Dhirubhai Ambani
Institute of Information and Communication Technology
Near Indroda Circle, Gandhinagar, Gujarat, India 382 007.
Tel.: +91 79 3052 0000 | Fax: +91 79 3052 0010 | Web: www.daiict.ac.in

Analog Communications and Transmission Line Theory (CT215)
1st In-Semester Examination

Closed Books and Closed Notes Examination

Date: 7 February 2018 **Time: 8:30 am to 10:30 am**

Answer all questions

Section A

Please write all answers of this section only in space given in this question paper.

1. What is the basic function of communication systems? (2 marks)

2 To transmit signal from one place to another with minimal distortion or attenuation.

2. Define message in terms on information. (2 marks)

2 Message is the information signal that is to be transmitted over the transmission channel.

3. Name three essential parts of any communication system? (3 marks)

3 Transmitter, Transmission Channel and Receiver are 3 essential parts of any communication system.

4. Name four unwanted and undesirable effects in signal transmission on transmission channel. (4 marks)

1.) Distortion 2.) Noise 3.) Interference
4 4.) Attenuation of signal.

5. What is the important characteristic of full-deplex system regarding transmission channel? (2 marks)

There should be transmitter and receiver present at
2 both end of communication system and using full duplex both can communicate with each other simultaneously.

6. Name two fundamental limitations of information transmission by electrical means using a communication system? (3 marks)

Noise and Bandwidth are limitations of information transmission.

3

7. In the electromagnetic spectrum, what VHF and UHF stands for? (2 marks)

VHF - Very High Frequency

UHF - Ultra High Frequency.

2

8. What is the full form of FDM, TDM, MA and CDMA in communication systems? (4 marks)

FDM - Frequency Division Multiplexing

TDM - Time Division Multiplexing

MA - Multiple Access

CDMA - Code Division Multiple Access.

4

9. In analog modulations, give full forms of CW, AM, FM, PM and VCO. (5 marks)

CW - Continuous Wave

AM - Amplitude Modulation

FM - Frequency Modulation

PM - Phase Modulation

VCO - Voltage Controlled Oscillator

5

10. What is the full form of DSBFC, DSBSC and SSBSC in AM modulation? (3 marks)

DSBFC - Double side Band Full Carrier

DSBSC - Double Side Band Suppressed Carrier

SSBSC - Single Side Band Suppressed Carrier

3

11. State the frequency ranges of AM broadcast services in medium-wave band in kHz and FM broadcasting in VHF band in MHz? (4 marks)

AM - 400 - 1600 KHz.

FM - 88.1 - 108 MHz.

3

12. In case of sinusoidal AM, P_T, P_C and m are total average power, average carrier power and modulation index, respectively. State relationship between them. (4 marks)

4

$$P_T = P_C\left(1 + \frac{m^2}{2}\right)$$

13. In case of sinusoidal FM, transmitted FM power and carrier power are P_T and P_C, respectively. State relationship between P_T and P_C. (2 marks)

$$P_T = P_C\left(1 + \frac{m_1^2}{2} + \frac{m_2^2}{2} + \dots\right)$$

0

In case of FM modulated signals, define deviation ratio (D) in terms of maximum frequency deviation (ΔF) and highest modulating frequency (F_m). What is the maximum deviation ratio allowed for commercially broadcast FM? (4 mark)

$D = \frac{\Delta F}{F_m}$

Maximum D for commercially broadcast FM is 1.

2

0

5. How many pairs of sidebands are present in case of AM and FM broadcast services? (4 mark)

There is one pair of sideband in AM. and infinite pairs of sideband in FM [depends on m]

0

16. Name four operating categories in frequency detection. (4 marks)

Limitator, differentiator, envelop detector and. dc. detectors.

0

17. What is the main disadvantage of direct FM for FM modulation? (3 marks)

Bandwidth required is very high. and the receiver circuit is complicated.

18. Give two advantages of SSBSC as compared with DSBFC (standard AM) and DSBSC? (4 marks)

1.) Half the Bandwidth

2.) Power consumption is less compared to DSBFC & DSBSC.

1

19. What is the goal of a communication system regarding source message? (2 marks)

The goal is to transmit source message in original form to the receiver without any attenuation.

2

Section B

Please write all answer of this section only in regular answer book (8 pages long).

1. (a) State and explain 5 benefits of modulation in communication systems.(6 marks)

   (b) Define modulation index (m) for AM. What is the normal range of m? Explain with the aid of block diagram, figures and equations, method of obtaining trapezoidal display, trapezoidal patterns for normal range of m as well as m >1. (6 marks)

   (c) The output of balance modulator is given by e (t) = k e_m (t) e_c (t) where k is a constant, e_c (t) and e_m (t) are carrier signal and modulation signal. The carrier signal of frequency f_c is given by $e_c(t) = E_{c\,max} \cos(2\pi f_c t)$ where $E_{c\,max}$ is peak amplitude. For sinusoidal AM, $e_m(t)$ is given by $E_{m\,max} \cos(2\pi f_m t)$ where $E_{m\,max}$ and f_m are peak amplitude and modulation frequency. With the aid of equations, explain SSBSC modulation and demodulation. (4 marks)

