Faculty of Engineering and Technology

Electrical and Computer Engineering Department

ENEE4113

Communications Lab

PreLab No.3

Frequency Modulation

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Frequency Modulation Using Simulink Matlab

Consider the frequency modulated signal:

$$s(t) = \cos(2\pi(20k)t + 6\sin(1000\pi t))$$

1. *Message Signal m(t):*

Since the modulated signal using **FM modulation** has the following general formula:

$$\boldsymbol{s(t) = A\cos[2\pi fct + \beta\ sin2\pi fmt]}$$

Where $\boldsymbol{\beta}$ **FM modulation index** = $\frac{\boldsymbol{peak\ frequency\ deviation}}{\boldsymbol{message\ bandwidth}} = \frac{\boldsymbol{Kf*Am}}{\boldsymbol{fm}} = \frac{\boldsymbol{\Delta f}}{\boldsymbol{fm}}$

So, we can find from the given formula the following values:

- Message frequency $Fm = 500\ Hz$.
- Carrier Signal $Fc = 20\ KHz$.
- Assuming that $Kf = 1$; then the $\boldsymbol{\beta} = \frac{\boldsymbol{1*Am}}{\boldsymbol{fm}} = \frac{\boldsymbol{Am}}{\boldsymbol{500}} \rightarrow \boldsymbol{Am = 3000}$.

So, the message signal will be: $m(\boldsymbol{t}) = \boldsymbol{Am\ \cos(2\pi fmt) = 3000\ cos(2\pi\ 500\ t)}$

2. *Plotting Message Signal m(t) and modulated signal s(t):*

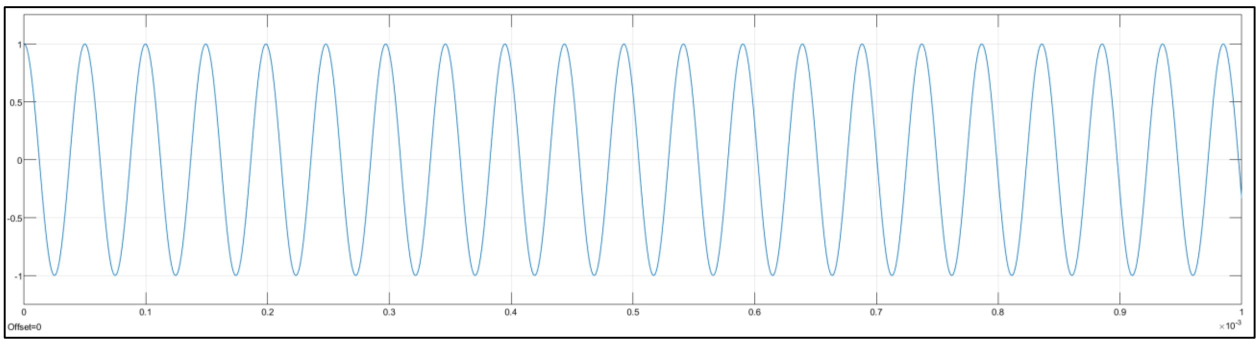

Figure 2 FM-Modulated signal s(t) in time domain.

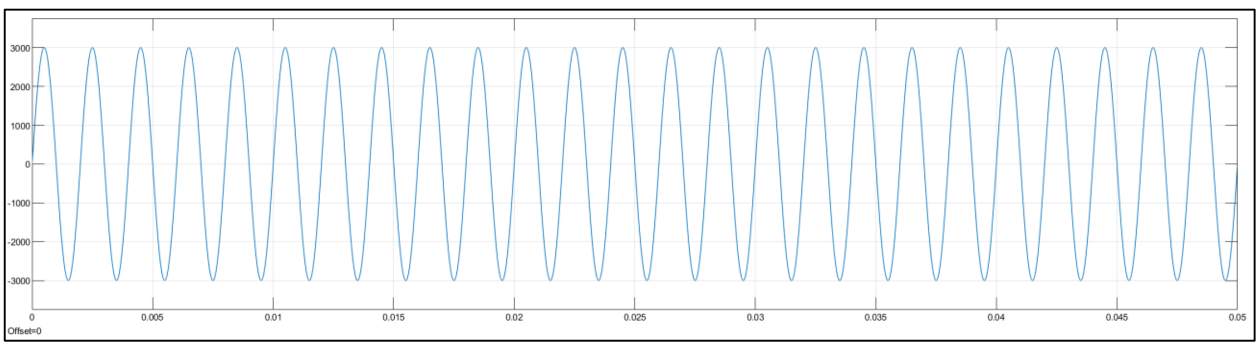

Figure 1 Message signal m(t) in time domain.

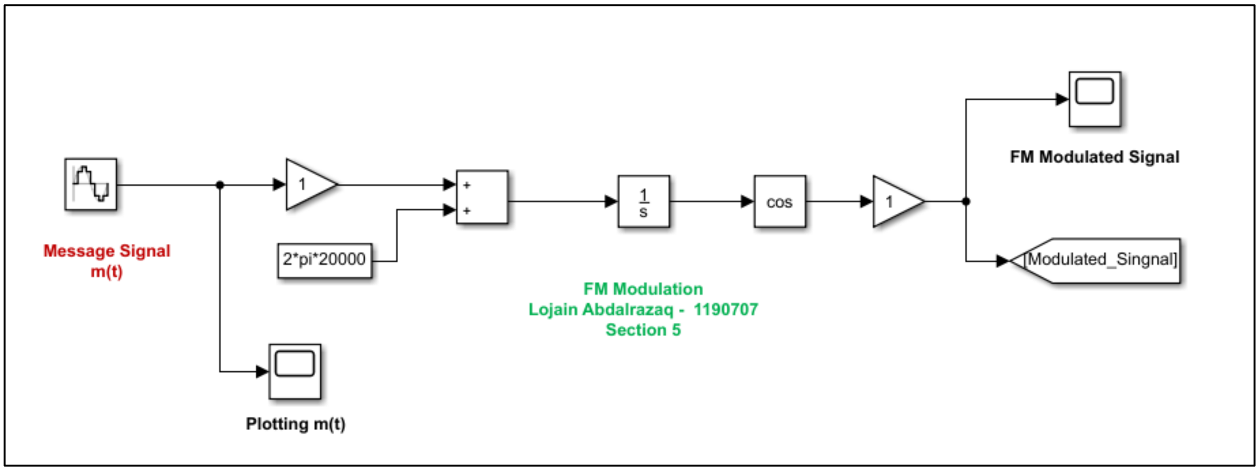

Figure 3 FM-Modulation Block Diagram using simulink.

3. Differentiate s(t) with respect to t and plot ds(t)/dt:

Now, the differentiate of the s(t) is as the following formula:

$$\boldsymbol{s(t) = A\cos[2\pi fct + \beta\ sin2\pi fmt]}$$

$$\boldsymbol{s`(t) = sin(\ (2\pi fct)\ +\ \beta sin(2\pi fmt))\ *\ ((2\pi fc) + 2 * \beta\ *\ fmcos\ (2\pi fmt))}$$

$$\boldsymbol{s`(t) =\ sin(\ (2\pi 20kt)\ +\ 6\ sin(2\pi 500t))\ *\ ((2\pi 20k)\ +\ 6000cos\ (2\pi 500t))}$$

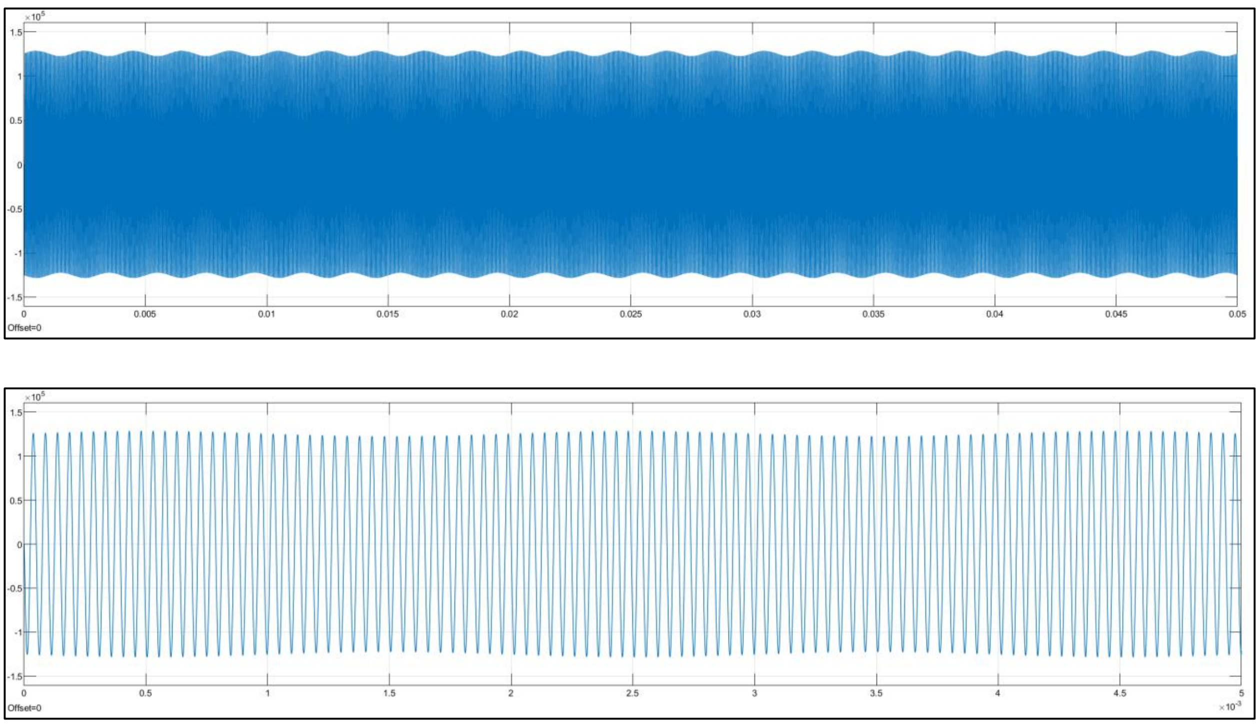

Figure 4 Differentiate s(t) plot in time domain.

It is noticed that it the differentiation transforms the FM waveform into an AM waveform.

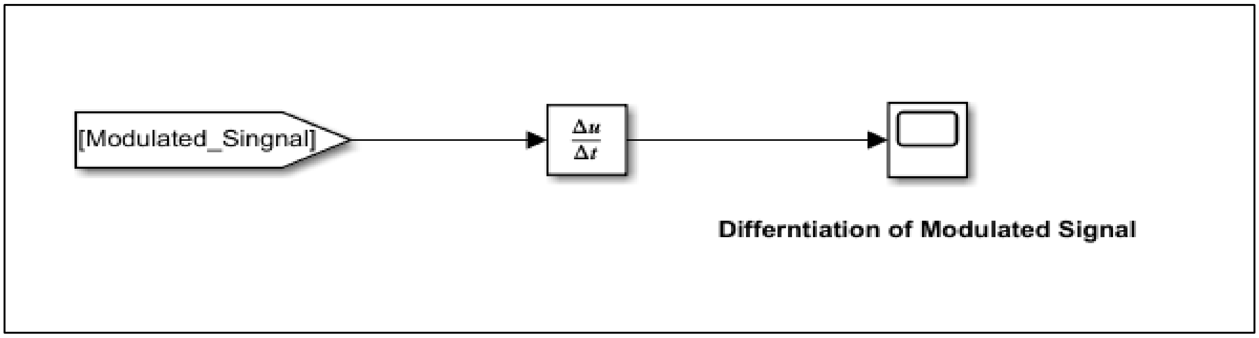

Figure 5 Differentiate FM Modulated signal block diagram.

