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| **Course Name:** | **Analogue Digital Systems** | **Semester:** | **IV** |
| **Date of Performance:** | **23 / 01 / 2024** | **Batch no.:** | **A - 2** |
| **Faculty Name:** | **Prof. Amrita Naiksatam** | **Roll no.:** | **16014022050** |
| **Faculty Sign & Date:** |  | **Grade / Marks:** | **\_\_\_ / 25** |

**Experiment no.: 2**

**Title: To generate and analyse Frequency Modulated Waveform using MATLAB**

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| **Aim and Objective of the Experiment:** |
| * To generate and analyze FM signal. |

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| **COs to be achieved:** |
| CO1: Analyze and compare analog modulation schemes. |

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| **Theory:** |
| Frequency modulation consists in varying the frequency of the carrier voltage in accordance with the instantaneous value of the modulating voltage. Thus the amplitude of the carrier does not change due to frequency modulation.  Let the modulating voltage be given by expression,  **Vm = Vm ∙ cosωmt**  Where, ωm is angular frequency of the signal & Vm is the amplitude.  Let the carrier voltage be given by expression,  **Vc = Vc ∙ sin(ωct + θ)**  On frequency modulation, the instantaneous value of modulated carrier voltage is given by,    Hence the frequency modulated carrier voltage is given by,  **V = Vc ∙ sin(wct + Kf ∙ Vm / ω ∙ sinωmt)**  The modulation index is defined as the ratio of frequency deviation to frequency of modulating signal, given by,  **mf = d / fm where deviation d = (fmax - fmin) / 2** |

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| **MATLAB code for FM:** |
| % Set the sampling frequency to 1kHz and carrier frequency to 200 Hz.  fs = 1000;  fc = 200;  t = (0:1/fs:0.2)';  % Create two-tone sinusoidal signal with frequencies 30 and 60 Hz.  x = sin(2\*pi\*30\*t) + 2\*sin(2\*pi\*60\*t);  % Set the frequency deviation to 50 Hz.  fDev = 50;  % Frequency modulate x.  y = fmmod(x, fc, fs, fDev);  % Create a figure  figure;  % Plot the graphs to show the original signal and modulated signal  subplot(2, 1, 1)  plot(t, x)  xlabel('Time (s)')  ylabel('Amplitude')  legend('Original Signal')  grid on;  title('Original Signal')  subplot(2, 1, 2)  plot(t, y)  xlabel('Time (s)')  ylabel('Amplitude')  legend('Modulated Signal')  grid on;  title('Frequency Modulated Signal')  sgtitle('ADC Experiment 3: Graphs of Original & Frequency Modulated Signals | 16014022050') |

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| **Observation Table / Screen Shots:** |
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| **Post Lab Subjective / Objective type Questions:** |
| 1. **What is the effect of modulating signal frequency variation on the FM signal?**   When the frequency of the modulating signal in frequency modulation (FM) varies, it directly affects the characteristics of the resulting FM signal. Specifically:   * Frequency Deviation: The amplitude of the modulating signal determines the frequency deviation of the FM signal. As the frequency of the modulating signal varies, the frequency deviation also changes. A higher frequency modulating signal results in a larger frequency deviation in the FM signal. * Spectral Broadening: Increasing the frequency of the modulating signal can lead to spectral broadening in the FM signal. This means that more frequency components are present in the frequency spectrum of the FM signal. * Bandwidth: The bandwidth of the FM signal is directly influenced by the frequency of the modulating signal. A higher frequency modulating signal results in a wider bandwidth for the FM signal. * Perceived Pitch: In the context of audio signals, varying the frequency of the modulating signal can affect the perceived pitch of the FM-modulated sound.  1. **State the advantages of angle modulation over amplitude modulation.**   Angle modulation, which includes both frequency modulation (FM) and phase modulation (PM), offers several advantages over amplitude modulation (AM):   * Improved Signal-to-Noise Ratio (SNR): Angle modulation techniques are less susceptible to noise and amplitude variations compared to AM. This leads to better SNR and improved signal quality. * Reduced Interference: FM and PM signals are less prone to interference from other signals or noise, resulting in clearer reception and improved communication quality. * Constant Amplitude: In AM, changes in amplitude can be affected by various factors, including atmospheric conditions and transmission path variations. Angle-modulated signals, on the other hand, maintain a constant amplitude, simplifying the demodulation process. * Capture Effect: In FM, when two signals with different frequencies are received, the receiver tends to "capture" the stronger signal and reject the weaker tone. This property enhances the selectivity of FM receivers. * Wide Frequency Range: FM signals can accommodate a wide frequency range without distortion, making them suitable for high-fidelity audio broadcasting and other applications where fidelity is crucial. * No Overmodulation Distortion: Unlike AM, FM signals do not suffer from overmodulation distortion, where excessive modulation can cause distortion and loss of information.  1. **Virtual Lab:** <https://kcgcollege.ac.in/Virtual-Lab/Electronics-and-Communication-Engineering/Exp-2/>   **Over-Modulation (Vm = 30V, Vc = 15V):**    **Perfect Modulation (Vm = 15V, Vc = 15V):**    **Under Modulation (Vm = 15V, Vc = 30V):**    **Demodulation:** |

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| **Conclusion:** |
| In conclusion, we meticulously analysed and compared graphs of the original signal and its frequency-modulated counterpart using MATLAB, providing valuable insights into the distinctive characteristics of frequency modulation. The graphical representation showcased the impact of modulation on signal properties, contributing to a deeper understanding of communication systems. |

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| **Signature of faculty in-charge with date:** |