(d) Assume $e_c(t)$ and $e_m(t)$ are carrier signal and modulation signal which are given in section (c). Describe with the aid of equations and a figure DSBSC using balanced modulator realized by a pair of closely matched FETs. (4 marks)

$V_c - V_m$

$V_c + V_m$

$I_1 = \alpha I_1 + \alpha V_1 + \beta V_1^2$

2. (a) Discuss all advantages and disadvantages of FM and AM modulation systems. What are the advantages and disadvantages of FM and AM broadcast services. (6 marks)

(b) For sinusoidal FM, give expression of bandwidth in terms of f_m and n. where n is highest order of significant side band frequency. Also, give Cason's rule for calculation of bandwidth FM signal of maximum deviation (δ or Δf) when order of side frequency is greater than (β +1). Where β is FM modulation index. (3 marks)

$2(\Delta f + f_c)$ β

(c) For sinusoidal FM, define modulation index (β or m_f). With Δf = 75 kHz, calculate bandwidth for m_f =15, 10 and 7 using two methods of calculation of bandwidth. Also, calculate f_m for different m_f. Comment on how these results and FM radio spectrum. Sketch FM radio spectrum using a suitable figure. (6 marks)

(d) Derive an expression for sinusoidal FM voltage V. Assume carrier signal of amplitude A and angular frequency ω_c, modulating signal of amplitude V_m and angular frequency ω_m, modulation index m_f and maximum frequency deviation δ. Give frequency spectrum of FM voltage in terms of Bessel functions. (5 marks)

3. (a) Calculate instantaneous phase $\phi(t)$ and instantaneous frequency f(t) for PM and FM modulations. PM modulated signal is defined as $x_c(t) = A_c \cos[2\pi f_c t + \phi(t)]$ with $\phi(t)=\phi_\Delta x(t)$. The FM modulated signal is defined as $x_c(t) = A_c \cos[2\pi f(t)]$ with $f(t) = f_c + f_\Delta x(t)$. Where x(t) is the message signal, ϕ_Δ is maximum phase shift, f_Δ is

$\phi_\Delta \cdot x(t)$

$\omega_c + \omega_m$ $\omega_c - \omega_m$

$\omega_m t$

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frequency deviation and f_c is carrier frequency. Also, derive an expression of FM signal in terms of integration of message signal. (4 marks)

(b) For PM modulated signal $x_c(t) = A_c \cos[2\pi f_c t + \phi(t)]$, calculate narrowband PM. Also show implementation of narrowband PM using a figure. (4 marks)

(c) Describe implementation of indirect FM transmitter with aid of equations and a block diagram. Also, show expression for narrowband FM using an expression based on results obtained in section (a). (4 marks)

(d) Describe in detail the concept of FM to AM conversion using a block diagram and equations. Also, discuss in details about balance discriminator, slope detection and frequency-to-voltage characteristic using figures. (8 marks)

BLE 5-2 Bessel Functions of the First Kind

	n or Order																
	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}	J_{11}	J_{12}	J_{13}	J_{14}	J_{15}	J_{16}
00	1.00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25	0.98	0.12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5	0.94	0.24	0.03	—	—	—	—	—	—	—	—	—	—	—	—	—	—
0	0.77	0.44	0.11	0.02	—	—	—	—	—	—	—	—	—	—	—	—	—
5	0.51	0.56	0.23	0.06	0.01	—	—	—	—	—	—	—	—	—	—	—	—
0	0.22	0.58	0.35	0.13	0.03	—	—	—	—	—	—	—	—	—	—	—	—
5	−0.05	0.50	0.45	0.22	0.07	0.02	—	—	—	—	—	—	—	—	—	—	—
0	−0.26	0.34	0.49	0.31	0.13	0.04	0.01	—	—	—	—	—	—	—	—	—	—
0	−0.40	−0.07	0.36	0.43	0.28	0.13	0.05	0.02	—	—	—	—	—	—	—	—	—
0	−0.18	−0.33	0.05	0.36	0.39	0.26	0.13	0.05	0.02	—	—	—	—	—	—	—	—
0	0.15	−0.28	−0.24	0.11	0.36	0.36	0.25	0.13	0.06	0.02	—	—	—	—	—	—	—
0	0.30	0.00	−0.30	−0.17	0.16	0.35	0.34	0.23	0.13	0.06	0.02	—	—	—	—	—	—
0	0.17	0.23	−0.11	−0.29	−0.10	0.19	0.34	0.32	0.22	0.13	0.06	0.03	—	—	—	—	—
0	−0.09	0.24	0.14	−0.18	−0.27	−0.06	0.20	0.33	0.30	0.21	0.12	0.06	0.03	0.01	—	—	—
0	−0.25	0.04	0.25	0.06	−0.22	−0.23	−0.01	0.22	0.31	0.29	0.20	0.12	0.06	0.03	0.01	—	—
0	0.05	−0.22	−0.08	0.20	0.18	−0.07	−0.24	−0.17	0.05	0.23	0.30	0.27	0.20	0.12	0.07	0.03	0.01
0	−0.01	0.21	0.04	−0.19	−0.12	0.13	0.21	0.03	−0.17	−0.22	−0.09	0.10	0.24	0.28	0.25	0.18	0.12

Sr. No. A17 06315

Dhirubhai Ambani
Institute of Information and Communication Technology, Gandhinagar

PLEDGE
I hereby Pledge that I shall answer the questions at the examination to the best of my ability and that I shall not resort to any unfair means of any nature.

