ECEN310 Communication Engineering (XMUT) Lab 2 (8%)

Complete the following three (3) exercises on analogue modulation techniques, and submit an individual report. See sample report format on our course website. Check with the teacher how to submit your report.

Part 1 Amplitude Modulation (AM)

The complex envelope of a conventional AM signal is given by

$$g(t) = A_c[1 + m(t)]$$

where the constant A_c has been included to specify the power level and *m(t)* is the modulating signal (which may be analog or digital). This equation reduces to the following representation for the transmitted AM signal:

$$s(t) = A_c[1 + m(t)]\cos(\omega_c t)$$

where ω_c is the carrier frequency.

A waveform illustrating the AM signal is shown in Figure 1. For convenience, it is assumed that the modulating signal *m(t)* is a sinusoid. $A_c[1 + m(t)]$ corresponds to the in-phase component *g(t)* of the complex envelope; it also corresponds to the real envelope $|g(t)|$when *m(t)* ≥ -1 (the usual case).

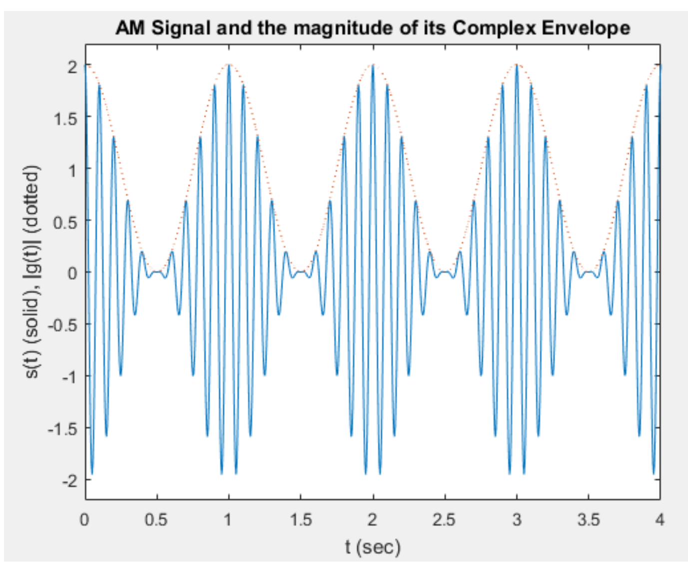

Figure 1: A typical AM signal waveform.

In this Lab exercise, we will investigate the properties of amplitude modulation (AM). We will use Matlab in the process. You have been introduced to Matlab in ECEN220; if you need revision on how to use Matlab, please refer to the introductory lecture materials in that course. A sample Matlab coding for the above AM signal is provided for you. Study these Matlab codes and modify it appropriately for the subsequent exercises.

```
% ECEN310 Example MATLAB codes for Amplitude Modulation

clear;
clf

fc = 10;              % carrier frequency, Hz
fa = 1;               % message frequency, Hz
Ta = 1/fa;            % message period, sec
dt = 4*Ta/800;        % define the time resolution between sample points
wc = 2*pi*fc;         % carrier in radian/sec
wa = 2*pi*fa;         % message in radian/sec
t = 0:dt:4*Ta;        % define the time indices

x = cos(wa*t);       % create the message waveform
x = x(:);

carrier = cos(wc*t);    % create the carrier waveform
carrier = carrier(:);

s = (1+x).*carrier;     % this is the resulting AM signal

%%% Command for Plotting the graphs %%%
plot(t,s,t,abs(1+x),':');
xlabel('t (sec)');
ylabel('s(t) (solid), |g(t)| (dotted)');    % g(t) is in-phase component of the complex envolope
axis([0 4 -2.2 2.2])
title('AM Signal and the magnitude of its Complex Envelope');
```

Exercise a) AM Signal with 50% and 100% Modulation

Let an AM signal with a carrier frequency of 10 Hz be modulated with a sinusoid signal having a frequency of 1 Hz. Furthermore. Let the percentage of modulation be 50% over the time interval $0 < t < 2$ *sec* and then change to 100% over $2 < t < 4$ *sec*. Plot the AM signal waveform over the interval of $0 < t < 4$ *sec*; show the magnitude of the complex envelope of the resulting AM waveform on the same plot. Also include the plot of the original modulating signal. What can you say about the results that you have obtained.

Exercise b) AM signal with 150% modulation

Assuming an AM signal same as Part 1, but now with 150% modulation.

Plot the AM signal waveform at the transmitter output. Show the magnitude of the complex envelope of the resulting AM waveform on the same plot. Also include the plot of the original modulating signal. Explain the results that you have obtained.

Part 2 Frequency Modulation (FM)

Frequency modulation (FM) is a special case of angle-modulated signaling, where the complex envelope is given by

$$g(t) = A_c e^{j\theta(t)}.$$

Here the real envelope, *R(t)* = |*g(t)*| = A_c, is a constant, and the phase *θ(t)* is a linear function of the modulating signal *m(t)*. However, *g(t)* is a *nonlinear* function of the modulation. Using the equation above, we find the resulting *angle-modulated* signal to be

$$s(t) = A_c \cos[\omega_c t + \theta(t)].$$

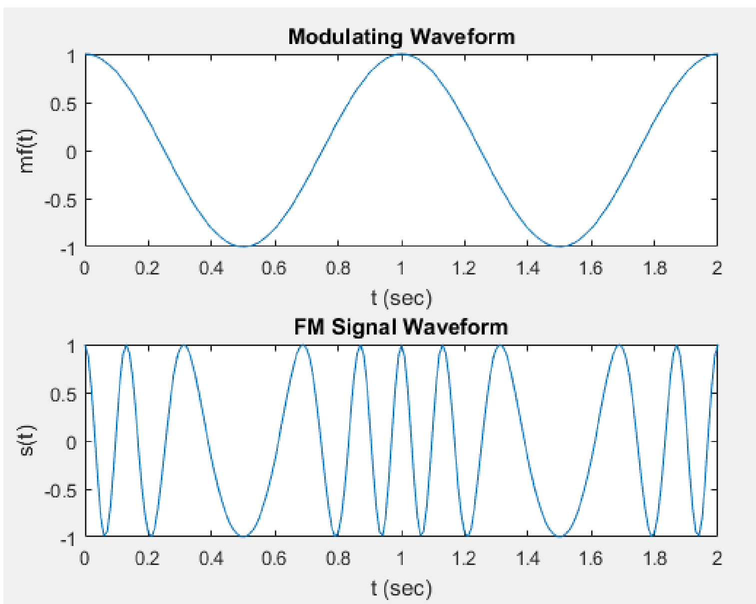

Figure 1: A typical FM signal waveform.

Exercise c) FM Signal with Sinusoidal Modulation

1. Plot the waveform of an FM signal that has a modulating signal of $m_f(t)=\cos(2\pi ft)$ with a modulating frequency of 1 Hz. Assume that the carrier frequency is 5 Hz and the modulation index is 3.

2. Plot the <u>spectrum</u> of the message and the modulated signals.

<u>Submission:</u>

You should submit an individual report containing, among other things, the <u>resulting plots for all the exercises above</u>, as well as <u>the respective Matlab codes, with proper comments explaining each of your steps in the Matlab codes</u>.

See sample report format on our course website. Check with the teacher how to submit your report.