FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ENEE 4113, Communication Laboratory

Experiment. 5 Prelab

Phase Modulation (PM)

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Simulation and Data analysis

Extract the message signal m (t) from s (t). [By hand solution].

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1) General formula of AM $S(t) = A_c\,[1 + m(t)]\cos(2\pi f_c t)$

in this case $A_c = 1 \Rightarrow f_c = 20000$ Hz

let $\emptyset = K_p A_m$, assume $A_m = 1$

$\pi = K_p(1)$

$\boxed{K_p = \pi}$

$m(t) = \cos(2\pi\, 500\, t)$

Figure 1: Extract MSG signal by hand calculations.

PM Modulation.

The figure below shows the block diagram for the PM modulation:

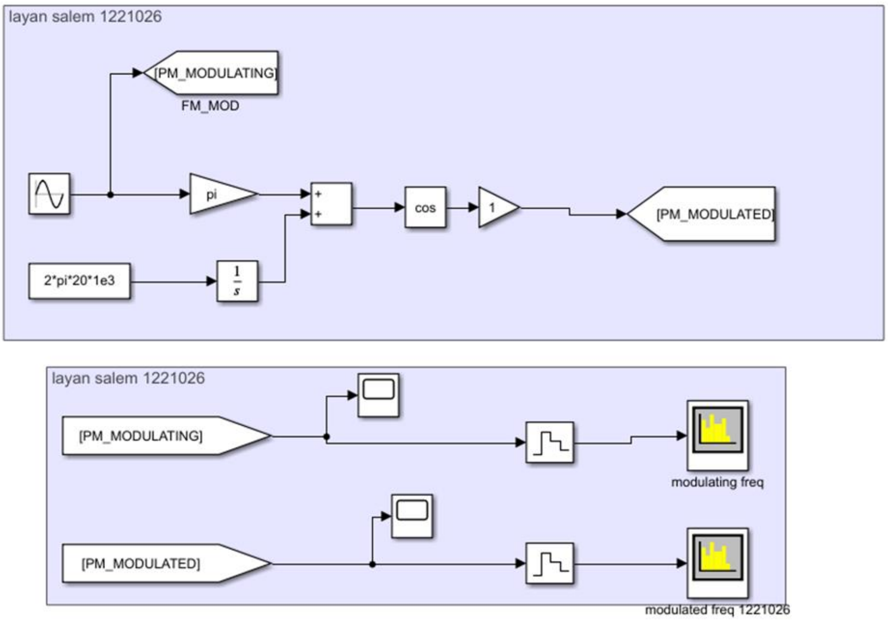


Figure 2: PM modulation block.

Plot 5 cycle from message signal m (t) and s (t) versus t.

→Time domain.

The message signal m (t) and modulated signal s (t) in time domain are shown below:

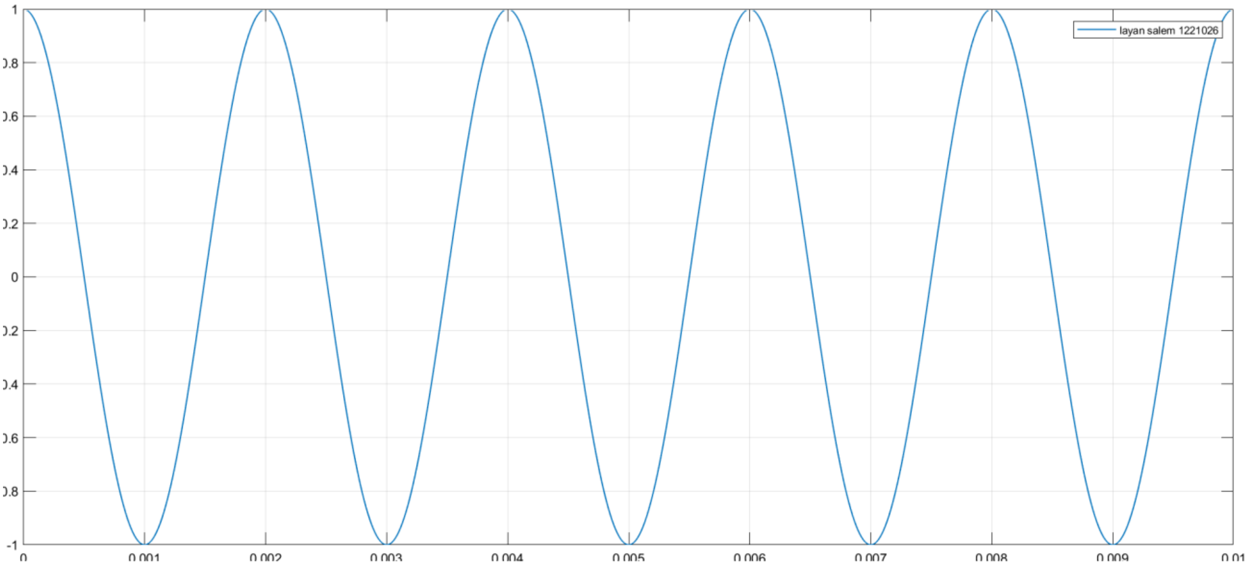


Figure 3: MSG signal in time domain

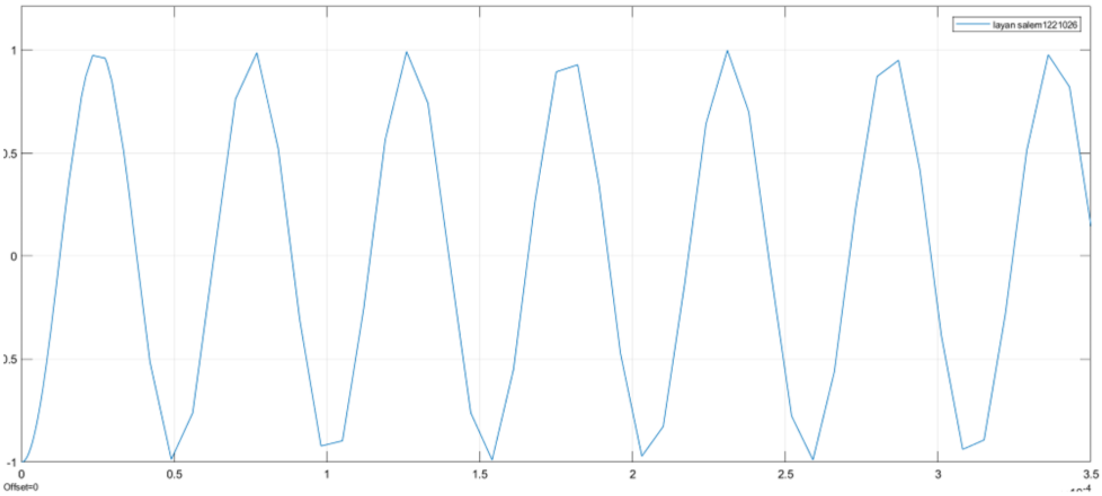


Figure 4: Modulated signal in time domain.

→Frequency domain.

The message signal and modulated signal in frequency domain are shown below:

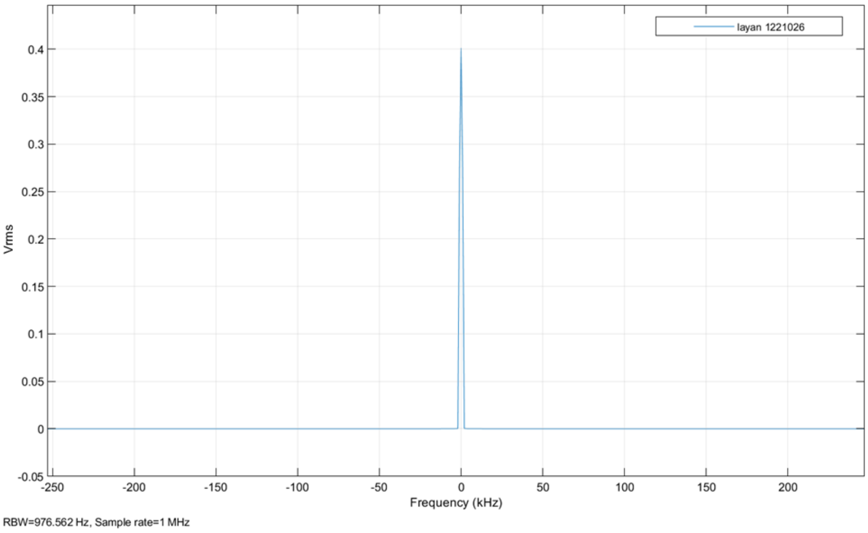


Figure 5: MSG signal in frequency domain.

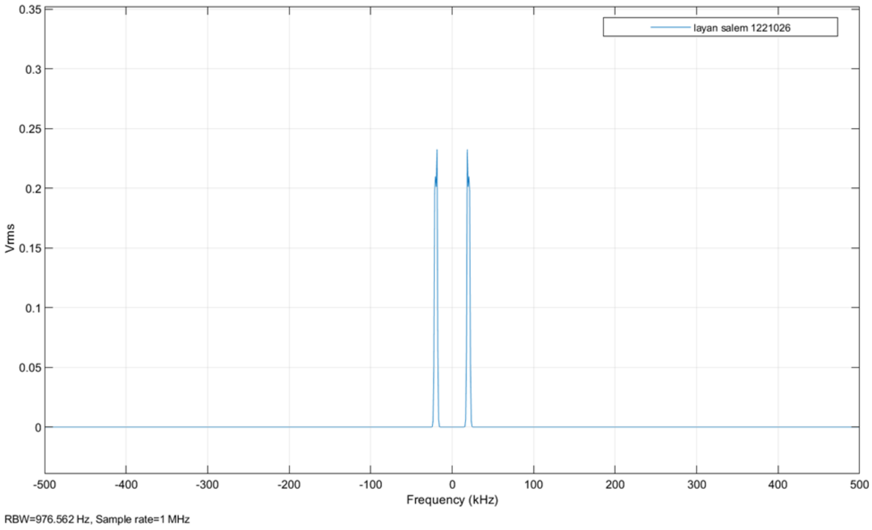


Figure 6 Modulated signal in frequency domain.

Differentiate s (t) with respect to t and plot ds (t)/dt. Notice how this operation transforms a PM waveform into an AM waveform.

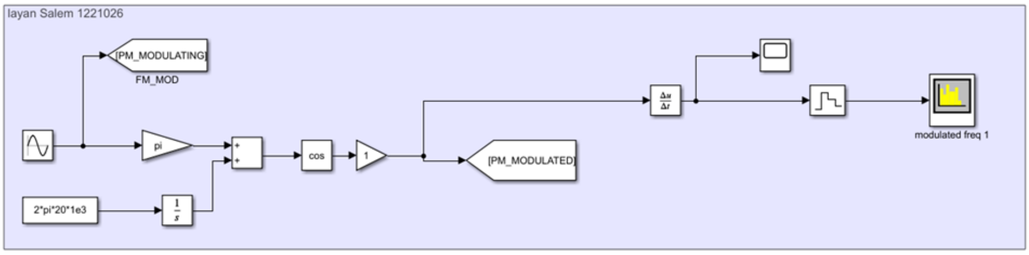


Figure 7: Differentiate s (t) block.

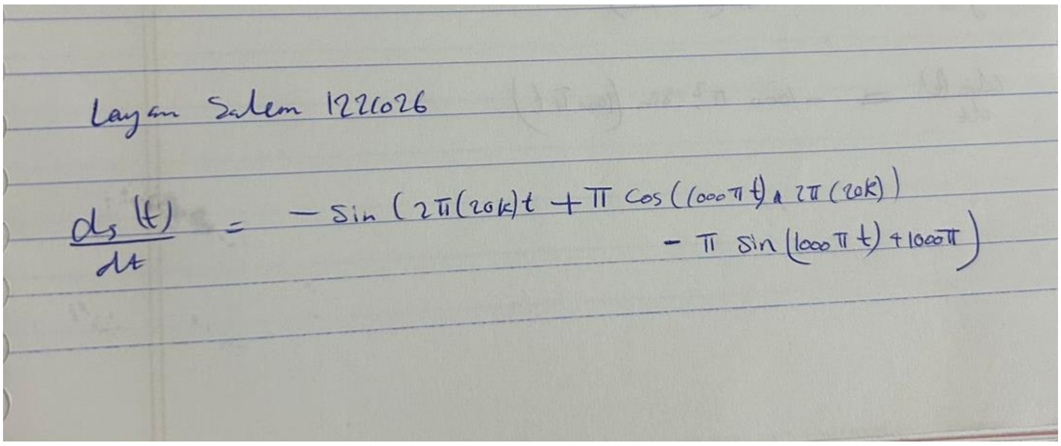


Figure 8: Differentiate s (t) with respect to t.

$\frac{d_s\,(t)}{dt}$ in time domain

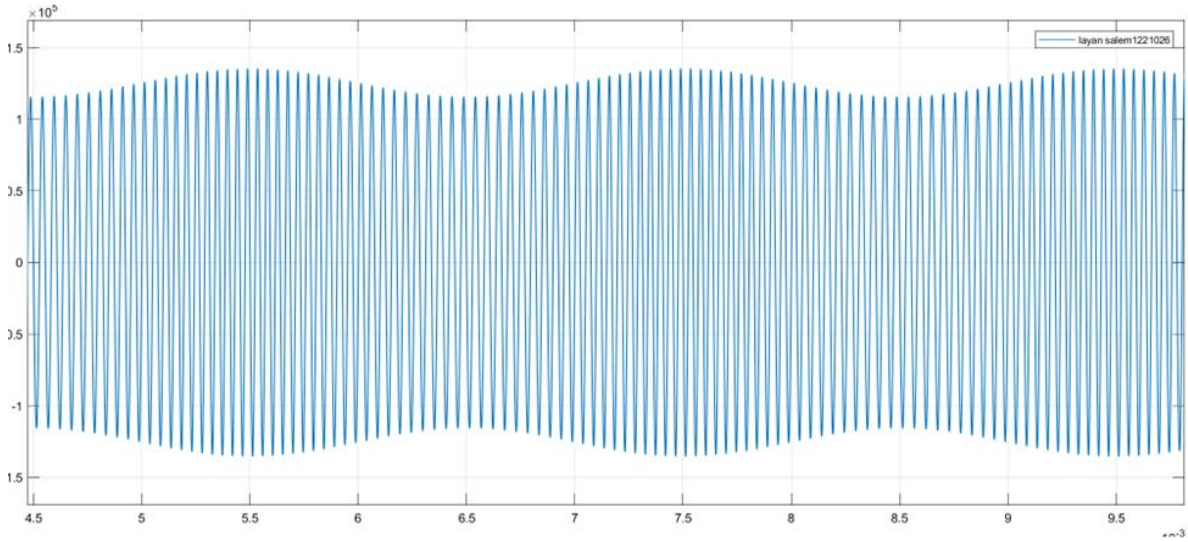


Figure9: ds (t)/dt in time domain.

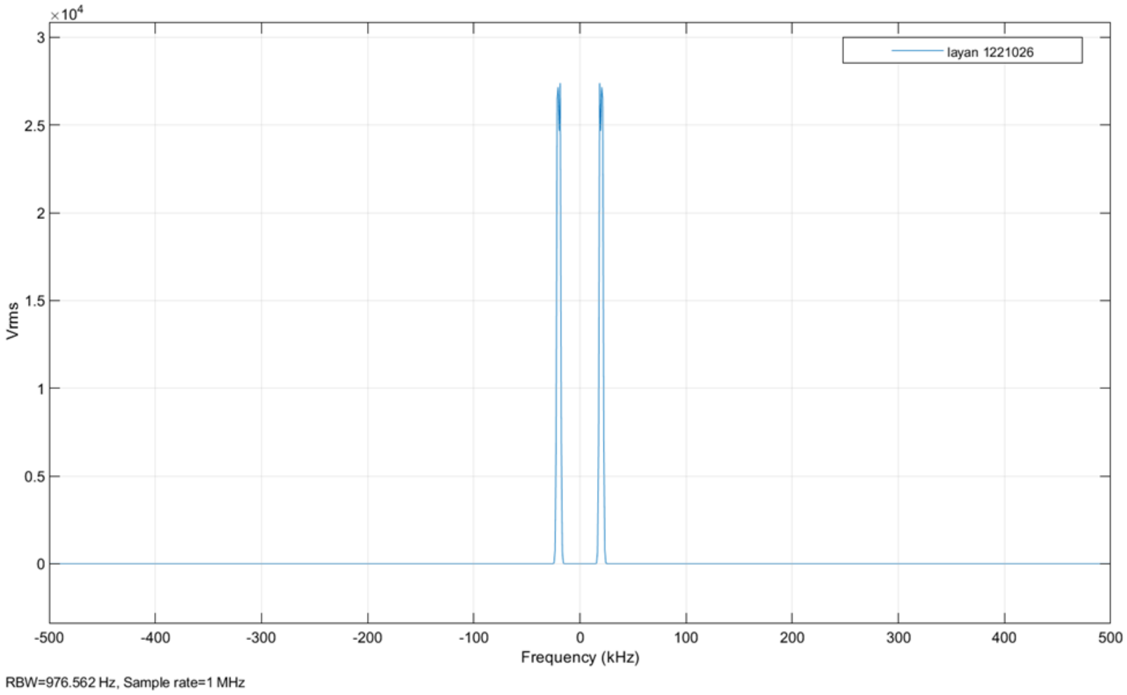
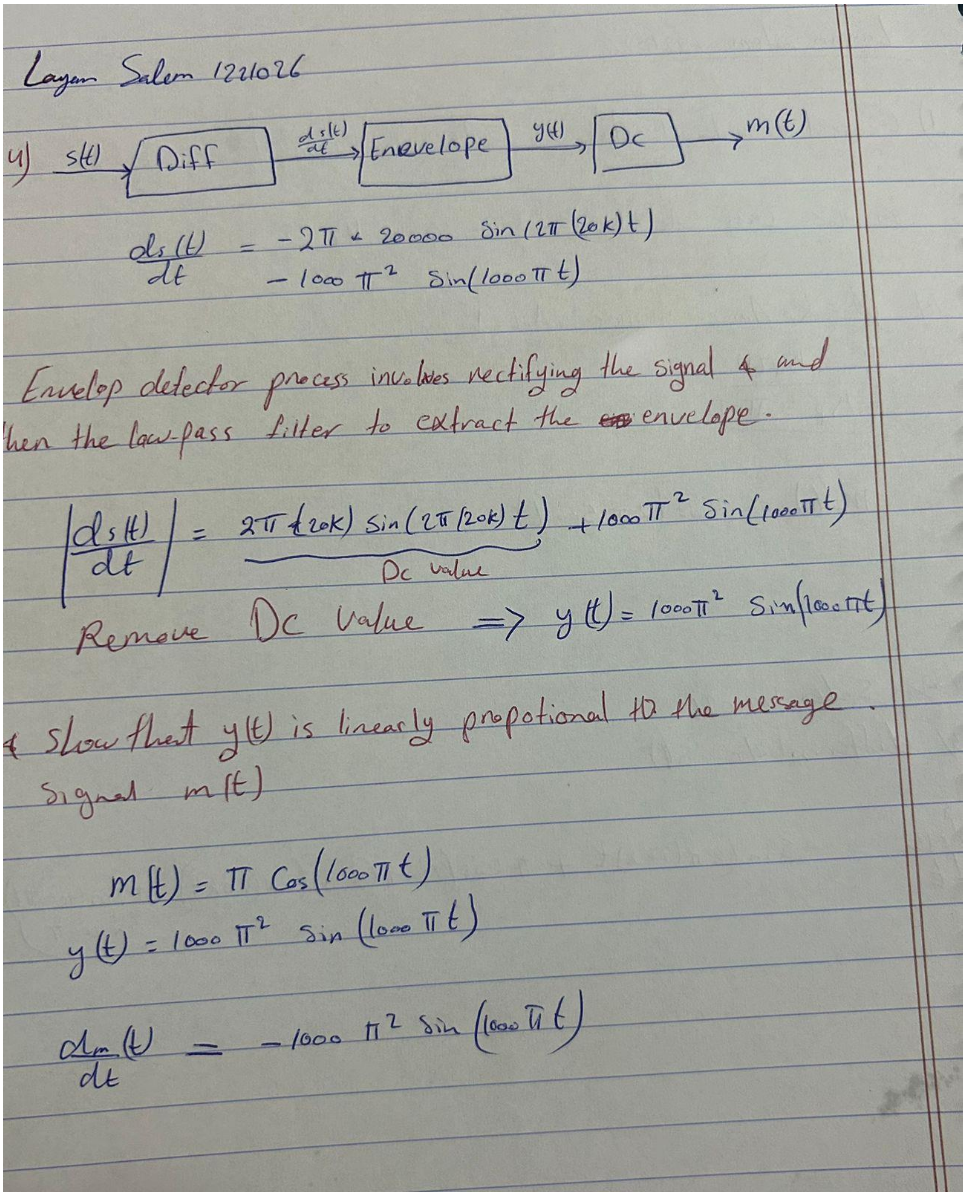


Figure 10 ds (t)/dt in frequency domain.

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, subtract the dc term and show that the Detector’s output is linearly proportional to m (t).



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4) $s(t) \rightarrow \boxed{\text{Diff}} \xrightarrow{\frac{ds(t)}{dt}} \boxed{\text{Envelope}} \xrightarrow{y(t)} \boxed{\text{Dc}} \rightarrow m(t)$

$$\frac{ds(t)}{dt} = -2\pi * 20000 \sin(2\pi(20k)t) - 1000\pi^2 \sin(1000\pi t)$$

Envelop detector process involves rectifying the signal ~~&~~ and then the low-pass filter to extract the envelope.

$$\left|\frac{ds(t)}{dt}\right| = \underbrace{2\pi(20k)\sin(2\pi(20k)t)}_{\text{Dc value}} + 1000\pi^2 \sin(1000\pi t)$$

Remove Dc Value $\Rightarrow y(t) = 1000\pi^2 \sin(1000\pi t)$

* Show that $y(t)$ is linearly propotional to the message signal $m(t)$

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

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

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

Figure11: Envelope detector extraction by hand solution.

PM Demodulation by PLL.

The figure below shows the block diagram for the PM demodulation using PLL:

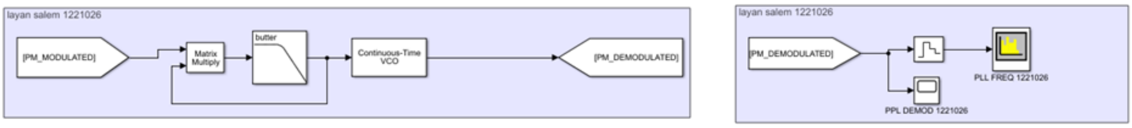

Figure 12: PM demodulation by PLL block.

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

→Time domain.

The message signal m (t) in time domain is shown below:

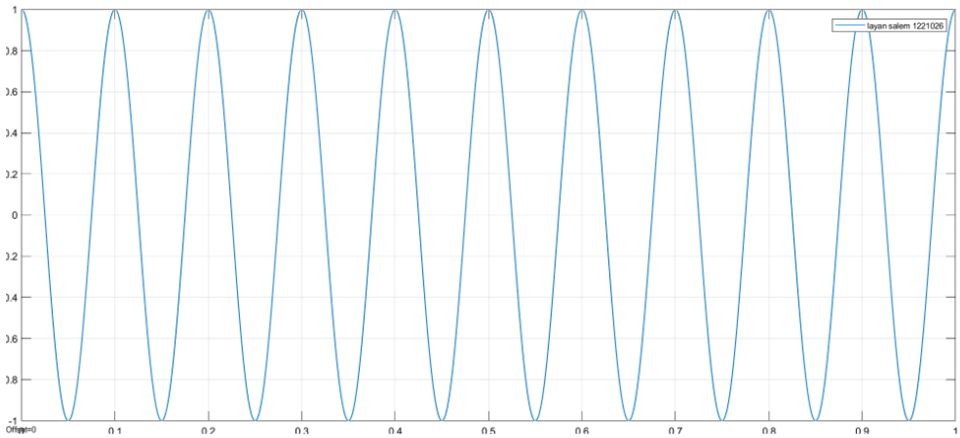

Figure 113: MSG signal in time domain by PLL.

→Frequency domain.