Supervisor's Signature : ....

Student's Signature: Hiloni Shah

Course : CT215

Name : Hilloni Shah H

Date : 7/2/18

Student Identity Number : 201601031

Number of Supplementaries :

Programme : B.Tech (ICT)

Questions	1	2	3	4	5	6	7	8	9	10	TOTAL
Marks Obtained	15	12.5	12	39.5							
Questions	11	12	13	14	15	16	17	18	19	20	
Marks Obtained											

S.A 8.1 S.B 47

Examiner's Signature

Start here

Ans - 1

a.) 5 benifits of modulation in communication system:-

* Effecient Transmission :
Using the modulation for transmission, the interference of noise signal can be controlled. The signal obtained at the receiver can be obtained in original form.
By modulating, signals can be sent to large distance using optical fibres, cables etc.

* Noise Reduction :-

The frequency of noise signal can be distinguished from that of information signal clearly by modulation. So, signal can remain intact.

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Wideband Noise Reduction is ~~a~~ also used for controlling the effects of noise. By modulating, the amplitude or frequency of carrier signal changes according to the input signal.

* Modulation to overcome Hardware Limitation :-

Certain types of devices can only be used for certain types of frequencies. Hence, the cost of Hardwarde increases for the efficient transmission. But by modulation, we can set the frequency as per the need of the hardware element and hence due to availability of wide variety of frequencies, modulation helps in overcoming the hardware limitation.

5

* Modulation for Bandwidth :-

Higher the Bandwidth lesser is the time for signal transmission. But, it ~~it~~ is difficult to transmit signal with more bandwidth. So, using modulation, the bandwidth of the signal can be changed as per the need and signal can be transmitted efficiently.

* Multiplexing :-

Without modulation, only one signal can transmit at a given frequency but by modulating we can use message signals having same frequency to transmit simultaneously at a given time by keep their carrier frequencies different. Hence FDM i.e. Frequency Division Multiplexing is used. Also

by TDM i.e Time Division Multiplexing different signals can be ~~set~~ sent at different time. And there's a switch in receiver to switch over one signal to another.
Multiple Access can be done to remotely access the given signal.

b) The modulation index for AM is the ratio of modulating ~~voltage~~ amplitude to that of carrier amplitude

$$m = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \quad 1$$

$E_m \Rightarrow$ Modulating Signal Amplitude
$E_c \Rightarrow$ Carrier Signal Amplitude.

$$m = \frac{E_m}{E_c}.$$

The normal range of m is from 0 to 1

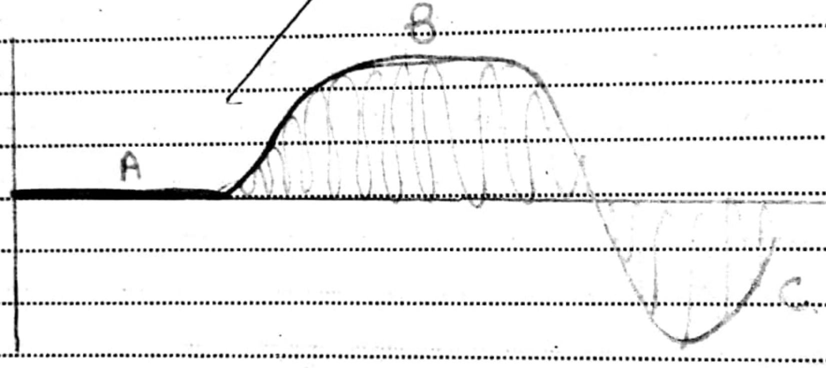
i.e. $0 \leq m \leq 1$ 1

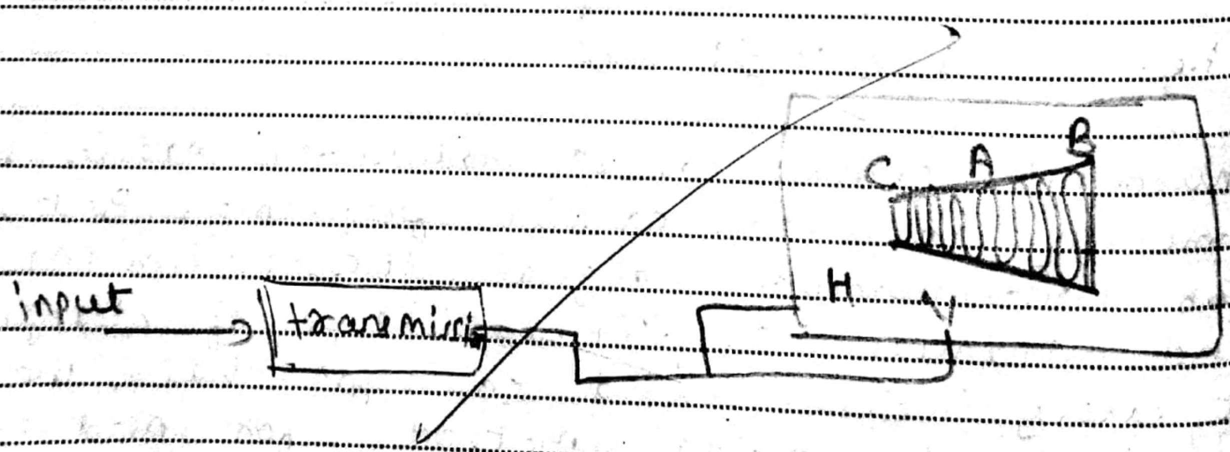
Sinusoidal signal can be modulated easily by combining it with carrier frequency. But for non-sinusoidal signal the maximum and minimum amplitude keeps of changing at every instant and so for that we use the trapezoidal method for modulation.

