Communications Lab
Experiment 2
Lab Report

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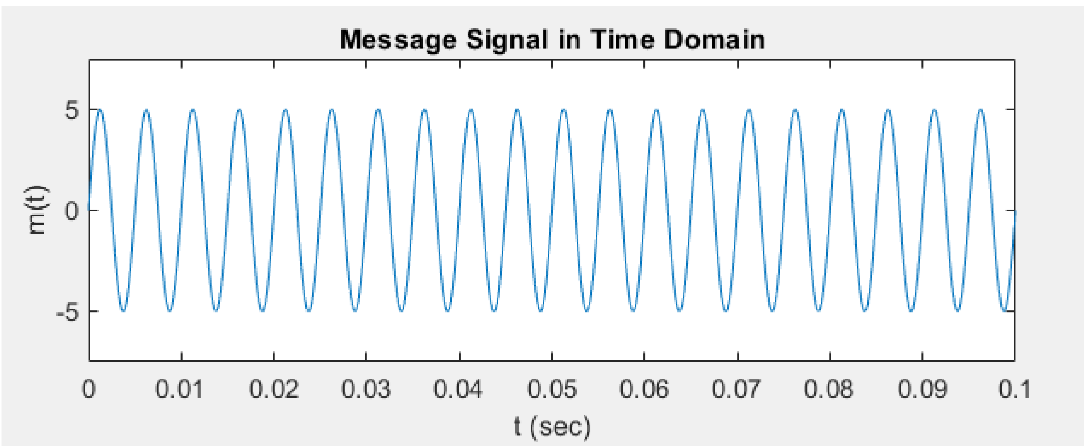
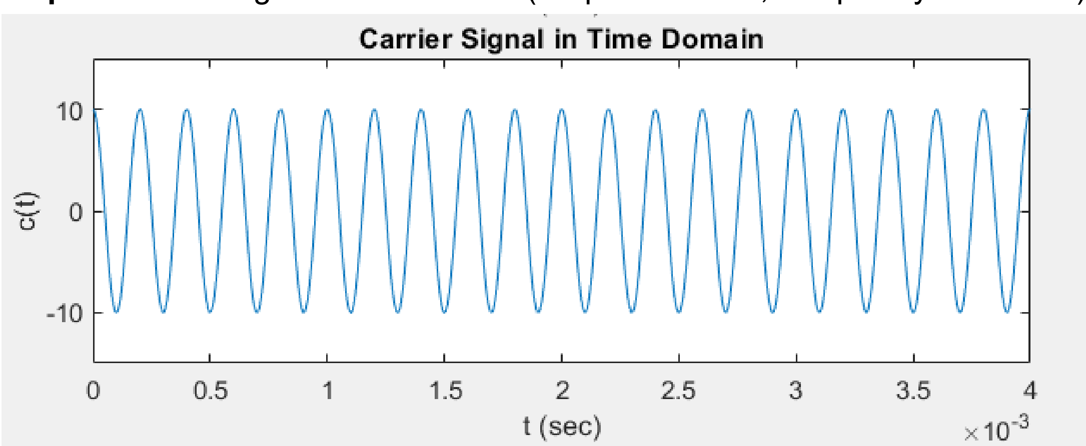
Frequency Modulation:
Frequency Modulation comes under the Phase Modulation scheme, here the message resides within the phase variations of the modulated signal.

FM Simulation on MATLAB:
Attached code: FM.m

Step 1: Generating a message signal. (Amplitude = 5 & Frequency = 200Hz)



Step 2: Generating the carrier wave. (Amplitude = 10 , Frequency = 5000Hz)



Step 3: Modulation. We add the integration of message as phase of carrier wave

It is a two step process:

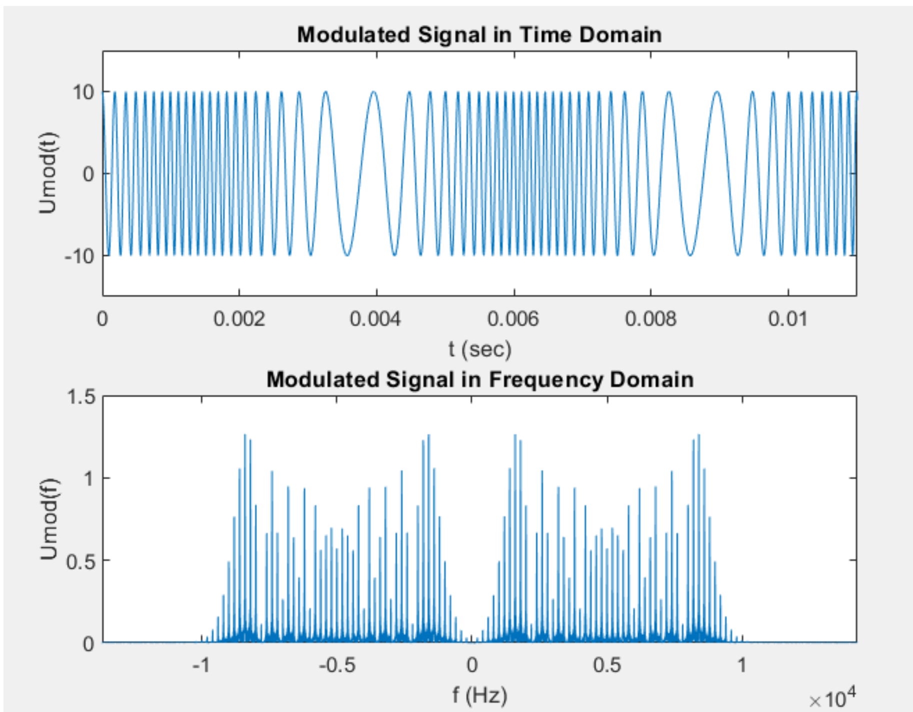
1. Integrating the message signal and multiplication with Kf = 750(sensitivity of the modulator).