The message signal m(t) in frequency domain are shown below:

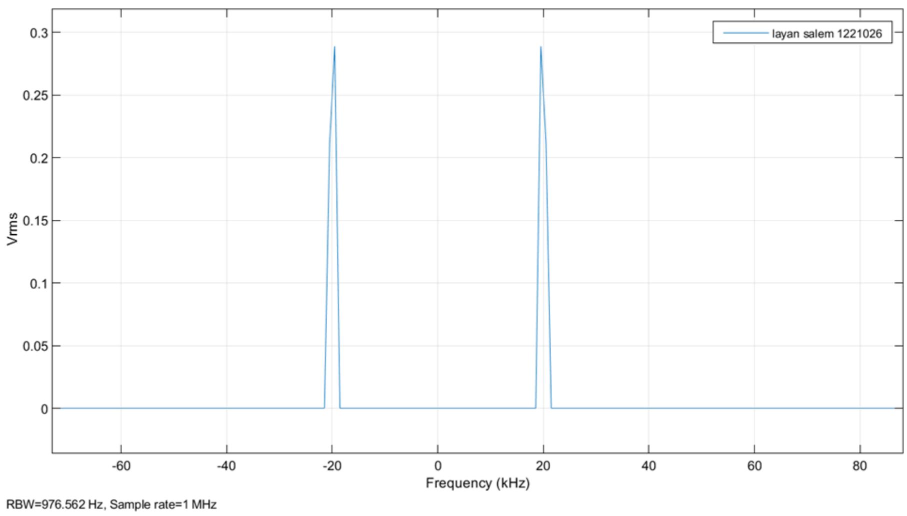

Figure 14: MSG signal in frequency domain using PLL.

PM Demodulation by envelop detector.

The figure below shows the block diagram for the PM demodulation using envelop detector:

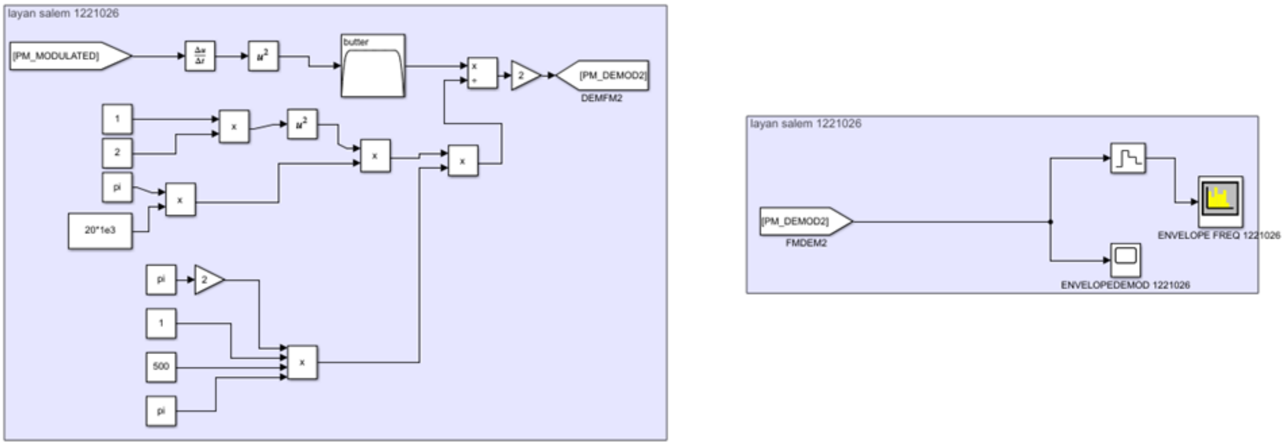

Figure 14: PM demodulation by envelope detector block.

Extract message signal by using envelope detector.

→Time domain.