In the trapezoidal method input is a non-sinusoidal wave. The center point of oscillator is at ~~at~~ the intersection of vertical and horizontal axis. When the amplitude of the input signal doesn't change, the signal in oscillator remains as input but for increase in amplitude it moves vertically up and horizontally right and for decrease in amplitude it moves vertically down and horizontally left.

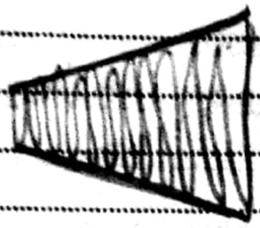
Figure shows the trapezoidal output. In minimum amplitude is zero, then we obtain a triangle instead of a trapezoida. Here point a has no change so, the signal remains as it is but at point B amplitude increase and decreases at point C

(1)





The outputs for different values of m are :-



(1)

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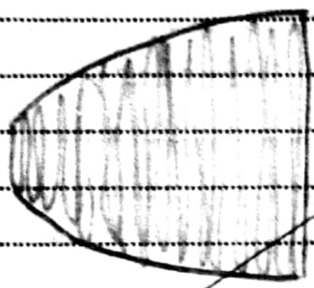

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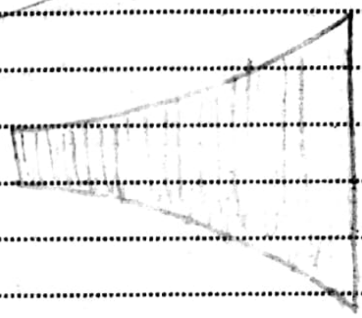


(4)

c.) Balance Modulator : $e(t) = k\, e_m(t)\, e_c(t)$

Modulating Signal : $e_m(t) = E_{m_{max}} \cos(2\pi f_m t)$

Carrier Signal : $e_c(t) = E_{c\,max} \cos(2\pi f_c t)$

The single ~~Sb~~ side band suppressed carrier can be obtain by multiplying the modulating signal and the carrier signal with each other. So, the final ~~answer~~ signal will be obtained in the form of

$e(t) = K\, e_m(t) \cos \omega_c t$

Now, the normal modulation signal is

$$e(t) = [E_{cmax} + e_m(t)] \cos \omega_c t$$

which results giving 3 frequencies
i.e. ω_c, $\omega_c + \omega_m$, $\omega_c - \omega_m$.

But by taking product carrier frequency is gone.

i.e.

$$e(t) = K\, e_m(t) \cos \omega_c t$$
$$= K\, [E_{m\,max} \cos \omega_m t] \cos \omega_c t$$

$$e(t) = \frac{K E_{m\,max}}{2} \left[\cos(\omega_m - \omega_c)t + \cos(\omega_m + \omega_c)t \right]$$

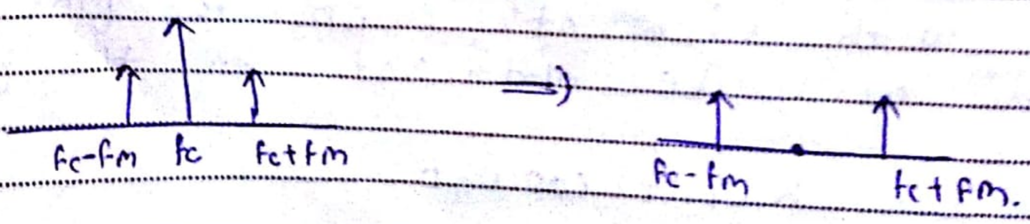
This is DSBSC.

Now, multiplying both signal i.e. input and carrier we get only one useful frequency.

$$e(t) = K\, e_m(t)\, e_c(t)$$

$$= K\, E_{m\,max} \cos \omega_m t \cdot E_{cmax} \cos \omega_c t$$

Here, carrier signal is eliminated



Now both the Upper Side Band (USB) and Lower Side Band (LSB) contains the same message signal only. So, if we use only ~~only~~ one sideband for transmission, it is called Single Side Band Suppressed Carrier (SSBSC) Transmission.

The bandwidth of SSBSC is 50% of the bandwidth of DSBSC. Also power required for transmission is less.

