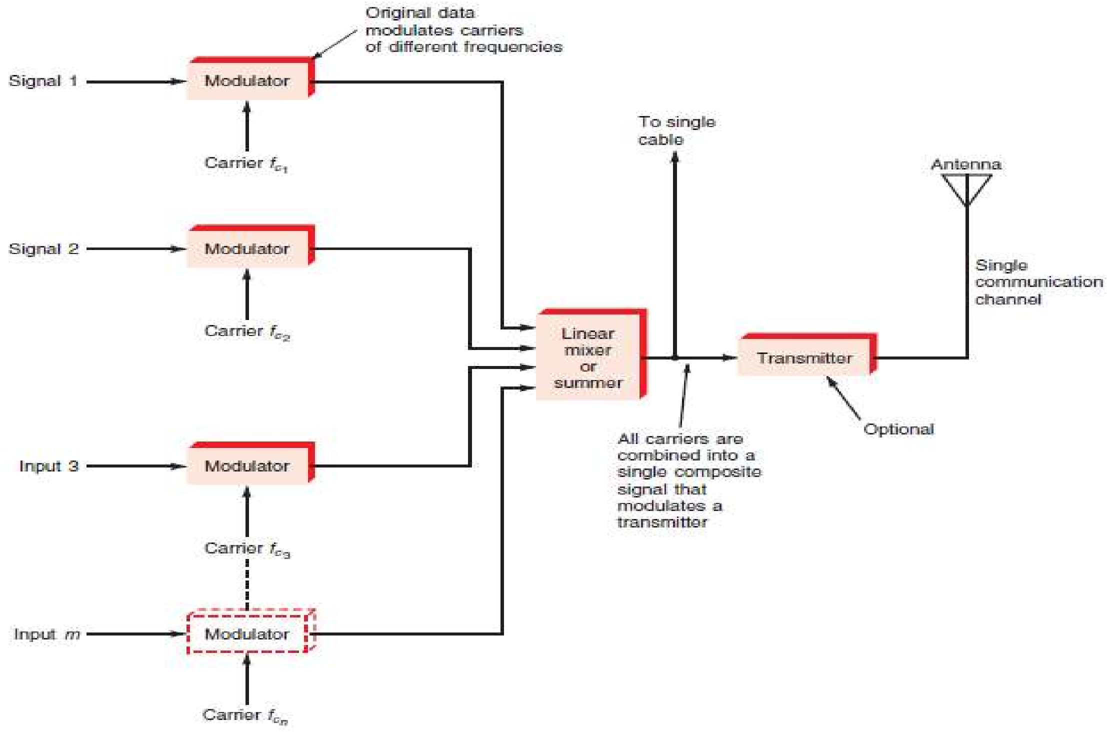
CMR
INSTITUTE OF
TECHNOLOGY

IAT-1
4^{th} Semester ECE
Scheme and Solution

Sub:	Principles of communication systems	Code:BEC402	
			Marks
1a.	With a neat block diagram , explain the working of a FDM transmitter and receiver		7



- Each signal to be transmitted feeds a modulator circuit.
- The carrier for each modulator (*fc*) is on a different frequency.
- The carrier frequencies are usually equally spaced from one another over a specific frequency range.
- These carriers are referred to as *subcarriers*.
- Each input signal is given a portion of the bandwidth.
- Any of the standard kinds of modulation can be used, including AM, SSB, FM, PM, or any of the various digital modulation methods.
- The FDM process divides up the bandwidth of the single channel into smaller, equally spaced channels, each capable of carrying information in sidebands.

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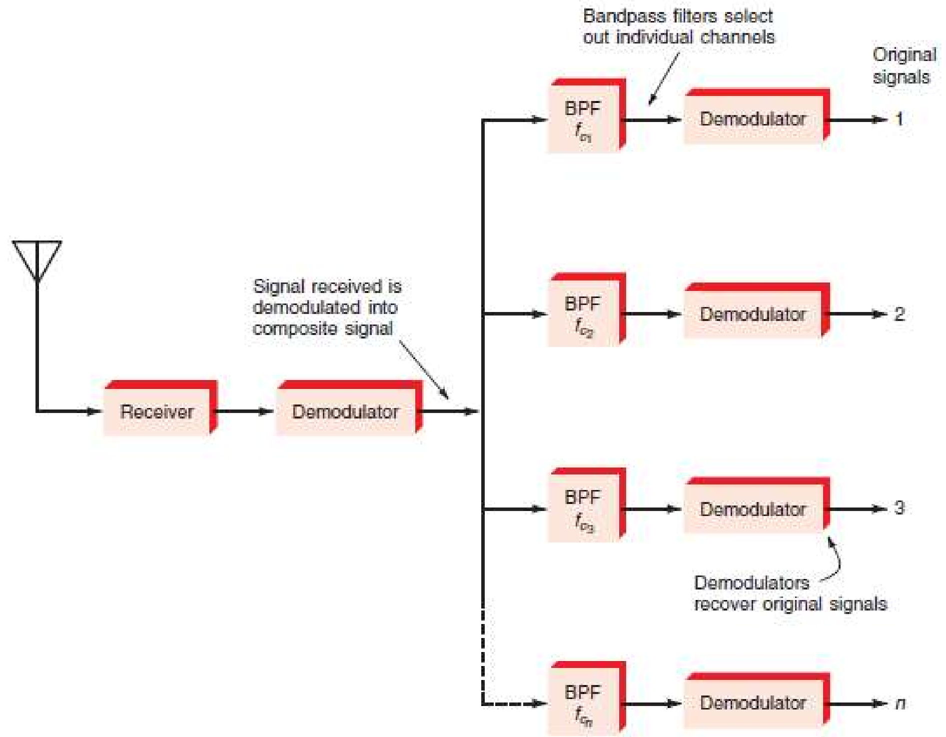
Figure The receiving end of an FDM system.



Block diagram :2*2=4M
Explanation:3 M

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<tr><td>1b.</td><td>

The input to an FM receiver has an S/N of 2.8. The modulating frequency is 1.5 kHz. The maximum permitted deviation is 4 kHz. What are (a) the frequency deviation caused by the noise and (b) the improved output S/N?

a. $\phi = \sin^{-1}\frac{N}{S} = \sin^{-1}\frac{1}{2.8} = \sin^{-1}0.3571 = 20.92^\circ \quad \text{or} \quad 0.3652 \text{ rad}$

$\delta = \phi(f_m) = (0.3652)(1.5 \text{ kHz}) = 547.8 \text{ Hz}$

b. $\frac{N}{S} = \frac{\text{frequency deviation produced by noise}}{\text{maximum allowed deviation}} = \frac{547.8}{4000}$

$\frac{N}{S} = 0.13695$

$\frac{S}{N} = \frac{1}{N/S} = 7.3$

1.5*2=3M

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<tr><td>2a</td><td>

Explain standard form of amplitude modulation along with its equation and explain each term. Derive the Spectral equation of AM wave and hence draw and explain the AM spectrum.

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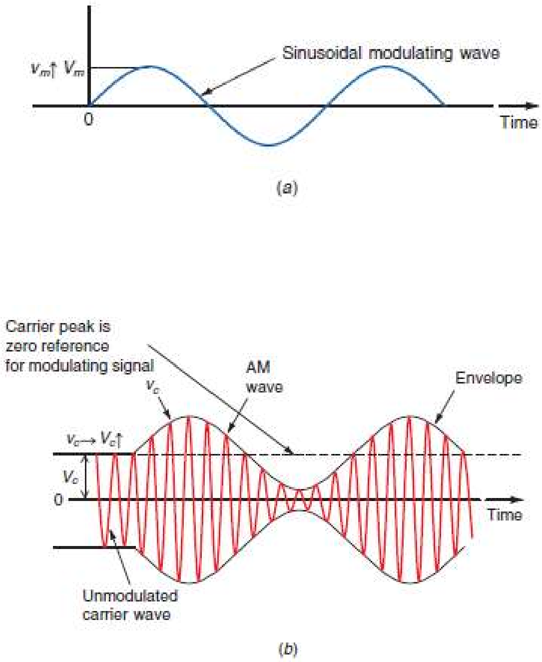
- Carrier wave is given as

