Faculty of Engineering & Technology Electrical & Computer Engineering Department

Communication Lab - ENEE4113

Experiment 5: Phase Modulation

Prelab #4

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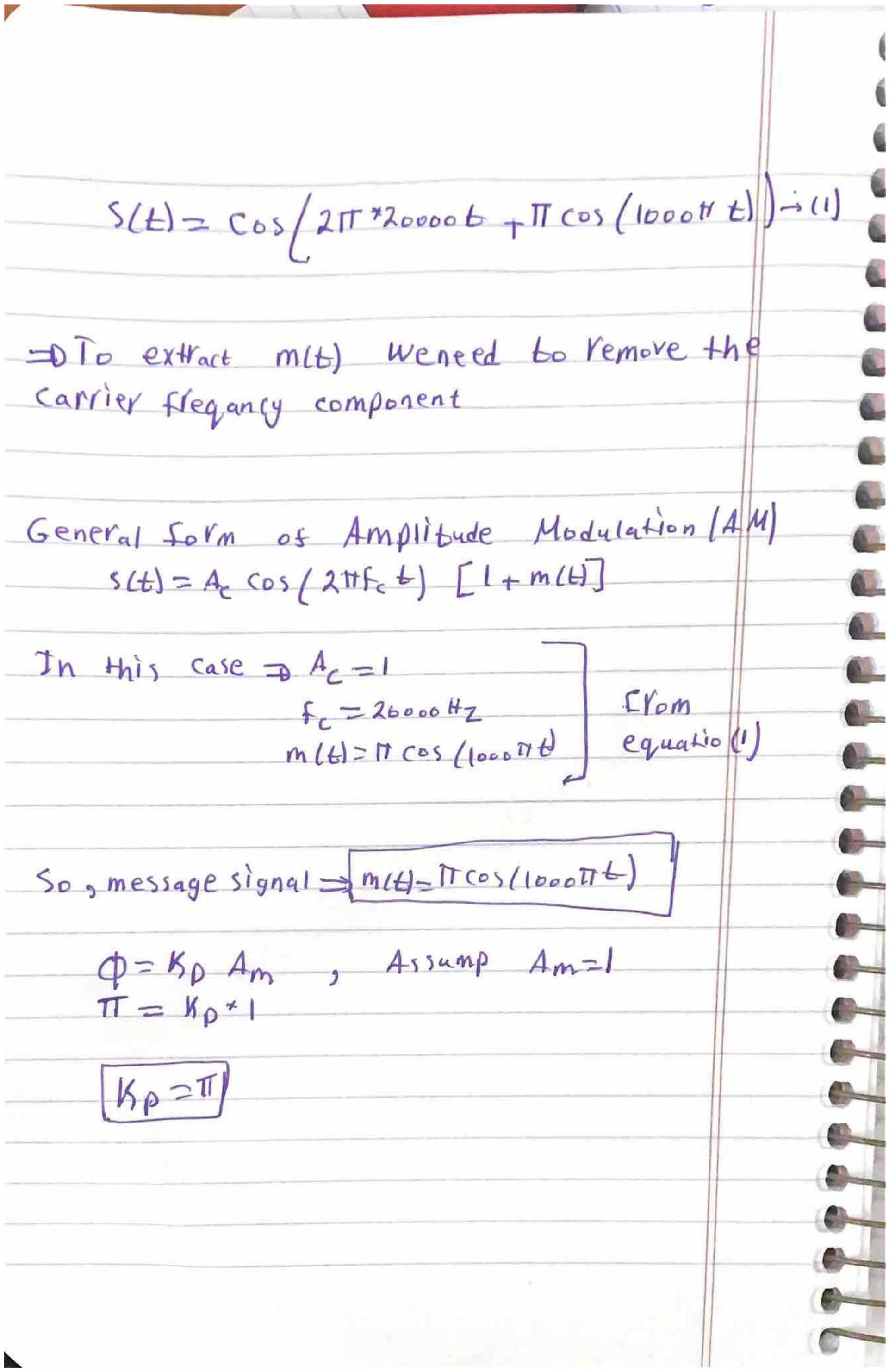
Extract the message signal m(t) from s(t)



$s(t) = \cos\left(2\pi * 20000t + \pi \cos(1000\pi t)\right) \rightarrow (1)$

⇒ To extract $m(t)$ we need to remove the carrier freqancy component

General form of Amplitude Modulation (AM)

$s(t) = A_c \cos(2\pi f_c t)\,[1 + m(t)]$

In this case ⇒ $A_c = 1$

$f_c = 20000\ Hz$

$m(t) = \pi \cos(1000\pi t)$

from equation (1)

So, message signal ⇒ $\boxed{m(t) = \pi \cos(1000\pi t)}$

$\Phi = K_p A_m$, Assump $A_m = 1$

$\pi = K_p * 1$

$\boxed{K_p = \pi}$

Figure 1: Steps to Extract the message signal m(t) from s(t)

