

JSS MAHAVIDYAPEETHA
JSS SCIENCE AND TECHNOLOGY UNIVERSITY

SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING



- Constituent College of JSS Science and Technology University
- Approved by A.I.C.T.E
- Governed by the Grant-in-Aid Rules of Government of Karnataka
- Identified as lead institution for World Bank Assistance under TEQIP Scheme



DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

**COMMUNICATION LAB –I
(20EC47L)**

Lab Location: AB202C

**Prepared by
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Vision statement of the JSS Science and Technology University

- Advancing JSS S&T University as a leader in education, research and technology on the International arena.
- To provide the students a universal platform to launch their careers, vesting the industry and research community with skilled and professional workforce.
- Accomplishing JSS S&T University as an epicenter for innovation, center of excellence for research with state of the art lab facilities.
- Fostering an erudite, professional forum for researchers and industrialist to coexist and to work cohesively for the growth and development of science and technology for betterment of society.

Mission statement of the JSS Science and Technology University

1. Education, research and social outreach are the core doctrines of JSS S&T University that are responsible for accomplishment of in-depth knowledge base, professional skill and innovative technologies required to improve the socio economic conditions of the country.
2. Our mission is to develop JSS S&T University as a global destination for cohesive learning of engineering, science and management which are strongly supported with interdisciplinary research and academia.
3. JSS S&T University is committed to provide world class amenities, infrastructural and technical support to the students, staff, researchers and industrial partners to promote and protect innovations and technologies through patents and to enrich entrepreneurial endeavors.
4. JSS S&T University core mission is to create a knowledge led economy through appropriate technologies, and to resolve societal problems by educational empowerment and ethics for better living.

Vision statement of the department of E&CE

Be a leader in providing globally acceptable education in electronics and communication engineering with emphasis on fundamentals-to-applications, creative-thinking, research and career- building.

Mission statement of the department of E&CE

1. To provide best infrastructure and up-to-date curriculum with a conducive learning environment.
2. To enable students to keep pace with emerging trends in Electronics and Communication Engineering.
3. To establish strong industry participation and encourage student entrepreneurship.
4. To promote socially relevant eco-friendly technologies and inculcate inclusive innovation activities.

Program Outcomes (POs)

1. **Engineering Knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. **Problem Analysis:** Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences
3. **Design/ Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.
4. **Conduct investigations of complex problems:** Using research based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.
5. **Modern Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitation.
6. **The Engineer and Society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
7. **Environment and Sustainability:** Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
9. **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
11. **Lifelong Learning:** Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

12. **Project Management and Finance:** Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Program Specific Outcomes (PSOs)

1. Analyze, design and provide engineering solutions in the areas of electronic circuits and systems.
2. Demonstrate the mathematical modeling techniques, nurture analytical and computational skills to provide engineering solutions in the areas of electronics and communication.
3. Ability to address multidisciplinary research challenges and nurture entrepreneurship.

Program Educational Objectives (PEOs)

1. To enable the graduates to have strong Engineering fundamentals in Electronics & Communication, with adequate orientation to mathematics and basic sciences.
2. To empower graduates to formulate, analyze, design and provide innovative solutions in Electronics & Communication, for real life problems.
3. To ensure that graduates have adequate exposure to research and emerging technologies through industry interaction and to inculcate professional and ethical values.
4. To nurture required skill sets to enable graduates to pursue successful professional career in industry, higher education, competitive exams and entrepreneurship.

Course Outcomes: After studying this course the students shall be able to:

1. Analyze various analog modulation and demodulation circuits.
2. Design various analog modulation circuits, frequency synthesizers, pre-emphasis and de-emphasis circuits.
3. Demonstrate the working of FDM, PLL, and Sample and hold circuits and its reconstruction.

LIST OF EXPERIMENTS

Sl.No	Experiments	Hours
1	Amplitude Modulation and Demodulation	3
2	DSB SC Modulation and Demodulation	3
3	Frequency Modulation and Demodulation	3
4	Pre Emphasis - De Emphasis Circuits	3
5	Verification of Sampling Theorem	3
6	PAM Generation and Reconstruction	3
7	PWM Generation and Reconstruction	3
8	PPM: Generation	3
9	Frequency division multiplexing and demultiplexing	3
10	Frequency synthesis using phase locked loop (PLL)	3

NOTE: A minimum of 10 (Ten) experiments have to be performed and recorded by the candidate to attain eligibility for University Practical Examination

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO9	PO10	PS11	PSO2	PSO3	PSO3
CO1	3	3										
CO2			3									
CO3	3	3	3		3	3	2		3		3	2
20EC 47L (Avg)	3	3	3	3	3	3	2		3		3	2

1. Amplitude Modulation & Demodulation

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

Apparatus Required:

Name of the Component/Equipment	Specifications/Range	Quantity
Transistor(BC 107)	$f_T = 300 \text{ MHz}$ $P_d = 1 \text{ W}$ $I_c(\text{max}) = 100 \text{ mA}$	1
Diode(0A79)	Max Current 35mA	1
Resistors	1K Ω , 2K Ω , 6.8K Ω , 10K Ω	1 each
Capacitor	0.01 μF	1
Inductor	130mH	1
CRO	20MHz	1
Function Generator	1MHz	2
Regulated Power Supply	0-30V, 1A	1

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

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

Where K_a 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 envelope detector produces an output signal that follows the envelop 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 E_{\max} and E_{\min} are the maximum and minimum amplitudes of the modulated wave.

Circuit Diagrams:

For modulation:

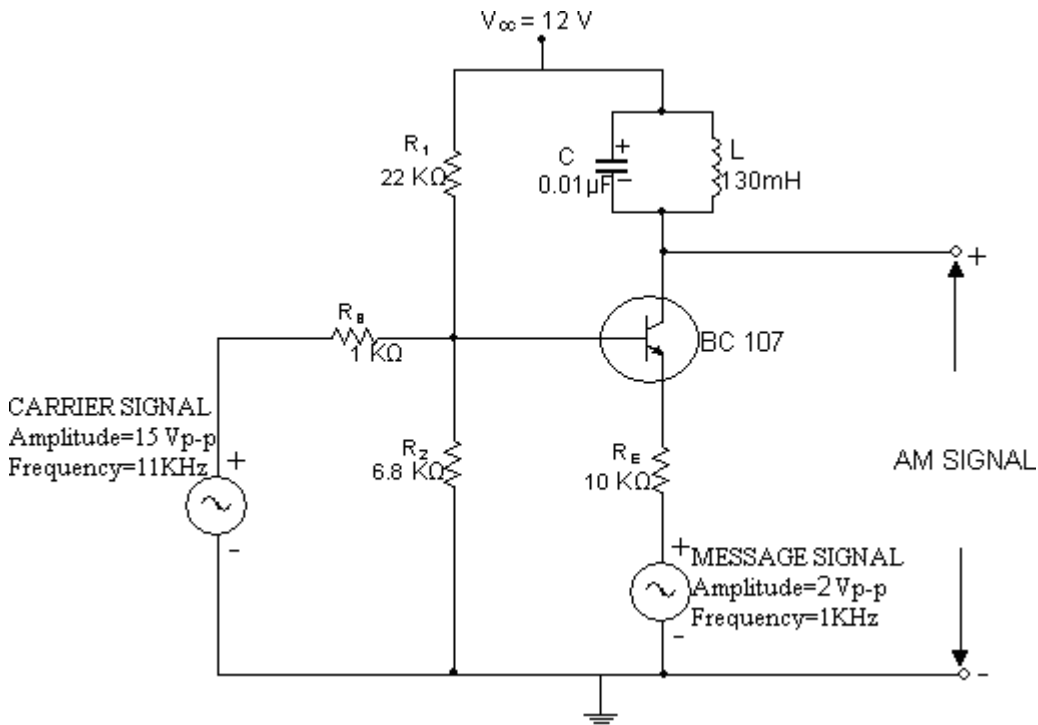


Fig.1.1. AM modulator

For demodulation:

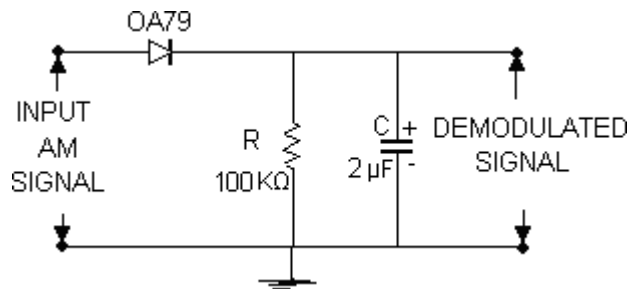


Fig.1.2. AM demodulator

Procedure:

1. The circuit is connected as per the circuit diagram shown in Fig.1.1
2. Switch on + 12 volts V_{CC} supply.

3. Apply sinusoidal signal of 1 KHz frequency and amplitude 2 V (p-p) as modulating signal, and carrier signal of frequency 11 KHz and amplitude 15 V (p-p).
4. Now slowly increase the amplitude of the modulating signal up to 7V and note down values of E_{\max} and E_{\min} .
5. Calculate modulation index using equation
6. Repeat step 5 by varying frequency of the modulating signal.
7. Plot the graphs: Modulation index vs. Amplitude & Frequency
8. Find the value of R from $f_m \approx \frac{1}{2RC}$ Taking $C = 0.01\mu\text{F}$
9. Connect the circuit diagram as shown in Fig1.2
10. Feed the AM wave to the demodulator circuit and observe the output
11. Note down frequency and amplitude of the demodulated output waveform.
12. Draw the demodulated wave form for $m=1$

Observations

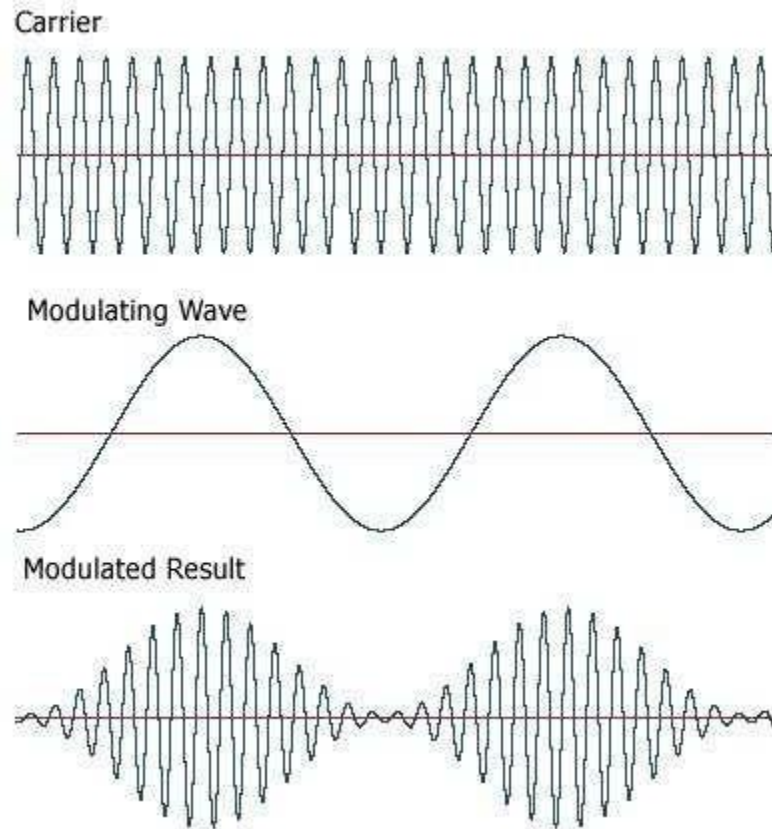
Table 1: $f_m=1\text{KHz}$, $f_c=11\text{KHz}$, $A_c=15\text{ V p-p}$.

S.No.	$V_m(\text{Volts})$	$E_{\max}(\text{volts})$	$E_{\min}(\text{Volts})$	m	%m (m x100)

Table 2: $A_m=4\text{ Vp-p}$ $f_c=11\text{KHz}$, $A_c=15\text{ V p-p}$.

S.No.	$f_m(\text{KHz})$	$E_{\max}(\text{volts})$	$E_{\min}(\text{Volts})$	m	%m (m x100)

Waveforms and Graphs:



Precautions:

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

2. DSB-SC Modulation and Demodulation

Aim: To generate AM-Double Side Band Suppressed Carrier (DSB-SC) signal.

Apparatus Required:

Name of the Component/Equipment	Specifications/Range	Quantity
IC 1496	Wide frequency response up to 100 MHz Internal power dissipation – 500mw(MAX)	1
Resistors	6.8K Ω	1
	10 K Ω , 3.9 K Ω	2 each
	1K Ω ,51 K Ω	3 each
Capacitors	0.1 μ F	4
Variable Resistor (Linear Pot)	0-50K Ω	1
CRO	100MHz	1
Function Generator	1MHz	2
Regulated Power Supply	0-30 v, 1A	1

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 Diagram:

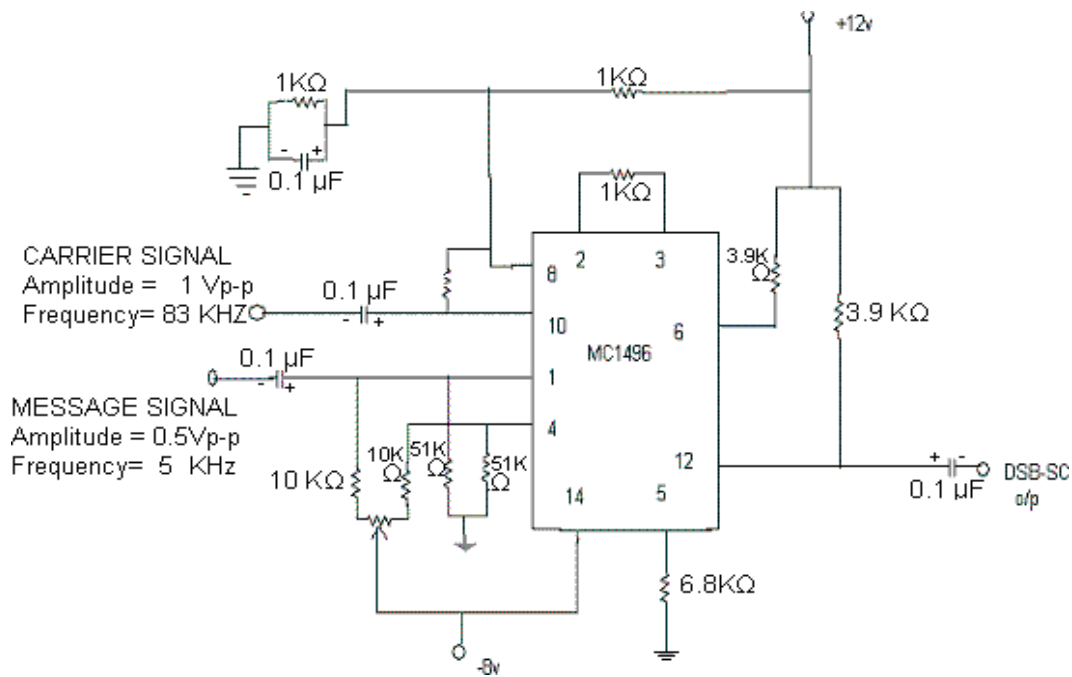
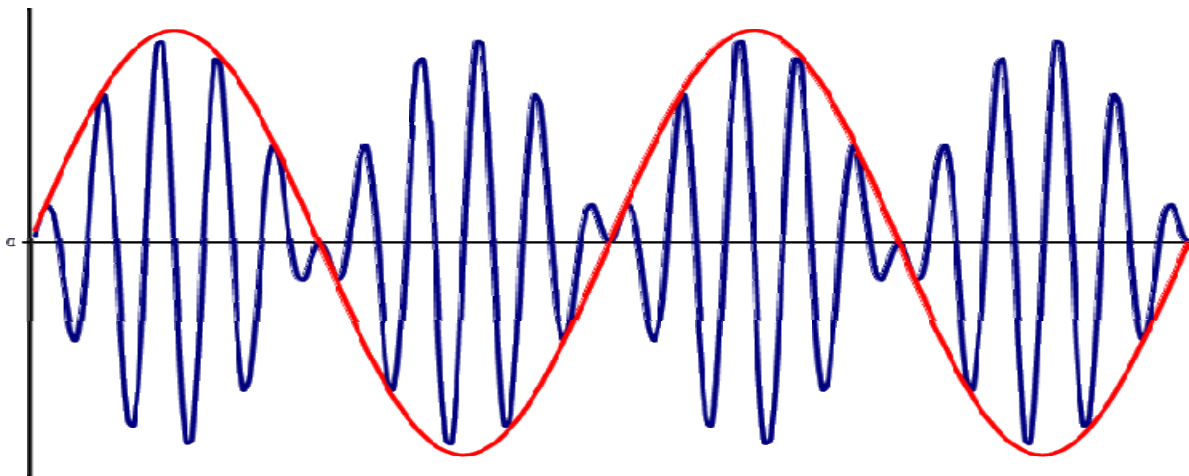


Fig.2.1. Balanced Modulator Circuit

Procedure:

1. Connect the circuit diagram as shown in Fig.1.
2. A Carrier signal of 1Vp-p amplitude and frequency of 83 KHz is applied as carrier to pin no.10.
3. An AF signal of 0.5Vp-p amplitude and frequency of 5 KHz is given as message signal to pin no.1.
4. Observe the DSB-SC waveform at pin no.12.

Waveforms:



3. 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.

Apparatus required:

Name of the Component/Equipment	Specifications/Range	Quantity
IC 566	Operating voltage –Max-24 Volts Operating current-Max.12.5 mA	1
IC 8038	Power dissipation – 750mW Supply voltage - ±18V or 36V total	1
IC 565	Power dissipation -1400mw Supply voltage - ±12V	1
Resistors	15 K Ω, 10 K Ω, 1.8 K Ω,	1,2,1
	39 K Ω, 560 Ω	2,2
Capacitors	470 pF, 0.1μF	2,1
	100pF , 0.001μF	1,1 each
CRO	100MHz	1
Function Generator	1MHz	2
Regulated Power Supply	0-30 v, 1A	1

Theory: The process, in which the frequency of the carrier is varied in accordance with the instantaneous amplitude of the modulating signal, is called “Frequency Modulation”. The FM signal is expressed as

$$V = A \sin [\omega c t + \Delta f / f_m \sin \omega m t]$$

Where A_c is the amplitude of the carrier Signal, f_c is the carrier frequency and

Δf is the modulation index of the FM wave

Circuit Diagrams:

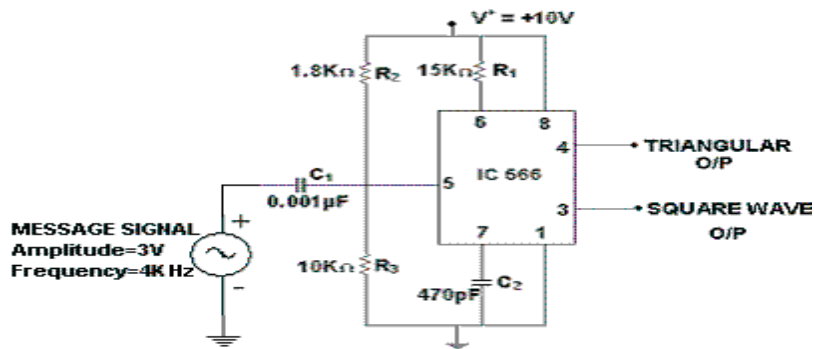


Fig.3.1. FM Modulator Using IC 566

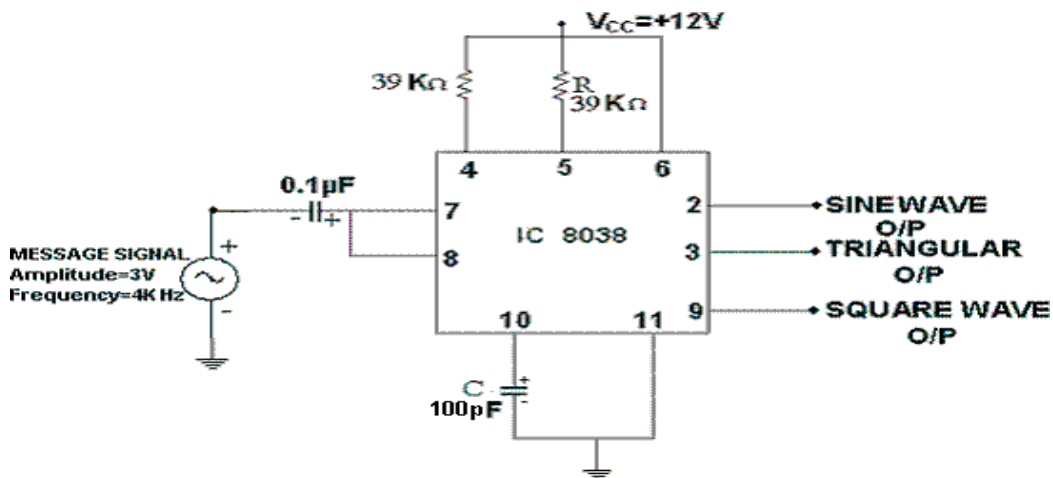


Fig.3.2. FM Modulator Circuit

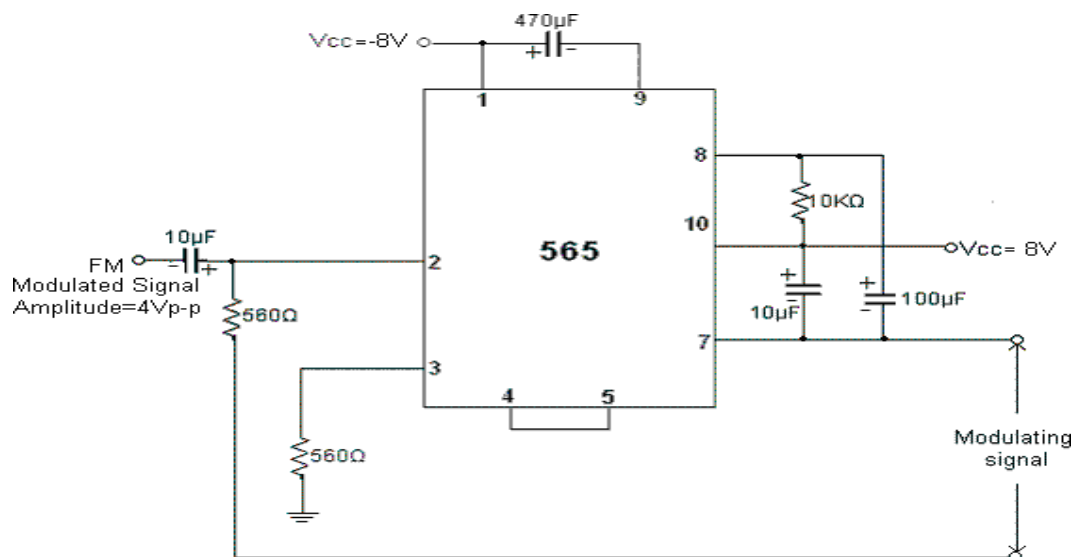


Fig.3.3. FM Demodulator Circuit

Procedure: Modulation:

1. The circuit is connected as per the circuit diagram shown in Fig.3.2
2. Without giving modulating signal observe the carrier signal at pin no.2 (at pin no.3 for IC 566). Measure amplitude and frequency of the carrier signal. To obtain carrier signal of desired frequency, find value of R from $f = 1 / (2\pi RC)$ taking $C=100\mu F$.
3. Apply the sinusoidal modulating signal of frequency 4 KHz and amplitude 3Vp-p at pin no.7. (pin no.5 for IC 566)

Now slowly increase the amplitude of modulating signal and measure f_{min} and maximum frequency deviation Δf at each step. Evaluate the modulating index ($m_f = \beta$) using $\Delta f / f_m$ where $\Delta f = |f_c - f_{min}|$. Calculate Band width. $BW = 2 (\beta + 1)f_m = 2(\Delta f + f_m)$

4. Repeat step 4 by varying frequency of the modulating signal.

Demodulation:

1. Connections are made as per circuit diagram shown in Fig.3.3
2. Check the functioning of PLL (IC 565) by giving square wave to input and observing the output
3. Frequency of input signal is varied till input and output are locked.
4. Now modulated signal is fed as input and observe the demodulated signal on CRO.
5. Draw the demodulated wave form.

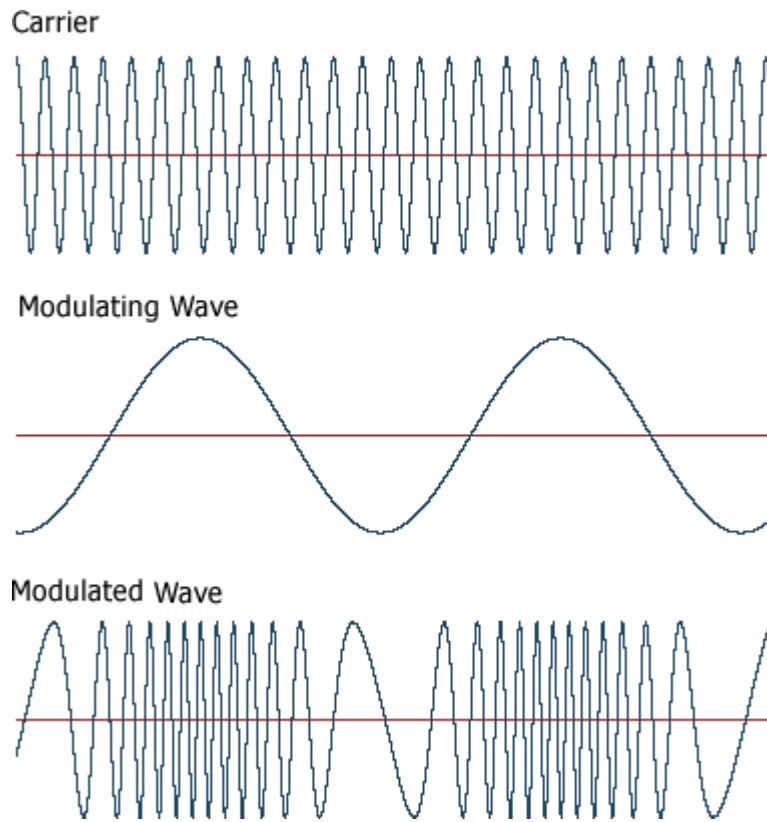
Table: 1 $f_c = 45\text{KHz}$

S.No.	$f_m(\text{KHz})$	$T_{max} (\mu\text{sec})$	$f_{min}(\text{KHz})$	$\Delta f (\text{KHz})$	β	BW (KHz)

Table 2: $f_m = 4 \text{ KHz}, f_c = 45 \text{ KHz}$

S.No.	$A_m (\text{Volts})$	$T (\mu\text{sec})$	$f_{min}(\text{KHz})$	$\Delta f (\text{KHz})$	β	BW(KHz)

Waveforms:



Precautions:

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

4. Pre-Emphasis & De-Emphasis

Aim:

- i) To observe the effects of Pre-emphasis on given input signal.
- ii) To observe the effects of De-emphasis on given input signal.

Apparatus Required:

Name of the Component/Equipment	Specifications/Range	Quantity
Transistor (BC 107)	$f_T = 300 \text{ MHz}$ $P_d = 1 \text{ W}$ $I_c(\text{max}) = 100 \text{ mA}$	1
Resistors	10 K Ω , 7.5 K Ω , 6.8 K Ω	1 each
Capacitors	10 nF	1
	0.1 μF	2
CRO	20MHZ	1
Function Generator	1MHZ	1
Regulated Power Supply	0-30V, 1A	1

Theory:

The noise has a effect on the higher modulating frequencies than on the lower ones. Thus, if the higher frequencies were artificially boosted at the transmitter and correspondingly cut at the receiver, an improvement in noise immunity could be expected, thereby increasing the SNR ratio. This boosting of the higher modulating frequencies at the transmitter is known as pre-emphasis and the compensation at the receiver is called de-emphasis.

Circuit Diagrams:

For Pre-emphasis:

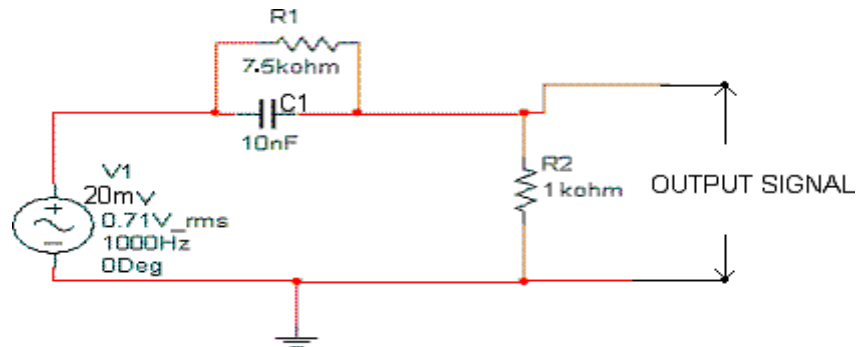


Fig.4.1. Pre-emphasis circuit

For De-emphasis:

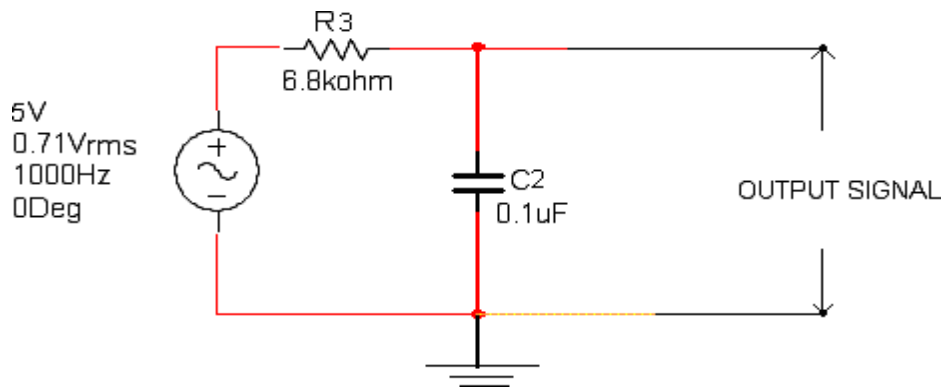


Fig.4.2. De-emphasis circuit

Procedure:

1. Connect the circuit as per circuit diagram as shown in Fig.4.1.
2. Apply the sinusoidal signal of amplitude 20mV as input signal to pre emphasis circuit.
3. Then by increasing the input signal frequency from 500Hz to 20 KHz, observe the output voltage (v_o) and calculate gain ($20 \log (v_o/v_i)$).
4. Plot the graph between gain Vs frequency.
5. Repeat above steps 2 to 4 for de-emphasis circuit (shown in Fig.4.2). by applying the sinusoidal signal of 5V as input signal

Sample readings:

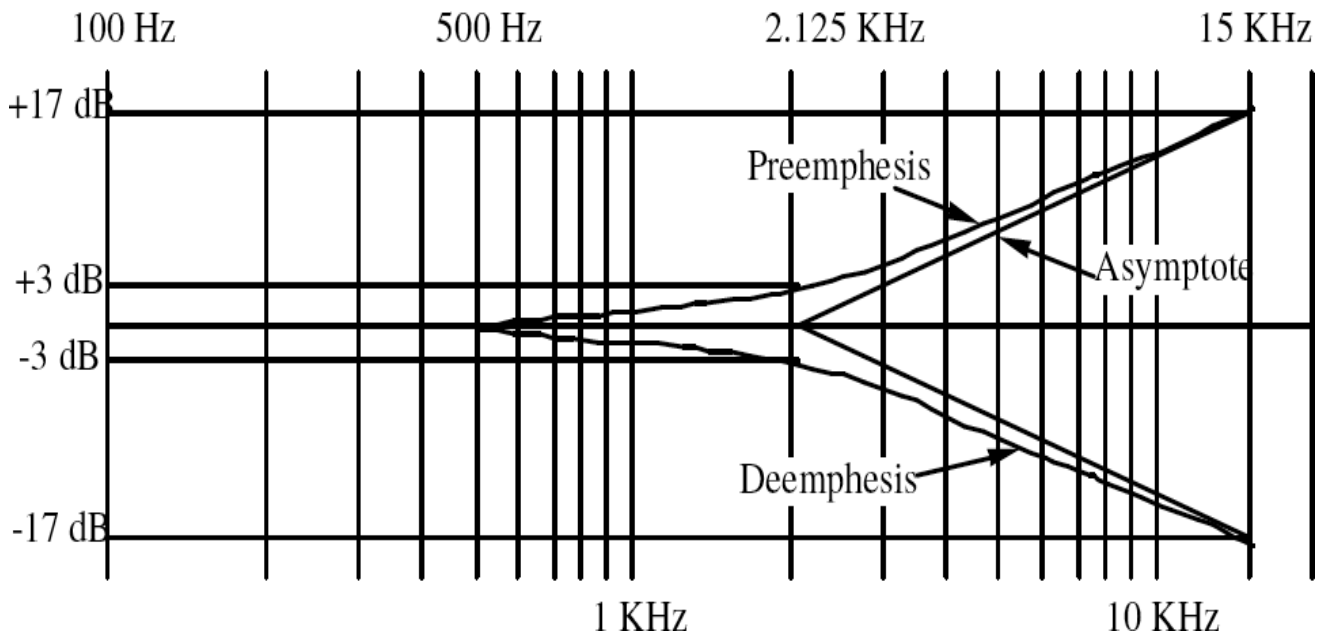
Table1: Pre-emphasis $V_i = 20\text{mV}$

Frequency(KHz)	$V_o(\text{mV})$	Gain in dB($20 \log V_o/V_i$)

Table2: De-emphasis $V_i = 5\text{v}$

Frequency(KHz)	$V_o(\text{Volts})$	Gain in dB($20 \log V_o/V_i$)

Graphs:



Precautions:

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

5. SAMPLING THEOREM VERIFICATION

Aim: To verify the Flat Top sampling theorem.

Apparatus Required:

1. Function Generator (1MHz)
2. Dual trace oscilloscope (20 MHz)
3. Power Supply
4. Op-amps, SL 100, MOSFET, Resistors, and capacitors

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:

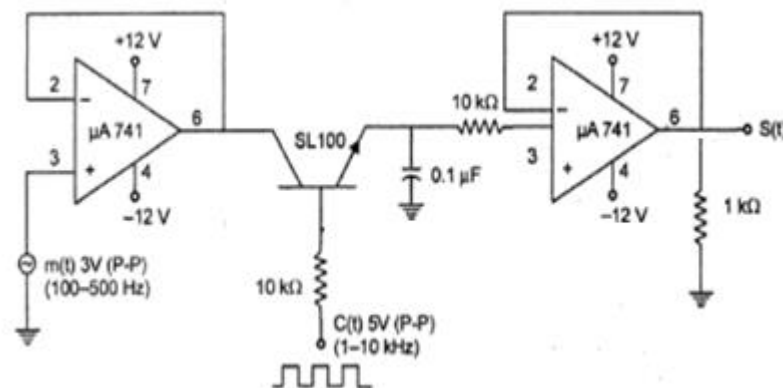


Fig: 5.1 Sampling Circuit using transistor

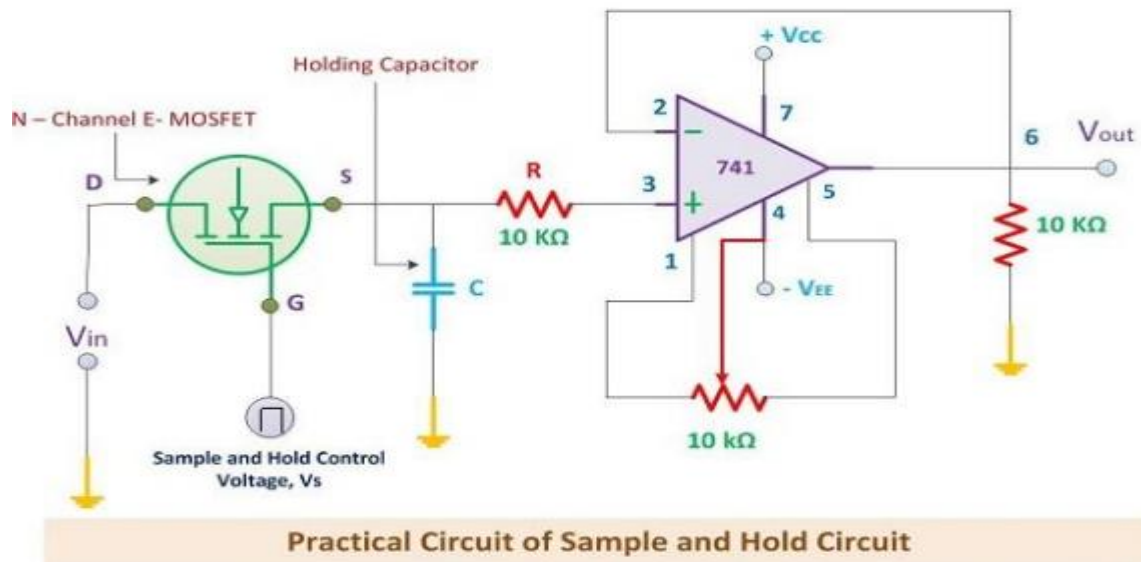


Fig: 5.2 Sampling Circuit using MOSFET

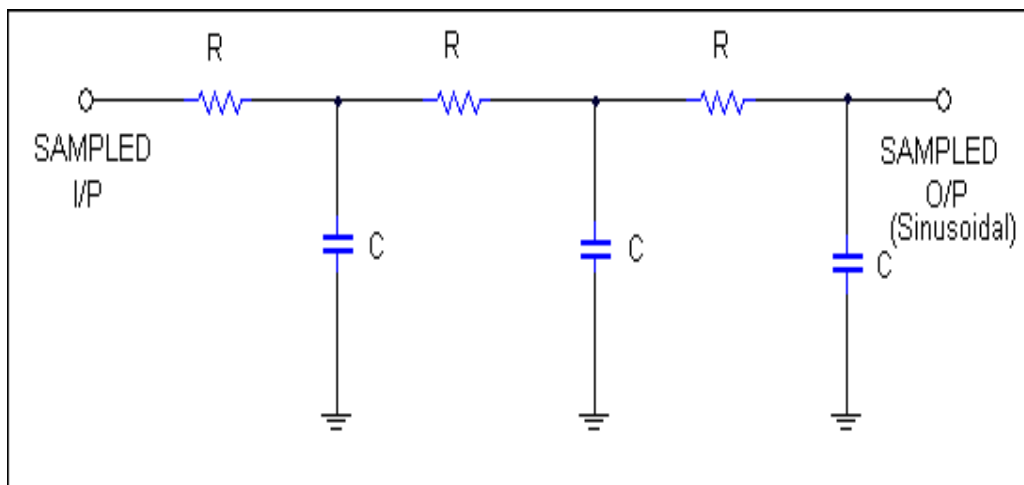


Fig: 5.2 Reconstructing Circuit

Procedure:

1. The circuit is connected as per the circuit diagram shown in the fig 5.1 or 5.2.
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 oscilloscope
5. Initially set the sampling frequency to 200Hz and observe the output on the CRO. Now vary the

amplitude of modulating signal and observe the output of sampling circuit. Note that the amplitude of the sampling pulses will be varying in accordance with the amplitude of the modulating signal.

6. Design the reconstructing circuit. Depending on sampling frequency, R & C values are calculated using the relations $F_s = 1/T_s$, $T_s = RC$. Choosing an appropriate value for C, R can be found using the relation $R=T_s/C$
7. Connect the sampling circuit output to the reconstructing circuit shown in Fig 5.2 or 5.3
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.

Design

(1) Flat top sampling

where $T_m = 3.3 \text{ ms}$

Assume $f_m = 300 \text{ Hz}$

Let

Let

\therefore

$$RC \ll T_m$$

$$RC = 1 \text{ ms}$$

$$R = 10 \text{ k}\Omega$$

$$C = 0.1 \text{ }\mu\text{F}$$

(2) Demodulation

Let

then

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

$$C_1 = 0.1 \text{ }\mu\text{F},$$

$$R_1 = 3.1 \text{ k}\Omega$$

$$\approx 3.3 \text{ k}\Omega$$

Waveforms:

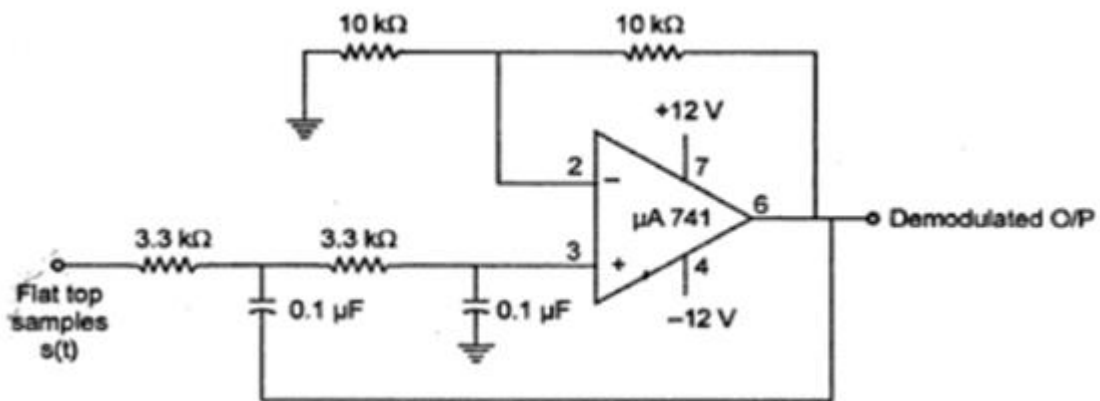
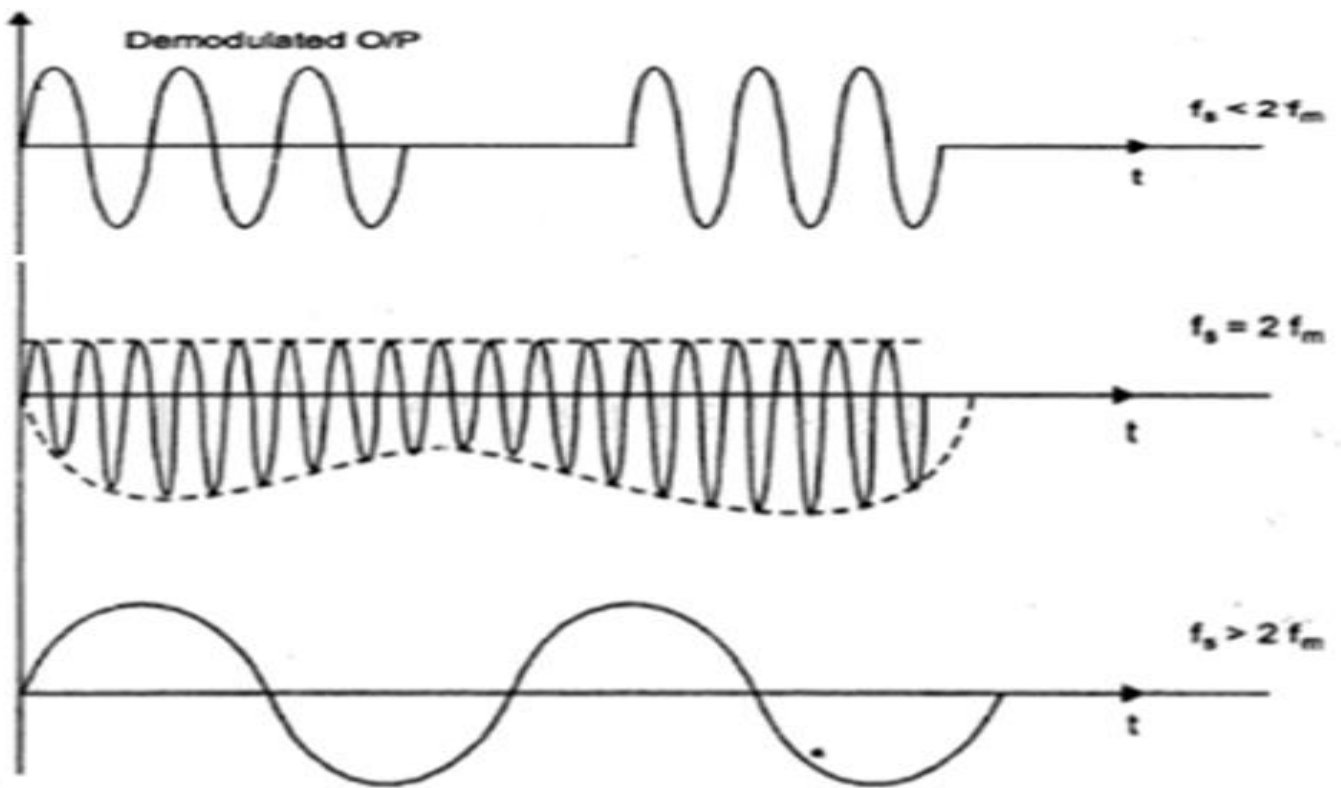
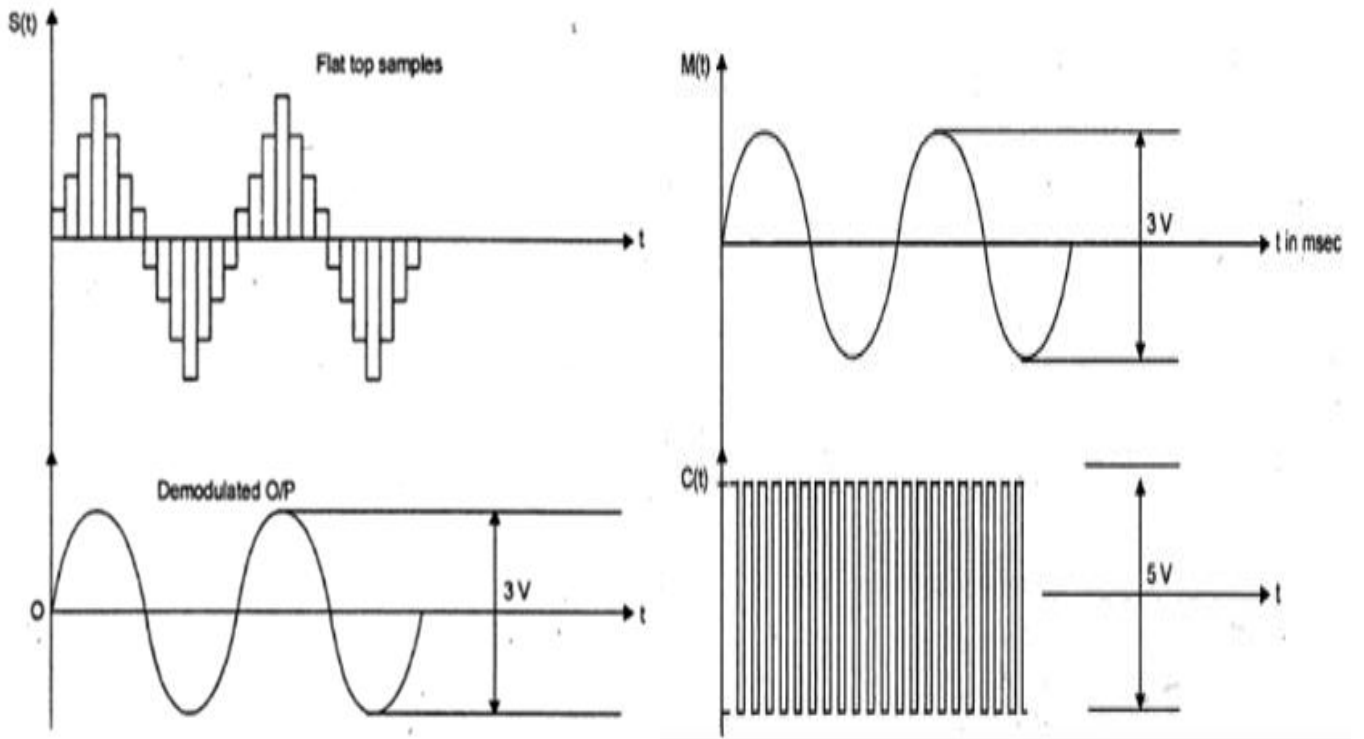


Fig: 5.3 Reconstructing Circuit



6. PULSE AMPLITUDE MODULATION & DEMODULATION

Aim: To generate the Pulse Amplitude modulated and demodulated signals.

Apparatus required:

Name of the Apparatus	Specifications/Range	Quantity
Resistors	1K Ω , 10K Ω , 100K Ω , 5.8K Ω , 2.2K Ω ,	Each one
Transistor	BC 107	2
Capacitor	10 μ F, 0.001 μ F	each one
CRO	30MHz	1
Function generator	1MHz	1
Regulated Power Supply	0-30V,1A	1
CRO Probes	---	1

Theory:

PAM is the simplest form of data modulation .The amplitude of uniformly spaced pulses is varied in proportion to the corresponding sample values of a continuous message $m(t)$.

A PAM waveform consists of a sequence of flat-topped pulses. The amplitude of each pulse corresponds to the value of the message signal $x(t)$ at the leading edge of the pulse.

The pulse amplitude modulation is the process in which the amplitudes of regularity spaced rectangular pulses vary with the instantaneous sample values of a continuous message signal in a one-one fashion. A PAM wave is represented mathematically as,

PAM is of two types

1) Double polarity PAM ==> This is the PAM wave which consists of both positive and negative pulses shown as

2) Single polarity PAM ==> This consists of PAM wave of only either negative (or) Positive pulses

Wave forms:

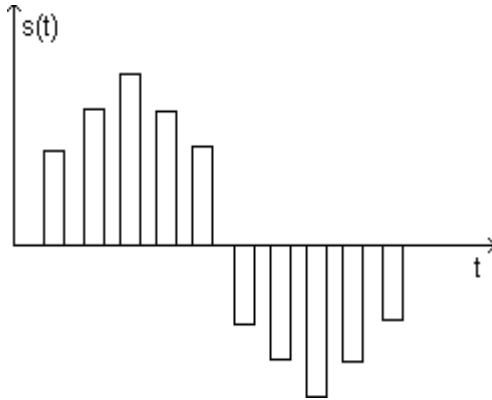


Fig. Bipolar PAM signal

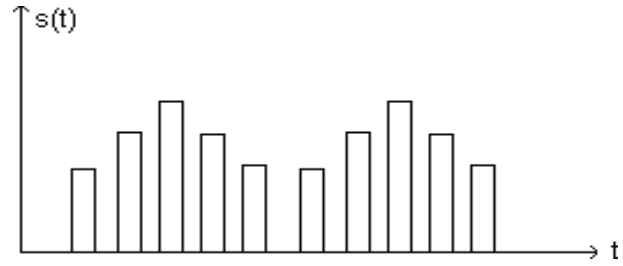


Fig. Single polarity PAM

Circuit Diagram:

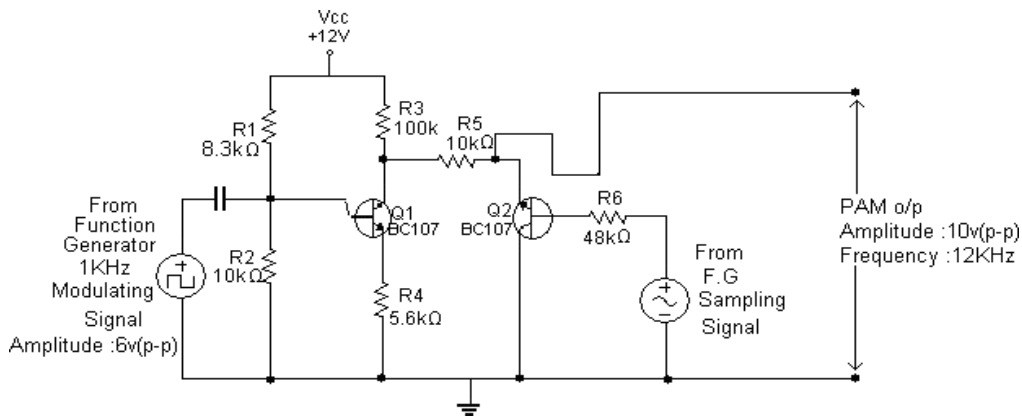


Fig: 6.1 Pulse Amplitude Modulation Circuit

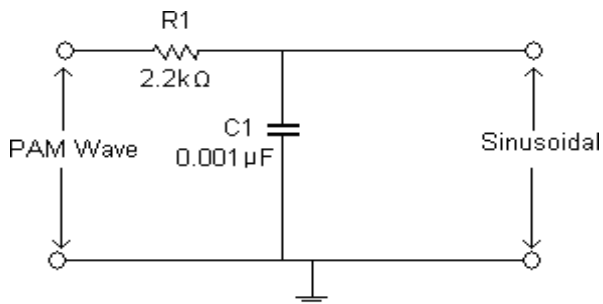


Fig .6.2 Demodulation Circuit

Procedure:

1. Connect the circuit as per the circuit diagram shown in the fig 6.1
2. Set the modulating frequency to 1KHz and sampling frequency to 12KHz
3. Observe the o/p on CRO i.e. PAM wave.
4. Measure the levels of E_{\max} & E_{\min} .
5. Feed the modulated wave to the low pass filter as in fig 6.2.
6. The output observed on CRO will be the demodulated wave.
7. Note down the amplitude (p-p) and time period of the demodulated wave. Vary the amplitude and frequency of modulating signal. Observe and note down the changes in output.
8. Plot the wave forms on graph sheet.

7. PULSE WIDTH MODULATION AND DEMODULATION

Aim: To generate the pulse width modulated and demodulated signals

Apparatus required:

Name of the Apparatus	Specifications/Range	Quantity
Resistors	1.2k Ω , 1.5 k Ω , 8.2 k Ω	1,1,2
Capacitors	0.01 μ F, 1 μ F	2,2
Diode	0A79	1
CRO	0-30, MHz	1
Function Generator	1MHz	1
RPS	0-30v,1A	1
IC 555	Operating tem :SE 555 -55°C to 125°C NE 555 0° to 70°C Supply voltage :+5V to +18V Timing : μ Sec to Hours Sink current :200mA Temperature stability :50 PPM/°C change in temp or 0-005% /°C.	1
CRO Probes	--	1

Theory:

Pulse Time Modulation is also known as Pulse Width Modulation or Pulse Length Modulation. In PWM, the samples of the message signal are used to vary the duration of the individual pulses. Width may be varied by varying the time of occurrence of leading edge, the trailing edge or both edges of the pulse in accordance with modulating wave. It is also called Pulse Duration Modulation.

Circuit Diagram:

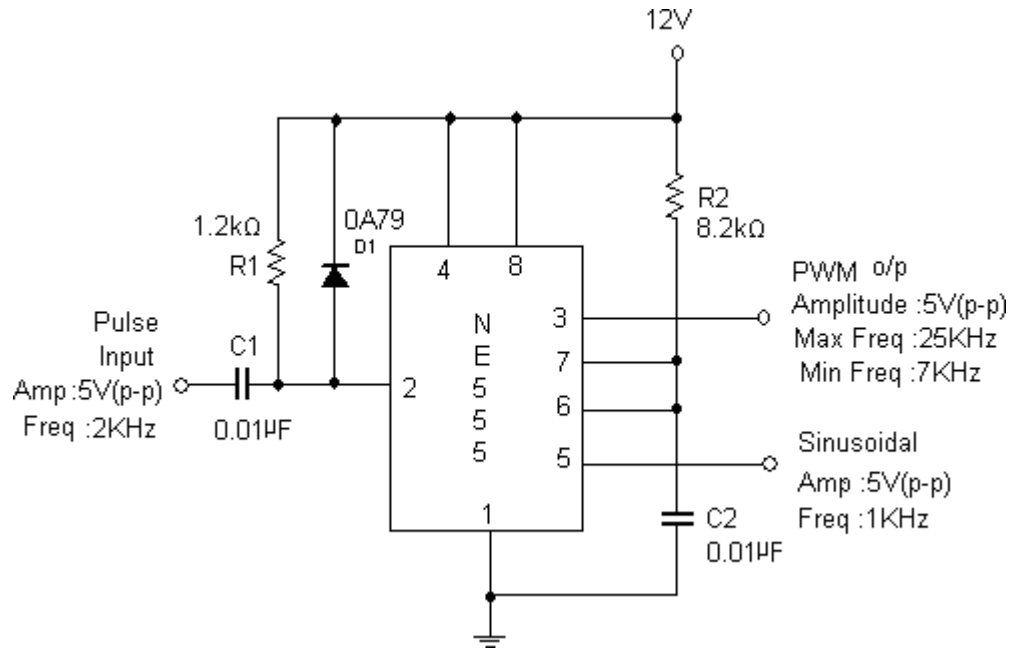


Fig: 7.1 Pulse Width Modulation Circuit

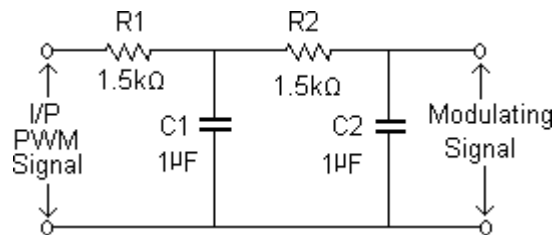


Fig: 7.2 Demodulation Circuit

Procedure:

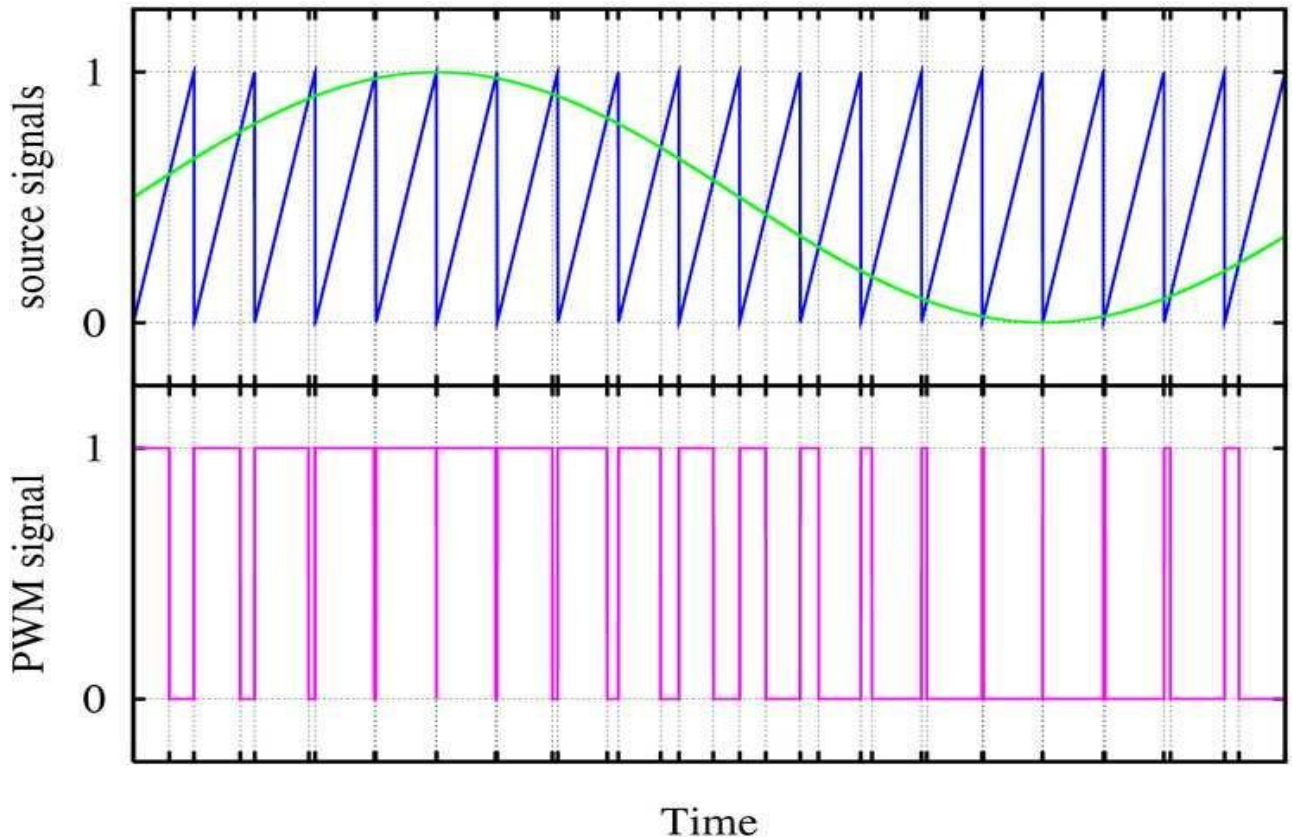
1. Connect the circuit as per circuit diagram shown in fig 7.1.
2. Apply a trigger signal (Pulse wave) of frequency 2 KHz with amplitude of 5v (p-p).
3. Observe the sample signal at the pin3.
4. Apply the ac signal at the pin 5 and vary the amplitude.

5. Note that as the control voltage is varied output pulse width is also varied.
6. Observe that the pulse width increases during positive slope condition & decreases under negative slope condition. Pulse width will be maximum at the +ve peak and minimum at the -ve peak of sinusoidal waveform. Record the observations.
7. Feed PWM waveform to the circuit of Fig.72 and observe the resulting demodulated waveform.

Observations:

S.No.	Control voltage (V_{P-P})	Output pulse width (m sec)

Waveforms :



8. PULSE POSITION MODULATION & DEMODULATION

Aim: To generate pulse position modulation and demodulation signals and to study the effect of amplitude of the modulating signal on output.

Apparatus required:

Name of the apparatus	Specifications/Range	Quantity
Resistors	3.9k Ω , 3k Ω , 10k Ω , 680k Ω	Each one
Capacitors	0.01 μ F, 60 μ F	2,1
Function Generator	1MHz	1
RPS	0-30v,1A	1
CRO	0-30MHz	1
IC 555	Operating tem :SE 555 -55°C to 125°C NE 555 0° to 70°C Supply voltage :+5V to +18V Timing : μ Sec to Hours Sink current :200mA Temperature stability :50 PPM/°C change in temp or 0-005% /°C.	1
CRO Probes	----	1

Theory:

In Pulse Position Modulation, both the pulse amplitude and pulse duration are held constant but the position of the pulse is varied in proportional to the sampled values of the message signal. Pulse time modulation is a class of signaling techniques that encodes the sample values of an analog signal on to the time axis of a digital signal and it is analogous to angle modulation techniques. The two main types of PTM are PWM and PPM. In PPM the analog sample value determines the position of a narrow pulse relative to the clocking time. In PPM rise time of pulse decides the channel bandwidth. It has low noise interference.

Circuit Diagram:

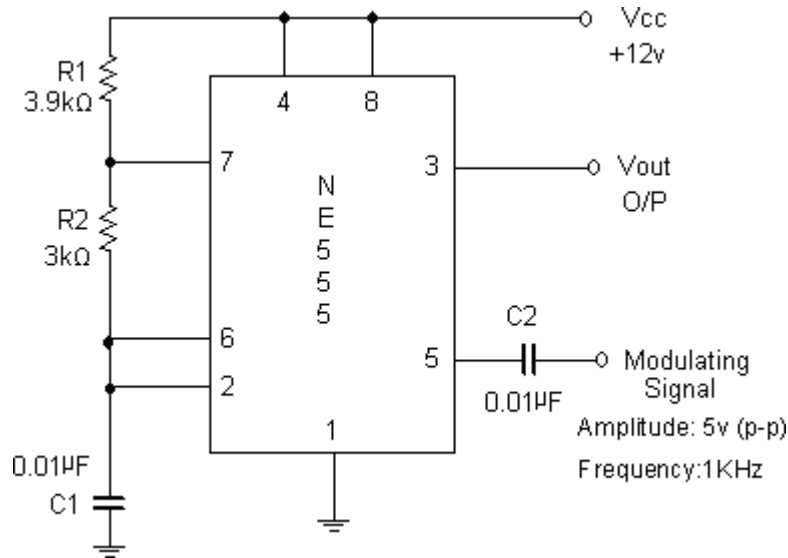


Fig: 8.1 Pulse Position Modulation Circuit

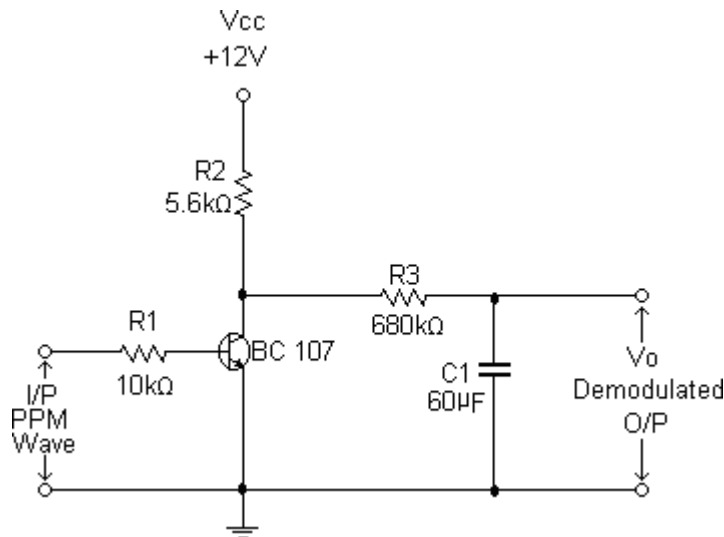


Fig: 8.2 Demodulation Circuit

Procedure:

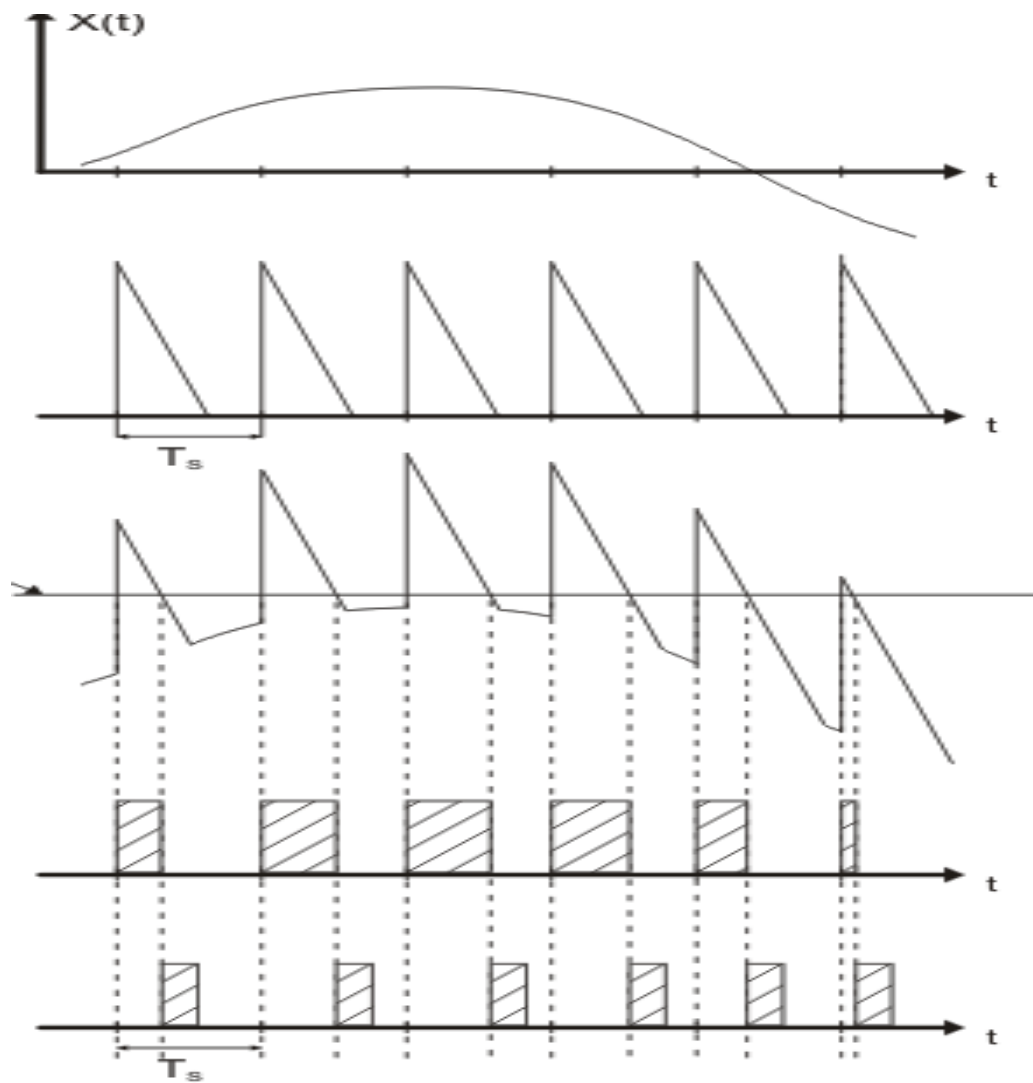
1. Connect the circuit as per circuit diagram as shown in the fig 8.1.
2. Observe the sample output at pin 3 and observe the position of the pulses on CRO and adjust the amplitude by slightly increasing the power supply. Also observe the frequency of pulse output.
3. Apply the modulating signal, sinusoidal signal of 2V_(p-p) (ac signal) 2v (p-p) to the control pin 5 using function generator.
4. Now by varying the amplitude of the modulating signal, note down the position of the pulses.

