ANALOG COMMUNICATIONS

LAB MANUAL

EC-351

Prepared by

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BAPATLA ENGINEERING COLLEGE: : BAPATLA (AUTONOMOUS)

BAPATLA-522 101

EC 351 ANALOG COMMUNICATIONS LAB

1. Amplitude Modulation and Demodulation
2. DSB SC Modulation and Demodulation
3. SSB SC Modulation and Demodulation
4. Frequency Modulation and Demodulation
5. Pre Emphasis - De Emphasis Circuits
6. Verification of Sampling Theorem
7. PAM generation and Reconstruction
8. PWM and PPM: Generation and Reconstruction
9. Frequency Division Multiplexing
10. Design of Mixer
11. Synchronous Detector.
12. Phase Locked Loop.
13. Diode Detector Characteristics.
14. AGC Characteristics.
15. Squelch Circuit.

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

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 MHz P_d = 1W I_c(max) = 100 mA	1
Diode(0A79)	Max Current 35mA	1
Resistors	1KΩ, 2KΩ, 6.8KΩ, 10KΩ	1 each
Capacitor	0.01µF	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 envelop 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:

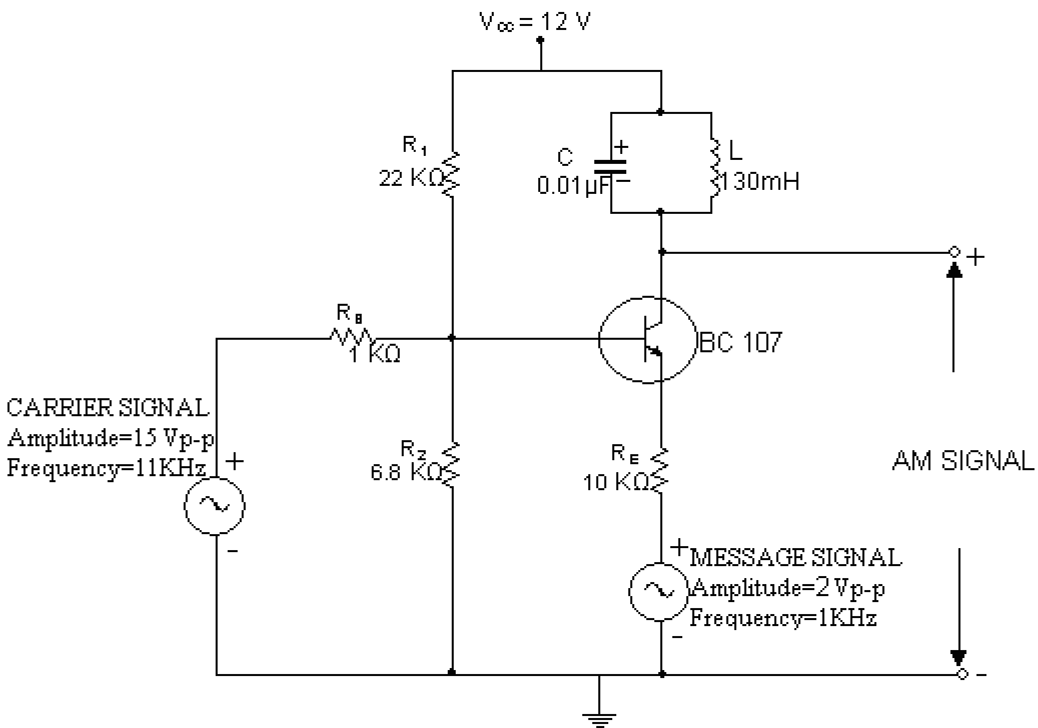


Fig.1. AM modulator

For demodulation:

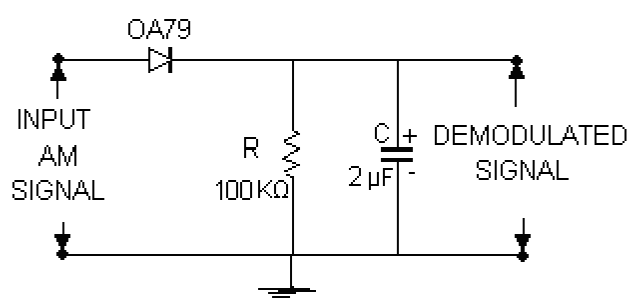


Fig.2. AM demodulator

Procedure:

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

3. Apply sinusoidal signal of 1 KHz frequency and amplitude 2 Vp-p as modulating signal, and carrier signal of frequency 11 KHz and amplitude 15 Vp-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 $f_m = \frac{1}{2\pi RC}$ taking C = 0.01μF
9. Connect the circuit diagram as shown in Fig.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 .,m=1

Observations

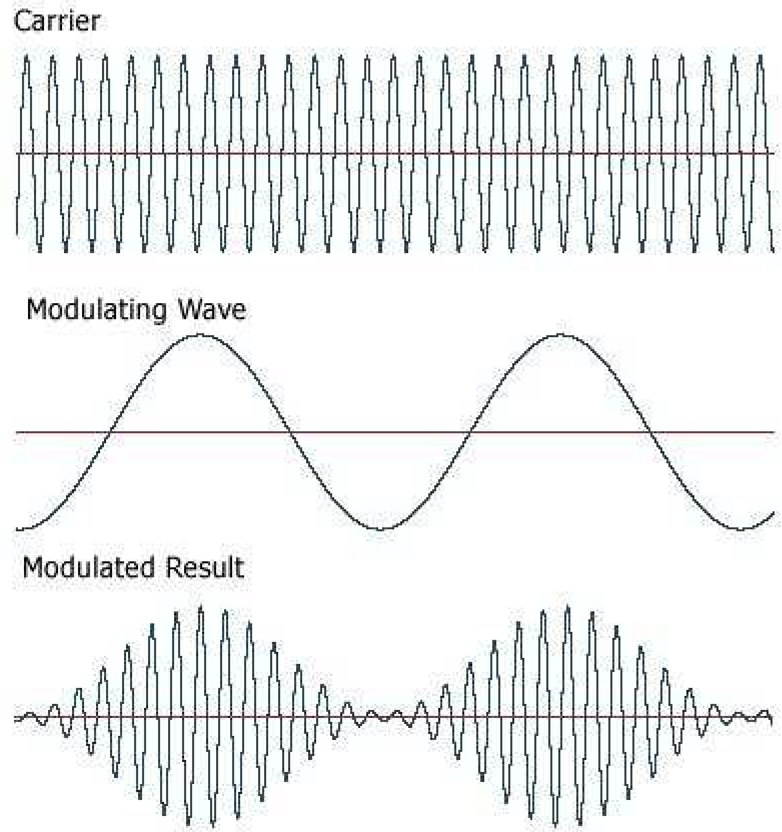
Table 1: f_m= 1KHz, f_c=11KHz, A_c=15 V p-p.

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

Table 2: A_m= 4 Vp-p f_c =11KHz, A_c=15 V p-p.

S.No.	f_m(KHz)	E_{max}(volts)	E_{min}(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	6.8KΩ 10 KΩ, 3.9 KΩ 1KΩ ,51 KΩ	1 2 each 3 each
Capacitors	0.1 μF	4
Variable Resistor (Linear Pot)	0-50KΩ	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:

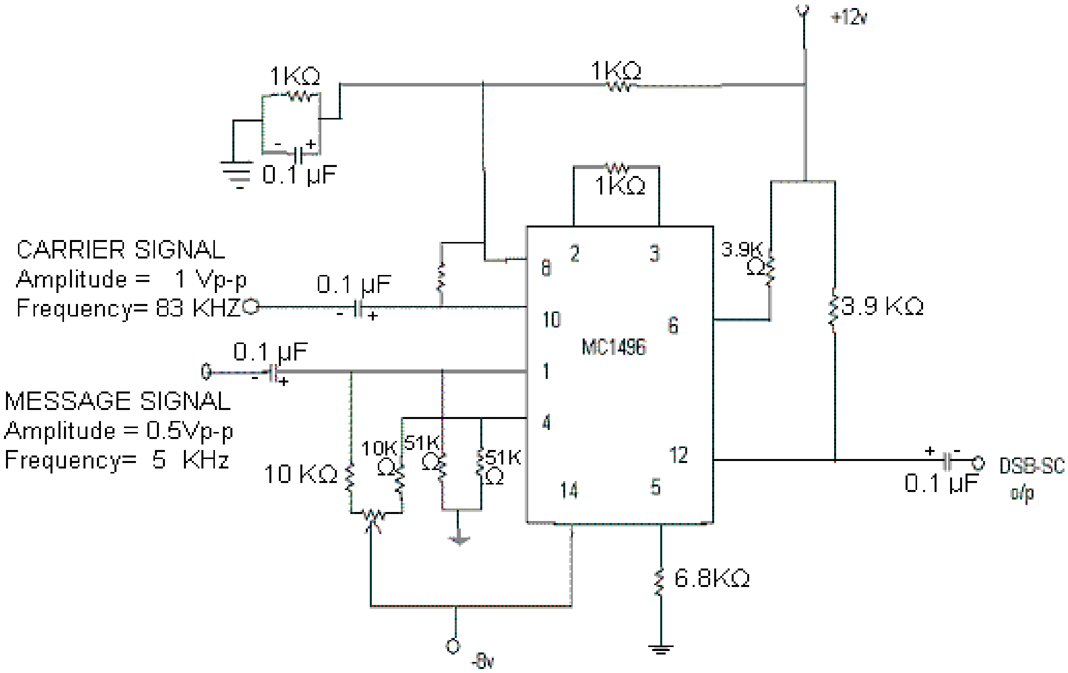
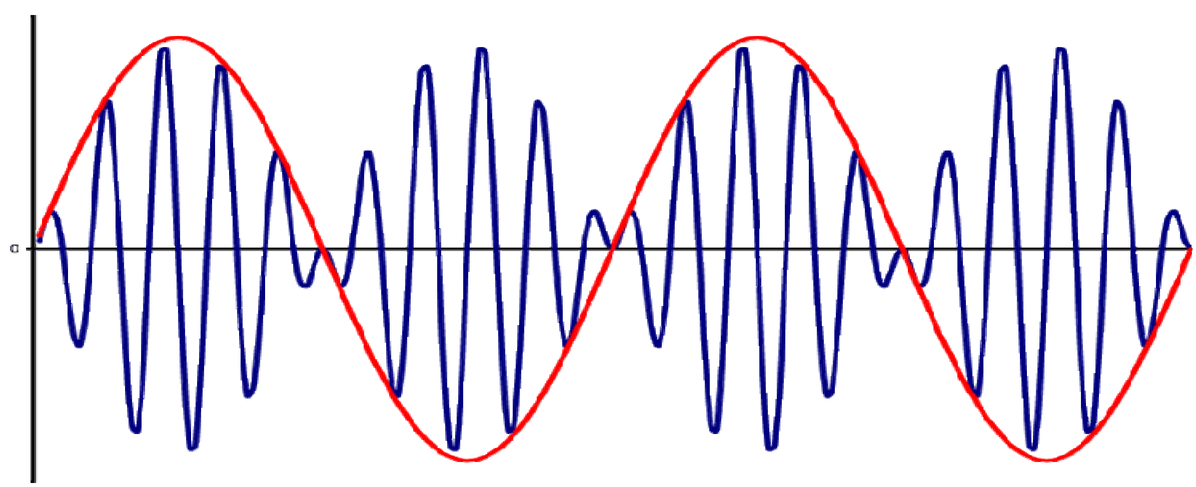


Fig.1. Balanced Modulator Circuit

Procedure:

1. Connect the circuit diagram as shown in Fig.1.
2. An 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.SSB Modulation and Demodulatiom

Aim: To generate the SSB modulated wave.

