ANALOG COMMUNICATIONS

LAB MANUAL

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Subject Code	:	AECB16
Regulations	:	R18
Class	:	IV Semester
Branch	:	ECE

Prepared by

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Department of Electronics & Communication Engineering
INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad – 500 043

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Electronics & Communication Engineering

Vision
To produce professionally competent Electronics and Communication Engineers capable of effectively and efficiently addressing the technical challenges with social responsibility.

Mission
The mission of the Department is to provide an academic environment that will ensure high quality education, training and research by keeping the students abreast of latest developments in the field of Electronics and Communication Engineering aimed at promoting employability, leadership qualities with humanity, ethics, research aptitude and team spirit.

Quality Policy
Our policy is to nurture and build diligent and dedicated community of engineers providing a professional and unprejudiced environment, thus justifying the purpose of teaching and satisfying the stake holders. A team of well qualified and experienced professionals ensure quality education with its practical application in all areas of the Institute.

Philosophy
The essence of learning lies in pursuing the truth that liberates one from the darkness of ignorance and Institute of Aeronautical Engineering firmly believes that education is for liberation. Contained therein is the notion that engineering education includes all fields of science that plays a pivotal role in the development of world-wide community contributing to the progress of civilization. This institute, adhering to the above understanding, is committed to the development of science and technology in congruence with the natural environs. It lays great emphasis on intensive research and education that blends professional skills and high moral standards with a sense of individuality and humanity. We thus promote ties with local communities and encourage transnational interactions in order to be socially accountable. This accelerates the process of transfiguring the students into complete human beings making the learning process relevant to life, instilling in them a sense of courtesy and responsibility.

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Electronics & Communication Engineering

Program Outcomes	
PO1	An ability to apply knowledge of basic sciences, mathematical skills, engineering and technology to solve complex electronics and communication engineering problems
PO2	An ability to identify, formulate and analyze engineering problems using knowledge of Basic Mathematics and Engineering Sciences
PO3	An ability to provide solution and to design Electronics and Communication Systems as per social needs
PO4	An ability to investigate the problems in Electronics and Communication field and develop suitable solutions.
PO5	An ability to use latest hardware and software tools to solve complex engineering problems
PO6	An ability to apply knowledge of contemporary issues like health, Safety and legal which influences engineering design
PO7	An ability to have awareness on society and environment for sustainable solutions to Electronics and Communication Engineering problems
PO8	An ability to demonstrate understanding of professional and ethical responsibilities
PO9	An ability to work efficiently as an individual and in multidisciplinary teams
PO10	An ability to communicate effectively and efficiently both in verbal and written form
PO11	An ability to develop confidence to pursue higher education and for life-long learning
PO12	An ability to design, implement and manage the electronic projects for real world applications with optimum financial resources
Program Specific Outcomes	
PSO1	**Professional Skills:** The ability to research, understand and implement computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient analysis and design of computer-based systems of varying complexity.
PSO2	**Problem-Solving Skills:** The ability to apply standard practices and strategies in software project development using open-ended programming environments to deliver a quality product for business success.
PSO3	**Successful Career and Entrepreneurship:** The ability to employ modern computer languages, environments, and platforms in creating innovative career paths, to be an entrepreneur, and a zest for higher studies.

ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

S. No.	Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
1	Amplitude modulation and demodulation	PO1, PO2	PSO1
2	DSB-SC Modulator & Detector	PO1, PO2	PSO1
3	SSB-SC Modulator & Detector (Phase Shift Method)	PO1, PO2	PSO1, PSO2
4	Frequency modulation and demodulation.	PO1, PO2	PSO1
5	Pre-emphasis & de-emphasis.	PO1, PO2, PO3	PSO1, PSO2
6	Frequency Division Multiplexing & De multiplexing	PO1, PO2, PO3	PSO1
7	Verification of sampling theorem	PO1, PO2	PSO1
8	Time Division Multiplexing & De multiplexing	PO1, PO2	PSO1
9	AGC Characteristics	PO1, PO2	PSO1
10	Characteristics of mixer	PO1, PO2, PO3	PSO1
11	Phase locked loop	PO1, PO2	PSO1
12	Generation of DSBSC using ring modulation.	PO1, PO2	PSO1
13	Frequency Synthesizer	PO1, PO2	PSO1, PSO2
14	Spectral analysis of AM and FM signals using spectrum analyzer	PO1, PO2, PO3	PSO1

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Certificate

This is to Certify that it is a bonafied record of Practical work done by Sri/Kum.______________________________bearing the Roll No.________________________of_____________ Class____ Branch in the______________________________laboratory during the Academic year_____________________under our supervision.

Head of the Department **Lecture In-Charge**

External Examiner **Internal Examiner**

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Electronics and Communication Engineering

Course Overview:

This course provides practical handson exposure to communication system buildingblocks.TheobjectiveofthislabistoteachstudentsAmplitudeand Frequency modulation. Generation and detection of AM, DSB-SC, SSB and FM signals. Time-division multiplexing systems, Frequency division multiplexing systems. Sampling THEORY, Pulse modulation.

Course Out-Come:

1. Demonstrate understanding of various amplitude modulation and demodulation techniques.
2. Demonstrate understanding of frequency modulation and demodulation technique.
3. Explain the Sampling Theorem
4. Explain the basic multiplexing techniques: FDM, TDM.
5. Understand and explain the AGC Characteristics.
6. Compare different modulations and to recognize the advantages and disadvantages of them.
7. Write programs using MATLAB

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Electronics & Communication Engineering

INSTRUCTIONS TO THE STUDENTS

1. Students are required to attend all labs.
2. Students should work individually in the hardware and software laboratories.
3. Students have to bring the lab manual cum observation book, record etc along with them whenever they come for lab work.
4. Should take only the lab manual, calculator (if needed) and a pen or pencil to the work area.
5. Should learn the pre lab questions. Read through the lab experiment to familiarize themselves with the components and assembly sequence.
6. Should utilize 3 hour"s time properly to perform the experiment and to record the readings. Do the calculations, draw the graphs and take signature from the instructor.
7. If the experiment is not completed in the stipulated time, the pending work has to be carried out in the leisure hours or extended hours.
8. Should submit the completed record book according to the deadlines set up by the instructor.
9. For practical subjects there shall be a continuous evaluation during the semester for 30 sessional marks and 70 end examination marks.
10. Out of 30 internal marks, 20 marks shall be awarded for day-to-day work and 10 marks to be awarded by conducting an internal laboratory test.

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ANALOG COMMUNICATION LAB SYLLABUS

Recommended Systems/Software Requirements:

Intel based desktop PC with minimum of 166 MHZ or faster processor with at least 64 MB RAM and 100MB free disk space. MATLAB and hardware related to experiments.

S.No.	List of Experiments	Page No.	Date	Remarks
1.	Amplitude modulation and demodulation	9-15		
2.	DSB-SC Modulator & Detector	16-21		
3.	SSB-SC Modulator & Detector (Phase Shift Method)	22-27		
4.	Frequency modulation and demodulation.	28-35		
5.	Pre-emphasis & de-emphasis.	36-42		
6.	Verification of sampling theorem	43-49		
7.	Frequency Division Multiplexing & De multiplexing	50-56		
8.	Time Division Multiplexing & De multiplexing	57-61		
9.	AGC Characteristics	62-66		
10.	Frequency Synthesizer	67-71		
11.	Characteristics of mixer	72-77		
12.	Spectral analysis of AM and FM signals using spectrum analyzer	78-82		
13.	Generation of DSBSC using ring modulation.	83-86		
14.	Phase locked loop	87-90		

EXPERIMENT No. 1
AMPLITUDE MODULATION AND DE-MODULATION

Aim:

1. To generate amplitude modulated wave and determine the percentage modulation.
2. To demodulate the modulated wave using envelope detector.

Apparatus Required:

SNo	Equipment Required	Range	Quantity
1.	Amplitude modulation & Demodulation kit	------	1
2.	Function Generator	(0-1)MHz	1
3.	CRO & Probes	(0-20)MHz	1
4.	Connecting Wires	-----------	7

Theory:

Amplitude Modulation is defined as a process in which the amplitude of the carrier wave c(t) is varied linearly with the instantaneous amplitude of the message signal

$$s(t) = A_c\left[1 + K_a m(t)\cos(2\pi f_c t)\right]$$

m(t).The standard form of an amplitude modulated (AM) wave is defined by

where *Ka* is a constant called the amplitude sensitivity of the modulator. The demodulation circuit is used to recover the message signal from the incoming AM wave at the receiver. An envelope detector is a simple and yet highly effective device that is well suited for the demodulation of AM wave, for which the percentage modulation is less than 100%.Ideally, an envelop detector produces an output signal that follows theenvelop of the input signal wave form exactly; hence, the name. Some version of this circuit is used in almost all commercial AM radio receivers. The Modulation Index is defined as,

$$m = \frac{(E_{max} - E_{min})}{(E_{max} + E_{min})}$$

where Emax and Emin are the maximum and minimum amplitudes of the modulated wave.

Procedure:

1. Switch on the trainer kit and check the o/p of carrier generator on oscilloscope.
2. Apply the 1KHz (2vp-p) A.F modulating signal to the AM modulation at AF i/p Terminal.
3. Connect the carrier signal (RF) at the carrier i/p of the modulator.
4. Connect the modulating (AF) signal to CH 1 and modulated signal (i.e, o/p of AM modulator) to CH 2 of a dual trace oscilloscope. Observe the o/p.
5. Calculate the maxima and minima points of modulated wave (o/p) on the CRO and the calculate the depth of modulation using the formula.

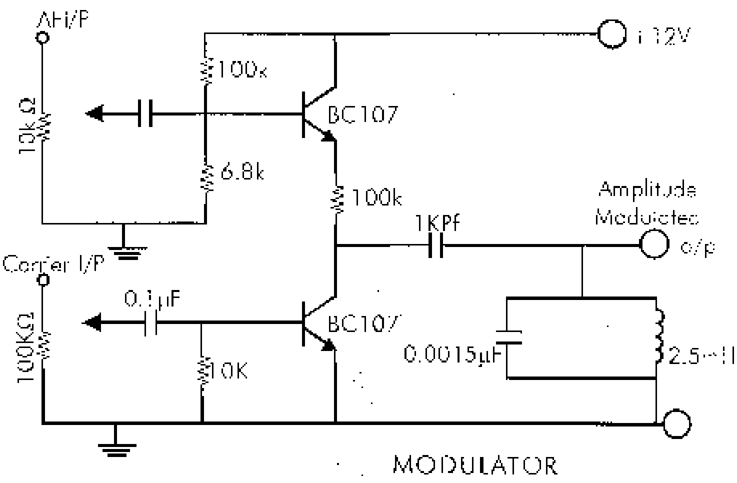
$$\text{Modulation index}(\mu) = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

$$\%\ \text{Modulation} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} \times 100$$

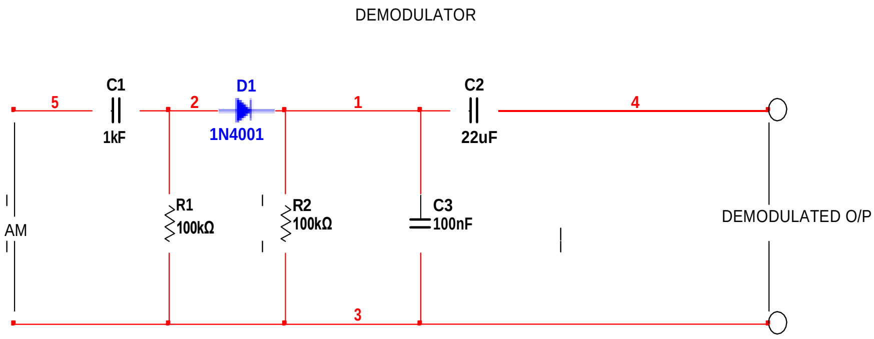
6. Vary the modulating frequency and amplitude and observe the effects of the o/p modulated waveform.
7. The depth of modulation can be varied by varying the potentiometer provided at AF input.
8. Repeat step 5 for 100% modulation, under modulation & over modulation.
9. Connect the o/p of the modulation circuit to the i/p of demodulator circuit and observe the o/p.
10. Connect the modulated signal (i/p demodulator) to CH 1 and (o/p of demodulator) to CH 2. Observe the WAVEFORMS.

Circuit Diagrams:

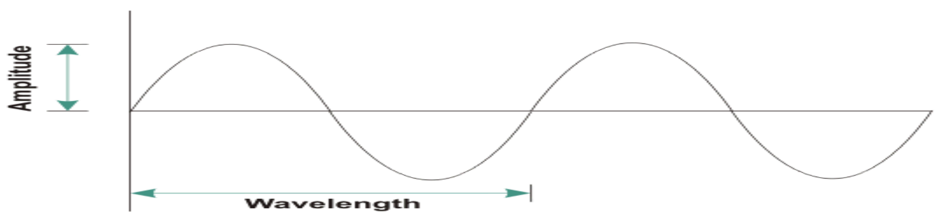
Modulator:



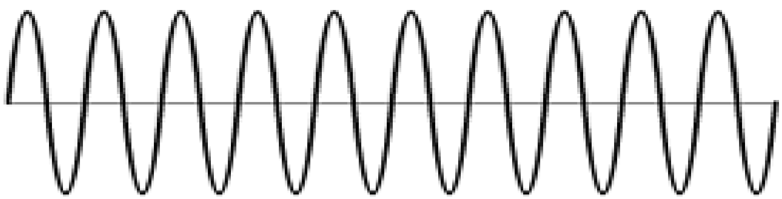
Demodulator



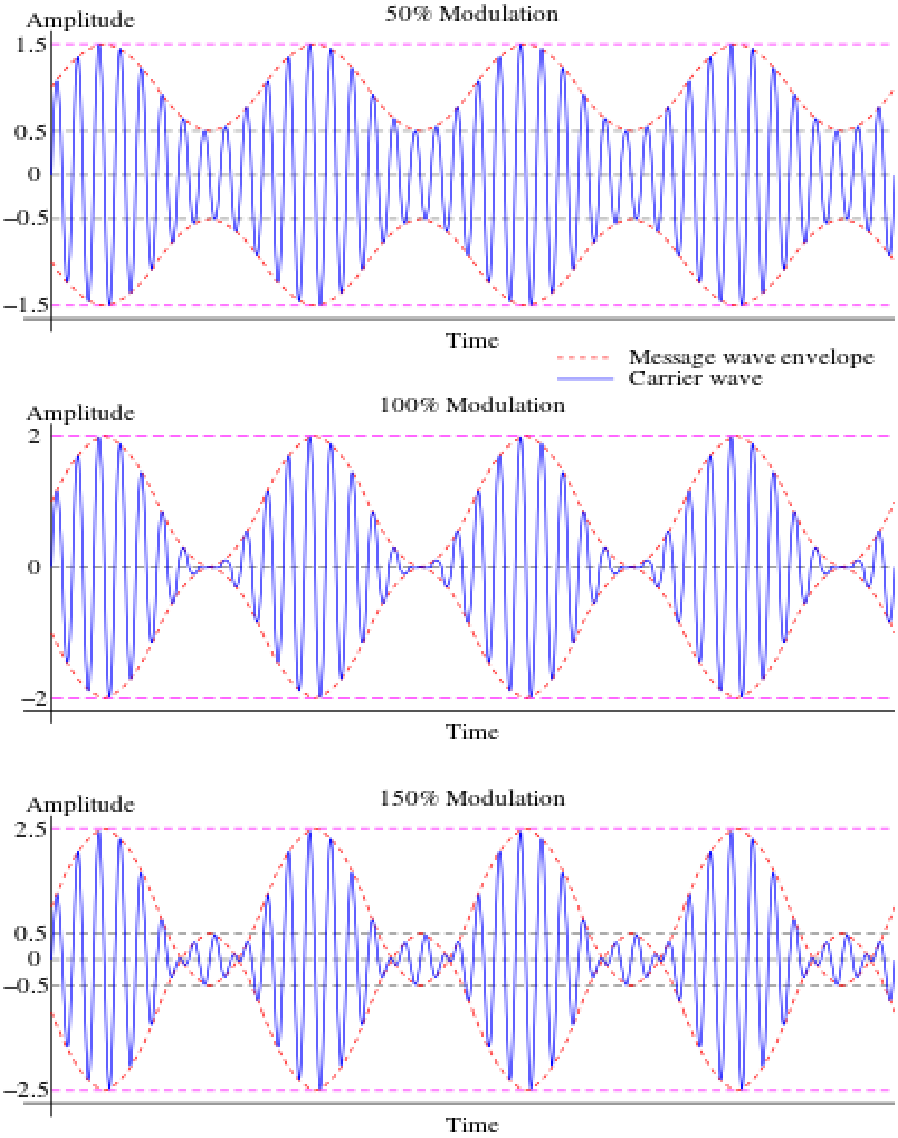
Expected Wave Forms:



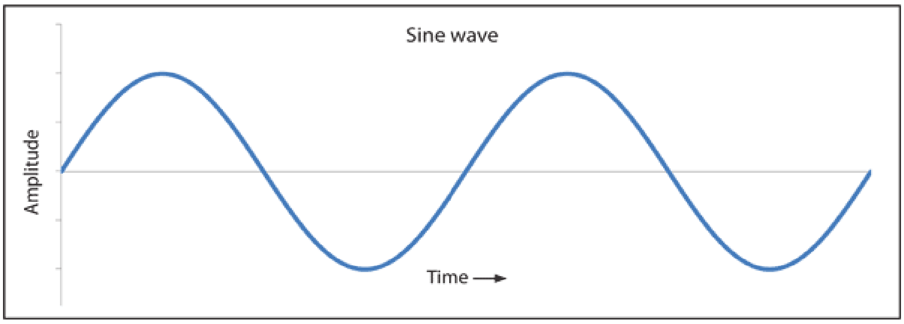
Message signal



Carrier signal



Types of Amplitude modulated waveforms



Demodulated signal

Tabular Column:

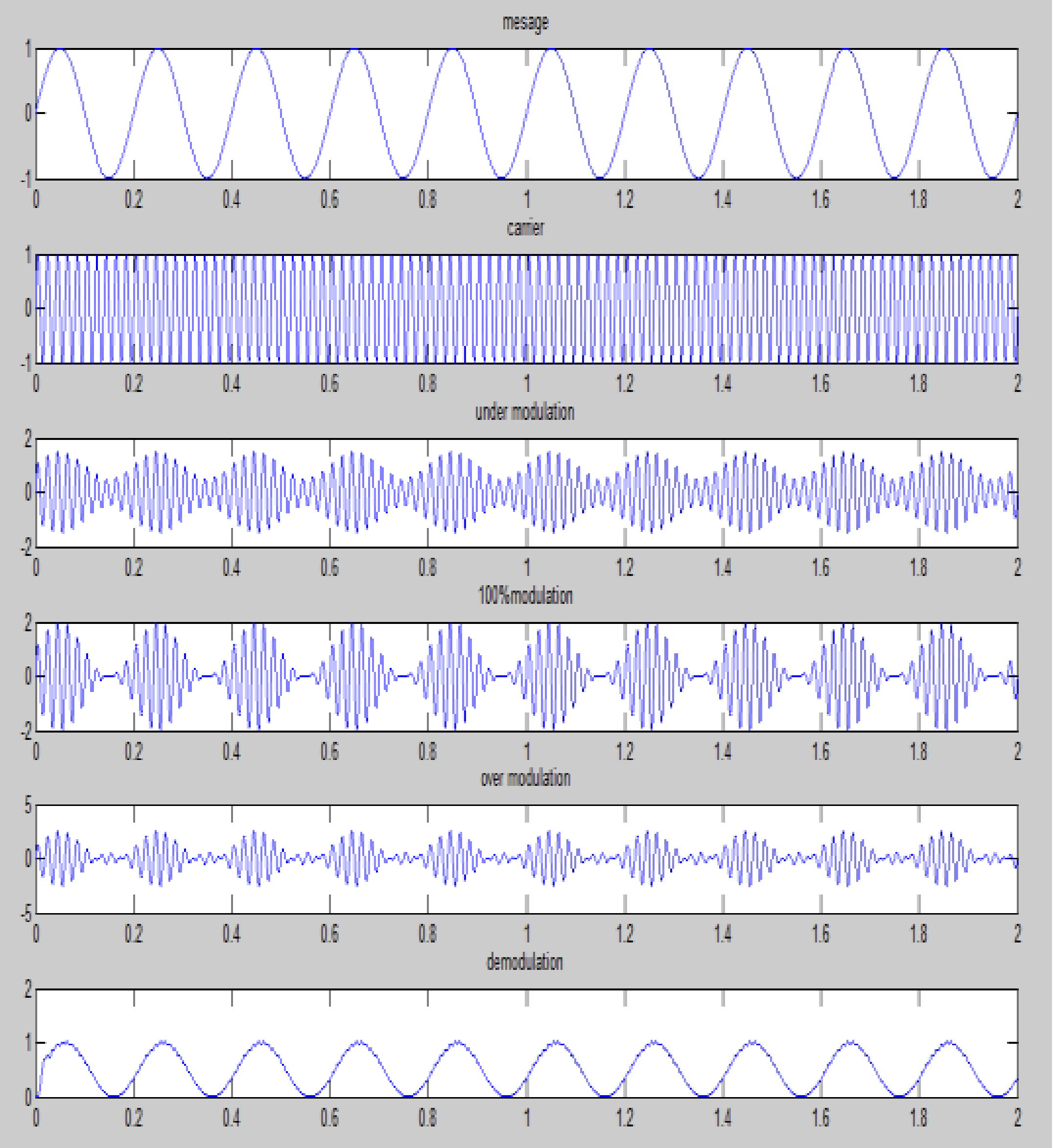
S. No	Vmax (Volts)	Vmin (Volts)	Theoritical μ= Vm/Vc	μ = Vmax-Vmin / Vmax+ Vmin

Matlab Program:

```
clc;
clear all;
close all;
t=[0:0.001:2];
f1=5;
m=sin(2*pi*f1*t);
subplot(6,2,[1,2]);
plot(t,m);
title('mesage');
f2=50;
c=sin(2*pi*f2*t);
subplot(6,2,[3,4]);
plot(t,c);
title('carrier');
m1=0.5;
s1=(1+(m1*m)).*c;
subplot(6,2,[5,6]);
plot(t,s1);
title('under modulation');
m2=1;
s2=(1+(m2*m)).*c;
subplot(6,2,[7,8]);
plot(t,s2);
title('100%modulation');
m3=1.5;
```

```
s3=(1+(m3*m)).*c;
subplot(6,2,[9,10]);
plot(t,s3);
title('over modulation');
s5=s2.*c;
[b,a]=butter(5,0.1);
s4=filter(b,a,s5);
subplot(6,2,[11,12]);
plot(t,s4);
title('demodulation' );
```

Expected Waveforms:



Precautions:

1. Check the connections before giving the power supply
2. Observations should be done carefully.

Pre Lab Questions

1. Why modulation is an essential process of communication system?
2. Explain Block diagram of Communication system?
3. Explain need for modulation?
4. Define Amplitude modulation?
5. How carrier is differing from message?

Post Lab Questions

1. What are the distortions that are likely to be present in the demodulated output when diode detector is used?
2. Explain how negative peak clipping occurs in the demodulated signal when diode detector is used?
3. Explain under modulation, 100% modulation, over modulation?
4. Explain High level modulation?
5. Write the formulae to calculate practical modulation index?

Result:

Thus the depth of modulation is calculated using hardware kits and matlab simulation program.

EXPERIMENT No. 2

DSB-SC MODULATION USING BALANCED MODULATOR

AIM:

To generate AM-Double Side Band Suppressed Carrier (DSB-SC) signal using Balanced Modulator.