Now, if we transmit upper side band only then frequency of transmitted signal is $\omega c + \omega m$.

To demodulate it we have to multiply it with the carrier signal having same amplitude and frequency used at the time of transmission.

$$\therefore \quad e(t) = K\, e_m(t) \cos \omega_c t$$

$$e(t) = K E_m \cos((\omega_c + \omega_m)t) \cdot \cos(\omega_c t)$$

$$e(t) = \frac{K E_m}{2} \left[\cos \omega_m t + \cos(2\omega_c + \omega_m)t \right]$$

We can see that the first signal is what we require as it is the message signal.

The value of $2\omega c + \omega m$ is less and so that signal can be discarded using a low pass filter.

Hence, the result / signal obtained after demodulation is

$$e(t) = \frac{KE_m}{2} \cos \omega_m t$$ which is

what we require.

d.) The balanced modulator works using the square, cube etc. of each signal. B, V^2, V^3 etc.

Let V_m and V_c be amplitude of ~~car~~ modulating & carrier of signals.

$$V_m = V_{g1} + V_{g2}$$
$$V_c = V_{g1} - V_{g2}$$

$$I_1 = I + \alpha V_m + \beta V_m^2$$
$$I_2 = I + \alpha V_c + \beta V_c^2$$

$$I_1 - I_2 = \alpha (V_m - V_c) + \beta (V_m - V_c)(V_m + V_c)$$

By solving the equations we get the modulated wave along with the two side bands.

2

Ans - 2

a.) Advantages of AM & FM modulation system :-

(A)

- ~~The Bandwidth~~ There is a lot of noise reduction using FM compared to the AM.
- A large bandwidth can be obtained using FM.
- In FM many side band frequencies are obtained whereas only two side bands in AM.
- The amplitude of signal remains constant in FM which is helpful in the transmission process.

Disadvantages :-

- The bandwidth for FM transmission is very large.
- The receiver circuit of FM becomes very complicated.
- The power consumption in AM is lower than FM.

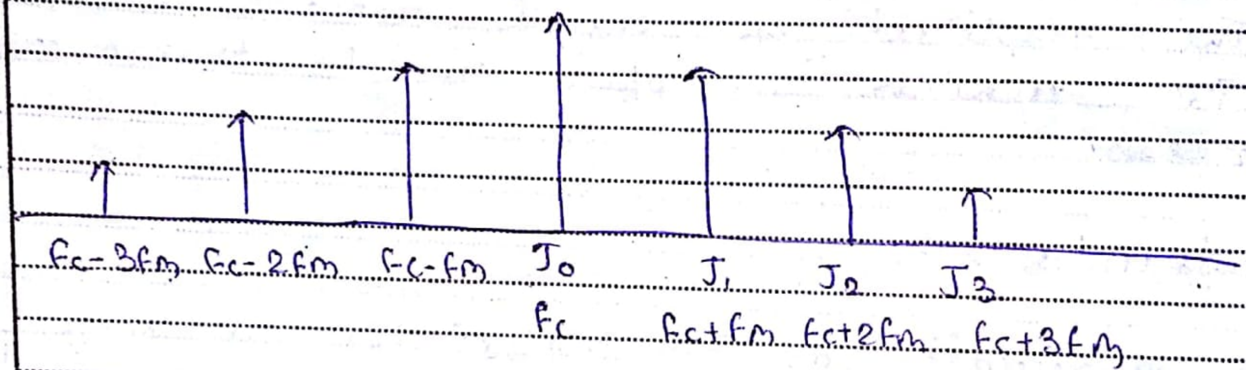
Advantages & Disadvantages of AM & FM broadcasts :-

- If FM is not modulated then in a particular area only one type of FM station can work.
- By doing DSBSC in AM the power used is only 33% of the total.
- In broadcast we have to see to it that no two signals match / have the same frequency as else the output would be distorted.

b.) If fm is the frequency of modulating signal and Δf is the deviation of ~~signal~~ frequency in carrier signal after modulation than

$$\delta = \frac{\Delta f}{f_m}$$

Now, during FM many side band frequencies are obtained like



Suppose, maximum n side bands are obtained, then the bandwidth is given by

$$\text{Bandwidth} = 2nf_m$$

n is the highest order of significant side band frequency.

The Carson's Rule states that for a high modulation index like $\beta \geq 6$, the bandwidth of the signal is twice the sum of deviation frequency and the modulating frequency.

$$\text{Bandwidth} = 2(\Delta f + f_m)$$

c.) $\Delta f = 75 KHz$

A-> $m_f = 15, 10, 7.$

For sinusoidal fm, the modulation index is the ratio of frequency deviation to that the modulating frequency

i.e $\boxed{m_f = \frac{\Delta f}{fm}}$

There are two method for calculating Bandwidth. One is the normal one. i.e.