Apparatus Required:

Name of the Component/Equipment	Specifications	Quantity
SSB system trainer board	---	1
CRO	30MHz	1

Theory:

An SSB signal is produced by passing the DSB signal through a highly selective band pass filter. This filter selects either the upper or the lower sideband. Hence transmission bandwidth can be cut by half if one sideband is entirely suppressed. This leads to single-sideband modulation (SSB). In SSB modulation bandwidth saving is accompanied by a considerable increase in equipment complexity.

Circuit Diagram:

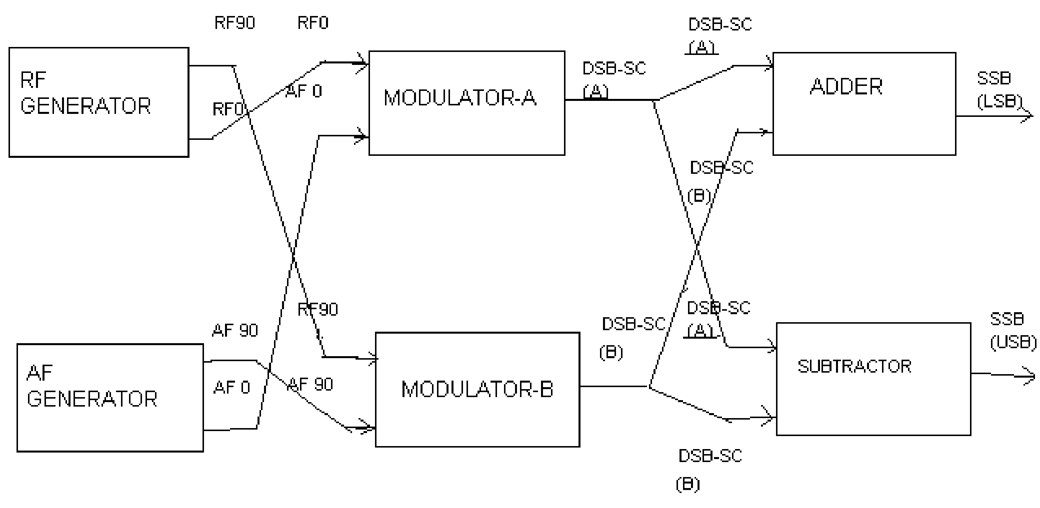


Fig. 1 Single Side Band system

Procedure:

1. Switch on the trainer and measure the output of the regulated power supply i.e., ±12V and -8V.
2. Observe the output of the RF generator using CRO. There are 2 outputs from the RF generator, one is direct output and another is 90^o out of phase with the direct output. The output frequency is 100 KHz and the amplitude is ≥ $0.2V_{PP}$. (Potentiometers are provided to vary the output amplitude).
3. Observe the output of the AF generator, using CRO. There are 2 outputs from the AF generator, one is direct output and another is 90^o out of phase with the direct output. A switch is provided to select the required frequency (2 KHz, 4KHz or 6 KHz). AGC potentiometer is provided to adjust the gain of the oscillator (or to set the output to good shape). The oscillator output has amplitude ≅ $10V_{PP}$. This amplitude can be varied using the potentiometers provided.
4. Measure and record the RF signal frequency using frequency counter. (or CRO).
5. Set the amplitudes of the RF signals to 0.1 V_{p-p} and connect direct signal to one balanced modulator and 90^o phase shift signal to another balanced modulator.
6. Select the required frequency (2KHz, 4KHz or 6KHz) of the AF generator with the help of switch and adjust the AGC potentiometer until the output amplitude is ≅ 10 V_{PP} (when amplitude controls are in maximum condition).
7. Measure and record the AF signal frequency using frequency counter (or CRO).
8. Set the AF signal amplitudes to 8 V_{p-p} using amplitude control and connect to the balanced modulators.
9. Observe the outputs of both the balanced modulators simultaneously using Dual trace oscilloscope and adjust the balance control until desired output wave forms (DSB-SC).
10. To get SSB lower side band signal, connect balanced modulator output (DSB_SC) signals to subtract or.
11. Measure and record the SSB signal frequency.
12. Calculate theoretical frequency of SSB (LSB) and compare it with the practical value.

    LSB frequency = RF frequency – AF frequency

13. To get SSB upper side band signal, connect the output of the balanced modulator to the summer circuit.
14. Measure and record the SSB upper side band signal frequency.
15. Calculate theoretical value of the SSB(USB) frequency and compare it with practical value. USB frequency = RF frequency + AF frequency

Observations:

Signal	Amplitude (volts)	Frequency (KHz)
Message signal	2	1
Carrier signal	2	100
SSB (LSB)	0.5	98.54
SSB (USB)	0.42	101.4

Precautions:

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

4. Frequency Modulation And Demodulation

Aim: 1. To generate frequency modulated signal and determine the modulation index and bandwidth for various values of amplitude and frequency of modulating signal.

2. To demodulate a Frequency Modulated signal using FM detector.

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, 39 K Ω, 560 Ω	1,2,1 2,2
Capacitors	470 pF, 0.1µF 100pF , 0.001µF	2,1 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

$$s(t) = A_c \cos(2\pi f_c + \beta \sin(2\pi f_m t))$$

Where A_C is amplitude of the carrier signal, f_C is the carrier frequency

β is the modulation index of the FM wave

Circuit Diagrams:

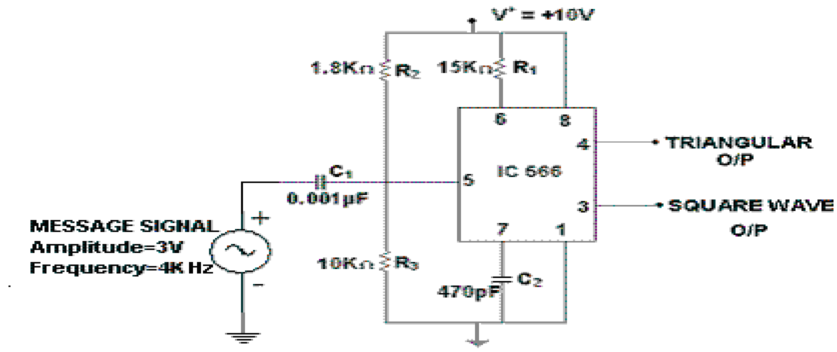


Fig.1. FM Modulator Using IC 566

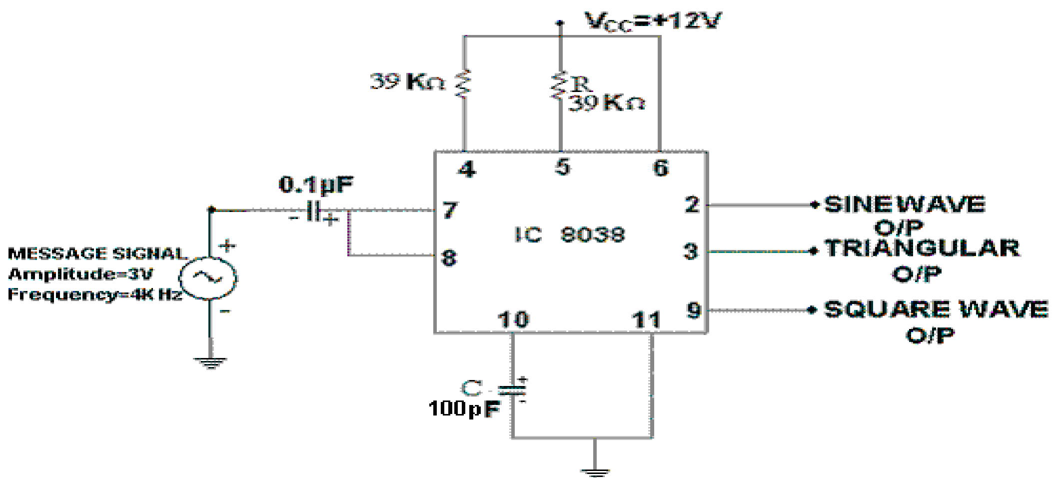


Fig.2. FM Modulator Circuit

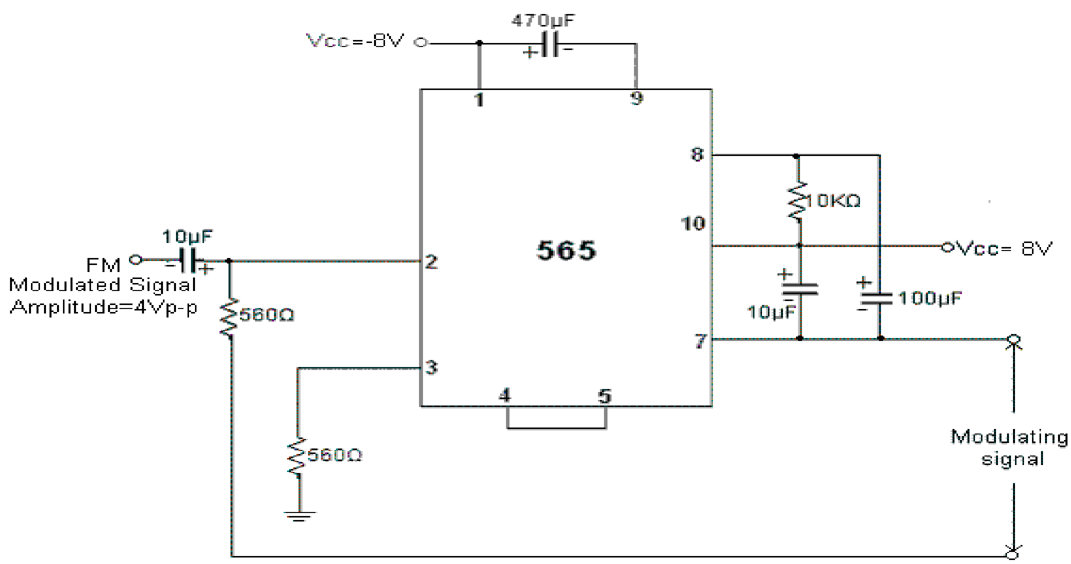


Fig.3. FM Demodulator Circuit

Procedure: Modulation:

1. The circuit is connected as per the circuit diagram shown in Fig.2(Fig.1 for IC 566)
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/ (2ΠRC) taking C=100pF.
3. Apply the sinusoidal modulating signal of frequency 4KHz 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 = β) using Δf / f_m where Δf = |f_c - f_{min}|. Calculate Band width. BW = 2 (β + 1)f_m = 2(Δf + 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
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 (output) on CRO.
5. Draw the demodulated wave form.