Plot 5 cycle from Message signal m(t) and s(t)

Block Diagram

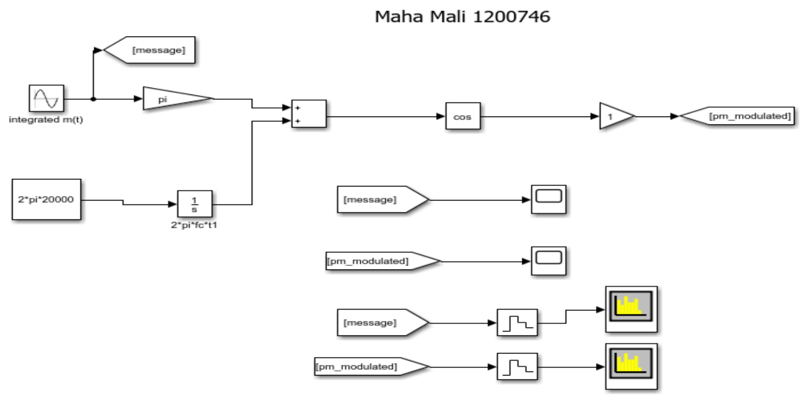


Figure 2: PM Modulation Block Diagram

Message Signal

Time Domine

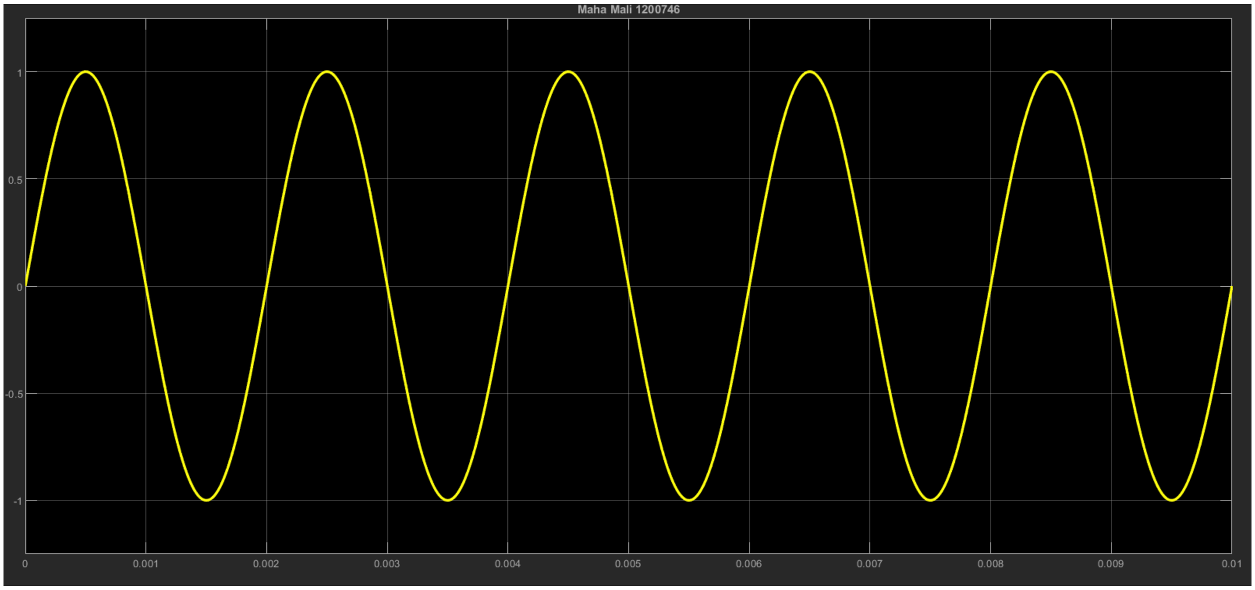


Figure 3: Message Signal in Time domine

From this graph we notice that we got the m(t) that we calculate it by hand with amplitude 1.