$B_{sal} = 2nfm$

other is Carson's Rule which states

$B_{aw} = 2(\Delta f + fm)$

10) $m_f = 15$, $\Delta f = 75 KHz.$

$fm = \frac{\Delta f}{m} = \frac{75k}{15} = \underline{\underline{5 KHz}}.$ 1/2

$B_1 = 2nfm$ [n = 16 for m = 15]

$= 2 \times 16 \times 5$

$= \underline{\underline{160 KHz}}$ 1/2

$B_2 = 2(\Delta f + fm)$ 1/2

$= 2(75 + 5) = 160 KHz$

2.) $m_f = 10$, $\Delta f = 75\,kHz$

$f_m = \frac{75}{10} = 7.5\,KHz$ 1/2

$B_1 = 2 \times 14 \times 7.5$ [$n = 14$ for $m = 10$]
$= 210\,KHz$ 1/2

$B_2 = 2(75 + 7.5)$ 1/2
$= 165\,KHz$

3.) $m_f = 7$, $\Delta f = 75\,kHz$

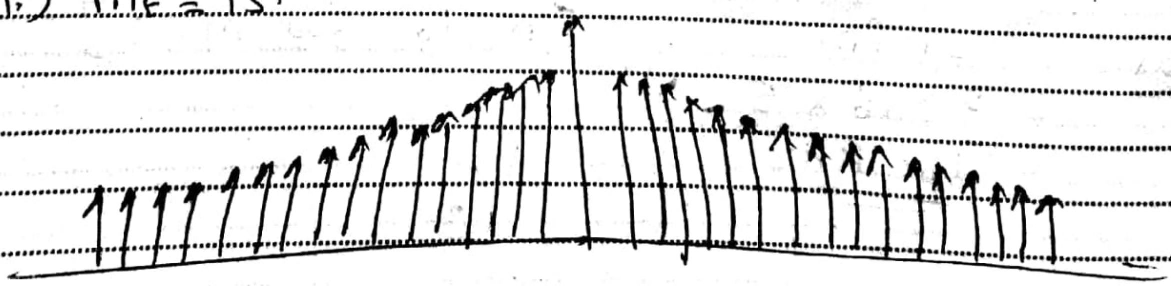
$f_m = \frac{75}{7} = 10.714\,KHz$ 1/2

$B_1 = 2 \times 10 \times 10.714$ [$n = 10$ for $m = 7$]
$= 214.28\,KHz$ 1/2

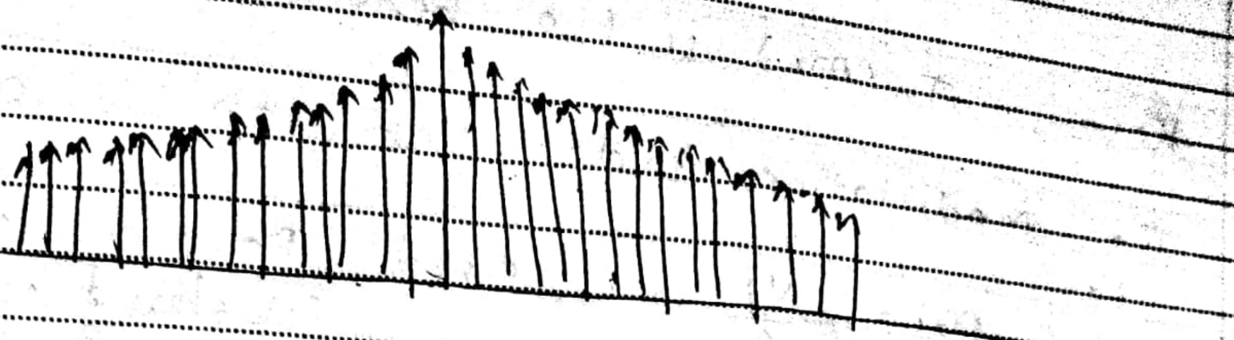
$B_2 = 2(75 + 10.714)$
$= 171\,KHz$ 1/2

Figures :-

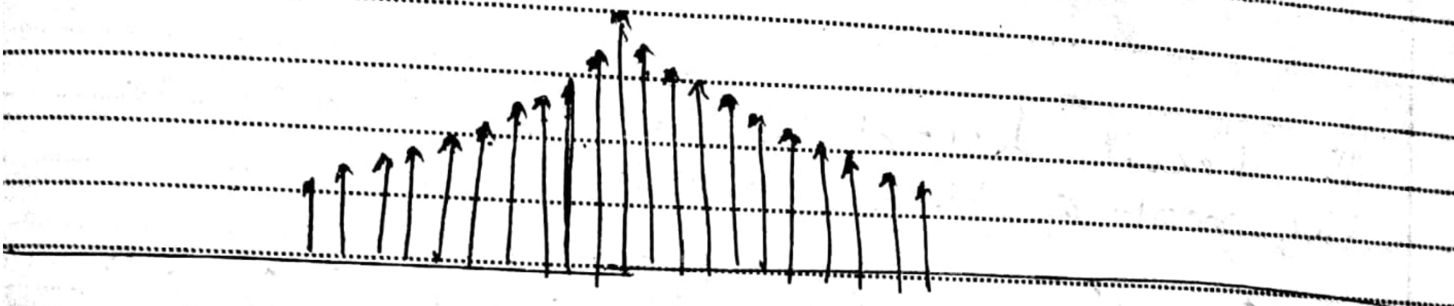
1.) $m_f = 15$.



$m = 10$



$m = 7$



We can say that with decreasing value of m, the bandwidth also decreases.

do) $e_c(t) = A \sin(\omega_c t + \phi_c)$

$e_m(t) = V_m \sin(\omega_m t + \phi_m)$

Here it input of FM is

$e_m(t) = V_m \sin \omega_1 t + V_m \sin \omega_2 t + \ldots$

$$e(t) = A \Big[J_0(m_f) \sin \omega_c t + J_1(m_f) \left[\sin(\omega_c + \omega_m)t - \sin(\omega_c - \omega_m)t\right] + J_2(m_f)\left[\sin(\omega_c + 2\omega_m)t - \sin(\omega_c - 2\omega_m)t\right] + \ldots \Big]$$

Here, $J_n(m_f)$ is the bessel function.

The modulation index for ith signal is

$m_i = \frac{V_i}{A_c}$ and Power of side band is $P_s = \frac{m_i^2 P_c}{4}$

The bessel function can be defined as the root of the equation

$$(m_f^2) \frac{d^2y}{dm_f^2} + m_f \frac{dy}{dm_f} + (m^2 - n^2) y = 0,$$

$$J_n(m_f) = \left(\frac{m_f}{2}\right)^n \left[\frac{1}{n!} - \frac{(m_f/2)^2}{1!(n-1)!} + \frac{(m_f/2)^4}{2!(n-2)!} - \frac{(m_f/2)^6}{3!(n-3)!} + \dots \right]$$

So, ~~Bef~~ The value of n depends on the modulation Index m.
As the m increases, the no. of side frequencies also increases.

By using Besseℓ function, easily output signal can be calculated.

Ans. - 3

a)

$x_c(t) = A_c \cos[2\pi f_c t + \phi(t)]$

The instantaneous phase for PM is

$\phi(t) = \phi_\Delta x(t)$

$\therefore \quad x_c(t) = A \cos[2\pi f_c t + \phi_\Delta x(t)]$

Now, $\theta \triangleq \omega_c t + \phi_\Delta x(t)$

When the differentiation of θ gives the frequency for PM.

$$\dot{\theta} = \frac{d}{dt}[\omega_c t + \phi_\Delta x(t)]$$

$$= \omega_c + \phi_\Delta \dot{x}(t)$$

$$2\pi f = 2\pi f_c + \phi_\Delta \dot{x}(t)$$

$$f = f_c + \frac{1}{2\pi}\phi_\Delta \dot{x}(t)$$

This gives instantaneous frequency for PM.

Now, for FM.

$x_c(t) = A_c \cancel{B} \cos 2\pi f(t)$

$f(t) = f_c + f_\Delta x(t)$

The instantaneous frequency of FM is

$$f_c + f_\Delta\, x(t).$$

Now, integrating it provides us with θ as the phase

$$\theta = \int_{t_0}^{t} f_c + f_\Delta\, x(t)\; dt + \phi(t_0)$$

$$\theta = f_c t + f_\Delta \int^{t} x(\lambda).d\lambda$$

Here $\phi(t_0)$ is the phase cond can also be zero. So, it is eliminated.

$$\therefore\ \theta = f_c t + f_\Delta \int^{t} x(\lambda).d\lambda.$$

Above equation gives the instantaneous phase of FM.

So, the FM signal in terms of integration is

$$e(t) = A_c \cos\left[\omega_c t + 2\pi f_\Delta \int^{t} x(\lambda).d\lambda\right]$$

Course

Date : ....

Number of Supplementaries : ....

Name : Hillari Shah

Student Identity Number : ...

Programme : ....

Supervisor's Signature : ....

Student's Signature: ....

Start here

d.) The FM - AM conversion is done on a time derivative input. So, the input signal has to be a differential equation.