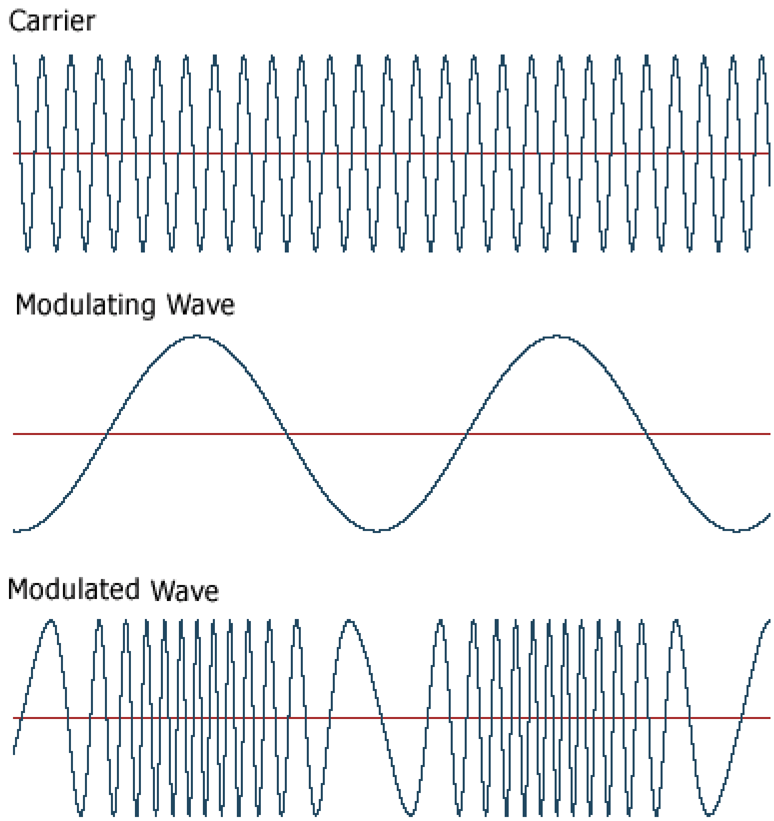
Table: 1 f_c = 45KHz

S.No.	f_m(KHz)	T_{max} (μsec)	f_{min}(KHz)	Δf(KHz)	β	BW (KHz)

Table 2: f_m = 4 KHz, f_c = 45 KHz

S.No.	A_m (Volts)	T (μsec)	f_{min}(KHz)	Δf (KHz)	β	BW(KHZ)

Waveforms:



Precautions:

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

5. 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 MHz P_d = 1W I_c(max) = 100 mA	1
Resistors	10 KΩ, 7.5 KΩ, 6.8 KΩ	1 each
Capacitors	10 nF 0.1 μF	1 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, there by 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:

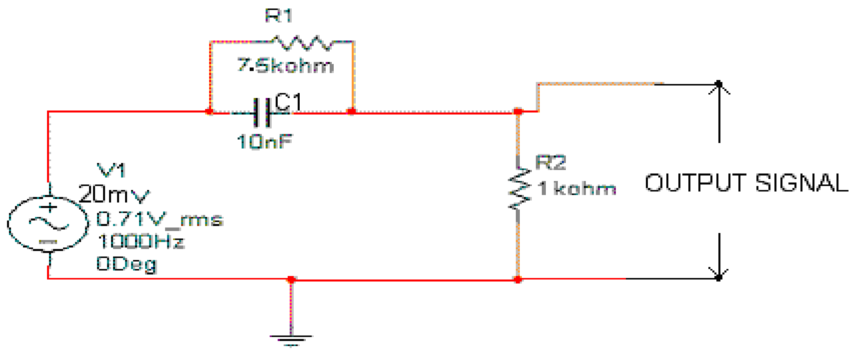


Fig.1. Pre-emphasis circuit

For De-emphasis:

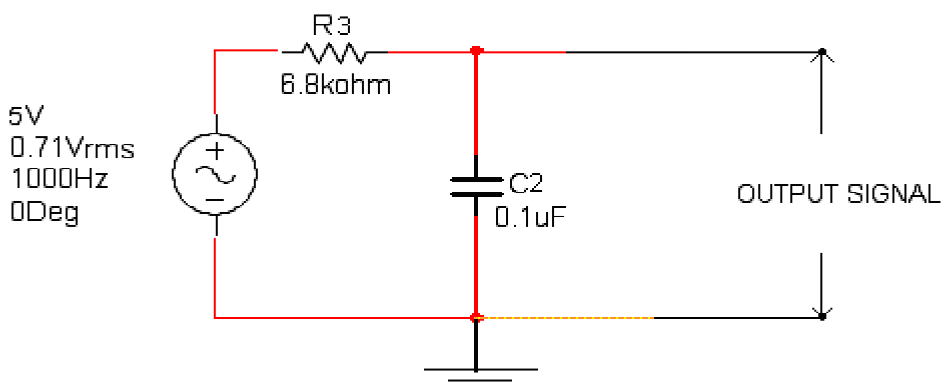


Fig.2. De-emphasis circuit

Procedure:

1. Connect the circuit as per circuit diagram as shown in Fig.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 20KHz, 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.2). by applying the sinusoidal signal of 5V as input signal

Sample readings:

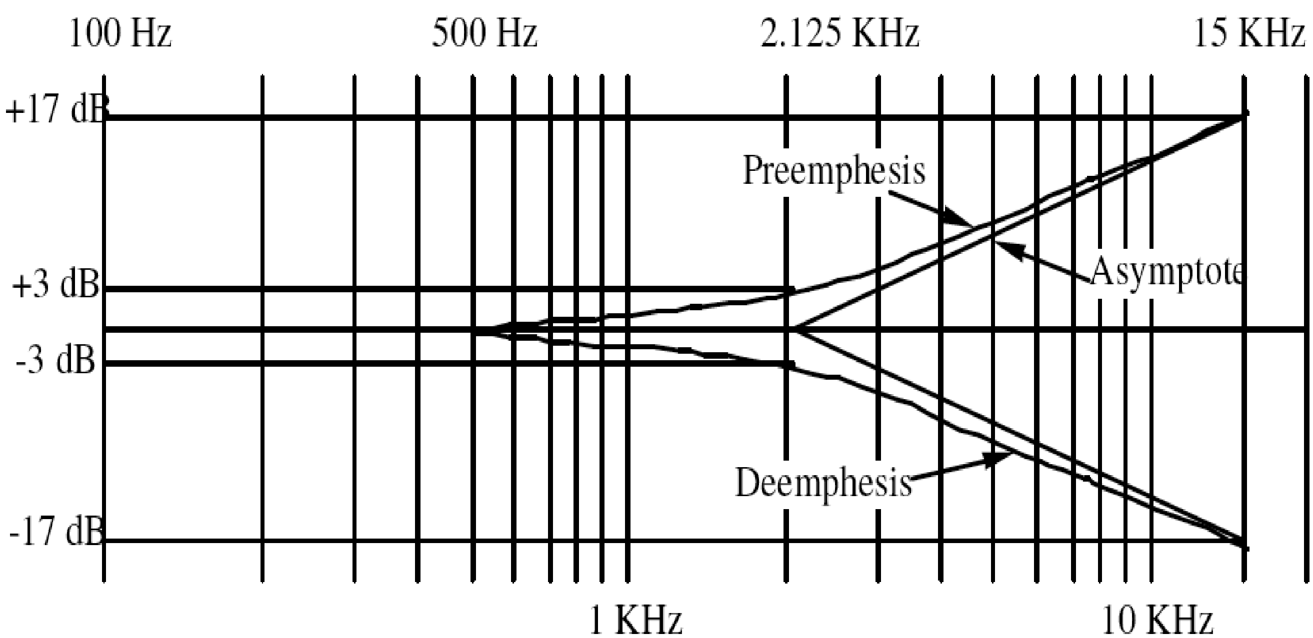
Table1: Pre-emphasis V_i = 20mV

Frequency(KHz)	Vo(mV)	Gain in dB(20 log V_o/V_i)

Table2: De-emphasis V_i = 5v

Frequency(KHz)	Vo(Volts)	Gain in dB(20 log V_o/V_i)

Graphs:



Precautions:

1. Check the connections before giving the power supply

Observation should be done carefully

6. SAMPLING THEOREM VERIFICATION

Aim: To verify the sampling theorem.