Frequency Domine

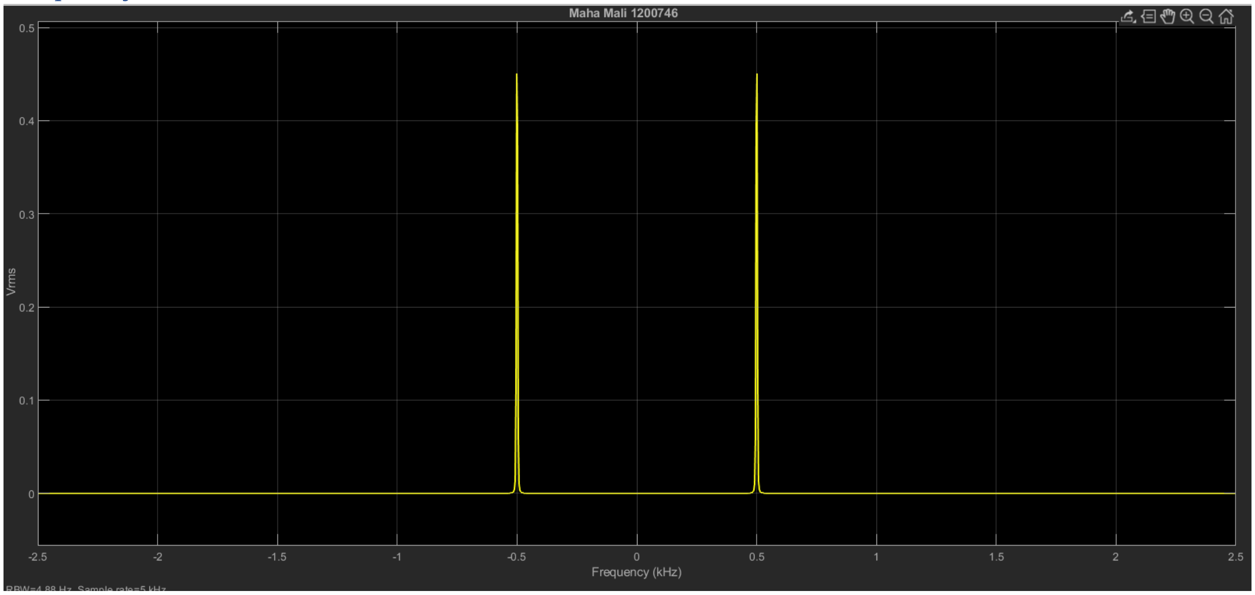


Figure 4: Frequency Domine

$$M(t) = 1coos(1000\pi t)$$

$$M(f) = \frac{1}{2}\delta(f - 500) + \frac{1}{2}\delta(f + 500)$$

The figure 5 show that we have two delta one at 500 Hz, and another on -500 Hz , according the equation for m(f).

Modulated signal s(t)

Time Domine

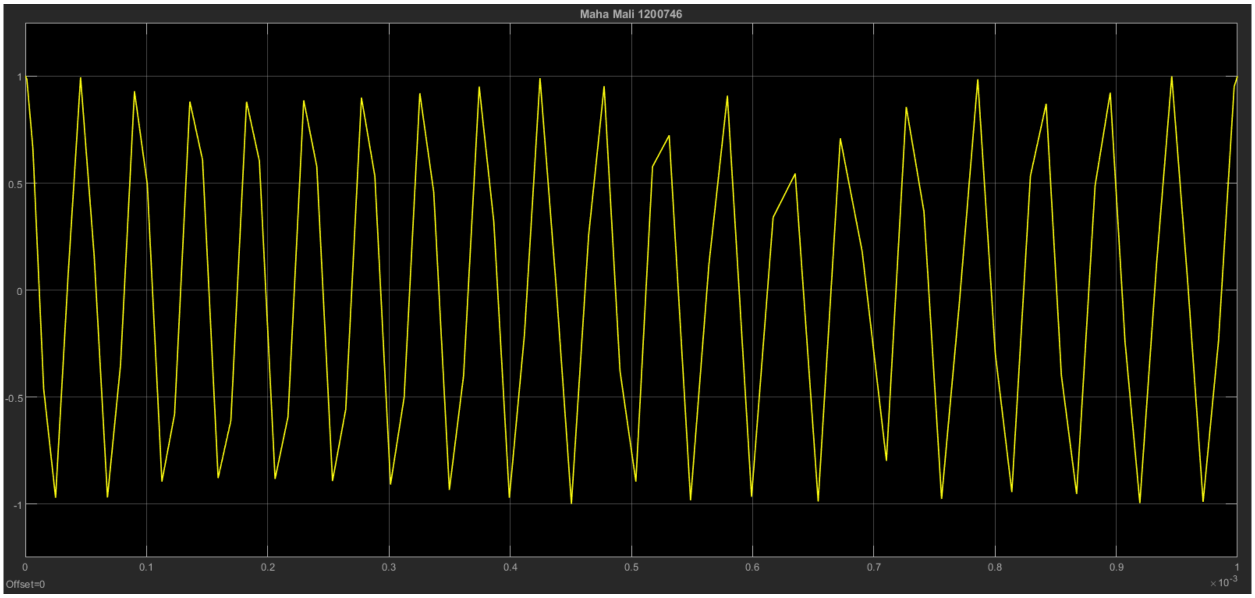


Figure 5: Modulated signal In Time Domine

Frequency Domine

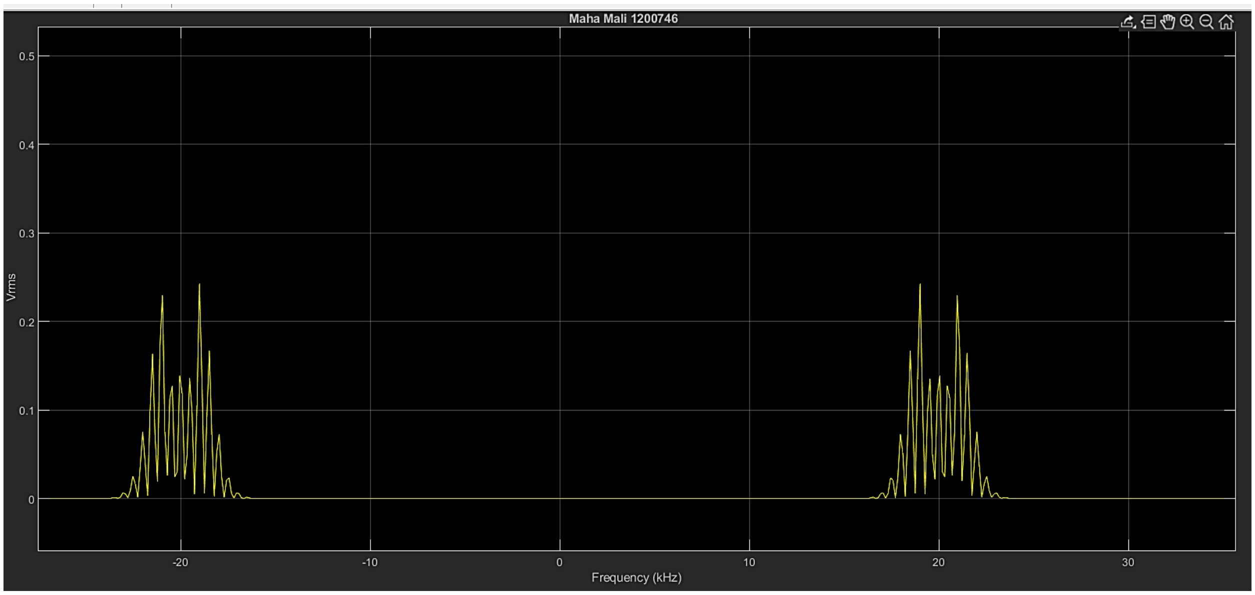


Figure 6: Modulated signal in frequency Domine

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

By Hand Solution

$$\frac{ds(t)}{dt} = -\sin\left(2\pi(20k)t + \pi\cos(1000\pi t)\right) \cdot \left(2\pi(20k) - \pi\sin(1000\pi t) \cdot 1000\pi\right)$$

Figure 7: Differentiate s(t)

Using Simulink

Block Diagram

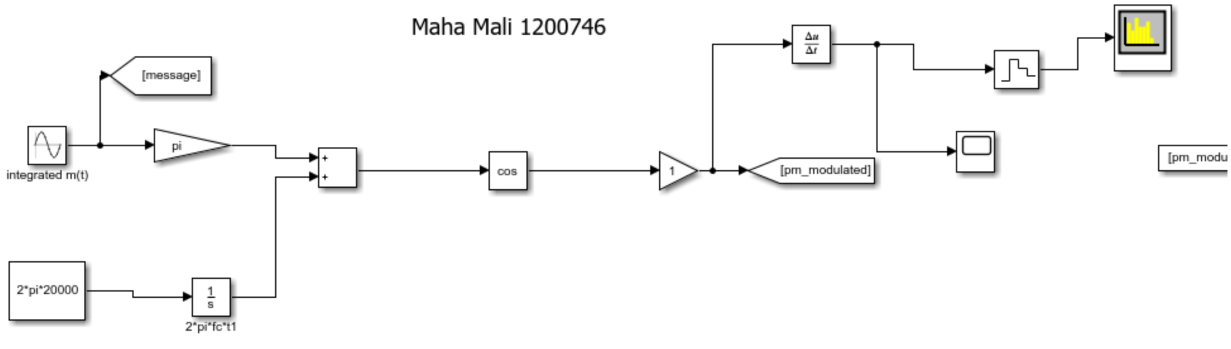


Figure 8: Block Diagram to Differentiate s(t)

Time domine

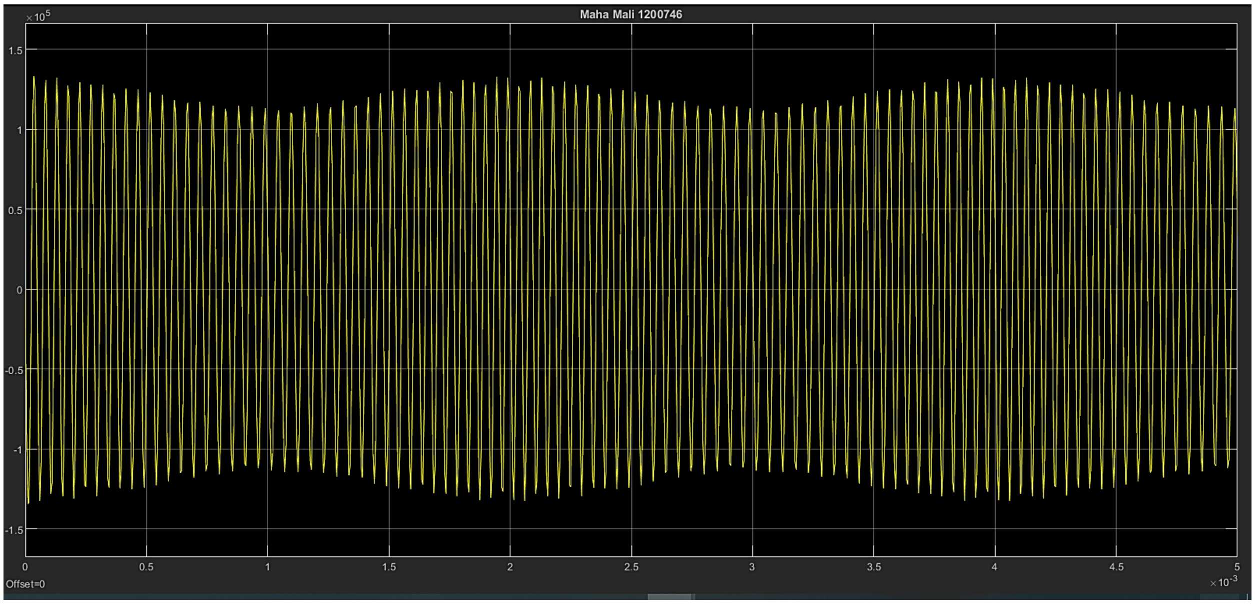


Figure 9: *Differentiate s(t) in time domine*

Frequency domine

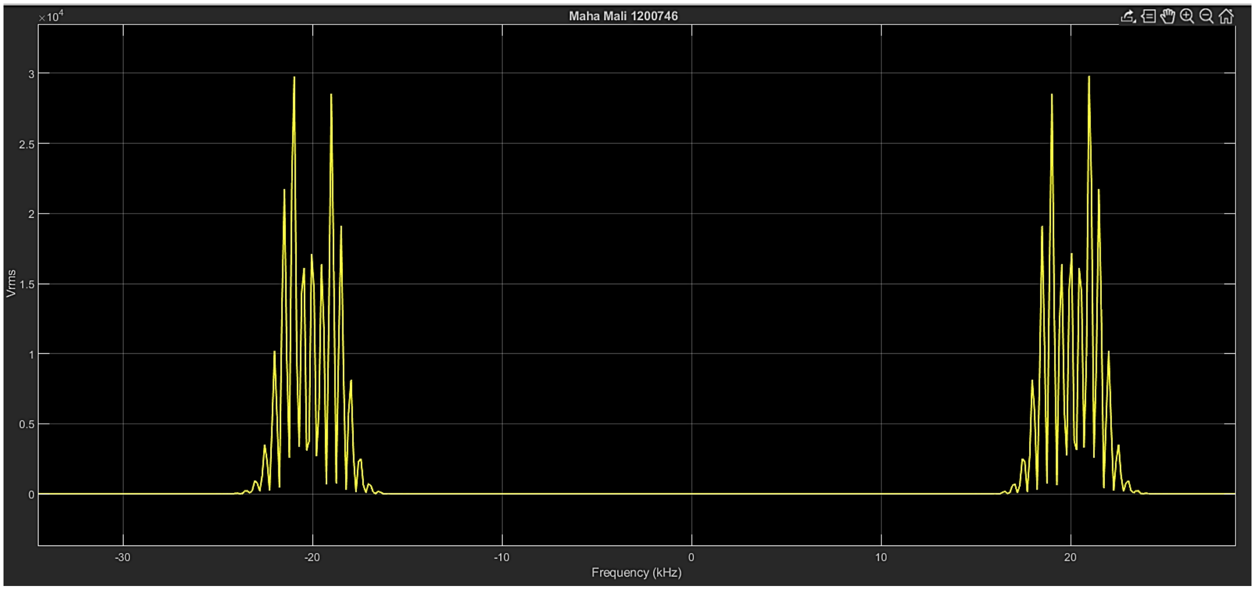


Figure 10: Differentiate s(t) in frequency domine

Differentiating the phase-modulated waveform s(t) = cos (2*pi*20000t+pi*cos(1000*pi*t)) with respect to time yields a signal with amplitude variations linked to the frequency of the message signal. This transformation resembles amplitude modulation (AM), where the message signal modulates the carrier's amplitude. The resulting signal takes on AM-like characteristics due to the changing amplitudes associated with the message frequency, demonstrating the interconnected nature of different modulation techniques within the context of signal processing.

Apply ds(t)/dt to an ideal envelope detector

By Hand Solution

$$s(t) \rightarrow \boxed{\text{differentiator}} \xrightarrow{\frac{ds(t)}{dt}} \boxed{\text{envelope}} \xrightarrow{y(t)} \boxed{DC} \xrightarrow{m(t)}$$

$$s(t) = \cos\left(2\pi * 20000t + \pi\cos(1000\pi t)\right)$$

$$\frac{ds(t)}{dt} = -2\pi * 20000\sin(2\pi * 20000t) - 1000\pi^2\sin(1000\pi t)$$

⇒ envelop detector process involves rectifying the signal & then low-pass filtering to extract the envelope

$$\Rightarrow \left|\frac{ds(t)}{dt}\right| = 2\pi * 20000\sin(2\pi * 20000t) + 1000\pi^2\sin(1000\pi t)$$

Remove DC Value ⇒ The DC Value is:

$$DC = 2\pi * 20000\sin(2\pi * 20000t)$$

$$y(t) = 1000\pi^2\sin(1000\pi t)$$

⇒ we need to show that y(t) is linearly proportional to the message signal m(t)

$$m(t) = \pi\cos(1000\pi t)$$

$$\frac{dm(t)}{dt} = -1000\pi^2\sin(1000\pi t)$$

Figure 11: Apply ds(t)/dt to an ideal envelope detector

Extract message signal by using phase-locked loop (PLL)

Block Diagram

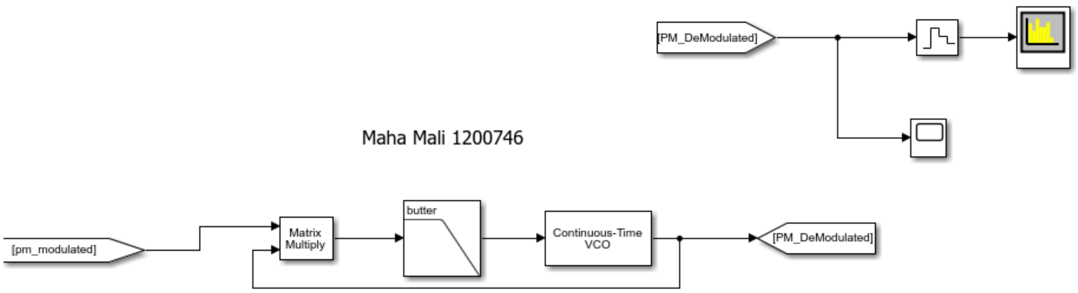


Figure 12: PM Demodulation by PLL Block Diagram

In time Domine

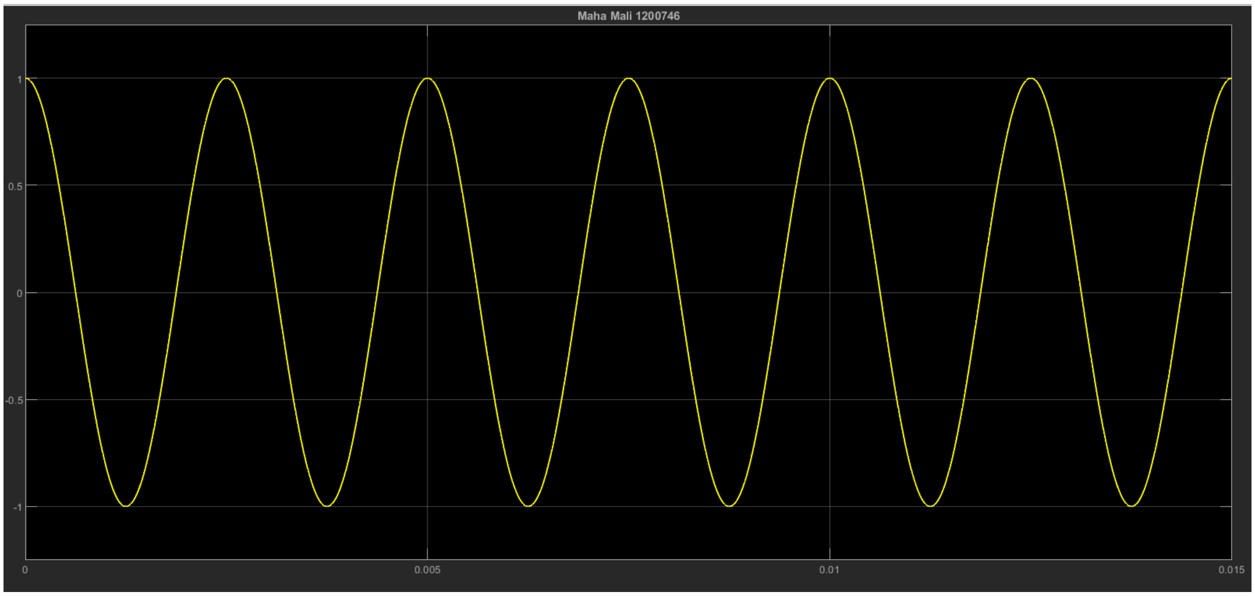


Figure 13: Demodulated signal in time domine

The figure 13 shows the amplitude of the demodulated signal has the same amplitude of message signal which is 1.

In frequency Domine

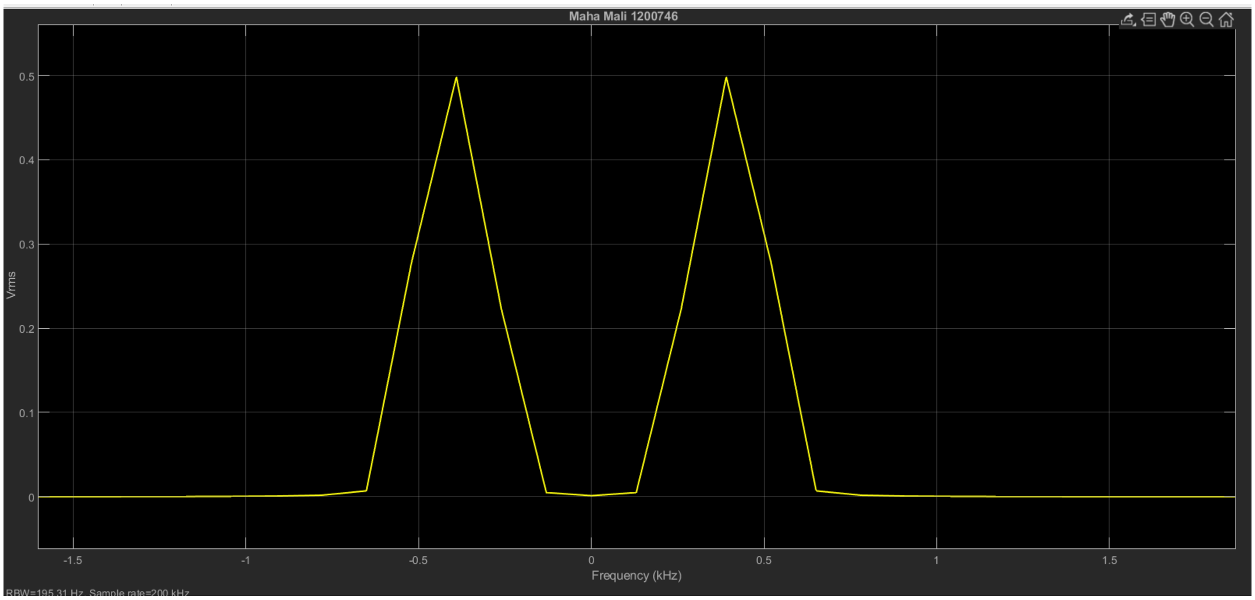


Figure 14: Demodulated signal in frequency domine

The figure show that the demodulated signal has the same frequency of message signal which is 500 Hz.

Extract the message signal by using the envelop detector

Block Diagram

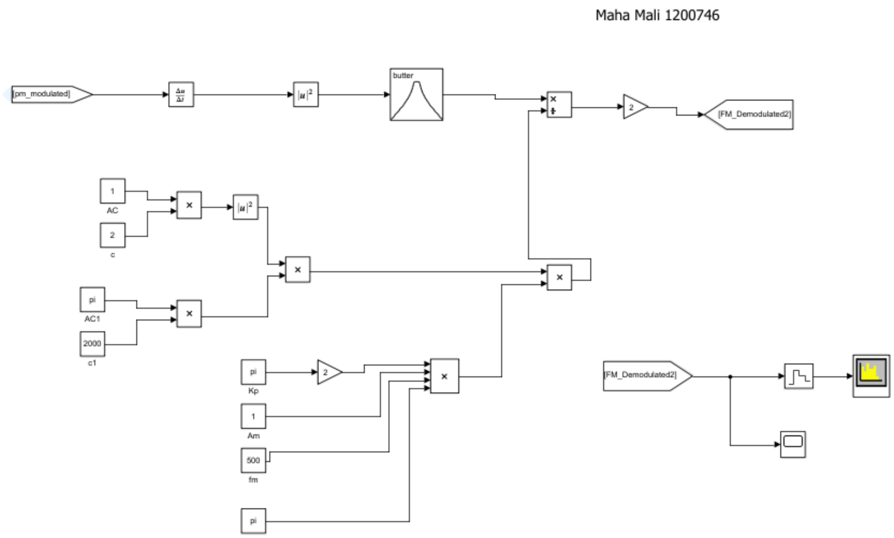


Figure 15: PM Demodulation by using the envelop detector Block Diagram

In Time Domine

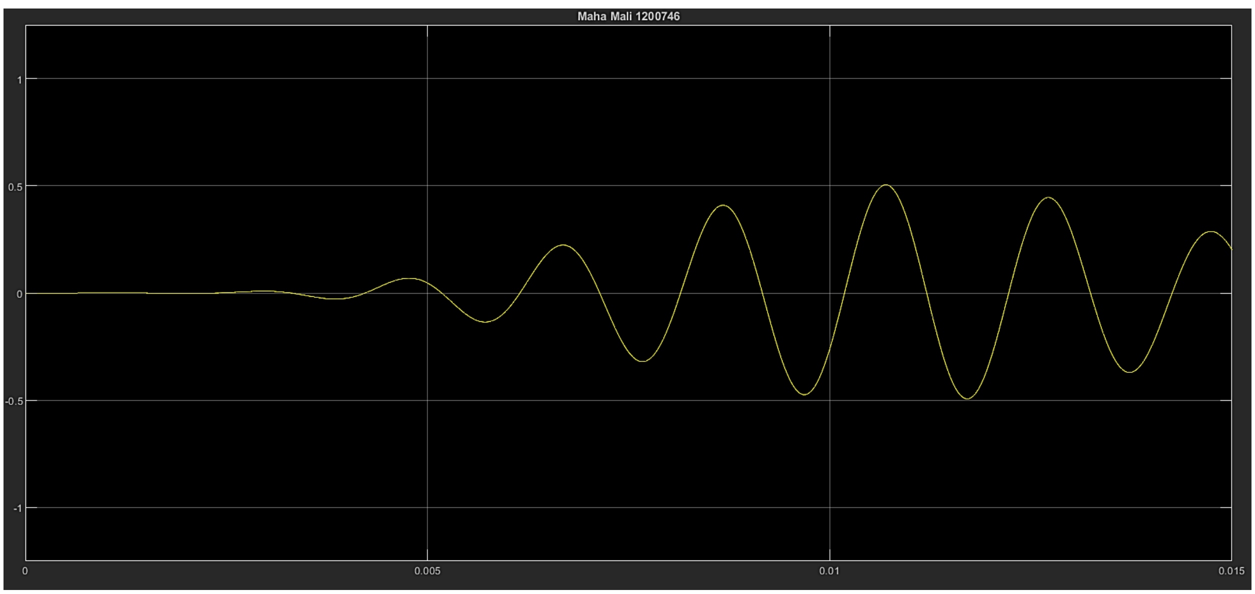


Figure 16: Demodulated signal in time domine

In frequency Domine

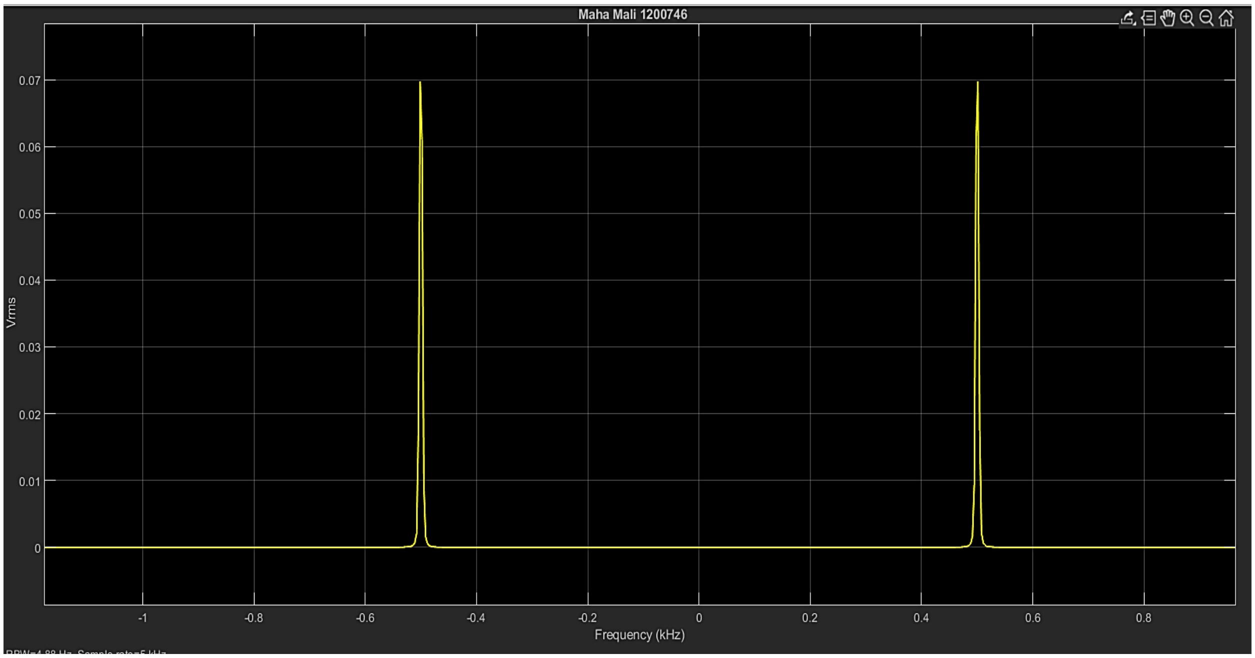


Figure 17: Demodulated signal in time domine

The figure show that the demodulated signal has the same frequency of message signal which is 500 Hz.