmitters [3]	E	5	**10**	**2**	**4**
9.	A PCS cellular receiver front-end is shown below Figure 5. The operating frequency is 1805-1880 MHz, and the	A	6	**10**	**3**	**5**

physical temperature of the system is 300 K. A noise source with noise power N_i = -95 dBm is applied to the receiver input.

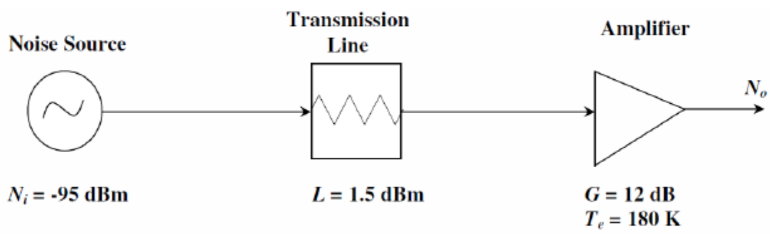


Figure 5.

a) What is the equivalent noise temperature of the source over the operating bandwidth?

b) What is the noise figure (in dB) of the amplifier?

c) What is the noise figure (in dB) of the cascaded transmission line and amplifier?

a) $T_e = \frac{N_i}{kB} = \frac{3.16\times10^{-6}}{1.38\times10^{-23}\times 75\times10^{6}} = 305.3\,\mathrm{K}$

b) $F_{amp} = 1+\frac{T_e}{T_0} = 1+\frac{180}{290} = 1.62 = 2\,\mathrm{dB}$

c) $F_{line} = 1+(L-1)T/T_0$, $F_{cas} = F_1 + \frac{F_2-1}{G_1} = 1.42 + \frac{1.62-1}{1/1.41} = 2.28 = 3.58\,\mathrm{dB}$

(b) b)Derive the expressions for output signal to noise ratio for Tandem connection of repeaters

i)Assuming all links are identical

ii)Assuming if any one link is much worse than others

[5]

OR

9 b)

b) i) The signal power and noise power measured at the end of an amplitude are 150µW and 1.5µW If the signal power at the output is 1.5W and noise power is 45mW.Calculate the amplifier noise factor and noise figure. [5]

Solution : P_{si} = 150 µW, P_{ni} =1.5µW, P_{so} = 1.5W

and P_{no} = 45 mW

$$\text{Noise factor} = \frac{P_{si}}{P_{ni}} \times \frac{P_{no}}{P_{so}} = 3$$

$$\text{Noise Figure} = 10 \log_{10} (\text{Noise factor}) = 10 \log_{10} (3)$$

$$= 4.77\ \text{dB.}$$

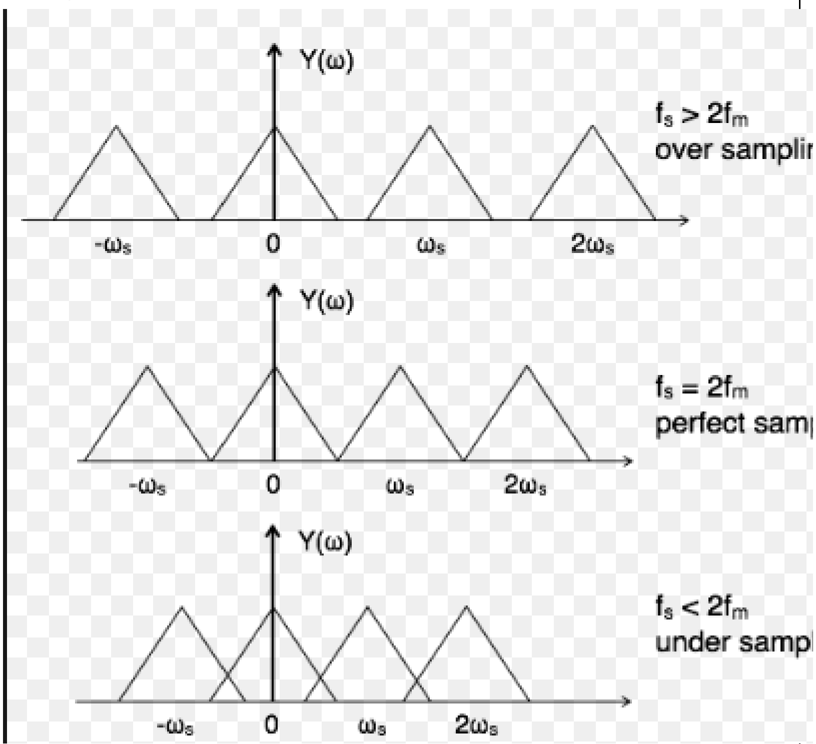
ii)The equivalent noise resistance for an amplifier is 300Ω and equivalent shot noise current 5µA. The amplifier is fed from 150Ω 10µV rms sinusoidal signal source. Calculate the individual noise voltage at the input signal to noise ratio in decibels. The noise bandwidth is 10MHz. [5]

Solution: let room temperature so that kT=4x10-21J

And qe=1.6x10-19C shot noise current is Ina=[2qeIEQBn]1/2=4nA

So noise voltage across source resistance is

InaRs=0.6µV shot noise current does not develop a voltage

	across Rn . The noise voltage generated by Rn is Vna=[4Rn kToBn]1/2=6.93µV Thermal noise voltage from source is Vns=[4RskToBn]1/2=4.9µV total noise voltage at input to the amplifier is Vn=[4.92+6.932+.62]1/2=8.51µV so signal to noise ratio in decibels is S/N=20logVs/Vn=1.4dB					
10 a)	a)Explain the generation and detection of pulse position modulation signal with neat diagram. Draw the various stages of waveforms during detection. [10]	A	7	**10**	**2**	**6**
	OR					
10 b)	b) I) State Nyquist theorem and explain the three following three cases with the frequency spectrum : i) When sampling frequency is twice the message signal frequency ii) When sampling frequency is greater than twice the message signal frequency iii) When sampling frequency is lesser than twice the message signal frequency [5] *The sampling frequency should be at least twice the highest frequency contained in the signal.* Or in mathematical terms: $$f_s \geq 2 f_c \qquad (1)$$ where f_s is the sampling frequency (how often samples are taken per unit of time or space), and f_c is the highest frequency contained in the signal.  II) With a neat sketch explain the transmitter and receiver of TDM. [5]					

Date: Signature of Paper Setter/s/ Moderator/s & Emp id