

COMMUNICATIONS LAB

ENEE4113

Experiment #:2

Experiment title: Double-side and Single-side Band Modulation

PreLab 2

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Section: 2

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1. Message Signal $m(t) = 0.85\cos(2\pi 1000t)$

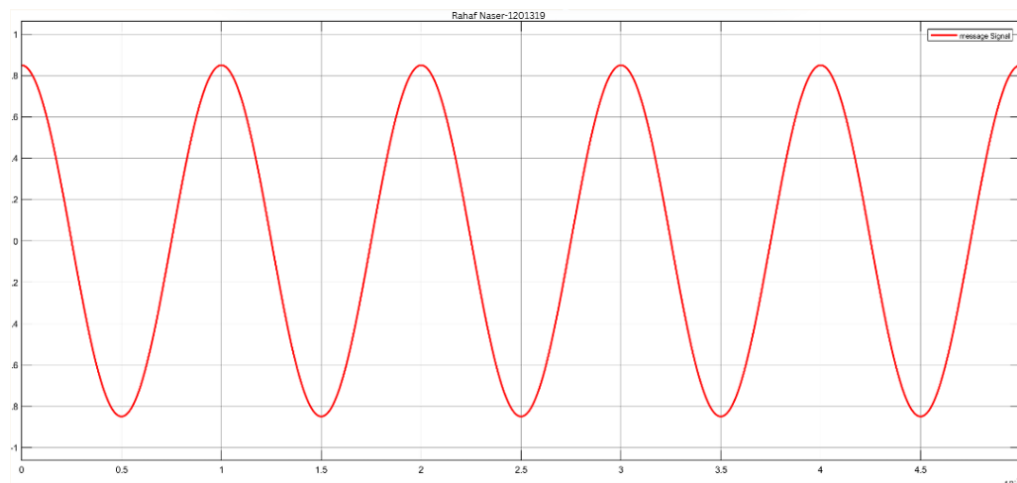


Figure 1: Message signal in the time domain

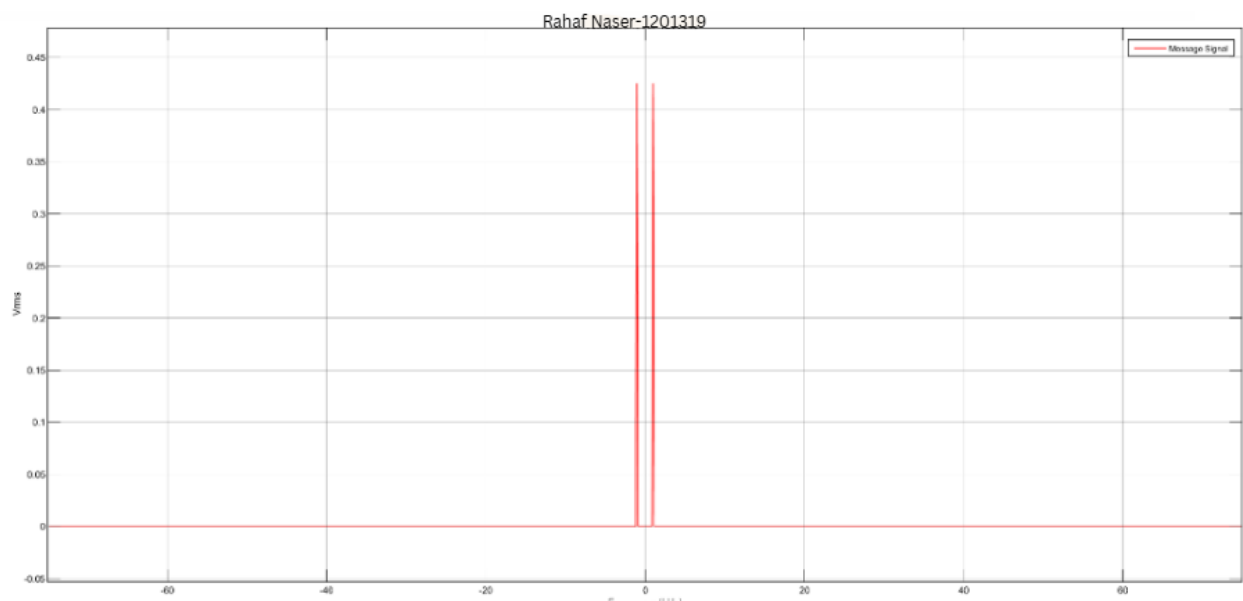


Figure 2: Message signal in the frequency domain

Message Signal Settings:

Amplitude:	<input type="text" value="0.85"/>	⋮
Bias:	<input type="text" value="0"/>	⋮
Frequency (rad/sec):	<input type="text" value="1000*2*pi"/>	⋮
Phase (rad):	<input type="text" value="pi/2"/>	⋮

2. Carrier Signal $c(t) = \cos(2\pi 1500t)$

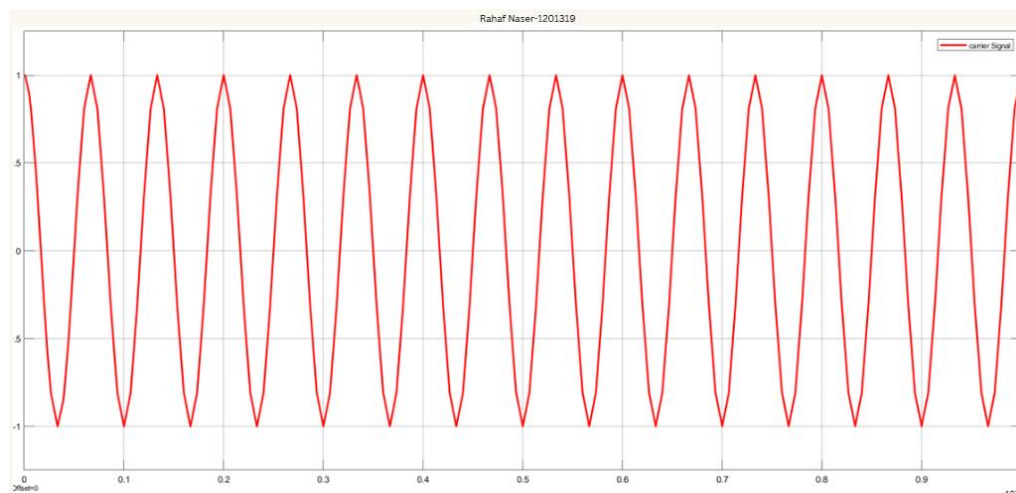


Figure 3: Carrier Signal in the time domain

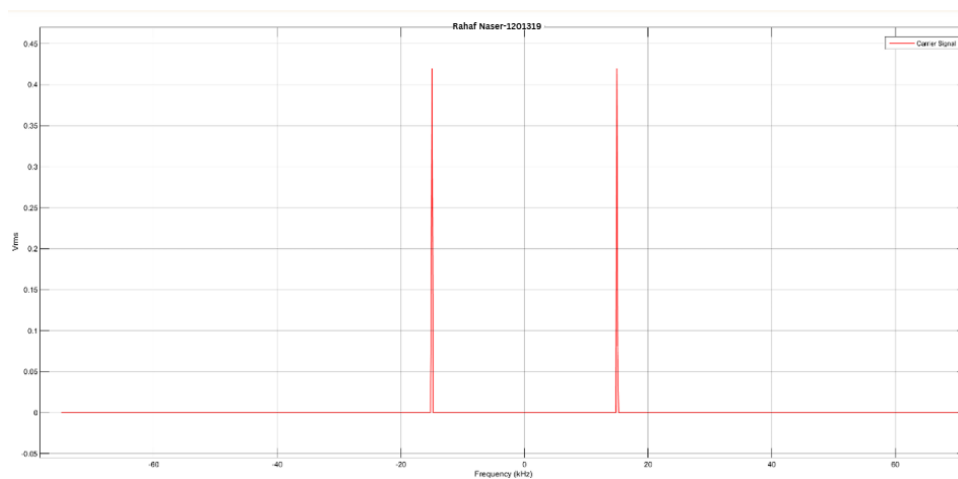


Figure 4: Carrier Signal in the frequency domain

Carrier Signal Settings:

Amplitude:	1
Bias:	0
Frequency (rad/sec):	$15000 \cdot 2 \cdot \pi$
Phase (rad):	$\pi/2$

3. Modulation and Demodulation of DSB-SC Modulation Block

DSB-SC Modulation block

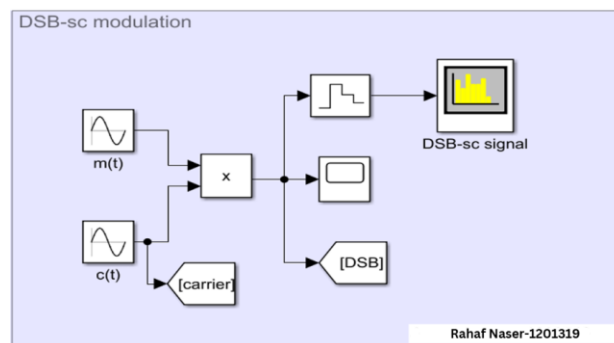


Figure 5: DSB-SC Modulation block

Modulated Signal of DSB-SC - $s(t)=m(t)c(t)$

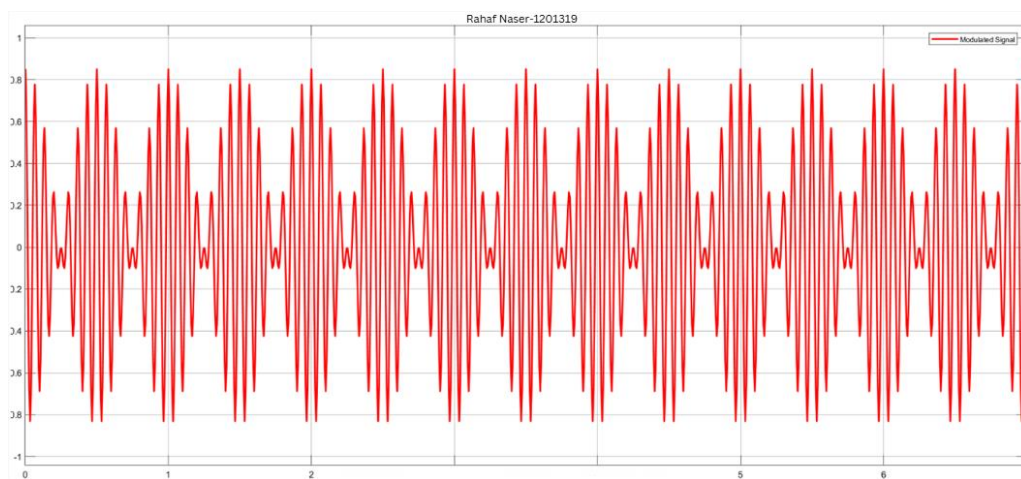


Figure 6: Modulated Signal of DSB-SC in the time domain

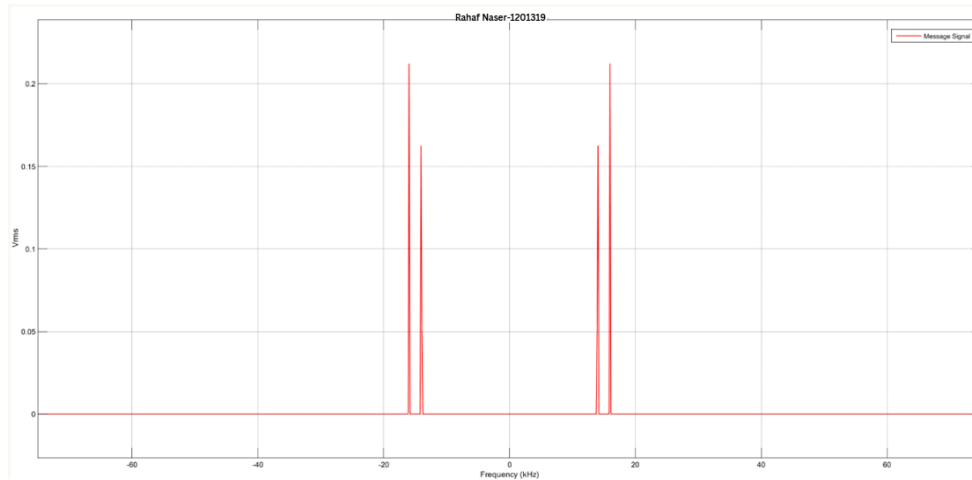


Figure 7: Modulated Signal of DSB-SC in the frequency domain

DSB-SC Demodulation Block:

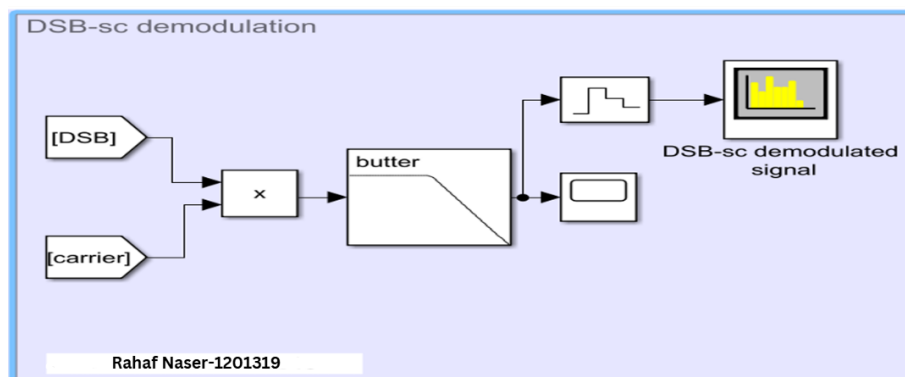


Figure 8: DSB-SC Demodulation Block

Demodulated Signal of DSB-SC:

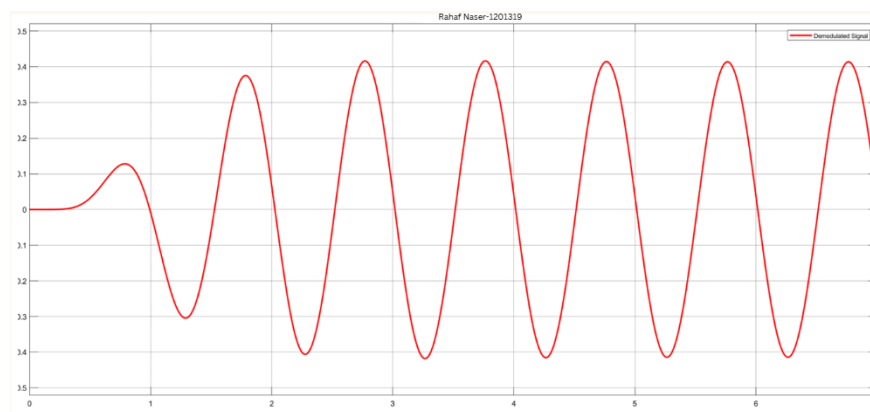


Figure 9: Demodulated Signal of DSB-SC in the time domain

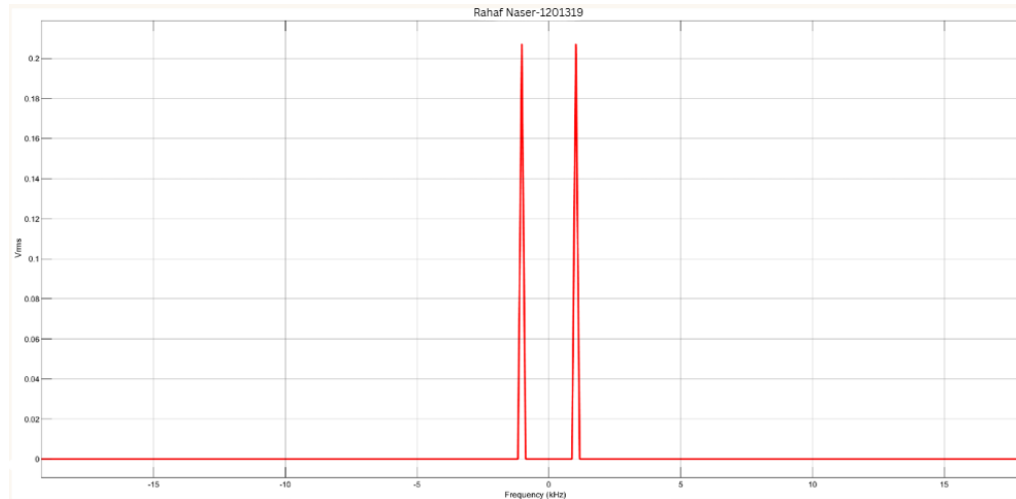


Figure 10: Demodulated Signal of DSB-SC in the frequency domain

4. Modulation and Demodulation of SSB-SC

4.1. SSB-SC Modulation Block – Method 1

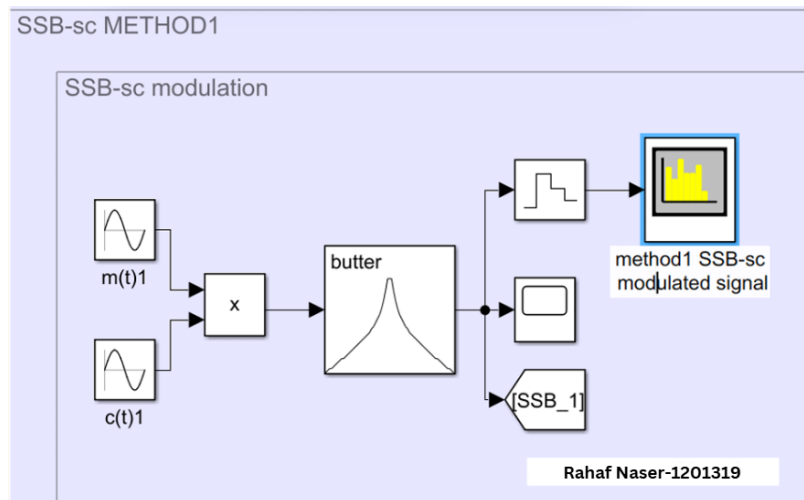


Figure 11: SSB-SC Modulation Block

Bandpass Filter Settings:

Filter type:	Bandpass
Filter order:	8
Lower passband edge frequency (rad/s):	$2\pi \cdot 13500$
Upper passband edge frequency (rad/s):	$2\pi \cdot 14500$

Modulated Signal - $s(t) = \frac{AmAc}{2} \cos(2\pi(fc - fm)t)$, for lower side band – Method 1

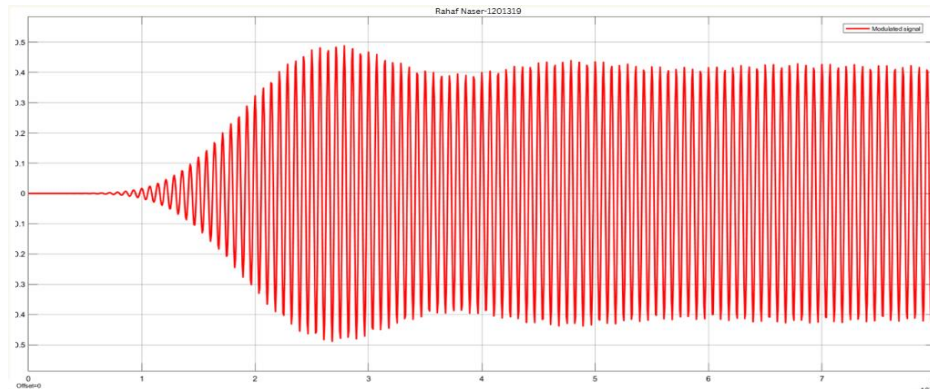


Figure 12: Modulated signal of SSB-SC in the time domain

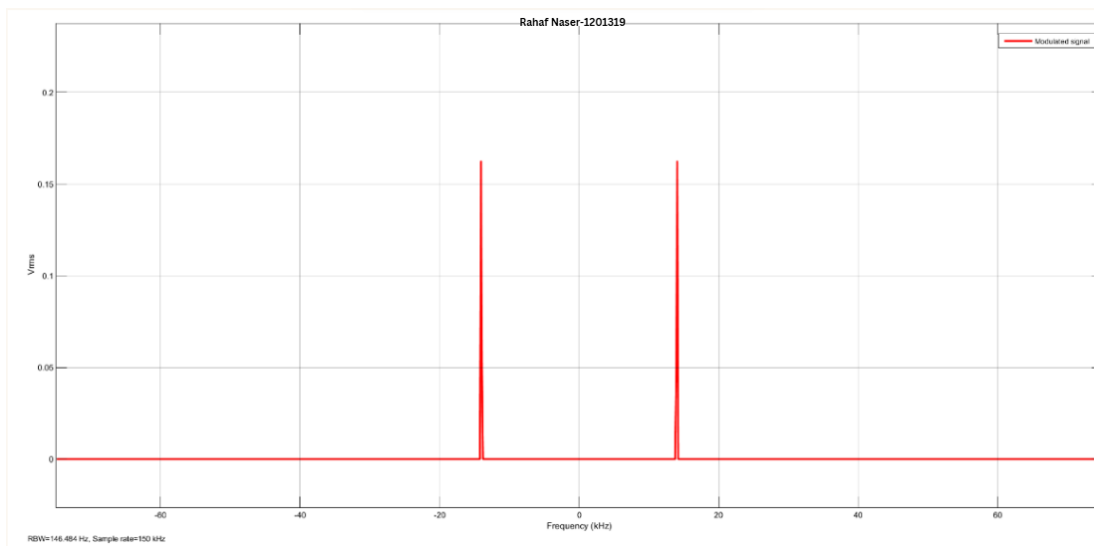


Figure 13: Modulated signal of SSB-SC in the frequency domain

Demodulation of SSB-SC, Method 1 :

Demodulation Block – Method 1:

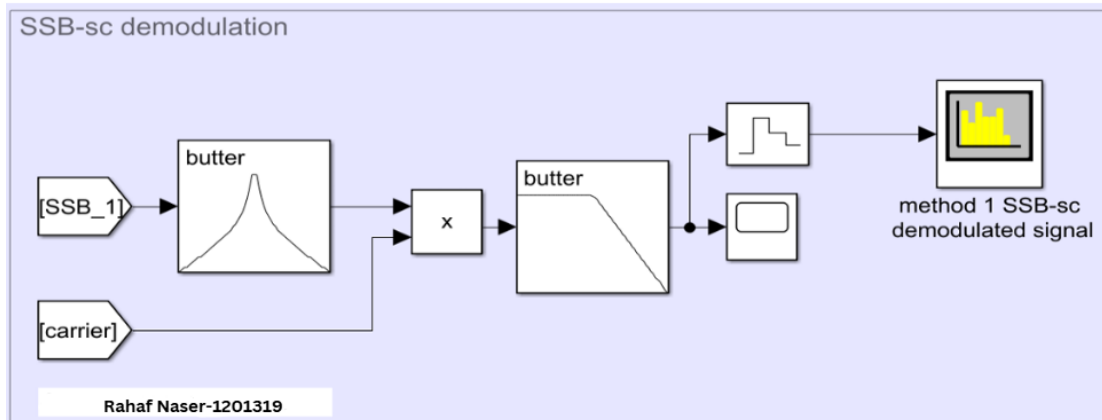


Figure 14: Demodulation Block – Method 1

Filter Settings:

Filter order:
8

Lower passband edge frequency (rad/s):
 $2\pi \times 13500$

Upper passband edge frequency (rad/s):
 $2\pi \times 14500$

Filter order:
8

Passband edge frequency (rad/s):
 $2\pi \times 1200$

Demodulated Signal:

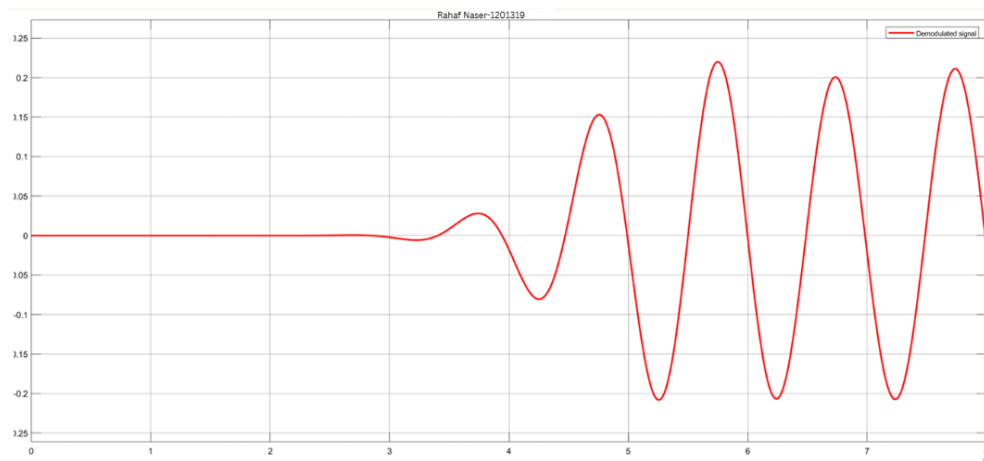


Figure 15: Demodulated signal Method 1 in the time domain

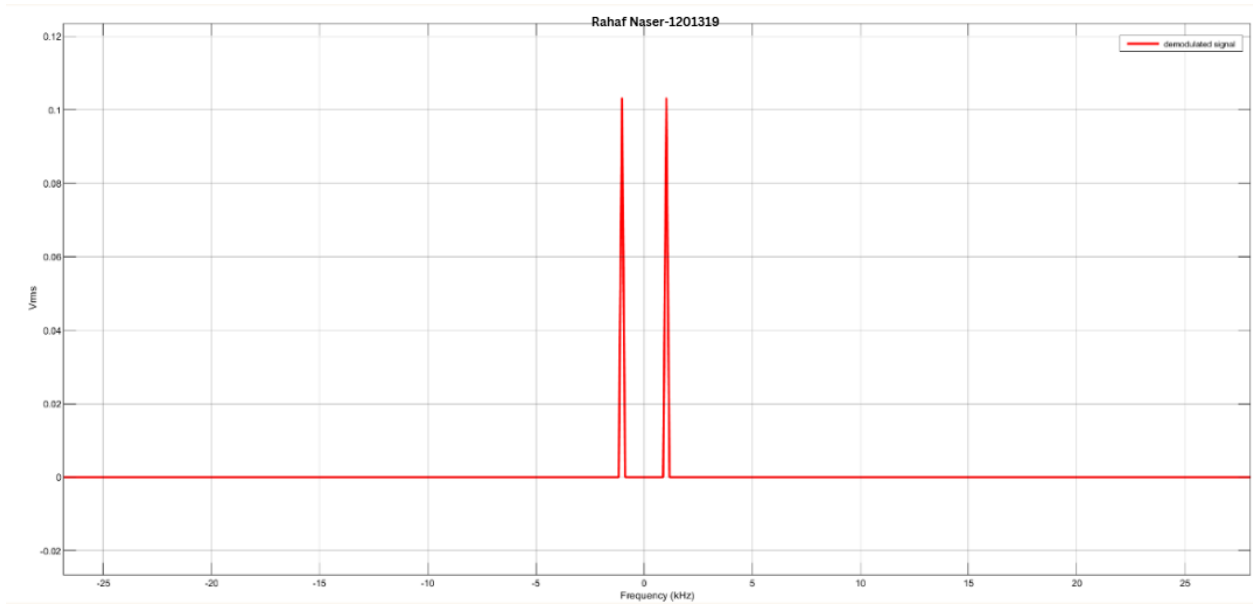


Figure 16: Demodulated signal Method 1 in the frequency domain

4.2. Method2: Modulation of SSB-SC, Method 2

SSB-SC Modulation Block – Method 2

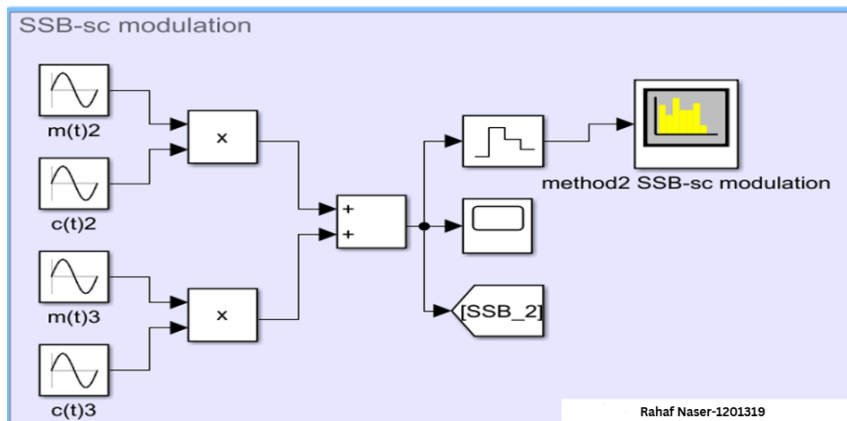


Figure 17: SSB-SC Modulation Block – Method 2

Modulated Signal for SSB-SC lower side band- $s(t) = \frac{AmAc}{2} \cos(2\pi(fc - fm)t)$ – Method 2

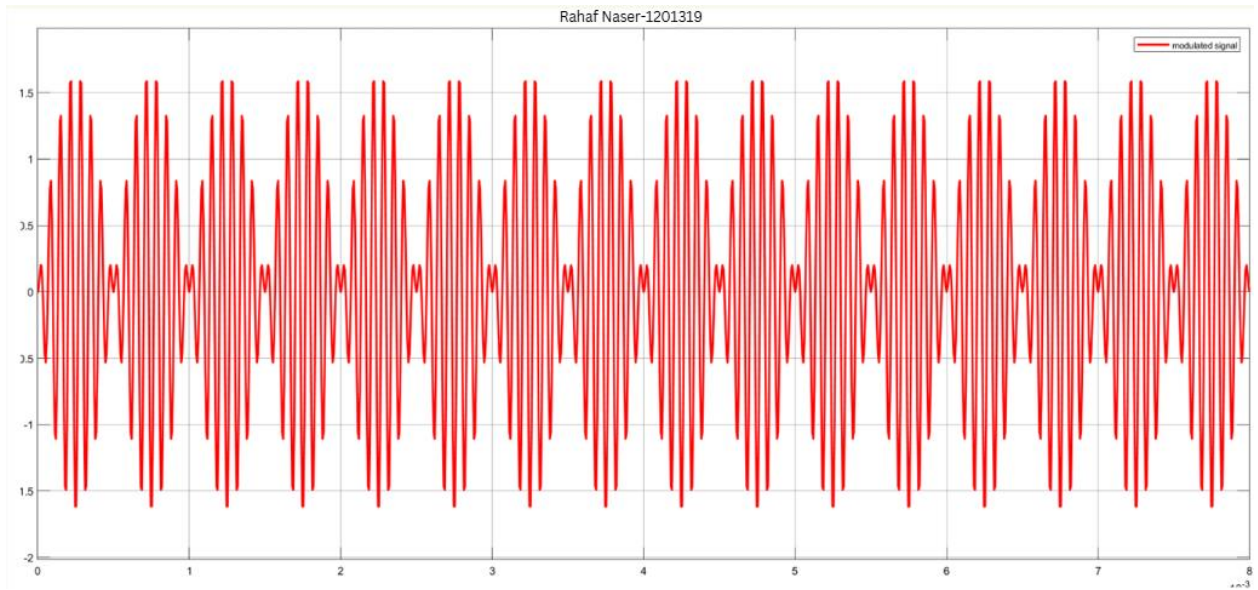


Figure 18: Modulated signal for SSB-SC in the time domain

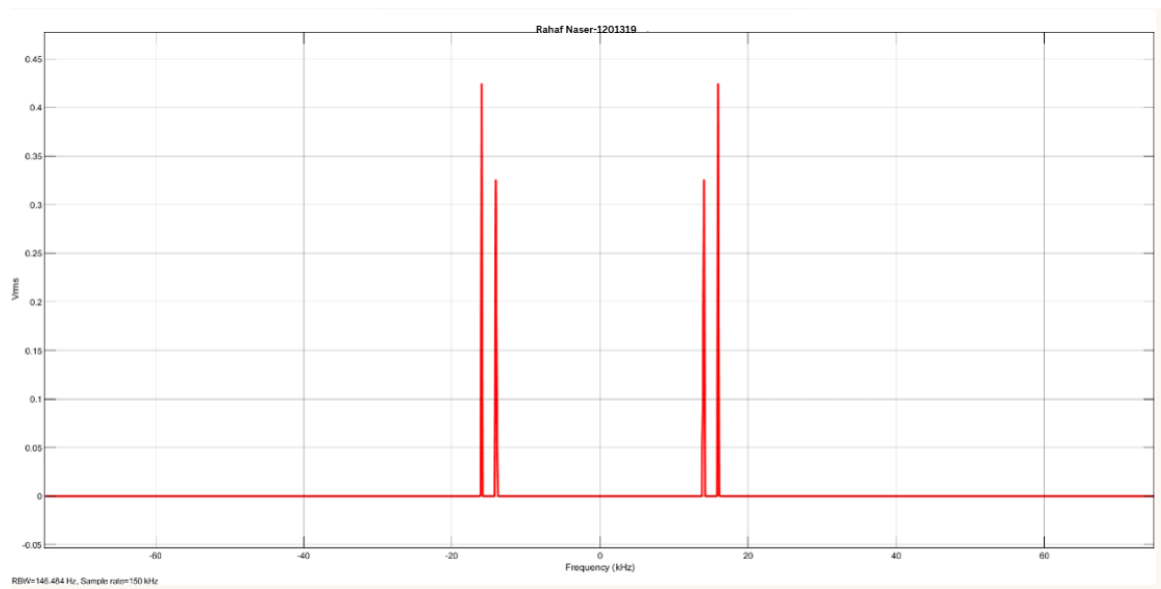


Figure 19: Modulated signal for SSB-SC in the frequency domain

SSB-SC Demodulation Block – Method 2:

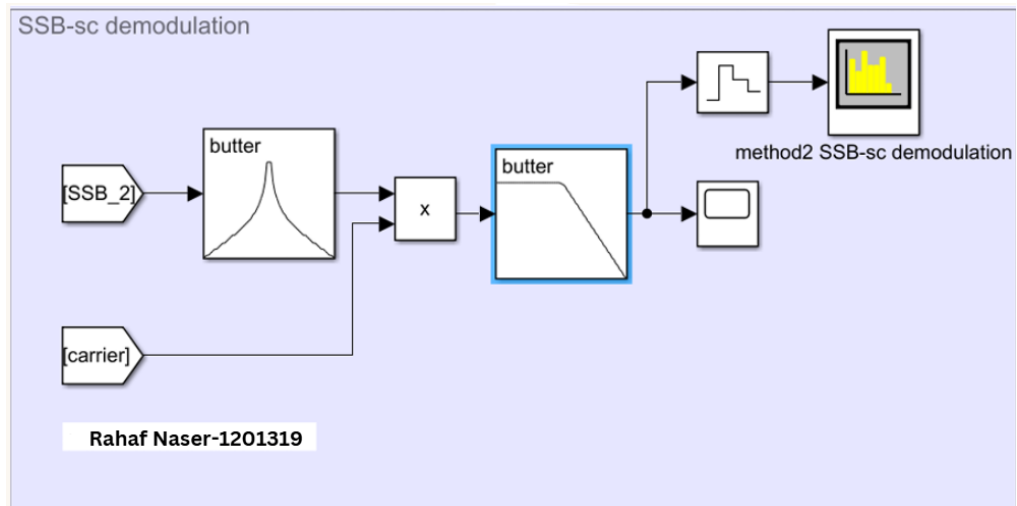


Figure 20: SSB-SC Demodulation Block – Method 2

Filter Settings:

Filter type:	Bandpass
Filter order:	8
Lower passband edge frequency (rad/s):	$2\pi \times 13500$
Upper passband edge frequency (rad/s):	$2\pi \times 14500$

Filter type:	Lowpass
Filter order:	8
Passband edge frequency (rad/s):	$2\pi \times 1200$

Demodulation of SSB-SC, Method 2:

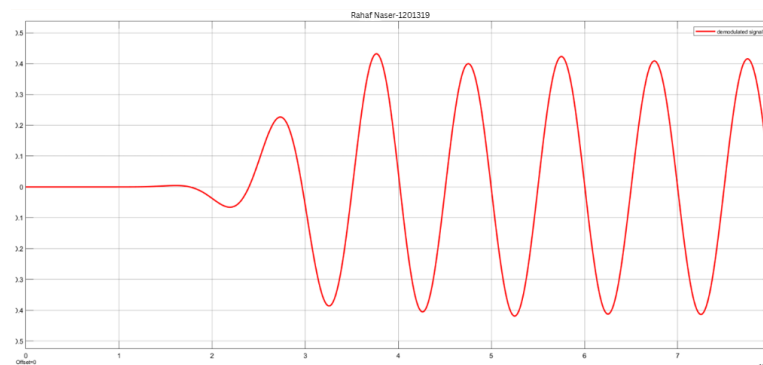


Figure 21: Demodulation of SSB-SC, Method 2 in the time domain

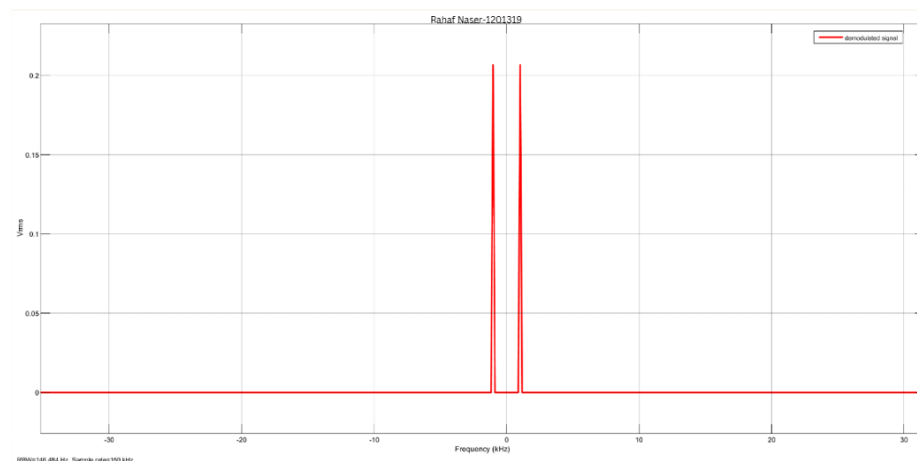


Figure 22: Demodulation of SSB-SC, Method 2 in the frequency domain

5. All System Blocks

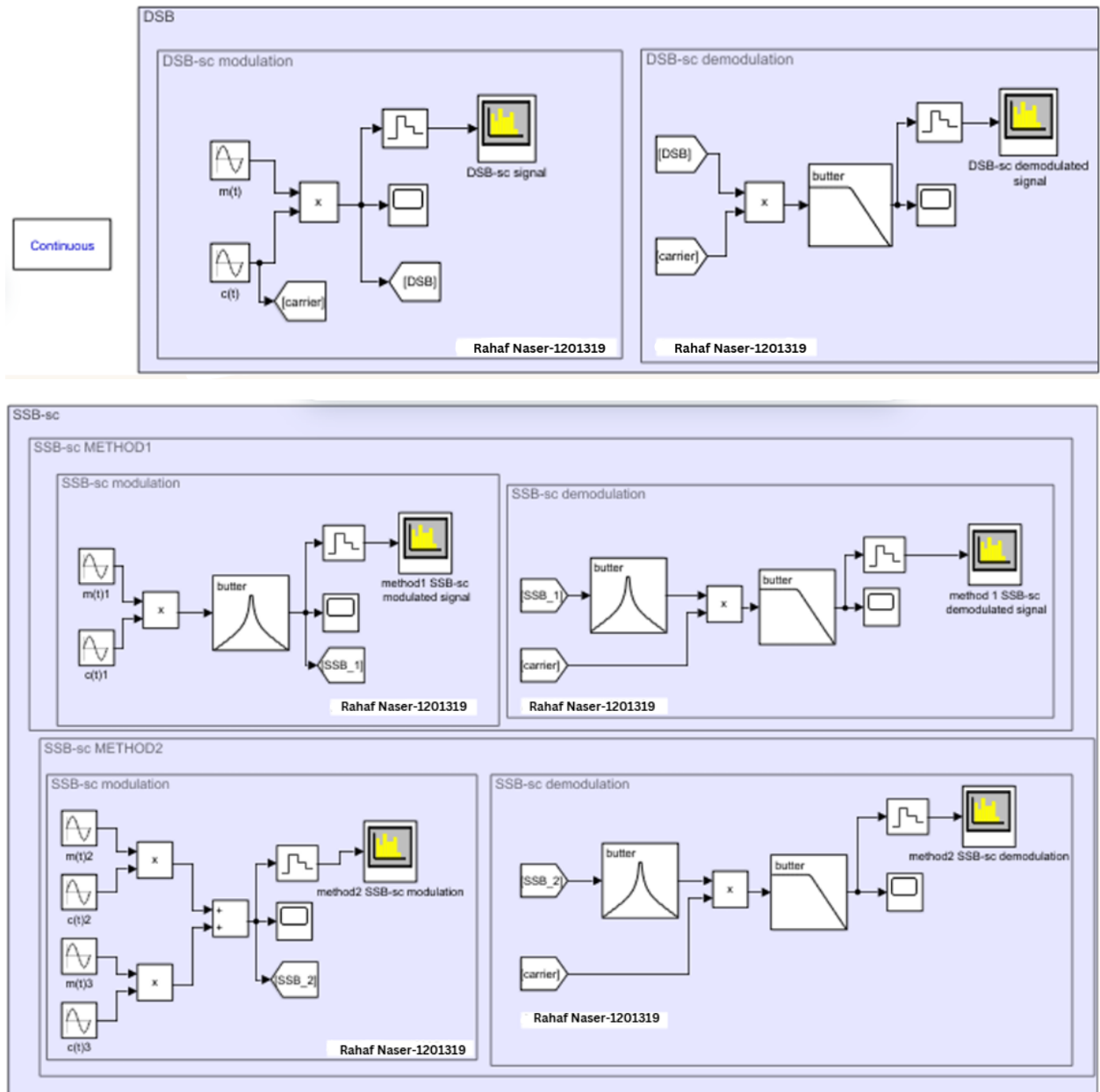


Figure 23: All System Blocks

Here's a discussion of the results for each part of experiment on Double-Sideband and Single-Sideband Modulation:

1. Message Signal

- **Time Domain Analysis:** The waveform shows a cosine wave at a frequency of 1000 Hz.
- **Frequency Domain Analysis:** The spectrum confirms a single frequency component at 1000 Hz.

2. Carrier Signal

- **Time Domain Analysis:** A high-frequency cosine wave at 15 kHz is observed.
- **Frequency Domain Analysis:** The spectrum indicates a sharp peak at 15 kHz.

3. DSB-SC Modulation and Demodulation

- **Modulated Signal:**
 - The multiplication of $m(t)m(t)$ and $c(t)c(t)$ results in a Double-Sideband Suppressed Carrier (DSB-SC) signal.
 - **Time Domain:** The modulated signal oscillates with the carrier frequency.
 - **Frequency Domain:** The spectrum shows two symmetric sidebands at 15000 ± 1000 Hz (14 kHz and 16 kHz).
- **Demodulation:**
 - By multiplying with the same carrier and applying a low-pass filter, the original message signal is recovered.
 - **Time Domain:** The demodulated waveform resembles the original message signal.
 - **Frequency Domain:** A peak is observed at 1000 Hz, indicating successful recovery.

4. SSB-SC Modulation and Demodulation

Method 1

- **Modulation:**
 - One of the sidebands (upper or lower) is filtered out.
 - **Time Domain:** The signal appears similar to DSB-SC but with lower power.
 - **Frequency Domain:** Only one sideband is present, either at 14 kHz (LSB) or 16 kHz (USB).
- **Demodulation:**
 - Using a coherent detector and filtering, the original message is retrieved.
 - **Time Domain:** The waveform is a clean reconstruction of $m(t)$.
 - **Frequency Domain:** A peak appears at 1000 Hz.

Method 2

- **Modulation:**
 - Another approach is used to suppress one sideband.
 - **Time Domain & Frequency Domain:** Results are similar to Method 1.
- **Demodulation:**
 - Filtering and mixing techniques are applied.
 - **Time Domain:** Signal recovery is comparable to Method 1.
 - **Frequency Domain:** The peak at 1000 Hz confirms successful demodulation.

5. Overall System Performance

- DSB-SC requires both sidebands for transmission, while SSB-SC is more bandwidth-efficient.
- SSB-SC methods produced similar results but may have different complexities in implementation.
- Demodulation in all cases successfully recovered the original message signal.