Apparatus Required:

1. Sampling theorem verification trainer kit

2. Function Generator (1MHz)

3. Dual trace oscilloscope (20 MHz)

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:

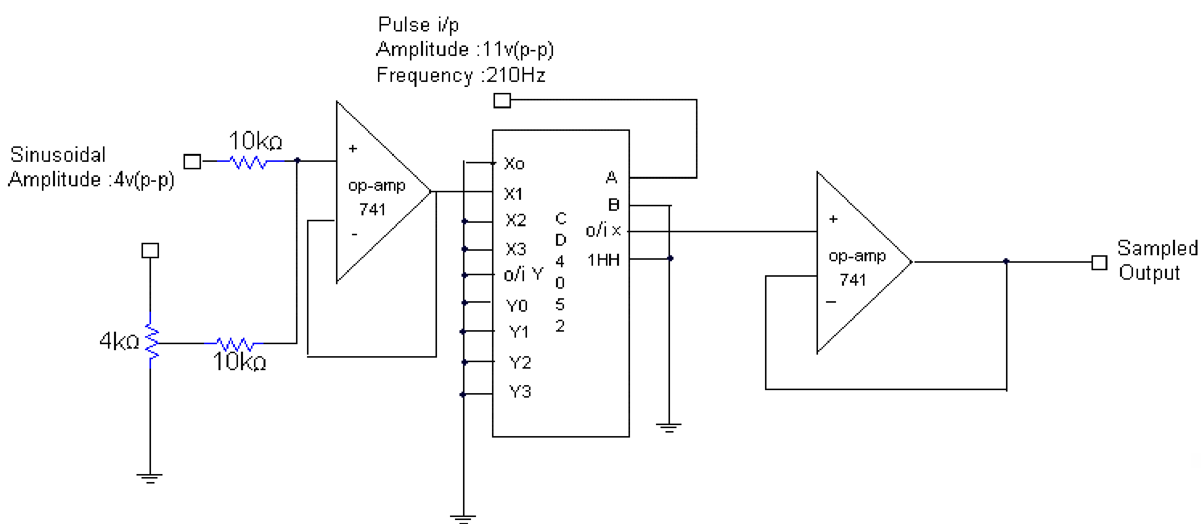


Fig: 1 Sampling Circuit

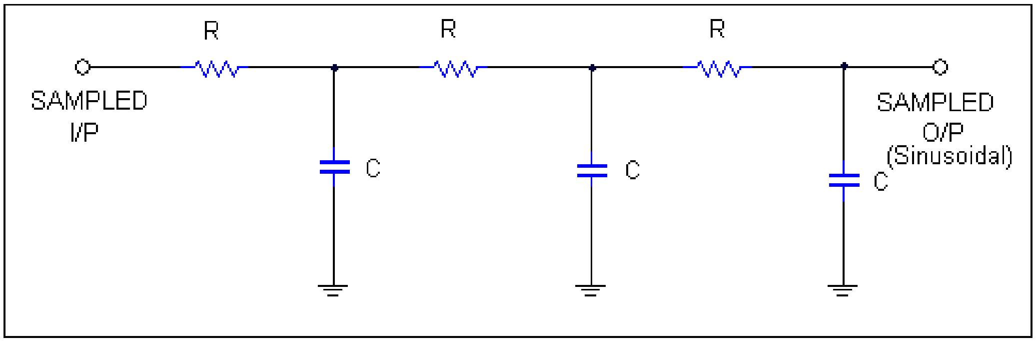
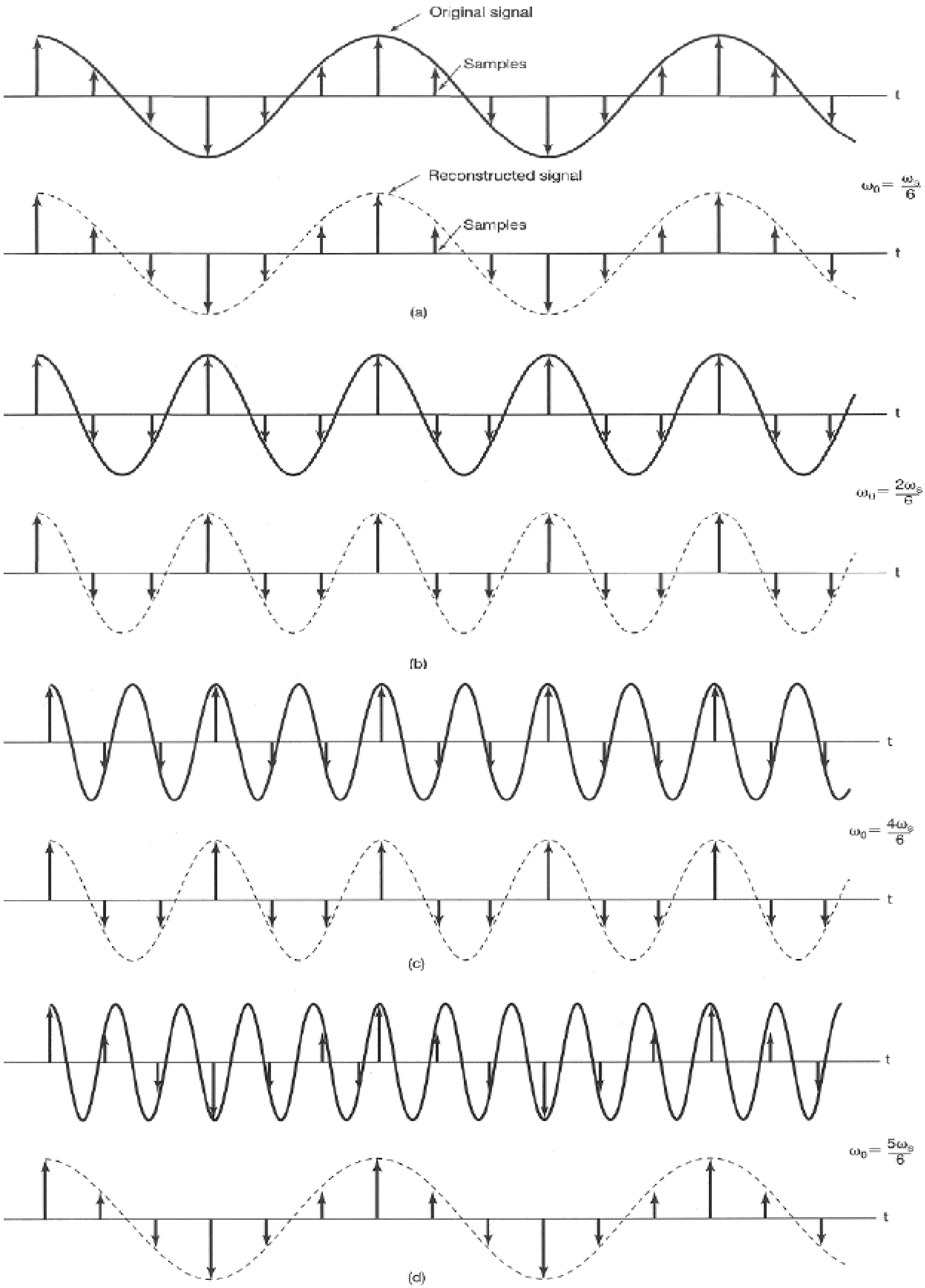


Fig: 2 Reconstructing Circuit

Procedure:

1. The circuit is connected as per the circuit diagram shown in the fig 1.
2. Switch on the power supply. And set at +11V and -11V.
3. Apply the sinusoidal signal of approximately 4V (p-p) at 105Hz frequency and pulse signal of 11V (p-p) with frequency between 100Hz and 4 KHz.
4. Connect the sampling circuit output and AF signal to the two inputs of oscilloscope
5. Initially set the potentiometer to minimum level and sampling frequency to 200Hz and observe the output on the CRO. Now by adjusting the potentiometer, 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 2
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 or more.


Original signal
Samples
t
Reconstructed signal
$\omega_0 = \frac{\omega_s}{6}$
Samples
t
(a)
t
$\omega_0 = \frac{2\omega_s}{6}$
t
(b)
t
$\omega_0 = \frac{4\omega_s}{6}$
t
(c)
t
$\omega_0 = \frac{5\omega_s}{6}$
t
(d)

7. PULSE AMPLITUDE MODULATION & DEMODULATION

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

Apparatus required:

Name of the Apparatus	Specifications/Range	Quantity
Resistors	1KΩ, 10KΩ, 100KΩ, 5.8KΩ, 2.2KΩ,	Each one
Transistor	BC 107	2
Capacitor	10µF, 0.001µF	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,

$$S(t) = \sum_{N=-\infty}^{\infty} [1+K_a\, x(nT_s)]\, P(t-nT_s)$$

Where

$x(nT_s)$ ==> represents the n^{th} sample of the message signal x(t)

K= ==> is the sampling period.

K_a ==> a constant called amplitude sensitivity

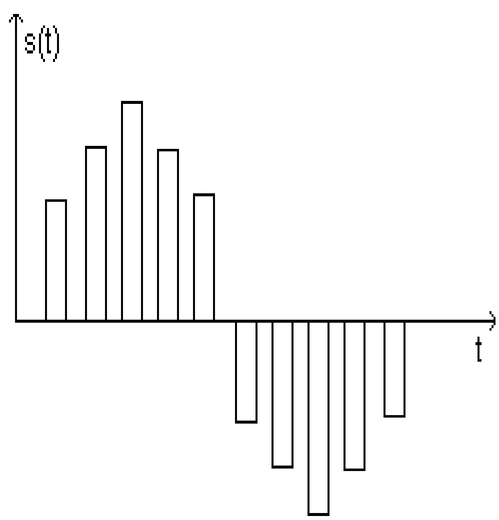
P (t) ==>denotes a pulse

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. In this the fixed dc level is added to the signal to ensure single polarity signal. It is represented as



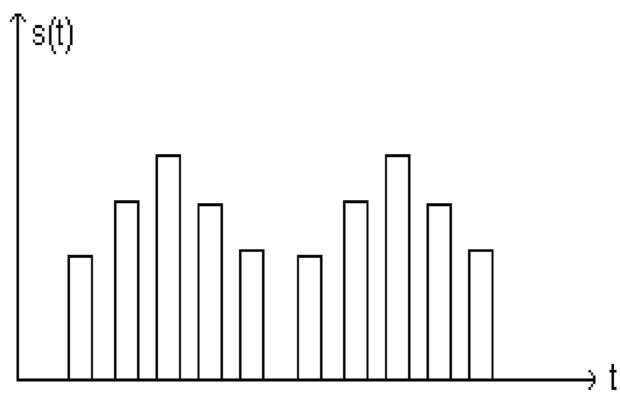


Fig: 1 Bipolar PAM signal

Fig: 2 Single polarity PAM

Circuit Diagram:

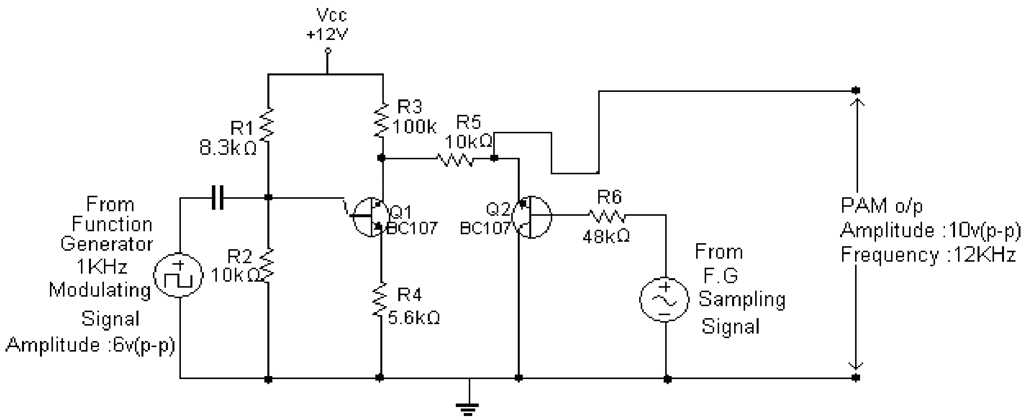


Fig: 3 Pulse Amplitude Modulation Circuit

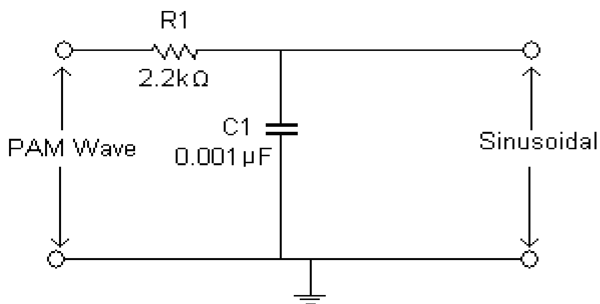


Fig: 4 Demodulation Circuit

Procedure:

1. Connect the circuit as per the circuit diagram shown in the fig 3
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 4.
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.

8(a). 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	1.2kΩ, 1.5 kΩ, 8.2 kΩ	1,1,2
Capacitors	0.01 μF, 1 μF	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^{o}C to 125^{o}C NE 555 0^{o} to 70^{o}C Supply voltage :+5V to +18V Timing :μSec to Hours Sink current :200mA Temperature stability :50 PPM/^{o}C change in temp or 0-005% /^{o}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:

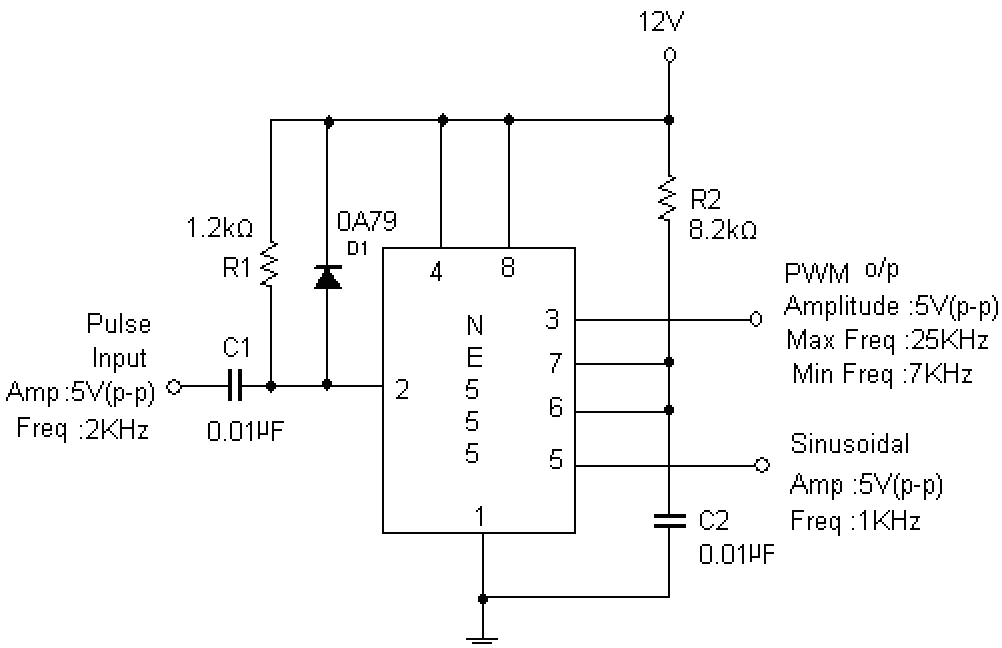


Fig: 1 Pulse Width Modulation Circuit

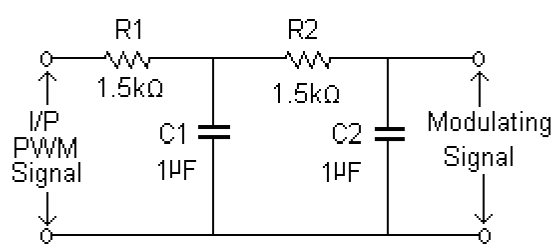


Fig: 2 Demodulation Circuit

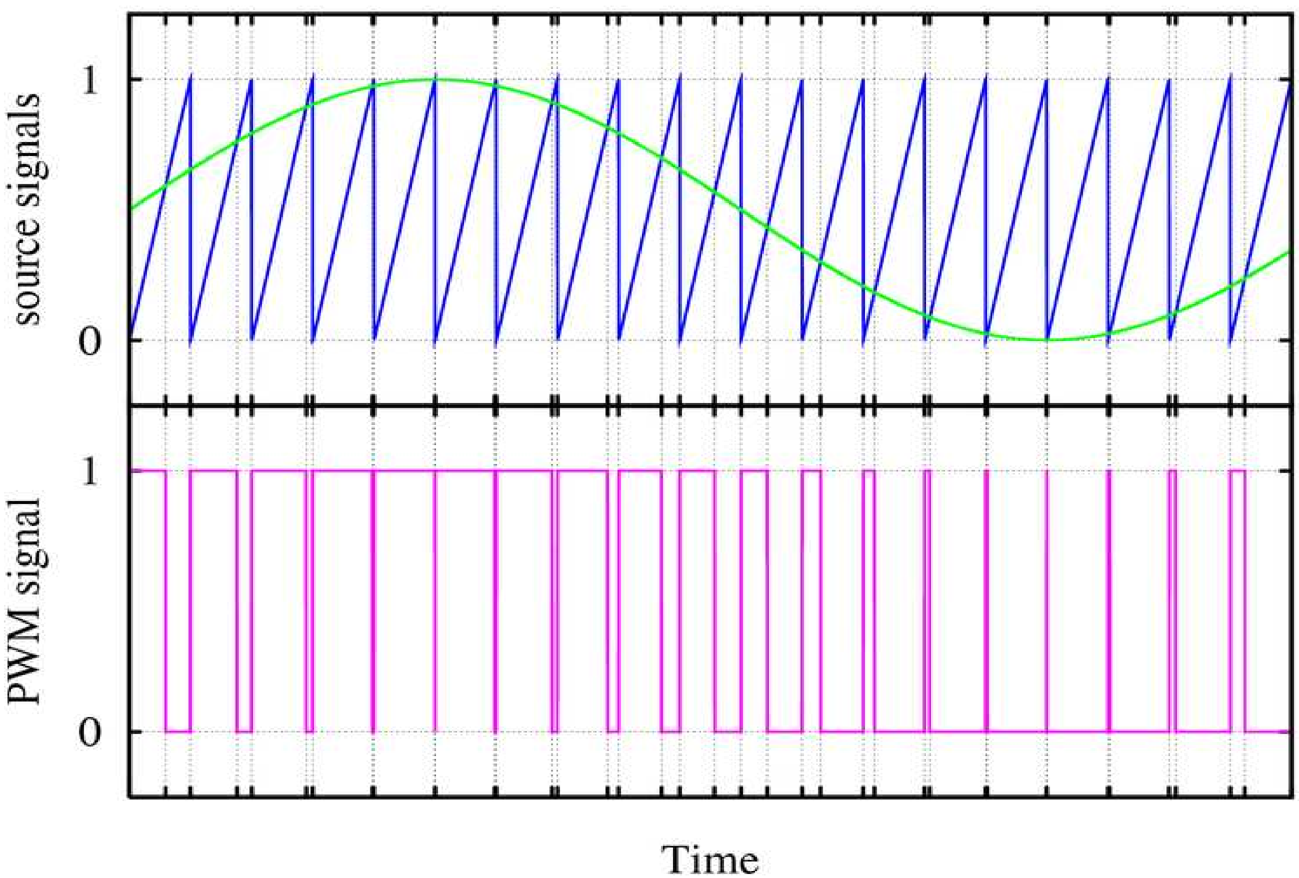
Procedure:

1. Connect the circuit as per circuit diagram shown in fig 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.2 and observe the resulting demodulated waveform.

Observations:

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



8(b). 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	3.9kΩ, 3kΩ, 10kΩ, 680kΩ	Each one
Capacitors	0.01µF, 60µF	2,1
Function Generator	1MHz	1
RPS	0-30v,1A	1
CRO	0-30MHz	1
IC 555	Operating tem :SE 555 -55^{o}C to 125^{o}C NE 555 0^{o} to 70^{o}C Supply voltage :+5V to +18V Timing :µSec to Hours Sink current :200mA Temperature stability :50 PPM/^{o}C change in temp or 0-005% /^{o}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:

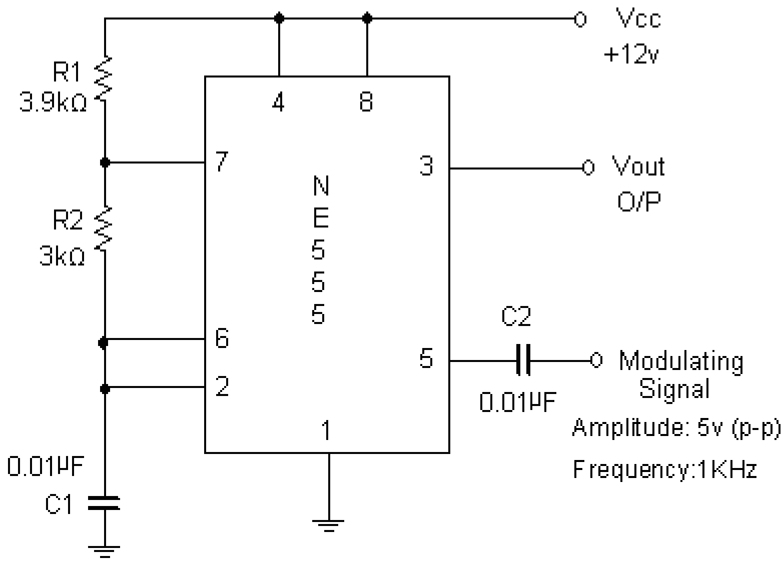


Fig: 1 Pulse Position Modulation Circuit

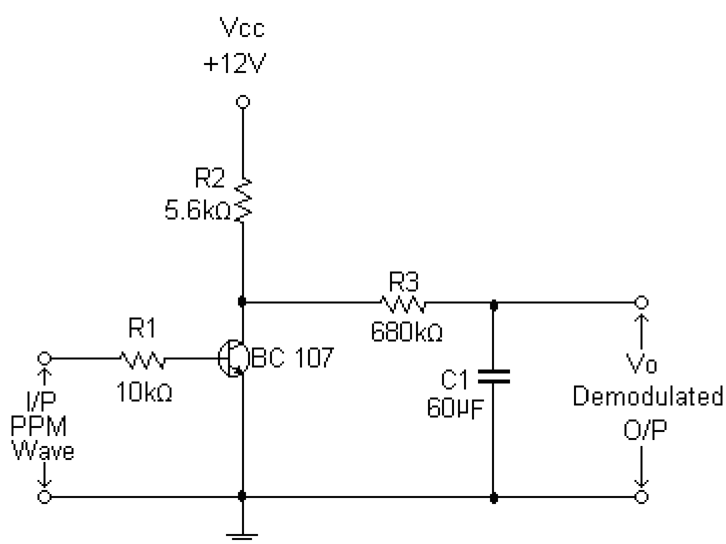


Fig: 2 Demodulation Circuit

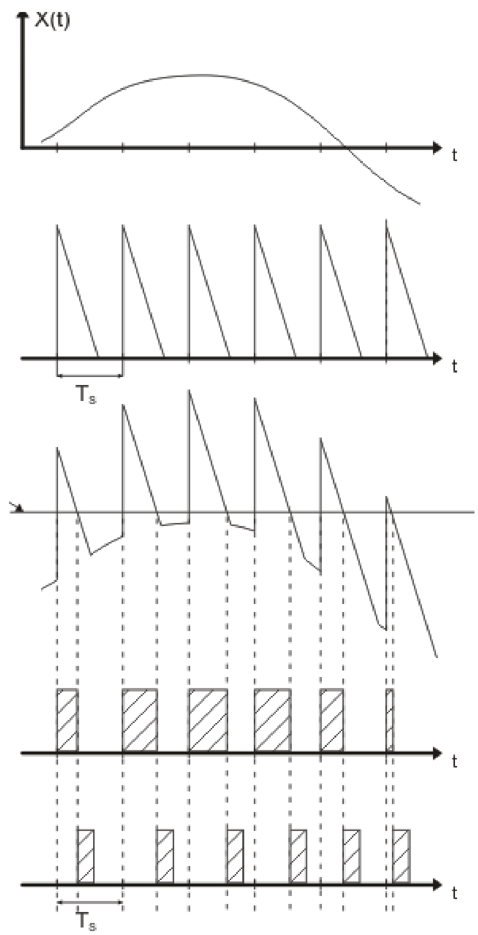
Procedure:

1. Connect the circuit as per circuit diagram as shown in the fig 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.2.
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)	



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	3.9kΩ, 3kΩ, 10kΩ, 680kΩ	Each one
Capacitors	0.01µF, 60µF	2,1
Function Generator	1MHz	1
RPS	0-30v,1A	1
CRO	0-30MHz	1
IC 555	Operating tem :SE 555 -55^{o}C to 125^{o}C NE 555 0^{o} to 70^{o}C Supply voltage :+5V to +18V Timing :µSec to Hours Sink current :200mA Temperature stability :50 PPM/^{o}C change in temp or 0-005% /^{o}C.	1
CRO Probes	----	1

Theory:

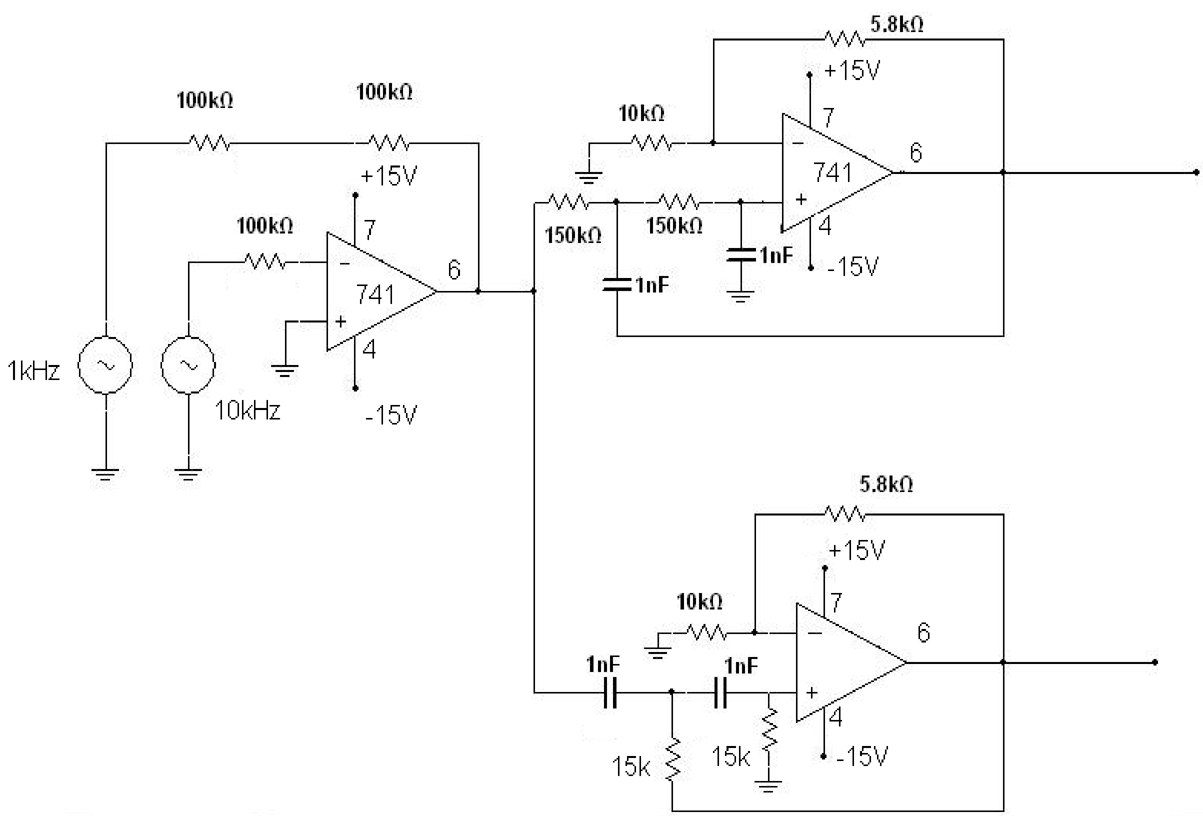
When several communications channels are between the two same point's significant economics may be realized by sending all the messages on one transmission facility a process called multiplexing. Applications of multiplexing range from the vital, if prosaic, telephone networks to the glamour of FM stereo 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 fc1, fc2,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 spectrumXb9f), 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:



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 Design of Mixer

Aim: To design and obtain the characteristics of a mixer circuit.

Apparatus Required:

Name of the Component/Equipment	Specifications/Range	Quantity
Transistors (BC 107)	f_T = 300 MHz P_d = 1W I_c(max) = 100 mA	1
Resistors	1 KΩ , 6.8 KΩ, 10KΩ	1 each
Capacitor	0.01μF	1
Inductor	1mH	1
CRO	20MHZ	1
Function Generator	1MHz	1
Regulated Power Supply	0-30v, 1A	1

Theory:

The mixer is a nonlinear device having two sets of input terminals and one set of output terminals. Mixer will have several frequencies present in its output, including the difference between the two input frequencies and other harmonic components.

Circuit Diagram:

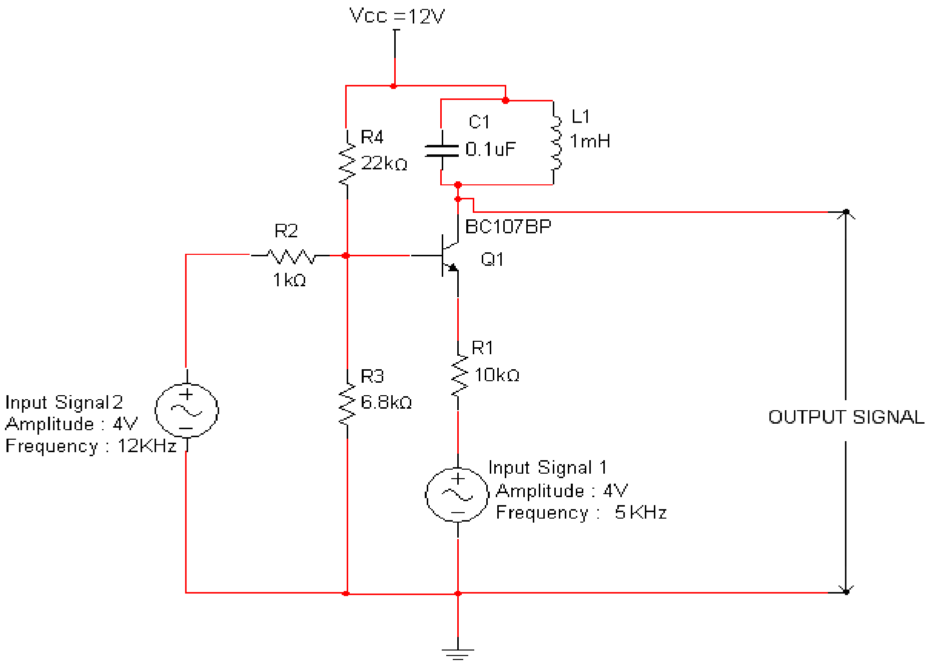


FIG.1. Mixer Circuit

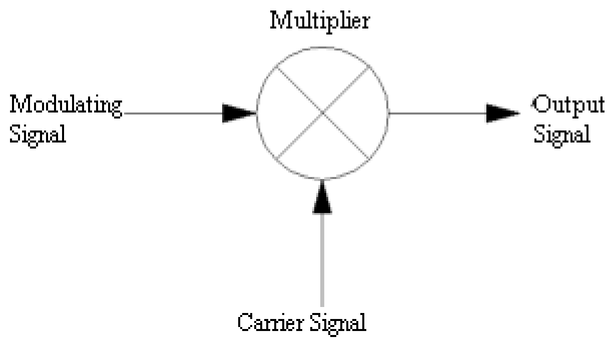
Procedure:

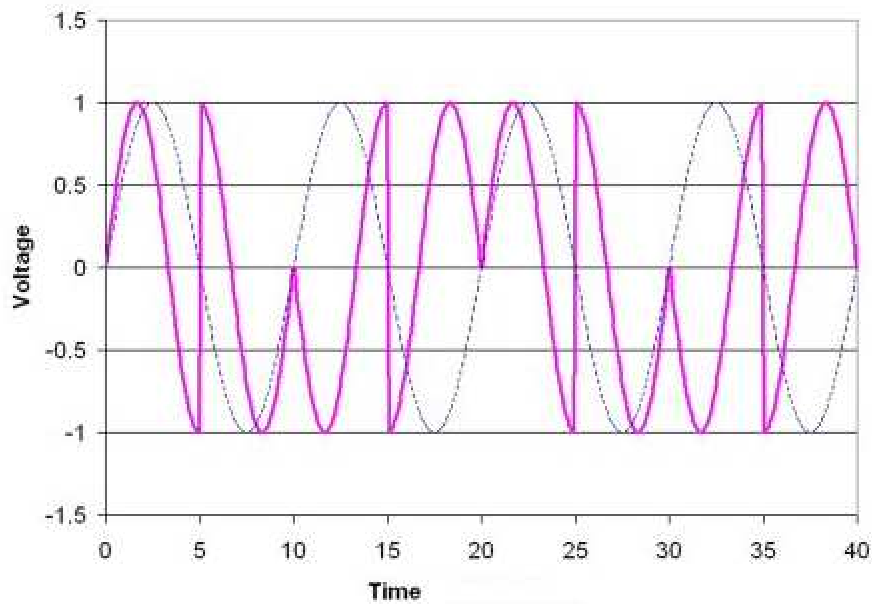
1. Connect the circuit as per the circuit diagram as shown in Fig.1. Assume C=0.1µF and calculate value of L_1 using $f=\dfrac{1}{2\pi\sqrt{L_1C_1}}$ where f=7KHz
2. Apply the input signals at the appropriate terminals in the circuit.
3. Note down the frequency of the output signal, which is same as difference frequency of given signals.

Sample readings:

Signal	Amplitude (Volts)	Frequency(KHz)
Input signal1	4	5
Input signal 2	4	12
Output signal	9	7

Waveforms:





Precautions:

1.Check the connections before giving the supply

2.Observations should be done carefully

11. Synchronous Detector

Aim: . To study about detection of AM demodulator (or) Syncronous Demodulator

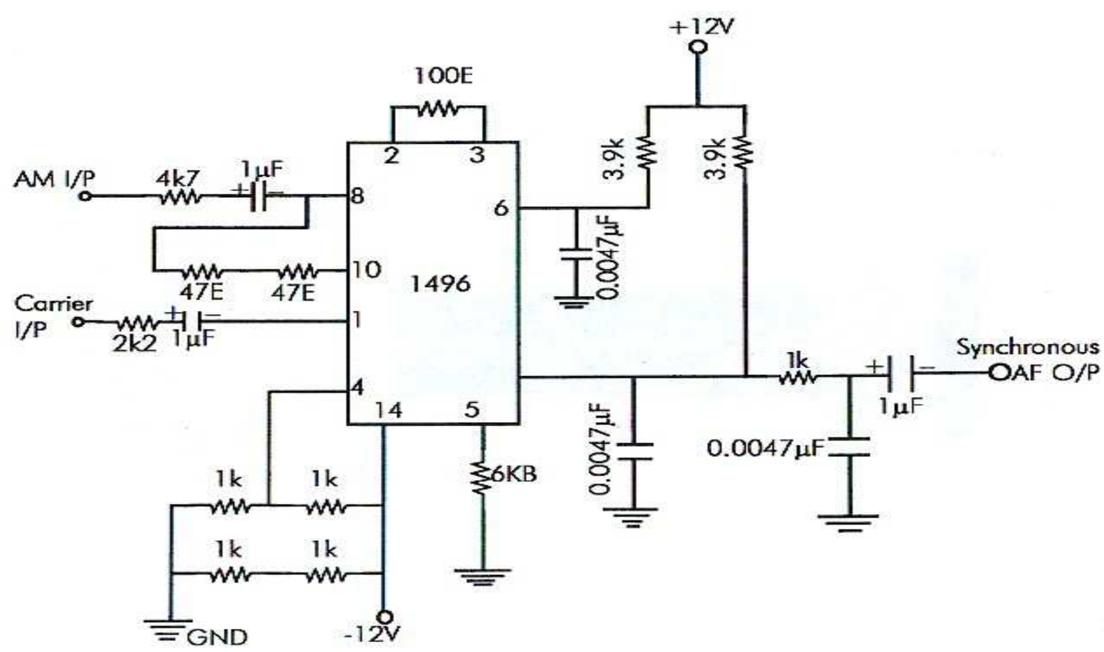
Theory:

The phase and frequency of the locally generated carrier in synchronous detector is extremely critical . Precision phase and frequency control of the local carrier needs an expensive and a complicated circuitry at the receiver. Pilot carrier is one synchronization technique.

A small amount of carrier signal known as pilot carrier is transmitted along with the modulated signal from the transmitter. This small amount of carrier signal is known as pilot carrier. This pilot carrier, separated at the receiver by an appropriate filter, is amplified, and is used to phase lock the locally generated carrier at the receiver. The phase locking provides synchronization. This system , where a weak carrier is transmitted along with AM –SC signal, is also referred to as partially suppressed carrier system, as the carrier is not totally suppressed

The process in which a large carrier is transmitted along with AM-SC signal is called amplitude modulation. The large carrier simplifies the reception system. The AM-SC with partially suppressed carrier is equivalent to an over modulated AM signal. The base band signal m(t) can be uniquely recovered from a DSB-SC wave S(t) by first multiplying s(t) with a locally generated sinusoidal wave and then low-pass filtering the product, as in fig. below.

Circuit Diagrams:



Procedure:

1. Observe the carrier signal at the terminal provided on the. Set it to 100 kHz. (For Synchronous ckt)

2. Connect 200 Hz AF signal externally from the signal generator to the AF input Terminal provided on the kit. Adjust the amplitude pot of signal generator such that you should observe on AM wave form at the AM output terminal.

3. Connect the carrier output to the carrier input of Syncronous circuit.

4. Connect the AM output to the AM input of the Syncrounous circuit.

5. Observe the Syncronous Detector AF output on the Oscilloscope.

12. 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 lend. 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 cantinues 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 O 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:

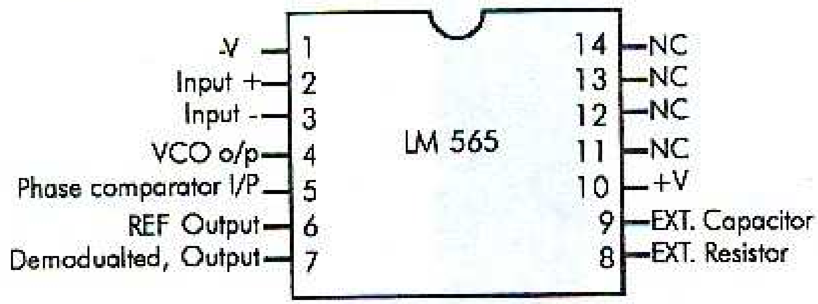
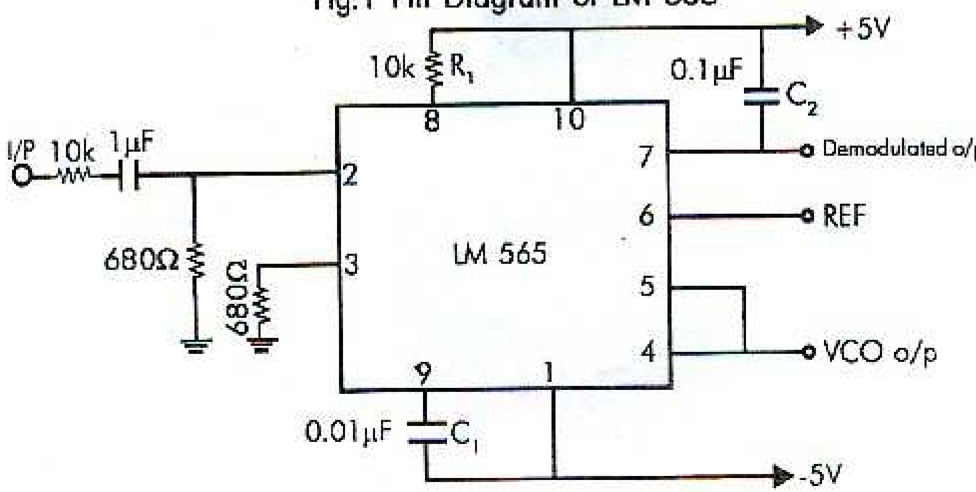


Fig.1 Pin Diagram of LM 565



Procedure:

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

13. Diode Detector Characteristics

Aim: . To obtain diode detector characteristics

Apparatus Required:

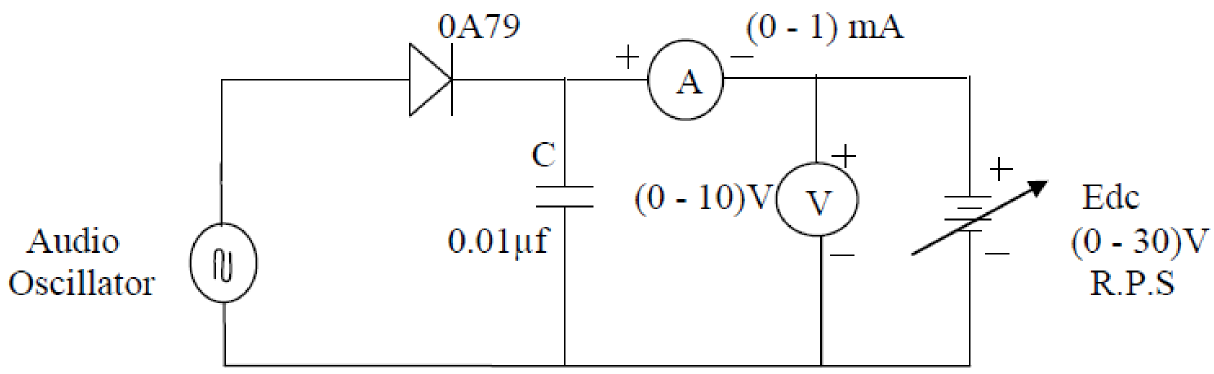
1. Function Generator
2. OA79 Diode
3. 0.1 µf Capacitor
4. 0-1 mA Ammeter
5. 0-l0V Voltmeter
6. 0-10V RPS

Theory:

The diode is by far the most common device used for A.M demodulation or detection. The simple diode detector has the disadvantages that demodulated output voltage in addition to being proportional to the modulating voltage, also has dc component which represents the average envelope amplitude(i.e. carrier strength) and a small R.F ripple. The unwanted components are removed in a practical detector.

