Experiment No. 1

1. AMPLITUDE MODULATION &DEMODULATION

I. AIM:

To perform the function of Amplitude Modulation & Demodulation (under modulation, perfect modulation & over modulation) and also calculate the modulation index.

II. APPARATUS:

1. Amplitude Modulation & Demodulation trainer kit.
2. C.R.O (20MHz)
3. Function generator (1MHz).
4. Connecting chords & probes.

III. THEORY:

Amplitude modulation is defined as the process in which the amplitude of the carrier wave c(t) is varied about a mean value, linearly with the baseband signal.

An AM wave may thus be dscribed, in the most general form, as a function of time as follows.

$S(t)=A_c\{1+K_a m(t)\}\cos(2\pi f_c t)$

Where K_a- Amplitude sensitivity of the modulator

S(t) –Modulated signal

A_c- carrier signal

m(t) –modulating signal

The amplitude of K_a m(t) is always less than unity, that is K_a m(t) <1 for all t.

It ensure that the function 1+K_a m(t) is always positive. When the amplitude sensitivity Ka of the modulator is large enough to make K_a m(t)>1 for any carrier wave becomes over modulated ,resulting in carrier phase reversal whenever the factor $1+K_a m(t)$ crosses zero. The modulate wave then exhibits envelope distortion.

The absolute maximum value of K_a m(t) multiplied by 100 is referred to as the percentage modulation.

$$\text{Or percentage modulation} = \frac{V_{max}-V_{min}}{V_{max}+V_{min}} \times 100$$

The carrier frequency f_c is much greater than the highest frequency component ω of the message signal m(t),that is $f_c >> W$

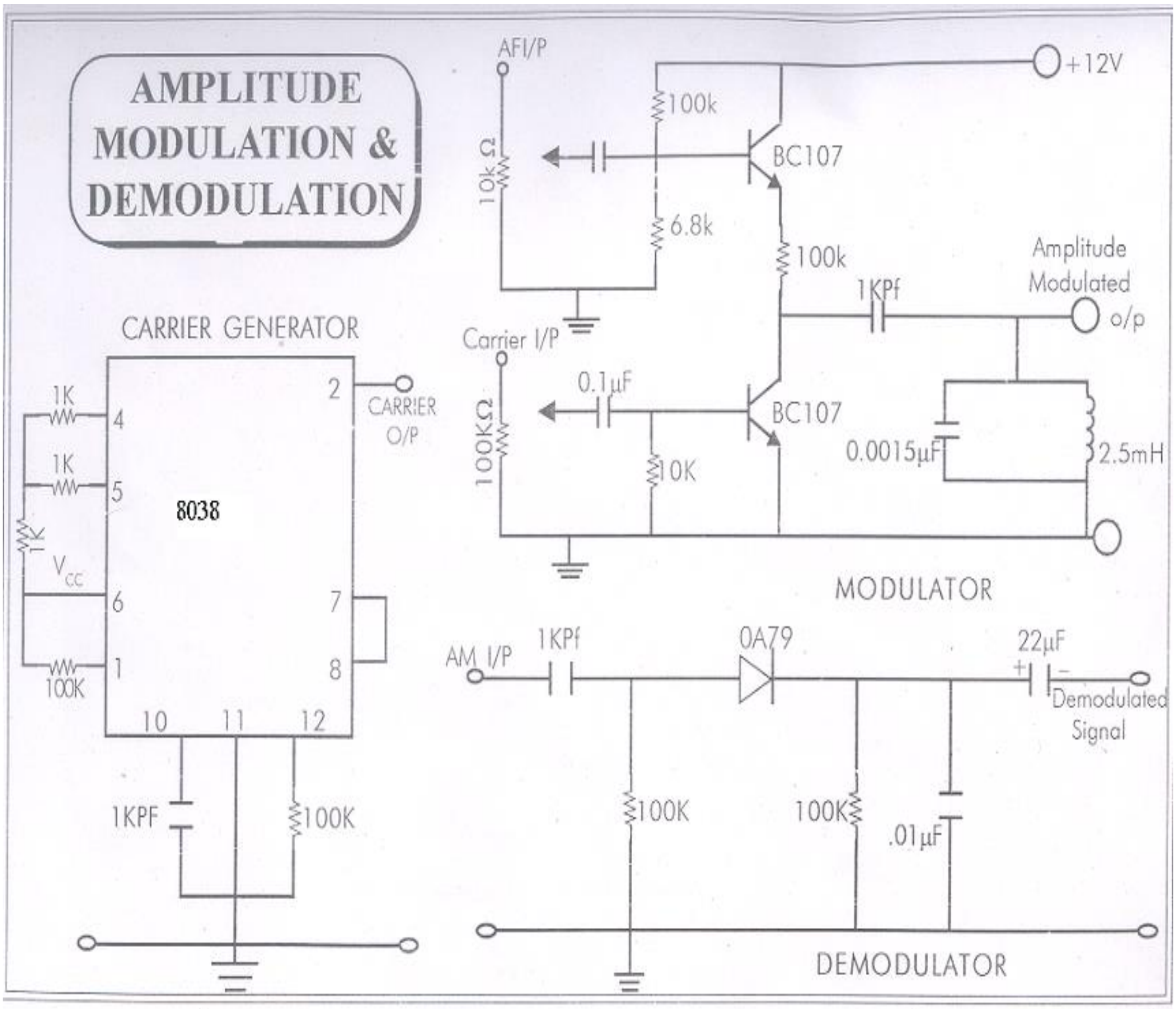
Where W is the message bandwidth.

If the condition is not satisfied, and envelope cannot be visualized satisfactorily.

The trainer kit has a carrier generator, which can generate the carrier wave of 100 KHz when the trainer is switched on.

The circuit's carrier generator, modulator and demodulator are provided with the built in supplies, no supply connections are to be given externally.

IV. CIRCUIT DIAGRAM:



V. PROCEDURE:

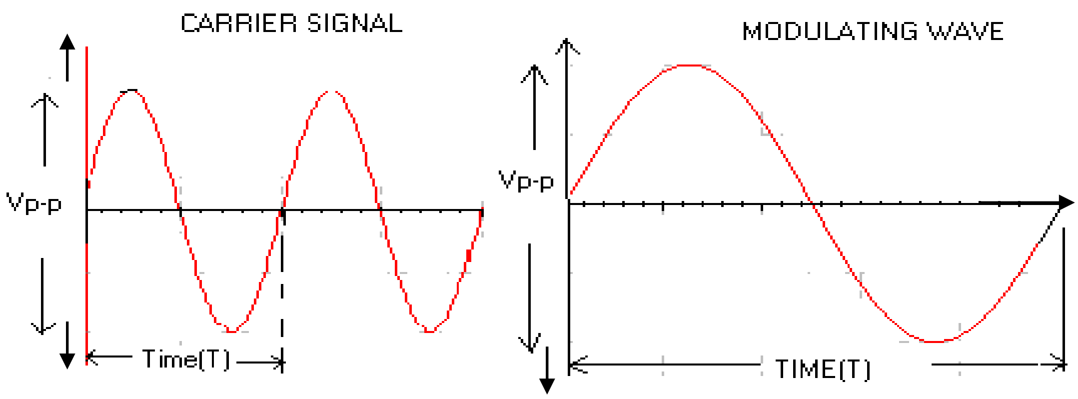
1. Switch on the trainer kit and check the O/P of the carrier generator on oscilloscope.
2. Connect around 1KHz with 2Volts .A.F signal at A.F I/P to the modulator circuit.
3. Connect the carrier signal at carrier I/P of the modulator circuit.
4. Observe the modulator output signal at AM O/p Spring by making necessary changes in A.F signal
5. Vary the modulating frequency and amplitude and observe the effects on the modulated waveform.
6. The depth of modulation can be varied using the variable knob provided at A.F input.
7. The percentage modulation can be calculated using the formula.

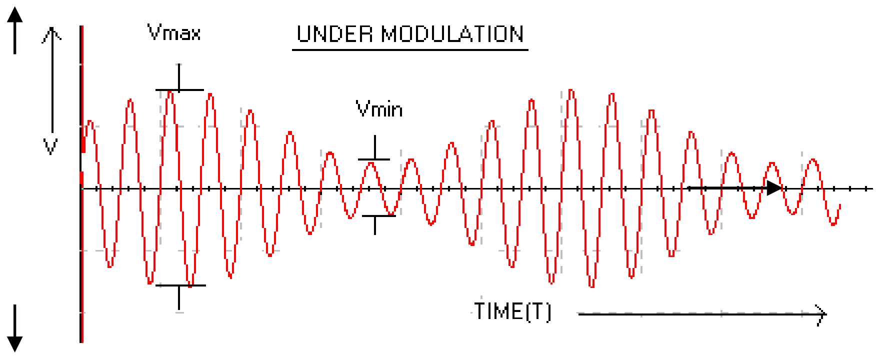
$$\text{Percentage modulation} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} \times 100$$

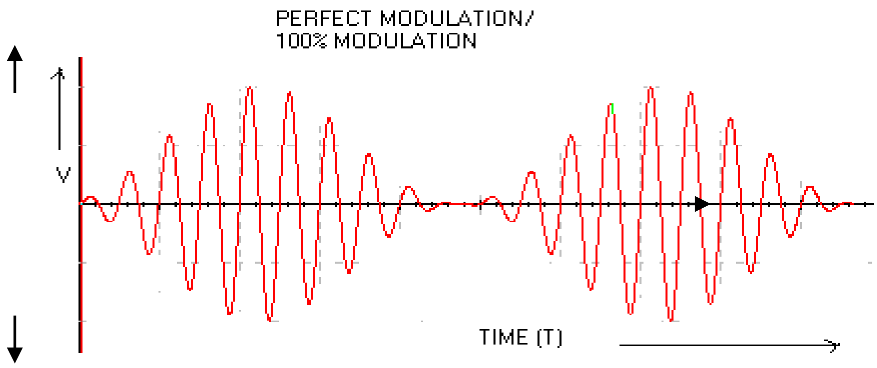
$$\text{Modulation factor} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

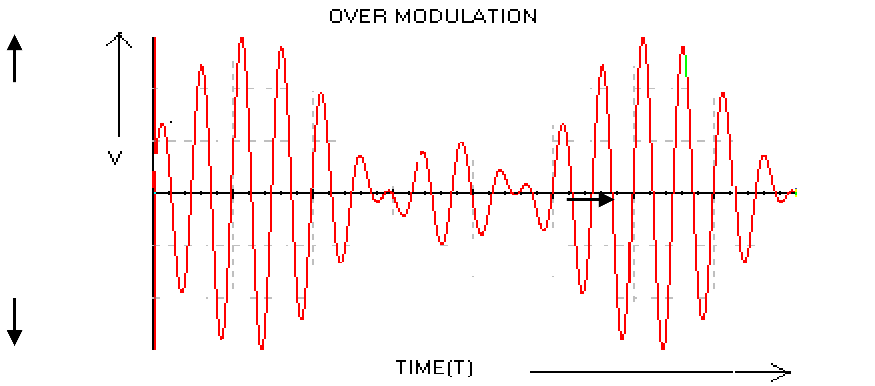
8. Connect the output of the modulator to the input of the demodulator circuit and observe the output.

VI. EXPECTED WAVEFORMS:

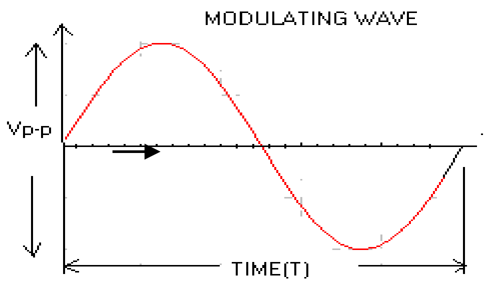








Demodulated signal



VII. RESULT:

VIII. APPLICATIONS:

1. Tele communications.
2. TV Transmitters.

IX. QUESTIONS:

1. Define AM and draw its spectrum?
2. Draw the phase representation of an amplitude modulated wave?
3. Give the significance of modulation index?
4. What is the different degree of modulation?
5 What are the limitations of square law modulator?
6. Compare linear and nonlinear modulators?
7. Compare base modulation and emitter modulation?
8 Explain how AM wave is detected?
9 Define detection process?
10. What are the different types of distortions that occur in an envelop detector? How can they be eliminated?

Experiment No. 2

DSB-SC Modulator and Demodulator

I. AIM:

To perform the characteristics of the Balanced Modulator as a

1. Frequency Doubler
2. DSB-SC Generator.

II. APPARATUS:

1. Balanced modulator trainer kit
2. C.R.O (20MHz)
3. Connecting chords and probes
4. Function generator (1MHz)

III. THEORY:

1. RF Generator:
Colpitts oscillator using FET is used here to generate RF signal of approximately 100 KHz Frequency to use as carrier signal in this experiment. Adjustments for Amplitude and Frequency are provided in panel for ease of operation.

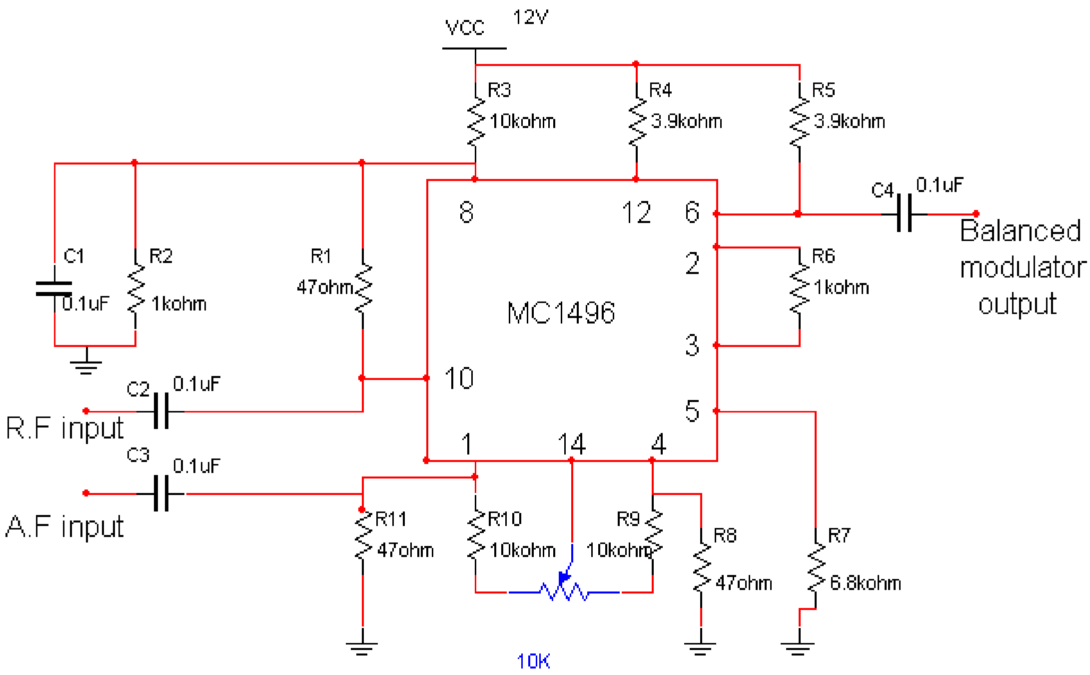
2. AF Generator:
Low Frequency signal of approximately 5KHz is generated using OP-AMP based wein bridge oscillator. IC TL 084 is used as an active component; TL 084 is FET input general purpose quad OP-AMP integrated circuit. One of the OP-AMP has been used as amplifier to improve signal level. Facility is provided to change output voltage.

3. Regulated Power Supply:
This consists of bridge rectifier, capacitor filters and three terminal regulators to provide required dc voltage in the circuit i.e. +12v, -8v @ 150 ma each.

4. Modulator:
The IC MC 1496 is used as Modulator in this experiment. MC 1496 is a monolithic integrated circuit balanced modulator/Demodulator, is versatile and can be used up to 200 MHz.

Multiplier:
A balanced modulator is essentially a multiplier. The output of the MC 1496 balanced modulator is proportional to the product of the two input signals. If you apply the same sinusoidal signal to both inputs of a ballooned modulator, the output will be the square of the input signal AM-DSB/SC: If you use two sinusoidal signals with deferent frequencies at the two inputs of a balanced modulator (multiplier) you can produce AM-DSB/SC modulation. This is generally accomplished using a high- frequency “carrier” sinusoid and a lower frequency “modulation” waveform (such as an audio signal from microphone). The figure 1.1 is a plot of a DSB-SC waveform, this figure is the graph of a 100 KHz and a 5 KHz sinusoid multiplied together. Figure 1.2 shows the circuit that you will use for this experiment using MC 1496-balanced modulator/demodulator.

IV. CIRCUIT DIAGRAM:



V. PROCEDURE:

(i)-Frequency Doubler

1. Connect the circuit as per the given circuit diagram.
2. Switch on the power to the trainer kit.
3. Apply a 5 KHz signal to both RF and AF inputs of 0.1V$_{P-P}$.
4. Measure the output signal frequency and amplitude by connecting the output to CRO.
5. Repeat the steps 3 and 4 by changing the applied input signal frequency to 100KHZ and 500 KHz. And note down the output signals.

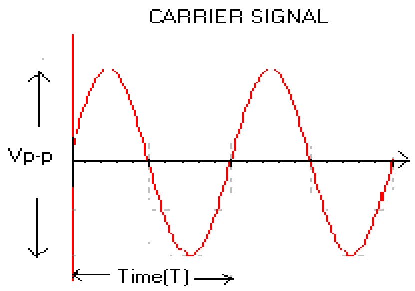
NOTE:- Amplitude decreases with increase in the applied input frequency.

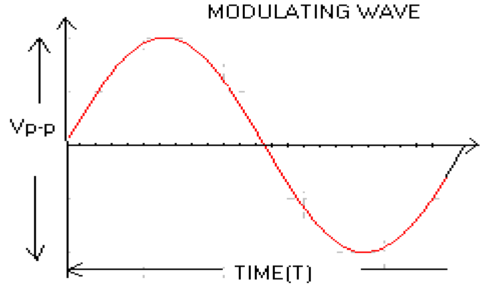
(ii)-Generation of DSB-SC

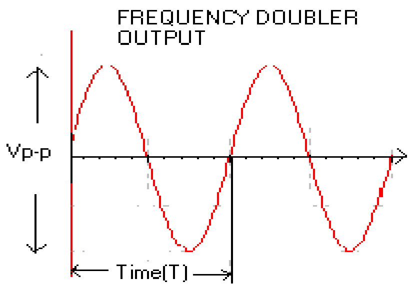
1. For the same circuit apply the modulating signal(AF) frequency in between 1Khz to 5Khz having 0.4 V$_{P-P}$ and a carrier signal(RF) of 100KHz having a 0.1 V$_{P-P}$.
2. Adjust the RF carrier null potentiometer to observe a DSB-SC waveform at the output terminal on CRO and plot the same.
3. Repeat the above process by varying the amplitude and frequency of AF but RF maintained constant.

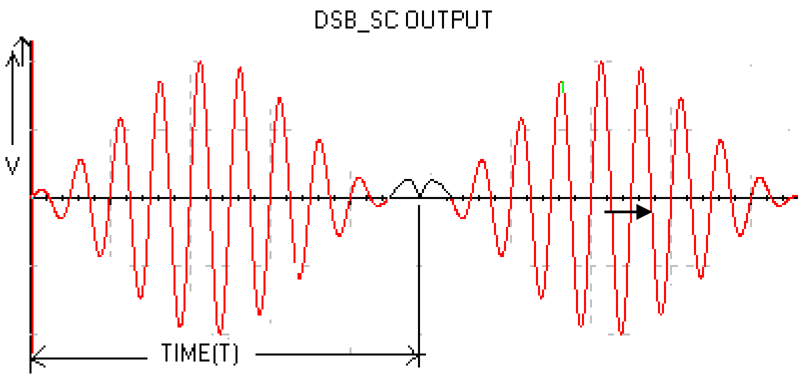
   NOTE:- Note down all the waveforms for the applied inputs and their respective outputs.

VI. EXPECTED WAVEFORMS:









Note: In frequency doubling If the input time period is "T" after frequency doubling the time period should be halved. i.e., "T/2".

VII. RESULT:

VIII. APPLICATIONS:

1. Tele communications.
2. TV Transmitters.

IX . QUESTIONS:

1. What are the two ways of generating DSB_SC.
2. What are the applications of balanced modulator?
3. What are the advantages of suppressing the carrier?
4. What are the advantages of balanced modulator?
5. What are the advantages of Ring modulator?
6. Write the expression for the output voltage of a balanced modulator?

Experiment No. 3

SSB-SC Modulator and Detector (Phase Shift Method)

I. AIM :

To perform the Single side band modulation

II. APPARATUS:

1. SSB trainer kit
2. C.R.O (20MHz)
3. Function Generator (1MHz).

III. THEORY:

This experiment consists of

1. R.F generator.
2. A.F generator.
3. Two balanced modulators.
4. Synchronous detector
5. Summer
6. Subtractor

1.RF generator:

Colpitts oscillator using FET is used here to generate RF signal of approximately 100KHz frequency to use as carrier signal in this experiment. Phase shift network is included in the same block to produce another carrier signal of same frequency with 90^0 out of phase. An individual controls are provided to vary the output voltage. Facility is provided to adjust phase of the output signal.

2.AF generator:

This is a sine cosine generator using OP-OMP. IC TL 084 is used as an active component; TL 084 is a FET input general purpose quad op-amp integrated circuit. A three-position switch is provided to select output frequency. An individual controls are provided to vary the output voltage. AGC control is provided to adjust the signal shape.

3.Balanced Modulator:

This has been developed using MC 1496 IC, is a monolithic integrated circuit Balanced modulator/demodulator, is versatile and can be used up to 200MHz. These modulators are used in this experiment to produce DSB_SC signals. Control is provided to balance the output.

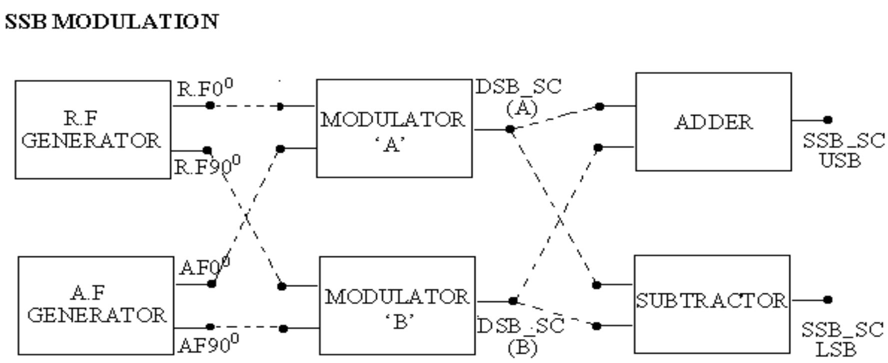
5. Summer and Subtractor:

These circuits are simple summing and subtracting amplifiers using OP-AMP. IC TL084 is used as an active component; TL 084 is a FET input General-purpose quad OP-AMP integrated circuit.

The phase shift method makes use of two balanced modulators and two phase shift networks as shown in figure. One of the modulators receives the carrier signal shifted by 90^0 and the modulating signal with 0^0 (sine) phase shift, where as the other receives modulating signal shifted by 90^0 (cosine) and the carrier (RF) signal with 0^0 phase shift voltage.

Both modulators produce an output consisting only of sidebands. It will be shown that both upper sidebands lead the reference voltage by 90^0, and the other lags it by 90^0. The two lower side bands are thus out of phase and when combined in the adder, they cancel each other. The upper side bands are in phase at the adder and therefore they add together and give SSB upper side band signal. When they combined in the subtractor, the upper side bands are cancel because in phase and lower side bands add together and gives SSB lower side band signal.

IV. CIRCUIT DIAGRAM:



V. PROCEDURE:

SSB MODULATION

1. Connect the circuit as per the given circuit diagram.
2. Switch on the kit and measure the output of regulated power supplies positive and negative voltages.

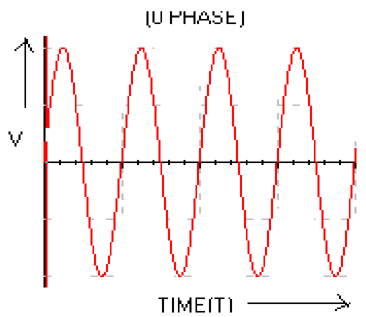
3. Observe the outputs of RF generators using CRO .Where one output is 0^0phase the another is 90^0 phase shifted(or) is a sine wave and shifted w.r.t other (or) is a cosine wave.

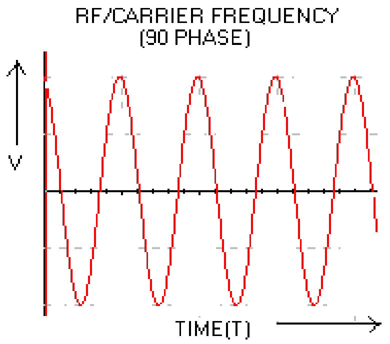
4. Adjust the RF output frequency as 100 KHz and amplitude as ≥ 0.2 V_{p-p} (Potentiometers are provided to vary the output amplitude & frequency).
5. Observe the two outputs of AF generator using CRO.
6. Select the required frequency (2 kHz, 4 kHz, 6 kHz) form the switch positions for A.F.
7. Adjust the gain of the oscillator by varying the AGC potentiometer and keep the amplitude of 10Vp-p.
8. Measure and record the above seen signals & their frequencies on CRO.
9. Set the amplitude of R.F signal to 0. 2Vp-p and A.F signal amplitude to 8Vp-p and connect AF-0^0 and RF-90^0 to inputs of balanced modulator A and observe DSB-SC(A) output on CRO. Connect AF-90^0 and RF-0^0 to inputs of balanced modulator B and observe the DSB-SC (B)out put on CRO and plot the same on graph.
10. To get SSB lower side band signal connect balanced modulator outputs (DSB-SC) to subtractor and observe the output wave form on CRO and plot the same on graph.
11. To get SSB upper side band signal, connect the output of balanced modulator outputs to summer circuit and observe the output waveform on CRO and plot the same on graph.
12. Calculate theoretical frequency of SSB (LSB & USB) and compare it with practical value.

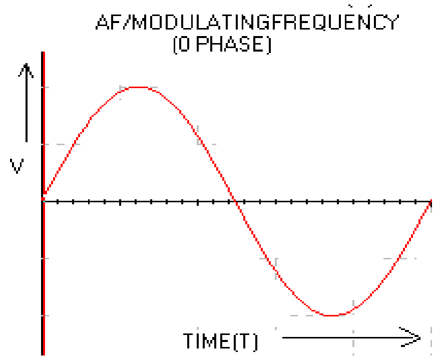
    USB = RF frequency + AF frequency.

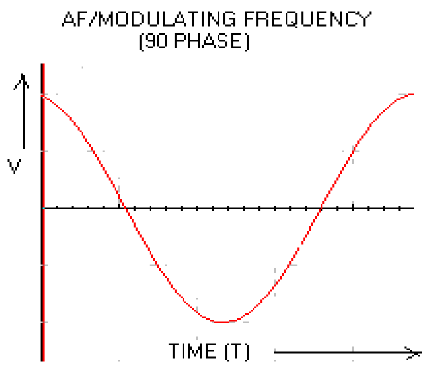
    LSB = RF frequency – AF frequency.
13. The SSB output connected to synchronous detector input and obtain the demodulated signal.

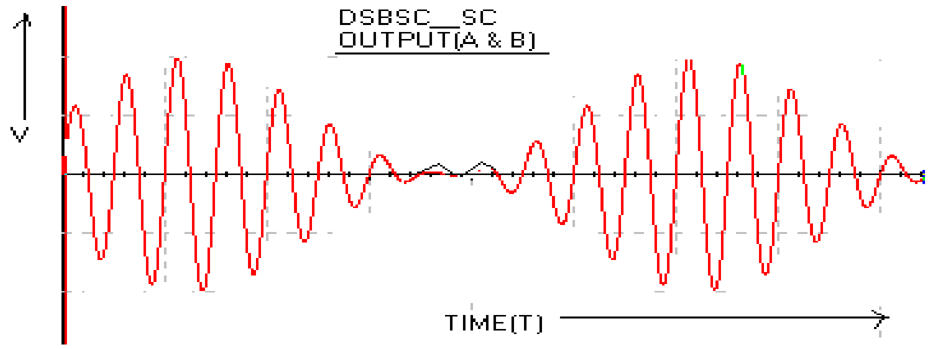
VI. EXPECTED WAVEFORMS:

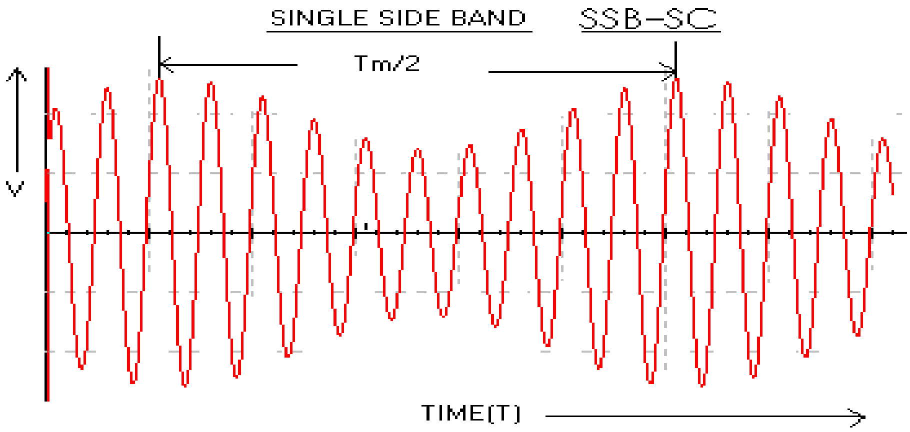












VII. RESULT:

VIII. APPLICATIONS:

1. Communication Systems.
2. Tele Communications.

IX. QUESTIONS:

1. What are the two ways of generation of SSB wave?
2. What are the features of filter method generation of SSB?
3. What are the advantages of phase shift method of SSB generation?
4. What are the disadvantages of phase shift method of SSB generation?
5. What are the advantages of SSB-SC AM?
6. What are the disadvantages of SSB-SC AM?
7. What are the applications of SSB-SC AM?

Experiment No. 4

FREQUENCY MODULATION & DEMODULATION

I. AIM:

To perform the functioning of Frequency modulation & demodulation and also calculate the modulation index.

II. APPARATUS:

1. Frequency modulation & demodulation trainer kit.
2. C.R.O (20MHz)
3. Function generator (1MHz).
4. Connecting chords & probes.

III. THEORY:

FM is a system in which the amplitude of the carrier wave c(t) is kept constant, while its frequency and the rate of changes are varied by the baseband signal.
By definition the amount by which the carrier is varied from its unmodulated signal is called the frequency deviation., is made proportional to the instantaneous amplitude of the modulating signal.
The rate at which this frequency variation changes or takes place is equal to the modulating frequency.
Fm is that form of angle modulation in which the instantaneous frequency f(t) is varied with the message signal m(t), as

$$F_i(t)=f_c+K_f m(t)$$

The term f_c represents the frequency of the unmodulated carrier, the constant K_f represents the frequency sensitivity of the modulator expressed in Hertz per volt.

Generation of FM signal:

There are essentially two basic methods of generating frequency-modulated signal, namely direct FM and indirect FM.
In direct FM the carrier signal is varied directly in accordance with the input base band signal, which is readily accomplished using a voltage-controlled oscillator.
In the indirect method the modulating signal is first use to produce a narrow band FM signal, and frequency multiplication is next used to increase the frequency deviation to desired level. The indirect method is preferred choice for FM when the stability of the carrier is of major concern as in commercial radio broadcasting.

Modulation index = firequency deviation / modulating signal frequency

Indirect FM:

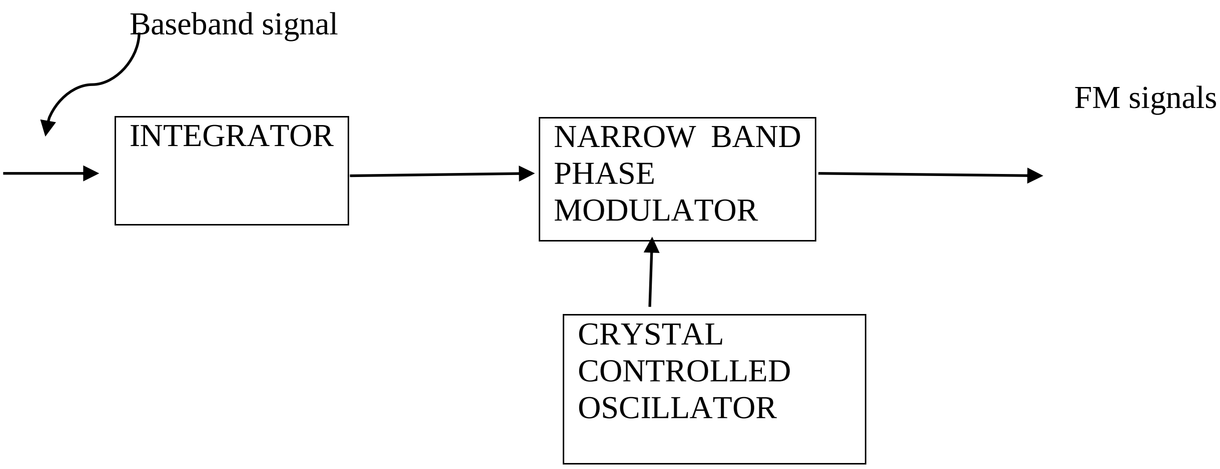
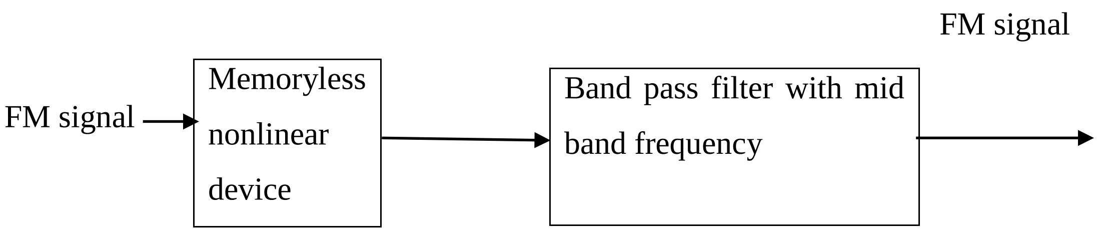


Fig (i): Indirect method of generating a wide band FM signal

The message signal m(t) is first integrated and then used to phase modulate a crystal controlled oscillator; the use of crystal control provides frequency stability. To minimize the distortion inherent in the phase modulator, the maximum phase deviation or modulation index β is kept small, there by resulting in an narrow band FM signal.

This signal is next multiplied in frequency in frequency by means of a frequency multiplier so as to produce the desired wide band FM signal.

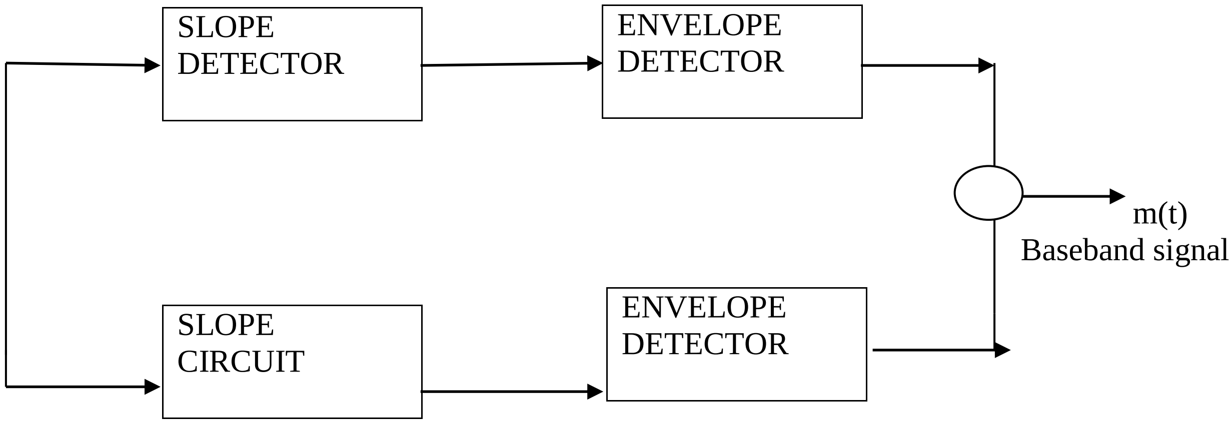


Fig(ii): Frequency Multiplier

Demodulation of FM signals:

Frequency demodulation is the process that enables us to recover the original modulating signal from a frequency-demodulated signal.

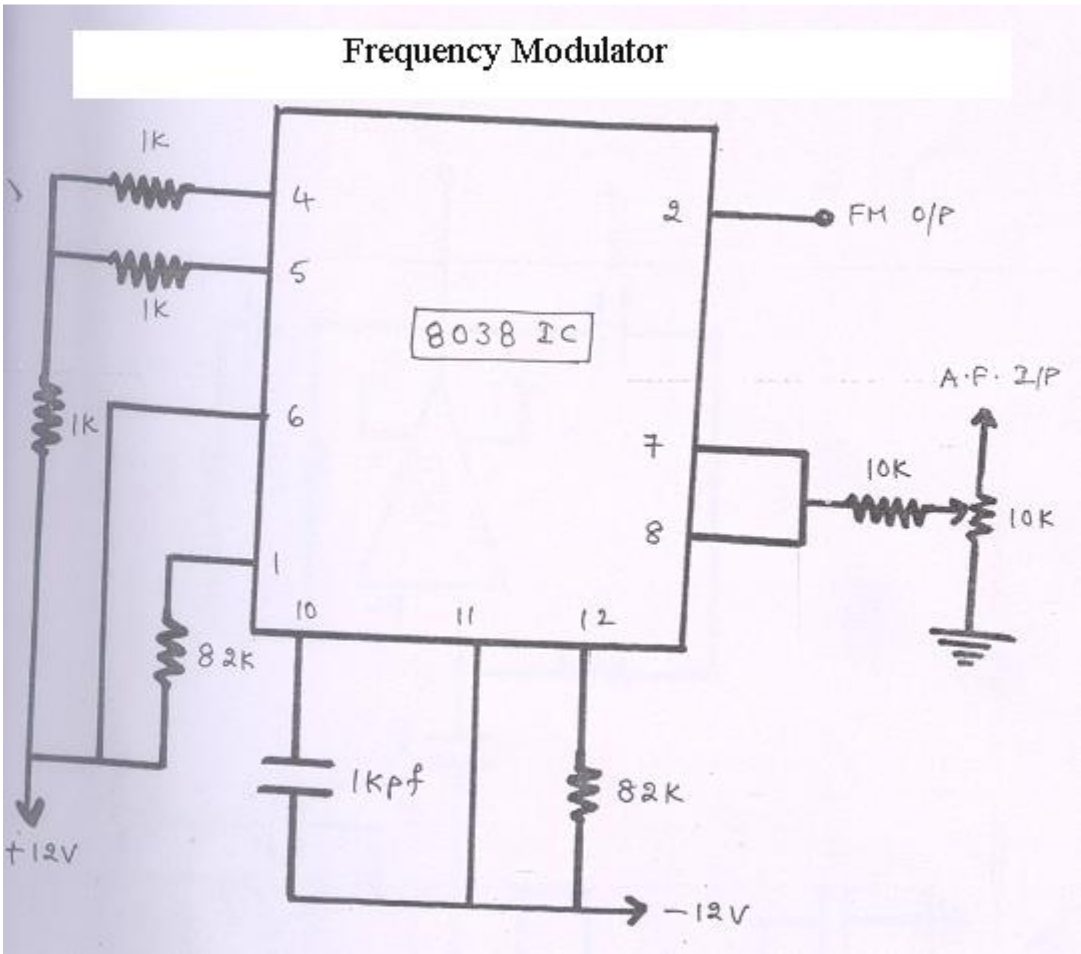
Here we describe a direct method of frequency discriminator, whose instantaneous output amplitude is directly proportional to the instantaneous frequency of the input FM signal.



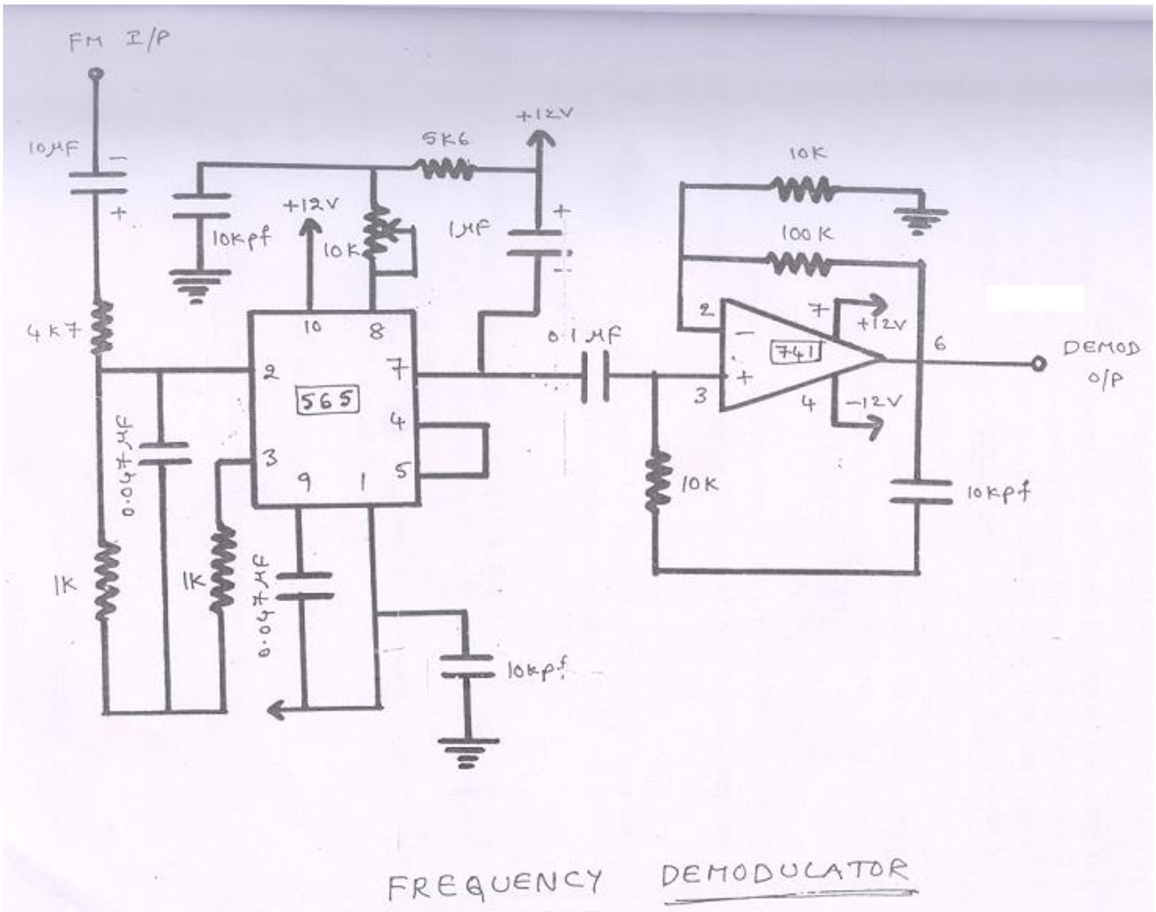
Fig(iii): Frequency Discriminator

IV.CIRCUIT DIAGRAM:

FREQUENCY MODULATION CIRCUIT DIAGRAM:



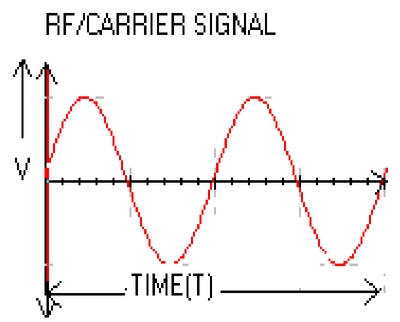
FREQUENCY DEMODULATION CIRCUIT DIAGRAM:

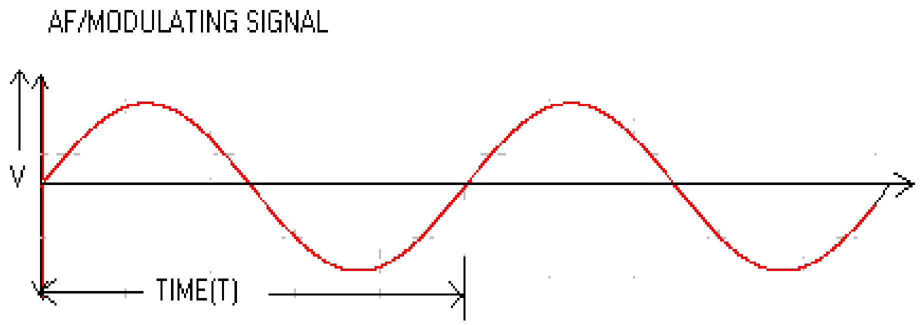


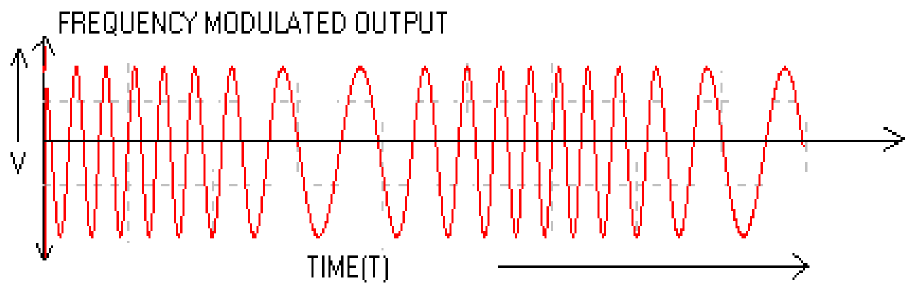
V. PROCEDURE:

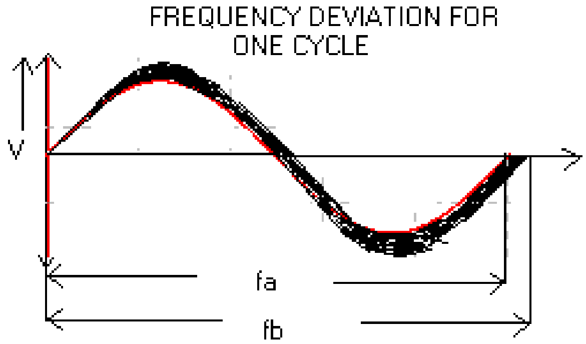
1. Switch on the power supply of the kit (without making any connections).
2. Connect Oscilloscope to the FM O/P and observe that the carrier frequency at that point without any A.F input.
3. Connect around 1KHz with 2 volts sine wave to the input of frequency modulator.
4. Now observe the frequency modulation output on the 1st channel of CRO and adjust the amplitude of the A.F signal to get clear frequency modulated waveform.
5. Vary the modulating frequency and amplitude and observe the effects on the modulated waveform.
6. Connect the FM o/p to FM i/p of demodulator.
7. Vary the potentiometer provided in the demodulator section.
8. Observe the demodulation output on second channel of CRO.

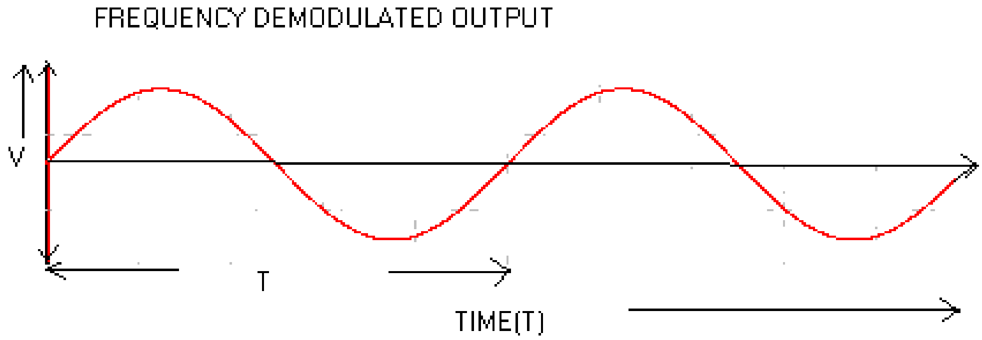
VI. EXPECTED WAVEFORMS:











Note: Note down all the input and output wave forms of the signals applied and obtained respectively.

VII. RESULT:

VIII. APPLICATIONS:

1. Mobile Communications.
2. Satellite Communications.

IX. QUESTIONS:

1 Define frequency modulation?
2. Mention the advantages of indirect method of FM generation?
3. Define modulation index and frequency deviation of FM?
4 What are the advantages of FM?
5. What is narrow band FM?
6. Compare narrow band FM and wide band FM?
7. Differentiate FM and AM?
8. How FM wave can be converted into PM wave?
9, State the principle of reactance tube modulator?
10. Draw the circuit of varactor diode modulator?
11. What is the bandwidth of FM system?
12. Want is the function of FM discriminator?
13. How does ratio detector differ from Fosterseely discriminator?
14 What is meant by linear detector?
15. What are the drawbacks of slope detector?

Experiment No. 5

PRE-EMPHASIS & DE-EMPHASIS

I. AIM: To perform the characteristics of Pre-Emphasis and De-Emphasis circuits.

II. APPARATUS:

1. Pre-emphasis & De-emphasis trainer kits.
2. C.R.O (20MHz)
3. Function generator (1MHz).
4. Patch chords and Probes.

III. THEORY:

Frequency modulation is much immune to noise than amplitude modulation and significantly more immune than phase modulation. A single noise frequency will affect the output of the receiver only if it falls with in its pass band.

The noise has a greater effect on the higher modulating frequencies than on lower ones. Thus, if the higher frequencies were artificially boosted at the transmitter and correspondingly cut at the receiver, improvement in noise immunity could be expected. This boosting of the higher frequencies, in accordance with a pre-arranged curve, is termed pre-emphasis, and the compensation at the receiver is called de-emphasis.

If the two modulating signals have the same initial amplitude, and one of them is pre-emphasized to (say) twice this amplitude, whereas the other is unaffected (being at a much lower frequency) then the receiver will naturally have to de-emphasize the first signal by a factor of 2, to ensure that both signals have the same amplitude in the output of the receiver. Before demodulation, I.e. while susceptible to noise interference the emphasized signal had twice the deviation it would have had without pre-emphasis, and was thus more immune to noise. Alternatively, it is seen that when this signal is de-emphasized any noise sideband voltages are de-emphasized with it, and therefore have a correspondingly lower amplitude than they would have had without emphasis again their effect on the output is reduced.

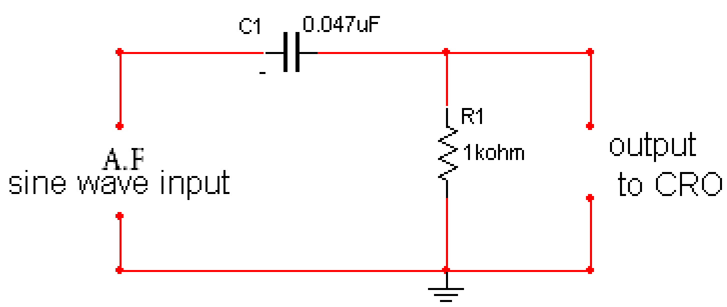
The amount of pre-emphasis in U.S FM broadcasting, and in the sound transmissions accompanying television, has been standardized at 75 microseconds, whereas a number of other services, notably CCIR and Australian TV sound transmission, use 50micro second. The usage of microseconds for defining emphasis is standard. 75 microseconds de-emphasis corresponds to a frequency response curve that is 3 db down at the frequency whose time constant is RC is 75 microseconds. This frequency is given by $f=1/2\Pi RC$ and it is therefore 2120 Hz; with 50-microseconds de-emphasis it would have been 3180 Hz. Figure I shows pre emphasis and de-emphasis curves for a 7 microseconds emphasis, as used in the united states.

If emphasis is applied to amplitude modulation, some improvement will also result, but it is not as great as in FM because the highest modulating frequencies in AM are no more affected by noise than any others.

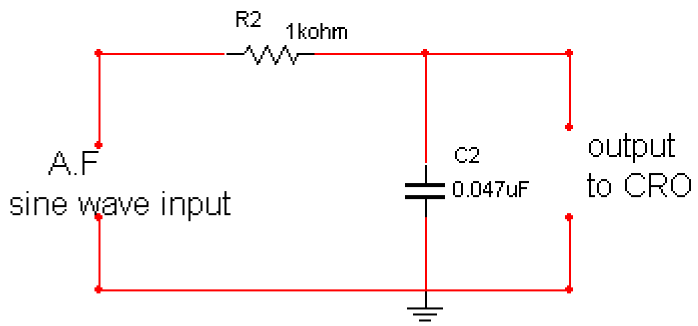
Apart from that, it would be difficult to introduce pre-emphasis and de-emphasis in existing AM services since extensive modifications would be needed, particularly in view of the huge numbers is receivers in use.

IV. CIRCUIT DIAGRAM:

PRE-EMPHASIS CIRCUIT



DE-EMPHASIS CIRCUIT



V. PROCEDURE:

I-PRE-EMPHASIS

1. Connect the circuit as per the circuit diagram
2. Apply a sine wave to the input terminals of 2 V_{P-P} $_{(Vi)}$
3. By varying the input frequency with fixed amplitude, note down the output amplitude (Vo) with respect to the input frequency.
4. Calculate the gain using the formula

   Gain = 20 log (V_O/ V_I) db

   Where V_O = output voltage in volts.

   V_I = Input voltage in volts.

   And plot the frequency response.

II-DE-EMPHASIS

1. Connect the circuit as per circuit diagram.
2. Repeat steps 2,3 & 4 of Pre-Emphasis to de-emphasis also.

VI. EXPECTED WAVEFORMS:

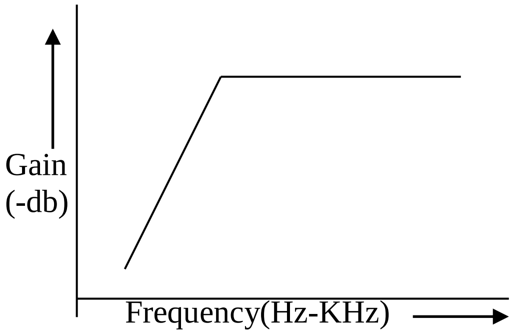


Fig: Pre-emphasis

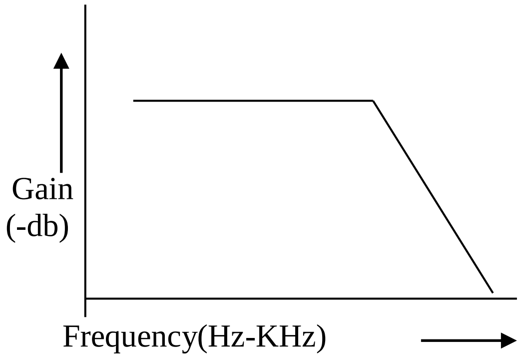


Fig: De-emphasis

VII. TABULAR COLUMN:

V_I =2v

S. No	Input Frequency (50Hz to 20KHz)	Out put voltage (Vo) (volts)	GAIN 20 log (V_O/ V_I) db

VIII. RESULT:

IX. APPLICATIONS:

1.FM transmitters.
2.FM Receivers.
3.FM Stereo systems.

X. QUESTIONS:

1. What is the need for pre-emphasis?
2. Explain the operation of pre-emphasis circuit?
3. Explain how Pre-emphasis operation is similar to high pass filter?
4. De-emphasis operation is similar to low pass filter justify?
5. What is de-emphasis?
6. Draw the frequency response of a pre-emphasis circuit?
7. Draw the frequency response of a de-emphasis circuit?
8. Give the formula for the cutoff frequency of the pre-emphasis circuit?
9. What is the significance of the 3db down frequency?

Experiment No. 6

TIME DIVISION MULTIPLEXING

I. AIM:

To perform time division multiplexing of Four signals

II. EQUIPMENTS AND COMPONENTS

(i) Apparatus:

1. TDM Trainer
2. Function generator
3. CRO
4. Bread Board
5. Power supply

(ii) Description of Apparatus:

1. CRO: The 20 MHz dual channel oscilloscope 201 is a compact, low line and light weight instrument. It is a general purpose Dual Trace Oscilloscope having both vertical amplifiers offering a bandwidth of DC- 20 MHz and maximum sensitivity of 2mv/cm.

   The 201 offers five separate add-on modules.
   - frequency counter
   - Curve tracer
   - Power supply
   - Function generator
   - Digital voltmeter

   The add-on modules enhance measuring capabilities of instrument at low cost.

2. This instrument is meant for giving three types of periodic waveforms – SINUSOIDAL, SQUARE and TRIANGULAR waveforms – where frequency can be selected from 0.1 Hz to 1 MHz and whose amplitude also can be selected from 0 to 20 volts peak to peak independently.

   The power on switch in pressed position will connect supply to the instrument. The amplitude switch varies the amplitude of output waveforms from 20 mv to 20 v(p-p). The function is a interlocked 3 station push button which switches to select the desired waveform for output.

3. Wire Connections are usually carried out using a system called Bread Board. It is a rectangular board divided into a number of nodes. This component has a provision on which any circuit can be constructed by interconnecting components such as resistors, capacitors, diodes, transistors etc., for testing the circuit.

(iii). Components

1. 100KΩ - resistor – 2 No.
2. 4.7KΩ - resistor – 2 No.
3. 5.6KΩ - resistor – 1 No.
4. 1KΩ - resistor – 2 No.
5. 10KΩ- resistor – 1 No.
6. 0.01 μF capacitor – 1 No.
7. 0.1 μF capacitor – 1 No.
8. BC 107 transistor – 1 No.

(iv) Description of Components:

a. 100KΩ - resistor

Most circuits need contrast resistances. There are different types of resistors available for different applications. Typical specifications of resistor are

Rating :	10Ω to 10MΩ
Wattage :	¼ W to 2 W
Tolerance :	Normally ±5% and above.

b. 4.7KΩ - resistor

Same as above

c. 5.6KΩ - resistor

Same as above

d. 1KΩ - resistor

Same as above

e. **10KΩ - resistor**

Same as above

f. 0.01 μF capacitor and 0.1 μF capacitor

Capacitors are made by sandwiching an insulating material between two conductors which form the electrodes. There are rated by their maximum working voltage. The breakdown voltage depends upon temperature and hence upon the losses in the dielectric.

The factors to be considered in the choice of capacitors are

1. Required capacity
2. Working voltage
3. Tolerances

The specifications of 0.01μF capacitor are

1. capacity – 0.01 μF

2. voltage range 16v to 3kv
3. tolerance ±10%

g. BC 107 transistor

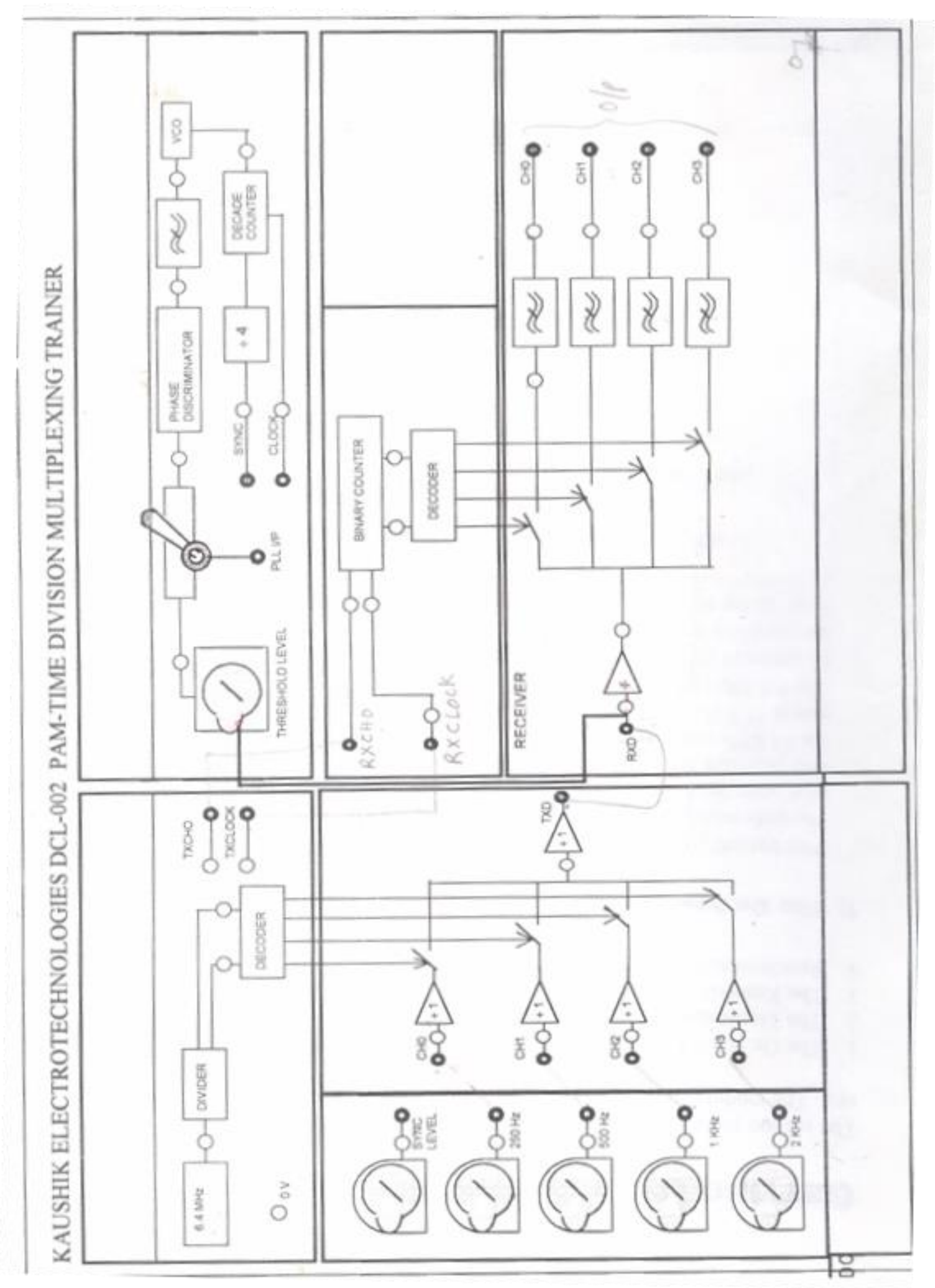
A bipolar junction transistor has two junctions. The conduction through the device involving two types of charge carriers holes and elements.

BJT's are available in two varieties: PNP and NPN. Either type can be treated as equivalent to two diodes connected back to back with three terminals leads, emitter, base and collector. Width of the base region is smaller than that of emitter or collector layers.

III. THEORY:-

Time division multiplexing enables the joint utilization of a common transmission channel by a plurality of independent message sources without mutual inference.
The circuit has 555 timer which generates a square wave which is then fed to the transistors to provide the bias current. Two message signals are square wave and some wave generated from frequency generator and they are time division multiplexed when square wave has ON and OFF Cycles. The multiplexed output is viewed on the CRO.

IV. CIRCUIT DIAGRAM:-



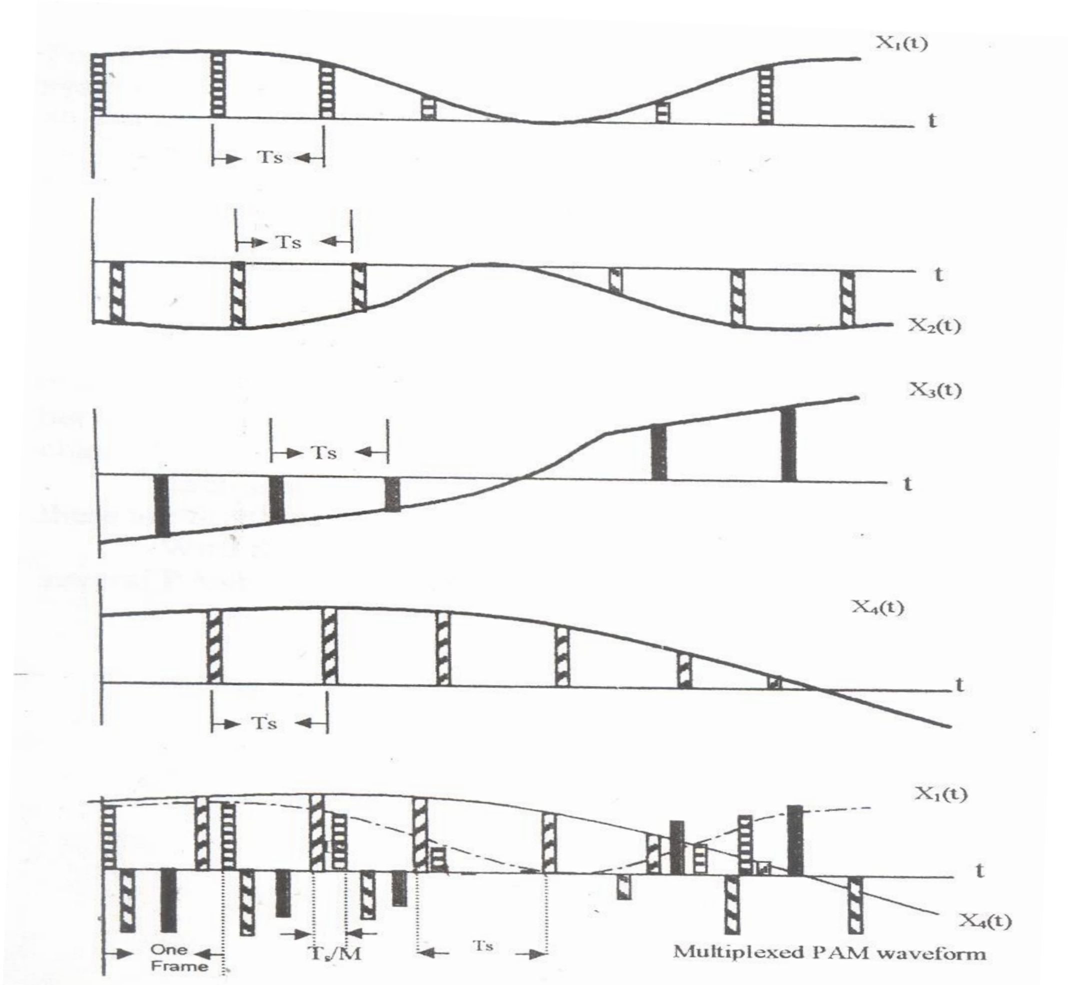
V. PROCEDURE-

i. connections can be made as per circuit diagram
ii. Switch on the trainer kit and observe the multiplexed signal at transmitter data work output.
iii. Transmitter data output is connected to receiver data input of receiver TDM section.
iv. Observe the demultiplexed signal on individual channels Ch0, Ch1, Ch2, Ch3
v. Draw the graph for input signals, multiplexed signal , and demultiplexed signals.

VI. OBSERVATIONS:

Input signals = ________________
Frequency = ________________
Amplitude = ________________
Multiplexed Output signal = ________________

VII. GRAPHS:



TDM waveforms

VIII RESULT:

Thus the time division multiplexing of a square wave and sine wave is generated and observed.

IX. INFERENCES:

From the above observation, we can infer that it is possible to covey different signals in different time slots using a single channel.

X. PRECAUTIONS:

1. Power handling capacity of resistor should be kept in mind while selecting R_L.
2. Contact wires must be checked before use.
3. Maximum forward current should not exceed value given in data sheet.
4. Reverse voltage across diode should not exceed peak inverse voltage (PIV).

XI. APPLICATIONS:

Telephone Channels.

XII. EXTENSION:

Observe the Time Division Multiplexed output of the four signals.

XIII. TROUBLE SHOOTING:

Sl.No.	Fault	Diagnosis
1	Overlapping of square and sinusoidal signal results	Synchronization of T^x and R^x is poor.
2	Output appears and suddenly disappear	Check the contact wires whether they are placed properly.

XIV. QUESTIONS:

1. Draw the 2 message signals that are time multiplexed.
2. What are the different band pass signalling schemes?
3. What is the sampling rate used in case of Fm=10 KHz?
4. Why flat top sampling must be preferred compared to natural sampling?
5. Highlight drawbacks of TDM.
6. Mention differences between FDM and TDM.
7. TDM is used in analog or digital transmission system.
8. Mention the applications of TDM.
9. Draw the block diagram for FDM systems.
10. Where is FDM used?

Experiment No. 7

VERIFICATION OF SAMPLING THEOREM

1. AIM:

To perform and verify the sampling theorem reconstruction of sampled waveform

2 EQUIPMENTS AND COMPONENTS

I. Apparatus:

1. Sampling theorem trainer kit
2. Function generator
3. CRO
4. Patch Cards

II. Description of Apparatus:

1. CRO: The 20 MHz dual channel oscilloscope 201 is a compact, low line and light weight instrument. It is a general purpose Dual Trace Oscilloscope having both vertical amplifiers offering a bandwidth of DC- 20 MHz and maximum sensitivity of 2mv/cm.

   The 201 offers five separate add-on modules.
   - frequency counter
   - Curve tracer
   - Power supply
   - Function generator
   - Digital voltmeter

   The add-on modules enhance measuring capabilities of instrument at low cost.

2. This instrument is meant for giving three types of periodic waveforms – SINUSOIDAL, SQUARE and TRIANGULAR waveforms – where frequency can be selected from 0.1 Hz to 1 MHz and whose amplitude also can be selected from 0 to 20 volts peak to peak independently.

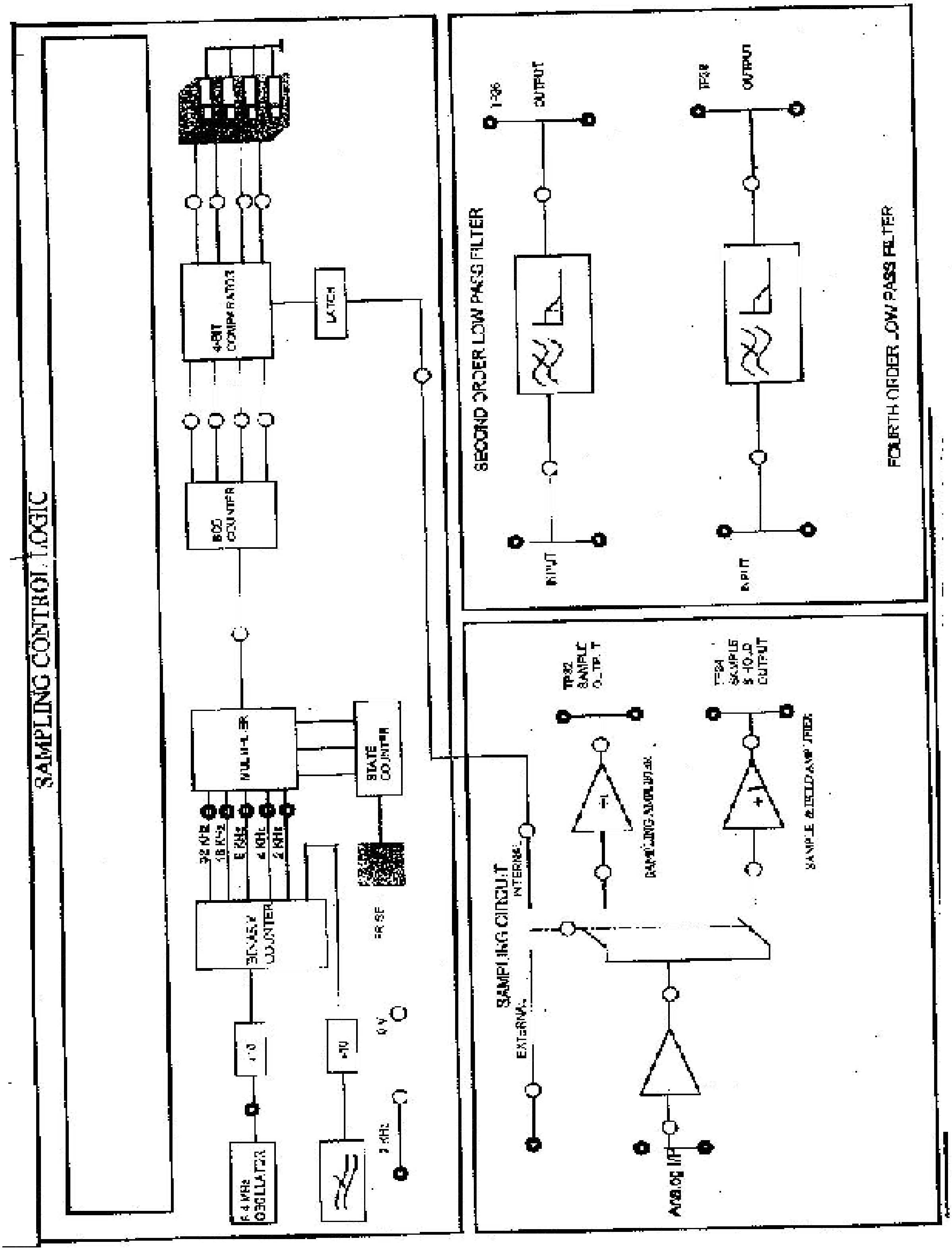
   The power on switch in pressed position will connect supply to the instrument. The amplitude switch varies the amplitude of output waveforms from 20 mv to 20 v(p-p). The function is a interlocked 3 station push button which switches to select the desired waveform for output.
3. Wire Connections are usually carried out using a system called Bread Board. It is a rectangular board divided into a number of nodes. This component has a provision on which any circuit can be constructed by interconnecting components such as resistors, capacitors, diodes, transistors etc., for testing the circuit.

3. THEORY:

When an analog signal message is conveyed over an analog communication system, the full message is typically used at all times. To send the same analog signal over a digicom system requires that only its samples are transmitted at periodic intervals. Because the receiver can therefore receive only samples of the message, it must attempt to reconstruct the original message at all times from only its samples. Methods exist whereby this desired end can be accomplished which include the sampling theorem.

Sampling theorem can be stated as follows: A signal f(t) , band limited such that it has no frequency components above f_m , can be uniquely determined and reconstructed by its values at regularly spaced intervals of Ts if and only if Ts < ½ Tm .

4. CIRCUIT DIAGRAM



5. PROCEDURE:

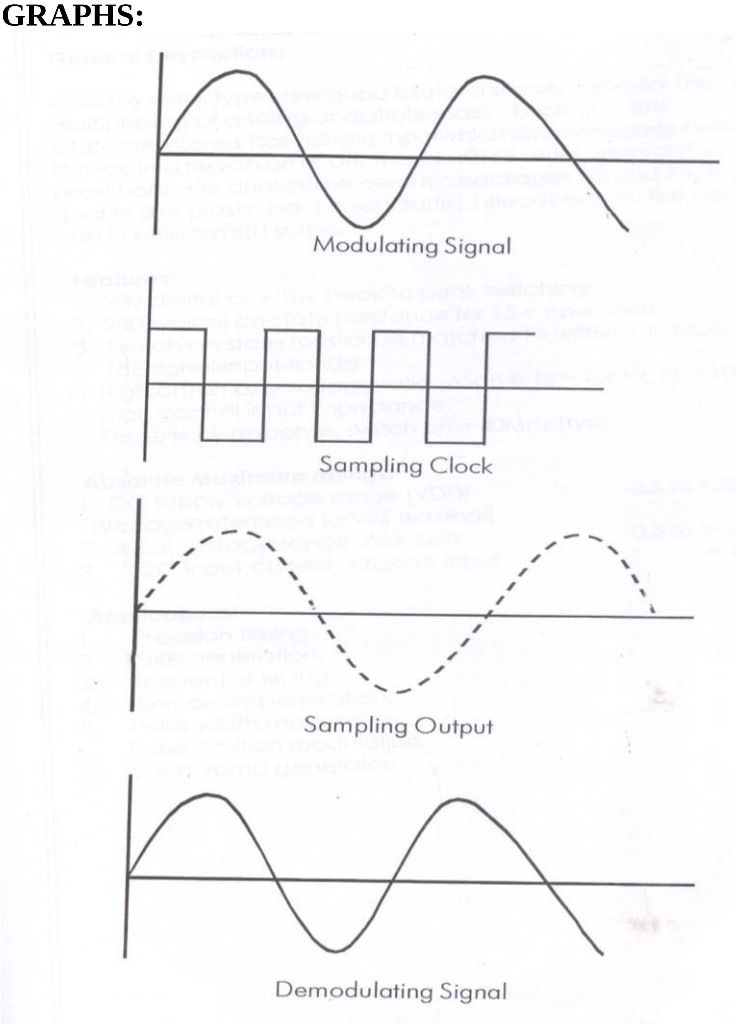
1. Connect the 2 KHz 5 V p-p signal generator on board to the analog signal input ,by means of the patch chords provided.
2. Connect the sampling frequency signal in the internal mode, by means of shorting pin provided.
3. Connect the S/H output to the input of the 2/4th order LPF.
4. If the external sampling frequency signal is used ,then connect the signal generator output to the sampling contrl input.

6. OBSERVATIONS:

Message signal voltage = ____________________
Message signal frequency = ____________________

Sampling signal voltage = ____________________
Sampling signal frequency = ____________________

7. GRAPHS:



8. RESULT:

A signal is naturally sampled and the reconstructed signal is observed and plotted.

9. INFERENCES:

We infer that the use of sample and hold logic compensates for the poor amplitude at the input of the low pass filter resulting in faithful reconstruction.

Pulse amplitude modulated signal and demodulated signals are observed.

10. PRECAUTIONS:

1. Power handling capacity of resistor should be kept in mind while selecting R_L.
2. Contact wires must be checked before use.
3. Maximum forward current should not exceed value given in data sheet.
4. Reverse voltage across diode should not exceed peak inverse voltage (PIV).

11. Applications:

Broad Casting, Digital communication.

12. EXTENSION:

We find the signal is reconstructed more faith fully in the case of sample-and-hold waveform rather in case of natural sampled waveform where the re-constructed signal suffers an amplitude distortion.

13. Trouble Shooting:

S.No.	Fault	Diagnosis
1	Output signal is same as input signal	Absence of carrier signal
2	Output appears and suddenly disappear	Check the contact wires whether they are placed properly.

14. QUESTIONS:

1 Define Sampling Theorem for Low pass signals.
2. What are the different base band signalling schemes?
3. What is the sampling rate used in case of voice signal transmission through telephone lines?
4. Compare natural sampling and flat top sampling.
5. Define sampling theorem for Band pass signals.
6. How to obtain flat top sampled signal?
7. Sampling Theorem is used in analog or digital transmission system. Give reasons.
8. When does aperture effect result and how to over come that?
9. Explain with waveform, the need of sampling theorem?
10. What is Nyquist Criterion?

Experiment No. 08

PULSE AMPLITUDE MODULATION AND DEMODULATION

1. AIM:

To generate pulse amplitude modulated signal and demodulate it.

2. EQUIPMENT AND COMPONENTS:

I. Apparatus:

1. PAM trainer kit
2. Function generator
3. CRO
4. Bread Board
5. Power supply

II. Description of Apparatus:

1. CRO: The 20 MHz dual channel oscilloscope 201 is a compact, low line and light weight instrument. It is a general purpose Dual Trace Oscilloscope having both vertical amplifiers offering a bandwidth of DC- 20 MHz and maximum sensitivity of 2mv/cm.
   The 201 offers five separate add-on modules.
   - frequency counter
   - Curve tracer
   - Power supply
   - Function generator
   - Digital voltmeter

   The add-on modules enhance measuring capabilities of instrument at low cost.

2. This instrument is meant for giving three types of periodic waveforms – SINUSOIDAL, SQUARE and TRIANGULAR waveforms – where frequency can be selected from 0.1 Hz to 1 MHz and whose amplitude also can be selected from 0 to 20 volts peak to peak independently.
   The power on switch in pressed position will connect supply to the instrument. The amplitude switch varies the amplitude of output waveforms from 20 mv to 20 v(p-p). The function is a interlocked 3 station push button which switches to select the desired waveform for output.

3. Wire Connections are usually carried out using a system called Bread Board. It is a rectangular board divided into a number of nodes. This component has a provision on which any circuit can be constructed by interconnecting components such as resistors, capacitors, diodes, transistors etc., for testing the circuit.

III. Components

1. 100KΩ - resistor – 1 No.
2. 4.7KΩ - resistor – 1 No.
3. 5.6KΩ - resistor – 1 No.
4. 1KΩ - resistor – 1 No.
5. 22 KΩ- resistor – 1 No.
6. 0.01 μF capacitor – 2 No.
7. BC 547 transistor – 1 No.
8. 555 Timer– 1 No

IV. DESCRIPTION OF COMPONENTS:

a. 100KΩ - resistor

Most circuits need contrast resistances. There are different types of resistors available for different applications. Typical specifications of resistor are

Rating :	10Ω to 10MΩ
Wattage :	¼ W to 2 W
Tolerance :	Normally ±5% and above.

b. 4.7KΩ - resistor

Same as above

c. 5.6KΩ - resistor

Same as above

d. 1KΩ - resistor

Same as above

e. 0.01 μF capacitor

Capacitors are made by sandwiching an insulating material between two conductors which form the electrodes. They are rated by their maximum working voltage. The breakdown voltage depends upon temperature and hence upon the losses in the dielectric.

The factors to be considered in the choice of capacitors are

1. Required capacity
2. Working voltage
3. Tolerances

The specifications of 0.01μF capacitor are

1. capacity – 0.01 μF
2. voltage range 16v to 3kv
3. tolerance ±10%

f. BC 547 transistor – 1 No.

A bipolar junction transistor has two junctions. The conduction through the device involving two types of charge carriers holes and elements.

BJT's are available in two varieties: PNP and NPN. Either type can be treated as equivalent to two diodes connected back to back with three terminal leads, emitter, base and collector. Width of the base region is smaller than that of emitter or collector layer.

g. 555 IC – 1 No

The NE/SE 555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays, or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms and the output structure can source or sink large currents or drive TTL circuits.

3. THEORY:-

In PAM the amplitude of regularly spaced rectangular pulse vary with Instantaneous sampled values of a continuous message signal.

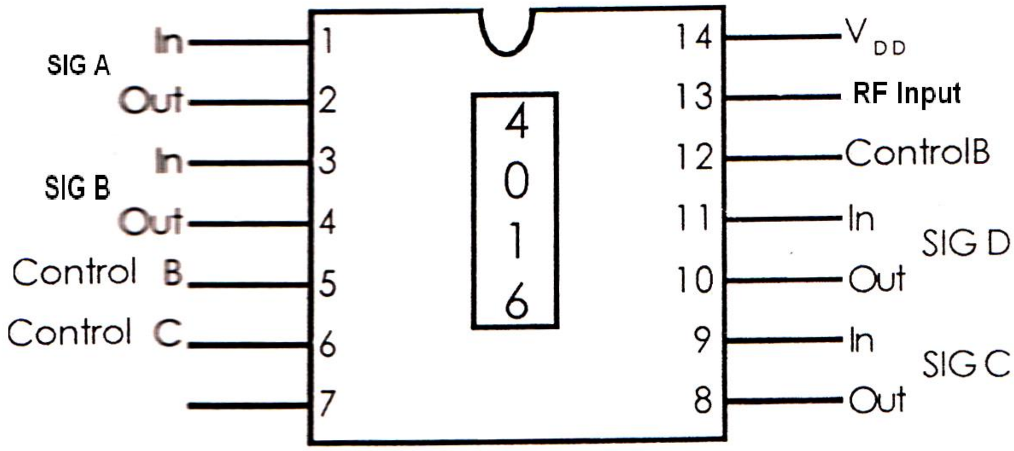
A PAM wave, $s(t) = \Sigma[\ 1 + Ka\ m(nTs)\ ] * g(t - nTs)$
Where summation is from $-\infty$to $+\infty$
$M(nTs)$= nth sample of the message signal
Ts = sampling method
Ka = is a constant called amplitude sensitivity
g(t) = denotes the pulse.
PAM signals can be easily demodulated by a Low Pass Filter with cut-off frequency large enough to accommodate the highest frequency component of the message signal m(t).

4.. CALCULATIONS

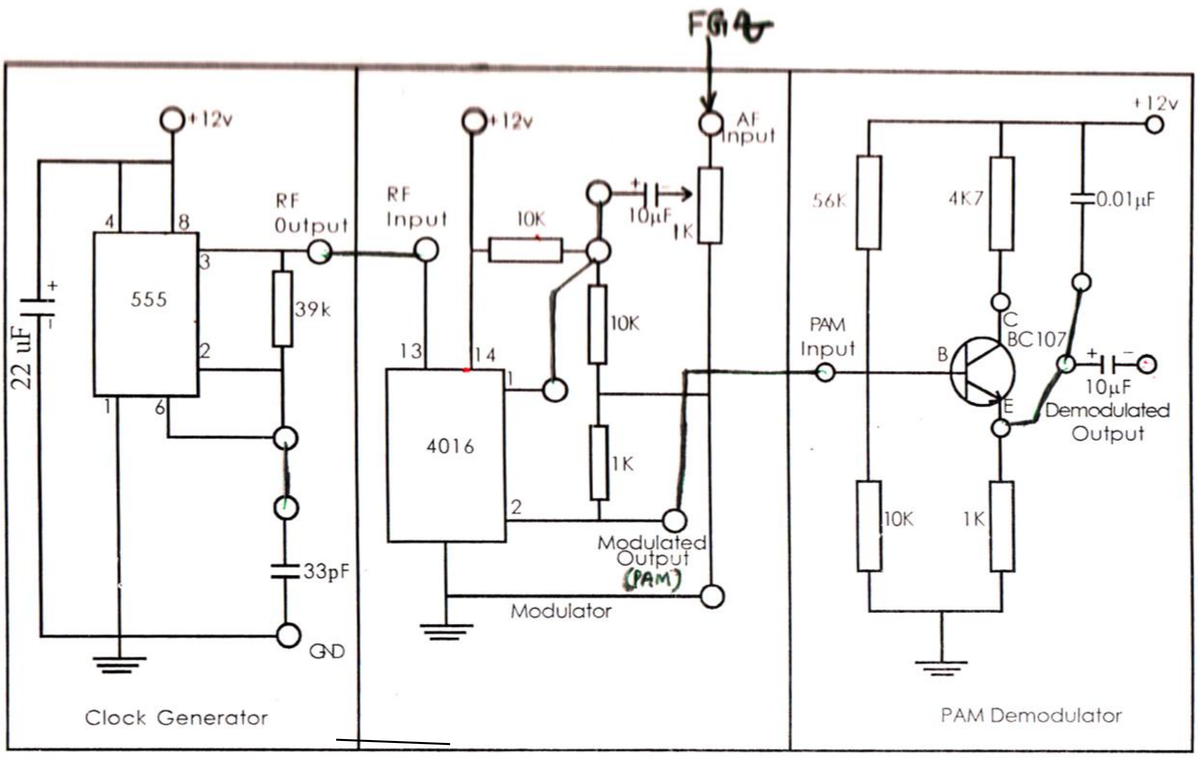
$F2 = 1 / 2\pi RC$
Since $C = 0.01\pi F$ find the value of R.

5. CIRCUIT DIAGRAM

Modulation and demodulation circuit



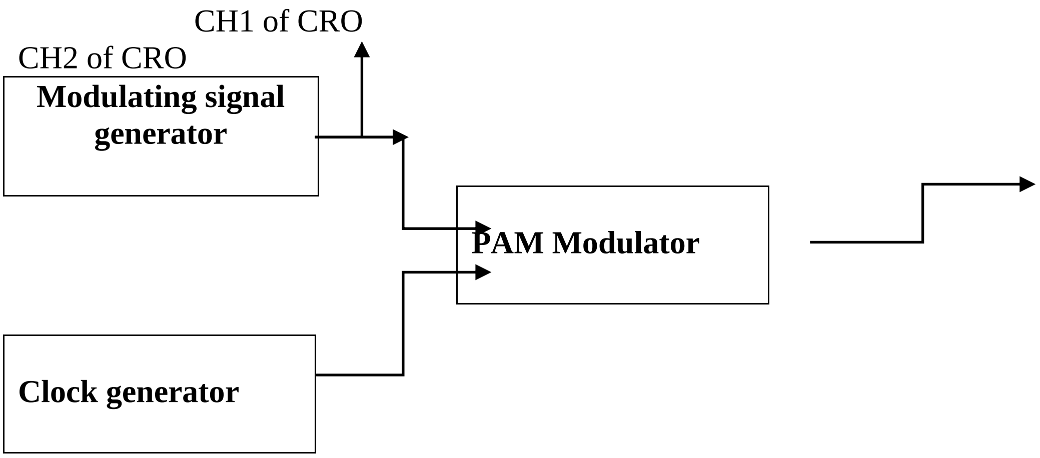
PIN Diagram of IC 4016



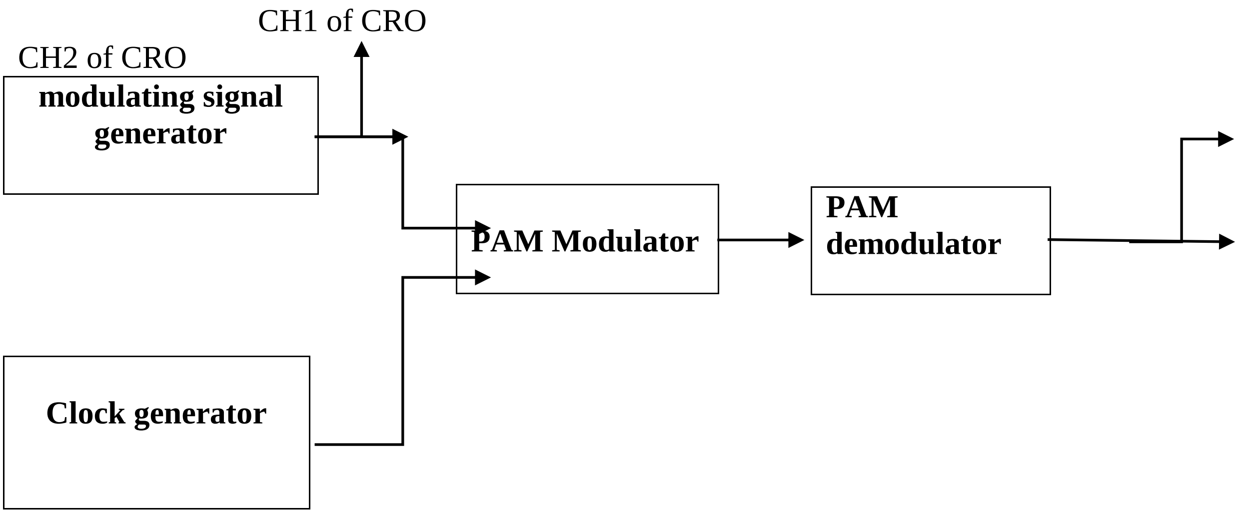
CONNECTION CIRCUIT DIAGRAM OF PAM

6. PROCEDURE:

1) Switch 'ON' the experimental kit.
2) Observe the modulating signal and the carrier clock generators outputs
3) Adjust the modulating signal generator O/P to 1 Vp-p amplitude .
4) Apply the modulating signal generator output and the clock generator output to the PAM modulator.
5) Following Fig . shows the Testing procedure.



6) By varying the amplitude of the modulating signal, depth of modulation changes.
7) During the demodulation ,connect PAM output to the input of PAM demodulator and observe the output of PAM demodulator.
8) Following Fig shows the testing procedure.

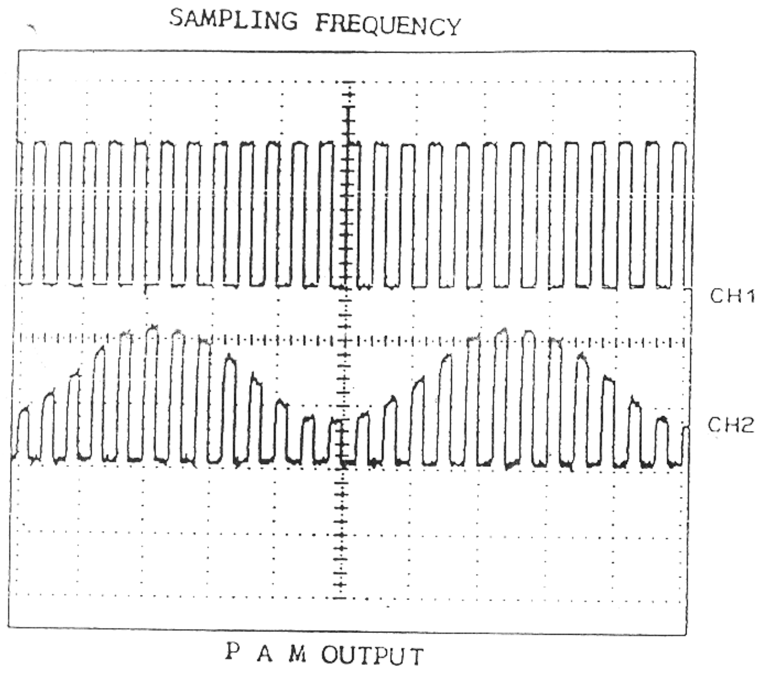


7. OBSERVATIONS:

Message signal voltage = ______________________
Message signal frequency = ______________________

Carrier signal voltage = ______________________
Carrier signal frequency = ______________________

8. GRAPH:



9. RESULT:

Thus the Pulse amplitude modulated signal is generated and detected. The corresponding graphs are drawn

10. INFERENCES:

Pulse amplitude modulated signal and demodulated signals are observed.

11. PRECAUTIONS:

1. Power handling capacity of resistor should be kept in mind while selecting R_L.
2. Contact wires must be checked before use.
3. Maximum forward current should not exceed value given in data sheet.
4. Reverse voltage across diode should not exceed peak inverse voltage (PIV).

12. APPLICATIONS:

Base band transmission.

13. EXTENSION:

Generate flat top sampled signal by using sample hold circuit

14. TROUBLE SHOOTING:

S.No.	Fault	Diagnosis
1	Output signal is same as input signal after modulator circuit.	Absence of carrier signal
2	Output appears and suddenly disappear	Check the contact wires whether they are placed properly.

15. QUESTIONS:

1. Compare flat top sampling and natural sampling.
2. Discuss the advantages of PAM.
3. What is sampling theorem?
4. Explain about TDM and FDM.
5. What is the purpose of sample and hold circuit?
6. What is Nyquist sampling rate?
7. What are the foremost common methods for pulse modules?
8. What is aperture effect?
9. When does aliasing error occur?
10. Disadvantages of PAM.

Experiment No.09

PULSE WIDTH MODULATION AND DEMODULATION

1. AIM:

To generate pulse width modulated signal and demodulate it.

2. EQUIPMENT AND COMPONENTS:

I. Apparatus:

a. PWM modulation Demodulation Trainer
b. Function generator
c. CRO
d. Bread Board
e. Power supply

II. Description of Apparatus:

1. CRO: The 20 MHz dual channel oscilloscope 201 is a compact, low line and light weight instrument. It is a general purpose Dual Trace Oscilloscope having both vertical amplifiers offering a bandwidth of DC- 20 MHz and maximum sensitivity of 2mv/cm.
   The 201 offers five separate add-on modules.
   - frequency counter
   - Curve tracer
   - Power supply
   - Function generator
   - Digital voltmeter

   The add-on modules enhance measuring capabilities of instrument at low cost.

2. This instrument is meant for giving three types of periodic waveforms – SINUSOIDAL, SQUARE and TRIANGULAR waveforms – where frequency can be selected from 0.1 Hz to 1 MHz and whose amplitude also can be selected from 0 to 20 volts peak to peak independently.
   The power on switch in pressed position will connect supply to the instrument. The amplitude switch varies the amplitude of output waveforms from 20 mv to 20 v(p-p). The function is a interlocked 3 station push button which switches to select the desired waveform for output.

3. Wire Connections are usually carried out using a system called Bread Board. It is a rectangular board divided into a number of nodes. This component has a provision on which any circuit can be constructed by interconnecting components such as resistors, capacitors, diodes, transistors etc., for testing the circuit.

III. Components

1. 10KΩ - resistor – 1 No.
2. 5.6KΩ - resistor – 1 No.
3. 0.01 μF capacitor – 1 No.
4. 555 IC

IV. Description of Components:

a. 10KΩ - resistor

Most circuits need contrast resistances. There are different types of resistors available for different applications. Typical specifications of resistor are

Rating	:	10Ω to 10MΩ
Wattage	:	¼ W to 2 W
Tolerance	:	Normally ±5% and above.

b. 5.6KΩ - resistor

Same as above

c. 0.01 μF capacitor

Capacitors are made by sandwiching an insulating material between two conductors which form the electrodes. There are rated by their maximum working voltage. The breakdown voltage depends upon temperature and hence upon the losses in the dielectric.

The factors to be considered in the choice of capacitors are

1. Required capacity
2. Working voltage
3. Tolerances

The specifications of 0.01μF capacitor are

1. capacity – 0.01 μF
2. voltage range 16v to 3kv
3. tolerance ±10%

d. 555 IC

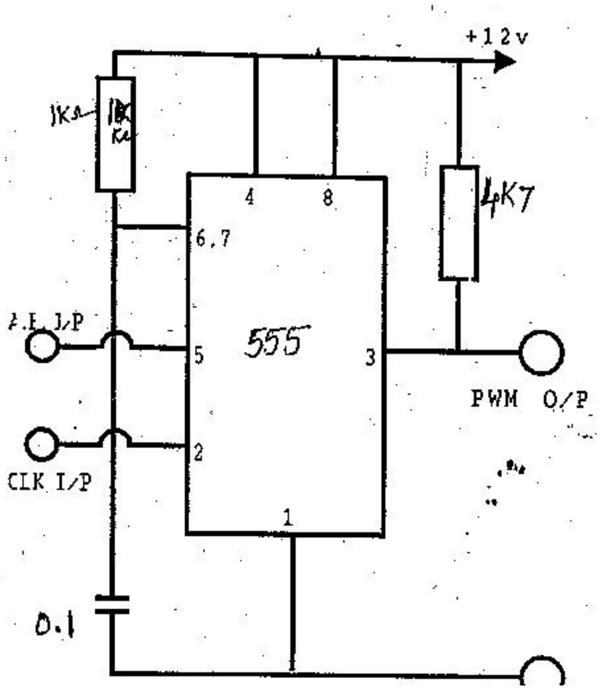
The NE/SE 555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays, or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms and the output structure can source or sink large currents or drive TTL circuits.

3. THEORY:-

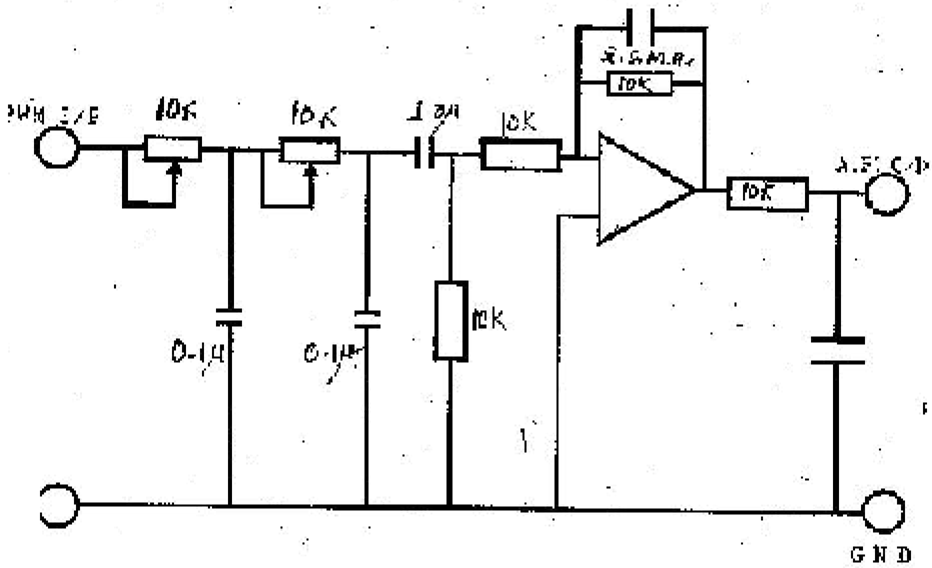
Pulse width modulation is also referred as pulse duration modulation or less often pulse length modulation. In this system we have a fixed amplitude and starting time of each pulse. But the width of each pulse is made properly proportional to the amplitude of the signal at that instant.

4. CIRCUIT DIAGRAM

MODULATOR CIRCUIT



DE MODULATOR CIRCUIT :



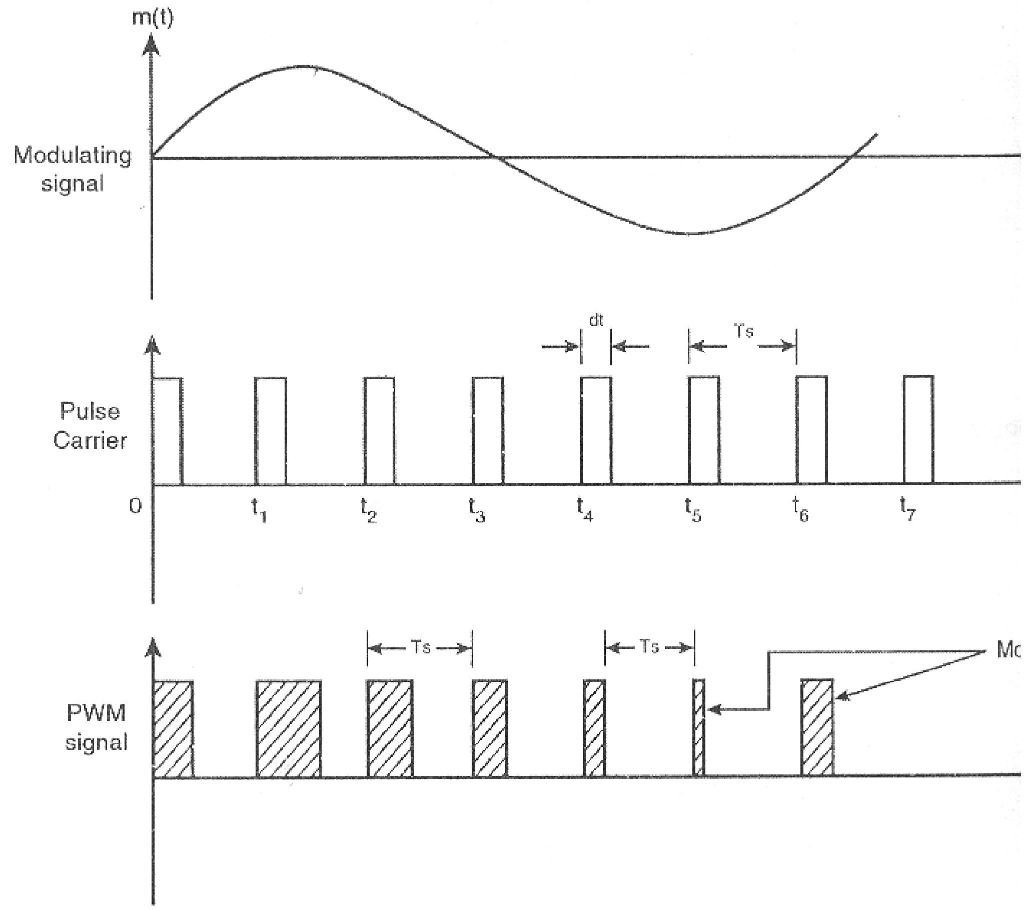
5. PROCEDURE:

1. Switch ON the trainer kit.
2. Connect the clock O/P to the I/P of clock terminal of PWM modulation.
3. Connect the AF O/P to the I/P of AF terminal of PWM modulation.
4. Observe the PWM output at pin 3 of 555 IC on CRO.
5. During the demodulation ,connect the PWM O/P of PWM modulation to the PWM I/P of PWM demodulation
6. Observe the demodulation output at AF O/P of PWM demodulation on CRO.

6. OBSERVATIONS:

Message signal voltage = ___________________
Message signal frequency = ___________________
Carrier signal voltage =________________________
Carrier signal frequency =________________________

7. GRAPHS



8. RESULT:

Thus the Pulse width modulated signal is generated and detected. The corresponding graphs are drawn

9. INFERENCES:

Pulse width modulated signal and demodulated signals are observed.

10. PRECAUTIONS:

1. Power handling capacity of resistor should be kept in mind while selecting R_L.
2. Contact wires must be checked before use.
3. Maximum forward current should not exceed value given in data sheet.
4. Reverse voltage across diode should not exceed peak inverse voltage (PIV).

11. APPLICATIONS:

Base band transmission.

12. EXTENSION:

Generate PWM signal using PAM by using another method (using triangular waveforms).

13. TROUBLE SHOOTING:

S.No.	Fault	Diagnosis
1.	Output signal is same as input signal after modulator	Absence of carrier signal
2	Output appears and suddenly disappear	Check the contact wires whether they are placed properly.

14. QUESTIONS:

1. What are the differences between PAM and PWM?
2. Highlight drawbacks of PWM.
3. Mention power consumption of PWM compared to PAM.
4. How PWM is advantageous than PAM.
5. PWM is analog or digital transmission system. Give reasons.
6. How we derive PWM from PAM.
7. Explain with wave form, the difference between PAM and PWM.
8. Explain the difference between PWM and PPM.
9. Which consumes more power PWM or PPM. Give reasons.
10. Define PWM.

Experiment No.10

PULSE POSITION MODULATION AND DEMODULATION

1. AIM:

To generate pulse position modulated signal and demodulate it.

2 EQUIPMENT AND COMPONENTS:

I. Apparatus:

1. PPM modulation and demodulation trainer
2. Function generator
3. CRO
4. Bread Board
5. Power supply

II. Description of Apparatus:

1. CRO: The 20 MHz dual channel oscilloscope 201 is a compact, low line and light weight instrument. It is a general purpose Dual Trace Oscilloscope having both vertical amplifiers offering a bandwidth of DC- 20 MHz and maximum sensitivity of 2mv/cm.

   The 201 offers five separate add-on modules.
   - frequency counter
   - Curve tracer
   - Power supply
   - Function generator
   - Digital voltmeter

   The add-on modules enhance measuring capabilities of instrument at low cost.

2. This instrument is meant for giving three types of periodic waveforms – SINUSOIDAL, SQUARE and TRIANGULAR waveforms – where frequency can be selected from 0.1 Hz to 1 MHz and whose amplitude also can be selected from 0 to 20 volts peak to peak independently.

   The power on switch in pressed position will connect supply to the instrument. The amplitude switch varies the amplitude of output waveforms from 20 mv to 20 v(p-p). The function is a interlocked 3 station push button which switches to select the desired waveform for output.

3. Wire Connections are usually carried out using a system called Bread Board. It is a rectangular board divided into a number of nodes. This component has a provision on which any circuit can be constructed by interconnecting components such as resistors, capacitors, diodes, transistors etc., for testing the circuit.

III. Components

1. 10KΩ - resistor – 2 No.
2. 5.6KΩ - resistor – 1 No.

3. 1KΩ - resistor – 2 No.
4. 2KΩ- resistor – 1 No.
5. 0.01 μF capacitor – 2 No.
6. 555 IC – 2 Nos.

IV. Description of Components:

a. 10KΩ - resistor

Most circuits need contrast resistances. There are different types of resistors available for different applications. Typical specifications of resistor are

Rating :	10Ω to 10MΩ
Wattage :	¼ W to 2 W
Tolerance :	Normally ±5% and above.

b. 5.6KΩ - resistor

Same as above

c. 1KΩ - resistor

Same as above

d. 2KΩ - resistor

Same as above

e. 0.01 μF capacitor

Capacitors are made by sandwiching an insulating material between two conductors which form the electrodes. There are rated by their maximum working voltage. The breakdown voltage depends upon temperature and hence upon the losses in the dielectric.

The factors to be considered in the choice of capacitors are

1. Required capacity
2. Working voltage
3. Tolerances

The specifications of 0.01μF capacitor are

1. capacity – 0.01 μF
2. voltage range 16v to 3kv
3. tolerance ±10%

f. 555 IC

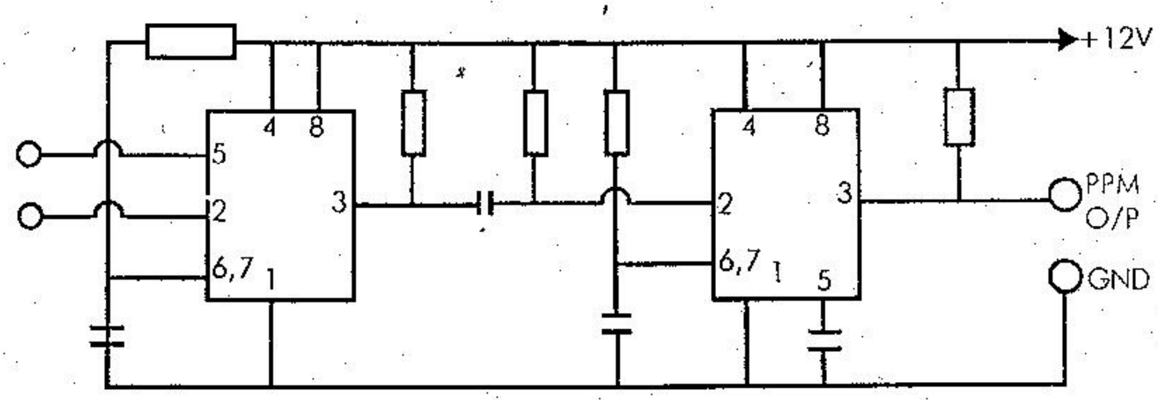
The NE/SE 555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays, or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms and the output structure can source or sink large currents or drive TTL circuits.

3. THEORY:-

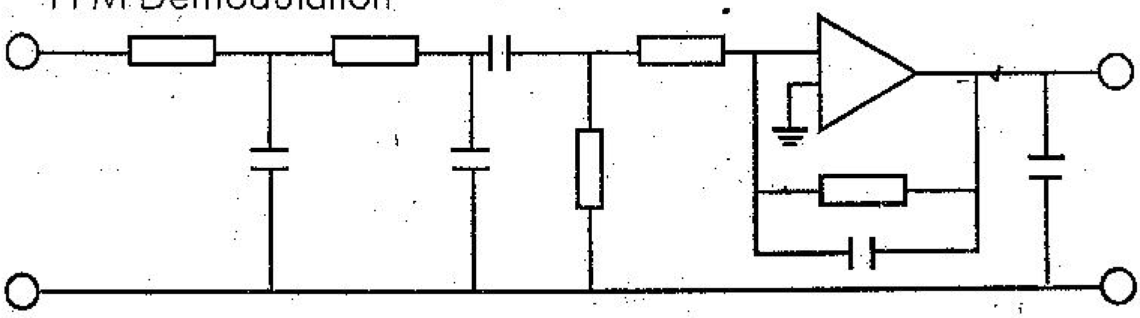
Pulse position modulation the position of the pulse is changed in accordance with the amplitude of the modulating signal. Width of the pulse is kept constant in this system, while the position of each pulse is changed in relation to the position of reference. Compare to PWM, PPM has the advantage of requiring constant transmitter output.

4. CIRCUIT DIAGRAM:-

PPM Modulation



PPM Demodulation



5. PROCEDURE

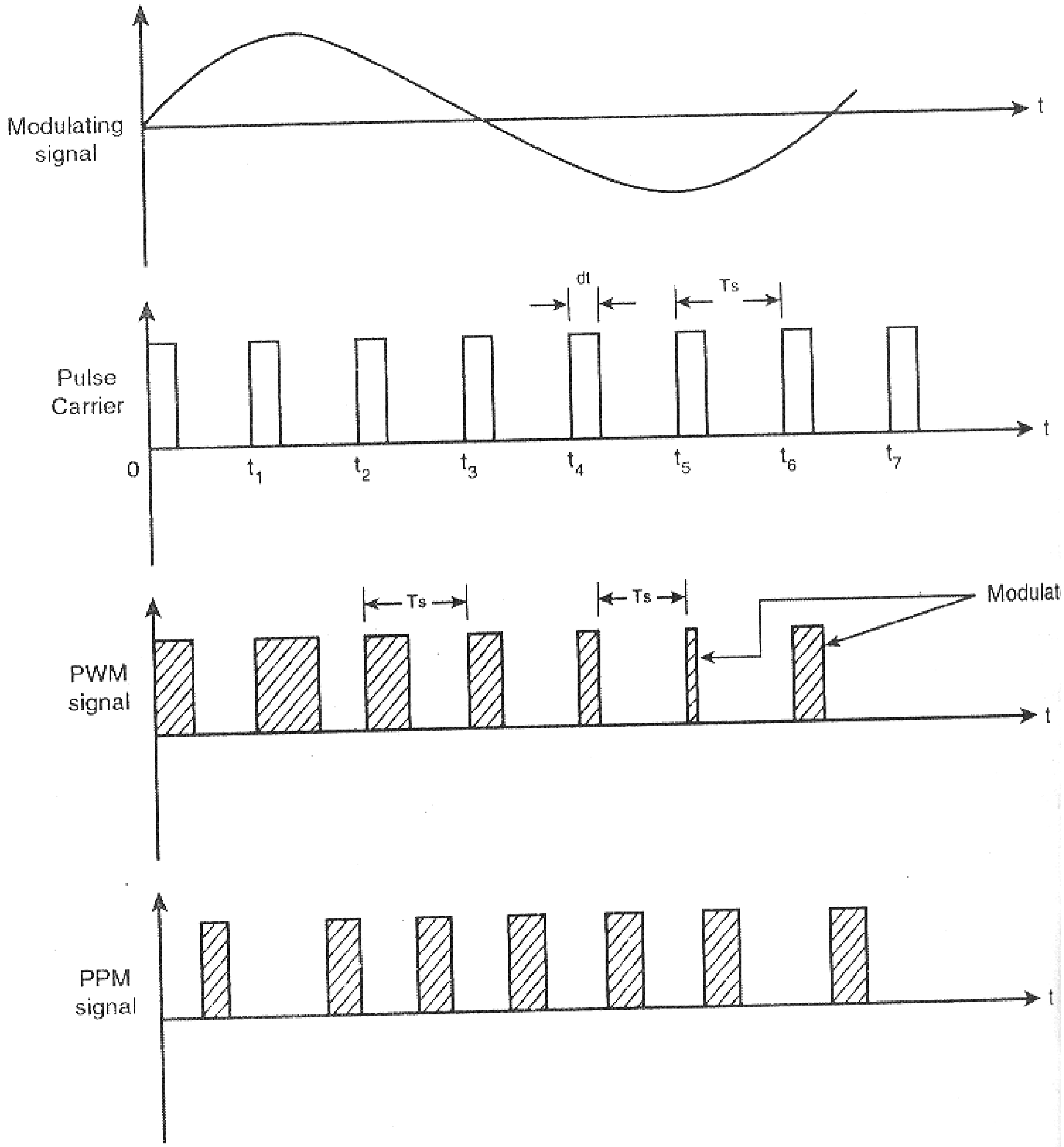
1. Switch On the trainer kit.
2. Connect the Clk output to the Pin 2 Of 555 IC
3. Connect the AF O/P to the Pin 5 of the 555 IC.
4. Observe the PPM O/P at Pin 3 of second IC 555 on CRO.
5. Connect the PPM O/P to the PPM I/P of PPM demodulation.
6. Observe the demodulated O/P on CRO.

6. OBSERVATIONS :

Message signal voltage = ___________________
Message signal frequency = ___________________

Carrier signal voltage = ___________________
Carrier signal frequency = ___________________

7. GRAPHS



8. RESULT:

Thus the Pulse position modulated signal is generated and observed. The corresponding graphs are drawn

9. INFERENCES:

Pulse position modulated signal and demodulated signals are observed.

10. PRECAUTIONS:

1. Power handling capacity of resistor should be kept in mind while selecting R_L.
2. Contact wires must be checked before use.
3. Maximum forward current should not exceed value given in data sheet.
4. Reverse voltage across diode should not exceed peak inverse voltage (PIV).

11. APPLICATIONS:

Base band transmission.

12. EXTENSION:

Generate PPM signal by using another technique (By applying PWM to differentiator and clipper circuit)

13. TROUBLE SHOOTING:

S.No.	Fault	Diagnosis
1.	Output signal is same as input signal after modulation	Absence of carrier signal
2	Output appears and suddenly disappear	Check the contact wires whether they are placed properly.

14. QUESTIONS:

1.What are the differences between PPM and PWM?
2. Highlight drawbacks of PPM.
3. Mention power consumption of PPM compared to PAM.
4. How PPM is advantageous than PAM.
5. PPM is analog or digital transmission system. Give reasons.
6. How we derive PPM from PWM.
7. Explain with wave form, the difference between PAM, PPM and PWM.
8. How to demodulate PPM signals?
9. Which circuit must be used to convert PPM to PWM?
10. Define PPM.

Experiment No. 11

FREQUENCY SYNTHESIZER

I. AIM: To perform the characteristics of frequency synthesizer using PLL

II. APPARATUS:

1. Frequency synthesizer trainer AET -26A
2. Dual trace C.R.O (20MHz)
3. Digital frequency counter or multimeter
4. Patch chords

III. THEORY:

Phase locked loop:

PLL stands for 'Phase locked loop' and it is basically a closed loop frequency control system, which functioning is based on phase sensitive detection of phase difference between the input and output signals of controlled oscillator
.

Before the input is applied the PLL is in free running state. Once the input frequency is applied the VCO frequency starts change and phase locked loop is said to be in captured mode. The VCO frequency continues to change until it equals the input frequency and PLL is then in the phase locked state. When phase locked the loop tracks any change in the input frequency through its repetitive action.

Frequency synthesizer:

The frequency divider is inserted between the VCO and the phase comparator. Since the output of the divider is locked to the input frequency f_{in}, VCO is running at multiple of the input frequency. The desired amount of multiplication can be obtained by selecting a proper divide by N network. Where N is an integer. For example $f_{out} = 5\ f_{in}$ a divide by N=10, 2 network is needed as shown in block diagram. This function performed by a 4 bit binary counter 7490 configured as a divide by 10, 2 circuit. In this circuit transistor Q_1 used as a driver stage to increase the driving capability of LM565 as shown in fig.b.

To verify the operation of the circuit, we must determine the input frequency range and then adjust the free running frequency F_{out} of VCO by means of R_1 (between 10^{th} and 8^{th} pin) and C1 (9^{th} pin), so that the output frequency of the 7490 driver is midway within the predetermined input frequency range. The output of the VCO now should be $5F_{in.}$

Free running frequency (f_0):

Where there is no input signal applied, it is in free running mode.
$F_0 = 0.3 / (R_tC_t)$ where R_t is the timing resistor
C_t is the timing capacitor.

Lock range of PLL (f_L)

$F_L = \pm 8f_0/V_{CC}$ where f_0 is the free running frequency

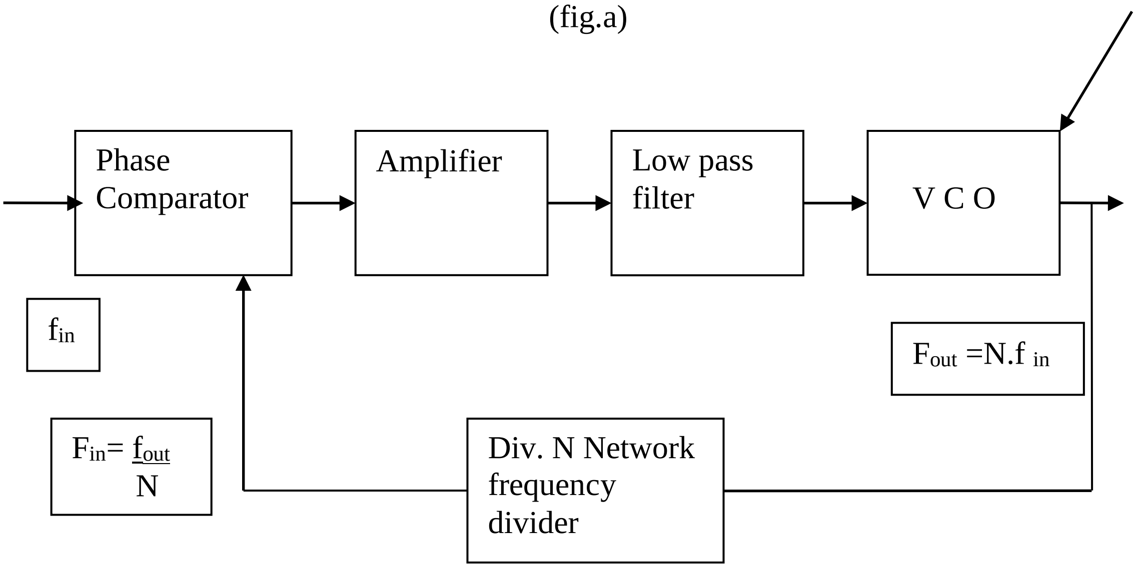
$= 2V_{CC}$

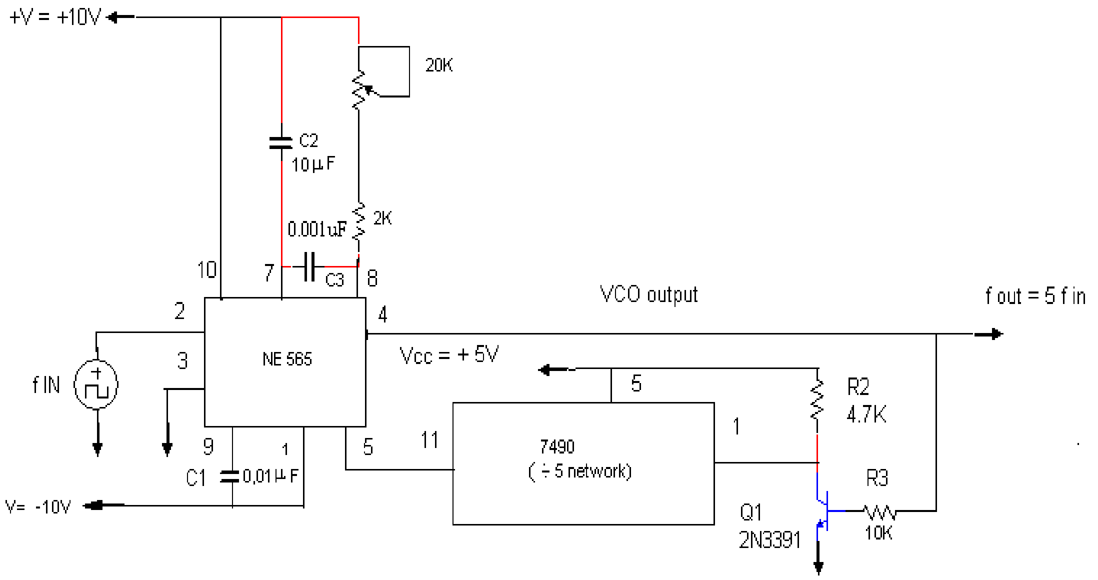
Capture range (f_C)

$$F_C = \frac{1}{2\pi}\sqrt{\frac{2\pi f_L}{3.6X10^3 XC_C}}$$

IV. CIRCUIT DIAGRAM:

(fig.a)





(fig.b)

V. PROCEDURE:

1. Switch on the trainer ad verify the output of the regulated power supply i.e. $\pm 5V$. These supplies are internally connected to the circuit so no extra connections are required.

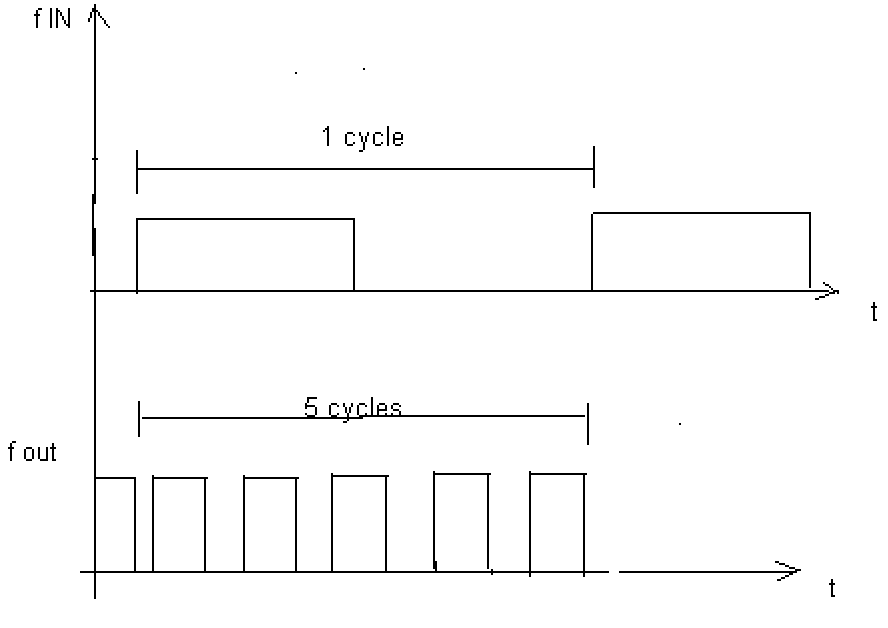
2. Observe output of the square wave generator using oscilloscope and measure the range with the help of frequency counter, frequency range should be around 1KHz to 10KHz.

3. Calculate the free running frequency range of the circuit (VCO output between 4^{th} pin and ground). For different values of timing resistor R_1 (to measure R_t switch off the trainer and measure R_t value using digital multimeter between given test points). And record the frequency values in tabular 1. $F_{out} = 0.3 / (R_tC_t)$ where R_t is the timing resistor and Ct is the timing capacitor = 0.01 μ f.

4. Connect 4^{th} pin of LM 565 (F_{out}) to the driver stage and 5^{th} pin (Phase comparator) connected to 11^{th} pin of 7490. Output can be taken at the 11^{th} pin of the 7490. It should be divided by the 10, 2 times of the f_{out}.

VI. EXPECTED WAVEFORMS:

Input waveforms



Output waveforms

VII. OBSERRVATION TABLE:

F_{in} KHz	$F_{out} = N f_{in}$ KHz	Divided by 10, 2

VIII. RESULT:

IX. APPLICATIONS:

1. Commercial SSB Transmitters.
2. Military multichannel SSB equipment.

X. QUESTIONS:

1. What are the applications of PLL?
2. What is PLL?
3. Define Lock range of a PLL.
4. What is a VCO?
5. What are the applications of frequency synthesizer?
6. What is meant by the free running frequency of PLL?
7. What is the operation of a frequency synthesizer?
8. Which block is mainly used in frequency synthesizer?

Experiment No.12

AGC CHARACTERISTICS

I. AIM: To perform the AGC characteristics.

II. APPARATUS:

1. AGC trainer kit.
2. Dual trace C.R.O (20MHz)
3. Digital frequency counter or multimeter
4. Patch chords

III. THEORY:

A Simple AGC is a system by means of which the overall gain of a radio receiver is varied automatically with the changing strength of the received signal, to keep the output substantially constant. A dc bias voltage, derived from the detector. The devices used in those stages are ones whose trans conductance and hence gain depends on the applied bias voltage or current. It may be noted in passing that, for correct AGC operation, this relationship between applied bias and transconductance need not to be strictly linear, as long as transconductance drops significantly with increased bias. All modern receivers are furnished with AGC, which enables tuning to stations of varying signal strengths without appreciable change in the size of the output signal thus AGC "irons out" input signal amplitude variations, and the gain control dose not have to be re adjusted every time the receiver is tuned from one station to another, except when the change in signal strengths is enormous. In addition, AGC helps to smooth out the rapid fading which may occur with long-distance short-wave reception and prevents the overloading of the last IF amplifier which might otherwise have occurred.

This kit consists of wired circuitry of:

1. RF Generator
2. AF Generator
3. Regulated power supply
4. AM Modulator
5. Demodulator (simple diode detector and AGC Circuit)

IV. DEVICE DESCRIPTION:

1. **RF Generator:**
   Colpitts oscillator using FET is used here to generate RF signal of 455 KHz frequency to use as carrier signal in this Experiment. Adjustments for amplitude and frequency are provided on panel for ease of operation.

2. **AF Generator:**
   Low frequency signal of approximately 1 KHz is generated using OP-AMP based wein bridge oscillator, required amplification and adjustable attenuation are provided.

3. **Regulated power supply:**
   This consists of bridge rectifier, capacitor filters and three terminal regulators to provide required DC voltages in the circuit i.e. +12v, _12v, +6v @150 mA each.

4. **AM Modulator:**
   Modulator section illustrates the circuit of modulating amplifier employing a transistor (BC 107) as an active device in common emitter amplifier mode.R1 and R2 establishes a quiescent forward bias for the transistor .The modulating signal is fed at the emitter section causes the bias to increase or decrease in accordance with the modulating signal.R4 is emitter resistance and C3 is by pass capacitor for carrier.Thus the carrier signal applied at the base gets amplified more when the amplitude of the modulating signal is at its maximum and less when the signal by the modulating signal output is amplitude-modulated signal. C2 couples the modulated signal to output of the Modulator.

5. **Detector And AGC Stage:**
   This circuit incorporates two-stage amplifier, diode detector and AGC circuit.
   a. **1st IF Amplifier:**
      Q2 (BF 495C) acts as 1^{st} IF Amplifier. The base of Q2 is connected through R5 (68K0 to the detector output. R6 (100E) and C4 (47n) is decoupling filter for +B line. The base potential depends on R4 (220k) base biasing resistor and the detector current supplied by R5. The detector current is proportional to the signal strength received. This controls the bias of Q2 (BF 495C) automatically to the signal received. This is called A.G.C. C6 (4.7/16) is used as base bias and AGC decoupling capacitor. The output of Q2 is available across the secondary of L8 (IF T2), the primary of which is tuned to IF by the capacitor C18 (2n7). This output is given to the base of Q3 (BF 495D).

b. 2nd IF Amplifier:

Q3 (BF 195C) acts as 2nd IF amplifier. The base bias for Q3 is provided by R7 (180k), C7 (47n) is used to keep the end 4 of L8 (IFT2) at ground potential for IF signal. The collector of Q3 is connected to the L9 (IFT3). L9 contains 200pf capacitor inside across the primary. The output of Q3 is available across the secondary of L9, the primary of which is tuned by the internal 200pf capacitor. R8 (220E), C8 (47n) consists the decoupling circuit for the collector supply of Q3. The output of Q3 is coupled to detector diode D1 (OA 79).

c. Detector:

Modulated IF signal from the secondary of L9 (IFT3) is fed to the detector diode D1. D1 rectifies the modulated IF signal & IF component of modulated signal is filtered by C8 (22n), R9 (680E0 & C14 (22n). R9 is the detector load resistor. The detected signal (AF signal) is given to the volume control P2 (10k Log) though maximum audio output-limiting resistor r21 (10k). It is also given to AGC circuit made of R5 (68k) and C6 (a.7/16).

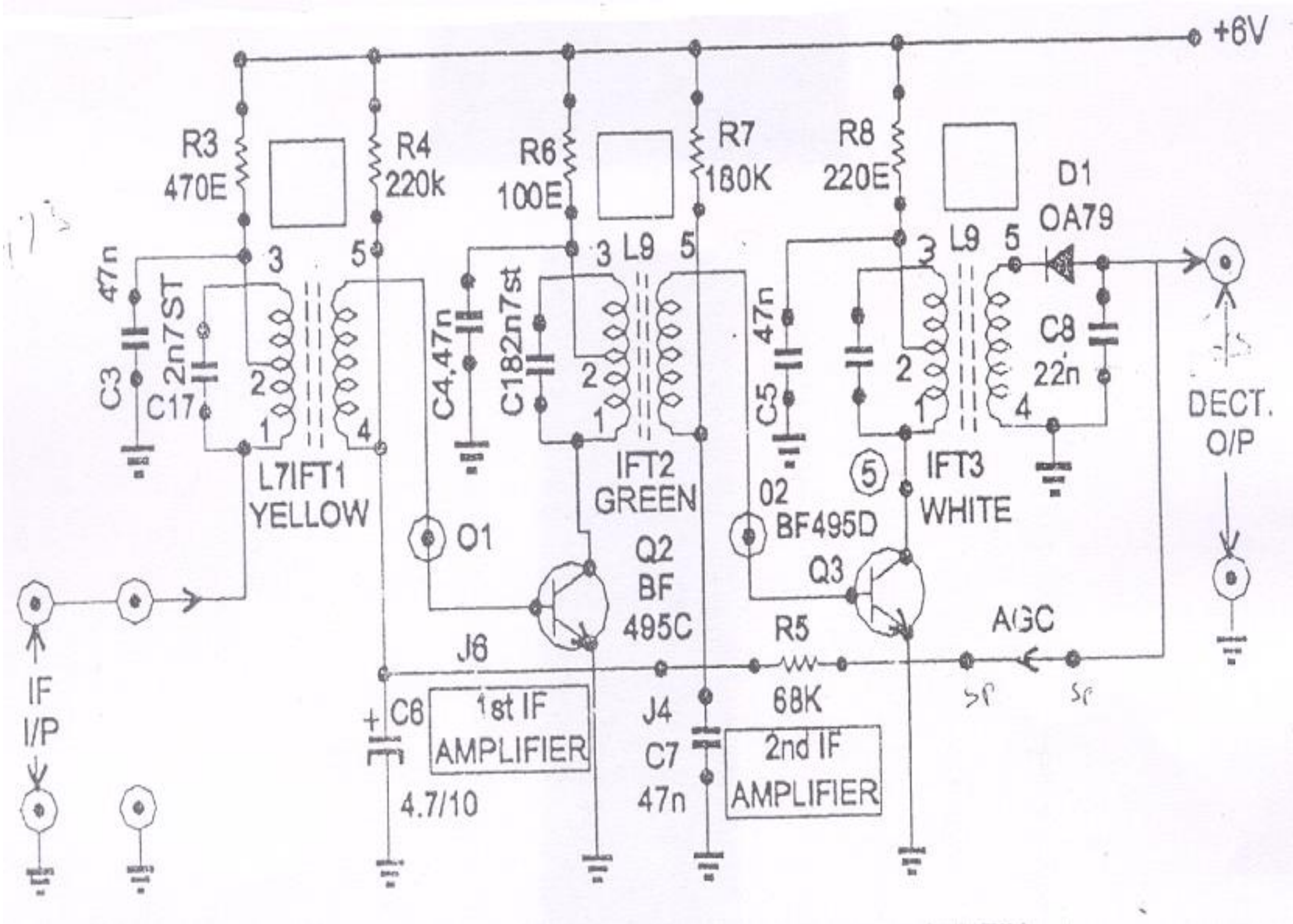
d. AGC

The sound received from the LS will depend on the strength of the signals received at the antenna. The strength of the received signals can vary widely due to fading. This will cause variations in sound which can be annoying. Moreover, the strength of signals can also be too large in close vicinity of MW transmitters causing overloading of the 2nd IF amplifier.

Automatic gain control (AGC) is used to minimize the variations in sound with changes in signal strength & to prevent overloading. The operation of AGC depends on the fact that the gain obtained from any transistor depend on its collector current & becomes less when the collector current is reduced to cut off (or increased to saturation

For AGC, DC voltage obtained from the detection of IF signals is applied to the 1st amplifier transistor base in such a way that an increase in this voltages reduces the gain of the transistor. The result is that when the strength of the incoming signal increases, the DC voltage also increase and this tends to reduce the gain of the amplifier thus not permitting the output to change much. Here R5 (68k) & C6 (4.7/16) performs this function. C6 (4.7/16) is the AGC decoupling capacitor to by pass any AF signals and keep the bias steady

V.CIRCUIT DIAGRAM:



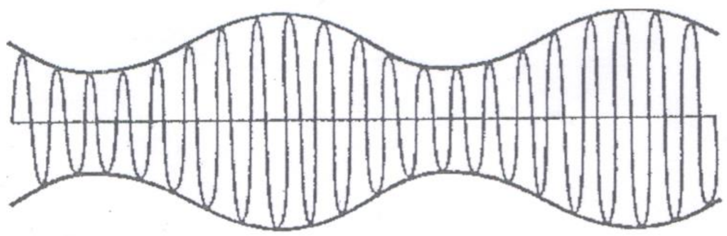
VI. PROCEDURE:

1. As the circuit is already wired you just have to trace the circuit according to the circuit diagram given above.
2. Connect the trainer to the mains and switch on the power supply.
3. Measures the output voltages of the regulated power supply circuit i.e. +12v and -12v, +6@150ma.
4. Observe outputs of RF and AF signal generator using CRO, note that RF voltage is approximately 50mVpp of 455KHz frequency and AF voltage is 5Vpp of KHz frequency.
5. Now vary the amplitude of AFsignal and observe the AM wave at output, note the percentage of modulation for different values of AF signal.
   % Modulation= (B – A) / (B + A) X 100
6. Now adjust the modulation index to 30% by varying the amplitudes of RF & AF signals simultaneously.
7. Connect AM output to the input of AGC and also to the CRO channel –1.
8. Connect AGC link to the feedback network through OA79 diode
9. Now connect CRO channel – 2 at output. The detected audio signal of 1KHz will be observed.
10. Calculate the voltage gain by measuring the amplitude of output signal (Vo) waveform, using formula A = Vo/Vi.

11. Now vary input level of 455KHz IF signal and observe detected 1KHz audio signal with and without AGC link. The output will be distorted when AGC link removed i.e. there is no AGC action.
12. This explains AGC effect in Radio circuit.

VII. EXPECTED WAVEFORMS:

.: AF Modulated RF Input.



: Detected Output With AGC:

VIII. RESULT:

IX. APPLICATIONS:

1. AM receivers.
2. Communication Systems.

X. QUESTIONS:

1. What do you mean by AGC ?
2. Explain how the gain is varied automatically in the radio receiver?
3. How the AGC helps in making the smooth waveform?
4. What is the main purpose of using the AGC .
5. What are the advantages received by employing AGC circuit in the receiver.
6. Write a short note on AGC.
7. What is AGC? Explain the circuit diagram of AGC.
8. What is the difference between delayed AGC and the simple AGC?

****

Experiment No. 13

PLL as FM Demodulator

I. AIM:

To perform the characteristics of PLL, and calculating its capture range, lock range and free running VCO frequency theoretically.

II. APPARATUS:

1. PLL Trainer Kit
2. C R O (20MHz)
3. Connecting wires

III. THEORY:

Phase Locked Loop is a versatile electronic servo system that compares the phase and frequency of a given signal with an internally generated reference signal. It is used in various applications like frequency multiplication, FM detector, AM modulator & De modulator and FSK etc.,

Free running frequency (f_0):

When there is no input signal applied to pin no:2 of PLL, it is in free running mode and the free running frequency is determined by the circuit elements R_t and C_t and is given by

$F_0 = 0.3/(R_tC_t)$ where R_t is the timing resistor
C_t is the timing capacitor

Lock range of PLL (f_L):

Lock range of PLL is in the range of frequencies in which PLL will remain lock, and this is given by

$f_L = \pm 8f_0 / V_{CC}$ Where f_0 is the free running frequency
$V_{CC} = V_{CC} - (-V_{CC})$

$= 2 V_{CC}$

Capture range (f_C):

The capture range of PLL is the range of frequencies over which PLL acquires the lock. This is given by

$$f_C = \frac{1}{2\Pi}\sqrt{\frac{2\Pi f_L}{3.6x10^3 xC_C}}$$ Where f_L is the lock range and
C_C is filter capacitor
$R = 3.6 \text{ X } 10^3$

IV.CIRCUIT DIAGRAM:

Circuit Diagram :

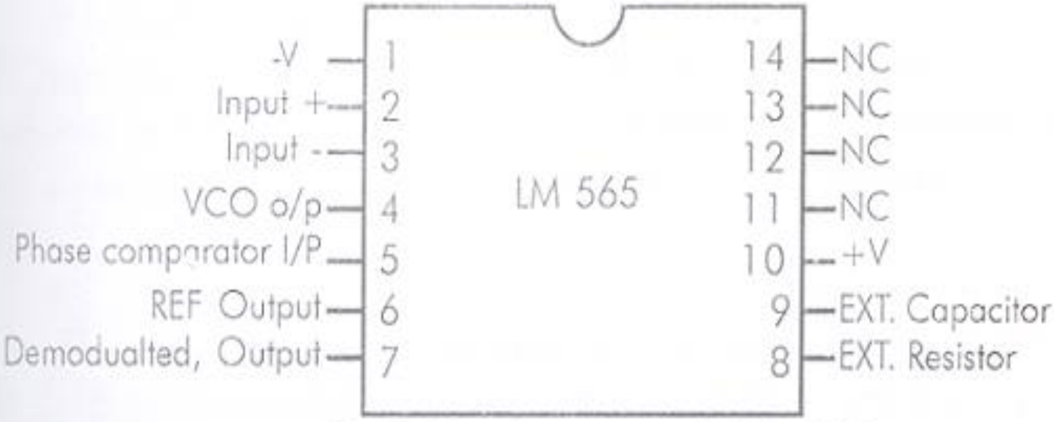


Fig.1 Pin Diagram of LM 565

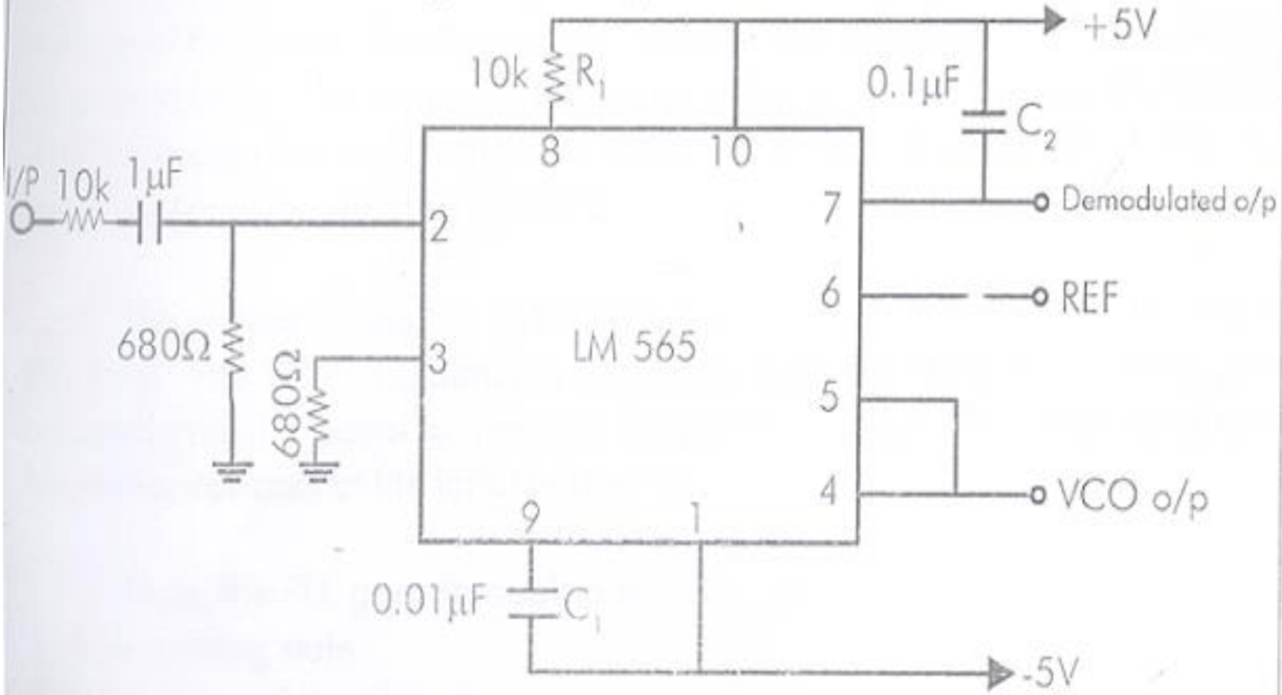


Fig.2 Circuit Diagram of LM 565

V. PROCEDURE:

1. Connect +5V to pin 10 of LM 565.
2. Connect +5V to pin 1.
3. Connect 10k resistor from pin 8 to +5V.
4. Connect 0.01μf capacitor from pin 9 to -5V.
5. Short pin 4 to pin 5.
6. Without giving input measure (f_o) free running frequency.
7. Connect pin 2 to oscillator or function generator through a 1uf capacitor, adjust the amplitude around 2Vpp.
8. Connect 0.1μf capacitor between pin 7 to +5V(C_2).
9. Connect the input signal to the Channel 1 of CRO.
10. Connect the output to the second Channel of CRO.
11. By varying the frequency in different steps observe that at one frequency , the wave form will be Phase locked.
12. Change R-C components to shift VCO center frequency and see how lock range of the input varies.
13. Compare the theoretical values and practical values.

VI. TABULAR COLOUMN:

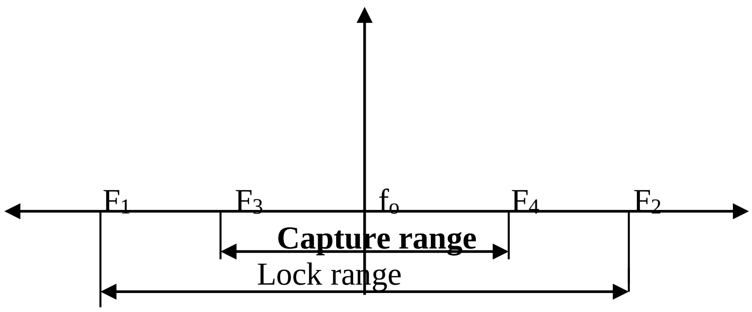
Lock range:

Theoretical Value (frequency in KHz)	Practical Value (frequency in KHz)

Capture range:

Filter Capacitor	Theoretical Value (frequency in KHz)	Practical Value (frequency in KHz)
0.1μF 0.2μF		

VII. CHARACTERISTICS OF PLL:



VII. RESULT:

VIII. APPLICATIONS:

1. Communication receivers.
2. FM demodulator.

X. QUESTIONS:

1. What are the applications of PLL?
2. What is a PLL?
3. What is a VCO?
4. Define the lock range of a PLL?
5. Define the capture range of PLL?
6. Give the expression for free running frequency f_0 of a PLL?
7. What is meant by the free running frequency of a PLL?
8. Give the formulae for the lock range and capture range of the PLL?

ANALOG COMMUNICATIONS
(MATLAB PROGRAMS)

[1] AMPLITUDE MODULATION& DEMODULATION (AM)

AIM: Write a MATLAB program to generate Amplitude Modulated signal, Amplitude Demodulated signal(using synchronous detector),and spectrum of AM signal.