4. *Applying ds(t)/dt to an ideal envelope detector s(t):*

Now, in this step, and taking the envelop detector of the differentiation signal s`(t) which can be done by taking its absolute value then applying it to the Hilbert transform to remove the negative part, and the DC term:

$$\boldsymbol{Envelop\ of\ s`(t)} = |\ \mathbf{sin}\big(\ (\mathbf{2\pi 20kt}) +\ \mathbf{6\ sin(2\pi 500t)}\big) * \ \big((\mathbf{2\pi 20k}) +\ \mathbf{6000cos}\ (\mathbf{2\pi 500t})\big)|$$

And subtracting the DC term, we get the following output:

$$\boldsymbol{Envelop\ of\ s`(t)} =\ \boldsymbol{6000cos}\ (\boldsymbol{2\pi 500t}))$$

Which is the same as the input message signal; in other words it is linearly proportional to the original message signal m(t).

5. *Extract message signal by using phase-locked loop (PLL):*

Finally, to extract the message signal m(t), the phase-locked loop was used. The message extracted is as the following:

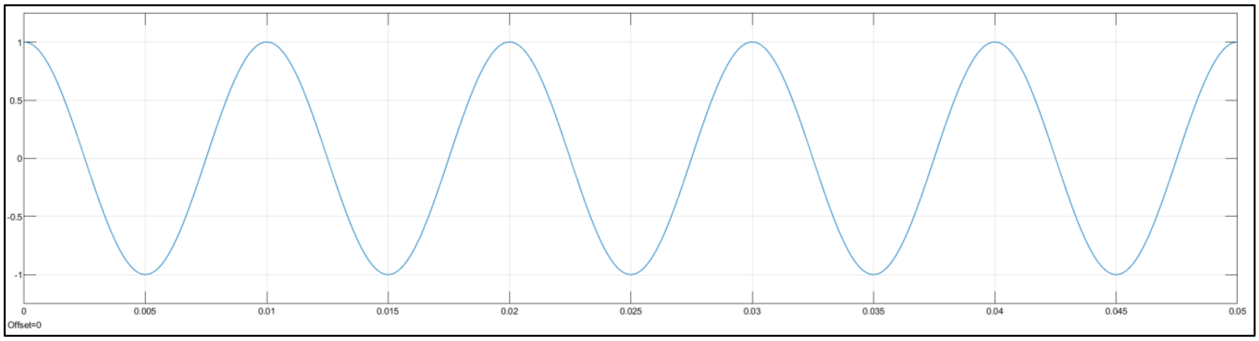

Figure 6 Demodulated signal using PLL in time domain.

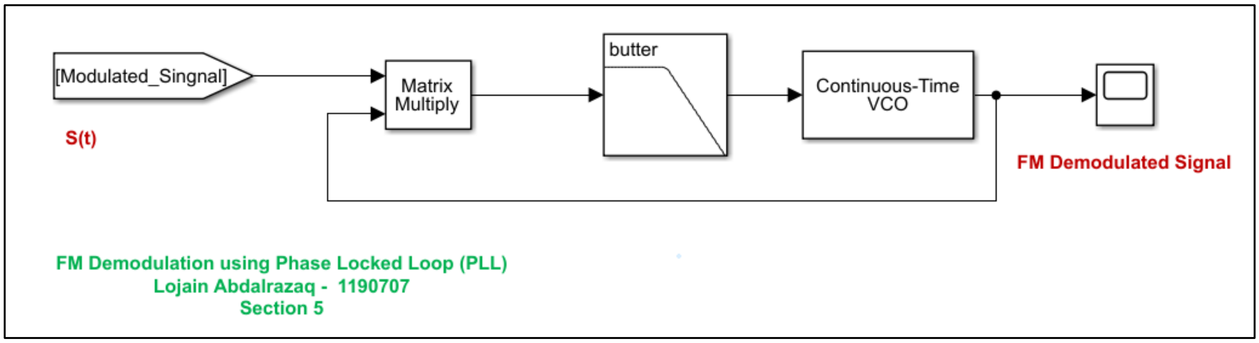

Figure 7 The block diagram of the PLL demodulation in Simulink.