Fig(1) shows a practical diode detector. In this diode has been reversed, so that the negative envelope is demodulated. This has no effect on detection, but it does ensure that a negative AGC voltage will be available. Here tow resistors are used to ensure that there is a series dc path to ground for the diode, but at the same time a low pass filter has been added in the form of R1-C1 , this has the function of removing any RF ripple that might still be present. Capacitor C2 is a coupling capacitor, whose main function is to prevent the diode dc output from reaching the volume control R4. The combination of R3 – C3 is low pass filter designed to remove AF components, proving a dc voltage whose amplitude is proportional to the carrier strength and which may be used for automatic gain control

Circuit Diagrams:



Procedure:

1. Make the connections as shown in the figure. Set the audio oscillator frequency to 1 KHz.

2. Increase the d.c. power supply voltage Edc to 2V to initially reverse bias the detector output.

3. Now increase the function generator output voltage to 1 Vrms.

4. Decrease Edc from 2V in steps of 0.2V and measure the current Idc flowing through the ammeter for each value of the d.c. voltage.

5. Bring the d.c. voltage Edc back to 2V. Repeat the experiment for the audio signal voltage of 2 Vrms and 3 Vrms. Plot the dc voltage Vs dc current characteristics of the detector with Edc on the negative scale.

Tabular form:

S.No:	$E_{p\text{-}p}$ = V		$E_{p\text{-}p}$ = V		$E_{p\text{-}p}$ = V	
	$E_{dc}(V)$	$I_{dc}(mA)$	$E_{dc}(V)$	$I_{dc}(mA)$	$E_{dc}(V)$	$I_{dc}(mA)$

14. AGC Characteristics.

Aim: . To study the AGC Characteristics

Apparatus Required:

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

1. RF Generator

2. AF Generator

3. Regulated power supply

4. AM Modulator

5. Demodulator (simple diode detector)

6. AGC circuit

(ii) Dual trace C.R.O

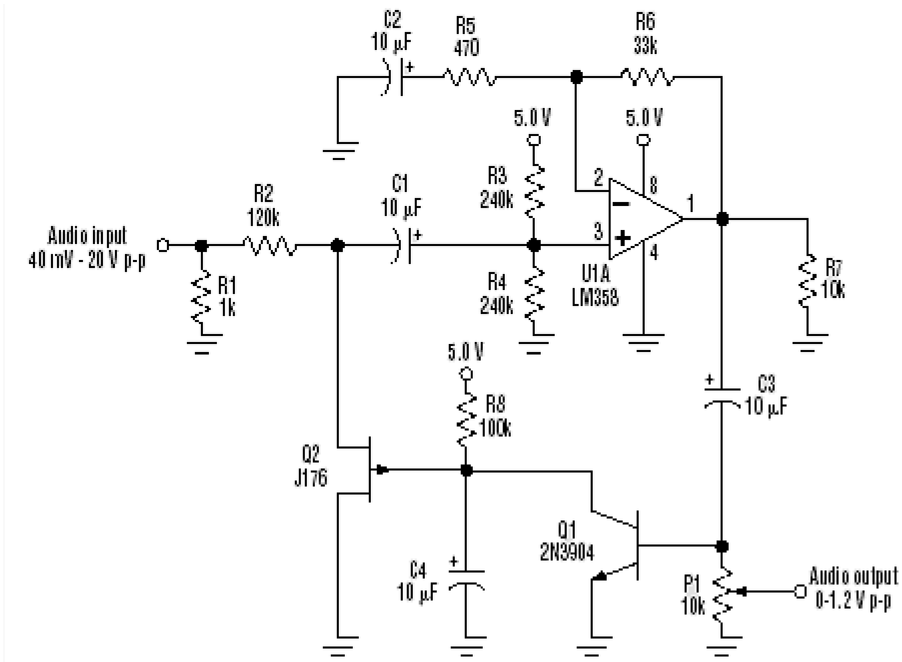
(iii) Connecting wires

Theory:

A Simple AGC is a system by means of which the overall gain of a radio receiver is varied automatically with the changing strength of the received signal, to keep the output substantially constant. The devices used in those stages are ones whose transconductance and hence gain depends on the applied bias voltage or current. It may be noted that, for correct AGC operation, this relationship between applied bias and transconductance need not to be strictly linear, as long as transconductance drops significantly with increased bias. All modern receivers are furnished with AGC, which enables tuning to stations of varying signal strengths without appreciable change in the size of the output signal thus AGC "irons out" input signal amplitude variations, and the gain control does not have to be re adjusted every time the receiver is tuned from one station to another, except when the change in signal strength is enormous.

In addition, AGC helps to smooth out the rapid fading which may occur with long-distance short-wave reception and prevents the overloading of the last IF amplifier which might otherwise have occurred.

Circuit Diagrams:



Procedure:

1. As the circuit is already wired you just have to trace the circuit according to the circuit diagram given above.
2. Connect the trainer to the mains and switch on the power supply.
3. Measures the output voltages of the regulated power supply circuit i.e. +12v and -12v, +6@150mA.
4. Observe outputs of RF and AF signal generator using CRO, note that RF voltage is approximately 50mVpp of 455 KHz frequency and AF voltage is 5Vpp of1 KHz frequency.
5. Now vary the amplitude of AF signal and observe the AM wave at output, note the percentage of modulation for different values of AF signal.
% Modulation= (Emax -Emin) /(Emax+Emin) × 100
6. Now adjust the modulation index to 30% by varying the amplitudes of RF & AF signals simultaneously.
7. Connect AM output to the input of AGC and also to the CRO channel -1
8. Connect AGC link to the feedback network through OA79 diode
9. Now connect CRO channel - 2 at output. The detected audio signal of 1 KHz will be observed.
10. Calculate the voltage gain by measuring the amplitude of output signal (Vo) waveform, using Formula A = *Vo/V i*
11. Now vary input level of 455 KHz IF signal and observe detected 1 KHz audio signal with and Without AGC link. The output will be distorted when AGC link removed i.e. there is no AGC action.
12. This explains AGC effect in Radio circuit.

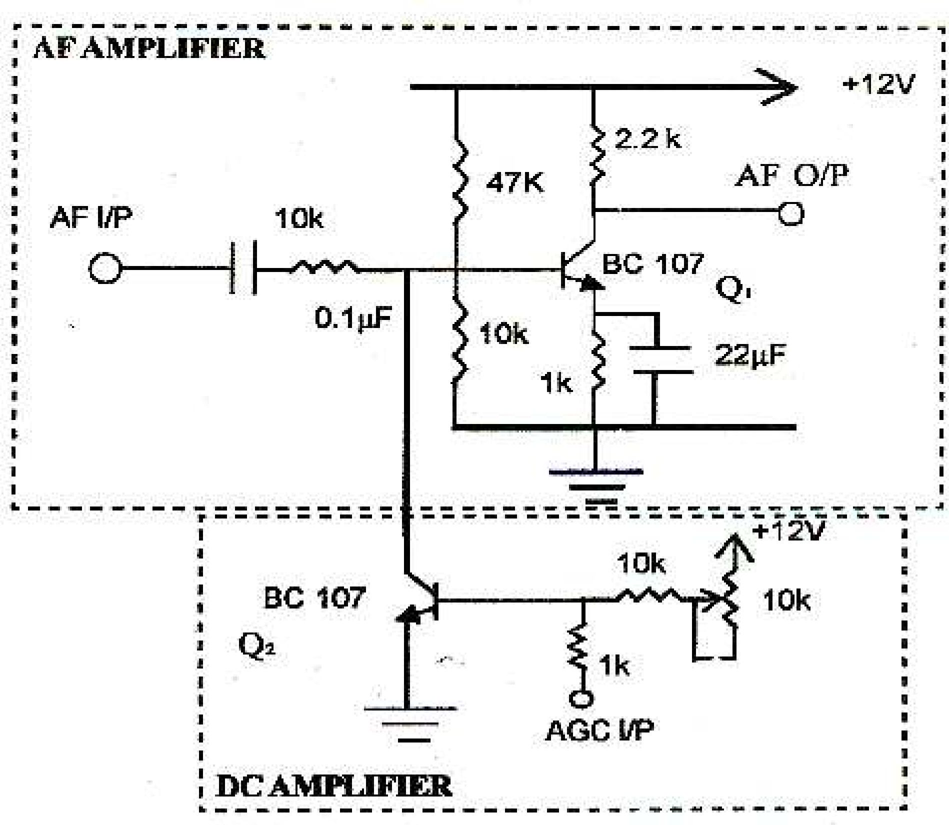
15. Squelch Circuit.

Aim: . To study Squelch circuit

Theory:

A **carrier squelch** or **noise squelch** is the simplest variant of all. It operates strictly on the signal strength, such as when television mutes the audio or blanks the video on "empty" channels, or when a walkie talkie mutes the audio when no signal is present. In some designs, the squelch threshold is preset. For example, television squelch settings are usually preset. Receivers in base stations at remote mountain top sites are usually not adjustable remotely from the control point.

Circuit Diagrams:



Procedure:

1. Study the circuit operation of squelch circuit.

2. Apply the 500Hz of A.F signal to the input of AM generator marked as A.F input. Observe the output of the AM generator using CRO. Adjust the amplitudes of A.F and A.M generators to get proper output of A.M wave form.

3. Now connect the A.M output to the input of the detector provided on board and monitor the detectors outputs of A.F and AGC . Measure the AGC output with a DC voltmeter.

4. Connect the A.F output from the detector to the input of the A.F amplifier and AGC output to the input of the DC amplifier.

5. Now you can study the effect of the squelch circuit by varying the amplitude of the A.M signal and adjust the sensitivity of squelch circuit by varying the potentiometer provided at the base of the transistor Q2.

Precautions.

1.Check the connections before giving the supply

2.Observations should be done carefully