2. DSB-SC MODULATION AND DEMODULATION

2.1 OBJECTIVE

To generate DSB-SC AM signal using balanced modulator. Calculate the modulation index and reconstruct the modulating signal using synchronous detector. Simulate DSBSC modulation in time domain using SCILAB.

2.2 HARDWARE REQUIRED:

S.No	Equipment/Component name	Specifications/Value	Quantity
1	Cathode Ray Oscilloscope	(0 – 20MHz)	1
2	Audio Frequency Oscillator	(0-2) MHz	2
3	Scientech Trainer kit	Scientech 2209	1

2.3 THEORY

Double Sideband-Suppressed carrier modulation, in which the transmitted power consists of only the upper and lower sidebands. It is basically an amplitude modulation wave without the carrier, therefore reducing power waste, giving it 50% efficiency. This is an increase compared to normal AM transmission, (DSB) has a maximum efficiency of 33.333%, since 2/3 of the power is in the carrier which carries no intelligence, and each sideband carries the same information. Single Side Band (SSB) Suppressed Carrier is 100% efficient.

2.3.1 BALANCED MODULATOR

The principle of operation of a balanced modulator states that if two signals at different frequencies are passed through a non-linear resistance then at the output, we get an AM signal with suppressed carrier. The device having a non-linear resistance can be a diode or a JFET or even a bipolar transistor.

BLOCK DIAGRAM

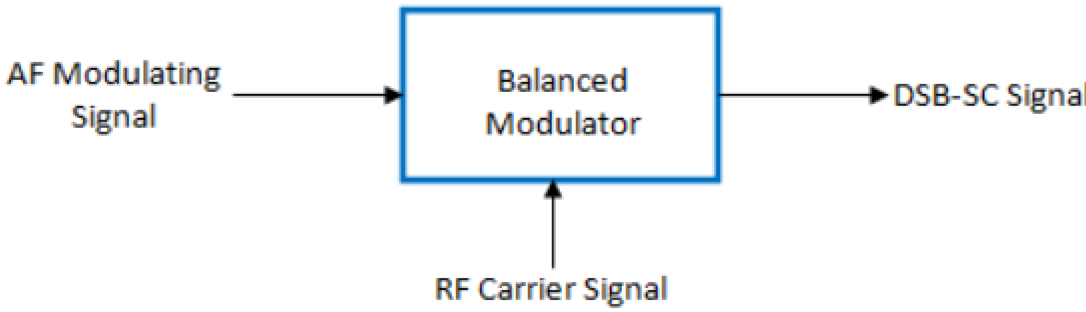

Fig 2.1 Balanced modulator

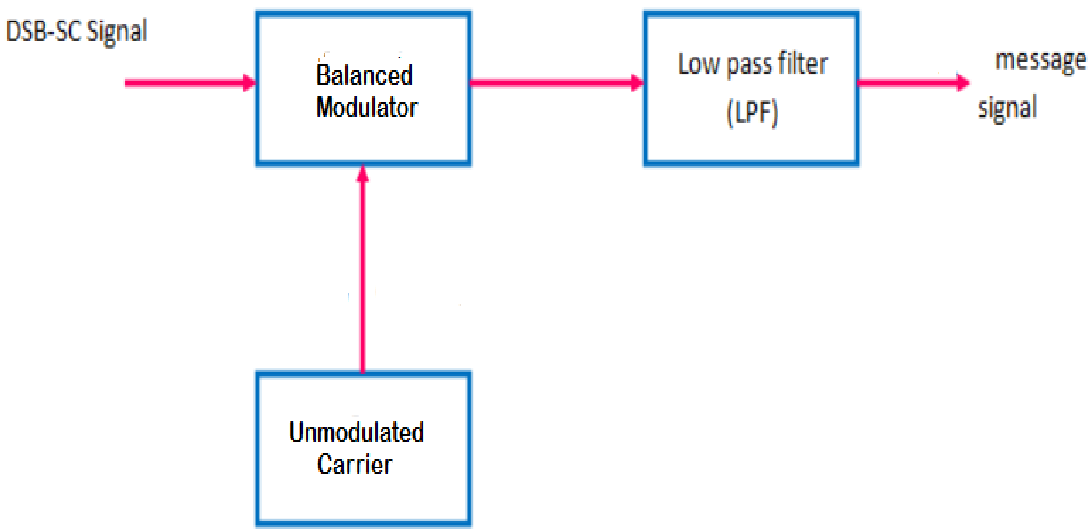

Fig 2.2 Synchronous detector

2.3.2 SYNCHRONOUS DETECTOR

Synchronous detection is used for the detection or demodulation of amplitude modulation (AM). Demodulation is performed by multiplying the modulated carrier by a sine wave that is phase locked to the incoming carrier. Another characteristic of synchronous detectors is that they are phase sensitive. The amplitude of the demodulated signal is a function of the relative phases of the incoming carrier and the carrier generated inside the receiver. In any receiver a key element is the detector. Its purpose is to remove the modulation from the carrier to give the audio frequency representation of the signal. This can be amplified by the audio amplifier ready to be converted into audible sound by headphones or a loudspeaker.

