QMP7.1D/F

Channabasaveshwara Institute of Technology

(Affiliated to VTU, Belagavi &Approved by AICTE, New Delhi)

(**NAAC Accredited & ISO 9001:2015 Certified Institution)**

NH206 (B.H.Road), Gubbi, Tumkur–572 216. Karnataka.

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

LAB MANUAL

COMMUNICATION LAB

BECL404

ECE / IV SEMESTER

SECTION: A & B

AY: 2025-26

NAME:____

USN:____

BATCH:________________________SECTION:__________________

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NH 206 (B.H. Road), Gubbi, Tumkur – 572 216.Karnataka.

Department of Electronics and Communication Engineering

Communication Lab (BECL404)
AY: 2025-26

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VISION OF THE INSTITUTE

"To create centers of excellence in education and to serve the society by enhancing the quality of life through value based professional leadership"

MISSION STATEMENT OF THE INSTITUTE

- **To provide high quality technical and professionally relevant education in a diverse learning environment.**
- **To provide the values that prepare students to lead their lives with personal integrity, professional ethics and civic responsibility in a global society.**
- **To prepare the next generation of skilled professionals to successfully compete in the diverse global market.**
- **To promote a campus environment that welcomes and honors women and men of all races, creeds and cultures, values and intellectual curiosity, pursuit of knowledge and academic integrity and freedom.**
- **To offer a wide variety of off-campus education and training programs to individuals and groups.**
- **To stimulate collaborative efforts with industry, universities, government and professional societies.**
- **To facilitate public understanding of technical issues and achieve excellence in the operations of the institute.**

QUALITY POLICY OF THE INSTITUTE

Our organization delights customers (students, parents and society) by providing value added quality education to meet the national and international requirements. We also provide necessary steps to train the students for placement and continue to improve our methods of education to the students through effective quality Management system, quality policy and quality objectives.

VISION OF THE DEPARTMENT

"To create globally competent Electronics and Communication Engineering professionals with ethical and moral values for the betterment of the society"

MISSION OF THE DEPARTMENT

- **To impart quality technical education in the field of electronics and communication engineering to meet the current/future global industry requirements.**
- **To create centres of excellence in the field of electronics and communication in collaboration with industry and universities.**
- **To nurture the technical/professional/engineering and entrepreneurial skills for overall self and societal upliftment.**
- **To orient the student community towards higher education, research and development activities.**
- **To provide a platform for equipping the students with necessary skills through co-curricular and extracurricular events.**
- **To have Industrial collaboration for strengthening the Teaching-Learning Process/Academics.**
- **To associate with industries for training the faculty on the latest technologies through continuous education programs.**

PROGRAM EDUCATIONAL OBJECTIVES

PEO1: Provide technical solutions to real-world problems in the areas of electronics and communication by developing suitable systems.

PEO2: Pursue an engineering career in Industry and/or pursue higher education and Research.

PEO3: Acquire and follow best professional and ethical practices in Industry and Society.

PEO4: Communicate effectively and have the ability to work in a team and to lead the team

PROGRAM SPECIFIC OBJECTIVES

PSO1: Specify, design, build and test analog and digital systems for signal processing, including multimedia applications, using suitable components or simulation tools.

PSO2: Understand and architect wired and wireless analog and digital communication systems as per specifications and determine their performance.

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Department of Electronics and Communication Engineering

SYLLABUS

Communication LAB

Subject Code: BECL404	IA Marks: 40
No. Of Practical Hrs/Week:02(Tutorial)+02(Laboratory)	Exam Hours: 03
Total no.of Practical Hrs.: 42	Exam Marks:60

1. Design and test a high-level collector Modulator circuit and demodulate the signal using a diode detector.
2. Test the Balanced Modulator/ Lattice Modulator (Diode Ring).
3. Design a Frequency modulator using a VCO and an FM demodulator using a PLL (UseIC566andIC565).
4. Design and plot the frequency response of Pre-emphasis and De-emphasis Circuits.
5. Design and test BJT/FET Mixer.
6. Design and test Pulse sampling, flat top sampling and reconstruction.
7. Design and test Pulse amplitude modulation and demodulation.
8. Generation and Detection of Pulse Position Modulation.
9. Generation and Detection of Pulse Width Modulation.
10. PLL Frequency Synthesiser.
11. Data formatting and Line Code Generation.
12. PCM Multiplexer and De-multiplexer.

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Department of Electronics and Communication Engineering

Communication Lab Course Objective's and Course Outcome's

Course Objectives:

This laboratory course enables students to

- Understand the basic concepts of AM and FM modulation and demodulation.
- Design and analyse the electronic circuits used for AM and FM modulation and demodulation circuits.
- Understand the sampling theory and design circuits that enable sampling and reconstruction of analogue signals.
- Design electronic circuits to perform pulse amplitude modulation, pulse position modulation and pulse width modulation.

Course Outcomes (Course Skill Set):

At the end of the course, the student will be able to:

1. Illustrate the AM generation and detection using suitable electronic circuits.
2. Design of FM circuits for modulation, demodulation and noise suppression.
3. Design and test the sampling, multiplexing, and pulse modulation techniques using electronic hardware.
4. Design and demonstrate the electronic circuits used for RF transmitters and receivers.

Program Outcomes (PO)

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7)

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

Programme Specific Outcomes (PSO)

PSO1: Build Analog and Digital Electronics systems for multimedia applications VLSI and Embedded Systems in Interdisciplinary research / development

PSO2: Design and develop communication Systems as per Real Time Applications and Current trends

‘Instructions to the candidates’

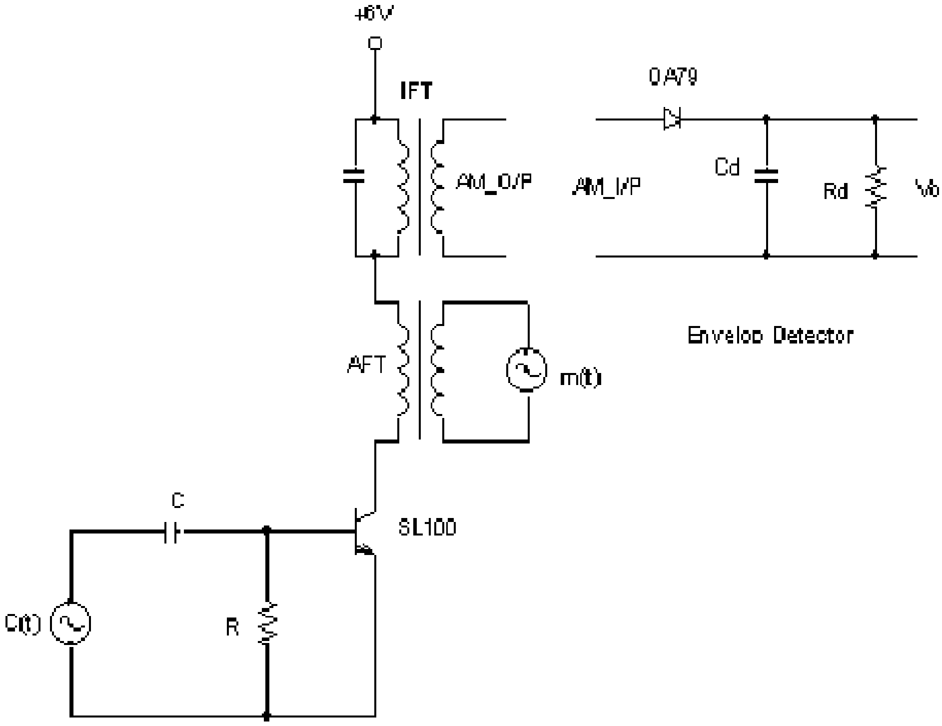
- The student should come with thorough preparation for the experiment to be conducted.
- The student should take prior permission from the concerned faculty before availing the leave.
- Students should come with the proper dress code and be present on time in the laboratory.
- Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects on the experiment conducted in the previous class.
- Students will not be permitted to attend the laboratory unless they bring the observation book fully completed in all respects for the experiment to be conducted in the present class.
- The experiment should be started after the staff-in-charge has checked the circuit diagram.
- All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.
- Wherever graphs are to be drawn, A-4 size graphs only should be used, and the same should be firmly attached in the practical record.
- The practical record and observation book should be neatly maintained.
- The student should obtain the signature of the staff-in-charge in the observation book after completing each experiment.
- Theory related to each experiment should be written in the practical record before the procedure in your own words with appropriate references.

CONTENTS

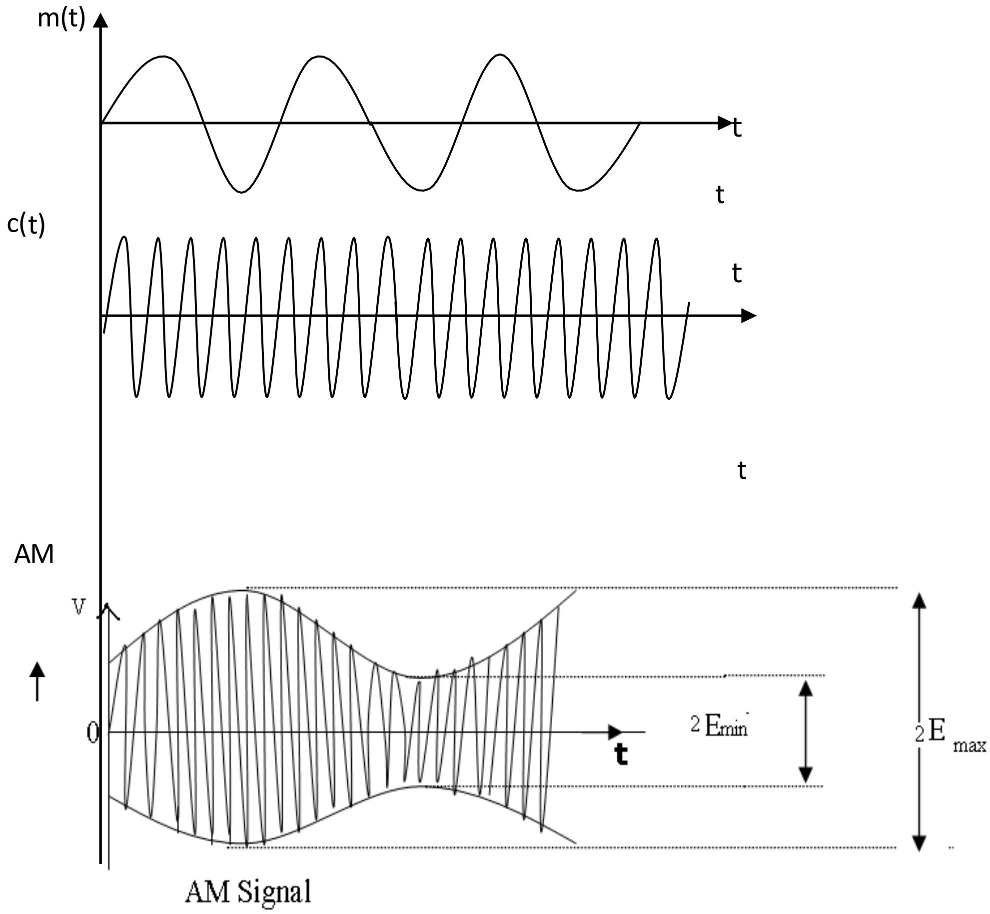
INDEXPAGE

Sl. No	Name of the Experiment	Date			Manual Marks (Max . 20)	Record Marks (Max. 10)	Signature (Student)	Signature (Faculty)
		Conduction	Repetition	Submission of Record				
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
Average								

Circuit Diagram:



Waveforms:



Experiment No.:01 **Date:** **Date:**

COLLECTOR MODULATOR

Aim:

Design and test a high-level collector Modulator circuit and Demodulation of the signal using a diode detector.

Apparatus:

Sl.No.	Particulars	Range	Quantity
1.	Transistor	SL100	01
2.	Resistors& Capacitors	As per design	-
3.	Diode	OA79	01
4.	IFT,AFT	-	01each
5.	Probes	-	03 set

Theory:

Amplitude modulation (**AM**) is a form of modulation in which the amplitude of a carrier wave is varied in direct proportion to that of a modulating signal. AM is commonly used at radio frequencies and was the first method used to broadcast commercial radio. The term "AM" is sometimes used generically to refer to the AM broadcast (Medium wave) band. In its basic form, amplitude modulation produces a signal with power concentrated at the carrier frequency and in two adjacent sidebands. Each sideband is equal in bandwidth to that of the modulating signal and is a mirror image of the other. Thus, most of the power output by an AM transmitter is effectively wasted, half the power is concentrated at the carrier frequency, which carries no useful information (beyond the fact that a signal is present), and the remaining power is split between two identical sidebands, only one of which is needed.

The modulator shown is a high-power class C amplifier with high-level modulation. The modulator is a linear power amplifier that takes a low-level modulating signal and amplifies it to a high power level. The modulating signal is coupled through modulating transformer AFT to the class C amplifier. The secondary winding of the modulation transformer is connected in series with the collector supply voltage Vcc of the class C amplifier. This means that the modulating signal is applied in series with the class C amplifier's collector power supply, thereby applying collector modulation.

In the absence of a modulating signal, there will be zero modulation voltage across the secondary of AFT. Therefore, the collector supply voltage will be applied directly to the class C amplifier generating current pulses of equal amplitudes and the output of the tuned circuit will be a steady sine wave.

When the modulating signal occurs, the ac voltage across the secondary of the modulating transformer will be added to and subtracted from the collector supply voltage.

Design:

f=455 kHz ® T=2.2μsec

For clamping: R_bC_b>>T4 Let R_bC_b=100T

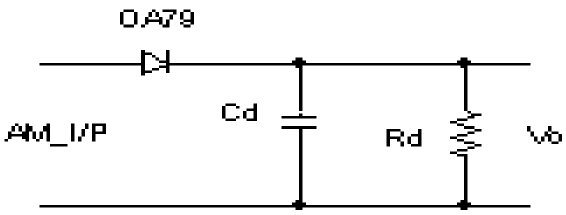
With R_b = 10kΩ, we get C_b= 0.022μF

Diode Detector :(Design)

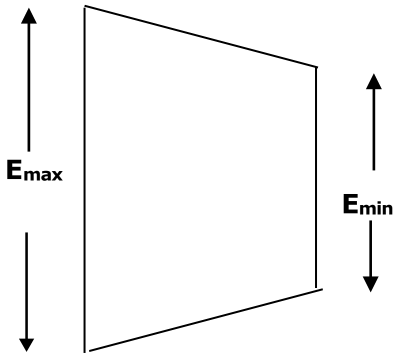
(1/fm)>>Rd Cd>>(1/fc);Let Rd Cd=100/fc Assume Cd =0.001 μf,

then Rd = 200 kΩ

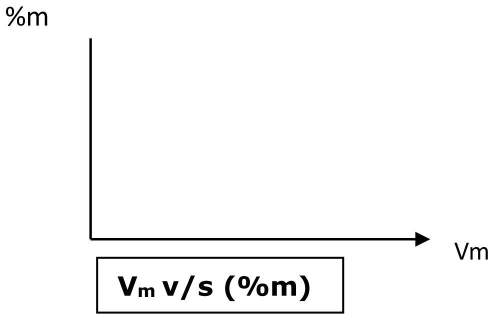
Demodulation Circuit:

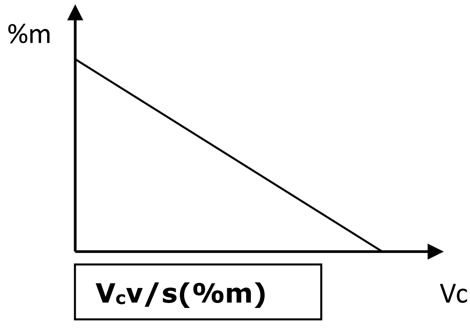


Transfer Characteristic Curve:



Ideal Plot





Formulae:

1. Power without modulation=Pc=$V^2/8R_L$
2. Modulation Index:%m=[(Emax–Emin)/(Emax+Emin)]* 100
3. Total power of AM Signal, Pt=Pc[1+(m^2/2)]

Note: To obtain the Trapezoidal waveform, feed the modulating signal to channel (i) and AM wave to channel (ii), press X-Y knob.

This varying supply voltage is then applied to the class C amplifier, resulting in variations in the amplitude of the carrier sine wave in accordance with the modulating signal. Due to this, amplitude of the current pulses also varies in accordance with the modulating signal. The tuned circuit then converts the current pulses into an amplitude modulated wave.

Modulation index

In AM, Modulation index is also called **Modulation depth**, indicates by how much the modulated variable varies around its 'original level'.