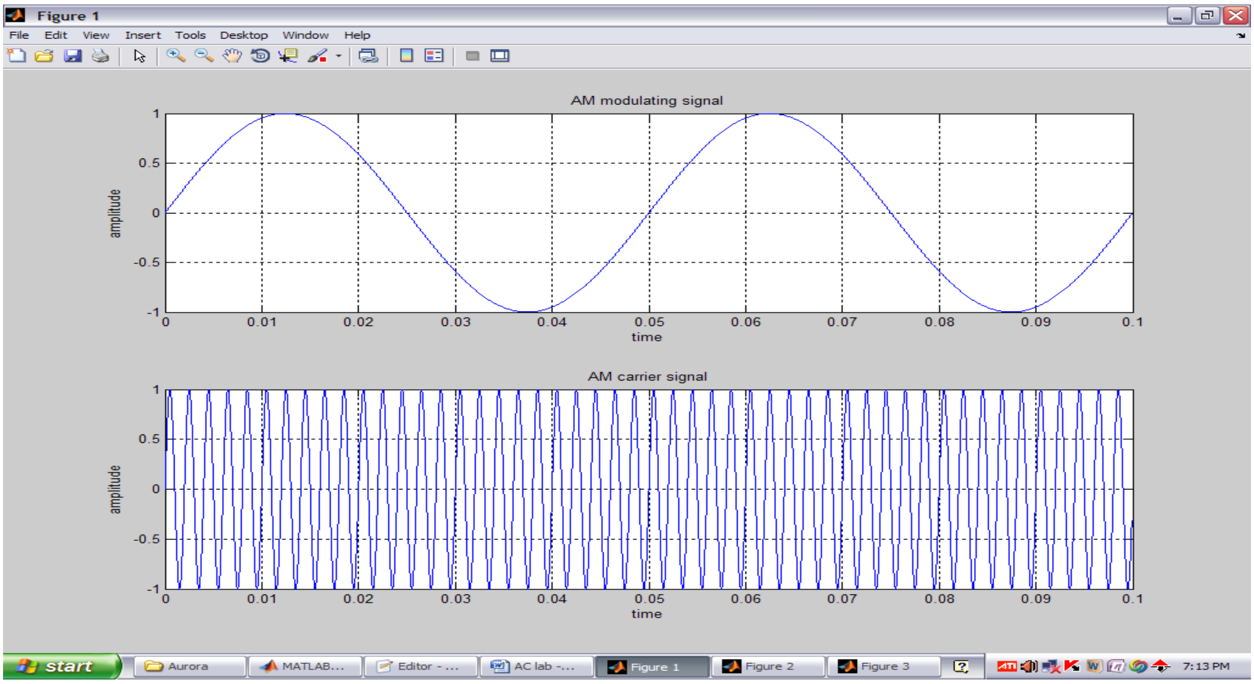
PROGRAM:

```
fm=20;
fc=500;
vm=1;
vc=1;
mu=0.8;    %  modulation index
% x-axis:Time(second)
t=0:0.00001:0.0999;
f=0:1:9999;
% y-axis:Voltage(volt)
V1=vc+mu*sin(2*pi*fm*t);      %upper envelop
V2=-(vc+mu*sin(2*pi*fm*t));  % lower envelop
Vm=vm*sin(2*pi*fm*t);
Vc=vc*sin(2*pi*fc*t);
Vam=vc*(1+mu*sin(2*pi*fm*t)).*(sin(2*pi*fc*t)); %%AM signal
Vr=Vam.*Vc;                     %  Synchronous detector
Vf=abs(fft(Vam,10000))/500;    % Spectrum
[b a] = butter(3,0.002);
out= filter(b,a,Vr);
%Plot modulating,carrier signal
figure(1);
subplot(211)
plot(t,Vm);
title('AM modulating signal');
xlabel('time'), ylabel('amplitude');grid on;
subplot(212)
plot(t, Vc);
title('AM carrier signal');
xlabel('time'), ylabel('amplitude');grid on;
% Plot AM in time domain and Frequency domain
```

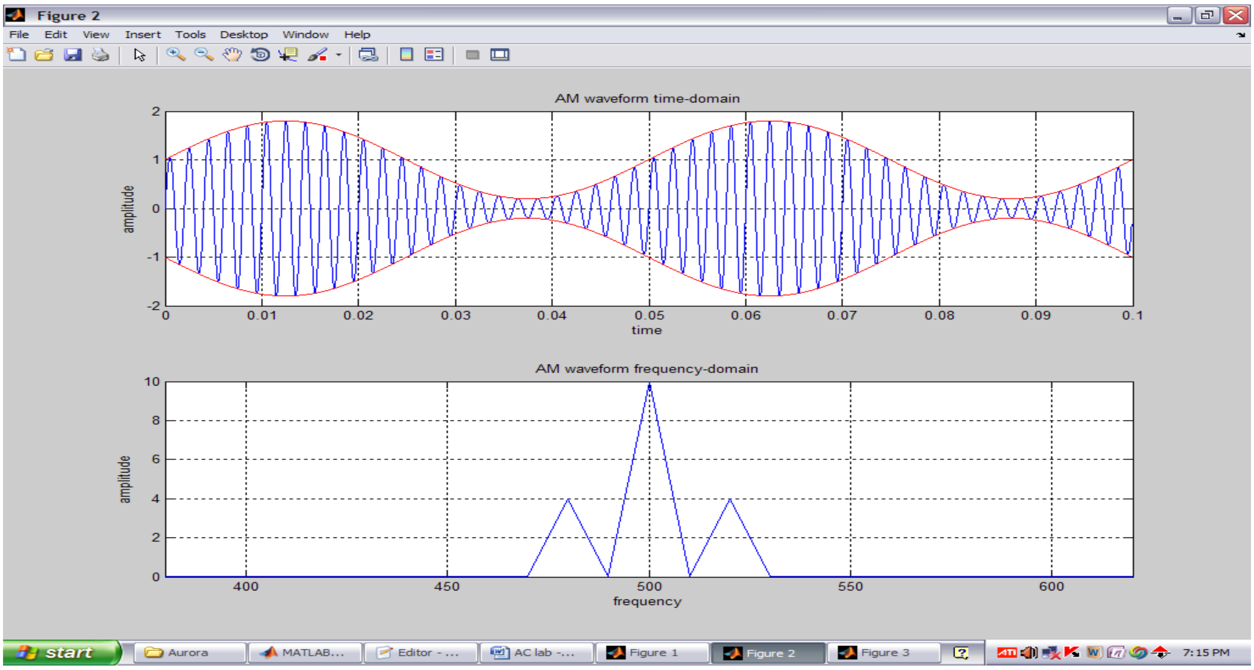
```
figure(2);
subplot(211)
plot(t,Vam);
holdon;
plot(t,V1,'r'),plot(t,V2,'r');
title('AM waveform time-domain');
xlabel('time'), ylabel('amplitude');grid on;
subplot(212)
plot(f*10,Vf);
axis([(fc-6*fm) (fc+6*fm) 0 10]);
title('AM waveform frequency-domain');
xlabel('frequency'), ylabel('amplitude');grid on;
figure(3)
plot(t,1.81*out)
title('AM Demodulated signal');
xlabel('time'), ylabel('amplitude');
grid
```

WAVEFORMS:

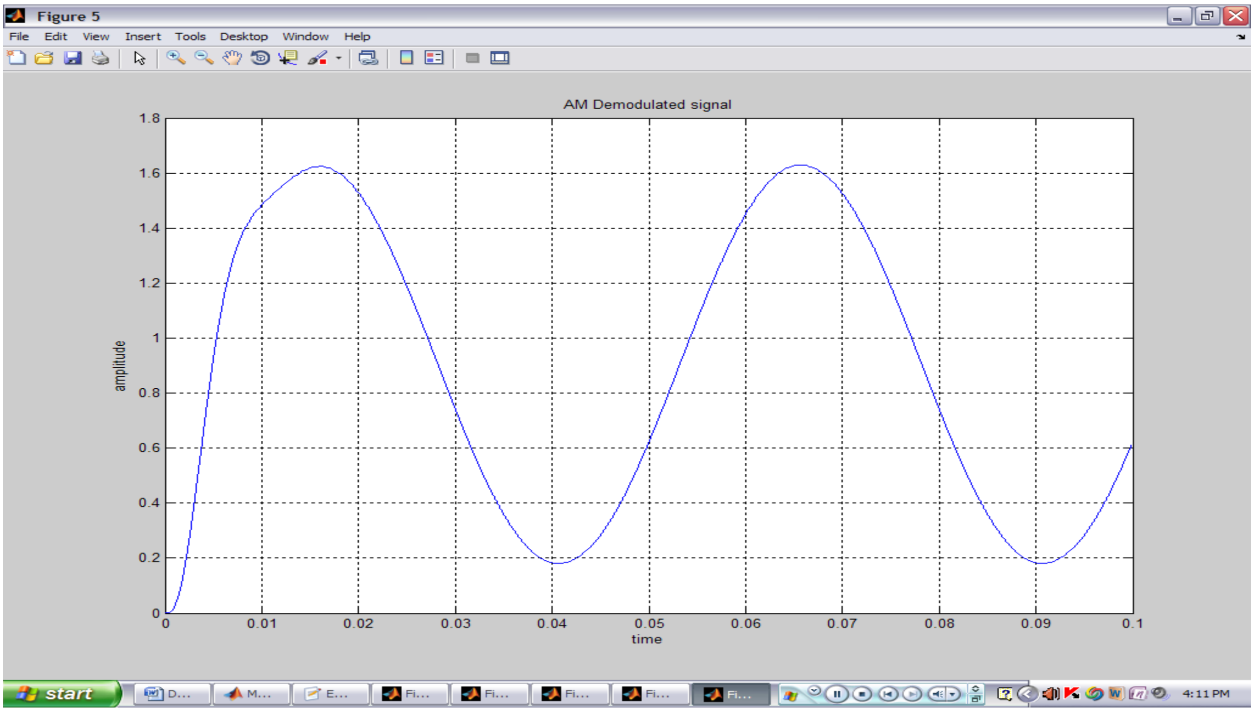
1) Message and carrier signal



2) Amplitude Modulated signal and frequency spectrum



3) Demodulated signal



[2] DOUBLE SIDE BAND SUPPRESSED CARRIER (DSB-SC) MODULTION & DEMODULATION

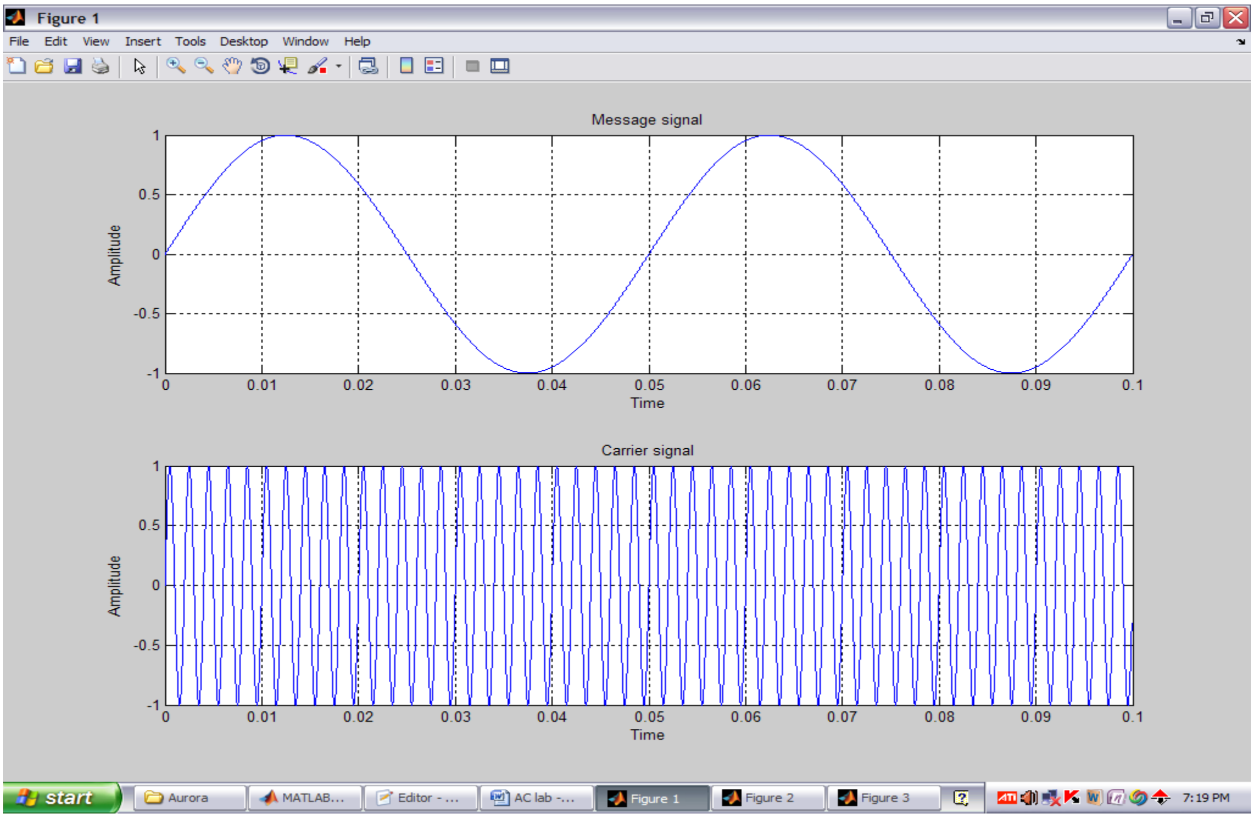
AIM: Write a MATLAB program to generate Double Side Band-Suppressed Carrier(DSB-SC) Amplitude Modulated signal, DSB-SC Demodulated signal,and spectrum of DSB-SC signal.

PROGRAM:

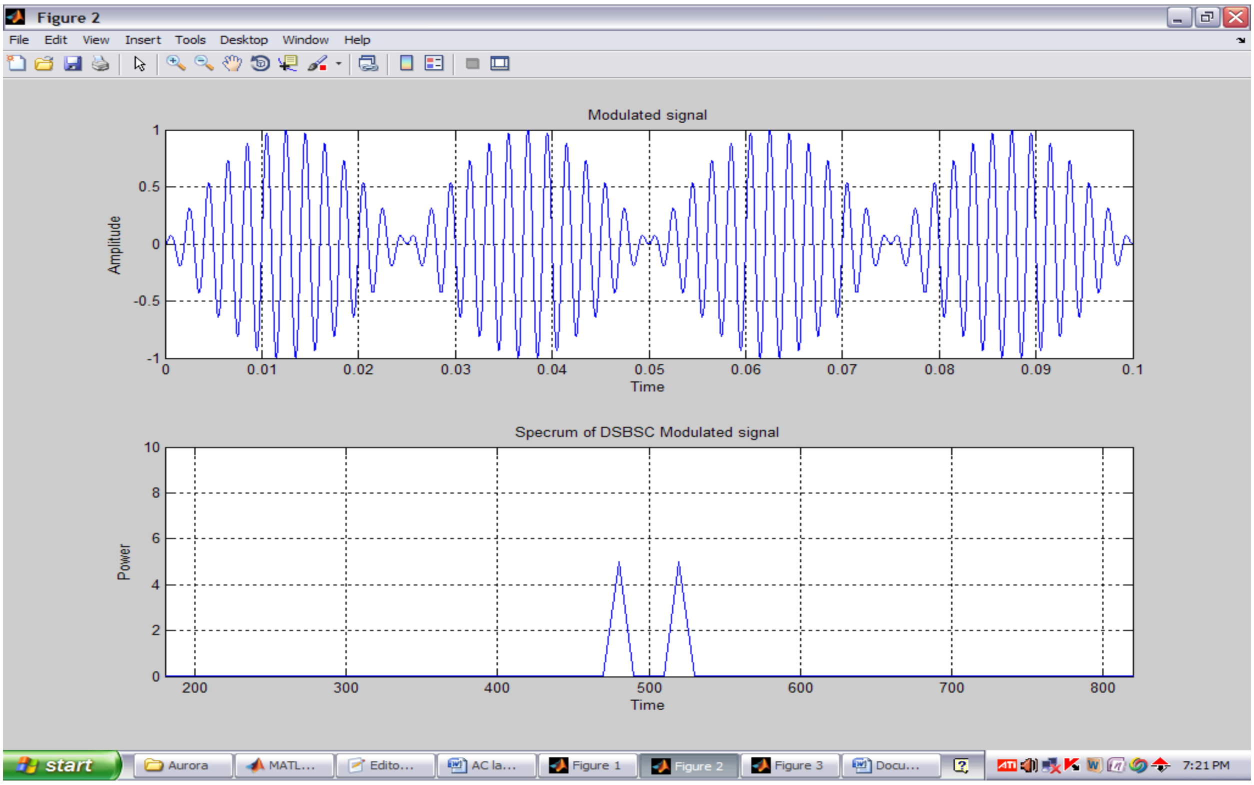
```
clearall;
closeall;
clc;
t=0:0.00001:0.0999;
f=0:1:9999;
Vm= 1;
Vc= 1;
fm = 20;
fc= 500;
message = Vm*sin(2*pi*fm*t);
carrier = Vc*sin(2*pi*fc*t);
dsbsc = message.*carrier;
demod = dsbsc.*carrier;
Vf=abs(fft(dsbsc,10000))/500;
%%% Demodulator using synchronous detector
[b a]=butter(2,0.002);
mr= filter(b,a,demod);
figure(1)
subplot(211)
plot(t,message)
xlabel('Time') ;ylabel('Amplitude');
title('Message signal');grid;
subplot(212)
plot(t,carrier);
xlabel('Time') ;ylabel('Amplitude');
title('Carrier signal');grid;
figure(2)
subplot(211)
plot(t,dsbsc);
xlabel('Time') ;ylabel('Amplitude');
title('Modulated signal');grid;
subplot(212)
plot(f*10,Vf);
axis([(fc-16*fm) (fc+16*fm) 0 10]);
xlabel('Time') ;ylabel('Power');
title('Specrum of DSBSC Modulated signal');grid;
figure(3)
plot(t,mr);
xlabel('Time') ;ylabel('Amplitude');
title('Demodulated signal');grid;
```

WAVEFORMS:

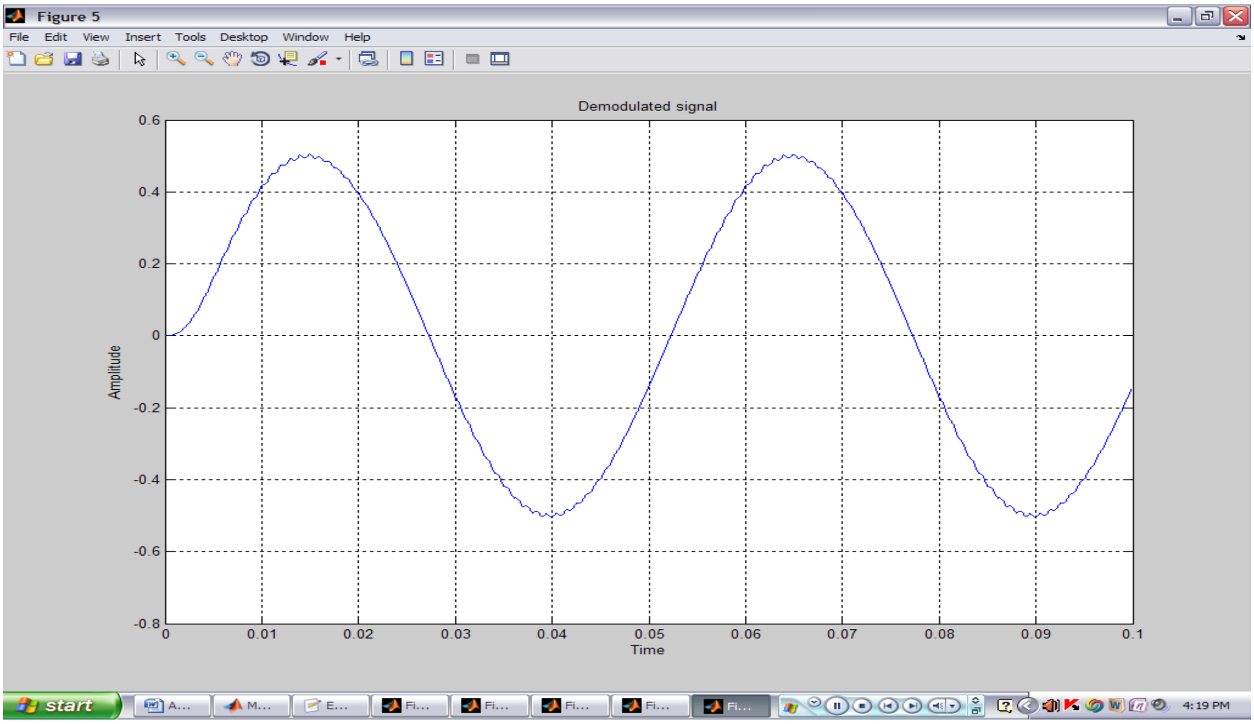
1) Message signal and carrier signal



2) DSB-SC signal and Spectrum of DSB-SC Signal



3) DSB-SC Demodulated wave



[3] SINGLE SIDE BAND SUPPRESSED CARRIER MODULATION (SSB) MODULATION & DEMODULATION

AIM: Write a MATLAB program to generate Single Side Band-Suppressed Carrier(SSB-SC) Modulated signal, SSB-SC Demodulated signal, and spectrum of SSB-SC signal.

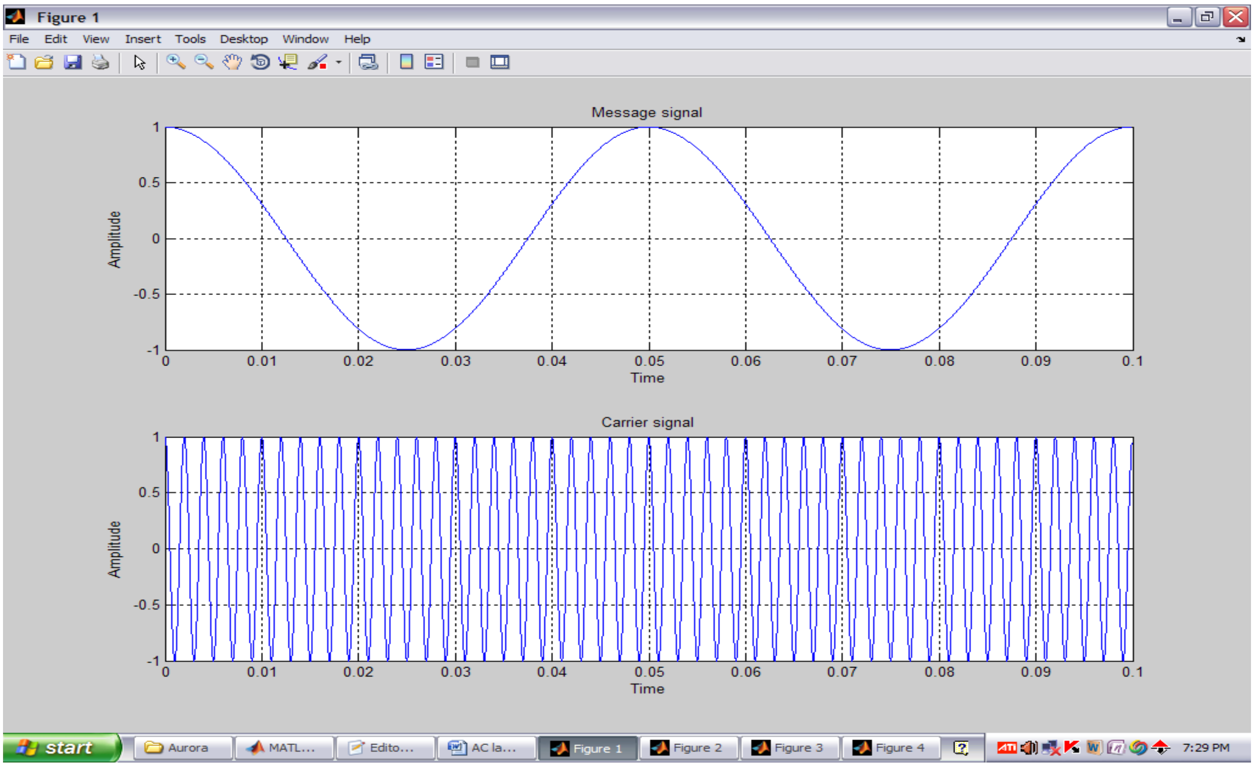
PROGRAM:

```
fm=20;
fc=500;
vm=1;
vc=1;
mu=0.1;
t=0:0.00001:0.0999;
f=0:1:9999;
m=vm*cos(2*pi*fm*t);  %% message
mp=vm*sin(2*pi*fm*t);
c=vc*cos(2*pi*fc*t);  %% carrier
cp=vc*sin(2*pi*fc*t);
ss1=m.*c;
ss2=mp.*cp;
upper=ss1-ss2;        %% upper sideband signal
lower=ss1+ss2;        %% lower sideband signal
Vfupper=abs(fft(upper,10000))/10000;  %% upper frequency
spectrum
Vflower=abs(fft(lower,10000))/10000;  %% lower frequency
spectrum
%%% demodulator using Synchronous detector %%%%
%% upper demodulated
vudemod=c.*upper;
[b a] = butter(2,0.002);
upperdemod= filter(b,a,vudemod);
%% lower demodulated
vldemod=c.*lower;
[b a]=butter(2,0.002);
lowerdemod=filter(b,a,vldemod);
figure(1)
```

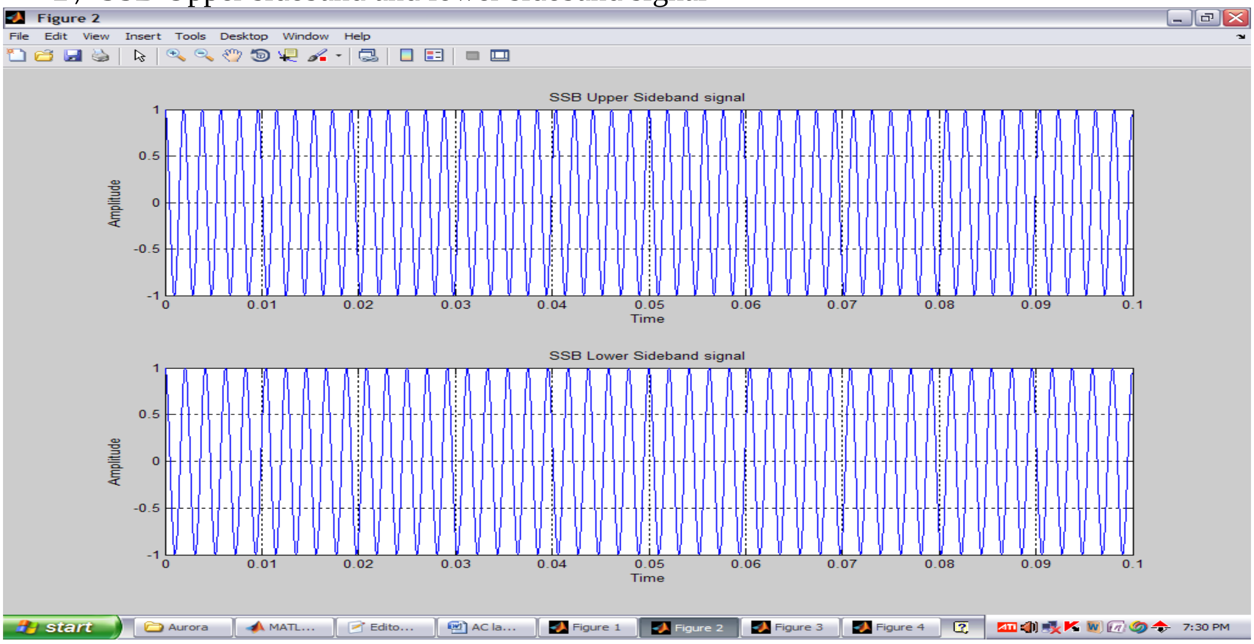
```
subplot(211);plot(t,m)
xlabel('Time') ;ylabel('Amplitude');
title('Message signal');grid;
subplot(212);plot(t,c)
xlabel('Time');ylabel('Amplitude');
title('Carrier signal');grid;
figure(2)
subplot(211);plot(t,upper)
xlabel('Time');ylabel('Amplitude');
title('SSB Upper Sideband signal');grid
subplot(212);plot(t,lower)
xlabel('Time');ylabel('Amplitude');
title('SSB Lower Sideband signal');grid
figure(3)
subplot(211);plot(f*10,Vfupper)
axis([(fc-20*fm) (fc+20*fm) 0 0.6]);
xlabel('Frequency');ylabel('Power');
title('SSB Upper Sidebsnd signal spectrum');grid
subplot(212);plot(f*10,Vflower)
axis([(fc-20*fm) (fc+20*fm) 0 0.6]);
xlabel('Frequency');ylabel('Power');
title('SSB Lower Sidebsnd signal spectrum');grid
figure(4)
subplot(211);plot(t,upperdemod)
xlabel('Time') ;ylabel('Amplitude');
title('Upper sideband Demodulated signal');grid;
subplot(212);plot(t,lowerdemod)
xlabel('Time') ;ylabel('Amplitude');
title('Lower sideband Demodulated signal');grid;
```

WAVEFORMS:

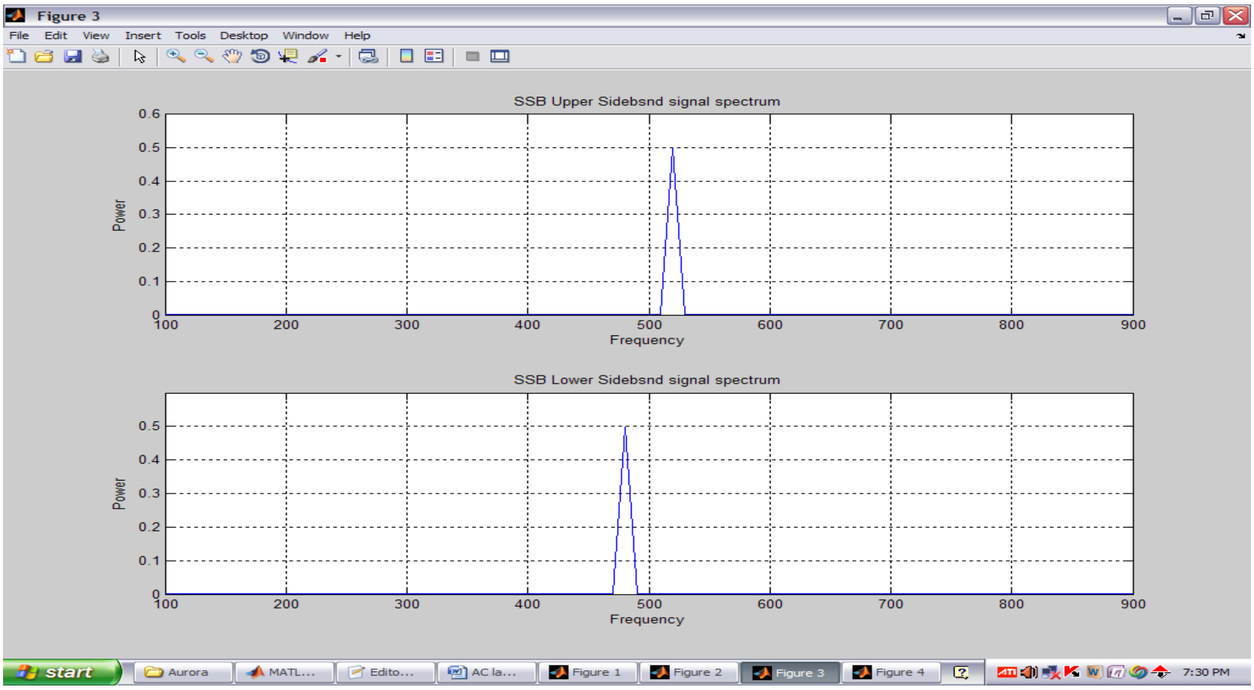
1) Message signal and carrier signal



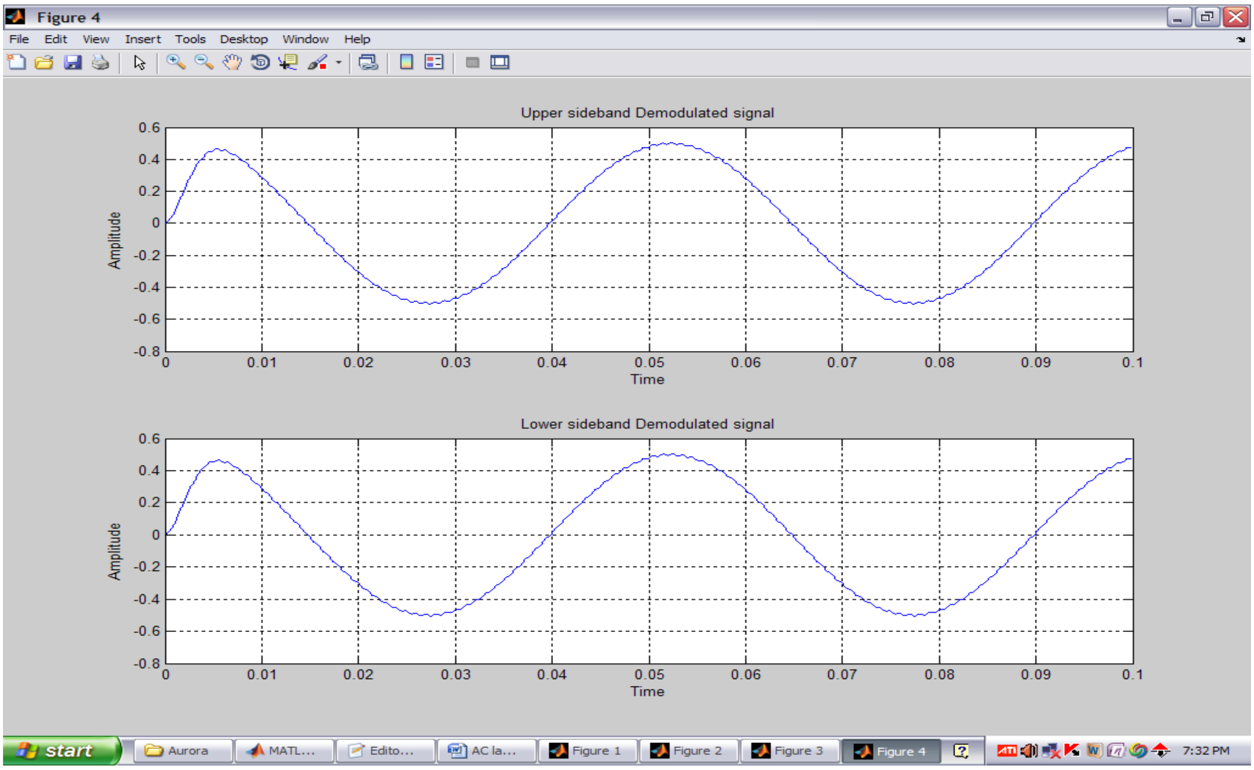
2） SSB Upper sideband and lower sideband signal



3) Spectrum of SSB Upper and lower sidebands.



4) Upper sideband and lower sideband Demodulated wave



[4] FREQUENCY MODULATION AND DEMODULATION (FM)

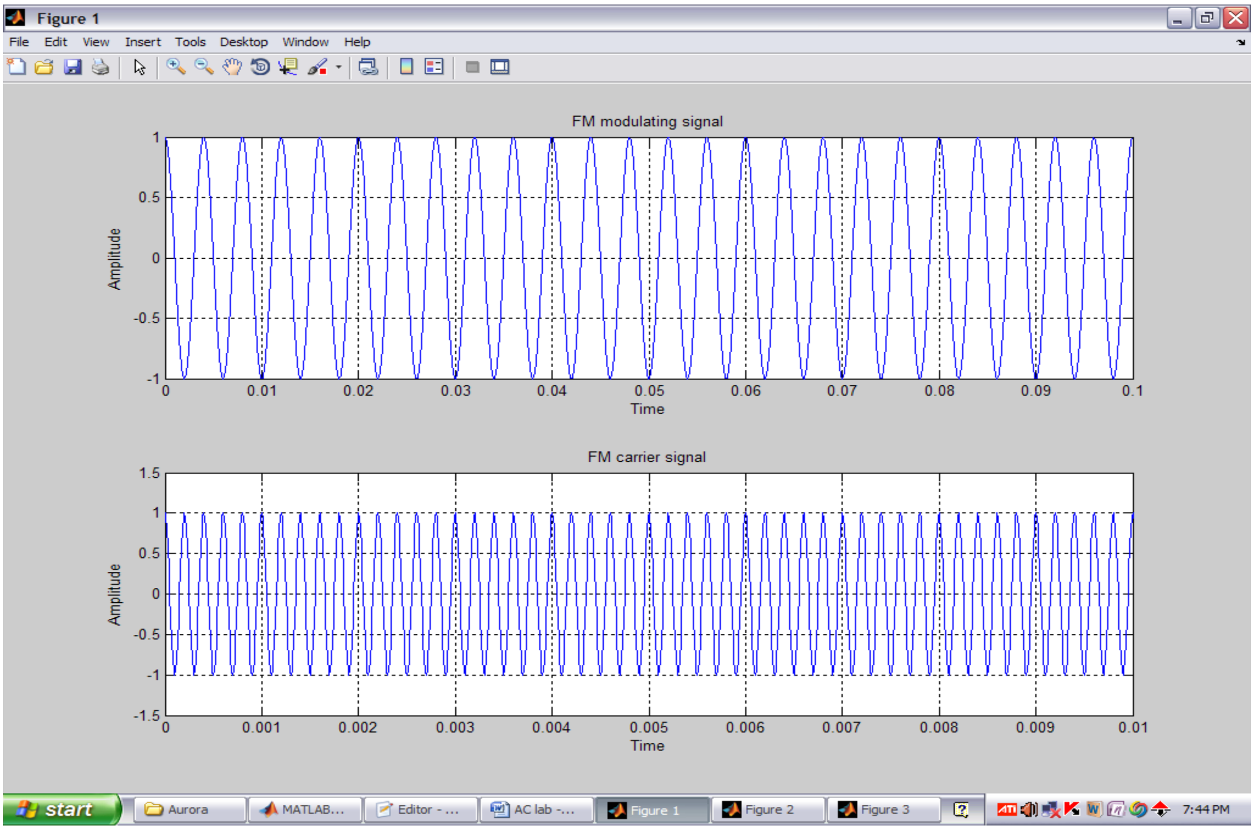
AIM: Write a MATLAB program to generate Frequency Modulated (FM) signal, spectrum of FM signal and FM demodulated signal using Phase Locked Loop (PLL).

PROGRAM:

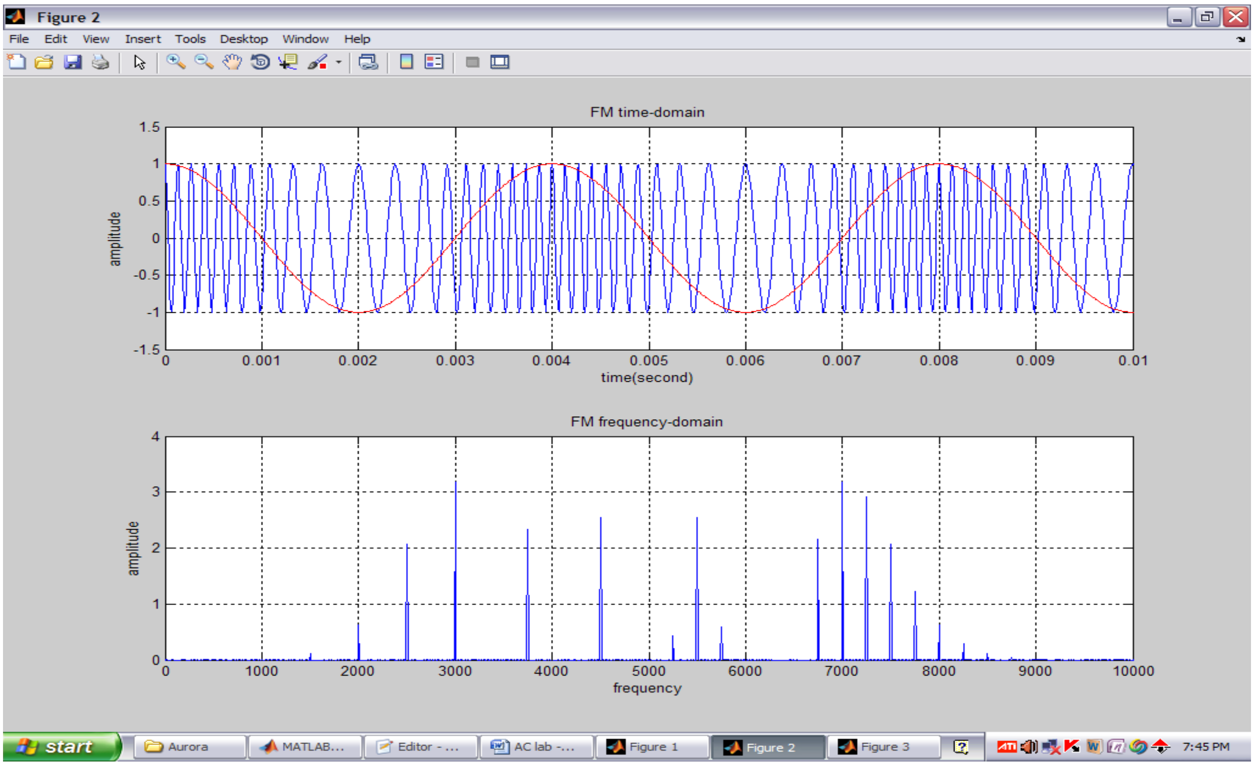
```
%The frequency modulation(FM)waveform in time and frequency
domain.
%fm=250HZ,fc=5KHZ,Vm=1V,Vc=1V,m=10,t=0:0.00001:0.09999
vc=1;                          % Carrier amplitude
vm=1;                          % Message Amplitude
fm=250;                        % Message frequency
fc=5000;                       % Carrier frequency
m=10;                          % beta
kf=100
t=0:0.00001:0.09999;
f=0:10:99990;
carrier=vc*cos(2*pi*fc*t);
message=vm*cos(2*pi*fm*t);
FM=vc*cos((2*pi*fc*t)+10*sin(2*pi*fm*t)); % FM wave
dem=(1/2*pi*10)*diff(10*sin(2*pi*fm*t))/0.2;   %%
Demodulation using PLL
vf=(fft(FM,10^4))/500;
figure(1);
subplot(211);plot(t,message);
xlabel('Time');ylabel('Amplitude');
title('FM modulating signal');grid
subplot(212);plot(t,carrier);
xlabel('Time');ylabel('Amplitude')
axis([0 0.01 -1.5 1.5]);
title('FM carrier signal');grid
figure(2);
subplot(211);plot(t,FM);hold on;
plot(t,message,'r');
axis([0 0.01 -1.5 1.5]);
xlabel('time(second)'),ylabel('amplitude');
title('FM time-domain');grid
gridon;
subplot(212)
plot(f,vf);
axis([ 0 10^4 0 4]);
xlabel('frequency'), ylabel('amplitude');
title('FM frequency-domain');
gridon;
figure(3)
plot(dem)
xlabel('Time'),ylabel('amplitude');
title('FM Demodulated signal');grid
gridon;
```

WAVEFORMS:

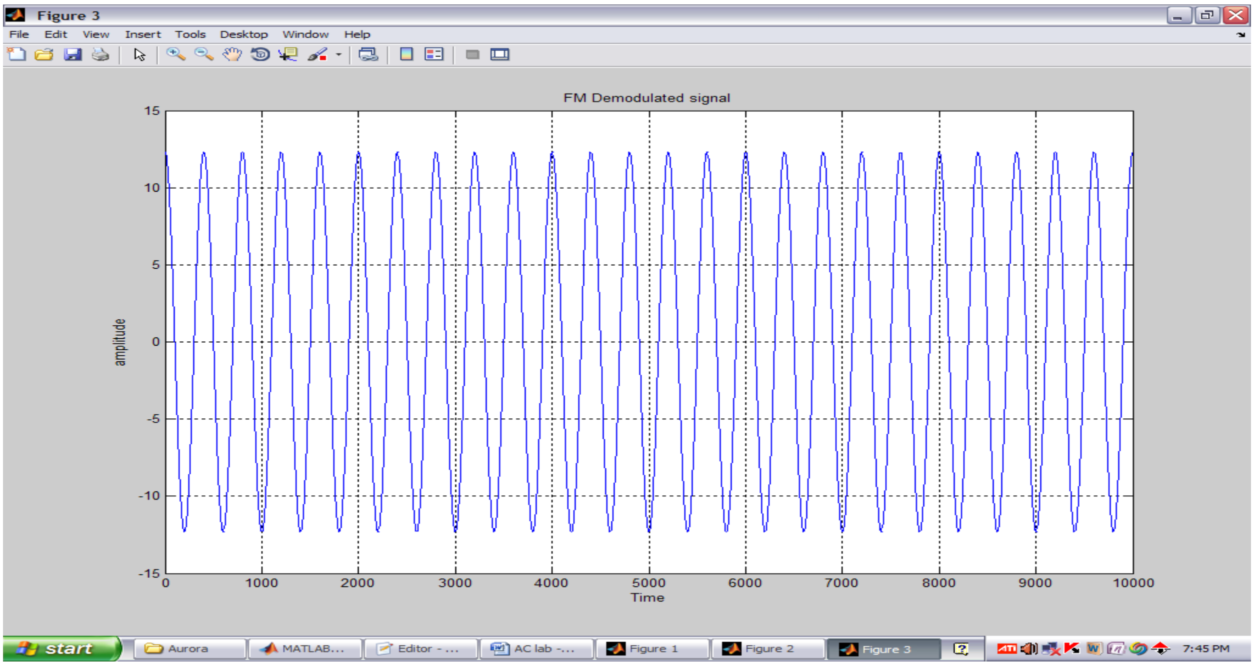
1) Modulating and carrier signal



2) Frequency Modulated signal and its spectrum



3) Demodulated signal



[5] TIME DIVISION MULTIPLEXING AND DEMULTIPLEXING

AIM: Write a MATLAB program to implement Time Division Multiplexing and de-multiplexing.

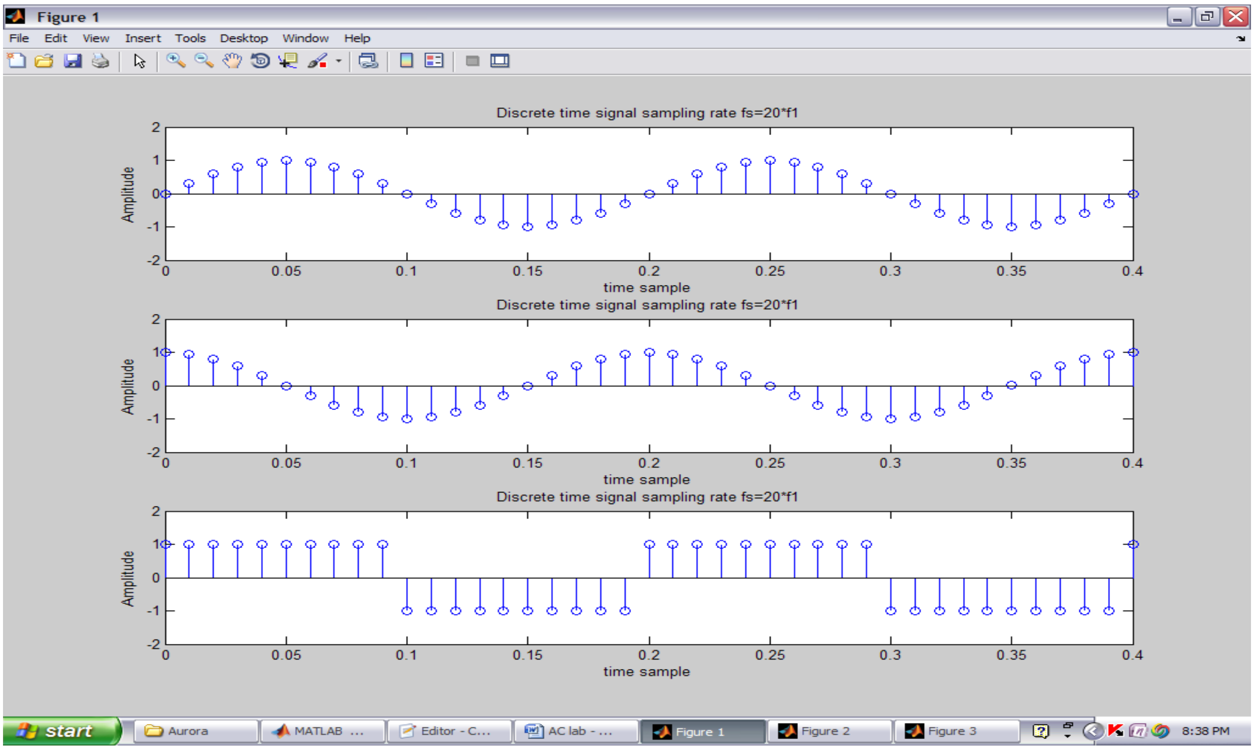
PROGRAM:

```
clc;
clearall;
t=-5:0.0001:5;
f1=5;
%f2=20;
% out=[]
%%%%%%%% Message signals %%%%%%%%%
           %%  1  %%
fs1=20*f1;
ts1=1/fs1;
n1=0:ts1:0.4;
message1=sin(2*pi*f1*n1);
           %%  2  %%
fs2=20*f1;
ts2=1/fs2;
n2=0:ts2:0.4;
message2=cos(2*pi*f1*n2);
           %%  3  %%
fs3=20*f1;
ts3=1/fs3;
n3=0:ts3:0.4;
message3=square(2*pi*f1*n3);
%%%%%%%%  MULTIPLEXING  %%%%%%%%%%%
k=1
for i=1:3:120
multiplex(i)=(message1(k));
multiplex(i+1)=(message2(k));
multiplex(i+2)=(message3(k));
       k=k+1;
end
%%%%%%%% DEMULTIPLEXING  %%%%%%%%%%%
q=1;
for p=1:1:120
if (q<120)
demul1(p)=multiplex(q);
demul2(p)=multiplex(q+1);
demul3(p)=multiplex(q+2);
    q=q+3
end
end
figure(1)
subplot(311);stem(n1,message1)
axis([0 0.4 -2 2])
xlabel('time sample');ylabel('Amplitude');
```

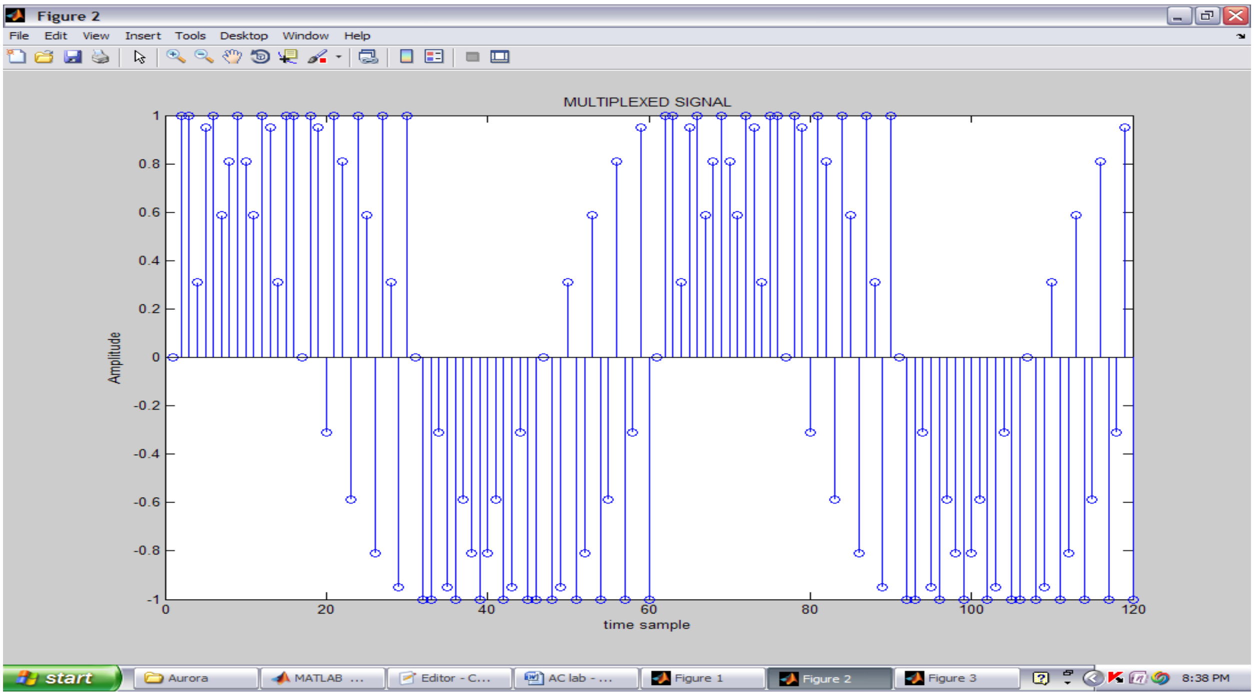
```
title('Discrete time signal sampling rate fs=20*f1');
subplot(312);stem(n2,message2)
axis([0 0.4 -2 2])
xlabel('time sample');ylabel('Amplitude');
title('Discrete time signal sampling rate fs=20*f1');
subplot(313); stem(n1,message3)
axis([0 0.4 -2 2])
xlabel('time sample');ylabel('Amplitude');
title('Discrete time signal sampling rate fs=20*f1');
figure(2)
stem(multiplex)
xlabel('time sample');ylabel('Amplitude');
title('MULTIPLEXED SIGNAL');
figure(3)
subplot(311);stem(demul1)
xlabel('time sample');ylabel('Amplitude');
title('DEMULTIPLEXED SIGNAL(message1)');
subplot(312);stem(demul2)
xlabel('time sample');ylabel('Amplitude');
title('DEMULTIPLEXED SIGNAL(message2)');
subplot(313);stem(demul3)
xlabel('time sample');ylabel('Amplitude');
title('DEMULTIPLEXED SIGNAL(message3)');
```

WAVEFORMS:

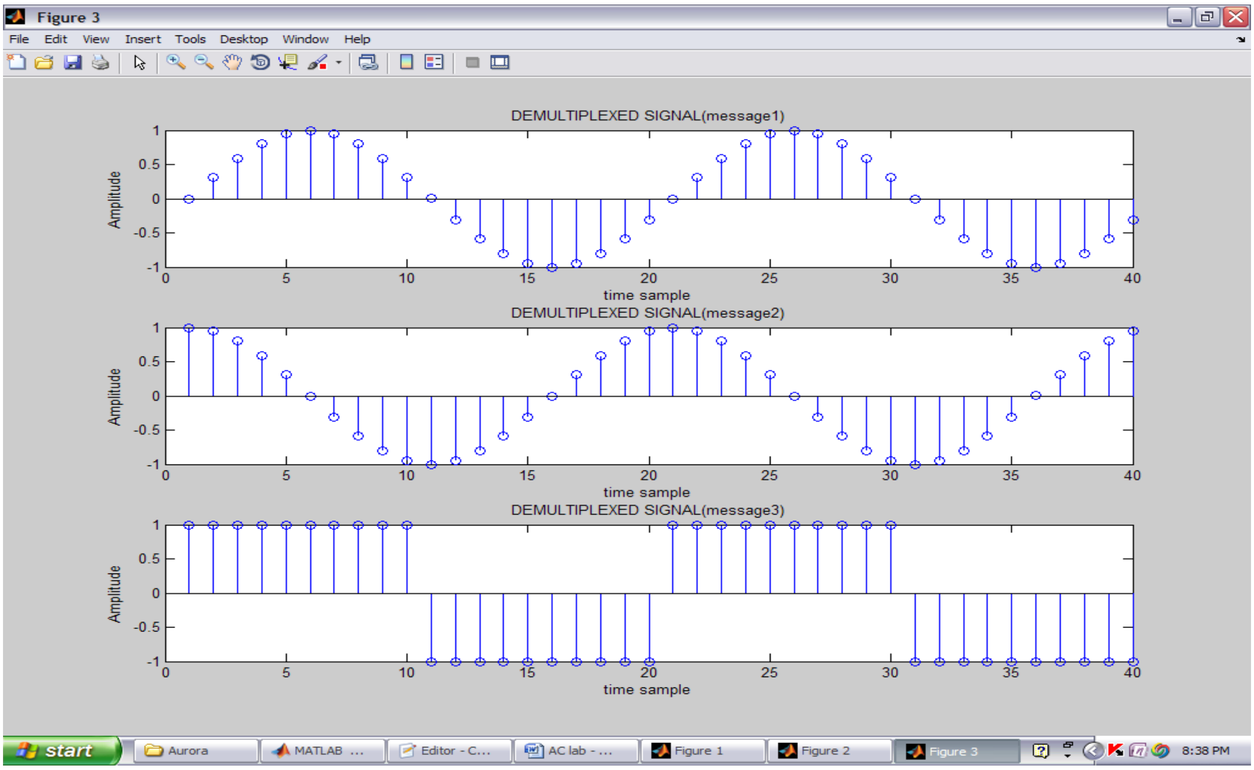
1) Message signals



2) Multiplexed signal



3) Demultiplxed signals



[6] FREQUENCY DIVISION MULTIPLEXING AND DEMULTIPLEXING

AIM: Write a MATLAB program to implement Frequency Division Multiplexing and demultiplexing

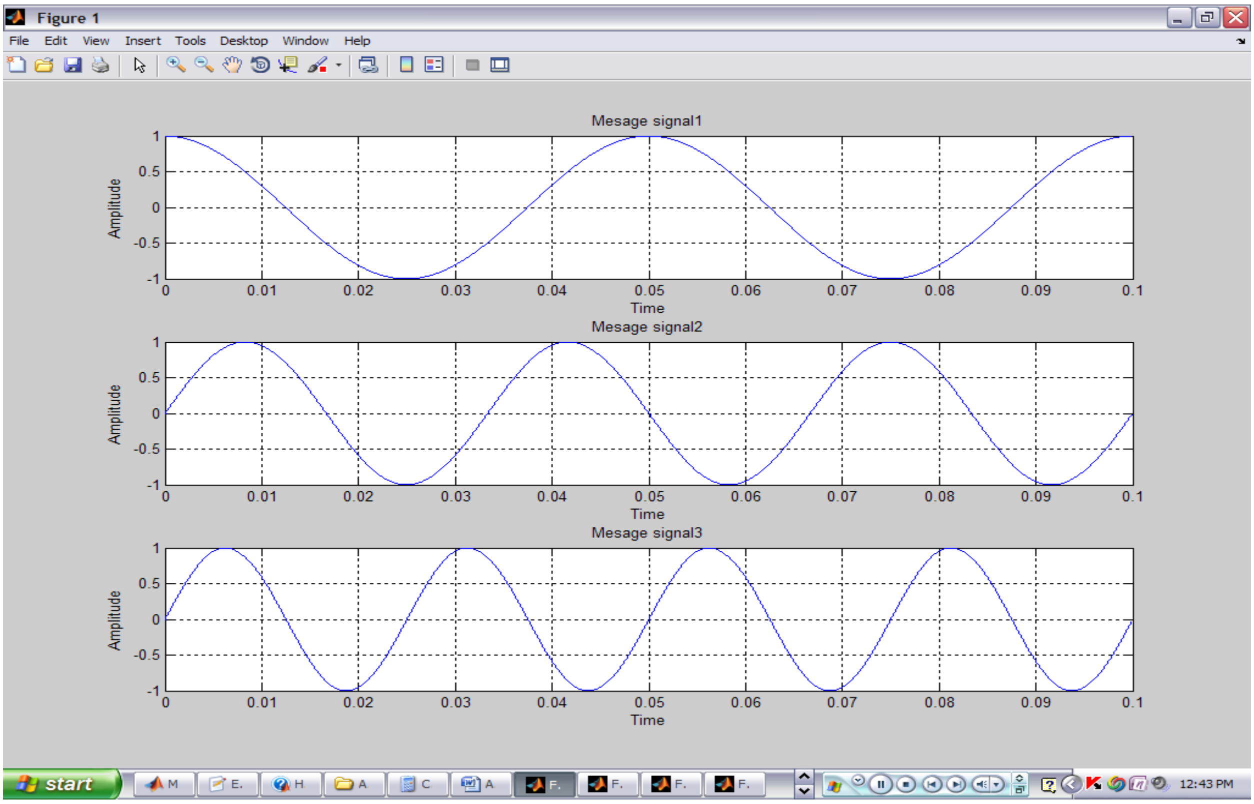
PROGRAM :

```
fm1=20;fm2=30;fm3=40;
fc1=100;fc2=1000;fc3=2000;
t=0:0.00001:0.0999;
f=0:1:9999;
%%%%% Message inputs  %%%%%%%%%
message1=cos(2*pi*fm1*t);
message2=sin(2*pi*fm2*t);
message3=sin(2*pi*fm3*t);
%%%%% LPF outputs %%%%%%%%%%%
[b1,a1] = butter(2,0.033)
m1= filter(b1,a1,message1);
[b2,a2] = butter(2,0.05)
m2= filter(b1,a1,message2);
[b3,a3] = butter(2,0.066)
m3= filter(b1,a1,message3);
%%%%% Modulator outputs %%%%%
y1=ammod(m1,fc1,100000);
y2=ammod(m2,fc2,100000);
y3=ammod(m3,fc3,100000);
%%%%% Combined signal %%%%%%
y=y1+y2+y3;
%%%%% Spectrum of Frequency Division Multiplexed signal %%%%
Vf=abs(fft(y,10000))/500;
%%%%% Bans Pass Filter outputs %%%%%
[b4,a4] = butter(1,[0.016 0.024],'bandpass')
out1= filter(b4,a4,y);
[b5,a5] = butter(1,[0.194 0.206],'bandpass')
out2= filter(b5,a5,y);
[b6,a6] = butter(1,[0.392 0.408],'bandpass')
out3= filter(b6,a6,y);
%%%%%% Demodulator Outputs %%%%%%55
demod1 = amdemod(y,fc1,100000)
demod2 = amdemod(y,fc2,100000)
demod3 = amdemod(y,fc3,100000)
%%%%%%% Figures  %%%%%%%%%%%%
figure(1)
subplot(311);plot(t,message1)
xlabel('Time');ylabel('Amplitude')
title('Mesage signal1');grid
subplot(312);plot(t,message2)
xlabel('Time');ylabel('Amplitude')
title('Mesage signal2');grid
subplot(313);plot(t,message3)
xlabel('Time');ylabel('Amplitude')
```

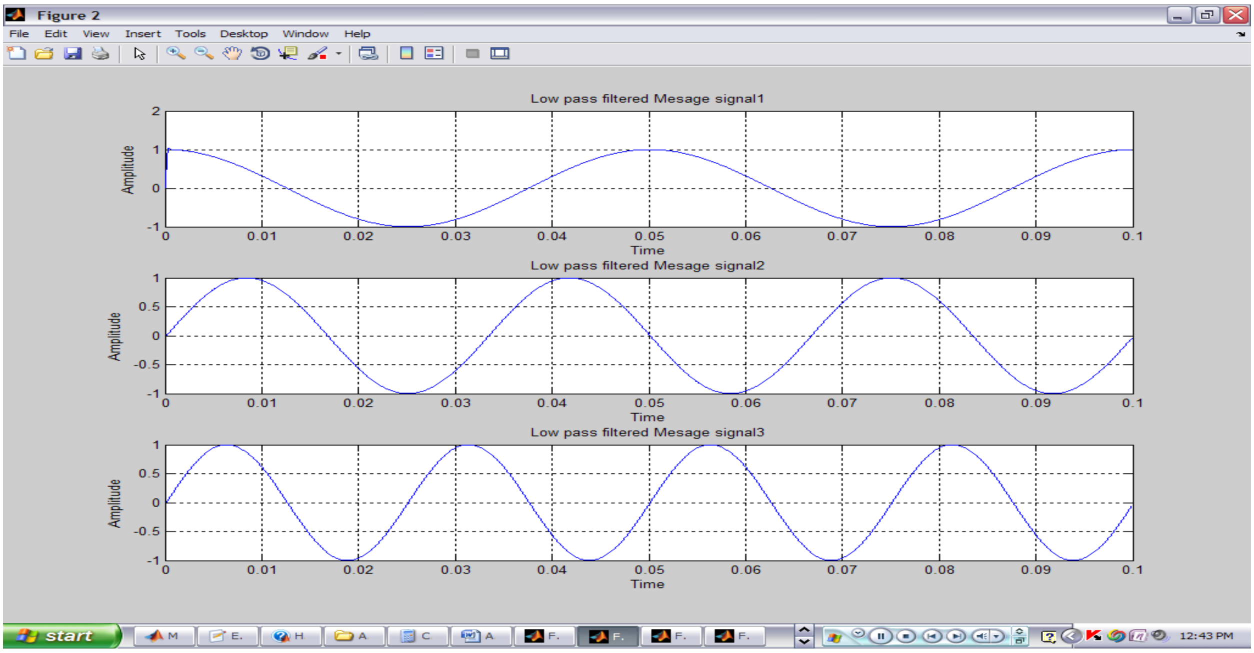
```
title('Mesage signal3');grid
figure(2);
subplot(311);plot(t,m1)
xlabel('Time');ylabel('Amplitude')
title('Low pass filtered Mesage signal1');grid
subplot(312);plot(t,m2)
xlabel('Time');ylabel('Amplitude')
title('Low pass filtered Mesage signal2');grid
subplot(313);plot(t,m3)
xlabel('Time');ylabel('Amplitude')
title('Low pass filtered Mesage signal3');grid
figure(3)
subplot(311);plot(t,y1)
xlabel('Time');ylabel('Amplitude')
title('Modulated signal1');grid
subplot(312);plot(t,y2)
xlabel('Time');ylabel('Amplitude')
title('Modulated signal2');grid
subplot(313);plot(t,y3)
xlabel('Time');ylabel('Amplitude')
title('Modulated signal3');grid
figure(4)
subplot(211);plot(t,y)
xlabel('Time');ylabel('Amplitude')
title('Combined Modulated signal1');grid
subplot(212);plot(f*10,Vf);
axis([(fc3-50*fm3) (fc3+50*fm3) 0 10]);
xlabel('Frequency');ylabel('Power')
title('Spectrum of FDM signal');grid
figure(5)
subplot(311);plot(t,out1)
xlabel('Time');ylabel('Amplitude')
title('BPF signal1');grid
subplot(312);plot(t,out2)
xlabel('Time');ylabel('Amplitude')
title('BPF signal2');grid
subplot(313);plot(t,out3)
xlabel('Time');ylabel('Amplitude')
title('BPF signal3');grid
figure(6)
subplot(311);plot(t,demod1)
xlabel('Time');ylabel('Amplitude')
title('Demodulated signal1');grid
subplot(312);plot(t,demod2)
xlabel('Time');ylabel('Amplitude')
title('Demodulated signal2');grid
subplot(313);plot(t,demod3)
xlabel('Time');ylabel('Amplitude')
title('Demodulated signal3');grid
```

WAVEFORMS:

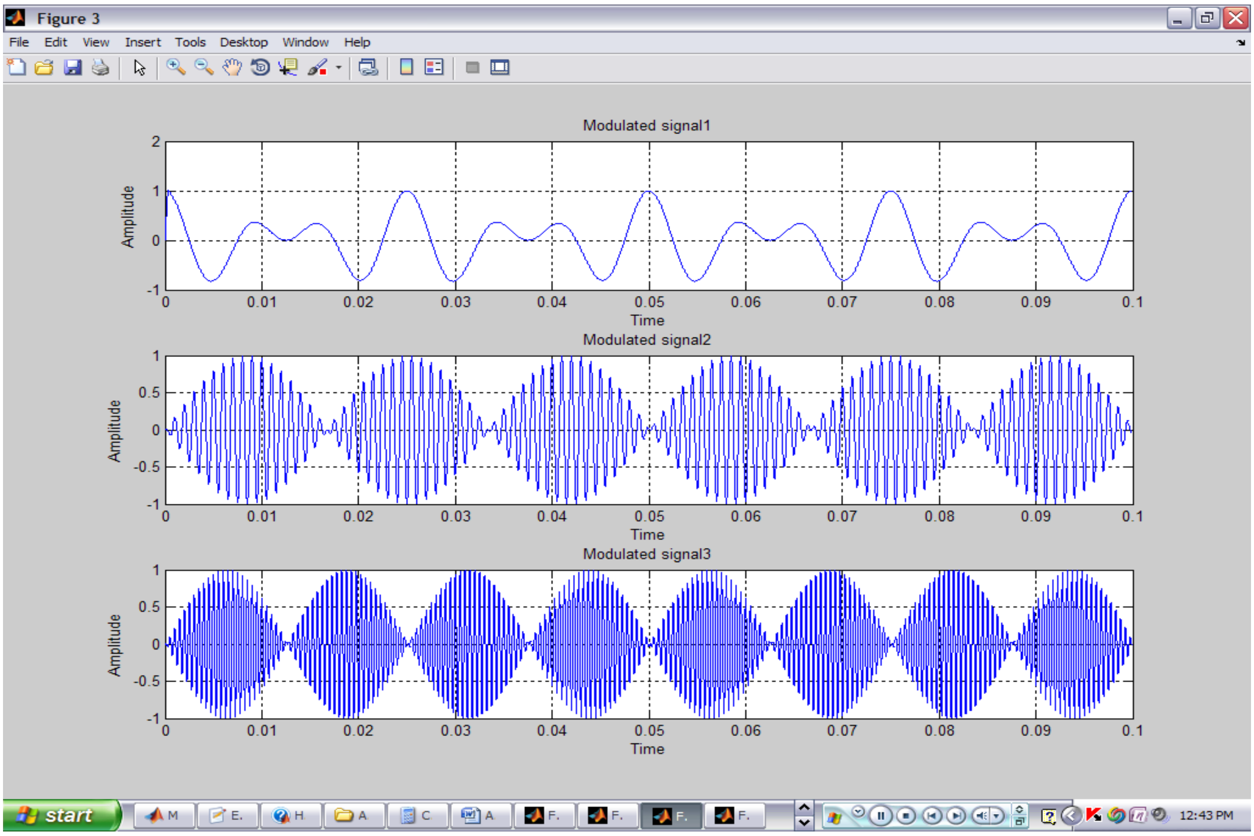
1) Message signals



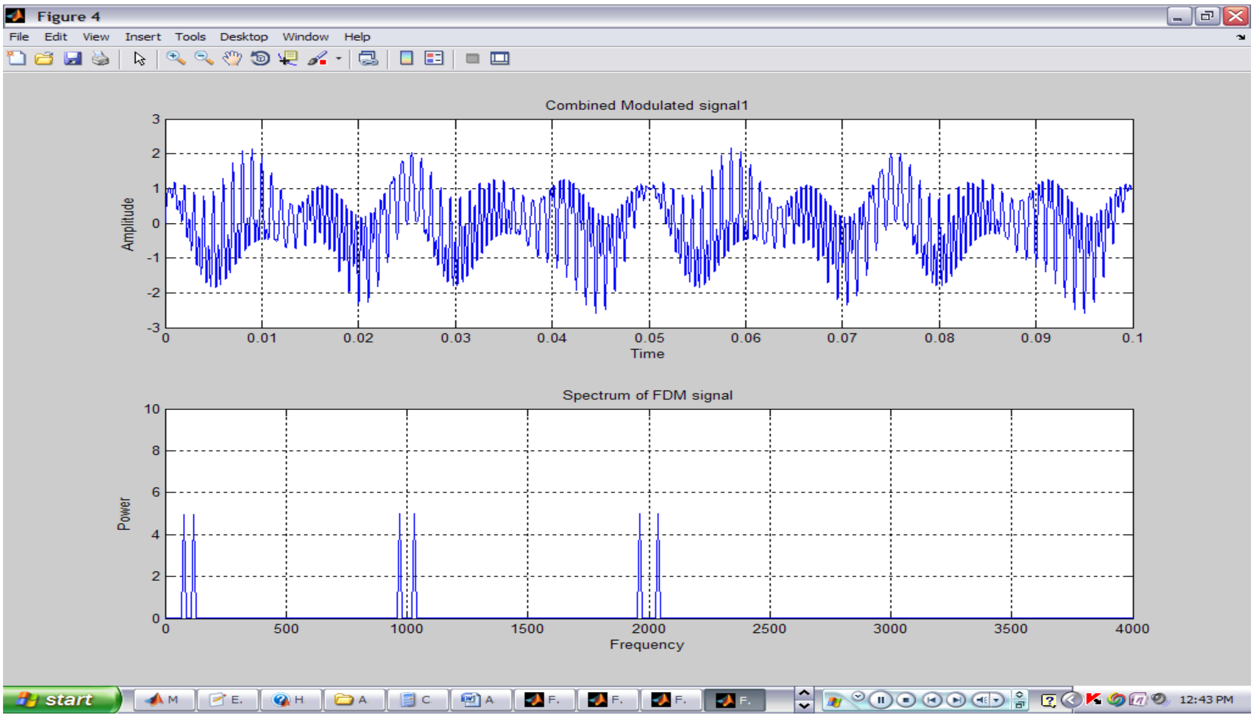
2) Low pass filtered message signals



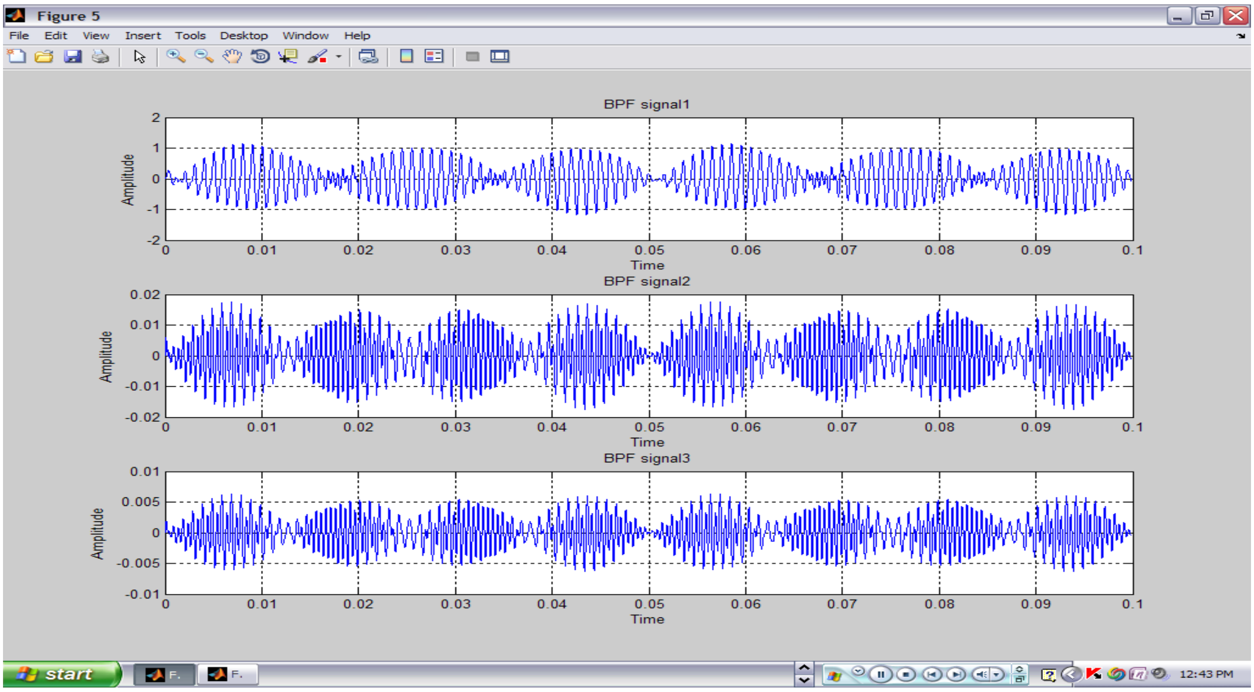
3) Modulated signals



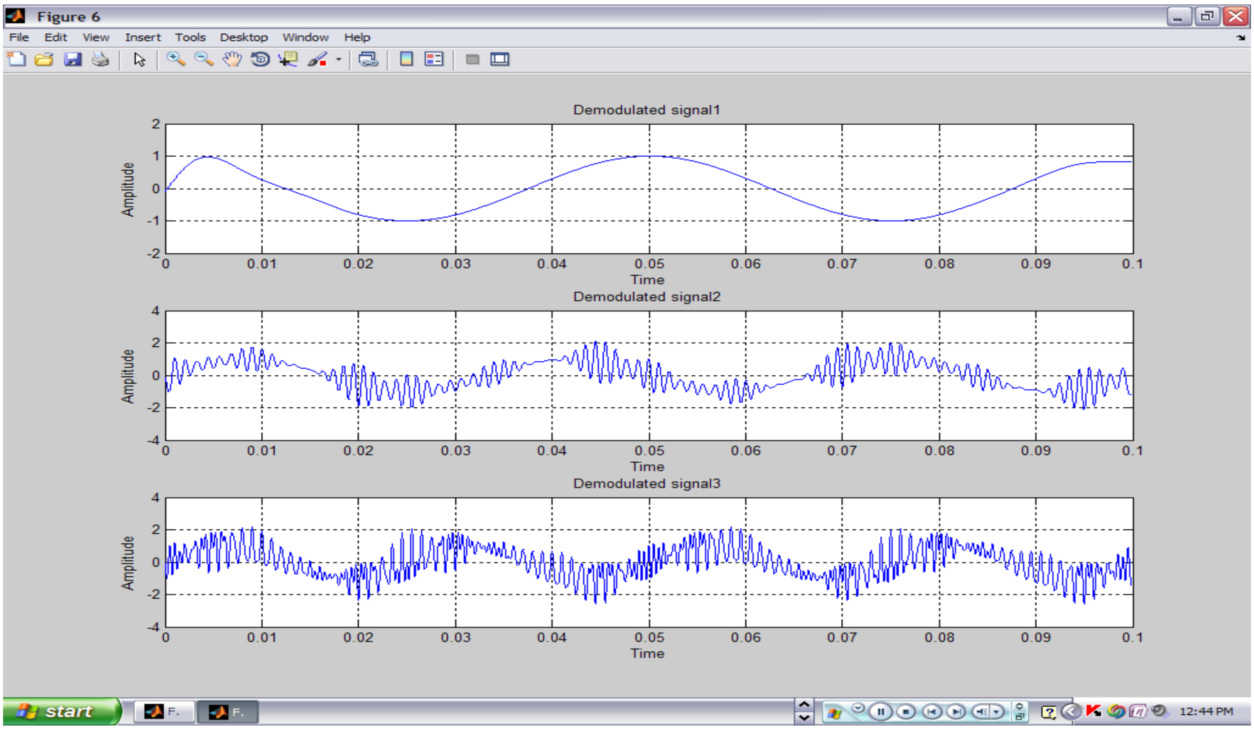
4) Combined signal (FDM signal) and its spectrum



5) Band pass filter outputs



6) Demodulated signals



[7] VERIFICATION OF SAMPLING THEOREM

AIM: Write a MATLAB program to verify the Sampling theorem

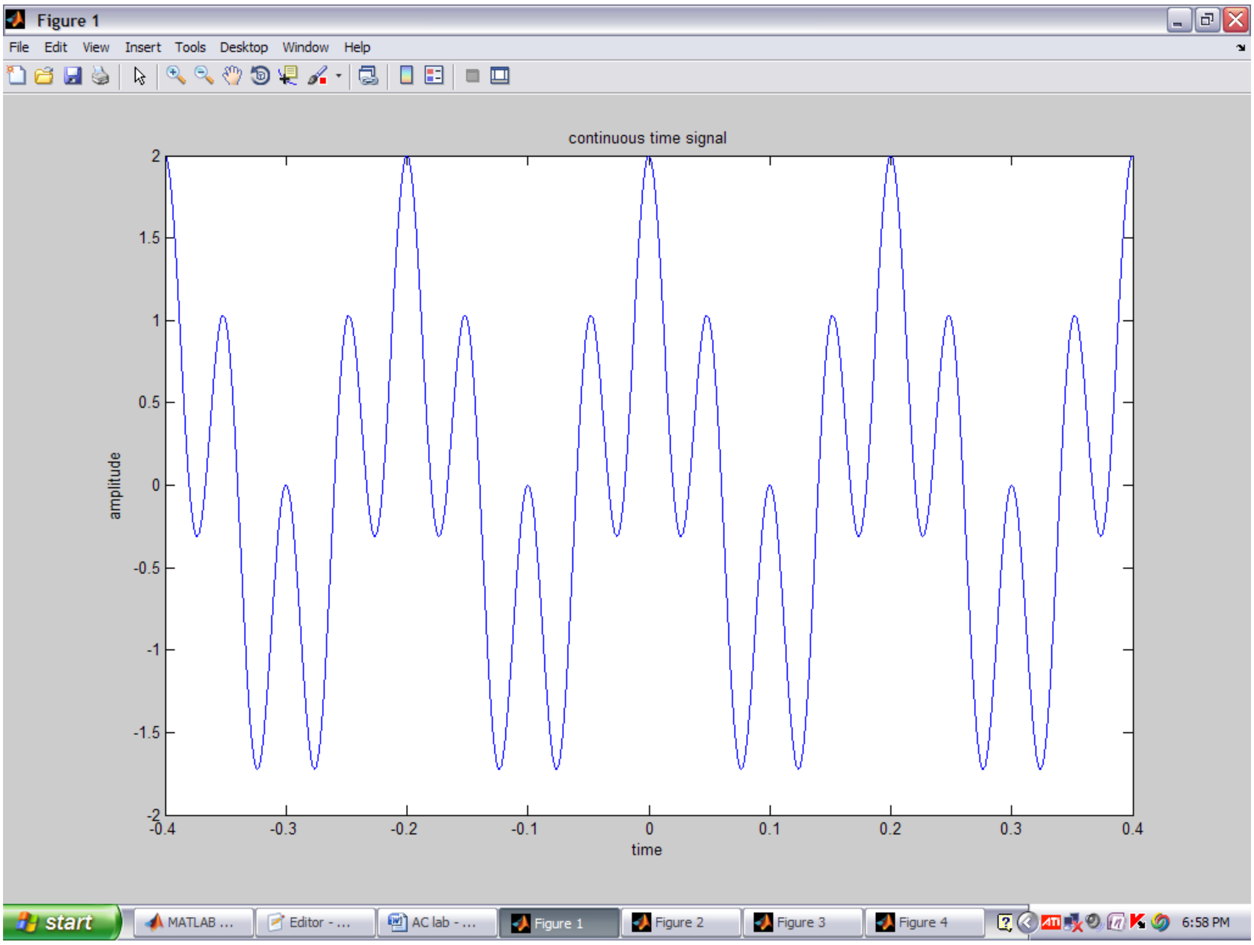
PRPGRAM:

```
clc;
clearall;
t=-5:0.0001:5;
f1=5;
f2=20;
x=cos(2*pi*f1*t)+cos(2*pi*f2*t);
figure(1)
plot(t,x)
axis([-0.4 0.4 -2 2])
xlabel('time');ylabel('amplitude')
title('continuous time signal');
%%%%%   case 1  %%%%%%%%
fs1=1.4*f2;
ts1=1/fs1;
n1=-0.4:ts1:0.4;
xs1=cos(2*pi*f1*n1)+cos(2*pi*f2*n1);
figure(2)
stem(n1,xs1)
axis([-0.4 0.4 -2 2])
holdon;
plot(t,x,'r');
holdoff
xlabel('time sample');ylabel('Amplitude');
title('Discrete time signal sampling rate fs<2*fmax');
%%%%%%%%   case  2  %%%%%%
fs2=2*f2;
ts2=1/fs2;
n2=-0.4:ts2:0.4;
xs2=cos(2*pi*f1*n2)+cos(2*pi*f2*n2);
figure(3)
stem(n2,xs2)
axis([-0.4 0.4 -2 2])
holdon;
plot(t,x,'r');
holdoff
xlabel('time sample');ylabel('Amplitude');
title('Discrete time signal sampling rate fs=2*fmax');
%%%%%%%  case 3  %%%%%%%%%
fs3=8*f2;
ts3=1/fs3;
n3=-0.4:ts3:0.4;
xs3=cos(2*pi*f1*n3)+cos(2*pi*f2*n3);
figure(4)
stem(n3,xs3)
```

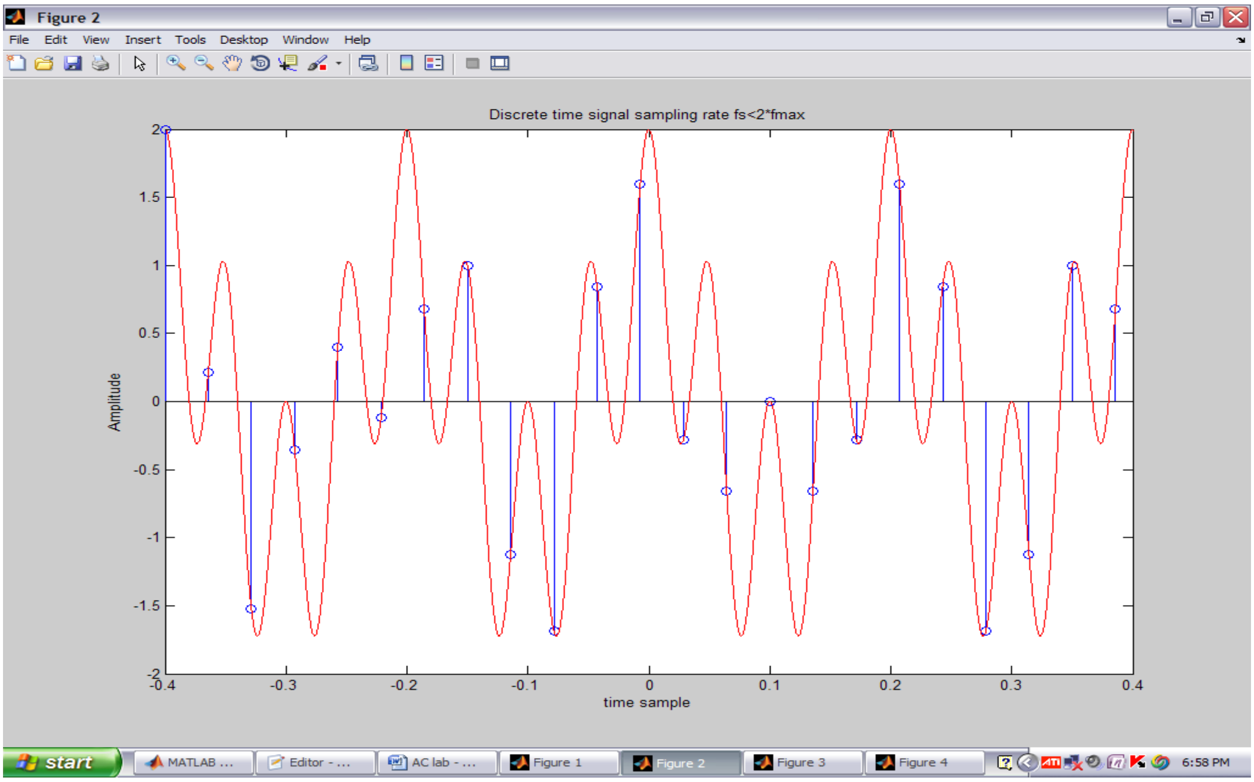
```
axis([-0.4 0.4 -2 2])
holdon;
plot(t,x,'r');
holdoff
xlabel('time sample');ylabel('Amplitude');
title('Discrete time signal sampling rate fs>2*fmax');
```

WAVEFORMS:

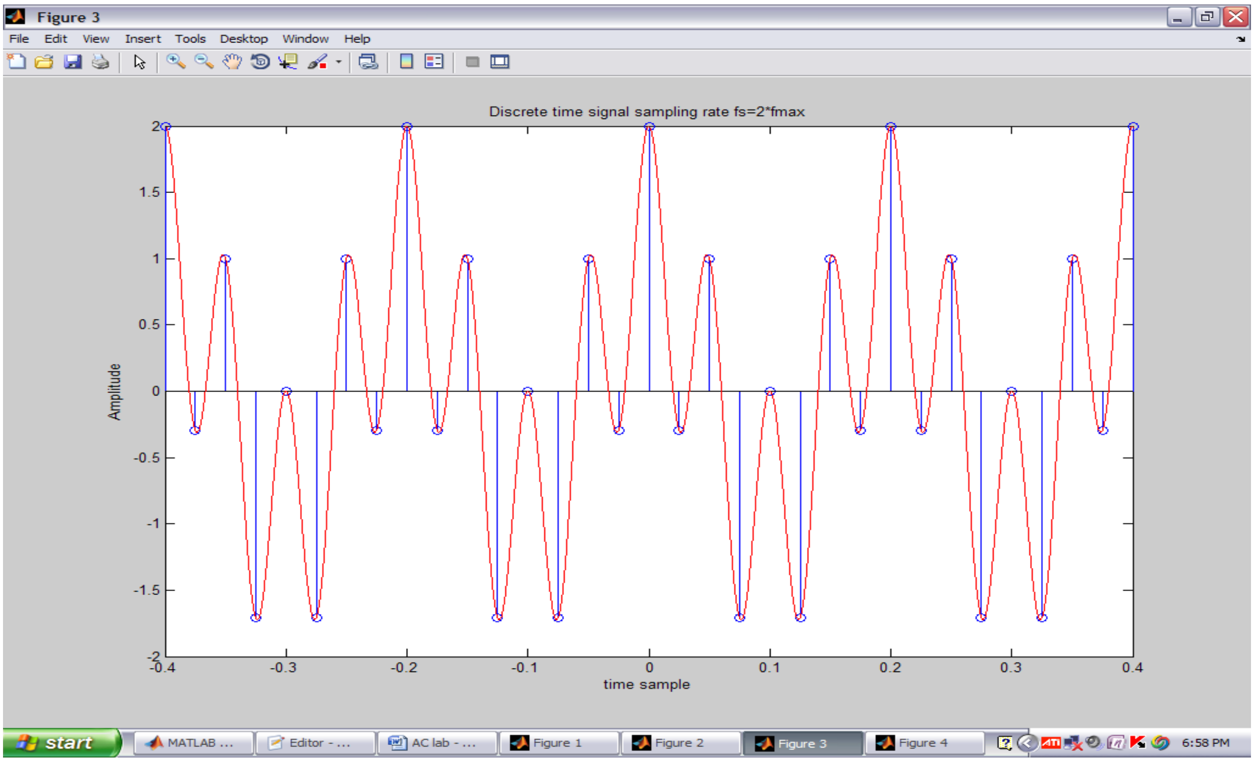
1) Continuous Time Signal



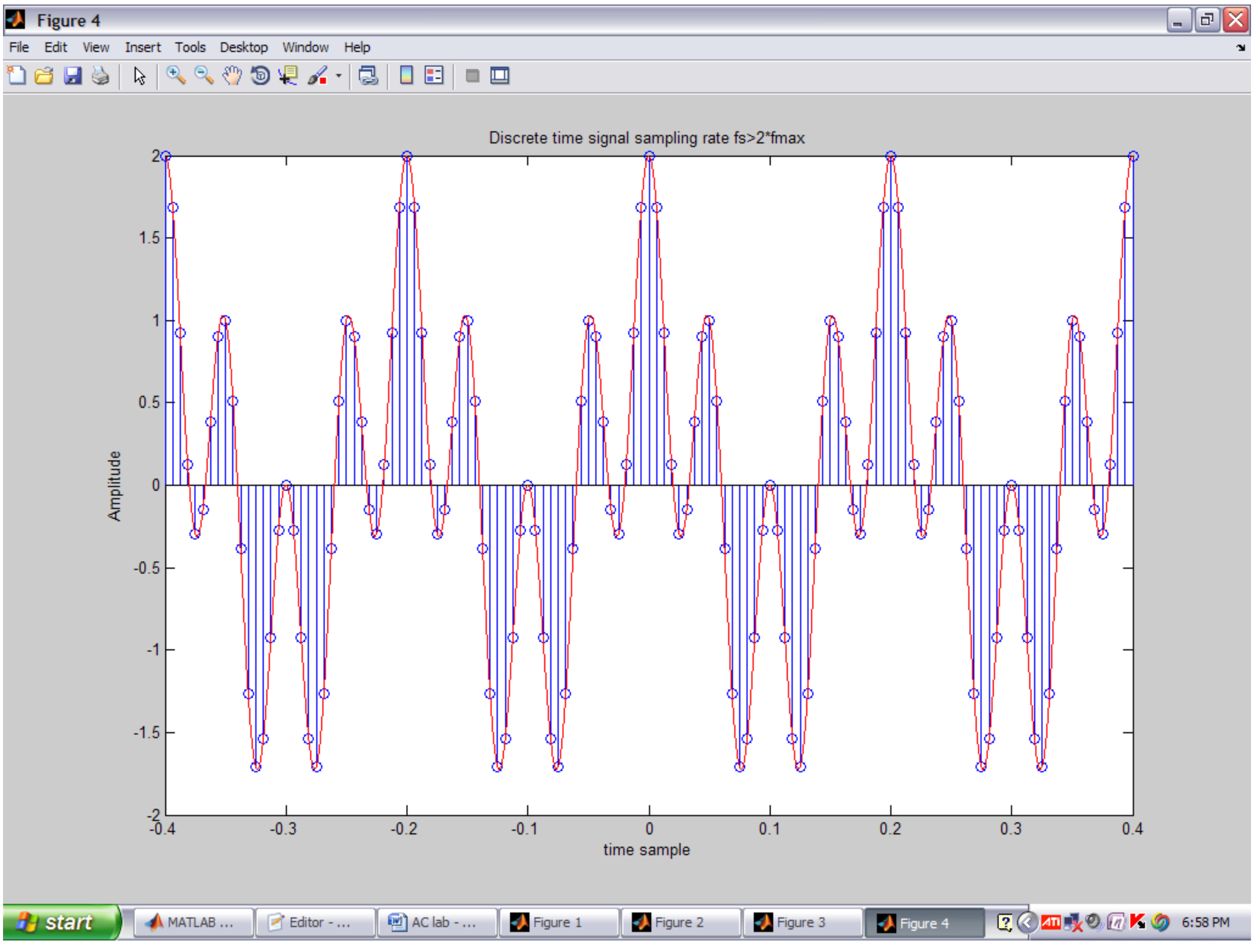
2) Discrete Time signal fs<2*fmax



3) Discrete Time signal fs=2*fmax



4) Discrete Time signal fs>2*fmax



[8] PULSE AMPLITUDE MODULATION(PAM)

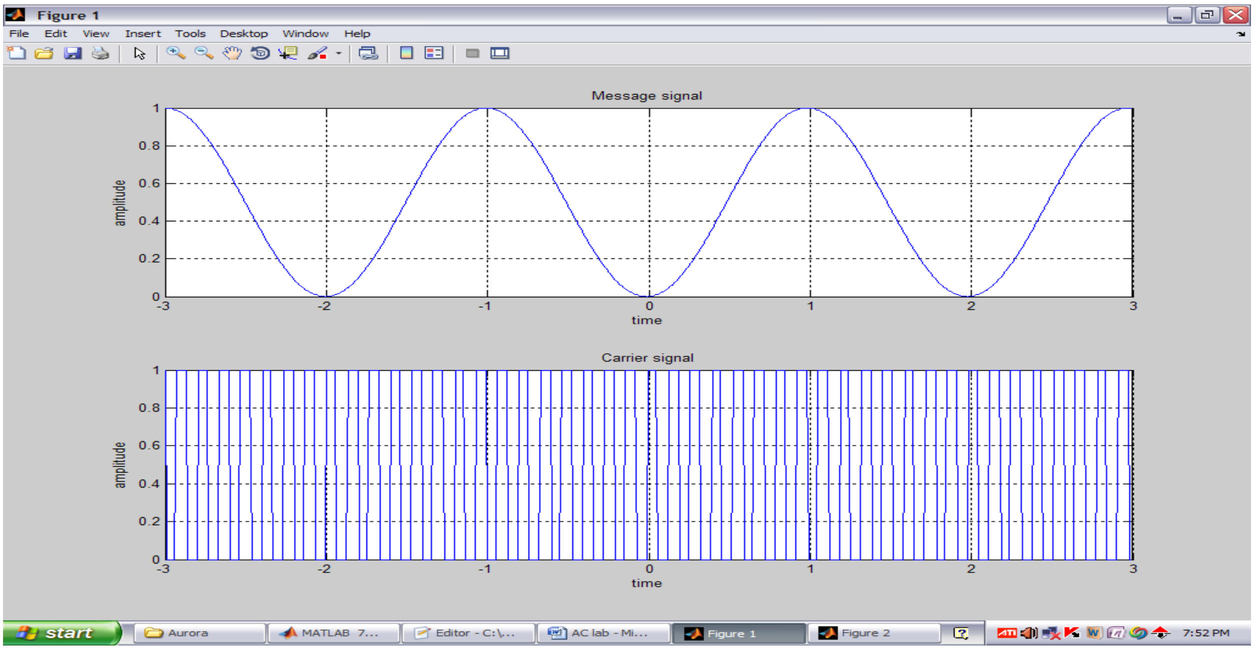
AIM: Write a MATLAB program to generate Pulse Amplitude Modulated (PAM) signal, and spectrum of PAM signal.

PROGRAM:

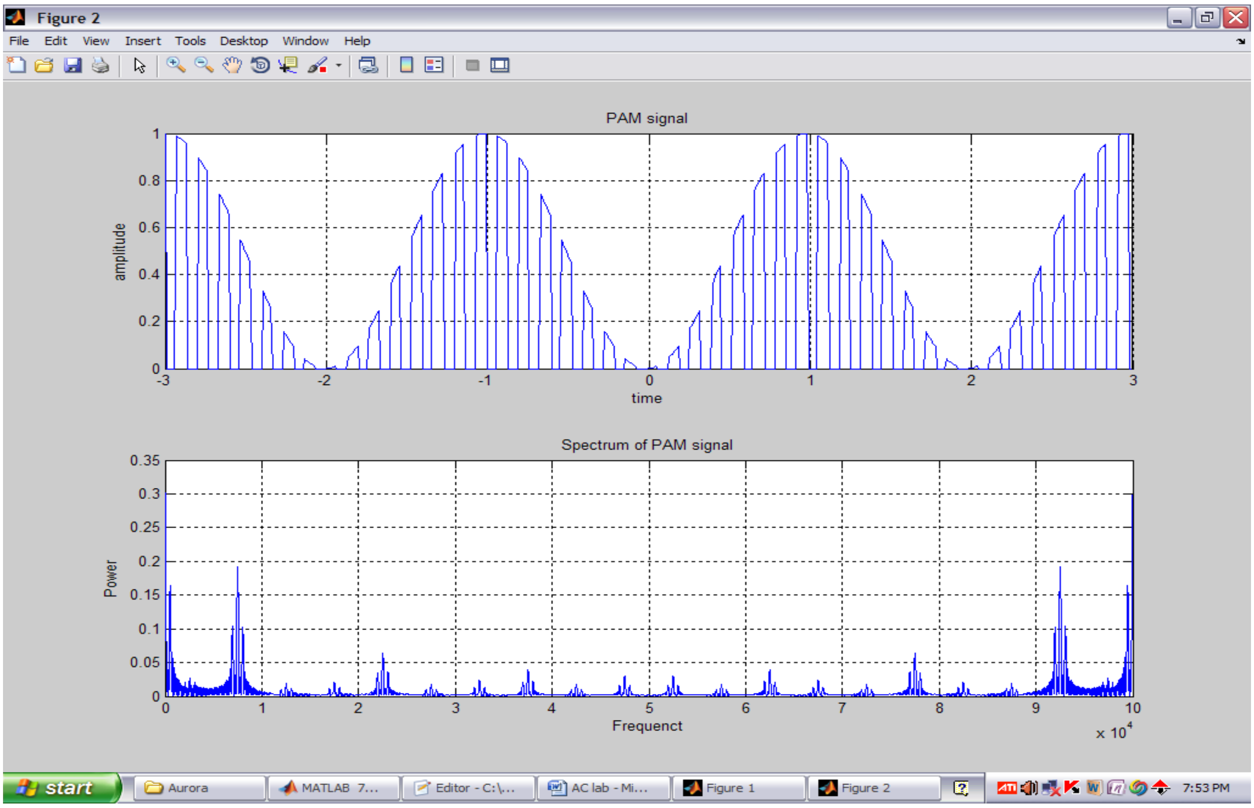
```
fm=100;
fc=1500;
t=-3:0.00995:3;
f=0:1:9999;
message=(1+cos(2*pi*fm*t))/2;
carrier=(1+square(2*pi*fc*t))/2;
pam=message.*carrier;
spectrum=abs(fft(pam,10000))/500;
figure(1)
subplot(211)
plot(t,message)
xlabel('time'), ylabel('amplitude');
title('Message signal');grid
subplot(212)
plot(t,carrier)
xlabel('time'), ylabel('amplitude');
title('Carrier signal');grid
figure(2)
subplot(211)
plot(t,pam)
xlabel('time'), ylabel('amplitude');
title('PAM signal');grid
subplot(212)
plot(f*10,spectrum)
xlabel('Frequenct'), ylabel('Power');
title('Spectrum of PAM signal');grid
```

WAVEFORMS:

1) Message signal and carrier signal



2) Pulse Amplitude Modulated signal and its spectrum



[9] PULSE WIDTH MODULATION (PWM)

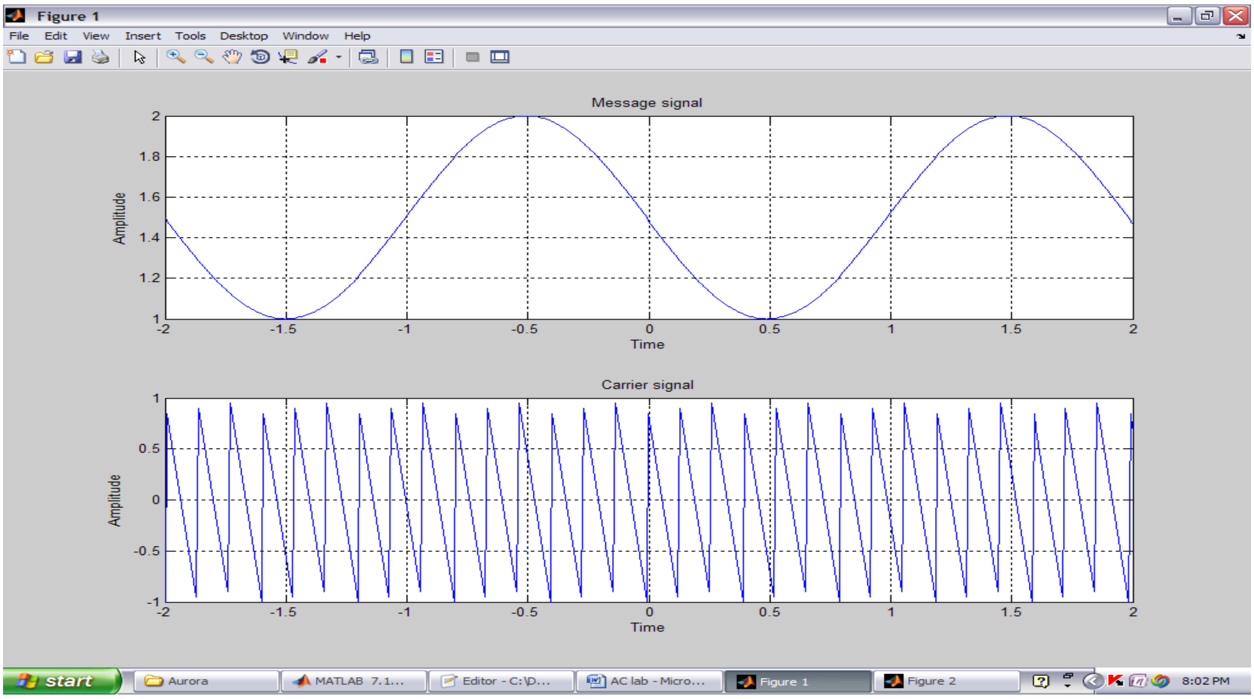
AIM: Write a MATLAB program to generate Pulse Width Modulated (PWM) signal, and spectrum of PWM signal.

PROGRAM:

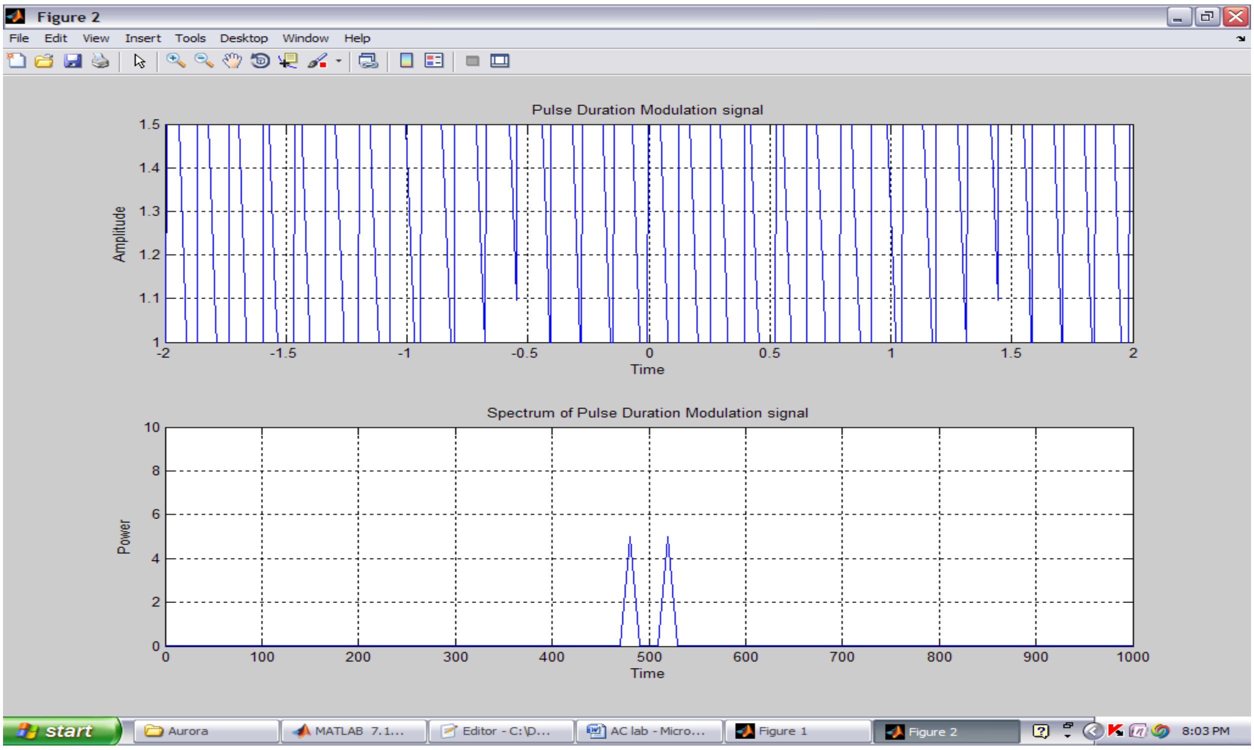
```
fm=100;
fc=1500;
t=-2:0.00995:2;
f=0:1:9999;
message=(3+sin(2*pi*fm*t))/2;
carrier=sawtooth(2*pi*fc*t);
p=message+carrier;
spectrum=abs(fft(dsbsc,10000))/500;
figure(1)
subplot(211)
plot(t,message)
xlabel('Time');ylabel('Amplitude')
title('Message signal');grid
subplot(212)
plot(t,carrier)
xlabel('Time');ylabel('Amplitude')
title('Carrier signal');grid
figure(2)
subplot(211)
plot(t,p)
axis([-2 2 1 1.5])
xlabel('Time');ylabel('Amplitude')
title('Pulse Duration Modulation signal');grid
subplot(212)
plot(f*10,spectrum)
axis([(fc-15*fm) (fc-5*fm) 0 10]);
xlabel('Time');ylabel('Power')
title('Spectrum of Pulse Duration Modulation signal');grid
```

WAVEFORMS:

1) Message signal and carrier signal



2) Pulse Width Modulated signal and its spectrum



ANALOG COMMUNICATIONS LAB (SIMULINK)

INTRODUCTION TO AMPLITUDE MODULATION

Purpose:

The objectives of this laboratory are:
1. To introduce the spectrum analyzer for frequency domain analysis of signals.
2. To identify various types of linear Amplitude modulated waveforms in time and frequency domain representations.
3. To implement theoretically functional circuits using the Communications Module Design System (CMDS).

Equipment List

1. PC with Matlab and Simulink.

2.Signal processing, communications tool boxes.

SIMULINK:

Simulink provides a block diagram environment for modeling and simulating the system.
Simulink is
1) Used to model, analyze and simulate dynamic systems using block diagrams.
2) Fully integrated with MATLAB , easy and fast to learn and flexible.
3) It has comprehensive block library which can be used to simulate linear, non–linear or discrete systems – excellent research tools(Signal processing, communications, image processing tool boxes etc…..).
4) Ccodes can be generated from Simulink models for embedded applications and rapidprototyping of control systems.

[1]Spectrum Analyzer and Function Generator.

This section deals with looking at the spectrum of simple waves. We first look at the spectrum of a simple sine wave.
To Start Simulink: Start Matlab then type simulink on the command line. A Simulink Library Window opens up as shown in figure 1

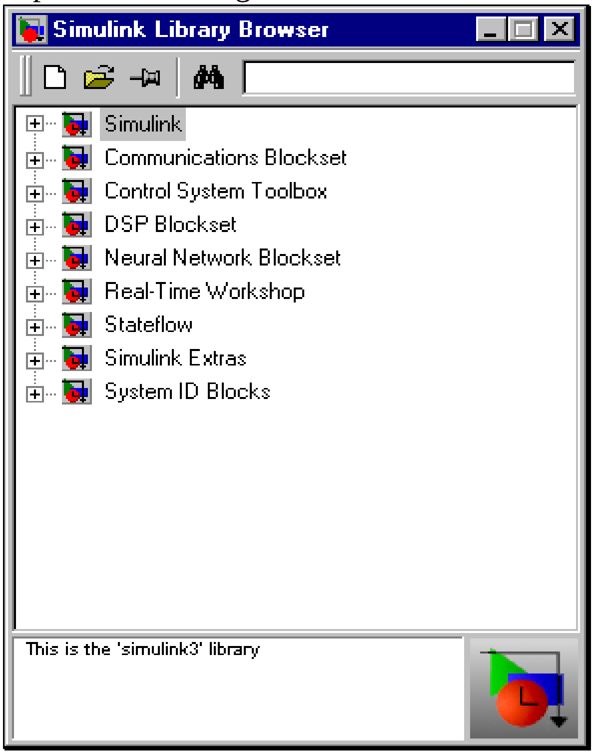


Figure 1.1

Spectrum of a simple sine wave: - Figure 1.2 shows the design for viewing the spectrum of a simple sine wave.

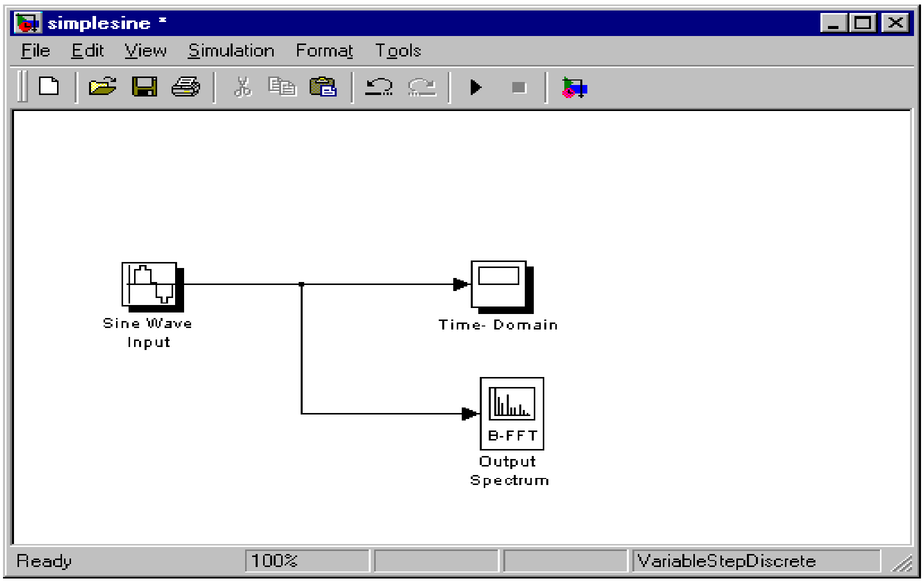
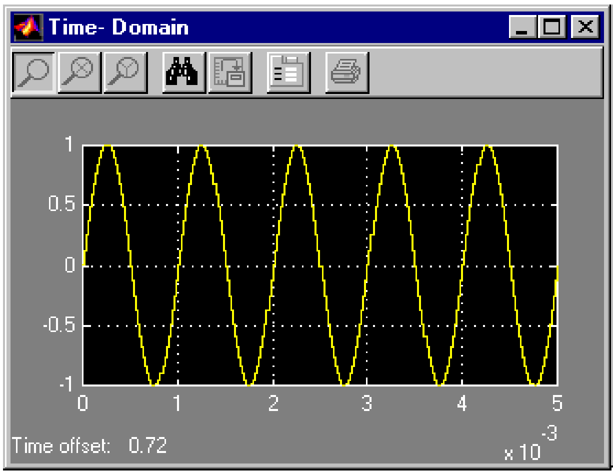


Figure 1.2

Figure 1.3 shows the time-domain sine wave and the corresponding frequency domain is shown in figure 1.4. The frequency domain spectrum is obtained through a buffered-FFT scope, which comprises of a Fast Fourier Transform of 128 samples which also has a buffering of 64 of them in one frame. The property block of the B-FFT is also displayed in figure 1.5.



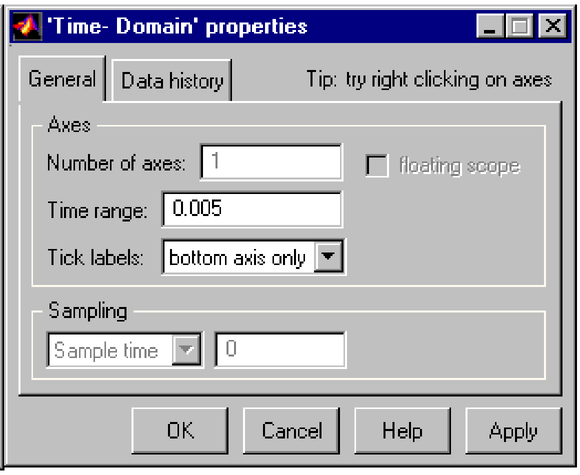


Figure 1.3 Figure 1.4

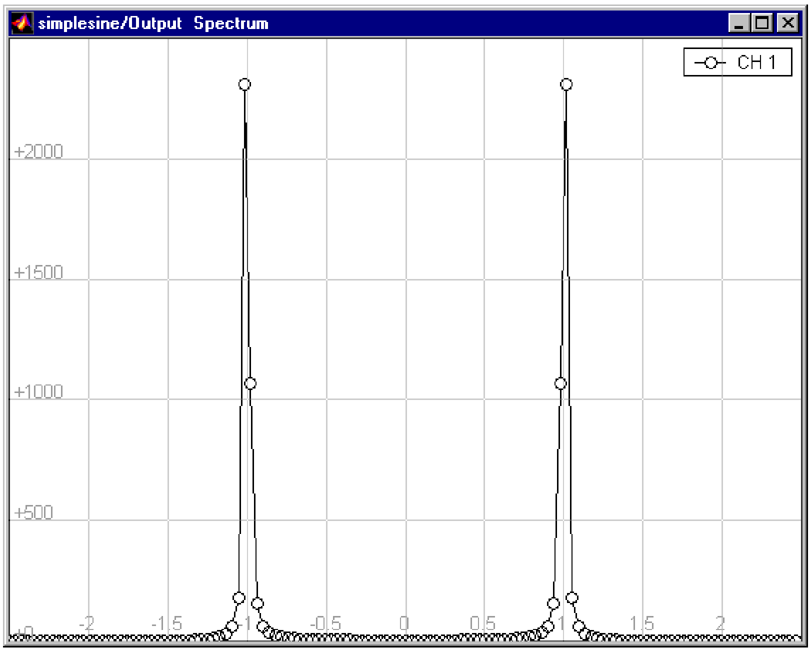
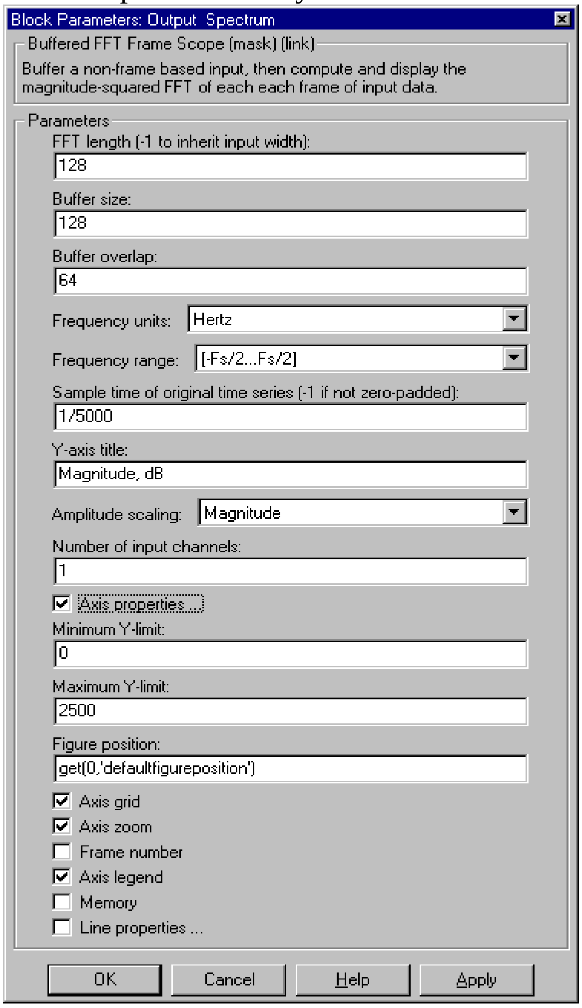


Figure 1.5

This is the property box of the Spectrum Analyzer



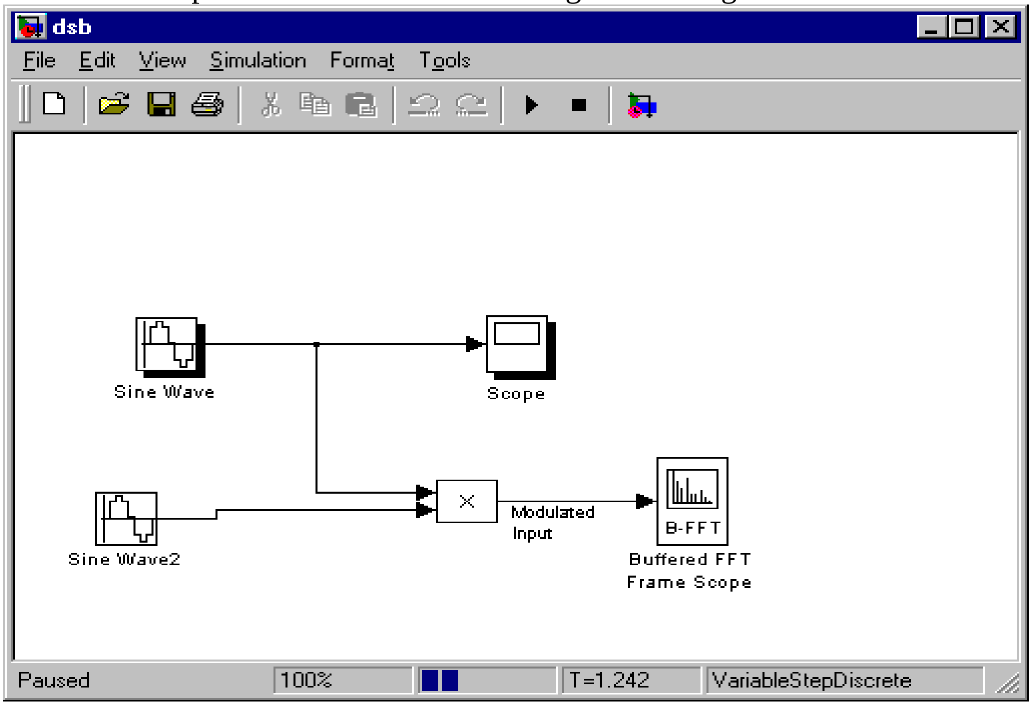
From the property box of the B-FFT scope the axis properties can be changed and the Line properties can be changed. The line properties are not shown in the above. The Frequency range can be changed by using the frequency range pop down menu and so can be the y-axis the amplitude scaling be changed to either real magnitude or the dB (log of magnitude) scale. The upper limit can be specified as shown by the Min and Max Y-limits edit box. The sampling time in this case has been set to 1/5000.

Note: The sampling frequency of the B-FFT scope should match with the sampling time of the input time signal.
Also as indicated above the FFT is taken for 128 points and buffered with half of them for an overlap.
Calculating the Power: The power can be calculated by squaring the value of the voltage of the spectrum analyzer.
Note: The signal analyzer if chosen with half the scale, the spectrum is the single-sided analyzer, so the power in the spectrum is the total power.

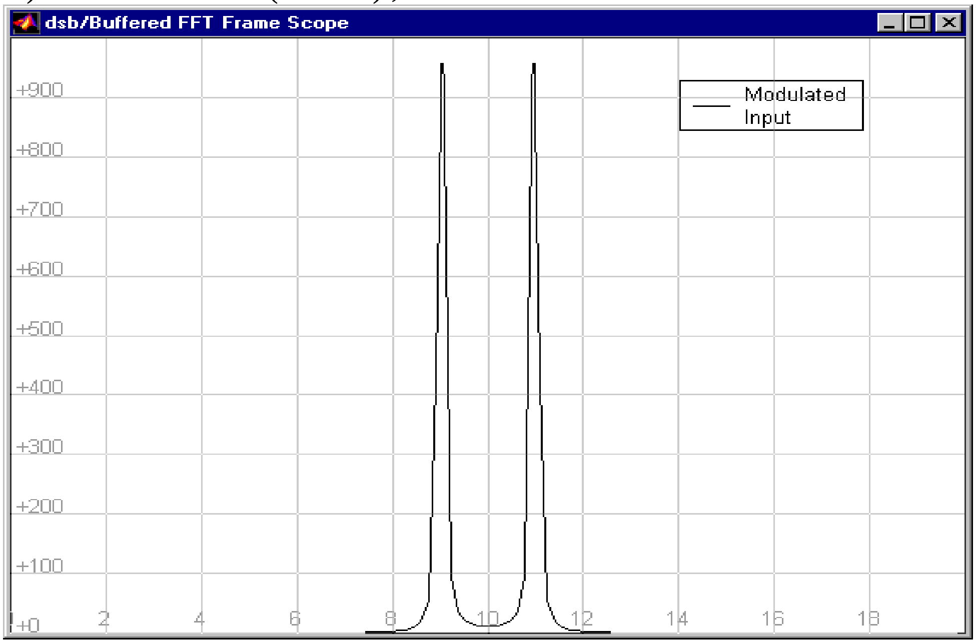
Similar operations can be done for other waveforms – like the square wave, triangular. These signals can be generated from the signal generator block.

[2].Double Side-Band Suppressed Carrier Modulation

Figure shows the implementation of a DSB-SC signal. The Signals are at 1kHz and 10kHz.



The output is shown below. It can be seen that the output consists of just two side bands at +(fc + fm) and the other at –(fc + fm) , i.e. at 9kHz and 11kHz.



By multiplying the carrier signal and the message signal, we achieve modulation.

$Y*m(t) = [k_m \cos(2\pi 1000t) * \cos(2\pi 10000t)]$

We observe the output to have no 10KHz component i.e., the carrier is not present. The output contains a band at 9KHz (fc-fm) and a band at 11KHz (fc+fm). Thus we observe a double side band suppressed carrier. All the transmitted power is in the 2 sidebands.

[3]Amplitude Modulation

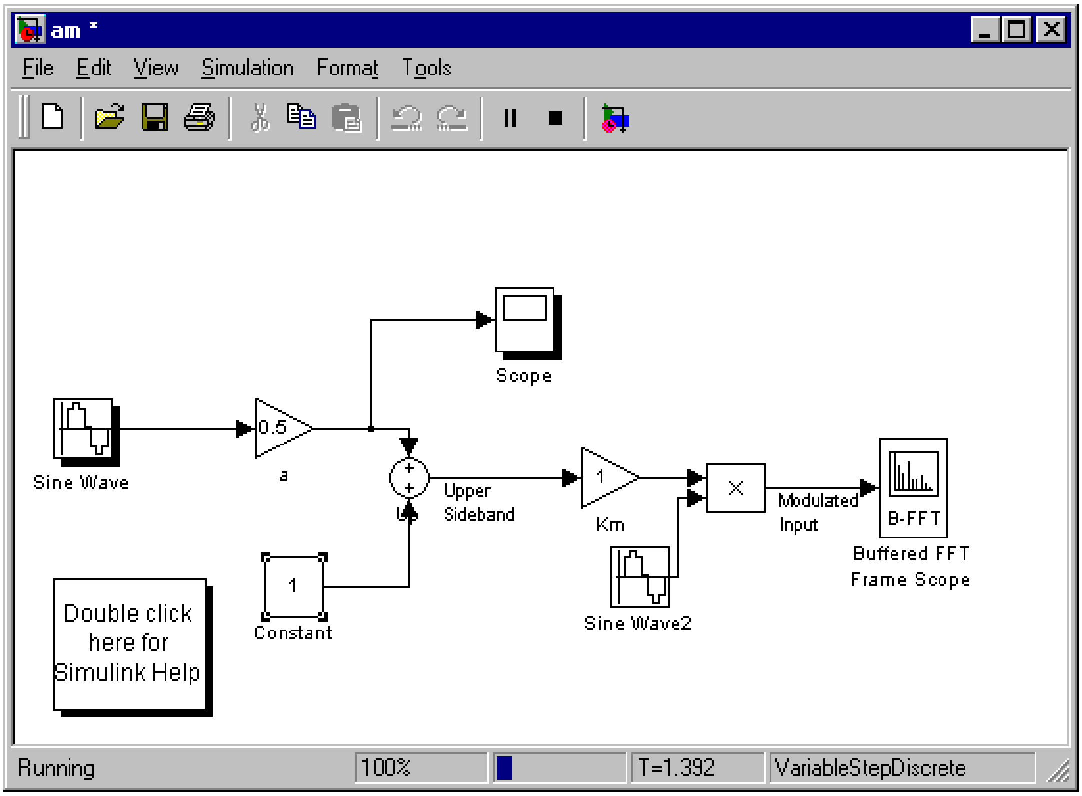
This experiment is the amplitude modulation for modulation index a = 1 and 0.5.

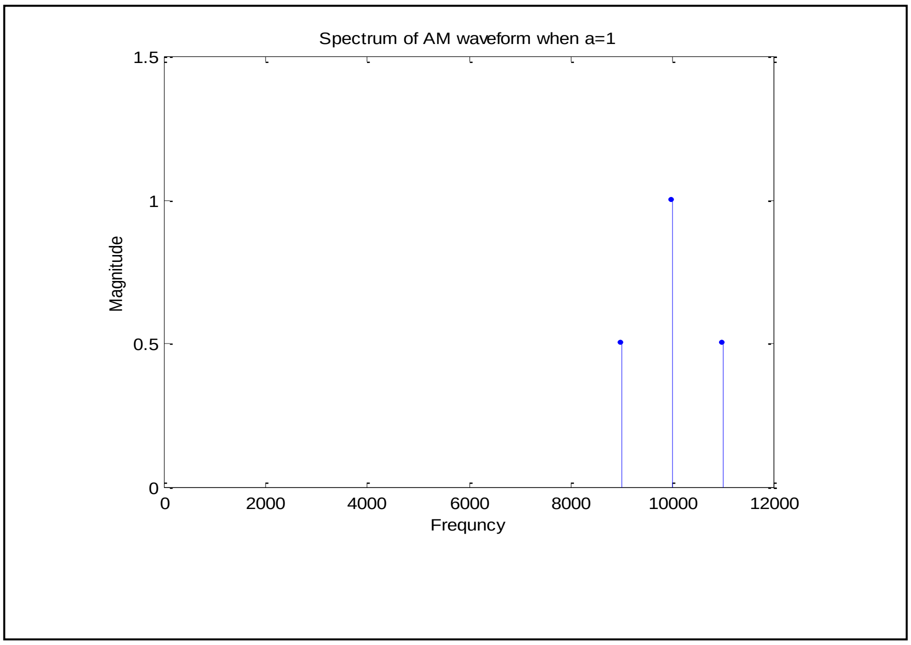
From the equation of the AM

$$y = k_m(1 + a \cdot \cos(2\pi(1000)t) \cdot \cos(2\pi(10000)t$$

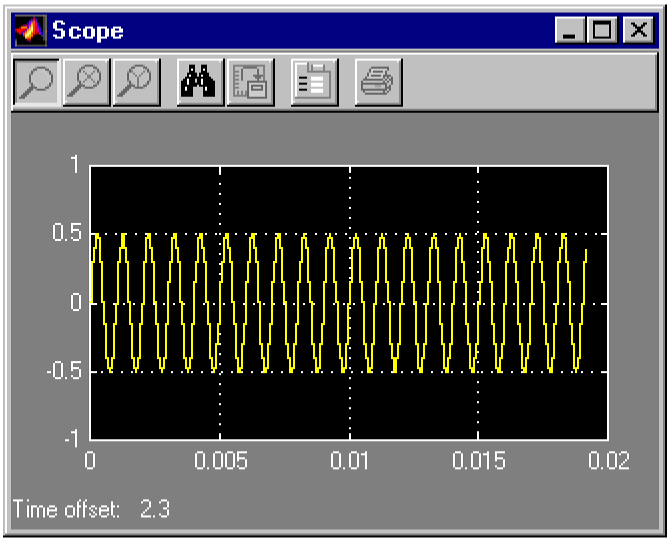
The representation of the signal in both time-domain and frequency domain when k_m=1 for a=1 and a=0.5 were found to be as shown in figures.

The experimental set up for generating an AM signal looks like this: -



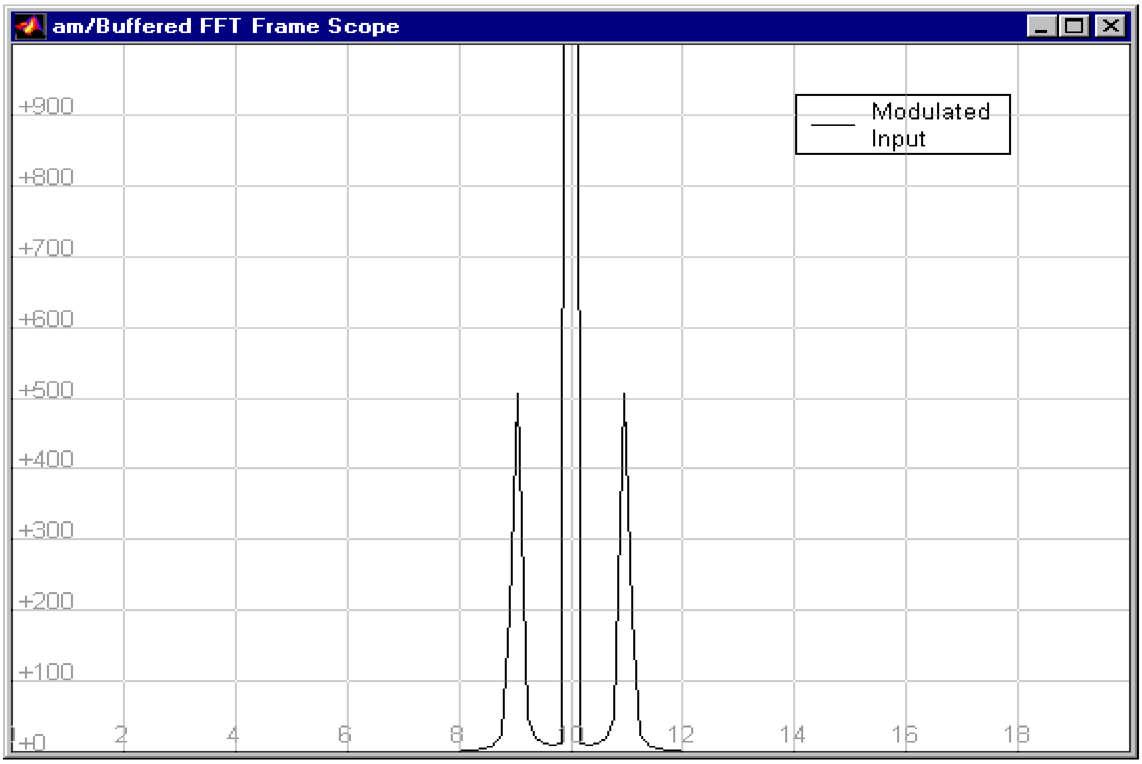


The input waveform 50% modulated is shown in figure

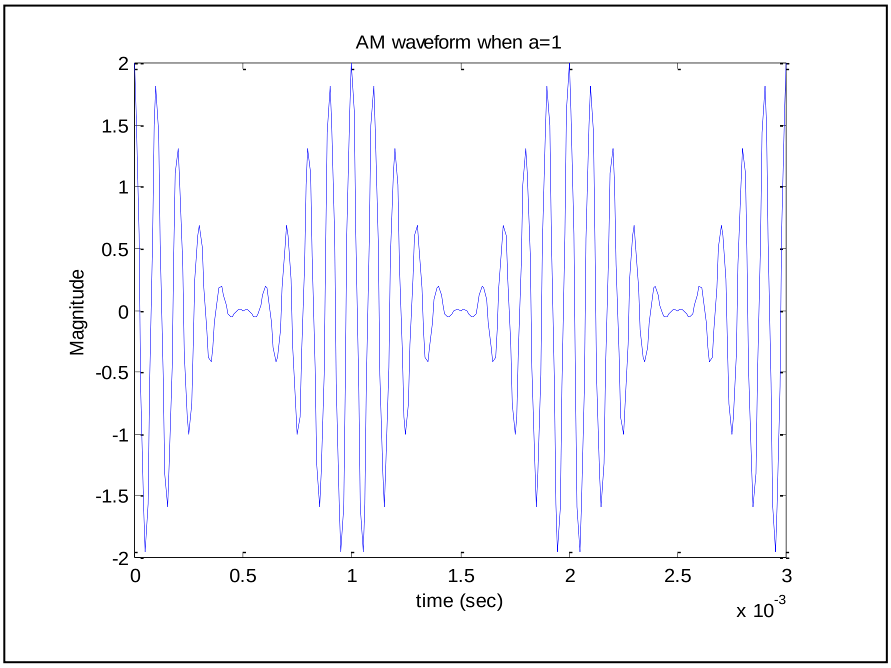


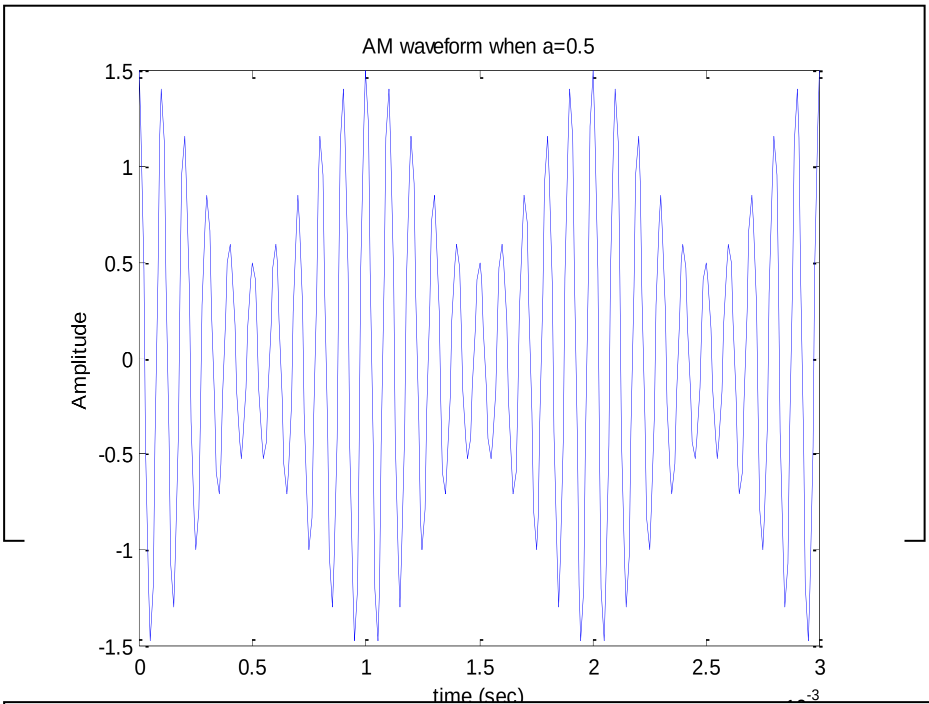
The output spectrum is shown below

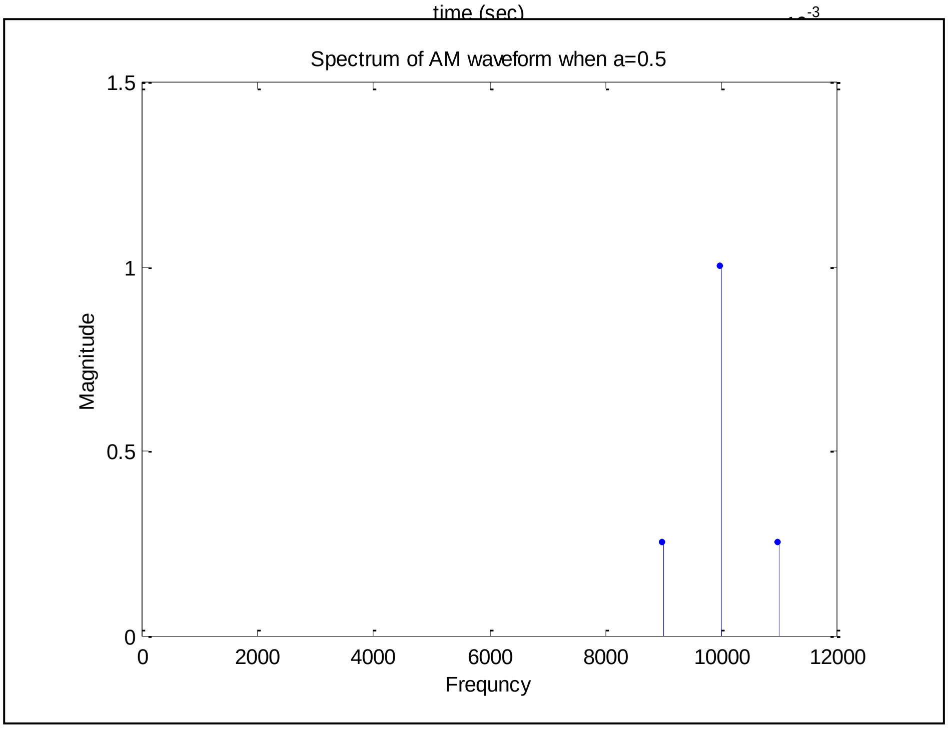
It must be noted here that the A.M signal can be converted into a DSB-SC signal by making the constant = 0.



The waveforms at various levels of modulation are shown in the following figures.



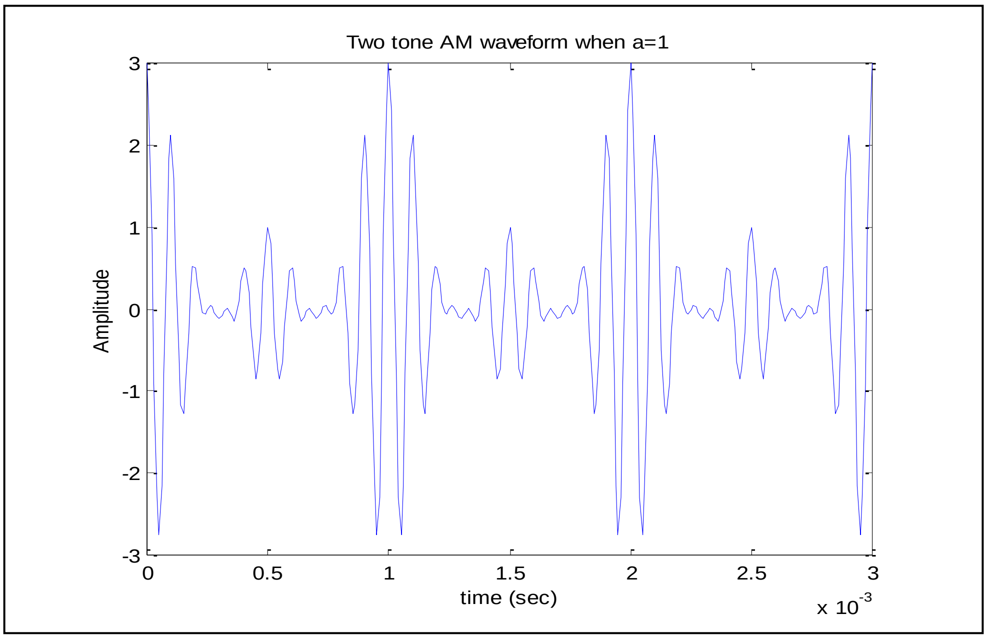




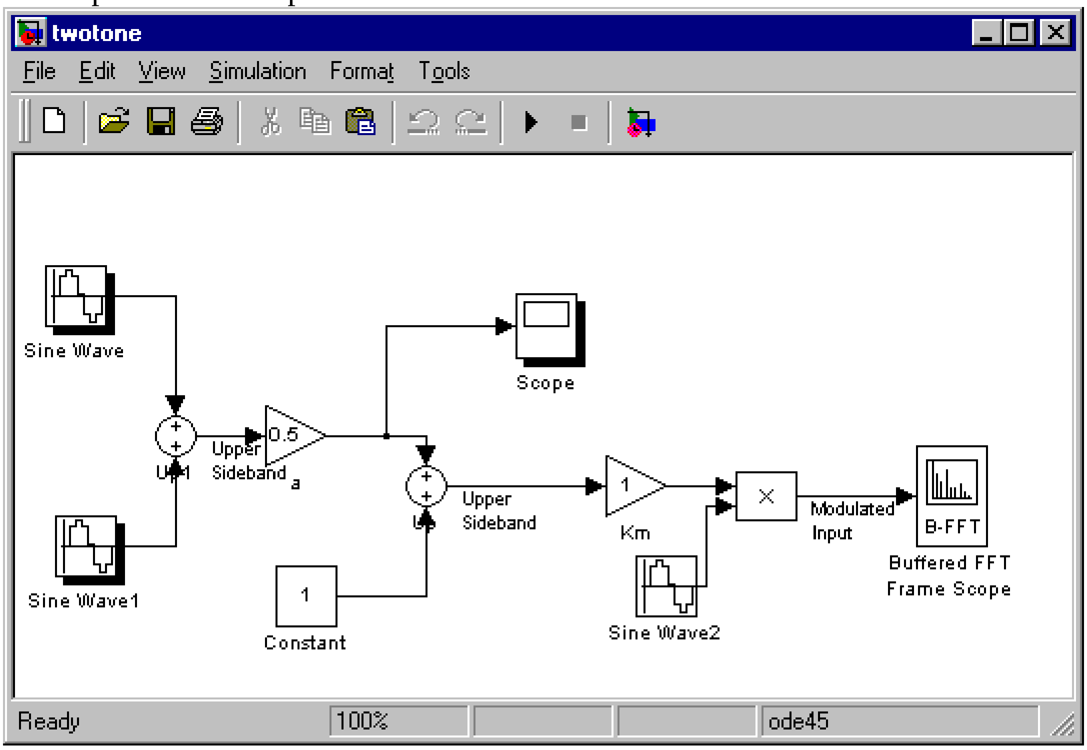
The results from the experiment were shown. The results from the experiment are pretty much the same as in the theoretical ones except there are 2 other peaks at 0 and 1000kHz. This is the same as earlier experiment. The cause of this problem is probably the multiplier.

[4]Two Tone AM Modulation

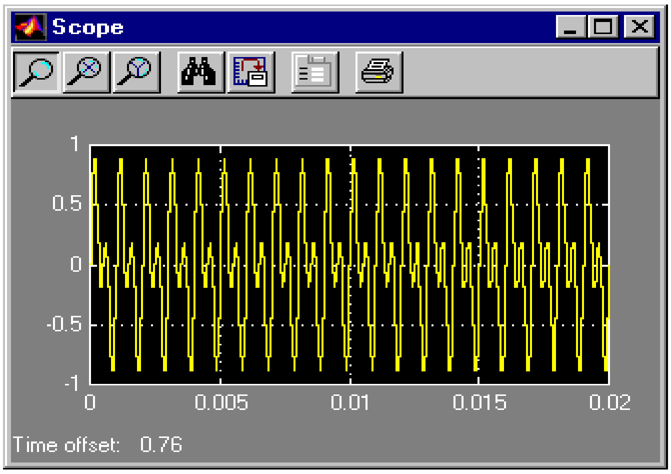
The last experiment in this section is the two tone modulation. In this experiment, the 2kHz signal had been added to the modulating signal in the above experiment. Theoretically, the representation of the modulated signal in time-domain and frequency domain would have been as in the figure below. In the figure, 1kHz and 2kHz signals were modulated with 10kHz carrier.



The experimental setup is shown below.

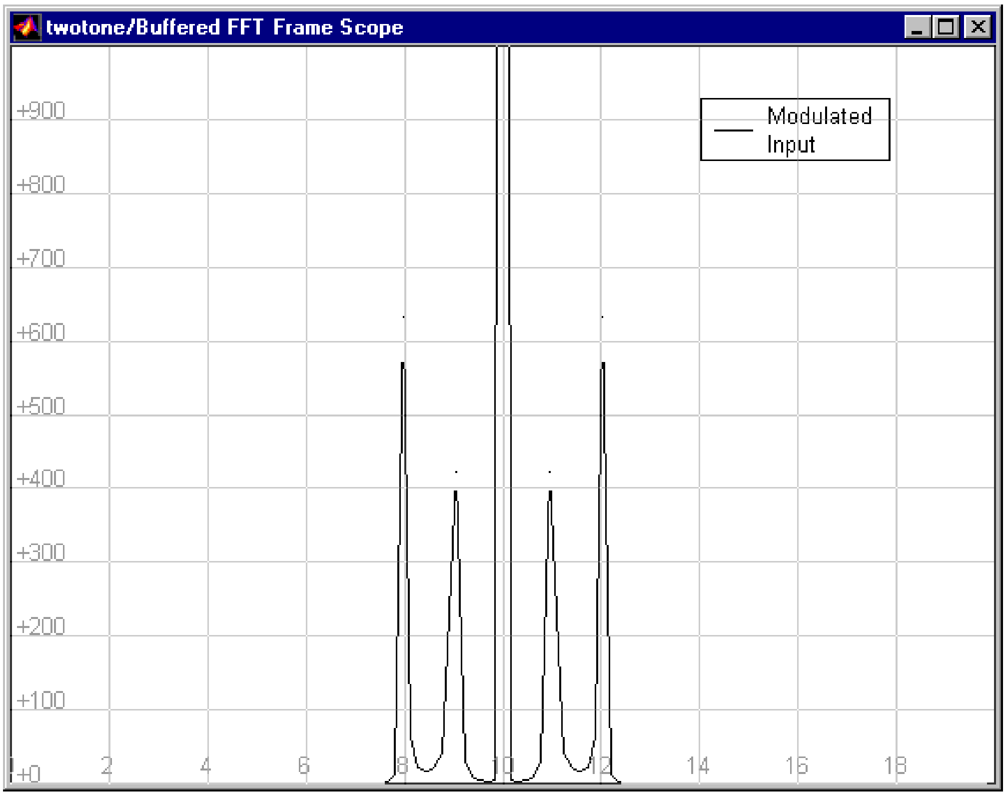


The two-tone waveform before being amplitude modulated.



The two-tone signal is amplitude modulated using the same block model discussed in the previous section. The output spectrum is shown in figure.. In this case the signals of 1kHz and 2kHz are modulated by a 10kHz carrier.

The output spectrum is shown in figure



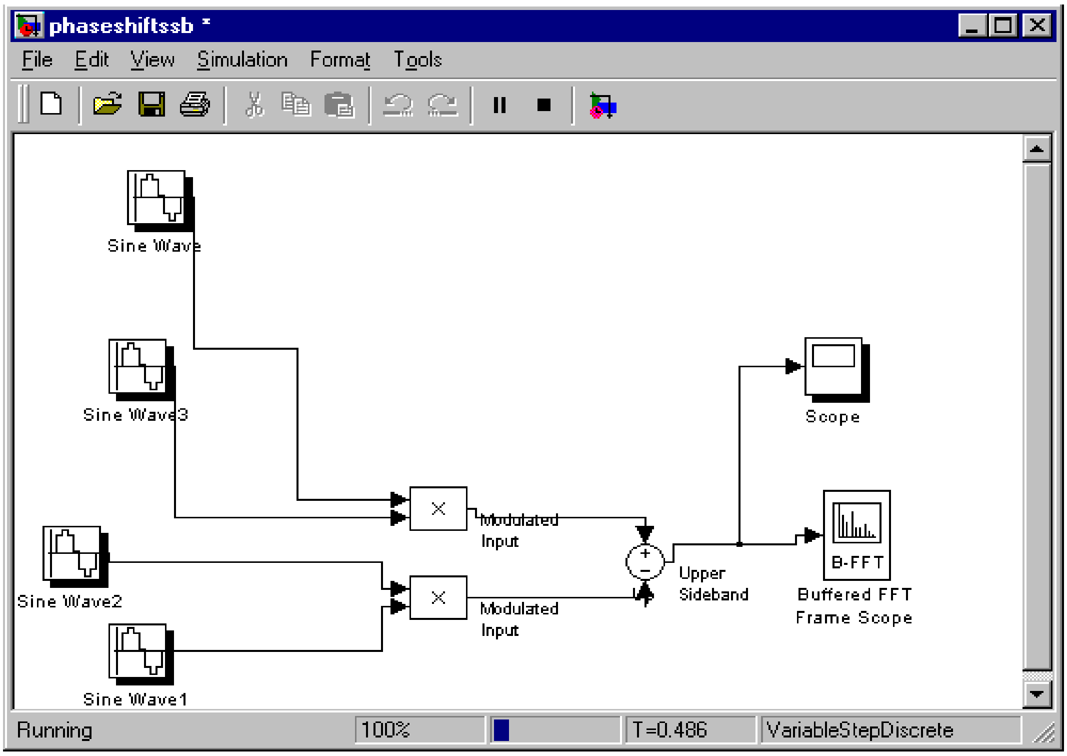
The result from the experiment was shown. The highest peak is at the carrier frequency as in the theoretical result. But there were differences on the sidebands. In the figure from MATLAB, both frequencies in the sidebands have the same magnitude, but from the experiment, the components at 9000Hz and 11000Hz have higher magnitude than the components at 8000Hz and 12000 Hz. There're also many small peaks of about 1000Hz apart in the experiment result. This might come from the incorrectly calibrated multiplier.

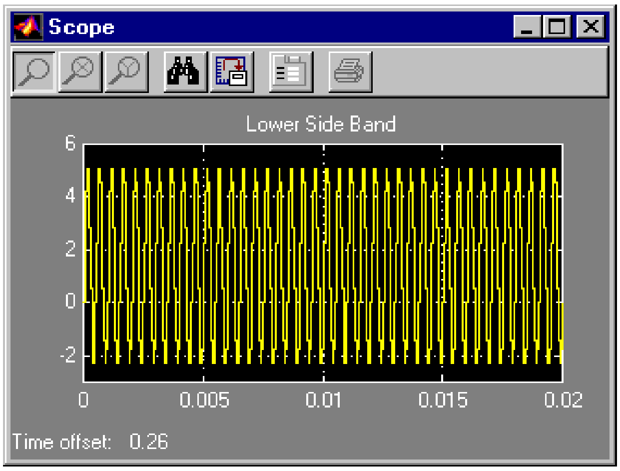
The final experiment in this section is to change the carrier frequency and the modulating frequency. When the carrier frequency increases, the spectrum of the modulated signal is expected to have the two sidebands centered at the new carrier frequency. And when one of the two modulating signals changes in frequency, the spectrum of the output signal should have two components move away from their original positions according to the change in frequency. The result from the experiment was shown. Both change in carrier frequency and modulating frequency is shown.

[5] Single Sideband Modulation(Phase Shift Method)

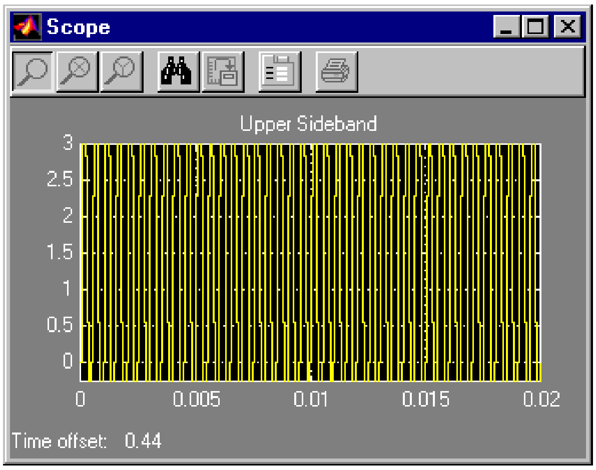
The DSB-SC signal occupies twice the space necessary than required for holding the information. Therefore, by chopping off one part of the DSBSC, more signal transmission can be achieved. Filtering the DSBSC gives the output as either a LSB(Lower side band) or a USB(Upper side band).The simulation set up for the SSB signal is shown in figure below. By operating the summer as an adder causes the USB to be produced. If the summer is operated as an inverter, then, the LSB will be retained.

Figure shows the experimental setup for the Phase Shift SSB Modulation. The signal consists of four input sine waves.



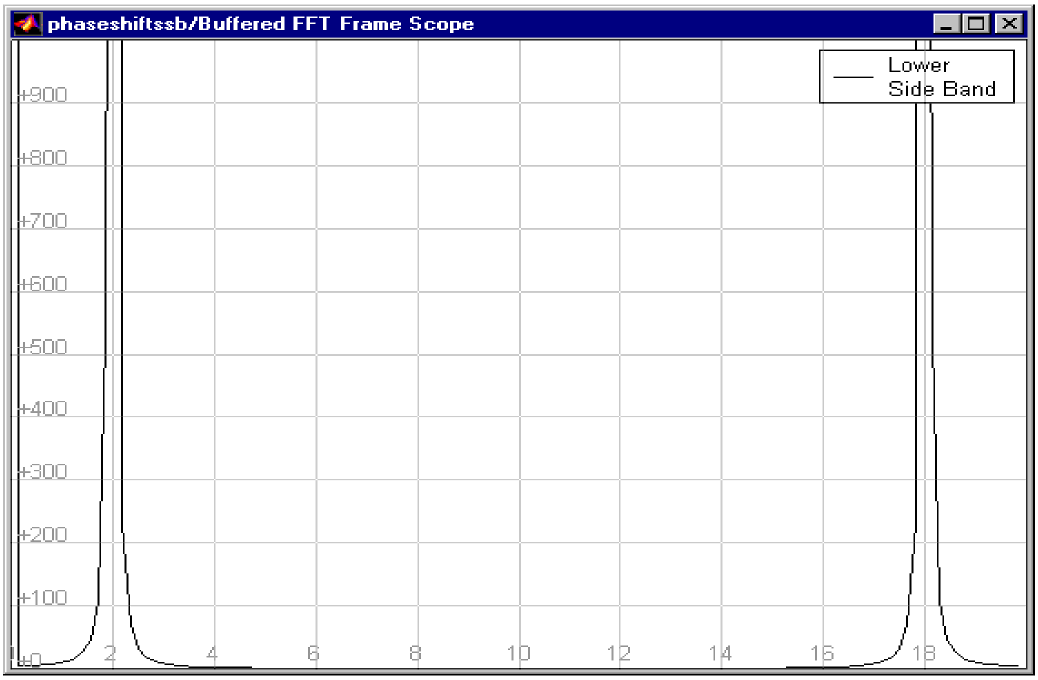


fig(a) Lower sideband modulated wave



fig(b)Upper sideband modulated wave

figure(a) represents the output waveform when the sign is + + and figure(b) represents the wave form for +-. They represent the lower and the upper-side bands respectively. The output spectrum is shown in figure



CONCLUSION:

We learnt how to operate the spectrum analyzer, oscilloscope and the function generator to generate and view different waveforms. We also performed the different modulation schemes – DSBSC, AM and SSB. We conclude that the DSBSC modulating system is better as no power is lost in the carrier. SSB permits more of the information to be transmitted over the same channel by chopping off the duplicate sideband.