$$x(t) = A \cos(\omega_c t + \phi)$$

$$\dot{\theta} \triangleq f_c + \phi_\Delta \dot{x}(t)$$

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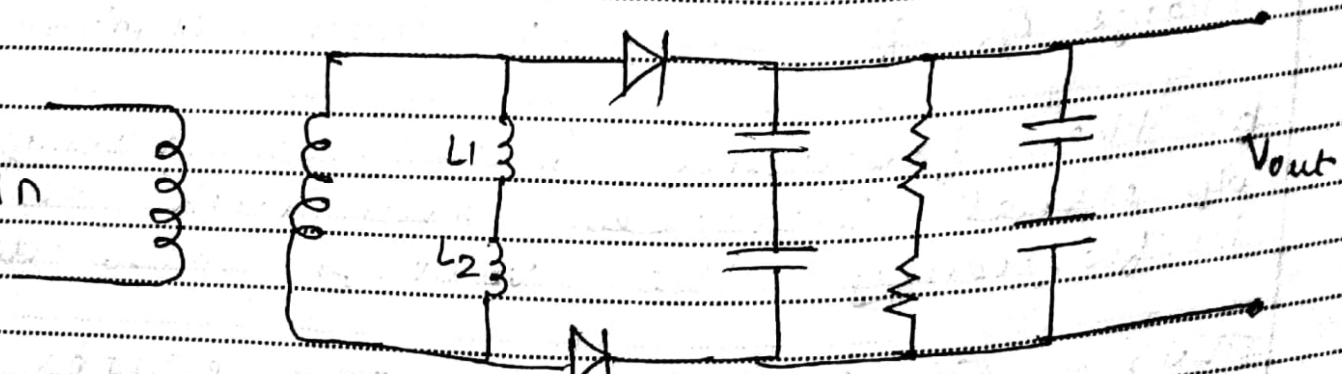
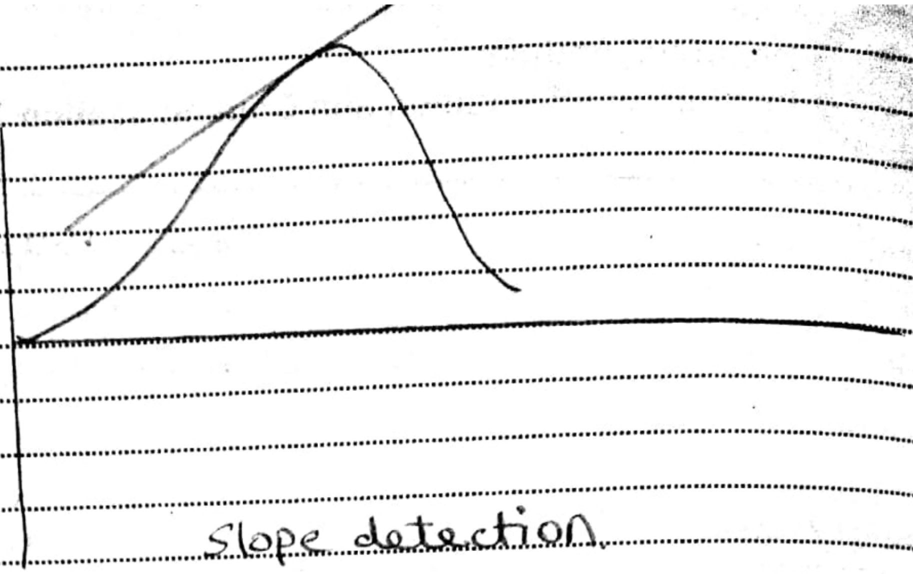
$$\dot{x}(t) = A(f_c(t) + \phi_\Delta x(t)) \sin(\omega_c t + \phi)$$

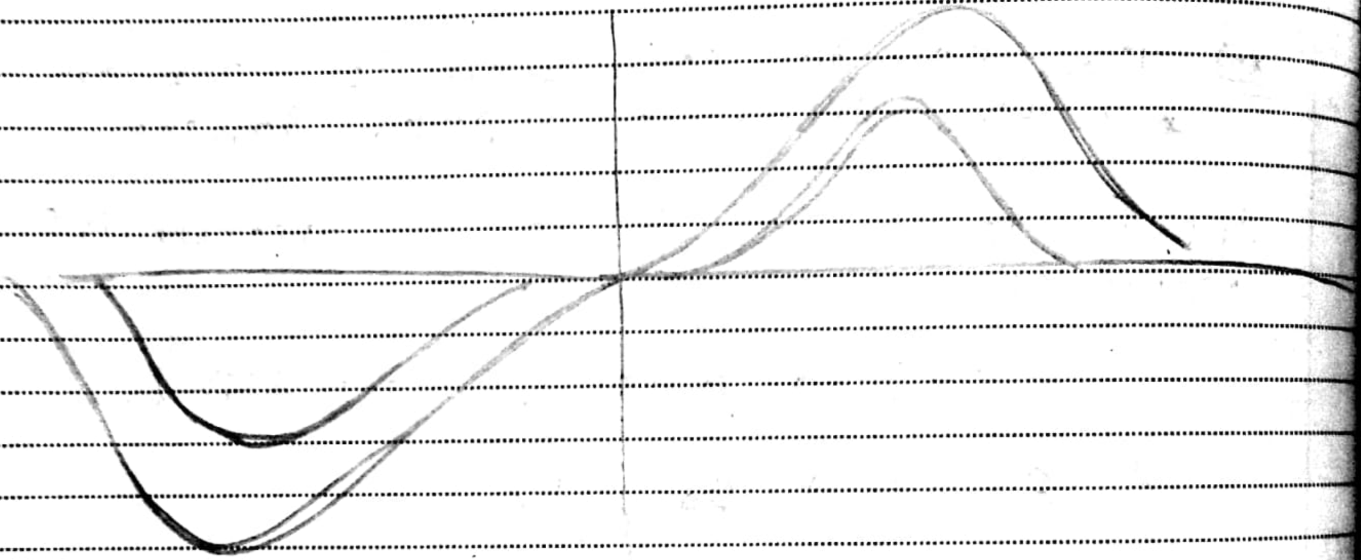
Block Diagram



Circuit of FM-AM conversion.



Slope detection.



~~In the circuit the place where frequency of input~~

The circuit works according to the change of frequency of input signal.

As the frequency increases, voltage of o/p signal increases and with decrease in frequency the voltage also decreases

Thus, FM to AM convertor works on the principle. It is also known as discrimin