# Introduction

Modulating the amplitude of a high frequency carrier signal with respect to a low frequency message signal is called Amplitude Modulation (AM). Objective of the following laboratory exercises is to generate and analyze various types of AM. AM techniques implemented in the following sections are: Double Sideband Suppressed Carrier (DSBSC), Double Sideband Large Carrier (DSBLC) and Single Sideband Suppressed Carrier (SSB-SC).

# A.4- Amplitude Modulation

## A.4.1. Experimental Setup for DSBSC Modulation

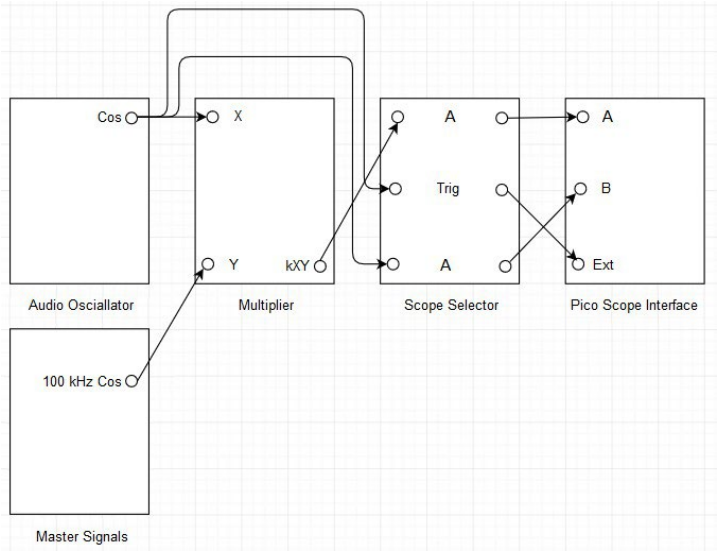



**Figure A.4.1: DSBSC modulator setup.**

## A.4.2. Laboratory Exercise for DSBSC Modulation

NOTE: Refer A.1 for more information about initial settings and connections of TIMS and Pico Scope interface.

**i.** Set an audio oscillator to generate 1 kHz cosine signal. NOTE: This will be used in the modulator setup.

**ii.** Make the modulator setup as shown in Figure A.4.1.

**iii.** Toggle the front panel switch of the multiplier to DC.

**iv.** Observe that the 1 kHz cosine signal is the message signal and the 100 kHz cosine signal is the carrier signal.

**v.** Observe that the external trigger is the message signal because the modulated signal should vary with respect to the message signal.

**vi.** Under the scope mode, for channel A and channel B, change the input range to $\pm$ 5 V and select the maximum number of bits as 12. Change the collection time to 200 $\mu$s/div and change the trigger options to auto and ext.

**vii.** Add two scope views under the scope mode. Select the second view, right click on it and disable B under channels. Select the third view, right click on it and disable A under channels. I.e., first view has signals from channel A and

channel B, second view has signal from channel A and third view has signal from channel B.

**viii.** Take a screenshot of output of the multiplier and output of the audio oscillator under the scope mode.Under the spectrum mode, for channel A and channel B, change the input range to $\pm$ 5 V. Change the spectrum range to 199.7 kHz and change the trigger options to auto and ext.

**ix.** Add two spectrum views under the spectrum mode. Select the second view, right click on it and disable B under channels. Select the third view, right click on it and disable A under channels. I.e., first view has signals from channel A and channel B, second view has signal from channel A and third view has signal from channel B.

**x.** In the second view zoom around 90 kHz to 110 kHz. Measure frequency of the modulated signal peaks with cursors.

**xi.** Take a screenshot of output of the multiplier and output of the audio oscillator under the spectrum mode.

### A.4.3. Experimental Setup for DSBSC Demodulation

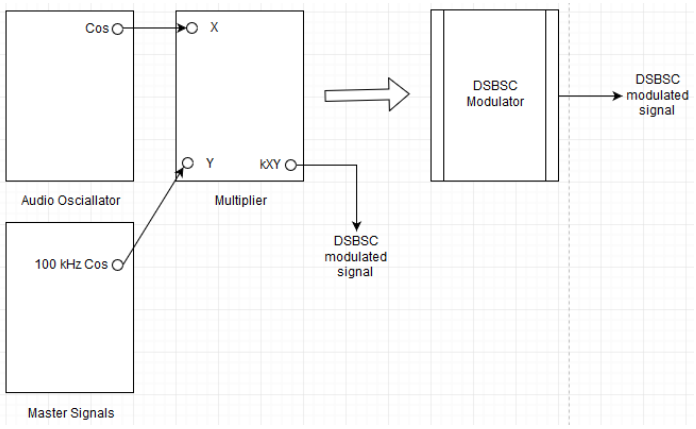
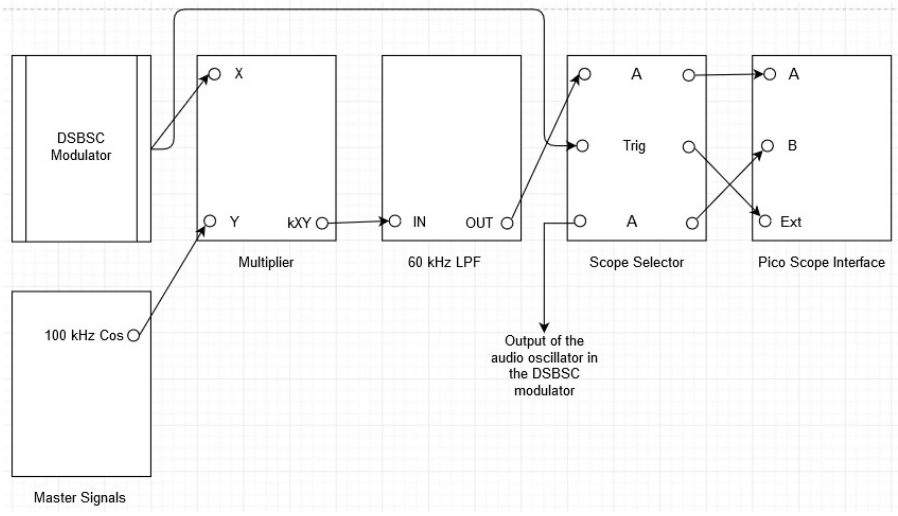



**Figure A.4.2.a: DSBSC modulator equivalent setup.**




A.4.2.

**Figure A.4.2.b: DSBSC demodulator setup.**

## A.4.4. Laboratory Exercise for DSBSC Demodulation

**i.** Retain the modulator setup and make the demodulator setup as shown in Figure A.4.2.b.

**ii.** Toggle the front panel switch of the multiplier at the demodulator to DC. Turn the knob of the 60 kHz Low Pass Filter (LPF) to minimum.

**iii.** Observe that the external trigger is the modulated signal because the demodulated message signal should vary with respect to the modulated signal.

**iv.** Under the scope mode, for channel A and channel B, change the input range to $\pm$ 5 V and select the maximum number of bits as 12. Change the collection time to 1 ms/div and change the trigger options to auto and ext.

**v.** Add two scope views under the scope mode. Select the second view, right click on it and disable B under channels. Select the third view, right click on it and disable A under channels. I.e., first view has signals from channel A and channel B, second view has signal from channel A and third view has signal from channel B.

**vi.** Adjust the knob of the 60 kHz LPF to obtain the demodulated message signal with minimum phase shift and equal amplitude.

**vii.** Measure frequency of the demodulated message signal and frequency of the message signal under the scope mode.

**viii.** Take a screenshot of output of the 60 kHz LPF and output of the audio oscillator under the scope mode.

**ix.** Under the spectrum mode, for channel A and channel B, change the input range to $\pm$ 5 V. Change the spectrum range to 199.7 kHz and change the trigger options to auto and ext.

**x.** Add two spectrum views under the spectrum mode. Select the second view, right click on it and disable B under channels. Select the third view, right click on it and disable A under channels. I.e., first view has signals from channel A and channel B, second view has signal from channel A and third view has signal from channel B.

**xi.** Measure frequency of the demodulated message signal peak and frequency of the message signal peak under the spectrum mode.

**xii.** In the second view zoom around 0 Hz to 5 kHz. Measure frequency of the demodulated message signal peak with cursor.

**xiii.** Take a screenshot of output of the 60 kHz LPF and output of the audio oscillator under the spectrum mode.

## A.4.5. Experimental Setup for DSBLC Modulation

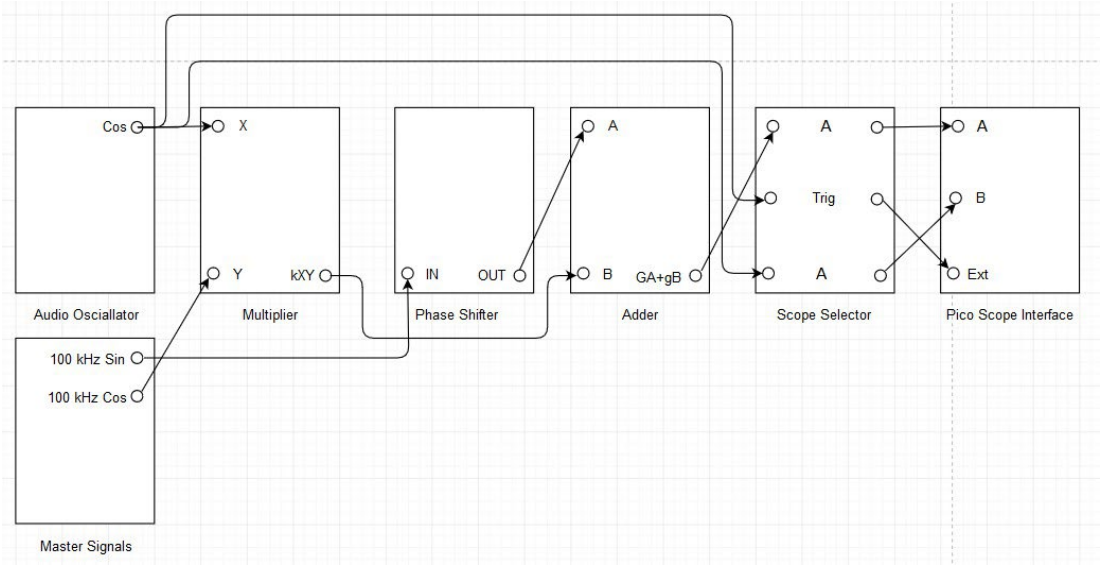



**Figure A.4.3: DSBLC modulator setup.**

## A.4.6. Laboratory Exercise for DSBLC Modulation

**i.** Set an audio oscillator to generate 1 kHz cosine signal.

**ii.** Make the modulator setup as shown in the Figure A.4.3.

**iii.** Toggle the on-board switch-frequency range of the phase shifter to HI, toggle the front panel switch of the phase shifter down and toggle the front panel switch of the multiplier to DC. Turn both the knobs of the phase shifter to maximum and turn both the knobs of the adder to minimum. NOTE: On board switch is a part of PCB of the module and front panel switch is present on the front end of the module.

**iv.** Increase the carrier signal at the adder to obtain a carrier signal with 4 V peak to peak amplitude.

**v.** Unplug the carrier signal at the adder and increase the sideband signal at the adder to obtain a DSBSC modulated signal with 4 V peak to peak amplitude.

**vi.** Plug the carrier signal back at the adder to obtain the DSBLC modulated signal.

**vii.** Observe that the carrier signal is added to the DSBSC modulated signal to obtain the DSBLC modulated signal.

**viii.** Adjust both the knobs of the phase shifter to obtain modulation index of 1.

**ix.** Keep the carrier signal at the adder constant and adjust the sideband signal at the adder to obtain modulation index of 0.

**x.** Measure $A_{max}$ and $A_{min}$ and calculate the observed modulation index.

**xi.** Take a screenshot of output of the adder and output of the audio oscillator under the scope mode.

**xii.** Measure the observed power difference between the carrier peak and the sideband peaks.

**xiii.** Take a screenshot of output of the adder and output of the audio oscillator under the spectrum mode.

**xiv.** Repeat step **ix** through step **xiii**, for modulation index of 0.4, 0.8 and 1, accordingly.

### A.4.7. Experimental Setup for DSBLC Demodulation

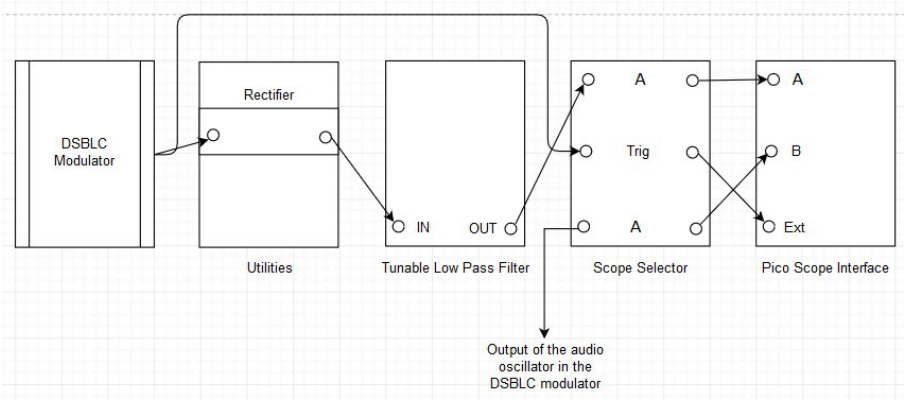



**Figure A.4.4: DSBLC demodulator setup.**

### A.4.8. Laboratory Exercise for DSBLC Demodulation

**i.** Retain the modulator setup with modulation index of 1 and make the demodulator setup as shown in Figure A.4.4.

**ii.** Toggle the front panel switch of the Tunable Low Pass Filter (TLPF) to wide. Turn both the knobs of the TLPF to minimum.

**iii.** Adjust both the knobs of the TLPF to obtain the demodulated message signal with minimum phase shift and equal amplitude.

**iv.** Take a screenshot of output of the TLPF and output of the audio oscillator under the scope mode.

**v.** Repeat step **iii** and step **iv**, for modulation index of 0, 0.4 and 0.8, accordingly.

**vi.** For modulation index of 1, zoom around 0 Hz to 5 kHz to measure frequency of the demodulated message signal peak.

**vii.** Take a screenshot of output of the TLPF and output of the audio oscillator under the spectrum mode.

### A.4.9. Experimental Setup for SSB Modulation

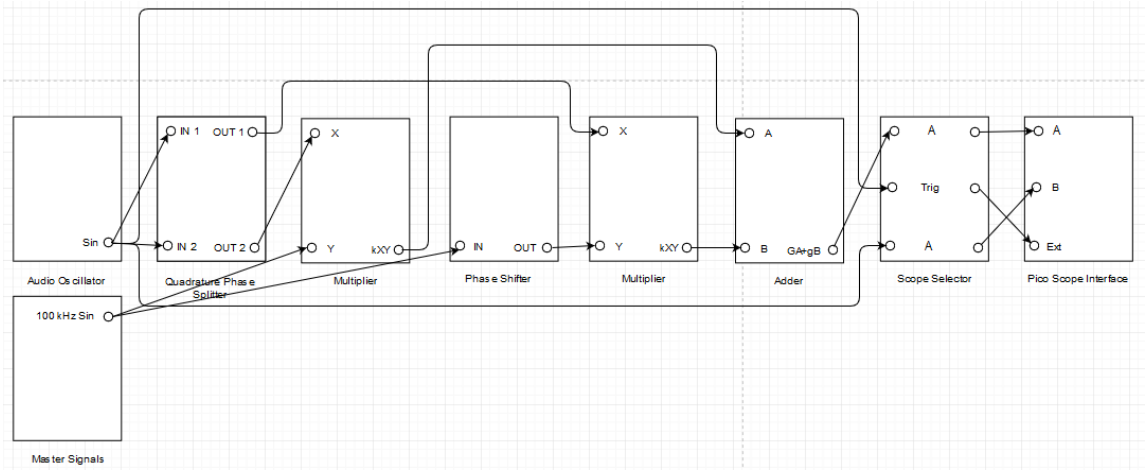



**Figure A.4.5: SSB modulator setup.**

### A.4.10. Laboratory Exercise for SSB Modulation

**i.** Set an audio oscillator to generate 1 kHz sine signal.

**ii.** Make the modulator setup as shown in Figure A.4.5.

**iii.** Toggle the on-board switch-frequency range of the phase shifter to HI and toggle the front panel switch of the multipliers to DC. Turn the fine knob of the phase shifter to minimum, turn the coarse knob of the phase shifter to maximum and turn both the knobs of the adder to maximum.

**iv.** For lower sideband modulation, toggle the front panel switch of the phase shifter down.

**v.** Adjust the coarse knob of the phase shifter to suppress the upper sideband to minimum.

**vi.** Take a screenshot of output of the adder and output of the audio oscillator under the spectrum mode.

**vii.** Observe that the envelope of the modulated signal is not flat. What does it signify?

**viii.** Take a screenshot of output of the adder and output of the audio oscillator under the scope mode.

**ix.** For upper sideband modulation, toggle the front panel switch of the phase shifter up. Repeat step **v** through step **viii**, accordingly.

## A.4.11. Experimental Setup for SSB Demodulation

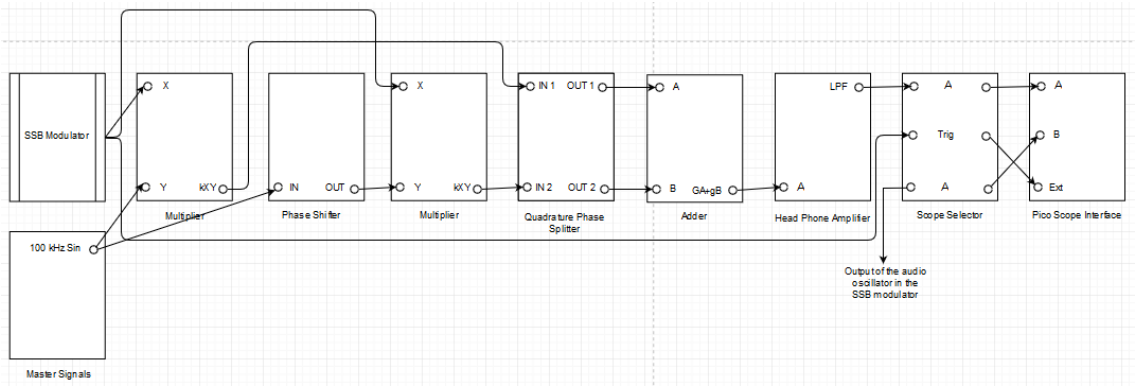



**Figure A.4.6: SSB demodulator setup.**

## A.4.12. Laboratory Exercise for SSB Demodulation

**i.** Retain the modulator setup with upper sideband modulation and make the demodulator setup as shown in Figure A.4.6.

**ii.** Toggle the on-board switch-frequency range of the phase shifter at the demodulator to HI, toggle the front panel switch of the multipliers at the demodulator to DC and toggle the front panel switch of the headphone amplifier to IN. Turn both the knobs of the phase shifter at the demodulator to minimum and turn both the knobs of the adder at the demodulator to minimum.

**iii.** For upper sideband demodulation, toggle the front panel switch of the phase shifter at the demodulator down.

**iv.** Adjust both the knobs of the adder at the demodulator and both the knobs of the phase shifter at the demodulator to obtain the demodulated message signal with minimum phase shift and equal amplitude.

**v.** Take a screenshot of output of the LPF at the headphone amplifier and output of the audio oscillator under the scope mode.

**vi.** Zoom around 0 Hz to 5 kHz to measure frequency of the demodulated message signal peak.

**vii.** Take a screenshot of output of the LPF at the headphone amplifier and output of the audio oscillator under the spectrum mode.

**viii.** For lower sideband demodulation, toggle the front panel switch of the phase shifter at the demodulator up. Repeat step **iv** through step **vii**, accordingly.