Lab Assignment - 2

MODULATION TECHNIQUES

Course Outcome: CO1: Familiarise the basic concepts of communication systems

Modulation is defined as the process of changing the characteristics (Amplitude, Frequency or Phase) of the carrier signal (high frequency signal) in accordance with the intensity of the message signal (modulating signal).

ANALOG MODULATION

1. Amplitude Modulation

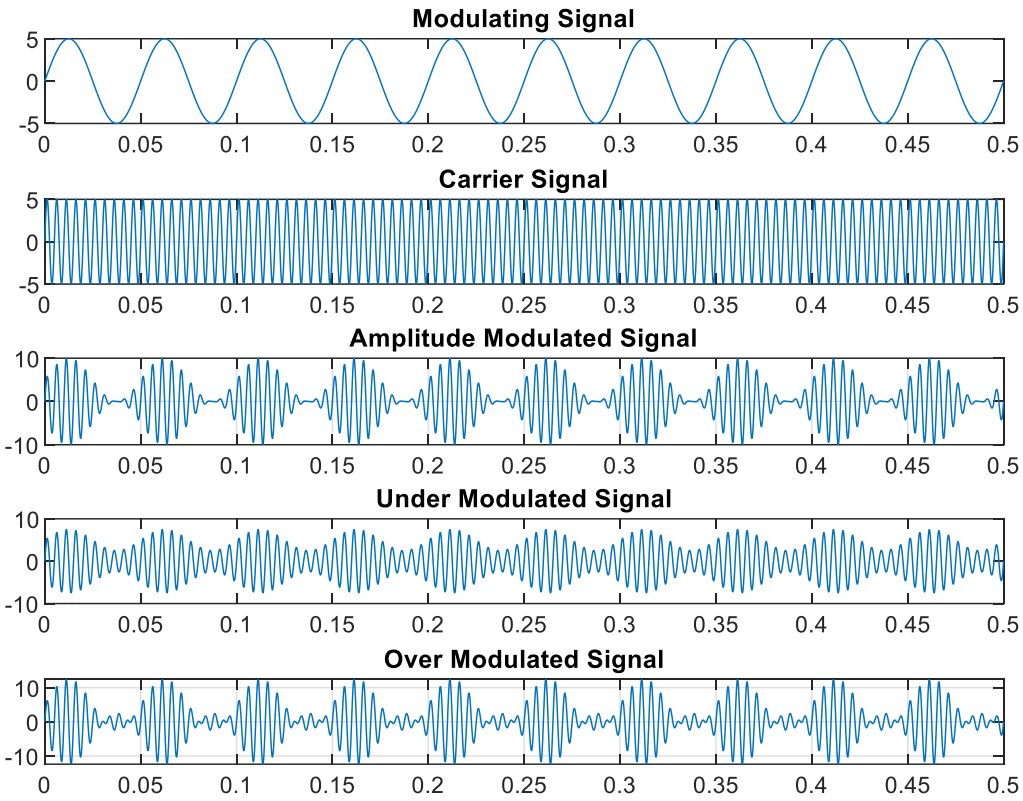
Theory

Amplitude modulation is defined as a system of modulation in which the amplitude of the carrier is varied in accordance with amplitude of the message signal (modulating signal).
Consider
Message signal, $m(t) = A_m \sin(2*pi*f_m*t)$
Carrier signal, $c(t) = Ac \sin(2*pi*f_c*t)$, Then,
Modulated signal, y(t) = Ac * (1+m*sin(2*pi*fm*t)).*sin(2*pi*fc*t), m is the modulation index
AM was the earliest modulation method used to transmit voice by radio.
Sample Program: (for m =0.5)

```
% Parameters
fs = 1000;              % Sampling frequency in Hz
t = 0:1/fs:1;           % Time vector (1 second duration)
fc = 100;               % Carrier frequency in Hz
fm = 10;                % Message frequency in Hz
Am = 5;                 % Amplitude of modulating signal
Ac = 5;                 % Amplitude of carrier signal


% Generate carrier and message signals
carrier = Ac*sin(2*pi*fc*t);            % Carrier signal
message = Am*sin(2*pi*fm*t);            % Message signal

% AM modulation
modulation_index = 0.5; % Modulation index (less than 1 for under modulation)
am_wave = Ac*(1 + modulation_index * sin(2*pi*fm*t)) .* sin(2*pi*fc*t);

% Plot the signals
figure;
subplot(3,1,1);
plot(t, message, 'b');
title('Message Signal');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(3,1,2);
plot(t, carrier, 'r');
title('Carrier Signal');
xlabel('Time (s)');
ylabel('Amplitude');
```

```
subplot(3,1,3);
plot(t, am_wave, 'k');
title('AM Wave (Under Modulation)');
xlabel('Time (s)');
ylabel('Amplitude');
```

Sample plot



2. Frequency Modulation

Theory

FM Modulation is a non-linear modulation technique. In FM, the frequency of carrier is varied in accordance with amplitude of modulating signal (AF signal). But amplitude is maintained constant. The most important feature of FM modulation is that it can provide better discrimination against noise and interference than AM. The disadvantage of FM is that it requires more transmission bandwidth than AM.

Frequency modulation is widely used for FM radio broadcasting. It is also used in telemetry, radar, seismic prospecting, and monitoring new-borns for seizures via EEG, two-way radio systems, music synthesis, magnetic tape-recording systems and some video-transmission systems.

Message signal, $m(t) = A_m \cos(2*pi*f_m*t)$

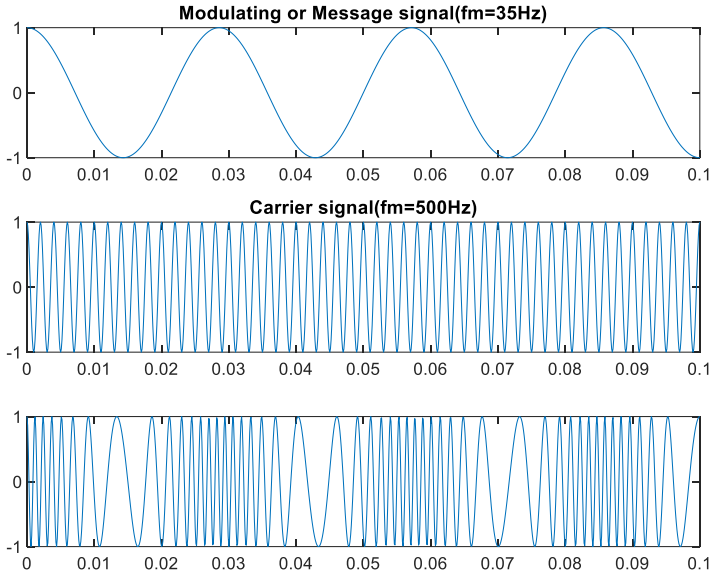
Carrier signal, $c(t) = Ac \cos(2*pi*f_c*t)$, Then,

Modulated signal, $y(t) = Ac * \cos((2*pi*f_c*t)+m_f*\sin(2*pi*fm*t))$,

m_f is the modulation index

m_f = frequency deviation/ modulating frequency.

Sample plot



3. Phase Modulation

Theory

In phase modulation, the instantaneous amplitude of the baseband signal modifies the phase of the carrier signal keeping its amplitude and frequency constant. (Frequency and phase modulation). Phase modulation is an integral part of many digital transmission coding schemes that underlie a wide range of technologies like Wi-Fi, GSM and satellite television. However it is not is widely used for transmitting analog audio signals via radio waves.

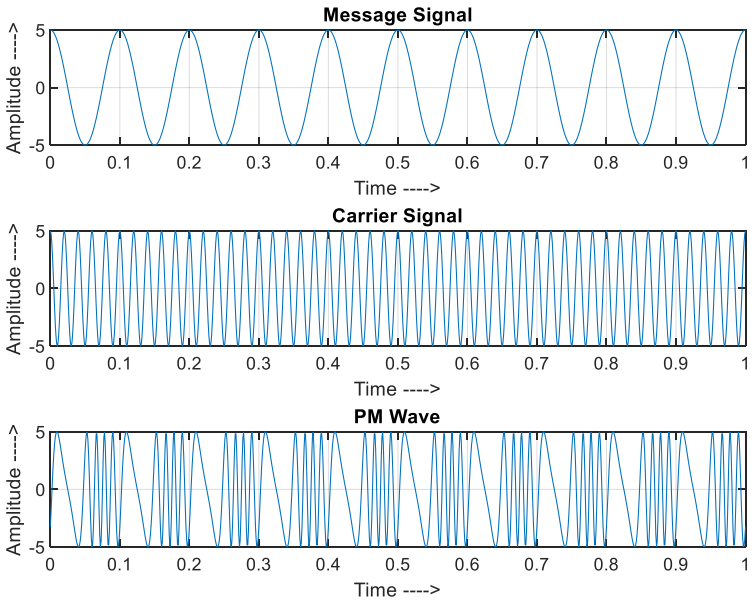
Message signal, $m(t) = A_m \cos(2*pi*f_m*t)$

Carrier signal, $c(t) = Ac \cos(2*pi*f_c*t + \varphi)$, Then,

Modulated signal, $y(t) = Ac * \cos((2*pi*f_c*t)+m_p*\cos(2*pi*fm*t))$, m_p is the modulation index

m_p = phase sensitivity * A_m

Sample Plot



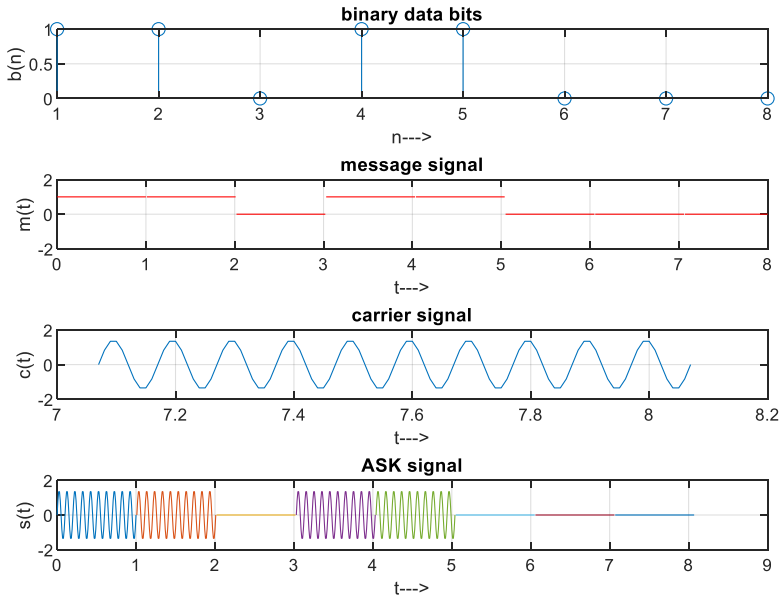
DIGITAL MODULATION

1. Amplitude Shift Keying (ASK)

Theory

Amplitude shift keying - ASK - is a modulation process, which imparts to a sinusoid two or more discrete amplitude levels. These are related to the number of levels adopted by the digital message. For a binary message sequence there are two levels, one of which is typically zero. The data rate is a sub-multiple of the carrier frequency. Thus the modulated waveform consists of bursts of a sinusoid.

Sample Plot



2. Frequency-shift keying (FSK)

Theory

Frequency-shift keying (FSK) is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier wave. The simplest FSK is binary FSK (BFSK). BFSK uses a pair of discrete frequencies to transmit binary (0s and 1s) information. With this scheme, the "1" is called the mark frequency and the "0" is called the space frequency.

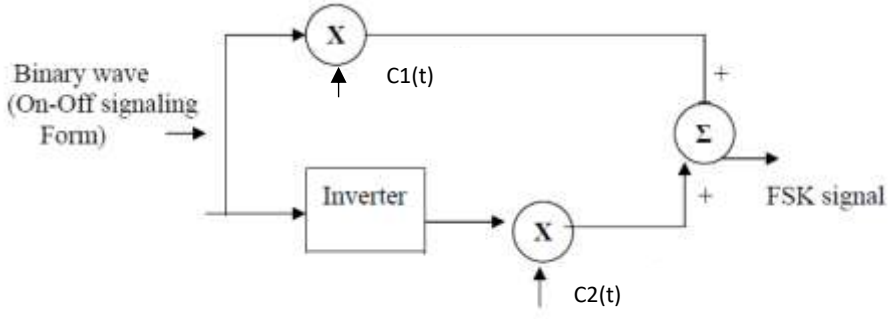
In binary FSK system, symbol 1 & 0 are distinguished from each other by transmitting one of the two sinusoidal waves that differ in frequency by a fixed amount.

$Si(t) = \sqrt{2E_b/Tb} \cos 2\pi f1t, \quad 0 \leq t \leq Tb$

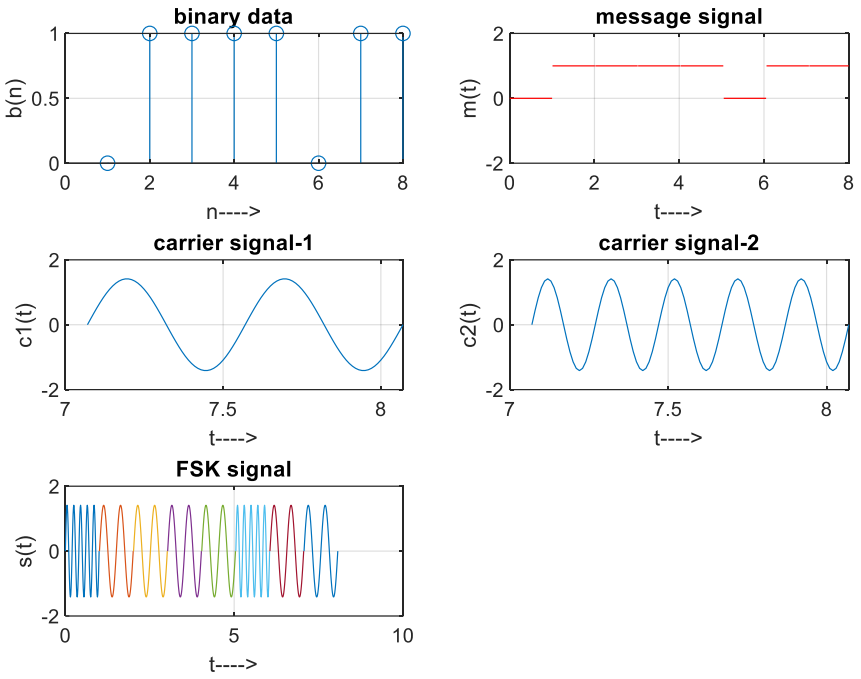
$0 \quad , \quad$ elsewhere

Where i=1, 2 & Eb=Transmitted energy/bit

FSK Transmitter



Sample plot

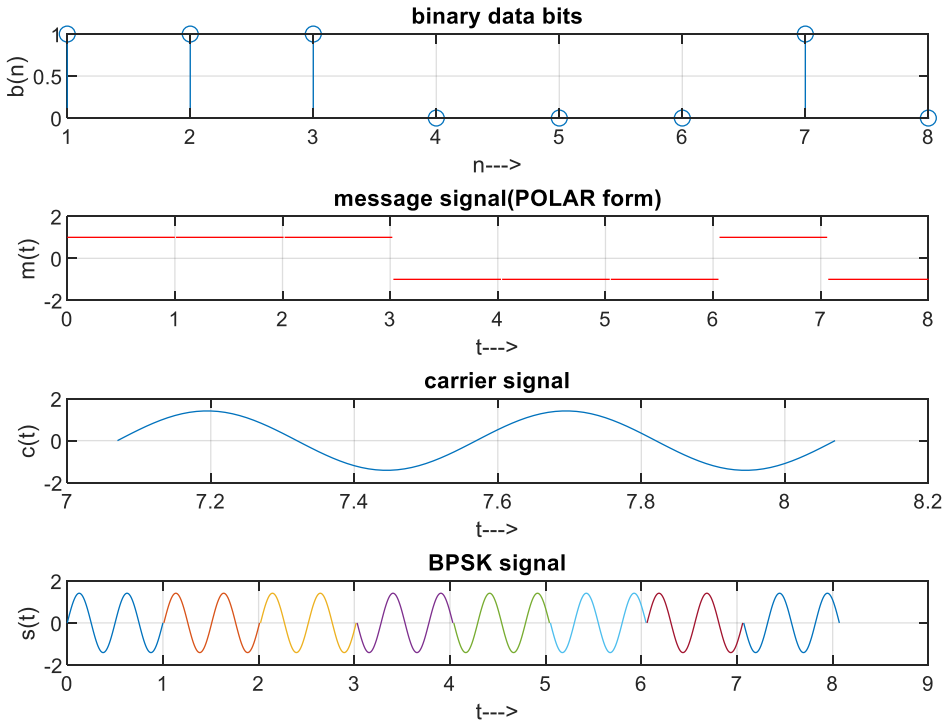


3. Phase Shift Keying (PSK)

Theory

PSK is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave). PSK uses a finite number of phases, each assigned a unique pattern of binary digits. Usually, each phase encodes an equal number of bits.

Sample Plot



Exercise

1. Generate AM wave for different modulation indices(m=1, 0.5 and 1.5). Plot all the waveforms(in a single figure).(Am=Ac=5V, fs=1000Hz, fm=20Hz)
2. Generate an AM wave with message signal 2cos(πt) and carrier 4Sin(1000πt +10). (Use deg2rad() function to convert phase from degrees to radians)
3. Generate an FM signal with m_f =10.
   (fs=10KHz, fm=35Hz, fc=500Hz, Am=Ac=1V, time vector, t=(0:.1*fs)/fs))
4. Generate an FM signal when message input is a sinusoidal wave and carrier is a rectangular waveform. (use in-built function, fmmod())
5. Generate a PM signal for modulation index, m_p = 4. (Am=Ac = 5V, fm = 10Hz, fc=50Hz, timevector,t = 0:0.001:1).
6. Generate the following signals using in-built functions in MATLAB. Perform both modulation and demodulation.
   a. AM signal (over modulation)
   b. FM signal
   c. PM signal
7. Generate ASK, FSK, PSK signal.