American International University- Bangladesh (AIUB)
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Experiment No:	**07**		
Experiment Name:	**Study of Frequency Modulation and Demodulation using Simulink (MATLAB)**		

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Title: Study of Frequency Modulation and Demodulation using simulink (MATLAB)

Abstract:

This experiment is designed to-

1. To understand the use of simulink for solving communication engineering problem.
2. To develope understanding of frequency Modulation and Demodulation using simulink.

Theoretical Background:

Amplitude modulation was the ~~fist~~ first type to be considered in analog modulation communication systems. Amplitude modulation has the obvious advantage of being simple and relatively bandwidth efficient. The disadvantages of amplitude modulation are [1]

* ~~Sei~~. Since the message is embedded in the amplitude of the carrier signal, the cost, performance, and the size of the linear amplifiers are difficult to accomplish for obtaining fair performance in AM system.

* When the message goes through a quiet period in Double side Band (DSB) or single

Side Band (SSB) system, very small carrier signals are transmitted. The absence of the signal tends to accentuate the noise.

* the passband bandwidth is small compared to the other modulation schemes, i.e. FM, cellular, Wi-Fi etc.

Angle Modulation:

In the first experiment, we analyed the effect of varying the amplitude of a sinusoidal carrier in compliance with the baseband (information) signal. A major improvement in performance in the transmission is achieved with angle modulation. In this type of modulation, the ampeitude of the carrier is kept constant. Angle modulation provides the improved noise performance.

phase Modulation and frequency Modulation are both the modulation techniques analyed in angle modulation. In this ~~seond~~ second experiment, we will examine the most common modulation scheme in daily life, namely, the Frequency Modulation, or FM.

Frequency Modulation:

The analog modulated signal described in time domain:

$$s(t) = A_c \cos[2\pi f_c t + \theta(t)] = \mathrm{Re}\{A * \exp(j\phi(t))\}$$

where A_c is the amplitude, then

the instantaneous phase is

$$\phi_i = 2\pi f_c t + \theta(t)$$

The instantaneous ~~phase is~~ frequency of the modulated signal is:

$$f_i(t) = \frac{1}{2\pi}\frac{d}{dt}[2\pi f_c t + \theta(t)] = f_c + \frac{1}{2\pi}\frac{d[\theta(t)]}{dt}$$

where $\frac{d[\theta(t)]}{dt}$ is called phase deviation.

The phase deviation of the carrier, $\phi(t)$ is related to the baseband message $m(t)$. Then,

$$\frac{d[\theta(t)]}{dt} = K_f\, m(t)$$

where K_f is frequency deviation constant

$$\phi(t) = K_f \int_{-\infty}^{t} m(\lambda)\, d\lambda$$

Finally, the frequency modulated signal is expressed as in time domain:

$$s(t) = A_c \cos\left[2\pi f_c t + K_f \int_{-\infty}^{t} m(\lambda)\, d\lambda\right]$$

Carson's rule is used to determine the bandwidth of the FM wave. According to the carson's rule, the bandwidth is given by:

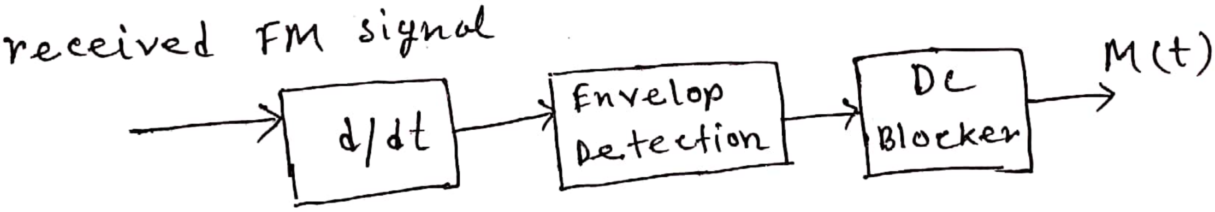
$B_t = 2W(1+D)$, where W is the bandwidth of the information signal, and D is the frequency deviation which is defined as for FM:

$$D = \frac{K_f}{2\pi W} \max|m(t)|$$

Frequency Demodulation

a. Demodulation using Differentiation:

A frequency discriminator theoretically extracts the message from the received FM signal.



The modulated signal $s(t)$ is:

$$\frac{ds(t)}{dt} = -A_c\left[2\pi f_c + K_f m(t)\right]\sin\left(2\pi f_c t + 2\pi K_f \int_{-\infty}^{t} m(\alpha)\,d\alpha\right)$$

The differentiated signal is both amplitude and frequency modulated, the envelope $A_c[2\pi f_c + k_c m(t)]$ is linearly related to message signal (amplitude component) and $\sin(2\pi f_c t + 2\pi k_f \int_{-\infty}^{t} m(\alpha)\,d\alpha)$ is high frequency component. Therefore, $m(t)$ can be recovered by an envelope detection of $\frac{ds(t)}{dt}$.

b. PLL Demodulation:

The PLL demodulation the FM signal using feedback force a Voltage-Controlled-Oscillator (VCO) to remain in phase with the carrier of the incoming signal. The message is ~~recovered~~ recovered as the control input of VCO [2].
In the simulation experiment (section-2), we used the VCO to demodulate the information signal.

Building Simulink Model of Frequency Modulation and Demodulation:
The frequency modulator and demodulator structures are as explained below. In the first ~~module~~ model, we are provided a FM structure that is very similar to the theoretical background of this experiment. In the ~~second~~ second model, It will show the frequency variations with respect to the input signal's waveform. In this case, we ~~will~~ had used the modulator and demodulator blocks provided by simulink.

Model-1:

Frequency Modulator and Demodulator:

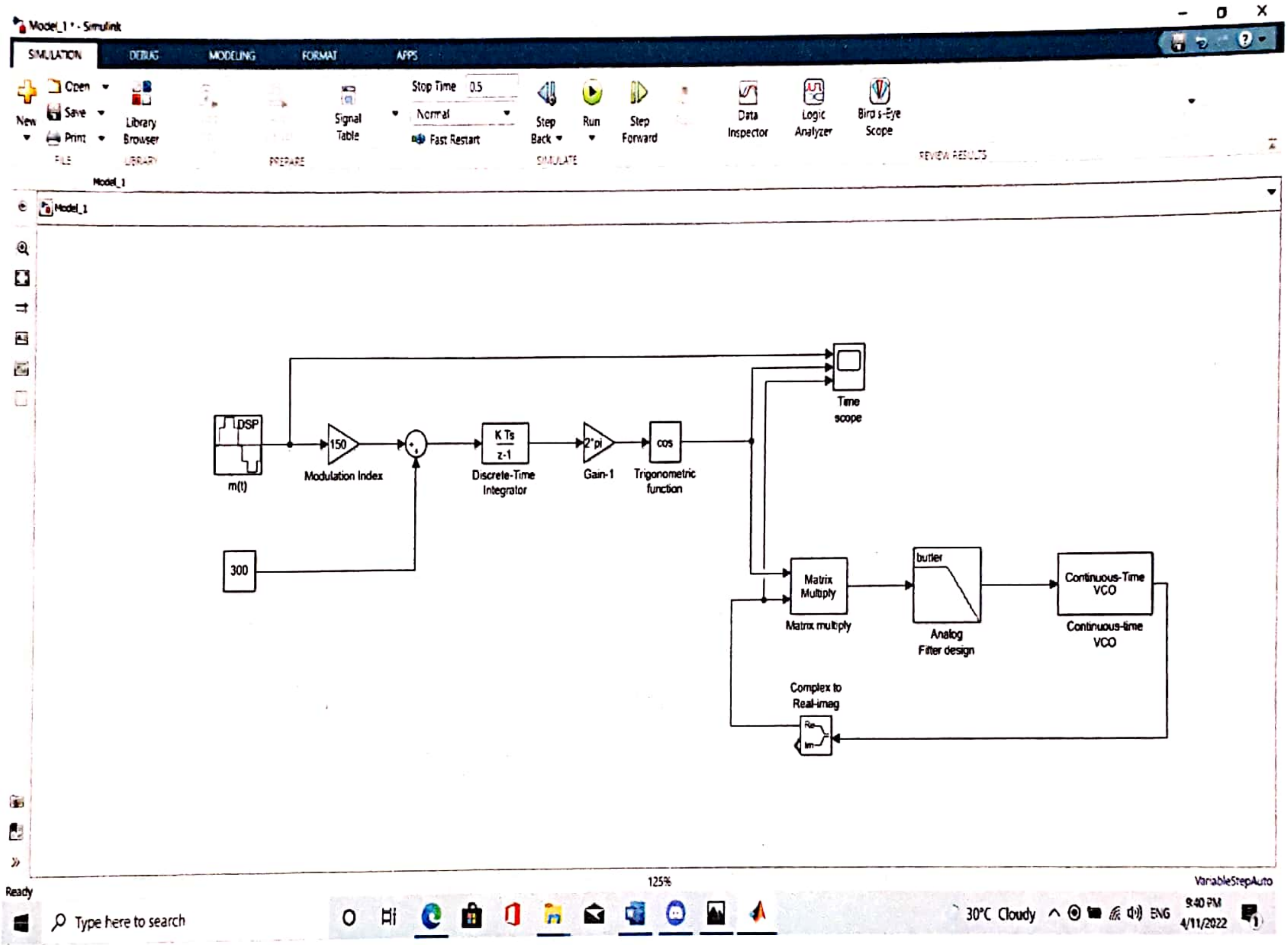


Figure 1: FM Modulator and Demodulator

Figure 2: Time Scope for Model-1

Model-2

In model-1, we had already learnt the theoretical fundations for FM. In the second model, instead of using complex modulator and demodulator structure, we have implemented an FM system using direct modulator and demodulator blocks defined in Simulink. The input, in this case, has three different forms sine wave, rectangular pulse train and triangular waves.

therefore, we did able to observe the frequency variations using variety of inputs

The model-2 is expressed as:

Model-2:

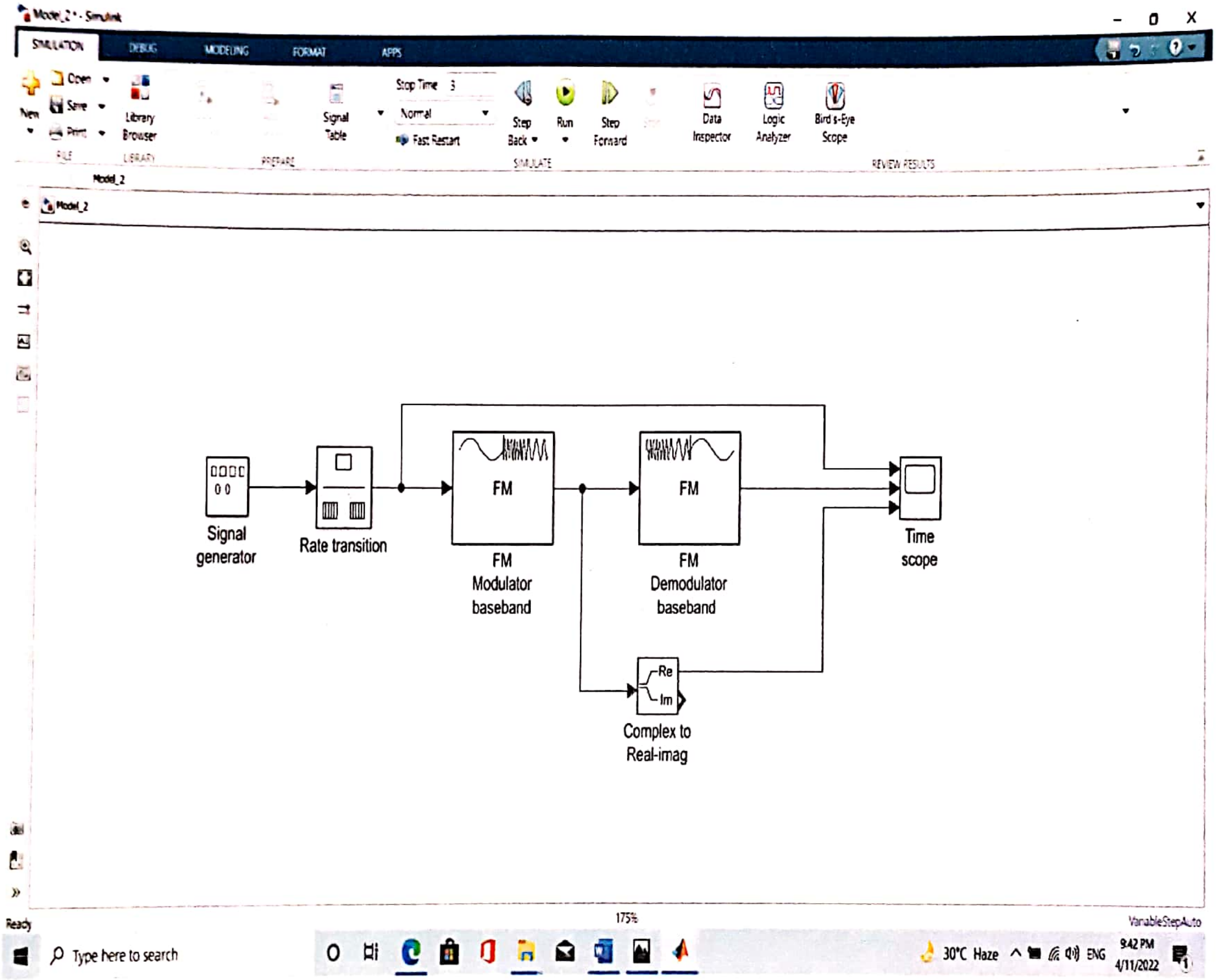


Figure 3: FM Model-2

Figure 4: Time Scope for Model-2