National University of Sciences and Technology (NUST)
School of Electrical Engineering and Computer Science

Department of Electrical Engineering and Computer Science

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Semester: 5th   Section: BEE 12C

EE-232: Signals and Systems

Lab 13: Frequency Modulation

Group Members

Name	Reg. No	PLO4 – CLO3 **Viva / Quiz / Lab Performance** **5 Marks**	PLO5 - CLO3 **Analysis of data in Lab Report** **5 Marks**	PLO8 - CLO4 **Modern Tool Usage** **5 Marks**	PLO9 - CLO4 **Ethics and Safety** **5 Marks**
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1 Table of Contents

2 Frequency Modulation

2.1 Objectives

- Understand the operations carried out in the frequency modulation and understand their applications
- Apply the concepts on real world signals and systems

2.2 Equipment

Software

- *MATLAB*

2.3 Lab Instructions

All questions should be answered precisely to get maximum credit. Lab report must ensure following items:

- Lab objectives
- MATLAB codes
- Results (Graphs/Tables) duly commented and discussed
- Conclusion

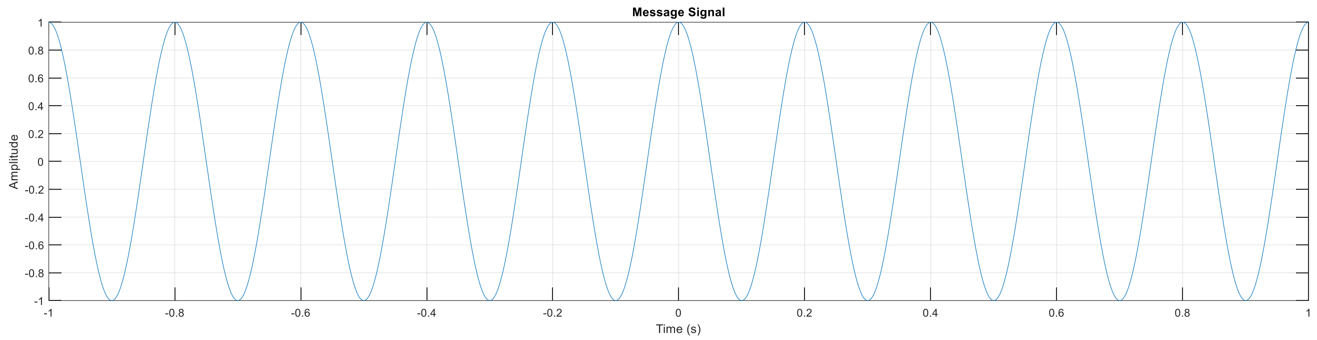
3 Lab Tasks

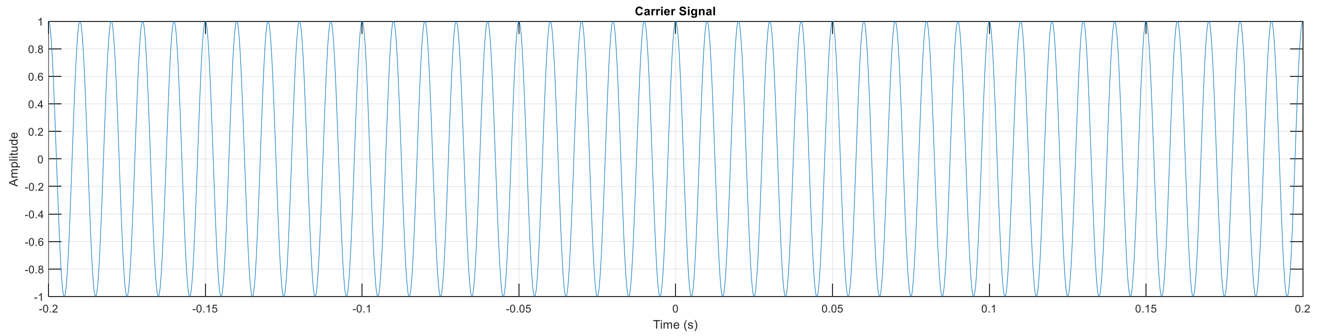
In the previous lab, amplitude modulation (AM) of a message signal with a carrier signal was introduced. The AM implementation required multiplying the message and carrier signals to make the transmission. In this lab, another type of modulation called frequency modulation (FM) will be considered.

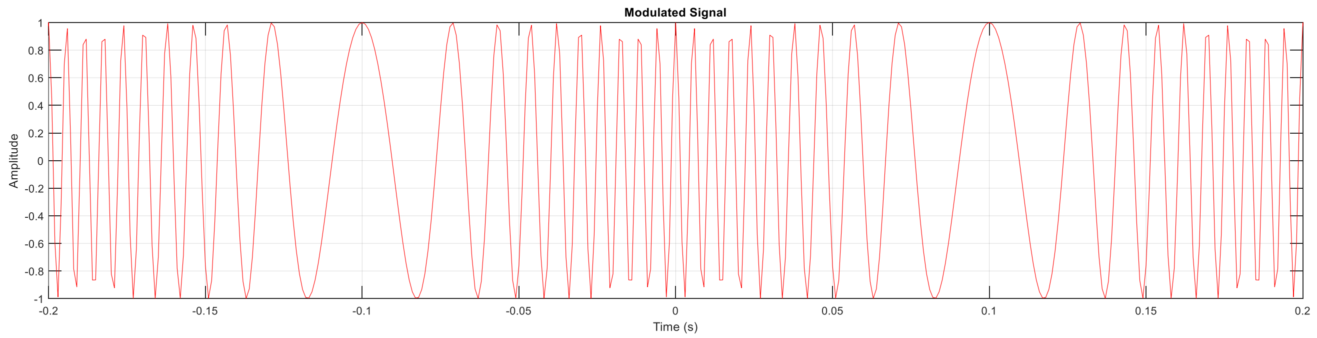
This lab is of an "open-ended" nature and as such requires that students come up with their own implementation of FM. The students must generate carrier and message signals and use their own approach to apply the modulation. The modulated signal must then be demodulated to acquire the message signal at the receiving end. Results from both modulation and demodulation must be provided. Provide the code and plots in MATLAB as well.

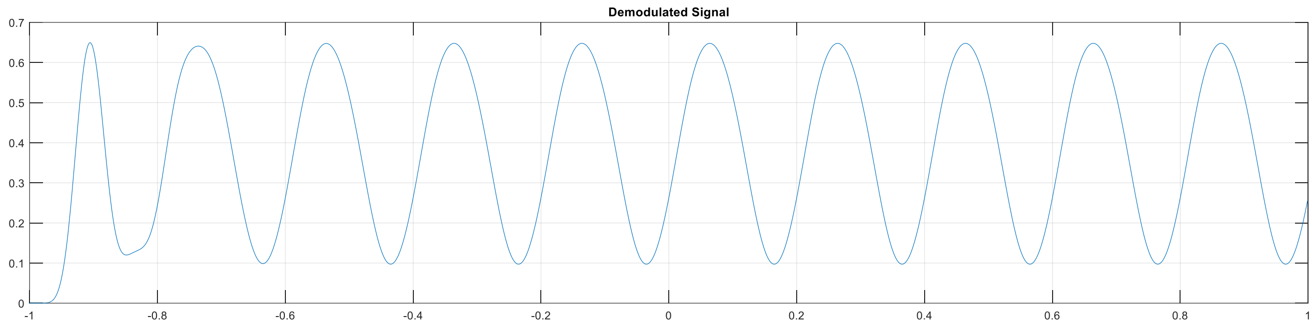
```
%% Modulation
fs = 1000;
t = -1:1 / fs:1;
L = length(t);
f_axis = fs * (-L / 2:(L / 2) + 1) / L;

A = 1;
fm = 5;
fc = 100;
beta = 15;

wm = 2 * pi * fm;
wc = 2 * pi * fc;
m = A * cos(wm * t); % signal
c = A * cos(wc * t);
mod_t = A * cos((wc * t) + beta * sin(wm * t));

figure
subplot(311)
plot(t, m);
grid
xlabel('Time (s)')
ylabel('Amplitude')
title('Message Signal')

subplot(312)
plot(t, c);
grid
xlabel('Time (s)')
ylabel('Amplitude')
title('Carrier Signal')

subplot(313)
```

```
plot(t, mod_t, 'Color', 'red');
grid
xlabel('Time (s)')
ylabel('Amplitude')
title('Modulated Signal')

%% Demodulation
diff_mod = diff(mod_t);
s = abs(diff_mod);
[b, r] = butter(10, (2 * pi * fm) / fs);
out_t = filter(b, r, s);
figure
subplot(211)
plot(t, m)
title('Message Signal')
subplot(212)
plot(t(1:end - 1), out_t)
title('Demodulated Signal')
```









4 Conclusion

In this lab we learnt and implemented the concepts of frequency modulation on MATLAB. We plotted and analyzed the carrier, message and modulated signal in time domain and observed the frequency alternation in the modulated signal with respect to the amplitude of the message signal. We also learnt how to demodulate the signal by the use of Butterworth filter.