$$\Theta(t) = 2\pi K_f \int m(\tau)d\tau$$

2. Adding this phase to the carrier wave.

$$y(t) = A_c cos(2\pi f_c t + \Theta(t))$$

Modulated Signal:

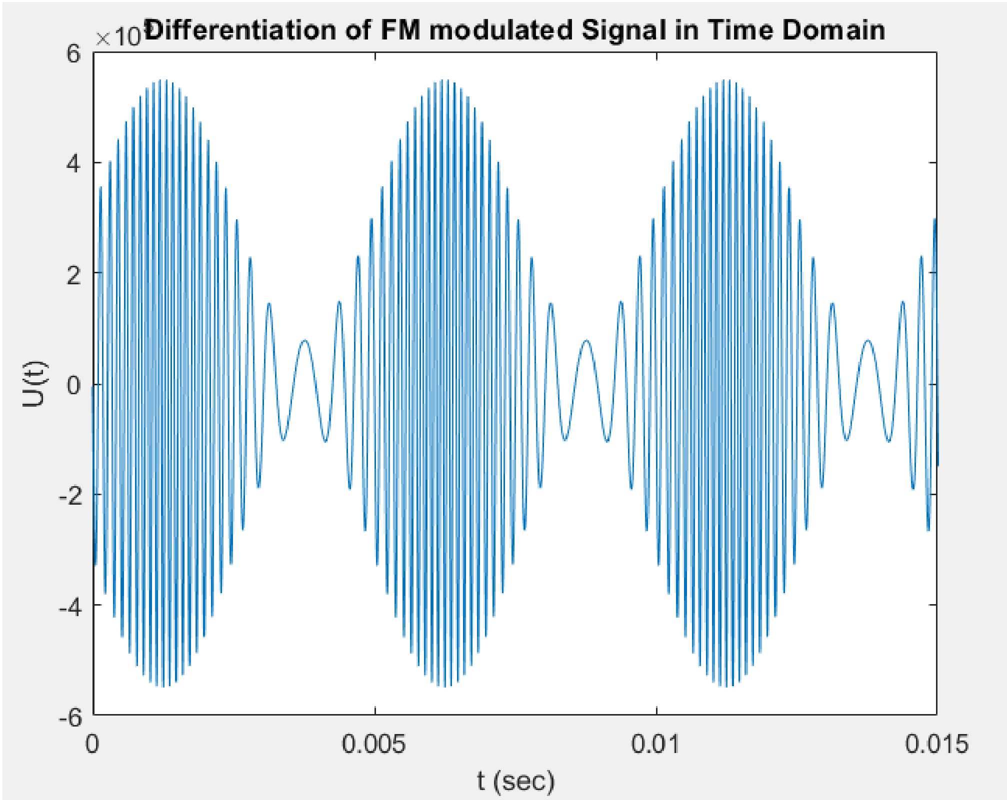


Step 4: Demodulation. We will follow the Frequency Discriminator method.

It is a three step process:

1. Differentiation of FM modulated signal using diff(FM_t)/Ts function in matlab. This function takes the difference of two consecutive elements of the array. As we are taking a small sampling period it gives a fair approximation of differentiation.

$$FM_{diff} = 2\pi Ac(f_c + K_f m(t)) \, sin(2\pi f_c t + 2\pi K_f \int m(\tau)d\tau)$$



2. Envelope detection. This is done by taking the Hilbert transform of the differentiated signal. And then computing the amplitude part of the differentiated FM signal.

$$FM_{envelope} = \left| FM_{diff} + j\widehat{FM}_{diff} \right|$$

$$\widehat{FM}_{diff} = 2\pi Ac(f_c + K_f m(t)) \cos(2\pi f_c t + 2\pi K_f \int m(\tau)d\tau)$$

Hence,

$$FM_{envelope} = \sqrt{(2\pi Ac(f_c + K_f m(t)))^2 \left[sin^2(2\pi f_c t + 2\pi K_f \int m(\tau)d\tau) + cos^2(2\pi f_c t + 2\pi K_f \int m(\tau)d\tau) \right]}$$

$$FM_{envelope} = 2\pi Ac(f_c + K_f m(t))$$

We get a complex sequence $FM_{diff} + j\widehat{FM}_{diff}$ when we use hilbert(FM_{diff}) in Matlab. Hence to get the envelope we used abs(hilbert(FM_{diff})).

3. Algebraic Manipulation. The received signal is of the format:

$$output = 2\pi A_c(f_c + K_f m(t))$$

Therefore,

$$m(t) = \frac{\frac{output}{2\pi A_c} - f_c}{K_f}$$

Final Output of demodulation.