Equipment & Components Required:

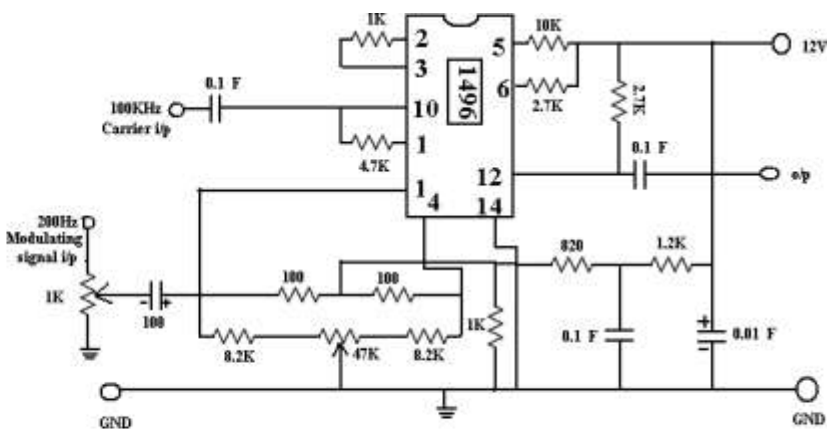
S.No	EQUIPMENT / COMPONENTS REQUIRED	Range	Quantity
1	Balanced modulator Trainer kit	--------	1
2	Function Generator	(0-1) MHz	1
3	C.R.O.	(0-20) MHz	1
4	Connecting wires.	-------	Required

Theory

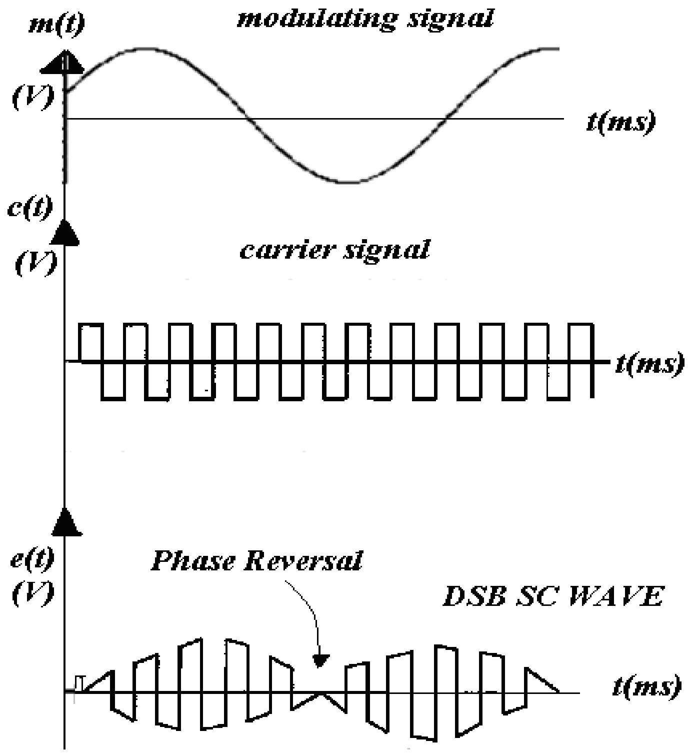
Balanced modulator is used for generating DSB-SC signal. A balanced modulator consists of two standard amplitude modulators arranged in a balanced configuration so as to suppress the carrier wave. The two modulators are identical except the reversal of sign of the modulating signal applied to them.

Circuit Diagrams

Balanced Modulator



Expected Wave Forms



Procedure

1. Switch on the balanced modulator trainer kit
2. Connect 200 Hz sine wave, and 100 KHz square wave from the function generators. Adjust R1 (1K linear pot). Connect oscilloscope to the output.
3. Vary R1 (1K) both clockwise and counter clockwise .Observe the output.
4. Disconnect the sine input to R1(1K) . The output should now be close to zero.
5. Increase the oscilloscope‟s vertical input sensitivity to measure the output voltage, E out carrier only.
6. Set the vertical input control to 1V /cm .Connect the sine input to R1 (1K) and adjust R1 for maximum output without producing clipping. Measure the peak side band output voltage Epk side bands = ------------------------
7. Calculate the carrier suppression in db.

   Suppression (db) = -20 log (Epk sideband/Eout carrier only)

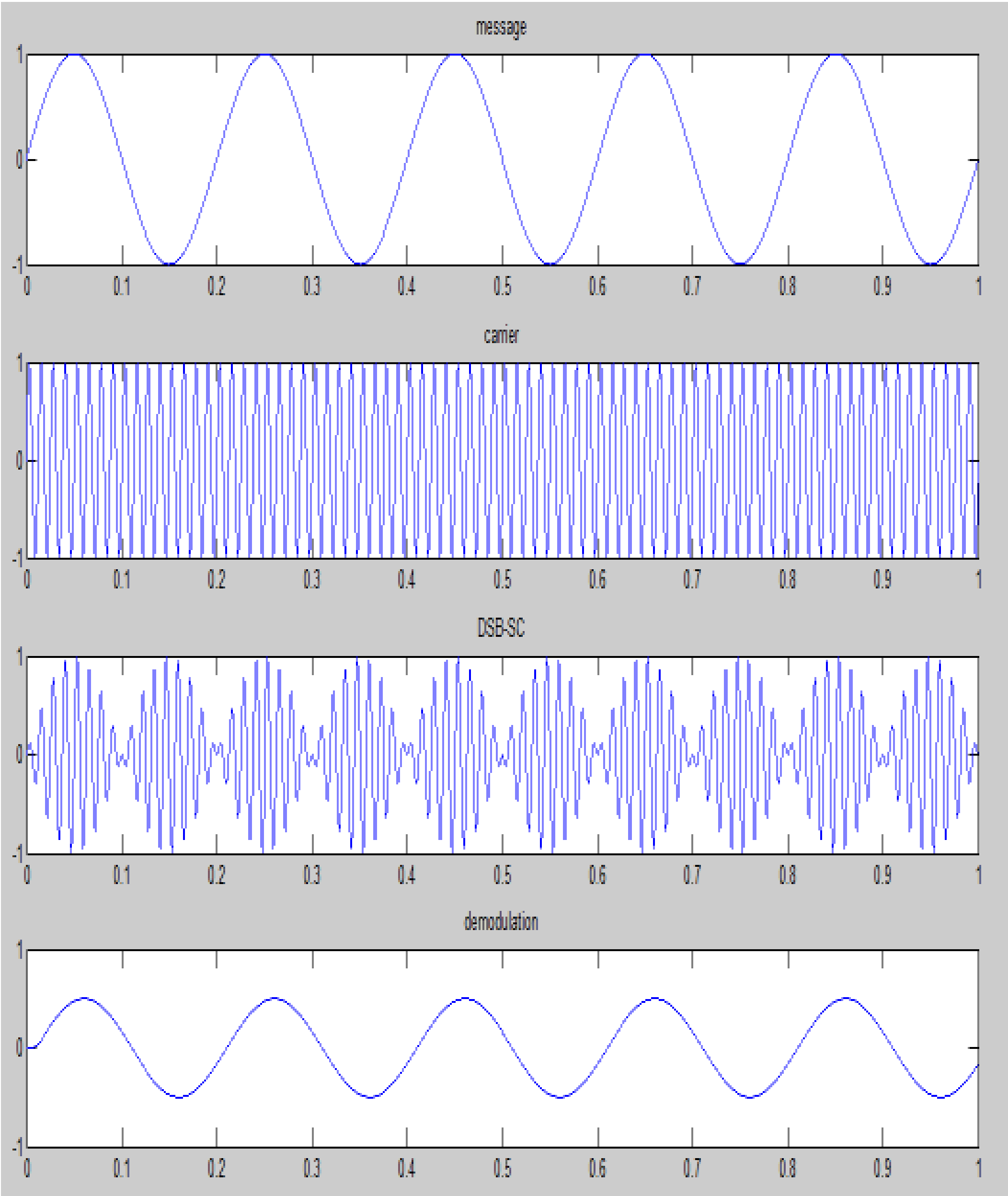
7 Precautions

1. Check the connections before giving the power supply
2. Observations should be done carefully.

Matlab Program:

```
clc;
clear all;
close all;
t=[0:0.001:1];
f1=5;
m=sin(2*pi*f1*t);
subplot(4,2,[1,2]);
plot(t,m);
title('message');
f2=80;
c=sin(2*pi*f2*t);
subplot(4,2,[3,4]);
plot(t,c);
title('carrier');
s=m.*c;
subplot(4,2,[5,6]);
plot(t,s);
title('DSB-SC');
s1=s.*c;
[b,a]=butter(5,0.1);
s2=filter(b,a,s1);
subplot(4,2,[7,8]);
plot(t,s2);
title('demodulation');
```

3.1.8 Expected Waveforms



Result:

The DSB-SC modulator is demonstrated and carrier suppression is calculated

EXPERIMENT No. 3

SINGLE SIDEBAND MODULATION AND DEMODULATION

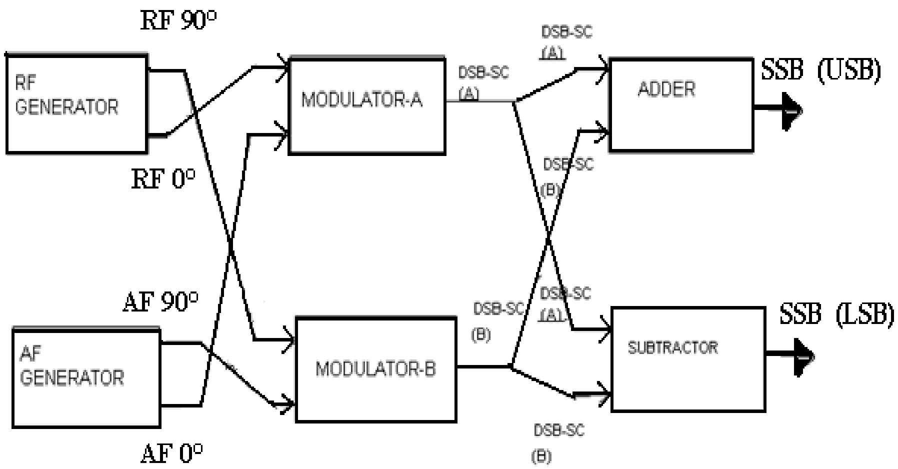
AIM:

To generate the SSB modulated wave using Phase shift method and demodulate the SSB modulated wave.

Equipment And Components Required

Sl No	EQUIPMENT / COMPONENTS REQUIRED	Range	Quantity
1	Single Side Band trainer kit	--------	1
2	C.R.O.	(0-20) MHz	1
3	Connecting wires.		10

Circuit Diagram



Procedure

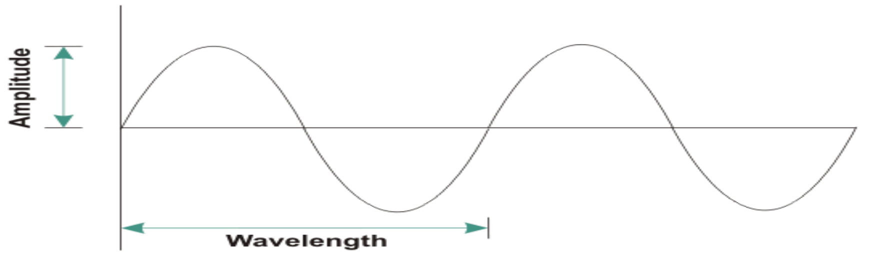
1. Switch on the trainer and measure the output of the regulated power supply i.e., ±12V and -8V.
2. Observe the output of the RF generator using CRO. There are 2 outputs from the RF generator, one is direct output and another is 90o out of phase with the direct output. Theoutput frequency is 100 KHz and the amplitude is ≥ 0.2VPP. (Potentiometers are provided to vary the output amplitude).
3. Observe the output of the AF generator, using CRO. There are 2 outputs from the AFgenerator, one is direct output and another is 90o out of phase with the direct output. A switch is provided to select the required frequency (2 KHz, 4KHz or 6 KHz).

AGC potentiometer is provided to adjust the gain of the oscillator (or to set the output to good shape). The oscillator output has amplitude   10VPP. This amplitude can be varied using the potentiometers provided.

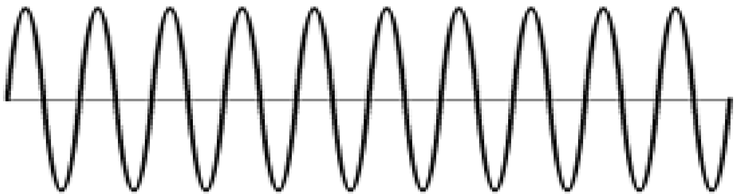
4. Measure and record the RF signal frequency using frequency counter. (or CRO).
5. Set the amplitudes of the RF signals to 0.1 Vp-p and connect direct signal to one balanced modulator and 90o phase shift signal to another balanced modulator.
6. Select the required frequency (2KHz, 4KHz or 6KHz) of the AF generator with the help of switch and adjust the AGC potentiometer until the output amplitude is 10 VPP (when amplitude controls are in maximum condition).
7. Measure and record the AF signal frequency using frequency counter (or CRO).
8. Set the AF signal amplitudes to 8 Vp-p using amplitude control and connect to the balanced modulators.
9. Observe the outputs of both the balanced modulators simultaneously using Dual trace oscilloscope and adjust the balance control until desired output wave forms (DSB-SC).
10. To get SSB lower side band signal, connect balanced modulator output (DSB_SC) signals to subtractor.
11. Measure and record the SSB signal frequency.
12. Calculate theoretical frequency of SSB (LSB) and compare it with the practical value.LSB frequency = RF frequency – AF frequency
13. To get SSB upper side band signal, connect the output of the balanced modulator to the summer circuit.
14. Measure and record the SSB upper side band signal frequency.
15. Calculate theoretical value of the SSB(USB) frequency and compare it with practical value.

    USB frequency = RF frequency + AF frequency generator, one is direct output and another is 90° out of phase with the direct output. A switch is provided to select the required frequency (2 KHz, 4KHz or 6 KHz). AGC potentiometer is provided to adjust the gain of the oscillator (or to set the output to good shape). The oscillator output has amplitude 10VPP. This amplitude can be varied using the potentiometers provided.USB frequency = RF frequency + AF frequency

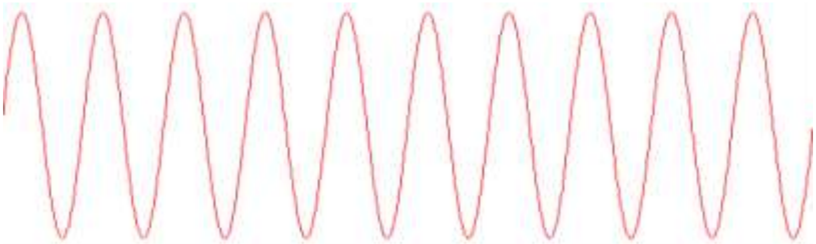
Expected waveforms



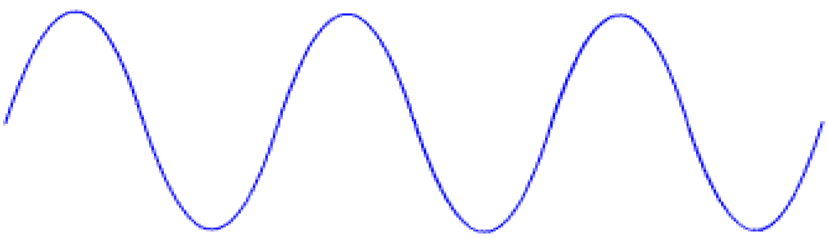
Message signal



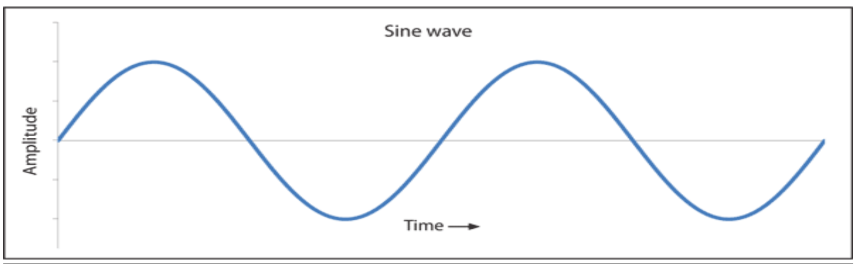
Carrier signal



SSB USB Signal



SSB LSB Signal



Demodulated signal

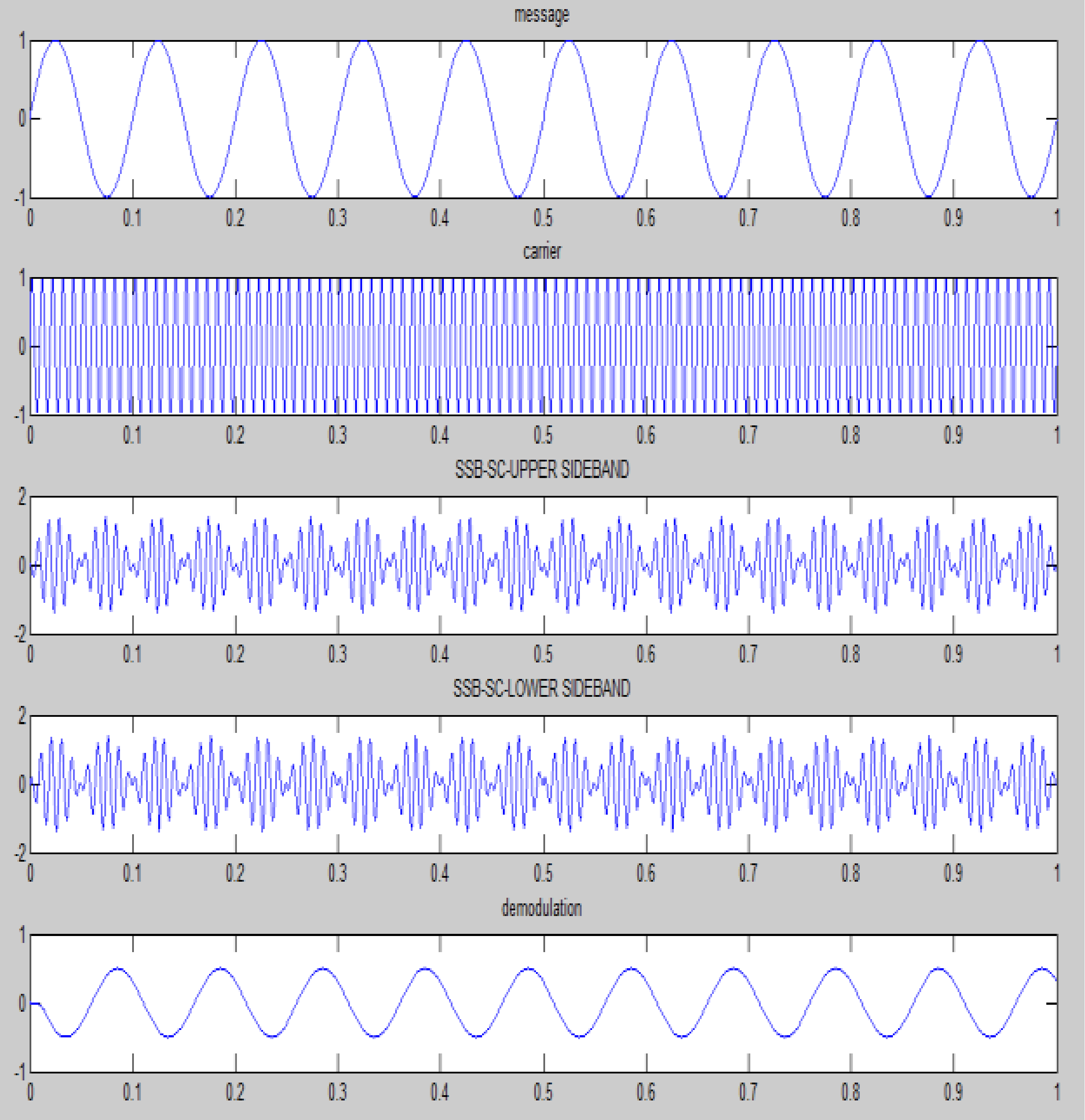
Tabular Column:

Signal	Amplitude (volts)	Frequency (KHz)
Message signal		
Carrier signal		
SSB (LSB)		
SSB (USB)		

Matlab Program:

```
clc;
clear all;
close all;
t=[0:0.001:1];
f1=5;
m1=sin(2*pi*f1*t);
m2=hilbert(m1);
subplot(4,2,[1,2]);
plot(t,m1);
title('message');
f2=100;
c1=sin(2*pi*f2*t);
c2=cos(2*pi*f2*t);
subplot(4,2,[3,4]);
plot(t,c1);
title('carrier');
subplot(4,2,[5,6]);
plot(t,s);
title('SSB-SC');
s1=s.*c1;
[b,a]=butter(5,0.1);
s2=filter(b,a,s1);
subplot(4,2,[7,8]);
plot(t,s2);title('demodulation');
```

Expected Waveforms



Precautions

1. Check the connections before giving the power supply
2. Observation should be done carefully.

Pre Lab Questions

1. Why modulation is an essential process of communication system?
2. Explain Block diagram of Communication system?
3. Explain need for modulation?

4. Define Amplitude modulation?

Lab Assignment

1. Generate SSBSC using filter method?
2. Observe the spectrum and calculate BW?

Post Lab Questions

1. Explain Phase shift method for generation of SSBSC
2. Write Power equation of SSBSC
3. Mention applications of SSBSC
4. Explain advantages of phase shift method
5. Explain COSTAS loop

Result:

The SSB modulated wave using Phase shift method is generated and SSB Modulated wave is demodulated.

EXPERIMENT No.4

FREQUENCY MODULATION AND DEMODULATION

AIM:

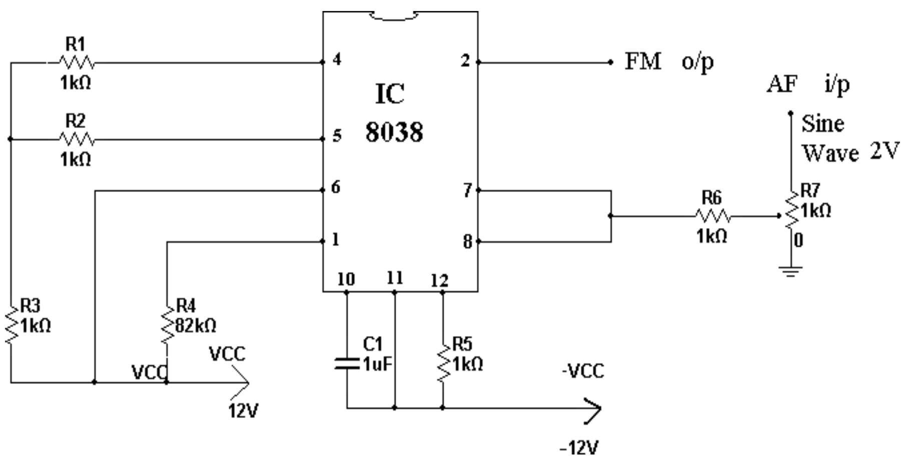
1. To generate frequency modulated signal and determine the modulation index and bandwidth for various values of amplitude and frequency of modulating signal.
2. To demodulate a Frequency Modulated signal using FM detector.

Equipment / Components Required

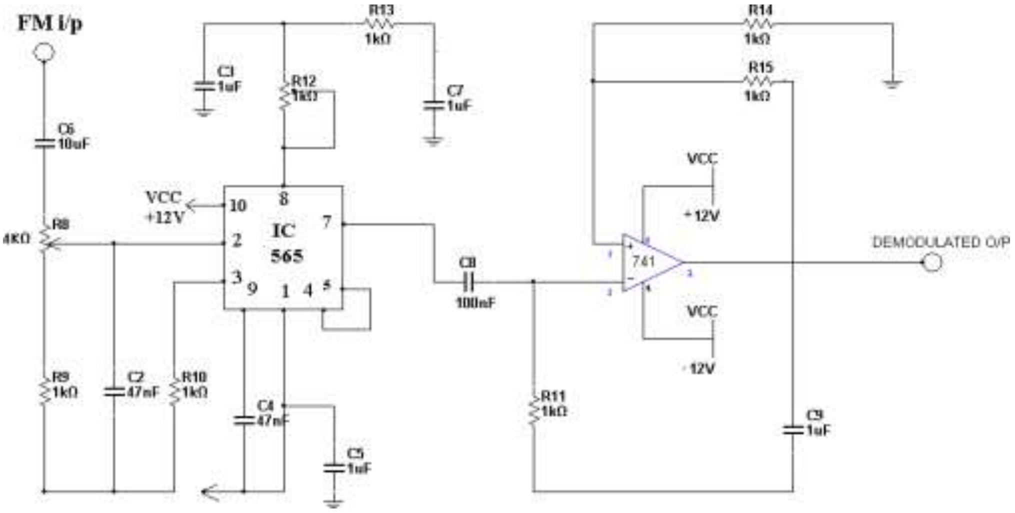
S. No	EQUIPMENT / COMPONENTS REQUIRED	Range	Quantity
1	Frequency modulation and Demodulation Trainer kit	--------	1
2	Function Generator	(0-1) MHz	1
3	C.R.O.	(0-20) MHz	1
4	Connecting wires.	-------	Required

Circuit Diagram :

FM Modulator:



FM Demodulator:



Theory

Frequency modulation is a system in which the frequency of the carrier is varied in accordance with the signal amplitude. Let‟s assume for the moment that the carrier of the transmitter is at its resting frequency (no modulation) of 100MHz and we apply a modulating signal. The amplitude of the modulating signal will cause the carrier to deviate from this resting frequency by a certain amount. If we increase the amplitude of this signal, we will increase the deviation to a maximum of 75 kHz as specified by the FCC. If we remove the modulating voltage, the carrier shifts back to resting frequency (100MHz). From this we can say that the deviation of the carrier is proportional to the amplitude of the modulating voltage. The shift in the carrier frequency from its resting point compared to the amplitude of the modulating voltage is called the deviation ratio (a deviation ratio of 5 is the maximum) allowed in commercially broadcast FM) The rate at which the carrier shifts from its resting point to a no resting point is determined by the frequency of the modulating signal. The interaction between the amplitude and frequency of the modulating signal on the carrier is complex and requires the use of Bessel‟s function to analyze the results). If the modulating signal is 15kHz at a certain amplitude and the carrier shift is 75 kHz, the transmitter will produce eight significant sidebands. This is known as the maximum deviation ratio. If the frequency deviation of the carrier is known and the frequency of the modulating signal is known then

Modulation index = freq dev / freq AF

Procedure

Modulation:

1. Switch on the frequency modulation trainer kit.
2. Connect oscilloscope to the FM o/p & observe the carrier frequency without any AF input.
3. Now observe the frequency-modulated o/p on the CRO and adjust the amplitude of the AF signal to get clear frequency modulated waveform.
4. Apply a 1 KHz (2Vp-p) sine wave (AF) to the i/p of frequency modulator at AF input.
5. Vary the modulating signal frequency f_m and amplitude & observe the effects on the modulated WAVEFORMS.

Demodulation:

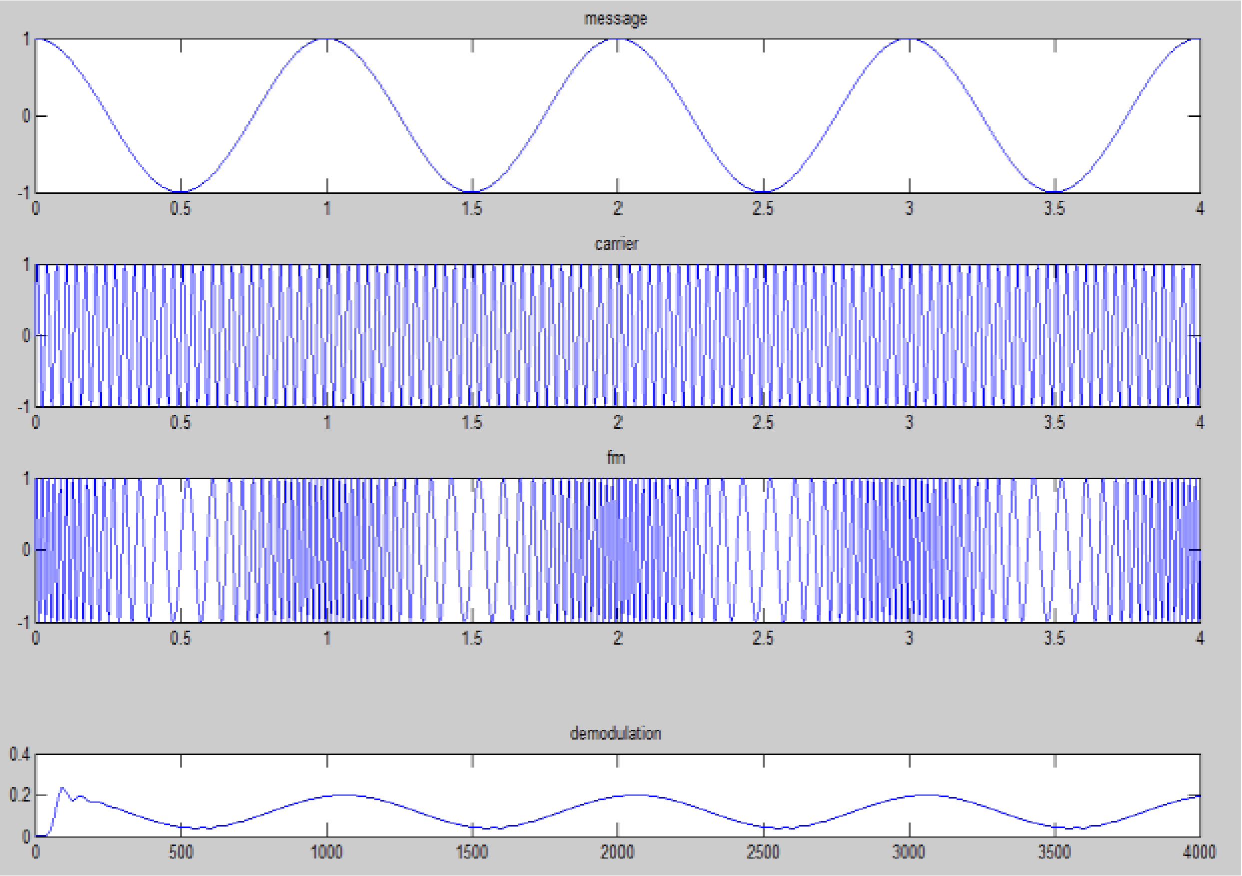
1. Connect the FM output to the input of the FM demodulator. Observe the output of the demodulator on the C.R.O..(Vary the potentiometer provided in the demodulator section).

Matlab Program:

```
clc;
clear all;
close all;
t=[0:0.001:4];f1=1;
m=cos(2*pi*f1*t);
subplot(4,2,[1,2]);
plot(t,m);
title('message');
f2=30;
c=sin(2*pi*f2*t);
subplot(4,2,[3,4]);
plot(t,c);
title('carrier');
mf=20;
s=sin((2*pi*f2*t)+(mf*sin(2*pi*f1*t)));
subplot(4,2,[5,6]);
plot(t,s);
title('fm');
syms t1;
```

```
x=diff(s);
y=abs(x);
[b,a]=butter(10,0.033);
s1=filter(b,a,y);
subplot(6,2,[11,12]);
plot(s1);
title('demodulation');
```

Expected Waveforms:



FM Modulation

S. No.	Modulating Signal Voltage (V)	Carrier Freq (KHz)	Change In Freq (KHz)	Freq Dev (KHz)	Mf =Freq dev/fm

FM Demodulation

S.No.	Mod-voltage (E_m) in mv	Modulating Frequency in (kHz)	Demodulated Signal voltage	Demodulated Signal frequency

Pre Lab Questions

1. Why modulation is an essential process of communication system?
2. Explain Block diagram of Communication system?
3. Define Frequency modulation?
4. What are the advantages of FM over AM
5. What are applications of FM?

Lab Assignment

1. Generate PM output using Frequency modulation?
2. Observe the spectrum and calculate BW?

Post Lab Questions

1. Define Modulation Index?
2. Define Frequency Deviation?
3. When the amplitude of modulating signal increases then the effect on freq deviation?
4. Compare AM & FM
5. Compare NBFM & WBFM.

Result

The process of frequency modulation and demodulation is demonstrated and the frequency deviation and modulation index is calculated

EXPERIMENT No.5

PRE – EMPHASIS AND DE- EMPHASIS

AIM:

a) To observe the effects of pre-emphasis on given input signal.

b) To observe the effects of De-emphasis on given input signal.

Equipment Required

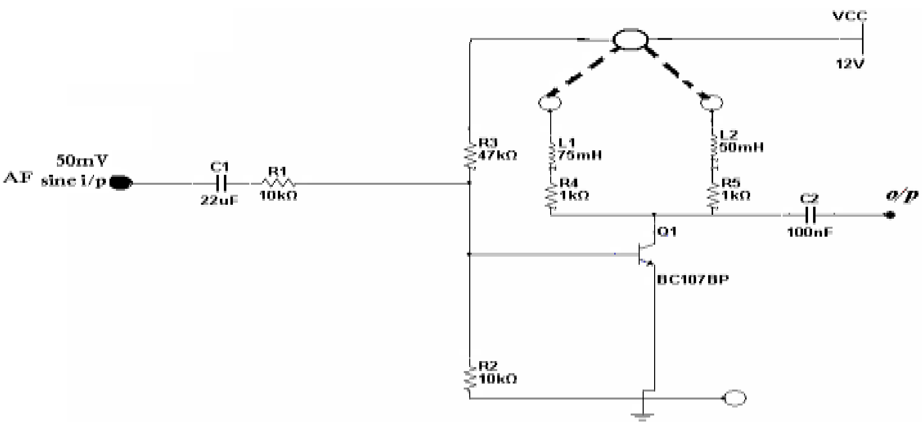
Sl No	EQUIPMENT / COMPONENTS REQUIRED	Range	Quantity
1	Pre emphasis and de emphasis Trainer kit	--------	1
2	Function Generator	(0-1) MHz	1
3	C.R.O.	(0-20) MHz	1
4	Connecting wires.	-------	Required

Theory

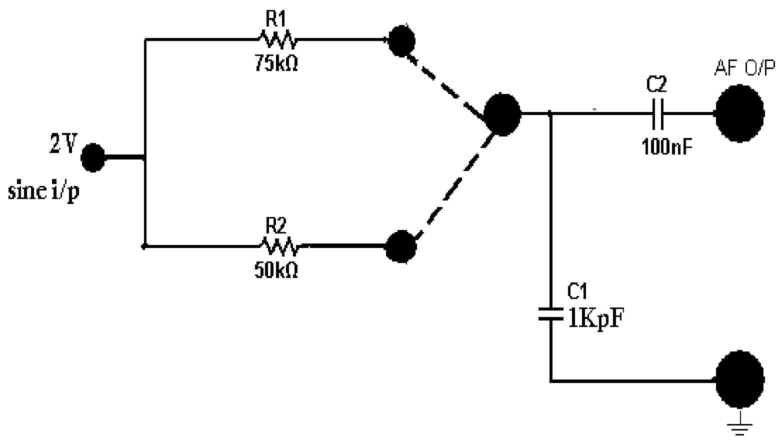
The noise triangle shows that noise has greater effect on the higher frequencies than on lower ones. Thus if higher frequencies were artificially boosted at the transmitter and correspondingly cut at the receiver, an improvement in noise immunity could be expected. This boosting of the higher modulating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

Circuit Diagram

Pre-emphasis:



De-emphasis



Procedure

Pre-emphasis

1. Switch on pre-emphasis and De- emphasis trainer
2. Connect AF signal to the input of the pre-emphasis circuit (say 75 μ sec)
3. Connect CH I input of CRO to the input of the pre-emphasis network .
4. Adjust the AF signal to the required amplitude level (say 4mv,6m----)
5. Observe the output waveform on CRO CH I by connecting either75 or 50mH.
6. By varying the AF signal frequency (keeping amplitude constant) in steps note down the corresponding i/p and o/p voltage in tabulated form as shown below.
7. Plot the graph between frequency (X-axis) and o/p voltage (Y-axis).
8. From the graph note the frequency at which o/p voltage is 70.7 %of i/p voltage and compare it with theoretical frequency.

   f (theoretical) = 1/2π RC (or) R/2πL
9. Repeat the above steps for 50 μ sec ,for pre-emphasis network.

   Where RC (or) L/R is time constant .

L = 75mH; R = 1kΩ for 75 μ sec

L = 50mH; R = 1kΩ for 50 μ sec

De-emphasis

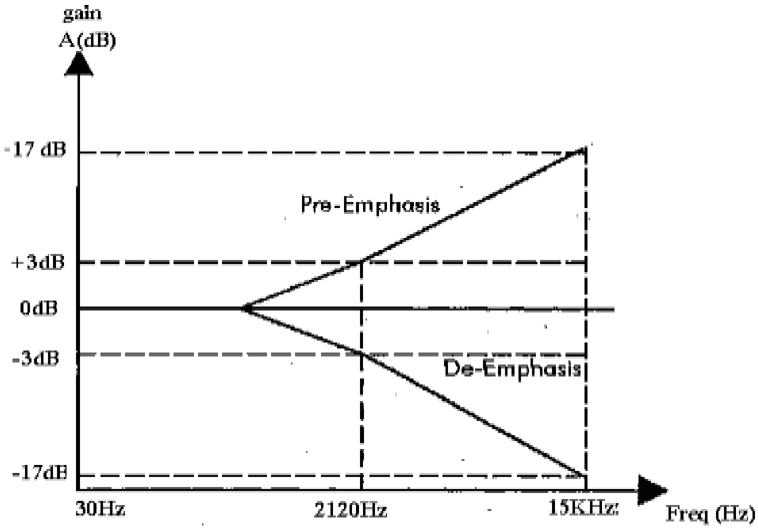
1. Connect the o/p of pre-emphasis to the i/p of the De-emphasis circuit.
2. Connect CH I i/p of CRO to the i/p of De-emphasis network & i/p to the o/p of De-emphasis network.

3. By varying the AF signal frequency (keeping amplitude constant) in steps note down the corresponding i/p & o/p voltages in tabulated form as shown below.
4. Plot the graph between log frequency on X – axis and attenuation on Y- axis to show the emphasis curve.
5. From the graph note the frequency at which the o/p voltage is 70.7 % of i/p voltage and compare it with the theoretical frequency.
6. Repeat above steps for 50 μ sec.
7. The theoretical frequency(f) = $1/2\pi RC$

R = 75 kΩ ; C = 1nf ; Time constant = 75 μ sec

R = 50kΩ ; C = 1nf ; Time constant = 50 μ sec

6.6 Expected Graph



75-μs Emphasis Curves

Tabular Column

PRE EMPHASIS				DE EMPHASIS			
Vi=50mV				Vi=2V			
Frequency (Hz)	I/p voltage (Vpp)	O/p voltage Vpp)	Attenuation (db)=20log (Vp/Vi)	Frequency (Hz)	I/p voltage (Vpp)	O/p voltage Vpp)	Attenuation (db)=20log (Vp/Vi)
100HZ				100HZ			
200				200			
400				400			
600				600			
800				800			

1k				1k			
2k				2k			
3k				3k			
4k				4k			
5k				5k			
6k				6k			
7k				7k			
8k				8k			
9k				9k			
10k				10k			
12k				12k			
14				14			
16k				16k			
18k				18k			
20k				20k			

Precautions

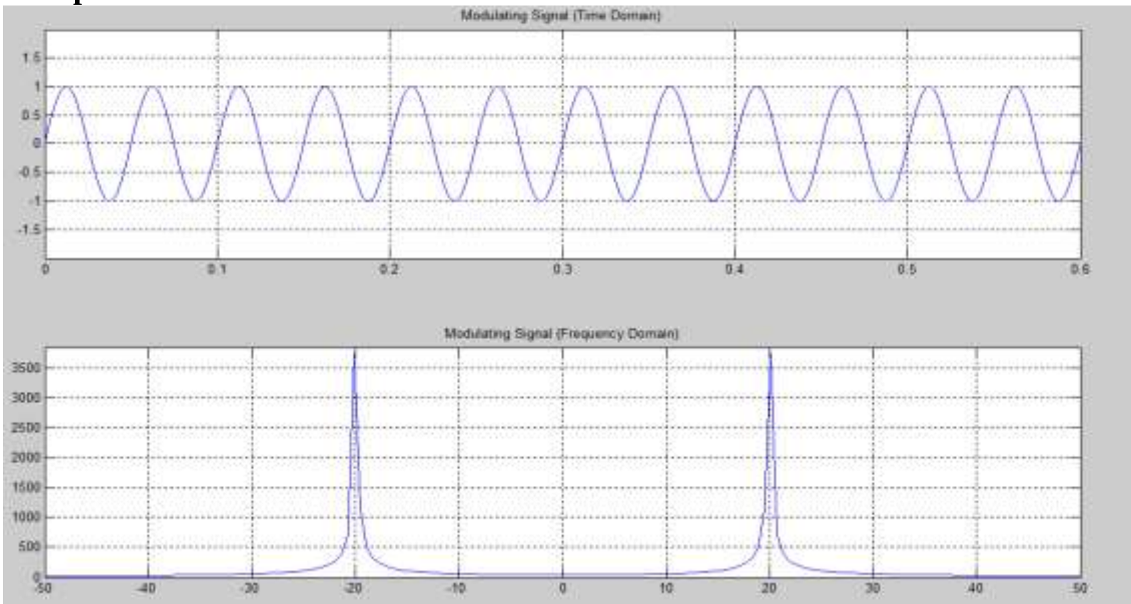
1. Check the connections before giving the power supply
2. Observation should be done carefully

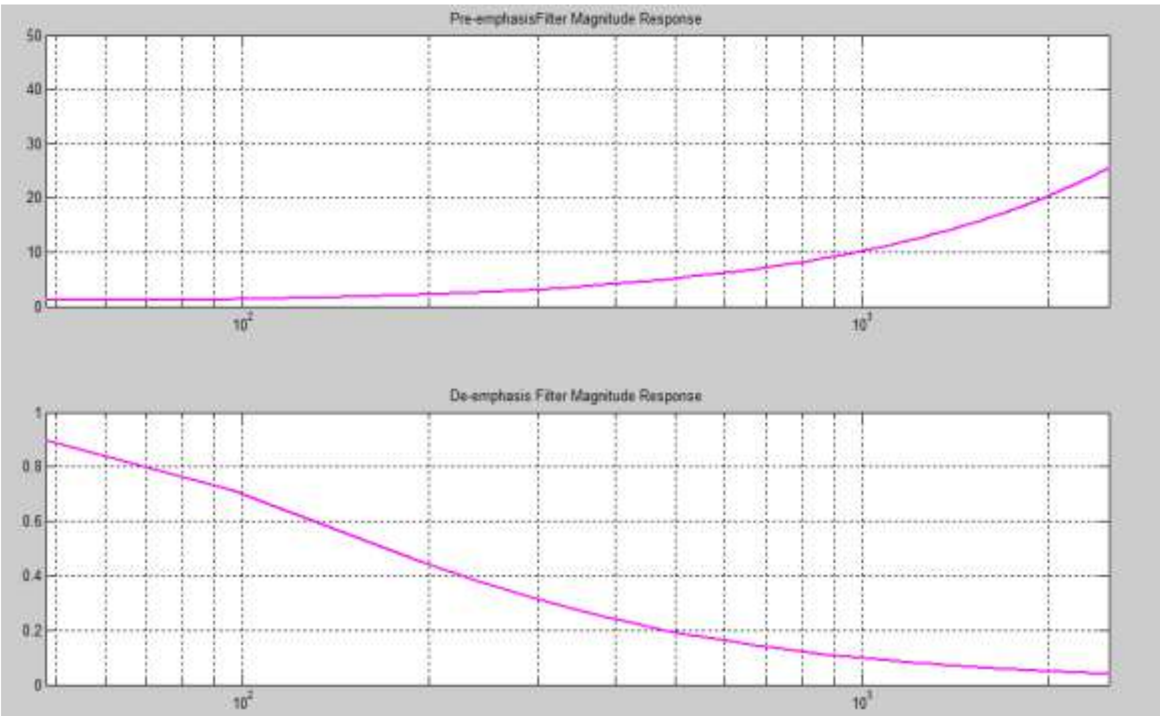
Matlab Program

```
close all
clear  all
clc
num_samples = 2^13;
fs=5000;
Ts=1/fs;
fm1=20;
fm2=30;
fc=200;
t=(0:num_samples-1)*Ts;
f=(-num_samples/2:num_samples/2-1)*fs/num_samples;
mt=sin(2*pi*fm1*t);
Mf=fftshift(abs(fft(mt)));
f_cutoff_pe=10;
Wn_pe=f_cutoff_pe/(fs/2);
```

```
[b_pe,a_pe]=butter(1,Wn_pe);
[H_pe,W]=freqz(a_pe,b_pe);
a_de=b_pe;
b_de=a_pe;
[H_de,W]=freqz(a_de,b_de);
mt_pe=filter(a_pe,b_pe,mt);
Mf_pe=fftshift(abs(fft(mt_pe)));
figure(1)
subplot(211);
plot(t,mt)
axis([0 .6 min(mt)-1 max(mt)+1])
grid on;title('Modulating Signal (Time Domain)')
subplot(212);
plot(f,Mf)
grid on;axis([-50 50 0 max(Mf)+100])
title('Modulating Signal (Frequency Domain)')
figure(2)
subplot(211)
semilogx(W*pi*(fs/2),abs(H_pe),'m','linewidth',2)
axis([0 fs/2 0 50])
grid on;
title('Pre-emphasisFilter Magnitude Response')
subplot(212)
semilogx(W*pi*(fs/2),abs(H_de),'m','linewidth',2)
axis([0 fs/2 0 1])
grid on;
title('De-emphasis Filter Magnitude Response')
```

Expected Waveforms





Pre Lab Questions

1. Define Frequency Deviation?
2. Define Modulation Index?
3. Define Frequency modulation?
4. What are the advantages of FM over AM
5. Explain high pass & low pass filters

Lab Assignment

1. Observe pre-emphasis output for L=100mH
2. Observe de-emphasis output for c=100µF

Post Lab Questions

1. Explain Pre-emphasis
2. Explain De-emphasis
3. Define noise triangle?
4. Define 3-dB frequency
5. Why FM having greater noise immunity?

RESULT:

The frequency response curve of pre-emphasis and de-emphasis is demonstrated.

EXPERIMENT No.6

VERIFICATION OF SAMPLING THEOREM

AIM:

To perform and verify the sampling theorem and reconstruction of sampled wave form.

Equipment Required

S.No	Equipment / Components Required	Range	Quantity
1	Sampling Theorem Trainer Kit	-----	1
2	Function Generator	(0-2) MHz	1
3	C.R.O.	(0-30) MHz	1
4	Connecting wires.	----	-
5.	BNC Probes		

Theory

Sampling theorem states that if the sampling rate in any pulse modulation system exceeds twice the maximum signal frequency the original signal can be reconstructed in the receiver with minimum distortion. Let m (t) be a signal whose highest frequency component is fm. Let the value of m (t) be obtained at regular intervals separated by time T far far less than (1/2 fm) The sampling is thus periodically done at each TS seconds. Now the samples m(nTS) where n is an integer which determines the signals uniquely. The signal can be reconstructed from these samples without distortion.

Time Ts is called the SAMPLING TIME.
The minimum sampling rate is called NYQUIST RATE.

The validity of sampling theorem requires rapid sampling rate such that at least two samples are obtained during the course of the interval corresponding to the highest frequency of the signal under analysis. Let us consider an example of a pulse modulated signal, containing speech information, as is used in telephony. Over standard telephone channels the frequency range of A.F. is from 300 Hz to 3400 Hz. For this application the sampling rate taken is 8000 samples per second. This is an International standard. We can observe that the pulse rate is more than twice the highest audio frequency used in this system. Hence the sampling theorem is satisfied and the resulting signal is free from sampling error.

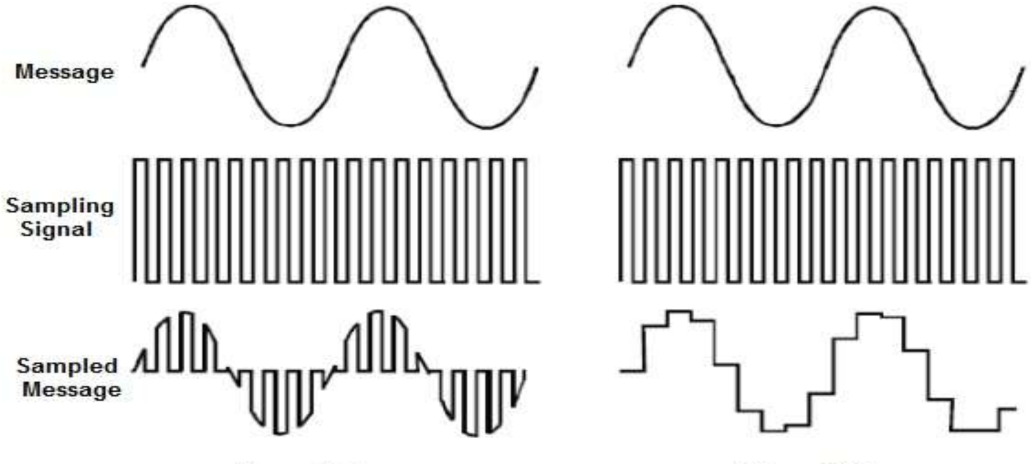
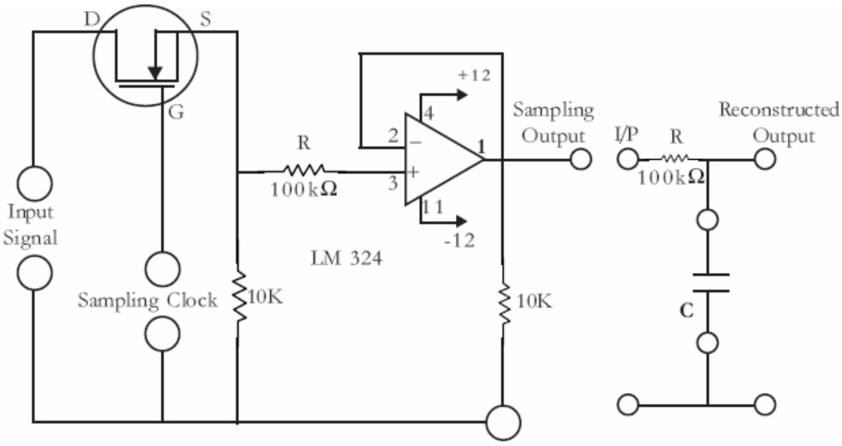


Figure 1(a) Figure 1(b)

Circuit Diagram



Procedure

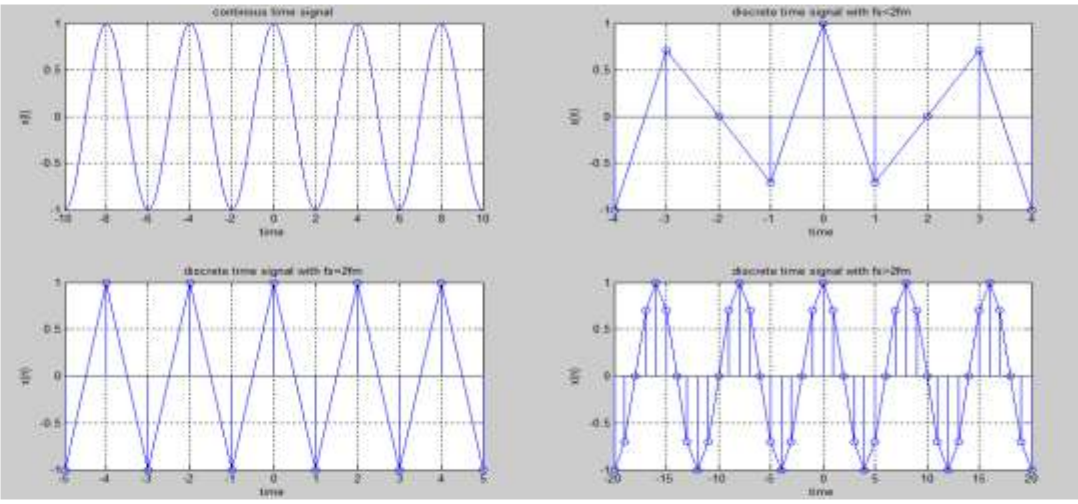
1. Connections are made as per the Circuit diagram.
2. Apply the input signal with a frequency of 500Hz (VP-P) using a function generator.
3. Sampling clock frequency which is variable of 3 KHz to 50KHz should be connected across the terminals which is indicated.
4. Now observe the sampling output of the circuit at the o/p.
5. By using the capacitors provided on the trainer, reconstruct the signal and Verify it with the given input.
6. Reconstructed signal voltage will be depends on capacitor value.
7. Vary the sampling frequency and study the change in reconstructed signal.
8. If the sampling clock frequency is below 20 KHz you will observe the distorted demodulated output.

Matlab Program

```
close all;
clear all
clc
t=-10:.01:10;
T=4;
fm=1/T;
x=cos(2*pi*fm*t); % input signal
subplot(2,2,1);
plot(t,x);
xlabel('time');
ylabel('x(t)');
title('continous time signal');
grid;
n1=-4:1:4;
fs1=1.6*fm;
fs2=2*fm;
fs3=8*fm;
%discrete time signal with fs<2fm
x1=cos(2*pi*fm/fs1*n1);
```

```
subplot(2,2,2);
stem(n1,x1);
xlabel('time');
ylabel('x(n)');
title('discrete time signal with fs<2fm');
hold on
subplot(2,2,2);
plot(n1,x1)
grid;
%discrete time signal with fs=2fm
n2=-5:1:5;
x2=cos(2*pi*fm/fs2*n2);
subplot(2,2,3);
stem(n2,x2);
xlabel('time');
ylabel('x(n)');
title('discrete time signal with fs=2fm');
hold on
subplot(2,2,3);
plot(n2,x2)
%discrete time signal with fs>2fm
grid;
n3=-20:1:20;
x3=cos(2*pi*fm/fs3*n3);
subplot(2,2,4);
stem(n3,x3);
xlabel('time');
ylabel('x(n)');
title('discrete time signal with fs>2fm');
hold on
subplot(2,2,4);
plot(n3,x3)
grid;
```

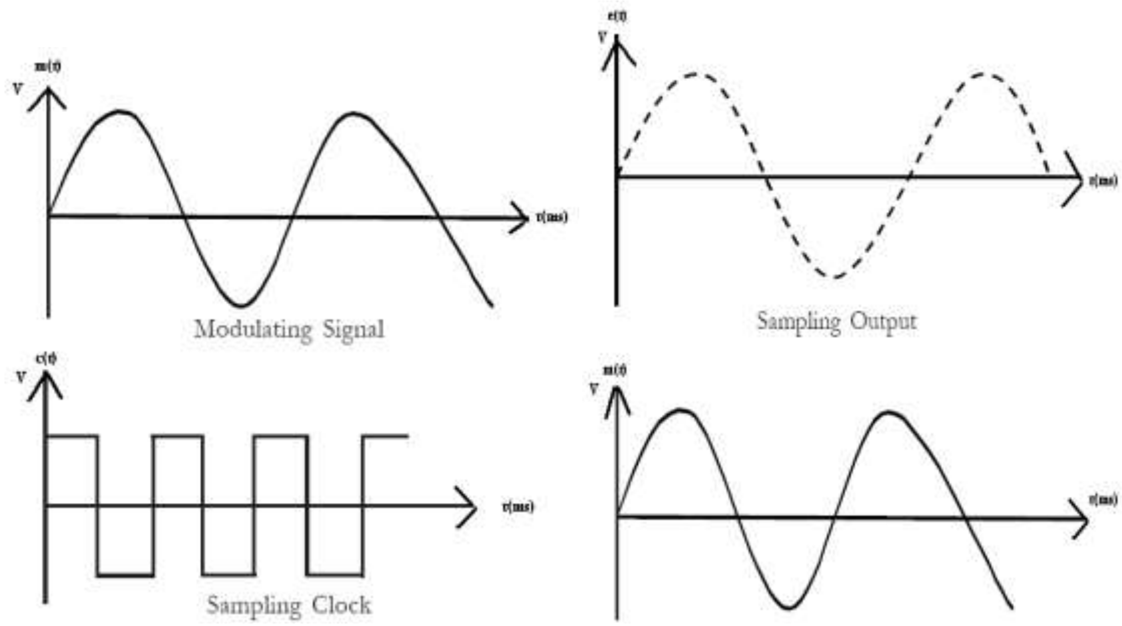
Expected Waveforms



Precautions

1. Check the connections before giving the power supply
2. Observation should be done carefully

Expected Waveforms



Pre Lab Questions

1. Define Sampling Theorem.
2. What is aliasing effect?
3. Explain Need for Sampling?

Lab Assignment

1. Observe the Sampling output of Triangular wave.
2. Observe the reconstruction waveform for fs<2fm.

Post Lab Questions

1. Define Nyquist Rate.
2. Explain different methods of Sampling.
3. How Sampling affects the input signal.

Result:

Hence, sampling theorem is verified and the sampled waveform is reconstruct

EXPERIMENT No. 7

FRERQUENCY DIVISION MULTIPLEXING

AIM:

To construct the frequency division multiplexing and demultiplexing circuit and to verify its operation

Equipment / Components Required:

S.No	EQUIPMENT / COMPONENTS REQUIRED	Range	Quantity
1	Frequency Division Multiplexing and Demultiplexing trainer Kit.	--------	1
2	C.R.O.	(0-20) MHz	1
3	Connecting wires.	-------	07

Theory

When several communications channels are between the two same point‟s significant economics may be realized by sending all the messages on one transmission facility a process called multiplexing. Applications of multiplexing range from the vital, if prosaic, telephone networks to the glamour of FM stereo and space probe telemetry system. There are two basic multiplexing techniques

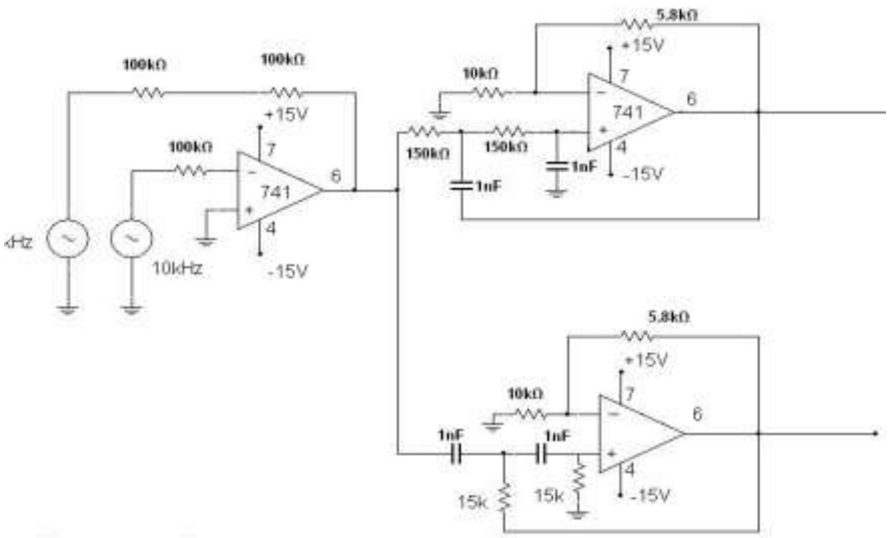
1. Frequency Division Multiplexing (FDM)
2. Time Division Multiplexing (TDM)

The principle of the frequency division multiplexing is that several input messages individually modulate the sub carrier‟s fc1, fc2, etc.after passing through LPFs to limit the message bandwidth. We show the sub carrier modulation as SSB, and it often is; but any of the CW modulation techniques could be employed or a Mixture of them. The modulated signals are then summoned to produce the base band signal with the spectrumXb9f), the designation "base band" is used here to indicate that the final carrier modulation has not yet taken place. The major practical problem of FDM is cross talks, the unwanted coupling of one message into another. Intelligible cross talk arises

Primarily because of non linearity‟s in the system, which cause 1 message signal to appear as modulation on sub carrier? Consequently, standard practice calls for negative

Feedback to minimize amplifier non linearity in FDM systems

Circuit Diagram:



Tabular Column

SIGNALS	Amplitude(V)	Time(ms)
Input 1		
Input 2		
Modulated input		
Demodulated output 1		
Demodulated output 2		

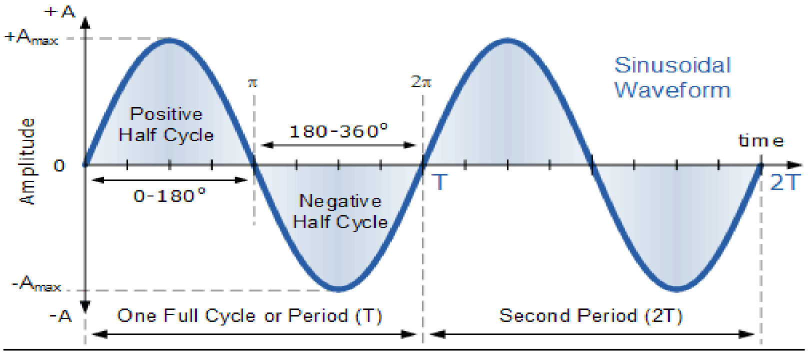
Procedure

1. Connections are given as per the CIRCUIT DIAGRAM.
2. The FSK signals are obtained with two different frequency pair with two different FSK generators.
3. The 2 signals are fed to op-amp which performs adder operation.
4. The filter is designed in such a way that low frequency signal is passed through the HPF.

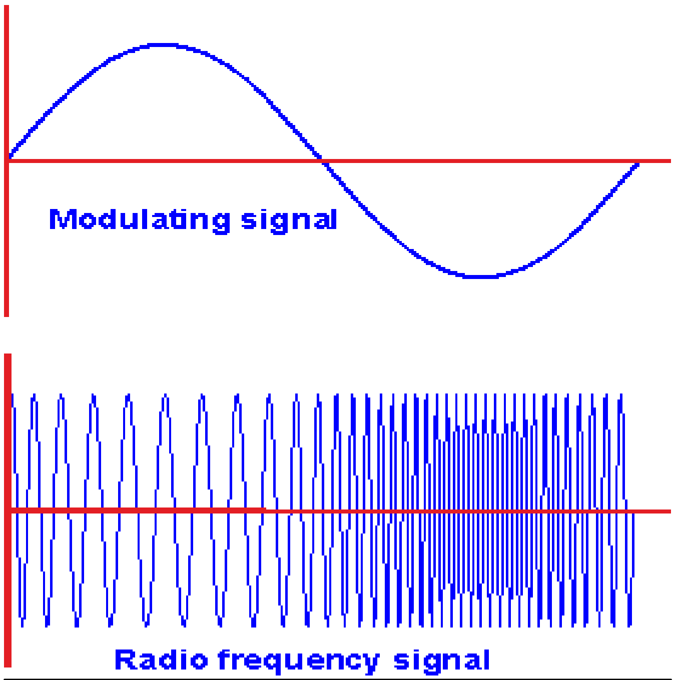
5.Fixed signal is obtained will be equal to the one signal obtained from FSK modulator.

Hardware Expected Waveforms:

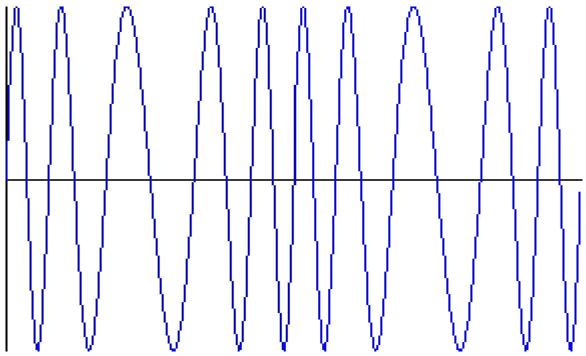
Message signal 1



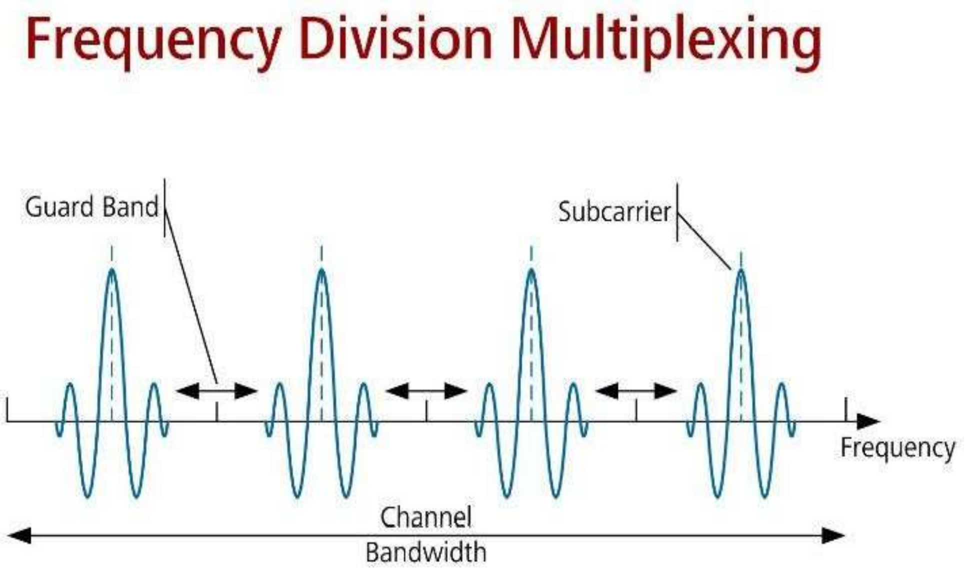
Message signal 2 and FM wave 1



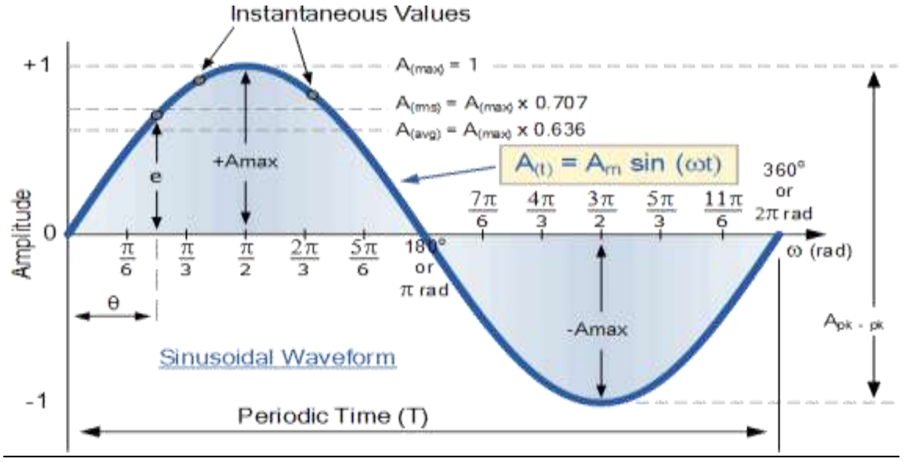
FM Wave 2

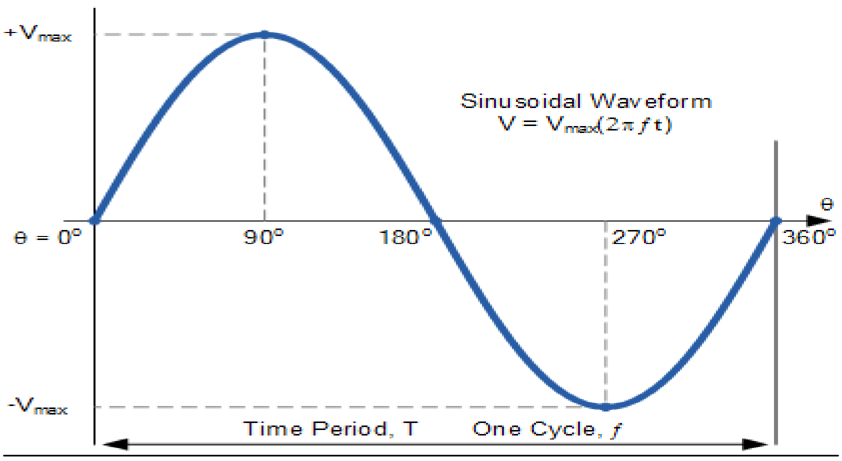


FDM Output



Demodulating Signals



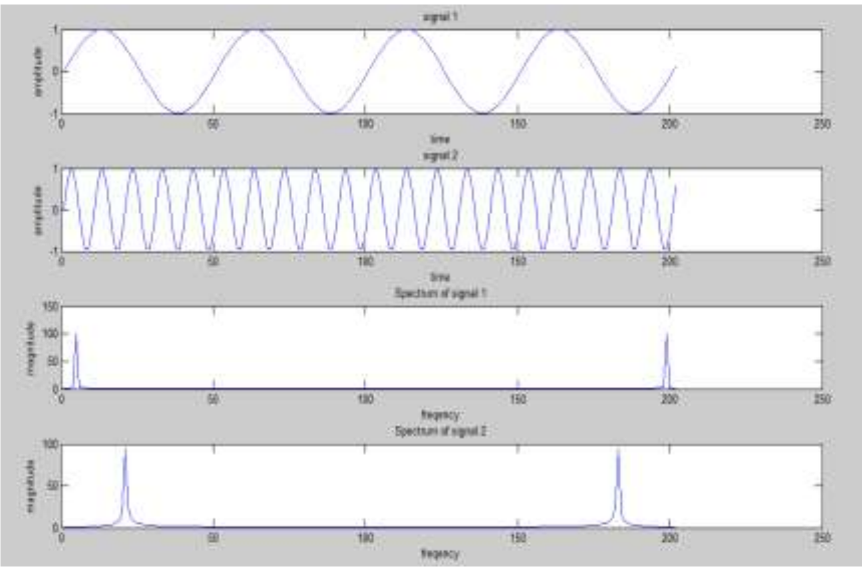


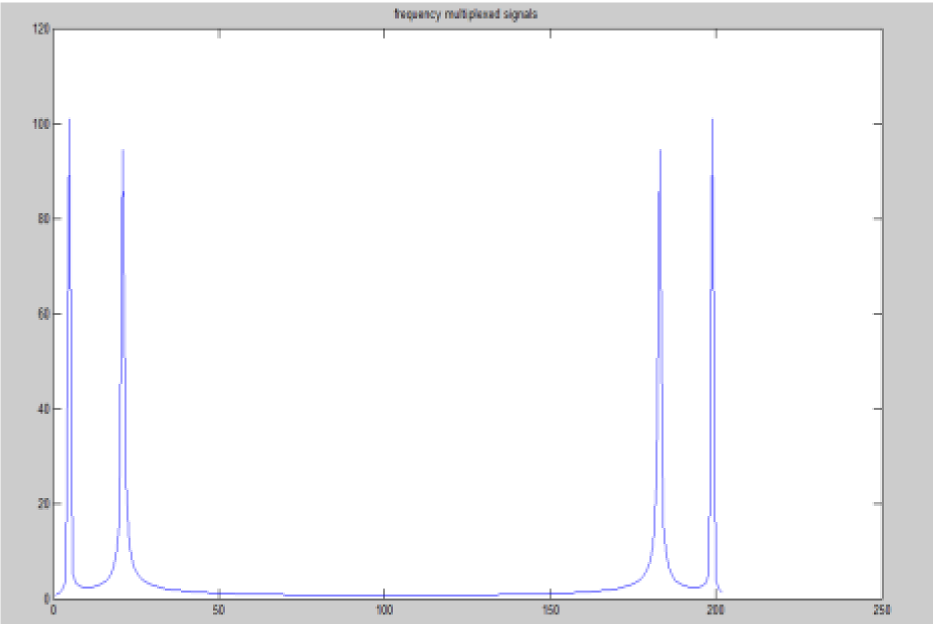
Matlab Program

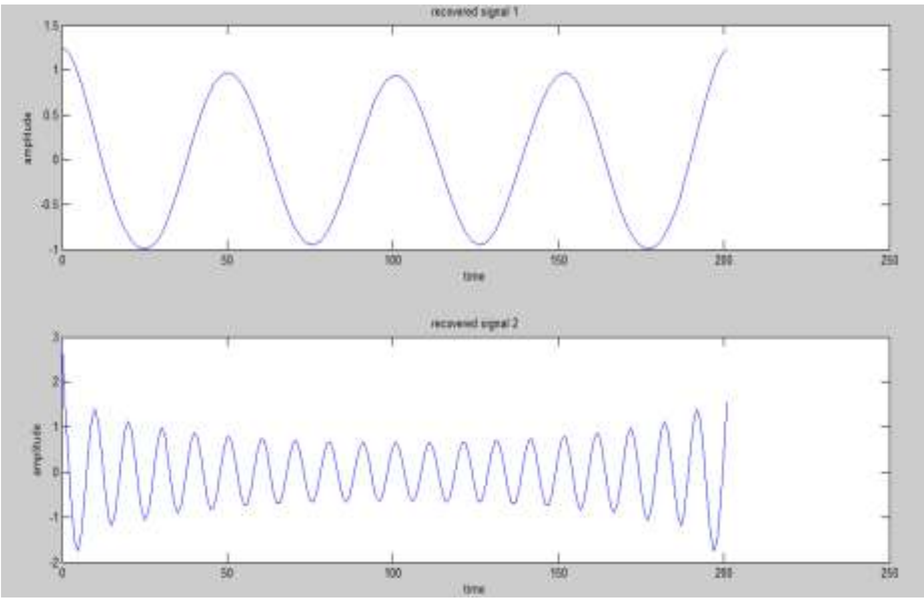
```
close all
clear  all
clc
Fs = 100; % sampling freq
t = [0:2*Fs+1]'/Fs;
x1 = sin(2*pi*2*t); % signal 1 signal
z1 = fft(x1);
z1=abs(z1);
x2 = sin(2*pi*10*t); % signal 2 signal
z2 = fft(x2);
z2=abs(z2);
figure;
subplot(4,1,1);
plot(x1);
title('signal 1');
xlabel('time');
ylabel('amplitude');
subplot(4,1,2);
plot(x2);
title('signal 2');
xlabel('time');
ylabel('amplitude');
subplot(4,1,3);\
plot(z1);
title('Spectrum of signal 1');
xlabel('freqency');
ylabel('magnitude');
subplot(4,1,4);
plot(z2);
title('Spectrum of signal 2');
xlabel('freqency')
ylabel('magnitude');
% freqency multiplexing
```

```
z=z1+z2;
figure;
plot(z);
title('frequency multiplexed signals');
figure;
% freqency demultiplexing
f1=[ones(10,1);
zeros(182,1);
ones(10,1)];%applying filter for signal 1
dz1=z.*f1;
d1 = ifft(dz1);
subplot(2,1,1)
plot(t*100,d1);
f2=[zeros(10,1);
ones(182,1);
zeros(10,1)];% applying filter for signal 2
dz2=z.*f2;
d2 = ifft(dz2);
title('recovered signal 1');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2)
plot(t*100,d2);
title('recovered signal 2');xlabel('time');ylabel('amplitude');
```

Waveforms


signal 1
amplitude
time
signal 2
amplitude
time
Spectrum of signal 1
magnitude
freqency
Spectrum of signal 2
magnitude
freqency


frequency multiplexed signals



Precautions

1. Check the connections before giving the supply
2. Observations should be done carefully

Pre Lab Question

1. Explain multiplexing?
2. Explain different types of multiplexing?
3. What are the advantages of multiplexing?

Lab Assignment

1. Observe FDM output at different channels?
2. Observe FDM output for 3 inputs using matlab code

Post Lab Questions

1. Explain Frequency-division multiplexing
2. Differentiate FDM & TDM
3. What is the BW of FDM
4. Explain FDM Generation

Result:

The frequency division multiplexing and demultiplexing is constructed and its operation is verified

EXPERIMENT No. 8

TIME DIVISION MULTIPLEXING

Aim:

To study the operation of Time-Division multiplexing.

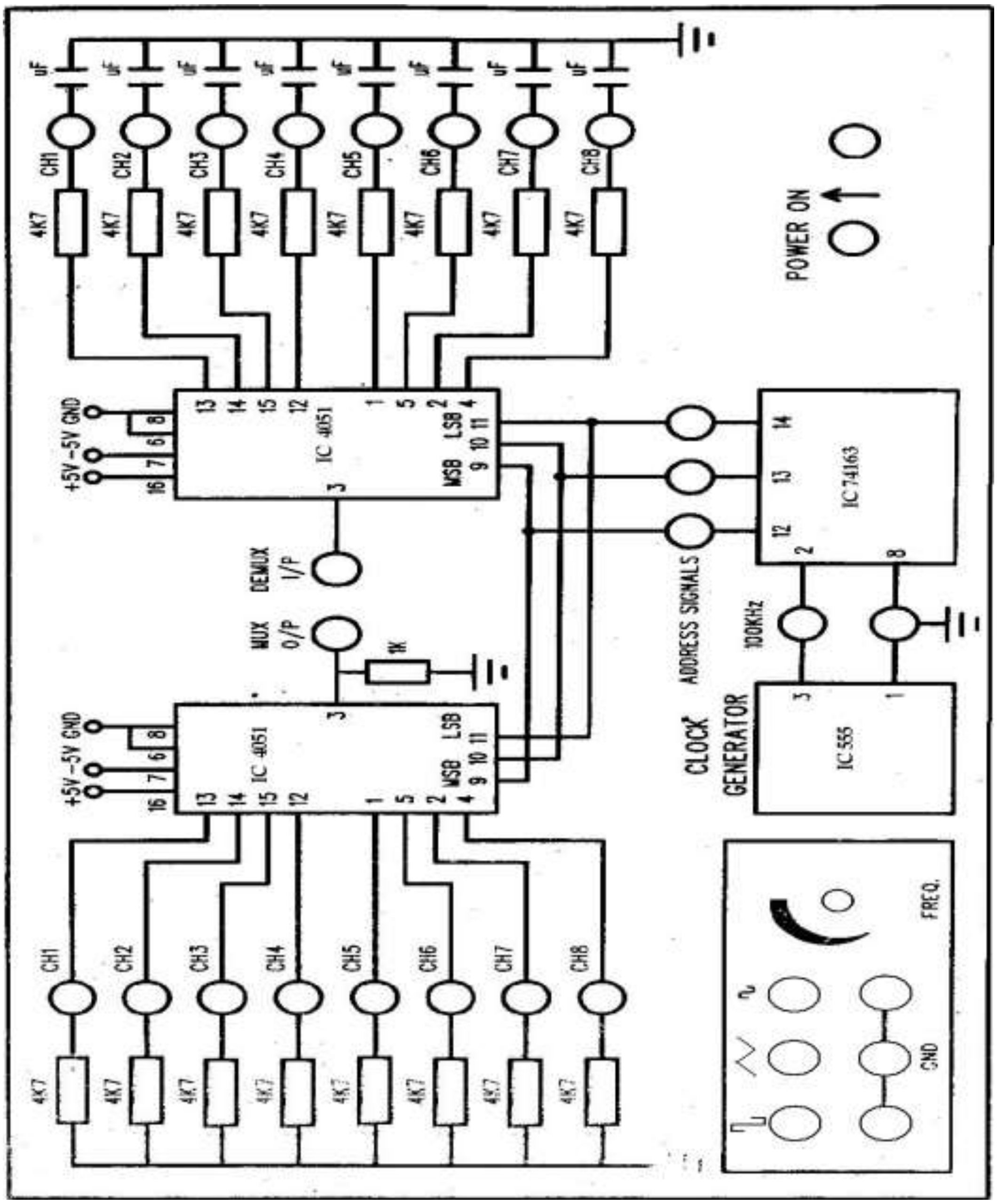
Equipment / Components Required

S. No	EQUIPMENT / COMPONENTS REQUIRED	Range	Quantity
1	Time-Division Multiplexing and Demultiplexing trainer Kit.	--------	1
2	C.R.O.	(0-20) MHz	1
3	Connecting wires.	-------	07

Theory

The TDM system is highly sensitive to dispersion in the common channel, that is, to variations of amplitude with frequency or lack of proportionality of phase with frequency. Accordingly, accurate equalization of both magnitude and phase response of the channel is necessary to ensure a satisfactory operation of the system. The primary advantage of TDM is that several channels of information can be transmitted simultaneously over a single cable. In the CIRCUIT DIAGRAM the 555 timer is used as a clock generator. This timer is a highly stable device for generating accurate time delays. In this circuit this timer generates clock signal, which is of 100 KHz frequency (approximately). This clock signal is connected to the 74163 IC. 74163 IC is a synchronous preset-able binary counter. It divides the clock signal frequency into three parts and those are used as selection lines for multiplexer and Demultiplexer. In built signal generator is provided with sine, square and triangle outputs with variable frequency. These three signals can be used as inputs to the multiplexer. IC 4051 is a 8 to 1 analog multiplexer. It selects one-of eight signal sources as a RESULT of a unique three-bit binary code at the select inputs. Again IC 4051 is wired as 1 to 8 De multiplexer. Demux input receives the data source and transmits the data signals on different channels.

Circuit Diagram

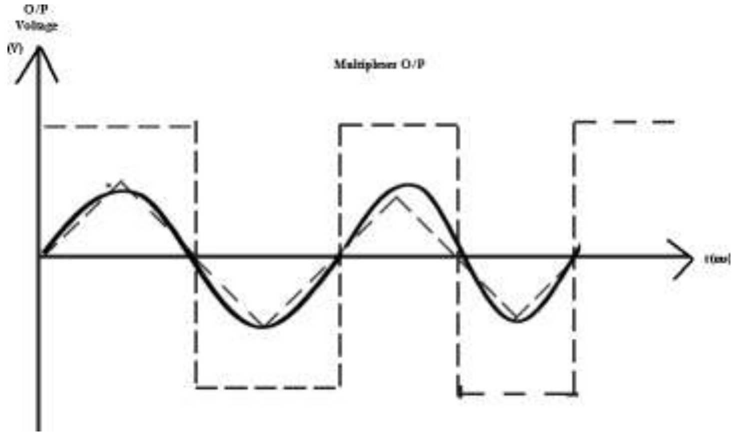


Procedure

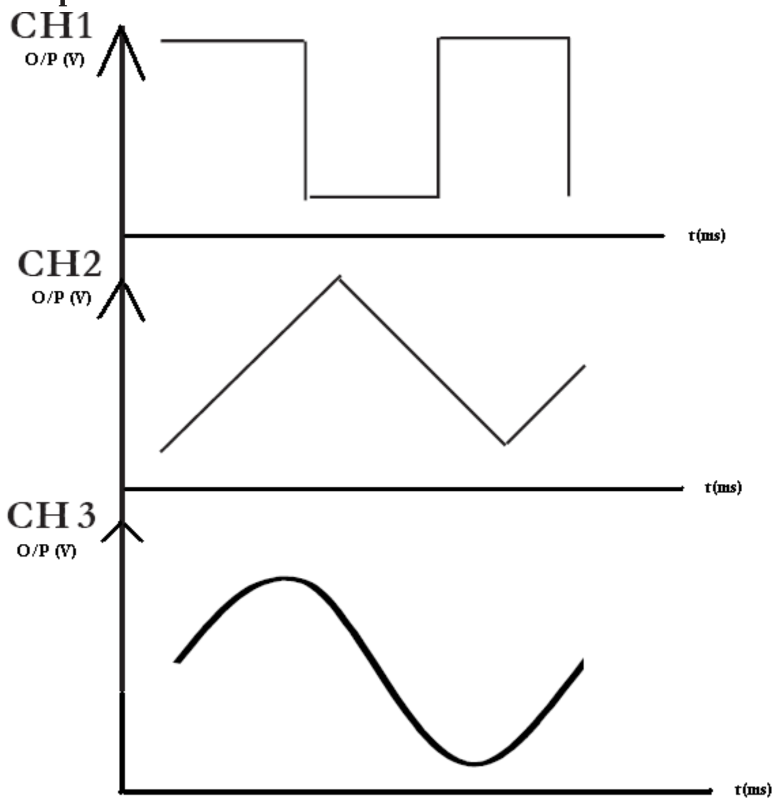
1. Switch on Time division multiplexing and demultiplexing trainer.
2. Connect the sine wave to ch1 , square wave to ch2 and Triangle wave form to Ch3Terminals of 8 to 1 multiplexer.
3. Observe the Multiplexer output on channel 1 of a CRO.
4. Connect Mux output to demux input.
5. Observe corresponding signal

Expected Waveforms (Hardware)

Multiplexer o/p:



De-Multiplexer Outputs:



Precautions

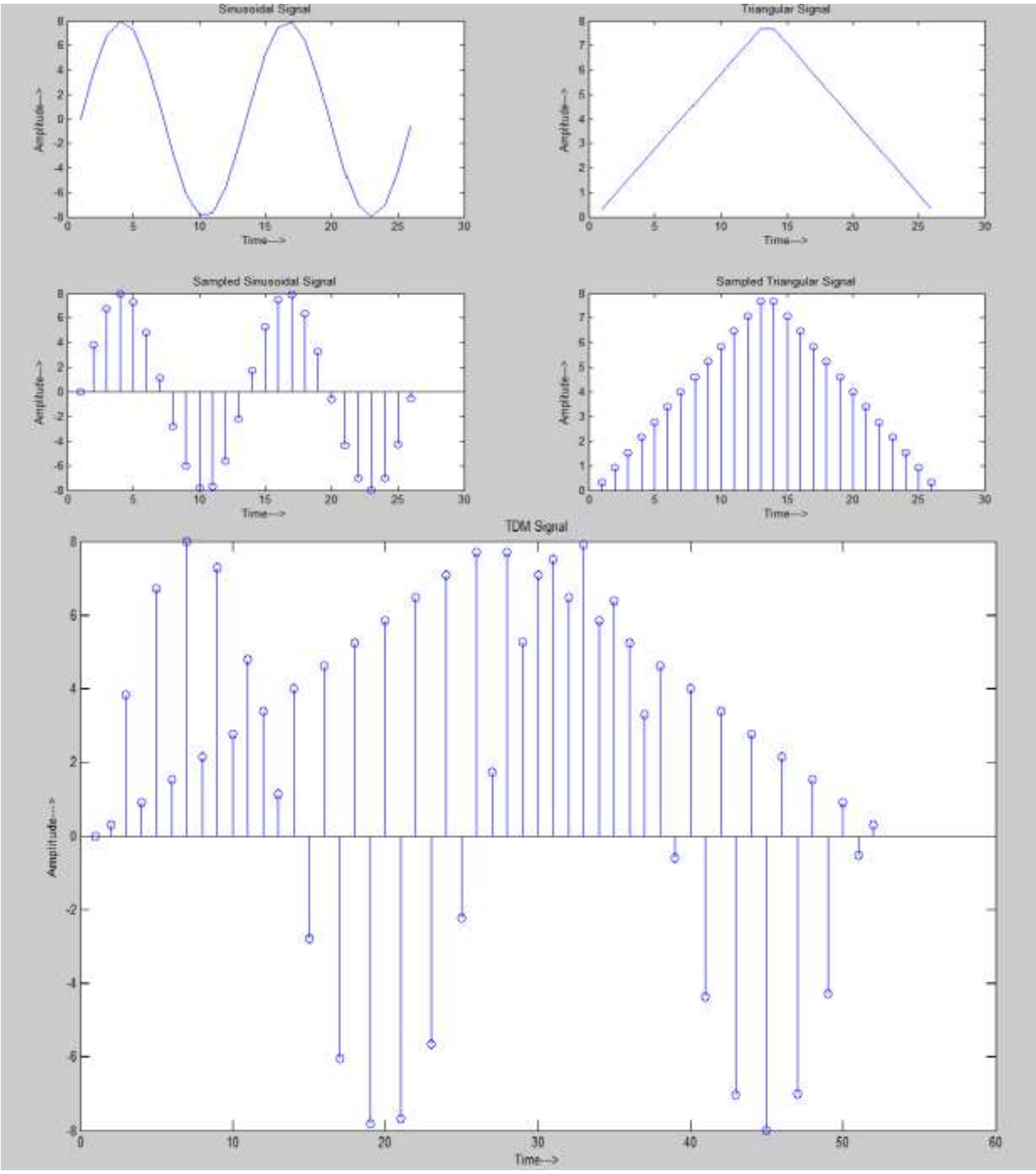
1. Check the connections before giving the power supply
2. Observation should be done carefully
3. Connect the circuit properly.
4. Apply the voltages wherever required.
5. Do not apply stress on the components.

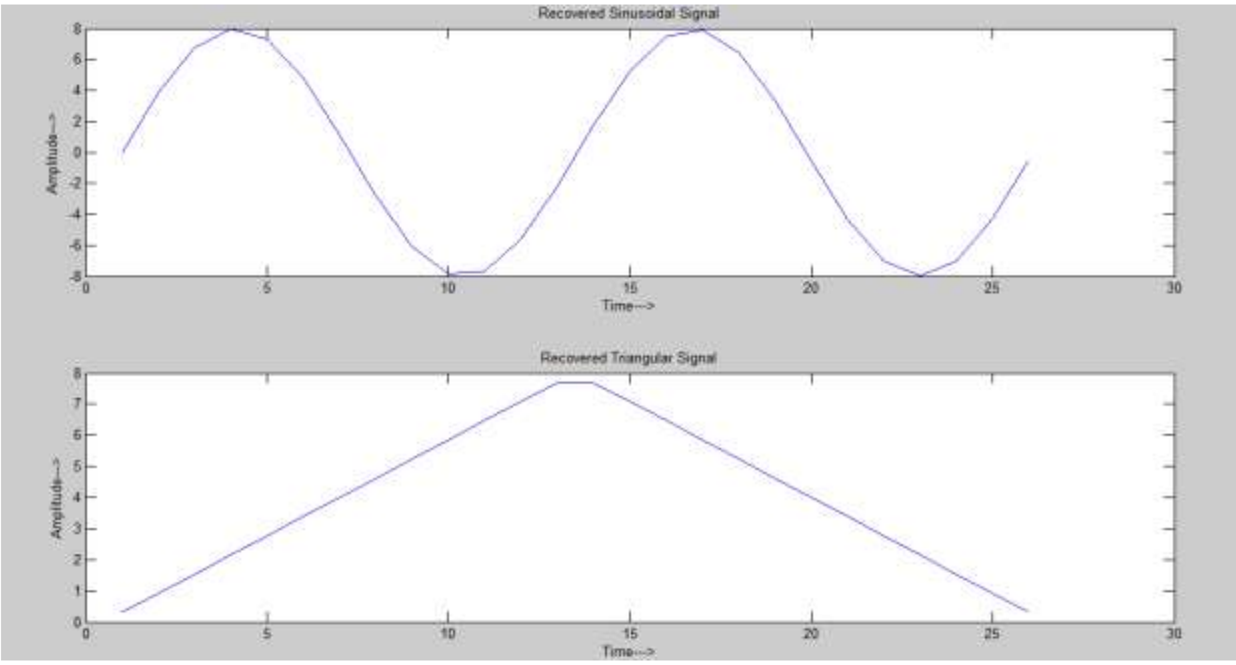
Matlab Program

```
clc;
close all;
clear all;
% Signal generation
x=0:.5:4*pi; % siganal taken upto 4pi
sig1=8*sin(x); % generate 1st sinusoidal signal
l=length(sig1);
sig2=8*triang(l); % Generate 2nd traingular Sigal
% Display of Both Signal
subplot(2,2,1);
plot(sig1);
title('Sinusoidal Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
subplot(2,2,2);
plot(sig2);
title('Triangular Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
% Display of Both Sampled Signal
subplot(2,2,3);
stem(sig1);
title('Sampled Sinusoidal Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
subplot(2,2,4);
stem(sig2);
title('Sampled Triangular Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
l1=length(sig1);
l2=length(sig2);
```

```
for i=1:l1
sig(1,i)=sig1(i); % Making Both row vector to a matrix
sig(2,i)=sig2(i);
end
% TDM of both quantize signal
tdmsig=reshape(sig,1,2*l1);
% Display of TDM Signal
figure
stem(tdmsig);
title('TDM Signal');
ylabel('Amplitude--->');
xlabel('Time--->');
% Demultiplexing of TDM Signal
demux=reshape(tdmsig,2,l1);
for i=1:l1
sig3(i)=demux(1,i); % Converting The matrix into row vectors
sig4(i)=demux(2,i);
end
% display of demultiplexed signal
figure
subplot(2,1,1)
plot(sig3);
title('Recovered Sinusoidal Signal'); ylabel('Amplitude--->');
xlabel('Time--->');
subplot(2,1,2)
plot(sig4);
title('Recovered Triangular Signal'); ylabel('Amplitude--->');
xlabel('Time--->');
```

Expected Waveforms





pre lab questions

1. Explain multiplexing?
2. Explain different types of multiplexing?
3. What are the advantages of multiplexing?

Lab Assignment

1. Observe TDM output at different channels?
2. Observe TDM output for 3 inputs using mat lab code

Post Lab Questions

1. Explain Time-division multiplexing
2. Differentiate FDM & TDM
3. What is the BW of TDM
4. Explain TDM Generation

Result:

The operation of time division multiplexing is studied

EXPERIMENT No. 9

AGC CHARACTERISTICS

9.1 Aim:

To study the AGC Characteristics.

9. 2 Equipment Required:

(i) AGC Characteristics circuit kit consists of wired circuitry:

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

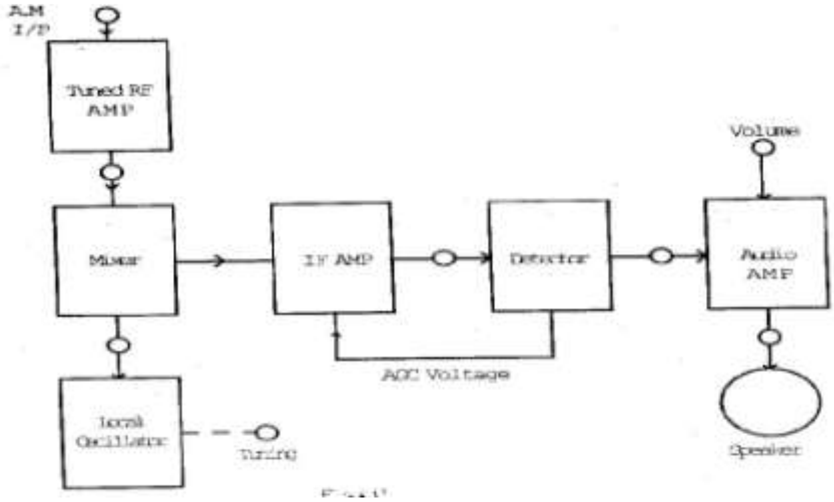
(ii) Dual traces C.R.O

(iii) Connecting wires

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. The devices used in those stages are ones whose transconductance and hence gain depends on the applied bias voltage or current. It may be noted 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 does not have to be re adjusted every time the receiver is tuned from one station to another, except when the change in signal strength is enormous.

Block Diagram



Expected Waveforms

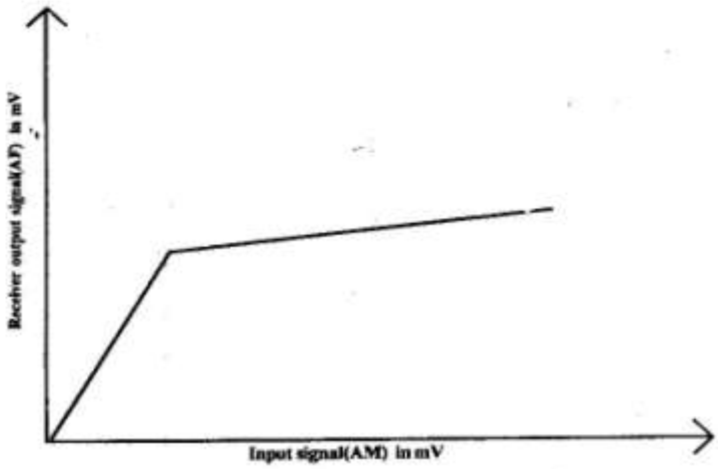


Fig.2. AGC characteristics curve

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 455 KHz frequency and AF voltage is 5Vpp of1 KHz frequency.

5. Now vary the amplitude of AF signal and observe the AM wave at output, note the percentage of modulation for different values of AF signal.% Modulation= (Emax -Emin) /(Emax+Emin) × 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 1 KHz will be observed.

10. Calculate the voltage gain by measuring the amplitude of output signal (Vo) waveform, using Formula A =Vo/V i

11. Now vary input level of 455 KHz IF signal and observe detected 1 KHz audio signal with and Without AGC link. The output will be distorted when AGC link removed i.e. there is no AGC action.

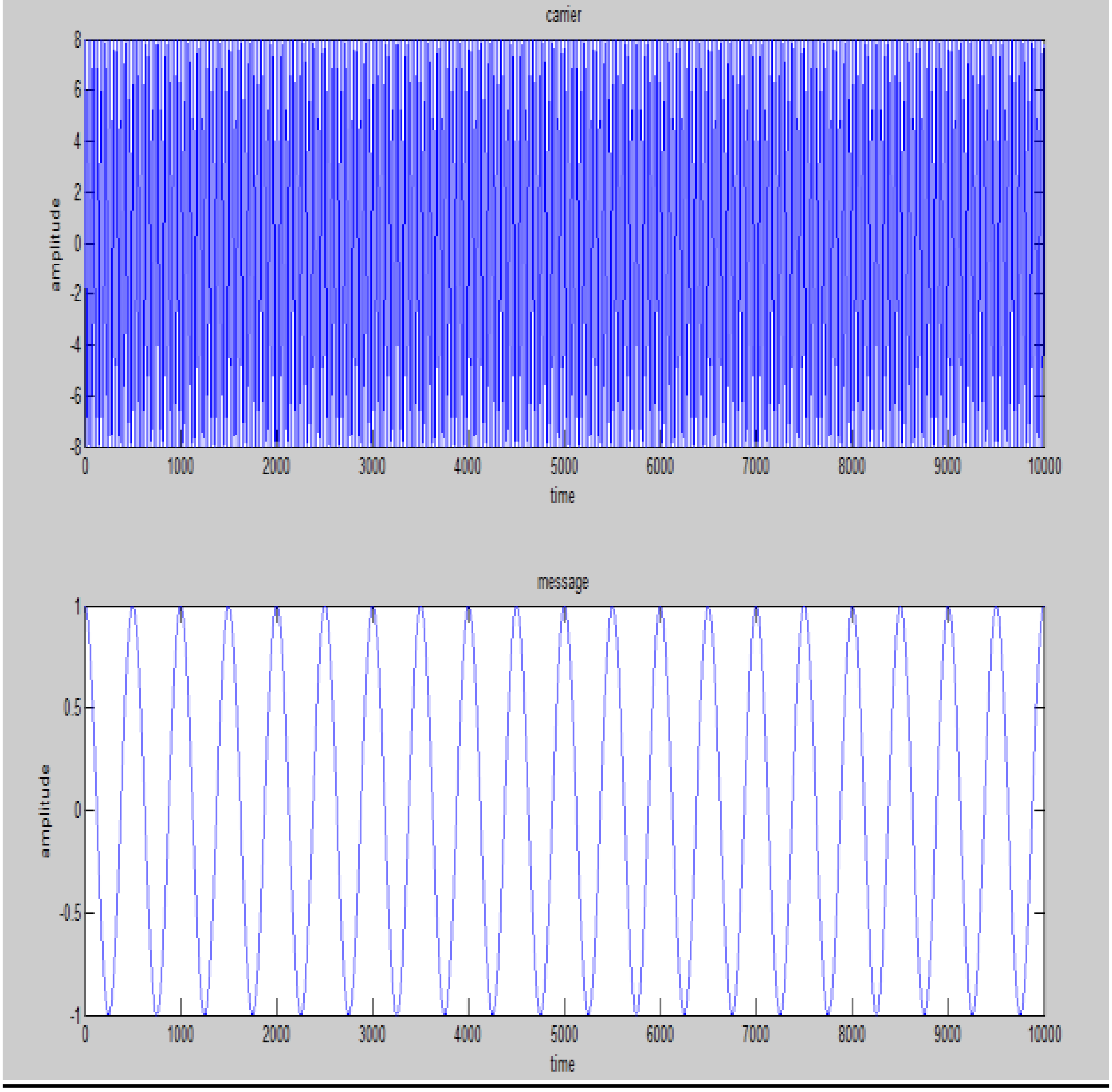
12. This explains AGC effect in Radio circuit.

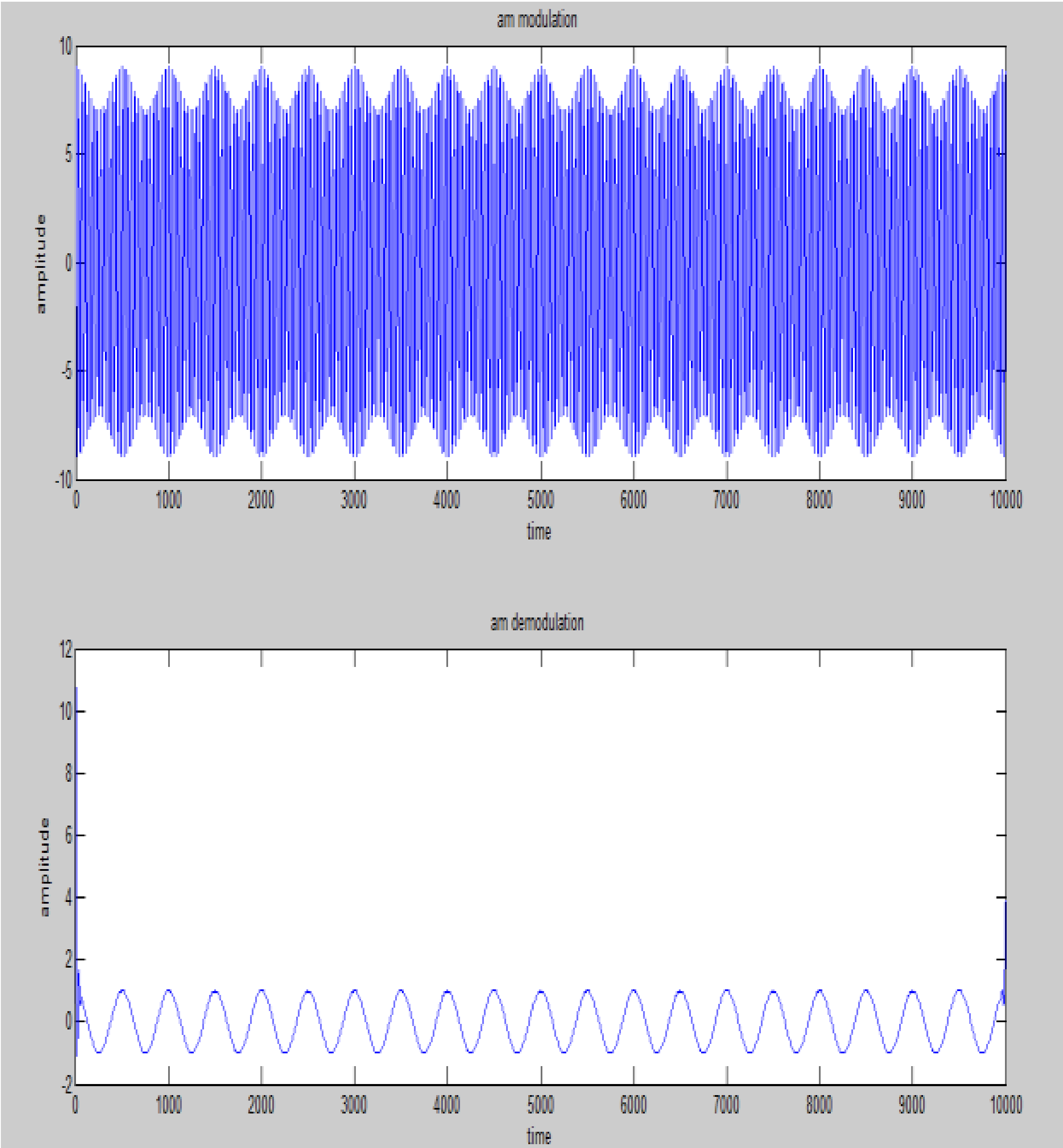
12.7 Mat Lab Program

```
close all
clear all
clc
Fs = 100e3; %sampling freq
t = 0:1/Fs:.1-1/Fs; % time variable
Am=2;
fm = 200; %fm 200 Hz
m = cos(2*pi*fm*t); %message signal
Fc = 3e3;
% am modulation
Ac = 8;
c=Ac.*cos(2*pi*Fc*t); %carrier signal
figure;
% ploting message and carrier signals
subplot(2,1,1);
```

```
plot(c);
title('carrier');
xlabel('time');
ylabel('amplitude');
subplot(2,1,2);
plot(m);
title('message');
xlabel('time');
ylabel('amplitude');
figure;
% ploting AM modulated output
s = ammod(m,Fc,Fs,0,Ac);
subplot(2,1,1);
plot(s);
title('am modulation ');
xlabel('time');
ylabel('amplitude');
z = amdemod(s,Fc,Fs,0,Ac);
subplot(2,1,2);
plot(z);
title('am demodulation ');
xlabel('time');
ylabel('amplitude');
```

Expected Waveforms





Tabular Column

Signal Type	Frequency	Amplitude
Modulating Signal		
Carrier Signal		
Modulated Signal		
De modulated Signal(without AGC)		
De modulated Signal(with AGC)		

Pre Lab Questions

1. Classify receivers
2. Explain Super heterodyne working principle.
3. List out the advantages and disadvantages of TRF receiver

Lab Assignment

1. Observe TRF Receiver characteristics?

Post Lab Questions

1 Define Sensitivity and Selectivity.

2. Define Image frequency rejection ratio.
3. Define image frequency.
4. Define Image frequency rejection ratio.

Result:

Thus AGC characteristics was studied and wave forms was observed.

EXPERIMENT No. 10
FREQUENCY SYNTHESIZER

Aim:

To study the operation of frequency synthesizer using PLL.

Equipment required:

Sl No	EQUIPMENT / COMPONENTS REQUIRED	Range	Quantity
1	Frequency synthesizer Trainer kit	--------	1
2	Function Generator	(0-1) MHz	1
3	C.R.O.	(0-20) MHz	1
4	Connecting wires.	-------	10
5	Digital Frequency multimeter		

Theory:

The frequency divider is inserted between the VCO and the phase comparator. Since the output of the divider is locked to the input frequency fin, 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 fout = 5 fin 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 Q1 used as a driver stage to increase the driving capacity 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 Fout of VCO by means of R1 (between 10th and 8th pin) and CI (9th pin), so that the output frequency of the 7490 driver ismidway within the predetermined input frequency range. The output of the VCO now should 5Fin.

Free running frequency (f_0):

Where there is no input signal applied, it is in free running mode.

$F_0 = 0.3 / (RtCt)$ where Rt is the timing resistor

Ct is the timing capacitor.

Lock range of PLL(f_L)

F_L = + $8f_0/Vcc$ where f_0 is the free running frequency

= 2VCC

Capture range (f_C)

$$F_C= 1/2\pi[(2\pi f_L/3.6*10^3*C_c]^{1/2}$$

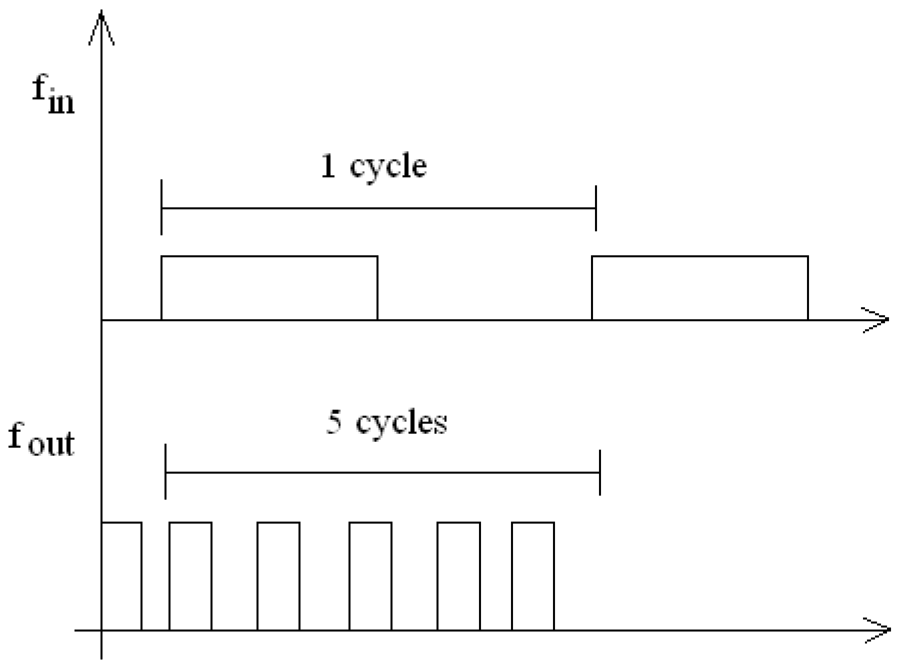
Procedure:

1. Switch on the trainer and verify the output of the regulated power supply i.e. + 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 1 KHz to 10 KHz.
3. Calculate the free running frequency range of the circuit (VCO output between 4th pin and ground). For different values of timing resistor R1 (to measure Rt switch off the trainer and measure Rt value using digital multimeter between given test points) . and record the frequency values in tabular 1. Fout = 0.3 /(RtCt) where Rt is the timing resistor and Ct is the timing capacitor =0.01 μf.
4. Connect 4th pin of LM 565 (Fout) to the driver stage and 5th pin (Phase comparator) connected to 11th pin of 7490. Output can be taken at the 11th pin of the 7490. It should be divided by the 10, 2 times of the fout.

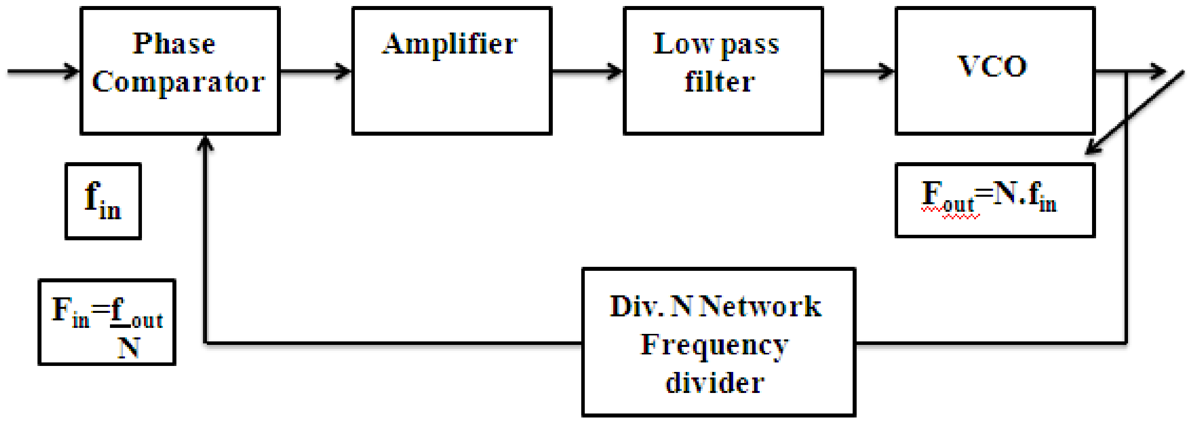
Precautions:

1. Check the connections before giving the power supply
2. Observation should be done carefully

Expected waveforms:



Circuit diagram:



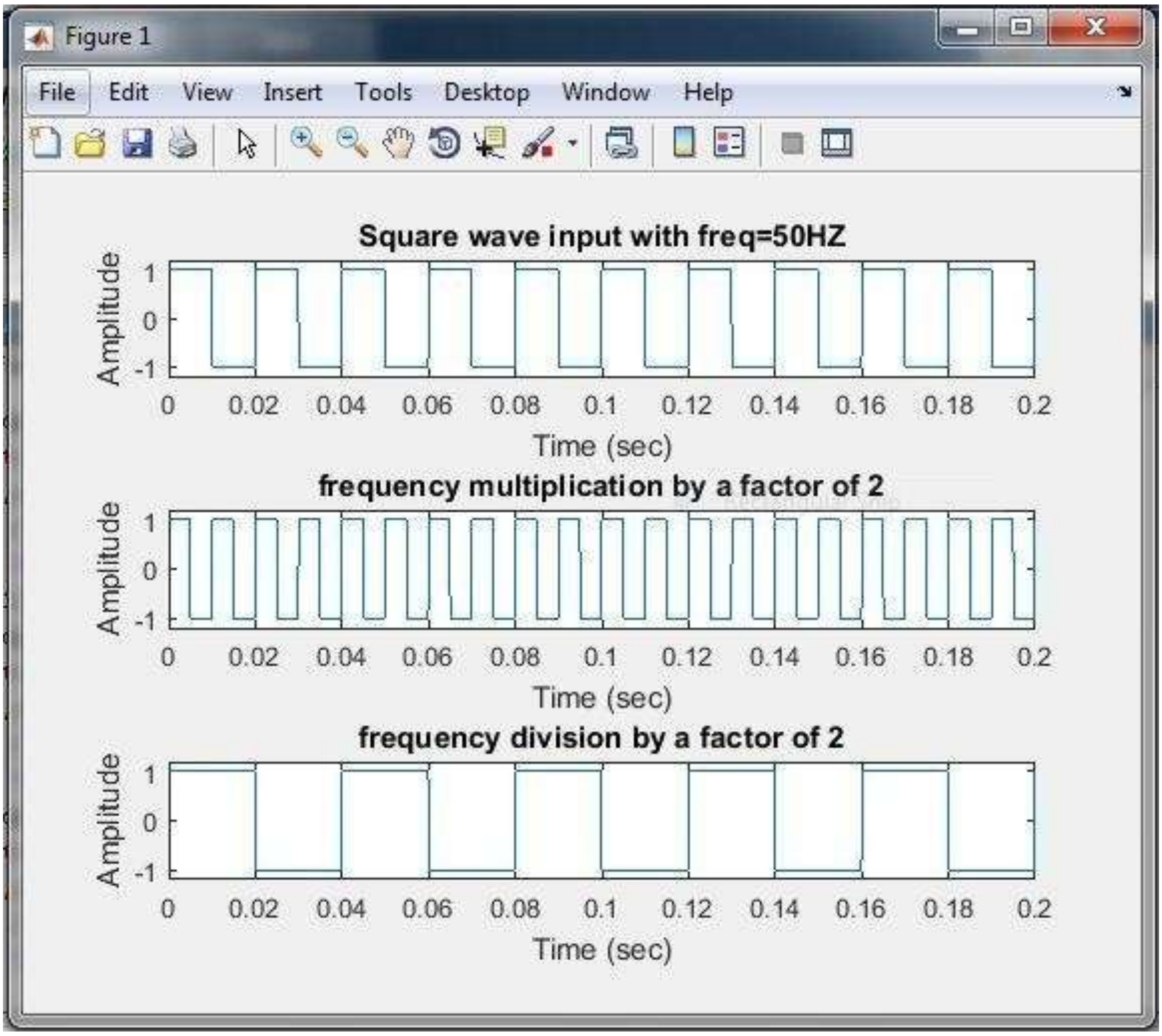
Tabular column:

Fin	Fout = N.Fin	Divided by 10,2

Program

```
close all;
clear  all;
clc
fs = 10000;
t = 0:1/fs:1.5;
f=50;
x1 = square(2*pi*f*t);
subplot(3,1,1)
plot(t,x1); axis([0 0.2 -1.2 1.2])
xlabel('Time (sec)');ylabel('Amplitude');
title('Square wave input with freq=50HZ');
t = 0:1/fs:1.5;
x2 = square(2*pi*2*f*t);
subplot(3,1,2)
plot(t,x2); axis([0 0.2 -1.2 1.2])
xlabel('Time (sec)');ylabel('Amplitude');
```

```
title('frequency multiplication by a factor of 2');
x3 = square(2*pi*f/2*t);
subplot(3,1,3)
plot(t,x3); axis([0 0.2 -1.2 1.2])
xlabel('Time (sec)');ylabel('Amplitude');
title('frequency division by a factor of 2');
```



Result:

Thus the frequency synthesizer is verified by using PLL.

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. 11
CHARACTERISTICS OF MIXER

AIM: To obtain the mixer characteristics of a super heterodyne receiver.

APPARATUS:

1. Receiver trainer
2. CRO
3. function generator

THEORY: The block diagram of the super heterodyne receiver is as shown. The receiver is divided into three parts 1.The high frequency section 2. The intermediate-frequency section and 3. The low frequency section. The following are the internal blocks of the receiver.

Receiving antenna: The electromagnetic waves as they travel from the transmitter, which strikes the receiving antenna and generates a small voltage in it usually less than 50 mill volts and often a few Microvolt. This signal strength depends on the power of the transmitter.

RF amplifier: The antenna signal is fed to the RF amplifier. The signal at the antenna has the lowest signal- noise level, and all the following amplifiers in the receiver circuits add some noise to the wanted signal. So the major function of the RF amplifier is to provide gain at the point of lowest noise in the system. The RF amplifier is the first stage of amplification and amplifies the incoming signal above the level of the internally generated noise and also to start the process of selecting the wanted station and rejecting the unwanted signals.

Local oscillator: this is an oscillator producing a sinusoidal output similar to the carrier wave in the transmitter. The local oscillator in low frequency system is always operated at a frequency higher than the incoming RF signal by an amount equal to the IF. In higher frequency bands the local oscillator may be operated above or below the incoming RF signal.

Mixer: The output signal from the RF amplifier is coupled to a mixer amplifier. The mixer performs a similar function in the transmitter. It has a high and low frequency input signal, it is biased nonlinearly, and it will produce the sum (L.O + RF)and difference (L.O – RF) frequencies.

Mixing of two signals to produce such components is called a heterodyne process. When this is carried out at frequencies, which are above the audio spectrum called „supersonic‟ frequencies, the type of receiver is called a super heterodyne receiver.

IF amplifier: The IF amplifier in the receiver consists of two stages of amplification and provides the main signal amplification and selectivity. The IF amplifiers are tuned circuits and operating at a fixed IF frequency of 455kHz. At the final output of the IF amplifier the 455kHz wave which is amplitude modulated by the wanted audio information. The selectivity of the IF amplifiers has removed the unwanted components generated by the mixing process.

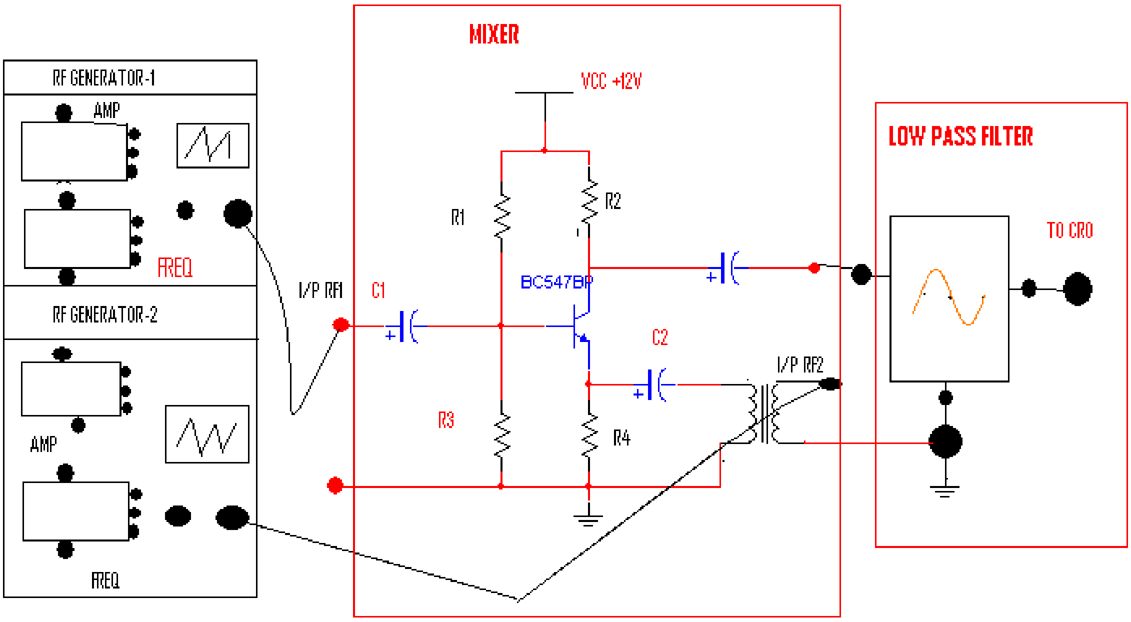
Detector: The function of the diode detector is to extract the audio signal from the signal at the output of the IF amplifier. The oscillator mixer circuits and the AM detector act similarly in terms of changing frequency. The oscillator mixer down converts the signal from an RF to an IF and the second detector down converts the signal from the IF to the message frequencies.

The AM detector circuit contains a half-wave rectifier followed by a low pass filter. The diode conducts every time the input signal applied to its anode is more +ve than the voltage on the top plate of the capacitor. When the voltage falls below the capacitor voltage the diode stops conduction and the voltage across the capacitor leaks away until the next input signal is able to switch on again. The results are an O/P which contains 1.the wanted audio information 23. Some ripple at the IF frequency and 3.a positive DC level.

Automatic gain control: The AGC circuit is used the DC voltage present at the output of the detector is further filtered and fed back to the first IF amplifier as a bias voltage to modify the gain of the amplifier relative to the signal strength at the antenna. When a strong signal is received, the detector DC output level is high and a large dc voltage is sent back to the first IF to reduce the gain. When the incoming signal is weak a smaller dc voltage is sent back to the IF amplifier to increase the gain. What -ever it may be the signal level at the output of the detector is constant for either a weak or strong signal at the antenna. So the AGC circuit is used to prevent very strong signals from over loading the receiver. It can also reduce the effect of fluctuations in the received signal strength.

Audio amplifier: At the input to the audio amplifier a low pass filter is used to remove the IF ripple and a capacitor blocks the DC voltage level. The audio amplifiers increase the strength of the signal to be presented across the speaker.

CIRCUIT DIAGRAM:



PROCEDURE:

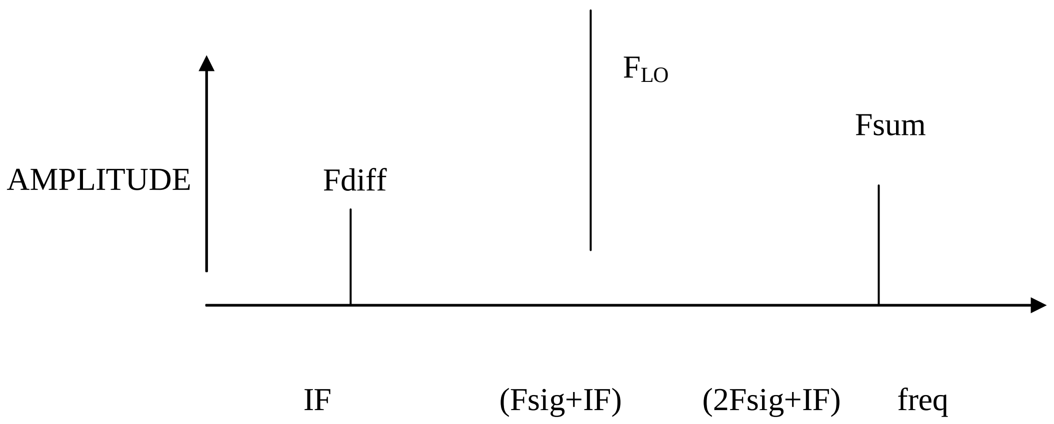
1. Experimental set up as shown in the block diagram.
2. Adjust RF generator -1 amplitude at 4V and frequency at 400KHz.
3. Adjust RF generator – 2 amplitude to 4V and frequency at 380 KHz.
4. Connect RF generator-1 o/p to RF1 input of the mixer.
5. Connect RF generator -2 o/p to the RF2 input of the mixer.
6. Connect the o/p of the mixer to the i/p of low pass filter.
7. Observe the o/p of low pass filter using CRO and measure the frequency of the o/p signal and it is equal to the difference of the frequencies of RF1 & RF2.
8. For different values of RF1 & RF2 frequencies measure the o/p frequencies and tabulate.

By mixing the local oscillator‟s output with the RF amplifier which produces three components as shown

The local oscillator frequency = Fsig+IF

The sum frequencies Fsum = 2Fsig+IF

The difference frequencies Fdiff = (Fsig +IF –Fsig)

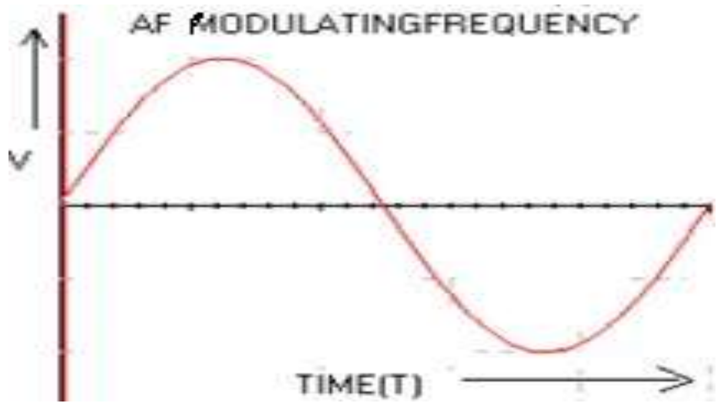


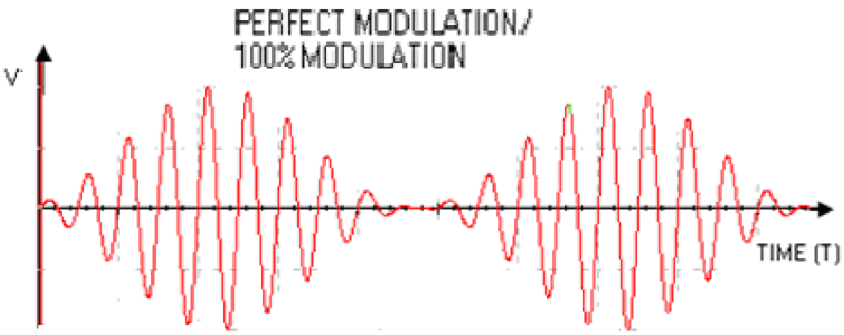
OBSERVATIONS

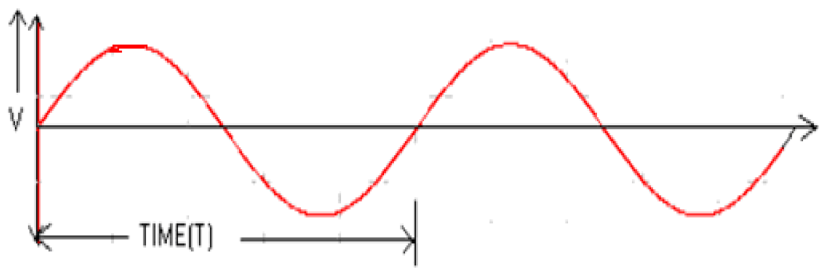
S.NO	INPUT	INPUT	OUTPUT
	Fx (KHz)	Fy (KHz)	F(x-y) (KHz)
1			
2			
3			
4			
5			
6			
7			
8			
9			

Fx=RF1 frequency Fy= RF2 frequency

MODEL WAVE FORMS:



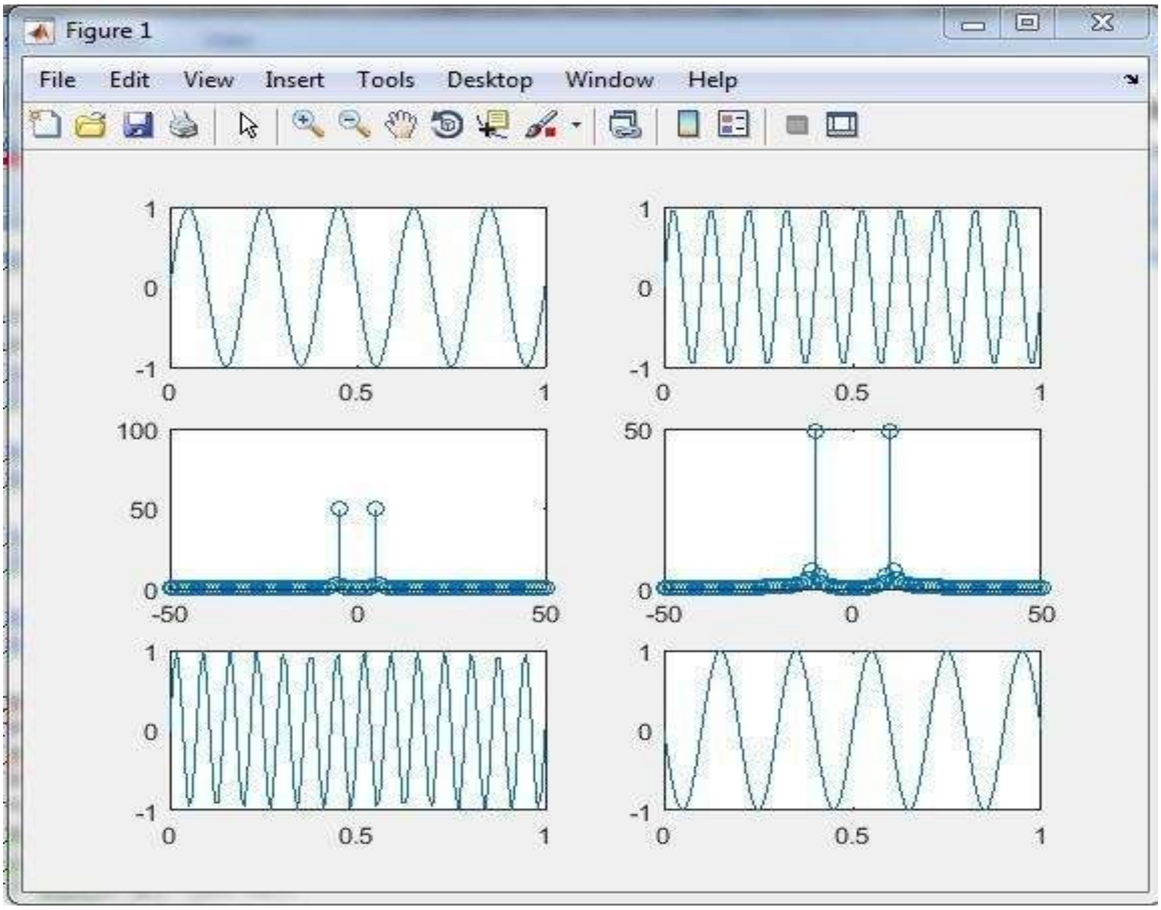




MATLAB Program

```
clc
clear all
fs=100;
n=0:0.01:1;
f1=sin(10*pi*n);
```

```
subplot(3,2,1)
plot(n,f1)
f2=sin(20*pi*n);
subplot(3,2,2)
plot(n,f2)

d1=length(f1);
t=-fs/2:1:fs/2;
ff1=abs(fft(f1,d1));
ff1=fftshift(ff1);
ff2=abs(fft(f2,d1));
ff2=fftshift(ff2);

subplot(3,2,3)
stem(t,ff1)

subplot(3,2,4)
stem(t,ff2)

m1=max(ff1);
m2=max(ff2);
for i=1:(length(ff1)/2)
if(ff1(i)==m1)
        value1=i;
end
end

for i=1:(length(ff2)/2)
if(ff2(i)==m2)
        value2=i;
end
end

qwer=(length(ff1)/2)-value1;
qwer2=(length(ff2)/2)-value2;
fs=qwer+qwer2;
fs1=qwer-qwer2;
y=sin(2*pi*fs*n);
subplot(3,2,5)
plot(n,y)
y1=sin(2*pi*fs1*n);
subplot(3,2,6)
plot(n,y1)
```



Pre lab questions:

1. Explain briefly super heterodyne receiver?
2. What is the function of the receiving antenna in the receiver?
3. What are the disadvantages for removing the RF amplifier in the receiver?
4. What is the function of the RF amplifier in a receiver?

Post lab questions:

1. The standard IF range is?
2. What is the function of IF amplifier in a receiver?
3. What is the function of detector?
4. If there is no AGC section in the receiver then what happens to the output?
5. What is the function of the audio amplifier?
6. What is the image frequency?

RESULT: The output characteristics of Mixer are observed.

EXPERIMENT No.12
STUDY OF SPECTRUM ANALYZER

AIM:

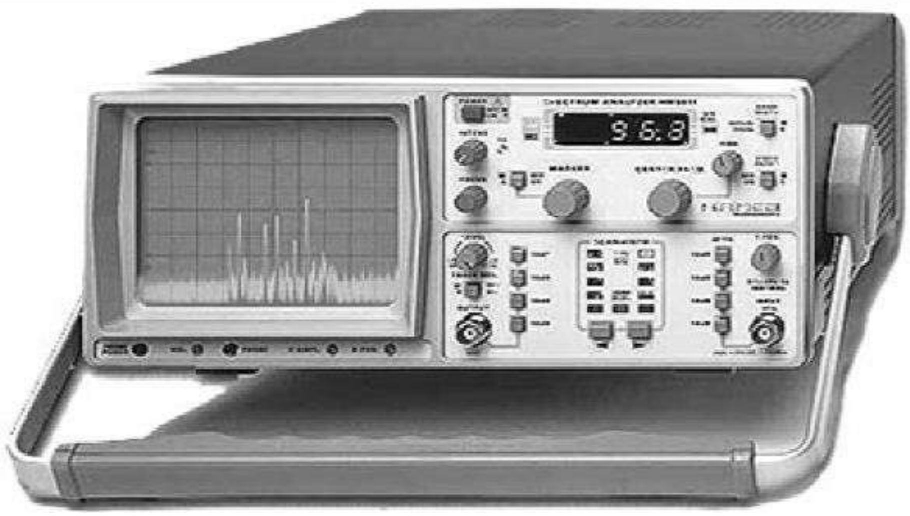
To study the operation of spectrum analyzer.

Equipment / components required:

S.No	EQUIPMENT / COMPONENTS REQUIRED	Range	Quantity
1	Spectrum Analyzer	--------	1
2	Any modulation system kit		1
3	Connecting wires.	-------	Required

Introduction

To analyze the AM and FM waveform using spectrum analyzer. The oscilloscope is the most common device used to display the signals, with time as x-axis. The signals which require time as x-axis, to display them are time domain signals. The signals which require frequency as x-axis, to display them are called frequency domain signals. Frequency domain display of signal consists of information of energy distributed of the signal. The analysis of such a frequency domain display of the signal is called spectral analysis of the signal. Thus the study of the energy distribution across the frequency spectrum if a given signal is defined as the spectral analysis. The instrument which graphically provides the energy distribution of a signal as a function of frequency on its CRT is called spectrum analyzer. It provides a calibrated graphical display with the frequency on horizontal axis and the signal component on the vertical axis, the sinusoidal components of which, the signal is made up of, are displayed as the vertical lines against frequency coordinates. The frequency of each vertical line gives the absolute amplitude if the component while the horizontal location gives that particular frequency.



HAMEG 5010 SPECTRUM ANALYZER

The analysis of electrical signals is a fundamental problem for many engineers and scientists. Even if the immediate problem is not electrical, the basic parameters of interest are often changed into electrical signals by means of transducers. The rewards for transforming physical parameters to electrical signals are great, as many instruments are available for the analysis of electrical signals in the time and frequency domain. The traditional way of observing electrical signals is to view them in time domain using oscilloscope. The time domain is used to recover relative timing and phase information which is needed to characterize electrical circuit behavior. How ever, not all circuit can be uniquely characterized from just time domain information. Circuit elements such as amplifiers, oscillators, mixers, modulators, detectors and filters are best characterized by their frequency response information. This frequency information is best obtained by viewing electrical signals in frequency domain. To display the signal in the frequency domain requires a device that can discriminate between frequency domains is the spectrum analyzer. It graphically displays the voltage or power as a function of frequency on a CRT. In the time domain, all frequency components of a signal are seen summed together. In the frequency domain, complex signals are separated in to their frequency components, and power level at each frequency is displayed. The frequency domain is a graphical representation of signal amplitudes as a function of frequency. The frequency domain contains information not found in time domain.

Types Of Spectrum Analyzers

There are two basic types of spectrum analyzers, swept-tuned and real time analyzers. The swept-tuned analyzers are tuned by electrically sweeping them over their frequency range. Therefore the frequency components of a spectrum are sampled sequentially in time. This enables periodic and random signals to be displayed, but makes it impossible to display transient response. Real time analyzers, on the other hand, simultaneously display the amplitude of all signals in the frequency range of the analyzer: hence the name real-time. This preserves the time dependency between signals which permits information to be displayed. Real time analyzers are capable of displaying transient response as well as periodic and random signals. The swept tuned analyzers are usually of the TRF (tuned radio frequency) or super heterodyne type. A TRF analyzer consists of a frequency range, a detector to produce vertical deflection on a CRT, and a horizontal scan generator used to synchronize the tuned frequency to the CRT horizontal deflection. It is a simple, inexpensive analyzer with wide frequency coverage, but lacks resolution and sensitivity. Because TRF analyzers have swept filter they are limited in sweep width.

Applications Of Spectrum Analyzers

1. **Modulation measurements**:
   When the frequency scan of spectrum analyzer is set to zero and x-axis is representing time instead of frequency, it operates as a fixed tuned receiver to measure amplitude against time. This is called its synchroscope mode. When analyzer is tuned to carrier frequency with bandwidth at least twice that of modulation frequency and with a linear display, the envelop of an AM signal is observed. Measuring the peak VP and through VT, modulation index can be determined. When operated in normal mode, two sidebands separated from the carrier by modulation frequency fm are observed. The modulation index can be calculated from the sidebands and carrier amplitude. Similarly it can be used to calculate the distortion occurring in modulation process. The sideband configuration in frequency modulation enables observer to calculate the frequency modulation index.

2. **Continuous wave signal frequency stability**
   The frequency drift of a signal can be measured by observing the excursions of the signal across the display. Over period of minutes, it gives long term stability while over period of seconds it gives short term stability.

3. **Harmonic distortion measurement**
   The distortion affects the frequency components of a signal to be transmitted. The harmonics appear as the additional signals in the spectrum analyzer at multiples of the carrier frequency. To keep it low, its measurement plays an important role. The spectrum analyzer can be used to make such distortion measurements.

4. **Noise measurement**
   The noise can be measured with very straightforward method using the spectrum analyzer. Similarly the measurement of impulse noise also can be measured using spectrum analyzer. The examples of impulse noise in the generation of voltage spikes due to engine ignition and electric motor commutation.

5. **Examining Pulse Modulation**
   This is the first application of spectrum analyzer. The spectrum analyzer can be used to
   Measure or evaluate the quality of the pulse modulation. The difficult task of measuring pulse Modulation of radar transmitters is possible due to spectrum analyzer. Apart from these common applications it is used in the following applications as well.
   1) In the fields of biomedical electronics, geological surveying, oceanography. It is used to analyze the water and air pollution.
   2) It is used to measure the antenna pattern.
   3) It is used to tune the parametric amplifier.
   4) It is used to examine the vibration signals from the automobiles,

airplanes, space vehicles bridges and other mechanical systems. It provides useful information about mechanical integrity, unbalance and bearing, gear wear.

5) It finds number of applications in the field of electronic testing related to trouble shooting and quality control.

EXPERIMENT No. 13

Generation of DSBSC using Ring modulation

AIM: To generate AM-Double Side Band Suppressed Carrier (DSB-SC) signal using Ring Modulator.

Equipment & Components Required

S.No	EQUIPMENT / COMPONENTS REQUIRED	Range	Quantity
1	Ring modulator Trainer kit	--------	1
2	Function Generator	(0-1) MHz	1
3	C.R.O.	(0-20) MHz	1
4	Connecting wires.	-------	Required

Theory

The operation of the ring modulator is explained with the assumptions that the diodes act as perfect switches and that they are switched ON and OFF by the RF carrier signal . This is because the amplitude and frequency of the carrier is higher than that of the modulating signal .

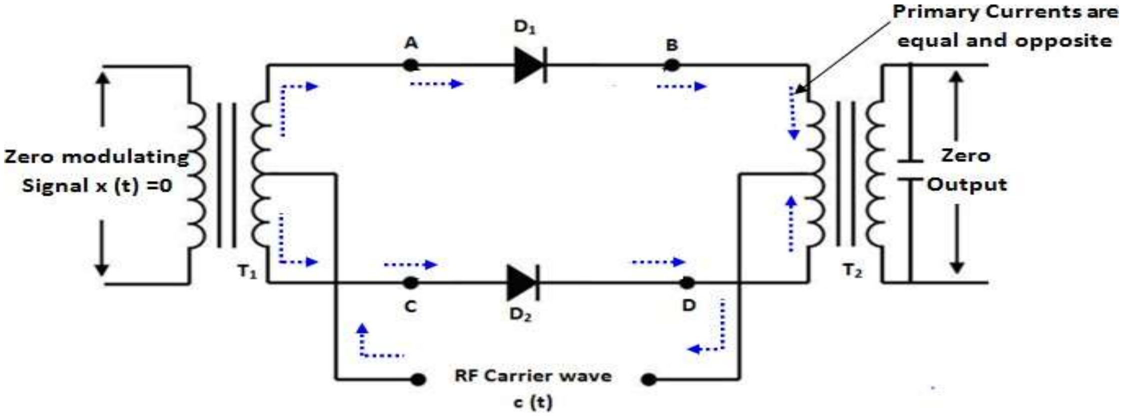
The operation can be divided into different modes without the modulating signal and with the modulating signal as follows :

Mode 1 : Carrier Suppression

To understand how carrier suppression takes place, let us assume that the modulating signal is absent and only the carrier signal is applied.

Hence x(t) = 0

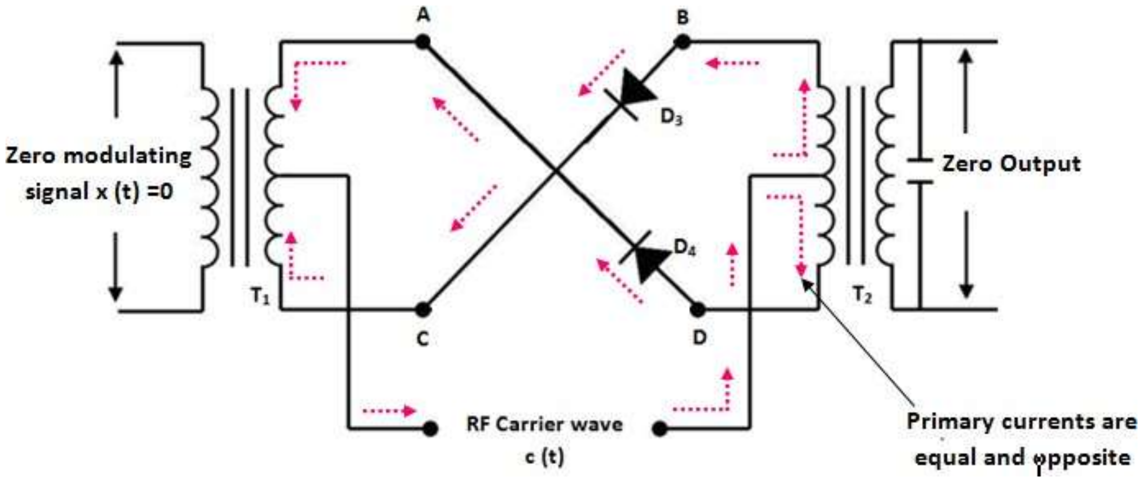
(i) Operation in the Positive half-cycle of Carrier



As shown in the fig , the diodes D_1 and D_2 are forward biased and the diodes D_3 and D_4 are reverse biased .We can observe that the direction of currents flowing through the primary windings of output transformer T_2 are equal and opposite to each other .Therefore, the magnetic fields produced by these currents are equal and opposite and cancel each other. Hence, the induced voltage in secondary winding is zero . Thus, the carrier is supported in the positive half-cycle

(ii) Operation in the Negative half-cycle of Carrier

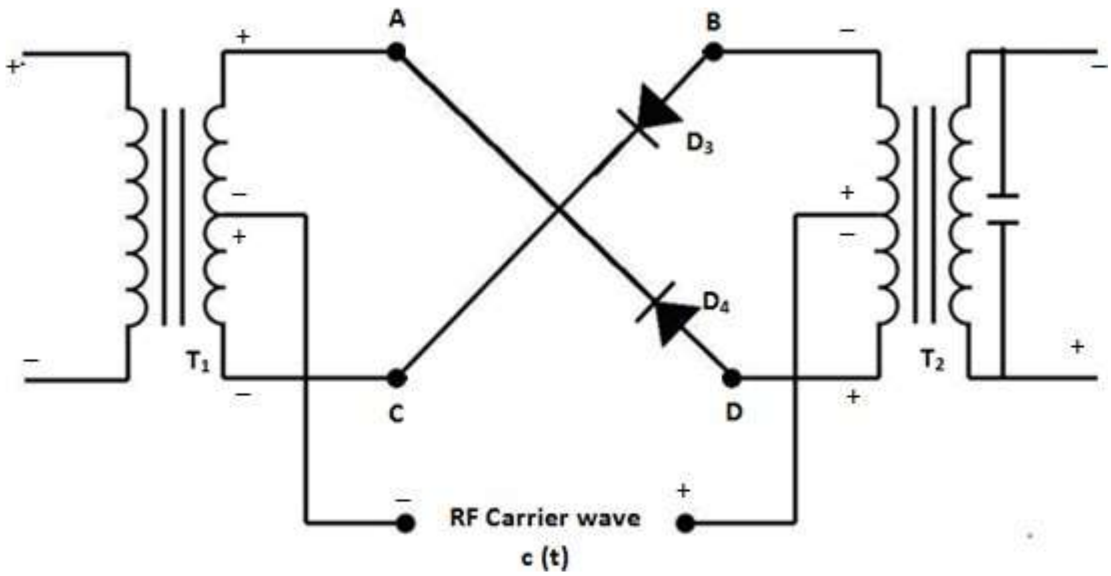
In this mode also let us assume that the modulating signal is zero .In the negative half-cycle of the carrier, the diodes D_3 and D_4 are forward biased and the diodes D_1 and D_2 are reverse biased .



In fig , the currents flowing in the upper and lower halves of the primary winding of T_2 are again equak and in opposite directions . This cancels the magnetic fields as explained in mode 1 (i) .Thus, the output voltage in this mode also is zero .Thus, the carrier is suppressed in the negative half-cycle as well .It is important to note that the perfect cancellation of the carrier will take place if and only if he characteristics of the diodes are perfectly matched and the centre tap is placed exactly at the centre of the primary transformer T_2 .

(ii) Operation in the Negative half-cycle of Modulating Signal

When modulating signal reverses the polarities, the operation of the circuit is same as that in the positive half-cycle discussed earlier .



Now, the only difference is that the diode pair D_3 D_4 will produce a positive output voltage whereas D_1 D2 will produce a negative output voltage as shown in the waveforms of fig .

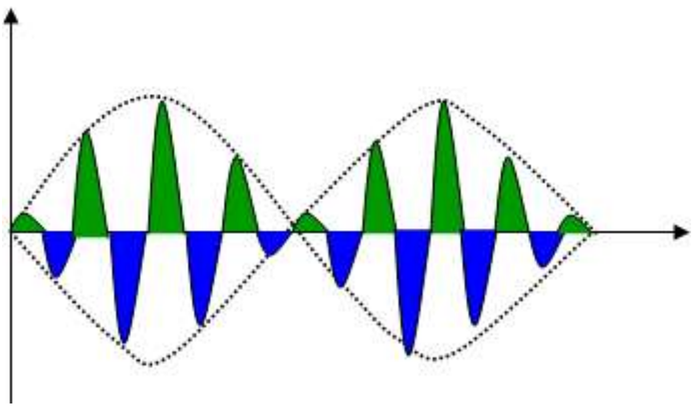
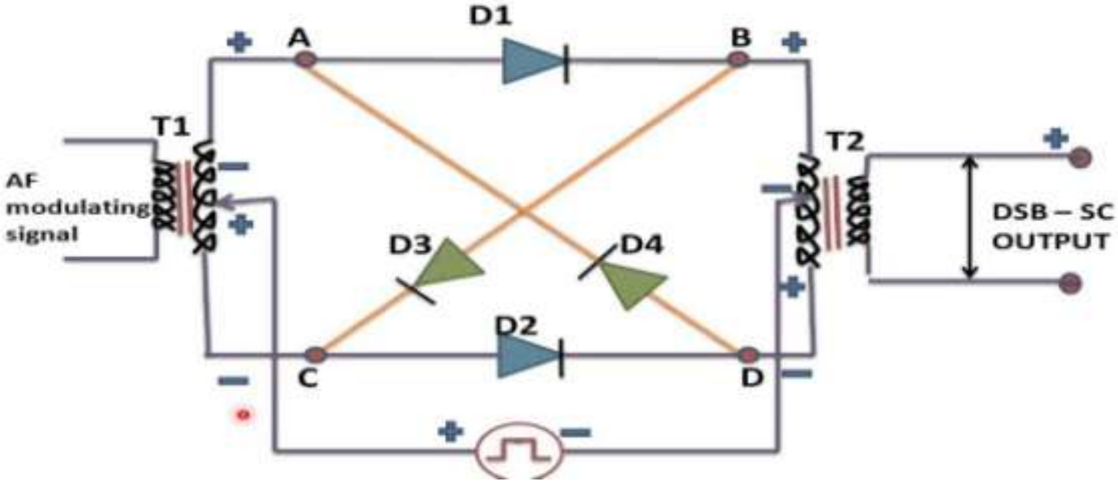


Fig: DSB –SC Output across secondary transformer

Circuit Diagrams

Ring Modulator



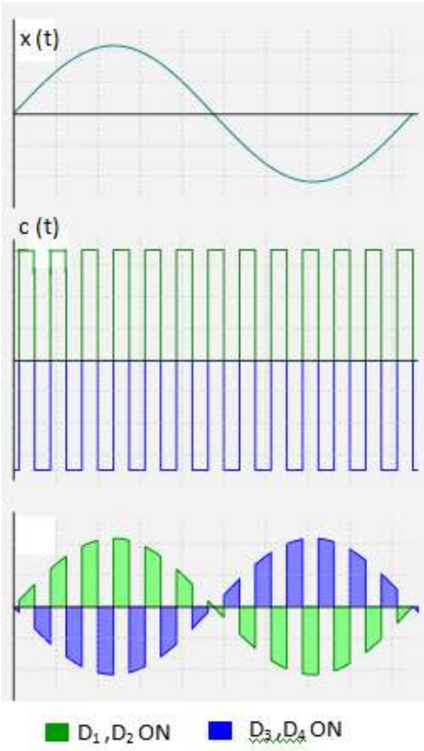
Procedure

1. Switch on the Ring modulator trainer kit
2. Generate the AF Modulating signal from the function generator and apply it to primary transformer.
3. Generate the carrier signal pulses from the function generator and apply it to the center tapped section
4. Observe different modes of operation in the kit
5. Finally observe the double side suppression carrier waveform accorss the Secondary transformer winding.

12. 6 Precautions

1. Check the connections before giving the power supply
2. Observations should be done carefully.

12.7 Expected Wave Forms

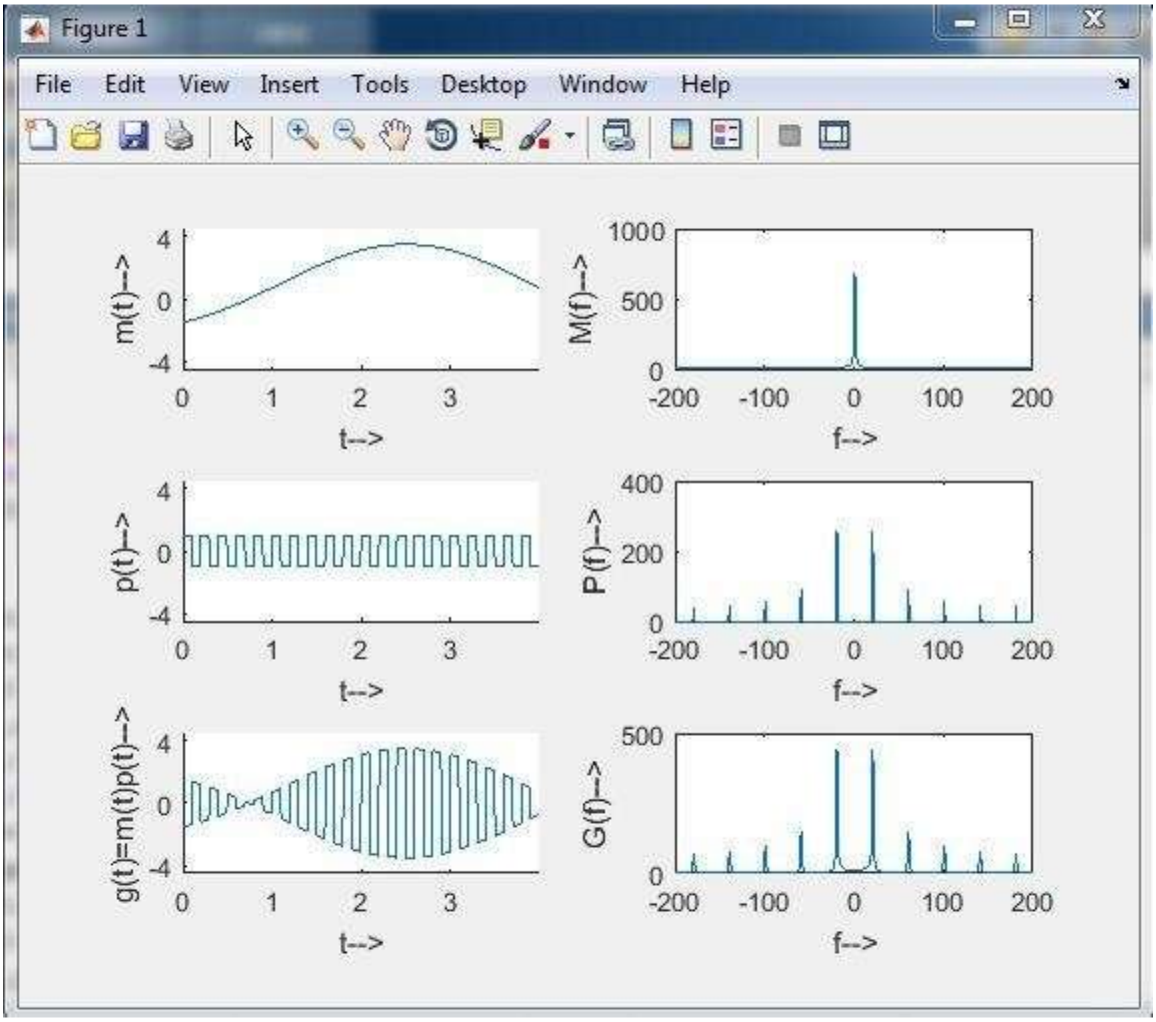


DSB-SC Signal at primary of T_2

Program

```
clc
clear all;
close all;
t=0:0.01:(4-0.01);
T=10;
f=1/T;
a=2*sin(2*pi*f*t)-1.5*cos(4*pi*f*t);
subplot(321);
axis([0 (4-0.01) -4.5 4.5]); hold on;
plot(t,a);
xlabel('t-->');
ylabel('m(t)-->');
pulses=[ones(1,10) -ones(1,10)];
pul=repmat(pulses,1,20);
subplot(323)
axis([0 (4-0.01) -4.5 4.5]); hold on;
plot(t,pul);
xlabel('t-->');
ylabel('p(t)-->');
subplot(325)
a1=pul.*a;
axis([0 (4-0.01) -4.5 4.5]); hold on;
plot(t,a1);
xlabel('t-->');
ylabel('g(t)=m(t)p(t)-->');
%%%%%%%%%%%%%%%FFT%%%%%%%%%
s1 = abs(fftshift((fft(a))));
subplot(322)
pt=20;
```

```
f=-199:200;
%f=-99:100;
%axis([0 (4-0.01) -4.5 4.5]); hold on;
%s1=s1(-99:100);
plot(f,s1);
xlabel('f-->');
ylabel('M(f)-->');
s2=fftshift(abs(fft(pul)));
subplot(324)
f=-199:200;
plot(f,s2);
xlabel('f-->');
ylabel('P(f)-->');
s3=fftshift(abs(fft(a1)));
subplot(326)
f=-199:200;
plot(f,s3);
xlabel('f-->');
ylabel('G(f)-->');
```



Result

The Ring modulator is demonstrated and carrier suppression is calculated

EXPERIMENT No. 14

PHASE LOCKED LOOP

AIM:

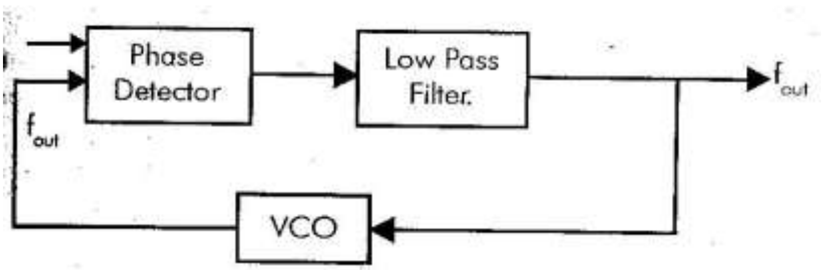
To compare the theoretical and practical values of capture range and lock range of phase locked loop.

Apparatus:

Sl.No	EQUIPMENT / COMPONENTS REQUIRED	Range	Quantity
1	PLL Trainer Kit.	--------	1
2	C.R.O.	(0-20) MHz	1
3	Function Generator (0-1MHz)		
3	Connecting wires.	-------	07

Theory:

A phase locked loop is basically a closed loop system designed to lock the output frequency and phase to the frequency and phase of an input signal. It is commonly abbreviated as PLL. PLL‟s are used in applications such as frequency synthesis, frequency modulation/demodulation, AM detection, tracking filters, FSK demodulator, tone detector etc. The block diagram of PLL is as shown below



PLL consists of

1. Phase detector
2. Low pass filter
3. Voltage controlled oscillator (VCO)

Procedure:

1. Connect the circuit as per the CIRCUIT DIAGRAM on the breadboard.

2. Without giving input signal, find out the output signal frequency, which is called free running frequency, F0
3. Now apply 1V, 1 KHz sinusoidal signal as input and slowly increase the input frequency and note down the corresponding output frequency
4. When input and output frequencies are equal, then note down it as F1 Now increase the input frequency slowly and the output frequency will also follow the input frequency. This follow up will continue until a certain frequency point F2Note down the value of F2.Continue to increase the input frequency and then the output frequency will be back to F0.
5. Now decrease the input frequency slowly and at one point input and output frequencies will be equal. Note down this point as *F3*.
6. Continue to decrease the input frequency. The output frequency will also follow once again, this follow up continues up to F4. Note down this frequency value and decrease the input frequency further. Then the output frequency will once again back to only.
7. Calculate the theoretical and practical values of free-running frequency lock range and capture range and compare them.

Free running frequency f0 = 1.2/4R1C1

Lock range fL = ±8 f0/V, Where V = +V-(-V) = 12-(-12) = 24

Theoretical lock range f = f0± fL

Capture Range fC = ± (fL/2π R1C1)1/2

Circuit Diagram :

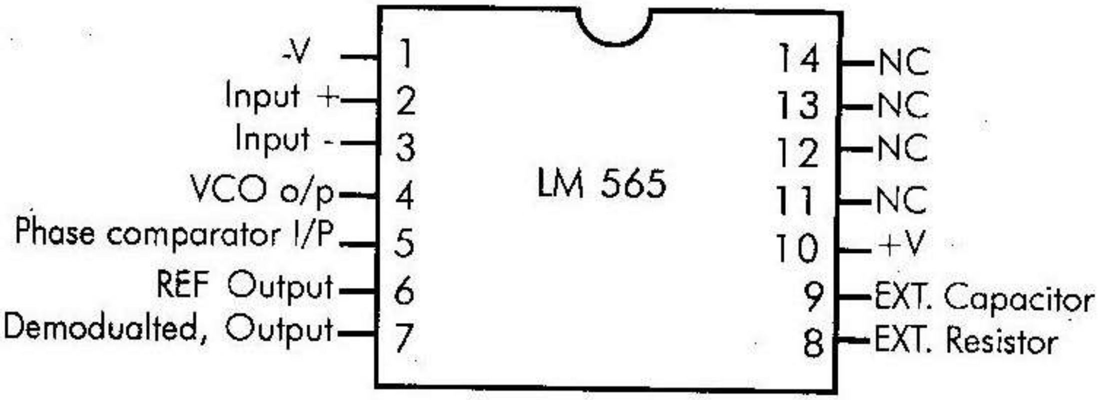


Fig.1 Pin Diagram of LM 565

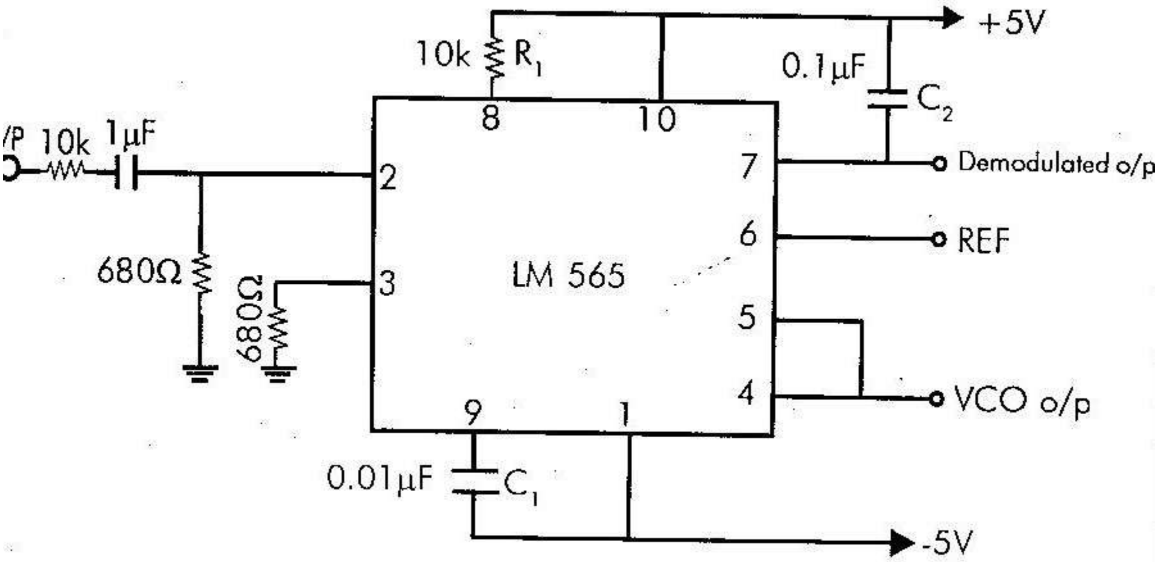
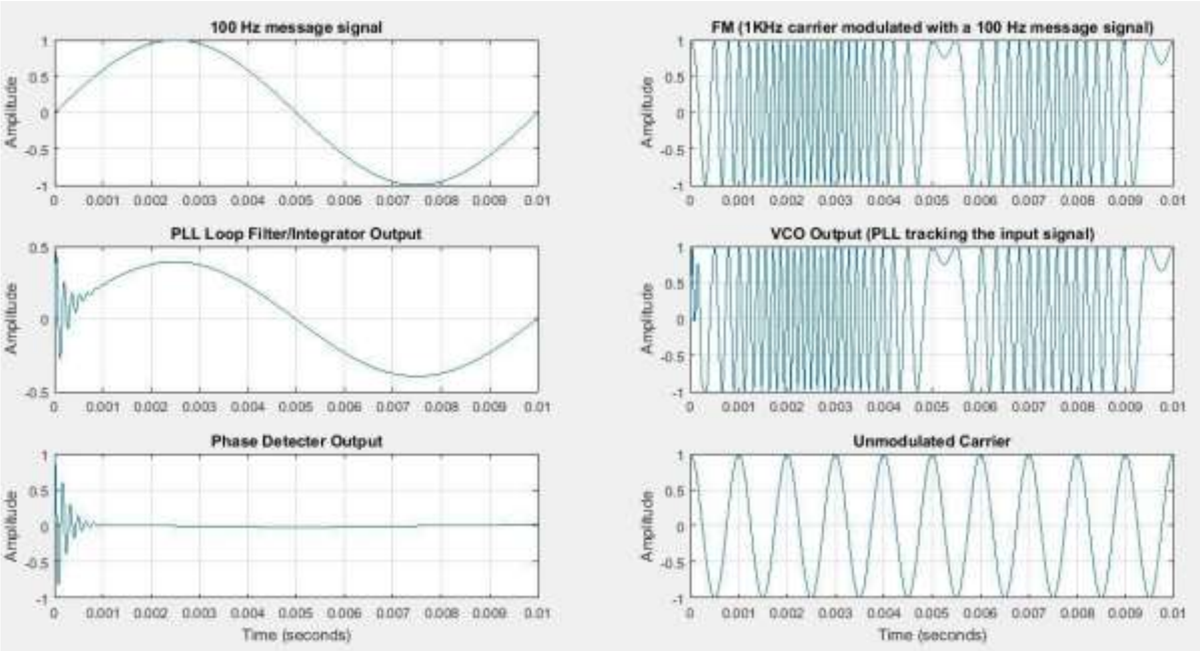


Fig.2 Circuit Diagram of LM 565

MATLAB Program

```
clear all; close all;
f=1000;%Carrier frequency fs=100000;%Sample frequency
N=5000;%Number of samples
Ts=1/fs;
t=(0:Ts:(N*Ts)- Ts);%Create the message signal
f1=100;%Modulating frequency
msg=sin(2*pi*f1*t);kf=.0628;%Modulation index
%Create the real and imaginary parts of a CW modulated carrier to be tracked.
Signal=exp(j*(2*pi*f*t+2*pi*kf*cumsum(msg)));%Modulated carrier
Signal1=exp(j*(2*pi*f*t));%Unmodulated carrier
%Initilize PLL Loop
```

```
 phi_hat(1)=30; e(1)=0; phd_output(1)=0; vco(1)=0;
%Define Loop Filter parameters(Sets damping)
kp=0.15; %Proportional constant
 ki=0.1; %Integrator constant %PLL implementation
 for n=2:length(Signal)
vco(n)=conj(exp(j*(2*pi*n*f/fs+phi_hat(n-1))));%Compute VCO
phd_output(n)=imag(Signal(n)*vco(n));%Complex multiply VCO x Signal input
 e(n)=e(n-1)+(kp+ki)*phd_output(n)-ki*phd_output(n-1);%Filter integrator
 phi_hat(n)=phi_hat(n-1)+e(n);%Update VCO
end;
%Plot waveforms
startplot = 1;endplot = 1000;
figure(1);subplot(3,2,1);
plot(t(startplot:endplot), msg(startplot:endplot));
title('100 Hz message signal');%xlabel('Time (seconds)');
ylabel('Amplitude');
grid;
figure(1);
subplot(3,2,2);plot(t(startplot:endplot), real(Signal(startplot:endplot)));
title('FM (1KHz carrier modulated with a 100 Hz message signal)');
%xlabel('Time (seconds)');
ylabel('Amplitude');grid;figure(1)subplot(3,2,3);plot(t(startplot:endplot), e(startplot:endplot));
title('PLL Loop Filter/Integrator Output');%xlabel('Time (seconds)');
ylabel('Amplitude');grid;subplot(3,2,4);
plot(t(startplot:endplot), real(vco(startplot:endplot)));
title('VCO Output (PLL tracking the input signal)');%xlabel('Time (seconds)');
ylabel('Amplitude');
grid;
subplot(3,2,5);
plot(t(startplot:endplot), phd_output(startplot:endplot));
title('Phase Detecter Output');
xlabel('Time (seconds)');
ylabel('Amplitude');
grid;subplot(3,2,6);
plot(t(startplot:endplot), real(Signal1(startplot:endplot)));
title('Unmodulated Carrier');
xlabel('Time (seconds)');
ylabel('Amplitude');
grid;
```



Result:

Thus the theoretical and practical values of lock range and capture range for PLL are calculated and compared.