For AM, **$\%m = [(E_{max} - E_{min}) / (E_{max} + E_{min})] * 100$**

If m = 0.5, the carrier amplitude varies by 50% above and below its unmodulated level, and for m = 1.0 it varies by 100%. Modulation depth greater than 100% is generally to be avoided - practical transmitter systems will usually incorporate some limiter circuit. Modulation circuit designs can be broadly divided into low and high-level.

Procedure:

1. Connections are made as shown in the figure.
2. Without applying the message signal m(t), apply the carrier signal C(t) and adjust its frequency until we get a proper output and note down its voltage as carrier voltage Vc.
3. Calculate the carrier Power Pc.
4. Apply the Modulating Signal m(t) and note down Emax and min from the modulated signal. Repeat the same for different voltages of m(t).
5. Calculate Modulation Index.
6. Connect the demodulator circuit and obtain the demodulated message output.
7. The frequency of the demodulated signal is equal to the message signal frequency.
8. Plot a Graph of (Vmv/s %m) and (Vc v/s %m)

Tabular Column:

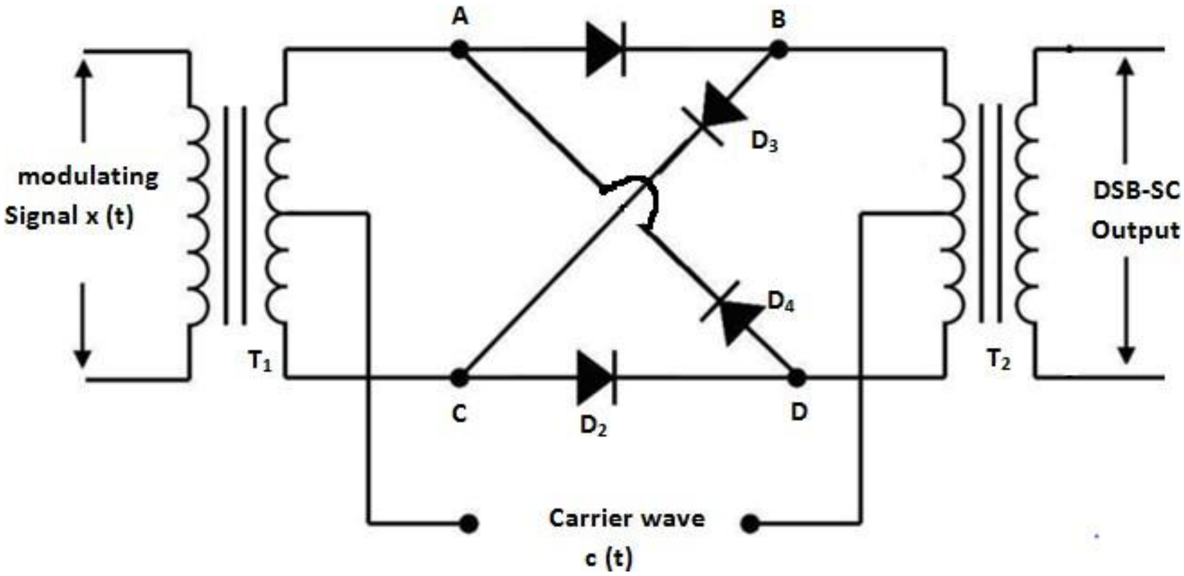
Sl.No.	V_m(p-p)volts	V_c(p-p)volts	E_{max}	E_{min}	Modulation index`m`(%)
1.					
2.					
3.					

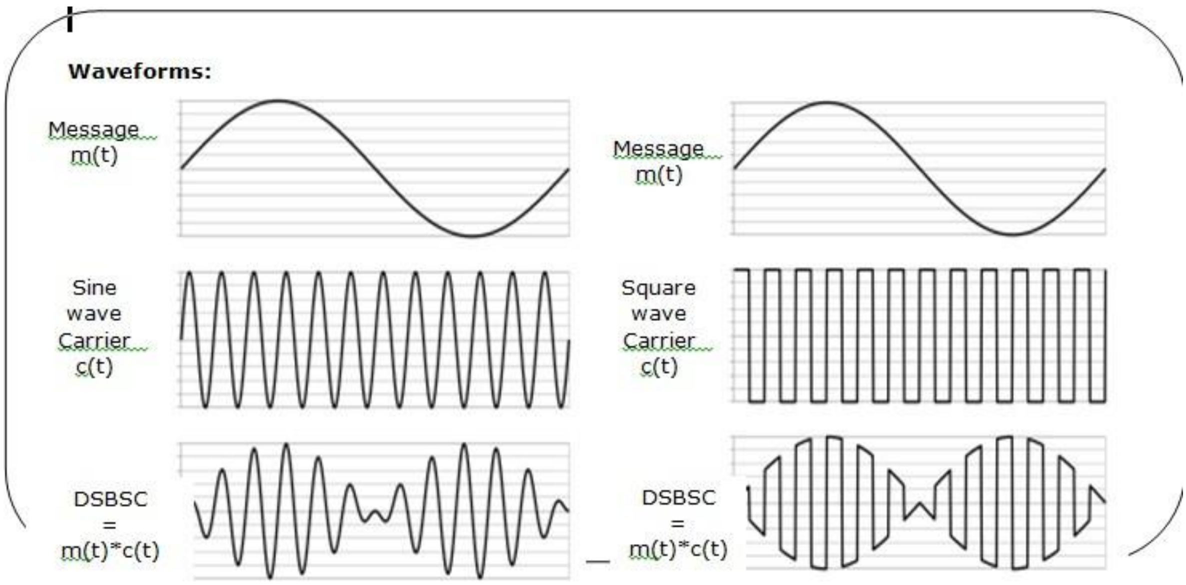
Diode/Envelope Detector

Sl.No.	Vo in Volt	Fo in Hz	F_m in Hz

Result:

Circuit Diagram:





EXPERIMENT No.:02

Date:

Balanced Modulator/Lattice Modulator (Diode Ring)

Aim: Test the Balanced Modulator/Lattice Modulator (Diode ring)and observe DSBSC Waveform.

Components and equipment required:

Sl.No	Apparatus	Range
1	2Audio Transformers	1:1turnsratio
2	2 Audio Signal Generators	100Hz–1MHz
3	4 Identical Diodes	OA79
4	CRO	Digital

Theory:

The DSBSC (Double Side band suppressed carrier) system is a continuous-wave modulation scheme in which the carrier is suppressed, and only the two sidebands (lower sideband, LSB, and upper sideband, USB) are transmitted. It is used to mix colour signals in colour TV transmission. Due to the absence of a carrier in DSBSC, the power required to transmit a DSBSC signal is much less compared to that required to transmit an AM signal.

Principle of Working:

The Circuit used for generating a DSBSC signal is a ring modulator. Four Identical diodes are connected in the form of a ring as shown in the circuit diagram. The output contains only a pair of sidebands symmetrically placed on either side of the carrier frequency position in the spectrum. The Input and Output transformers are audio frequency transformers of a 1:1 ratio and must be identical.

Procedure:

1. Circuit connections are made as shown in the circuit diagram.
2. The Modulating and the carrier signal generators are switched ON.
3. The frequency of the modulating signal is kept at 500Hz.
4. The frequency of the carrier signal is kept at 10 KHz.
5. With fine-tuning of frequencies of modulating and carrier signals, a perfect DSBSC waveform is observed on the CRO.
6. The variation in the DSBSC output is observed by varying the signal

   Amplitude and frequencies of both modulating and carrier signals.

Result: Peak to Peak amplitude of DSBSC Signal:__________Volts

Circuit Diagram:

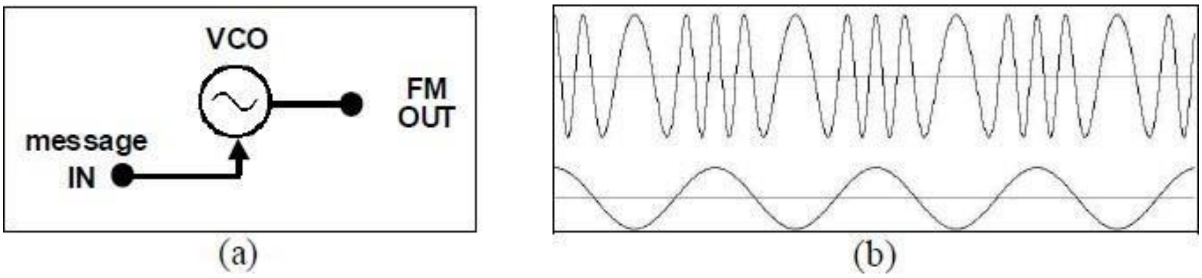


Figure.1: FM by VCO (a), and Resulting Output (b)

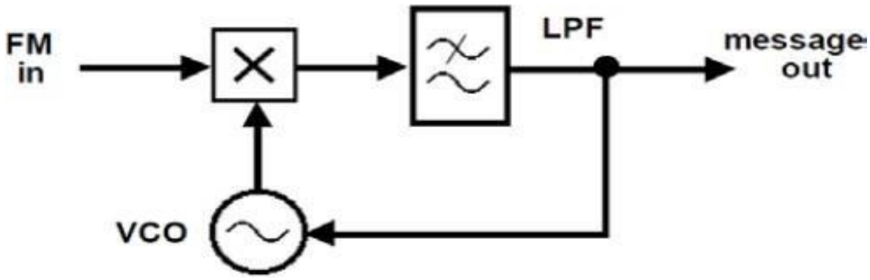


Figure 2: Phase Locked Loop (PLL)

EXPERIMENT No.:3 **Date:**

FREQUENCY MODULATION USING VCO AND PLL FM DEMODULATOR.

Aim: To Implement Frequency Modulation using VCO and Phase locked loop (PLL) for FM demodulation.

FM Generation:

A simple and direct method of generating an FM signal is to use a voltage-controlled oscillator (VCO). The frequency of such an oscillator can be varied by the magnitude of an input (control) voltage. The block diagram of the VCO-FM generator is shown in Figure.

For the VCO to work as a frequency modulator, it has to manifest a linear relation between the magnitude of the input signal and the output oscillation. Large signal amplitude may take the system out of its linear range of operation. Therefore, a careful design of the deviation sensitivity of the VCO is required to ensure linear operation over the full range of input signal amplitudes.

1. FM Bandwidth

In theory, an FM modulated signal will have an infinite number of sidebands and hence an **infinite bandwidth. Still, in** practice, all significant sideband energy (98% or more) is concentrated within the transmission bandwidth B_T defined by Carson's rule. $B_T = 2\Delta f + 2f_m$

$= 2f_m(1+\beta)$

$= 2\Delta f\,(1 + (1/\beta))$

β: is the FM modulation index, and it is equal to $\Delta f/f_m$

There are a few interesting points of summary relative to frequency modulation bandwidth:

1. The bandwidth of a frequency-modulated signal varies with both deviation and modulating frequency.
2. Increasing modulating frequency reduces modulation index - it reduces the number of sidebands with significant amplitude and hence the bandwidth.
3. Increasing the modulating frequency increases the frequency separation between sidebands.
4. The frequency modulation bandwidth increases with modulation frequency but it is not directly proportional to it.

2. FM signal types

There are two types of FM signal:

Narrow band signal (NBFM):

In this type **$\Delta f << f_m$ thus β<<1,** and its bandwidth is approximately $2f_m$ based on Carson's rule.

Wide band signal (WBFM):

In this type $\Delta f >> f_m$ thus β>>1, and its bandwidth is approximately $2\Delta f$ based on Carson's rule.

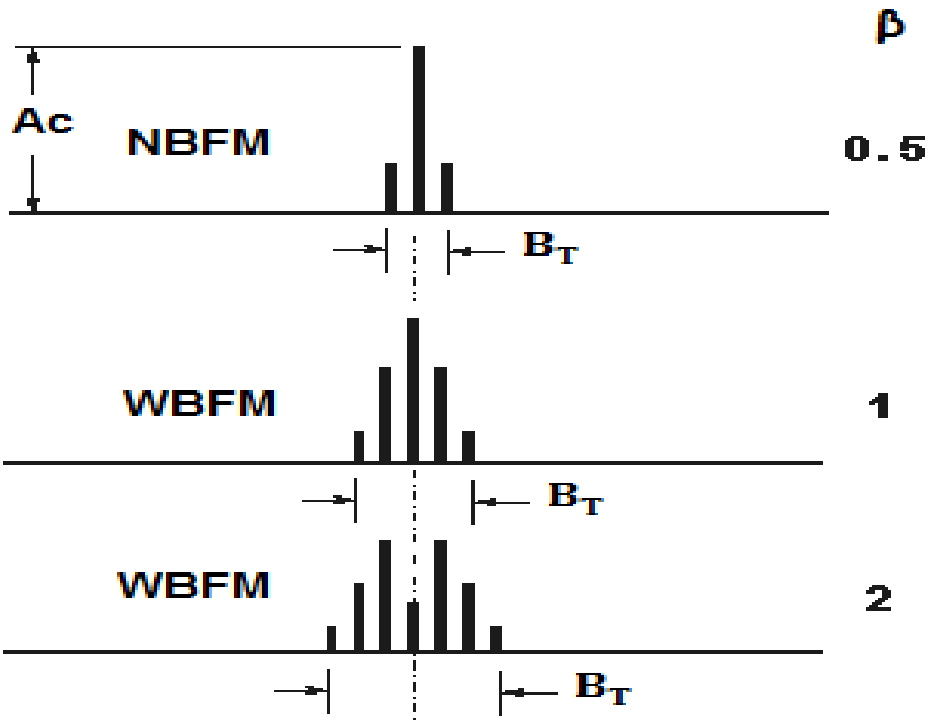


Figure.3: FM signal types

3. Phase Locked Loop:

The block diagram of a phase-locked loop (PLL) is shown in Figure. The principle of operation is simple. Suppose there is a non-modulated carrier at the input. If the VCO was tuned precisely to the frequency of the incoming carrier (ω_0), then the instantaneous output would be a DC voltage of magnitude depending on the phase difference between the output of the VCO and the incoming carrier. Now, suppose the incoming carrier starts to drift slowly in frequency; then the output voltage will vary with the frequency variation. If the incoming carrier is frequency modulated by a message, the output of the PLL will follow the message.

4. Frequency discriminator

FM can be demodulated as well by using a differentiator or a frequency discriminator. Frequency discrimination can be achieved by applying the FM signal to the linear part (transition region) of a BPF, as depicted in Figure 4. The output of the discriminator is both FM and AM modulated. The message can be recovered by applying the discriminator output to an envelope detector, as shown in Figure 5. The BPF of the 100 kHz channel filter module has a close-to-linear pattern in the band 80-90 kHz.

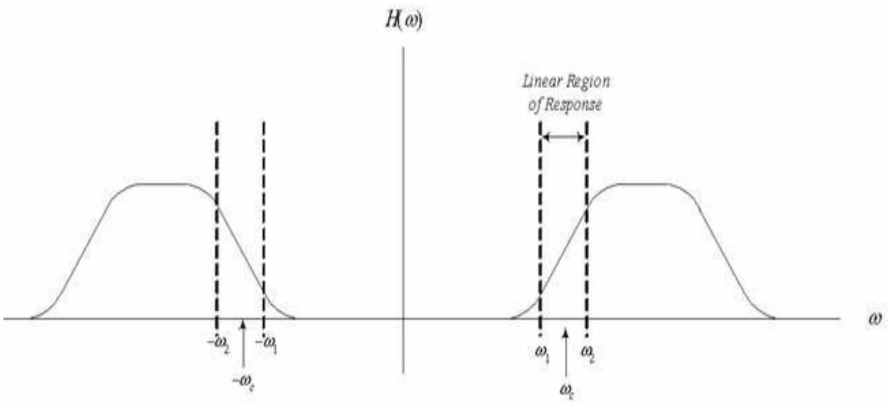


Figure.4: The BPF of the100kHz channel filter

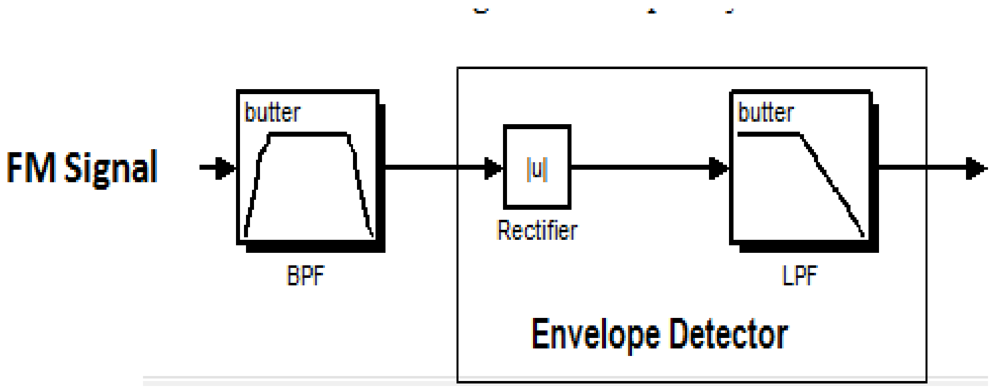


Figure.5: Frequency Discriminator

Modules Needed:

The following plug-in modules are needed to complete the experiment: Audio Oscillator, VCO, Multiplier, 100kHz channel filter, Utilities, Tunable LPF

Part I: Setting the Frequency Deviation

The frequency deviation is equal to the product of $V_{in(Max)}$and Gain. Our objective is to design the Gain that yields a frequency deviation of ±2 kHz.

1. Set a DC voltage of 2V as input to the VCO.
2. Set the Gain control fully anti-clockwise and the output frequency to 10 kHz.
3. Advance the Gain control until the frequency changes by 2kHz.
4. Change the Variable DC to +2V and confirm that the deviation is about 2 kHz in the other direction. Record the measured frequency.

Part ll: Time Domain and Frequency Domain Analysis

1. Fix the message frequency from the Audio Oscillatorto1kHz.
2. Plot the message signal, carrier signal & the modulated signal in lab sheet.
3. Plot the spectrum of the modulated signal using Pico Scope, in lab sheet.
4. Vary the message frequency and describe the impact on the spectrum of the FM signal.
5. Plot the spectrum of the FM signal at the minimum and maximum frequencies of the Audio oscillator.
6. Reset the frequency of the message to 1 kHz, and vary the deviation ratio (by varying the Gain in the VCO).Describe the effect on the spectrum of the FM signal (make sure you do not overload the VCO).
7. Plot the spectrum at the minimum value and maximum Gain setting (before overload).
8. Explain the obtained spectra in light of Carson's Rule for bandwidth estimation.

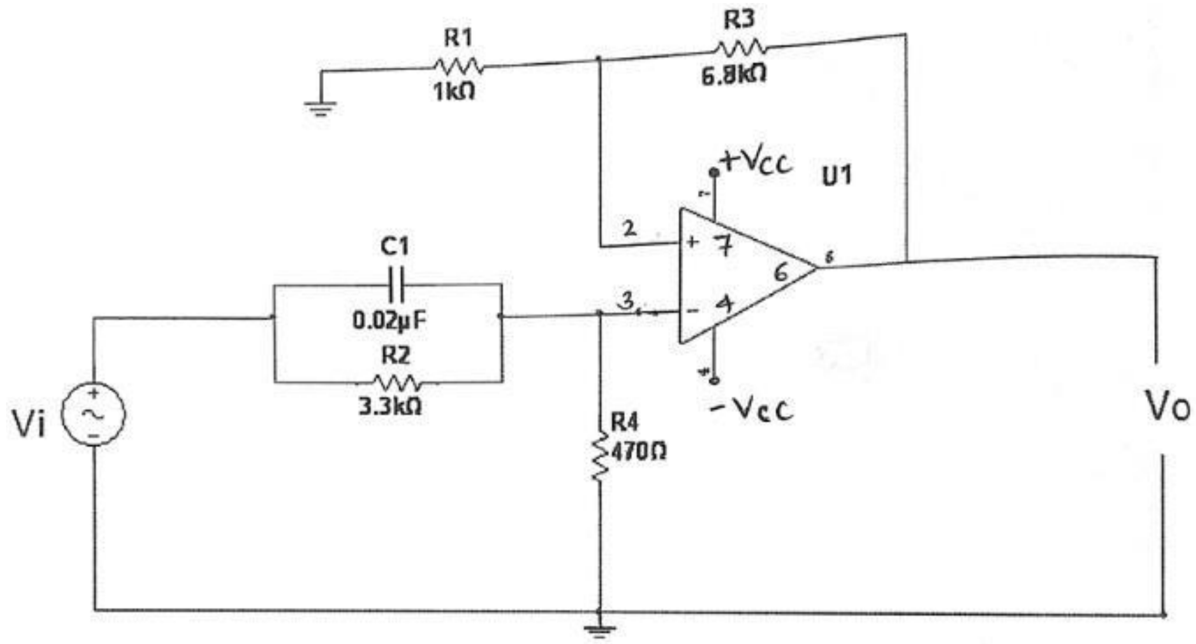
Part III: FM Demodulation Using PLL

1. Reconstruct the FM modulator as in the previous part.
   - Let the message frequency be 1kHz from the Audio Oscillator,
   - Let the carrier frequency be 85kHz from VCO,
   - Let the modulator VCO gain be around 20%of the maximum value.

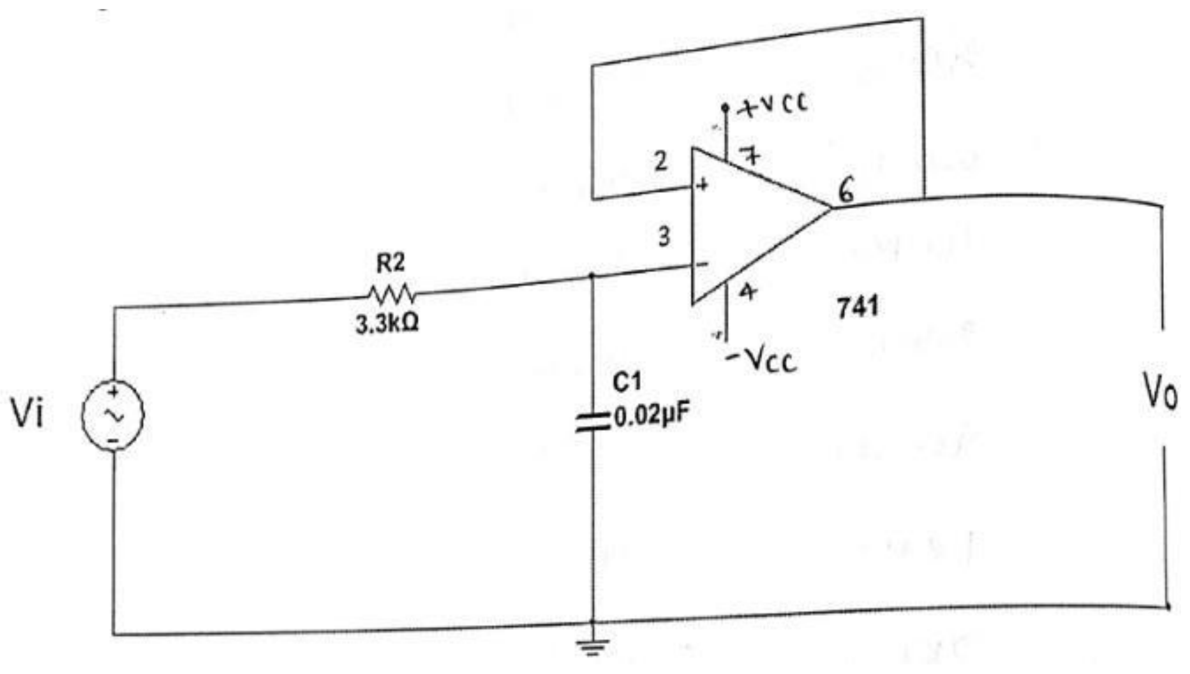
2. Model the PLL demodulator illustrated in Figure3.
   - For the filter use RC LPF provided in the Utilities Module.
   - In the Multiplier module set the toggles witch to AC.
   - Set the VCO in the demodulator to 85 kHz.
   - Set the Gain control to 20% of its maximum.

3. Connect the output of the modulator to the input of the demodulator.
4. The PLL may or may not lock onto the incoming FM signal. Tune the Gain (and, if necessary, the centre frequency) of the PLL-VCO until you obtain lock.
5. Examine the output of the PLL VCO and compare it with the original message.
6. Plot the message signal and recovered signal in lab sheet.

Pre-Emphasis



De-Emphasis:



EXPERIMENT No.: 04 **Date:**

Pre-Emphasis & De-Emphasis

Aim: Design and plot the frequency response of Pre-Emphasis and De-Emphasis Circuits.

Components Required:

Sl.No	Apparatus	Range/Specifications
1	Op-Amp	μA741
2	Audio Signal Generator	100Hz–1MHz
3	Resistors	3.3KΩ(02 No's) 470Ω(02No.s)
4	Capacitors	0.022μf
5	CRO	Digital

Theory: The Power Spectral Density of the message signal falls off at higher frequencies as shown in graph. On the other hand the Power spectral Density of noise increases rapidly with frequency as shown in figure. Consequently, the signal-to-noise ration reduces drastically. To improve the signal-to-noise ration artificially, it is required to emphasize or boost up high frequency components of the message signal prior to modulation. This boosting of higher modulating frequencies in accordance with a pre-arranged curve is known as **"Pre- Emphasis"**. The reverse process is done at the receiver after discrimination (Demodulation). This reverse process is called as "De-Emphasis". Pre-Emphasis is achieved with a high pass circuit followed by a voltage follower using Op-amp, with RC time constant equal to the standard value of 75μ sec for FM. A low pass circuit followed by another voltage follower using Op-amp is used as De-Emphasis circuit.

Procedure:

Pre-Emphasis

1. Connections are made as shown in the circuit diagram
2. Apply a Sine wave of 0.5V_{p-p} amplitude, vary the frequency and note down the gain of the circuit.
3. Plot a graph of Normalized gain V/s frequency.

De-Emphasis

1. Connections are made as shown in the circuit diagram.
2. Apply a Sine wave of 0.5V_{p-p} amplitude, vary the frequency and note down the gain of the circuit.
3. Plot a graph of Normalized gain V/s frequency.

Design:

Pre-Emphasis Circuit

RC=75 μsec for standard FM broadcasting.

Given f_1=2.1KHz, f_2=15KHz

f_0= {(1)/ (2∏RC)} =2.12 KHz

Let C = 0.022μf

Since, RC=75μsec

R=(75μsec/0.022μf)=3.4KΩ,Choose R=3.3KΩ

Message Bandwidth

wc=[(1)/(2∏RC)]=15KHz

R=[(1)/(2∏wc)]=482Ω

Chooser= 470Ω

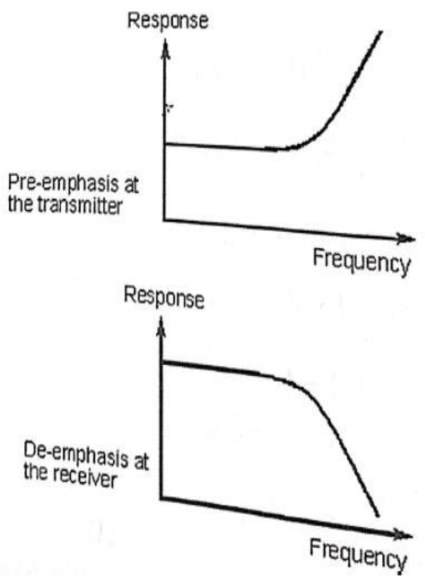
De-Emphasis Circuit

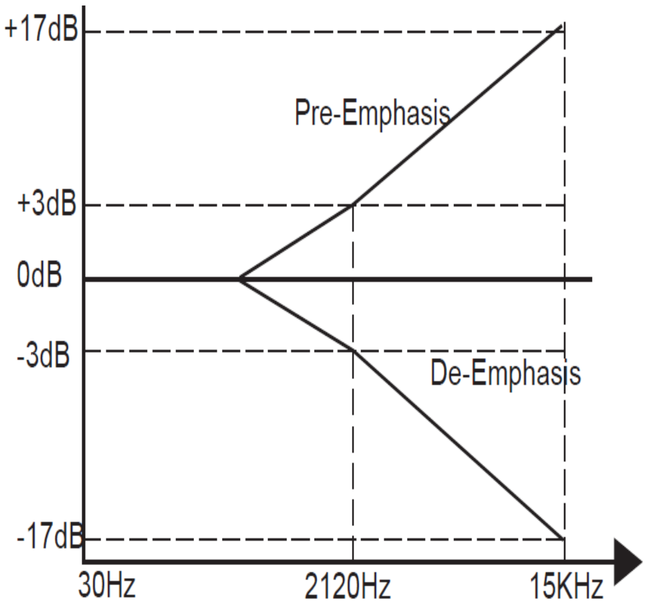
RC=75 μsec

f_c={(1)/(2∏RC)}=2.12 kHz

R=3.3KΩ and C=0.022μf

Graph:





75-μs Emphasis Curves

Tabular Column:

Pre-Emphasis: Input Voltage=0.5V_{p-p}

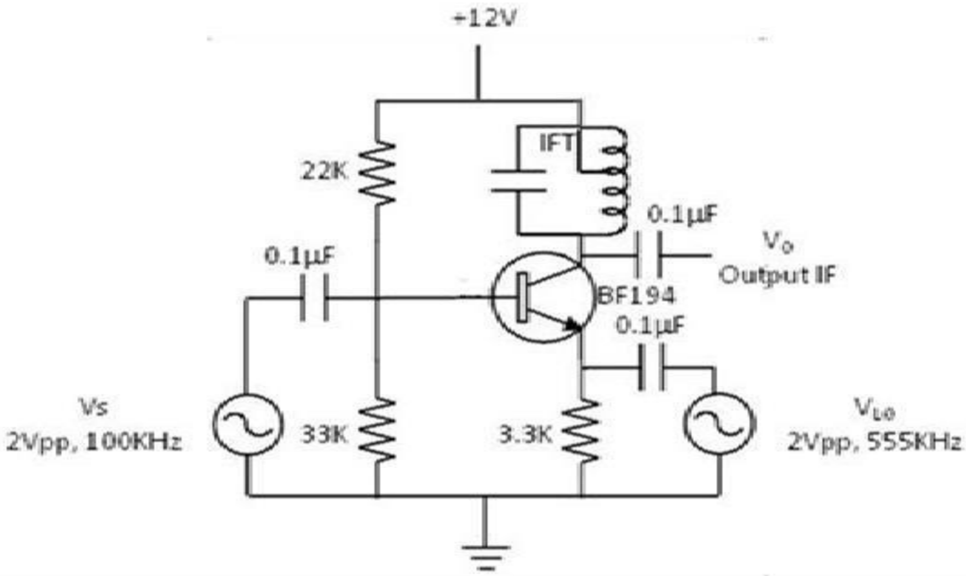
Sl.No	Frequency in Hz	Output Voltage V_{out}	Gain in dB=$20\log_{10}(V_{out}/V_{in})$

De-Emphasis: Input Voltage=0.5V_{p-p}

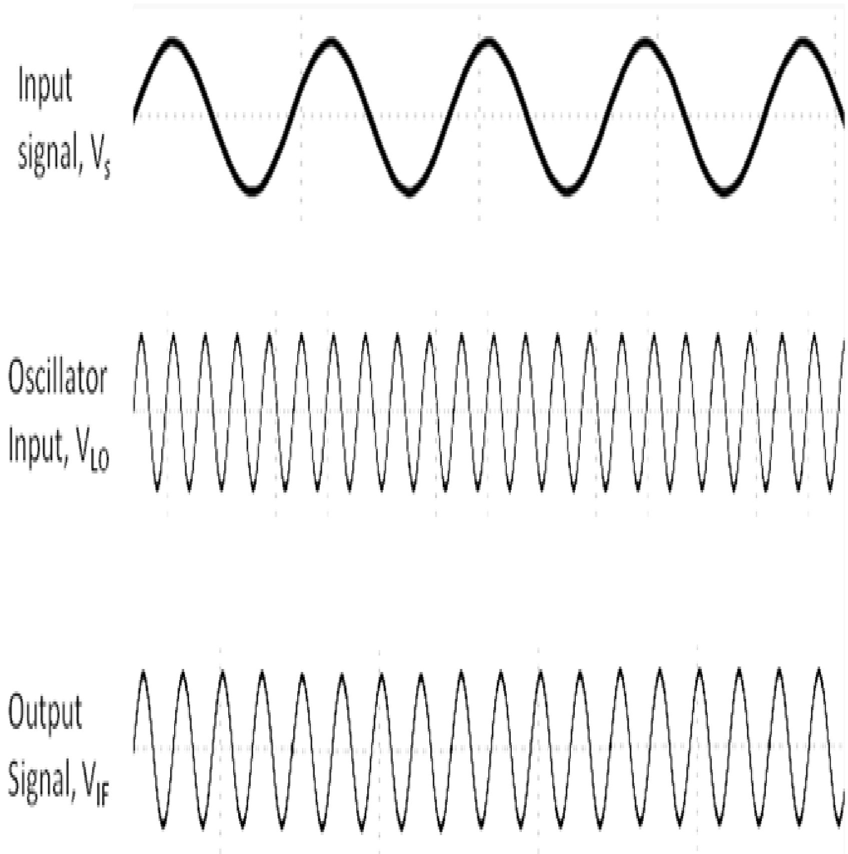
Sl.No	Frequency in Hz	Output Voltage V_{out}	Gain in dB=$20\log_{10}(V_{out}/V_{in})$

Result: Pre-Emphasis & De-Emphasis characteristics are verified by plotting response Curves.

Circuit Diagram:



Waveforms:



EXPERIMENT No.: 05 **Date:**

BJT/FET Mixer

Aim: To design and test a mixer circuit using a transistor.

Tabular Column:

Sl. No.	Item & Specification	Quantity
1	Resistor-22K, 33K,3.3K	1No.each
2	Transistor BF194	1No.
3	Capacitor-0.1F	1No.
4	IFT	1No.
5	Signal Generator	2Nos.
6	CRO	1No.
7	Power Supply-=12V	1No.
8	Multimeter	1No.
9	Bread Board	1No.
10	Wires and probes	-

THEORY:

A mixer or frequency converter is actually a nonlinear resistor with two sets of input terminals and one set of output terminals. The two inputs to the mixer are the input signal and the local oscillator signal. The output of the mixer contains many frequencies, including the sum and difference frequencies between the two input signals. The mixer output is commonly tuned to the difference frequency. This frequency is called the intermediate frequency (IF).

The input to the mixer is the input signal voltage with magnitude V_S and frequency f_S. The output is usually a current component at IF frequency having a magnitude I_{IF} proportional to V_S. The proportionality constant is called transconductance and is given by

$$G_C = I_{IF}/V_S$$

The conversion transconductance of a transistor mixer is of the order of 6ms. Mixing occurs when the mixer's transconductance varies with the local oscillator voltage.

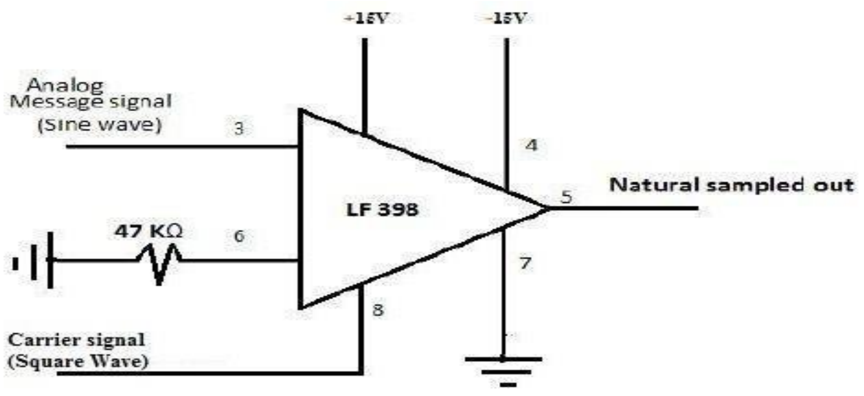
PROCEDURE:

1. Test all the components and probes.
2. Set up the circuit as shown in figure on a breadboard.
3. Switch on the power supply.
4. Check the dc conditions of the transistor and make sure that it is working in the active region.
5. Feeda2Vpp, 100 KHz sine wave signal at the base of the transistor as shown in figure.
6. Feeda2Vpp, 555 KHz sine wave signal at the emitter of the transistor as shown in figure.
7. Observe the output wave form on a CRO and measure the frequency. Adjust the IFT to obtain455KHz as the peak output frequency.
8. Plot the input /output waveforms.
9. Measure the output ac current (I_{IF}) and the input ac voltage (V_S) using a multimeter. Calculate the transconductance using the equation $g_C=I_{IF}/V_S$.
10. Check the output for100KHz and 355 KHz inputs.

Note: The IFT centre tap point should be connected to Vcc. Connect one of the other two terminals of the IFT primary to the collector of the transistor. Try both terminals and select the one that gives the better output.

Result: The transistor mixer circuit is designed for the difference frequency.

Circuit Diagram: (Natural Sampling):



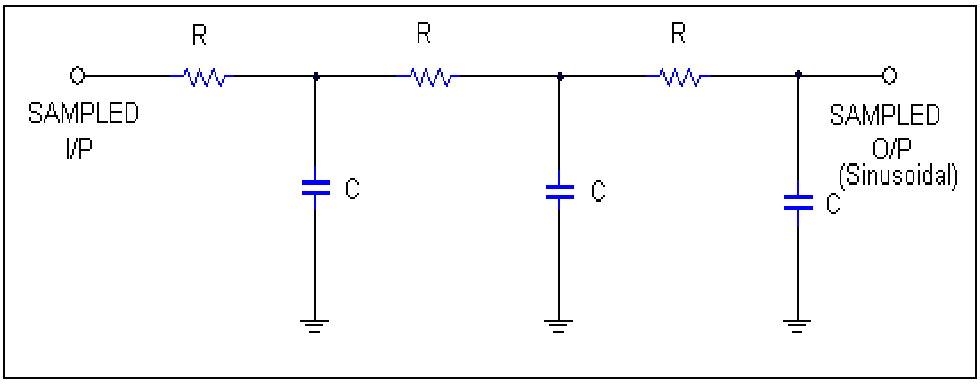


Figure 6.1 : Natural Sampling using LF398

Filter Design:

fs= 1/ Ts ; Ts=RC ; R=Ts/C Cut off frequency of the filter

fo>>fm

Choose fo=2kHz,fo=1/2∏RCAssumeC=0.1μf,thenR=500Ω

EXPERIMENT No.: 06 **Date:**

PULSESAMPLING, FLAT TOP SAMPLING AND RECONSTRUCTION

Aim: To conduct an experiment to generate pulse sampling and to demodulate the same.

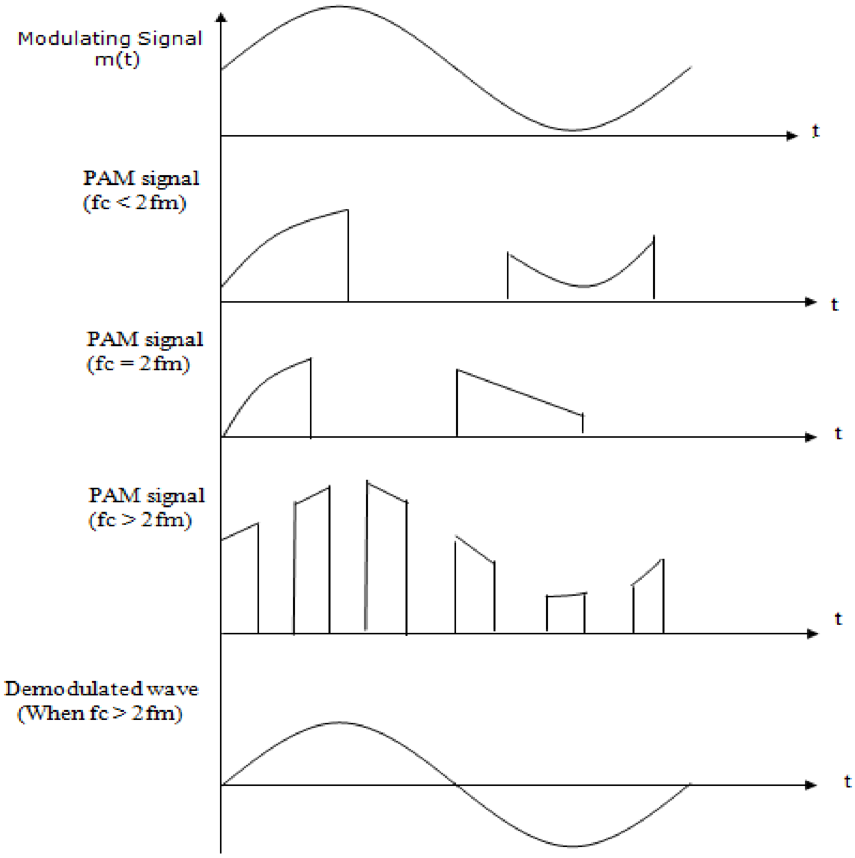
Apparatus Required:

Sl.No.	Apparatus	Range	Quantity
1	Sample & hold IC– LF398	-	1
2	Resistors& Capacitor	As Per the design	-
3	Springboard + connecting wires	-	1Set

Procedure:

1. Check the components/equipment for their working condition.
2. Connections are made as shown in the circuit diagram.
3. Apply the square wave carrier signal of15-20KHz of 20% duty cycle.
4. Apply a sine wave modulating signal of frequency fm=1kHz with 5V peak-to-peak amplitude.
5. Turn on the offset and vary the offset voltage until the desired waveform is observed on the CRO.
6. Observe the output waveform.
7. Connect the sampled output as an input to the low pass filter and reconstruct the original message signal and note fo and Vo.
8. Repeat the above steps for fc=2fm and fc<2fm.

Waveforms:



Tabular Column:

Vc(p-p)= ___________ V, Vm(p-p)= __________V

Sl. No	Sampling Methods	Fc in Hz	Fm in Hz	Vo of Demodulated Signal in Volt	Fo of Demodulated Signal in Hertz
1	Under Sampling (Fc< 2Fm)				
2	Nyquist Rate (Fc= 2Fm)				
3	Over Sampling (Fc>2Fm)				

FLAT TOP SAMPLING AND RECONSTRUCTION

Aim: To verify the Flat Top sampling theorem.

Apparatus Required:

Sl. No.	Apparatus	Range	Quantity
1	Function Generator	1MHz	1
2	Op-amps Transistor	μA741 SL100	2 1
3	Resistors and capacitors	As per design	
4	Dual trace oscilloscope	20MHz	1

Theory:

The analog signal can be converted to a discrete-time signal by a process called sampling. The sampling theorem for a band-limited signal of finite energy can be stated as: "**A band-limited signal of finite energy, which has no frequency component higher than W Hz is completely described by specifying the values of the signal at instants of time separated by 1/2W seconds**"

It can be recovered from knowledge of samples taken at the rate of 2W per second.

Circuit diagram:

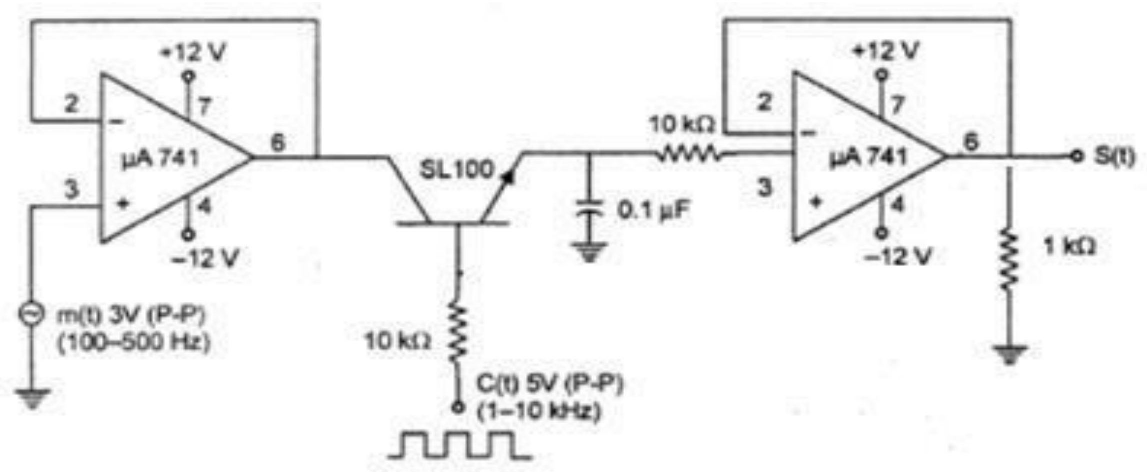


Fig 6.2: Sampling Circuit using transistor

Design

(1) Flat top sampling

$$RC \ll T_m$$

where $T_m = 3.3$ ms

Assume $f_m = 300$ Hz

Let $RC = 1$ ms

Let $R = 10$ kΩ

$\therefore$ $C = 0.1$ μF

(2) Demodulation

$$f = \frac{1}{2\pi RC} = 500 \text{ Hz}$$

Let $C_1 = 0.1$ μF,

then $R_1 = 3.1$ kΩ

$\simeq 3.3$ kΩ

Circuit Diagram

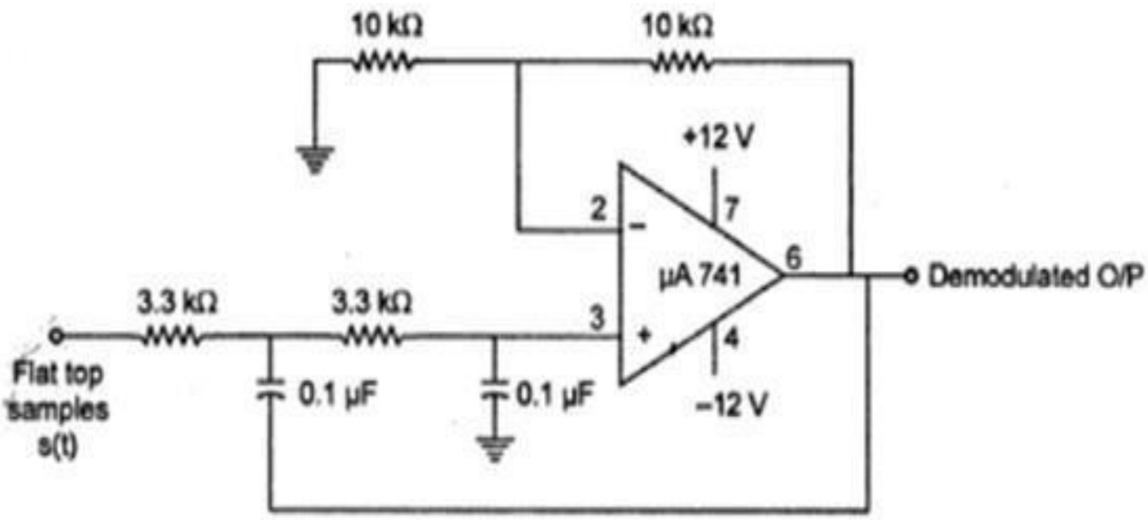
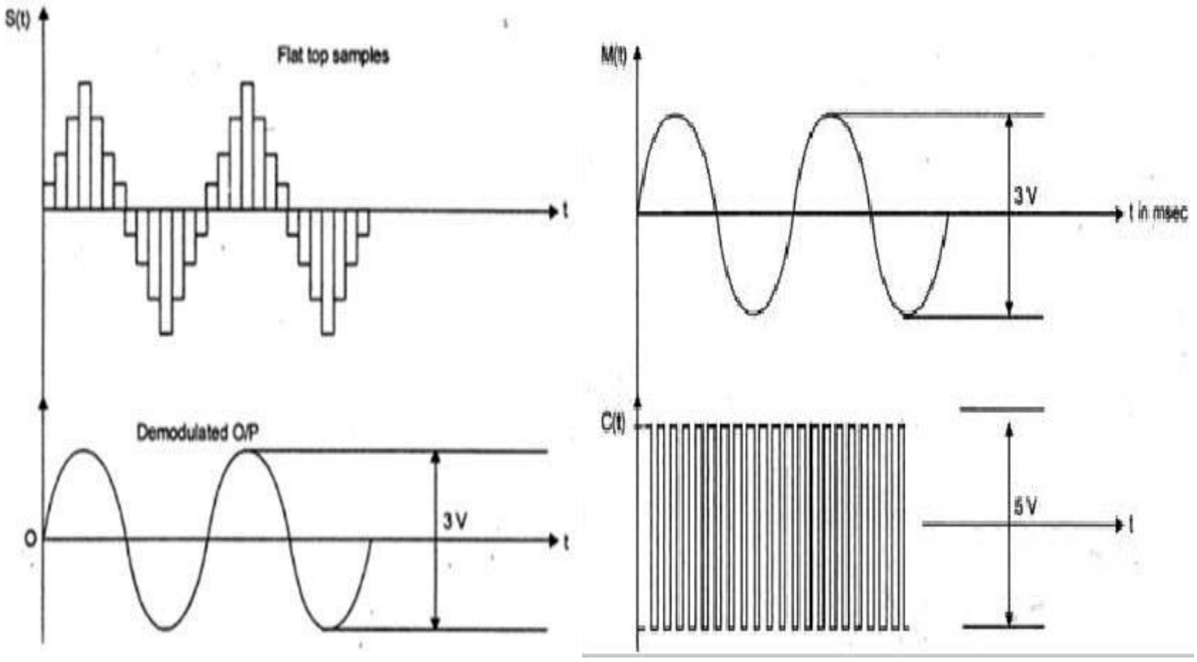


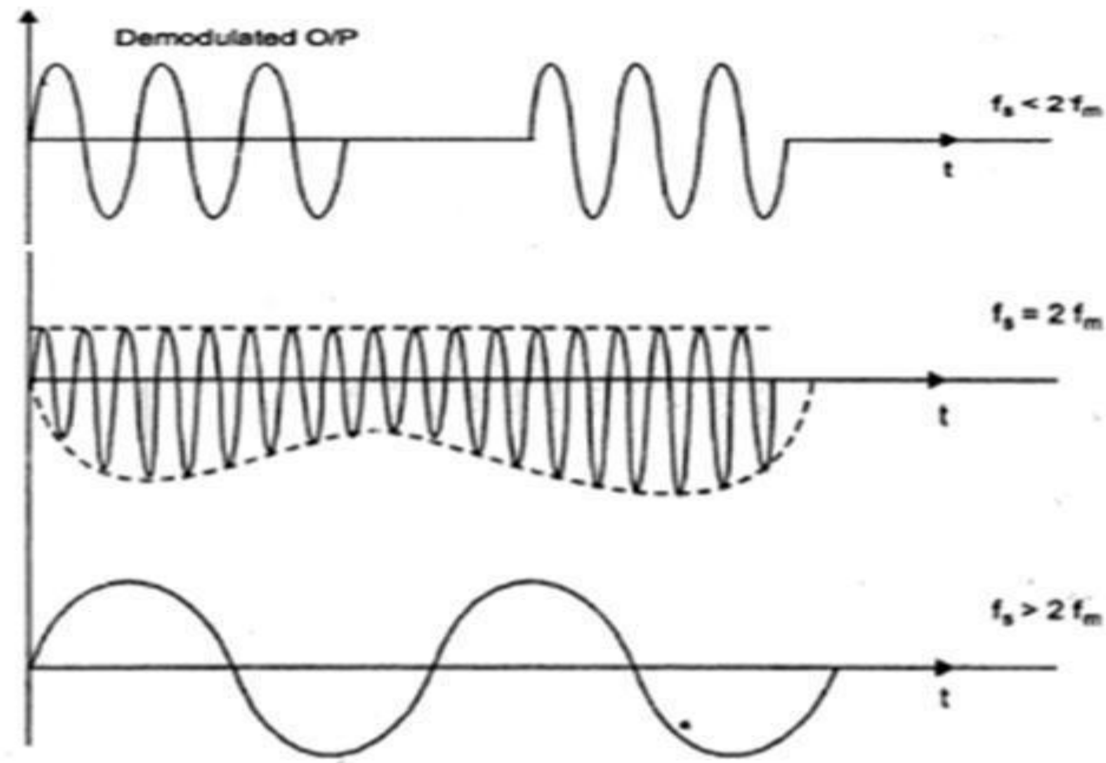
Fig 6.3: Reconstruction circuit using Op-amp

Procedure:

1. The circuit is connected as per the circuit diagram shown in Figure 5.1 or 5.3.
2. Switch on the power supply and set at +12V and -12V.
3. Apply the sinusoidal signal of approximately 3V (p-p) at 100-500 Hz frequency and pulse signal of 5V (p-p) with frequency between 100Hz and 10 KHz.
4. Connect the sampling circuit output and AF signal to the two inputs of the oscilloscope
5. Initially set the sampling frequency to 200Hz and observe the output on the CRO. Now vary the amplitude of the modulating signal and observe the output of the sampling circuit. Note that the amplitude of the sampling pulses will vary in accordance with the amplitude of the modulating signal.
6. Design the reconstruction circuit. Depending on sampling frequency, R & C values are calculated using the relations Fs = 1/Ts, Ts = RC. Choosing an appropriate value for C, R can be found using the relation R=Ts/C
7. ConnectthesamplingcircuitoutputtothereconstructingcircuitshowninFig5.4
8. Observe the output of the reconstructing circuit (AF signal) for different sampling frequencies. The original AF signal would appear only when the sampling frequency is 200Hz to 500Kz.

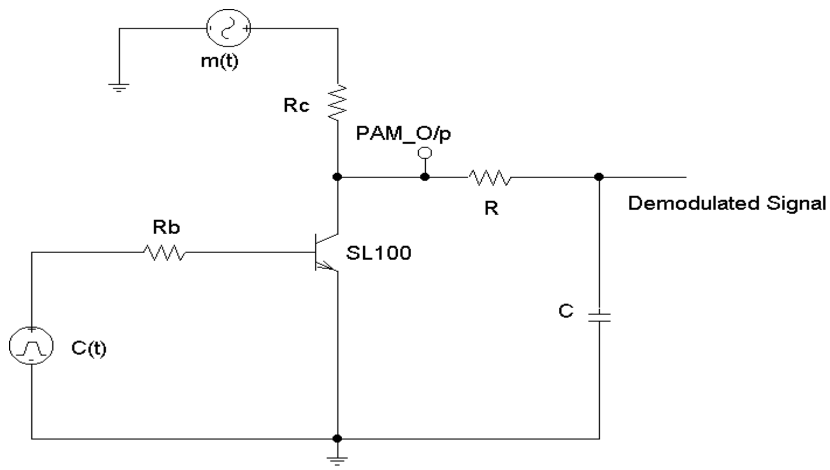
Waveforms:





Result: Sampling Theorem is verified for Pulse sampling & flat top sampling circuits.

Circuit Diagram:



Design:

Specifications: Ic=1mA, hfe=100, $V_{CE(}$sat)=0.3V, $V_{BE(}$sat)=0.7V, fm=100Hz

Biasing:

V_m(t)=Ic Rc + $V_{CE(}$sat)

Let V_m(t) =2.5V peak +3V DC shift=5.5V peak signal

Then Rc = 5.2 kΩ

V_c(t)=$I_B R_B$+$V_{BE(}$sat)

Let Vc(t)=2Vpeak – peak (1V peak) & I_B=IC /hfe=10 μA

1 = R_B10⌈A + 0.7

∴R_B=30KΩ

Filter:

Cut off frequency of the filter fo>>fm

Choose fo = 500 Hz,fo = 1 / 2πRC

Assume C=0.1μf, then R=3.3kΩ

Tabular Column:

Sl. No	V_c(p-p) in Volt	fc in Hz	V_m(p-p) in Volt	fm in Hz	Vo of the demodulated signal in Volts	Fo of the demodulated signal in Hz

EXPERIMENT No: 7 **Date:**

PULSE AMPLITUDE MODULATION

Aim:

To conduct an experiment to generate PAM signal and to demodulate it.

Apparatus:

Sl. No.	Particulars	Range	Quantity
1.	Transistor	SL100	01
2.	Resistors & Capacitors	As per design	-
3.	Springboard + connecting wires	-	01set

Theory:

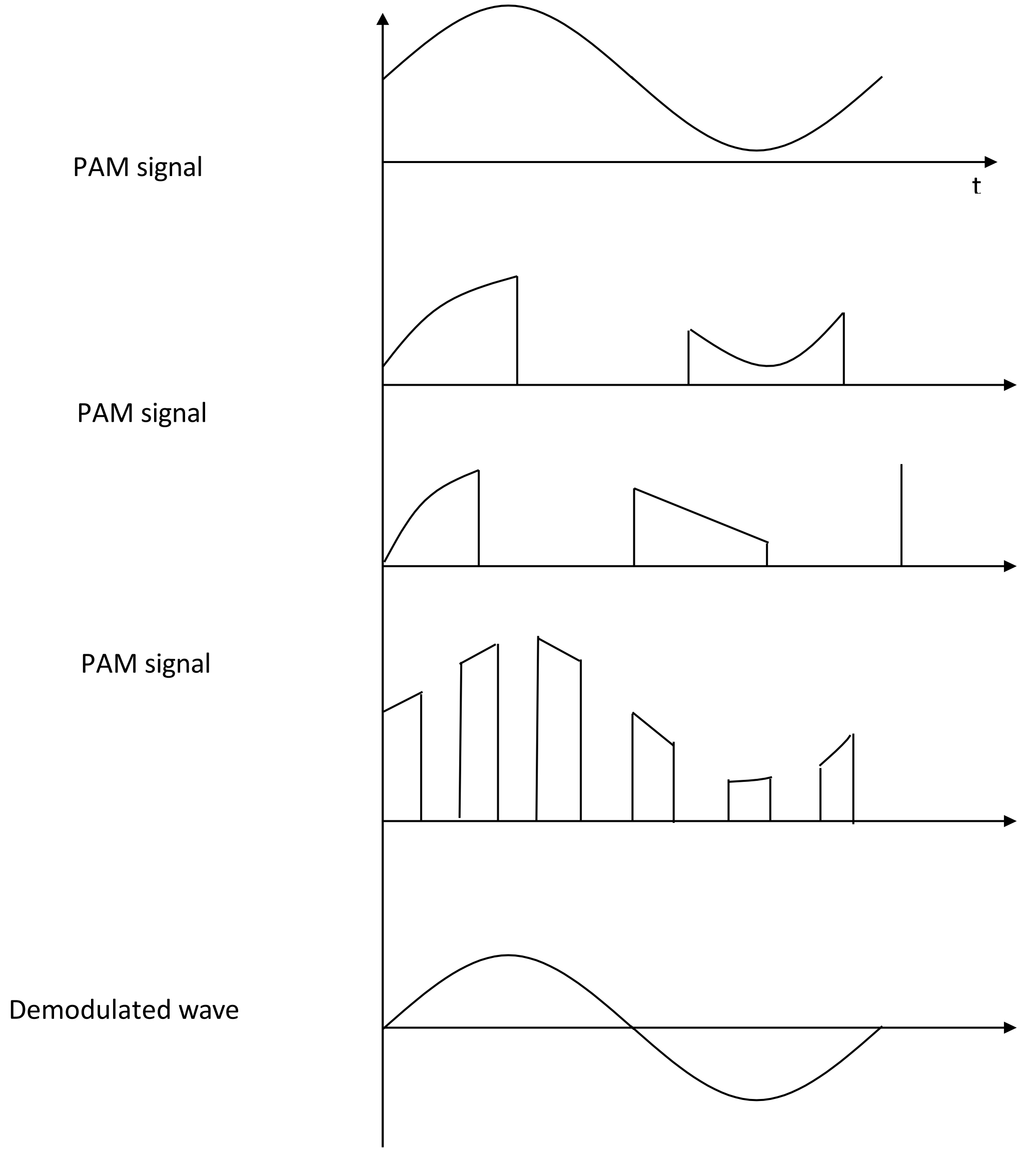
Pulse-amplitude modulation, acronym **PAM**, is a form of signal modulation where the message information is encoded in the amplitude of a series of signal pulses. Demodulation is performed by detecting the amplitude level of the carrier at every symbol period. The samples are taken at regular intervals of time. Each sample is a pulse whose amplitude of the variable at the instant of time at which the sample is taken. It is a simple process.

Pulse-amplitude modulation is now rarely used, having been largely superseded by pulse-code modulation, and more recently, by pulse-position modulation. The widely popular Ethernet communication standard is a good example of PAM usage.

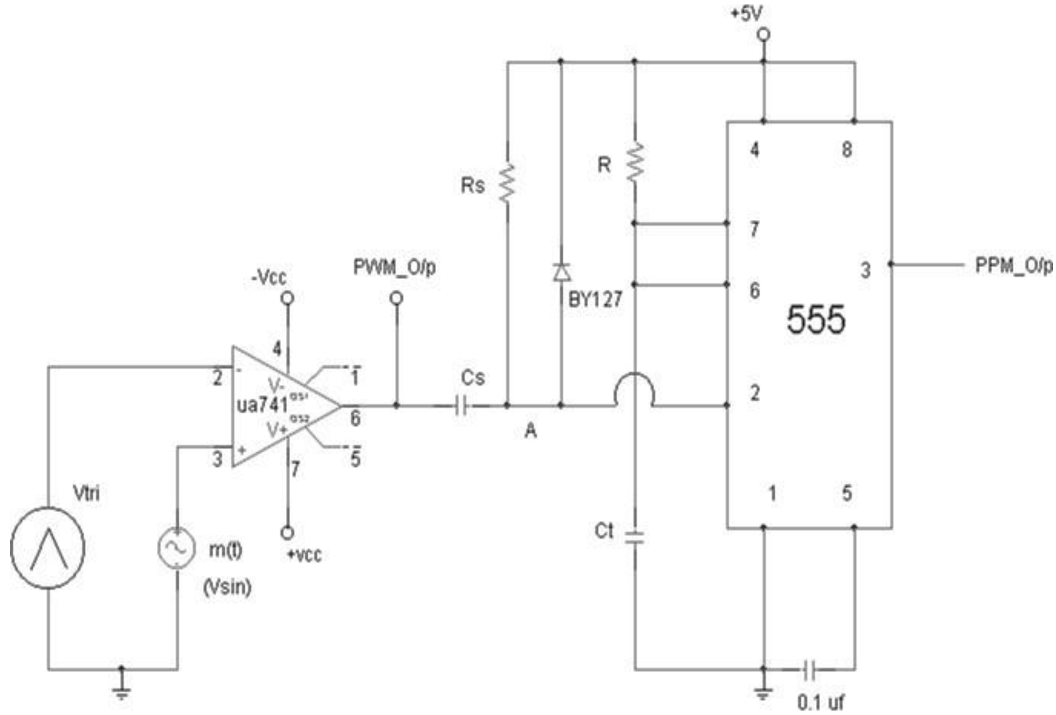
Tabular Column:

Vc(p-p)=__________V, Vm(p-p)=________________V

Sl. No.	Sampling methods	Fc in Hz	fmin Hz	Vo of demodulated Signal in Volt	fo of demodulated signal in Hz
1	Under Sampling (fc<2fm)				
2	Nyquist Rate fc=2fm				
3	Over Sampling fc>2fm				



Circuit Diagram:



Experiment No: 08 **Date:**

GENERATION AND DETECTION OF PULSE POSITION MODULATION

Aim: To conduct an experiment to generate PPM signal and to measure critical amplitude.

Apparatus Required:

Sl. No.	Particulars	Range	Quantity
1.	ICs	555,uA741	01each
2.	Resistors & Capacitor	As per design	-
3.	DiodeBY127	-	01
4.	Spring board + connecting wires	-	01set

Theory:

Pulse Position Modulation: In this type the amplitude and width of the pulse are kept constant, with reference to the position of a reference pulse. It is changed according to the instantaneous sampled value of the modulating signal. Hence, the transmitter has to send synchronising pulses to keep the transmitter and receiver in Synchronism. It has an advantage over that of PWM i.e it handles constant power output. But it requires synchronisation at the transmitter as well as the receiver, which is a disadvantage. **Pulse-position modulation** is a form of signal modulation in which M message bits are encoded by transmitting a single pulse in one of 2^M possible time-shifts. This is repeated every T seconds, such that the transmitted bit rate is M/T bits per second. It is primarily useful for optical communications systems, where there is no multipath interference.

Procedure:

1. Check the components/equipment for their working condition.
2. Connections are made as shown in the circuit diagram.
3. Check the output of Monostable Multivibrator (unmodulated carrier) for the designed pulse width by giving an unmodulated PWM signal (m(t) amplitude set to zero).
4. By increasing the amplitude of the modulating signal, observe the PWM waveform and then observe the PPM waveform.

To find the critical amplitude and the dynamic range:

As the amplitude of the modulating signal is increased, the position of the pulses will vary. Keep on increasing the amplitude of the modulating signal until the pulses disappear. The corresponding amplitude of the modulating signal is the critical amplitude. The dynamic range is the difference between the critical amplitude and the amplitude of the modulating signal at which the PPM just begin.

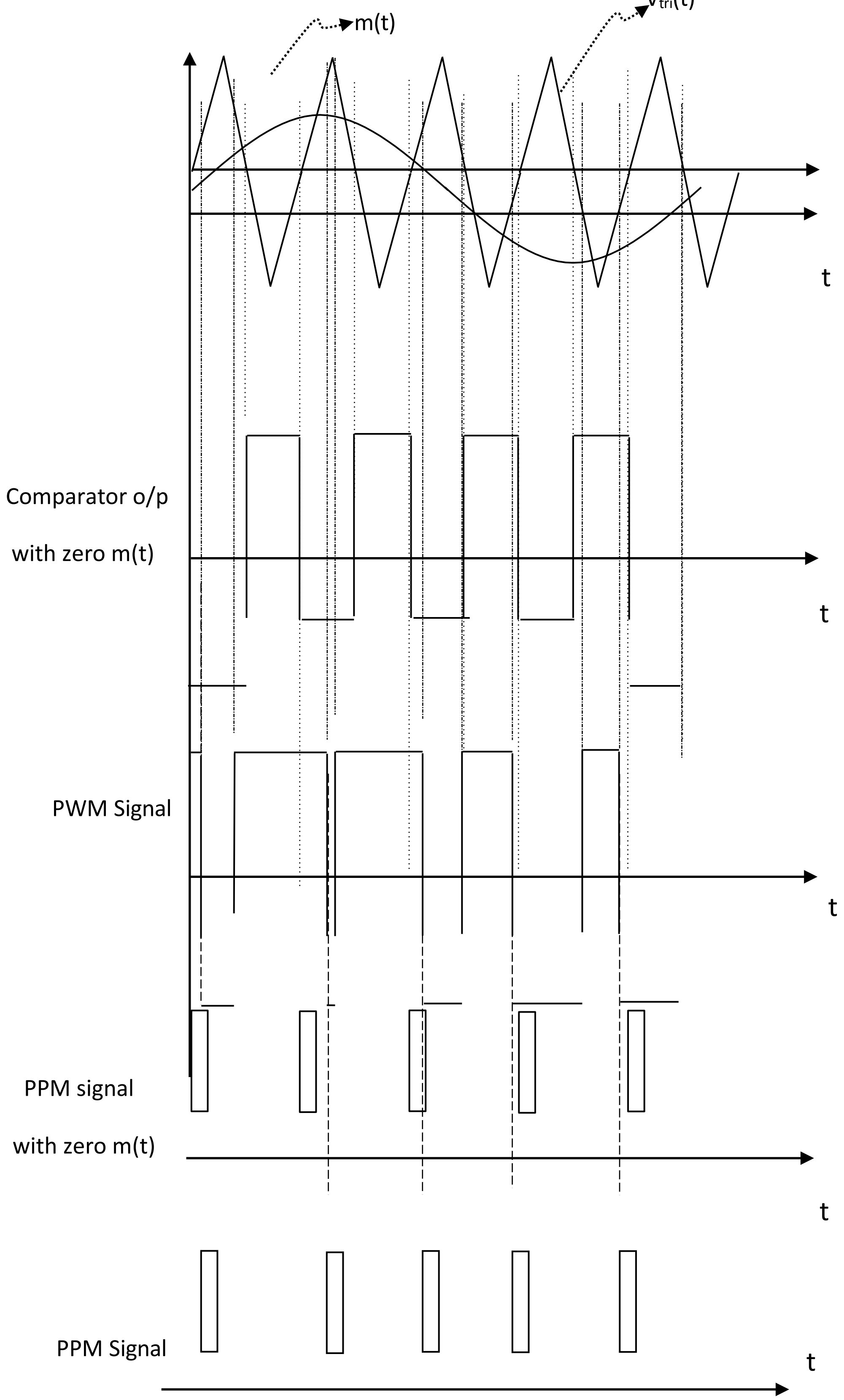
Result:

Pulse width =__________ms

Dynamic range =__________Volt

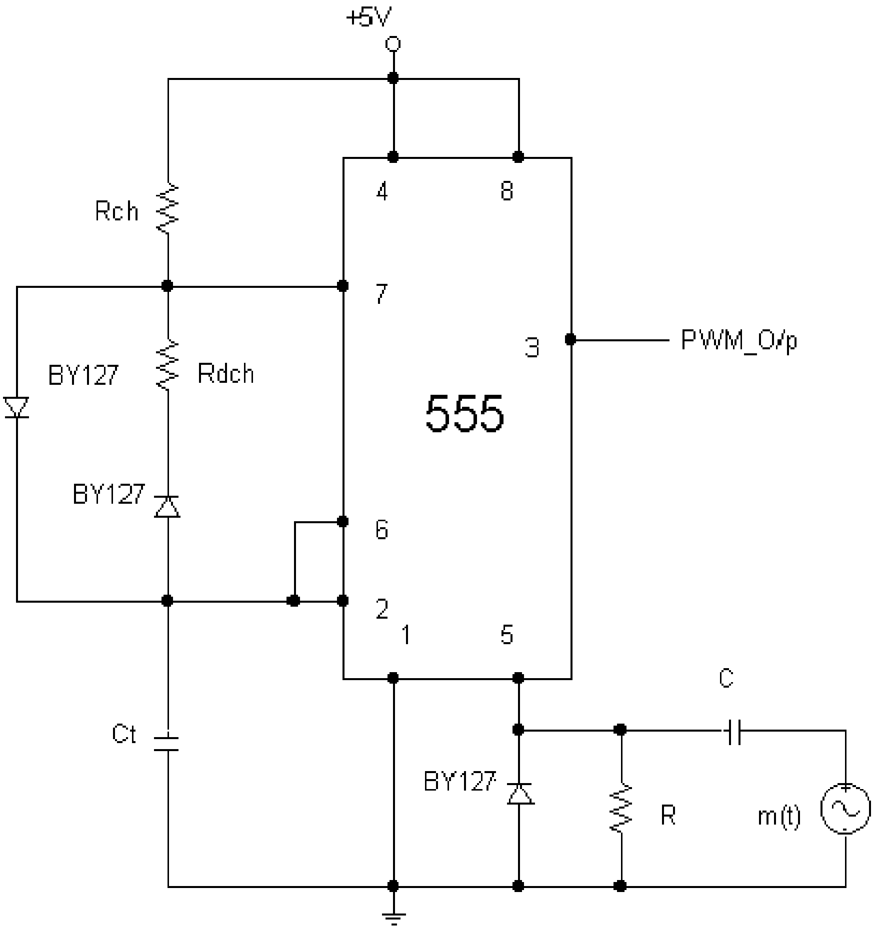
Critical Amplitude =__________Volt

Wave forms:



m(t)
Vtri(t)
t
Comparator o/p
with zero m(t)
t
PWM Signal
t
PPM signal
with zero m(t)
t
PPM Signal
t

Circuit Diagram:



Design:

Specifications: fc=1kHz, Duty cycle =50%

Hence T=1/fc=1ms,Ton=0.5ms and Toff=0.5ms

Astable Multivibrator:

Ton = 0.693 (Rch + Rf) Ct, Toff=0.693(Rdch+Rf)Ct

Since duty cycle = 50 %, Ton = Toff = 0.5 ms

Assume Ct=0.1μf and the forward resistance of the diode RF=100Ω

Then Rch=Rdch=7.146KΩ

Clamping Circuit:

Negative peak of the modulating signal should be clamped to zero volts.

RC >> 1 / fm, therefore RC = 100/fm

Choose C=10μf, fm=100Hz then R=100kΩ

EXPERIMENT No: 09 **Date:**

GENERATION AND DETECTION OF PULSEWIDTH MODULATION

Aim: To conduct an experiment to generate a PWM signal and to measure the critical amplitude.

Apparatus:

Sl.No.	Particulars	Range	Quantity
1.	IC	555Timer	01
2.	Resistors & Capacitors	As per design	-
3.	DiodeBY127	-	03
4.	Spring board + connecting wires	-	01set

Theory:

Pulse width modulation is also known as pulse duration modulation. Three variations of pulse width modulation is possible.

1. The leading edge of the pulse is held constant and the change in pulse width in accordance to the information signal.
2. The tail edge is held constant, and with respect to it pulse width is measured.
3. The centre of the pulse is held constant and pulse width changes on either side of the centre of the pulse.

Pulse-width modulation of a signal or power source involves the modulation of its duty cycle, to either convey information over a communications channel or control the amount of power sent to a load.

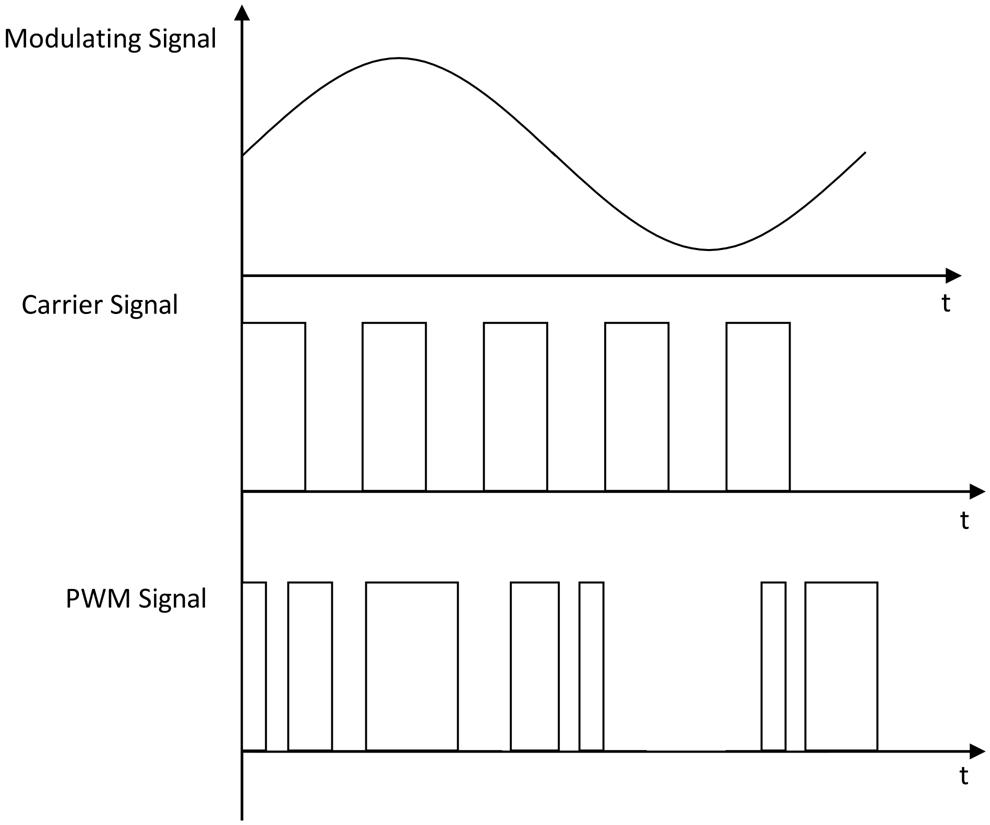
Procedure:

1. Check the components/equipment for their working condition.
2. Connections are made as shown in the circuit diagram.
3. Keeping the modulating signal with minimum amplitude, observe the astable multivibrator output and verify the frequency and duty cycle.
4. Apply the modulating signal with frequency f_m at some convenient amplitude.
5. Observe the PWM waveform.
6. Observe the variation of pulse width with respect to the clamped modulating signal (at Pin No.5).

Tabular Column: fm = ______________Hz

Unmodulated Carrier Signal			**Modulated Signal**		**Dynamic range in volt**
Ton in ms	**Toff in ms**	**Fc in Hz**	**Max. width in ms**	**Min. width in ms**	

Waveforms:



Reference waveform

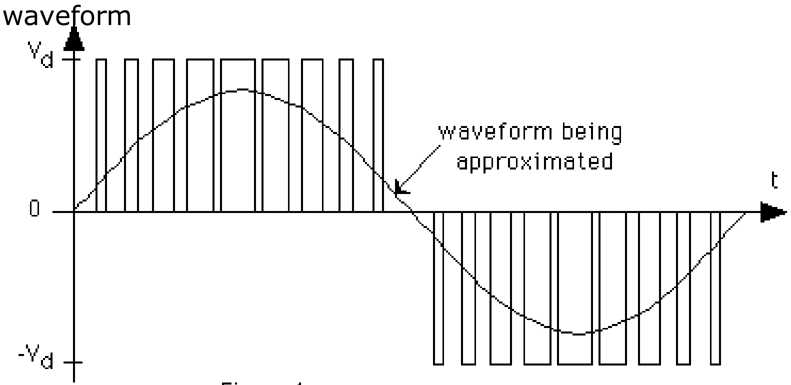


Figure 1

To find the critical amplitude and the dynamic range:

As the amplitude of the modulating signal is increased the width of the pulses during the negative half cycle of the modulating signal will reduce and during positive half cycle will increase. Keep on increasing the amplitude of the modulating signal until the pulses will disappear for the first time either because the width of the pulse may become zero during negative half cycle or the width of the pulse may become so large that it combines with the neighboring pulse during positive half cycle. The corresponding amplitude of the modulating signal is the critical amplitude.

The dynamic range is the difference between the critical amplitude and the amplitude of the modulating signal at which the PWM just begin.

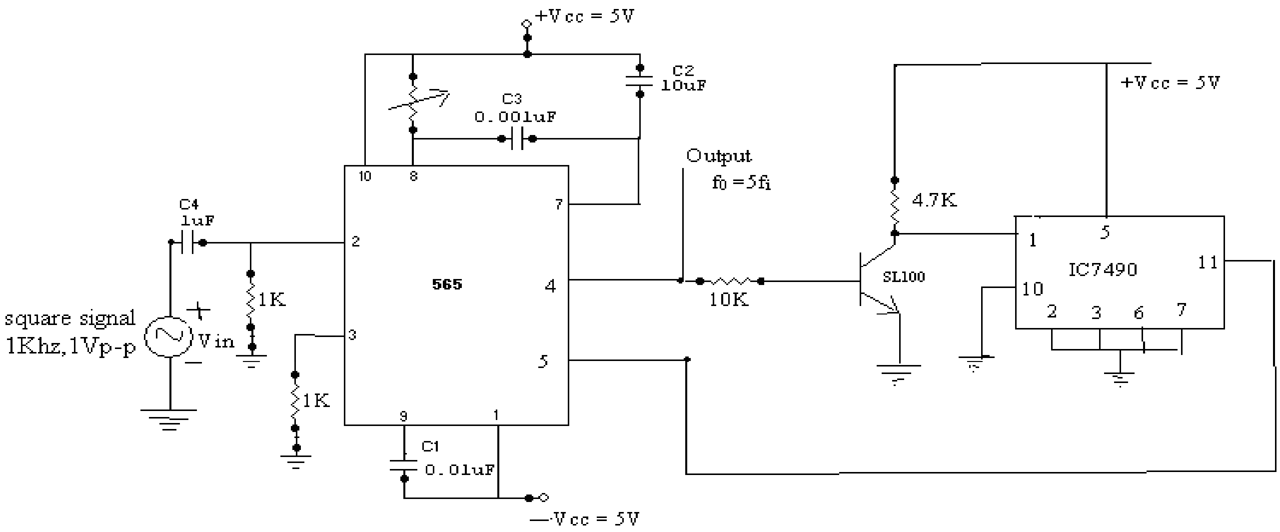
Result:

Pulse width = _________ms

Dynamic range = ________Volt

Critical Amplitude = ______Volt

Circuit Diagram:



Design:

The centre frequency of the PLL is determined by the free-running frequency of the VCO which is given by

f_{out} =1.2/4R_1C_1Hz f_L = ±8 f_{out}/ V

Where V= (Vcc-(-Vcc)) = 10Vf_C=±[f_L/(2лx3.6x10^3xC_2)]$^{1/2}$

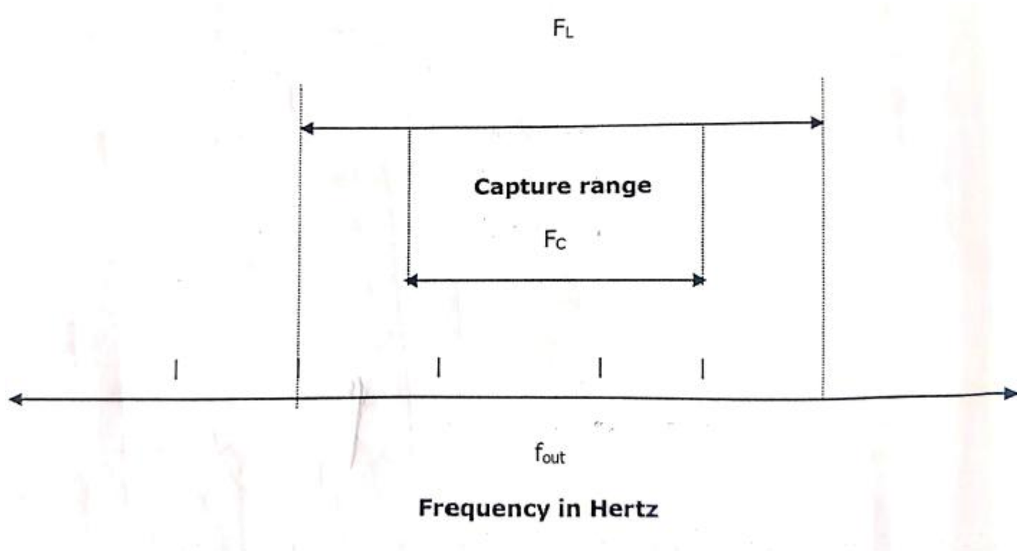
Where 3.6K is the internal resistance of the capacitor C_2

f_{out}= 1.2/ (4x 4.3x10^3x0.01x10^{-6}) = 70KHz

f_L=±(8x70K)/10=±56KHz

f_C= ±49.75KHz

Lock Range



EXPERIMENT No: 10 **Date:**

FREQUENCY SYNTHESIS USING PLL

Aim: To study the frequency synthesis of PLL.

Theory:

Procedure for Frequency Synthesis:

1. Make the connections as shown in the circuit diagram.
2. Insert the Mod-5 counter between pin 4 and 5.
3. Usingfunctiongeneratoratpin2applysquarewaveoffrequency1KHzto get 1V p_p input signal.
4. By adjusting the DRB, set the VCO frequency till PLL is locked. Measure & note down the output frequency, it should be 5 times the input frequency.

Result:

Thus using IC NE565 PLL the capture range and the locking range were determined.

NOTE:

Procedure for finding the capture and locking range of PLL

1. Make the Connections as shown in the circuit diagram.
2. Measure and note down the frequency of 565 at pin 4 using CRO without input signal at pin 2.
3. Set the input signal at pin 2 to get 1Vp_p. Increase the input signal frequency slowly at the point of centre frequency f_{out}. At some frequency VCO output will suddenly shift from f_{out}.
4. Measure and note down the frequency that is the lower edge of the Capture range f_{C1}
5. Increase the input signal frequency further till the output signal VCO is in phase with Input.
6. Measure and note down the frequency that is the upper edge of the Lockrange f_{L2}.
7. Now start decreasing at the point of center frequency f_{out}. At some frequency VCO output shifts from f_{out}.
8. Measure and note down the frequency that is the upper edge of the Capture range f_{C2}.
9. Increase the input signal frequency further, till the output signal VCO is in phase with Input.
10. Decrease the input signal frequency further till the output signal VCO is out phase with Input.
11. Measure and note down the frequency that is the lower edge of the Lock range f_{L1}
12. Calculate Locking range as f_{L2}-f_{L1} and capture range as f_{C2}-f_{C1}.

Result: Frequency Synthesis is designed and verified using PLL.

EXPERIMENT No: 11 **Date:**

DATA FORMATTING & LINE CODE GENERATION

Aim: To study Pulse data coding techniques for NRZ formats & generation of Line Codes.

Apparatus:

Sl.No.	Particulars	Range	Quantity
1.	Data Encoding kit	(Digital Trainer Kit)	01
2.	Data bit generator	--	01
3.	Patch cords	--	05
4.	CRO	20MHz	01
5.	CRO Probes	--	02

Block Diagram:

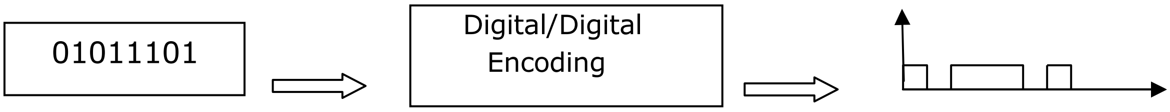
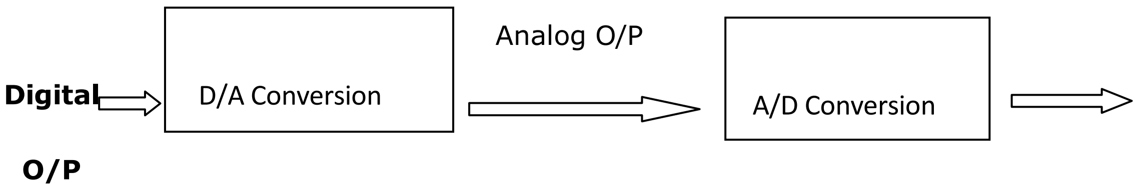


Fig1: Digital-to-Digital Encoding



Theory:

Digital-to-digital conversion is the representation of digital information by a digital signal. In this conversion, the binary 1's and 0's generated by a computer are translated into a sequence of voltage pulses that can be propagated over a wire. Figure 1 shows the relationship between the digital information, the digital-to-digital encoding hardware and the resultant digital signal. There are many mechanisms for digital-to-digital conversion; these are unipolar, polar and bipolar encoding/conversion. In our present experiment, we are using the polar conversion method.

Polar Encoding: It uses two voltage levels, one positive and one negative. Of many existing variations of polar conversion, we will examine only the three most popular: Non-return to zero (NRZ), Return to zero (RZ), and Biphase. NRZ encoding includes two methods: Non-return to zero, level (NRZ-L), and Non-return to zero invert (NRZ-I). Biphase also refers to two methods. The first, Manchester, is the method used by Ethernet LANs. The second, Differential Manchester, is the method used by Token Ring LANs.

Non-Return to Zero(NRZ): In NRZ encoding, the level of the signal is always either positive or negative. The two most popular methods of NRZ transmission are:

NRZ-L: In this encoding method, the level of the signal depends on the type of bit it represents. A positive voltage usually means the bit is a '0', and a negative voltage means the bit is a '1' (or vice-versa). Thus, the level of the signal is dependent upon the state of the bit.

It is the simplest form of data representation. The NRZ (L) waveform simply goes low for one bit time to represent a data '0'& high for one bit time to represent a data '1'. Thus, the signal alternates only when there is a data change.

NRZ-I: In this method, an inversion of the voltage level represents a 1 bit. It is the transition between a positive and negative voltage, not the voltages themselves that represents a 1 bit. A '0' bit is represented by no change.

Non-Return-To Zero (Mark):[NRZ(M)]:

The NRZ (M) code is very similar to the NRZ (L)code. Here if Logic 1 is to be transmitted. The new level is the inverse of the previous level i.e., a change in level occurs. If a data '0' is to be transmitted, the level remains unchanged.

Thus, in the case of the NRZ (M) waveform, the present level is related to the previous levels. See figure 2. Thus, no longer is the absolute value of the signal necessary instead it is the change in the level for which we look now.

Remember: A change means a logic'1'
No change means logic '0

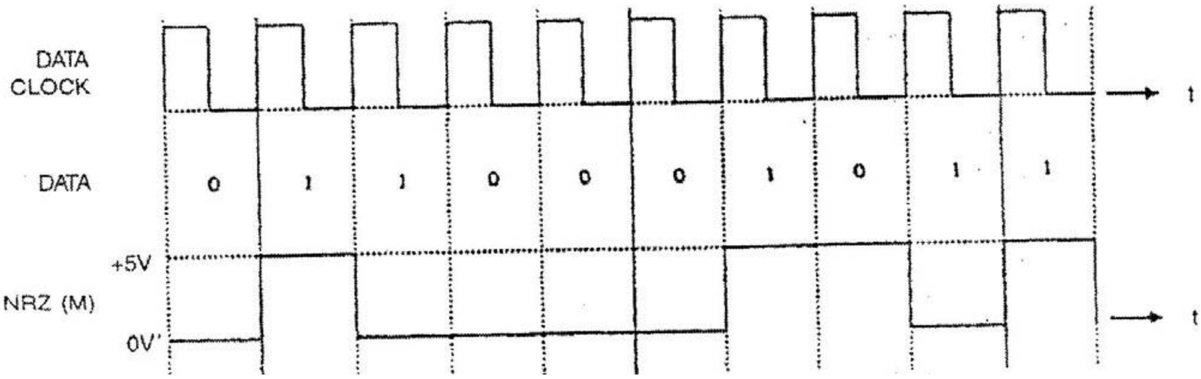


Fig 2: NRZ (M) waveform for a given data stream.

Return to Zero: This method uses three values: positive, negative and zero. The signal changes not between bits but during each bit. A positive voltage means 1 and negative voltage means 0.

Biphase: In this the signal changes at the middle of the bit interval but does not return to zero. Instead it continues to the opposite pole.

Biphase (Manchester) Coding:

The encoding rules for biphase (Manchester) code are as follows: A data '0' is encoded as a low level during first half of the bit time and a high level during the second half. A data'1' is encoded as a high level during first half of the bit time and a low level during the second half. Thus string of 1's or 0's as well as any mixture of them will not pass any synchronization problem in receiver.

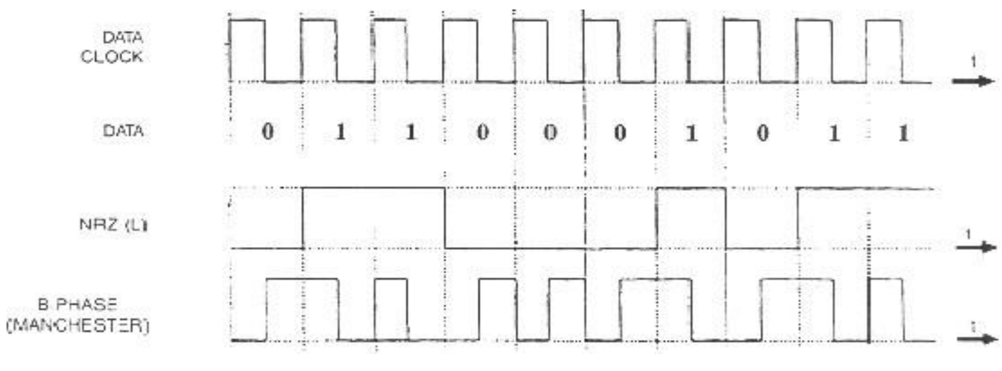


Fig.3: Biphase (Manchester) wave form for a given data stream

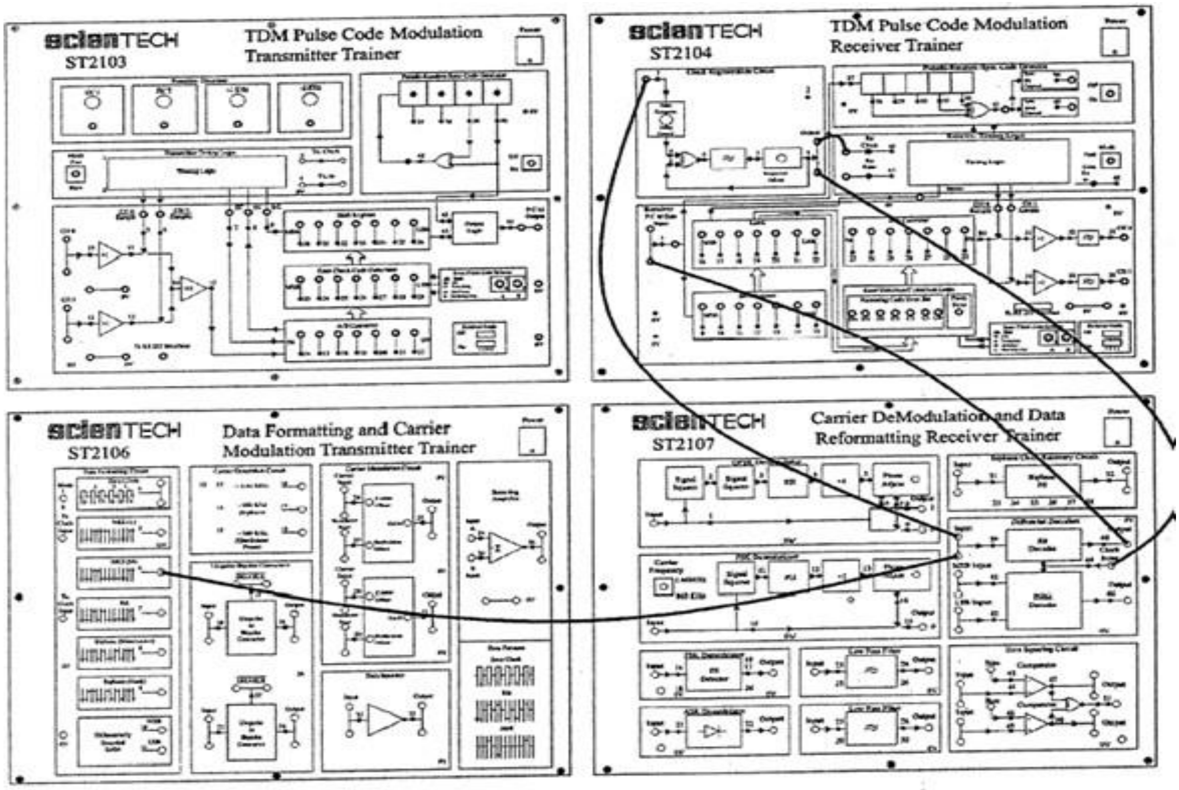
Procedure:

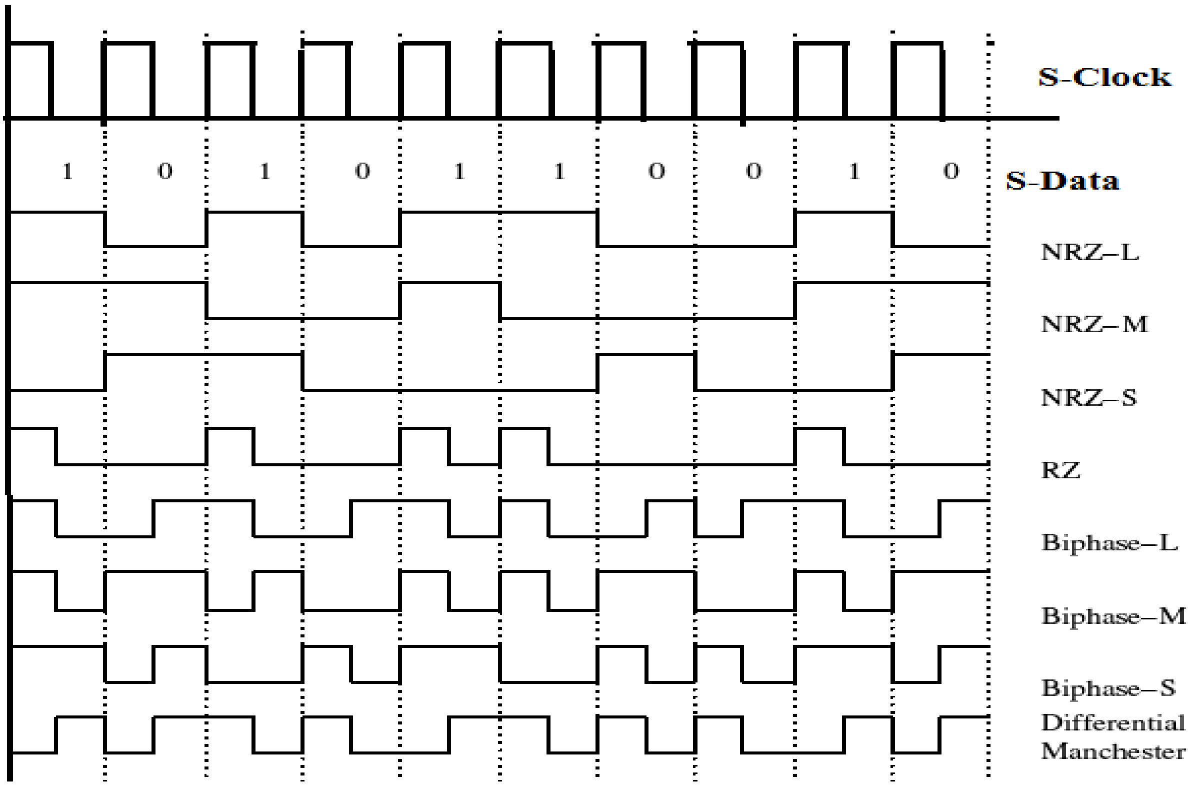
1. Data is generated with the help of a data bit generator.
2. Connect the data O/P of the data generator to the Tx data I/P of the trainer kit.
3. Now connect the clock of the generator to the Tx clock of the kit and ground with the ground terminal of the kit.
4. Select the data on the data generator and load it in the trainer kit by pressing load button.
5. Now observe the O/P of the NRZ-L, NRZ-M and Bi-phase.

Result:

Observed different data formatting methods & generation of line codes.

Circuit Connections at digital trainer kit:





Waveforms of Data Formats

EXPERIMENT No: 12 **Date:**

PCM MULTIPLEXER AND DEMULTIPLEXER

Aim: Study of Pulse Code modulation (PCM)and its demodulation.

Apparatus Required:

Sl.No.	Component	Quantity
1.	PCM modulation/demodulation ST2103 trainer.	1
2.	CRO	1
3.	Connecting leads	2

Theory:

Pulse Code Modulation technique involves following steps:

(a) Sampling:

TheanalogsignalissampledaccordingtotheNyquistcriteria.TheNyquistcriteria states that for faithful reproduction of a band limited signal, the sampling rate must be at least twice the highest frequency component present in the signal. So sampling frequency ≥ 2 fm, where fm is maximum frequency component present in the signal. Practically the sampling frequency is kept slightly more than the required rate.

(b) Allocation of Binary Codes:

Each binary word defines a particular narrow range of amplitude level. The sampled value is then approximated to the nearest amplitude level. The sample is then assigned a code corresponding to the amplitude level, which is then transmitted. This process is called quantization and it is generally carried out by the A/D Converter as shown below in figure 01

Procedure:

1. Ensure that the MODE switch should be in FAST mode.
2. Connect CH0 & CH1 to DC1 AND DC2.
3. Ensure that the DC1 and DC2 controls, in Function Generator Block should be in fully clockwise direction and ~1 KHz and 2 KHz signal controls set at 10Vpp.
4. Now turn ON the kit and see that the LED glows.
5. With the help of Digital Voltmeter, adjust the DC1 amplitude control until the DC1 output measures 0V.
6. Observe the output on the A/D Converter Block LED's (D0 to D6). The LED's represent the state of the binary PCM word allocated to the PAM sample being processed.
7. Adjust the D.C input from +5V to −5V insteps of 1V.
8. Observe the output of +5V is as follows:

D6	D5	D4	D3	D2	D1	D0
1	1	1	1	1	1	1

Where for the negative values it is less than 1000000.For−5V the output is as follows:

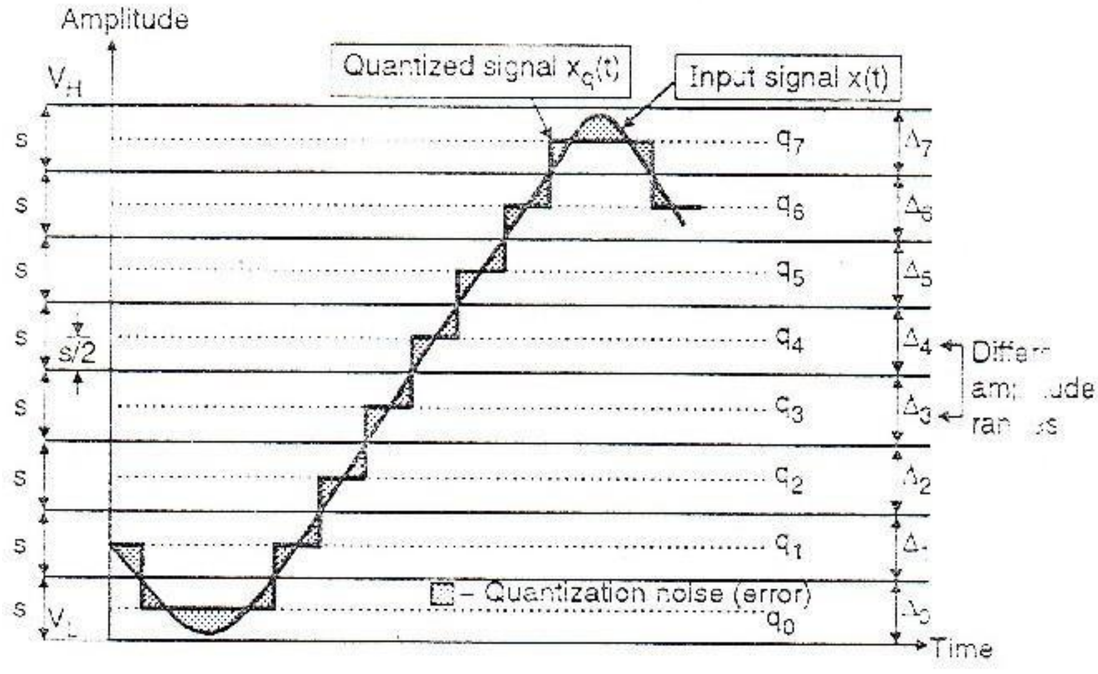
D6	D5	D4	D3	D2	D1	D 0
0	0	0	0	0	0	0

This is obtained at the approximately full anticlockwise position of the DC Control.

9. Turn the DC1 control fully anticlockwise and repeat the above procedure by varying the DC2 control.
10. Trigger the dual trace oscilloscope externally by theCH.1 signal available at

t.p.12 & observe the signal at CH.0 and CH.1 at t.p.5 with reference to the signal at t.p.7.

Now connect the oscilloscope channel 1 to CH1 sample at t.p.6 and sketch the three waveforms

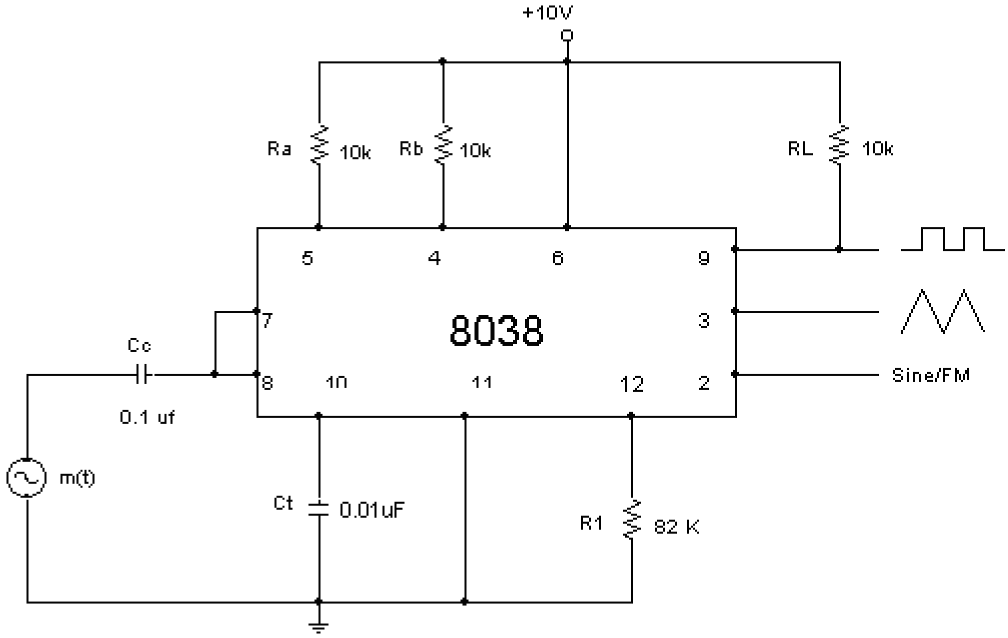


Process of quantization

Fig.1

Result: The PCM Modulation is performed and demodulated.

Circuit Diagram:



Design:

Specifications: Carrier frequency, fc = 3 kHz

fc = 0.3 / (R Ct)   Where R = Ra = Rb

Assume R=Ra=Rb=10kΩ then Ct=0.01 μf

Choose RL = 10 kΩ, R1 = 82 kΩ, Cc = 0.1 μf

Date:

ADDITIONAL EXPERIMENTS BEYOND SYLLABUS

FREQUENCY MODULATION

Aim: To conduct an experiment to generate a frequency-modulated wave and to measure frequency deviation and modulation index.

Apparatus:

Sl.No.	Particulars	Range	Quantity
1.	IC 8038	-	4
2.	Resistors & Capacitors	As per design	1each
3.	CRO Probes	-	2set

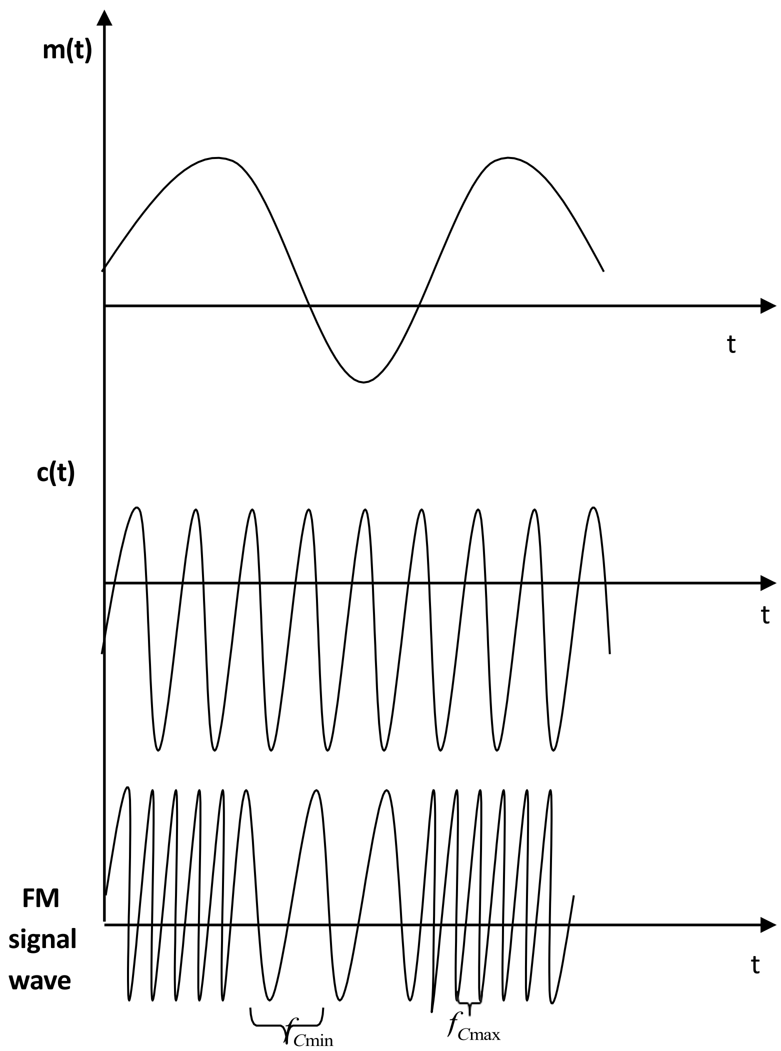
Theory:

Frequency modulation (**FM**) is a form of modulation that represents information as variations in the instantaneous frequency of a carrier wave. In analog applications, the carrier frequency is varied in direct proportion to changes in the amplitude of an input signal. Digital data can be represented by shifting the carrier frequency among a set of discrete values, a technique known as frequency- shift keying.

FM is commonly used at VHF radio frequencies for high-fidelity broadcasts of music and speech. Normal (analog) TV sound is also broadcasted using FM. A narrowband form is used for voice communications in commercial and amateur radio settings. The type of FM used in broadcast is generally called wide-FM, or W- FM. In two-way radio, narrowband narrow-FM (N-FM) is used to conserve bandwidth. In addition, it is used to send signals into space.

FM is also used at intermediate frequencies by most analog VCR systems, including VHS, to record the luminance (black and white) portion of the video signal. FM is the only feasible method of recording video to and retrieving video from magnetic tape without extreme distortion, as video signals have a very large range of frequency components — from a few hertz to several megahertz, too wide for equalizers to work with due to electronic noise below -60 dB. FM also keeps the tape at saturation level, and therefore acts as a form of noise reduction, and a simple limiter can mask.

Waveforms:



Tabular Column:

fc = ____________Hz, fm = ____________Hz

Sl.No	Vm in V	fc_{max} Hz	fc_{min} Hz	TM_1 Hz	TM_2 Hz	TM Hz	® = TM/fm	B_T=2TM+2f m In Hz

Where $\partial_1 = f_{C\max} - f_C, \partial_2 = f_C - f_{C\min}$

variations in the playback output, and the FM capture effect removes print- through and pre-echo. FM is also used at audio frequencies to synthesise sound. This technique, known as FM synthesis, was popularised by early digital synthesisers and became a standard feature for several generations of personal computer sound cards.

Modulation index

In FM, the modulation index indicates how much the modulated variable varies around its unmodulated level. For FM,

$$h = \frac{\Delta f}{f_m} = \frac{f_\Delta |x_m(t)|}{f_m}$$

With a tone-modulated FM wave, if the modulation frequency is held constant and the modulation index is increased, the (non-negligible) bandwidth of the FM signal increases, but the spacing between spectra stays the same. If the frequency deviation is held constant and the modulation index increased, the bandwidth stays roughly the same, but the spacing between spectra decreases.

Procedure:

1. Check the components/Equipments for their working condition.
2. Connections are made as shown in the circuit diagram.
3. By switching off the modulating signal m(t) note the frequency of the carrier wave at Pin No.2 of IC-8038.
4. Apply the modulating signal with suitable amplitude to get the FM signal.
5. Note the maximum ($f_{c\,max}$) and minimum ($f_{c\,min}$) frequency of the carrier wave in FM signal.
6. Calculate the frequency deviation, modulation index and bandwidth.

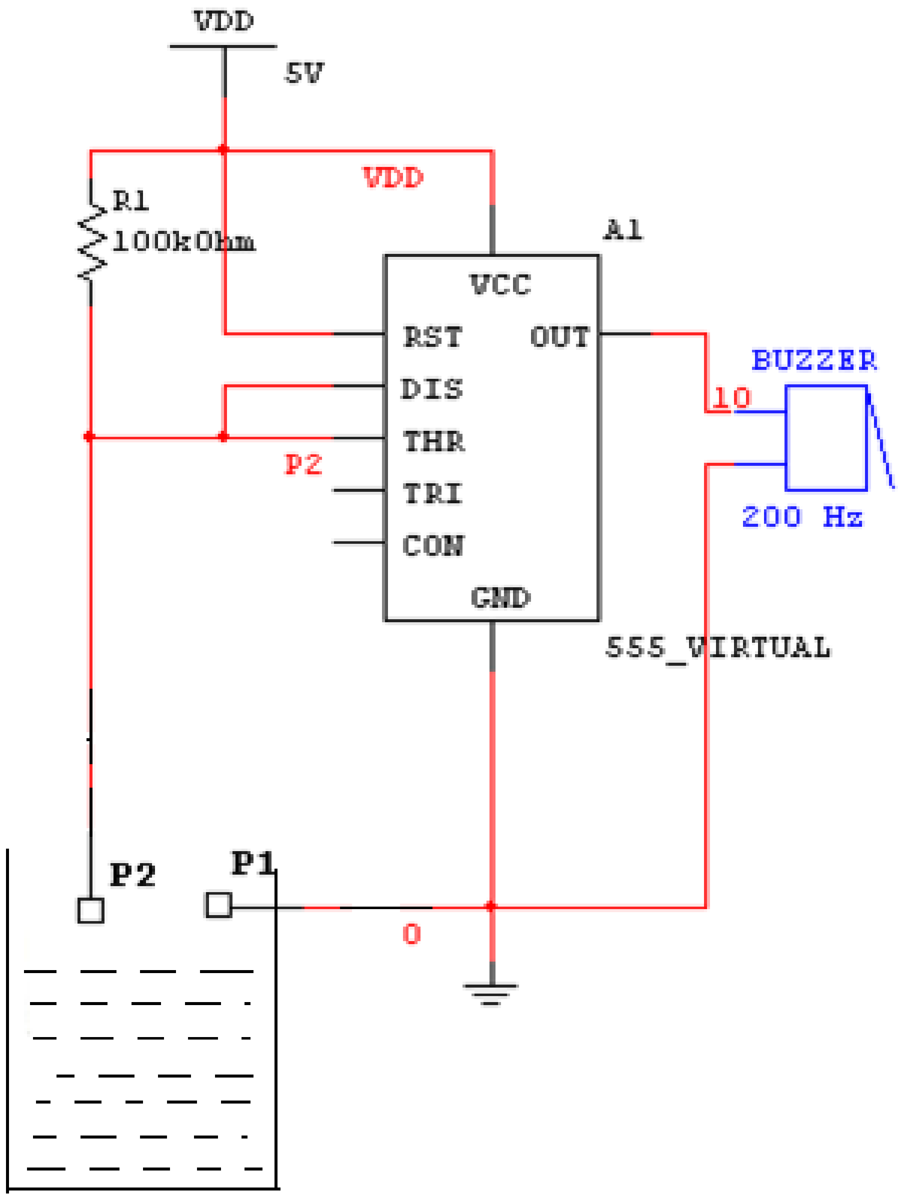
Result:

Modulation index= ___________

Maximum Frequency Deviation = _____Hz.

Bandwidth of Operation = ____________Hz.

Circuit Diagram



MINI PROJECT

MINI PROJECT-1: WATER LEVEL INDICATOR USING 555 TIMER

Aim: To make water level detecting alarm using 555 Timer IC.

Apparatus:

Sl. No.	Particulars	Range	Quantity
1.	IC	555 Timer	1
2.	Resistor	100KΩ	1
3.	Buzzer	6-12V	1
4.	Connecting wires	-	1 set

Procedure:

1. Rig up the circuit as shown in the circuit diagram.
2. Apply+5V supply to VCC (pin no 8).
3. Keep the probes/ wires inside the water container.
4. Observe the output.

Working:

The circuit is normally disabled, and it gets enabled only when the probes touch the water. The distance between the probes should be less than a few centimeters to ensure that the conduction between the probes will take place when water is touched to these probes. When the water level rises to the height of the probes, then the 555 circuit will get enabled and the output is given to the mini loudspeaker/ Buzzer which then beeps.

Result: