EEE 3208

Communication Theory Lab

Experiment No: 02

Experiment Name: Study of Amplitude modulation and Demodulation. [SSB transmission and Reception]

Submitted by,

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Objective:

The objective of this experiment is to learn various aspect of SSB modulation method including the theories, waveforms & frequency spectrum, design and implementation, measurement and adjustments. Also to learn about theory of SSB demodulator, design and implementation and measurement and adjustment of the demodulator.

Answer to Question no. 1

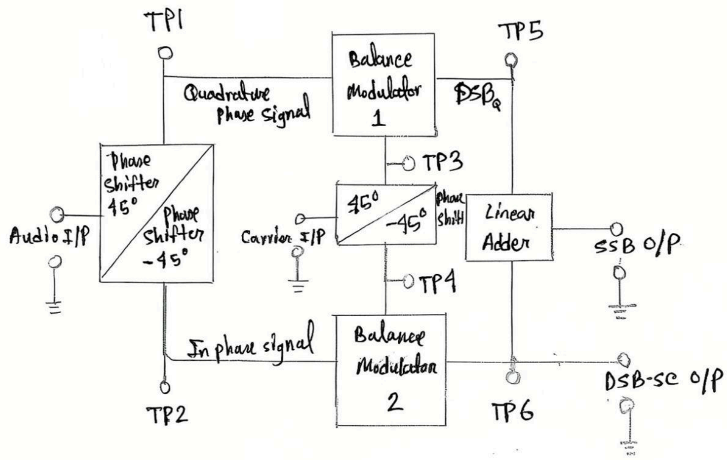


Fig: Block Diagram of Transmitter

Fig. Block diagram of the Transmiter

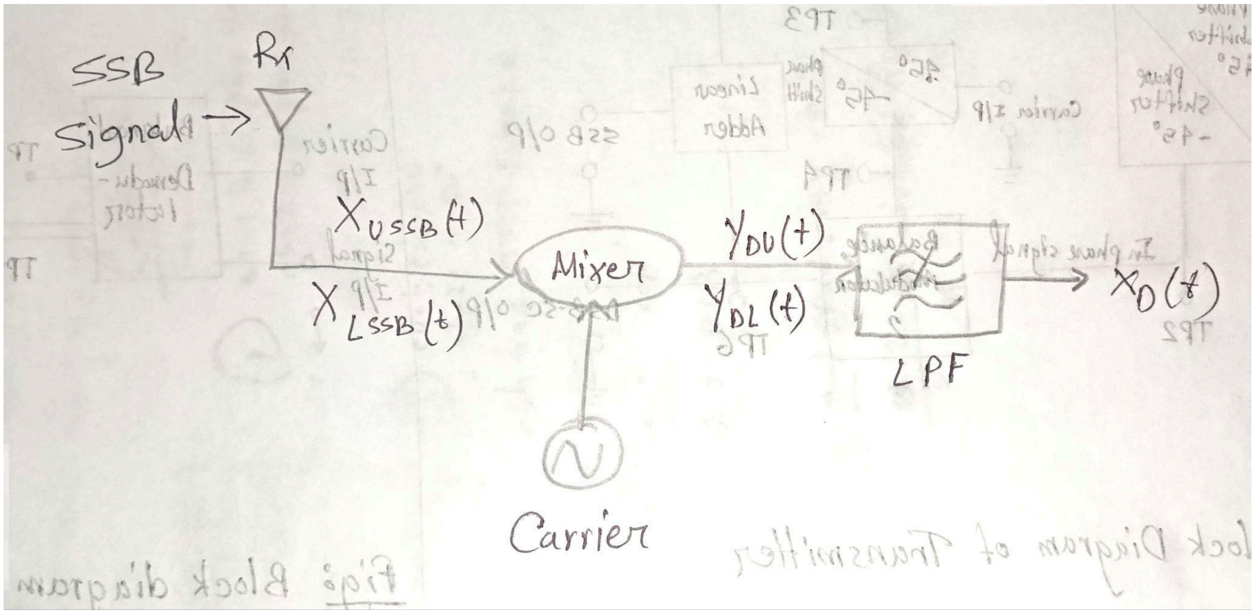


Fig. Block diagram of the Reciever

Answer to Question no. 2

Function of the blocks of SSB modulator:

1. Audio Input
- This is the modulating signal. It represents the low-frequency signal such as voice or audio that needs to be transmitted.

2. Phase Shifter (±45°)
- This block shifts the phase of the audio input signal by +45° and -45° to generate two signals: one is in phase ("In-Phase Signal") and the other is quadrature ("Quadrature Phase Signal").
- These two phase-shifted signals are needed for the suppression of one sideband during the modulation process.

3. Carrier Input
- This is the high-frequency carrier signal used for modulation. It is used as a reference in the modulation process and is combined with the audio signal in the balance modulators.

4. Balance Modulators (1 and 2)
- Balance Modulator 1
  - Adds the quadrature phase signal (+45°) with the carrier signal and produces a double sideband signal in quadrature, denoted as "DSBQ".
- Balance Modulator 2
  - Adds the in-phase signal (-45°) with the carrier signal and produces a double sideband signal in phase, denoted as "DSB1".
- Both the modulators reject the carrier component, and hence two DSB-SC signals are obtained.

5. Second Phase Shifter (±45°)
- The respective carrier signal is phase-shifted by -45° and +45° and provided to the two respective balance modulators for good sideband suppression.

6. Linear Adder

- Linear adder adds outputs from Balance Modulator 1 and Balance Modulator 2.
- Depending on the phase relationship, either the upper or lower sideband gets canceled at the time of addition, and a Single Sideband (SSB) is obtained.

7. Outputs

- DSB-SC Output
  - This is the intermediate stage of the accessible double-sideband suppressed carrier signal.
- SSB Output
  - Single-sideband signals are the final output, either in the upper or the lower sideband, ready to be transmitted.

Function of the blocks of SSB Demodulator:

1. SSB Input Signal

- It is the received SSB carrying either the Upper Sideband (USB) or the Lower Sideband (LSB).
- It is already the modulated signal from the SSB modulator.

2. Rx (Receiver)

- The receiver or antenna receives the SSB signal coming from the channel and gives it to the following demodulator for further processing.
- It also include amplification and noise reduction.

3. Mixer

- This is the main part of demodulation.
- Here, the received SSB signal, X_USSB(t) or X_LSSB(t), is mixed with a locally generated carrier signal.
- A frequency translation takes place and it results in two outputs:
  - y_DU(t): Demodulated Upper Sideband signal.

-y_DL(t): Demodulated Lower Sideband signal.
This stage reconversion of the received signal frequency components back to their original baseband position.

4. Carrier Signal Generator

- It generates a carrier signal which is in frequency as well as phase synchronism with the carrier employed at the transmitter.
- The resulting signal will be utilized for mixing and recovery of the baseband signal.

5. Low-Pass Filter (LPF)

- LPF extracts from the mixer output the baseband signal, that is X_D(t).
- The high-frequency components generated during the mixing process, sum frequencies that incorporate undesired harmonics, are suppressed by it while allowing the original modulated signal to pass through.

6. Output X_D(t)

- The final output is the baseband signal, which is similar to original audio or data signal transmitted by the modulator.

Answer to Question no. 3

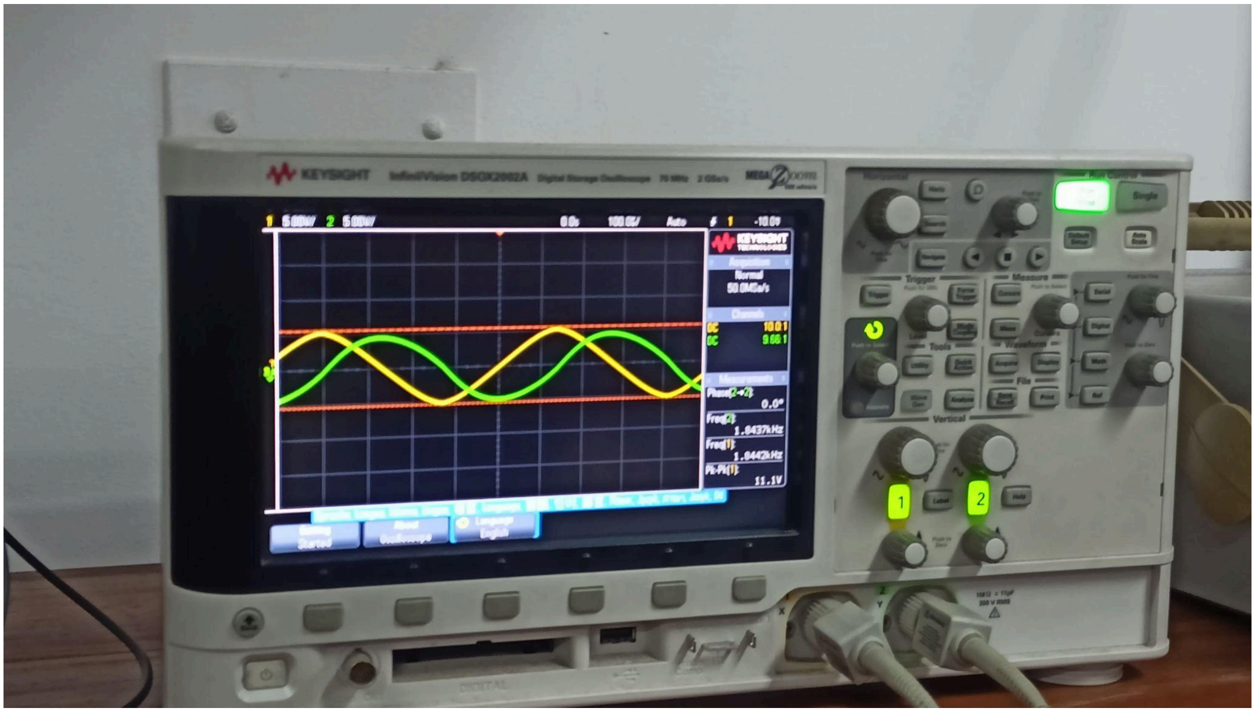


Figure 01: Message Signals at 0° (yellow) & 90° (green) Phases

After placing the oscillator probes in TP1 and TP2, The first figure displays the waveform of the message signals used in (SSB) modulation process. The observations are:

Channel 1 (Yellow Trace): 1.84kHz This is the message signal with a 0° phase and is the in-phase component. The waveform is sinusoidal.
Channel 2 (Green Trace): This is the 90° phase-shifted message signal. It displays the quadrature-phase component of the message signal. This waveform is orthogonal (90° out of phase) from the 0° phase message signal.

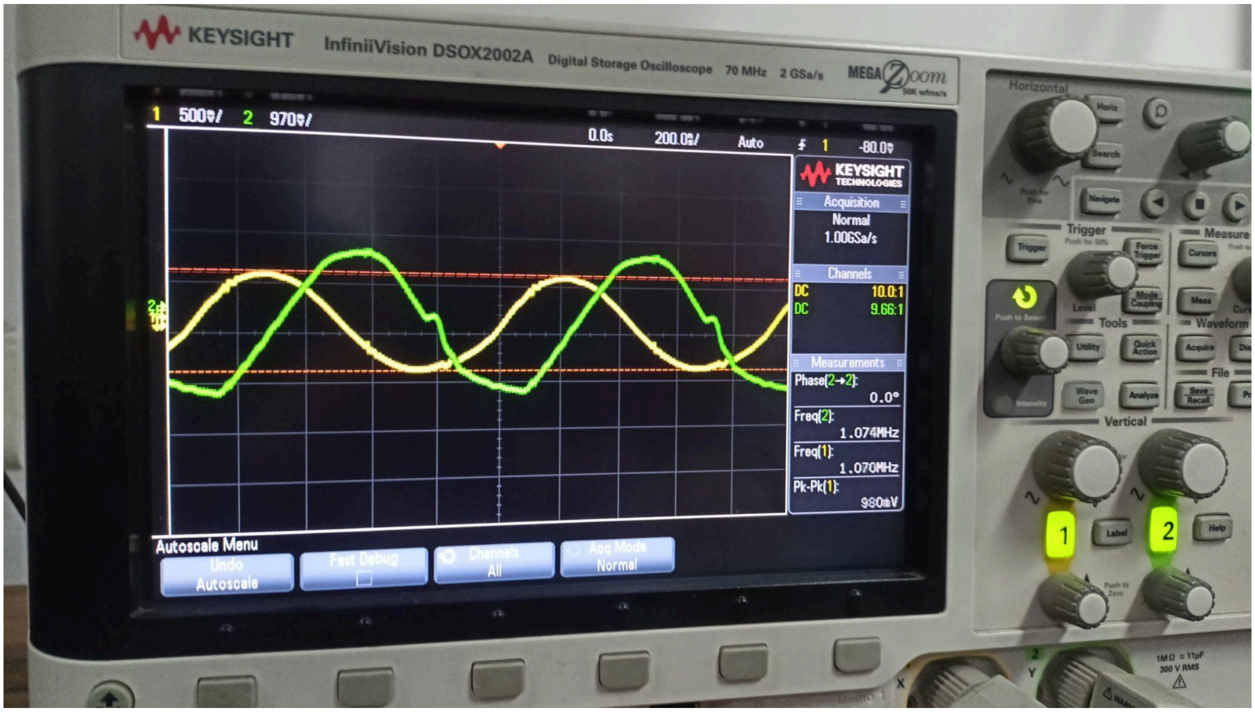


Figure 02: Carrier Signals at 0°(yellow) & 90°(green) Phases

After placing the oscillator probes in TP3 and TP4, The second figure shows the carrier signals used in the SSB modulation proces. The Observed points:

Channel 1 (Yellow Trace): This shows the waveform for the carrier signal that is in-phase for the 0° carrier. The frequency of the carrier signal is higher than message signal, which agrees with SSB modulation.

Channel 2 (Green Trace): This is the waveform of the carrier signal phase-shifted by 90° to represent the quadrature-phase carrier. Like the message signals, this carrier signal is orthogonal to the 0° phase carrier signal.

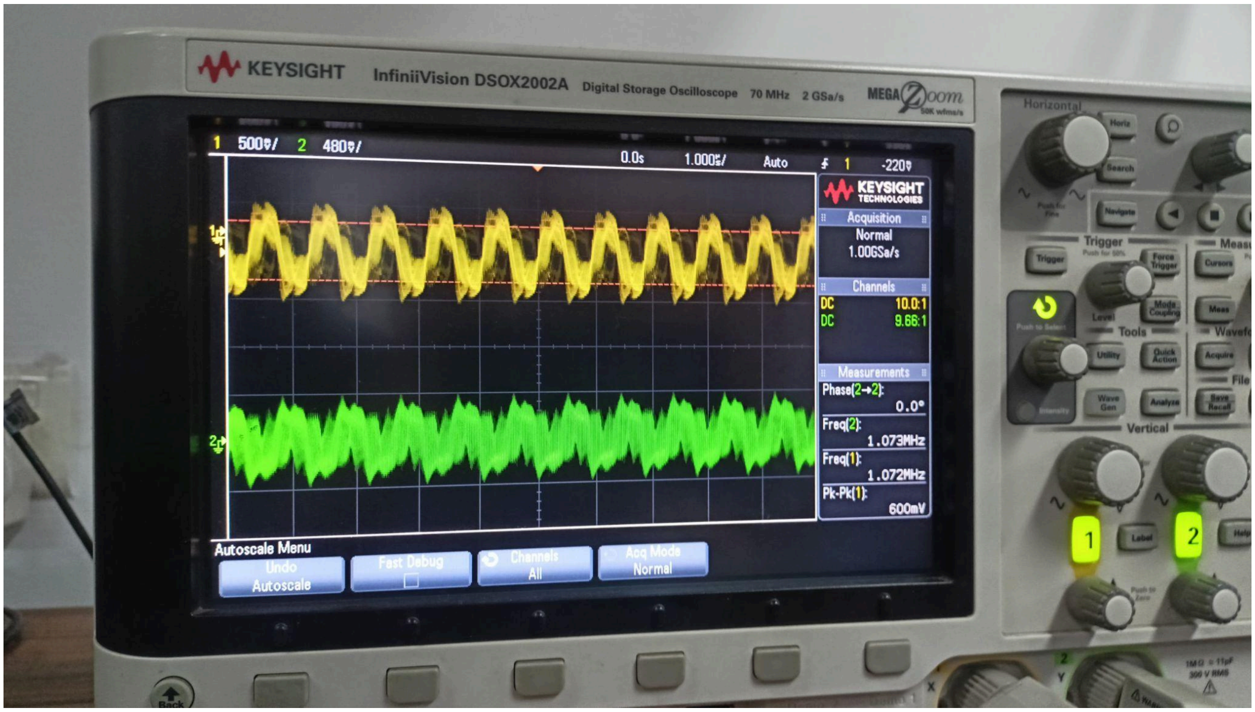


Figure 03: SSB Signal (yellow trace) & DSB Signal (green race) Comparison

After placing the oscillator probes in TP6, The third pic shows comparison of the waveforms for the Single Sideband (SSB) signal and the Double Sideband (DSB) signal recorded on an oscilloscope.

Channel 1 (Yellow Trace): This is the SSB modulated signal. The SSB signal has a small frequency range, since it only sends one of the sidebands either upper or lower of the modulated signal.

Channel 2 (Green trace): this is the DSB signal. In DSB, both the sidebands, the upper and the lower, are transmited along with the carrier. The wave form appears to be more dense compared to the SSB signal due to its extra sideband information content. Larger signal amplitude variations in this trace indicate mixtures of the two sidebands.

The following frequency measurements confirm that the SSB and DSB signals have different frequencies. On the other hand, it is seen how one sideband is suppressed on the SSB signal that results in reduced bandwidth.

Figure 04: Input Audio Message(yellow) Signal & Demodulated (green) Signal

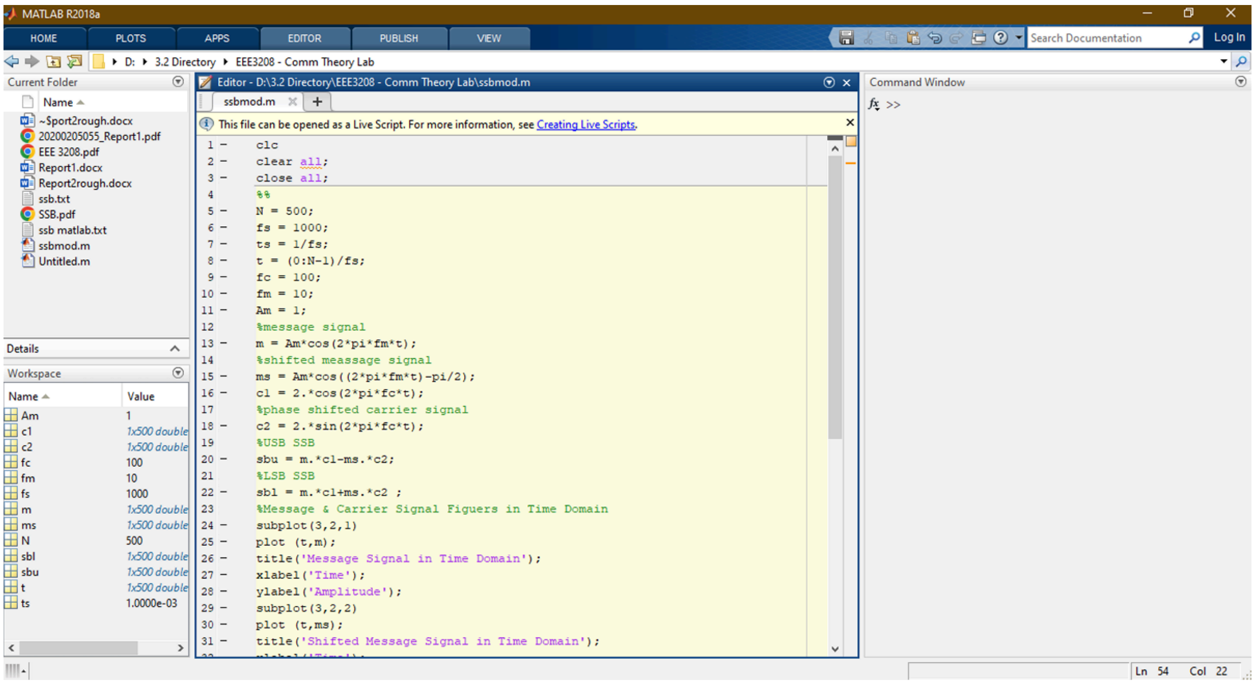
After placing the oscillator probes in input and output, The fourth image compares the input audio message signal and the demodulated signal after processing.

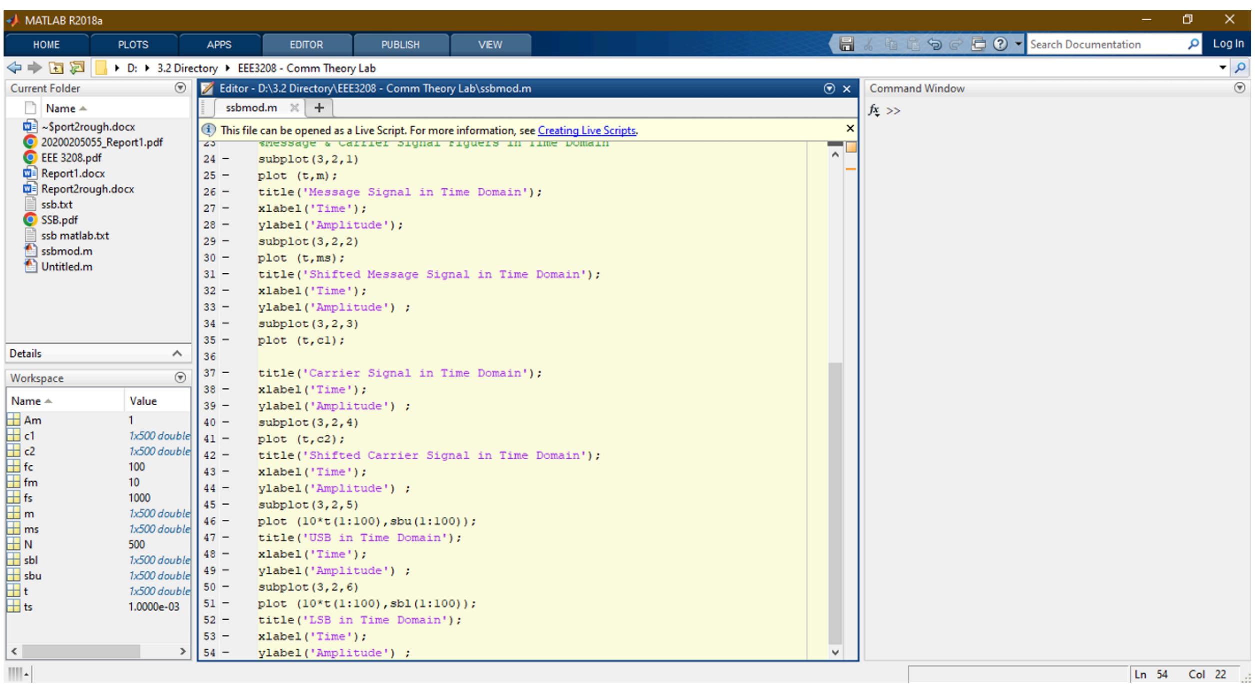
Channel 1 (Yellow Trace): This trace represents the audio message signal that is used for modulation; it is a smooth waveform at a frequency of about 1.860 kHz and a height that represents the original information.

Channel 2 (Green Trace): This shows signal at the output. The waveform is essentially similar to the original audio message which means the SSB signal has been successfully demodulated. The slight distortions seen might have occurred due to noise or during modulation-demodulation. The frequency readings on the oscilloscope show that the frequency of the demodulated signal matches the frequency of the input signal. This shows that the transmitted information has been accurately recovered. Also, the peak-to-peak amplitude values of the demodulated signal prove that it is true to the original message.

Answer to Question no. 4

For modulation and demodulation, matlab codes are provided:





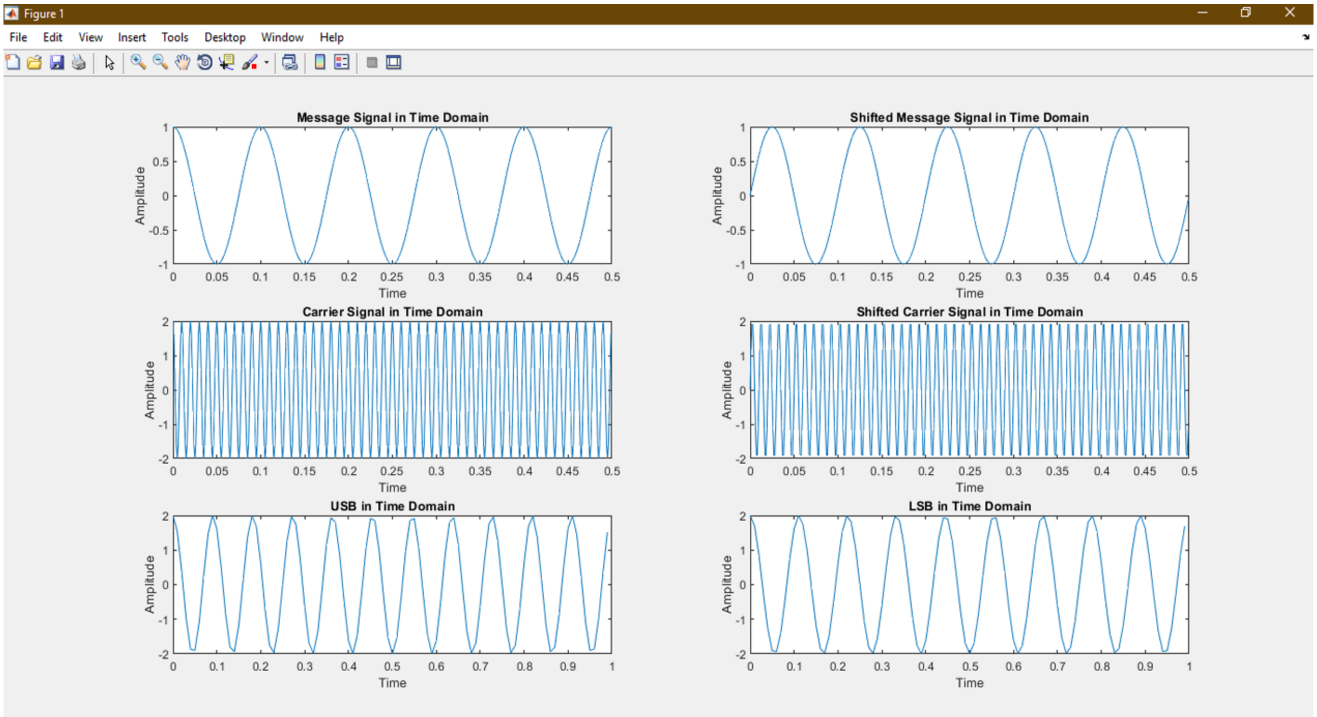


Figure 1
File Edit View Insert Tools Desktop Window Help
Message Signal in Time Domain
Shifted Message Signal in Time Domain
Carrier Signal in Time Domain
Shifted Carrier Signal in Time Domain
USB in Time Domain
LSB in Time Domain
Amplitude
Time

DISCUSSION:

The single side band method makes use of the sideband's ability to contain the message. Between fc, fc-fm and fc+fm, our message signal lies in side bands so we can easily cutoff carrier frequency (fc) and one of the side bands from our signal. 80-90% of information lies in frequency of a signal. SSB is better than DSB in terms of power consumption, bandwidth, expenses Signal to Noise ratio etc. In SSB method , it also eliminate he distortion, noise and fading of signal since we won't be sending the carrier frequency. Here always Fc(carrier frequency) is much greater than Fm(message frequency). Since fc>>fm, fc contains more noise, distortion and fading.
Required power in SSB SC(supressed carrier) method is much lower compared to DSB TC and DSB SC method because we are sending only one side band instead of both side bands or the complete carrier+ side bands. However, complexity is a disadvantage of this method.
There are two types of method to generate SSB signal. In Filter method, Message signal is amplitude modulated using DSB first, then a bandpass filter is used o separate LSB and USB.
But in our lab we used PHASE SHIFT METHOD using Balanced Modulator. In this method main signal is called as 'in phase' which is shifted by 90 degree and it's called Quadrature signal. In phase signal will be mixed with in phase carrier and Quadrature signal will be mixed with Quadrature carrier.
In the circuit, we get SSB LSB by adding DSB1 and DSBq. we get SSB USB by subtracting DSB1 and DSBq which is an operation of COS function. Shifting a signal from 45 to -45 degree actually shifts it to 90 degree. In TP1 and TP2 , phase shift of message signal is observed. In TP3 and TP4, phase shift of carrier is observed. In TP5, SSB output is observed. In TP6, DSB SC can be observed but not necessary.
Since the carrier freq (fc) in both modulation and demodulation process is same, it is called Homodyne process and it must be maintained.
In order to remove carrier frequency (2fc+/- fm) , we use a Low pass filter in Demodulator after the mixer to let only fm pass. Since carrier frequency is

very high so the LPF eliminates Fc and only lets the desired message signal frequency pass through the output.
In time domain, message signal and SSB(LSB) signal and SSB(USB) signals are Pure sinusoidal but DSB TC is not pure sinusoidal. So to get pure sinusoidal we use SSB. since it doesn’t contain high frequency Fc.
We use SSB mainly in military purpose where point to point communication is preferred.