Manual for Communication Systems Laboratory (EEE/ECE F311)

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Experiment 4: DSB-SC & SSB-SC Modulation and Demodulation

Aim: This experiment is intended to make the student to perform experiments on DSB-SC and SSB-SC Modulation and demodulation using Emona Telecoms-Trainer 101 kit.

Equipment Required: EMONA Telecom Trainer Kit 101, Digital Storage Oscilloscope (DSO), headset, connecting patch cards etc.
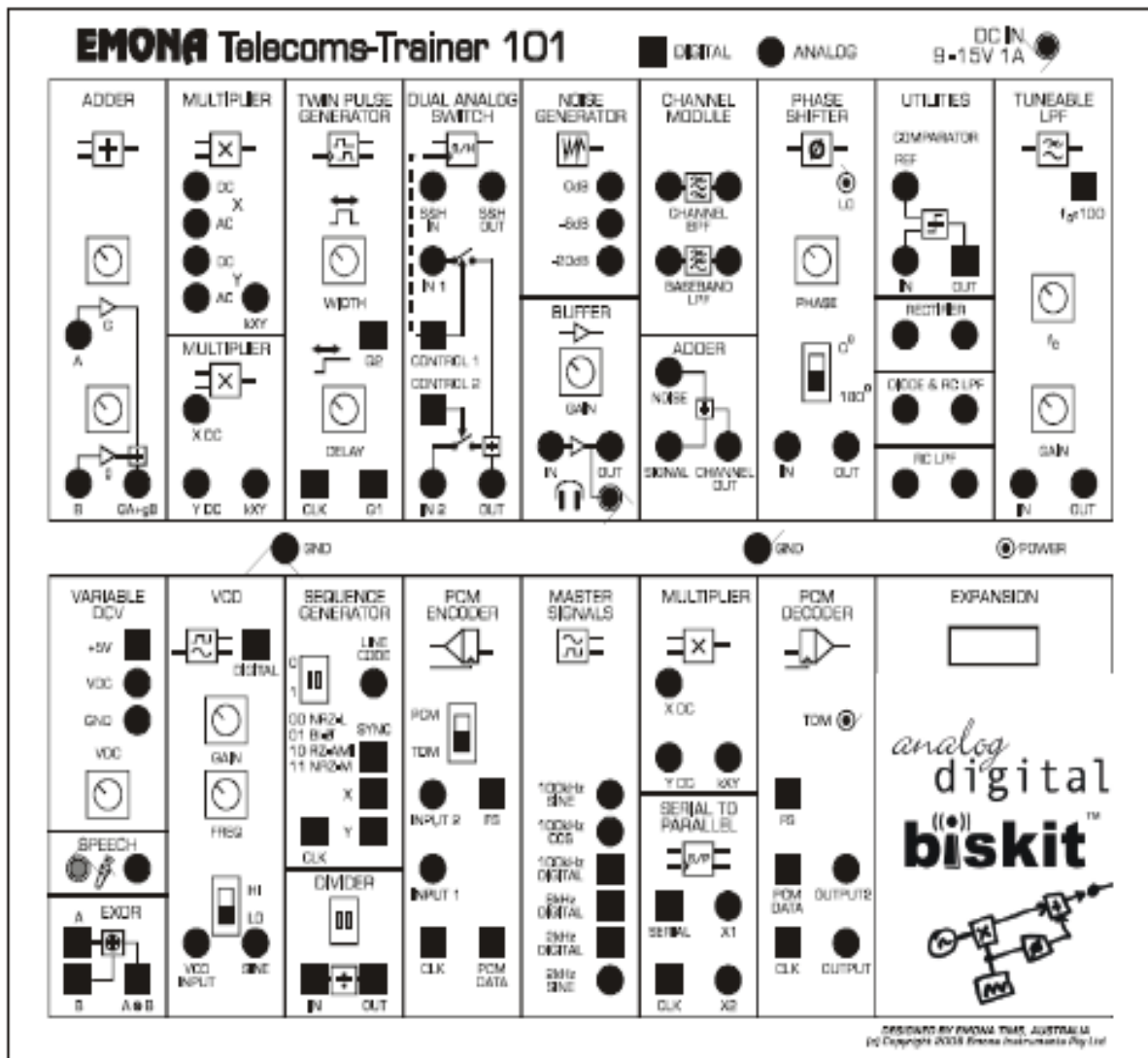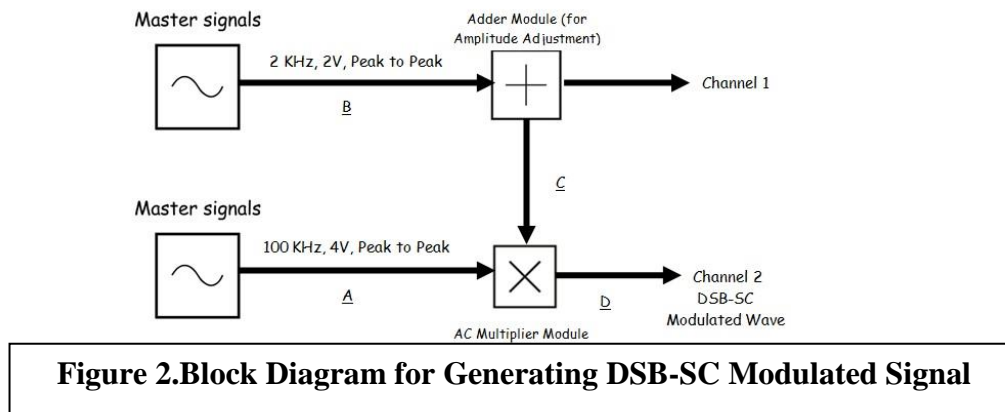

Figure 1.Blocks on EMONA Kit

A –Generation of a DSB-SC Modulated Signal

DSB-SC modulated signal is mathematically represented as $y(t) = A\ Cos\ (2\pi f_c t)\ sin\ (2\pi f_m t)$, where f_c is the carrier frequency and f_m is the message frequency. Let the Message Signal be a 2 Khz Sinusoid and the Carrier be a 100 KHz Sinusoid. Let the peak to peak amplitude of the message and carrier signals be 2V and ~ 4V, respectively. Use the block diagram in Figure 2, for connecting the circuit.

Figure 2.Block Diagram for Generating DSB-SC Modulated Signal

1) Measure the message signal amplitude using DSO and calculate the message power in the modulated signal and tabulate them in Table 1.

2) Observe the DSB-SC Modulated signal, by connecting **Channel 2** of DSO at Observation point <u>D</u>. Obtain the message and modulated waveforms on the DSO with the message signal in the upper half and the DSB-SC signal in the lower half. It is advised that the DSO be triggered using the message signal.

3) Sketch the waveform in observation book. How is this different from AM modulation with carrier? Is there a phase Reversal of the carrier at the notch points, where the waveform has decayed to zero amplitude? Why? Reason it out and note it in observation book.
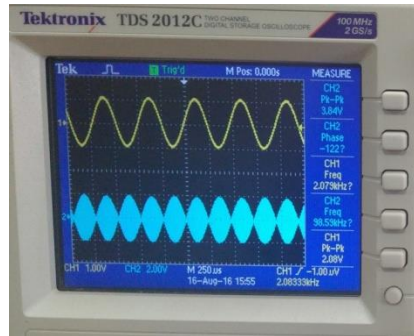
Fig 3 DSB SC Signal and Message signal

Old DSO (Model No. TDS 2012C)

4) Go to MATH mode and use FFT feature of the DSO to obtain the spectrum of DSB-SC signal. How many distinct spectral peaks are there and what are their frequencies? Is there any carrier component?

New DSO (Model No. TBS 1102B-EDU)

Use FFT feature of the DSO to obtain the spectrum of DSB-SC signal. How many distinct spectral peaks are there and what are their frequencies? Is there any carrier component?
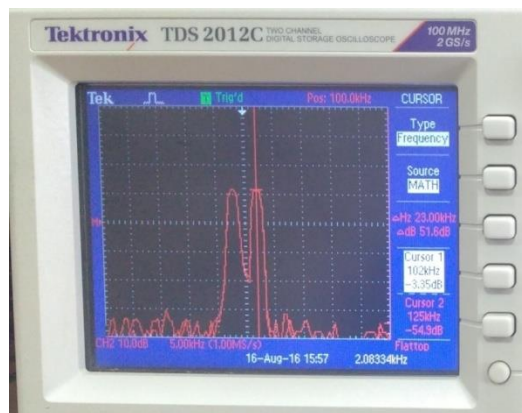

Fig 4 Spectrum of the DSB SC Signal

5) Measure the Power in side bands from the spectrum and tabulate in Table 1. See whether the total Power in sidebands is equal to the Calculated Message signal Power in modulated signal from Time Domain.

	Time Domain		Frequency Domain					Demodulated Signal (Time Domain)		Frequency Domain
Sl. No	Message Amplitude (V)	Message Power in modulated signal	Frequency of USB	Power in USB	Frequency of LSB	Power in LSB	Total Message Power	Message Amplitude	Message Power	Message Power

Table 1: Message and Sideband Powers in DSB-SC

6) Increase the message signal amplitude to 3V peak to peak, by turning Adder module's Gain control and notice the effect on the DSB-SC signal. Measure and tabulate the results in Table1.

B – Demodulation of DSB-SC Signal: Synchronous Demodulation

Demodulation of DSB-SC signal is accomplished by multiplying the DSB-SC signal with a local carrier that is perfectly synchronous to the carrier used for modulation. There are several ways of generating a synchronous local carrier. In this experiment, we simply use the same carrier both for modulation and demodulation.

Generate DSB-SC modulated signal as done in **Part A**. Use the diagram in **Figure 5** to connect blocks to demodulate the DSB-SC signal.
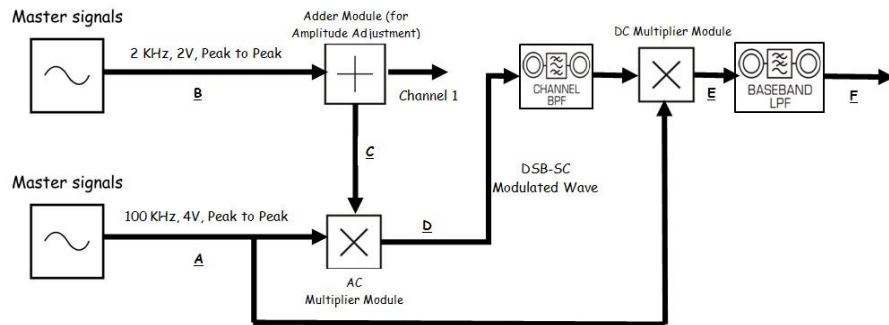
Figure5.Block Diagram for Demodulating DSB-SC Modulated Signal Using Synchronous Carrier

Old DSO (Model No. TDS 2012C)

1) Observe the signal at Observation point E by connecting to *Channel 2* of DSO. Go to 'MATH' mode and Use FFT feature of the DSO and obtain the spectral components. What Frequency component you observe? Do they include a component corresponding to message signal?

New DSO (Model No. TBS 1102B-EDU)

Observe the signal at Observation point E by connecting to *Channel 2* of DSO. Use FFT feature of the DSO and obtain the spectral components. What Frequency component you observe? Do they include a component corresponding to message signal?

2) Observe the signal at Observation point F by connecting to *Channel 2* of DSO. Compare the demodulated output (Channel 2) and the message signal (channel 1). Is there a difference? If yes, why?
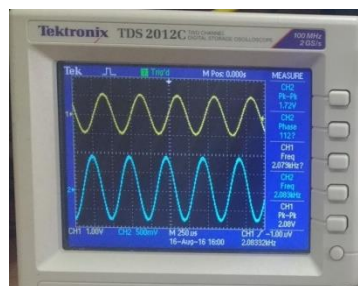

Figure 6 Demodulated Signal compared with message signal

3) Tabulate the demodulated message amplitude and calculated power in Table 1.