When an AM signal or already modulated signal is applied to linear input of another balance modulator (AM generator), and an unmodulated Carrier is applied to the switching input, neglecting the higher order harmonics of the switching waveform, We obtain the output that is has one side modulation only. And when we pass it to the Low pass Filter, the low pass Filter will only pass the lower frequency and block all other higher frequency. Hence over message signal which is of lower frequency then the carrier signal will pass from Low pass filter and the carrier frequency will be blocked.

2.4 PRE LAB QUESTIONS

1. What are the applications of DSBSC?
2. Draw the spectrum of DSB-SC AM signal in which the modulating signal $E_m\cos\omega_m t$ modulates a carrier signal $E_c\cos\omega_c t$.
3. What is the percentage of power saving for DSBSC when compared with AM having 100% depth of modulation?
4. A DSB-SC signal is generated using the carrier signal cos $(\omega_c t+\theta)$ and modulating signal m(t). What is the envelope detector output of this DSB-SC signal?
5. A 4 GHz carrier is DSB-SC modulated by a low-pass message signal with maximum frequency of 2 MHz. The resultant signal is to be ideally sampled. Determine the minimum frequency of the sampling impulse train.

MODEL GRAPH

DSB-SC MODULATION

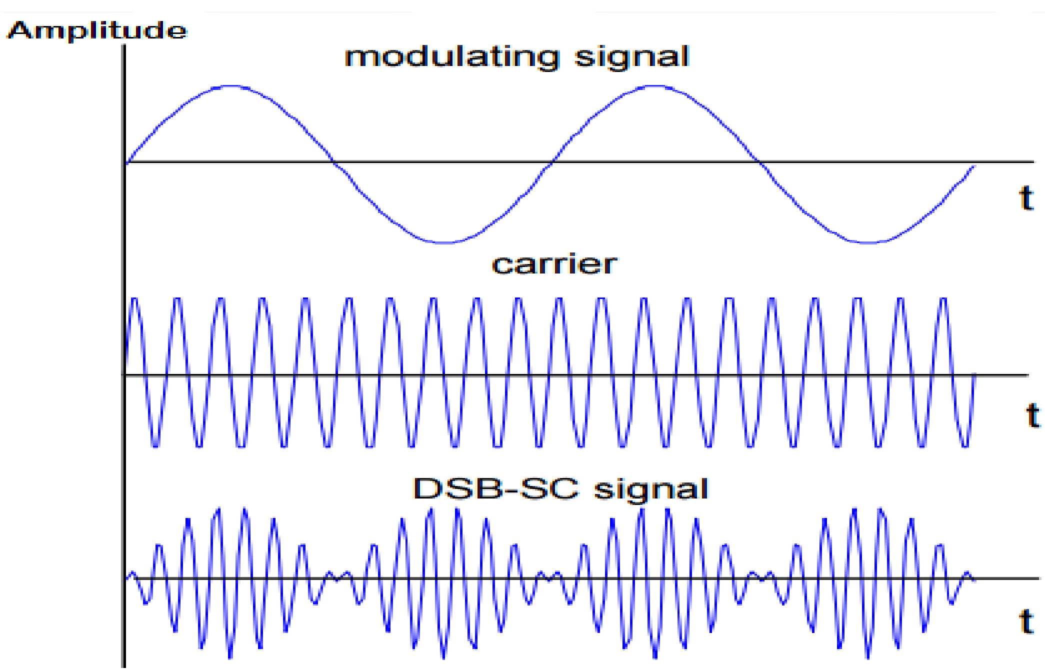

Fig 2.3 DSB-SC modulation waveforms

DSB-SC DEMODULATION

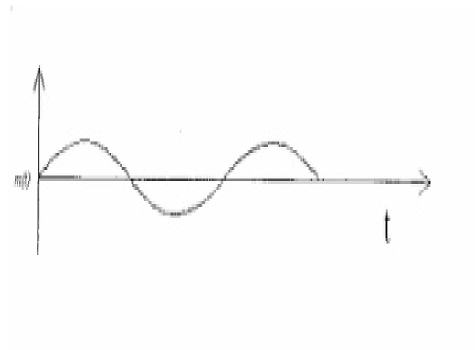

Fig 2.4 DSB-SC demodulation waveform

2.5 LAB PROCEDURE

2.5.1 DSB-SC MODULATION

1. Set the input signal fm as 2 KHz and 400mV sinusoidal signal in AFO
2. Set the carrier signal fc as 100 KHz and 400mV sinusoidal signal in AFO
3. The Double sideband suppressed carrier Amplitude Modulated wave is taken from the output of the balanced modulator.
4. Note down E_{max} and E_{min} from the Output waveform.
5. Calculate modulation index using the formula.

$$\text{Modulation index } m = \frac{\text{Emax} - \text{Emin}}{\text{Emax} + \text{Emin}}$$

6. Vary the Carrier Adjust pot of first balance modulator to see the 100% modulation.
7. Plot the input signals and obtained DSB-SC AM signal in graph sheet.

2.5.2 DSB-SC DEMODULATION

1. Give the output of First Balance modulator (DSBSC-AM) into message input of second Balanced Modulator.
2. Feed the same carrier signal in Second Balance Modulator also.
3. Observe the Double Modulated output from balanced modulator 2 and Vary the ‘Carrier Adjust’ Pot ‘P2’ for perfect one-side modulated wave.
4. Now feed this Double Modulated signal at Low Pass Filter for perfect message signal.
5. Plot the demodulated signal in graph sheet.

2.6 OBSERVATION

DSB-SC MODULATION

Modulating signal				Carrier signal			
Signal Type	**Amplitude**	**Time Period**	**Frequency**	**Signal Type**	**Amplitude**	**Time Period**	**Frequency**
Sine wave				Sine wave			

Modulated Output			
Signal Type	**E_{max}**	**E_{min}**	**Modulation index**
AM			

DSB-SC DEMODULATION

Demodulated output			
Signal Type	**Amplitude**	**Time Period**	**Frequency**
Sine wave			

2.7 POST LAB QUESTIONS

1. Use SCILAB to produce DSBSC wave for a sinusoidal modulating signal of 1 KHz and carrier signal of 10 KHz.

2.8 LAB RESULT

Thus the DSB-SC modulation and demodulation was performed.

3. FREQUENCY MODULATION & DEMODULATION

3.1 Objective

To perform frequency modulation and demodulation process using audio frequency signal with adjustable amplitude & frequency (300Hz-3.4 KHz) with the help of Trainer kit. Simulate the Frequency Modulation (FM) wave in time domain using SCILAB.

3.2 Hardware Required

S.No	Equipment/Component name	Specifications/Value	Quantity
1	Cathode Ray Oscilloscope	(0 – 20MHz)	1
2	Audio Frequency Oscillator	(0-2) MHz	2
3	FM Trainer kit	ST8203	1

3.3 Theory

Frequency modulation is a process of changing the frequency of a carrier wave in accordance with the slowly varying base band signal. The main advantage of this modulation is that it can provide better discrimination against noise. The frequency of the carrier is made to increase as the voltage in the information signal increases and to decreases in frequency as it reduces. Higher the amplitude gives increased frequency.

3.3.1 Frequency Modulator

The FM modulator is used to combine the carrier wave and the information signal. The varactor and reactance modulator are two different methods to perform frequency modulation process. In varactor modulator when the information signal applied to the varactor diode, the capacitance will be increased and decreased in sympathy with the incoming signal. The changing value of capacitance causes the oscillator frequency to increase and decrease under the control of the information signal. The output is therefore a FM signal. In reactance modulator, the changing information signal being applied to the base has the same effect as changing the bias voltage applied to the transistor and this would have the effect of increasing and decreasing the value of this capacitance. As the capacitance is parallel with the tuned circuit the variations in value will cause the frequency of resonance to change and hence the carrier frequency will be varied in sympathy with the information signal input.

3.3.2 FM Demodulator

The extraction of information signal from the modulated signal is done by demodulators. The basic requirement of FM demodulator is therefore to convert frequency changes into changes in voltage, with the minimum amount of distortion. The demodulator converts FM into AM and then to the base band signal (information/audio signal). Foster Seeley uses double tuned RF transformer to convert frequency variations in the received FM signal to amplitude variations. These amplitude variations are then rectified and filtered to provide a dc output voltage. This voltage varies in both the amplitude and polarity as the input signal varies in frequency.