The message signal m (t) in time domain is shown below:

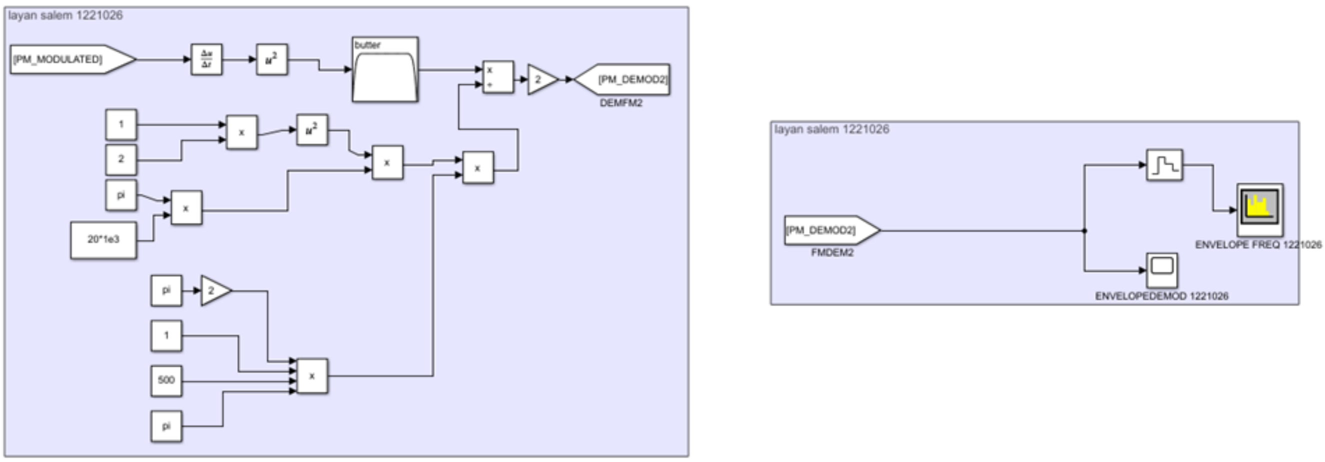

Figure 16: MSG signal in time domain by Envelope detector.

→Frequency domain.

The message signal m(t) in frequency domain are shown below:

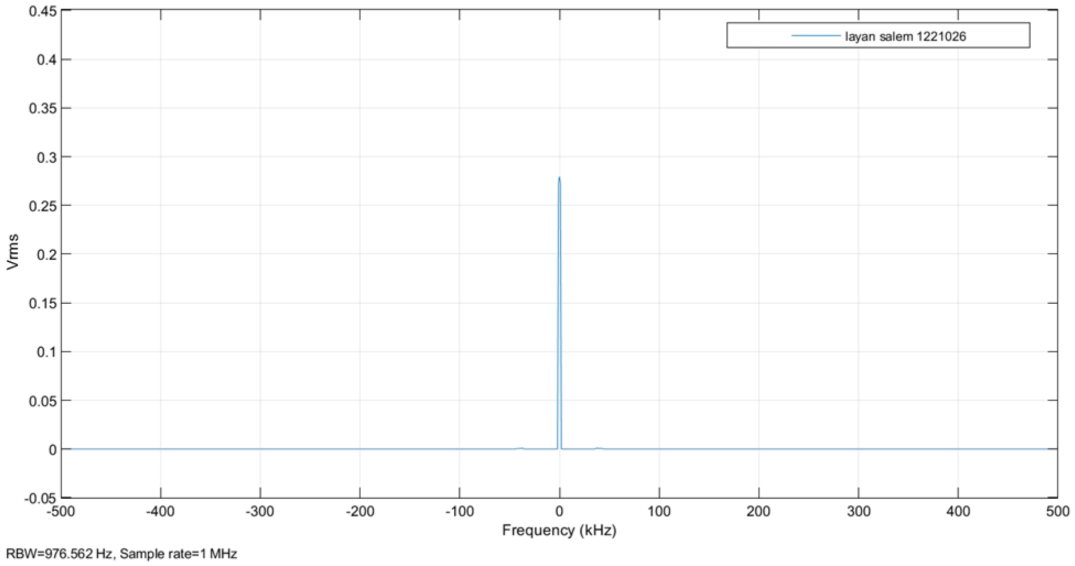

Figure 17: MSG signal in frequency domain using Envelope detector.

The demodulation process involved differentiating the PM signal to transform it into an amplitude-modulated waveform. The envelope detector extracted the original message signal from this transformed waveform. The time-domain graph showed a close match to the expected message signal, with some minor distortion likely introduced by the VCO block used in MATLAB Simulink.