5. During the demodulation process, give the PPM signal as input to the demodulated circuit as shown in Fig.82.
6. Observe the o/p on CRO.
7. Plot the waveform.

Observations:

Modulating signal Amplitude(V_{p-p})	Time period(ms)		Total Time period(ms)
	Pulse width ON (ms)	Pulse width OFF (ms)	

Waveforms



9. FREQUENCY DIVISION MULTIPLEXING

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

Apparatus required:

Name of the apparatus	Specifications/Range	Quantity
Resistors	3.9k Ω , 3k Ω , 10k Ω , 680k Ω	Each one
Capacitors	0.01 μ F, 60 μ F	2,1
Function Generator	1MHz	1
RPS	0-30v,1A	1
CRO	0-30MHz	1
IC 555	Operating tem :SE 555 -55°C to 125°C NE 555 0° to 70°C Supply voltage :+5V to +18V Timing : μ Sec to Hours Sink current :200mA Temperature stability :50 PPM/°C change in temp or 0-005% /°C.	1
CRO Probes	----	1

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 subcarriers f_{c1} , f_{c2} , etc. After passing through LPFs to limit the message bandwidth. We show the subcarrier 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 baseband signal with the spectrum $X_b(f)$, the designation “baseband” 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 subcarrier. Consequently, standard practice calls for negative feedback to minimize amplifier non linearity in FDM systems

Circuit diagram:

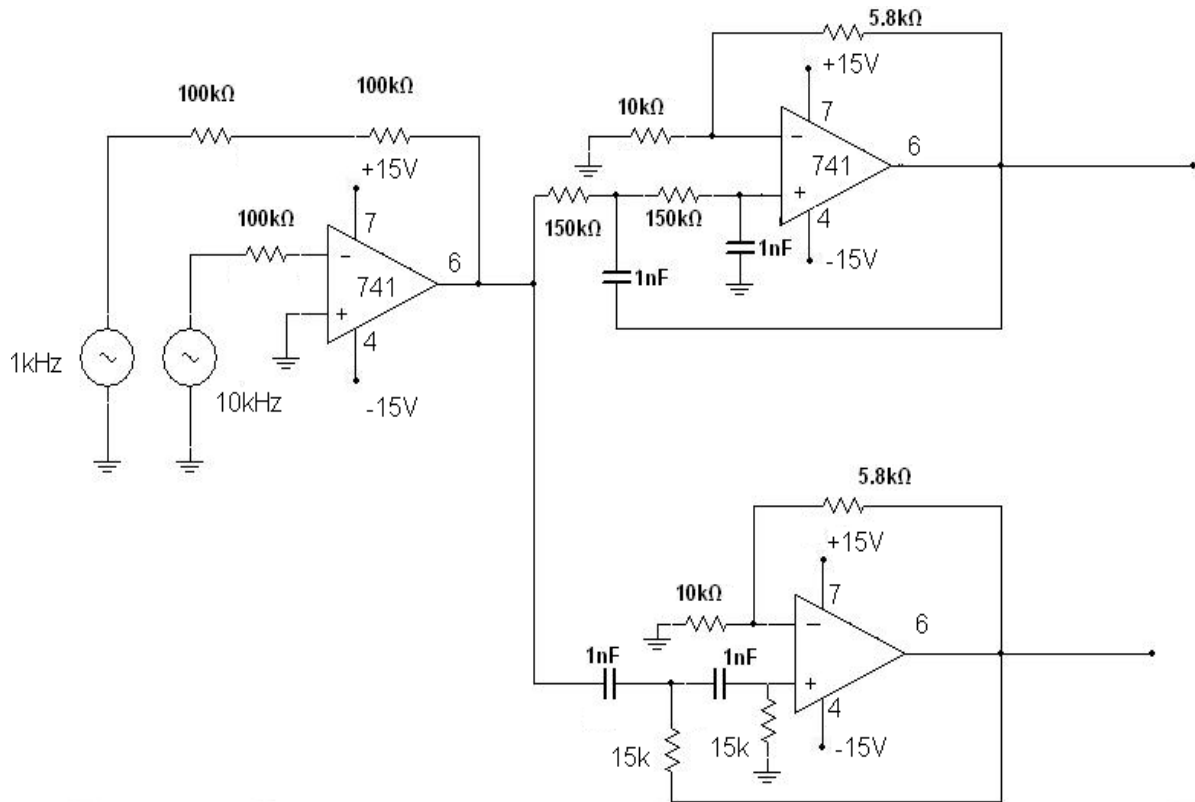


Fig: 9.1: Frequency division multiplexing

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.

Tabular column:

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

10. Phase Locked Loop

Aim: To study phase lock loop and its capture range, lock range and free running VCO

Theory:

PLL has emerged as one of the fundamental building block in electronic technology. It is used for the frequency multiplication, FM stereo detector , FM demodulator , frequency shift keying decoders, local oscillator in TV and FM tuner. It consists of a phase detector, a LPF and a voltage controlled oscillator (VCO) connected together in the form of a feedback system. The VCO is a sinusoidal generator whose frequency is determined by a voltage applied to it from an external source. In effect, any frequency modulator may serve as a VCO.

The phase detector or comparator compares the input frequency, f_{in} , with feedback frequency , f_{out} , (output frequency). The output of the phase detector is proportional to the phase difference between f_{in} , and f_{out} , . The output voltage of the phase detector is a DC voltage and therefore m is often refers to as error voltage. The output of the phase detector is then applied to the LPF , which removes the high frequency noise and produces a DC level. The DC level, in term is the input to the VCO.

The output frequency of the VCO is directly proportional to the input DC level. The VCO frequency is compared with the input frequencies and adjusted until it is equal to the input frequency. In short, PLL keeps its output frequency constant at the input frequency.

Thus, the PLL goes through 3 states.

1. Free running state.
2. Capture range / mode
3. Phase lock state.

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

Lock Range or Tracking Range:

It is the range of frequencies in the vicinity of f_0 over which the VCO, once locked to the input signal, will remain locked .

Capture Range : (f C) : Is the range of frequencies in the vicinity of 'f O' over which the loop will acquire lock with an input signal initially starting out of lock .

Circuit Diagrams:

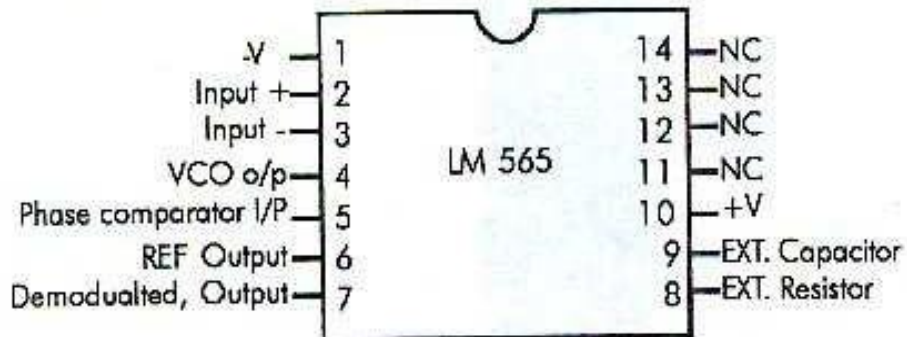


Fig.1 Pin Diagram of LM 565

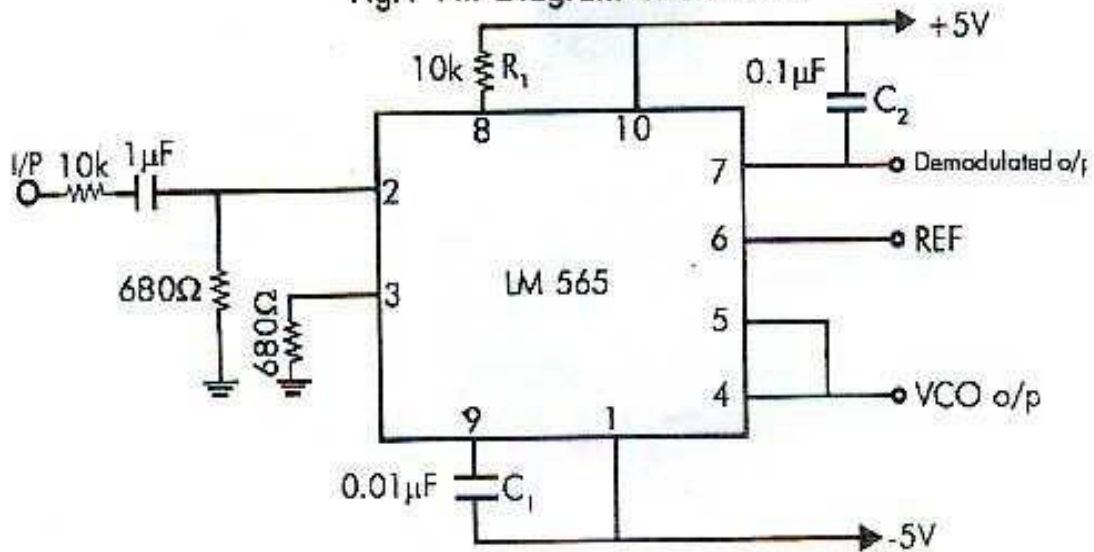


Fig 11.1 Circuit diagram of PLL

Procedure:

1. Connect + 5V to pin 10 of LM 565. Connect -5V to pin 1.
2. Connect 10k resistor from pin 8 to + 5V Connect 0.01 μf capacitor from pin 9 to – 5V
3. Short the pin 4 to pin 5.
4. Without giving input measure (f O) free running frequency.
5. Connect pin 2 to oscillator or function generator through a 1μf capacitor, adjust the amplitude around 2Vpp.
6. Connect 0.1 μf capacitor between pin 7 and + 5V (C₂)
7. Connect output to the second channel of the CRO.
8. By varying the frequency in different steps observe that of one frequency the wave form will be phase locked.
9. Change R-C components to shift VCO center frequency and see how lock range of the input varies

Observations:

Free running Frequency (Hz)	Frequency (Hz)	
	Capture Mode	Lock range
	Upper &Lower Limit	Upper &Lower Limit

Result: