4. Select the Foster Seeley or ratio detector switch in position.
5. Connect the input of Low pass filter /amplifier block with the output from the Foster Seeley/ratio detector block.
6. Measure the amplitude and frequency of audio signal (demodulated signal).
7. Adjust the audio oscillator block's amplitude and frequency pots and compare the original audio signal with the final demodulated signal.

3.6 Observation – Hardware

Signal Name	Amplitude	Frequency		Time period	
Modulating signal (input signal)	1.72V	1.7kHz		0.58ms	
Carrier signal	4.12V	410kHz		2.47μs	
Modulated signal (output signal)	584mV	F1	F2	T1	T2
		14.28kHz	25kHz	70μs	40μs
Demodulated Signal (Foster Seeley)	3.56V	1.7kHz		0.58ms	

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

3.6.1 Model Graph

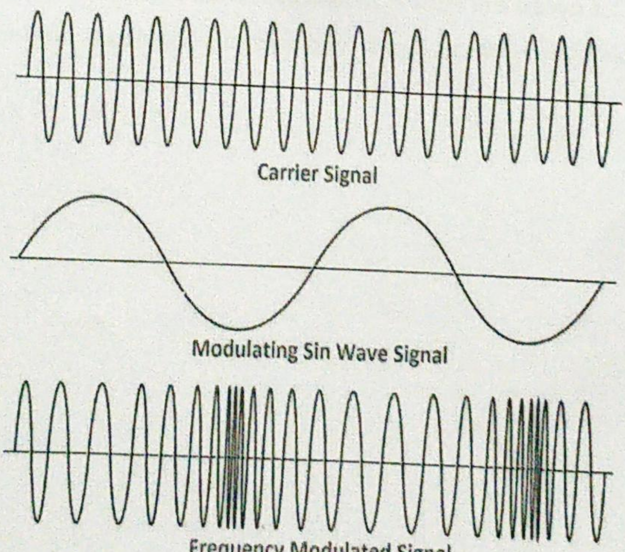

Fig 3.3 Frequency modulated waveforms

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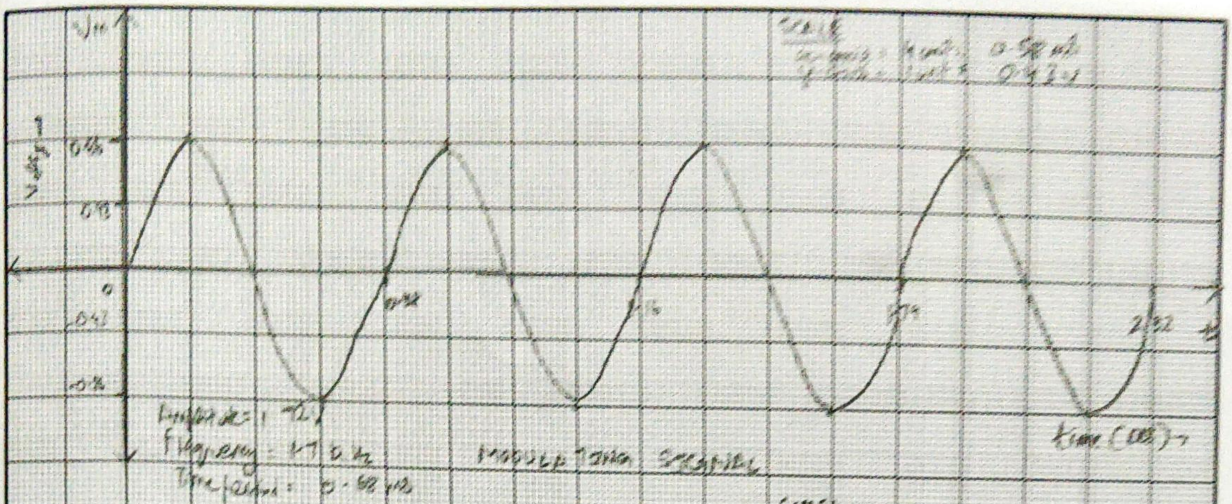
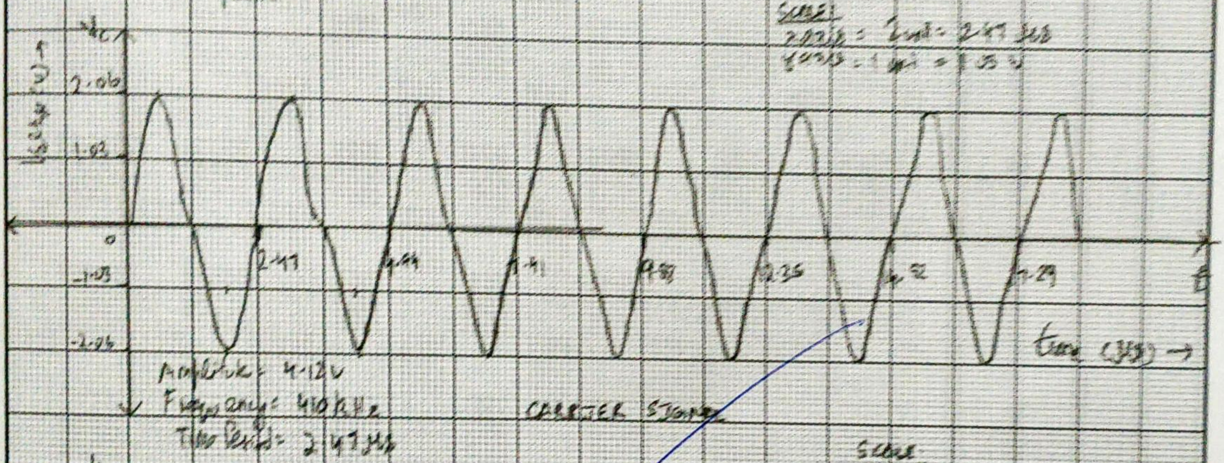
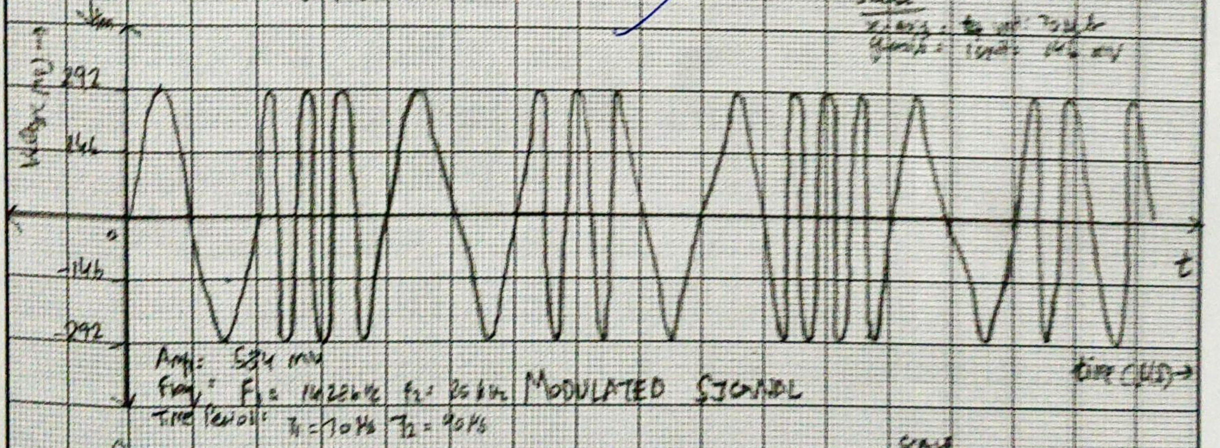
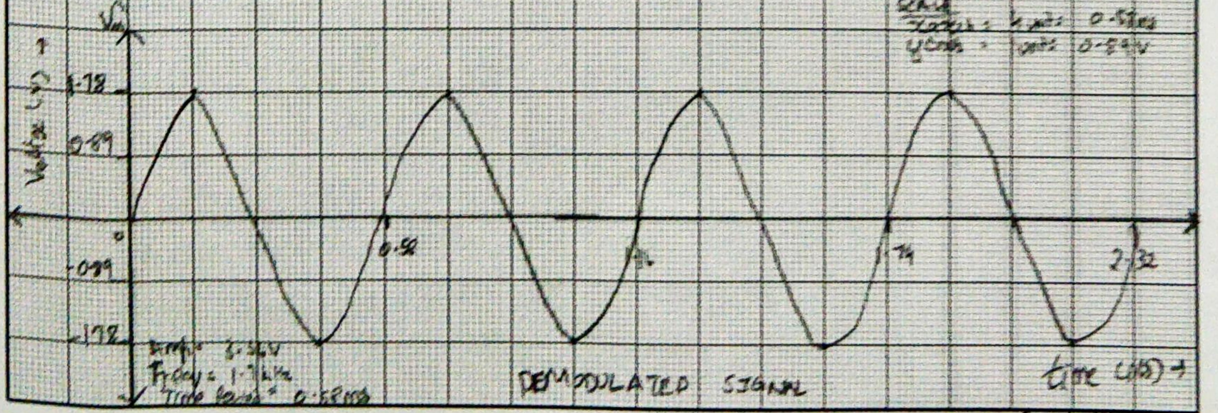
Frequency Modulation









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Analog and Digital Communication Lab

Experiment 3: Frequency Modulation and Demodulation

I. Pre-Lab Questions:

1. The carrier frequency in an FM modulator is 1000 kHz. If the modulating frequency is 15 kHz, what are the first three upper sideband and lower side band frequencies?

Soln. Carrier freq = 1000 kHz

Modulating frequency = 15 kHz

Upper side band frequencies

- First sideband freq. $f_c + f_1$ = 1000k + 15k = 1015 kHz
- Second sideband freq = $f_c + 2f_1$ = 1000k + 30k = 1030 kHz
- Third sideband freq = $f_c + 3f_1$ = 1000k + 45k = 1045 kHz

Lower sideband freq.

- First sideband freq : $f_c - f_1$ = 985 kHz
- Second sideband freq = $f_c - 2f_1$ = 970 kHz
- Third sideband freq = $f_c - 3f_1$ = 955 kHz

2. A frequency modulated wave is given as $S(t) = 10\sin(2\pi 10^8 t + 5\sin 400\pi t)$, identify carrier frequency and maximum frequency deviation of the signal.

Soln. Standard equation of FM wave

$$s(t) = A_c \cos(2\pi f_c t + B\sin(2\pi f_m t))$$

$A_c = 10V$ $f_c = 10^8$ Hz $B = m_a = 5$ $f_M = 200$ Hz

$$m_a = \frac{\Delta f}{f_m} \Rightarrow \Delta f = m_a f_M$$

$$= 5 \times 200$$

Frequency deviation = 1k Hz

3. Give Carson's rule to calculate the bandwidth of the system.

Soln. The Carson bandwidth rule is expressed as $CBR = 2(\Delta f + f_m)$ where CBR is the Carsons Bandwidth Requirement. Δf - max freq. deviation f_m - message signal freq.

4. A 25 MHz carrier is modulated by a 400 Hz audio sine wave. If the carrier voltage is 4V and the maximum frequency deviation is 10 kHz, write down the voltage equation of the FM wave.

Soln. Voltage eqn of FM wave is

$$e = E_c \cos(\omega_c t + m_a \sin \omega_s t).$$

$$\omega_c = 2\pi f_c = 2\pi \times 25 \times 10^6 = 1.57 \times 10^8 \text{ rad/s.}$$

$$\omega_s = 2\pi f_s = 2\pi \times 400 = 2513 \text{ rad/s.}$$

$$m_a = \frac{\Delta f}{f_s} = \frac{10 kHz}{400 Hz} = 25.$$

$$\therefore e = 4 \cos(1.57 \times 10^8 t + 25 \sin 2513 t).$$

5. When a singe tone modulating signal $\cos(15\pi 10^3 t)$ frequency modulates a carrier of 10 MHz and produces a frequency deviation of 75 kHz. Calculate the modulation index of FM?

Soln.

$$f_m = \frac{15\pi \times 10^3}{2\pi} = 7.5 kHz$$

$$\Delta f = 75 kHz$$

$$m_a = \frac{\Delta f}{f_m} = \frac{75 kHz}{7.5 kHz}$$

$\therefore$ Modulation index of FM (m_a) = 10.