Block Diagram for Modulation and Demodulation

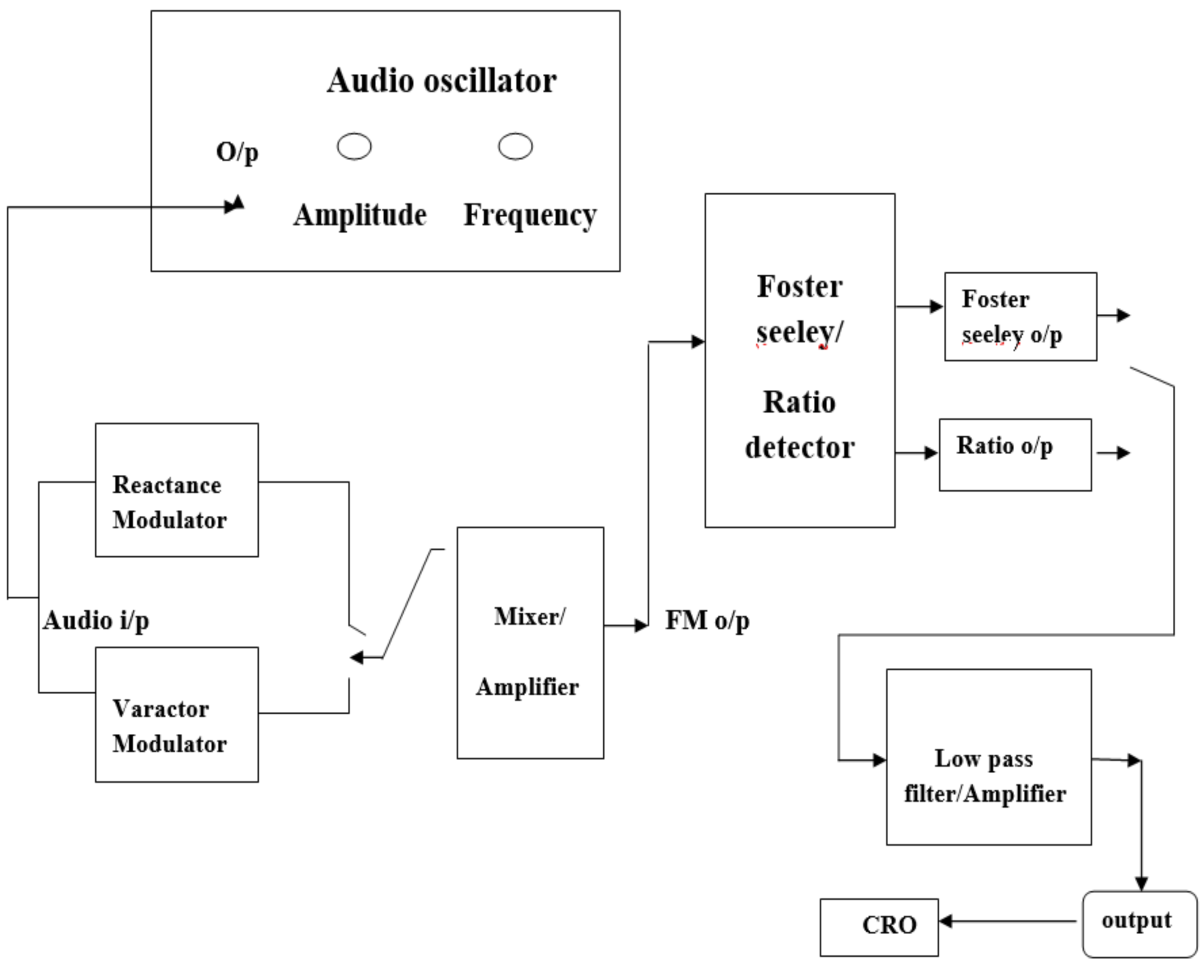

Fig 3.2 Frequency modulation and demodulation

3.4 Pre-Lab Questions

1. The carrier frequency in an FM modulator is 1000 kHz. If the modulating frequency is 15 kHz, what are the first three upper sideband and lower sideband frequencies?

2. A frequency modulated wave is given as $s(t)=10\sin(2\pi x10^8t+5\sin400\pi t)$, identify carrier frequency and maximum frequency deviation of the signal.

3. Give the Carson's rule to calculate bandwidth of the system

4. A 25 MHz carrier is modulated by a 400 Hz audio sine wave. If the carrier voltage is 4V and the maximum frequency deviation is 10 kHz, write down the voltage equation of the FM wave.

5. When a single tone modulating signal $\cos(15\pi10^3t)$ frequency modulates a carrier of 10MHz and produces a frequency deviation of 75 KHz calculate the modulation index of FM?

3.5 Lab Procedure

3.5.1 Frequency Modulator

1. Turn on power to the trainer kit and set the 5 volts amplitude and frequency of 1KHz in the audio oscillator (i.e modulating signal) to the trainer kit-ST8203 module.
2. Connect the output socket of the audio oscillator block to the audio input socket of the modulator circuit's block.
3. Select reactance/varactor modulator switch in position. These switches the output of the modulator through to the input of the mixer/amplifier block and the FM output appears once it is connect to the display (Digital/Analog oscilloscope).
4. Adjust the audio oscillators amplitude pot throughout its range note time period of modulated signal for one cycle as T1 and T2 using oscilloscope.
5. Measure the frequency of the FM output signal with F1 and F2 (using F=1/T).This is because the audio information is contained entirely in the signal's frequency and not in its amplitude.

3.5.2 Frequency Demodulator

1. Make the connection as per the block diagram.
2. Turn on power to the ST8203 module.
3. FM output from mixer/amplifier block is connected to the input of Foster Seeley detector or ratio detector block.

4. Select the Foster Seeley or ratio detector switch in position.
5. Connect the input of Low pass filter /amplifier block with the output from the Foster Seeley/ratio detector block.
6. Measure the amplitude and frequency of audio signal (demodulated signal).
7. Adjust the audio oscillator block's amplitude and frequency pots and compare the original audio signal with the final demodulated signal.

3.6 Observation – Hardware

Signal Name	Amplitude	Frequency		Time period	
Modulating signal (input signal)					
Carrier signal					
Modulated signal (output signal)		**F1**	**F2**	**T1**	**T2**
Demodulated Signal (Foster Seeley)					

3.6.1 Model Graph

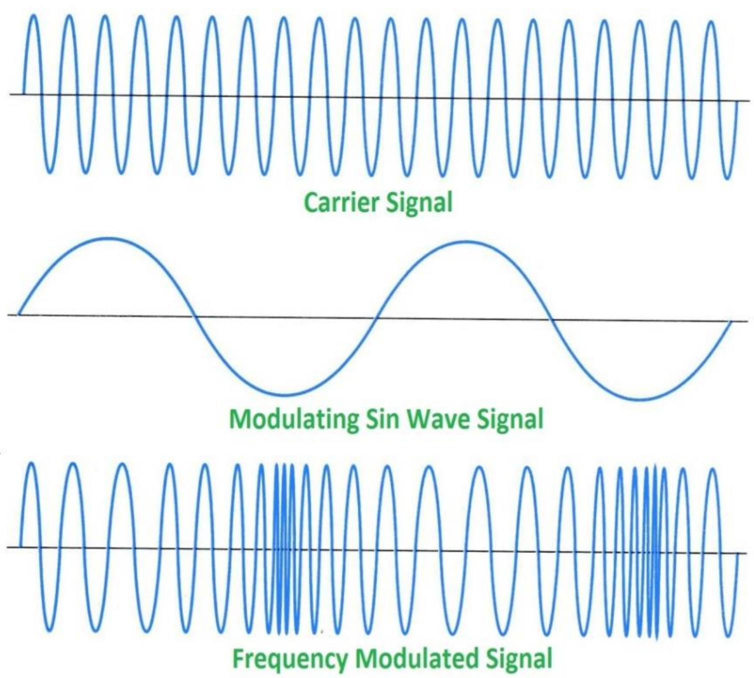

Fig 3.3 Frequency modulated waveforms

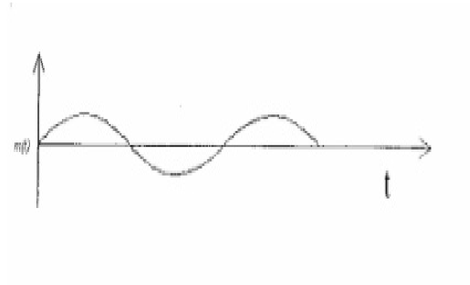

Fig 3.4 Frequency demodulated waveforms

3.7 Post Lab Questions

1. With the following data, use SCILAB to generate and plot time domain representation of Frequency Modulation signal

Carrier frequency fc = 1 kHz
Amplitude Carrier frequency = Ac = 9 V
Modulating frequency =300 Hz
Amplitude Modulating Signal Vm = 4.5 V

3.8 LAB RESULT

Thus the Frequency modulation and demodulation process in a trainer kit was performed and the modulation of FM signal was simulated using Scilab for the given carrier and modulating signal.