Old DSO (Model No. TDS 2012C)

4) Go to 'MATH' mode and Use FFT feature of the DSO and obtain the spectral components. What Frequency component you observe? Measure the message power from the spectral domain and tabulate in Table 1.

New DSO (Model No. TBS 1102B-EDU)

Use FFT feature of the DSO and obtain the spectral components. What Frequency component you observe? Measure the message power from the spectral domain and tabulate in Table 1.
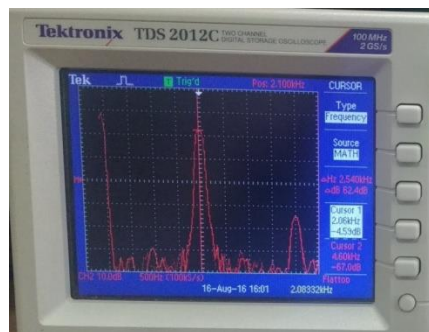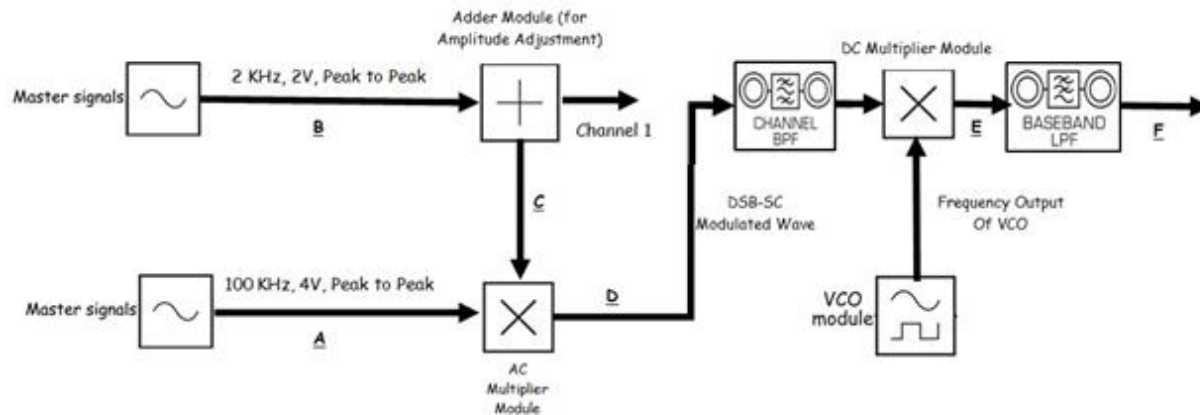

Fig 7 Spectrum of the Demodulated signal

5) Comment on the results in Table 1 with respect to the message powers, before modulation and after demodulation

C –DSB- SC Demodulation with Asynchronous LO

Demodulation of DSB-SC signal is accomplished by multiplying the DSB-SC signal with a local carrier that is perfectly synchronous to the carrier used for modulation. In this experiment, we study the effect of asynchronous LO at the demodulator.

Generate DSB-SC modulated signal as done in **Part A**. Use the diagram in **Figure 8** to connect blocks to demodulate the DSB-SC signal.

1) Adjust the VCO to provide 100 KHz signals using Sine Output. Use DSO features to

**Figure8. Block Diagram for Demodulating DSB-SC
Modulated Signal – Effect of Asynchronous LO**

    measure the frequency of the VCO output signal. Make sure that the gain knob of the VCO is positioned to middle of its range. Observe the 100 KHz Master signal and the VCO output (100 KHz signal) simultaneously in 2 channels of the DSO. Are you able to trigger and get stable display on the screen? If the waveforms are not stable, explain the reasons.

2) Observe the demodulated message signal at observation point F, by connecting to channel 2. Connect the original message signal to Channel 1. Trigger the DSO with original message signal. Is the demodulated message signal in Channel 2 stable? If not why?

3) Vary the frequency of VCO slightly and see if the demodulated signal becomes stable.

4) Does your observation match with the theory you studied?

D –Phase Shifting of Signal

The Phase Shifter module introduces a phase shift between its input and output. The amount of phase shift is controlled by the user, via the front panel phase knob and the 0/180 degree switch together. The variable phase shifter is capable of varying the magnitude of phase shift through 360 degrees in two steps. The 180 degree switch selects the step or region of interest.

If the input is Cos ($2\pi f_c t$), then the output is Cos ($2\pi f_c t - \Phi$) where Φ lies between 0 and 180.

For a general sinusoid signal the phase shift can be implemented using the Emona kit as follows:
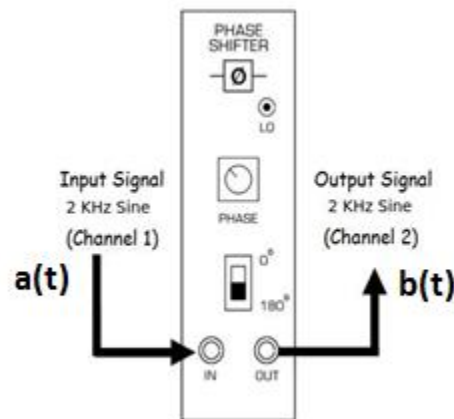

Figure 9.Block Diagram for Operating Phase Shifter Block

Using Phase Shifter Block:

The signal to be shifted is connected to the input of the Phase shifter block along with Channel 1 and the output phase shifted wave is connected to Channel 2 as shown in Figure 9.

1. Set the phase adjust control knob to the middle and phase control knob to 180°position. Observe the output waveform in the DSO and check whether the waveform is out of phase with the input signal.

2. Now set the phase control knob to 0° and vary the phase adjust control knob. Observe the waveform simultaneously on the DSO along with phase. Using the Phase adjust knob set the phase shift to 90° and observe the waveform.

3. Any two signals between which the phase shift is to be measured must be connected to Channel 1 and Channel 2 of the DSO to measure the Phase Shift. The 'Measure' or the display button of the DSO can be used to calculate the phase difference of one wave w.r.t the other.

Use of Lissajous diagrams for Phase Shift Measurements: These diagrams are a good way of observing the phase difference between two sinusoidal signals of same amplitude and frequency. For example, if two signals $a(t) = A\cos(2\pi f_c t + f_1)$ and $b(t) = A\cos(2\pi f_c t + f_2)$ are available, their relative phase difference can be observed in the form of Lissajous diagrams on the DSO.

For this, one needs to do the following:

1.Connect a(t) to Channel 1 and b(t) to Channel 2 of DSO. Make sure that the amplitudes of the displayed signals are same.
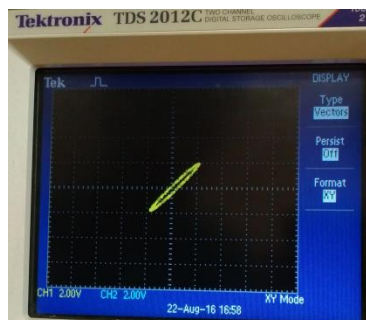
Old DSO (Model No. TDS 2012C)

2. Press the button, "DISPLAY" on the DSO. It allows you to put the display of the DSO into various modes. The usual mode is "YT" mode, which is default and will be displayed on the screen. This means that the X-axis id time and Y axis is amplitude.
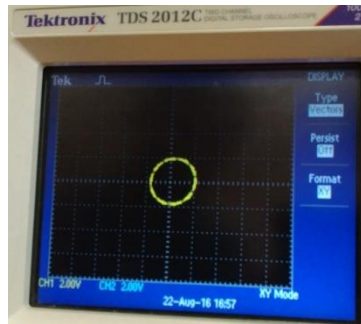
New DSO (Model No. TBS 1102B-EDU)

Press the button, "UTILITY" on the DSO and then go to "DISPLAY". It allows you to put the display of the DSO into various modes. The usual mode is "YT" mode, which is default and will be displayed on the screen. This means that the X-axis id time and Y axis is amplitude.

3. One can change the display mode to XY mode by pressing the corresponding button. This implies that both X axis and Y axis are now accepting signals from Channel 1 and Channel 2 of the DSO inputs and the display on the screen is the movement of the electronic spot, as result of application of voltages simultaneously in X and Y directions.

3. If the phase shift between the signals a(t) and b(t) is zero, you will see the diagram on the display as in the following Figure.

4. On the other hand, if the phase shift between the signals a(t) and b(t) is 90°, you will see the diagram on the display as in the following Figure.

5. Can you guess what will be the display if the phase shift between the signals a(t) and b(t) is 45º ?

E –Generation of a SSB-SC Modulated Signal

A popular method for generating SSB-SC signal is through phase shifting method (Hilbert Transform). SSB-SC modulated signal is mathematically represented as

φ$_{SSB(t)}$ = m(t) cos(2πf$_c$t) ± mˆ (t) sin(2πf$_c$t),

where f_c is the carrier frequency and f_m is the message frequency, **m(t)** is the message signal and **mˆ (t)** is the Hilbert transform of **m(t).** *It is well known that the Hilbert transform, for a narrowband signal can be implemented using a 90 degree phase shifter.*

φ$_{USB(t)}$ = **m(t) cos(2πf$_c$t) - mˆ (t) sin(2πf$_c$t),**

φ$_{USB(t)}$ = **m(t) cos(2πf$_c$t) + mˆ (t) sin(2πf$_c$t),**

Let the Message Signal be a 2 KHz Sinusoid and the Carrier be a 100 KHz Sinusoid. Let the peak to peak amplitude of the message and carrier signals be 2V and ~ 4V, respectively. Implement the block diagram in Figure 10, using relevant blocks on Emona kit.
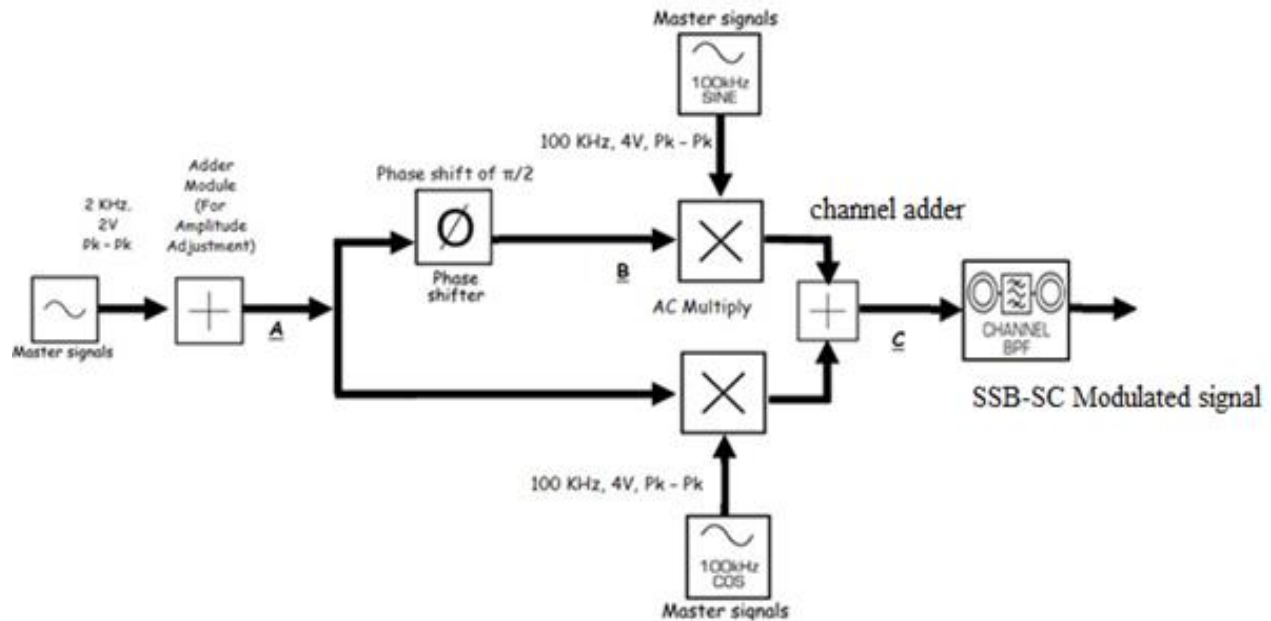
Figure 10. Block Diagram for Generating SSB Modulated Signal

1. Observe and adjust the Phase Shifter knob to obtain a 90^0 phase shifted output of message signal from observation point B.

2. Observe the SSB-SC Modulated signal, by connecting Channel 2 of DSO at Observation point C. Obtain the message and modulated waveforms on the DSO with the message signal in the upper half and the SSB signal in the lower half of the screen.

3. Sketch the waveform in observation book. How is this different from AM modulation with carrier? Is there a phase Reversal of the carrier at the notch points, where the waveform has decayed to zero amplitude? Why? Reason it out and note it in observation book.

4. Use FFT feature of the DSO to obtain the spectrum of SSB-SC signal. How many distinct spectral peaks are there and what are their frequencies? Is there any carrier component? Which side band do you find in the spectrum, USB or LSB? Adjust the Phase Shifter Knob, so as to completely suppress one of the side bands.

5. Change the position of the switch on the Phase shifter module and note its effect.

F – Demodulation of DSB-SC Signal: Synchronous Demodulation

Demodulation of SSB-SC signal is accomplished by multiplying the SSB signal with a local carrier that is perfectly synchronous to the carrier used for modulation. There are several ways of generating a synchronous local carrier. In this experiment, we simply use the same carrier both for modulation and demodulation.

Generate SSB modulated signal as done in Part E. Use the diagram in Figure 11 to connect blocks to demodulate the SSB signal.
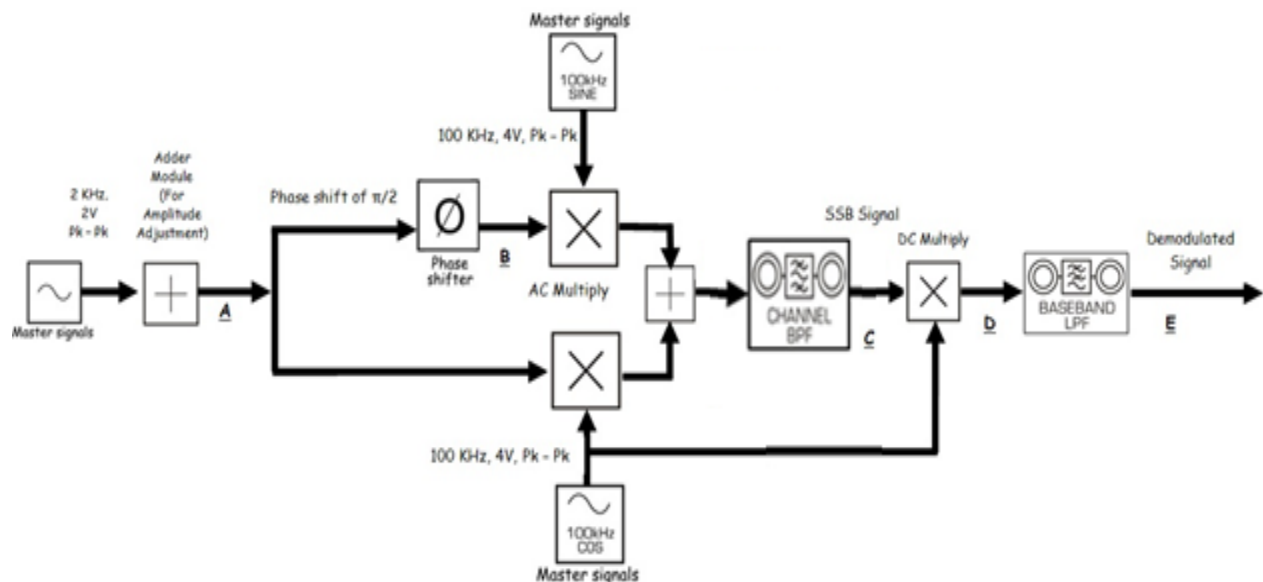

Figure 11.Block Diagram for Demodulating SSB Modulated Signal Using Synchronous Carrier

What is the relationship between the original message and the recovered message? Are they in the same phase? If not, Why?

G – Conclusions

List out your learning's from the above experiments.