$$v_c = V_c \sin 2\pi f_c t$$

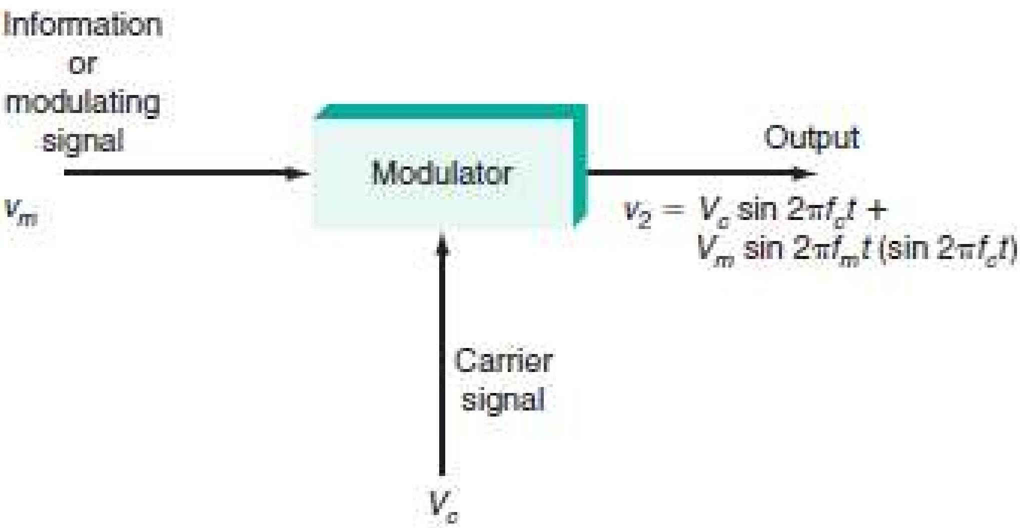
- A sine wave modulating signal can be expressed

$$v_m = V_m \sin 2\pi f_m t$$

- fm- frequency of message signal
- fc- frequency of carrier signal
- fm<<fc
- In amplitude modulation, it is particularly
- important that the peak value of the modulating signal be less than the peak value of the carrier



Amplitude modulator showing input and output signals.



$$v_2 = (V_c + V_m \sin 2\pi f_m t) \sin 2\pi f_c t = V_c \sin 2\pi f_c t + (V_m \sin 2\pi f_m t)(\sin 2\pi f_c t)$$

- $Vc \sin 2\pi fc\ t$ is the carrier waveform, and $(Vm \sin 2\pi fmt)$ $(\sin 2\pi fc\ t)$ is the carrier waveform multiplied by the modulating signal waveform.
- It is the second part of the expression that is characteristic of AM.
- A circuit must be able to produce mathematical multiplication of the carrier and modulating signals in order for AM to occur. The AM wave is the product of the carrier and modulating signals.
- The circuit used for producing AM is called a *modulator*

Waveforms and block diagram: 3M
Equations : 3M
Explanation :4 M

3a A standard AM broadcast station is allowed to transmit modulating frequencies upto 5 KHz. If the AM station is transmitting on a frequency of 980 KHz, compute the maximum and minimum frequencies in the upper and lower sidebands and the total bandwidth occupied by the AM station. **4**

$f_m = 5\ KHz$
$f_c = 980\ KHz$ —— 1M

$f_{USB} = f_c + f_m = 985\ KHz.$

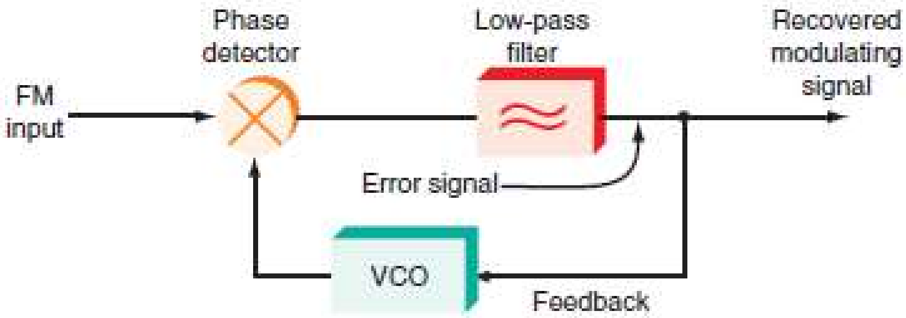
$f_{LSB} = f_c - f_m = 975\ KHz$ —— 1M

Total bandwidth $= 2f_m$
$= 10\ KHz$ } —— 2M

3b Explain the basic block diagram of PLL. **6**

- A *phase-locked loop* (PLL) is a frequency- or phase-sensitive feedback control circuit used in frequency demodulation, frequency synthesizers, and various filtering and signal detection applications.
- All phase-locked loops have the three basic elements:

1. A **phase detector** is used to compare the FM input, sometimes referred to as the *reference signal,* to the output of a VCO.
2. The **VCO** frequency is varied by the dc output voltage from a low-pass filter.
3. The **low-pass filter** smoothens the output of the phase detector into a control voltage that varies the frequency of the VCO.

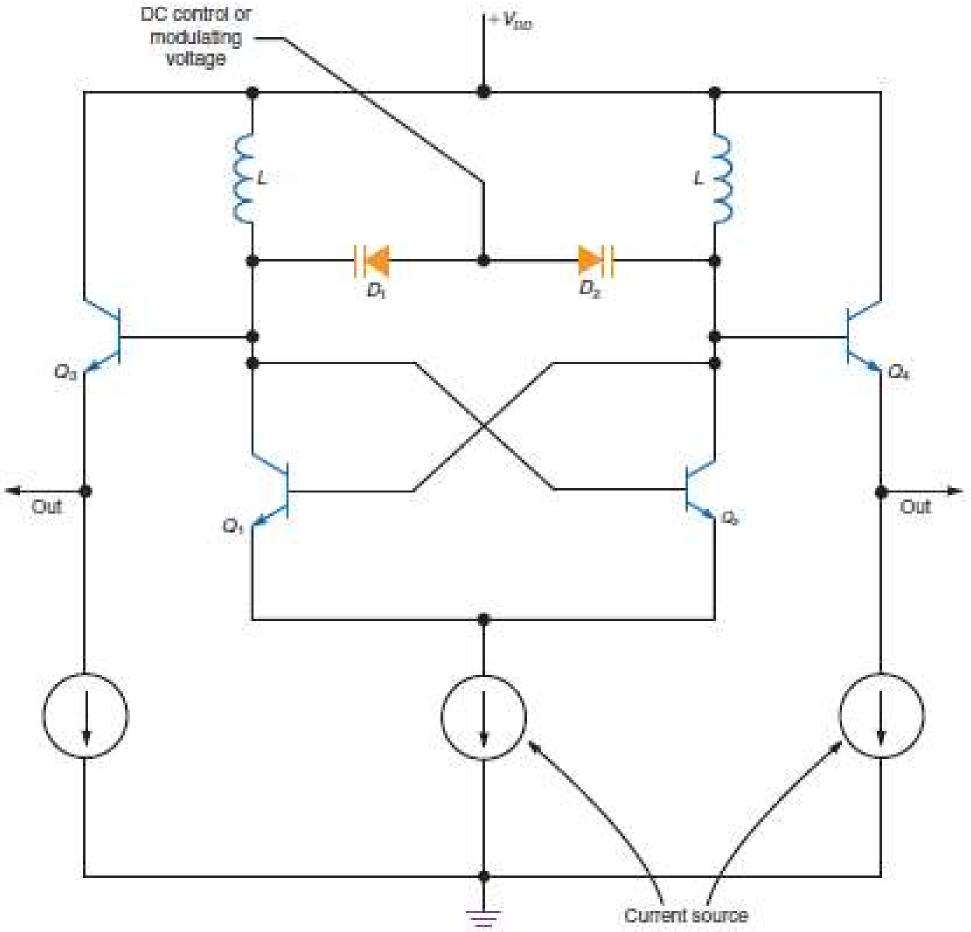


Block diagram:3M

Explanation:3M

4a Explore with a neat diagram the concept of frequency modulation with a VCO. **6**

- Oscillators whose frequencies are controlled by an external input voltage are generally referred to as *voltage-controlled oscillators (VCOs)*.
- This circuit uses silicon-germanium (SiGe) bipolar transistor to achieve an operating frequency centered near 10 GHz.
- The oscillator uses cross - coupled transistors $Q1$ and $Q2$ in a multivibrator or flip-flop type of design.
- The signal is a sine wave whose frequency is set by the collector inductances and varactor capacitances.
- The modulating voltage, usually a binary signal to produce FSK, is applied to the junction of $D1$ and $D2$.



Students can use any VCO based circuit (even IC VCO)
Circuit diagram:3M
Explanation:3M

4b A 400W carrier is modulated on a depth of 75%, calculate the total power in the modulated wave for the following forms of AM:i) Double Side Band with Full Carrier (DSBFC) **4**
ii) Double Side Band with Suppressed Carrier (DSBSC)
iii) Single Side Band Suppressed Carrier (SSB).

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

Given: $P_c = 400\,W$

$m = 0.75$

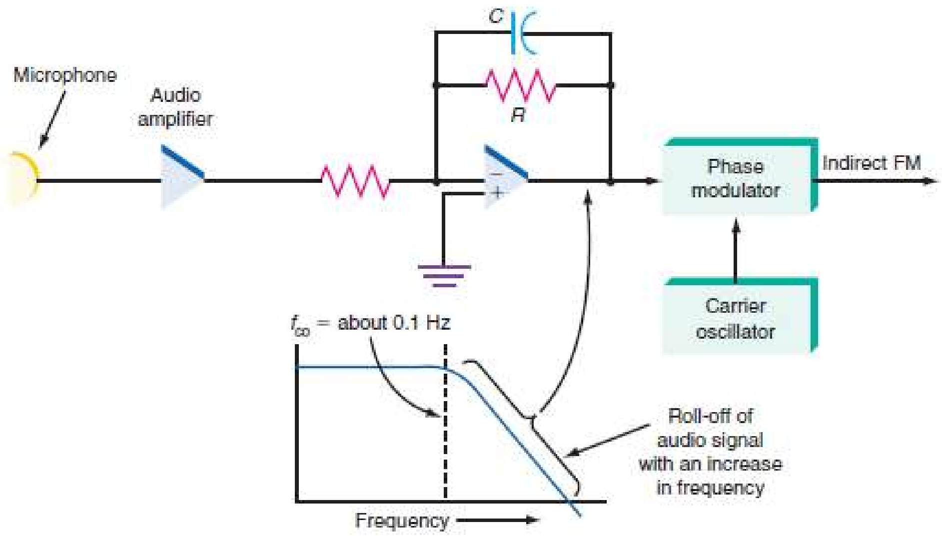
i) DSBFC $\quad P_t = 400\left(1+\frac{0.75^2}{2}\right)$

$= 512.5\,W$ —— 1M

2

	ii) DSB $P_t = P_c \cdot \frac{m}{2} = 112.5\,W$ —— 1M iii) SSB $= \frac{P_t'}{2} = 56.25\,W$ —— 1M	
5a.	Identify a method used to convert a phase-modulated (PM) signal into a frequency-modulated (FM) signal.	6

Using a low-pass filter to roll off the audio modulating signal amplitude with frequency.



- To make PM compatible with FM, the deviation produced by frequency variations in the modulating signal must be compensated for.
- This can be done by passing the intelligence signal through a low-pass *RC* network.
- This low-pass filter, called a *frequency-correcting network, predistorter,* or *1/f filter,* causes the higher modulating frequencies to be attenuated.
- Although the higher modulating frequencies produce a greater rate of change and thus a greater frequency deviation, this is offset by the lower amplitude of the modulating signal, which produces less phase shift and thus less frequency deviation.
- The predistorter compensates for the excess frequency deviation caused by higher modulating frequencies.
- The result is an output that is the same as an FM signal.
- The FM produced by a phase modulator is called *indirect FM.*

Block diagram:3M
Explanation:3M

5b.	Compare Single Sideband Modulation (SSB) with Double Sideband Suppressed Carrier (DSB-SC) and Conventional AM.	4

Feature	**DSB (Double Sideband)**	**SSB (Single Sideband)**
Bandwidth	**2 × message bandwidth (2B)**	**1 × message bandwidth (B)**
Power Efficiency	Low (Carrier consumes power)	High (No carrier, only one sideband)
Complexity	Simple (Easy to generate/detect)	Complex (Requires special filters)
Signal Quality	Good, but redundant sideband	Can distort if not properly demodulated
Applications	AM radio, TV broadcasting	Military, HF radio, Voice communication

1*4=4M

6a. A single tone FM signal is given by s(t)=5sin(8π×10^6 t+10sin2π×10^3 t) volts. Determine i) Modulation index , ii) Modulation frequency iii) Frequency deviation iv) Carrier frequency — **4**

Given: $A_c = 5$

Standard Equation

$$s(t) = A_c \sin(2\pi f_c t + m_f \sin 2\pi f_m t) \quad \text{— 1M}$$

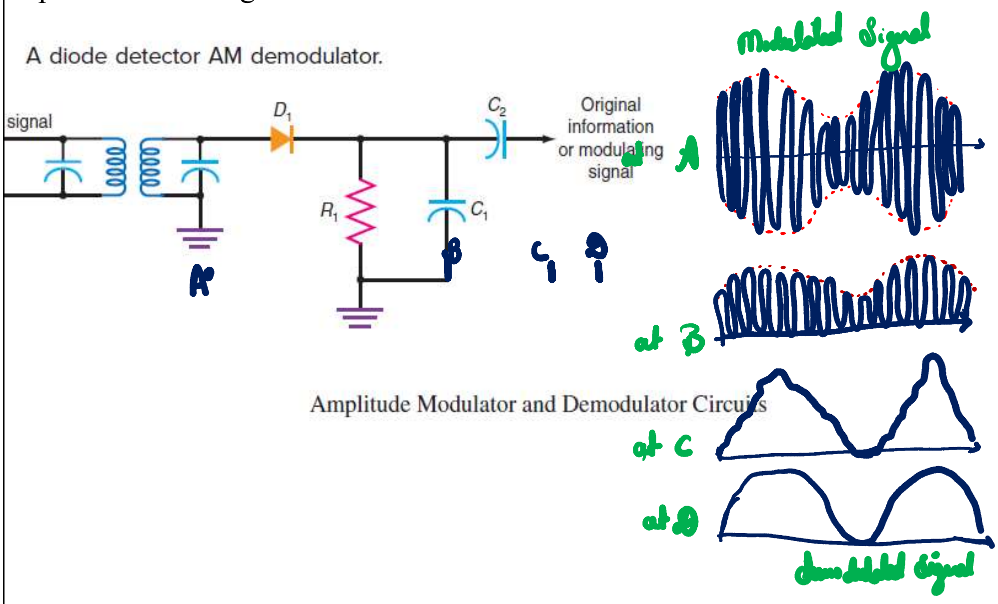
$f_c = 4\times10^6\ Hz$ — 1M

$m_f = 10$

$f_m = 1\ kHz$ — 1M

$m_f = \frac{f_d}{f_m} \Rightarrow f_d = 10\ kHz$ — 1M

6b. Explain the working of a diode detector circuit for AM demodulation. — **6**



- The AM signal is usually transformer-coupled and applied to a basic half wave rectifier circuit consisting of *D*1 and *R*1.
- The diode conducts when the positive half-cycles of the AM signals occur.
- During the negative half-cycles, the diode is reverse-biased and no current flows through it.
- As a result, the voltage across *R*1 is a series of positive pulses whose amplitude varies with the modulating signal.
- A capacitor *C*1 is connected across resistor *R*1, effectively filtering out the carrier and thus recovering the original modulating signal.
- On each positive alternation of the AM signal, the capacitor charges quickly to the peak value of the pulses passed by the diode.
- When the pulse voltage drops to zero, the capacitor discharges into resistor *R*1.
- The time constant of *C*1 and *R*1 is chosen to be long compared to the period of the carrier.

Block diagram:2M

Waveform:2M

Explanation:2M

7a.	A radio station transmits an AM wave with a total power of 1000W at a modulation index of 0.5. Calculate the carrier power and sideband power.	4

Given :- $P_t = 1000\ W$ $m = 0.5$

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

$P_c = 888.88\ W$ — 1M

Sideband power = $P_{SSB} = \frac{P_t - P_c}{2}$ — 1M

$P_{SSB} = 55.55\ W$ — 1 M

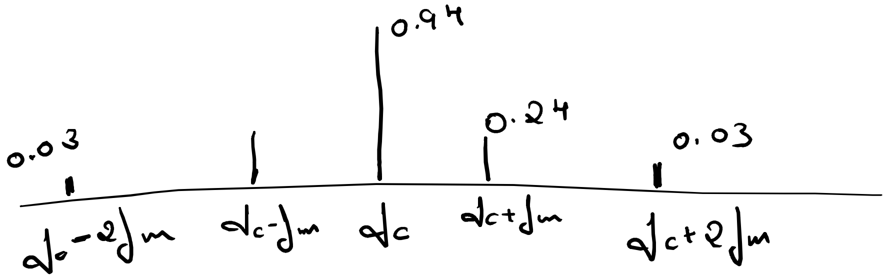
7b.	Draw the frequency spectrums and calculate bandwidth when fm=50 Hz for each case. i)modulation index 0.5 ii)modulation index 3	6

Table given below shows carrier and sideband amplitudes for different modulation indices of FM signals based on the Bessel functions.

Modulation Index	Carrier	Sidebands (Pairs)															
		1st	2d	3d	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th
0.00	1.00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
0.25	0.98	0.12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
0.5	0.94	0.24	0.03	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1.0	0.77	0.44	0.11	0.02	—	—	—	—	—	—	—	—	—	—	—	—	—
1.5	0.51	0.56	0.23	0.06	0.01	—	—	—	—	—	—	—	—	—	—	—	—
2.0	0.22	0.58	0.35	0.13	0.03	—	—	—	—	—	—	—	—	—	—	—	—
2.5	−0.05	0.50	0.45	0.22	0.07	0.02	—	—	—	—	—	—	—	—	—	—	—
3.0	−0.26	0.34	0.49	0.31	0.13	0.04	0.01	—	—	—	—	—	—	—	—	—	—
4.0	−0.40	−0.07	0.36	0.43	0.28	0.13	0.05	0.02	—	—	—	—	—	—	—	—	—
5.0	−0.18	−0.33	0.05	0.36	0.39	0.26	0.13	0.05	0.02	—	—	—	—	—	—	—	—

1) modulation index 0.5

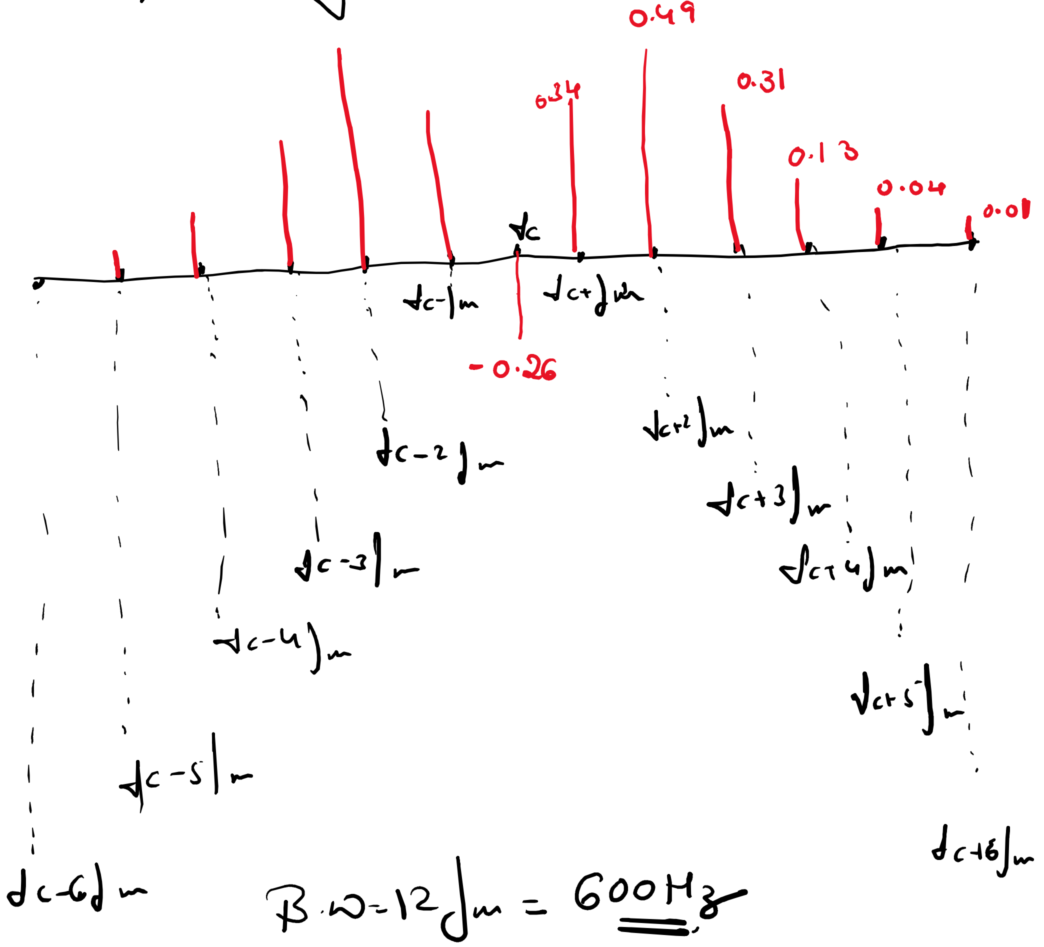
2 pairs of sidebands



Bandwidth = $4 f_m = 4 \times 50 = 200\ Hz$.

ii) modulation index of 3.

6 pairs of sidebands.



$B.W = 12 f_m = 600 Hz$

Each spectrum 2M $\Rightarrow$ $2 \times 2 = 4$ M

Bandwidth 1M $\Rightarrow$ $1 \times 2 = 2$M